INSTRUCTION MANUAL

FOR

BE1-11*f*

Feeder Protection System

Basler Electric

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Preface

This instruction manual provides information about the installation and operation of the BE1-11*f* Feeder Protection System. To accomplish this, the following information is provided:

- General information and a quick start guide
- Controls and indicators
- Inputs and outputs
- Protection and control functions
- Reporting and alarms information
- Mounting and connection diagrams
- BESTCOMS*Plus*® software
- Communication and security
- Testing and troubleshooting procedures
- Specifications
- Time curve characteristics
- RTD module (optional)

Optional instruction manuals for the BE1-11*f* include:

- Modbus™ communication protocol (Basler Electric part number 9424200991)
- Distributed Network Protocol (DNP) (Basler Electric part number 9424200992)
- IEC 61850 communication protocol (Basler Electric part number 9424200892)

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 BE1-11*f*. 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.

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.

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

The following information provides a historical summary of the changes made to the BE1-11*f* hardware, firmware, and software. The corresponding revisions made to this instruction manual (9424200990 Rev K) are also summarized. Revisions are listed in chronological order.

Hardware Version and Date	Change
—, Oct-08	• Initial release
A, Oct-08	• Changed resistor values for the 15th harmonic
B, Nov-08	• Changed “BE1-11F” to “BE1-11*f*” on the front-panel overlay
C, Nov-08	• Changed the circuit board cover to allow better access to the contact sense jumpers on the rear of the unit
D, Jun-09	• Released BESTCOMS*Plus* version 2.04.01 and application firmware version 1.01.00 • Added Fiber Ethernet option
E, Aug-09	• Added support for SEF option for ground current • Released BESTCOMS*Plus* version 2.05.00 and application firmware version 1.02.00
F, Jan-10	• Released BESTCOMS*Plus* version 2.06.01 and application firmware version 1.03.00
G, Jun-10	• Released BESTCOMS*Plus* version 2.07.03 and application firmware version 1.03.01
H, Jul-10	• Improved Ethernet module
J, Nov-10	• Released BESTCOMS*Plus* version 2.08.01 and application firmware version 2.04.00
K, Mar-11	• Improved digital board
L, Apr-11	• Replaced obsolete LCD
M, Sep-11	• Updated Ethernet board to prevent fast transient failures • Updated T1 through T4 on magnetics board to improve metering
N, Nov-11	• Released BESTCOMS*Plus* version 2.11.01 and application firmware version 2.05.00
O	• This revision letter not used
P, Sep-12	• Improved keyboard
Q	• This revision letter not used
R, Oct-12	• Released BESTCOMS*Plus* version 3.00.02 and application firmware version 2.06.00
S, Nov-12	• Released BESTCOMS*Plus* version 3.01.01 and application firmware version 2.06.01

Application Firmware Version and Date	Change
1.00.00, Oct-08	• Initial release

Application Firmware Version and Date	Change
1.01.00, Apr-09	• Added user programmable alarms 9-16 • Added I1 mode for 50 and 51 element • Added time curves A1, B1, C1, D1, E3, and F1 for 51 element • Added support for password expiration dates • Added support for login lockout on incorrect password • Added Target Reset Key and Alarm Reset Key to logic • Added phase rotation reversal • Allowed energy data to be edited through the front panel • Enhanced Fault Reports • Moved the 62 menus from under Protection to Control • Changed defaults for DST to match US central
1.02.00, Aug-09	• Added support for SEF option for ground current • Made internal improvements invisible to the user
1.03.00, Nov-09	• Improved Comtrade report • Improved calculation of power values • Improved access timeout length • Improved sequence of events downloading/viewing • Improved communications to prevent lockups • Improved RAM write access during relay startup • Improved operation of hold attribute on contact outputs • Improved three-wire power metering
1.03.01, May-10	• Improved low-voltage metering • Improved 81R (rate of change of frequency) function • Improved resolution of values on COMTRADE report
2.04.00, Aug-10	• Implemented IEC 61850 protocol option • Under Settings Explorer, moved Display Units from System Parameters to General Settings
2.04.01, Mar-11	• Implemented Secure Access Login for Modbus • Implemented Alarm Resetting function for Modbus
2.04.02, Jun-11	• Improved IEC 61850 communications
2.05.00, Oct-11	• Added Output Override Alarms • Enhanced voltage settings resolution for 27, 59, and 81 elements
2.05.01, Jun-12	• Improved target reporting
2.06.00, Sep-12	• Added support for RTD module (49RTD protection and analog input protection elements) • Added unbalance current protection mode for the 50 and 51 elements • Added support for enhanced front panel in J type case • Added security logging
2.06.01, Nov-12	• Changes invisible to the user

BESTCOMS*Plus*® Software Version and Date	Change
2.02.01, Oct-08	• Initial Release
2.03.01, Feb-09	• Changed time delay increment from 0.01 to 1 for all 27 and 59 elements
2.04.01, May-09	• Added optional fiber optic Ethernet to General Settings, Style Number screen • Added support for password expiration dates • Added Setting Display Modes setting on System Parameters, Sensing Transformers screen • Added user programmable alarms 9-16 on Alarm Configuration, User Programmable Alarms screen • Added curve selection of A1, B1, C1, D1, E3, and F1 for Protection, Current, Inverse Overcurrent • Added a button for Export Metering • Added an option to upload settings and logic at the same time • Added Target Reset Key and Alarm Reset Key to logic • Added Phase Rotation Reversal • Enhanced General Settings, Device Info screen • Improved Alarm Configuration, Alarms screen • Improved Target Configuration, Targets screen
2.05.00, Jul-09	• Updated Basler Electric Device Package Uploader screen • Added option C) 0.01 - 7.5 Amp (SEF) to Ground CT Option on Style Number screen • Added timing curve graphs for 27 and 59 functions when using inverse timing mode
2.06.01, Dec-09	• Added Edit button to Analog Metering, Energy screen • Added “0 = No Password Expiration” to Days to Expiration setting on User Name Setup screen • Removed USB COM alarm choice from Alarm Settings screen • Improved Inverse Overcurrent settings screens • Improved Table Curve screens for inverse overcurrent elements • Changed the overall look and feel of the BESTCOMS*Plus* shell • Added 25 Hz frequency option under Nominal Settings on the Power System screen • BESTCOMS*Plus* shell enhancements • Added Windows® 7 32-bit compatibility
2.06.02, Jan-10	• Added Upgrade Style Number to the Communication pull-down menu
2.07.01, Mar-10	• Added Windows® 7 64-bit compatibility and removed Windows 2000 compatibility
2.07.03, Jun-10	• Added Option 2 to style number for custom builds

BESTCOMS*Plus*® Software Version and Date	Change
2.08.00, Aug-10	• Under Settings Explorer, moved Display Units from System Parameters to General Settings • Added Recloser, Breaker Status, and 86 Lockout Status to Metering Explorer under Status • Added Edge Triggers to BESTLogic*Plus* (firmware dependent) • Added Logic Labels to BESTLogic*Plus* (firmware dependent) • Added Auto Export Metering function • Added “P” case option on Style Number screen • Implemented IEC 61850 protocol option
2.08.01, Oct-10	• Improved Off-Page logic • Enhanced IEC 61850 logic inputs and outputs
2.10.02, Jun-11	• Added the ability to select what data to view/export from the Preview Metering and Export Metering buttons • Added the ability to save workspace • Added the ability to auto reconnect when connection is lost • Added the ability to close multiple views • Enhanced BESTLogic*Plus*
2.11.01, Nov-11	• Added Output Override Alarm settings • Added IRIG Decoding setting on Clock Setup screen • Enhanced voltage settings resolution for 27, 59, and 81 elements • Enhanced settings file printout
2.11.02, Dec-11	• Improved metering and settings file printouts • Added options to print Modbus and DNP points in settings file printouts • Improved Phasor Diagrams in Metering
2.13.00, Apr-12	• Changes invisible to the user
2.14.00, Jul-12	• Changes invisible to the user
3.00.02, Sep-12	• Added support for BE1-11*f* firmware version 2.06.00 • Updated the settings compare feature to include Modbus™ and DNP differences
3.01.01, Nov-12	• Changes invisible to the user

Manual Revision and Date	Change
—, Oct-08	• Initial release
A, Mar-09	• Added GOST-R Certification in Section 1, *General Information* • Added Note #1 to style chart in Section 1, *General Information* • Removed references to preprogrammed logic schemes not included in the relay from Section 12, *Application* • Improved Section 14, *Testing* • Minor text edits throughout manual

Manual Revision and Date	Change
B, Jun-09	• Changed “BESTlogic+” to “BESTLogic*Plus*” • Added Fiber Optic Ethernet option • Added “Modbus/TCP and DNP 3.0 with BESTNet*Plus*” option for Ethernet Protocol • Updated Figures 4-3, 4-4, 4-8, 8-9, 8-23, and 10-1 • Section 6: Added Setting Display Modes under Sensing Transformer Settings • Section 8: Changed User Programmable Alarms from 8 to 16 • Section 9: Added I1 mode for 50 and 51 functions • Section 13: Added Figure 13-11, H1 Case Rear Panel Terminal Connections (Option Fiber Optic Ethernet Shown) • Section 14: Improved functional test procedure • Section 15: Updated all web page figures • Appendix A: Added Time Curves A1, B1, C1, D1, E3, and F1 • Appendix A: Added Voltage Inverse Time Curves for 27/59 functions • Appendix B: Updated Logon procedure and list of menu tree items
C, Aug-09	• Updated Figure 1-1, Style Chart, and other relevant references to support SEF option for ground current • Renamed “Neutral Current” option to “Ground Current” in Figure 1-1, Style Chart • Updated Figure 3-25, Basler Electric Device Package Uploader
D, Aug-09	• Updated Style Chart in Section 1 to show note #2 for Sensitive Earth Fault in the Ground Current box • In Section 1, under General Specifications, Type Tests, changed IEEE C37.90.1, “2004” to “2002” • In Section 1, under General Specifications, Type Tests, changed IEEE C37.90.3, “2006” to “2001” • In Section 9, changed 27 and 59 time delays from “0 or 50 to 600,000 ms” to “50 to 600,000 ms”
E, Oct-09	• Added Note #3 to Style Chart in Section 1 (If Phase Current choice is 1, Ground Current choice must be B.) • Improved listing of Standards and CE Compliance in Section 1, General Information, General Specifications • Section 1: Added statement about an evaluation copy of BESTWAVE*Plus*™ being included on the product CD
F, Jul-10	• Replaced Figures 13-17, 13-25, and 13-26 (added a connection between C16 (VN) and C14 (VB))

Manual Revision and Date	Change
G, Nov-10	• Added P Case Option and IEC 61850 Ethernet Protocol option to the Style Chart in Section 1 • Added EN 61000-6-2 and EN 61000-6-4 under General Specifications, CE Compliance in Section 1 • Added DNP Certification, IEC 61850 Certification, and IP Class under General Specifications in Section 1 • Added Display Units in Section 4 • Added Configure Ethernet Port under Ethernet in Section 5 • Added Recloser, Breaker Status, and 86 Lockout Status under Status in Section 8 • Added Figure 13-3, H1 Panel-Mount Case Dimensions
H, Mar-11	• Replaced Figure 3-13, Auto Export Metering (added Filter button on screen) • Replaced Figure 13-18, Voltage Sensing, Alternate VTP Inputs. (Added connection between C14 & C16 in image B • Improved BE1-11*f* image on front cover
I	• This revision letter not used
J, Sep-12	• Converted manual into new style and structure • Added support for BE1-11*f* firmware version 2.06.00 and BESTCOMS*Plus* version 3.00.02
K, Nov-12	• Added Storage statement in the *Quick Start* chapter • Minor text edits throughout manual

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Introduction

The BE1-11*f* Feeder Protection System provides flexible, reliable, and economical feeder protection, control, monitoring, and measurement functions. The BE1-11*f* offers breaker failure protection, overcurrent, over/undervoltage, over/underfrequency, directional overcurrent, directional power, RTD (Resistance Temperature Detector) with remote module, and fuse loss protection. It offers breaker- and trip-circuit monitoring, and oscillography and sequential events recording. Control features include virtual selector switches, circuit breaker control, virtual lockout, and variable-mode timers. System metering, status information, and fault locating are available at the relay front panel and through the relay communication ports. The capabilities of the BE1-11*f* make it suitable for use in overcurrent feeder or OEM cubicle switchgear protection applications. Suitable BE1-11*f* applications include distributed generation, intertie protection, network directional overcurrent feeder applications, and stand-alone distribution or transmission breaker failure applications.

A front-panel USB port or optional rear Ethernet port enables local communication between the relay and a PC operating with BESTCOMS*Plus*® software. BESTCOMS*Plus* software simplifies the commissioning process by providing a graphical interface for setting the relay and configuring a protection and control scheme for your application. Through BESTCOMS*Plus*, all relay settings and logic can be retained in a file for printing or uploading to other BE1-11*f* relays. Oscillography and sequential events records can be retrieved from a relay, viewed, and printed.

Front-panel features include a large, backlit alphanumeric display and LED indicators that display system parameters, relay settings, and relay status. Pushbuttons enable navigation through the display menu, changes to settings, resetting of targets (with password access), and direct access to virtual switches.

Applications

The capabilities of the BE1-11*f* make it ideally suited for applications with the following attributes:

- Isolation between the RTDs and the relay due to distance between the relay package and the RTD module
- Low burden to extend the linear range of CTs
- The flexibility provided by wide setting ranges, multiple setting groups, and multiple coordination curves in one unit
- The economy and space savings provided by a multifunction, multiphase unit. This one unit can provide all of the protection, control, metering, and local and remote indication functions required for typical applications.
- Directional control and fault recording
- High-speed Ethernet communications and protocol support
- The capabilities of a numeric multifunction relay
- The small size and limited behind-panel projection facilitates modernizing protection and control systems in existing equipment
- Detection of low ground current levels (SEF option)
- IEC 61850 functionality
- Logic library with the following schemes: Basic overcurrent protection, overcurrent with reclose, overcurrent with control, feeder protection with interlock, BUS, BACKUP

Features

The BE1-11*f* relay includes many features for the protection, monitoring, and control of power system equipment. These features include protection and control functions, metering functions, and reporting and alarm functions. A highly flexible programmable logic system called BESTlogic™*Plus* 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 user interface provide easy access to the features provided.

The following information summarizes the capabilities of this multifunction device. Each feature, along with its setup and use, is described in greater detail in the later chapters of this manual.

General Features

HMI (Human-Machine Interface)

Each BE1-11*f* has a front-panel display and LED indicators. Relays in an H or P style case have five LED indicators: Power Supply Status, Relay Trouble Alarm, Minor Alarm, Major Alarm, and Trip. Relays in a J style case have 12 LED indicators: Power Supply Status, Relay Trouble Alarm, Minor Alarm, Major Alarm, Trip, Select Control Switch, Operate Control Switch, and Indicator 1 through 7 (programmable in BESTlogic*Plus)*. The backlit, 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 enable navigation through the LCD menu tree. Parameters are changed using the Edit pushbutton. Targets, alarms, and other registers are cleared with the Reset pushbutton. In Edit mode, the scrolling pushbuttons provide data entry selections. Edit mode is indicated by an LED on the Edit pushbutton. Relays in a J-style case have pushbuttons for selecting and controlling the virtual control switches.

The LCD has automatic priority logic to govern which metering values are displayed on the screen so that when an operator approaches, the metering data of most interest is automatically displayed without having to navigate the menu structure. Scrollable metering parameters are selected on the General Settings, Front Panel HMI settings screen in BESTCOMS*Plus*.

Device Information

The version of the embedded software (firmware), serial number, and style number are available from the front-panel display or the communication ports.

Three free-form fields (Device ID, Station ID, and User ID) can be used to enter information to identify the relay. These fields are used by many of the reporting functions to identify the relay reporting the information. Examples of relay identification field uses include station name, circuit number, relay system, and purchase order, and others.

Device Security

Passwords provide access security for six distinct functional access areas: Read, Control, Operator, Settings, Design, and Administrator. Each username/password is assigned an access area with access to that area and each area below it. An administrator password provides access to all six of the functional areas.

A second dimension of security is provided by the ability 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 through the Ethernet port.

Security settings affect read and write access. Refer to the *Security* chapter for more information.

Setting Groups

Four setting groups allow adaptive relaying to be implemented to optimize BE1-11*f* settings for various operating conditions. Automatic and external logic can be employed to select the active setting group.

Clock

The clock is used by the logging functions to timestamp events. BE1-11*f* timekeeping can be self-managed by the internal clock or coordinated with an external source through a network or IRIG device.

A backup capacitor and additional battery backup are provided for the clock. During a loss of operating power, the backup capacitor maintains timekeeping for up to 24 hours depending on conditions. As the capacitor nears depletion, the backup battery takes over and maintains timekeeping. The backup battery has a life expectancy of greater than five years depending on conditions.

IRIG

A standard unmodulated IRIG-B input receives time synchronization signals from a master clock. Automatic daylight saving time compensation can be enabled and set for floating or fixed dates.

NTP (Network Time Protocol)

NTP synchronizes the real-time clock to network time servers through the Ethernet port. BESTCOMS*Plus* is used to establish the priority of time reference sources available to the relay, IRIG-B, NTP, DNP, and RTC (real-time clock). The NTP address is set using BESTCOMS*Plus*.

Communications

Three independent communication ports provide access to all relay functions. A USB (universal serial bus) port is located on the front panel, a two-wire RS-485 port is located on the rear panel, and an optional Ethernet port is also located on the rear panel. The RS-485 and Ethernet ports are electrically isolated.

Modbus™ and DNP3 protocols are optionally available for the RS-485 or Ethernet communication port. The IEC 61850 protocol is optionally available for the Ethernet port. Separate instruction manuals cover each available protocol. Consult the product bulletin or Basler Electric for availability of these options and instruction manuals. Modbus sessions can be operated simultaneously over the Ethernet and RS-485 ports.

System Parameters

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

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

An auxiliary voltage sensing input (Vx) provides protection capabilities for over/undervoltage monitoring of the fundamental and third harmonic voltage 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 has low burden and is isolated. Neutral, positive-sequence, and negative-sequence current magnitudes are derived from the three-phase currents. An independent ground current input is available for direct measurement of the current in a transformer neutral, tertiary winding or flux balancing current transformer. Either one or two sets of CTs are provided in the BE1-11*f* depending on the style number. Refer to the style chart for more information.

Programmable Inputs and Outputs

Programmable contact inputs and outputs are described in the following paragraphs.

Programmable Inputs

Programmable contact sensing inputs with programmable signal conditioning provide a binary logic interface to the protection and control system. Each input function and label is programmable using

BESTlogic*Plus*. A user-meaningful label can be assigned to each input and to each state (energized and de-energized) for use in reporting functions. Board mounted jumpers support dual voltage ratings.

Relays in a J style case are equipped with seven contact sensing inputs. Relays in an H or P style case are equipped with five contact sensing inputs.

Programmable Outputs

Programmable general-purpose contact outputs provide a binary logic interface to the protection and control system. One programmable, failsafe contact output serves as an alarm output. Each output function and label is programmable using BESTlogic*Plus*. A user-meaningful name can be assigned to each output and to each state (energized and de-energized) 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.

Relays in a J style case are equipped with eight general-purpose contact outputs. Relays in an H or P style case are equipped with five general-purpose contact outputs.

Reporting and Alarms

Several reporting and alarm functions provide fault reporting, demand, breaker, and trip circuit monitoring. Reporting of power quality, energy data, and general status is also provided.

Alarms

Extensive self diagnostics will trigger a fatal relay trouble alarm if any of the relay core functions are compromised. 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 or minor alarm LEDs on the front panel. Major and minor alarm points can also be programmed to any output contact including OUTA. Over 50 alarm conditions are available to be monitored including user-definable logic conditions using BESTlogic*Plus*.

Active alarms can be read and reset at the front panel or through 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.

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 Monitor (52TCM)

The trip circuit of a breaker or lockout relay can be monitored for loss of voltage (fuse blown) or loss of continuity (trip coil open). Additional trip or close circuit monitors can be implemented in BESTlogic*Plus* using additional inputs, logic timers, and programmable logic alarms.

Demands

Demand values are continuously calculated for phase currents, neutral current, negative-sequence current, ground current, real power, reactive power, and apparent power. The demand interval and demand calculation method are independently settable for phase, neutral, and negative-sequence measurements. Demand reporting records peak and present demand with time stamps for each register.

Power Quality

The BE1-11*f* offers IEC 61000-4-30 Class B power quality measurement performance. Power quality settings include a fixed or sliding reference mode, dip hysteresis, dip ratio, swell hysteresis, and swell ratio.

Energy Data Reporting

Energy information in the form of watthours and varhours is measured and reported by the BE1-11*f*. Both positive and negative values are reported in three-phase, primary units.

General Status Reporting

The BE1-11*f* provides extensive general status reporting for monitoring, commissioning, and troubleshooting. Status reports are available from the front-panel display or the communication ports.

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. 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. A copy of BESTwave is included on the BE1-11 product CD.

Sequence of Events Recorder

A Sequence of Events Recorder (SER) 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.

Protection and Control

Protection functions consist of Sync-Check, Undervoltage, Overvoltage, Frequency, Instantaneous Overcurrent, Breaker Failure, Inverse Overcurrent, Power (optional), Thermal, Analog, and Recloser protection. Virtual Control Switches, Timers, a Lockout Function, and a Breaker Control Switch make up the control functions. The following paragraphs describe each protection and control function.

Sync-Check (25) Protection

With the auxiliary voltage input connected to the bus, one sync-check function provides synchronism protection. 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 (25VM) provides independent dead/live voltage closing logic.

Undervoltage (27P) and Overvoltage (59P) Protection

Five phase undervoltage and four phase overvoltage elements are included. Phase undervoltage/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, under/overvoltage protection can be set for either phase-to-phase voltage or phase-to-neutral voltage. The 27P elements are equipped with an undervoltage inhibit feature. Inverse or definite time can be selected. Refer to the *Time Curve Characteristics* chapter.

Auxiliary Undervoltage (27X) and Auxiliary Overvoltage (59X) Protection

Four auxiliary overvoltage and four auxiliary undervoltage elements provide over/undervoltage protection. Auxiliary voltage protection elements can be set to individually monitor the third harmonic, neutral-shift, positive-sequence, negative-sequence, or auxiliary fundamental voltages. Ground unbalance protection is provided when the auxiliary voltage input is connected to a source of 3V0 such as a broken-delta VT. The 27X is equipped with an undervoltage inhibit feature. Inverse or definite time can be selected. Refer to the *Time Curve Characteristics* chapter.

Frequency (81) Protection

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

Note

BE1-11*f* relays enabled for IEC-61850 communication (style Fxxxx5xxxxxxxx) have their frequency protection elements fixed at four underfrequency elements, two overfrequency elements, and two frequency rate-of-change elements.

Instantaneous Overcurrent (50) Protection

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

Instantaneous overcurrent elements can be set for single-phase, three-phase, ground, neutral, positive-sequence, negative-sequence, or unbalanced protection.

Breaker Failure (50BF) Protection

One breaker failure function provides protection and security for the power system against failure of the monitored breaker.

Inverse Overcurrent (51) Protection

Seven inverse overcurrent elements can be set for single-phase, three-phase, ground, neutral, positive-sequence, negative-sequence, or unbalanced protection. Inverse-overcurrent functions employ a dynamic integrating timing algorithm covering a range from pickup to 40 times pickup with selectable instantaneous or integrated reset characteristics. Inverse time overcurrent curves conform to IEEE Std C37.112-1996 - *IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays,* 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. Refer to the *Time Curve Characteristics* chapter for more information about the inverse overcurrent protection characteristic curves.

Phase inverse overcurrent elements can be voltage restrained or controlled for generator backup applications. Negative-sequence current protection (46) is included as a mode of the 51 (inverse overcurrent) element. Each inverse overcurrent element can be individually set for forward, reverse, or non-directional control.

A separate ground current input provides ground overcurrent protection for a separate ground CT. Optionally, an SEF (sensitive earth fault) version of the separate ground CT is available.

Power (32) Protection (style FxxxxxxxDxxxxx)

Two directional power elements can be set for forward or reverse, overpower or underpower protection. The element can be used for any application requiring directional power flow detection including intertie protection (interconnects between an electric utility and a source of non-utility generation). The power measurement algorithm is adapted as appropriate for any possible three-phase or single-phase voltage transformer connection. Directional power is calibrated on a three-phase basis regardless of the voltage transformer connection used. Directional Power Protection can be set for one of three, two of three, three of three, or total power.

Note

BE1-11*f* relays enabled for IEC-61850 communication (style Fxxxx5xxDxxxxx) have their power protection elements fixed at one underpower element and one overpower element.

Resistance Temperature Detector (49RTD) Protection

Six resistance temperature detector elements provide over/undertemperature protection in applications where a remote RTD module is connected to the relay via Ethernet or RS-485 cable. For more information, refer to the *RTD Module* chapter.

Analog Input Protection

Eight analog input protection elements monitor external analog input signals when two remote RTD modules are connected via an Ethernet or RS-485 cable. Four analog inputs are provided with each RTD module. For more information, refer to the *RTD Module* chapter.

Fuse Loss (60FL)

A fuse loss element protects against false tripping due to a loss of voltage sensing. Voltage transformer circuit monitoring adds security by detecting problems in the voltage transformer sensing circuits and preventing mis-operations of the 25, 27P, 47, 59P, and 51/27 functions.

Breaker Control Switch (101)

Tripping and closing of a selected breaker can be controlled by the virtual breaker control switch. The virtual breaker control switch is accessed locally at the front panel or remotely through the communication ports.

Virtual Control Switches (43)

Five virtual control switches are accessed locally at the front panel or remotely through the communication ports. Virtual switches can be used to trip and close additional switches or breakers, or enable and disable certain functions.

Logic Timers (62)

Eight logic timers with six modes of operation emulate virtually any type of timer.

Lockout Functions (86)

Two lockout elements are provided.

BESTlogic™*Plus* Programmable Logic

Each BE1-11*f* 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 may have. Programming with BESTlogic*Plus* 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.

Refer to the *BESTlogicPlus* chapter for more information on logic schemes. Custom logic settings allow you to tailor the relay functionality to match the needs of your operation's practices and power system requirements.

Metering Functions

Metering is provided for the following parameters:

- Primary and secondary voltages (P-P, P-N, V1, V2, 3V0, Vx, Vx 3rd harmonic)
- Frequency (phase and auxiliary)
- Primary and secondary currents (phase, ground, I1, I2, 3I0)
- Power (real, reactive, apparent)
- Power factor
- Energy (total watthours and total varhours)

For details on metering functions, refer to the *Metering* chapter.

Model and Style Number Description

BE1-11*f* relay electrical characteristics and operational features are defined by a combination of letters and numbers that make up the style number. The style number describes the options included in a specific device and appears on labels located 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 model number and style number are shown in Figure 1.

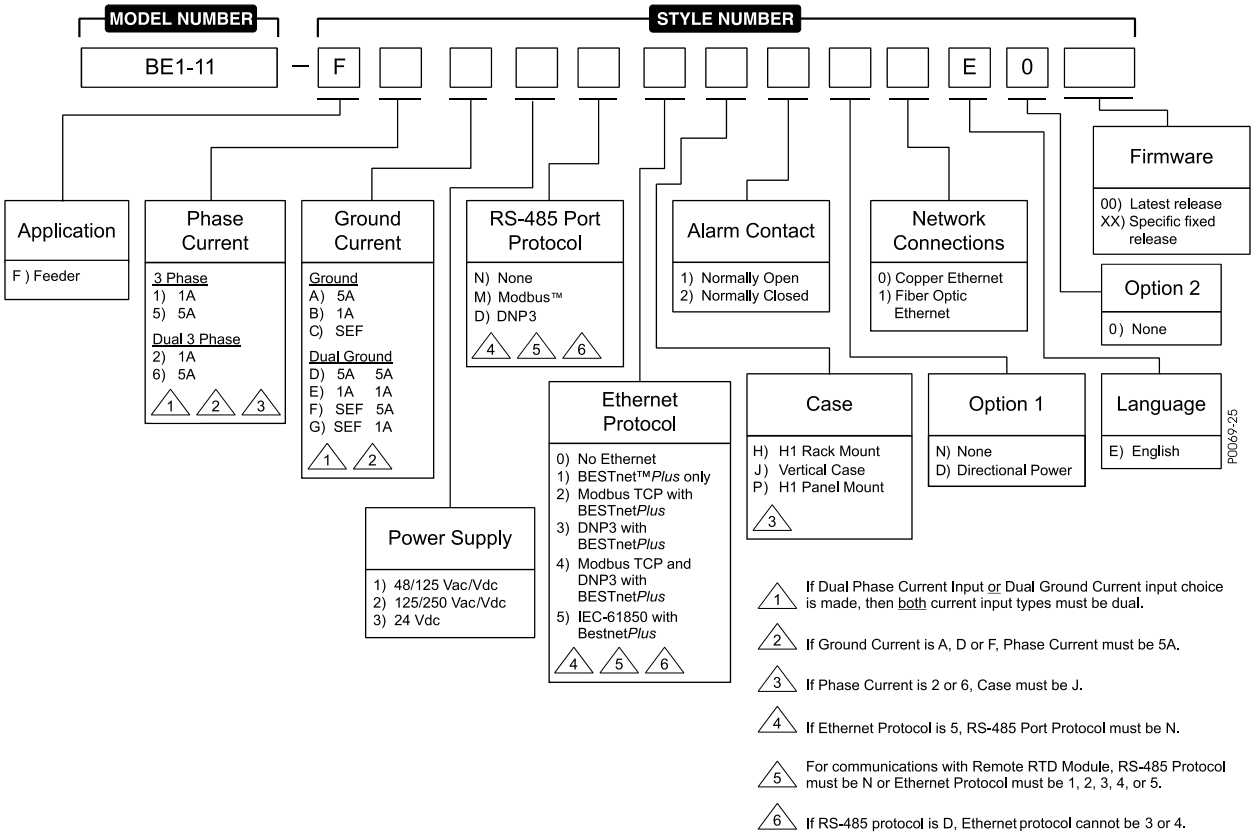


Figure 1. Style Chart

Quick Start

This chapter provides basic installation and setup information about the BE1-11*f* Feeder Protection System. BE1-11*f* relays are delivered with a BE1-11 product CD. Upon receipt of the relay, check the model and style number against the requisition and packing list for agreement. If there is evidence of shipping damage, file a claim with the carrier, and notify the Basler Electric Regional Sales Office, your sales representative, or a sales representative at Basler Electric, Highland, Illinois.

If the BE1-11*f* is not installed immediately, store it in the original shipping carton in a moisture- and dust-free environment.

Included on the BE1-11 product CD:

- BESTCOMS*Plus*® Software
- BESTwave™ Software
- BEST61850 Software
- Quick Start Guide
- Communications Quick Start Guide
- Instruction Manual
- Modbus™ Instruction Manual
- DNP Instruction Manual
- IEC 61850 Instruction Manual

Note
Do not connect a USB cable between the PC and the BE1-11*f* until BESTCOMS*Plus* is installed. Connecting a USB cable before setup is complete may result in errors.

Register Relay

End users are encouraged to register their relays with Basler Electric. A peel-off label on the front panel of each relay directs users to complete registration on-line at http://www.basler.com/register. Registering your relays with Basler Electric will give you access to the latest BESTCOMS*Plus* software and firmware updates for your devices. The registration process takes only a few minutes. Please have the serial number(s) of your relay(s) available when registering.

Install BESTCOMSPlus® Software

BESTCOMS*Plus* software is built on the Microsoft® .NET Framework. The setup utility that installs BESTCOMS*Plus* on your PC also installs the BE1-11 plugin and the required version of .NET Framework (if not already installed). BESTCOMS*Plus* operates with systems using Windows® XP 32-bit SP3, Windows Vista 32-bit SP1 (all editions), Windows 7 32-bit (all editions), and Windows 7 64-bit (all editions). System recommendations for the .NET Framework and BESTCOMS*Plus* are listed in Table 1.

Table 1. System Recommendations for BESTCOMS*Plus* and the .NET Framework

System Type	Component	Recommendation
32/64 bit	Processor	1.0 GHz
32/64 bit	RAM	512 MB (minimum)
32 bit	Hard Drive	75 MB (if .NET Framework is already installed on PC.)
		925 MB (if .NET Framework is not already installed on PC.)
64 bit	Hard Drive	75 MB (if .NET Framework is already installed on PC.)
		2.1 GB (if .NET Framework is not already installed on PC.)

To install BESTCOMS*Plus*, a Windows user must have Administrator rights.

1. Insert the BE1-11 product CD into the PC CD-ROM drive.
2. When the BE1-11 Product CD menu appears, click the installation button for BESTCOMS*Plus*. The setup utility installs BESTCOMS*Plus*, the .NET Framework (if not already installed), the USB driver, and the BE1-11 plugin for BESTCOMS*Plus* on your PC.

When BESTCOMS*Plus* installation is complete, a Basler Electric folder is added to the Windows programs menu. This folder is accessed by clicking the Windows Start button and then accessing the Basler Electric folder in the Programs menu. The Basler Electric folder contains an icon that starts BESTCOMS*Plus* when clicked.

Power Up and Activate the BE1-11 Plug-In

The BE1-11 plugin is a module that runs inside the BESTCOMS*Plus* shell. The BE1-11 plugin contains specific operational and logic settings for only BE1-11 relays. Uploading settings to the BE1-11*f* is possible only after activating the BE1-11 plugin.

Note that if a relay is not connected, you will not be able to configure certain Ethernet settings. Ethernet settings can be changed only when an active USB or Ethernet connection is present. Refer to the *Communication* chapter for more information.

USB Connection

The USB driver was copied to your PC during BESTCOMS*Plus* installation and is installed automatically after powering the BE1-11*f*. USB driver installation progress is shown in the Windows Taskbar area. Windows will notify you when installation is complete.

Connect a USB cable between the PC and your BE1-11*f* relay. A typical USB cable with a B-type connector is shown to the right.

NOTE

In some instances, the Found New Hardware Wizard will prompt you for the USB driver. If this happens, direct the wizard to the following folder:

C:\Program Files\Basler Electric\BESTCOMSPlus\USBDeviceDrivers\

Apply Operating Power

The nominal power supply values are listed on the front-panel label. See Figure 2 for an example.

Figure 2. Front Panel Label Example

Connect rear terminals A6, A7, and A8 (ground) to a power supply. Figure 3 shows the rear terminals of the BE1-11*f* in a J type case. Figure 4 shows the rear terminals of the BE1-11*f* in an H or P type case. Apply operating power consistent with the nominal power supply values listed on the front-panel label. Wait until the boot sequence is complete.

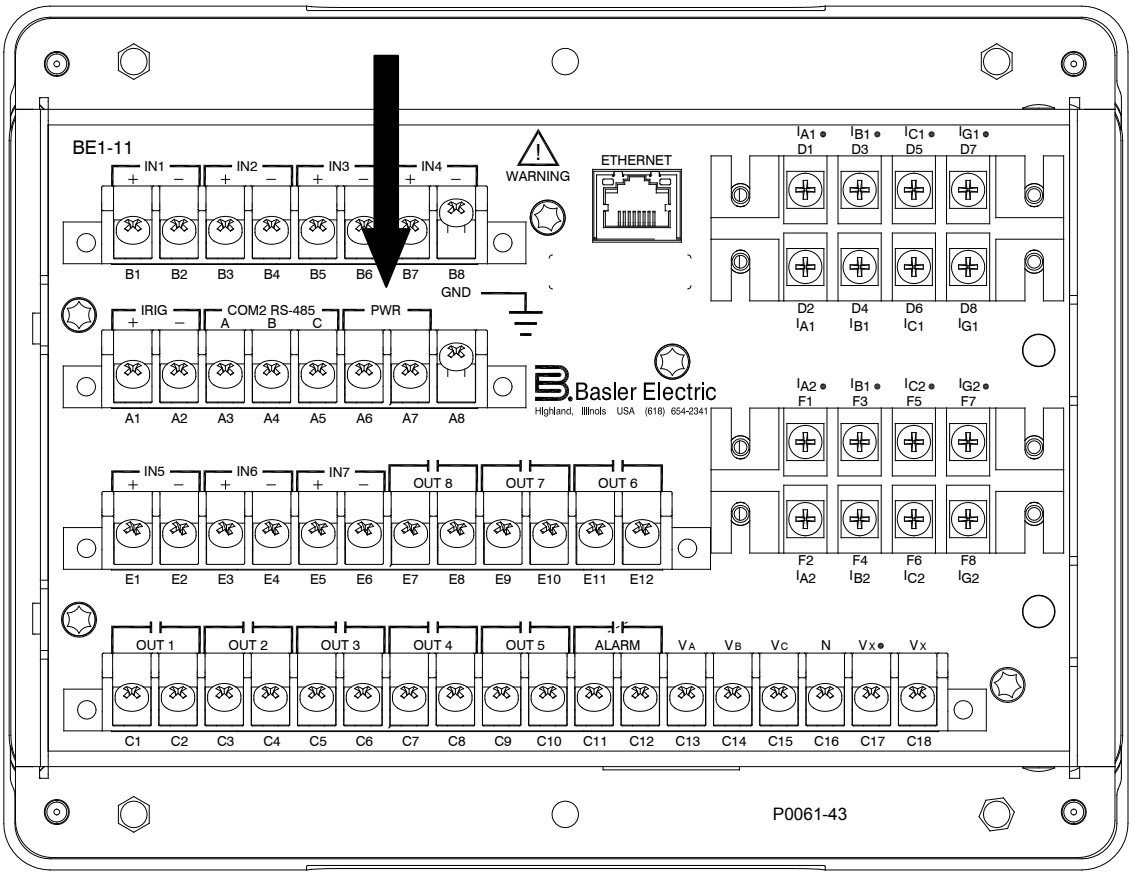


Figure 3. PWR Rear Terminals (J Type Case)

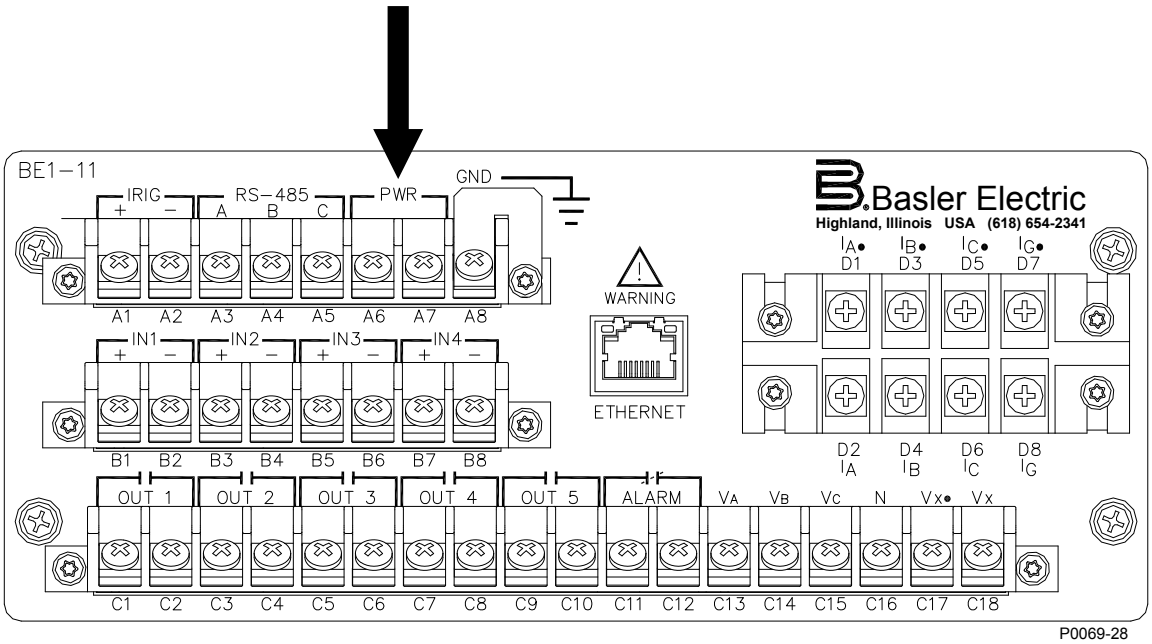


Figure 4. PWR Rear Terminals (H or P Type Case)

Start BESTCOMS*Plus*® and Activate BE1-11 Plugin

To start BESTCOMS*Plus*, click the Start button, point to Programs, Basler Electric, and then click the BESTCOMS*Plus* icon. During initial startup, the BESTCOMS*Plus* Select Language screen is displayed (Figure 5). You can choose to have this screen displayed each time BESTCOMS*Plus* is started, or you can select a preferred language and this screen will be bypassed in the future. Click OK to continue. This screen can be accessed later by selecting Tools and Select Language from the menu bar.

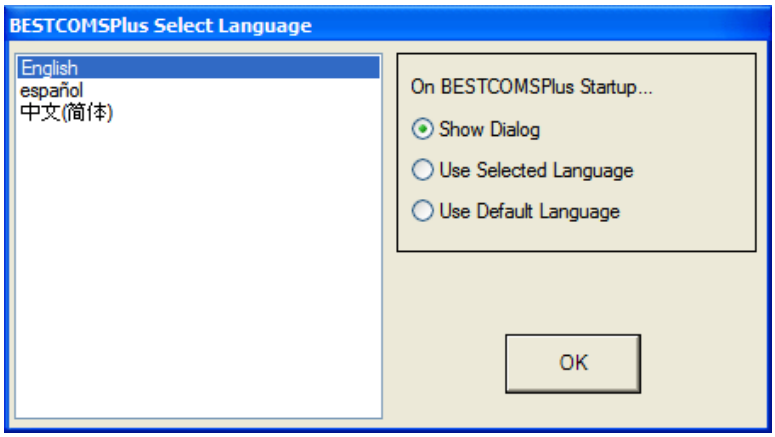


Figure 5. BESTCOMS*Plus* Select Language Screen

The BESTCOMS*Plus* splash screen is shown for a brief time. See Figure 6.

Figure 6. BESTCOMS*Plus* Splash Screen

The BESTCOMS*Plus* platform window opens. Select New Connection from the Communication pull-down menu and select BE1-11. See Figure 7. The BE1-11 plugin is activated automatically after connecting to a BE1-11*f*.

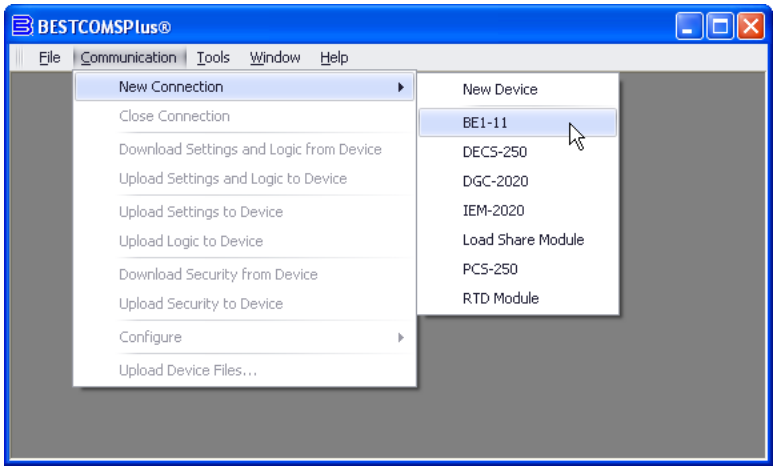


Figure 7. Communication Pull-Down Menu

The BE1-11 Connection screen shown in Figure 8 appears. Select USB Connection and then click the Connect button.

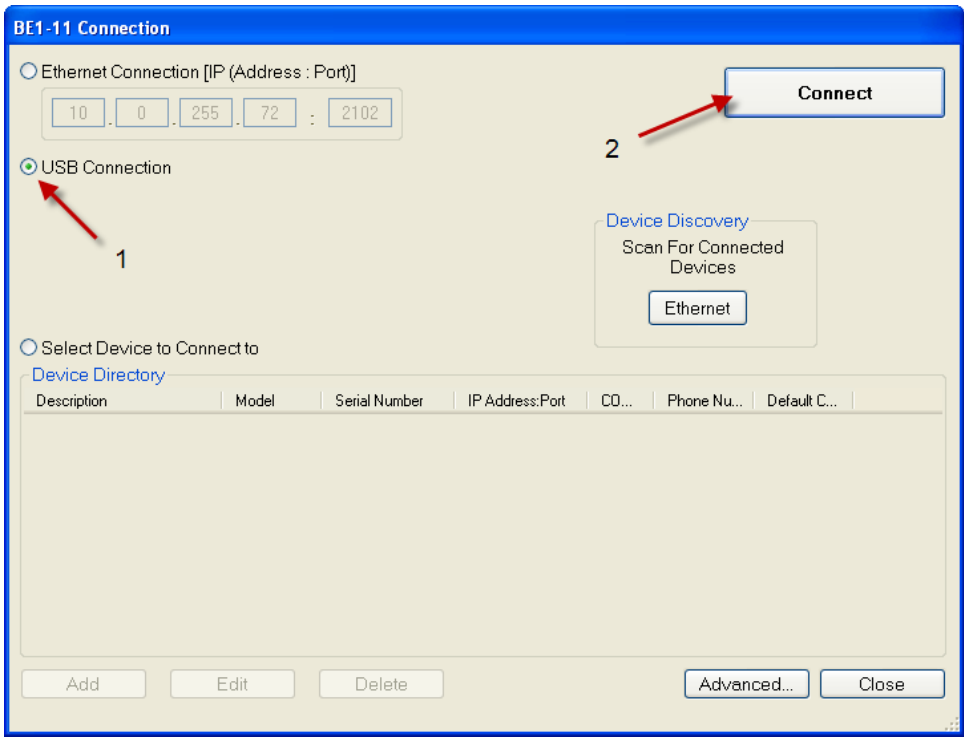


Figure 8. BE1-11 Connection Screen

The BE1-11 plugin opens indicating that activation was successful. You can now configure the BE1-11*f* communication ports and other BE1-11*f* settings.

Programming the Relay

This section contains an introduction to BESTCOMS*Plus*, explains summary screens, and gives an example of settings elements and programming logic.

Introduction to BESTCOMS*Plus*®

BESTCOMS*Plus* is a Windows®-based, PC application that provides a user-friendly, graphical user interface (GUI) for use with Basler Electric communicating products. The name BESTCOMS*Plus* is an acronym that stands for Basler Electric Software Tool for Communications, Operations, Maintenance, and Settings.

BESTCOMS*Plus* provides the user with a point-and-click means to set and monitor the BE1-11*f*. The capabilities of BESTCOMS*Plus* make the configuration of one or several BE1-11*f* Feeder Protection Systems fast and efficient. A primary advantage of BESTCOMS*Plus* is that a settings scheme can be created, saved as a file, and then uploaded to the BE1-11*f* at the user's convenience.

The BE1-11 plugin opens inside the BESTCOMS*Plus* main shell. The same default logic scheme that is shipped with the BE1-11*f* is brought into BESTCOMS*Plus* by downloading settings and logic from the relay or by selecting application type "F" on the Style Number screen. This gives the user the option of developing a custom setting file by modifying the default logic scheme or by building a unique scheme from scratch.

BESTlogic™*Plus* Programmable Logic is used to program BE1-11*f* logic for protection elements, inputs, outputs, alarms, etc. This is accomplished by the drag-and-drop method. The user can drag elements, components, inputs, and outputs onto the program grid and make connections between them to create the desired logic scheme.

BESTCOMS*Plus* also allows for downloading industry-standard COMTRADE files for analysis of stored oscillography data. Detailed analysis of the oscillography files can be accomplished using BESTwave™ software.

Figure 9 illustrates the typical user interface components of the BE1-11 plugin with BESTCOMS*Plus*.

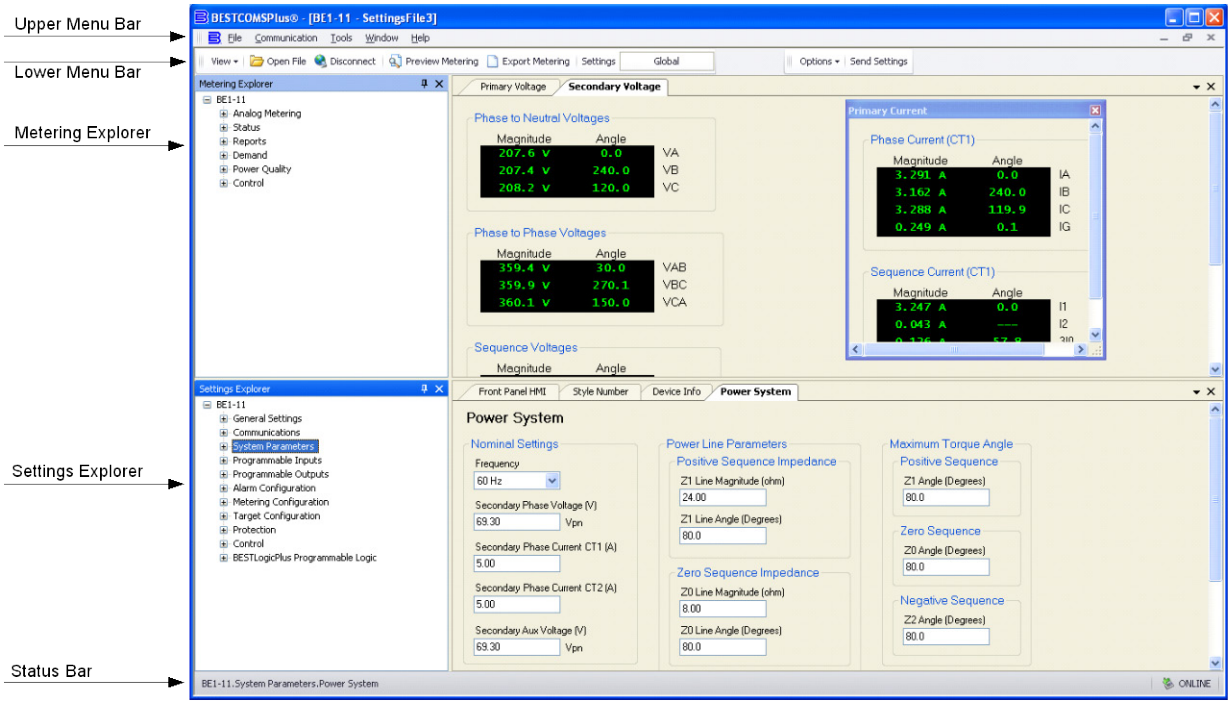


Figure 9. BESTCOMS*Plus* Typical User Interface Components

Click the View drop-down button to switch between the Settings Explorer and Metering Explorer or split the view between both. The Settings Info Panel displays settings ranges. A workspace can be opened, saved, or set as default. See Figure 10.

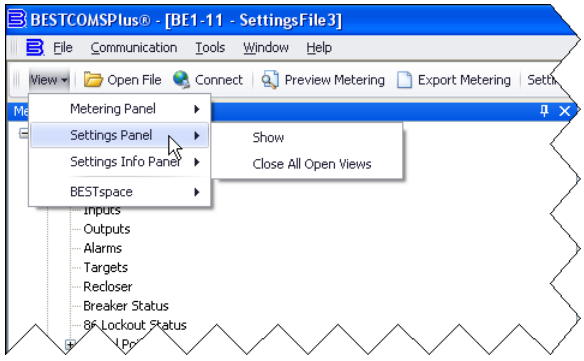


Figure 10. View Drop-Down Button

Summary Screens

Summary screens provide an overview of the system setup. The legend, located in the lower right-hand corner, provides interpretation for the various indicated colors. The current state of a protection and control function or element is indicated by the color of the adjacent indicator. If the function is enabled, the color is green. If the function is disabled only by a setting (such as zero), the color is yellow. If the function is disabled only by a mode, the color is blue. If the function is disabled by both a setting and mode, the color is gray. The System Summary screen is available by clicking BE1-11 in the Settings Explorer as shown in Figure 11. Summary screens are also available for General Settings, Alarm Configuration, Protection, and Control.

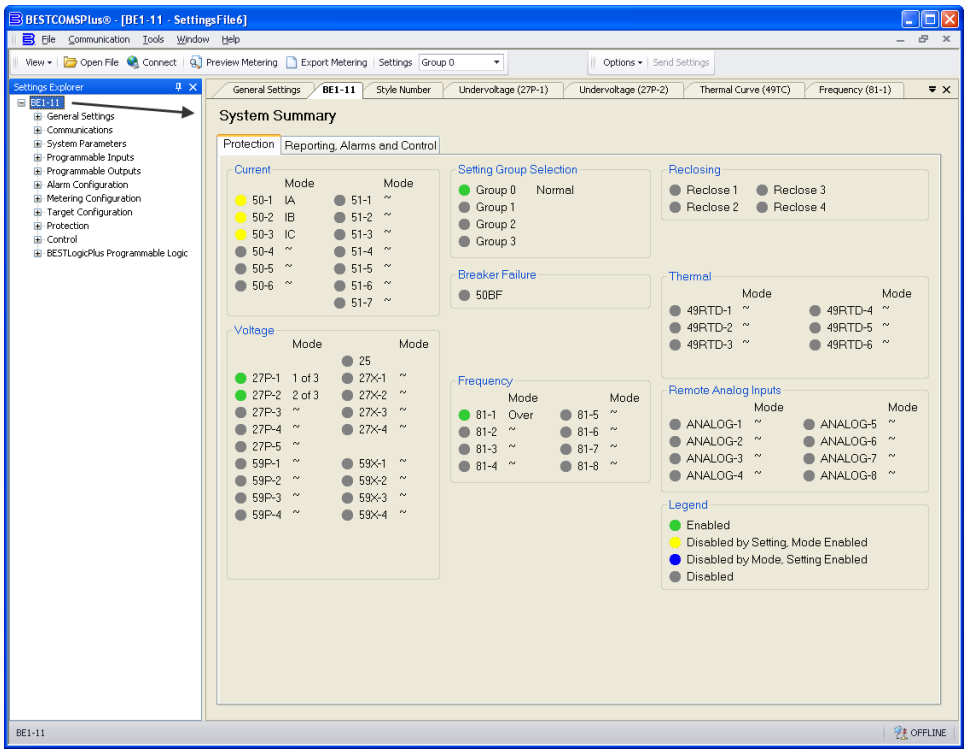


Figure 11. System Summary Screen

Programming Example

Changing default logic is sometimes required to match the protection requirements of the system. Additionally, elements must be enabled and operating settings set. This example demonstrates how to configure typical nominal settings and program the 50-3 instantaneous overcurrent element. System nominal quantities are set to 69.3 volts and 3.6 amps. The 50-3 element is set for a 5.62 amp pickup and a 30 second time delay. Additionally, the element pickup output is logically wired to output 4 and a user alarm.

Step 1: Start BESTCOMS*Plus* and select New Connection, BE1-11 from the Communication pull-down menu to connect to the BE1-11*f*. See Figure 7.

Step 2: The BE1-11 Connection screen appears. See Figure 8. Select USB Connection and click Connect.

Step 3: Select Download Settings and Logic from Device from the Communication pull-down menu. This copies all settings and logic from the BE1-11*f* to BESTCOMS*Plus*.

Step 4: Click on the View drop-down button and de-select Show Metering Panel and Show Setting Information. See Figure 10. This maximizes the workspace.

Step 5: In the Settings Explorer, click the “+” next to BE1-11. This expands the sub menus in the tree. Now expand System Parameters and select the Power System screen. See Figure 12.

Step 6: Under Nominal Settings, enter settings for (secondary) Phase Voltage (69.3 V) and (secondary) Phase Current (3.6 A).

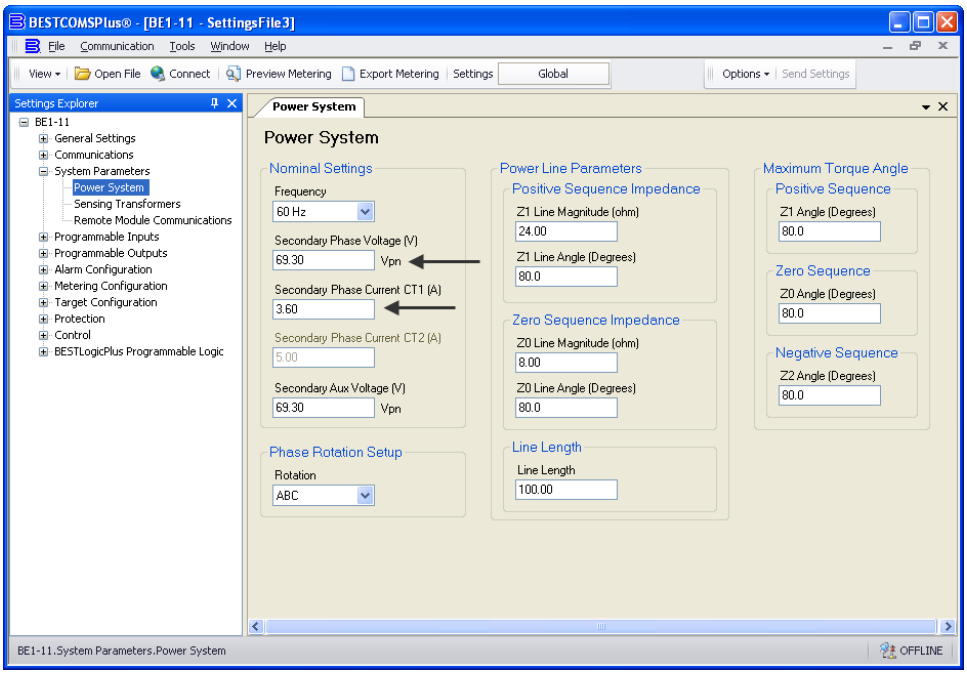


Figure 12. Power System Screen

Step 7: In the Settings Explorer, expand Protection, Current and select the Instantaneous Overcurrent (50-3) screen. See Figure 13.

Step 8: Select the Mode (3 Phase) and enter settings for Pickup (5.62 A) and Time Delay (30,000 ms).

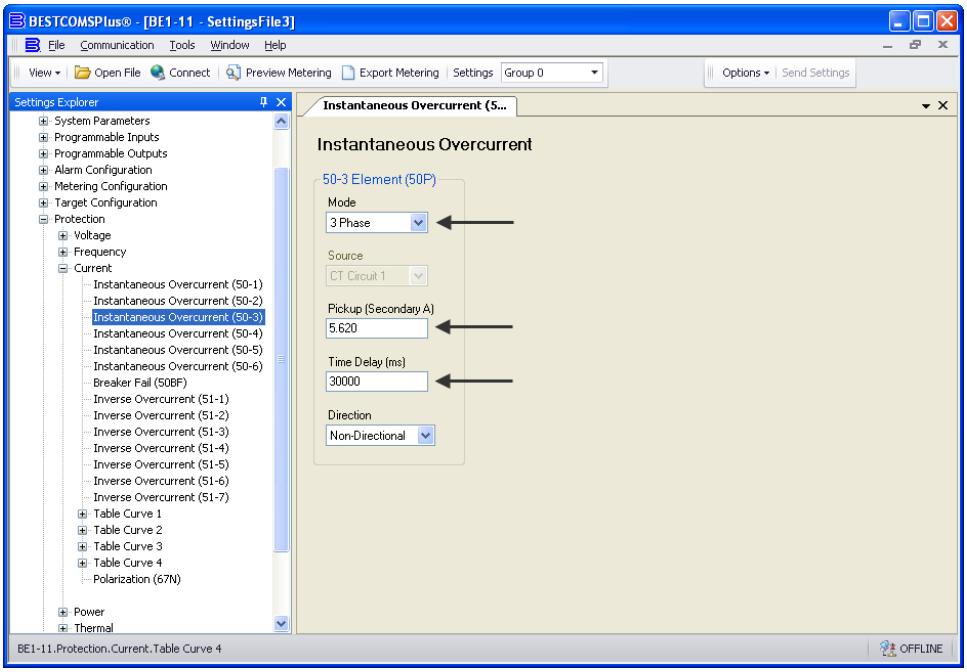


Figure 13. Instantaneous Overcurrent (50-3) Screen

Step 9: In the Settings Explorer, click BESTlogic*Plus* Programmable Logic to open the logic diagram. Click the Logic Page 1 tab. See Figure 14. Examine the 50-3 element. The Logic 0 connected to the Block input indicates that the 50-3 element is never blocked.

Off-Page Inputs/Outputs are used to make connections between logic pages and help keep logic diagrams free from clutter. The Trip output is connected to an Off-Page Output named 50-3 Trip. This 50-3 Trip Off-Page Output is carried over to Logic Page 2 (Figure 15) where it becomes an Off-Page Input. The 50-3 Trip Off-Page Input and several others are AND gated to the Trip Bus

Off-Page Output which is carried over to Logic Page 3 (Figure 16) where it becomes an Off-Page Input. The Trip Bus Off-Page Input in connected to physical Output 1 on the relay. Therefore, the OUT1 contacts operate when the 50-3 element is tripped.

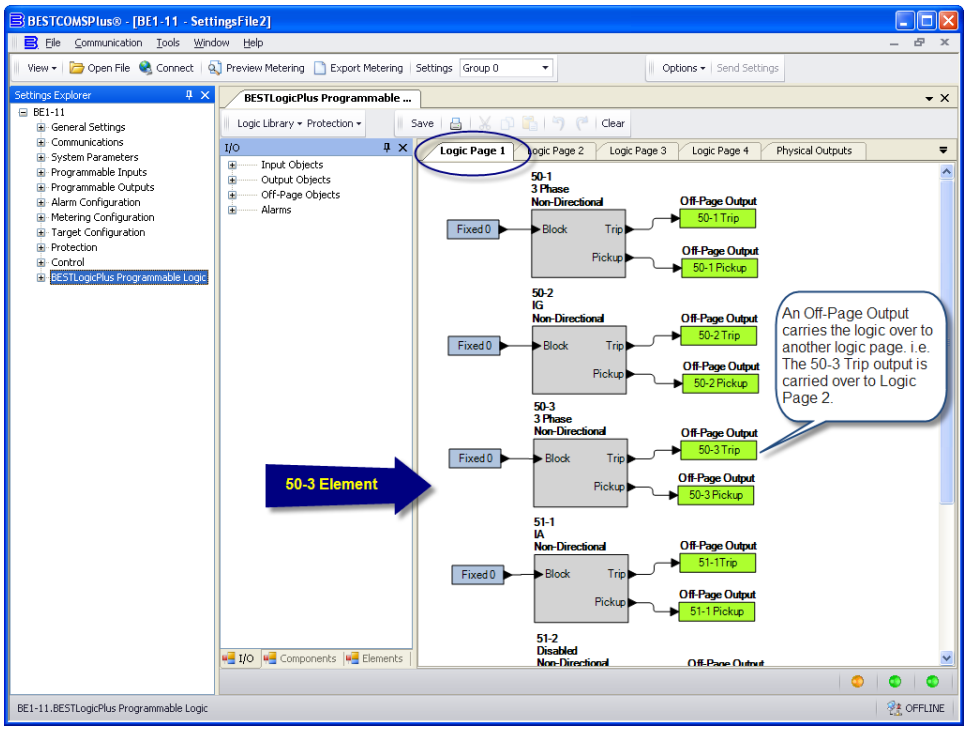


Figure 14. BESTlogic*Plus* Logic Page 1

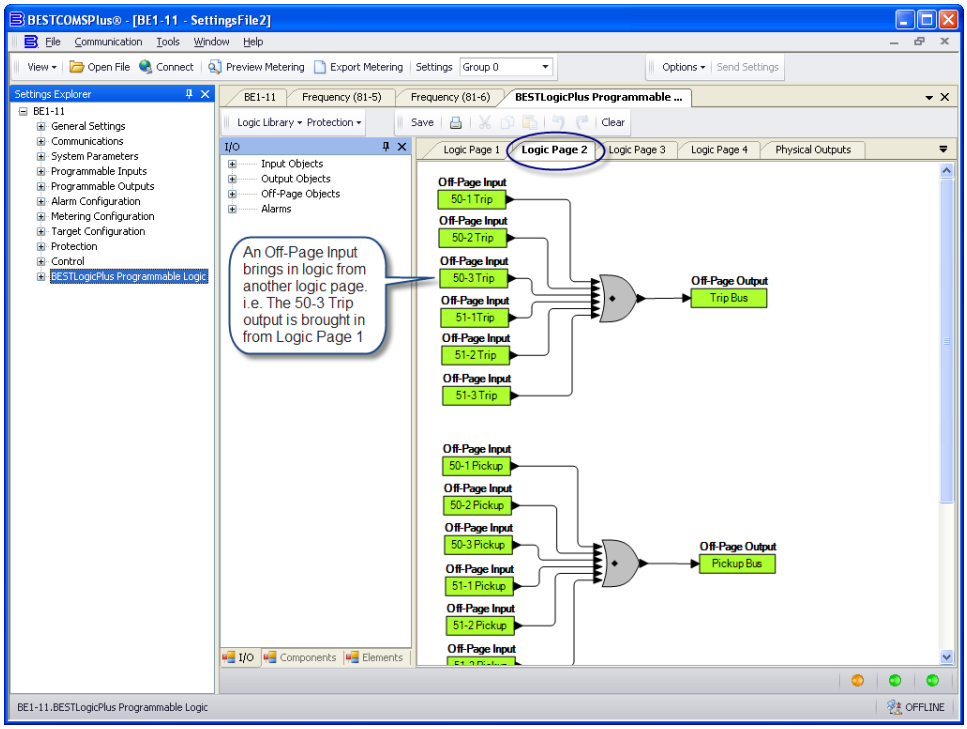


Figure 15. BESTlogic*Plus* Logic Page 2

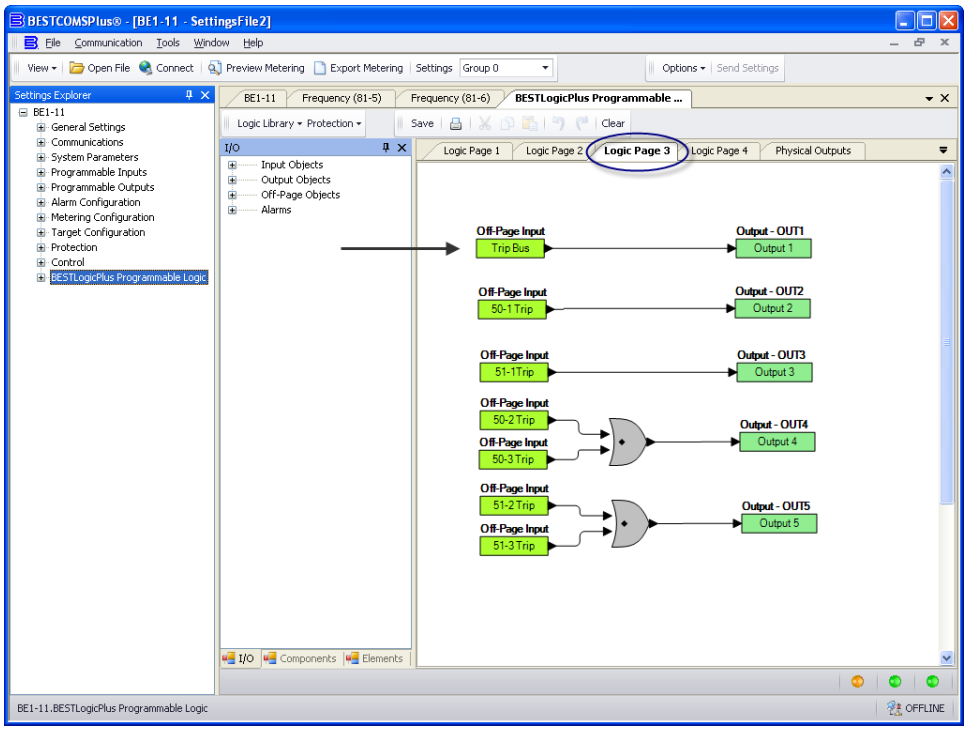


Figure 16. BESTlogic*Plus* Logic Page 3

Step 10: In this step, the Pickup output of the 50-3 element is connected to Output 4. When the Pickup output of the 50-3 element is true, the label of Output 4 is displayed in the fault report and/or sequence of events report. The label is named in Step 12. Click the Logic Page 1 tab and then click the I/O tab at the bottom. Expand Output Objects and then Physical Outputs. Click and drag OUT4 over to the logic diagram. Click on the Pickup output of the 50-3 element and drag it to the input of OUT4 to make a connection. Refer to Figure 17.

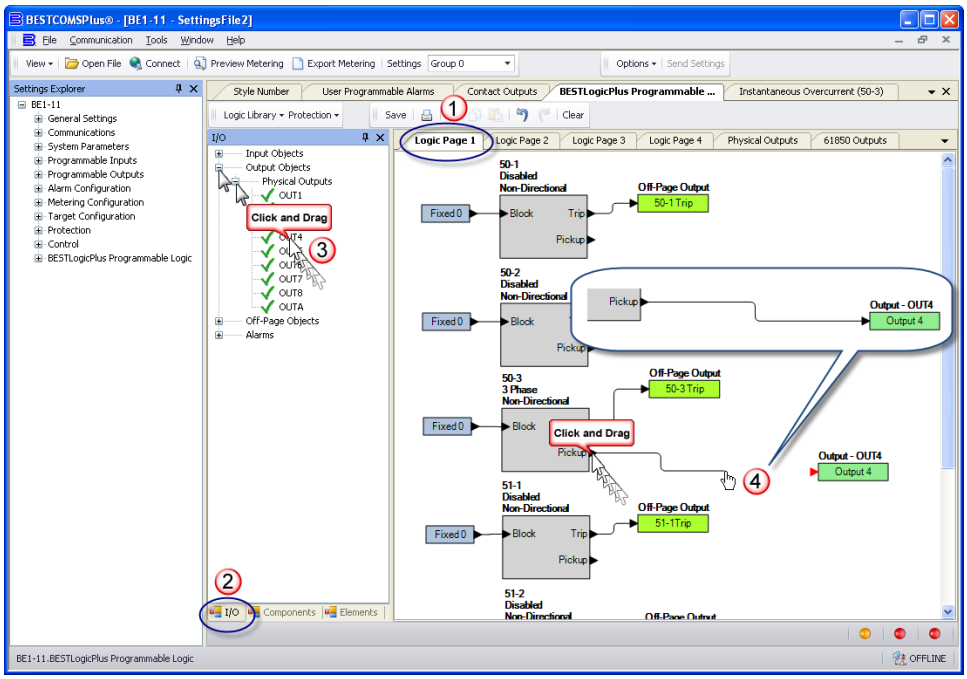


Figure 17. BESTlogic*Plus* Programming OUT4

Step 11: In this step, the Pickup output of the 50-3 element is connected to User Alarm 1. When the Pickup output of the 50-3 element is true, the label of the user alarm is displayed on the Alarms screen on the front-panel display and in the fault report and/or sequence of events report. The

label is named in Step 13. Click the Logic Page 1 tab and then click the Elements tab at the bottom. Locate the User Alarm 1 element. Click and drag USERALM1 over to the logic diagram. Click on the Pickup output of the 50-3 element and drag to the input of USERALM1 to make a connection. Refer to Figure 18.

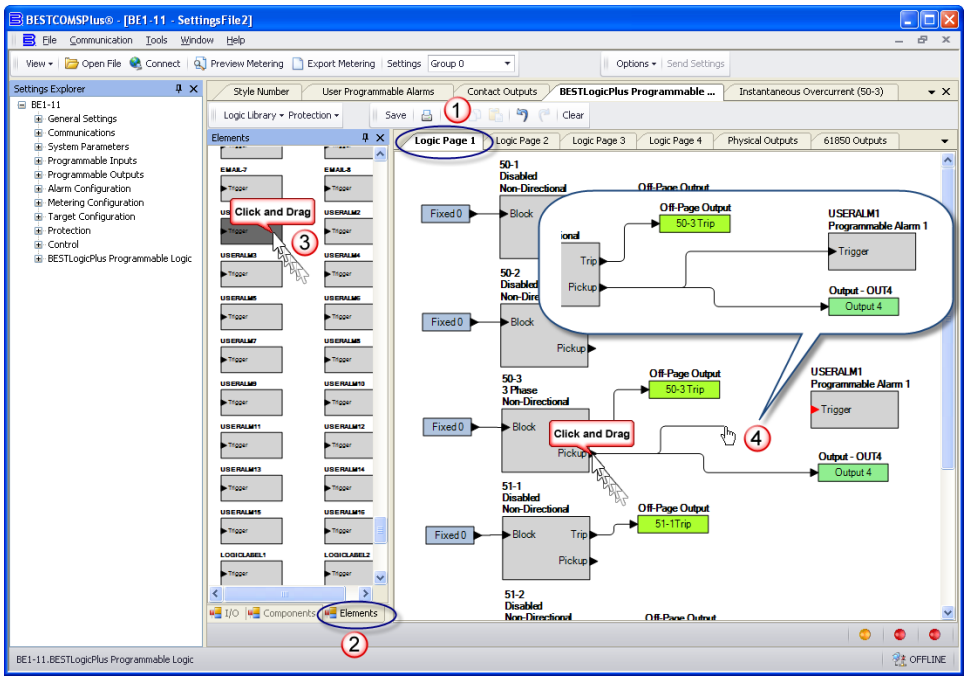


Figure 18. BESTlogic*Plus* Programming User Alarm 1

Step 12: Click the Save button to save the logic to BESTCOMS*Plus* memory for later inclusion in the settings file. See Figure 19.

Figure 19. BESTlogic*Plus* Toolbar

Step 13: In the Settings Explorer, expand Programmable Outputs, Contact Outputs, and name Output #4 (50-3 Pickup) as shown in Figure 20.

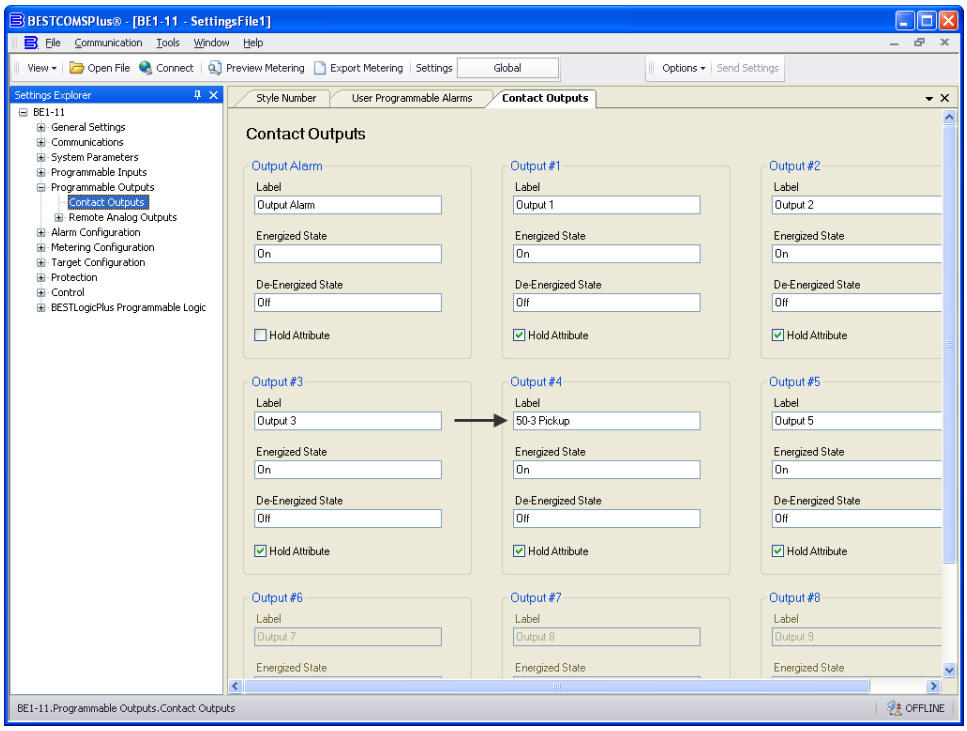


Figure 20. Contact Outputs Screen

Step 14: In the Settings Explorer, expand Alarm Configuration, User Programmable Alarms, and name User Programmable Alarm #1 (50-3 Pickup) as shown in Figure 21.

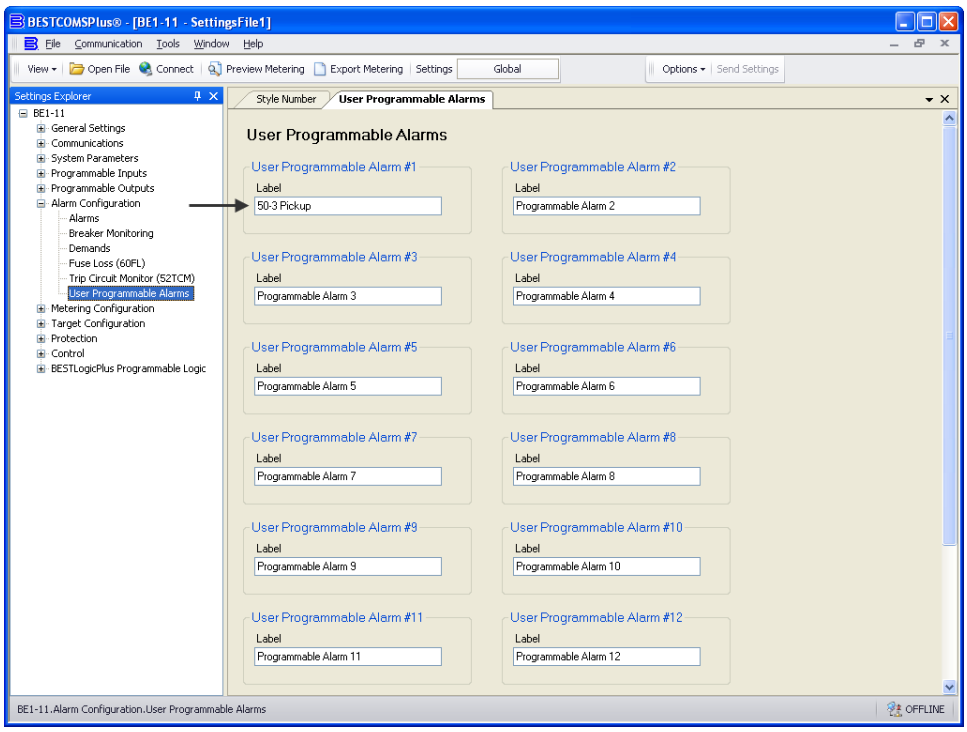


Figure 21. User Programmable Alarms Screen

Step 15: Figure 22 shows the user-defined labels of OUT4 and USERALM1 that were named in Step 13 and Step 14.

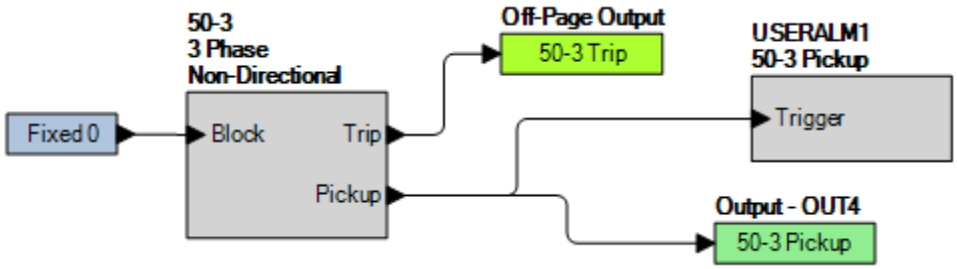


Figure 22. OUT4 and USERALM1 with User-Defined Labels

Step 16: Select Save from the File pull-down menu to save your new settings file.

Step 17: To make your new settings active in the BE1-11*f*, select Upload Settings and Logic to Device from the Communication pull-down menu. Enter the username and password.

Maintenance

Preventative maintenance consists of periodic replacement of the backup battery and periodically checking that the connections between the BE1-11*f* and the system are clean and tight. BE1-11*f* units are manufactured using state-of-the-art, surface-mount technology. As such, Basler Electric recommends that no repair procedures be attempted by anyone other than Basler Electric personnel.

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.

Controls and Indicators

BE1-11*f* controls and indicators are located on the front panel and include sealed membrane switches, LED (light emitting diode) indicator lamps, and a multiple-line, alphanumeric LCD (liquid crystal display).

Illustrations and Descriptions

The HMI (Human-Machine Interface) of a BE1-11*f* in a J type case is illustrated in Figure 23 and described in Table 2. The locators and descriptions of Table 2 correspond to the locators shown in Figure 23.

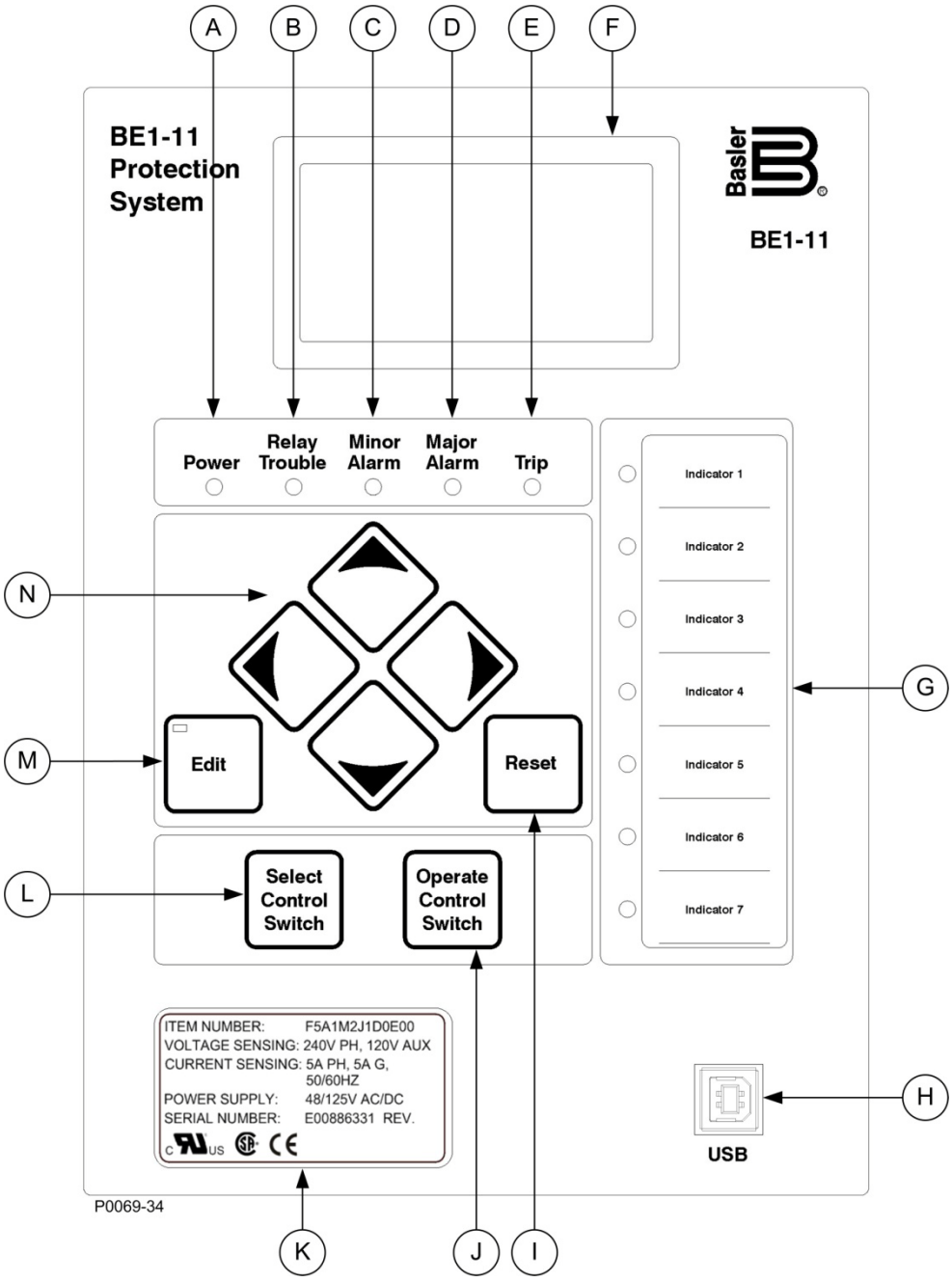


Figure 23. Front Panel (J Type Case)

Table 2. Front Panel Descriptions (J Type Case)

Locator	Description
A	Power Indicator – This green LED lights when operating power is applied to the relay.
B	Relay Trouble Indicator – This red LED lights momentarily during start-up and lights continuously when a relay failure is detected. The *Contact Inputs and Outputs* chapter provides a complete description of all relay failure alarm diagnostics.
C, D	Minor Alarm, Major Alarm Indicators – These red LEDs light to indicate that a programmable alarm has been set. Each indicator can be programmed to annunciate one or more conditions. The *Alarms* chapter provides detailed information about programming alarms.
E	Trip Indicator – A flashing red 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.
F	Display – 64 x 128 dot pixels 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, and diagnostic information is provided by the LCD. Information and settings are displayed in a menu.
G	Indicators – These red LEDs are programmable through BESTlogic™*Plus*. An indicator label can be attached next to each LED. Labels of typical system conditions are provided. Refer to the BESTlogic*Plus* chapter for information on assigning logic elements to LED indicators. Indicator status is also available through the Metering Explorer in BESTCOMS*Plus*.
H	USB – This universal serial bus port is used to communicate with the relay using BESTCOMS*Plus*.
I	Reset Pushbutton – Pressing this button resets the Trip LED, sealed-in Trip Targets, Peak Demand Currents, and Alarms.
J	Operate Control Switch – This pushbutton operates a 43 virtual control switch after it has been selected using the *Select Control Switch* (L). Refer to the *Virtual Control Switches (43)* chapter for more information about the control switches.
K	Identification Label – This label lists the style number, serial number, sensing input current and voltage range, and power supply input voltages.
L	Select Control Switch – This pushbutton selects an enabled 43 virtual control switch. The *Operate Control Switch* (J) operates the switch after it has been selected. Refer to the *Virtual Control Switches (43)* chapter for more information about the control switches.
M	Edit Pushbutton – Settings changes are made at the front panel using this pushbutton. When pushed, this switch lights to indicate that Edit mode is active. When you are finished making settings changes (using the scrolling pushbuttons) and the Edit switch is pressed again, the switch light turns off to indicate that your settings changes have been saved. If changes are not completed and saved before the access timeout length setting expires, the relay will automatically exit the Edit mode without saving any changes and announce an Access Error.
N	Scrolling Pushbuttons – Use these four switches to navigate (UP/DOWN/LEFT/RIGHT) through the LCD menu tree. When in Edit mode, the LEFT and RIGHT scrolling pushbuttons select the variable to be changed. The UP and DOWN scrolling pushbuttons change the variable.

The front-panel interface of a BE1-11*f* in a H or P type case is illustrated in Figure 24 and described in Table 3. The locators and descriptions of Table 3 correspond to the locators shown in Figure 24.

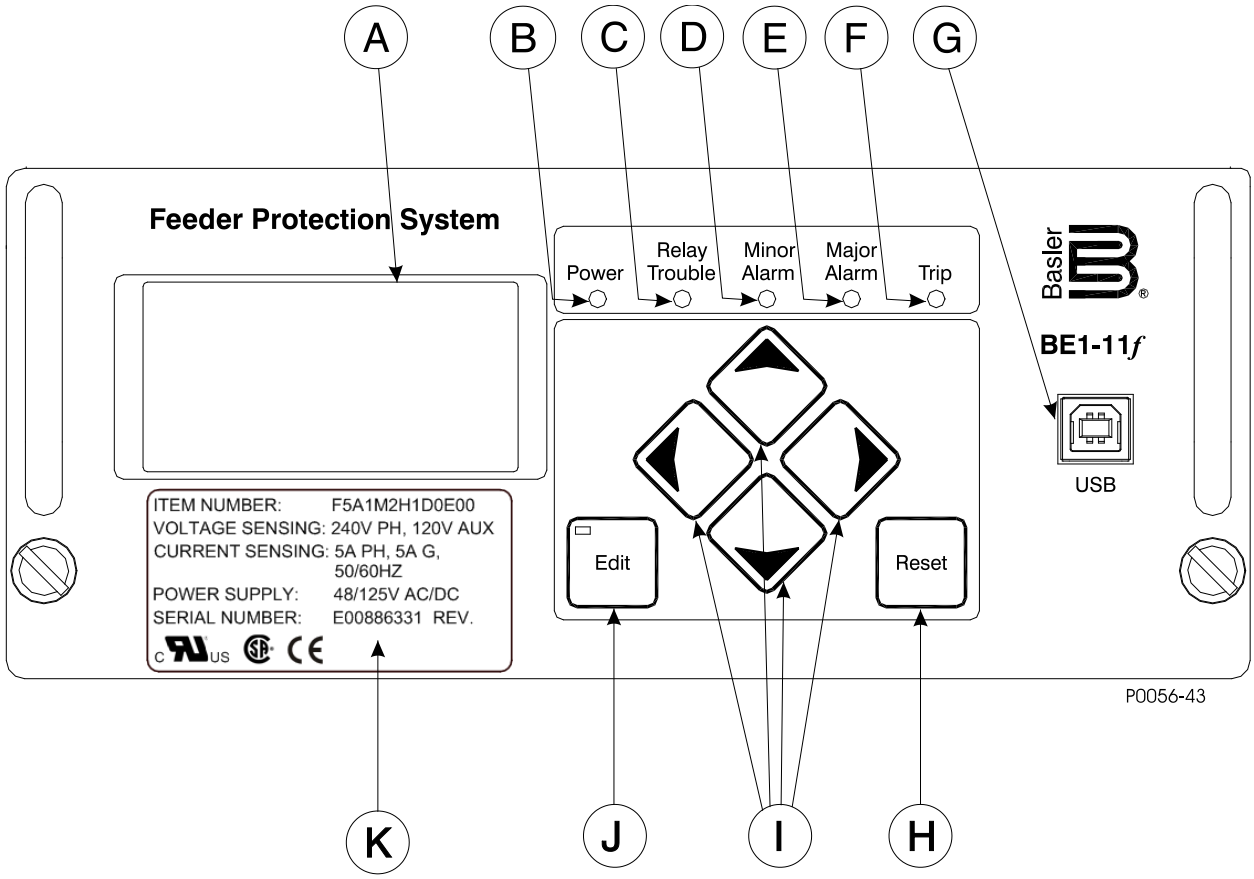


Figure 24. Front Panel (H or P Type Case)

Table 3. Front Panel Descriptions (H or P Type Case)

Locator	Description
A	Display – 64 x 128 dot pixels 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, and diagnostic information is provided by the LCD. Information and settings are displayed in a menu.
B	Power Indicator – This green LED lights when operating power is applied to the relay.
C	Relay Trouble Indicator – This red LED lights momentarily during start-up and lights continuously when a relay failure is detected. The *Contact Inputs and Outputs* chapter provides a complete description of all relay failure alarm diagnostics.
D, E	Minor Alarm, Major Alarm Indicators – These red LEDs light to indicate that a programmable alarm has been set. Each indicator can be programmed to annunciate one or more conditions. The *Alarms* chapter provides detailed information about programming alarms.
F	Trip Indicator – A flashing red 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	USB – This universal serial bus port can be used to communicate with the relay using BESTCOMS*Plus*.
H	Reset Pushbutton – Pressing this button resets the Trip LED, sealed-in Trip Targets, Peak Demand Currents, and Alarms.

Locator	Description
I	Scrolling Pushbuttons – Use these four switches to navigate (UP/DOWN/LEFT/RIGHT) through the LCD menu tree. When in Edit mode, the LEFT and RIGHT scrolling pushbuttons select the variable to be changed. The UP and DOWN scrolling pushbuttons change the variable.
J	Edit Pushbutton – Settings changes are made at the front panel using this pushbutton. When pushed, this switch lights to indicate that Edit mode is active. When you are finished making settings changes (using the scrolling pushbuttons) and the Edit switch is pressed again, the switch light turns off to indicate that your settings changes have been saved. If changes are not completed and saved before the access timeout length setting expires, the relay will automatically exit the Edit mode without saving any changes and announce an Access Error.
K	Identification Label – This label lists the style number, serial number, sensing input current and voltage range, and power supply input voltages.

Menu Navigation

A menu tree with a Metering branch and a Settings branch can be accessed through the front-panel controls and display. A greater level of detail in a menu branch is accessed using the right scrolling pushbutton. The left scrolling pushbutton is used to return to the top of the menu branch.

Figure 25 illustrates the organization of the front-panel display menu tree structure.

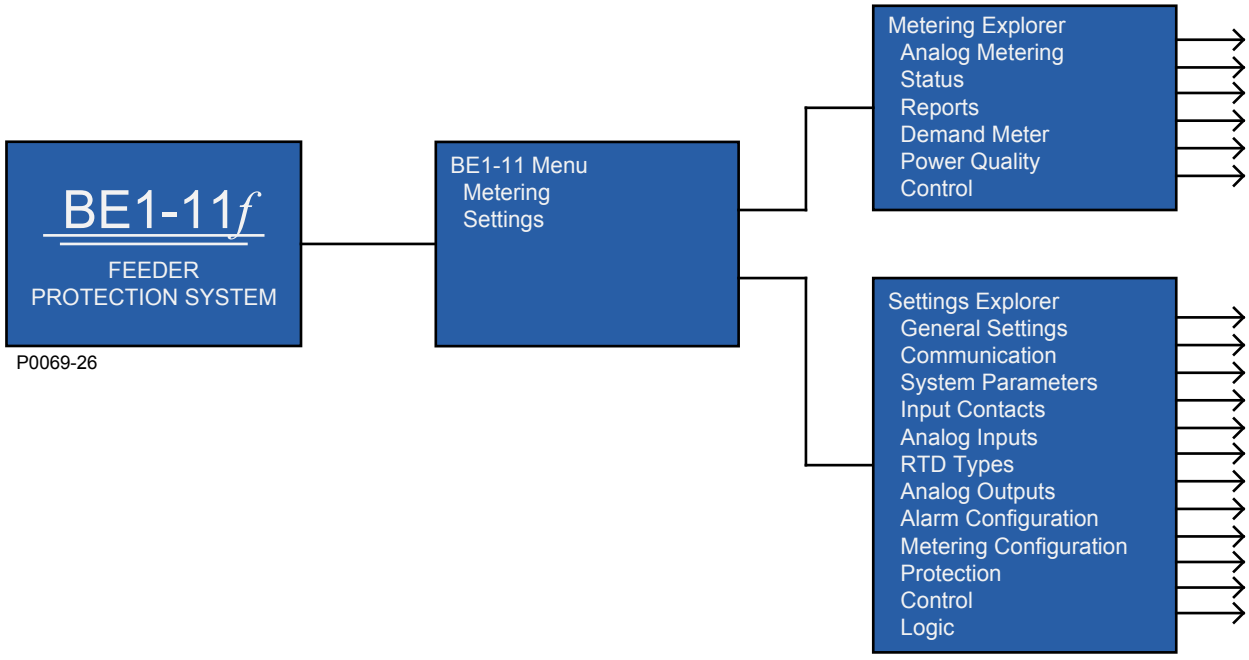


Figure 25. Front-Panel Display Menu Tree Layout

Front Panel Operations

The following paragraphs describe how the front-panel interface is used to set and control relay functions.

Entering Usernames and Passwords

If password security has been initiated for a function, the front-panel display will prompt you to enter a username and password when the Edit pushbutton is pressed. To gain access, you must enter the appropriate username and password. You can enter usernames and passwords by performing the following procedure:

1. Press the Edit pushbutton.
2. Enter the username by pressing the UP or DOWN scrolling pushbuttons until the proper first character of the username appears. Pressing the UP pushbutton scrolls through the alphabet and then the numbers in ascending order. Pressing DOWN scrolls through the numbers and then the alphabet in descending order.
3. Press the RIGHT scrolling pushbutton to move the cursor to the next character of the username and select the appropriate character.
4. Continue the process until the entire username has been spelled out. Press the Edit pushbutton when finished.
5. Repeat Steps 2 through 4 for the PASSWORD.
6. Press the Edit pushbutton.
7. If the proper username and password have been entered, the screen will flash the type of **ACCESS** that has been granted. If an incorrect password has been entered, the screen will flash **READ ACCESS**.
8. Once you gain access, it remains in effect until the access timeout length setting expires. 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.

To close access immediately, press the Reset button while any non-settings screen is displayed. The relay should flash “Read Only” on the LCD screen to indicate access through the front panel has been terminated.

Entering Settings

Settings for protection functions can be edited by using the RIGHT, LEFT, UP, and DOWN front-panel navigation keys. Navigate to Settings, Protection.

To edit a setting using the manual scrolling pushbuttons, perform the following procedures:

1. After scrolling to the desired settings group and element category, 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 username and password. See the paragraphs, *Entering Usernames and Passwords*, for details on entering usernames and passwords from the front panel. 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 51-1 pickup as 7.3 amps, you would place the cursor in the PU field and press the UP pushbutton until the 7 is showing. Then press the RIGHT pushbutton to move the cursor over to the right side of the decimal and press the UP pushbutton until the 3 is showing. Other settings require scrolling through a list of selections. For example, you would move the cursor over to the CRV field and then scroll through a list of available TCC curves.
4. Once all of the settings on the screen have been entered, press the Edit pushbutton a second time and the settings will be validated. If the settings are in range, the 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 Edit LED will go out.

Performing Control Operations

Control operations can be executed by navigating to Metering, Control. These functions allow you to control the state of virtual switches, override logic, control the active setting group, 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 for the action to be executed.

To operate the switch, use the following procedure:

1. Use the scrolling pushbuttons to scroll to Metering, Control, Virtual Switches, 43-1.
2. Press the Edit pushbutton to gain access. If password security has been initiated for control functions, you will be prompted to enter the appropriate username and password. Once access is gained to the control function, press the Edit pushbutton and the Edit LED will light.
3. Press the UP or DOWN scrolling key to select the new state for the switch. The “PUL” selection will pulse the state of the switch from its present state to the opposite state for approximately 200 milliseconds. The “SET” selection will set the state of the switch to TRUE. The “RST” selection will set the state of the switch to FALSE. The allowable states are dependent upon the logic mode setting for the switch. If the switch is set to Switch mode, only the “SET” and “RST” will function. If the switch is set to Pulse mode, only the “PUL” selection will function. If the switch is set to Switch/Pulse mode, any of the selections will function.
4. Press the Edit pushbutton a second time and the switch will change to the selected position 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 Edit LED will go out.

Resetting Functions

The Reset pushbutton is context sensitive. Its function is dependent upon the screen that is presently being displayed. For example, pressing the Reset key when the Demand screen is displayed will reset the demands but it will not reset the alarms, etc. It is necessary to scroll through the menu tree to the appropriate alarm screen to reset an alarm. You are prompted for a username and password when using the Reset key.

Display Setup

BESTCOMS*Plus* Navigation Path: Settings Explorer, General Settings, Front Panel HMI

Front Panel Navigation Path: Settings Explorer, Control, General Settings, Front Panel HMI

The contrast of the front-panel LCD (liquid crystal display) can be adjusted to suit the viewing angle used or compensate for environmental conditions. When Invert Display is enabled, the display is inverted to have black letters on a white background.

A power saving feature, referred to as Sleep mode, will dim the front-panel LCD backlight when a front-panel key is not pressed for more than the user settable time delay. Normal display operation is resumed when any front-panel button is pressed. Sleep mode is enabled and disabled in BESTCOMS*Plus*.

When Screen Scrolling is enabled, the front-panel summary screen will scroll through the list of Scrolling Screen Items. The Scroll Time Delay determines the scrolling speed. When this feature is enabled and no screens are selected, only Target and Alarm statuses are shown on the front-panel summary screen. You must navigate to the BE1-11*f* Feeder Protection System screen in order for screen scrolling to begin.

The BESTCOMS*Plus* Front Panel HMI screen is illustrated in Figure 26. Settings are listed in Table 4.

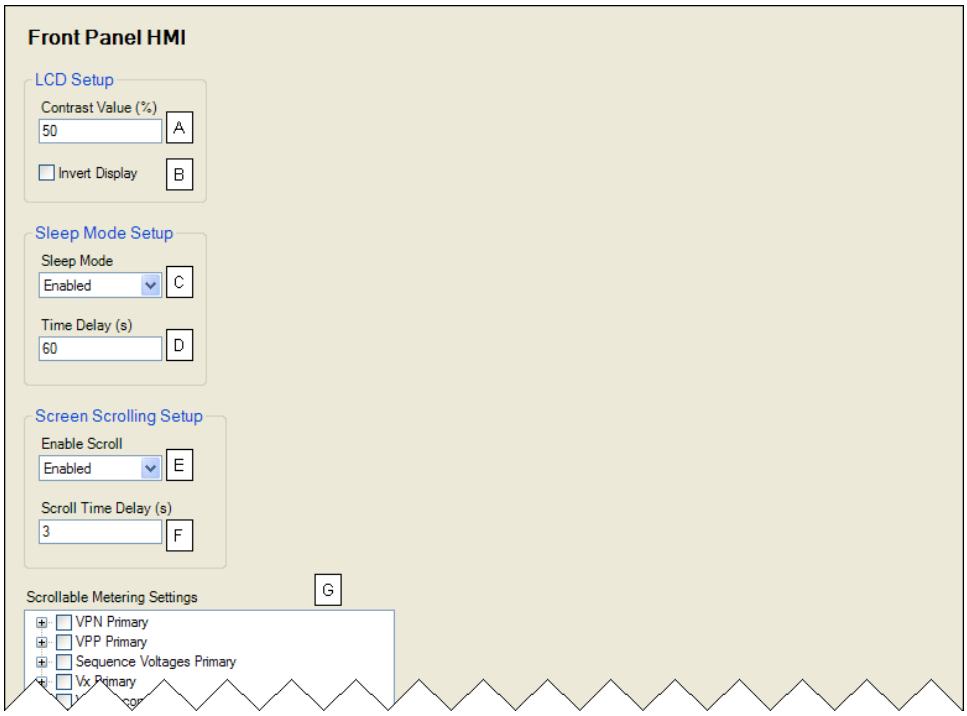


Figure 26. Front-Panel Display Setup Screen

Table 4. Settings for Front-Panel Display

Locator	Setting	Range	Increment	Unit	Default
A	LCD Contrast Value	25 to 100	1	percent	50
B	Invert Display	Disabled or Enabled	n/a	n/a	Disabled
C	Sleep Mode	Disabled or Enabled	n/a	n/a	Enabled
D	Sleep Mode Time Delay	1 to 120	1	seconds	1
E	Enable Scroll	Disabled or Enabled	n/a	n/a	Enabled
F	Scroll Time Delay	1 to 600	1	seconds	3
G	Scrollable Metering Settings	All Metering Screens	n/a	n/a	None

Contact Inputs and Outputs

BE1-11*f* Feeder Protection Systems provide up to seven contact inputs, up to eight general-purpose contact outputs, and one dedicated, fail-safe alarm contact output. Each input and output is isolated and terminated at separate terminals. This section describes the function and setup of each input and output.

Contact-Sensing Inputs

A BE1-11*f* in a J type case has seven contact inputs to initiate relay actions. Four contact inputs are provided in an H or P type case. Each isolated input requires an external wetting voltage. The 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 BE1-11*f* relay uses wide-range ac/dc power supplies that cover several common control voltage ratings. To 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.

The contact input circuits are polarity sensitive. When an ac wetting voltage is applied, the input signal is half-wave rectified by the opto-isolator diodes. The contact inputs drive BESTlogic™*Plus* variables IN1 through IN4 (H or P type case) or IN1 through IN7 (J type case). Each contact input is completely programmable so meaningful labels can be assigned to each input and the logic-high and logic-low states. The *BESTlogicPlus* chapter provides more information about using contact inputs in your programmable logic scheme.

Contact-Sensing Input Jumpers

Note
The BE1-11*f* relay is delivered with the jumpers in the HIGH position. Read the following paragraphs before placing the relay in service.

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

Table 5. Contact-Sensing Turn-On Voltages

Style Option	Nominal Input Voltage	Contact Sensing Turn-On Voltage *	
		Jumper Installed (Low Position)	Jumper Not Installed (High Position)
Fxx1xxxxxxxxx	48 Vdc or 125 Vac/dc	26 to 38 Vdc	69 to 100 Vdc 56 to 97 Vac
Fxx2xxxxxxxxx	125/250 Vac/dc	69 to 100 Vdc 56 to 97 Vac	138 to 200 Vdc 112 to 194 Vac
Fxx3xxxxxxxxx	24 Vdc	n/a	Approx. 5 Vdc

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

Each BE1-11*f* is delivered with the contact-sensing jumpers disconnected for operation in the higher end of the control voltage range. If the contact-sensing inputs are to be operated at the lower end of the control voltage range, the jumpers must be installed.

Contact-Sensing Jumper Configuration in a J Type Case

The following paragraphs describe how to locate and remove/change the contact-sensing input jumpers:

1. Remove the relay from service and de-energize it.

2. The contact-sensing input jumpers are located behind the rear terminal blocks that are used for input connections. Using a 7/64” hex tool, remove the rear terminal block(s) associated with the input(s) that you want to configure. Observe all electrostatic discharge (ESD) precautions when handling the relay.
3. Using the input labels on the rear panel as a guide, locate the appropriate jumper terminal block that is mounted on the circuit board. Each terminal block has two sets of pins. With the jumper as installed at the factory, one pin should be visible when viewed from the back of the unit. This configuration allows the inputs to operate at the higher end of the control voltage range. Figure 27 illustrates the location of the contact-sensing jumpers. The jumpers are shown in the HIGH position.
4. To select operation at the lower end of the control voltage range, install the jumper across the two pins using needle-nose pliers. Use care when removing and installing each jumper so that no components are damaged.
5. When all jumpers are positioned for operation in the desired control voltage range, reinstall the rear terminal block(s).
6. Using a 7/64” hex tool, tighten the screws to 10 in-lbs (1.12 N•m).

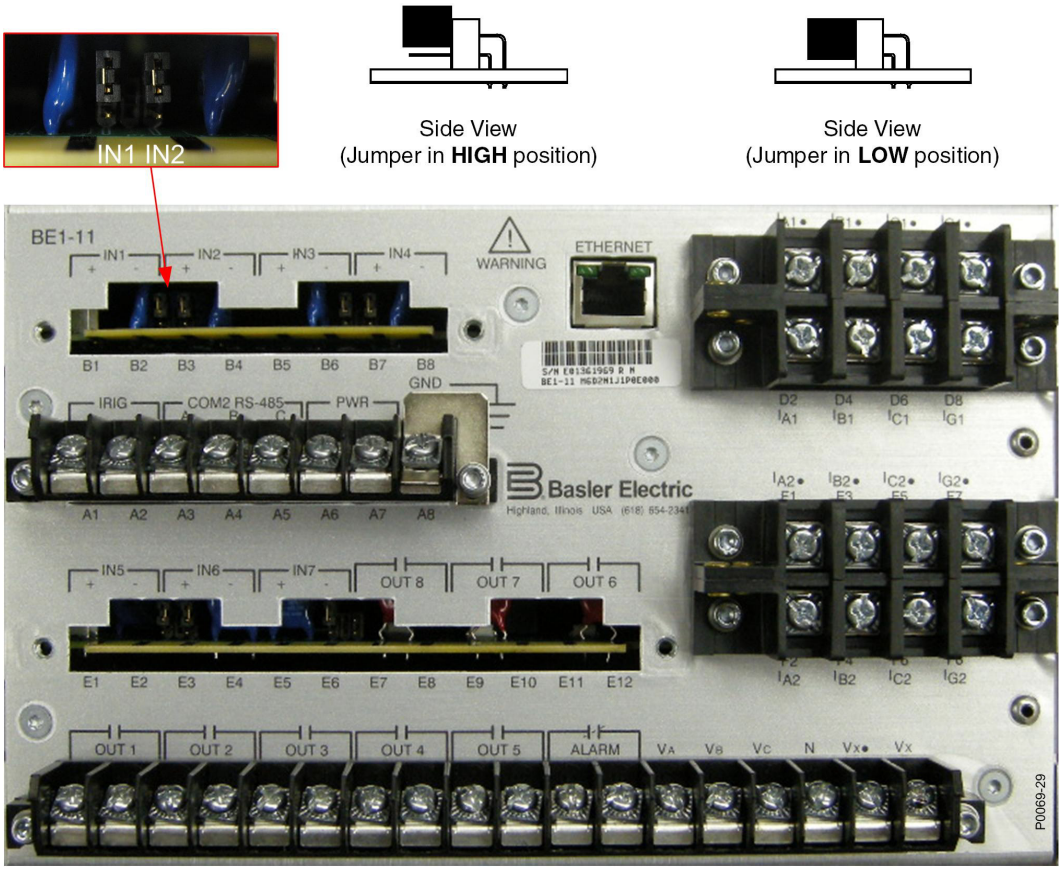


Figure 27. Contact-Sensing Jumper Locations (J Type Case)

Contact-Sensing Jumper Configuration in an H or P Type Case

The following paragraphs describe how to locate and remove/change the contact-sensing input jumpers:

1. Remove the relay from service and de-energize it.
2. Remove the drawout assembly by loosening the two thumbscrews and pulling the assembly out of the case. Observe all electrostatic discharge (ESD) precautions when handling the drawout assembly.

3. Locate the two jumper terminal blocks that are mounted on the Digital Circuit Board. The Digital Circuit Board is the middle board in the assembly and the jumper terminal blocks are located on the component side of the circuit board. Each terminal block has two sets pins. With the jumper as installed at the factory, one pin should be visible when viewed from the side of the unit. This configuration allows the inputs to operate at the higher end of the control voltage range. Figure 28 illustrates the location of the contact-sensing jumpers. The jumpers are shown in the HIGH position.
4. To select operation at the lower end of the control voltage range, install the jumper across the two pins. Use care when removing and installing each jumper so that no components are damaged.
5. When all jumpers are positioned for operation in the desired control voltage range, prepare to place the drawout assembly back into the case.
6. Align the drawout assembly with the case guides and slide the assembly into the case.
7. Tighten the screws.

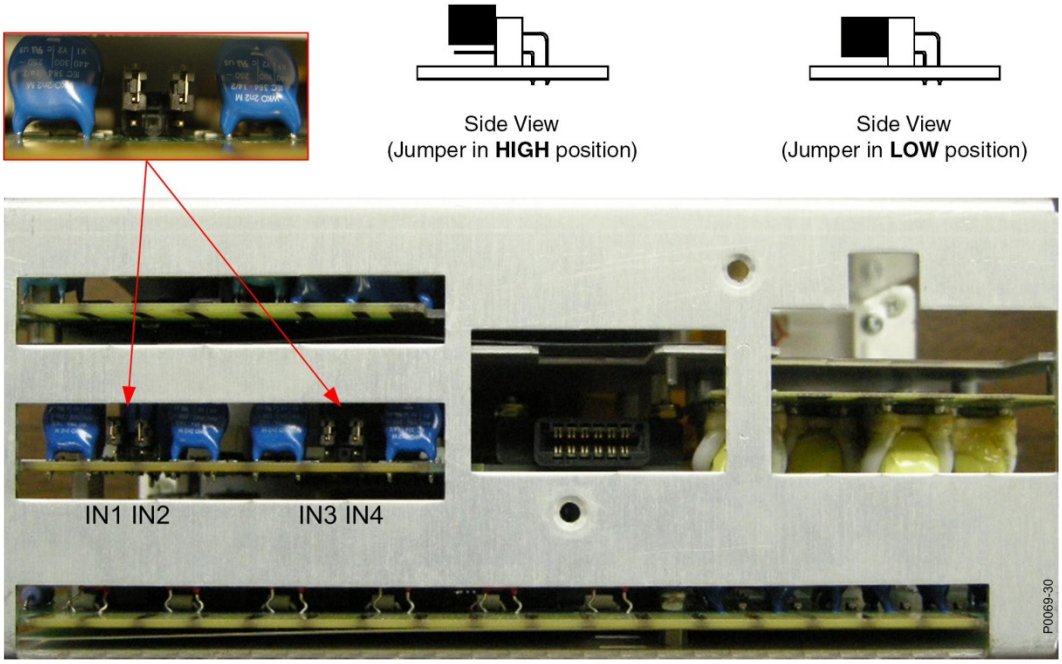


Figure 28. Contact-Sensing Jumper Locations (H or P Type Case)

Digital Input Conditioning Function

Status of the contact-sensing inputs is checked every 1 millisecond. 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. (See Figure 29.)

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

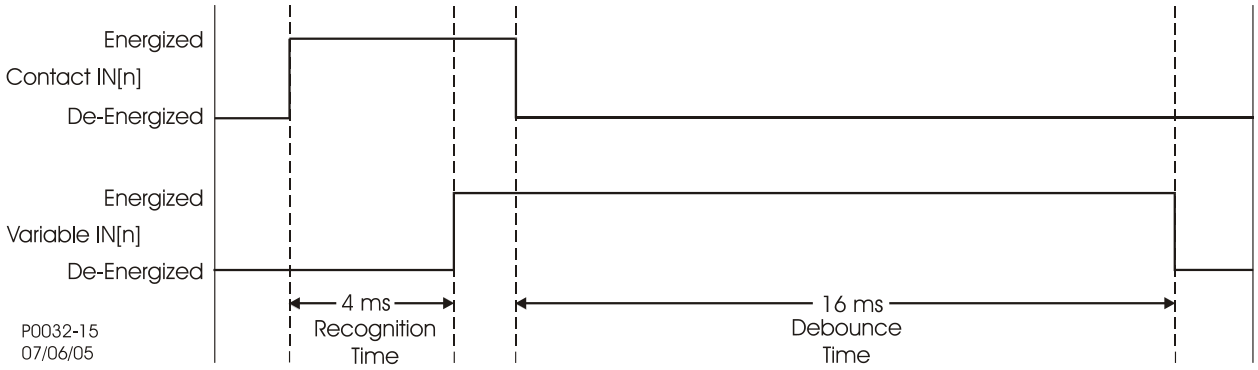


Figure 29. Digital Input Conditioning Timing Diagram

Setting the Contact Inputs

BESTCOMS*Plus* Navigation Path: Settings Explorer, Programmable Inputs, Contact Inputs

Front Panel Navigation Path: Settings Explorer, Contact Inputs

Settings and labels for the contact inputs are set using BESTCOMS*Plus*®.

Each of the inputs has two settings and three labels. The settings are Recognition Time and Debounce Time. The labels include a label to describe the input, a label to describe the Energized State, and a label to describe the De-Energized State. Labels are used by the BE1-11*f*'s reporting functions.

To edit the settings or labels, use the Settings Explorer to open the Programmable Inputs, Contact Inputs tree branch as shown in Figure 30.

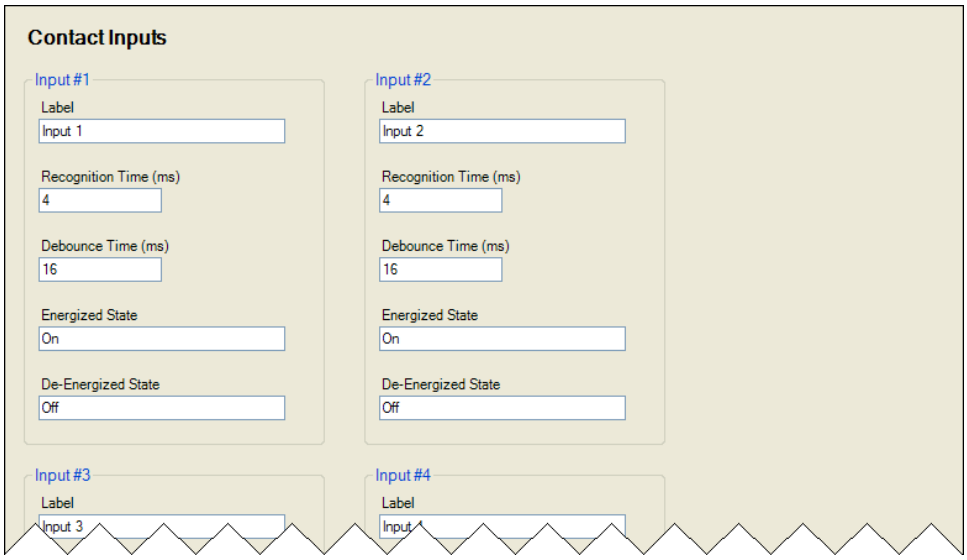


Figure 30. Contact Inputs Screen

See Table 6 for a list of settings and their defaults.

Table 6. Contact Input Settings

Setting	Range	Increment	Unit	Default
Label	User programmable label for the input contact. Used by the reporting function to give meaningful identification to the input contact. This label can be up to 64 characters long.			
Recognition Time	4 to 255	1 *	milliseconds	4
Debounce Time	4 to 255	1 *	milliseconds	16
Energized State	User programmable label for the energized state of the contact. Used by the reporting function to give meaningful identification to the state of the input contact. This label can be up to 64 characters long.			
De-Energized State	User programmable label for the de-energized state of the contact. Used by the reporting function to give meaningful identification to the state of the input contact. This label can be up to 64 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 higher 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.

Settings for contact inputs can also be entered through the front panel.

See the *Terminals and Connectors* chapter for an illustration of the programmable output terminals. Contact output electrical ratings are listed in the *Specifications* chapter.

Retrieving Contact-Sensing Input Status

Contact input status is determined through BESTCOMS*Plus* by using the Metering Explorer to open the Status, Inputs tree branch. BESTCOMS*Plus* must be online with the BE1-11*f* to view contact input status. Alternately, status can be determined through the front-panel display by navigating to the Metering, Status, Inputs screen.

Contact Outputs

A BE1-11*f* in a J type case has eight contact outputs (OUT1 through OUT8) and one failsafe, normally open or closed (when de-energized) alarm contact output (OUTA). Five contact outputs (OUT1 through OUT5) are provided in an H or P type case.

Each output is isolated and rated for tripping duty. OUT1 through OUT8 are Form A (normally open), and OUTA is Form B (normally closed) or Form A (normally open).The style number determines the type of alarm contact output. A trip coil monitoring circuit is hardwired across OUT1. See the *Trip Circuit Monitor (52TCM)* chapter for details.

Contact outputs OUT1 through OUT8 and OUTA are driven by BESTlogic*Plus* expressions for OUT1 through OUT8 and OUTA. The use of each contact output is completely programmable so you can assign meaningful labels to each output and to the logic 0 and logic 1 states of each output. The *BESTlogicPlus* chapter has more information about programming output expressions in your programmable logic schemes.

BESTLogic*Plus* expressions for OUT1 through OUT8 and OUTA drive contact outputs OUT1 through OUT8 and OUTA. The state of the contact outputs 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 31 shows a diagram of the contact output logic for the general-purpose contact outputs. The OUT1 relay closes when the 50-1 element is in a trip condition.

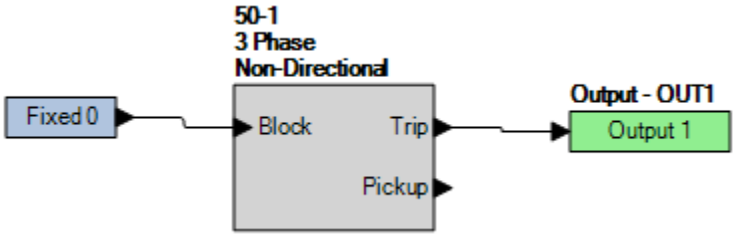


Figure 31. Output Logic, General Purpose Contact Outputs

Figure 32 illustrates the contact output logic for the failsafe alarm contact output when OUTA is normally closed (style xxxxxxx2xxxxxx). The OUTA relay closes when the 50-1 element is in a trip condition.

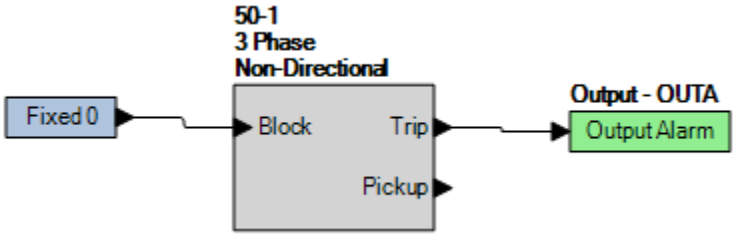


Figure 32. Output Logic, Failsafe Alarm Contact Output

Relay Trouble Alarm Disable

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 7. If any one of these points asserts, the failsafe alarm output relay de-energizes and closes/opens (depending on style number) the OUTA contact, the front-panel Relay Trouble LED lights, all output relays are disabled, logic OUTA is set, and the relay is taken offline. The relay trouble alarms function is not programmable.

Table 7. Relay Trouble Alarms

Name	Description
NVMH Settings File Not Opened	Error opening settings file
Update NVM Blocks Failed	Error writing settings file
NVMH Saving Blocks Error	Error writing settings file
NVMH Flash File Error	Error writing settings file
Flash Error	Flash file system error
uP Reset	Repetitive reboot
Cal Error	Calibration error
Cal Defaults Loaded	Relay not calibrated
Defaults Loaded	Defaults have been loaded
uP Overload	Microprocessor is busy
Power Supply	Input power is too low/failed

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 might 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 might be damaged. Of the three items, only item three is an issue for electronic relays like the BE1-11*f*.

Contact Output Seal-In Logic

To prevent the output relay contacts from opening prematurely, a 200 millisecond hold timer can be selected with BESTCOMS*Plus*. If the protection engineer desires seal-in logic with feedback from the breaker position logic, he/she can provide this logic by modifying the logic for the tripping output. To do this, use one of the general purpose timers (62) and set it for Pickup/Dropout mode. 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. The same can be done for the closing output. Figure 33 provides a seal-in logic diagram.

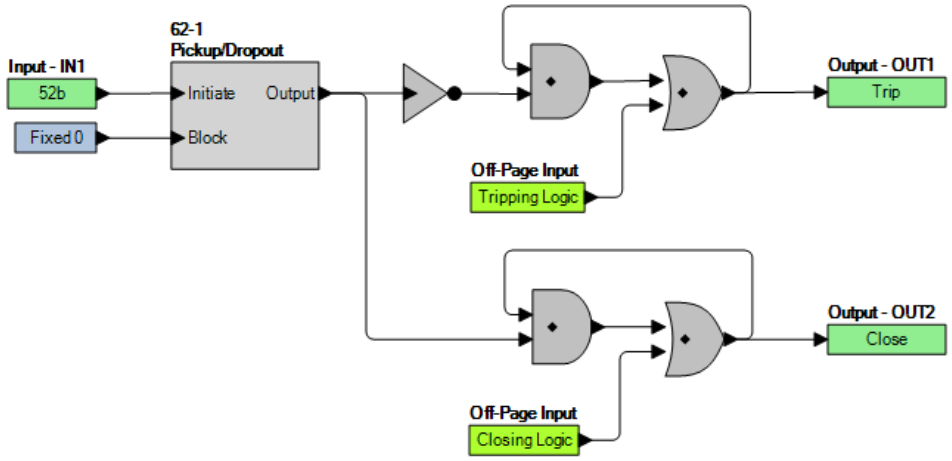


Figure 33. Contact Output Seal-In Logic Diagram

Setting the Contact Outputs

BESTCOMS*Plus* Navigation Path: Settings Explorer, Programmable Outputs, Contact Outputs

Front Panel Navigation Path: Not available through the front panel

Settings and labels for the contact outputs are set using BESTCOMS*Plus*®.

Each of the outputs has one setting and three labels. The setting consists of a Hold Attribute. The labels include a label to describe the output, a label to describe the Energized State, and a label to describe the De-Energized State. Labels are used by the BE1-11*f*'s reporting functions.

To edit the settings or labels, use the Settings Explorer to open the Programmable Outputs, Contact Outputs tree branch as shown in Figure 34.

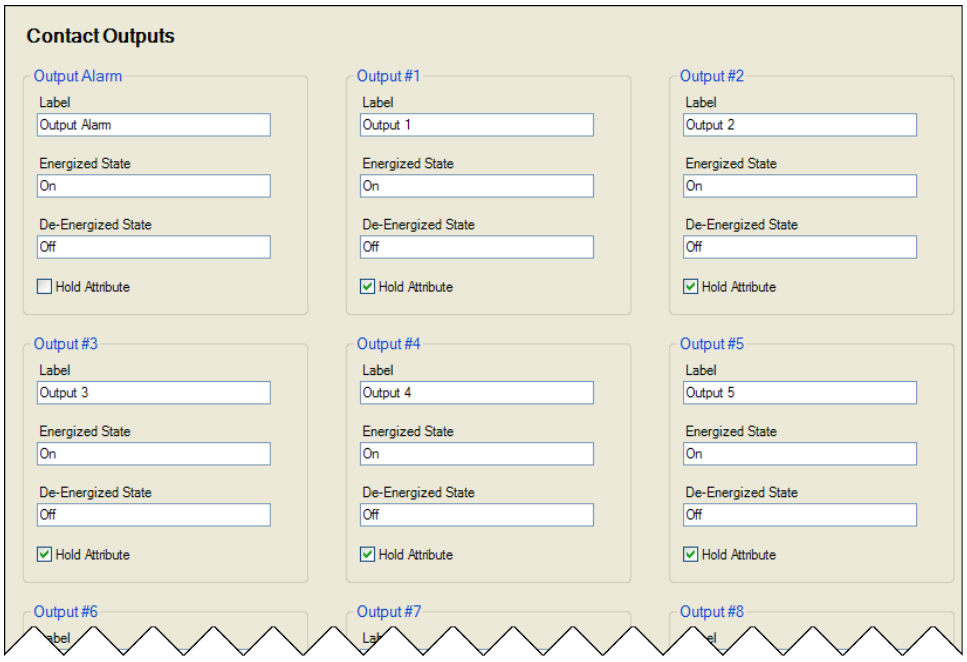


Figure 34. Contact Outputs Screen

Contact Output Logic Override Control

BESTCOMS*Plus* Navigation Path: Metering Explorer, Control, Output Override

Front Panel Navigation Path: Metering Explorer, Control, Output Override Contacts

Each contact output can be controlled directly using the select-before-operate output control function. The output logic expression that normally controls the state of an output 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 the *Alarms* chapter for more information about programmable alarms. Output logic override control is achieved using the front-panel interface or BESTCOMS*Plus*. Use the Metering Explorer to open the Control, Output Override screen. Refer to Figure 35.

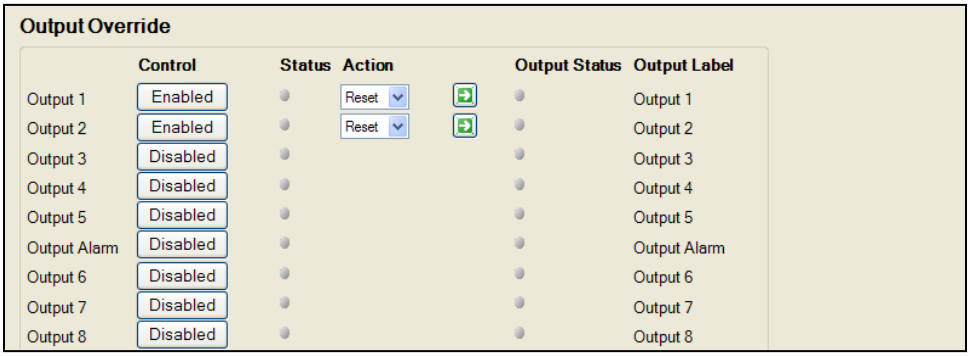


Figure 35. Output Override Screen

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. It can only be enabled through a communication port using BESTCOMS*Plus* (Figure 35). Click on the Disabled button next to the output you want to control. This button will change to Enabled and the following three action choices will appear to the right: Reset, Set, and Pulse.

Pulsing a Contact Output

Pulsing BE1-11*f* outputs provides the user the ability to test the operability of an output without energizing a measuring or timing element. This feature is useful when testing the protection and control system. When pulsed, an output 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 is returned automatically to logic control.

In the Action column, select Pulse from the drop-down menu and click on the green arrow to the right. Pulse override control can also be accessed at the Metering, Control, Override Output Contacts screen of the front-panel display by selecting PUL in the Override State field for the output contact to be pulsed.

Changing the State of a Contact Output

Outputs can be forced to an energized (logic 1 or true) state or to a de-energized (logic 0 or false) state. This feature can be used to disable a contact during testing.

In the Action column, select Set or Reset from the drop-down menu and click on the green arrow to the right. Contact output override control can also be accessed at the Metering, Control, Override Output Contacts screen of the front-panel display by entering a SET (logic 1 or true) or RST (logic 0 or false) in the Override State field for the contact output to be controlled.

Returning a Contact Output to Logic Control

When the output logic has been overridden and the contact is held in an energized or de-energized state, it is necessary to return the output to logic control.

Click on the Enabled button next to the output you want to change to logic control. This button changes to Disabled and the action choices disappear. Logic control can also be achieved at the Metering, Control, Override Output Contacts screen of the front-panel display by setting Override Enable to Disabled.

See the *Terminals and Connectors* chapter for an illustration of the programmable output terminals. Contact output electrical ratings are listed in the *Specifications* chapter.

Retrieving Contact Output Status

Output status is determined through BESTCOMS*Plus* by using the Metering Explorer to open the Status/Outputs tree branch. BESTCOMS*Plus* must be online with the BE1-11*f* to view contact output status. Alternately, status can be determined through the front-panel display by navigating to the Metering, Status, Outputs screen.

Sync-Check Protection (25)

The sync-check (25) element provides breaker closing supervision by comparing the voltage magnitude, angle, and frequency of the phase voltage to the voltage magnitude, angle, and frequency of the auxiliary voltage to determine synchronism.

Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational setting are configured on the Sync-Check settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Voltage, Sync-Check (25)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Voltage Protection, Sync Check 25

Element Operation

When monitored voltage between the sources meets angle, voltage, and slip criteria, the element 25 output becomes true. In BESTlogic*Plus*, the 25 output can be connected to other logic elements to annunciate the condition or control other elements in logic. The 25 logic output becomes true when all three of the following conditions are met:

1. Phase angle between sources is less than the Slip Angle setting.
2. Frequency error between sources is less than the Slip Frequency setting. (Note: When the Source Freq > Destination Freq setting box is checked, only generator frequency greater than bus frequency is allowed.)
3. Voltage magnitude between sources is less than setting. (Note: The voltage used by the relay for this feature is a voltage magnitude measurement, not a voltage phasor measurement.)

Voltage thresholds are entered in percent allowing the use of non-equal transformers with the sync-check function. The sync-check element 25 logic output is true when the criteria are met for the entered nominal bus voltage, nominal line voltage, and allowable percent difference. For example, the sensing for the generator is on one side of a step-down transformer and the sensing for the bus is on the other. Dead/Live values are entered as percent as well.

Note
The sync-check function will not work if VTX connections are set for residual voltage input.

Measuring slip frequency directly allows the sync-check element to rapidly determine if systems are in synchronism and requires no timer or inherent delay (as compared to systems that check only that the phase angle is held within a window for some stretch of time). The moment that conditions 1, 2, and 3 (listed above) are met, the systems can be considered in synchronism, and the 25 logic output becomes true. Refer to the *Metering* chapter for more information about slip frequency measurement.

VT Connections

The sync-check element compares the phase (generator) voltage to the auxiliary (bus) voltage. Proper connection of the voltage transformer inputs is vital for correct operation of the sync-check element.

For clarification on single-phase VTP connections, refer to the *Typical Connections* chapter. 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:

Terminals Va (C13), Vb (C14), and Vc (C15) are connected in parallel. The single-phase signal is connected between the parallel group and terminal N (C16).

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

Terminals Vb (C14), Vc (C15), and N (C16) are connected in parallel. The single-phase signal is connected between terminal Va (C13) and the parallel group.

Note that the voltage monitor (described below) performs three of three testing for all connections. For 3W and 4W, phases A, B, and C are actually tested. For single-phase connections, the terminals are connected in parallel as described above and the single-phase is tested three times. This is implemented in this way for convenience, allowing the exact same code for both conditions.

Caution

The Aux VT Connection must be properly selected on the Sensing Transformers screen in BESTCOMS*Plus*. Refer to the *Configuration* chapter for more information on this setting.

Angle Compensation

Compensation for phase angle differences between the phase and auxiliary VT connections (including single-phase VTP connections) are possible with the Angle Compensation setting. That is, for a VTP selection of phase-to-phase and a VTX selection of phase-to-neutral, a value of 30° should be defined for angle compensation.

Voltage Monitoring

The sync-check element 25 logic output provides closing supervision for only the live line/live bus condition. The 25VM logic output is provided for conditions where the bus and/or the line are dead. In BESTlogic*Plus*, the 25VM output can be connected to other logic elements to annunciate the condition or control other elements in logic. A live condition for either the phase voltage or auxiliary voltage is determined when the measured voltage on the respective input is above the live voltage threshold established by the Live Voltage setting and below the dead voltage threshold established by the Dead Voltage setting. The Dropout Delay setting provides hysteresis for the 25VM output.

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

The 25VM logic is illustrated in Figure 36. Any combination of logic settings can be selected for the Voltage Monitor Logic on the Sync-Check (25) settings screen in BESTCOMS*Plus*. When a logic combination is selected, the sync-check element closes the respective switch in Figure 36 associated with each of the outputs.

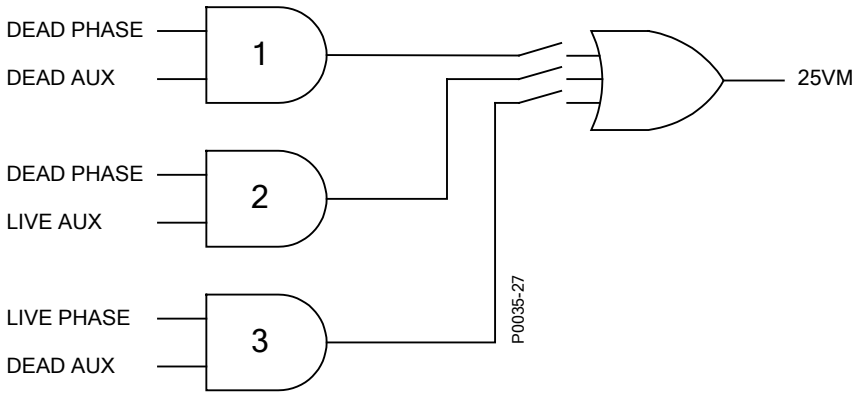


Figure 36. Voltage Monitor Logic

Element Blocking

Fuse Loss

The fuse loss (60FL) element of the BE1-11*f* can be used to block the 25 element when fuse loss or loss of potential is detected in a three-phase system.

If the 60FL element trip logic is true and Block Phase/V1 is enabled, all functions that use the phase voltage are blocked. See the *Fuse Loss (60FL)* chapter for more information on the 60FL functions.

Block Logic Input

This input allows for logic supervision or control of the element.

The sync-check element has a Block logic input which when true, disables the element by forcing the element 25 and 25VM outputs to logic 0. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Sync-check element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The sync-check element logic block is illustrated in Figure 37. Logic inputs and outputs are summarized in Table 8.

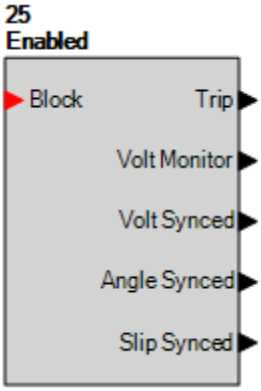


Figure 37. Sync-Check Element Logic Block

Table 8. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 25 function when true
Volt Monitor	Output	True when the bus and/or line is dead
Volt Synced	Output	True when the voltage magnitude between sources is less than setting
Angle Synced	Output	True when the phase angle between sources is less than the Slip Angle setting
Slip Synced	Output	True when the frequency error between sources is less than the Slip Frequency setting

Operational Settings

Sync-check element operational settings are configured on the Sync-Check (25) settings screen (Figure 38) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 9.

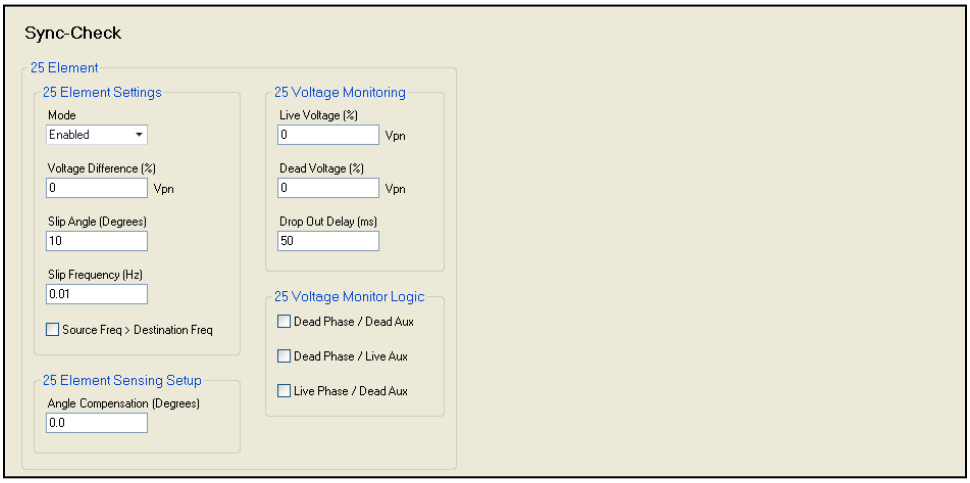


Figure 38. Sync-Check Settings Screen

Table 9. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled or Enabled	n/a	n/a	Disabled
Voltage Difference	0 or 1 to 50	1	percent	0
Slip Angle	1 to 99	1	degrees	10
Slip Frequency	0.01 to 0.5	0.01	hertz	0.01
Source Freq > Destination Freq	Disabled or Enabled	n/a	n/a	Disabled
Angle Compensation	0 to 359.9	0.1	degrees	0
25 VM Live Voltage	0 or 10 to 90	1	percent	0
25 VM Dead Voltage	0 or 10 to 90	1	percent	0
25 VM Drop Out Delay	0 or 50 to 60,000	varies	milliseconds	50
25 Voltage Monitor Logic	0 = Disabled 123, 12, 13, 23	n/a	n/a	0

Phase Undervoltage Protection (27P)

Five phase undervoltage protection (27P) elements monitor the sensing voltage applied to the BE1-11*f*. An element can be configured to protect against undervoltage when the phase voltage decreases below a defined level.

The five, identical phase undervoltage protection elements are designated 27P-1, 27P-2, 27P-3, 27P-4, and 27P-5. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Undervoltage settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Voltage, Undervoltage (27P)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Voltage Protection, Undervoltage 27P

Element Operation

Phase undervoltage protection can be used to prevent large transformer and equipment damage when an undervoltage condition exists. For example, an undervoltage condition could occur when a tap changing control fails.

Modes of Protection

Three modes of protection are available. The One of Three mode activates protection when one of the three phases of voltage decreases below the Pickup setting. The Two of Three mode activates protection when any two of the three phases of voltage decrease below the Pickup setting. The Three of Three mode activates protection when all three phases of voltage decrease below the Pickup setting.

Voltage Response

The phase undervoltage element can be set to monitor VPP or VPN. This is determined by the 27/59 Mode parameter of the phase VT connections found on the System Parameters/Sensing Transformers settings screen in BESTCOMS*Plus*. For more information on the VTP setup for PP or PN voltage response, see the *Configuration* chapter.

Pickup and Trip

When the measured voltage decreases below the voltage threshold established by the Pickup setting, the element Pickup output becomes true. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements in logic.

Assertion of the Pickup output initiates a timer which begins timing toward a trip. The timing mode can be set for definite or inverse. For details on the inverse time curve, refer to the *Time Curve Characteristics* chapter.

The duration of the timer is established by the Time Delay (definite timing) or Time Dial (inverse timing). A Time Delay or Time Dial setting of zero (0) makes the 27P element instantaneous with no intentional time delay.

If an undervoltage pickup condition persists for the duration of the element Time Delay setting or calculated inverse time, the element Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

If the pickup condition subsides before the element time delay or calculated inverse time expires, the timer and Pickup output are reset, no corrective action is taken, and the element is rearmed for any other occurrences of undervoltage.

Voltage Inhibit

The Voltage Inhibit setting impedes phase undervoltage element operation during undervoltage conditions that may occur during equipment startup. This setting is expressed in primary or secondary voltage depending on the Settings Display Mode selected on the General Settings/Display Units settings screen in BESTCOMS*Plus*. Its unit of measure depends upon the phase VT connection setting. For four-wire or phase-to-neutral sensing connections, the inhibit level is expressed in Vpn. For three-wire or phase-to-phase sensing connections the inhibit level is expressed in Vpp.

Element Blocking

Fuse Loss

The fuse loss (60FL) element of the BE1-11*f* can be used to block 27P protection when fuse loss or loss of potential is detected in a three-phase system.

If the 60FL element trip logic is true and Block Phase/V1 is enabled, all functions that use the phase voltage are blocked. See the *Fuse Loss (60FL)* chapter for more information on the 60FL function.

Block Logic Input

This input allows for logic supervision or control of the element.

Each phase undervoltage protection element has a Block logic input which when true, disables an element by forcing the element Trip and Pickup outputs to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Phase undervoltage element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The phase undervoltage element logic block is illustrated in Figure 39. Logic inputs and outputs are summarized in Table 10.

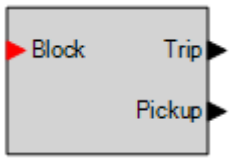


Figure 39. Phase Undervoltage Element Logic Block

Table 10. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 27P function when true
Trip	Output	True when the 27P element is in a trip condition
Pickup	Output	True when the 27P element is in a pickup condition

Operational Settings

Phase undervoltage element operational settings are configured on the Undervoltage (27P) settings screen (Figure 40) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 11.

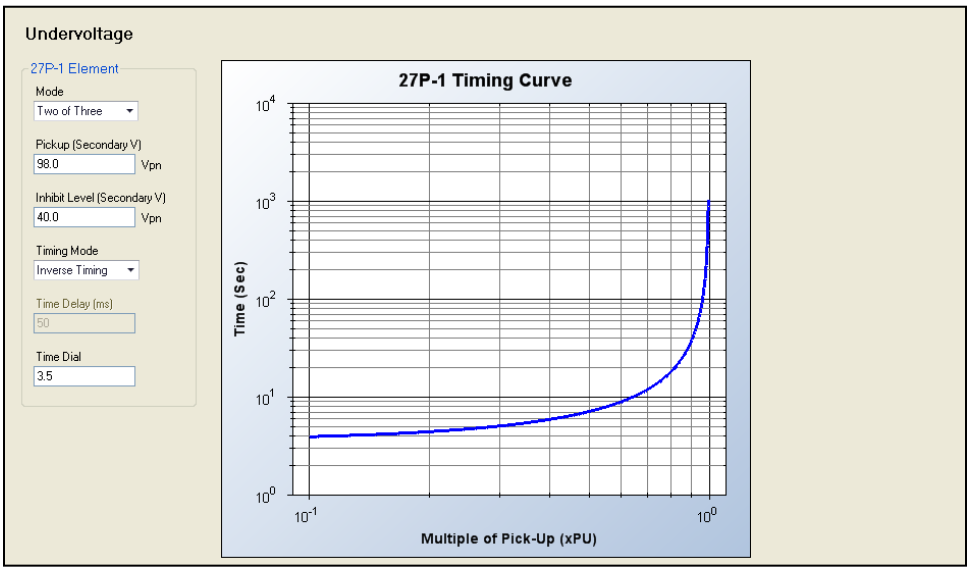


Figure 40. Phase Undervoltage Settings Screen

Table 11. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled, One of Three, Two of Three, or Three of Three	n/a	n/a	Disabled
Pickup	0 or 1 to 300	0.1	volts	0
Inhibit Level	0 to 1 to 300	0.1	volts	0
Timing Mode	Definite or Inverse	n/a	n/a	Definite
Time Delay (Definite Timing)	50 to 600,000	varies	milliseconds	50
Time Dial (Inverse Timing)	0 to 9.9	0.1	units	0

Auxiliary Undervoltage Protection (27X)

Four auxiliary undervoltage protection (27X) elements monitor the phase and auxiliary voltage applied to the BE1-11*f*. An element can be configured to protect against undervoltage by monitoring neutral-shift voltage, positive-sequence voltage, negative-sequence voltage, fundamental voltage on the Vx input, or third-harmonic voltage on the Vx input.

The four, identical auxiliary undervoltage protection elements are designated 27X-1, 27X-2, 27X-3, and 27X-4. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Undervoltage (27X) settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Voltage, Undervoltage (27X)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Voltage Protection, Undervoltage 27X

Element Operation

Auxiliary undervoltage protection can be used to protect equipment from damage caused by phase failure, positive/negative phase sequence, or phase unbalance.

Modes of Protection

Five modes of protection are available: 3V0, V1, V2, Vx Fundamental, and Vx Third Harmonic.

3V0 Mode

3V0 mode provides voltage unbalance protection in a three-phase system. The 3V0 measurement increases as the three-phase voltages become unbalanced.

V1 Mode

V1 mode provides positive phase-sequence protection in a three-phase system. The V1 measurement increases as the phase sequence is brought forward.

V2 Mode

V2 mode provides negative phase-sequence protection in a three-phase system. The V2 measurement increases as voltage becomes unbalanced or the phase sequence is reversed.

Vx Fundamental Mode

Vx Fundamental mode provides ground offset detection on high impedance ground systems or phase undervoltage protection in sync-check applications.

Vx Third Harmonic Mode

Vx Third Harmonic mode provides internal generator short detection.

Connections

Connections are made on the rear of the BE1-11*f*. The phase VT inputs (Va, Vb, Vc) are used when 3V0, V1, or V2 mode is selected. The auxiliary VT input (Vx) is used when Vx Fundamental or Vx Third Harmonic mode is selected. For an illustration of terminals, refer to the *Terminals and Connectors* chapter.

Sensing Configuration

If Vx Fundamental or Vx Third Harmonic mode is selected, the Auxiliary VT Connection parameter must be configured. The Aux VT Connection parameter specifies how the auxiliary VT input (Vx) is connected.

The auxiliary VT input (Vx) can be connected to AB, BC, CA, AN, BN, CN, or Ground. The Aux VT Connection parameter is found on the System Parameters/Sensing Transformers settings screen in BESTCOMS*Plus*. Auxiliary VT connection settings are listed in Table 12. For more information on the auxiliary VT setup, see the *Configuration* chapter.

Table 12. Auxiliary VT Configuration

Aux VT Connection	Mode	Unit
AB, BC, CA	Vx Fundamental, Vx Third Harmonic	VPP
AN, BN, CN	Vx Fundamental, Vx Third Harmonic	VPN
Ground	Vx Fundamental, Vx Third Harmonic	VPN
Don't care	V1, V2, and 3V0	VPN

Pickup and Trip

When the measured voltage decreases below the voltage threshold established by the Pickup setting, the element Pickup output becomes true. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements in logic.

Assertion of the Pickup output initiates a timer which begins timing toward a trip. The timing mode can be set for definite or inverse. For details on the inverse time curve, refer to the *Time Curve Characteristics* chapter.

The duration of the timer is established by the Time Delay (definite timing) or Time Dial (inverse timing). A Time Delay or Time Dial setting of zero (0) makes the 27X element instantaneous with no intentional time delay.

If an undervoltage pickup condition persists for the duration of the element Time Delay setting or calculated inverse time, the element Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

If the pickup condition subsides before the element time delay or calculated inverse time expires, the timer and Pickup output are reset, no corrective action is taken, and the element is rearmed for any other occurrences of undervoltage.

Voltage Inhibit

The Voltage Inhibit setting impedes auxiliary undervoltage element operation during undervoltage conditions that may occur during equipment startup. This setting is expressed in primary or secondary voltage depending on the Settings Display Mode selected on the General Settings/Display Units settings screen in *BESTCOMSPlus.*

Its unit of measure depends upon the auxiliary VT connection setting and 27X element mode selected. For AB, BC, and CA sensing connections in Vx Fundamental or Vx Third Harmonic mode, the inhibit level is expressed in Vpp. For AN, BN, CN, or Ground sensing connections in Vx Fundamental or Vx Third Harmonic mode, the inhibit level is expressed in Vpn. The inhibit level is always expressed in Vpn for V1, V2, and 3V0 modes of the 27X element.

Element Blocking

Fuse Loss

The fuse loss (60FL) element of the BE1-11*f* can be used to block 27X protection when fuse loss or loss of potential is detected in a three-phase system.

If the 60FL element trip logic is true and Block Phase/V1 is enabled, the 27X function will be blocked when configured for V1 mode. If Block V2 is enabled, the 27X function will be blocked when configured for V2 mode. If Block 3V0 is enabled, the 27X function will be blocked when configured for 3V0 mode. See the *Fuse Loss (60FL)* chapter for more information on the 60FL function.

Block Logic Input

This input allows for logic supervision or control of the element.

Each auxiliary undervoltage protection element has a Block logic input which when true, disables an element by forcing the element Trip and Pickup outputs to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Auxiliary undervoltage element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The auxiliary undervoltage element logic block is illustrated in Figure 41. Logic inputs and outputs are summarized in Table 13.

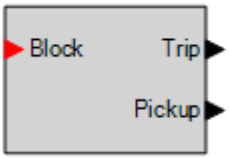


Figure 41. Auxiliary Undervoltage Element Logic Block

Table 13. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 27X function when true
Trip	Output	True when the 27X element is in a trip condition
Pickup	Output	True when the 27X element is in a pickup condition

Operational Settings

Auxiliary undervoltage element operational settings are configured on the Undervoltage (27X) settings screen (Figure 42) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 14.

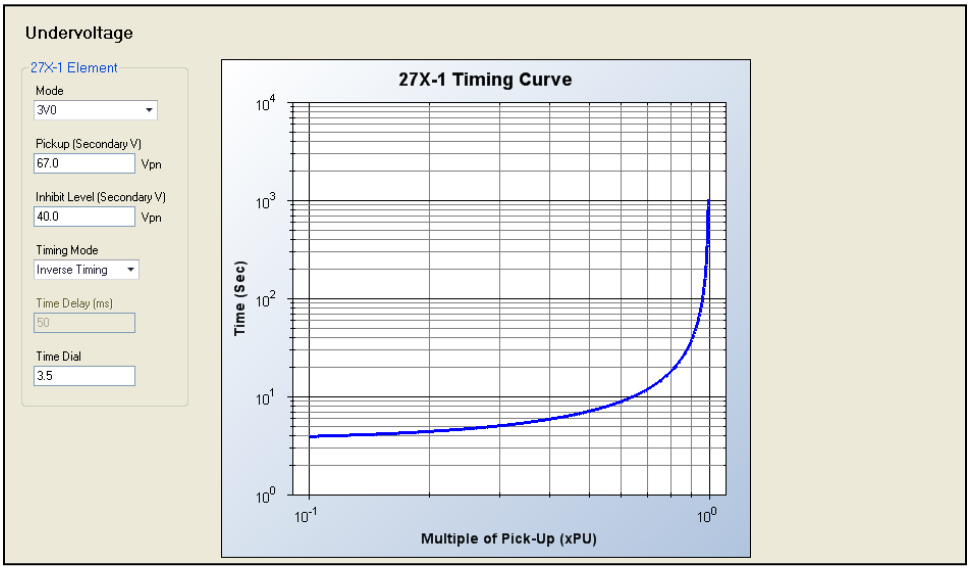


Figure 42. Auxiliary Undervoltage Settings Screen

Table 14. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode *	Disabled, 3V0, V1, V2, Vx Fundamental, Vx Third Harmonic	n/a	n/a	Disabled
Pickup	0 or 1 to 150	0.1	volts	0
Inhibit Level	0 or 1 to 150	0.1	volts	0
Timing Mode	Definite or Inverse	n/a	n/a	Definite
Time Delay (Definite Timing)	50 to 600,000	varies	milliseconds	50
Time Dial (Inverse Timing)	0 to 9.9	0.1	units	0

* To use 3V0, V1, or V2, the VTP connection cannot be single-phase.

Sequence Voltage Protection (47)

Negative- and positive-sequence voltage protection is included as modes of the 27X (Auxiliary Undervoltage) and 59X (Auxiliary Overvoltage) elements. Refer to the *Auxiliary Undervoltage Protection (27X)* and *Auxiliary Overvoltage Protection (59X)* chapters for information on how to set up and program the V2 (negative-sequence voltage) and V1 (positive-sequence voltage) modes of the 27X and 59X elements.

Phase Overvoltage Protection (59P)

Four phase overvoltage protection (59P) elements monitor the sensing voltage applied to the BE1-11*f*. An element can be configured to protect against overvoltage when the phase voltage increases above a defined level.

The four, identical overvoltage protection elements are designated 59P-1, 59P-2, 59P-3, and 59P-4. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Overvoltage settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Voltage, Overvoltage (59P)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Voltage Protection, Overvoltage 59P

Element Operation

Overvoltage protection can be used to prevent large transformer and equipment damage when an overvoltage condition exists. For example, an overvoltage condition could occur when the tap changing control fails.

Modes of Protection

Three modes of protection are available. The One of Three mode activates protection when one of the three phases of voltage increases above the Pickup setting. The Two of Three mode activates protection when any two of the three phases of voltage increases above the Pickup setting. The Three of Three mode activates protection when all three phases of voltage increase above the Pickup setting.

Voltage Response

The overvoltage element can be set to monitor VPP or VPN. This is determined by the 27/59 Mode parameter of the phase VT connections found on the System Parameters/Sensing Transformers settings screen in BESTCOMS*Plus*. For more information on the VTP setup for PP or PN voltage response, see the *Configuration* chapter.

Pickup and Trip

When the measured voltage increases above the voltage threshold established by the Pickup setting, the element Pickup output becomes true. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements in logic.

Assertion of the Pickup output initiates a timer which begins timing toward a trip. The timing mode can be set for definite or inverse. For details on the inverse time curve, refer to the *Time Curve Characteristics* chapter.

The duration of the timer is established by the Time Delay (definite timing) or Time Dial (inverse timing). A Time Delay or Time Dial setting of zero (0) makes the 59P element instantaneous with no intentional time delay.

If an overvoltage pickup condition persists for the duration of the element Time Delay setting or calculated inverse time, the element Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

If the pickup condition subsides before the element time delay or calculated inverse time expires, the timer and Pickup output are reset, no corrective action is taken, and the element is rearmed for any other occurrences of overvoltage.

Element Blocking

Fuse Loss

The fuse loss (60FL) element of the BE1-11*f* can be used to block 59P protection when fuse loss or loss of potential is detected in a three-phase system.

If the 60FL element trip logic is true and Block Phase/V1 is enabled, all functions that use the phase voltage are blocked. See the *Fuse Loss (60FL)* chapter for more information on the 60FL function.

Block Logic Input

This input allows for logic supervision or control of the element.

Each phase overvoltage protection element has a Block logic input which when true, disables an element by forcing the element Trip and Pickup outputs to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Overvoltage element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The overvoltage element logic block is illustrated in Figure 43. Logic inputs and outputs are summarized in Table 15.

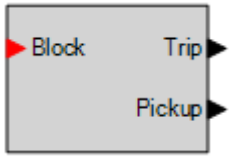


Figure 43. Overvoltage Element Logic Block

Table 15. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 59P function when true
Trip	Output	True when the 59P element is in a trip condition
Pickup	Output	True when the 59P element is in a pickup condition

Operational Settings

Overvoltage element operational settings are configured on the Overvoltage settings screen (Figure 44) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 16.

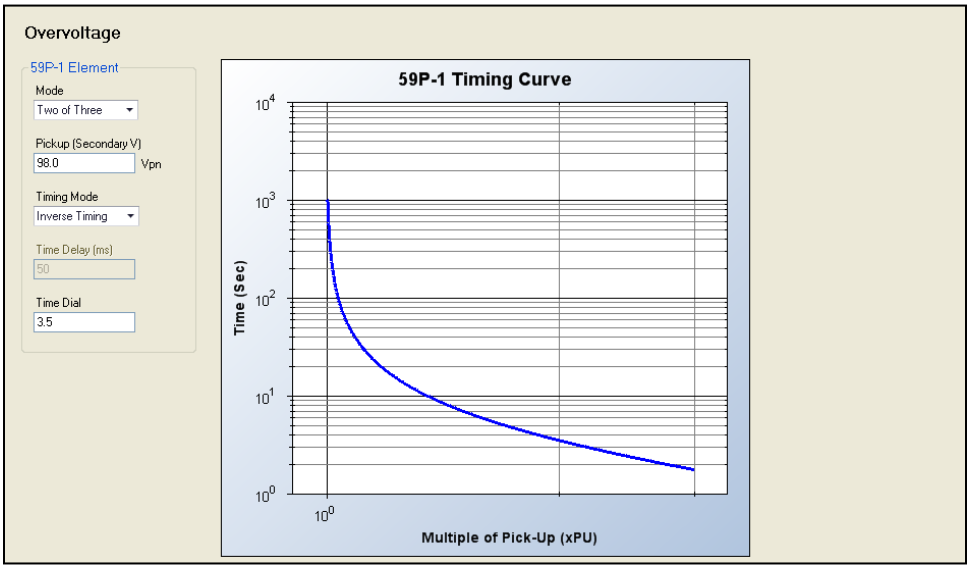


Figure 44. Overvoltage Settings Screen

Table 16. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled, One of Three, Two of Three, or Three of Three	n/a	n/a	Disabled
Pickup	0 or 1 to 300	0.1	volts	0
Timing Mode	Definite or Inverse	n/a	n/a	Definite
Time Delay (Definite Timing)	50 to 600,000	varies	milliseconds	50
Time Dial (Inverse Timing)	0 to 9.9	0.1	units	0

Auxiliary Overvoltage Protection (59X)

Four auxiliary overvoltage protection (59X) elements monitor the phase and auxiliary voltage applied to the BE1-11*f*. An element can be configured to protect against overvoltage by monitoring neutral-shift voltage, positive-sequence voltage, negative-sequence voltage, fundamental voltage on the Vx input, or third-harmonic voltage on the Vx input.

The four, identical auxiliary overvoltage protection elements are designated 59X-1, 59X-2, 59X-3, and 59X-4. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Overvoltage (59X) settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Voltage, Overvoltage (59X)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Voltage Protection, Overvoltage 59X

Element Operation

Auxiliary overvoltage protection can be used to protect equipment from damage caused by phase failure, positive/negative phase sequence, or phase unbalance.

Modes of Protection

Five modes of protection are available: 3V0, V1, V2, Vx Fundamental, and Vx Third Harmonic.

3V0 Mode

3V0 mode provides voltage unbalance protection in a three-phase system. The 3V0 measurement increases as the three-phase voltages become unbalanced.

V1 Mode

V1 mode provides positive phase-sequence protection in a three-phase system. The V1 measurement increases as the phase sequence is brought forward.

V2 Mode

V2 mode provides negative phase-sequence protection in a three-phase system. The V2 measurement increases as voltage becomes unbalanced or the phase sequence is reversed.

Vx Fundamental Mode

Vx Fundamental mode provides ground offset detection on high impedance ground systems or phase overvoltage protection in sync-check applications.

Vx Third Harmonic Mode

Vx Third Harmonic mode detects an increase in third harmonic.

Connections

Connections are made on the rear of the BE1-11*f*. The phase VT inputs (Va, Vb, Vc) are used when 3V0, V1, or V2 mode is selected. The auxiliary VT input (Vx) is used when Vx Fundamental or Vx Third Harmonic mode is selected. For an illustration of terminals, refer to the *Terminals and Connectors* chapter.

Sensing Configuration

If Vx Fundamental or Vx Third Harmonic mode is selected, the Auxiliary VT Connection parameter must be configured. The Aux VT Connection parameter specifies how the auxiliary VT input (Vx) is connected. The auxiliary VT input (Vx) can be connected to AB, BC, CA, AN, BN, CN, or Ground. The Aux VT

Connection parameter is found on the System Parameters/Sensing Transformers settings screen in BESTCOMS*Plus*. Auxiliary VT connection settings are listed in Table 17. For more information on the auxiliary VT setup, see the *Configuration* chapter.

Table 17. Auxiliary VT Configuration

Aux VT Connection	Mode	Unit
AB, BC, CA	Vx Fundamental, Vx Third Harmonic	VPP
AN, BN, CN	Vx Fundamental, Vx Third Harmonic	VPN
Ground	Vx Fundamental, Vx Third Harmonic	VPN
Don't care	V1, V2, and 3V0	VPN

Pickup and Trip

When the measured voltage increases above the voltage threshold established by the Pickup setting, the element Pickup output becomes true. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements in logic.

Assertion of the Pickup output initiates a timer which begins timing toward a trip. The timing mode can be set for definite or inverse. For details on the inverse time curve, refer to the *Time Curve Characteristics* chapter.

The duration of the timer is established by the Time Delay (definite timing) or Time Dial (inverse timing). A Time Delay or Time Dial setting of zero (0) makes the 59X element instantaneous with no intentional time delay.

If an overvoltage pickup condition persists for the duration of the element Time Delay setting or calculated inverse time, the element Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

If the pickup condition subsides before the element time delay or calculated inverse time expires, the timer and Pickup output are reset, no corrective action is taken, and the element is rearmed for any other occurrences of overvoltage.

Element Blocking

Fuse Loss

The fuse loss (60FL) element of the BE1-11*f* can be used to block 59X protection when fuse loss or loss of potential is detected in a three-phase system.

If the 60FL element trip logic is true and Block Phase/V1 is enabled, the 59X function will be blocked when configured for V1 mode. If Block V2 is enabled, the 59X function will be blocked when configured for V2 mode. If Block 3V0 is enabled, the 59X function will be blocked when configured for 3V0 mode. See the *Fuse Loss (60FL)* chapter for more information on the 60FL function.

Block Logic Input

This input allows for logic supervision or control of the element.

Each auxiliary overvoltage protection element has a Block logic input which when true, disables an element by forcing the element Trip and Pickup outputs to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Auxiliary overvoltage element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The auxiliary overvoltage element logic block is illustrated in Figure 45. Logic inputs and outputs are summarized in Table 18.

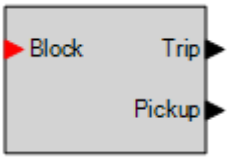


Figure 45. Auxiliary Overvoltage Element Logic Block

Table 18. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 59X function when true
Trip	Output	True when the 59X element is in a trip condition
Pickup	Output	True when the 59X element is in a pickup condition

Operational Settings

Auxiliary overvoltage element operational settings are configured on the Overvoltage (59X) settings screen (Figure 46) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 19.

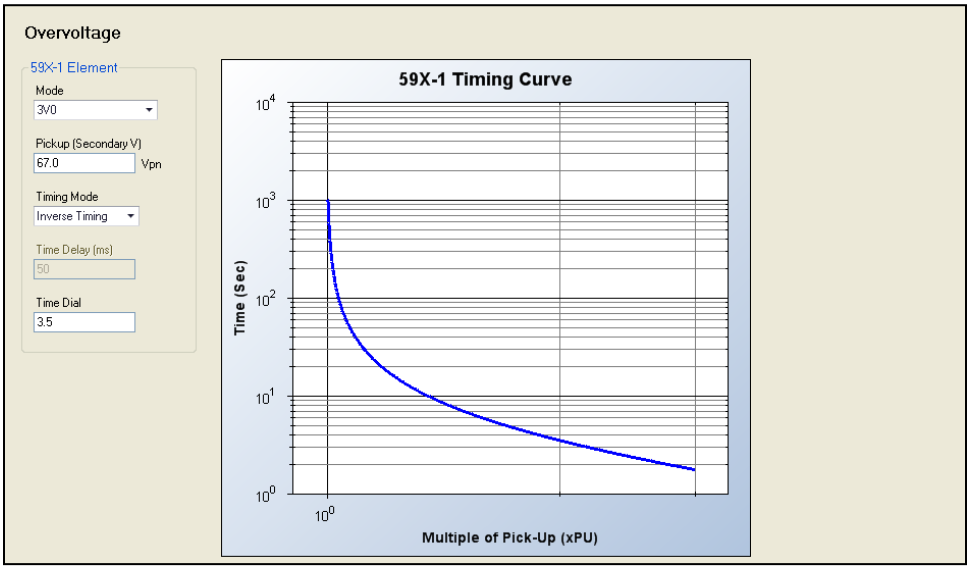


Figure 46. Auxiliary Overvoltage Settings Screen

Table 19. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode *	Disabled, 3V0, V1, V2, Vx Fundamental, Vx Third Harmonic	n/a	n/a	Disabled
Pickup	0 or 1 to 150	0.1	volts	0
Timing Mode	Definite or Inverse	n/a	n/a	Definite
Time Delay (Definite Timing)	50 to 600,000	varies	milliseconds	50
Time Dial (Inverse Timing)	0 to 9.9	0.1	units	0

* To use 3V0, V1, or V2, the VTP connection cannot be single-phase.

Frequency Protection (81)

Eight frequency protection (81) elements monitor the frequency of the sensing voltage applied to the BE1-11*f*. An element can be configured to protect against underfrequency, overfrequency, or the rate of frequency change.

The eight, identical frequency protection elements are designated 81-1, 81-2, 81-3, 81-4, 81-5, 81-6, 81-7, and 81-8. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Frequency settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

Note
BE1-11*f* relays enabled for IEC-61850 communication (style Fxxxx5xxxxxxxx) have their frequency protection elements fixed at four underfrequency elements, two overfrequency elements, and two frequency rate-of-change elements.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Frequency, Frequency (81)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Frequency Protection 81

Frequency Measurement

For four-wire or single-phase sensing connections, the power system frequency is measured through the BE1-11*f* A-phase sensing voltage input. For a three-wire connection, the power system frequency is measured through the A- and B-phase sensing voltage connections. Power system frequency is also measured through the BE1-11*f* auxiliary voltage (Vx) sensing input. Refer to the *Typical Connections* chapter for information on voltage connections.

To measure frequency, the voltage sensed by the BE1-11*f* must be greater than 10 Vac. The measured frequency is the average of two cycles of voltage measurement.

Underfrequency and Overfrequency Protection

Underfrequency and overfrequency protection can be useful for detecting load shedding or islanding. For example, when a source of distributed generation (DG) is suddenly separated or isolated from the electric utility, the frequency will change quickly from the nominal value (except for the improbable case of a perfect load-to-generation match). This makes frequency measurement an excellent method for detecting an island condition.

Any of the eight 81 elements can be configured for underfrequency or overfrequency protection.

Mode

Underfrequency or overfrequency protection is selected through the Mode setting. A setting of Under selects underfrequency protection and a setting of Over selects overfrequency protection.

Sensing Source

Underfrequency or overfrequency protection can be applied to the voltage sensed at the BE1-11*f* phase VT input or auxiliary VT (Vx) input. A Source setting of Phase VT selects the voltage sensed at the phase VT input and a Source setting of Aux VT selects the voltage sensed at the Vx input.

Security of a load shedding scheme can be enhanced by monitoring two independent VT circuits.

Pickup and Trip

When the measured frequency decreases below (underfrequency protection) or increases above (overfrequency protection) the frequency threshold established by the Pickup setting for three consecutive sensing voltage cycles, the element Pickup output becomes true. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements in logic.

Assertion of the Pickup output initiates a timer which begins timing toward a trip. The duration of the timer is established by the Time Delay setting. A Time Delay setting of zero (0) makes the 81 element instantaneous with no intentional time delay.

If an underfrequency or overfrequency pickup condition persists for the duration of the element Time Delay setting, the element Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

If the pickup condition subsides before the element time delay expires, the timer and Pickup output are reset, no corrective action is taken, and the element is rearmed for any other occurrences of underfrequency or overfrequency.

Voltage Inhibit

The Voltage Inhibit setting impedes underfrequency/overfrequency element operation during undervoltage conditions that may occur during equipment startup. This setting is expressed in primary or secondary voltage depending on the Settings Display Mode selected on the General Settings/Display Units settings screen in BESTCOMS*Plus* and its unit of measure depends upon the phase VT connection setting. For four-wire or phase-to-neutral sensing connections that inhibit level is expressed in Vpn. For three-wire or phase-to-phase sensing connections the inhibit level is expressed in Vpp.

Element Blocking

This input allows for logic supervision or control of the element.

Each frequency protection element has a Block logic input which when true, disables an element by forcing the element Trip and Pickup outputs to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Frequency Rate-of-Change Protection

When a source of DG is suddenly separated from the electric utility, the frequency rate-of-change (ROC) will increase or decrease rapidly. Frequency ROC protection provides high-speed detection of an islanding situation that may not be detected by overfrequency or underfrequency protection. A frequency ROC protection element can be used for load shedding in conjunction with an underfrequency protection element to accelerate shedding during a substantial overload or inhibit shedding following a sudden, transient decrease in frequency. An 81 element can be configured to respond to positive ROC, negative ROC, or either condition.

Any of the eight 81 elements can be configured for frequency rate-of-change (ROC) protection.

Mode

An 81 element is configured for rate-of-change protection, only positive rate-of-change protection, or only negative rate-of-change protection through the Mode setting.

Sensing Source

Frequency ROC protection can be applied to the voltage sensed at the BE1-11*f* phase VT input or auxiliary VT (Vx) input. A Source setting of Phase VT selects the voltage sensed at the phase VT input and a Source setting of Aux VT selects the voltage sensed at the Vx input.

Security of a load shedding scheme can be enhanced by monitoring two independent VT circuits.

Pickup and Trip

When the rate of frequency change (expressed in hertz per second) exceeds the threshold established by the Pickup setting for three consecutive sensing voltage cycles, the element Pickup output becomes true. Pickup detection time varies according to the value of the fault frequency. When the frequency greatly exceeds the pickup setting, pickup detection occurs very quickly. More precise and less quick pickup detection occurs when the fault frequency is much closer to the Pickup setting. Pickup detection times are summarized as follows:

- Faults exceeding the pickup setting by 0.57 Hz/s are detected in 2 cycles
- Faults exceeding the pickup setting by 0.24 Hz/s are detected in 4 cycles
- Faults exceeding the pickup setting by 0.08 Hz/s are detected in 8 cycles
- No pickup detection time will be greater than 16 cycles

In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements of logic.

Assertion of the Pickup output initiates a timer which begins timing toward a trip. The duration of the timer is established by the Time Delay setting. A Time Delay setting of zero (0) makes the 81 element instantaneous (with the exception of the pickup detection time).

If an ROC pickup condition persists for the duration of the element Time Delay setting, the element Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Recording* chapter for more information about target reporting.

If the pickup condition subsides before the element time delay expires, the timer and Pickup output are reset, no corrective action is taken, and the element is rearmed for any other occurrences of a frequency ROC fault.

Inhibit Functions

Frequency ROC protection can be inhibited by the degree of underfrequency or overfrequency or the percentage of negative sequence voltage.

The Overfrequency Inhibit setting disables frequency ROC protection when the sensed frequency exceeds the setting threshold. Likewise, the Underfrequency Inhibit setting disables frequency ROC protection when the sensed frequency decreases below the setting threshold.

Frequency ROC protection can be inhibited when the percentage of negative sequence voltage exceeds the limit established by the Negative Sequence Inhibit setting. A Negative Sequence Inhibit setting of zero (0) inhibits this feature.

Element Blocking

Frequency element blocking operates in a similar manner to the torque control contact of an electromechanical relay.

Each frequency protection element has a Block logic input which when true, disables an element by forcing the element Trip and Pickup outputs to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Frequency element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The frequency element logic block is illustrated in Figure 47. Logic inputs and outputs are summarized in Table 20.

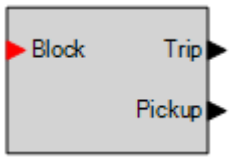


Figure 47. Frequency Element Logic Block

Table 20. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 81 function when true
Trip	Output	True when the 81 element is in a trip condition
Pickup	Output	True when the 81 element is in a pickup condition

Operational Settings

Frequency element operational settings are configured on the Frequency settings screen (Figure 48) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 21.

Figure 48. Frequency Settings Screen

Table 21. Operational Settings

Setting		Range	Increment	Unit of Measure	Default
Mode		Disabled, Over, Under, Rate of Change, Positive Rate of Change, or Negative Rate of Change	n/a	n/a	Disabled
Source		Phase VT or Aux VT	n/a	n/a	Phase VT
Pickup		0 or 0.2 to 20 for ROC mode 0 or 15 to 70 for O/U mode	0.01	hertz/sec (ROC) hertz (O/U)	0
Time Delay		0 to 600,000	varies	milliseconds	0
Voltage Inhibit		0 or 15 to 250	0.1	volts *	20
81ROC	Over Frequency	15 to 70 Hz	0.01	hertz	61
	Under Frequency	15 to 70 Hz	0.01	hertz	59
	Negative Sequence Inhibit	0 to 99	1	percent	20

* Phase-to-phase and phase-to-neutral settings depend on the Phase VT and Aux VT connection settings. Refer to the *Configuration* chapter for more information on these settings.

Sequence Overcurrent Protection (46)

Negative- and positive-sequence current protection are included as modes of the 50 (Instantaneous Overcurrent) and the 51 (Inverse Overcurrent) elements. Refer to the chapters on *Instantaneous Overcurrent Protection (50) and Inverse Overcurrent Protection (51)* for information on how to set up and program the I2 (negative-sequence current) and I1 (positive-sequence current) modes of the 50 and the 51 elements.

For years, protection engineers have enjoyed increased sensitivity to phase-to-ground unbalances with the application of ground relays. Ground relays can be set more sensitively than phase relays because a balanced load has no ground (3_{I0}) current component. When using negative-sequence mode, the 50 and 51 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 when using negative-sequence mode for the 50 or 51 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 49.

The phase-to-phase fault is made up of both positive and negative-sequence components as shown in Figure 50 or a phase-to-phase fault, the magnitude of the negative-sequence component is $1/\sqrt{3}$ (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.

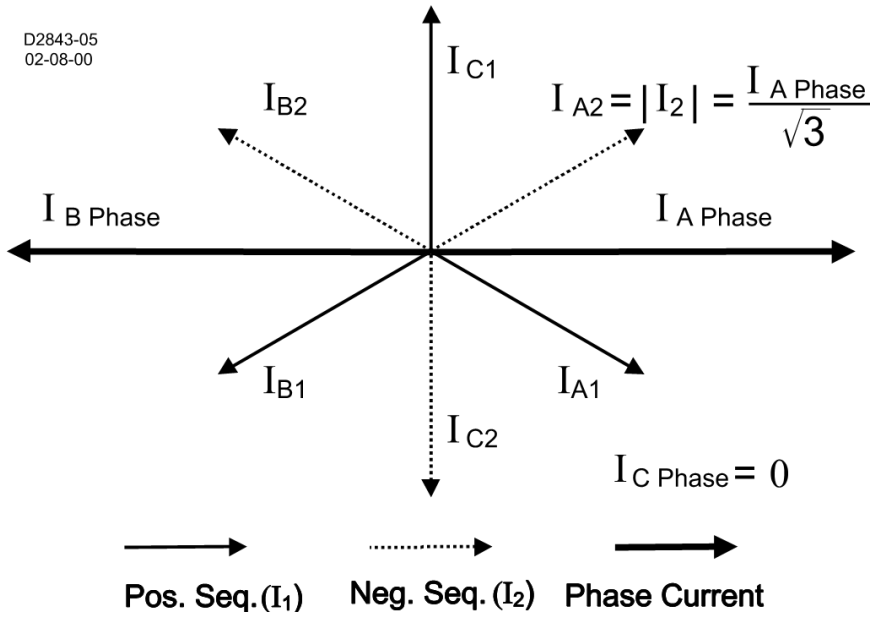


Figure 49. Sequence Components for an A-B Fault

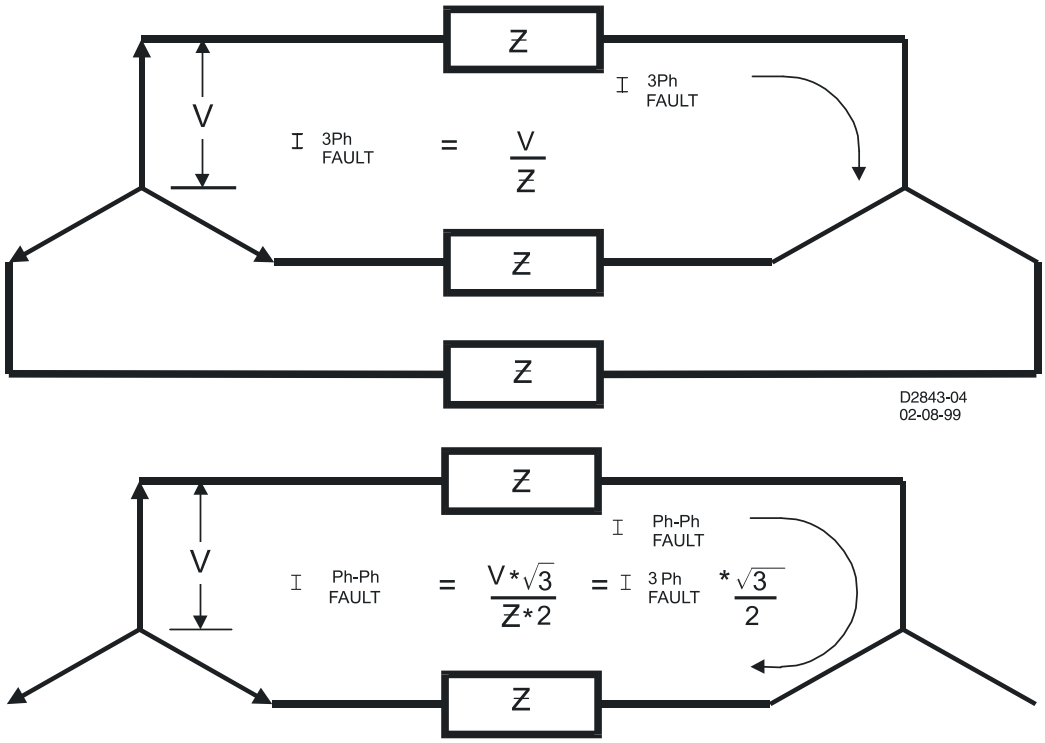


Figure 50. Phase-to-Phase Fault Magnitude

Negative-Sequence Coordination Settings

The 51-x negative-sequence 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 22).

Table 22. Fault Type Multipliers

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

For example, a downstream phase 51-x element has a pickup of 150 amperes. The upstream 51-x negative-sequence 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 51-x negative-sequence element would be shifted to the right by the appropriate factor m. Thus, the characteristic would be plotted on the coordination graph with pickup at: (200 amperes) ∗ 1.732 = 346 amperes.

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

Instantaneous Overcurrent Protection (50)

Six instantaneous overcurrent protection (50) elements monitor the current applied to the BE1-11*f*. An element can be configured to protect against overcurrent by monitoring a single- or three-phase system, neutral current, positive-sequence current, negative-sequence current, ground current, or unbalanced current.

The six, identical instantaneous overcurrent protection elements are designated 50-1, 50-2, 50-3, 50-4, 50-5, and 50-6. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Instantaneous Overcurrent settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Current, Instantaneous Overcurrent (50)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Current Protection, Instant Overcurrent 50

Element Operation

Instantaneous overcurrent protection can be used to protect equipment from damage caused by phase failure, forward/reverse phase sequence, or phase unbalance.

Modes of Protection

Nine modes of protection are available: IA, IB, IC, Three-Phase, 3I0, I1, I2, IG, and Unbalance.

IA, IB, or IC Mode

The instantaneous overcurrent protection elements include three independent comparators and timers, one for each phase. Mode selection determines which phase pickup is required to activate protection.

Three-Phase Mode

Three-phase mode provides overcurrent protection in a three-phase system when all three phases increase above the Pickup setting.

3I0 Mode

3I0 mode provides neutral overcurrent protection in a three-phase system.

I1 Mode

I1 mode provides positive-sequence overcurrent protection in a three-phase system.

I2 Mode

I2 mode provides negative-sequence overcurrent protection in a three-phase system.

IG Mode

IG mode provides ground fault protection in a three-phase system.

Unbalance Mode

Unbalance mode provides unbalanced overcurrent protection. Two methods are available to calculate unbalanced current. The first method is based on the negative-sequence current divided by the positive-sequence current while the second method is based on the average current. The calculation method must

be specified on the System Parameters, Sensing Transformers screen in BESTCOMS*Plus*. Refer to the *Configuration* chapter for more information.

CT Source

The CT Source setting configures an instantaneous overcurrent element to monitor CT Circuit 1 or CT Circuit 2 on relays equipped with two sets of CTs. CT Circuit 1 terminals are designated D1 (IA1) through D8 (IG1) and CT Circuit 2 terminals are designated F1 (IA2) through F8 (IG2). For an illustration, refer to the *Terminals and Connectors* chapter.

Direction

An instantaneous overcurrent element can be configured for forward or reverse tripping. Refer to the *Directional Overcurrent Protection (67)* chapter for more information.

Pickup and Trip

When the measured current increases above the current threshold established by the Pickup setting, the element Pickup output becomes true. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements in logic.

Assertion of the Pickup output initiates a timer which begins timing toward a trip. The duration of the timer is established by the Time Delay setting. A Time Delay of zero (0) makes the 50 element instantaneous with no intentional time delay.

If an overcurrent condition persists for the duration of the element Time Delay setting, the element Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

If the pickup condition subsides before the element time delay expires, the timer and Pickup output are reset, no corrective action is taken, and the element is rearmed for any other occurrences of overcurrent.

Element Blocking

This input allows for logic supervision or control of the element.

Each instantaneous overcurrent element has a Block logic input which when true, disables an element by forcing the element Trip and Pickup outputs to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Instantaneous overcurrent element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The instantaneous overcurrent element logic block is illustrated in Figure 52. Logic inputs and outputs are summarized in Table 23.

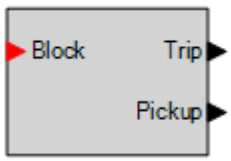


Figure 51. Instantaneous Overcurrent Element Logic Block

Table 23. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 50 function when true
Trip	Output	True when the 50 element is in trip condition
Pickup	Output	True when the 50 element is in pickup condition

Operational Settings

Instantaneous overcurrent element operational settings are configured on the Instantaneous Overcurrent (50) settings screen (Figure 52) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 24.

Figure 52. Instantaneous Overcurrent Settings Screen

Table 24. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled, IA, IB, IC, 3 Phase, 3I0, I1, I2, IG, or Unbalance	n/a	n/a	Disabled
Source *	CT Circuit 1 or CT Circuit 2	n/a	n/a	CT Circuit 1
Pickup	0 or 0.5 to 150 (5A CTs) 0 or 0.1 to 30 (1A CTs) 0 or 0.01 to 7.5 (SEF)	varies	amps	0
	0 or 5 to 50 (Unbalance mode)	1	percent	
Time Delay	0 to 60,000	1	milliseconds	0
Direction	Forward, Reverse, or Non-Directional	n/a	n/a	Non-Directional

* For relays equipped with two sets of CTs.

Breaker Failure Protection (50BF)

The breaker failure protection (50BF) element provides protection and security for the power system against failure of the monitored breaker.

Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Breaker Fail (50BF) screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Current, Breaker Fail (50BF)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Current Protection, Breaker Fail 50BF

Element Operation

The 50BF element monitors the current to determine whether or not current continues to flow into a faulted circuit some time after a circuit breaker has been directed to interrupt the circuit. In the event that current continues to flow into the faulted circuit (after a defined period of time has elapsed sufficient for the breaker to have interrupted the current), then the circuit breaker is considered to have failed, and steps must be initiated to trip the next set of breakers upstream in the power system. Breaker failure protection may be applied to any portion of the power system where failure of a circuit breaker to operate properly could result in severe system damage or instability.

Contact Sensing

Before any relay output can occur, there must first be an initiating signal from external contacts. Two possible initiating signals are either the 52 Breaker Fail Initiate (52BFI) signal or the 50 Breaker Fail Initiate (50BFI) signal. Contact sensing circuitry allows the relay to monitor external contacts for the presence of these signals.

Logic to start the breaker failure timer via the 52BFI input is provided with breaker status supervision. Both the breaker status and the 52 BFI logic input must be true for the 52BFI logic input to cause a trip condition. Information on setting up the breaker status logic can be found in the *Breaker Monitoring* chapter.

Control Timer

The control timer provides a window of opportunity for a breaker failure output. It improves dependability by sealing in the initiate request to prevent stopping of a breaker failure timing if the tripping relay drops out prematurely. The control timer is initiated by a 50BFI signal. Upon sensing the 50BFI transition from a 0 to 1 state, the control timer seals in the 50BFI signal for the duration of the Control Timer setting. If the control timer expires and the 50BFI signal is still present, an alarm signal occurs. A control timer setting of zero (0) disables the control timer seal-in function allowing the control timer to follow the 50BFI input.

Pickup and ReTrip

Phase and neutral fault detectors monitor current in the phases and the ground current input. At least one of these fault detectors must be picked up to start the breaker failure delay timer.

The adjustable delay timer allows current to decay after the breaker is tripped. The delay timer is initiated when either the 52BFI input or the 50BFI input becomes true. When both signals are false, the breaker delay timer is stopped.

When the delay timer is actively timing, the ReTrip output is true. The delay timer can be stopped by either the fast current detector or the Block logic input being asserted. In BESTlogic*Plus*, the ReTrip output can be connected to other logic elements to annunciate the condition or control other elements in logic.

If sensed current exceeds the Phase or Ground Pickup setting and the delay time expires in the window of opportunity (before the control timer expires), the Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

Fast Current Detector

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

CT Source

The CT Source setting configures the breaker failure element to monitor CT Circuit 1 or CT Circuit 2 on relays equipped with two sets of CTs. CT Circuit 1 terminals are designated D1 (IA1) through D8 (IG1) and CT Circuit 2 terminals are designated F1 (IA2) through F8 (IG2). For an illustration, refer to the *Terminals and Connectors* chapter.

Programmable Alarm

A Breaker Failure alarm is provided to indicate an alarm condition when the 50BF element trips. The alarm appears on the front-panel display, web page interface, and on the Alarms metering screen in BESTCOMS*Plus*. Refer to the *Alarms* chapter for information on how to program alarms.

Element Blocking

This input allows for logic supervision or control of the element. Element blocking is a useful feature to prevent inadvertent backup tripping during testing.

The breaker failure protection element has a Block logic input which when true, disables an element by forcing the element Trip and ReTrip outputs to logic 0 and resetting the element timers. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Breaker failure element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The breaker failure element logic block is illustrated in Figure 53. Logic inputs and outputs are summarized in Table 25.

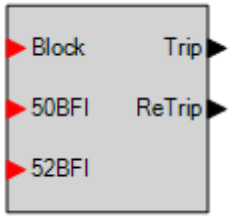


Figure 53. Breaker Failure Element Logic Block

Table 25. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 50BF function when true
50BFI	Input	Starts the 50BF timer when true
52BFI	Input	Starts the 50BF timer when true
Trip	Output	True when the 50BF Delay Timer is actively timing
ReTrip	Output	True after the 50BF Delay Timer expires

Operational Settings

Breaker failure element operational settings are configured on the Breaker Fail (50BF) settings screen (Figure 54) in BESTCOMS*Plus*. Settings ranges and defaults are summarized in Table 26.

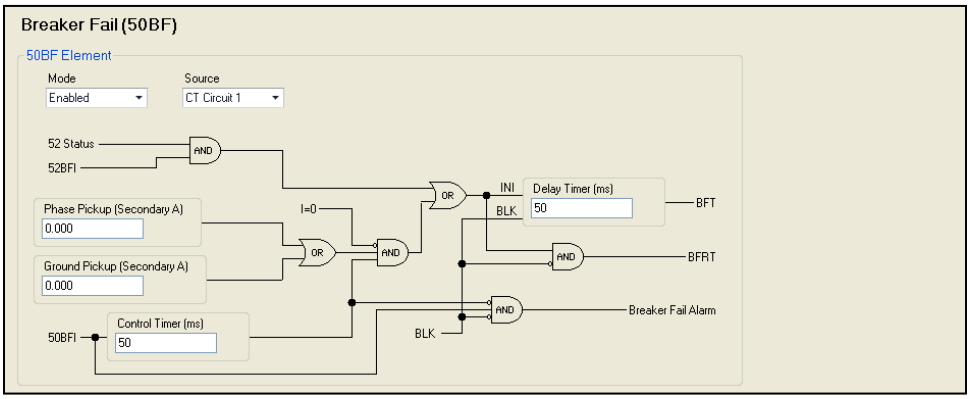


Figure 54. Breaker Fail Settings Screen

Table 26. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled or Enabled	n/a	n/a	Disabled
Source *	CT Circuit1 or CT Circuit 2	n/a	n/a	CT Circuit 1
Pickup (Phase & Ground)	0 or 0.25 to 10.00 (5A CTs) 0 or 0.05 to 2.00 (1A CTs) 0 or 0.01 to 0.5 (SEF)	varies	amps	0
Control Timer	0 or 50 to 999	varies	milliseconds	50
Delay Timer	0 or 50 to 999	varies	milliseconds	50

* For relays equipped with two sets of CTs.

Inverse Overcurrent Protection (51)

Seven inverse overcurrent protection (51) elements monitor the current applied to the BE1-11*f*. An element can be configured to protect against overcurrent by monitoring a single- or three-phase system, neutral current, positive-sequence current, negative-sequence current, ground current, or unbalanced current.

The seven, identical inverse overcurrent protection elements are designated 51-1, 51-2, 51-3, 51-4, 51-5, 51-6, and 51-7. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Inverse Overcurrent settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

Note
BE1-11*f* relays enabled for IEC-61850 communication (style Fxxxx5xxxxxxxx) have their inverse overcurrent protection elements fixed at five inverse overcurrent elements without voltage control and two inverse overcurrent elements with voltage control.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Current, Inverse Overcurrent (51)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Current Protection, Inverse Overcurrent 51

Element Operation

Inverse overcurrent protection can be used to protect equipment from damage caused by phase failure, forward/reverse phase sequence, or phase unbalance.

Modes of Protection

Nine modes of protection are available: IA, IB, IC, Three-Phase, 3I0, I1, I2, IG, and Unbalance.

IA, IB, or IC Mode

The inverse overcurrent protection elements include three independent comparators and timers, one for each phase. Mode selection determines which phase pickup is required to activate protection.

Three-Phase Mode

Three-phase mode provides overcurrent protection in a three-phase system when all three phases increase above the Pickup setting.

3I0 Mode

3I0 mode provides neutral overcurrent protection in a three-phase system.

I1 Mode

I1 mode provides positive-sequence overcurrent protection in a three-phase system.

I2 Mode

I2 mode provides negative-sequence overcurrent protection in a three-phase system.

IG Mode

IG mode provides ground fault protection in a three-phase system.

Unbalance Mode

Unbalance mode provides unbalanced overcurrent protection. Two methods are available to calculate unbalanced current. The first method is based on the negative-sequence current divided by the positive-sequence current while the second method is based on the average current. The calculation method must be specified on the System Parameters, Sensing Transformers screen in BESTCOMS*Plus*. Refer to the *Configuration* chapter for more information.

CT Source

The CT Source setting configures an inverse overcurrent element to monitor CT Circuit 1 or CT Circuit 2 on relays equipped with two sets of CTs. CT Circuit 1 terminals are designated D1 (IA1) through D8 (IG1) and CT Circuit 2 terminals are designated F1 (IA2) through F8 (IG2). For an illustration, refer to the *Terminals and Connectors* chapter.

Direction

An inverse overcurrent element can be configured for forward or reverse tripping. Refer to the *Directional Overcurrent Protection (67)* chapter for more information.

Programmable Curves

Each 51 inverse overcurrent element has a Curve setting. See the *Time Curve Characteristics* chapter for details on each of the curves available. The user can select integrating reset timing to make the protective element use integrated reset and emulate an electromechanical induction disk reset characteristic. An available programmable curve can be used to create a custom curve by selecting coefficients in the inverse time characteristic equation.

Inverse overcurrent characteristics for trip and reset programmable curves are defined by Equation 1 and Equation 2. These equations comply with IEEE Std C37.112-1996 - *IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays*. The curve-specific coefficients are defined for the standard curves as listed in the *Time Curve Characteristics* chapter. When inverse time overcurrent 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 27.

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

Equation 1. Time OC Characteristics for Trip

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

Equation 2. Time OC Characteristics for Reset

Table 27. Definitions for Equations 9-1 and 9-2

Parameter	Description	Explanation
T_T	Time to trip	Time that the 51-x function will take to time out and trip.
D	Time dial setting	Time dial setting for the 51-x 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.

Parameter	Description	Explanation
K	Constant	Characteristic minimum delay term.
T_R	Time to reset	Relevant if 51-x function is set for integrating reset.
R	Coefficient specific to selected curve	Affects the speed of reset when integrating reset is selected.

Curve coefficients are entered on the Inverse Overcurrent (51) settings screen in BESTCOMS*Plus*. Programmable curve coefficients can be entered only when the P curve is chosen for the protection element from the Curve drop-down menu.

Table Curves

BESTCOMS*Plus* is used to set the 51 element Table Curves (T1, T2, T3, and T4). Using the Settings Explorer within BESTCOMS*Plus*, open the Protection, Current, Table Curve (1, 2, 3, or 4) tree branch and select the table curve to be modified. Refer to Figure 55. A minimum of 2 and maximum of 40 points can be entered for any one T curve. When you are satisfied with the values chosen, select Save Curve. Use the Settings Explorer to browse to the 51-x element you wish to program and use the drop-down menu under Curve to select T1, T2, T3, or T4.

Table curves can be entered regardless of the curve chosen for the protection element. However, the table curve will not be enabled until T1, T2, T3, or T4 is selected as the curve for the protective element.

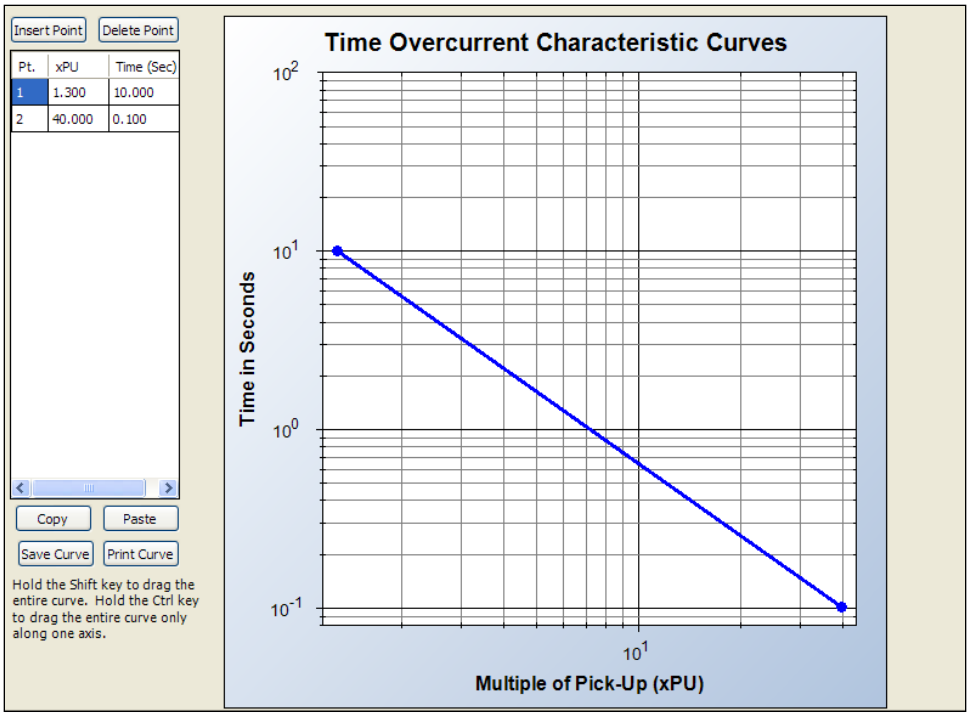


Figure 55. Inverse Overcurrent Table Curve

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 I2 mode. The 46 curve was designed for use with the I2 mode. However, in actuality, the 46 curve can be selected for use with any mode of the inverse overcurrent element as well.

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 the *Time Curve Characteristics* chapter. 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.

Pickup and Trip

When the measured current increases above the current threshold established by the Pickup setting, the element Pickup output becomes true. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements in logic.

Assertion of the Pickup output initiates a timer which begins timing toward a trip. The duration of the timer is established by the Time Dial and Curve settings. A Time Dial setting of zero (0) makes the 51 element instantaneous with no intentional time delay.

If an overcurrent pickup condition persists for the duration of the calculated inverse time, the element Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

If the pickup condition subsides before the calculated inverse time expires, the timer and Pickup outputs are reset, no corrective action is taken, and the element is rearmed for any other occurrences of overcurrent.

Voltage Restraint Mode (51/27R)

When a 51 element is set for 3 Phase, IA, IB, or IC mode, the 51 element can be set for voltage control or voltage restraint mode of operation. This feature is used to allow increased phase overcurrent sensitivity while providing security from operation due to load current. This feature is also often used for generator backup protection to ensure delayed tripping during a short-circuit where the fault current contribution from the generator falls to a value close to the full-load rating of the generator.

A Voltage Restraint threshold of zero (0) disables voltage restraint/control and allows the 51 element to operate normally.

Control Mode

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

Restraint Mode

When set for Restraint mode of operation, the pickup of the 51 element is adjusted based upon the magnitude of the measured voltage. Figure 56 shows how the 51 Pickup setting is adjusted in response to the measured voltage level. Equation 3 determines the pickup level for the 51 element when the measured voltage is between 25% and 100% of the Voltage Restraint threshold. Below 25%, the pickup level stays at 25%. Above 100%, the pickup level stays at 100%. For example, if the Voltage Restraint threshold is set for 120 V and the measured voltage on the appropriate phase is 100 V (83% of the Voltage Restraint threshold), the phase overcurrent pickup level will be reduced to 83% of its setting. When set for this mode of operation, the 51 element Pickup setting is typically set above worst case, load current levels.

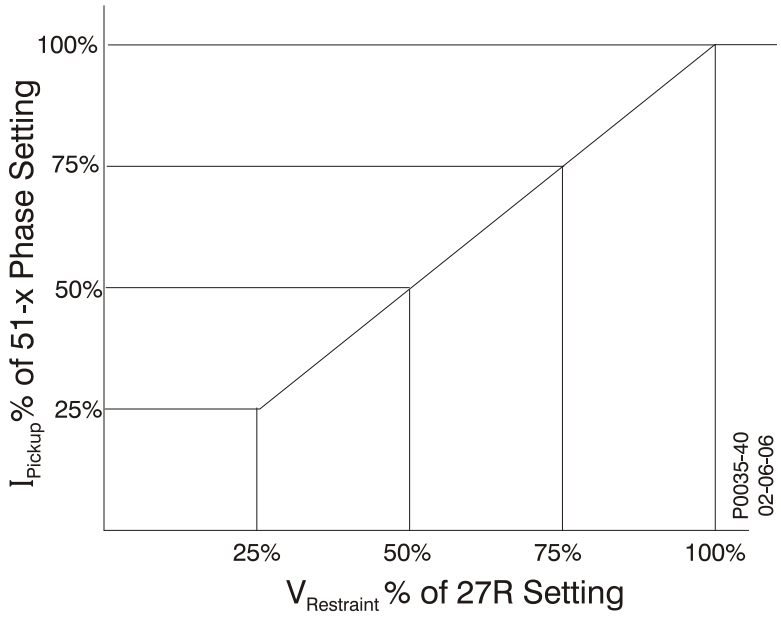


Figure 56. 51 Phase Pickup Level Compensation

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

Equation 3. Restraint Pickup Level

Phase VT Configuration

The 51/27R function can be set to monitor either Vpp or Vpn depending upon the Phase VT Connection settings. See the *Configuration* chapter for details on how to set the phase VT connections. Table 28 shows which voltage measurements are used by each 51 element for each possible phase VT connection and 51/27 voltage monitoring mode setting.

Table 28. Phase VT Connection Cross Reference

Phase VT Connection	51/27 Mode	51A	51B	51C
4W	Vpp	Vab	Vbc	Vca
4W	Vpn	Van	Vbn	Vcn
3W	Vpp	Vab	Vbc	Vca
AN	Vpn	Van	n/a	n/a
BN	Vpn	n/a	Vbn	n/a
CN	Vpn	n/a	n/a	Vcn
AB	Vpp	Vab	n/a	n/a
BC	Vpp	n/a	Vbc	n/a
CA	Vpp	n/a	n/a	Vca

Note

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

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

Element Blocking

Fuse Loss

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

Block Logic Input

This input allows for logic supervision or control of the element.

Each inverse overcurrent element has a Block logic input which when true, disables an element by forcing the element Trip and Pickup outputs to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Inverse overcurrent element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The inverse overcurrent element logic block is illustrated in Figure 57. Logic inputs and outputs are summarized in Table 29.

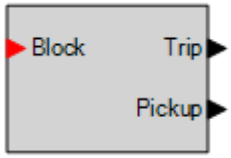


Figure 57. Inverse Overcurrent Element Logic Block

Table 29. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 51 function when true
Trip	Output	True when the 51 element is in trip condition
Pickup	Output	True when the 51 element is in pickup condition

Operational Settings

Inverse overcurrent element operational settings are configured on the Inverse Overcurrent (51) settings screen (Figure 58) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 30.

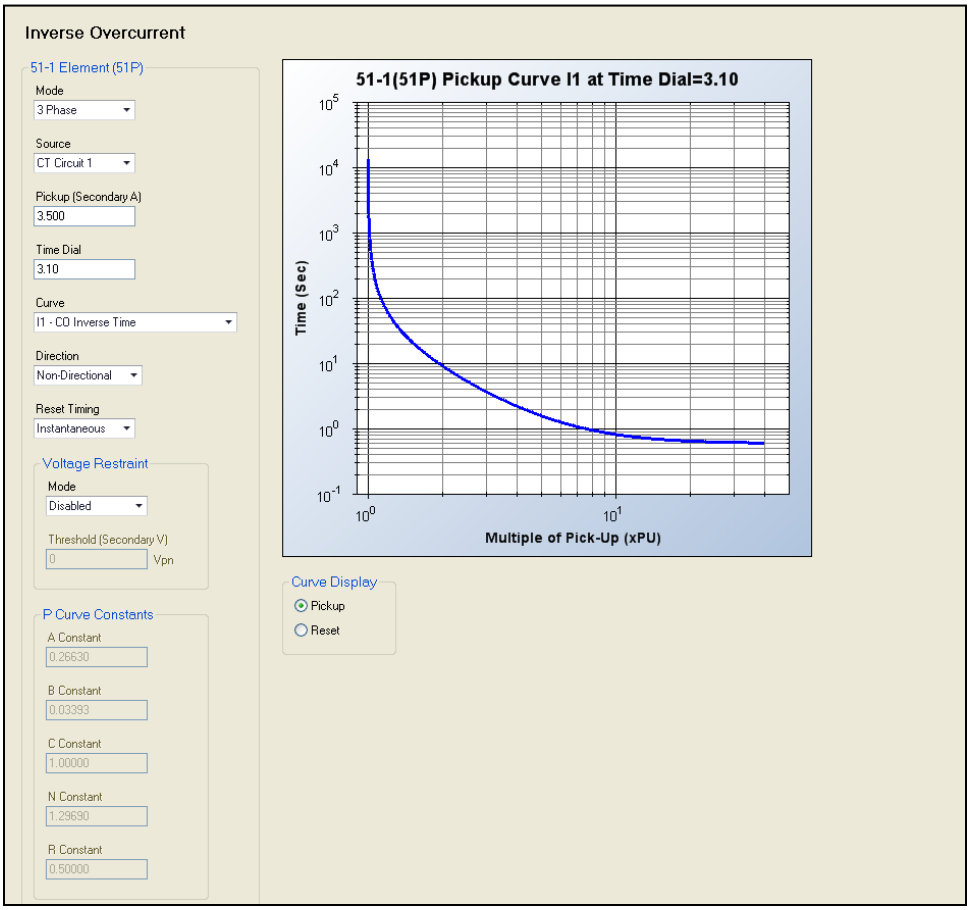


Figure 58. Inverse Overcurrent Settings Screen

Table 30. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled, IA, IB, IC, 3 Phase, 3I0, I1, I2, IG, or Unbalance	n/a	n/a	Disabled
Source *	CT Circuit 1 or CT Circuit 2	n/a	n/a	CT Circuit 1
Pickup	0 or 0.5 to 16 (5A CTs) 0 or 0.1 to 3.2 (1A CTs) 0 or 0.01 to 0.8 (SEF)	varies	amps	0
	0 or 5 to 50 (Unbalance mode)	1	percent	
Time Dial	0 to 9.9 0.0 to 99 (46 only)	varies	units	0
Curve	See the *Time Curve Characteristics* chapter.	n/a	n/a	S1
Direction	Forward, Reverse, or Non-Directional	n/a	n/a	Non-Directional
Reset Timing	Integrating or Instantaneous	n/a	n/a	Instantaneous

Setting	Range	Increment	Unit of Measure	Default
A Coefficient	0 to 600	0.00001	A Coefficient	0.26630
B Coefficient	0 to 25	0.00001	B Coefficient	0.03393
C Coefficient	0 to 1	0.00001	C Coefficient	1.00000
N Coefficient	0.5 to 2.5	0.00001	N Coefficient	1.29690
K Coefficient	n/a	n/a	K Coefficient	0.02800
R Coefficient	0 to 30	0.00001	R Coefficient	0.50000
Voltage Restraint Mode	Disabled, Control, or Restraint	n/a	n/a	Disabled
Voltage Restraint Setpoint	0 or 30 to 250	varies	volts	0

* For relays equipped with two sets of CTs.

Directional Overcurrent Protection (67)

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

On relays equipped with two sets of CTs, the directional element can monitor CT Circuit 1 or CT Circuit 2. The CT source is selected on the Sensing Transformers settings screen in BESTCOMS*Plus*®.

Polarization Methods

The polarization methods are as follows:

- Positive-Sequence Polarization – Forward direction is detected when the apparent Z_1 angle (angle of V_1/I_1) is equal to the positive-sequence maximum torque angle (MTA), ±90°.
- Negative-Sequence Polarization – Forward direction is detected is when the apparent Z_2 angle (angle of $-V_2/I_2$) is equal to the negative-sequence maximum torque angle (MTA), ±90°. (See Note 1.)
- Zero-Sequence Voltage Polarization – Forward direction is detected is when the apparent Z_0 angle (angle of V_0/I_0) is equal to the zero-sequence maximum torque angle (MTA), ±90°. (See Note 1.) However, the relay has two forms of zero-sequence voltage available to it (calculated V_0 from the phase voltages or V_X from a broken delta VT) and two forms of zero-sequence current available to it (calculated I_0 from the phase currents or I_G from the relay's IG1 or IG2 input). This results in four options for zero-sequence voltage polarization:
    - Calculated V_0 verses calculated I_0
    - Calculated V_0 verses I_G
    - V_x verses calculated I_0
    - V_x verses I_G
    - All four forms of zero-sequence voltage polarizations use the same MTA value.
- Zero-Sequence Current Polarization – Forward direction is detected is when the phase angle of current in the ground CT input (IG) is in phase with the calculated I_0, ±90°.

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

Note 1: The negative and zero-sequence angle of maximum torque has a built in 180-degree phase shift that arises out of the calculation methods described at the end of this chapter.

Positive-Sequence Polarization is used to determine direction for three-phase faults. Under these conditions, very little negative or zero-sequence quantities are present, making the other polarization methods unreliable for this fault condition. For close-in faults, the relay will also need to depend on memory voltage to determine direction (see below). Positive-sequence bits are used to supervise the elements in single or 3 phase mode.

To provide memory, the positive-sequence voltage is stored continuously until a fault occurs. Memory voltage is used when the positive-sequence voltage falls below the minimum acceptable level of 12 volts. The BE1-11*f* maintains memory voltage for 20 cycles to allow tripping for close in faults. When using memory voltage polarization, the relay assumes nominal system frequency.

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

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

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

Polarization summary for tripping elements is as follows:

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

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

Polarization Settings

Polarization methods are configured on the Polarization (67N) settings screen (Figure 59) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 31.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Current, Polarization (67N)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Current Protection, Directional Current 67

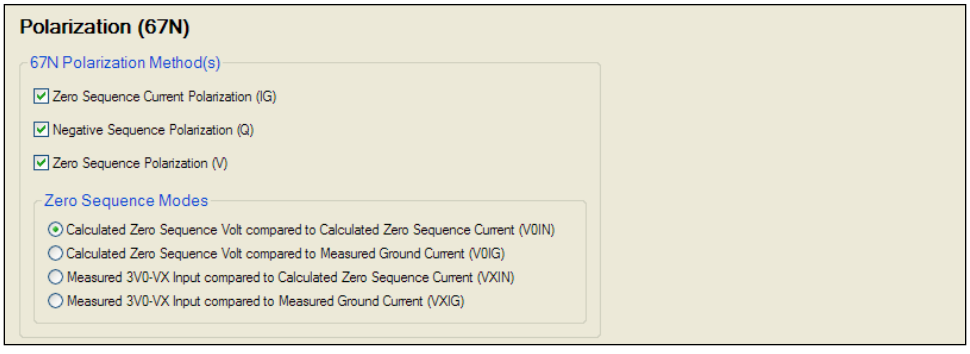


Figure 59. Polarization (67N) Settings Screen

Table 31. Polarization Settings

Setting	Range/Purpose		Default
67N Polarization Method	IG	= Use Zero Sequence Current Polarization	IG/Q/V
	Q	= Use Negative Sequence Polarization	
	V	= Use Zero Sequence Polarization	
	IG/Q/V	= Use all three polarization methods	
	IG/Q	= Use IG and Q polarization methods	
	IG/V	= Use IG and V polarization methods	
	Q/V	= Use Q and V polarization methods	
Zero-Sequence Mode	VOIN	= Calculated Zero Sequence Volt, Calculated Zero Sequence Current	VOIN
	VOIG	= Calculated Zero Sequence Volt, Measured Ground Current	
	VXIN	= Measured 3V0-VX, Calculated Zero Sequence Current	
	VXIG	= Measured 3V0-VX, Measured Ground Current	

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

Maximum Torque Angle and Directional Tests

The directional algorithm requires a user settable maximum torque angle (MTA). There is an MTA setting for positive-sequence calculations, an MTA setting for negative-sequence calculations, and an MTA setting for zero-sequence calculations. These settings are separate from the power line impedance parameters (Z_1 and Z_0 used for distance to fault calculations) because some applications require a polarizing MTA different from the "distance to fault" line impedance angle.

Each MTA can be set over the range of 0 to 90 degrees (I lag E) in 1 degree steps. These parameters are input into the BE1-11*f* using BESTCOMS*Plus*. Open the System Parameters, Power System tree branch.

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

Note that (not forward) does not necessarily imply reverse. Sufficient current and voltage must be present to declare direction. Internally, the BE1-11*f* also uses several constant limits to determine if the system levels are adequate to perform reliable directional tests and set directional bits. See Table 32.

Table 32. Internal Constants

Internal Constant	Purpose	Value
Positive-Sequence Current	Minimum 3I1 current threshold for Positive-Sequence test	0.50 A
Zero-Sequence Current	Minimum 3I0 current threshold for Current Polarization test	0.25 A
Ground current (IG)	Minimum Ground (IG) current threshold for Current Polarization test	0.50A
Negative-Sequence Voltage	Minimum V2 voltage threshold for Negative-Sequence test	3.33% of V nominal

Internal Constant	Purpose	Value
Zero-Sequence Voltage	Minimum V0 voltage threshold for Zero-Sequence test	3.33% of V nominal
External Zero-Sequence Voltage (VX Input)	Minimum external 3V0 voltage threshold for Zero-Sequence test	10% of V nominal
Negative-Sequence Ratio	Minimum ratio between 3I1 and 3I2 for Negative-Sequence test	9%
Zero-Sequence Ratio	Minimum ratio between 3I1 and 3I0 for Zero-Sequence test is 9%	9%

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

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

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

The direction bits are updated once per half-cycle. Under sudden current reversal conditions, depending on the change in magnitude of the forward current to reverse current, the DFT (Discrete Fourier Transform) could require one cycle to determine polarity of the fault. Beyond this, the 50-x element adds an additional half-cycle delay when operating in direction mode for security, for an overall response time of a 50-x element to sudden current reversal of approximately two cycles.

Theory of Using Sequence Impedances for Fault Direction

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

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

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

Equation 4. Local Substation Voltage

Note this equation is true independent of the fault type or the faulted phase. For any fault type or faulted phase we will find some value for I_{012} and then whatever we find, we insert it into the equation above. Independent of however I_{012} works out, solving the above equation for impedance seen by the relay (Equation 5):

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

Equation 5. Impedance Seen by the Relay

If $V_{0,Source}$ and $V_{2,Source}$ are very small (Equation 6):

$$Z_{0,Relay} \approx -Z_{0,Source}$$
$$Z_{2,Relay} \approx -Z_{2,Source}$$

Equation 6. Impedance with Small V_0 and V_2 Source Voltages

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

The positive-sequence impedance as seen by the relay is quite a bit more complicated since $V_{1,Source}$ is not negligible. One simple application to study is the three-phase fault and the B to C phase fault (Equation 7):

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

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

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

Directional relaying would not be of much value in a radial system where all current flow will be forward. In two source systems, as shown in Figure 60, a profile of sequence voltages in the system will show V_0 and V_2 at either source will still be negligible in normal operation, and V_0 and V_2 only show up during fault conditions with their maximum value being at the fault location, with current flowing from X and Y in a current division rule applied to the symmetrical component network that represents the fault impedances and the fault type. Independent of the fault type and how the sequence currents divide in the system, the sequence voltages and hence sequence impedances measured by the relay will still be dependent on $V_{Relay}=V_{Source} - Z_{Source} I_{Source}$. The relay will sense the zero and negative-sequence impedances in the opposite direction as the direction to the fault, looking back toward the source. But for the three-phase fault the relay will sense the positive-sequence impedance in the line between the relay and the fault location. The sensed zero-sequence current can be shifted notably when zero-sequence coupling between adjacent lines is involved. However, since a large phase angle window of ±90° from the MTA is being utilized for directional decisions, the direction decision is not highly sensitive to zero-sequence coupling effects.

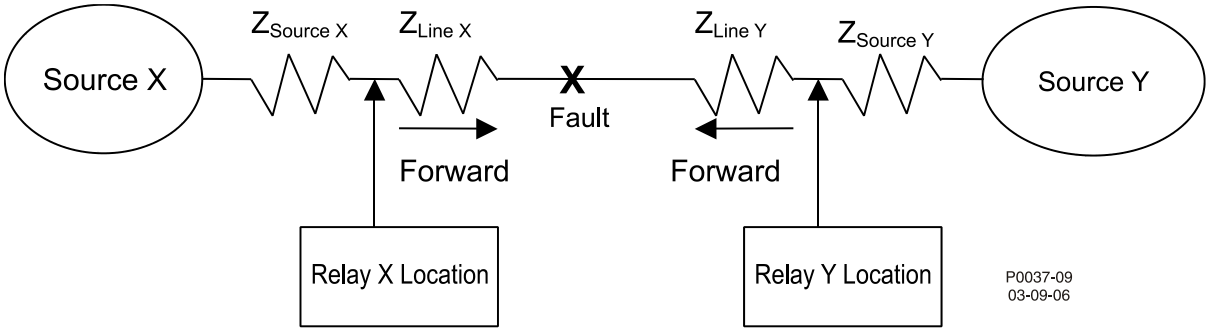


Figure 60. Directional Overcurrent Relaying

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

Power Protection (32)

Two power protection (32) elements monitor three-phase real power (watts). An element can be configured to protect against overpower or underpower conditions. These elements are available only in style FxxxxxxxDxxxxx of the BE1-11*f*.

The two, identical power protection elements are designated 32-1 and 32-2. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Power settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

Note
BE1-11*f* relays enabled for IEC-61850 communication (style Fxxxx5xxDxxxxx) have their power protection elements fixed at one overpower element and one underpower element.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Power, Power (32)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Power Protection, Power 32

Element Operation

Power protection can be used in applications where excessive power flow in the tripping direction is bad. Overpower and/or underpower protection is desirable in applications where:

- Power flows into a generator, indicating loss of prime mover torque (motoring).
- Power flows into the secondary of a station distribution transformer, indicating an industrial or private customer is supplying power into the utility system.
- Excessive load has been connected to a system.
- Overload has been placed on a distribution system.
- Overspeeding is a prime concern.
- An open breaker creates an overload on a local generation facility.

Mode

In Total Power mode, if total power is above or below pickup, and in the set direction, the element will pick up. In modes 1 of 3, 2 of 3, or 3 of 3, a single-phase power pickup value is automatically calculated based on the three-phase power setting. If the single-phase power is above or below the calculated pickup value (1 of 3, 2 of 3, or 3 of 3) and in the set direction, the element will pick up. The element will remain in the picked-up condition until power flow falls below the dropout ratio of 95% of the actual pickup.

To clarify the difference between 3 of 3 and Total Power modes, assume that 3 of 3 mode has been selected and the three-phase pickup setting is 30 watts. Therefore, the relay will pick up when each phase exceeds 10 watts (three-phase setting/3). Alternately, if two phases are zero (0) watts and the third phase is 50 watts, the relay will not pickup because two of the phases have not exceeded the single phase pickup threshold required for 3 of 3 operation. All three phases must exceed the single-phase pickup threshold for operation to occur. However, if the 32 element was set for Total Power mode, the same power values previously mentioned would result in a pickup condition because “Total Power” (0 + 0 + 50 watts) exceeds the three-phase pickup setting of 30 watts. For details on power calculations, refer to the *Configuration* chapter.

Bus CT Configuration

On relays equipped with two sets of CTs, the power element can monitor CT Circuit 1 or CT Circuit 2. The CT source is selected on the Sensing Transformers settings screen in BESTCOMS*Plus*.

Direction of Power Flow

In addition to exceeding the power pickup threshold, direction of power flow (forward or reverse) must match the directional setting for the 32 element to operate. In the BE1-11*f*, the forward and reverse directions are defined by the polarity voltage and current connections to the relay as shown in Figure 61. Based on IEEE polarity convention, forward power is defined as bus to line and reverse power is defined as line to bus.

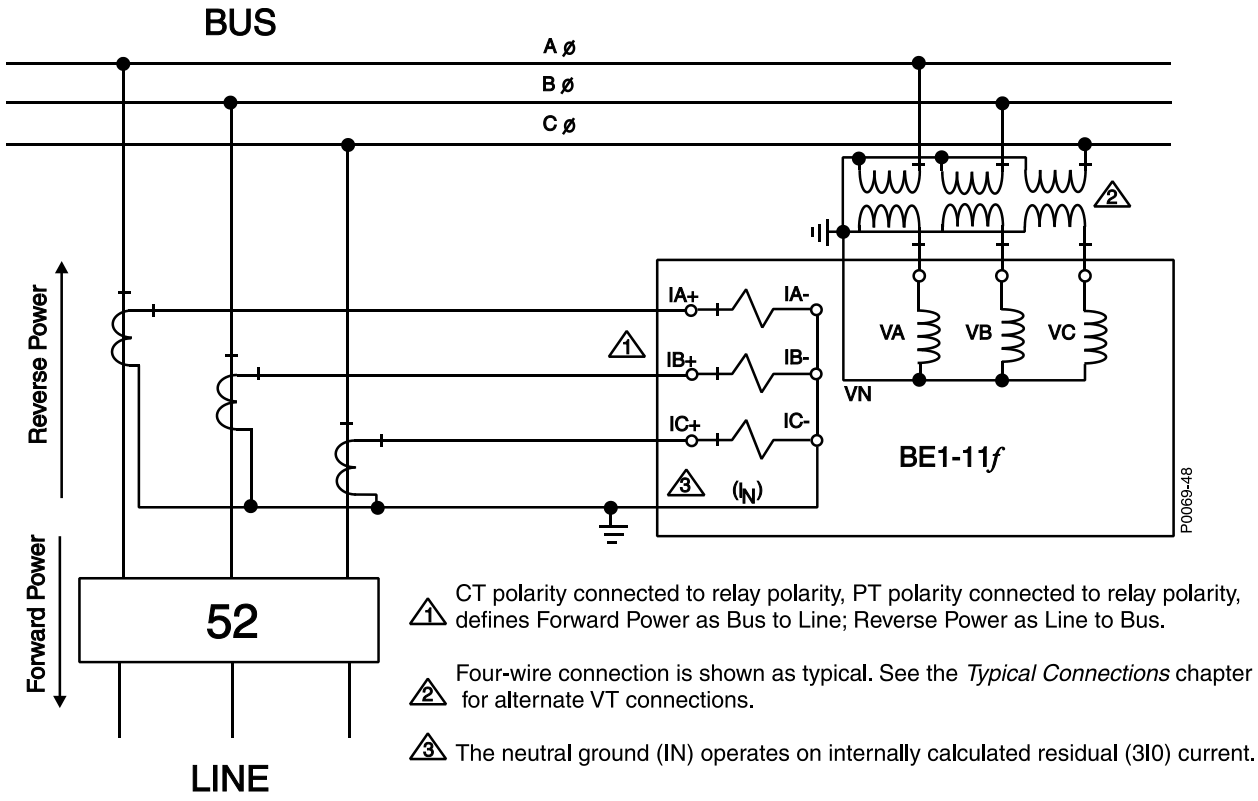


Figure 61. Direction of Power Flow Defined by the Polarity of Voltage and Current Connections

Establishing Forward and Reverse Pickup Values

Three-phase power pickup settings for the power elements are always positive regardless of the directional setting. However, it is useful in understanding the element response to visualize the forward direction as positive power and the reverse direction as negative power. If we think in terms of a forward and reverse scale with zero (0) in the middle as shown in Figure 62, positive and negative power flows relative to the forward and reverse directional setting. For example, assume an intertie application where the Area EPS (electric utility) requires the Local EPS (source of non-utility generation) to separate from the Area EPS (trip the intertie breaker) if any power flows towards the Area EPS. For illustrative purposes, assume that the BUS in Figure 61 is the Local EPS, 52 is the intertie breaker, and LINE is the Area EPS. Normal power flow is from the Area EPS to the Local EPS, which happens to be an industrial facility with local generation used for peak shaving.

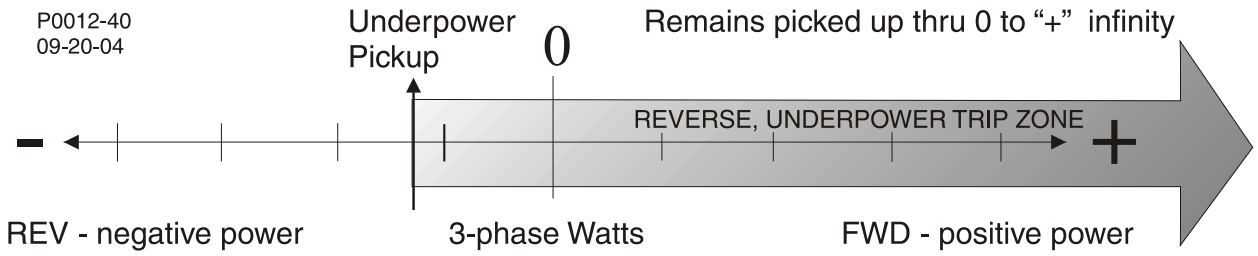


Figure 62. Forward and Reverse Pickup Values

Assuming polarity current and voltage connections as shown in Figure 61, forward power is defined as flowing into the Area EPS and reverse power is defined as flowing into the Local EPS. For this application, the 32 element should be set to trip for minimum underpower in the reverse direction (to the Local EPS). Therefore, the settings would be Reverse, Under, and 1 watt. To increase sensitivity, mode selection should be 3 of 3 which requires each phase power to fall below ⅓ of the three-phase power setting or 0.33 watts. Assume that normal power absorbed by the load is 4 kW in the reverse or negative direction on our scale. If load is suddenly lost at the industrial plant while the peak shaving generation is running, power may flow towards the Area EPS depending on the load to generation ratio. What was a negative 4 kW passes through 0 watts on its way to some positive power level. However, in doing so, passes through the negative underpower trip threshold of Reverse, Under, 0.33 watts/phase, resulting in a 32 trip and opening of the intertie circuit breaker. From negative 0.33 to positive infinity, the 32 element remains in a picked up condition as shown in Figure 62. A trip time delay should be included to ensure that the 32 element does not operate for a transient power condition.

Pickup and Trip

When the calculated real power increases above or decreases below the threshold established by the Pickup setting, the element Pickup output becomes true. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements in logic.

Assertion of the Pickup output initiates a timer which begins timing toward a trip. The duration of the timer is established by the Time Delay. A Time Delay setting of zero (0) makes the 32 element instantaneous with no intentional time delay.

If a power pickup condition exists for the duration of the element Time Delay, the element Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

If the pickup condition subsides before the element time delay expires, the timer and Pickup output are reset, no corrective action is taken, and the element is rearmed for any other occurrences of over/under power.

Element Blocking

Fuse Loss

The fuse loss (60FL) element of the BE1-11*f* can be used to block 32 protection when fuse loss or loss of potential is detected in a three-phase system.

If the 60FL element trip logic is true and Block Power/Power Factor is enabled, all functions that use power measurements are blocked. See the *Fuse Loss (60FL)* chapter for more information on the 60FL function.

Block Logic Input

This input allows for logic supervision or control of the element.

Each power protection element has a Block logic input which when true, disables an element by forcing the element Trip and Pickup outputs to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Power element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The power element logic block is illustrated in Figure 63. Logic inputs and outputs are summarized in Table 33.

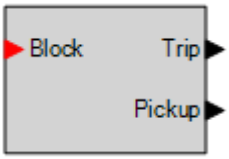


Figure 63. Power Element Logic Block

Table 33. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 32 function when true
Trip	Output	True when the 32 element is in a trip condition
Pickup	Output	True when the 32 element is in a pickup condition

Operational Settings

Power element operational settings are configured on the Power (32) settings screen (Figure 64) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 34.

Figure 64. Power Settings Screen

Table 34. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled, One of Three, Two of Three, Three of Three, or Total Power	n/a	n/a	Disabled
Pickup	0 or 1 to 6,000 (5A CTs) 0 or 1 to 1,200 (1A CTs)	varies	watts	0
Time Delay	0 or 50 to 600,000	varies	milliseconds	0
Direction	Forward or Reverse	n/a	n/a	Forward
Over Under	Over or Under	n/a	n/a	Over

Recloser Protection (79)

The recloser protection (79) element automatically recloses circuit breakers, which have been tripped by protective relays or other devices in power transmission and distribution systems.

Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Recloser (79) screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs, operational settings, and an overall logic diagram appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Recloser (79)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Reclosing 79

Element Operation

The recloser protection (79) element 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.

Modes of Operation

Two modes of operation are available: Power Up to Lockout and Power Up to Reclose.

Power Up to Lockout

When power is lost during a reset condition, the relay goes to lockout after power is restored.

Power Up to Reclose

When power is lost during a reset condition, the relay initiates a first programmed reclose after power is restored if the breaker is open (52b) and the Initiate input of the 79 element is true.

Inputs

Recloser element logic inputs are described in the following paragraphs.

Initiate

The Initiate input is used with the Breaker Status logic element to start the reclose timers at each step of the reclosing sequence. To start the automatic reclose timers, the Initiate input must be true when the Breaker Status logic element indicates that the breaker has tripped. To ensure that the Initiate input is recognized, a recognition dropout timer holds the Initiate input true for approximately 225 milliseconds after it goes to a false state. This situation may occur if the Initiate 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 Initiate signal will be recognized as true even if the breaker status input is slow in indicating breaker opening. Information on setting up the breaker status logic can be found in the *Breaker Monitoring* chapter. Figure 65 illustrates the recognition dropout logic and timing relationship.

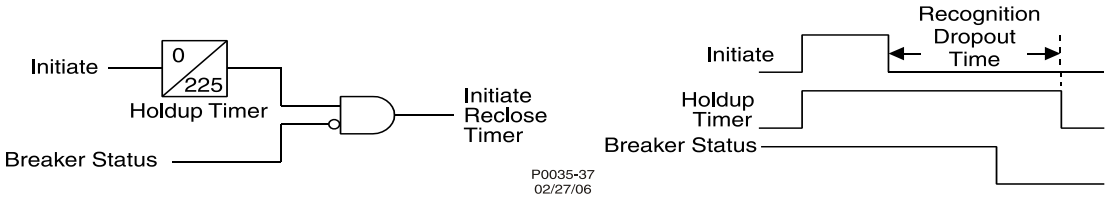


Figure 65. Recognition Dropout Timing

Wait

A true signal at the Wait 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.

DTL (Drive to Lockout)

When true, the DTL input forces the reclosing function into the Lockout position. Lockout persists for the period defined by the Reset Time after the DTL input becomes false and the breaker is closed.

Zone Pickup and Zone Trip

To coordinate tripping and reclosing sequences with downstream protective relays and reclosers, the BE1-11*f* senses fault current from downstream faults when a user programmable logic of the 79ZONE setting picks up and then drops out without a trip output. Typically, the low-set instantaneous Pickup output (phase or neutral) or the inverse time overcurrent Pickup output (phase or neutral) is used for the zone sequence settings.

If the upstream relay (BE1-11*f*) senses that a downstream device has interrupted fault current, the BE1-11*f* will increment the trip/reclose sequence by one operation. This occurs because the BE1-11*f* recognizes that a non-blocked low set (50-x phase or neutral) element picked up and reset before timing out to trip.

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.

Outputs

Recloser element logic outputs are described in the following paragraphs.

Close

The Close 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 Close output to become false (before the breaker close signal (52a) becomes true):

- The reclose fail timer times out.
- The recloser goes to lockout.
- The Wait logic is asserted.

Reset

The Reset output provides reset indication and is true when the recloser is in the Reset position.

Lockout

The Lockout 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 input is true.
- The Reclose Fail (79F) is true.
- The maximum reclose cycle time is exceeded.

Running

The Running output is true when the recloser 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.

SCB (Sequence Controlled Blocking)

The SCB output becomes true when either the Breaker Status or the Close input is true and the sequence operation (shot counter) matches one of the programmed steps of the SCB function. Figure 66 illustrates SCB logic.

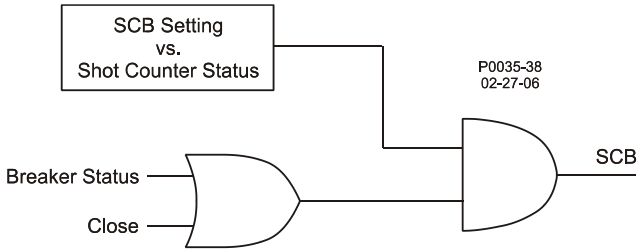


Figure 66. 79SCB Logic

Reclosing Fail Timer (79F)

This timer begins when the Close output becomes true and continues counting until the Breaker Status becomes true. If the 79F timer times out, the recloser function is driven to lockout and the Lockout output becomes true. The relay remains in lockout until the breaker is manually closed and the Breaker Status remains true for the reset time. The reset time is set on the Recloser screen in BESTCOMS*Plus*.

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 to 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 (0). The maximum cycle time is set on the Recloser screen in BESTCOMS*Plus*.

Sequence Controlled Blocking (SCB)

The SCB output is true when breaker status = closed or the Close output is true and the reclose sequence step is enabled with a nonzero value. A zero (0) disables the SCB output. This setting can be changed on the Recloser settings screen in BESTCOMS*Plus* by checking the appropriate Trip box.

Figure 67 shows a logic timing diagram showing all possible sequence controlled blocks enabled (true). In Figure 68, 79RTD is the reclose reset time delay and 79#TD is the reclose time delay where # is the reclose shot number.

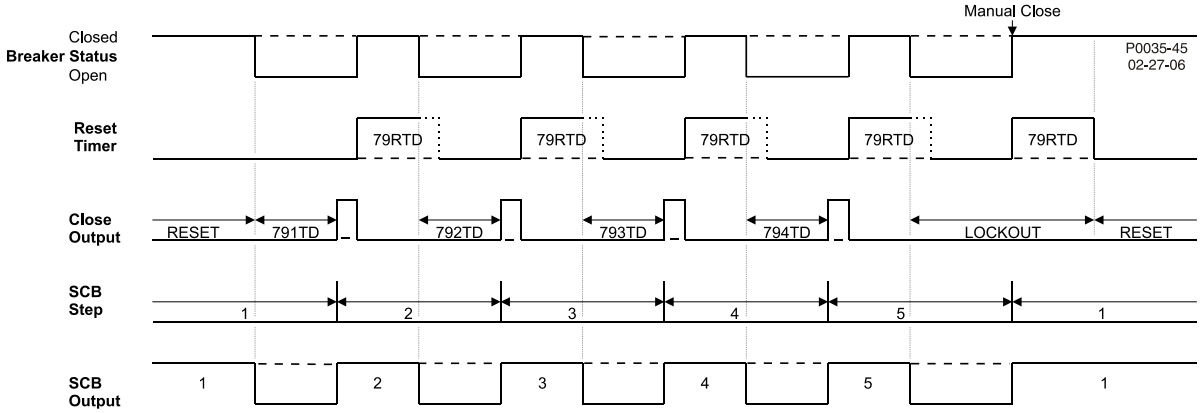


Figure 67. SCB=1/2/3/4/5 Logic Timing Diagram

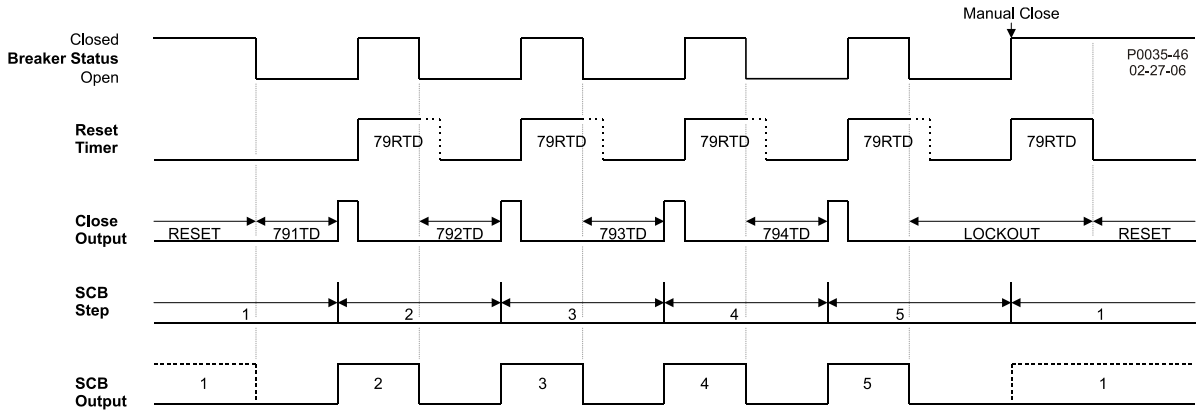


Figure 68. SCB=2/3/4/5 Logic Timing Diagram

Setting Group Selection

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 in the *Setting Groups* chapter.

Logic Connections

Recloser element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The recloser element logic block is illustrated in Figure 69. Logic inputs and outputs are summarized in Table 35.

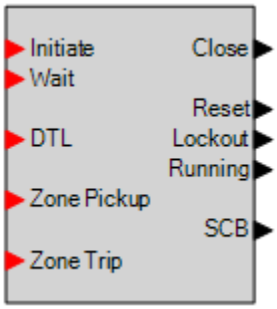


Figure 69. Recloser Element Logic Block

Table 35. Logic Inputs and Outputs

Name	Logic Function	Purpose
Initiate	Input	Initiates the operation of the reclosing function
Wait	Input	Momentarily disables, but does not reset the recloser
DTL	Input	Disables the recloser (Drive To Lockout)
Zone Pickup	Input	Defines which logic elements should be considered zone sequence pickups
Zone Trip	Input	Defines which logic elements should be considered zone sequence trips
Close	Output	True at the end of each reclose time delay and remains true until the breaker closes
Reset	Output	True when the recloser is in the Reset position

Name	Logic Function	Purpose
Lockout	Output	True when the recloser is in the Lockout state
Running	Output	True when the reclose is running
SCB	Output	True when either the Breaker Status or the Close input is true and the sequence operation (shot counter) matches one of the programmed steps of the SCB function

Operational Settings

Recloser element operational settings are configured on the Recloser (79) settings screen (Figure 70) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 36.

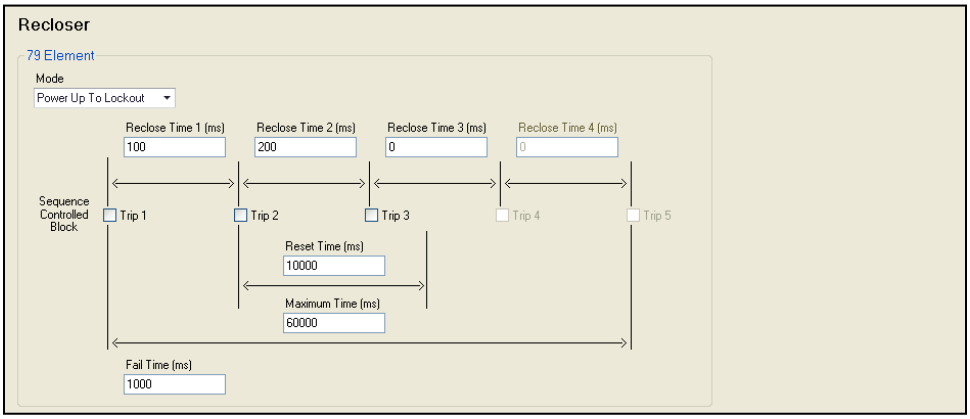


Figure 70. Recloser Settings Screen

Table 36. Operational Settings

Setting	Range	Increment	Default
Mode	Disabled, Power Up To Lockout, or Power Up To Reclose	n/a	Disabled
Time	0 or 100 to 600,000 ms	varies	Reclose Time 1, 2, 3, and 4 = 0 (Disabled) 79R = 10,000 79F = 1,000 79M = 60,000
SCB	1. *SCB* true during Reset and while timing to Reset after Lockout. 2. *SCB* true when *Close* is true for first reclose and while timing to Reset after first reclose. 3. *SCB* true when *Close* is true for second reclose and while timing to Reset after second reclose. 4. *SCB* true when *Close* is true for third reclose and while timing to Reset after third reclose. 5. *SCB* true when *Close* is true for fourth reclose and while timing to Reset after fourth reclose.	0	SCB

Logic Diagram

Figure 71 illustrates an overall logic diagram for the recloser element.

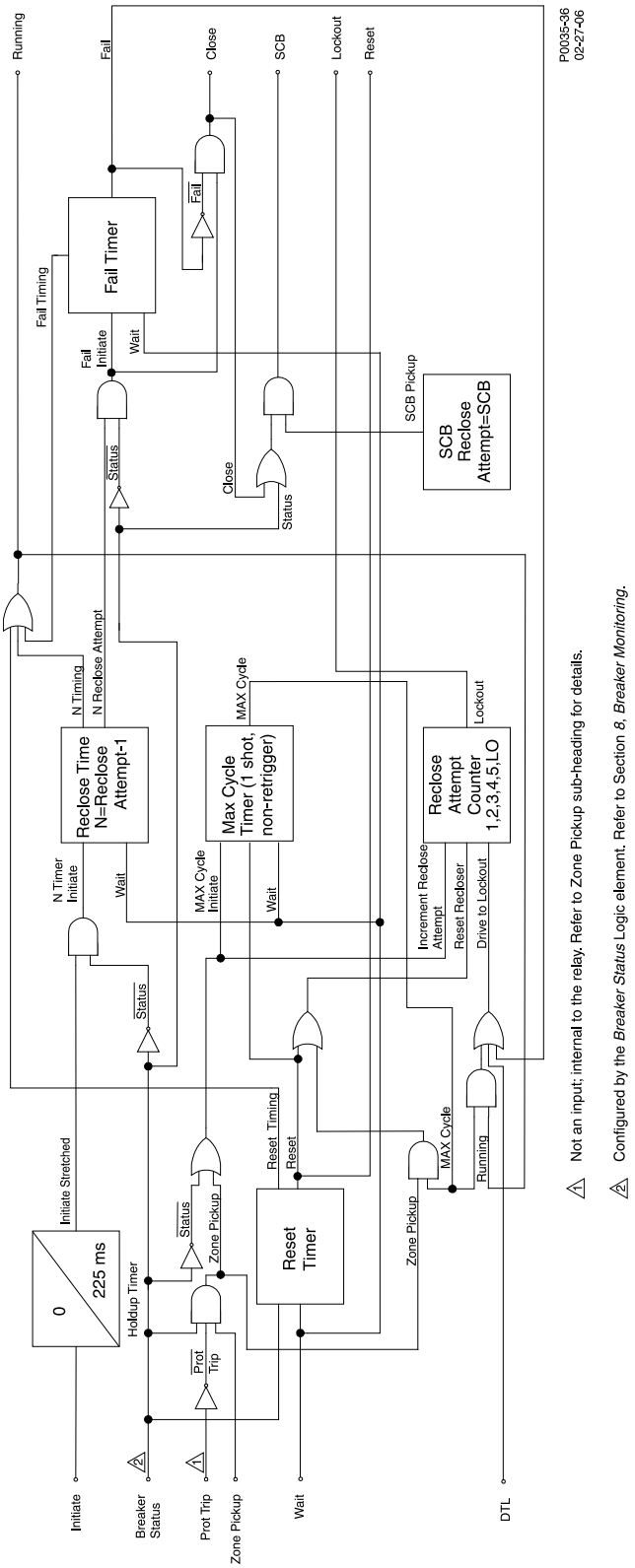


Figure 71. Overall Logic Diagram for Reclosing

Resistance Temperature Detector Protection (49RTD)

Six resistance temperature detector (49RTD) elements provide over/undertemperature protection in applications when a remote RTD module is connected via Ethernet or RS-485. Refer to the *RTD Module* chapter for information on mounting, connections, communication setup, and specifications.

The six, identical remote RTD protection elements are designated 49RTD-1, 49RTD-2, 49RTD-3, 49RTD-4, 49RTD-5, and 49RTD-6. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Remote RTD (49RTD) settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this section.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Thermal, Resistance Temperature Detector (49RTD)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Thermal Protection, Resistance Temp 49RTD

Element Operation

Each RTD input can be configured to protect against high, low, or both temperature conditions.

Modes of Protection

Three modes of protection are available: Over, Under, and Over/Under.

In Over mode, if the temperature of the RTD is above the Over Pickup setting, the element will pick up. In Under mode, if the temperature of the RTD is below the Under Pickup setting, the element will pick up. In Over/Under mode, if the temperature of the RTD is above the Over Pickup setting or below the Under Pickup setting, the element will pick up. The element will remain in the picked-up condition and continue timing towards a trip unless the temperature falls below the Over Pickup setting or rises above the Under Pickup setting.

Source

The Source setting selects which RTD input to monitor. Refer to the *RTD Module* chapter for more information.

Pickup and Trip

When the measured remote RTD input value increases above (Over mode) or decreases below (Under mode) the pickup setting, the element pickup output becomes true. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements in logic.

Assertion of the Pickup output initiates a timer which begins timing toward a trip. The duration of the timer is established by the Time Delay setting. A Time Delay setting of zero (0) makes the element instantaneous with no intentional time delay.

If a pickup condition persists for the duration of the element Time Delay setting, the element Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

If the pickup condition subsides before the element time delay expires, the timer and Pickup output are reset and no corrective action is taken.

Voting

The Voting parameter defines the number of RTDs in the group that must exceed the pickup setting to cause a trip. For example, if the 49RTD-1 Voting setting is three, then at least 3 RTDs in the selected group must exceed the pickup setting to cause a trip.

Element Blocking

This input allows for logic supervision or control of the element.

Each remote RTD input protection element has a Block logic input which when true, disables an element by forcing the element Trip and Pickup outputs to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Remote RTD input element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The remote RTD input element logic block is illustrated in Figure 72. Logic inputs and outputs are summarized in Table 37.

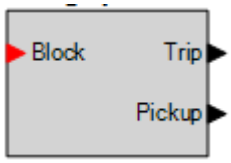


Figure 72. Remote RTD Input Element Logic Block

Table 37. Logic Inputs and Outputs

Name	Function	Purpose
Block	Input	Disables the 49RTD function when true
Trip	Output	True when the 49RTD element is in trip condition
Pickup	Output	True when the 49RTD element is in pickup condition

Operational Settings

Remote RTD input element operational settings are configured on the Resistance Temperature Detector settings screen (Figure 73) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 38.

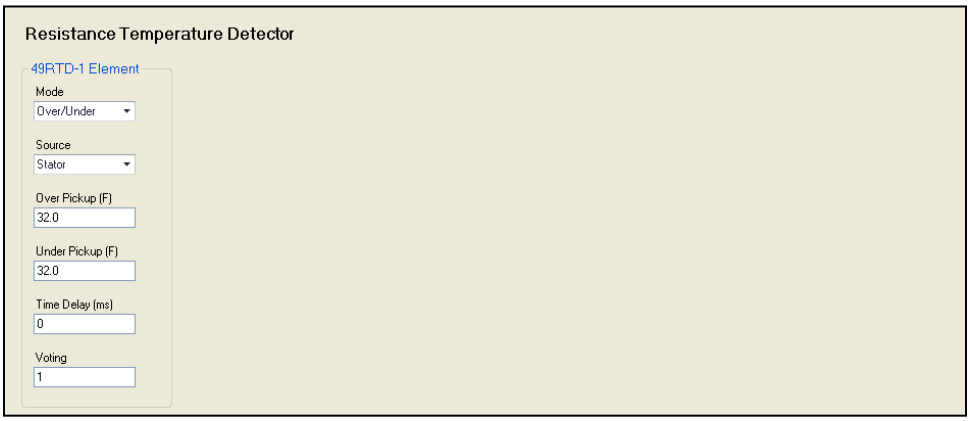


Figure 73. Resistance Temperature Detector Settings Screen

Table 38. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled, Over, Under, or Over & Under	n/a	n/a	Disabled
Source	RTD Group 1 to RTD Group 4	n/a	n/a	RTD Group 1
Over Pickup	32 to 482 degrees F or 0 to 250 degrees C	Calculated (F) 1 (C)	degrees	32
Under Pickup	32 to 482 degrees F or 0 to 250 degrees C	Calculated (F) 1 (C)	degrees	32
Time Delay	0 to 600,000	varies	milliseconds	0
Voting	1 to 24	1	units	1

Remote RTD Metering

RTD metering values are obtained through BESTCOMS*Plus* by using the Metering Explorer to open the Analog Metering, RTD Meter tree branch. BESTCOMS*Plus* must be online with the BE1-11*f* to view RTD metering. Alternately, values can be obtained through the front-panel display by navigating to the Metering, Analog Metering, RTD Meter Input screen.

Analog Input Protection

Eight analog input protection elements monitor external analog input signals when two remote RTD modules are connected via Ethernet or RS-485. Four analog inputs are provided with each RTD module. Refer to the *RTD Module* chapter for information on mounting, connections, communication setup, and specifications.

The eight, identical remote analog input protection elements are designated ANALOG-1, ANALOG-2, ANALOG-3, ANALOG-4, ANALOG-5, ANALOG-6, ANALOG-7, and ANALOG-8. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Remote Analog Input settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Protection, Remote Analog Inputs

HMI Navigation Path: Settings Explorer, Protection, Analog Protection

Element Operation

Modes of Protection

Two modes of protection are available: Over and Under.

In Over mode, if the analog input value is above the Over Pickup setting, the element will pick up. In Under mode, if the analog input value is below the Under Pickup setting, the element will pick up.

Source

The *Source* setting selects which analog input to monitor. Refer to the *RTD Module* chapter for more information.

Pickup and Trip

When the measured remote analog input value increases above (Over mode) or decreases below (Under mode) the pickup setting, the element pickup output becomes true. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements in logic.

Assertion of the Pickup output initiates a timer which begins timing toward a trip. The duration of the timer is established by the Time Delay setting. A Time Delay setting of zero (0) makes the element instantaneous with no intentional time delay.

If a pickup condition persists for the duration of the element Time Delay setting, the element Trip output becomes true. In BESTlogic*Plus*, the Trip output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action. If a target is enabled for the element, the BE1-11*f* will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

If the pickup condition subsides before the element time delay expires, the timer and Pickup output are reset and no corrective action is taken.

Inhibit Level

Remote analog input protection is inhibited when the monitored analog input value decreases below the Inhibit Level setting. This setting is available only in the Under protection mode.

Element Blocking

This input allows for logic supervision or control of the element.

Each remote analog input protection element has a Block logic input which when true, disables an element by forcing the element Trip and Pickup outputs to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Remote analog input element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The remote analog input element logic block is illustrated in Figure 74. Logic inputs and outputs are summarized in Table 39.

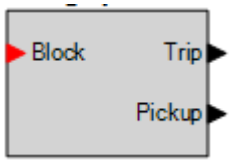


Figure 74. Remote Analog Input Element Logic Block

Table 39. Logic Inputs and Outputs

Name	Function	Purpose
Block	Input	Disables the analog input element when true
Trip	Output	True when the analog input element is in trip condition
Pickup	Output	True when the analog input element is in pickup condition

Operational Settings

Remote analog input element operational settings are configured on the Remote Analog Input settings screen (Figure 75) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 40.

Figure 75. Remote Analog Input Settings Screen

Table 40. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled, Over, or Under	n/a	n/a	Disabled
Source	Module 1 or 2, Input 1, 2, 3, or 4	n/a	n/a	Module 1, Input 1
Pickup	–99,999.9 to 99,999.9	0.1	n/a	0
Inhibit	–99,999.9 to 99,999.9	0.1	n/a	0
Time Delay	0 to 60,000	varies	milliseconds	0

Remote Analog Input Metering

Analog input metering values are obtained through BESTCOMS*Plus* by using the Metering Explorer to open the Analog Metering, Analog Inputs tree branch. BESTCOMS*Plus* must be online with the BE1-11*f* to view analog input metering. Alternately, values can be obtained through the front-panel display by navigating to the Metering, Analog Metering, Analog Input screen.

Virtual Control Switches (43)

Five virtual control switch (43) elements provide manual control, locally and remotely, without using physical switches and/or interposing relays.

The five, identical virtual control switch elements are designated 43-1, 43-2, 43-3, 43-4, and 43-5. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Virtual Control Switches (43) settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Settings Navigation Path: Settings Explorer, Control, Virtual Control Switches (43)

HMI Settings Navigation Path: Settings Explorer, Control, Virtual Switch 43

BESTCOMS*Plus* Control Navigation Path: Metering Explorer, Control, Virtual Switches

HMI Control Navigation Path: Metering Explorer, Control, Virtual Switches

Element Operation

Virtual control switches can 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 control switch can be used to reduce costs with the added benefit of being able to operate the switch both locally through the front panel and remotely from a substation computer or through an Ethernet connection to a remote operator's console.

Mode

Three operating modes are available: Switch/Pulse, Switch, and Pulse. 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.

Switch/Pulse Mode

In Switch/Pulse mode, each switch can be controlled to reset, set, or pulse. Assertion of the Set input forces the output to set (logic 1). Assertion of the Reset input forces the output to reset (logic 0). Assertion of the Pulse input toggles the output from its current state to the opposite state and then back to the original state.

Switch Mode

In Switch mode, the switch emulates a two-position selector switch, and only set and reset commands are accepted. Assertion of the Set input forces the output to set (logic 1). Assertion of the Reset input forces the output to reset (logic 0).

Pulse Mode

In Pulse mode, a momentary close, spring-return switch is emulated and only the pulse command is accepted. Assertion of the Pulse input toggles the output from its current state to the opposite state and then back to the original state.

Customized Labels

User specified labels can be assigned to each virtual switch and to both states of each switch. The labels can be up to 64 characters long. In the previous ground cutoff switch example, you may enable one of the switches in the Switch mode and connect the output of that switch to the blocking input of a 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 may set the switch label to be

59N CUTOFF. The closed position of the switch may be labeled DISABLD and the open position may be labeled NORMAL.

Control of Virtual Control Switches

The state of the virtual control switches can be controlled using the Select/Operate Control Switch buttons on the front panel or through BESTCOMS*Plus* when the connection state is active. Using select-before-operate, perform the following steps to control a switch using BESTCOMS*Plus*:

1. Use the Metering Explorer to open the Control/Virtual Switches tree branch (Figure 76).
2. Click the 43-# button to **select** it. Login may be required. The On or Off indicator (current state) will begin to flash.
3. Click on the 43-# button a second time to **operate** it. After clicking Yes, the On or Off indicator (previous state) will stop flashing and the Off or On indicator (current/new state) will illuminate.

Note

If Step 3 is not performed within 30 seconds of Step 2, the LED will stop flashing and the 43-# button will have to be reselected.

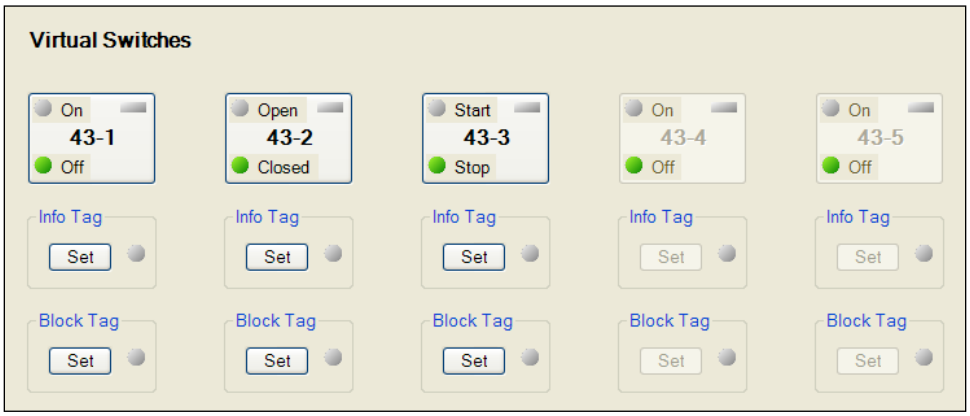


Figure 76. Virtual Switches Control Screen

Tagging of Virtual Control Switches

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

Tagging of virtual control switches can be accomplished through the front panel and through BESTCOMS*Plus*. Use the Metering Explorer in BESTCOMS*Plus* to open the Control/Virtual Switches tree branch. Click on the Set button for Info Tag or Block Tag. If tagging is successful, the indicator to the right of the Set button will turn green. A tagged switch is indicated by an amber indicator in the upper right corner of the element button. Click on the Reset button to clear a tag. Refer to Figure 76.

The Block Tag has priority over the Informational Tag. Once the Block Tag has been placed, the Informational Tag cannot be changed until the Block Tag is removed. In other words, you must choose to place the Informational Tag before placing the Block Tag.

Each tag is placed with an “owner”. A tag must be removed by the same “owner” that placed it. For example, if a tag is placed through BESTCOMS*Plus*, it can be removed only through BESTCOMS*Plus*. It cannot be removed through the front panel. If a tag is placed through the front panel, it can be removed only through the front panel. This applies for all other forms of communication when placing tags.

A Block Tag alarm indicates when a block tag is in place. Refer to the *Alarms* chapter for information on how to program alarms.

Logic Connections

Virtual control switch element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The virtual control switch element logic block is illustrated in Figure 77. Logic inputs and outputs are summarized in Table 41.

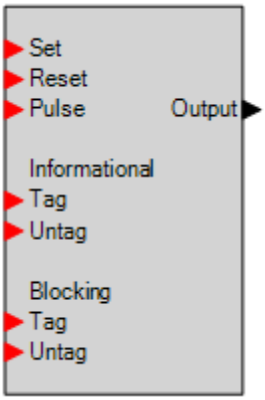


Figure 77. Virtual Control Switch Element Logic Block

Table 41. Logic Inputs and Outputs

Name	Logic Function	Purpose
Set	Input	Sets the state of the output to true
Reset	Input	Sets the state of the output to false
Pulse	Input	Momentarily changes state of the output
Informational Tag	Input	Sets an informational tag on the 43 element
Informational Untag	Input	Removes the informational tag from the 43 element
Blocking Tag	Input	Sets a blocking tag on the 43 element
Blocking Untag	Input	Removes the blocking tag from the 43 element
Output	Output	True when the 43 element is set

Operational Settings

Virtual control switch element operational settings are configured on the Virtual Control Switches (43) settings screen (Figure 78) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 42.

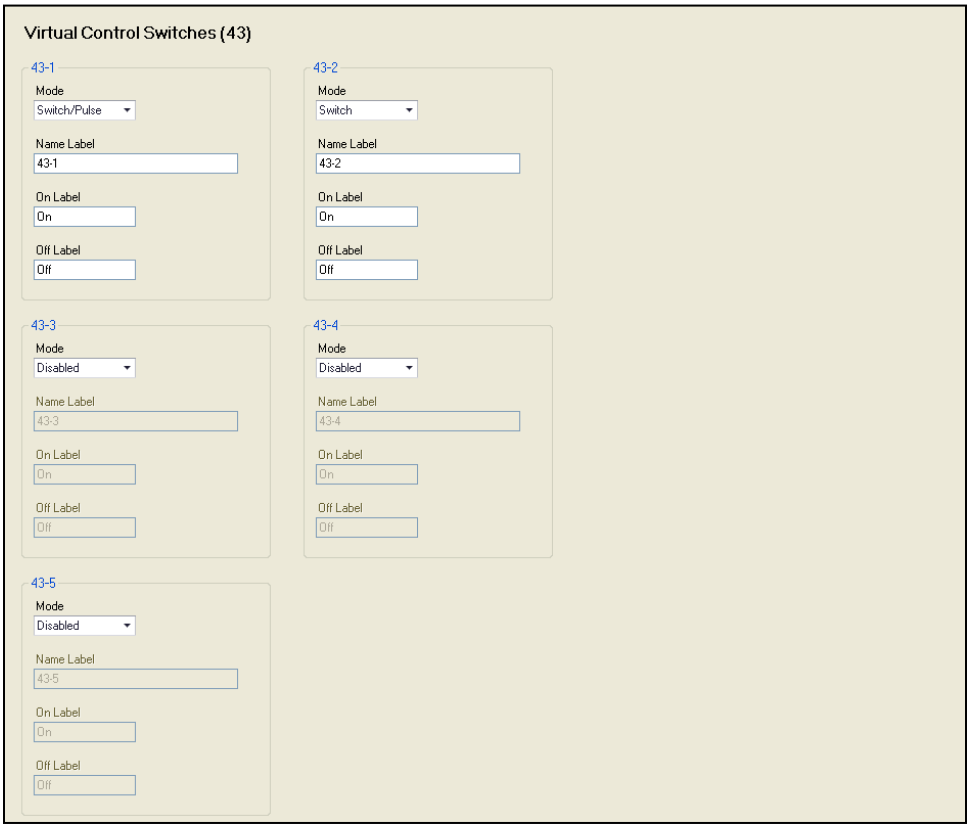


Figure 78. Virtual Control Switches Settings Screen

Table 42. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled, Switch/Pulse, Switch, or Pulse	n/a	n/a	Disabled
Name Label	64 characters maximum	n/a	n/a	43-x
On Label	64 characters maximum	n/a	n/a	On
Off Label	64 characters maximum	n/a	n/a	Off

Logic Timers (62)

Eight logic timer (62) elements emulate virtually any type of timer used in power system applications.

The eight, identical logic timer elements are designated 62-1, 62-2, 62-3, 62-4, 62-5, 62-6, 62-7, and 62-8. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Logic Timers (62) settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Control, Logic Timers (62)

HMI Navigation Path: Settings Explorer, Control, Timer Setup 62, Settings Group x (x = 0 to 3)

Element Operation

Each timer has two time delay settings. The duration of the timers is established by the Time Delay 1 (T1) setting and the Time Delay 2 (T2) setting. Assertion of the Initiate input starts the timing sequence.

The functioning of the output is dependent upon the type of timer as specified by the mode setting. In BESTlogic*Plus*, the output can be connected to other logic elements or a physical relay output to alert the operator of a condition. If a target is enabled for the element, the BE1-11*f* will record a target when the output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

Mode

Six operating modes are available: Pickup/Dropout, One-Shot/Non-Retrig, One-Shot/Retrig, Oscillator, Integrating Timer, and Latched.

Pickup/Dropout Mode

The output changes to logic true if the Initiate input is true for the Duration of Pickup Time Delay (T1). See Figure 79. If the Initiate input toggles to false before time T1, the T1 timer is reset. Once the output of the timer toggles to true, the Initiate input must be false for the Duration of Dropout Time Delay (T2). If the Initiate input toggles to true before time T2, the output stays true and the T2 timer is reset.

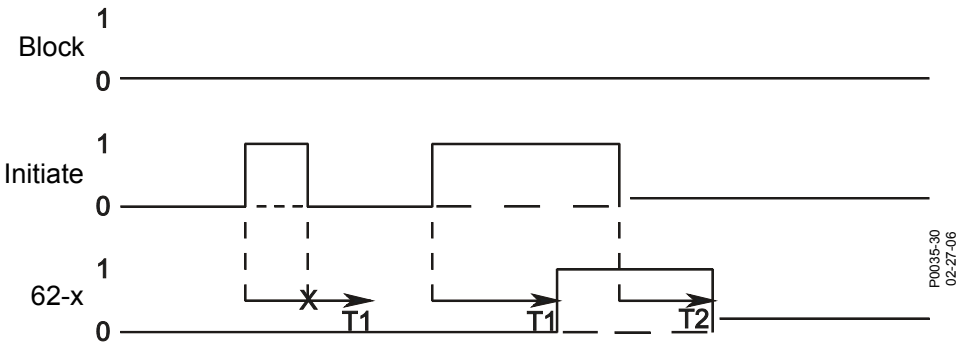


Figure 79. Pickup/Dropout Mode

One-Shot/Non-Retriggerable Mode

The one-shot nonretriggerable timer starts its timing sequence when the Initiate input changes from false to true. See Figure 80. The timer will time for Delay Time (T1) and then the output will toggle to true for Duration Time (T2). Additional initiate input changes of state are ignored until the timing sequence is completed. If the T2 timer is set to 0, this timer will not function. The timer will return to false if the Block input becomes true.

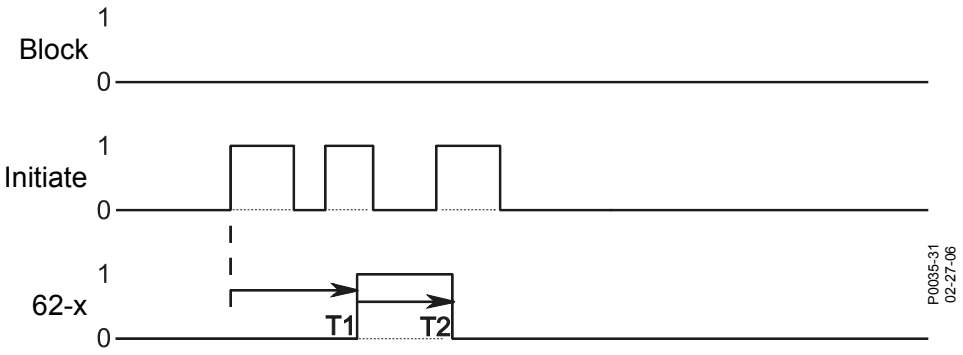


Figure 80. One-Shot/Non-Retriggerable Mode

One-Shot/Retriggerable Mode

The one-shot retriggerable timer starts its timing sequence when the Initiate input changes from false to true. See Figure 81. The timer will time for Delay Time (T1) and then the output will toggle to true for Duration Time (T2). Additional initiate input changes of state are ignored until the timing sequence has been completed. If a new false-to-true transition occurs on the Initiate input, the output is forced to logic false and the timing sequence is restarted. If the T2 timer is set to 0, this timer will not function. The timer will return to false if the Block input becomes true.

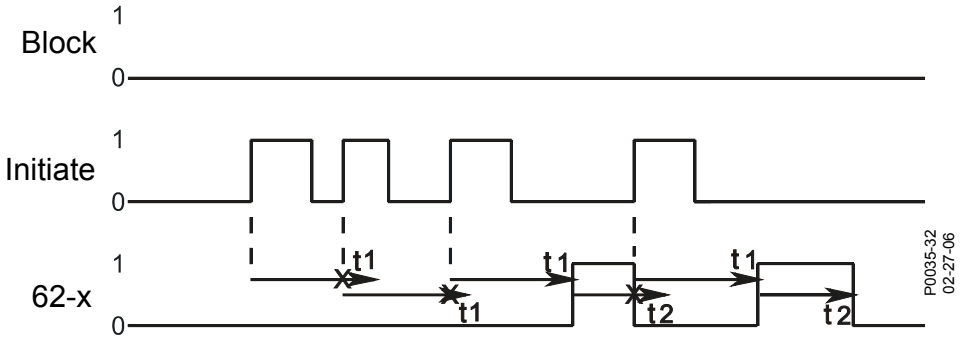


Figure 81. One-Shot/Retriggerable Mode

Oscillator Mode

In this mode, the Initiate input is ignored. See Figure 82. If the Block input is false, the output oscillates with an ON time (T1) and an OFF time (T2). When the Block input is held true, the oscillator stops and the output is held off.

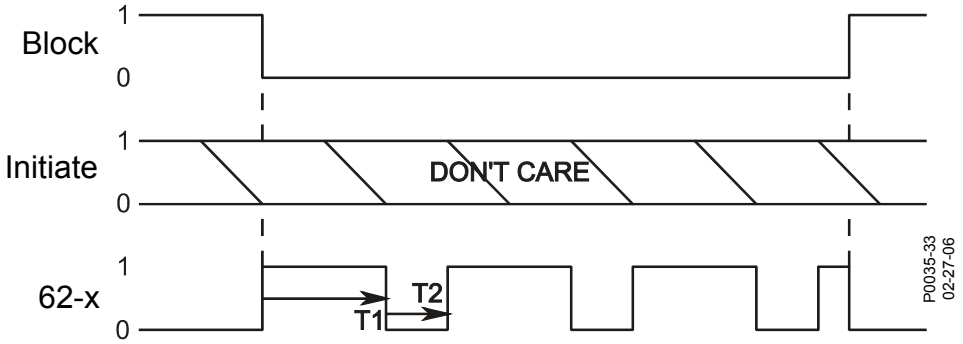


Figure 82. Oscillator Mode

Integrating Timer Mode

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. T1 defines the time delay for the output to change to true if the initiate input becomes true and stays true. 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 83, T2 is set to half of the T1 setting. The initiate input becomes true and the timer starts integrating toward pickup. Prior to timing out, the Initiate input 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 timer's output is toggled to true. Then later, the initiate Input becomes false and stays false for the duration of T2. At that point, the output of the timer is toggled to false.

This type of timer is useful in applications where a monitored signal might 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. An instantaneous overcurrent (50) element 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 input became false.

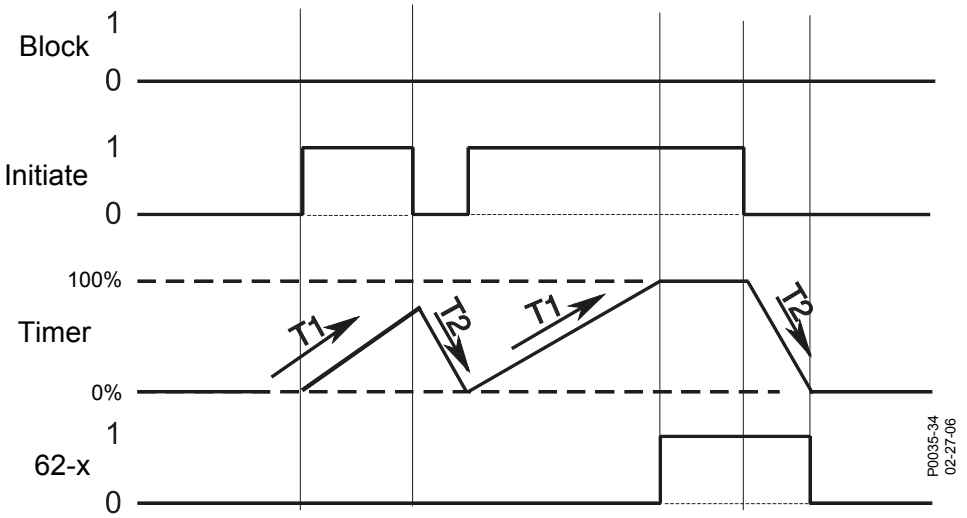


Figure 83. Integrating Timer Mode

Latched Mode

A one shot timer starts its timing sequence when the Initiate input changes from false to true. The timer will operate for Delay Time (T1) and then the output will latch true. Additional Initiate input changes of state are ignored. Time (T2) is ignored. Refer to Figure 84.

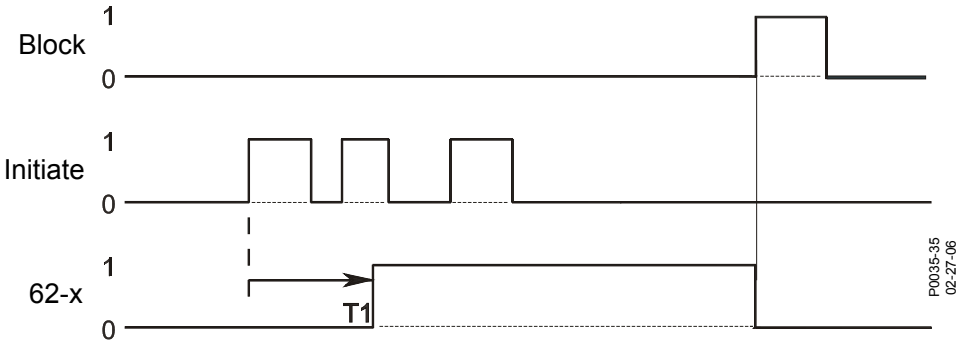


Figure 84. Latched Mode

Element Blocking

This input allows for logic supervision or control of the element.

Each logic timer element has a Block logic input which when true, disables an element by forcing the element output to logic 0 and resetting the element timer. An element Block input is connected to the desired logic in BESTlogic*Plus*.

Logic Connections

Logic timer element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The logic timer element logic block is illustrated in Figure 85. Logic inputs and outputs are summarized in Table 43.

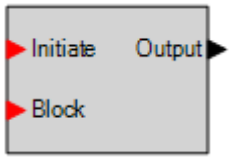


Figure 85. Logic Timer Element Logic Block

Table 43. Logic Inputs and Outputs

Name	Logic Function	Purpose
Initiate	Input	Starts the 62 timing sequence
Block	Input	Disables the 62 function when true
Output	Output	True when 62 timing criteria have been met according to mode

Operational Settings

Logic timer element operational settings are configured on the Logic Timers (62) settings screen (Figure 86) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 44.

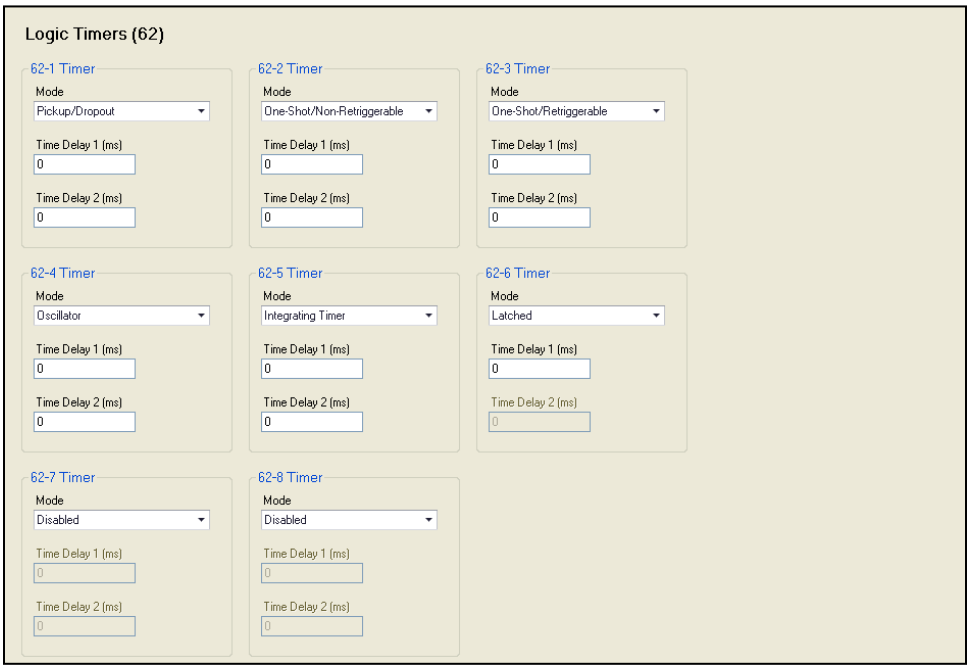


Figure 86. Logic Timers Settings Screen

Table 44. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled, Pickup/Dropout, One-Shot/Non-Retriggerable, One-Shot/Retriggerable, Oscillator, Integrating Timer, or Latched	n/a	n/a	Disabled
T1 Time, T2 Time	0 to 9,999,000	varies	milliseconds	0

Lockout Functions (86)

Two lockout function (86) elements can be used to prevent operation of circuit breakers or other devices until the condition causing lockout is eliminated.

The two, identical lockout function elements are designated 86-1 and 86-2. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Lockout Functions screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Control, Lockout Functions (86)

HMI Navigation Path: Settings Explorer, Control, Lockout 86

Element Operation

When the Set input is asserted, the output of the function becomes true (breaker opens). When the Reset input is asserted, the output becomes false (breaker closes). If both inputs are asserted at the same time, the Set input will have priority and drive the output to true. The state of the function is stored in nonvolatile memory.

Logic Connections

Lockout function element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The lockout function element logic block is illustrated in Figure 87. Logic inputs and outputs are summarized in Table 45.

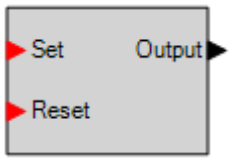


Figure 87. Lockout Function Element Logic Block

Table 45. Logic Inputs and Outputs

Name	Logic Function	Purpose
Set	Input	Sets the state of the output to true
Reset	Input	Sets the state of the output to false
Output	Output	True when the Set input is asserted

Operational Settings

Lockout function element operational settings are configured on the Lockout Functions (86) settings screen (Figure 88) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 46.

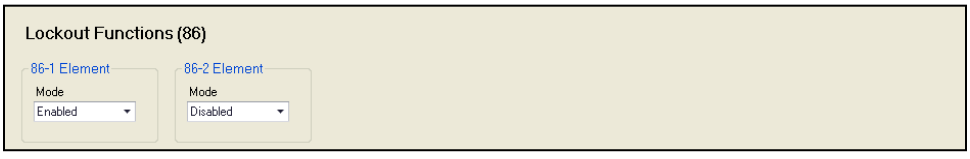


Figure 88. Lockout Functions Settings Screen

Table 46. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled or Enabled	n/a	n/a	Disabled

Retrieving Lockout Status from the Relay

Lockout status can be viewed through BESTCOMS*Plus*, the front-panel display, and the web page interface.

To view 86 lockout status using BESTCOMS*Plus*, use the Metering Explorer to open the Status, 86 Lockout Status screen shown in Figure 89. To view lockout status from the front-panel display, navigate to Metering Explorer, Status, 86 Lockout Status.

Figure 89. 86 Lockout Status Screen

Breaker Control Switch (101)

The breaker control switch (101) element provides manual control of a circuit breaker or switch without using physical switches 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 front panel and remotely from a substation computer or Ethernet connection to an operator's console.

Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Breaker Control Switch settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Settings Navigation Path: Settings Explorer, Control, Breaker Control Switch (101)

HMI Settings Navigation Path: Settings Explorer, Control, Breaker Switch 101

BESTCOMS*Plus* Control Navigation Path: Metering Explorer, Control, Breaker Control Switch

HMI Control Navigation Path: Metering Explorer, Control, 101 Breaker Control SW

Element Operation

The breaker control switch emulates a typical breaker control switch with a momentary close, spring return, trip contact output (Trip), a momentary close, spring return, close contact output (Close), a trip slip contact output (TSC), and a close slip contact output (CSC). The trip slip contact output retains the status of the last trip control action. That is, it is true (closed) in the after-trip state and false (open) in the after-close state. The close slip contact output retains the status of the last close control action. It is false (open) in the after-trip state and true (closed) in the after-close state. Figure 90 shows the state of the TSC and CSC logic outputs with respect to the state of the Trip and Close outputs.

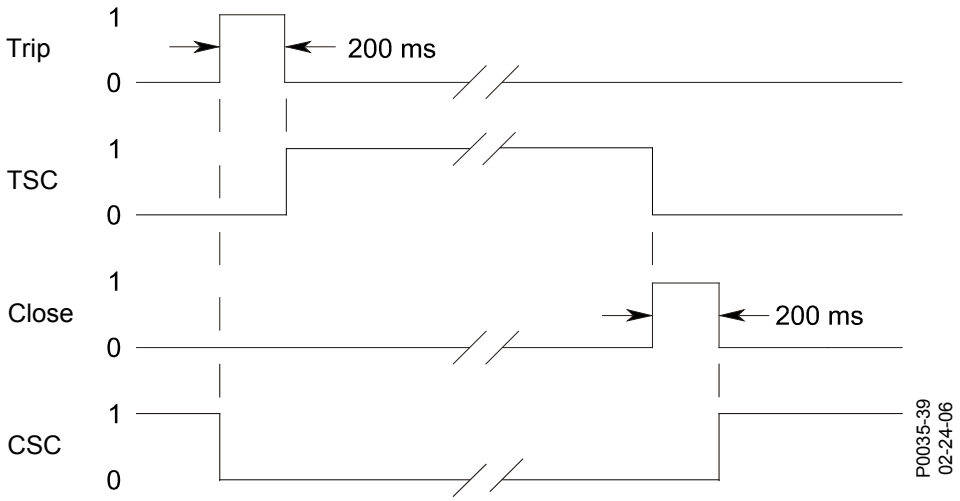


Figure 90. Breaker Control Switch State Diagram

When the breaker control switch is controlled to trip, the Trip output pulses true (closed) for approximately 200 milliseconds and the TSC output goes true (closed). When the breaker control switch is controlled to close, the CSC output pulses true (closed) and the TSC goes false (open). The status of the slip contact outputs 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.

Control of Breaker Control Switch

The state of virtual control switches can be controlled using the front-panel interface or through BESTCOMS*Plus* when the connection state is active. Using select-before-operate, perform the following steps to control the switch using BESTCOMS*Plus*:

1. Use the Metering Explorer to open the Control/Breaker Control Switch tree branch (Figure 91).
2. Click on either the TRIP or CLOSE button to **select** it. Login may be required. The green selection indicator will begin to flash.
3. Click on the TRIP or CLOSE button a second time to **operate** it. The green selection indicator will stop flashing and the proper status indicator will illuminate.

Note

If Step 3 is not performed within 25 seconds of Step 2, the button will stop flashing and either the TRIP or CLOSE button will have to be re-selected.

Figure 91. Breaker Control Switch Control Screen

Tagging of Breaker Control Switch

The breaker control switch provides tagging to indicate that the switch function is, or may be, under revision. There are two tagging modes, Informational and Blocking. When in Informational mode, the switch will still be operational when tagged. When in the Blocking mode, the switch will not be operational while tagged. A tagged switch is indicated by an amber indicator on this screen.

Tagging of the breaker control switch can be accomplished through the front panel and through BESTCOMS*Plus*. Use the Metering Explorer in BESTCOMS*Plus* to open the Control/Breaker Control Switch tree branch. Click on the Set button for Informational Tag, Blocking Tag, or both. If tagging is successful, a green indicator to the right of the Set button will illuminate.

The Blocking Tag has priority over the Informational Tag. Once the Blocking Tag has been placed, the Informational Tag cannot be changed until the Blocking Tag is removed. In other words, you must choose to place the Informational Tag before placing the Blocking Tag.

Each tag is placed with an “owner”. A tag must be removed by the same “owner” that placed it. For example, if a tag is placed through BESTCOMS*Plus*, it can be removed only through BESTCOMS*Plus*. It cannot be removed through the front panel. If a tag is placed through the front panel, it can be removed only through the front panel. This applies for all other forms of communication when placing tags.

A 101 Tag alarm is also provided to indicate that the 101 is tagged. Refer to the *Alarms* chapter for information on how to program alarms.

Logic Connections

Breaker control element logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The breaker control element logic block is illustrated in Figure 92. All logic inputs use rising-edge detection for recognition. Logic inputs and outputs are summarized in Table 47.

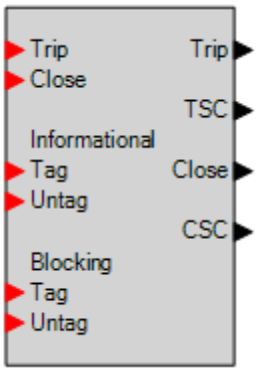


Figure 92. Breaker Control Element Logic Block

Table 47. Logic Inputs and Outputs

Name	Logic Function	Purpose
Trip	Input	Sets the state of the 101 element to Trip
Close	Input	Sets the state of the 101 element to Close
Informational Tag	Input	Sets an informational tag on the 101 element
Informational Untag	Input	Removes the informational tag from the 101 element
Blocking Tag	Input	Sets a blocking tag on the 101 element
Blocking Untag	Input	Removes the blocking tag from the 101 element
Trip	Output	True if the 101 element is in the Trip state
TSC	Output	True after the Trip output momentarily closes
Close	Output	True if the 101 element is in the Close state
CSC	Output	True after the Close output momentarily closes

Operational Settings

Breaker control element operational settings are configured on the Breaker Control Switch (101) settings screen (Figure 93) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 48.

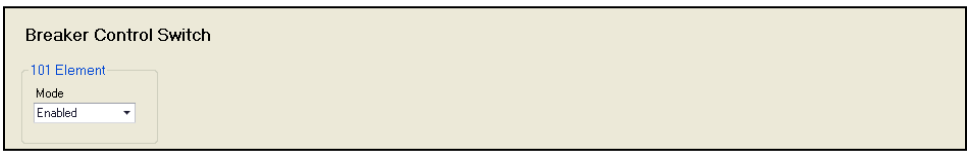


Figure 93. Breaker Control Switch Settings Screen

Table 48. Operational Settings

Setting	Range	Increment	Unit of Measure	Default
Mode	Disabled or Enabled	n/a	n/a	Disabled

Setting Groups

Four setting groups allow 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 are endless.

The four setting groups are designated Setting Group 0, Setting Group 1, Setting Group 2, and Setting Group 3. Setting group logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and setting group operational settings are configured on the Setting Group Setup screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, General Settings, Setting Group Setup

HMI Navigation Path: Settings Explorer, General Settings, Settings Group

Setting Group Functions

The group of settings that is active at any point in time is controlled by the setting group selection logic. This function logic allows for manual (logic) selection.

Logic Inputs

The function monitors logic inputs D0 through D3 and changes the active setting group according to the status of these inputs. These inputs can be connected to logic expressions such as contact sensing inputs.

Logic Outputs

The function logic has four logic variable outputs, SG0 through SG3. The appropriate variable is asserted when each setting group is active. These logic variables can be used in programmable logic to modify the logic based upon which setting group is active.

The SGCACTIVE logic output is asserted when setting group control is active. The SGCLOVRD logic output is asserted when setting group control is overridden by logic.

Changing Setting Groups

When the BE1-11*f* 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 BE1-11*f* off line. When a setting group changes according to current level (Phase, 3I0, or I2), and the 79 recloser is not in reset, the 79 element settings will not change to the new settings until the 79 element returns to reset. The active setting group is saved in nonvolatile memory so that the BE1-11*f* will power up using the same setting group that was active when it was powered down. To prevent the BE1-11*f* from changing settings while a fault condition is in process, setting group changes are blocked when the BE1-11*f* is in a picked-up state. Since the BE1-11*f* is completely programmable, the fault condition is defined by the pickup logic expression in the fault reporting functions. See the *Fault Reporting* chapter for more information.

Setting Group Selection

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 BE1-11*f* stays in that group regardless of the state of the manual logic control conditions.

Manual (logic) selection reads the status of the logic inputs to the setting group selection function block to determine what setting group should be active. **For the logic inputs to determine which setting group should be active, the AUTOMATIC input must be logic 0.** The function block operational mode setting determines how it reads these logic inputs. There are three possible logic modes as shown in Table 51.

Discrete Inputs

When the setting group selection function block is enabled for Discrete Inputs, there is a direct correlation 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, etc. The active setting group latches-in after the input is read so they can be pulsed. It is not necessary that the input be maintained. If one or more inputs are asserted at the same time, the numerically higher setting group will be activated. A pulse must be present for approximately one second for the setting group change to occur. After a setting group change occurs, no setting group change can occur within two times the SGC alarm on time. Any pulses to the inputs will be ignored during that period.

Figure 94 shows an example of how the inputs are read when the setting group selection function mode is enabled for Discrete Inputs. Note that a pulse on the D3 input while D0 is also active does not cause a setting group change to SG3 because the AUTOMATIC input is active.

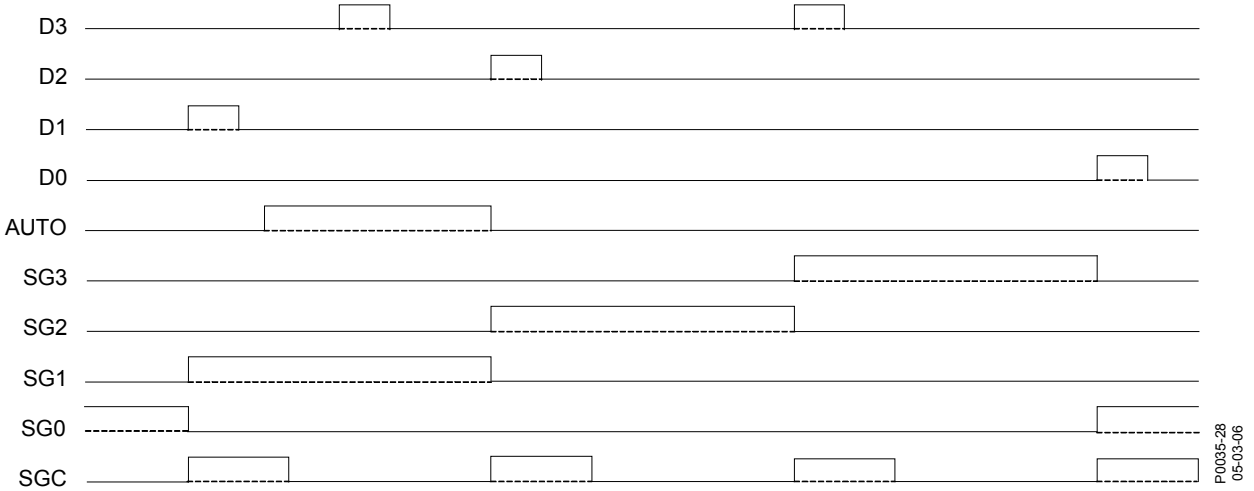


Figure 94. Input Control Discrete Inputs

Binary Inputs

When the setting group selection function block is enabled for Binary Inputs, the inputs on D0 and D1 are read as binary encoded (Table 49). Inputs D2 and D3 are ignored. A new coded input must be stable 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.

Table 49. Setting Group Binary Codes

Binary Code		Setting Group
D1	D0	
0	0	SG0
0	1	SG1
1	0	SG2
1	1	SG3

When the setting group selection function mode is enabled for Binary Inputs, the active setting group is controlled by a binary signal applied to discrete inputs D0 and D1. This requires separate logic equations for only D0 and D1 if all setting groups are to be used. Figure 95 shows how the active setting group follows the binary sum of the D0 and D1 inputs except when blocked by the AUTOMATIC input. Note that a pulse on the D1 input while D0 is also active does not cause a setting change to SG3 because the AUTOMATIC input is active.

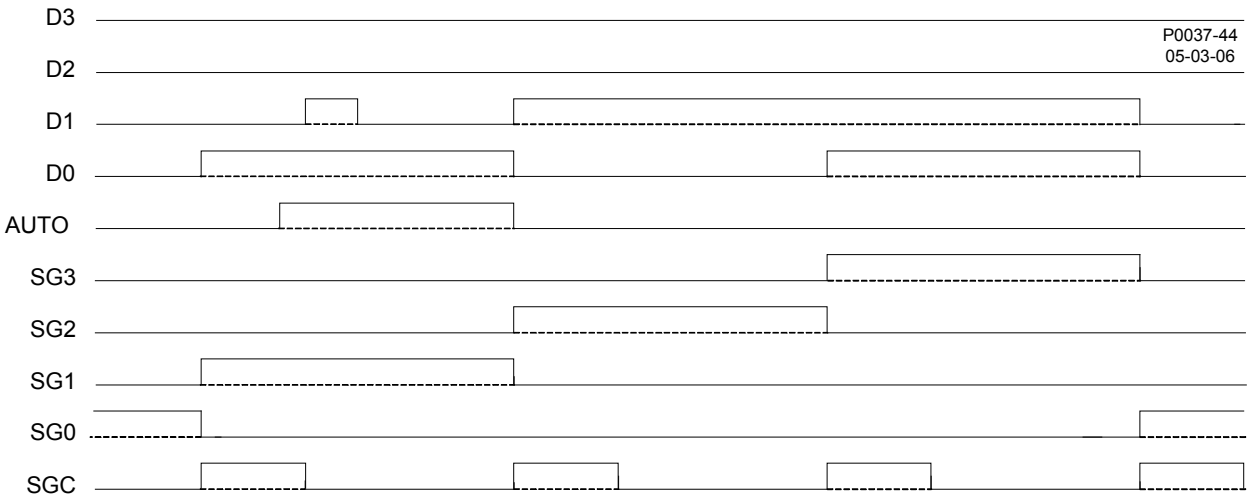


Figure 95. Input Control Binary Inputs

Alarm and Timer

The setting group selection function logic also has an alarm output variable called Setting Change (Setting Group Changed). This output is asserted whenever the BE1-11*f* switches from one setting group to another. The Setting Change 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 BE1-11*f* changes to a new setting group. See the *Alarms* chapter for more information on setting up alarms.

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

The SGC Active (Setting Group Change Active) alarm output is typically used to provide an external acknowledgment that a setting group change has 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 BESTCOMS*Plus*®.

Automatic Setting Group Selection

The setting group element has the built-in ability to automatically change setting groups. One method is based on the history of the current sensed by the relay. Another method is based upon the status of the reclose function (79) or fuse loss logic (60FL). To enable automatic change of setting groups, setting group selection must be enabled and the AUTOMATIC input must be logic 1.

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

The automatic setting group selection can 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 threshold for a period of time indicating an open breaker, then the relay will 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 will move to an alternate setting group that can 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 can 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 Switch Threshold and Return Threshold 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 changes 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 threshold" for the "switch time" and will return from the setting group when current falls below the "return threshold" for the "return time." However, if the Switch Threshold is 0 and a nonzero switch-to time is entered, the relay will change to the indicated setting group after the switch-to time.

If the monitored element is 60FL, first, second, third, or fourth reclose, the switch time, switch 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 threshold is zero, the group’s switch time delay is zero, and the monitored element is any overcurrent element (i.e., not 60FL), then the relay will never automatically switch to that setting group.

Five settings for each group 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 set in amps. 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 51 phase current (IP). If you wish to switch settings based upon unbalance, you could set it to monitor 51 neutral current (3I0), or 51 negative-sequence current (I2).

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 amps, 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.

Note the difference in operation when a switch threshold of 0.5 amps is used. For this setting, the group is selected when current rises above 0.5 amps.

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 setting 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 setting group until returned manually by logic override control.

Group Control by Monitoring Reclose Status

The active setting group can also be controlled by the status of the reclose (79) function. Upon entering a reclose operation, as the relay steps through an automatic reclose operation, the relay can be instructed to change to an appropriate setting group. If the monitored element is 1st reclose, 2nd reclose, 3rd reclose, or 4th reclose, the switch time, switch threshold, return time, and return threshold are ignored.

When setting group changes are made, the relay will stay in the last group selected until the relay returns to a reset condition. Upon the return to a reset condition, the relay restores Setting Group 1.

The points in the reclose process that the first, second, third, and fourth reclose setting causes a change to the desired setting group is when A, the referenced reclose occurs and B, after the breaker closes.

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 closes from lockout. The active group would return to group 0 when the recloser resets if any of the close operations prior to lockout was successful. Setting Groups 2 and 3 are not used (the 51 phase element is monitored by settings but the switch-to threshold and switch-to time delay are zero, so a switch to Setting Groups 2 or 3 settings never occurs). Refer to Figure 96.

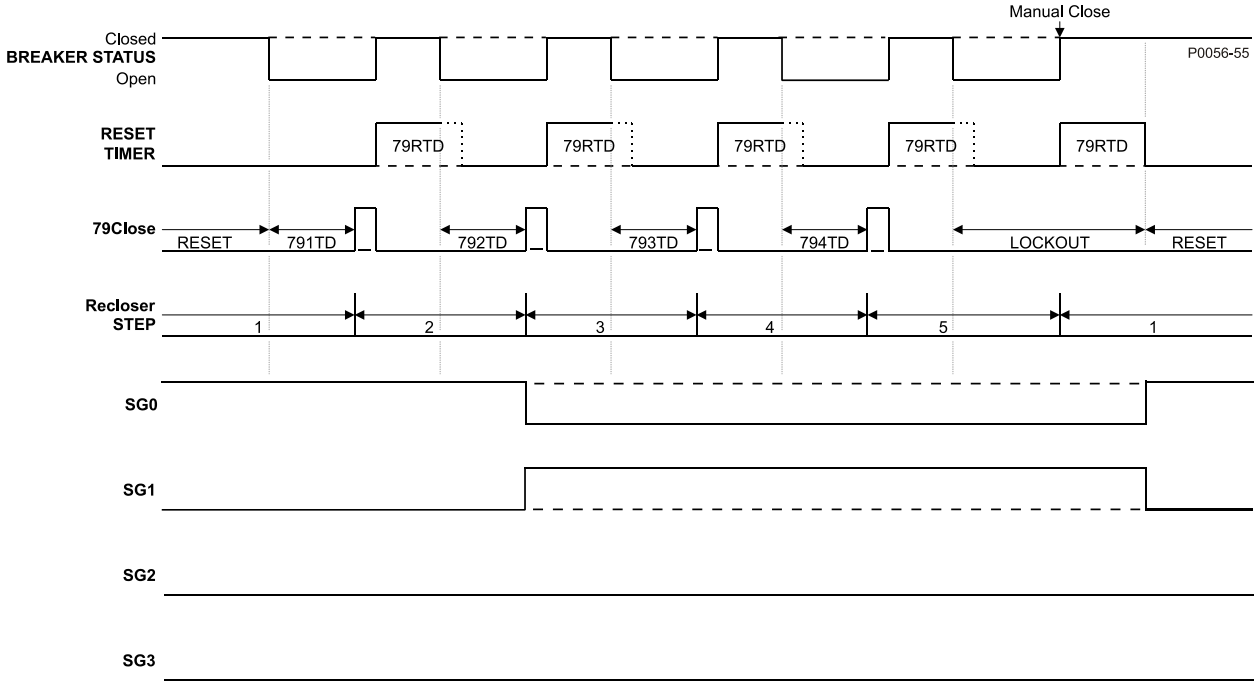


Figure 96. Change Group on Recloser Shot

Group Control by Monitoring Fuse Loss Status

The active setting group can also be controlled by the status of the fuse loss function (60FL). The relay can be instructed to change to Setting Group 1. If the monitored element is 60FL, the switch threshold, return time, and return threshold are ignored.

Logic Connections

Setting group logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The setting group logic block is illustrated in Figure 97. Logic inputs and outputs are summarized in Table 50.

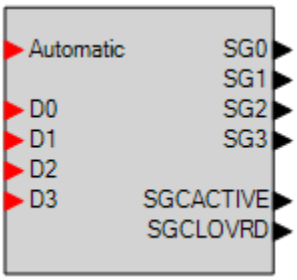


Figure 97. Setting Group Logic Block

Table 50. Logic Inputs and Outputs

Name	Logic Function	Purpose
Automatic	Input	True when automatic control is enabled and false when logic control is enabled
D0, D1, D2, D3	Inputs	Meaning depends upon the Mode setting
SG0, SG1, SG2, SG3	Outputs	True for the active setting group
SGCACTIVE	Output	True when Setting Group Control is Active
SGCLOVRD	Output	True when Setting Group Control is overridden by logic

Operational Settings

Setting group operational settings are configured on the Setting Group Setup screen (Figure 98) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 51.

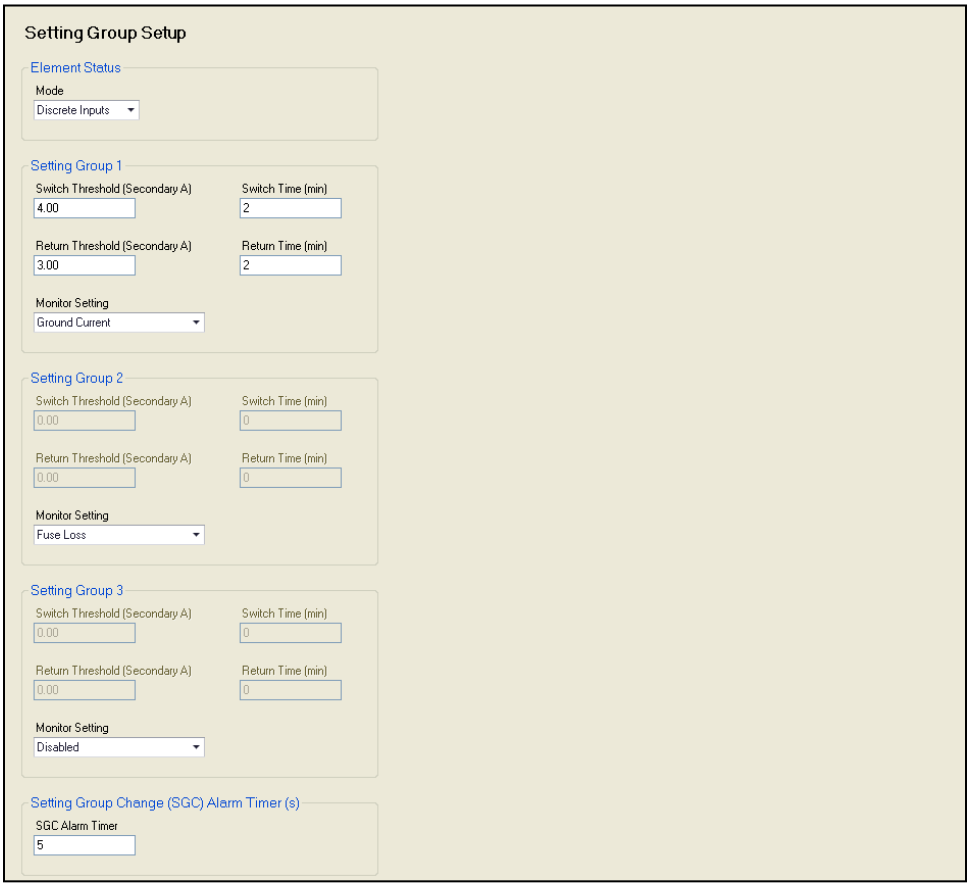


Figure 98. Setting Group Setup Screen

Table 51. Operational Settings

Setting	Range	Purpose	Default
Mode	Disabled Discrete Inputs Binary Inputs	Sets the mode of the setting group selection function. (If Auto mode is desired, logic mode must be either 1 or 2.)	Disabled
Switch Time	0 = Disabled 1 to 60 minutes	Time, in minutes, that determines when a setting change occurs once the Switch Threshold setting is exceeded.	0

Setting	Range	Purpose	Default
Switch Threshold	0 to 25A (5A CTs) 0 to 5A (1A CTs)	Measured current of the SG0 Monitor Setting that must be exceeded for a setting group change to occur. (Set in increments of 0.01A)	0
Return Time	0 = Disabled 1 to 60 minutes	Time, in minutes, that determines when a return to SG0 will occur once the monitored current has decreased below the Return Threshold setting.	0
Return Threshold	0 to 25A (5A CTs) 0 to 5A (1A CTs)	Measured current of the SG0 Monitor Setting that the monitored current must decrease below in order for a return to SG0. (Set in increments of 0.01A)	0
Monitor Setting	Disable IP, IG, I2, 3I0 60FL	Determines when automatic setting group changes occur. IP, IG, I2, or 3I0 can be selected so that setting group changes are based on load current. Fuse Loss (60FL) can also be used to switch setting groups. If 60FL is entered as the Monitor Setting, the Switch Time, Switch Threshold, Return Time, and Return Threshold parameters are not required.	Disable
Setting Group Change (SGC) Alarm Timer	0 = Disabled 1 - 10 seconds	Measured in seconds, the SGC alarm timer sets the amount of time the alarm is on.	5

Logic Override of the Setting Group Selection Function

Setting group control can be overridden to allow manual setting group control.

BESTCOMS*Plus* Navigation Path: Metering Explorer, Control, Setting Group Control

HMI Navigation Path: Metering Explorer, Control, Settings Group Control

Use the Metering Explorer in BESTCOMS*Plus* to open the Control, Setting Group Control tree branch as shown in Figure 99. Select a setting group to change to or return to logic control. The Active Setting Group is also displayed on this screen.

Figure 99. Setting Group Control Screen

Manual setting group control can also be achieved by navigating to the Metering, Control, Settings Group Control screen on the front-panel display.

Metering

The BE1-11*f* measures the voltage and current inputs, displays those values in real time, records those values every quarter-second, and calculates other quantities from the measured inputs.

Metering Explorer

The Metering Explorer is a convenient tool within BESTCOMS*Plus*® that contains analog metering, status, reports, demands, power quality, and control. Control screens include virtual switches, breaker control switch, output override, and setting group control. Details of the Analog Metering branch are described in this chapter. Refer to the appropriate chapters in this manual for information on status, reports, demand, power quality, and control. Metering values can be exported to a *.csv (comma-separated values) file.

The Metering Explorer has a “docking” feature allowing the user to arrange and dock metering screens. A blue transparent square representing the screen being moved, seven arrow buttons, and a tabs button appear when holding down the left mouse button on a metering tab and dragging it to an arrow box used for docking.

Holding the left mouse button down on a metering tab and dragging it anywhere other than an arrow box will place it as a floating metering screen. This floating screen can later be closed by clicking on the in the upper right corner.

See Figure 100. Table 52 explains the call-outs in Figure 100.

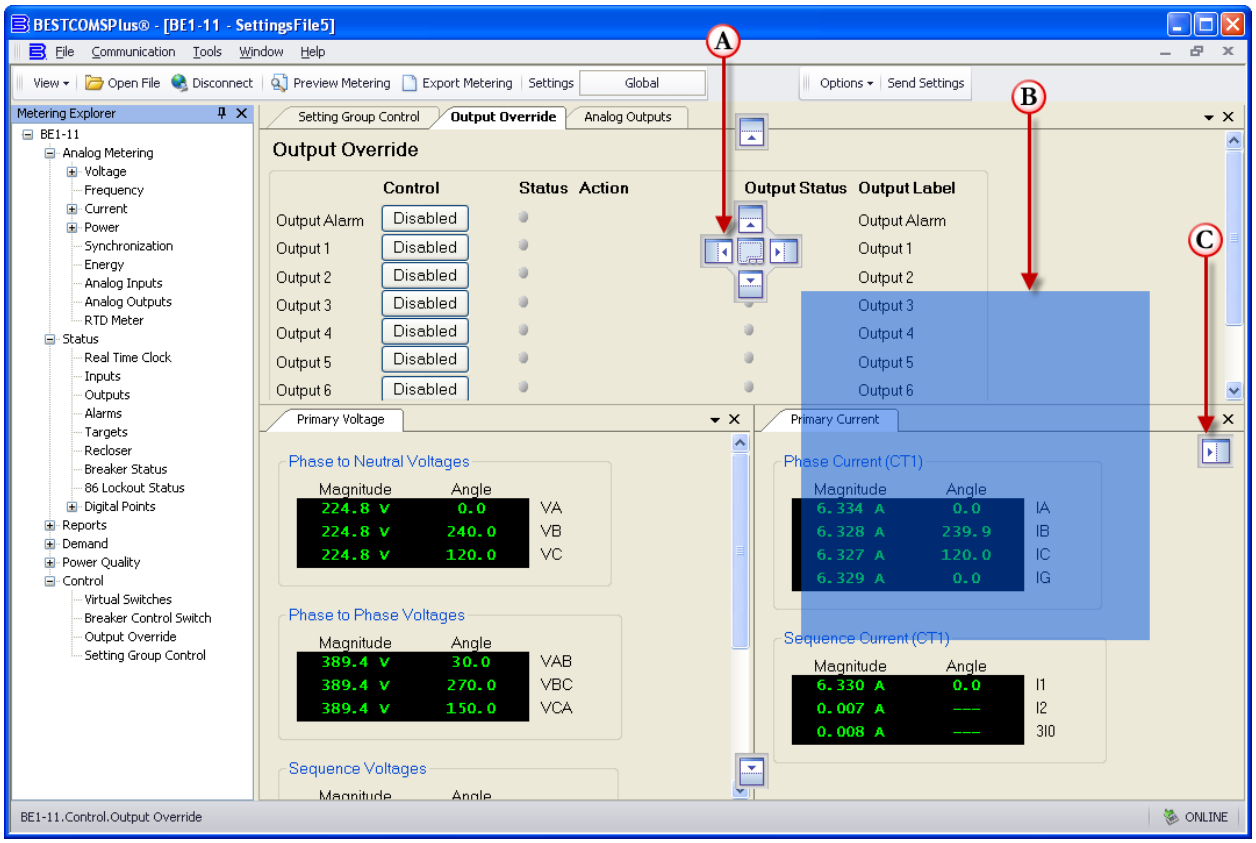


Figure 100. Metering, Docking Options

Table 52. Explanation of Figure 100 Call-Outs

Call-Out	Explanation
A	Holding the left mouse button down on a metering tab and dragging it to one of the four arrow boxes will place it inside the selected window on the location selected. To place the metering tab as a tab inside the selected window, drop it on the tabs button in the center of the arrow buttons.
B	This blue transparent square represents the screen being moved.
C	Holding the left mouse button down on a metering tab and dragging it to the right, down, left, or up arrow box will place it across the side/bottom/top of the screen. Click on the (thumbtack) to dock it on the side bar. To display a screen that is docked, simply use the mouse to hover the pointer over the tab on the side bar.

Analog Metering Functions

BE1-11*f* analog metering functions include voltage, frequency, current, power, synchronization, and energy. Metered values are viewed through the Metering Explorer in BESTCOMS*Plus*, the front-panel display, or the web page interface on Ethernet equipped relays. Refer to the *BESTnet™Plus* chapter for more information. Metering functions are summarized in the following paragraphs. For information on power, VA, and var calculations, refer to the *Configuration* chapter.

Auto Ranging

The BE1-11*f* automatically scales metered values. Table 53 illustrates the ranges for each value metered.

Table 53. Auto Ranging Scales for Metered Values

Metered Value	Unit Display Ranges			
	Whole Units	Kilo Units	Mega Units	Giga Units
Current	0 A to 999 A	10 kA to 999 kA	1 MA	n/a
Voltage	0 V to 999 V	0 kV to 999 kV	n/a	n/a
Apparent Power	n/a	0 kVA to 999 kVA	1 MVA to 999 MVA	1 GVA to 1000 GVA
Reactive Power	n/a	0 kvar to 999 kvar	1 Mvar to 999 Mvar	1 Gvar to 1000 Gvar
Real Power	n/a	0 kW to 999 kW	1 MW to 999 MW	1 GW to 1000 GW
Frequency	10 to 125 Hz	n/a	n/a	n/a

Voltage - Primary and Secondary

The BE1-11*f* meters primary and secondary phase-to-neutral voltages (VA, VB, VC), phase-to-phase voltages (VAB, VBC, VCA), positive-sequence voltage (V1), negative-sequence voltage (V2), neutral-shift voltage (3V0), auxiliary voltage (Vx), and 3rd harmonic auxiliary voltage (Vx 3rd Harmonic). The Phase VT connection determines what is measured. The auxiliary voltage input is user selectable. Refer to the *Configuration* chapter for more information on configuring Phase VT and AUX VT.

Primary and secondary voltage metering data is found in BESTCOMS*Plus* (Figure 101) and on the Metering, Analog Metering, Voltage screen of the front-panel display. A phasor diagram is also provided in BESTCOMS*Plus*.

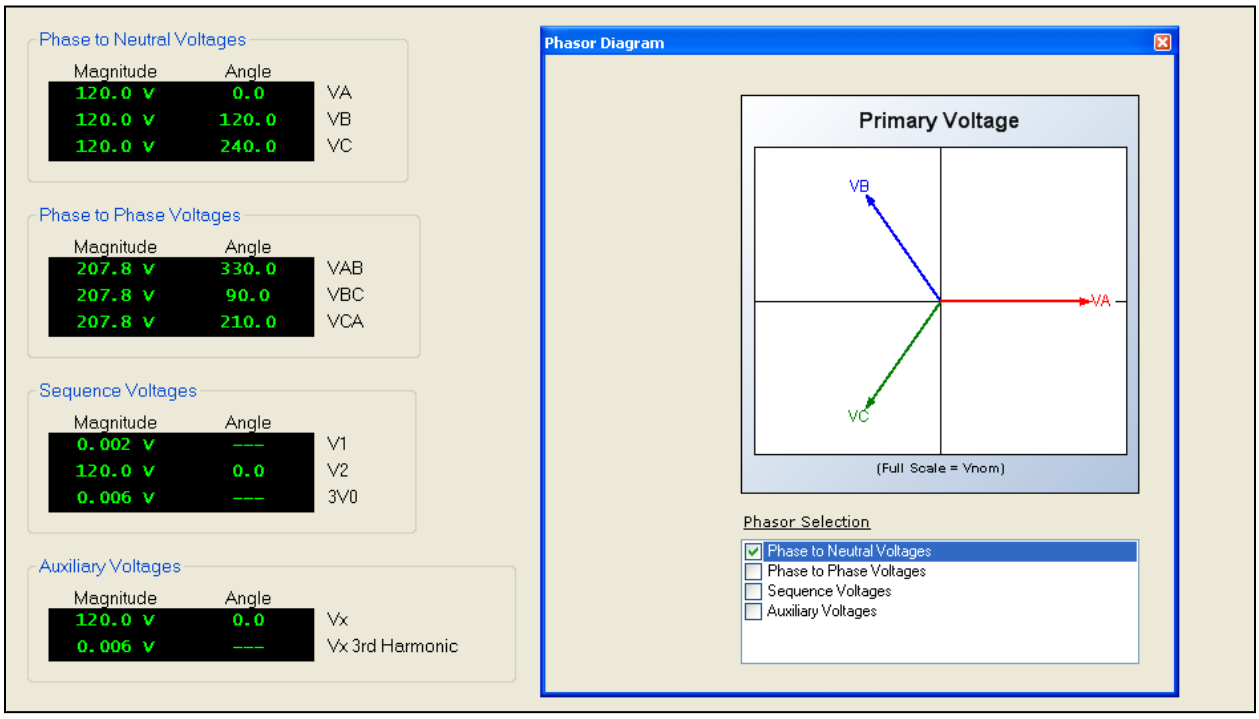


Figure 101. Analog Metering, Voltage Screen

Current - Primary and Secondary

Metered current includes primary and secondary phase currents (IA, IB, IC), ground current (IG), positive-sequence current (I1), negative-sequence current (I2), and neutral current (3I0). All current measurements are auto ranging.

Values are provided for CT Circuit 1 and CT Circuit 2 (for relays equipped with two sets of CTs).

Primary and secondary current metering data is found in BESTCOMS*Plus* (Figure 102) and on the Metering, Analog Metering, Current screen of the front-panel display. A phasor diagram is also provided in BESTCOMS*Plus*.

Figure 102. Analog Metering, Current Screen

Power

Power metering data is found in BESTCOMS*Plus* (Figure 103) and on the Metering, Analog Metering, Power screen of the front-panel display. A phasor diagram is also provided in BESTCOMS*Plus*.

Real Power

Real power is metered over a range of –7,500 kilowatts to +7,500 kilowatts on five-ampere nominal systems. One-ampere nominal systems meter real power over a range of –1,500 watts to +1,500 watts. Phases A, B, C, and total phase are included.

Reactive Power

Reactive power is metered over a range of –7,500 kilovars to +7,500 kilovars on five ampere nominal systems. One ampere systems meter reactive power over a range of –1,500 kilovars to +1,500 kilovars. Phases A, B, C, and total phase are included.

Apparent Power

Metered apparent power is displayed over a range of –7,500 kilovoltamperes to +7,500 kilovoltamperes on five-ampere nominal systems. One-ampere nominal systems meter reactive power over a range of –1,500 kilovoltamperes to +1,500 kilovoltamperes. Phases A, B, C, and total phase are included.

Power Factor

Power factor is metered over a range of maximum lagging (–0.00) to unity (1.00) to maximum leading (+0.00) for phases A, B, and C, and for total phase.

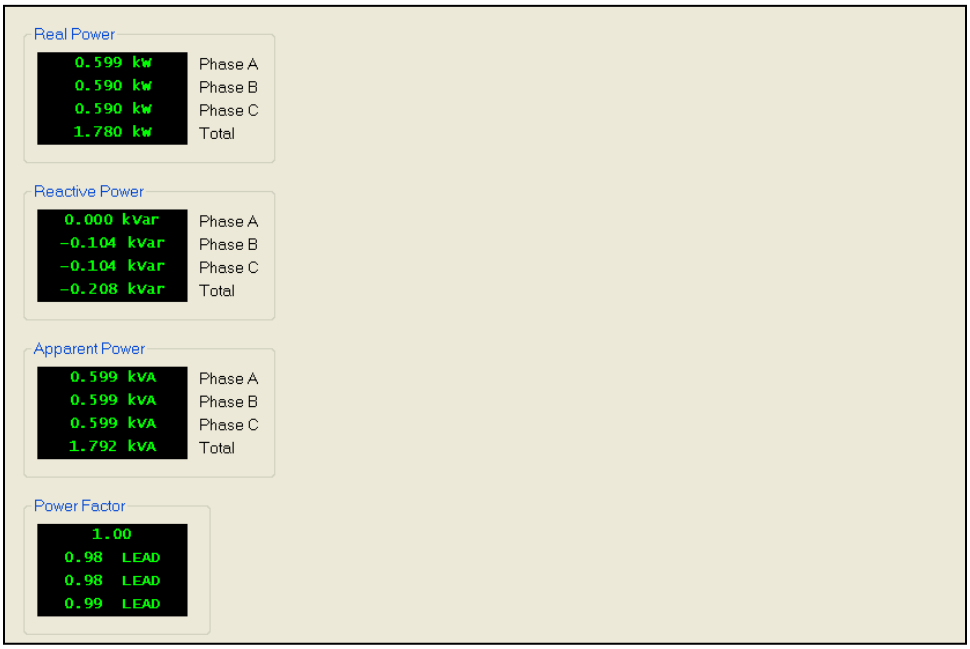


Figure 103. Analog Metering, Power Screen

Frequency

Frequency is metered over a range of 10 to 125 hertz. If the measured frequency is outside this range, the display will show “---“.

Frequency is sensed from Va to N on the back of the relay. Refer to the *Typical Connections* chapter for three-wire and four-wire connection diagrams. The frequency of the auxiliary voltage input (VX) is also measured.

Frequency metering data is found in BESTCOMS*Plus* (Figure 104) and on the Metering, Analog Metering, Frequency screen of the front-panel display.

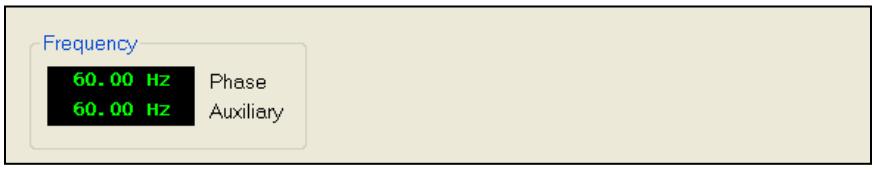


Figure 104. Analog Metering, Frequency Screen

Synchronization

Slip Frequency, Slip Angle, and Voltage Difference are metered.

Synchronization metering data is found in BESTCOMS*Plus* (Figure 105) and on the Metering/Analog Metering/Synchronization screen of the front-panel display.

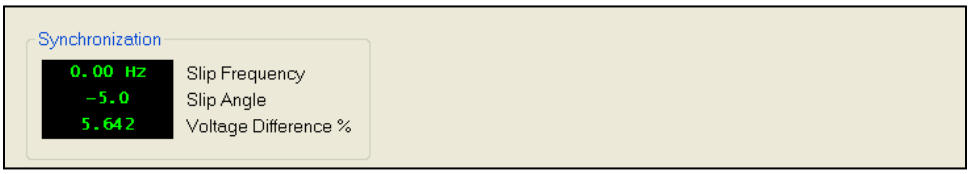


Figure 105. Analog Metering, Synchronization Screen

Energy

Energy is metered for positive and negative watthours and varhours. Watthour and varhour values are calculated per minute as shown in Equation 8.

$$\frac{\text{Primary VT Ratio} \times \text{Primary CT Ratio}}{60 \text{ minutes}} \times \text{Secondary Watts or Vars}$$

Equation 8. Energy Data Equation

Watt and var values are updated every 250 milliseconds and watthour and varhour values are logged once every minute. Energy registers are stored in nonvolatile memory at 15-minute intervals.

Watthour values and varhour values can be read, reset, or changed through the front panel or communication ports. A lagging power factor load will report positive watts and positive vars.

Energy metering data is found in BESTCOMS*Plus* (Figure 106) and on the Metering, Analog Metering, Energy screen of the front-panel display.

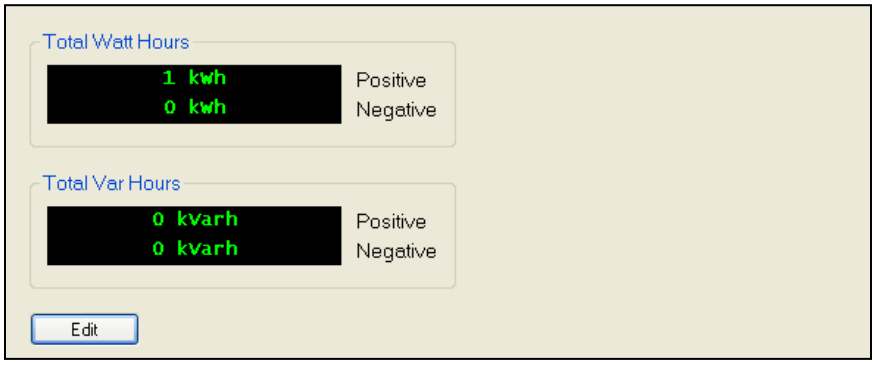


Figure 106. Analog Metering, Energy Screen

Click the Edit button to change the values. The Meter Energy Editor screen appears as shown in Figure 107. Make the desired changes and then click Upload Data to Device. A username and password are required to upload data. Click Close when finished.

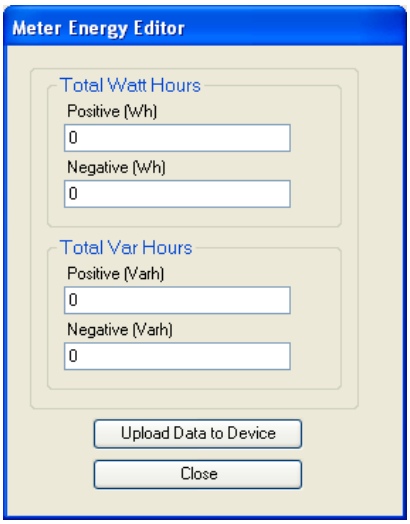


Figure 107. Meter Energy Editor Screen

Analog Inputs and Outputs

The following screens are used when an optional RTD module is connected to the BE1-11*f*. For more information, refer to the *RTD Module* chapter.

The Analog Inputs screen is shown in Figure 108 and the Analog Outputs screen is shown in Figure 109.

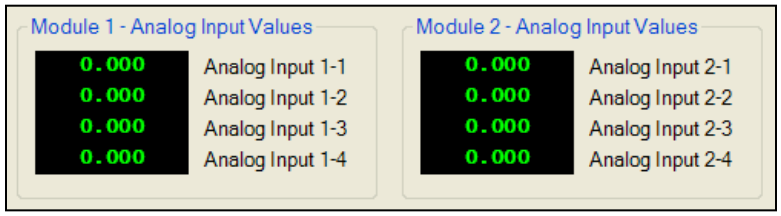


Figure 108. Analog Metering, Analog Inputs Screen

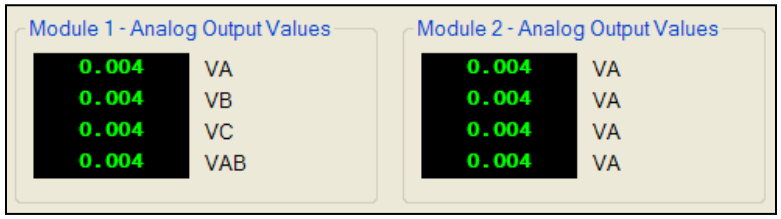


Figure 109. Analog Metering, Analog Outputs Screen

RTD Meter

Figure 110 illustrates the RTD Meter screen. Temperatures are displayed from the optional RTD modules.

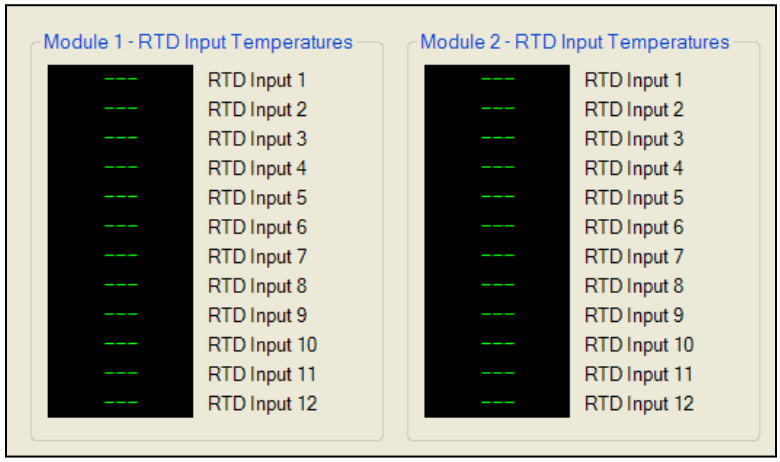


Figure 110. RTD Meter Screen

Sequence of Events

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 700 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. Over 1,000 records are stored in nonvolatile 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

BE1-11*f* relays have three relay identification fields: Device ID, Station ID, and User ID. These fields are used in the header information lines of the sequence of events records. Refer to the *BESTCOMSPlus®* chapter for information on relay identification settings.

For user-programmable logic variables (contact sensing inputs, contact outputs, and virtual control switches), the user-programmed variable name, and state names are logged in the SER report instead of the generic variable name and state names.

When a monitored event occurs or a monitored variable changes state, the SER logs all event data listed in Table 54.

Table 54. Event Data Recorded

Event Data Recorded	Description
TIME STAMP	Date of change in format YYYY-MM-DD
	Time of change in 24 hour format HH:MM:SS.mmm
SYNC	Time Sync Status, one of: IRIGB, DNP, NTP, RTC, NO_SYNC
DEVICE ID	User entered device name string
TYPE	Point Type, one of: ALRM (alarm), CONF (configurable), LGIC (logic), PROT (protection), STAT (status), TRBL (trouble), TRGT (target), USER (user)
NUM	Basler Point Name (not localized to local language)
DESCRIPTION	Localized or user entered string description of point
STATUS	Localized or user entered string status of point (Open, Closed, Trip, etc.)

Retrieving SER Information

Sequence of events data can be obtained through BESTCOMS*Plus* and the web page interface.

Viewing and Downloading SER Data through BESTCOMS*Plus®*

Use the Metering Explorer to open the Reports, Sequence of Events screen. If an active connection to a BE1-11*f* is present, the sequence of events will automatically download. Using the Options button, you can copy or save the Sequence of Events to a *.csv (comma-separated values) file. The Download button is used to refresh/update the list of events. The Clear button will clear all events. See Figure 111.

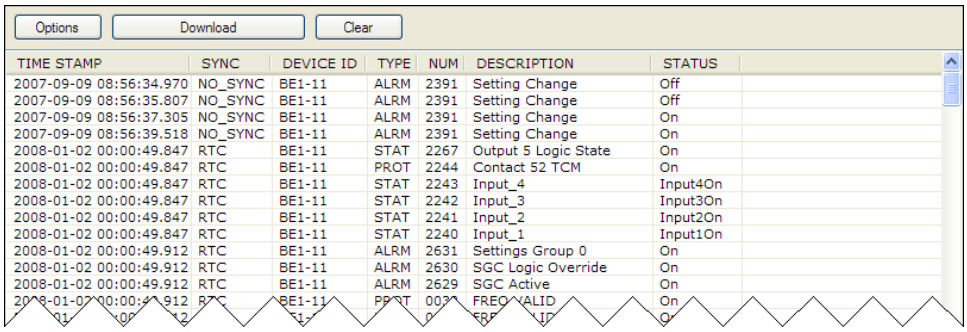


Figure 111. Sequence of Events Screen

Viewing SER Data through the Web Page Interface

Sequence of events summary can be viewed through the web page interface. Refer to the *BESTnet™Plus* chapter.

Fault Reporting

The fault reporting function records and reports information about faults that have been detected by the relay. The BE1-11*f* provides many fault reporting features. These features include Fault Summary Reports, Oscillographic Records, Distance to Fault, and Targets.

Fault Reporting Trigger Logic

Logic expressions are used to define the three conditions for fault reporting. These conditions are Trip, Picked Up, and Logic trigger. An oscillographic record is triggered when either the Pickup or Logic input is true. You can also force a trigger using BESTCOMS*Plus*®.

Figure 119 illustrates how each of these logic expressions is used by the various relay functions. Fault trigger logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*. The *BESTlogicPlus* chapter provides information about using BESTlogic*Plus* to program the relay. Figure 112 illustrates the fault reporting trigger logic block.

Figure 112. Fault Reporting Trigger Logic Block

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 front panel. 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.

Picked Up

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 the Trip LED on the front panel. 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 front panel.

Targets

Each protective function logs target information to the fault reporting function when a trip condition occurs and the trip output of the logic block becomes true (refer to Figure 119 and Table 58, call-out B). Table 55 lists targets as displayed. All targets are enabled by default.

Table 55. Targets as Displayed

Target	Description
27P-#-A/B/C	Phase Undervoltage, A, B, or C
27X-#-3V0	Auxiliary Undervoltage, 3V0-3ph VT
27X-#-V1	Auxiliary Undervoltage, Positive-Sequence
27X-#-V2	Auxiliary Undervoltage, Negative-Sequence
27X-#-AUX	Auxiliary Undervoltage, Fundamental VX
27X-#-3RD	Auxiliary Undervoltage, 3rd Harmonic VX
32-#-A/B/C/T-Over	Power, Phase A, B, C, or Total, Overpower
32-#-A/B/C/T-Under	Power, Phase A, B, C, or Total, Underpower
49RTD-# RTD-#-#	Over/Undertemperature
50-#-A/B/C	Instantaneous Overcurrent, Phase A, B, or C
50-#-Residual	Instantaneous Overcurrent, Residual
50-#-IND GND	Instantaneous Overcurrent, Independent Ground
50-#-Pos SEQ	Instantaneous Overcurrent, Positive-Sequence
50-#-Neg SEQ	Instantaneous Overcurrent, Negative-Sequence
50-#-Unbalance	Instantaneous Overcurrent, Unbalance
50-#-67-A/B/C	Directional Instantaneous Overcurrent, Phase A, B, or C
50-#-67-Residual	Directional Instantaneous Overcurrent, Residual
50-#-67-IND GND	Directional Instantaneous Overcurrent, Independent Ground
50-#-67-Neg SEQ	Directional Instantaneous Overcurrent, Negative-Sequence
50BF	Breaker Failure
51-#-A/B/C	Inverse Overcurrent, Phase A, B, or C
51-#-Residual	Inverse Overcurrent, Residual
51-#-IND GND	Inverse Overcurrent, Independent Ground
51-#-Pos SEQ	Inverse Overcurrent, Positive-Sequence
51-#-Neg SEQ	Inverse Overcurrent, Negative-Sequence
51-#-Unbalance	Inverse Overcurrent, Unbalance
51-#-67-A/B/C	Directional Inverse Overcurrent, Phase A, B, or C
51-#-67-Residual	Directional Inverse Overcurrent, Residual
51-#-67-IND GND	Directional Inverse Overcurrent, Independent Ground
51-#-67-Neg SEQ	Directional Inverse Overcurrent, Negative-Sequence
59-#-A/B/C	Phase Overvoltage, A, B, or C
59X-#-3V0	Auxiliary Overvoltage, 3V0-3ph VT
59X-#-V1	Auxiliary Overvoltage, Positive-Sequence
59X-#-V2	Auxiliary Overvoltage, Negative-Sequence
59X-#-AUX	Auxiliary Overvoltage, Fundamental VX
59X-#-3RD	Auxiliary Overvoltage, 3rd Harmonic VX
60FL	Fuse Loss Detection
62-#	Timer Output

Target	Description
81-#-Over	Frequency, Over
81-#-Under	Frequency, Under
81-#-ROC	Frequency, Rate of Change
86-#	Lockout Function
Analog In #	Remote Analog Input

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.

Target Settings

Targets are enabled using BESTCOMS*Plus*. Use the Settings Explorer to open the Target Configuration tree branch. You can select which protective elements trigger a target by selecting Enabled or Disabled from the Mode drop-down menu next to the targets. See Figure 113.

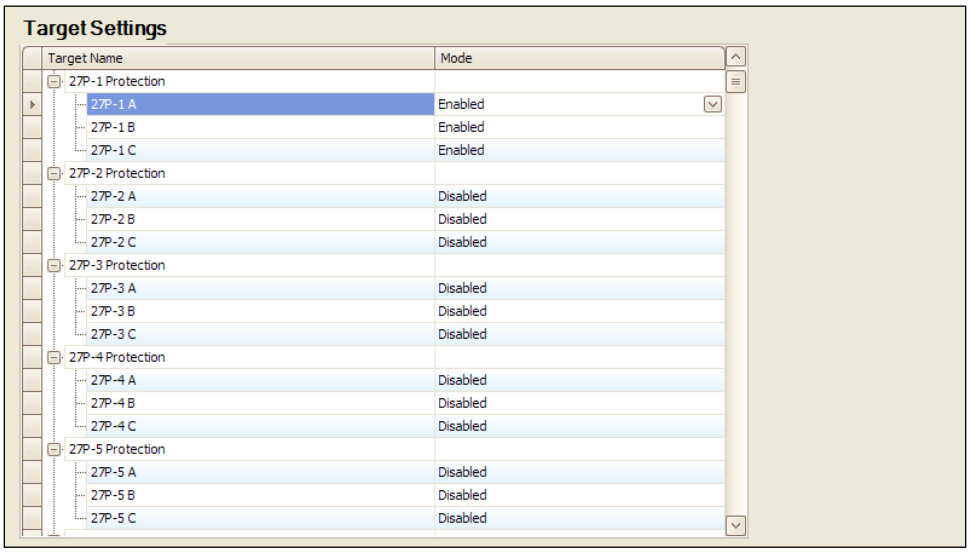


Figure 113. Target Settings Screen

Retrieving Target Information and Resetting Targets

To view targets at the front-panel display, navigate to the Metering, Status, Targets screen. 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 *Fault Reports.*

When a protective trip occurs and targets are logged, the front-panel Trip LED seals-in. The target can be viewed on the front-panel display by navigating to the Metering, Status, Targets screen.

To view target status using BESTCOMS*Plus*, use the Metering Explorer to open the Status, Targets screen shown in Figure 114.

Figure 114. Targets Screen

Targets can also be viewed through the web page interface. Refer to the *BESTnetPlus* chapter.

Targets can be cleared through BESTCOMS*Plus* or by pressing the front-panel Reset button while viewing the Targets screen. Targets cannot be reset through the web page interface.

A BESTlogic*Plus* expression can be used to reset the targets. Use the Settings Explorer within BESTCOMS*Plus* to open the BESTlogic*Plus* Programmable Logic tree branch. Select the Target Reset logic block from the list of Elements. Use the drag and drop method to connect a variable or series of variables to the Reset input. The target reset logic block is shown in Figure 115.

Figure 115. Target Reset Logic Block

Pressing the front-panel Reset key clears the targets and the Trip LED. Depending on device security setup, a username and password may be required to reset targets at the front panel. Logging in is not required if the Unsecured Access Level is set to Operator or higher. Target reset can also be set outside of security control, allowing reset without logging in. Refer to the *Security* chapter for more information.

A target reset key is available as a status input in BESTlogic*Plus*. Refer to the *BESTlogicPlus* chapter for more information.

Fault Reports

The BE1-11*f* records information about faults and creates fault summary reports. A maximum of 255 fault summary reports are stored in nonvolatile memory. When a new fault summary report is generated, the relay discards the oldest of the 255 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.

Five different event types are generated by the BE1-11*f*: Trip, Pickup, Logic, Breaker Failure, and Forced Trigger.

BE1-11*f* relays have three relay identification fields: Device ID, Station ID, and User ID. These fields are used in the header information lines of the fault reports. Refer to the *BESTCOMSPlus* chapter for information on relay identification settings.

Viewing and Downloading Fault Data through BESTCOMS*Plus*®

To view fault summary reports using BESTCOMS*Plus*, use the Metering Explorer to open the Reports, Fault Records screen shown in Figure 116. This screen shows a list of faults along with number, date, time, event type, and number of oscillographic records for each fault.

From this screen, you can choose to View All or View New fault reports. Then select 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 116, fault 3 is highlighted.

The Download button allows you to download and save all files associated with the selected fault. These files include oscillographic records. The Refresh button refreshes the list of fault reports on the screen (Figure 116) that are available to view/download. The Reset button resets new faults. The Trigger button manually triggers a fault.

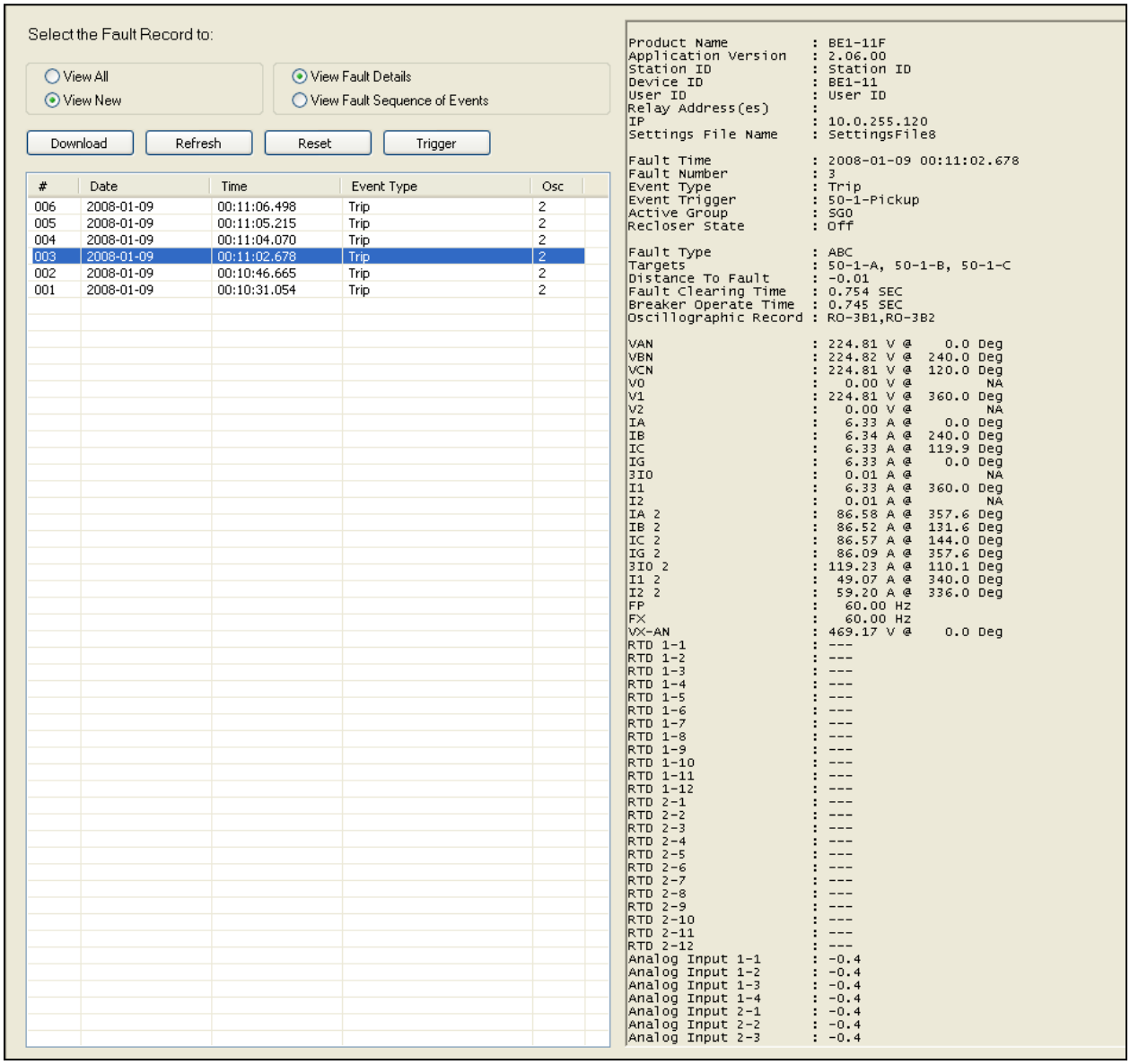


Figure 116. Fault Reports Screen

Viewing and Downloading Fault Data through the Web Page Interface

Fault report data can be viewed through the web page interface. For more information, refer to the *BESTnetPlus* chapter.

Viewing Fault Data through the Front-Panel Display

Fault report data for the last 10 faults can be viewed through the front-panel display by navigating to Metering, Reports, Fault Reports.

Fault Summary Report Items

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 items are contained in a typical fault summary report.

- *Product Name.* This line reports the product name.
- *Application Version.* This line reports the version of firmware inside the product.
- *Station ID, Device ID, and User ID.* These lines report station, device, and user information as defined by *BESTCOMSPlus* on the *Device Info* screen.
- *Relay Address.* This line reports the communications port address(es) that the report was requested from. The addresses are assigned using BESTCOMS*Plus* or the front-panel interface.
- *Settings File Name.* This line reports the name of the settings file that was active at the time of the fault.
- *Fault Time.* This line reports the time and date 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 Fault Trigger logic. Refer to Figure 119 and Table 58, call-out A.
- *Fault Number.* This line reports the sequential number (from 1 to 255) assigned to the report by the BE1-11*f*.
- *Event Type.* This line reports the type of event that occurred. There are five event categories:
  1. Trip: A fault was detected as defined by the pickup expression and the relay tripped to clear the fault.
  2. 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.
  3. Logic: A fault report was recorded by the logic trigger expression but no fault was detected as defined by the pickup expression.
  4. Breaker Failure: A fault was detected as defined by the pickup expression and the breaker failure trip became true before the fault was cleared.
  5. Forced Trigger: A fault report was triggered through the BESTCOMS*Plus* interface.
- *Event Trigger.* This line reports the logic variables in the picked up or logic trigger expressions that became true to trigger the recording of the event.
- *Active Group.* This line reports what setting group was active at the time that the fault occurred.
- *Recloser State.* This line reports the state of the recloser shot counter prior to the fault that triggered the report.
- *Fault Type.* Indication of phases involved in the fault.
- *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 119 and Table 58, call-out B.
- *Distance to Fault.* This line reports the distance to the fault on the line. Units are the same as the units used to determine line length. Refer to Figure 119 and Table 58, call-out F.
- *Fault Clearing Time.* This line reports the time from when the relay detected the fault until the relay detected that the fault had cleared. Refer to Figure 119 and Table 58, call-out C.
  - If the fault report was triggered through the BESTCOMS*Plus* interface, 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 trigged until the fast current detector function detects that the arc has been extinguished.

- *Oscillographic Record.* This line reports the number of oscillographic records that are stored in memory for this fault report. Refer to Figure 119 and Table 58, call-out E. Recording of oscillographic records is described later in this chapter.
- *VA, IA, IA 2 (CT2), VB, IB, IB 2 (CT2), VC, IC, IC 2 (CT2).* These lines report the phase voltage and 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 voltages and currents are for the power system cycle two cycles prior to the end of the fault. Refer to Figure 119 and Table 58, call-out F.
- *V0, V1, V2.* These lines report the three-phase residual, positive-sequence, and negative-sequence 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 119 and Table 58, call-out F.
- *IG, IG 2 (CT2).* This line reports the ground current magnitude and angle measured two power system cycles immediately following the trip trigger. If the fault is cleared prior to the relay tripping, the recorded fault current is for the power system cycle two cycles prior to the end of the fault. Refer to Figure 119 and Table 58, call-out F.
- *I0, I0 2 (CT2), I1, I1 2 (CT2), I2, I2 2 (CT2).* These lines report the three-phase residual, positive-sequence, and negative-sequence 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 119 and Table 58, call-out F.
- *FP, FX.* This line reports the frequency for the phase voltage input and auxiliary voltage input measured immediately following the trip trigger. Refer to Figure 119 and Table 58, call-out F.
- *VX.* This line reports the auxiliary voltage magnitude and angle 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 119 and Table 58, call-out F.
- *RTD.* These lines report the values of the RTDs when an optional remote RTD module is connected.
- *Analog Inputs.* These lines report the values of the analog inputs when an optional remote RTD module is connected.

Oscillographic Records

Recording Oscillographic Records

Each time the fault reporting function starts recording a fault summary report, it freezes a user-defined 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 nonvolatile memory. As additional faults are recorded, the oldest records are overwritten. The fault reporting function can record up to 32 oscillographic records based on IEEE Std C37.111-1999 - *IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems*. The number of records to store is selectable by the user. Maximum data capture resolution is 32 samples per cycle and is user selectable. The relay can store up to 2,048 cycles of data at 8 samples per cycle or 512 cycles of data at 32 samples per cycle. Refer to Table 56 for Oscillographic Records Settings.

All channels are recorded (IA, IA 2, IB, IB 2, IC, IC 2, IG, IG 2, VA, VB, VC, VX, FP, FX, Analog Inputs, and RTDs) as they happen in real time.

A settings snapshot is taken and recorded with each event. This snapshot will be stored in a file that can later be uploaded to the device to return it to the settings that were active at the time of the recording.

BE1-11*f* relays have three relay identification fields: Device ID, Station ID, and User ID. These fields are used in the header information lines of the oscillographic records. Refer to the *BESTCOMSPlus* chapter for information on relay identification settings.

Oscillographic Records Settings

The oscillographic records settings are programmed through BESTCOMS*Plus*. Use the Settings Explorer to open the Metering Configuration, Fault Records screen as shown in Figure 117. Enter the values for Sample Resolution, Number of Records to Store, and Prefault Cycles.

Figure 117. Fault Records Screen

Table 56 summarizes the oscillographic records settings.

Table 56. Oscillographic Records Settings

Setting	Range	Increment	Default
Sample Resolution	32, 16, or 8	n/a	32
Number of Records to Store	32, 16, 8, or 4	n/a	32
Prefault Cycles	0 to 16	1	2

Retrieving Oscillographic Records

Oscillographic records can be downloaded through the Reports, Fault Reports screen in BESTCOMS*Plus* (Figure 116). See *Fault Reports* earlier in this chapter. Oscillographic records can also be downloaded through the web page interface. For more information, refer to the *BESTnetPlus* chapter.

Distance to Fault

The BE1-11*f* calculates distance to fault each time a fault record is triggered. Distance to fault is calculated and displayed based on the power line parameters entered using BESTCOMS*Plus* or the front-panel interface. Table 57 provides the power line operating settings.

Table 57. Power Line Operating Settings

Setting	Range	Increment	Unit of Measure	Default
Z1 Line Magnitude	0.05 to 200 (5A CTs) 0.01 to 40 (1A CTs)	varies	ohms	24
Z1 Line Angle	0 to 90	1	degrees	80
Z0 Line Magnitude	0.05 to 650 (5A CTs) 0.01 to 130 (1A CTs)	varies	ohms	8
Z0 Line Angle	0 to 90	1	degrees	80
Line Length	0.01 to 130	0.01	units	100

Line Length describes the power line parameters for which distance is to be computed over. The parameters should be entered in units per line length with line length being the actual length of the power line. Line length is entered as unit-less quantities and, therefore, can be entered in kilometers or miles. Therefore, the distance results would be in whatever units the line length represented.

Using the Settings Explorer in BESTCOMS*Plus*, power line parameters can be entered on the System Parameters, Power System screen. Settings are provided for Positive-Sequence Impedance, Zero-Sequence Impedance, and Line Length. Refer to Figure 118.

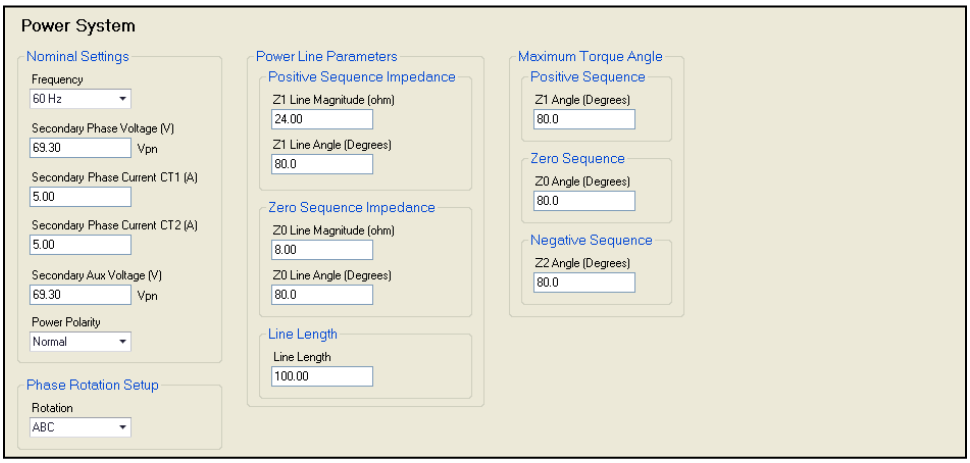


Figure 118. Power System Screen

Note that both Z1-MAG and Z0-MAG are scaled by 10 times to represent the entire length of the power line. Since the units are in kilometers, the distance results would also be in kilometers.

Distance calculations are performed post-fault using vector data captured during the actual fault. Pre-fault current vectors are captured three cycles prior to pickup. Fault voltage and current vectors are captured two cycles after the trip command is issued. The two-cycle wait time allows line transients to settle to provide results that are more accurate.

To perform the actual distance calculation, the BE1-11*f* first must determine the faulted phase. Faults can be categorized depending on the lines faulted. The various categories are LLL, LL, LLG, or LG where L = line and G = ground.

To determine the faulted phase, the fault vectors are compensated for load flow using the pre-fault data. Next, the compensated vectors are run through a series of sequence component comparisons. Once the faulted phase is determined, the fault data along with the line parameters are applied using the Takagi algorithm to determine the impedance of the faulted line. The impedance is divided by the impedance per unit length to determine the distance to fault. This method assumes the line is homogenous and that the line parameters do not change over the length specified. For a non-homogenous line, the distance would need to be manually corrected.

The distance-to-fault results are limited to ±300% of the specified line length. This limit prevents erroneous results from being displayed for non-overcurrent type faults, such as over or undervoltage faults. A computed value greater than maximum line length is reported as n/a (not applicable).

Protective Fault Analysis

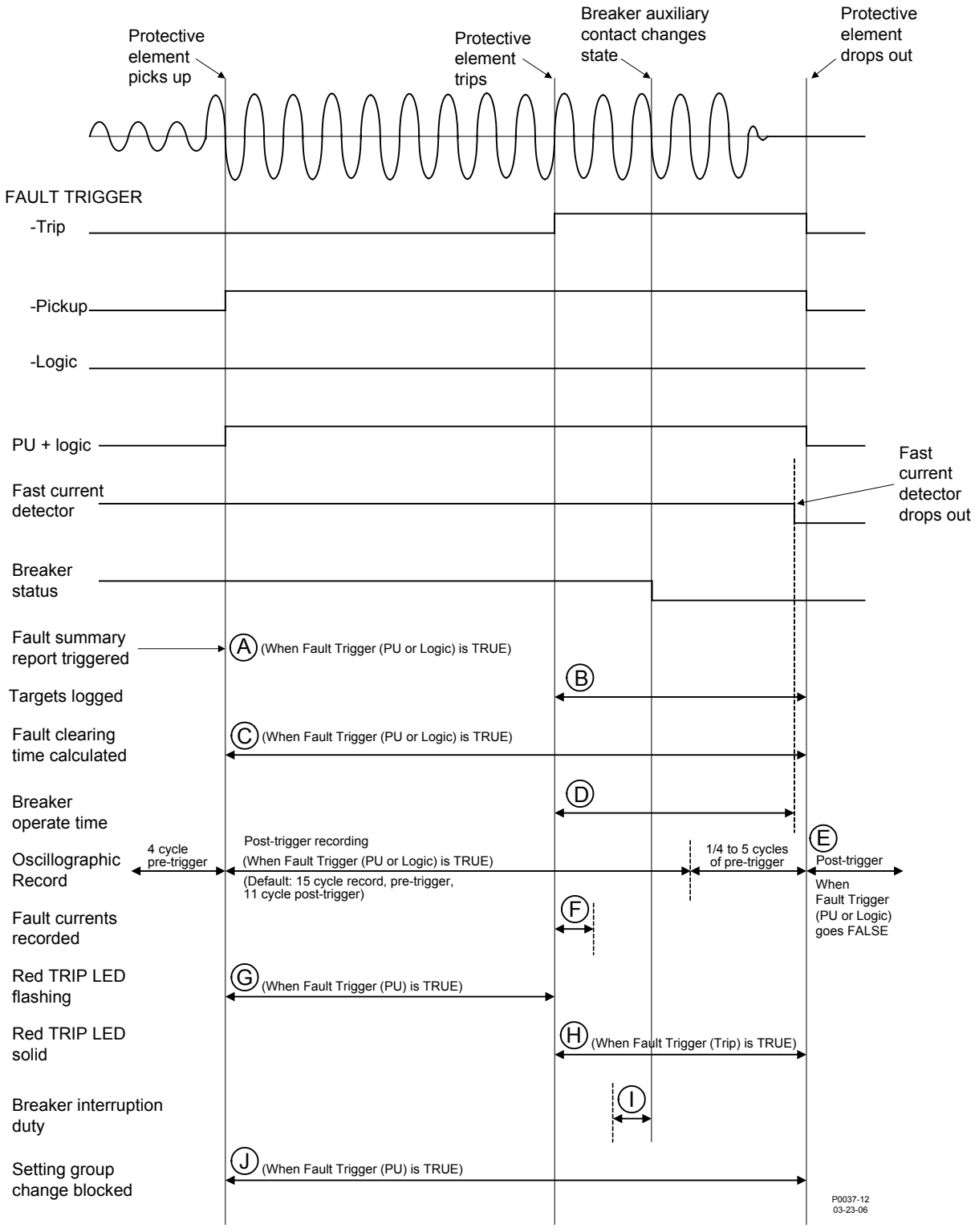


Figure 119. Protective Fault Analysis

Table 58. Legend for Figure 119

Locator	Description
A	A fault summary report and an oscillograph record are triggered when the Pickup logic expression becomes true.
B	During the time that the 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 BESTCOMS*Plus*.
C	Fault clearing time is calculated as the duration of the time that the Pickup logic expression is true.
D	Breaker operate time is calculated as the time from when the Trip logic expression becomes true until the fast 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 Pickup logic 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 the Pickup logic expression becomes false.
F	Recorded fault current, voltage, and distance magnitudes are displayed on the Targets screen of the front-panel display. The same information including phase voltage frequency, auxiliary voltage frequency, and voltage and current angles are recorded in the fault summary report. The magnitude, angle, and distance results are based on data captured two cycles after the trip output goes true. This two-cycle delay allows the line transients to settle to provide data that is more accurate. The post fault current vectors are compared to pre-fault current vectors captured three cycles prior to protective pickup to perform distance calculations. If the Trip expression does not become true, the fault was cleared by a down-stream device. For these pickup-only events, fault current, voltage, angle, and distance recorded in the fault summary report will be for the power system cycle ending two cycles prior to the end of the fault record. This is also the case if the fault record was triggered through BESTCOMS*Plus*.
G	During the time that the 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 Trip expression is true, the red Trip LED on the front panel lights steadily indicating that the relay is in a tripped state. If targets have been logged for the fault, the Trip LED is sealed in until the targets have been reset.
I	Breaker operations and interruption duty functions are driven by the breaker status function. The operations counter is incremented on breaker opening. The magnitudes of the currents that are used for accumulating breaker duty are recorded for the power system cycle ending when the breaker status changes state. Thus, breaker duty is accumulated every time that the breaker opens even if it is not opening under fault.
J	Setting group changes are blocked when the Pickup expression is true to prevent protective functions from being reinitialized with new operating parameters while a fault is occurring.

Alarms

The BE1-11*f* monitors internal relay systems, external relay interfaces, and power system equipment and annunciates an alarm when one of these components fail. An alarm can be configured as latching or non-latching with a status of major or minor. Latching alarms are stored in nonvolatile memory and are retained even when relay operating power is lost. Active alarms are displayed on the front-panel display, web page interface, and through BESTCOMS*Plus*® until they are cleared. Non-latching alarms are cleared when relay operating power is lost.

If an alarm is configured as Major, a front-panel Major Alarm LED lights when the alarm is active. The front-panel Minor Alarm LED operates in a similar manner. Each alarm provides a logic output that can be connected to a physical output or other logic input using BESTlogic™*Plus* Programmable Logic.

The ability to program the reporting and display of alarms along with the automatic display priority feature of the front-panel display gives the relay the functionality of a local and remote alarm annunciator. See the *Controls and Indicators* chapter for more information on the automatic display priority logic.

A detailed list of alarms is provided in Table 59.

Table 59. Available Alarms

Name	Description
Fuse Loss	One or more phases of voltage lost
43-1 TagB Status	43-1 virtual switch block tag set
43-2 TagB Status	43-2 virtual switch block tag set
43-3 TagB Status	43-3 virtual switch block tag set
43-4 TagB Status	43-4 virtual switch block tag set
43-5 TagB Status	43-5 virtual switch block tag set
101 TagB Status	101 breaker control switch block tag is set
Recloser Fail	Reclose fail timer timed out before breaker closed
Recloser Lockout	Recloser went through sequence without success
Breaker Fail	Breaker failure
Trip Coil Monitor	Monitored trip circuit open
IP Demand	Phase current demand
3I0 Demand	Neutral current unbalance demand
I2 Demand	Negative-sequence current unbalance demand
IG Demand	Ground current demand
VAR Pos Demand	Positive var demand maximum exceeded
Var Neg Demand	Negative var demand maximum exceeded
Watt Fwd Demand	Forward watt demand maximum exceeded
Watt Rev Demand	Reverse watt demand maximum exceeded
S Demand	Apparent power (VA) demand maximum exceeded
Changes Lost	Password access lost. Read only
Real Time Clock	Real-time clock not set
Date Time Set	The date/time was set by the user
Firmware Change	Firmware has been changed
Freq Out Of Range	Frequency is out of range
Eth Link Lost	Ethernet communication lost

Name	Description
Irig Sync Lost	IRIG failed to synchronize
Logic Equal None	Active logic = NONE
No User Setting	User settings do not exist
NTP Sync Lost	National Time Protocol (NTP) sync lost
Dnp Polls Error	DNP polling failure
Setting Change	Setting change made by user
Output Override	One or more output contacts have logic output override condition
Analog	Analog-to-digital converter error
uP Reset Alarm	Microprocessor watchdog circuit timed out
Breaker Monitor 1	Breaker alarm 1 threshold exceeded
Breaker Monitor 2	Breaker alarm 2 threshold exceeded
Breaker Monitor 3	Breaker alarm 3 threshold exceeded
Fault Report Timeout	True if fault event trigger lasts longer than 60 seconds
Programmable Alarm 1	Programmable alarm 1 is true
Programmable Alarm 2	Programmable alarm 2 is true
Programmable Alarm 3	Programmable alarm 3 is true
Programmable Alarm 4	Programmable alarm 4 is true
Programmable Alarm 5	Programmable alarm 5 is true
Programmable Alarm 6	Programmable alarm 6 is true
Programmable Alarm 7	Programmable alarm 7 is true
Programmable Alarm 8	Programmable alarm 8 is true
Programmable Alarm 9	Programmable alarm 9 is true
Programmable Alarm 10	Programmable alarm 10 is true
Programmable Alarm 11	Programmable alarm 11 is true
Programmable Alarm 12	Programmable alarm 12 is true
Programmable Alarm 13	Programmable alarm 13 is true
Programmable Alarm 14	Programmable alarm 14 is true
Programmable Alarm 15	Programmable alarm 15 is true
Programmable Alarm 16	Programmable alarm 16 is true
SGC Active	Active setting group changed
SGC Logic Override	Setting group control was overridden by logic
Settings Group 0	Setting group 0 is active
Settings Group 1	Setting group 1 is active
Settings Group 2	Setting group 2 is active
Settings Group 3	Setting group 3 is active
RTD Out of Range	Remote Module 1 or 2 Alarm
Defaults Cal Loaded	Remote Module 1 or 2 Alarm
Defaults Loaded	Remote Module 1 or 2 Alarm
Flash Failure	Remote Module 1 or 2 Alarm

Name	Description
RTD Comm Send Fail	Remote Module 1 or 2 Alarm
RTD Comm Receive Fail	Remote Module 1 or 2 Alarm
Output 1 Override Control	Override enabled on Output 1
Output 2 Override Control	Override enabled on Output 2
Output 3 Override Control	Override enabled on Output 3
Output 4 Override Control	Override enabled on Output 4
Output 5 Override Control	Override enabled on Output 5
Output Alarm Override Control	Override enabled on Output Alarm
Output 6 Override Control	Override enabled on Output 6
Output 7 Override Control	Override enabled on Output 7
Output 8 Override Control	Override enabled on Output 8

Alarm Settings

BESTCOMS*Plus* Navigation Path: Settings Explorer, Alarm Configuration, Alarms

HMI Navigation Path: Not available through the front panel

Alarms are enabled using BESTCOMS*Plus*. Use the Settings Explorer to open the Alarm Configuration, Alarms tree branch. Configure alarms by selecting Disabled, Latching, or Non-Latching from the Minor and Major drop-down menus next to the alarms. Refer to Figure 120.

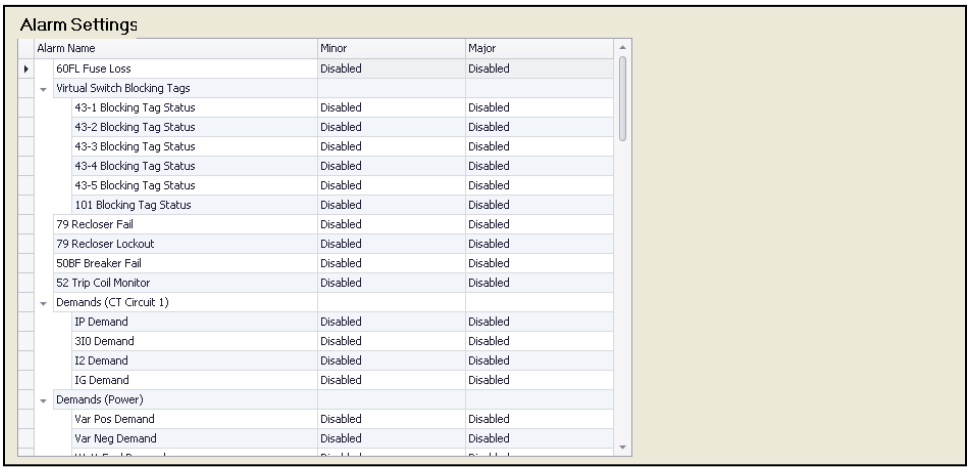


Figure 120. Alarm Settings Screen

User Programmable Alarms

BESTCOMS*Plus* Navigation Path: Settings Explorer, Alarm Configuration, User Programmable Alarms

HMI Navigation Path: Not available through the front panel

Sixteen user programmable alarms are available. BESTlogic*Plus* Programmable Logic is used to set up alarm logic. User alarm labels are programmed on the User Programmable Alarms screen (Figure 121) under Alarm Configuration. When active, the label of a user alarm is displayed on the Alarms screen on the front-panel display and in the fault report and/or sequence of events report.

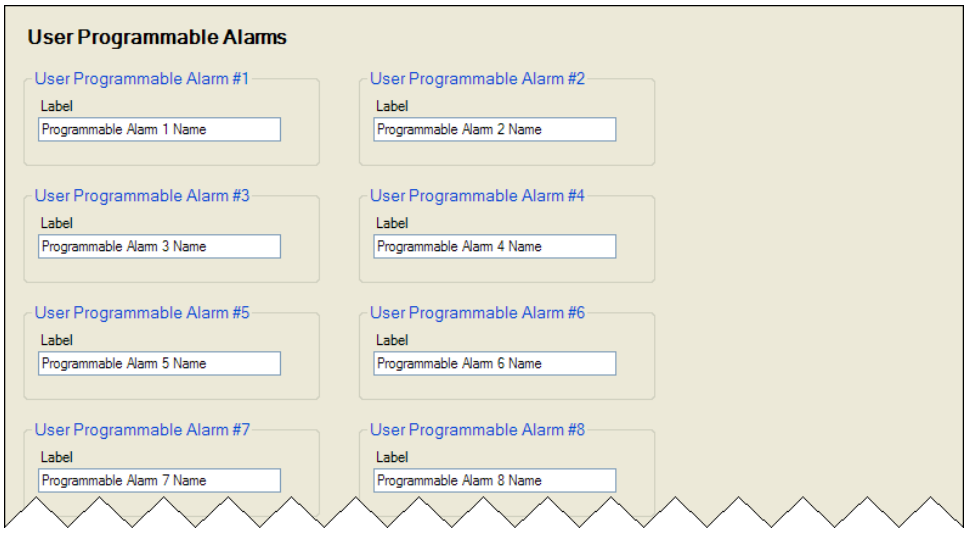


Figure 121. User Programmable Alarms Screen

Retrieving Alarm Information

BESTCOMS*Plus* Navigation Path: Metering Explorer, Status, Alarms

HMI Navigation Path: Metering Explorer, Status, Alarms

Alarms can be viewed through BESTCOMS*Plus*, the front-panel display and LED indicators, and the web page interface. Alarms are displayed in the fault reports and sequence of events reports.

To view alarms at the front-panel display, navigate to the Metering, Status, Alarms screen. All active alarms will be shown on this screen. The front-panel navigation keys can be used to scroll through the list of active alarms.

To view alarm status using BESTCOMS*Plus*, use the Metering Explorer to open the Status, Alarms screen shown in Figure 122. Alarms can be reset by clicking the Reset Alarms button under the appropriate column.

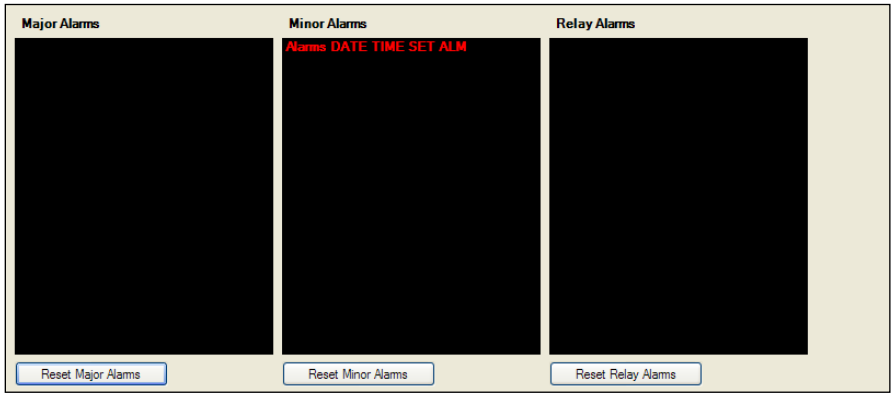


Figure 122. Alarms Screen

Resetting Alarms

A BESTlogic*Plus* expression can be used to reset the alarms. Use the Settings Explorer within BESTCOMS*Plus* to open the BESTlogic*Plus* Programmable Logic tree branch. Select the Major Alarm Reset or Minor Alarm Reset logic block from the list of Elements. The Major Alarm Reset will reset all major alarms. The Minor Alarm Reset will reset all minor alarms. Use the drag-and-drop method to connect a variable or series of variables to the Reset input. The alarm reset logic blocks are shown in Figure 123.

Figure 123. Alarm Reset Logic Block

Alarms can be cleared by pressing the Reset button on the front-panel interface while the Alarms screen is being displayed or through BESTCOMS*Plus*. Alarms cannot be reset through the web page interface.

Pressing the front-panel Reset key clears the alarms and the Major Alarm or Minor Alarm LED. Depending on device security setup, a username and password may be required to reset alarms at the front panel. Logging in is not required if the Unsecured Access Level is set to Operator or higher. Alarm reset can also be set outside of security control, allowing reset without logging in. Refer to the *Security* chapter for more information.

An alarm reset key is available as a status input in BESTlogic*Plus*. Refer to the *BESTlogicPlus* chapter for more information.

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* chapter 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 (52TCM)* chapter.

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 50BF function, the 60FL function, the 25 function, the 79 function, and the 52TCM function. The breaker status logic block is shown in Figure 124.

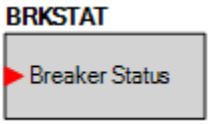


Figure 124. Breaker Status Logic Block

BESTlogic™*Plus* Settings for Breaker Status

Since the relay is completely programmable, it is necessary to program which logic variable will monitor breaker status. Breaker status is programmed using BESTCOMS*Plus*®. Use the Settings Explorer to open the BESTlogic*Plus* Programmable Logic tree branch and select the Breaker Status logic block from the list of Elements. Use the drag and drop method to connect a variable or group of variables to the input. Refer to the *BESTlogicPlus* chapter for more information on setting BESTlogic*Plus* programmable logic.

Table 60 summarizes the BESTlogic*Plus* settings for Breaker Status.

Table 60. BESTlogic*Plus* Settings for Breaker Status

Setting	Range/Purpose	Default
Breaker Status	True when the breaker is closed (e.g., 52a logic).	0

Retrieving Breaker Status and Operation Counter Information

BESTCOMS*Plus* Navigation Path: Metering Explorer, Status, Breaker Status

HMI Navigation Path: Metering Explorer, Status, Breaker Status

Breaker status can be viewed through BESTCOMS*Plus*, the front-panel display, and the web page interface.

To view breaker status using BESTCOMS*Plus*, use the Metering Explorer to open the Status, Breaker Status screen shown in Figure 125. To view breaker status at the front-panel display, navigate to Metering Explorer, Status, Breaker Status.

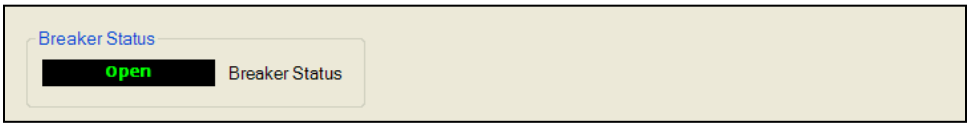


Figure 125. Breaker Status Screen

The number of breaker operations can be read at the front-panel display. 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 front-panel display. To view the breaker status using BESTCOMS*Plus*, use the Metering Explorer to open the Control, Breaker Control Switch tree branch.

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

Breaker duty monitoring is discussed in the following paragraphs.

Breaker Duty Monitoring

When the breaker opens, the current interrupted in each pole of the circuit breaker is accumulated by the breaker duty monitor. Breaker opening is defined by the breaker status monitoring function (Breaker Status). Figure 126 illustrates breaker status during a fault and protective trip. Table 61 serves as a legend for the call-outs of Figure 126.

Each time the breaker trips, the breaker duty monitor updates two sets of registers for each pole of the breaker. In the Accumulated I Duty registers, the breaker duty monitor adds the measured current in primary amperes. In the Accumulated I^2 Duty registers, the function adds the measured current in primary amperes squared. The user selects which of the two sets of duty registers are reported and monitored when setting up the breaker duty monitor.

Even though duty register values are calculated and stored in primary amperes or primary amperes-squared, the duty value is reported as a percent of maximum. The user sets the value that the relay will use for 100 percent duty (D_{MAX}). The value set for maximum duty is used directly for reporting the accumulated I Duty. The square of the value set for maximum duty is used for reporting the accumulated I^2 duty.

Since the true measure of contact wear includes a factor for arcing time (t), an assumed arcing time for the breaker should be included when choosing the setting for 100 percent interruption duty (D_{MAX}).

When testing the relay by injecting currents into the relay, the values in the duty registers should be read and recorded prior to the start of testing. Once testing is complete and the relay is returned to service, the registers should be reset to the original pre-test values. A block accumulation logic input can be used when testing so that simulated breaker duty is not added to the duty registers. The Block logic input of the breaker duty function is an OR logic term (e.g., IN1 or OUT5) which blocks the breaker monitoring logic when true (1). Block is set to zero to disable blocking. When breaker monitoring is blocked (logic expression equals 1), breaker duty is not accumulated.

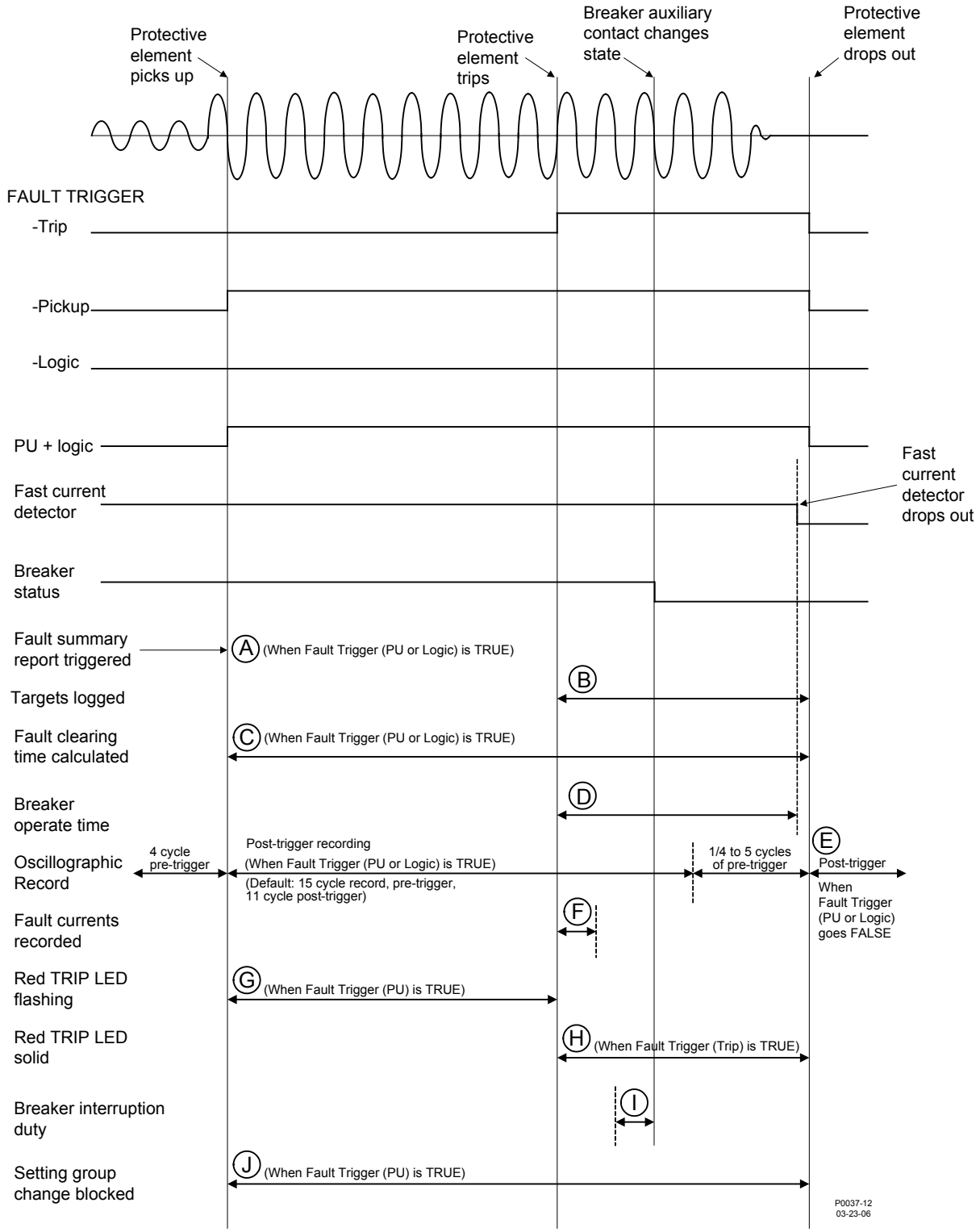


Figure 126. Protective Fault Analysis

Table 61. Legend for Figure 126

Locator	Description
A	A fault summary report and an oscillograph record are triggered when the Pickup logic expression becomes true.
B	During the time that the 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 BESTCOMS*Plus*.
C	Fault clearing time is calculated as the duration of the time that the Pickup logic expression is true.
D	Breaker operate time is calculated as the time from when the Trip logic expression becomes true until the fast 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 Pickup logic 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 the Pickup logic expression becomes false.
F	Recorded fault current, voltage, and distance magnitudes are displayed on the Targets screen of the front-panel display. The same information including phase voltage frequency, auxiliary voltage frequency, and voltage and current angles are recorded in the fault summary report. The magnitude, angle, and distance results are based on data captured two cycles after the trip output goes true. This two-cycle delay allows the line transients to settle to provide data that is more accurate. The post fault current vectors are compared to pre-fault current vectors captured three cycles prior to protective pickup to perform distance calculations. If the Trip expression does not become true, the fault was cleared by a down-stream device. For these pickup-only events, fault current, voltage, angle, and distance recorded in the fault summary report will be for the power system cycle ending two cycles prior to the end of the fault record. This is also the case if the fault record was triggered through BESTCOMS*Plus*.
G	During the time that the 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 Trip expression is true, the red Trip LED on the front panel lights steadily indicating that the relay is in a tripped state. If targets have been logged for the fault, the Trip LED is sealed in until the targets have been reset.
I	Breaker operations and interruption duty functions are driven by the breaker status function. The operations counter is incremented on breaker opening. The magnitudes of the currents that are used for accumulating breaker duty are recorded for the power system cycle ending when the breaker status changes state. Thus, breaker duty is accumulated every time that the breaker opens even if it is not opening under fault.
J	Setting group changes are blocked when the 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

BESTCOMS*Plus* Navigation Path: Settings Explorer, Alarm Configuration, Breaker Monitoring

HMI Navigation Path: Settings Explorer, Alarm Configuration, Breaker Monitor

Breaker Duty Monitoring settings are made using BESTCOMS*Plus*. Use the Settings Explorer to open the Alarm Configuration, Breaker Monitoring tree branch shown in Figure 127.

Using the pull-down menus and settings boxes, make the application-appropriate settings to the breaker duty monitoring function.

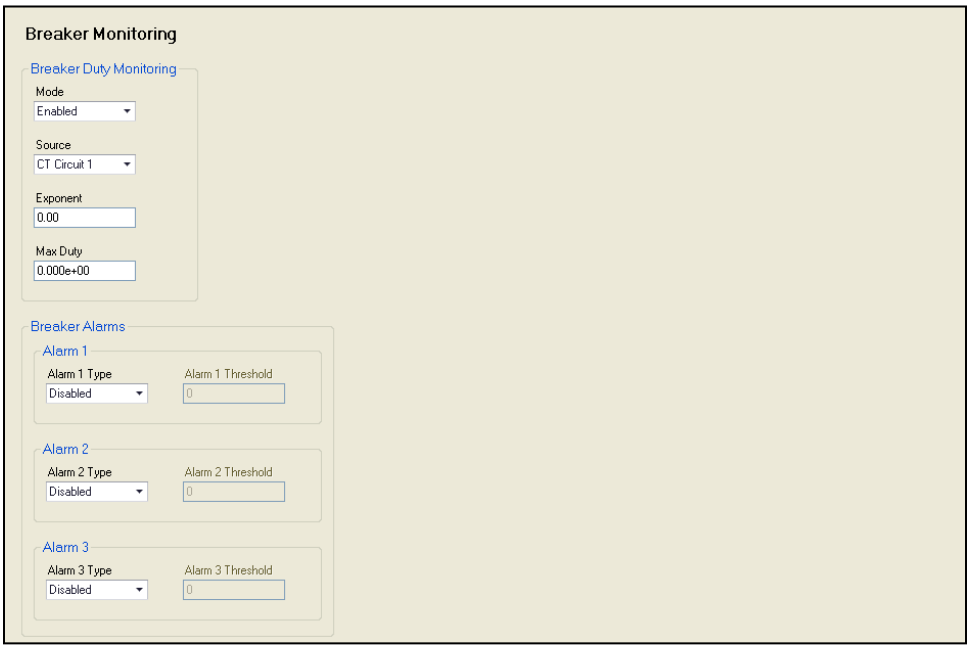


Figure 127. Breaker Monitoring Screen

To connect the Block logic input, use the Settings Explorer within BESTCOMS*Plus* to open the BESTlogic*Plus* Programmable Logic tree branch and select the breaker monitor logic block from the list of *Elements*. Use the drag and drop method to connect a variable or series of variables to the input. Refer to the *BESTlogicPlus* chapter for more information on setting BESTlogic*Plus* programmable logic.

The breaker monitor logic block is shown in Figure 128.

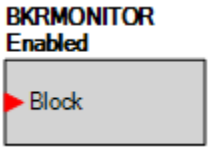


Figure 128. Breaker Monitor Logic Block

Table 62 summarizes the Breaker Duty Monitoring settings.

Table 62. Breaker Duty Monitoring Settings

Function	Range/Purpose	Default
Mode	Disabled or Enabled	Disabled
Source	Select CT Circuit 1 or CT Circuit 2	CT Circuit 1
Exponent	1 to 3 in increments of 0.01	0
Max Duty	0 to 42,000,000 in increments of 1 The Max Duty parameter represents the maximum duty that the breaker contacts can withstand before needing service. Max Duty is programmed in primary amperes using exponential floating point format.	0.000e+00
Block	Logic input that blocks the breaker monitoring logic when true. When true, breaker operations are not counted.	0

Retrieving Breaker Duty Information

BESTCOMS*Plus* Navigation Path: Metering Explorer, Reports, Breaker Monitor

HMI Navigation Path: Metering Explorer, Reports, Breaker Report

Breaker duty values can be read at the front-panel display. 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 BESTCOMS*Plus*. Use the Metering Explorer to open the Reports, Breaker Monitor screen shown in Figure 129.

Figure 129. Breaker Report Screen

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 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* chapter 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. *Breaker Alarms* provides more information about this feature.

Breaker Alarms

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

Breaker Alarms Settings

BESTCOMS*Plus* Navigation Path: Settings Explorer, Alarm Configuration, Breaker Monitoring

HMI Navigation Path: Settings Explorer, Alarm Configuration, Breaker Monitor

Settings are made using BESTCOMS*Plus*. Use the Settings Explorer to open the Alarm Configuration, Breaker Monitoring tree branch shown in Figure 127.

Using the pull-down menus and settings boxes, make the application-appropriate settings to the breaker alarms.

Table 63 summarizes the breaker alarms settings.

Table 63. Breaker Alarms Settings

Setting		Range/Unit of Measure/Increment	Default
Mode		Disabled, Duty, Operation, or Clearing Time	Disabled
Threshold	Duty	0 to 100 percent, increment = 1	0
	Operation	0 to 99,999 breaker operations, increment = 1	0
	Clearing Time	0 to 1,000 milliseconds, increment = 1	0

Demands

Demand recording promotes the ability of an electric power provider to plan for future upgrades. For example, increasing load, over time, at a substation will be reflected in the demand values. This growing demand can be addressed through additional capacity before the increasing load becomes an issue.

The BE1-11*f* continuously calculates demand values for current, watts, vars, and VA. Demand values are recorded with timestamps for peak demands and present demands. Programmable alarm points can be set to alarm if thresholds are exceeded for overload and unbalanced loading conditions. For information on enabling alarms, refer to the *Alarms* chapter.

Current

Demand values are continuously calculated for phase currents (IA, IA 2, IB, IB 2, IC, IC 2), neutral current (3I0, 3I0 2), negative-sequence current (I2, I2 2), and ground current (IG, IG 2).

Demand Current Reporting Settings

BESTCOMS*Plus* Navigation Path: Settings Explorer, Alarm Configuration, Demands

HMI Navigation Path: Settings Explorer, Alarm Configuration, Demands

Settings are made using BESTCOMS*Plus*®. Use the Settings Explorer to open the Alarm Configuration, Demands tree branch. Demand settings for current thresholds include Phase, Neutral/Ground, and Negative-Sequence. Enter the appropriate demand current reporting settings. Refer to Figure 130.

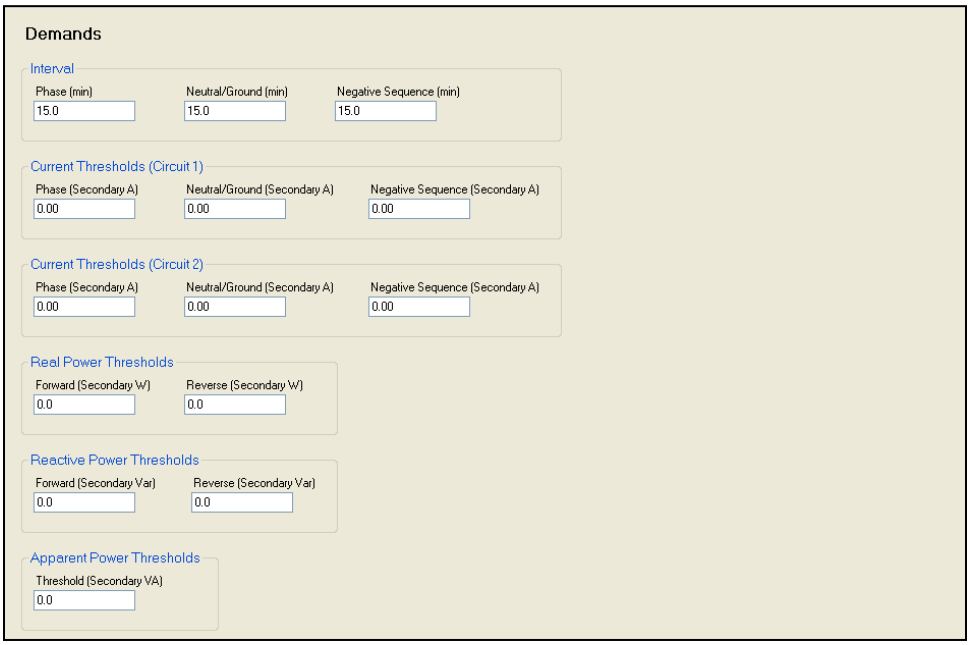


Figure 130. Demands Screen

Table 64 summarizes the demand current reporting settings.

Table 64. Demand Current Reporting Settings

Setting	Range	Increment	Unit of Measure	Default
Phase Interval	0 or 1 to 60	0.5	minutes	15
Neutral/Ground Interval	0 or 1 to 60	0.5	minutes	15
Negative-Sequence Interval	0 or 1 to 60	0.5	minutes	15
Phase Current Threshold	0 or 0.5 to 16	0.01	amps	0
Neutral/Ground Current Threshold	0 or 0.5 to 16	0.01	amps	0
Negative-Sequence Current Threshold	0 or 0.5 to 16	0.01	amps	0

Power

Demand values are continuously calculated for real power (A kW, B kW, C kW, Total kW), reactive power (A var, B var, C var, Total var), and apparent power (A VA, B VA, C VA, Total VA).

Demand Power Reporting Settings

BESTCOMS*Plus* Navigation Path: Settings Explorer, Alarm Configuration, Demands

HMI Navigation Path: Settings Explorer, Alarm Configuration, Demands

Settings are made using BESTCOMS*Plus*. Use the Settings Explorer to open the Alarm Configuration, Demands tree branch. Demand settings for real power thresholds include Forward Watt and Reverse Watt. Demand settings for reactive power include Forward Var and Reverse Var. A setting for apparent power threshold is also provided. The demand power interval is defined by the Phase Interval setting. Enter the appropriate demand power reporting settings. Refer to Figure 130.

Table 65 summarizes the demand power reporting settings.

Table 65. Demand Power Reporting Settings

Setting	Range	Increment	Unit of Measure	Default
Forward Watt Threshold	0 or 1 to 8,500	varies	watts	0
Reverse Watt Threshold	0 or 1 to 8,500	varies	watts	0
Forward var Threshold	0 or 1 to 8,500	varies	vars	0
Reverse var Threshold	0 or 1 to 8,500	varies	vars	0
VA Threshold	0 or 1 to 8,500	varies	VA	0

Retrieving Demand Reporting Information

BESTCOMS*Plus* Navigation Path: Metering Explorer, Demand

HMI Navigation Path: Metering Explorer, Demand Meter

Values and timestamps in the demand registers are reported in primary values. They can be read at the front-panel display, through BESTCOMS*Plus*, and through the web page interface.

Peak demand values can be preset by pressing the Edit key and changing the value. Write access to the Reports functional area is required to preset values at the front panel.

To access demand data through BESTCOMS*Plus*, use the Metering Explorer to open the Demand tree branch and select Demand Current (Figure 131), Demand Power (Figure 132), Demand Reactive Power,

or Demand Apparent Power. The Demand Reactive Power and Demand Apparent Power screens are similar.

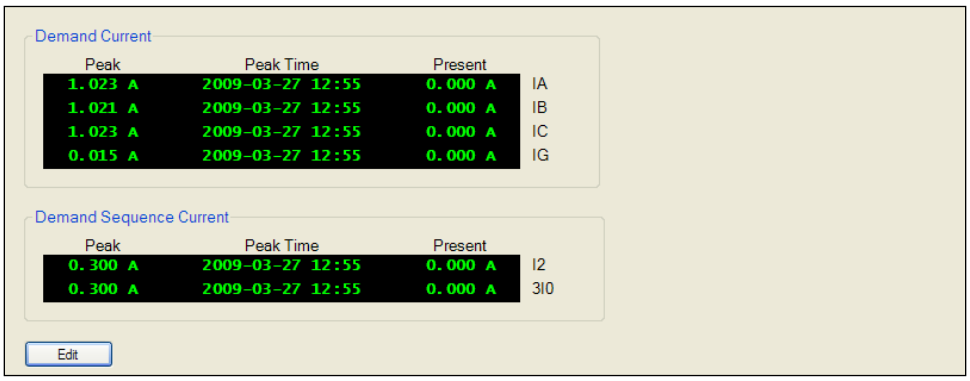


Figure 131. Demand Current Screen

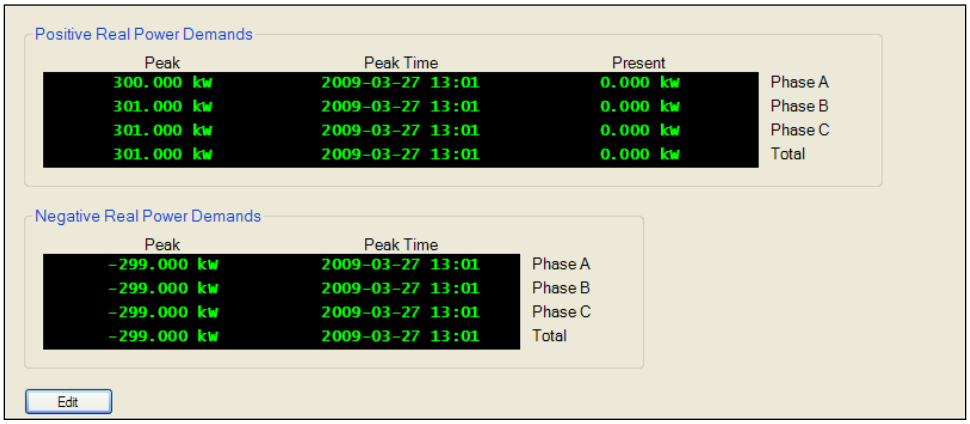


Figure 132. Demand Power Screen

Refer to the *BESTnet™Plus* chapter for information on viewing the demands through the web page interface.

Load Profile

The load profile recording function provides a running average of the demand and helps a customer determine when power factor is poor during certain times of the day, week, or month and they are paying a penalty. The load profile recording function uses a 4,000-point data array for data storage of three-phase watt, three-phase var, and phase current demand readings.

At the specified (programmed) interval, the load profile function takes the data from the demand calculation register and places it in a data array. If the programmed interval is set to 15 minutes, it will take 41 days and 16 hours to generate 4,000 entries. Load profile data is smoothed by the demand calculation function. If a step change is made in primary current, with the demand interval set for fifteen minutes, and the load profile recording interval set for one minute, it would take approximately 15 minutes for the load (step change) to reach 90% of the final level.

Setting the Load Profile Recording Function

BESTCOMS*Plus* Navigation Path: Settings Explorer, Metering Configuration, Load Profile

HMI Navigation Path: Settings Explorer, Metering Configuration, Data Log Settings

For load profile recording to log data, you must enable the function and set the demand logging interval. This can be done through BESTCOMS*Plus*®. Use the Settings Explorer to open the Load Profile screen under Metering Configuration.

The BESTCOMS*Plus* Load Profile screen is illustrated in Figure 133. Settings are listed in Table 66.

Figure 133. Load Profile Screen

Table 66. Settings for Load Profile

Setting	Range	Increment	Unit	Default
Enable Log	Disabled or Enabled	n/a	n/a	Enabled
Sample Delta	1 to 60	1	minutes	15

Retrieving Load Profile Recorded Data

BESTCOMS*Plus* Navigation Path: Metering Explorer, Reports, Load Profile

HMI Navigation Path: Not available through the front panel

Recorded load profile data can be downloaded through BESTCOMS*Plus* on the Load Profile screen under Reports of the Metering Explorer.

Power Quality

The BE1-11*f* offers class B power quality measurement performance as defined by IEC 610004-30. Power quality data consists of voltage, distortion, and dips/swells. Power quality is reported through BESTCOMS*Plus*®, the front-panel interface, and the web page interface. Refer to the *BESTnet™Plus* chapter for information on viewing the demands through the web page interface.

Power Quality Settings

BESTCOMS*Plus* Navigation Path: Settings Explorer, Metering Configuration, Power Quality

HMI Navigation Path: Settings Explorer, Metering Configuration, Power Quality

Settings are made using BESTCOMS*Plus*. Use the Settings Explorer to open the Metering Configuration, Power Quality tree branch.

Using the pull-down menus and buttons, make the application appropriate power quality settings. Refer to Figure 134.

Figure 134. Metering Configuration, Power Quality Screen

Table 67 summarizes the power quality settings.

Table 67. Power Quality Settings

Setting	Range	Increment	Unit of Measure	Default
Reference Mode	Fixed or Sliding	n/a	n/a	Fixed
Dip Hysteresis	1 to 1.3	0.01	units	1
Dip Ratio	0 or 0.7 to 1	0.01	units	0
Swell Hysteresis	0.7 to 1	0.01	units	1
Swell Ratio	0 or 1 to 1.3	0.01	units	0

Retrieving Power Quality Data

BESTCOMS*Plus* Navigation Path: Metering Explorer, Power Quality

HMI Navigation Path: Metering Explorer, Power Quality

Power quality data can be viewed using BESTCOMS*Plus*, through the front-panel interface, and through the web page interface. To view data using BESTCOMS*Plus*, use the Metering Explorer to open the Power Quality tree branch.

Power Quality Voltage

Figure 135 illustrates the Power Quality, Voltage screen.

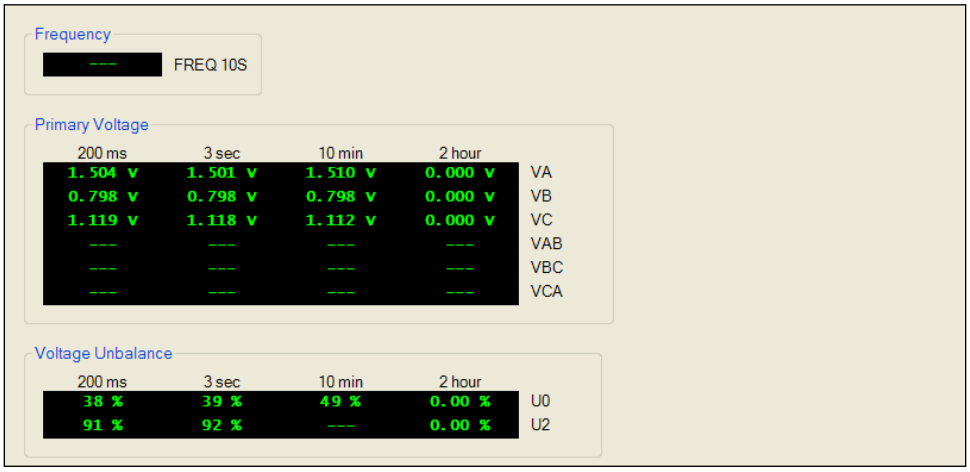


Figure 135. Power Quality, Voltage Screen

Distortion

The BE1-11*f* calculates distortion using Equation 9.

$$\sqrt{\left(\frac{Avg\ Mean\ Square\ Voltage}{Avg\ Sos\ Fund\ Voltage} - 1\right) \times 100}$$

Equation 9. Distortion Calculation

Figure 136 illustrates the Power Quality, Distortion screen.

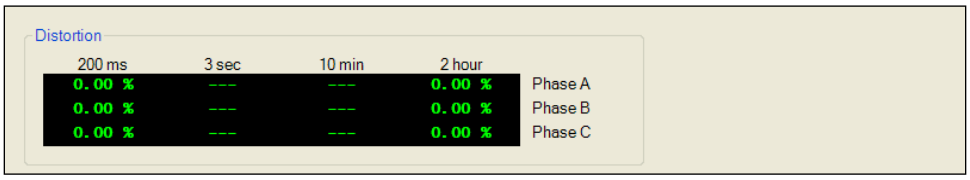


Figure 136. Power Quality, Distortion Screen

Dip/Swell

Figure 137 illustrates the Power Quality, Dip/Swell screen. The red indicator changes to green when the threshold specified in Power Quality Settings has been exceeded.

Figure 137. Power Quality, Dip/Swell Screen

Harmonics

Figure 138 illustrates the Power Quality, Harmonic Voltage screen. The Harmonic Current screen is similar.

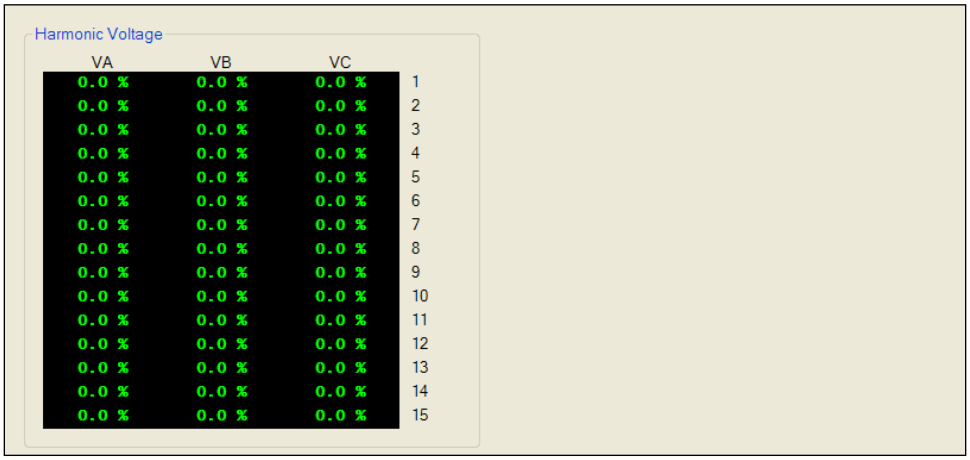


Figure 138. Power Quality, Harmonic Voltage Screen

Refer to the *BESTnetPlus* chapter for information on viewing power quality data through the web page interface.

Trip Circuit Monitor (52TCM)

A trip circuit monitor (52TCM) element continually monitors the circuit breaker trip circuit for voltage and continuity.

Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Trip Circuit Monitor (52TCM) settings screen in BESTCOMS*Plus*. A summary of the logic output and operational settings appear at the end of this chapter.

Element Operation

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. The 52TCM element detects this condition and signals an alarm. In BESTlogic*Plus*, the Alarm output can be connected to other logic elements or a physical relay output to annunciate the condition and initiate corrective action.

Breaker Status

Breaker status (open or closed) is obtained through the breaker status reporting function (configured by the Breaker Status logic block). Refer to the *Breaker Monitoring* chapter for more information.

Programmable Alarm

A 52 Trip Coil Monitor alarm occurs when the breaker status reporting function detects a closed breaker and no trip circuit voltage for the duration of a 500 millisecond coordination delay. The alarm appears on the front-panel display, web page interface, and on the Alarms metering screen in BESTCOMS*Plus*. Refer to the *Alarms* chapter for information on how to program alarms.

Detector Circuit

The detector circuit used by the 52TCM element is placed in parallel with the OUT1 contact when the TCM jumper is installed on relays in a J type case (Figure 139). The detector circuit is hardwired across the OUT1 contact on relays in an H or P type case (Figure 140). 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.

The amount of current drawn through the optical isolator circuit depends on the total input impedance for each power supply voltage rating. See Table 68 (J type case) and Table 69 (H or P type case).

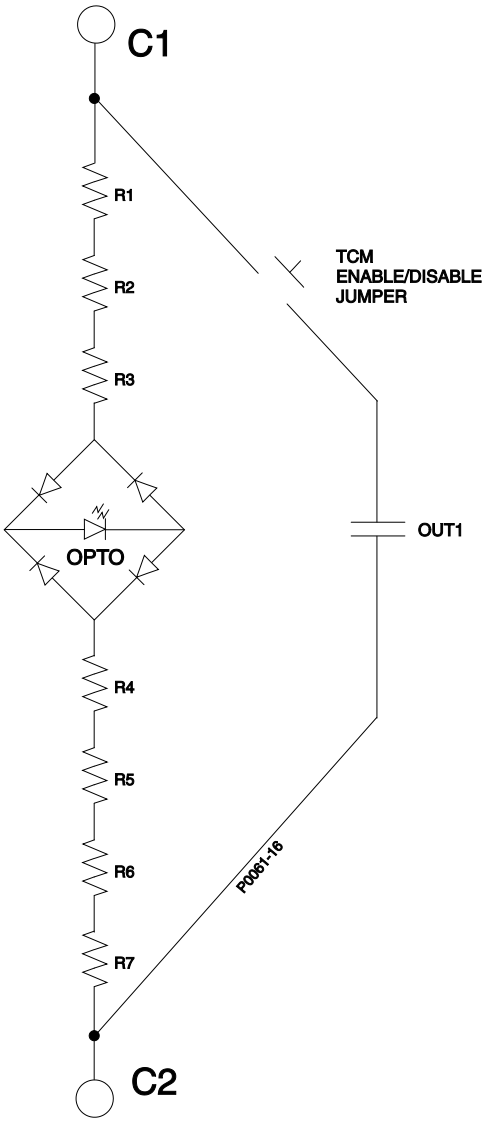


Figure 139. Trip Detector Circuit (J Type Case)

Table 68. Current Draw for each Power Supply Voltage Rating (J Type Case)

Power Supply Voltage Rating	Resistor	R Total	Optical Isolator	
			Off (25% V)	On (80% V)
24 Vdc	R1 - R7 = 2.2 kΩ	15.4 kΩ	6.0 V (390 uA)	19.2 V (1.25 mA)
48/125 Vdc	R1 = 6.8 kΩ R2 - R7 = 4.7 kΩ	35 kΩ	12.0 V (343 uA)	38.4 V (1.10 mA)
125/250 Vdc	R1 - R7 = 13 kΩ	91 kΩ	31.2 V (344 mA)	100 V (1.10 mA)

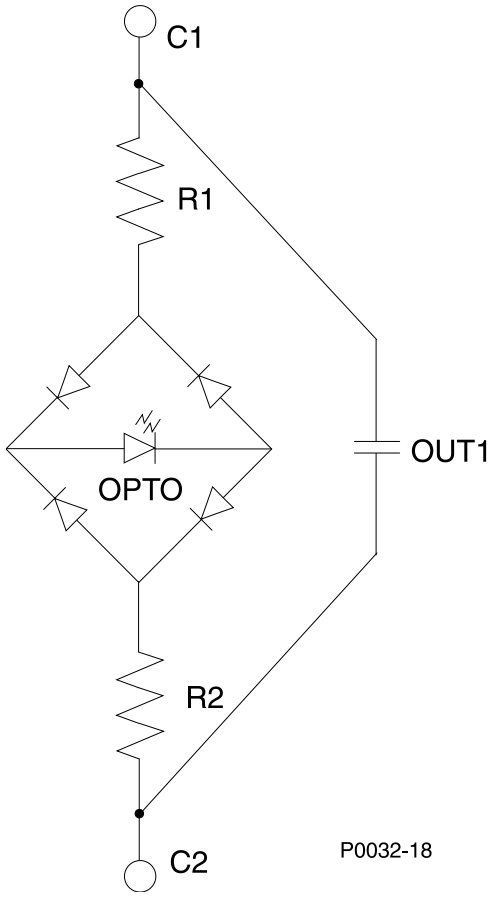


Figure 140. Trip Detector Circuit (H or P Type Case)

Table 69. Current Draw for each Power Supply Voltage Rating (H or P Type Case)

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	26.4 V (0.68 ma)	38.4 V (1.02 ma)
125/250 Vdc	47 kΩ	94 kΩ	68.7 V (0.71 ma)	100 V (1.06 ma)

Figure 141 illustrates typical trip circuit monitor connections for the BE1-11*f*.

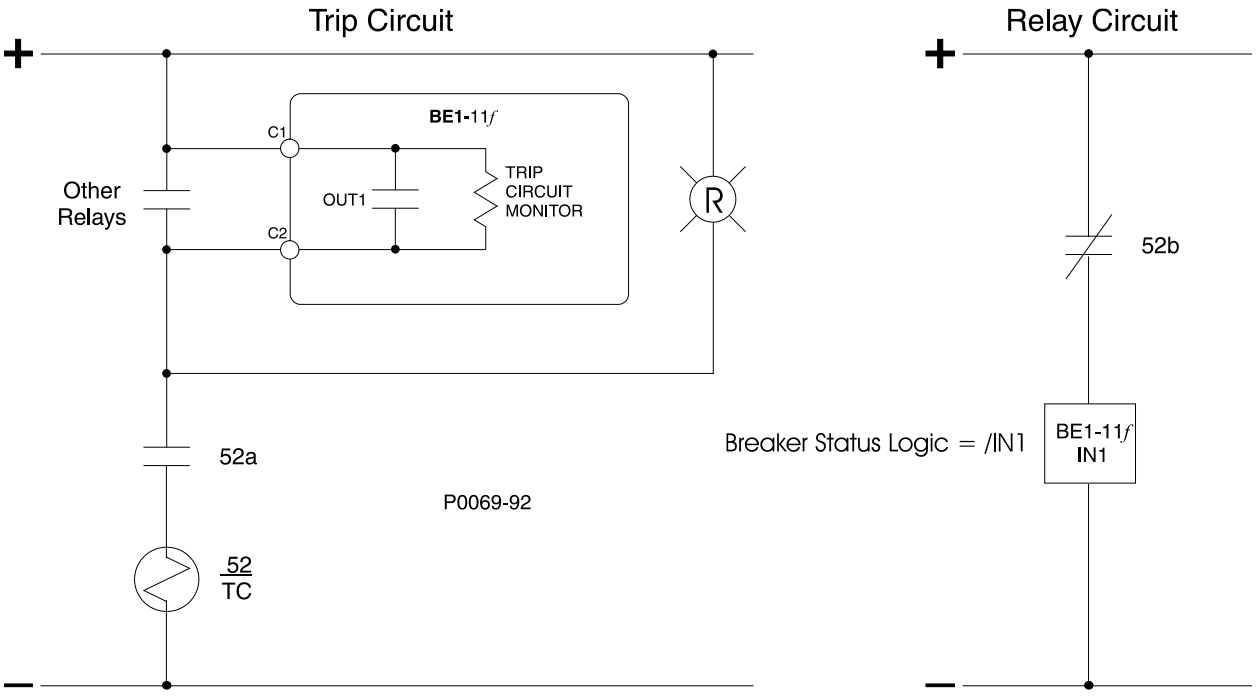


Figure 141. Trip Circuit Voltage and Continuity Monitor

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 BE1-11*f* 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 BE1-11*f* to use one of the other output relays for tripping. In this situation, the trip circuit monitor function will not be available.

In Figure 142, 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 142 to isolate the TCM circuit from the effects of 62X.

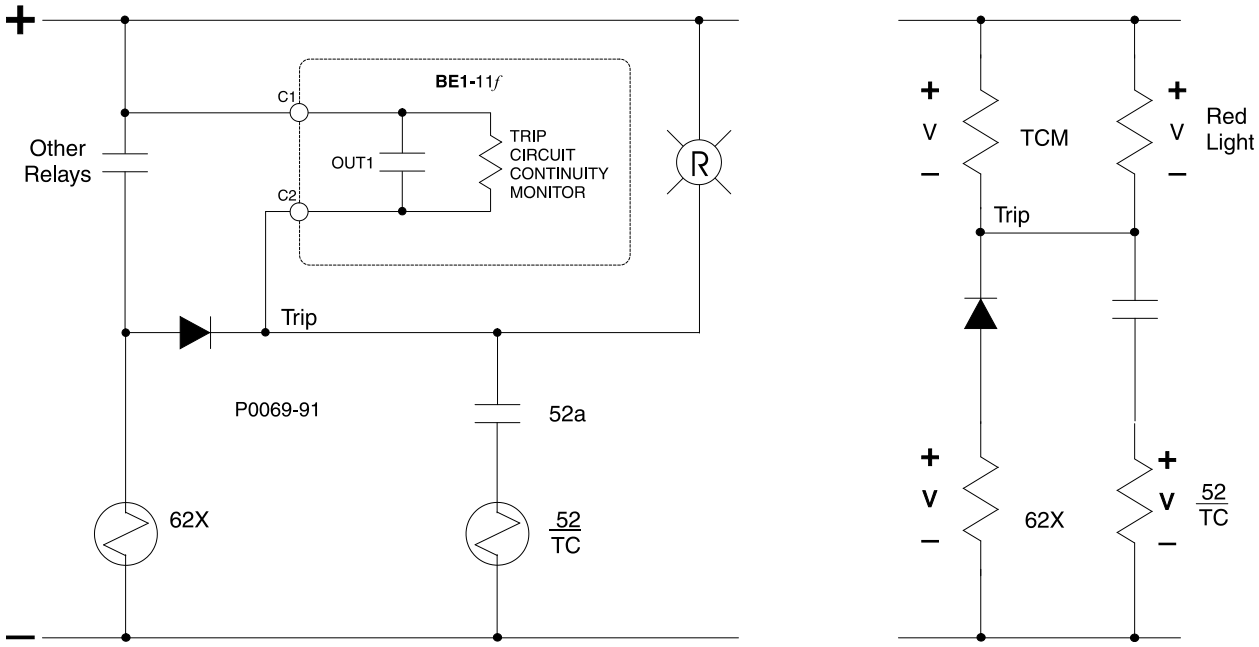


Figure 142. TCM with Other Devices

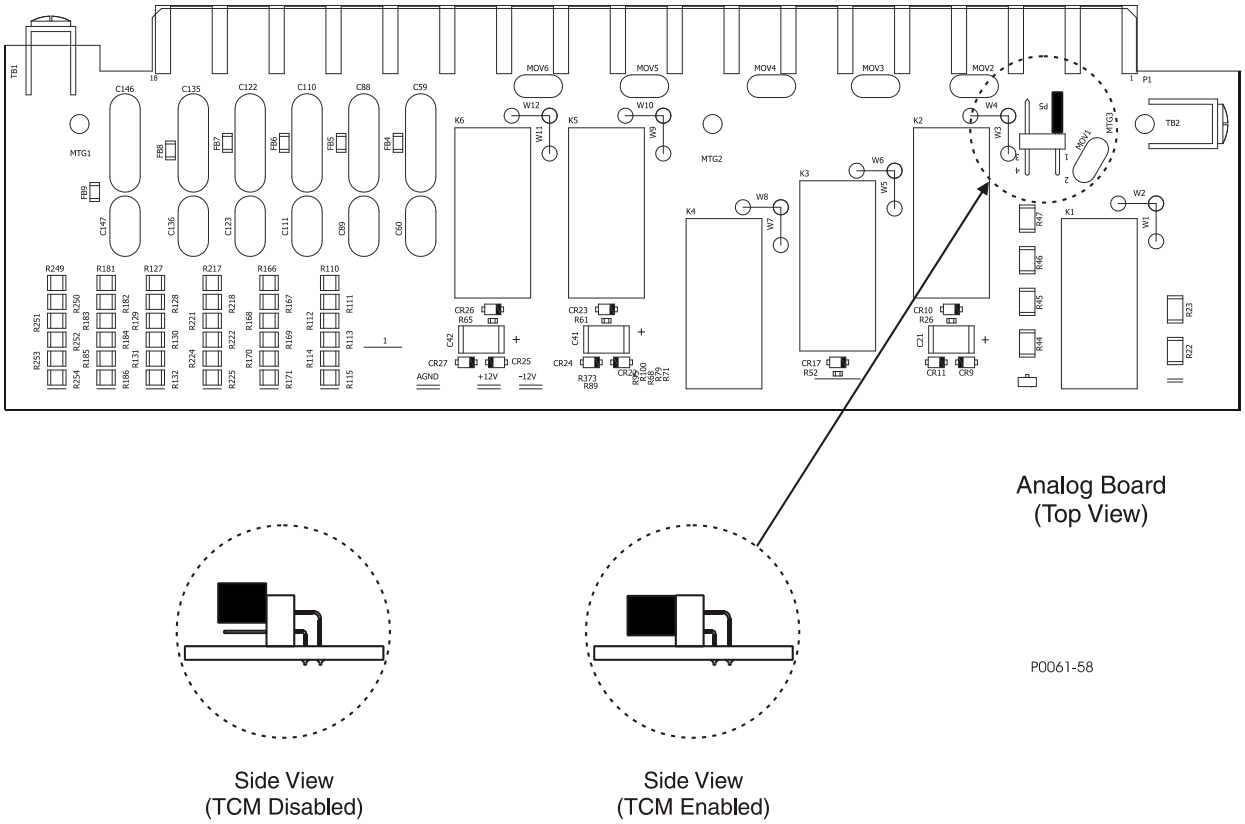
Trip Circuit Monitor (52TCM) Enable/Disable Jumper (J Type Case)

Note
A BE1-11*f* relay in a J type case is delivered with the trip circuit monitor enabled (TCM jumper connected). Read the following paragraphs before placing the relay in service.

The trip circuit monitor draws a small amount of current, even when the contact is open. See Table 68 for actual values. If the output is connected to light loads or digital inputs, it may be necessary to remove the jumper to prevent the trip circuit monitor from activating those inputs.

The following paragraphs describe how to locate and connect/remove the trip circuit monitor jumper:

1. The trip circuit monitor jumper is located behind the rear terminal block that is used for OUT1 through OUTA and voltage sensing input connections. Using a 7/64” hex tool, remove the rear terminal block. Observe all electrostatic discharge (ESD) precautions when handling the relay.
2. Locate the jumper terminal block that is mounted on the left side of the circuit board. The terminal block has four pins. With the jumper as installed at the factory, the jumper should be connected across pins 1 and 2 (left side) when viewed from the back of the unit. This jumper configuration enables the trip circuit monitor. Figure 143 illustrates the location of the jumper terminal block as well as the position of the jumper connected.
3. To disable the trip circuit monitor, remove the jumper from the two pins using needle-nose pliers. Use care when removing the jumper so that no components are damaged. Retain the jumper for enabling the trip circuit monitor in the future.
4. After removing the jumper to disable the trip circuit monitor, reinstall the rear terminal block.
5. Tighten the screws using a 7/64” hex tool. A torque of 10 in-lbs (1.12 N•m) is recommended.



Note: Relays are shipped from the factory with the jumper connected (TCM enabled).

Figure 143. Trip Circuit Monitor Enable/Disable Jumper Location

Logic Connections

Trip circuit monitor logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The trip circuit monitor element logic block is illustrated in Figure 144. The logic output is summarized in Table 70.

Figure 144. Trip Circuit Monitor Element Logic Block

Table 70. Logic Output

Name	Logic Function	Purpose
Alarm	Output	True when voltage is not detected in the trip circuit

Operational Settings

Trip circuit monitor element operational settings are configured on the Trip Circuit Monitor (52TCM) settings screen (Figure 145) in BESTCOMS*Plus*. Setting ranges and defaults are summarized in Table 71.

Figure 145. Trip Circuit Monitor Settings Screen

Table 71. Operational Settings

Setting	Range	Default
Mode	Disabled or Enabled	Disabled

Fuse Loss (60FL)

The fuse loss (60FL) element detects fuse loss or loss of potential in a three-phase system.

Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Fuse Loss (60FL) settings screen in BESTCOMS*Plus*. A summary of the logic output and operational settings appear at the end of this chapter.

BESTCOMS*Plus* Navigation Path: Settings Explorer, Alarm Configuration, Fuse Loss (60FL)

HMI Navigation Path: Settings Explorer, Alarm Configuration, Fuse Loss 60FL

Element Operation

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 the *Configuration* chapter for information on changing the nominal voltage and current values.

When the 60FL element logic becomes true, the Fuse Loss output becomes true. A logic diagram is shown in Figure 146. Logic parameters are shown in Table 72.

Trip Logic: 60FL Trip = (A * C * G * J * P) + (E * F * G * J) (See Table 72.)

Reset Logic: 60FL Reset = H * /K * /L (See Table 72.)

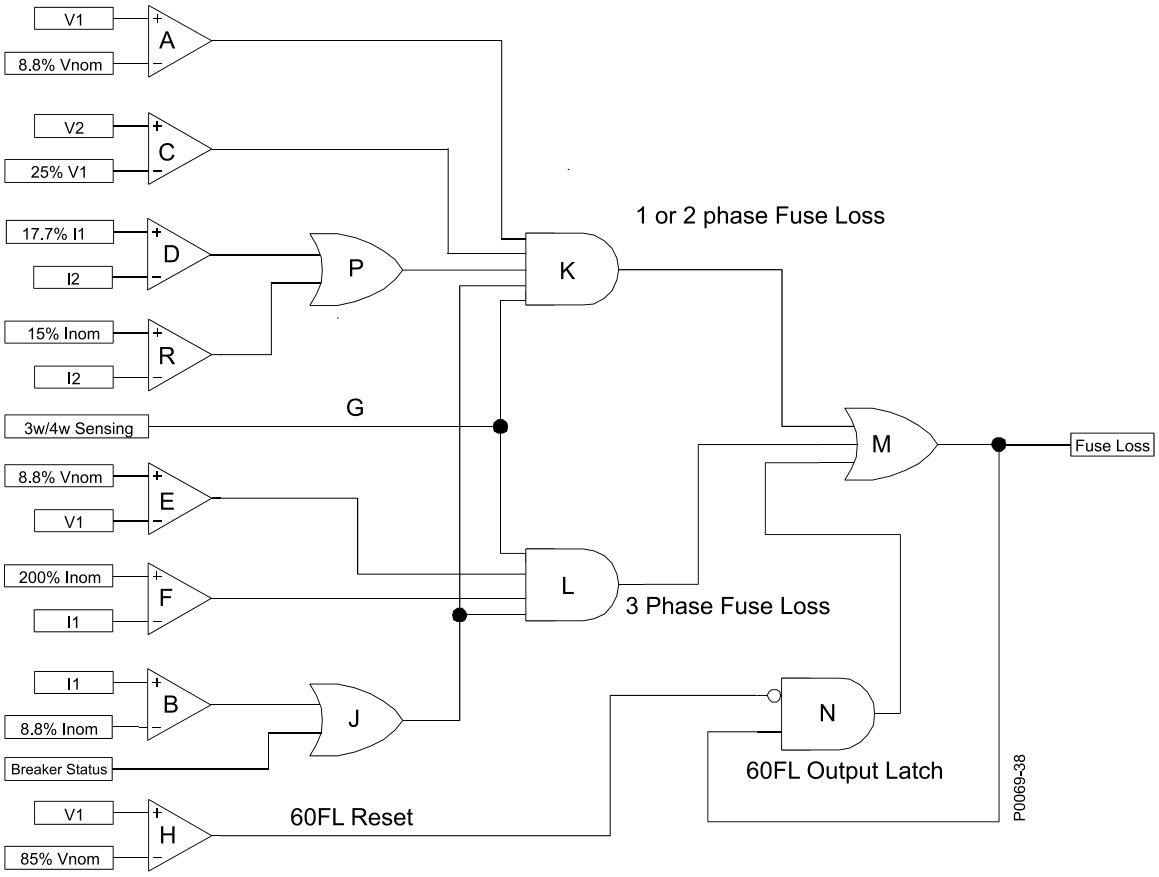


Figure 146. Fuse Loss Element Logic

Table 72. Fuse Loss Logic Parameters

Input	True Condition
A	Positive-sequence volts greater than 8.8% of the nominal voltage; Detects minimum voltage is applied.
B	Positive-sequence amps greater than 8.8% of the nominal current; Detects minimum current is applied.
C	Negative-sequence volts greater than 25% of the pos-seq volts; Detects loss of 1 or 2 phase voltages.
D	Negative-sequence amps less than 17.7% of the pos-seq amps; Detects a normal current condition.
E	Positive-sequence volts less than 8.8% of the nominal voltage; Detects loss of three-phase voltage.
F	Positive-sequence amps less than 200% of the nominal current; Detects a normal load current condition.
G	Three-wire or four-wire sensing selected.
H	Positive-sequence volts greater than 85% of nominal voltage; Detects a restored voltage condition.
J	(B + Breaker Status) Note: Breaker Status is configured by the Breaker Status logic block.
K	(A * C * G * J * P); Detects when either one or two phases are lost.
L	(E * F * G * J); Detects when all three phases are lost.
M, N	Latches the 60FL output until the reset criteria are met.
P	(R+D); Logical OR of comparators R and D to detect a normal current condition.
R	Negative-sequence amps less than 15% of the nominal current; Detects a normal current condition.

Function Blocking

User selectable block settings determine how the 51/27R, 25, 27, 59, 27X, 59X, and 32 protection functions operate when a fuse loss condition exists. The Block Voltage Control (51/27) setting assumes that the voltage is V_{NOM} when Fuse Loss 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 Block Voltage settings determine which voltage functions are blocked when the Fuse Loss logic is true. The Block Power/Power Factor setting blocks the power based functions when the Fuse Loss logic is true.

Directional Supervision

The directional tests are also supervised by the fuse loss element. If the 60FL logic is true, then voltage sensing was lost or is unreliable. Under this condition positive, negative, and zero-sequence directional tests are disabled and their bits are cleared. There is no user setting to enable or disable this supervision. Current polarization is not affected by the 60FL since it does not rely on voltage sensing. Similarly, zero-sequence voltage polarization can be performed only if 3P4W sensing is selected. The following qualifiers are applied to the voltage polarized ground direction element based on the user selected input quantity:

- V0IN inputs:
  Test: 60FL=FALSE & 3P4W=TRUE & (IN > minimum) & (IN > I1*8%) & (V0 > minimum)
- V0IG inputs:
  Test: 60FL=FALSE & 3P4W=TRUE & (IG > minimum) & (V0 > minimum)
- VXIN inputs:
  Test: (IG > minimum) & (IN > I1*8%) & (VX > minimum)
- VXIG inputs:
  Test: (IG > minimum) & (VX > minimum)

Programmable Alarm

The BE1-11*f* indicates an alarm condition when the 60FL element detects a fuse loss or loss of potential. The alarm appears on the front-panel display, web page interface, and on the Alarms metering screen in BESTCOMS*Plus*. Refer to the *Alarms* chapter for information on how to program alarms.

Logic Connections

Fuse loss logic connections are made on the BESTlogic*Plus* screen in BESTCOMS*Plus*. The fuse loss element logic block is illustrated in Figure 147. The logic output is summarized in Table 73.

Figure 147. Fuse Loss Element Logic Block

Table 73. Logic Output

Name	Logic Function	Purpose
Fuse Loss	Output	True when the 60FL logic is true

Operational Settings

Fuse loss element operational settings are configured on the Fuse Loss (60FL) settings screen (Figure 148) in BESTCOMS*Plus*. Settings are summarized in Table 74.

Figure 148. Fuse Loss Settings Screen

Table 74. Operational Settings

Setting	Purpose
Block Voltage Control (51/27)	When enabled and the 60FL logic is true (voltage sensing is lost), the current tripping level is controlled by the 51 function and the 27R function is inhibited. When enabled and the 60FL logic is false, the current tripping level is controlled by the 51/27R function.
Block Phase/V1 Voltage Elements	All functions that use phase voltage (P) and positive-sequence voltage (V1) measurements are blocked when the 60FL logic is true. (25, 27, and 59)
Block 3V0 Voltage Elements	All functions that use the three-phase residual voltage (3V0) measurement are blocked when the 60FL logic is true. (27X, 59X - 3V0 mode)
Block V2 Voltage Elements	All functions that use the negative-sequence voltage (V2) measurement are blocked when the 60FL logic is true. (27X, 59X - V2 mode)
Block Power/Power Factor Elements	All functions that use the power measurements are blocked when the 60FL logic is true. (32)

BESTnet™*Plus*

BE1-11*f* Feeder Protection Systems with an Ethernet port have a web page interface that can be used to view relay status, real-time data, demand data, faults, sequence of events, and power quality. Refer to the *Communication* chapter for information about configuring the BE1-11*f* to communicate through the Ethernet port. Verify that Enable Web Pages is selected on the Settings, Communications, Ethernet screen in the Settings Explorer of BESTCOMS*Plus*® or on the Settings, Communication, Ethernet screen of the front-panel display. Using a web browser, enter the IP Address of your BE1-11*f* relay in the address bar. The relay's IP address is found on the front-panel display under Settings, Communication, Ethernet. Figure 149 shows an example for a BE1-11*f* with an IP address of 10.0.1.106.

Figure 149. Address Bar of Web Browser

Status Page

Figure 150 illustrates the Status (home) page. Device information, firmware version, breaker status, lockout status, recloser status, alarm status, targets, local inputs status, and local outputs status are shown on this page. A green indicator illuminates to indicate an energized state for inputs and outputs.

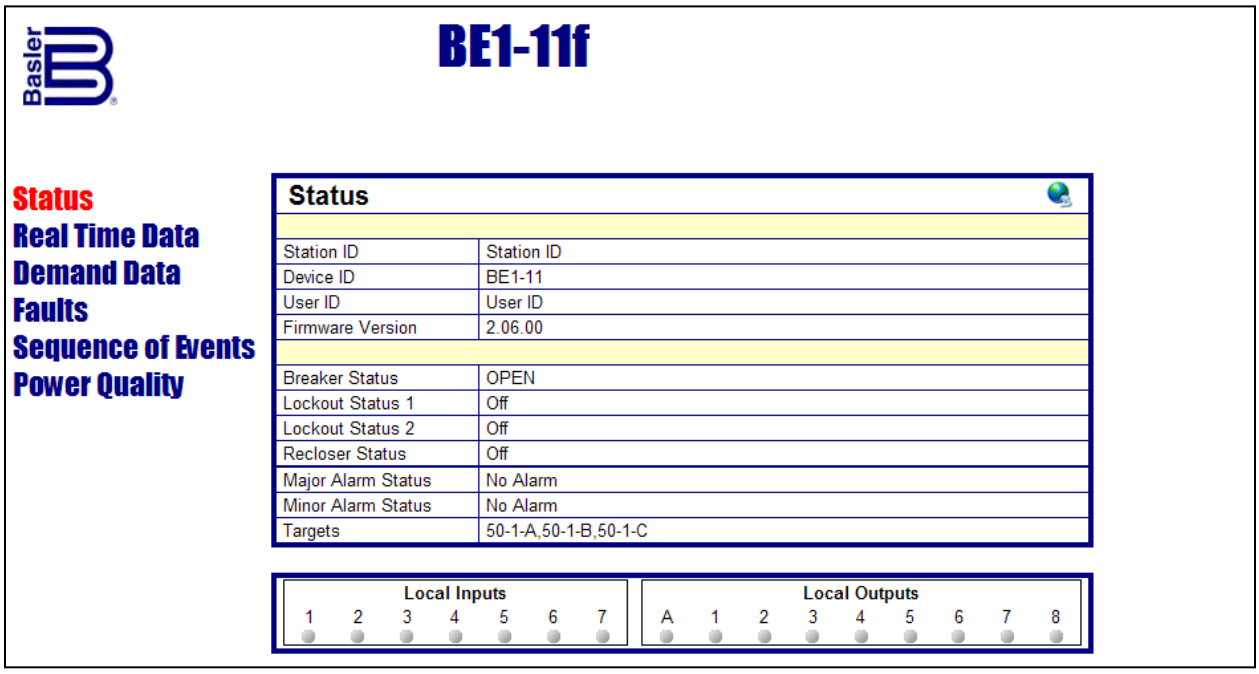
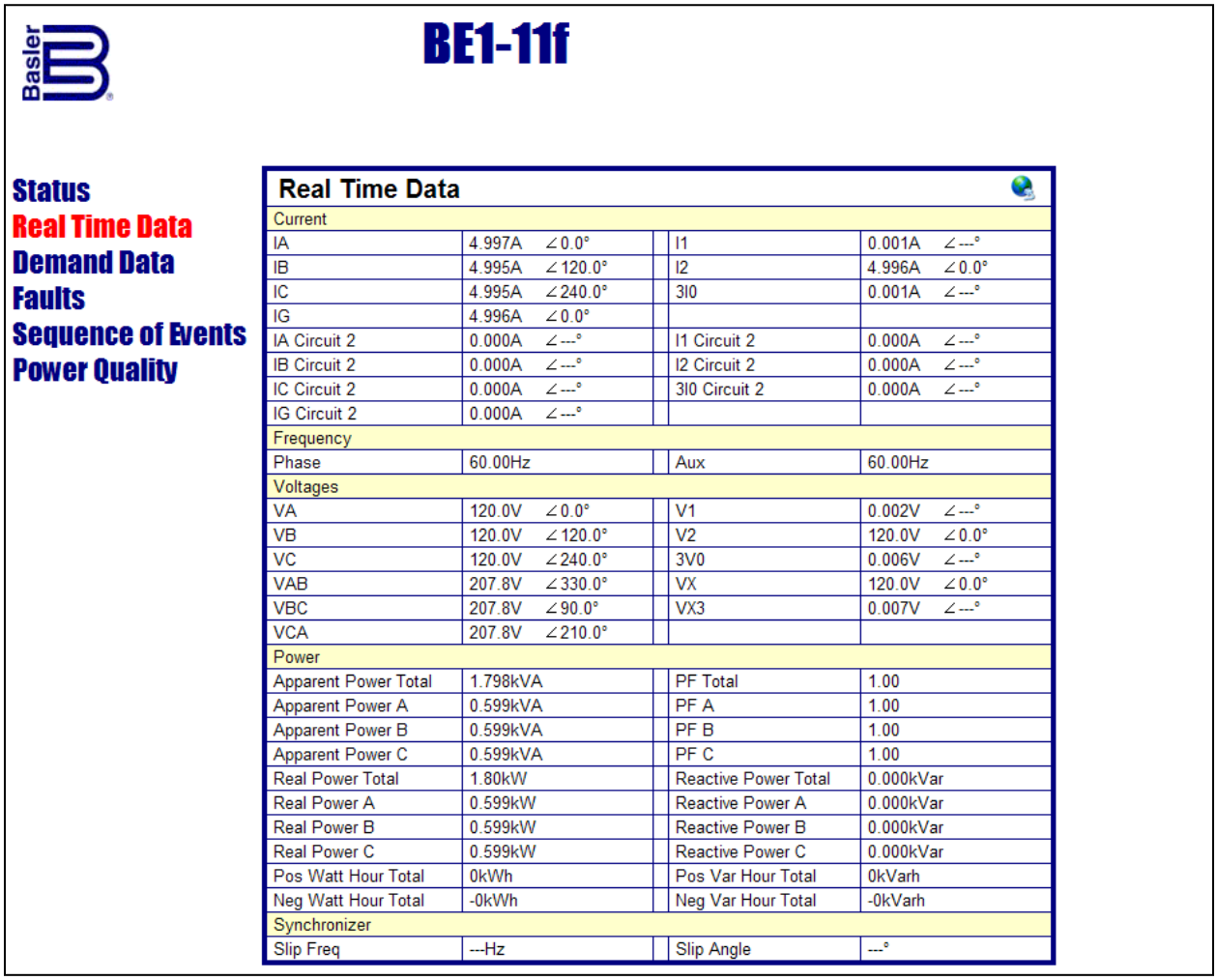


Figure 150. Status Page (Home Page)

Real Time Data

Figure 151 illustrates the Real Time Data page. Values for currents, frequency, voltages, and power are shown on this page.



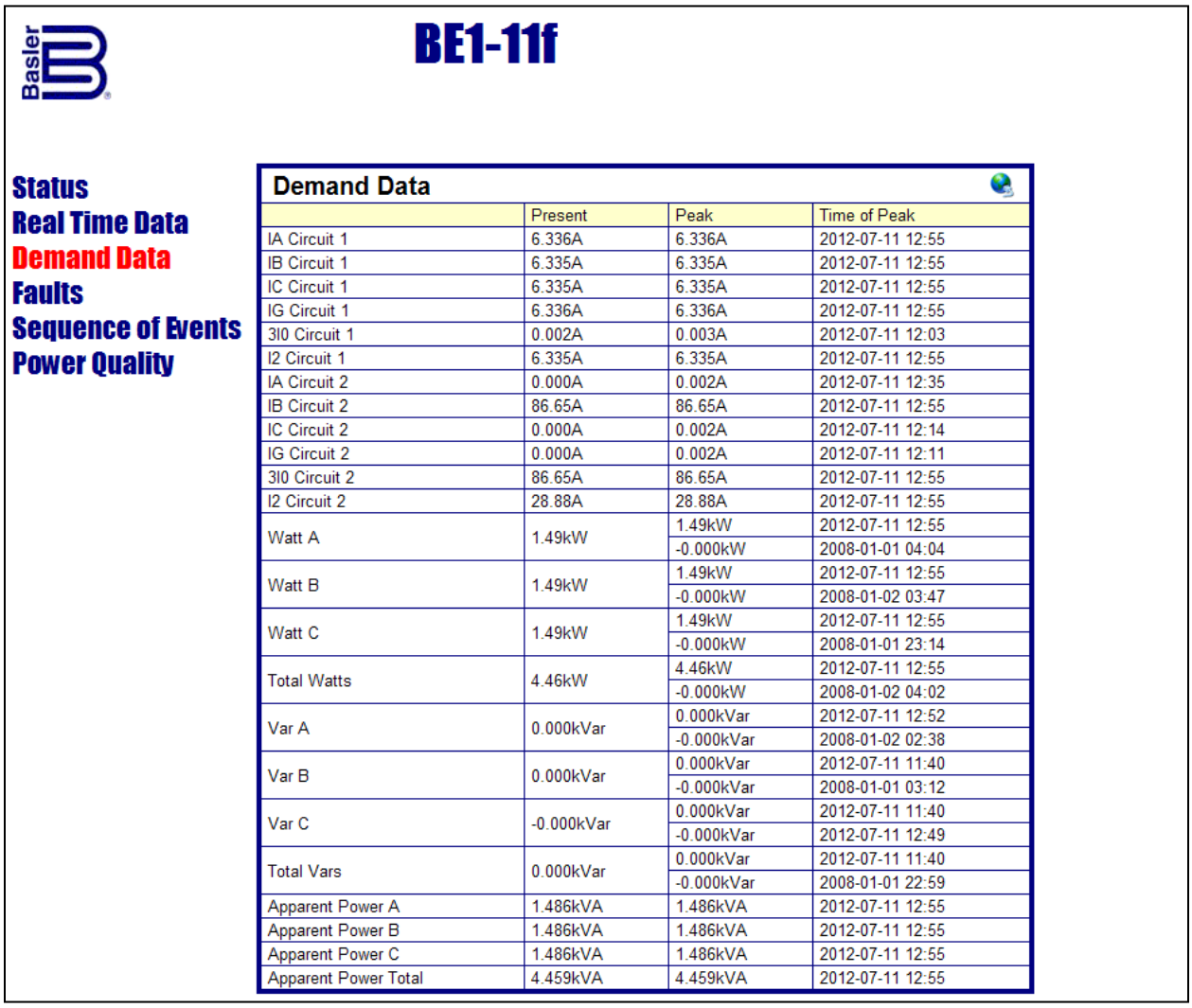
Real Time Data

Current			
IA	4.997A ∠0.0°	I1	0.001A ∠---°
IB	4.995A ∠120.0°	I2	4.996A ∠0.0°
IC	4.995A ∠240.0°	3I0	0.001A ∠---°
IG	4.996A ∠0.0°		
IA Circuit 2	0.000A ∠---°	I1 Circuit 2	0.000A ∠---°
IB Circuit 2	0.000A ∠---°	I2 Circuit 2	0.000A ∠---°
IC Circuit 2	0.000A ∠---°	3I0 Circuit 2	0.000A ∠---°
IG Circuit 2	0.000A ∠---°		
Frequency			
Phase	60.00Hz	Aux	60.00Hz
Voltages			
VA	120.0V ∠0.0°	V1	0.002V ∠---°
VB	120.0V ∠120.0°	V2	120.0V ∠0.0°
VC	120.0V ∠240.0°	3V0	0.006V ∠---°
VAB	207.8V ∠330.0°	VX	120.0V ∠0.0°
VBC	207.8V ∠90.0°	VX3	0.007V ∠---°
VCA	207.8V ∠210.0°		
Power			
Apparent Power Total	1.798kVA	PF Total	1.00
Apparent Power A	0.599kVA	PF A	1.00
Apparent Power B	0.599kVA	PF B	1.00
Apparent Power C	0.599kVA	PF C	1.00
Real Power Total	1.80kW	Reactive Power Total	0.000kVar
Real Power A	0.599kW	Reactive Power A	0.000kVar
Real Power B	0.599kW	Reactive Power B	0.000kVar
Real Power C	0.599kW	Reactive Power C	0.000kVar
Pos Watt Hour Total	0kWh	Pos Var Hour Total	0kVarh
Neg Watt Hour Total	-0kWh	Neg Var Hour Total	-0kVarh
Synchronizer			
Slip Freq	---Hz	Slip Angle	---°

Figure 151. Real Time Data Page

Demand Data

Figure 152 illustrates the Demand Data page. Present and peak demand values are shown on this page.



Demand Data

	Present	Peak	Time of Peak
IA Circuit 1	6.336A	6.336A	2012-07-11 12:55
IB Circuit 1	6.335A	6.335A	2012-07-11 12:55
IC Circuit 1	6.335A	6.335A	2012-07-11 12:55
IG Circuit 1	6.336A	6.336A	2012-07-11 12:55
3I0 Circuit 1	0.002A	0.003A	2012-07-11 12:03
I2 Circuit 1	6.335A	6.335A	2012-07-11 12:55
IA Circuit 2	0.000A	0.002A	2012-07-11 12:35
IB Circuit 2	86.65A	86.65A	2012-07-11 12:55
IC Circuit 2	0.000A	0.002A	2012-07-11 12:14
IG Circuit 2	0.000A	0.002A	2012-07-11 12:11
3I0 Circuit 2	86.65A	86.65A	2012-07-11 12:55
I2 Circuit 2	28.88A	28.88A	2012-07-11 12:55
Watt A	1.49kW	1.49kW	2012-07-11 12:55
		-0.000kW	2008-01-01 04:04
Watt B	1.49kW	1.49kW	2012-07-11 12:55
		-0.000kW	2008-01-02 03:47
Watt C	1.49kW	1.49kW	2012-07-11 12:55
		-0.000kW	2008-01-01 23:14
Total Watts	4.46kW	4.46kW	2012-07-11 12:55
		-0.000kW	2008-01-02 04:02
Var A	0.000kVar	0.000kVar	2012-07-11 12:52
		-0.000kVar	2008-01-02 02:38
Var B	0.000kVar	0.000kVar	2012-07-11 11:40
		-0.000kVar	2008-01-01 03:12
Var C	-0.000kVar	0.000kVar	2012-07-11 11:40
		-0.000kVar	2012-07-11 12:49
Total Vars	0.000kVar	0.000kVar	2012-07-11 11:40
		-0.000kVar	2008-01-01 22:59
Apparent Power A	1.486kVA	1.486kVA	2012-07-11 12:55
Apparent Power B	1.486kVA	1.486kVA	2012-07-11 12:55
Apparent Power C	1.486kVA	1.486kVA	2012-07-11 12:55
Apparent Power Total	4.459kVA	4.459kVA	2012-07-11 12:55

Figure 152. Demand Data Page

Faults

Fault Summary

Figure 153 illustrates the Fault Summary page. To view fault details and download oscillography files, click on a fault in the fault summary list.

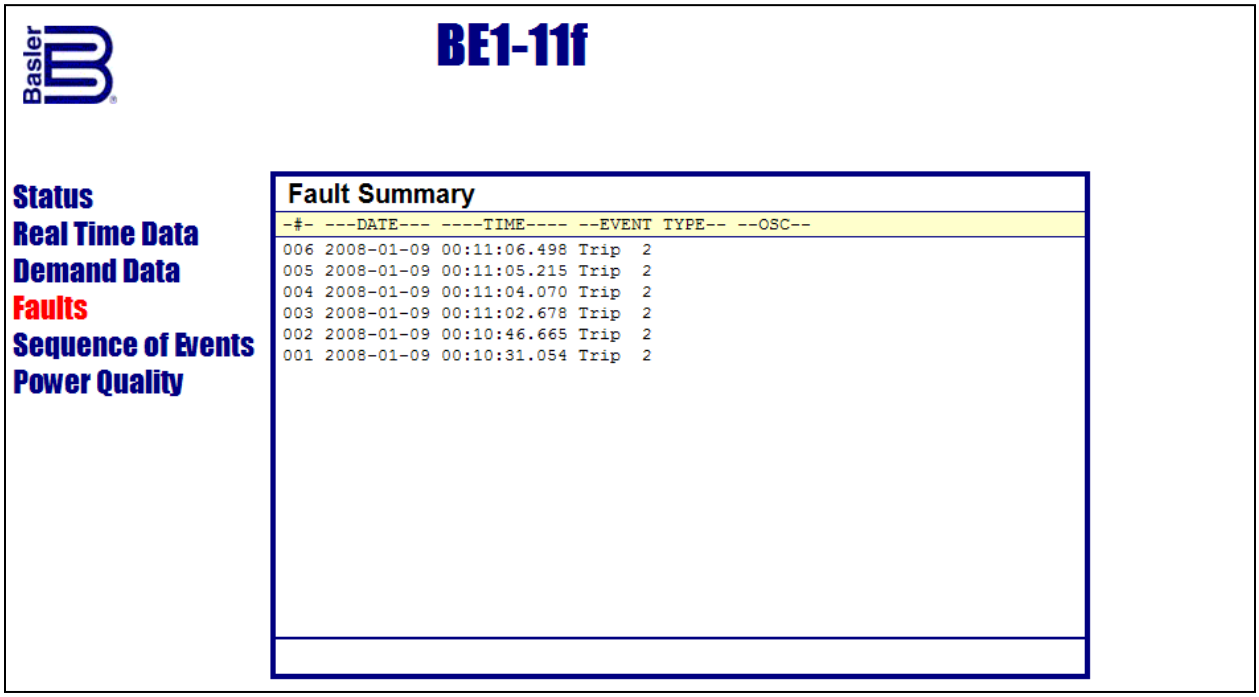


Figure 153. Fault Summary Page

Fault Details

Figure 154 illustrates the Fault Details page. Use the buttons to download oscillography files.

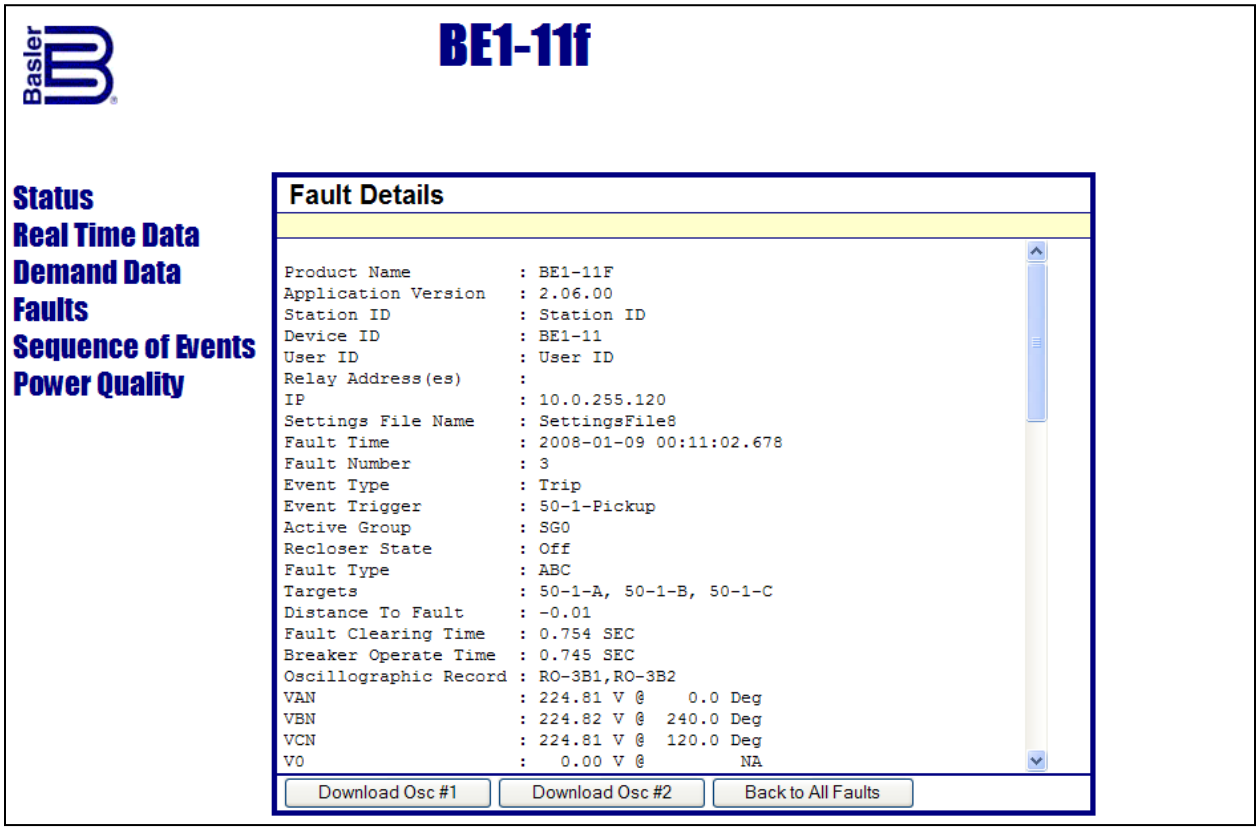


Figure 154. Fault Details Page

Sequence of Events

Figure 155 illustrates the Sequence of Events Summary page. A summary of the sequence of events is shown on this screen. The view can be customized by clicking on View New, View Protection, View Alarms, or View Targets. A selected subset of event data can be downloaded as a *.csv (comma-separated values) file.

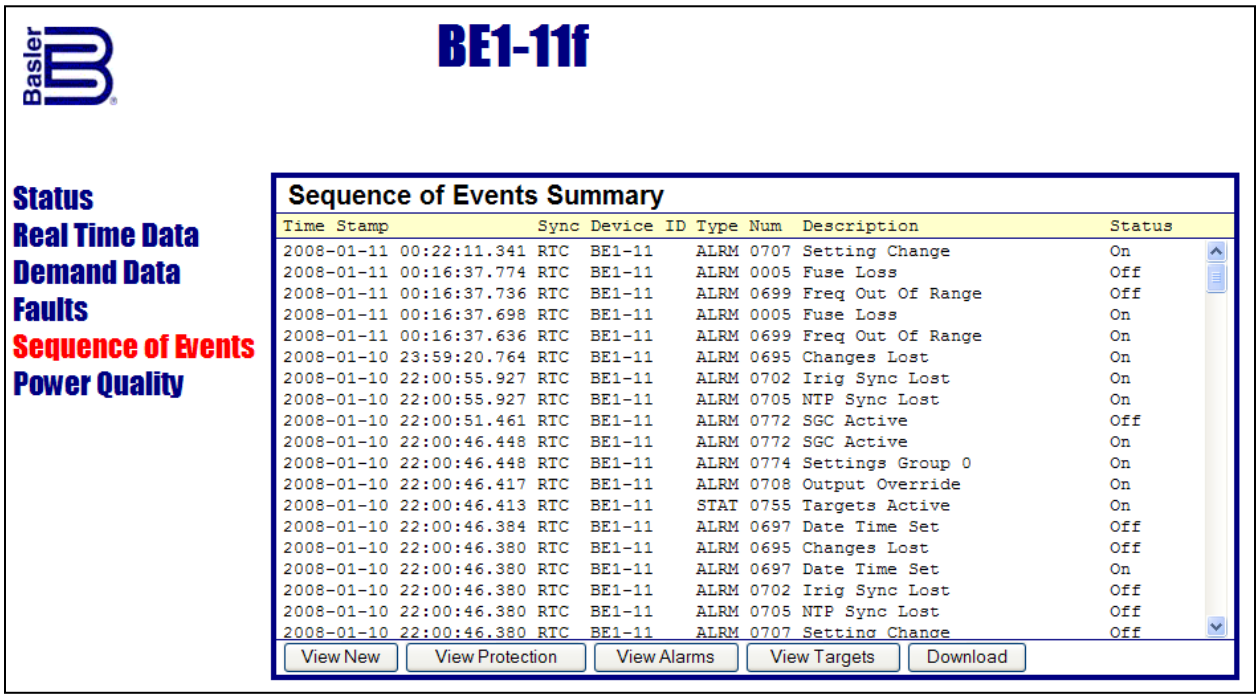
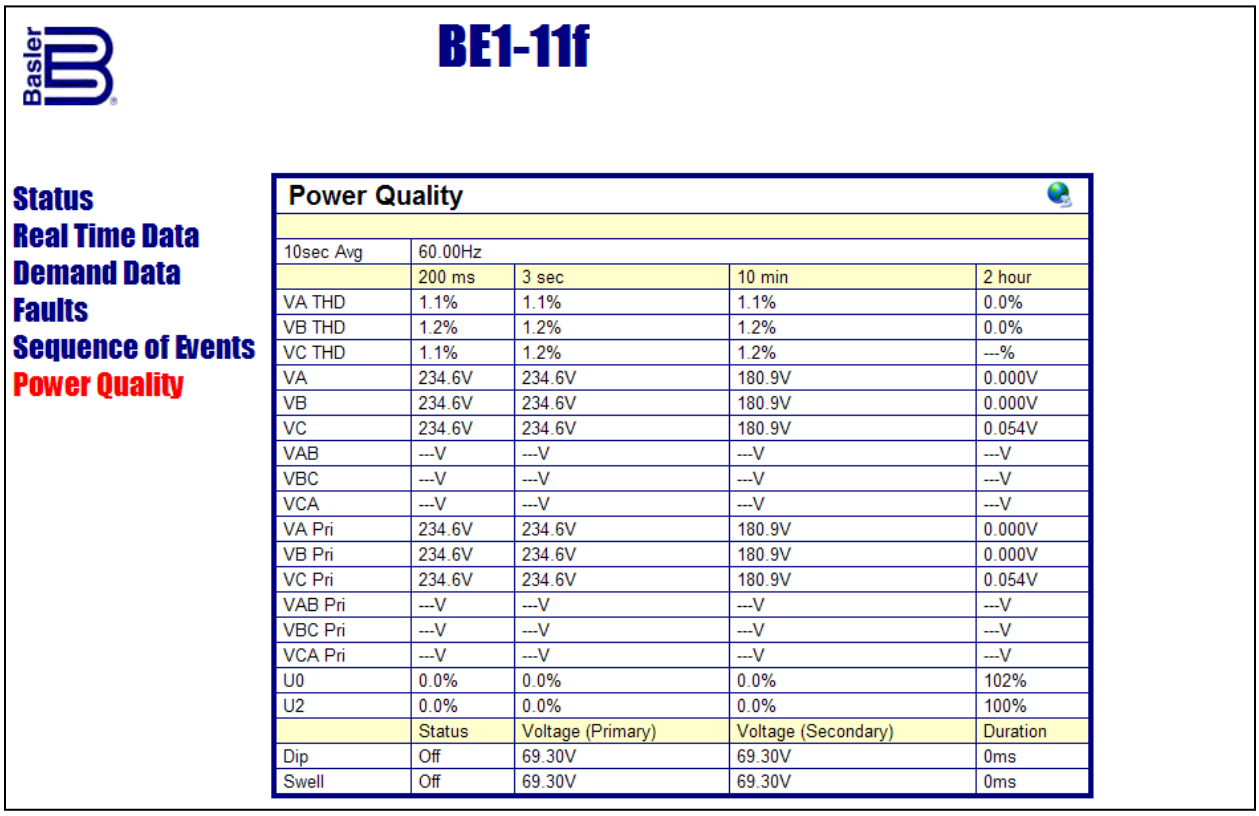


Figure 155. Sequence of Events Summary Page

Power Quality

Figure 156 illustrates the Power Quality page.



Power Quality

10sec Avg	60.00Hz			
	200 ms	3 sec	10 min	2 hour
VA THD	1.1%	1.1%	1.1%	0.0%
VB THD	1.2%	1.2%	1.2%	0.0%
VC THD	1.1%	1.2%	1.2%	---%
VA	234.6V	234.6V	180.9V	0.000V
VB	234.6V	234.6V	180.9V	0.000V
VC	234.6V	234.6V	180.9V	0.054V
VAB	---V	---V	---V	---V
VBC	---V	---V	---V	---V
VCA	---V	---V	---V	---V
VA Pri	234.6V	234.6V	180.9V	0.000V
VB Pri	234.6V	234.6V	180.9V	0.000V
VC Pri	234.6V	234.6V	180.9V	0.054V
VAB Pri	---V	---V	---V	---V
VBC Pri	---V	---V	---V	---V
VCA Pri	---V	---V	---V	---V
U0	0.0%	0.0%	0.0%	102%
U2	0.0%	0.0%	0.0%	100%
	Status	Voltage (Primary)	Voltage (Secondary)	Duration
Dip	Off	69.30V	69.30V	0ms
Swell	Off	69.30V	69.30V	0ms

Figure 156. Power Quality Page

Mounting

BE1-11*f* relays are available in two case configurations. J-option relays are supplied in a non-drawout, S1-size case that fits in a standard S1 panel opening. H- and P-option relays are supplied in an H1-size case with drawout capabilities. An H1 case can be adapted to a panel or rack for single- or double-case mounting. Adapter plates are sold separately. A BE1-11*f* relay can be mounted at any convenient angle.

J Type Case Cutouts and Dimensions

Front dimensions are shown in Figure 157 and side dimensions are shown in Figure 158. Case cutout and drilling dimensions are shown in Figure 159. Dimensions are shown in inches [millimeters]. The adapter bracket shown in Figure 160 allows a single relay to be mounted in a GE S2 or FT21/22 opening. The adapter bracket shown in Figure 161 allows a single relay to be mounted in an FT-31/32 opening. The adapter bracket shown in Figure 162 allows a single relay to be mounted in a Basler M1, GE M1, or GE M2 opening.

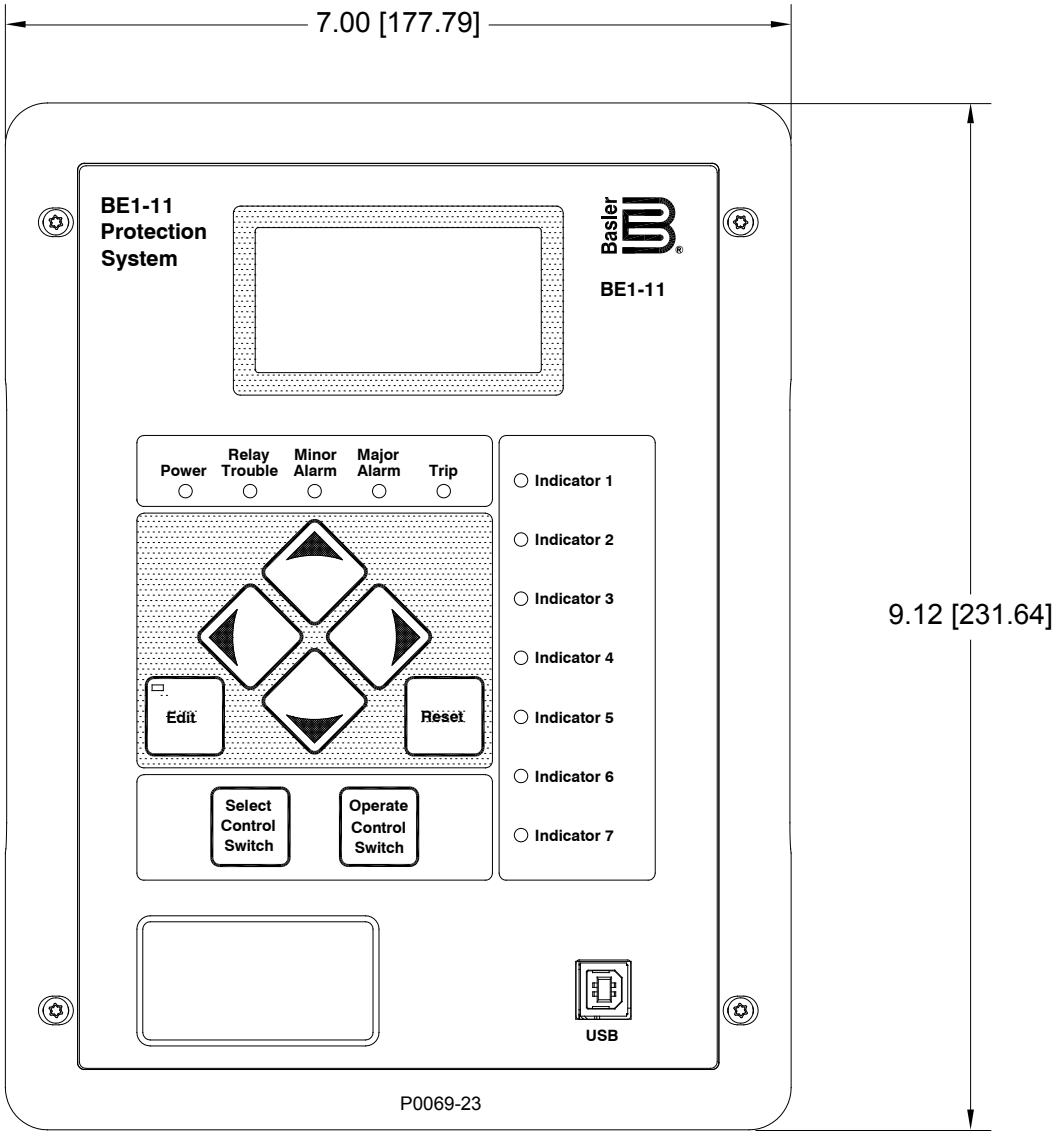


Figure 157. J Type Case - Front Dimensions

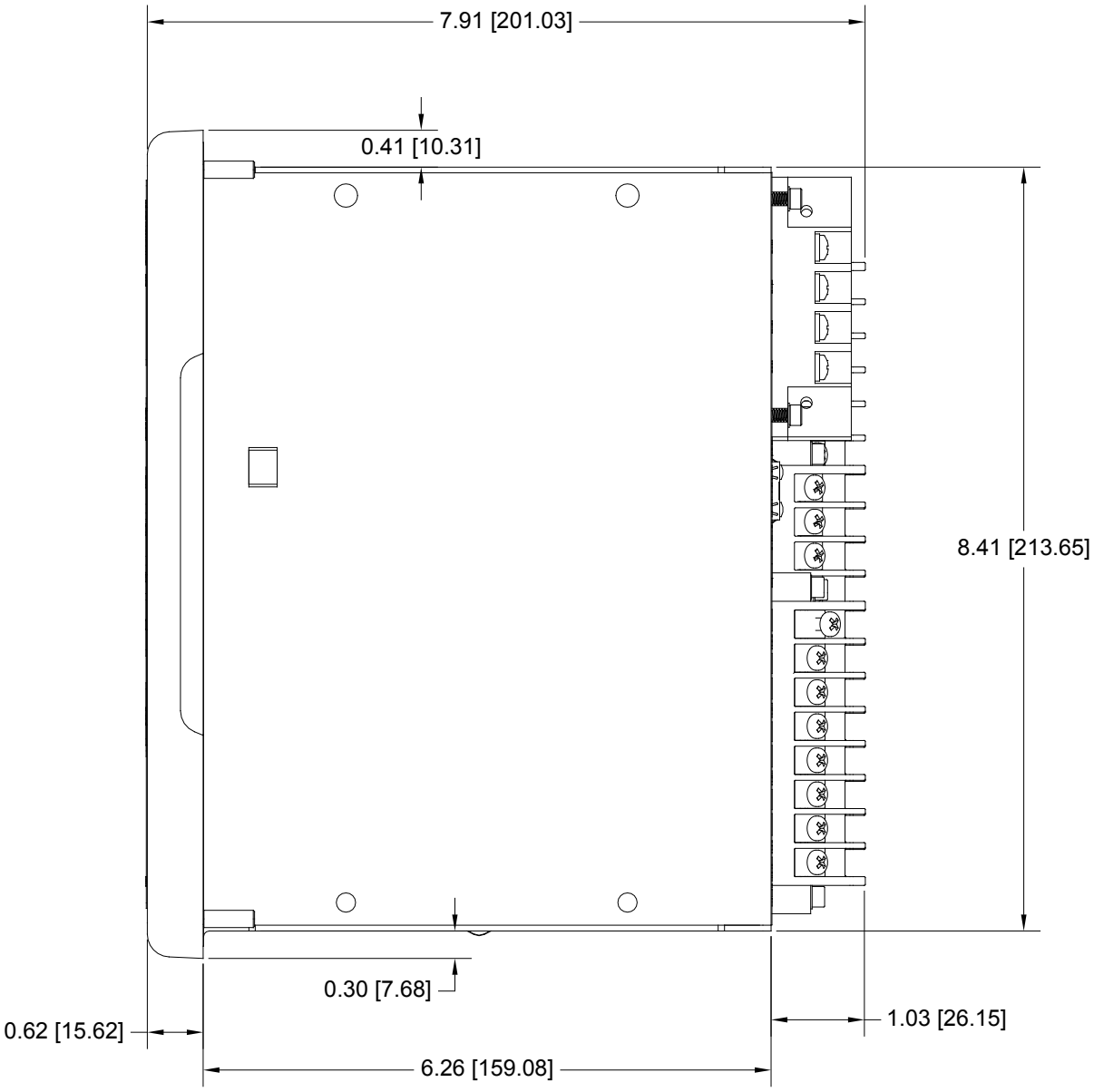


Figure 158. J Type Case - Side Dimensions

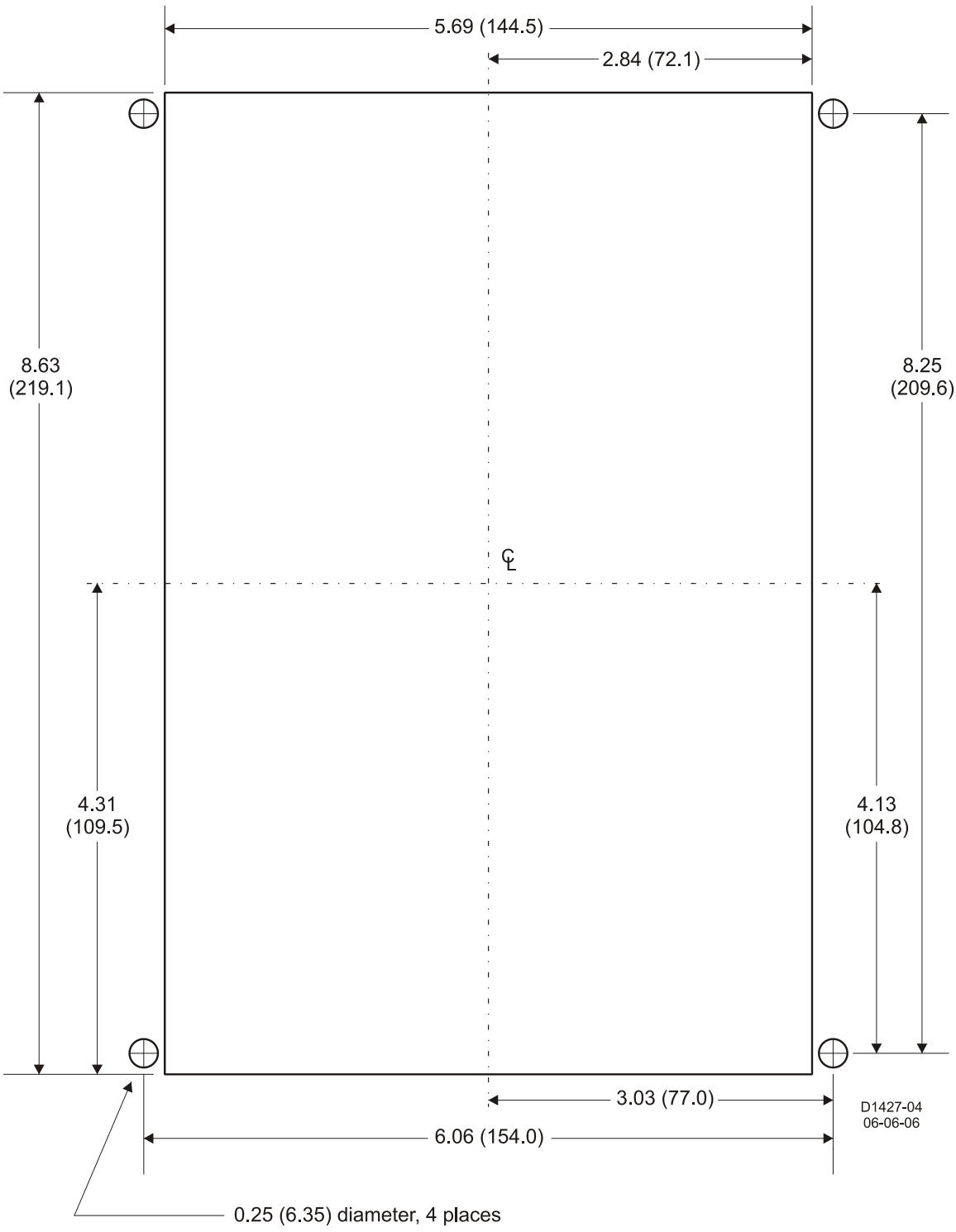


Figure 159. J Type Case - Cutout and Drilling Dimensions

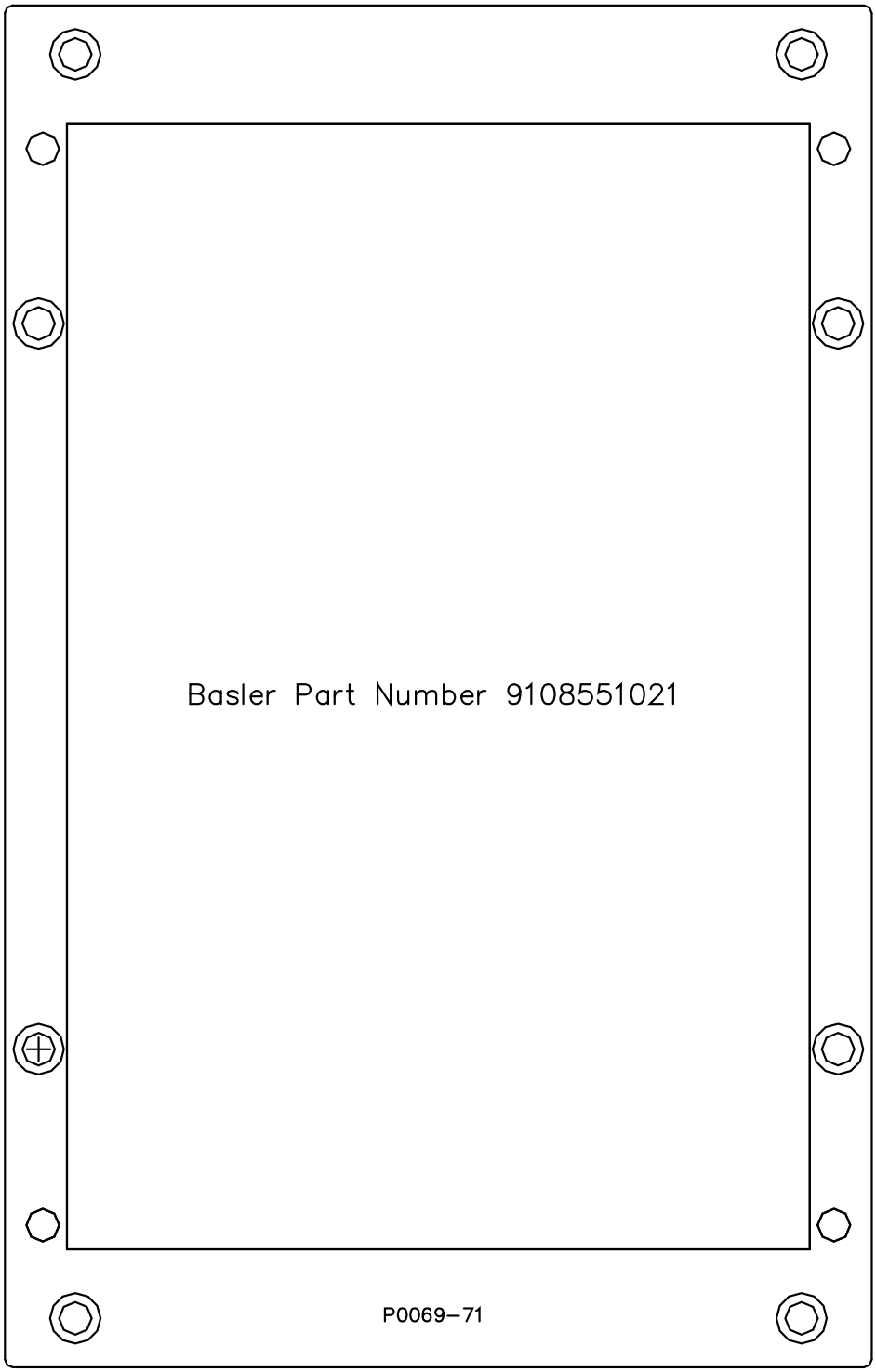


Figure 160. Adapter Plate for GE S2 and FT21/22 Opening

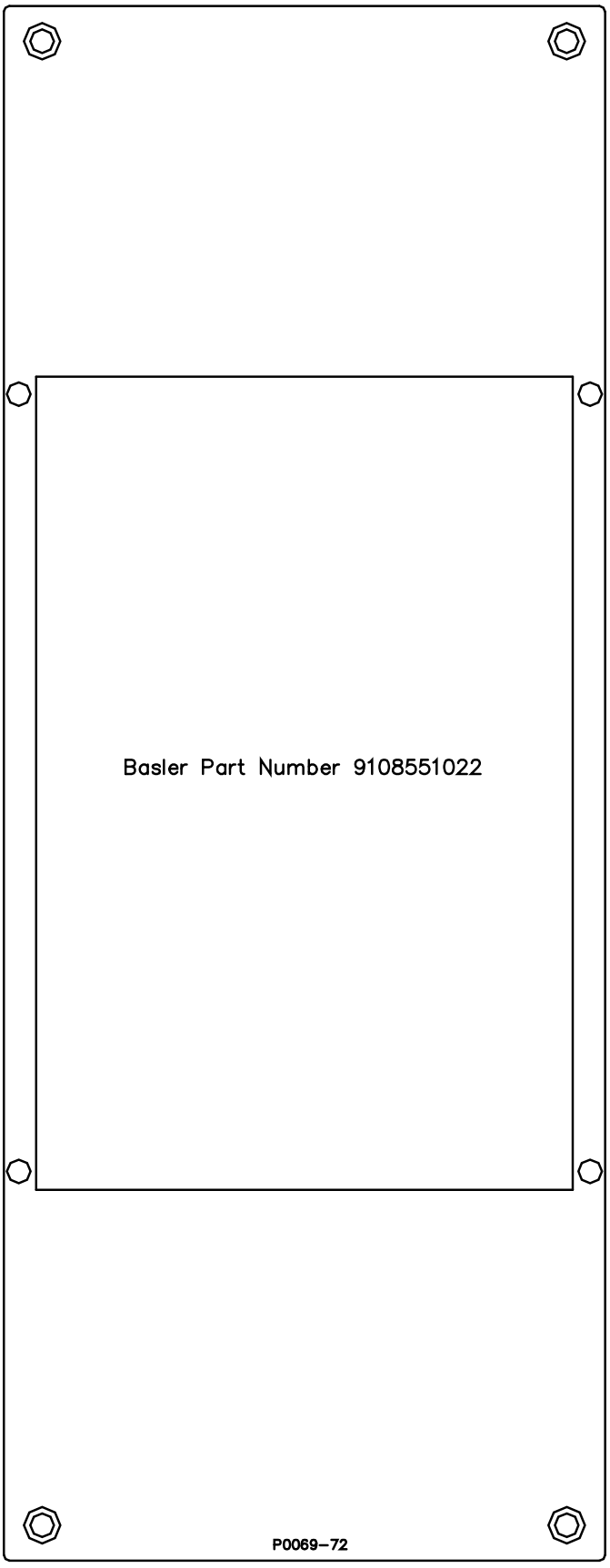


Figure 161. Adapter Plate for FT31/32 Opening

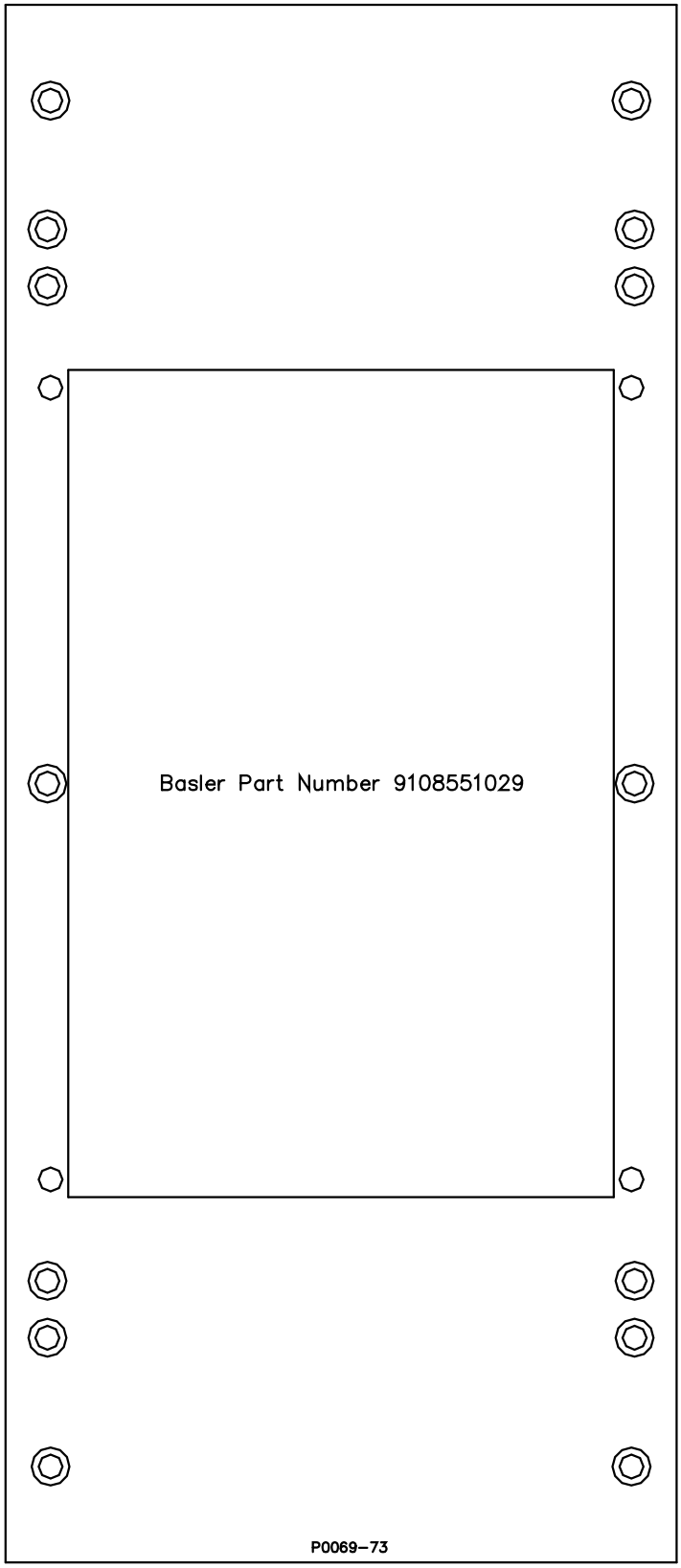


Figure 162. Adapter Plate for Basler M1, GE M1, and GE M2 Opening

H or P Type Case Cutouts and Dimensions

H1 rack-mount package dimensions are shown in Figure 163. H1 panel-mount package dimensions are shown in Figure 164.

Adapter bracket 9289924100 allows a single relay to be mounted in a 19-inch rack (see Figure 165). A second adapter bracket (9289929100) performs the same function but includes a cutout for an ABB FT switch (see Figure 166).

Two escutcheon plates are available for panel mounting. Part number 9289900017 is used for panel mounting a single relay. Part number 9289900016 is used to panel mount two dovetailed relays.

Mounting plate cutout and drilling dimensions for a single H1 relay are shown in Figure 167. If a single H1 relay (H style case) is to be panel mounted without an escutcheon plate, the cutout and drilling dimensions of Figure 168 should be used. If a single H1 relay (P style case) is to be panel mounted without an escutcheon plate, the cutout and drilling dimensions of Figure 169 should be used.

Mounting plate cutout and drilling dimensions for two dovetailed H1 relays are shown in Figure 170. Figure 171 gives the cutout and drilling dimensions for panel mounting two dovetailed cases without an escutcheon plate.

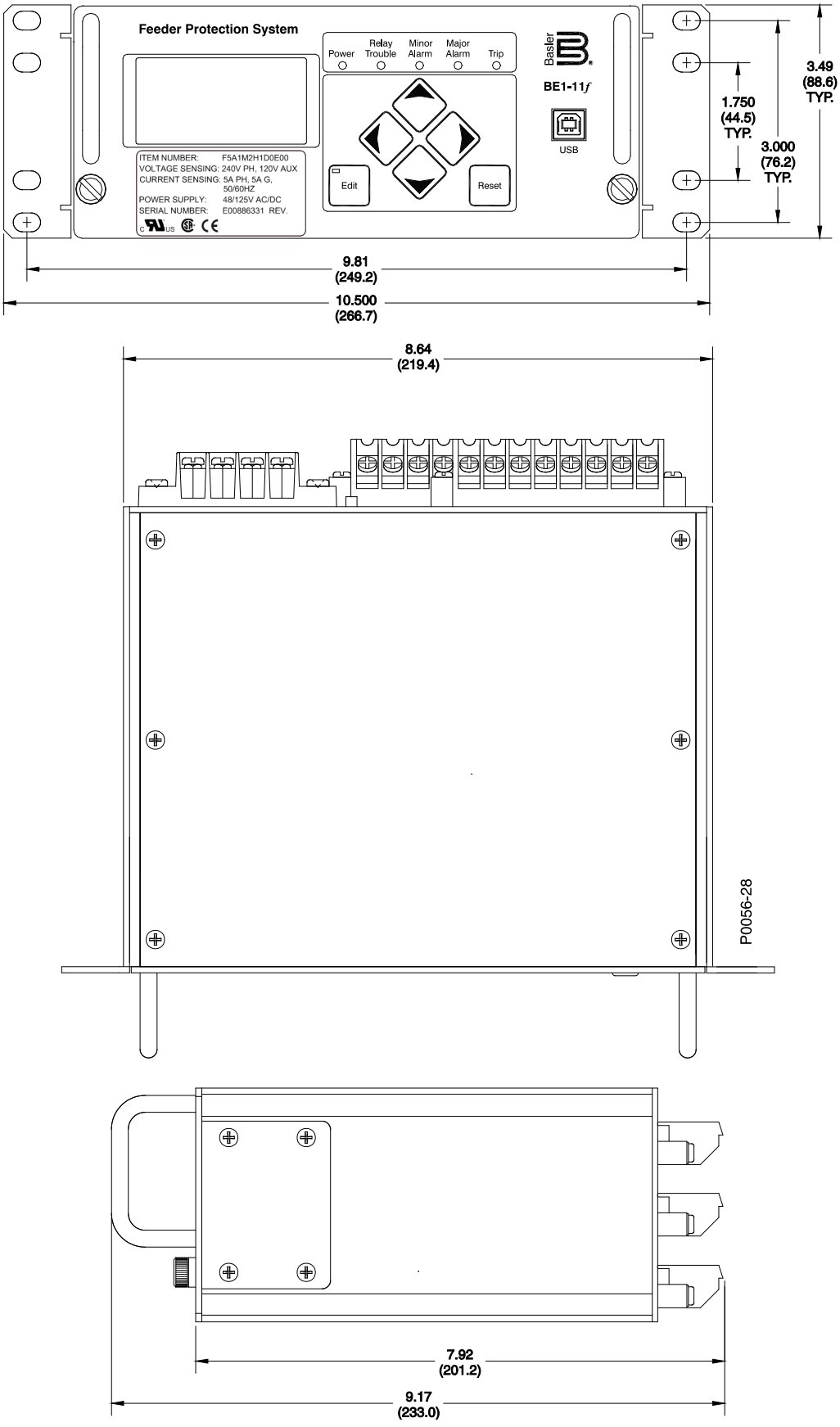


Figure 163. H1 Rack-Mount Case Dimensions

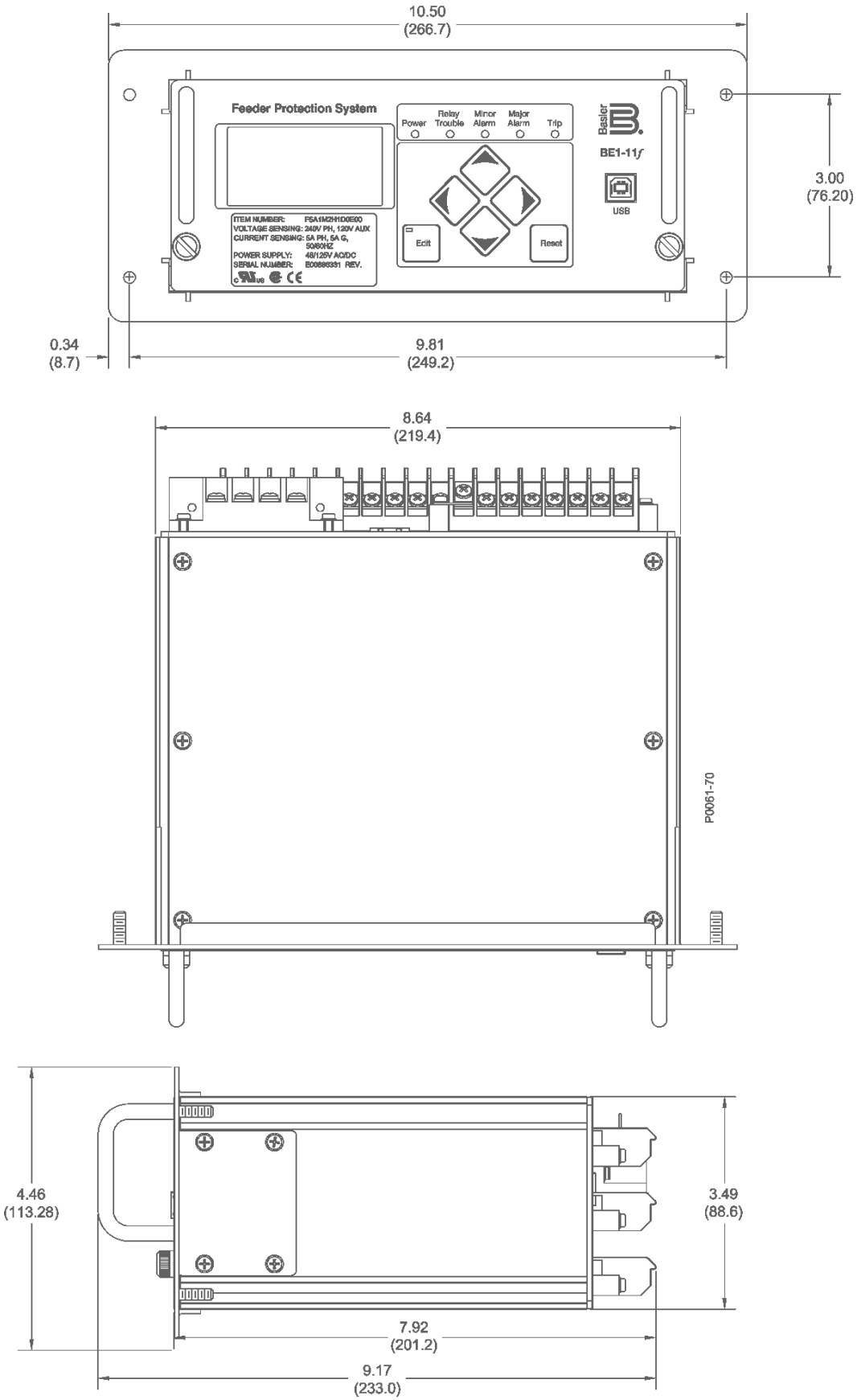


Figure 164. H1 Panel-Mount Case Dimensions

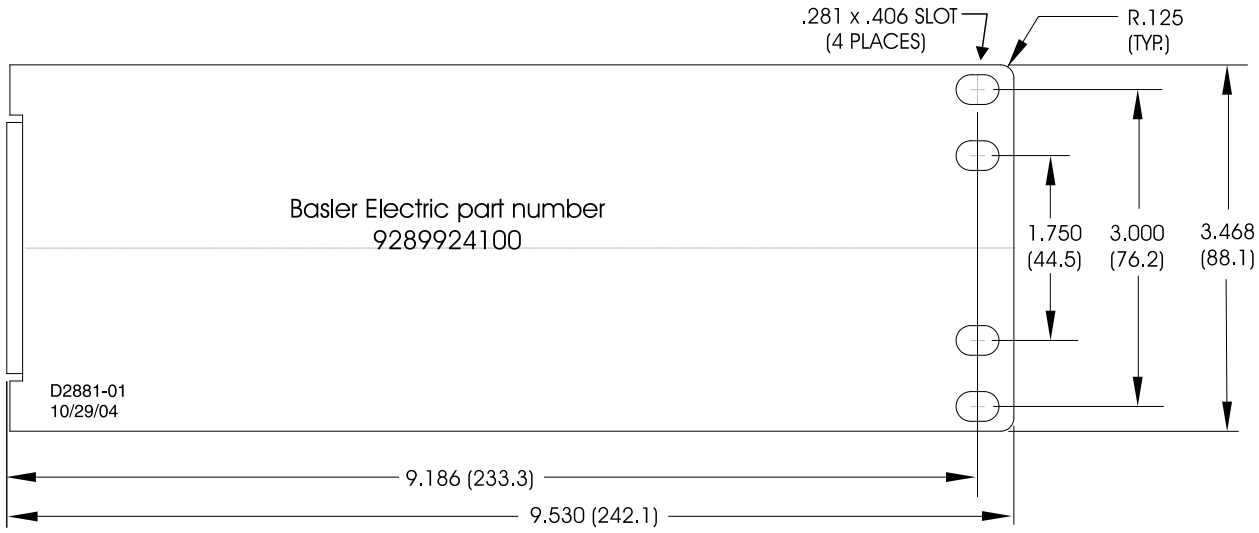


Figure 165. Adapter Bracket for Mounting a Single Relay in a 19-inch Rack

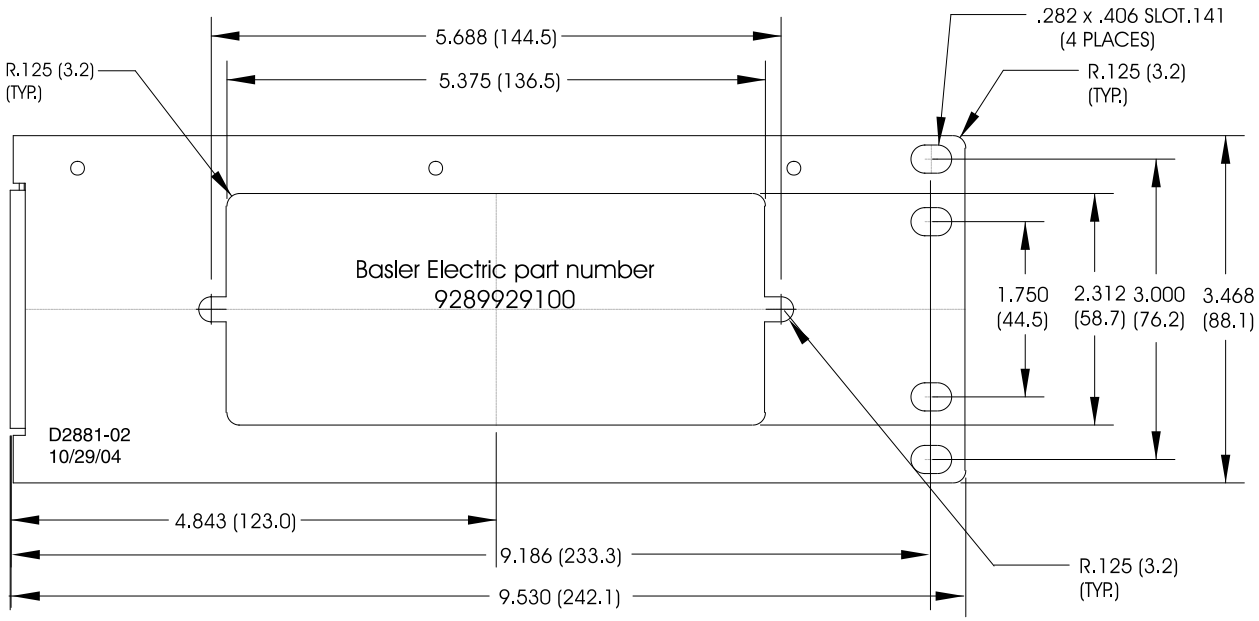
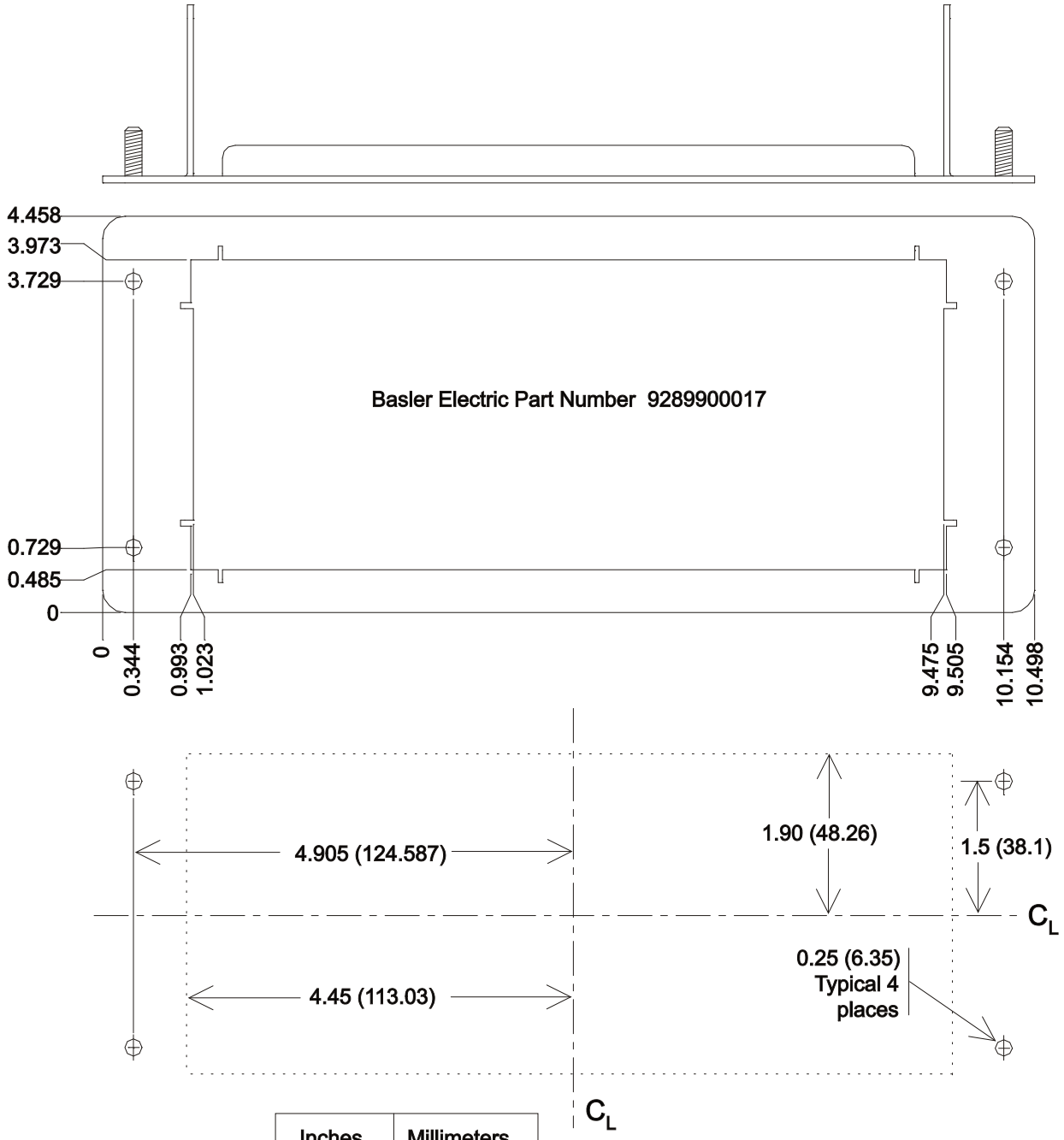


Figure 166. Adapter Bracket for 19-inch Rack Mount with ABB FT Cutout Switch



Inches	Millimeters
0	0
0.344	8.738
0.485	12.319
0.729	18.517
0.993	25.222
1.023	25.984
3.729	94.717
3.973	100.914
4.458	113.233
9.475	240.665
9.505	241.427
10.154	257.912
10.498	266.650

Figure 167. Single H1 Relay Escutcheon Plate and Cutout Dimensions

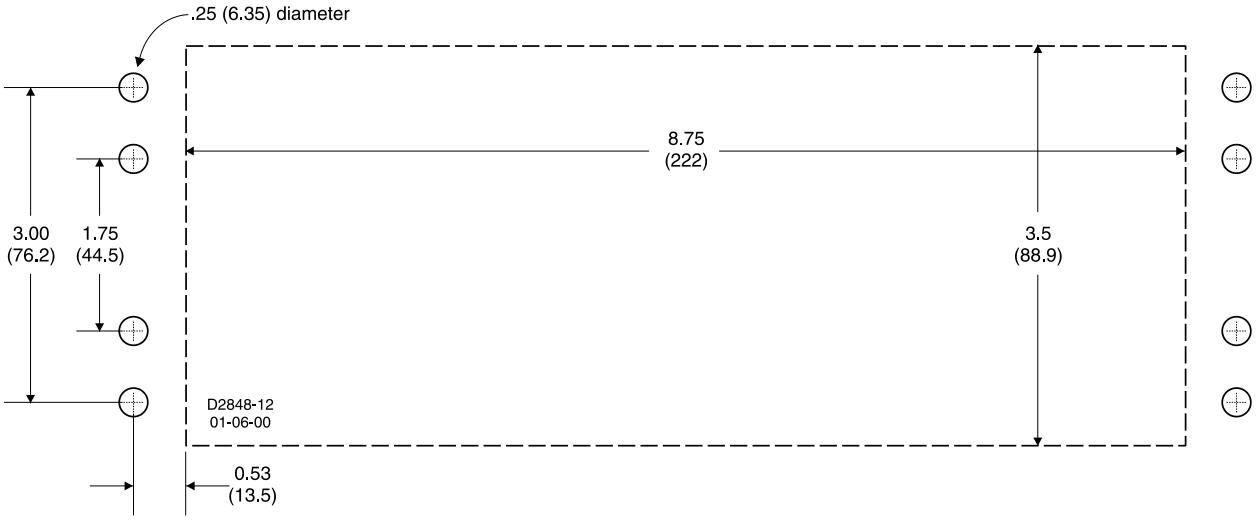


Figure 168. Single H1 Relay (H Style Case) Mounting Dimensions for Panel Mounting (No Escutcheon Plate)

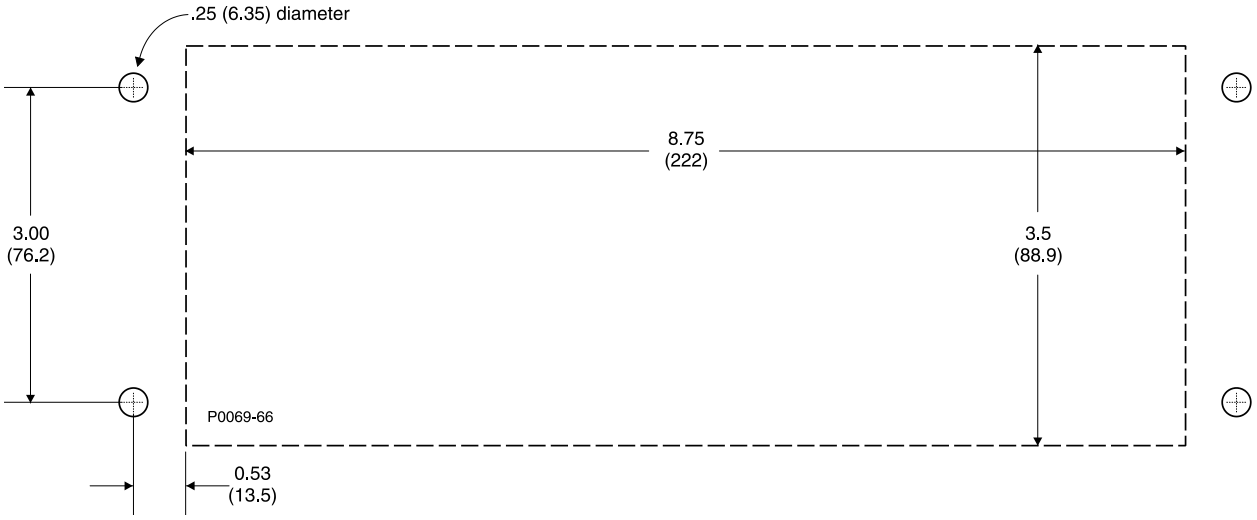


Figure 169. Single H1 Relay (P Style Case) Mounting Dimensions for Panel Mounting (No Escutcheon Plate)

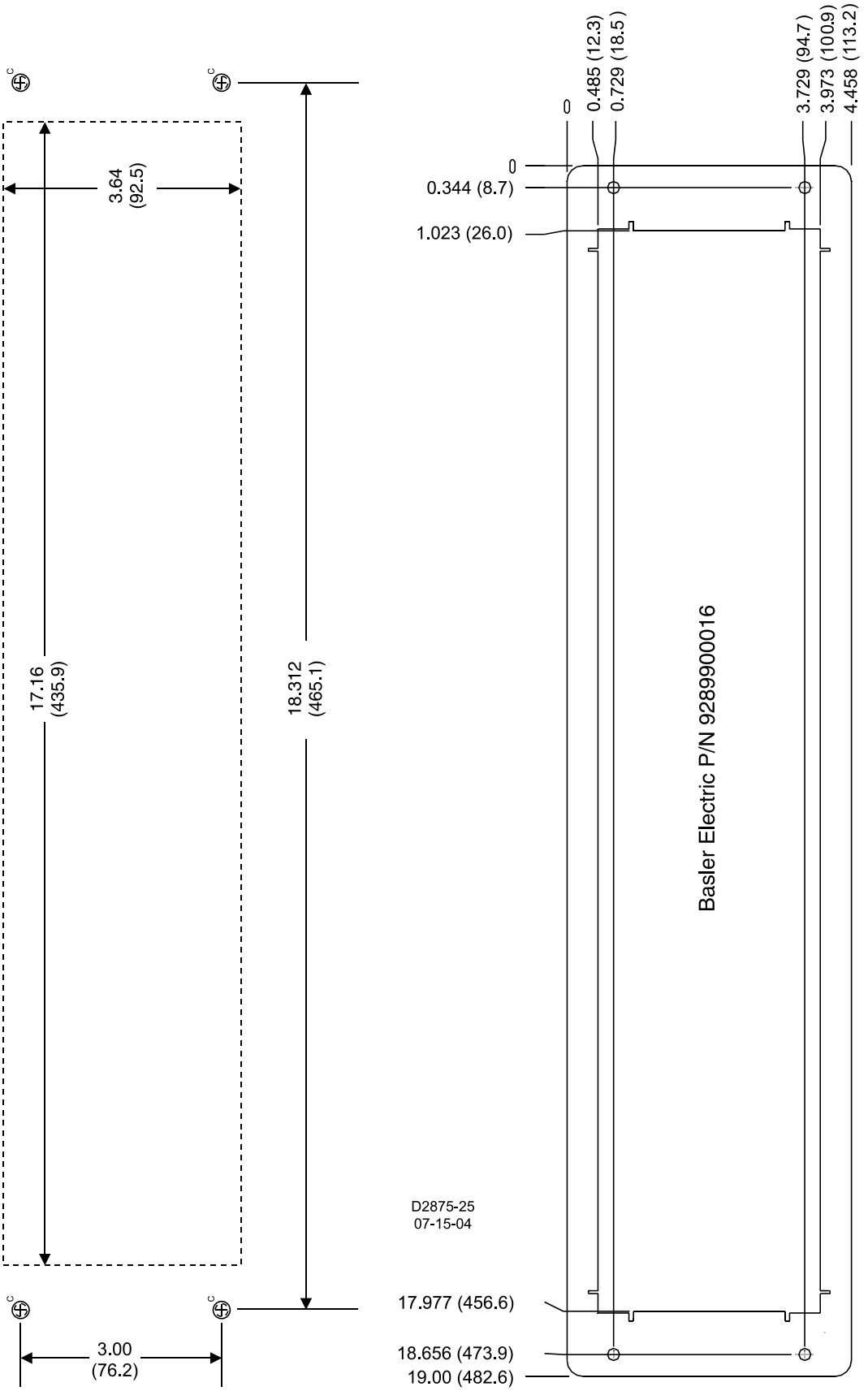


Figure 170. Dovetailed H1 Relay Escutcheon Plate and Cutout Dimensions

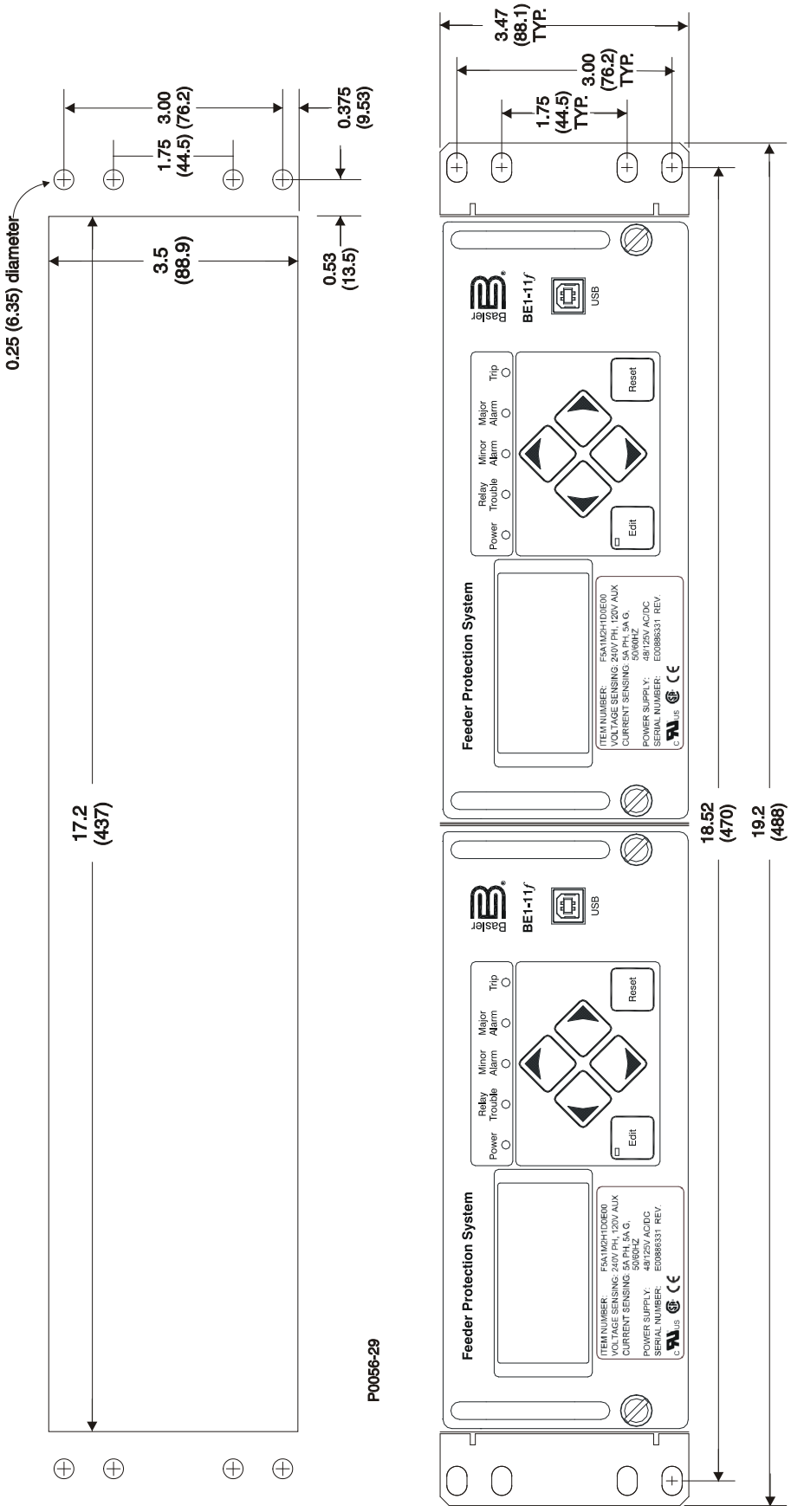


Figure 171. Mounting Dimensions for Panel Mounting Two H1 Relays without an Escutcheon Plate

Dovetailing Procedure

Basler H1 cases can be interlocked by means of a tenon and mortise on the left and right sides of each case. The following paragraphs describe the procedure of dovetailing two cases. Figure 172 illustrates the process.

Step 1: Remove the draw-out assembly from each case by rotating the two captive, front-panel screws counterclockwise and then sliding the assembly out of the case. Observe electrostatic discharge (ESD) precautions when handling the draw-out assemblies.

Step 2: Remove the mounting bracket from the side of each case where the two cases will mate. Each bracket is held in place by four Phillips screws.

Step 3: The rear panel must be removed from one of the cases in order for the two cases to be joined. On that panel, remove the Phillips screw from each corner of the rear panel except for the screw at the upper left-hand corner (when looking at the rear of the case). This screw is closest to Terminal Strip A.

Step 4: Turn the screw nearest to Terminal Strip A counterclockwise until the rear panel can be removed from the case. If you have difficulty removing this screw, use the alternate method described in Step 4a. Otherwise, proceed to Step 5.

Step 4a: Use a Torx® T15 driver to remove the two screws attaching Terminal Strip A to the rear panel. Remove the terminal strip and set it aside. Remove the remaining Phillips screw from the rear panel and set the rear panel aside.

Step 5: Arrange the two cases so that the rear dovetailed edge of the case without a rear panel is aligned with the front dovetailed edge of the case with the rear panel installed. Once the dovetails are aligned, slide the cases together.

Step 6: Position the rear panel on the case from which it was removed. Make sure that the panel orientation is correct. Perform Step 6a if Terminal Strip A was not removed during the disassembly process. Perform Step 6b if Terminal Strip A was removed during disassembly.

Step 6a: Position the rear panel over the case and align the screw closest to Terminal Strip A with its mating hole. Tighten the screw while maintaining proper alignment between the rear panel and case. Finish attaching the panel to the case by installing the remaining three Phillips screws. When installed, the rear panels prevent the two cases from sliding apart.

Step 6b: Align the rear panel with the case and install the four Phillips screws that hold the rear panel in place. Position Terminal Strip A in its panel opening and replace the two Torx® T15 screws. When installed, the rear panels prevent the two cases from sliding apart.

Step 7: Mount the case assembly in the desired rack or panel opening and reinstall the draw-out assembly in each case.

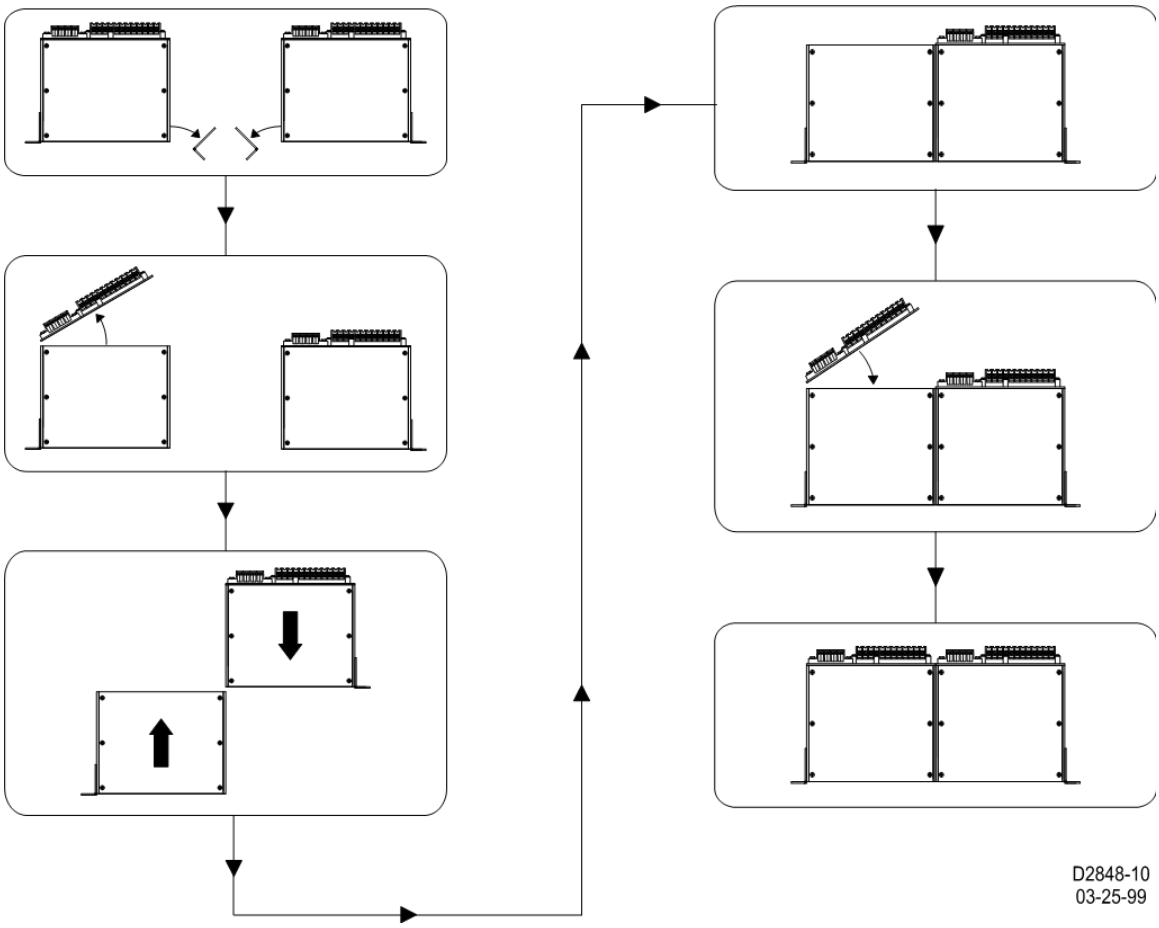


Figure 172. Dovetailing Procedure

Terminals and Connectors

Connections to the relay are dependent on the application and logic scheme selected by the user. As a result, some relay inputs and outputs may not be used for a given application. Before energizing a relay, make sure the connections match the options associated with the model and style number found on the relay nameplate. Refer to the style chart in the *Introduction* chapter 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.

Note

Connections to the relay voltage inputs, contact inputs, power supply inputs, and contact outputs should be made with a minimum wire size of 14 AWG (2.08 mm^2).

Connections to the relay current inputs and ground terminal should be made with a minimum wire size of 12 AWG (3.31 mm^2).

When the BE1-11*f* is configured in a system with other protective devices, a separate ground bus lead is recommended for each relay.

BE1-11*f* relays are supplied in either an S1 size case (J option) or an H1 size case (H or P option).

J Type Case

Figure 173 shows the rear-panel connections with an RJ45 Ethernet connector. Figure 174 shows the rear-panel connections with a fiber optic Ethernet connector.

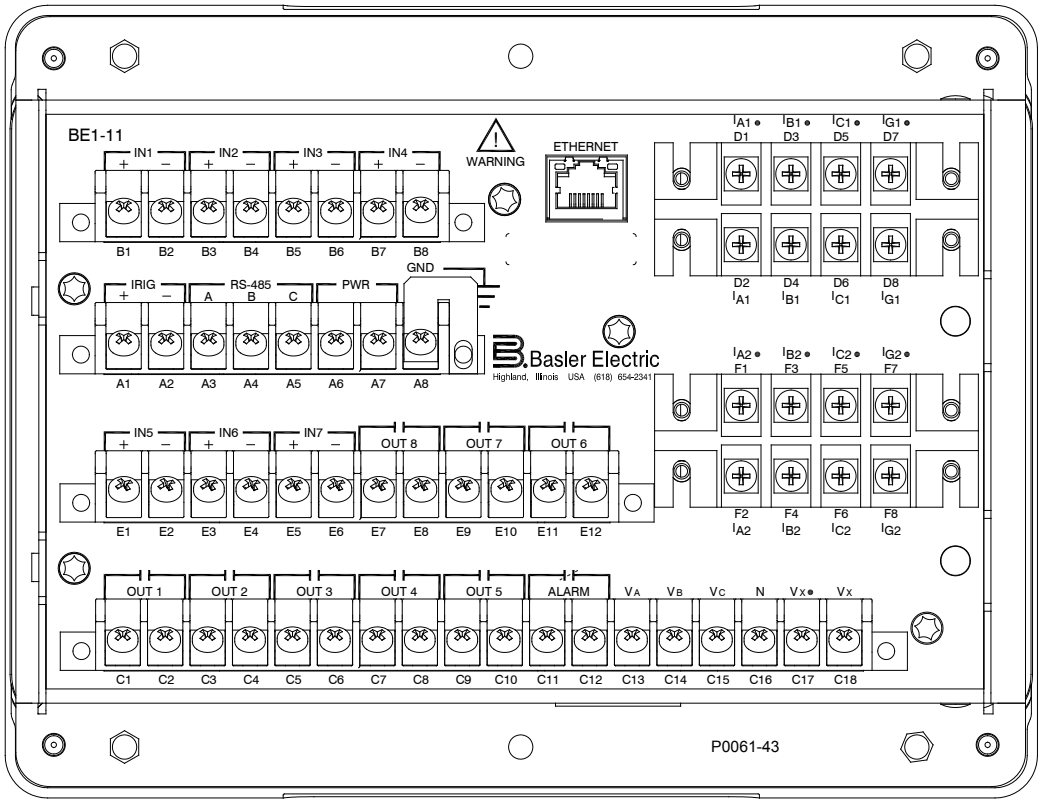


Figure 173. Rear-Panel Connections with RJ45 Ethernet (J Type Case)

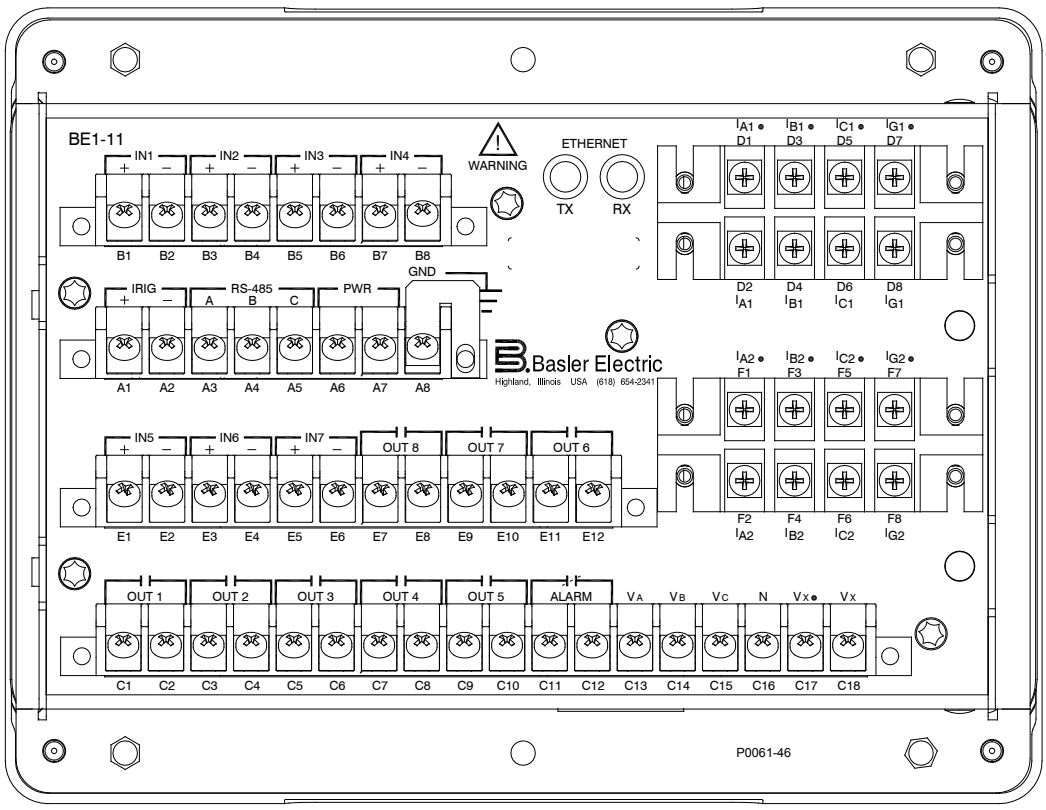


Figure 174. Rear-Panel Connections with Fiber Optic Ethernet (J Type Case)

Terminal Blocks

J-style cases use two sizes of terminal blocks.

The terminal blocks used for current sensing connections use 8/32 inch screws with lock washers. The lock washer is an integral part of the current-sensing wiring system and must not be removed. Without the lock washer, the terminal screw may bottom out and prevent a tight fit against the lug. The torque applied to the terminal screws should not exceed 1.5 inch-pounds (1.69 N•m). Each terminal block screw accommodates a lug no wider than 0.344 inches (8.6 millimeters).

All other terminal blocks use 6/32 inch screws. The torque applied to these screws should not exceed 12 inch-pounds (1.35 N•m). Each terminal block screw accommodates a lug no wider than 0.320 inches (8.1 millimeters).

H or P Type Case

Figure 175 shows the rear-panel connections with an RJ45 Ethernet connector. Figure 176 shows the rear-panel connections with a fiber optic Ethernet connector.

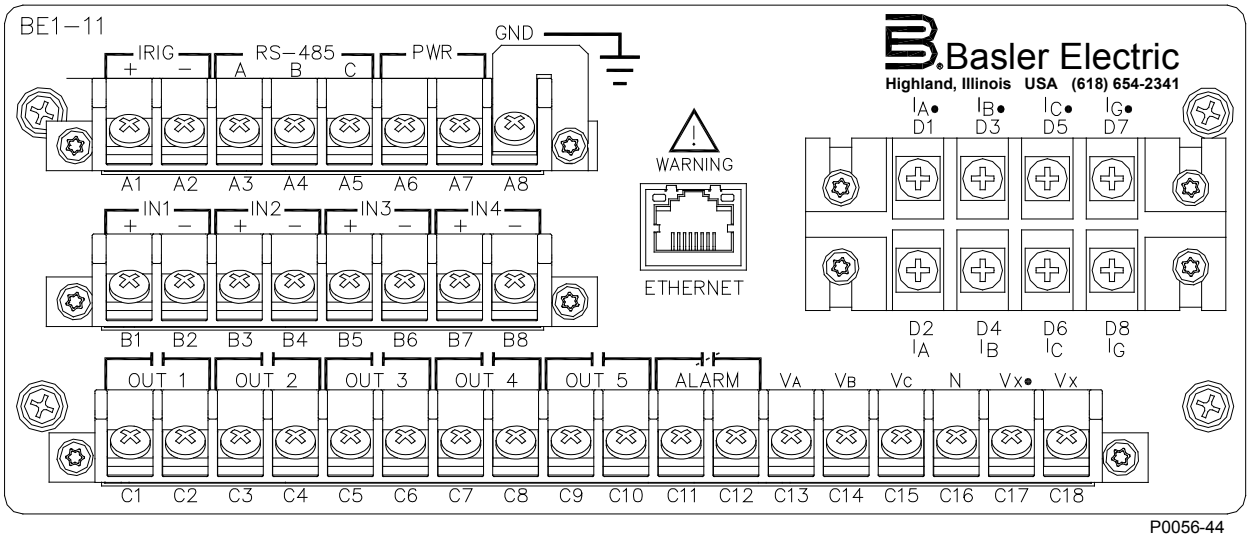


Figure 175. Rear-Panel Connections with RJ45 Ethernet (H or P Type Case)

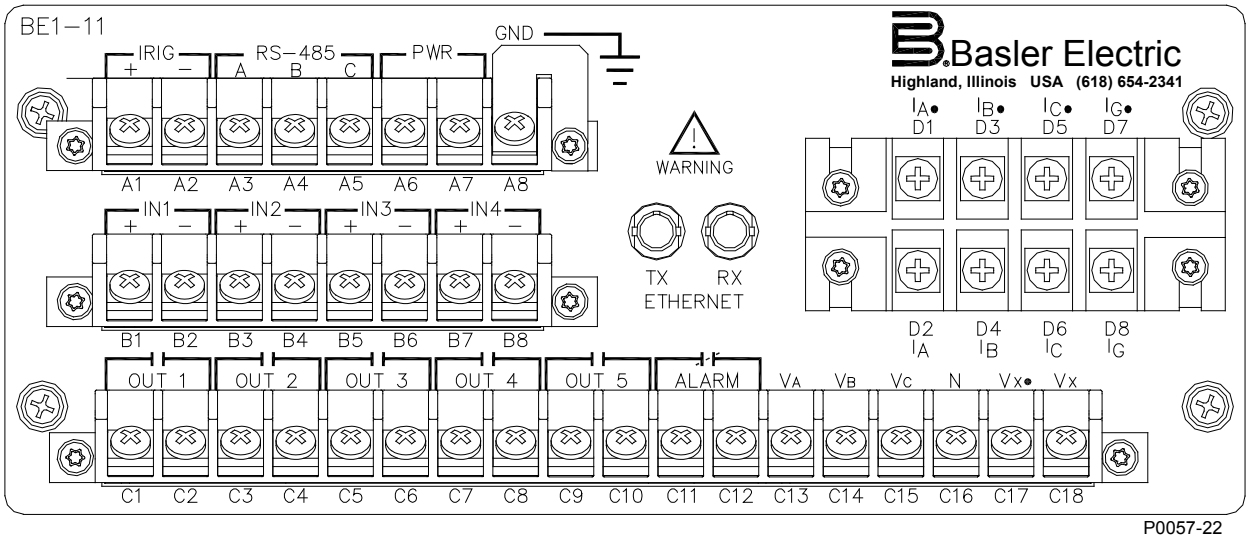


Figure 176. Rear-Panel Connections with Fiber Optic Ethernet (H or P Type Case)

Terminal Blocks

H- or P-style cases use two sizes of terminal blocks.

The terminal block used for current sensing connections uses 8/32 inch screws with lock washers. The lock washer is an integral part of the current-sensing wiring system and must not be removed. Without the lock washer, the terminal screw may bottom out and prevent a tight fit against the lug. The torque applied to the terminal screws should not exceed 15 inch-pounds (1.69 N•m). Each terminal block screw accommodates a lug no wider than 0.344 inches (8.6 millimeters).

All other terminal blocks use 6/32 inch screws. The torque applied to these screws should not exceed 12 inch-pounds (1.35 N•m). Each terminal block screw accommodates a lug no wider than 0.320 inches (8.1 millimeters).

CT Polarity

CT polarity is critical to the proper operation of the BE1-11*f*. The following provides fundamental information on CT polarity and protective relays.

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 Figure 177 and Figure 178).

On occasion, however, protection engineers will encounter situations where CT polarity is reversed for a specific application. That is, non-polarity of the CT secondary will be in phase with the primary current flow (Figure 179). 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.

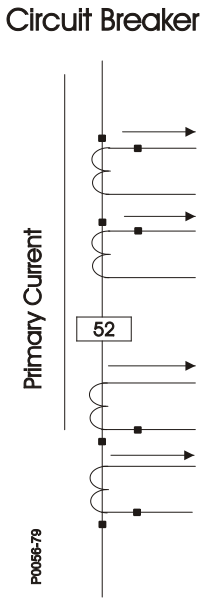


Figure 177. Standard CT Polarity

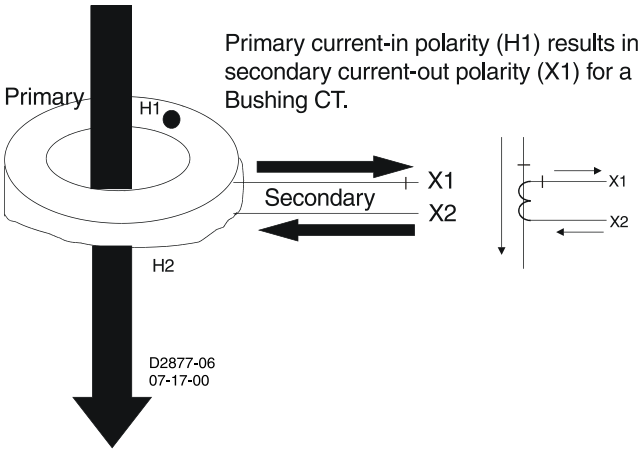


Figure 178. Current Transformer Action

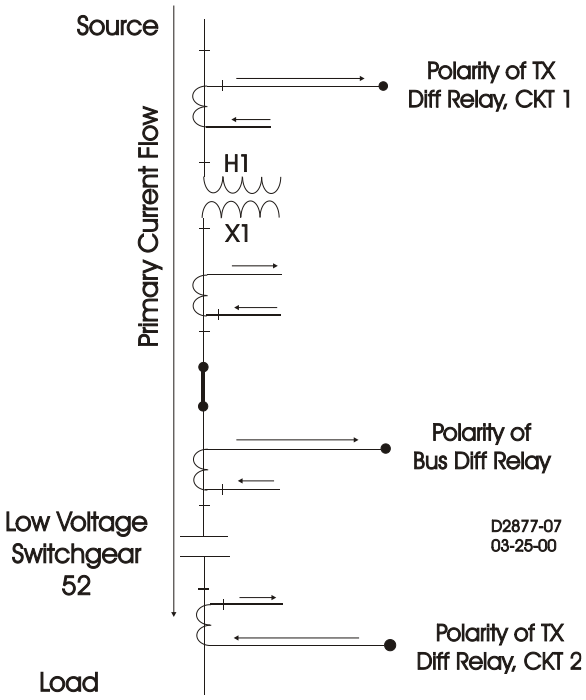


Figure 179. Example of Reversed CT Polarity

Typical Connections

Typical external dc connections for the BE1-11*f* in an H or P type case are shown in Figure 180.

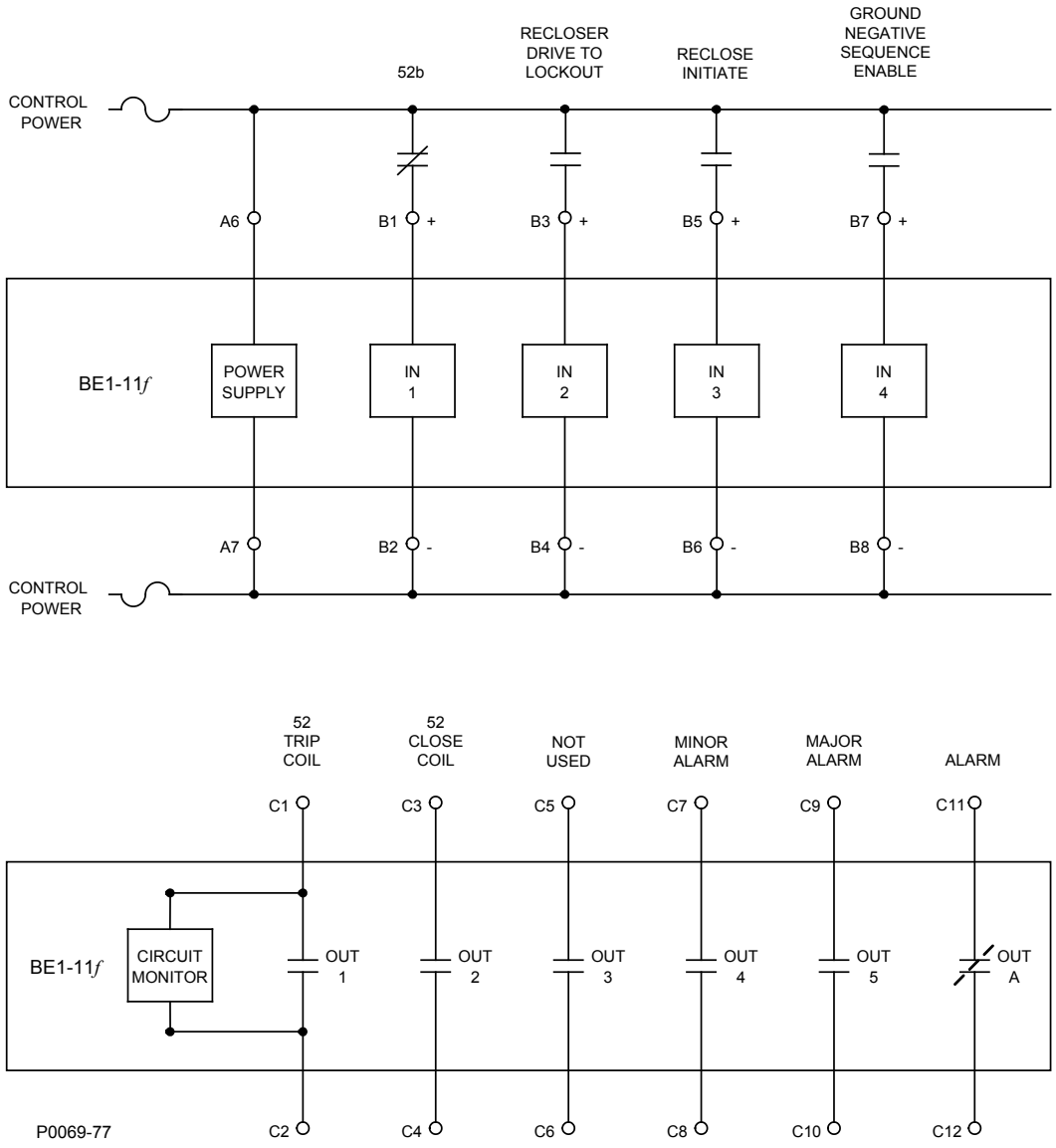


Figure 180. Typical External DC Connections (H or P Type Case)

Typical external dc connections for the BE1-11*f* in a J type case are shown in Figure 181.

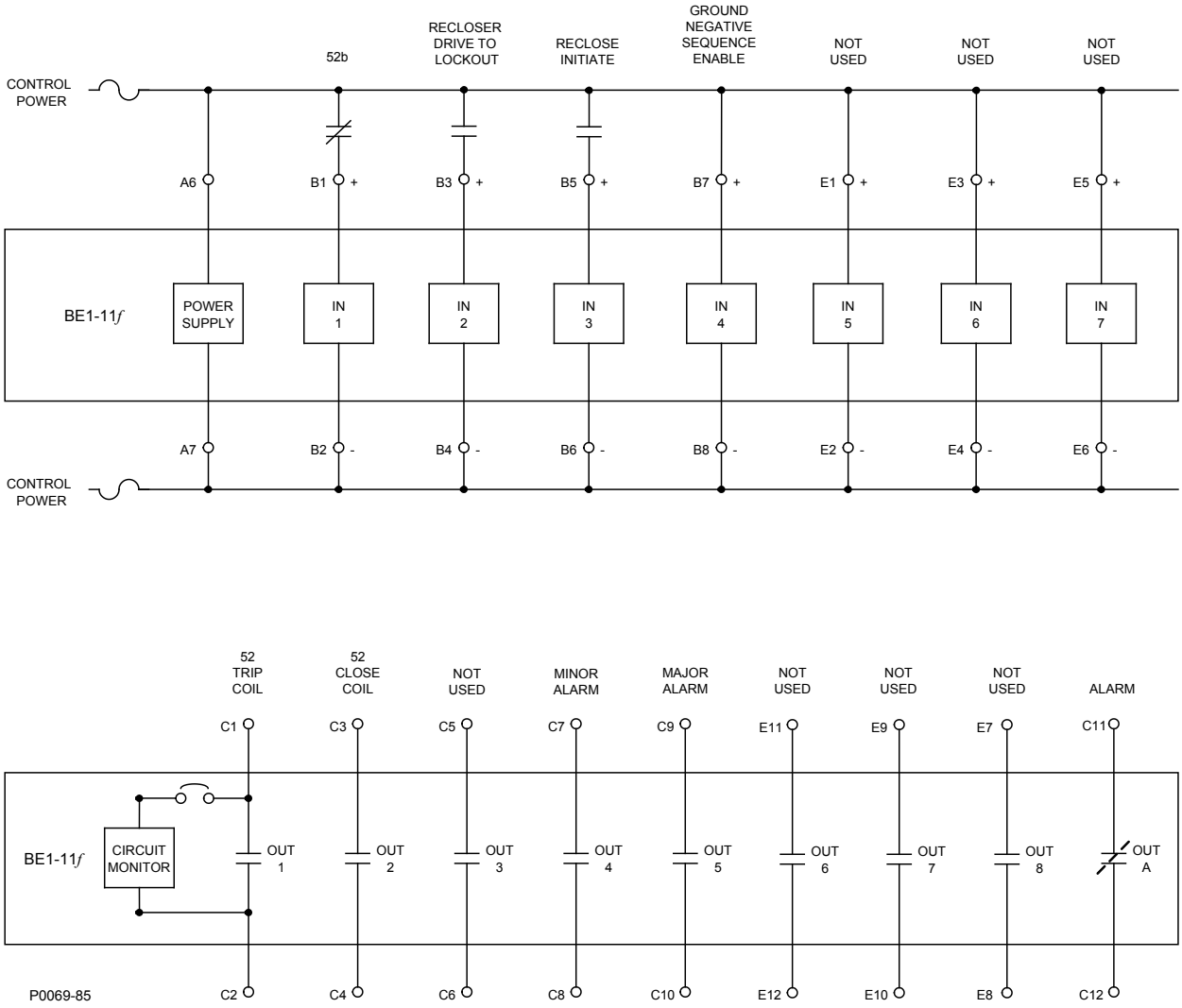


Figure 181. Typical External DC Connections (J Type Case)

Typical external ac connections for the BE1-11*f* are shown in Figure 182.

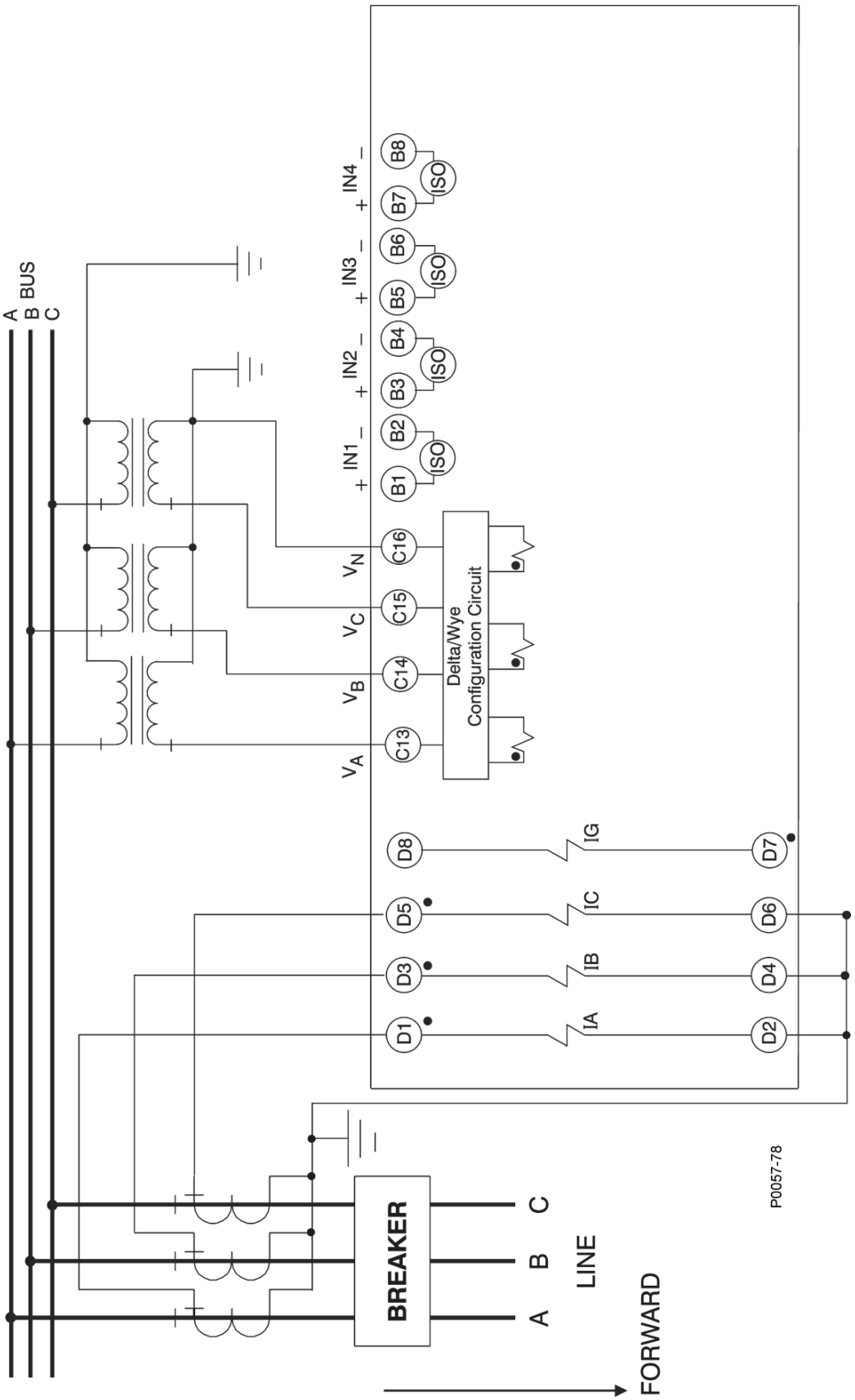


Figure 182. Typical AC Connections

Three-phase voltage sensing, alternate VT inputs are shown in Figure 183.

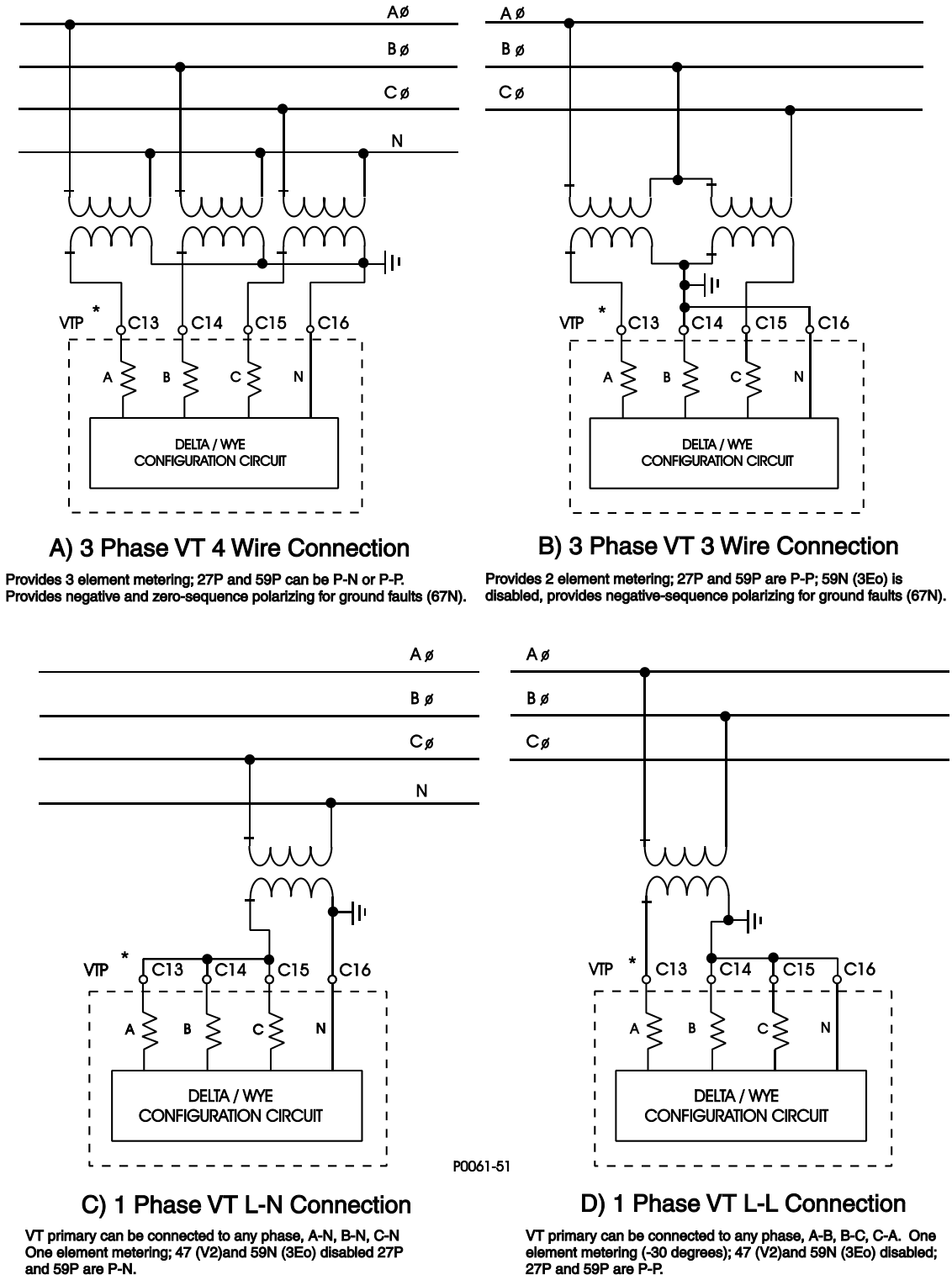


Figure 183. Three-Phase Voltage Sensing, Alternate VTP Inputs

Power System Applications

The following figures show examples of the applications that can be served by the Basler Electric BE1-11*f* Feeder Protection System. Many of these applications can be used in concert with other Basler numeric systems such as the BE1-851 Overcurrent Protection System, the BE1-11*g* Generator Protection System, or any other member of the BE1-11 family of relays.

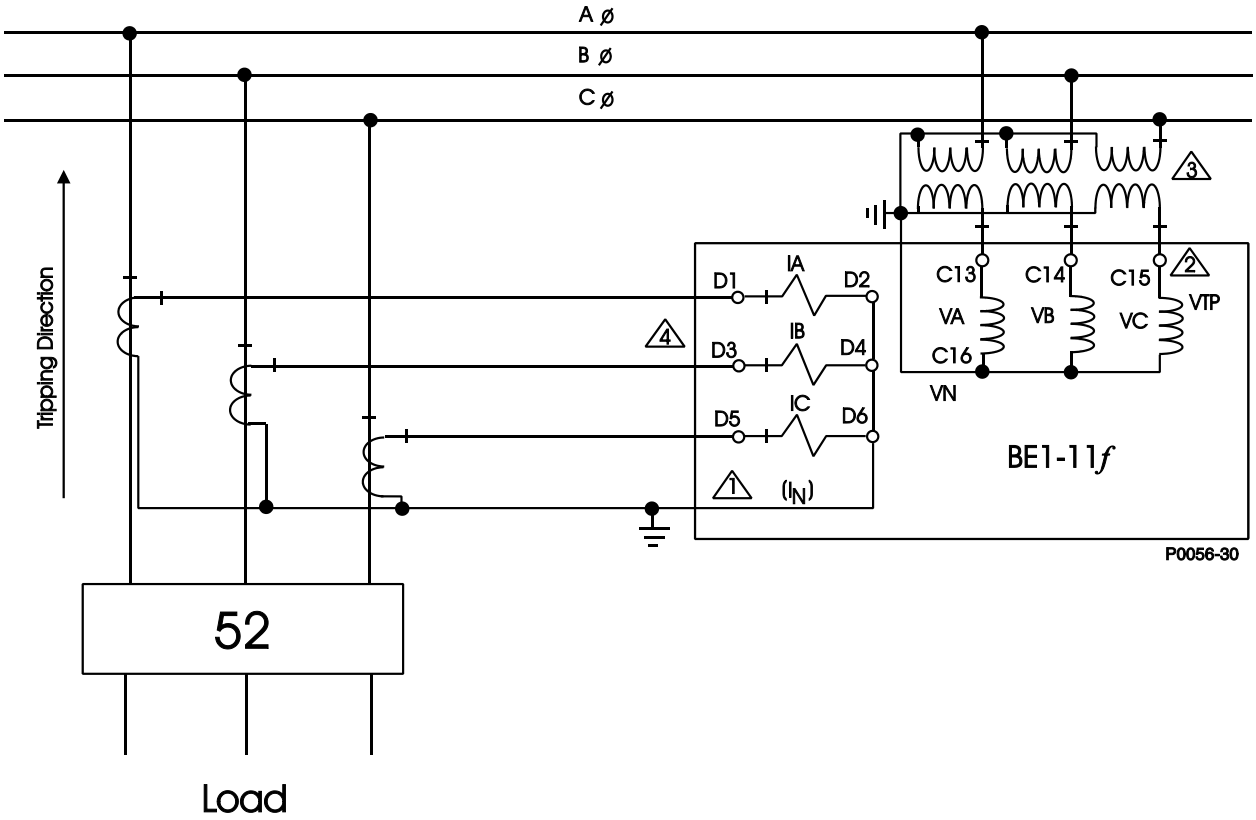


Figure 184. Overcurrent Protection of Typical Loads - Distribution Circuit, Motor, or Reactor

Notes for Figure 184:

1. The neutral ground (IN) operates on internally calculated residual (3I0) current.
2. VTP connections shown are for H1 case.
3. 4-wire connection shown as typical. See the *Typical Connections* chapter for alternate VTP connections.
4. The polarity of metered watts and vars can be adjusted using BESTCOMS*Plus*®.

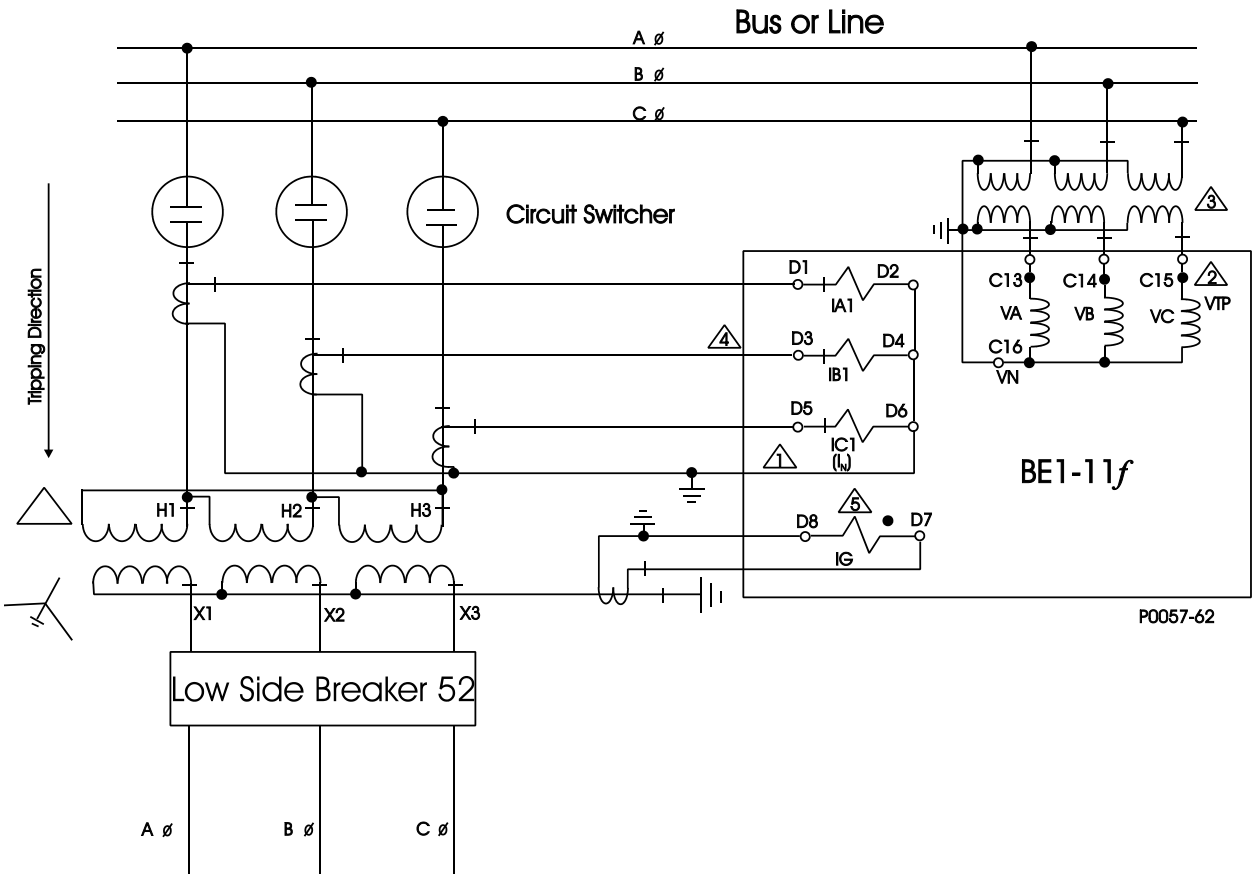


Figure 185. Overcurrent Protection of a Delta-Wye Grounded Transformer (Radial Load) with Independent Ground Input (IG) connected for low side Ground Fault Protection

Notes for Figure 185:

1. The neutral ground (IN) operates on internally calculated residual (3I0) current.
2. VTP connections shown are for H1 case.
3. 4-wire connection shown as typical. See the *Typical Connections* chapter for alternate VTP connections.
4. The polarity of metered watts and vars can be adjusted using BESTCOMS*Plus*.
5. Independent Ground Input (IG) connected to detect low side ground faults.

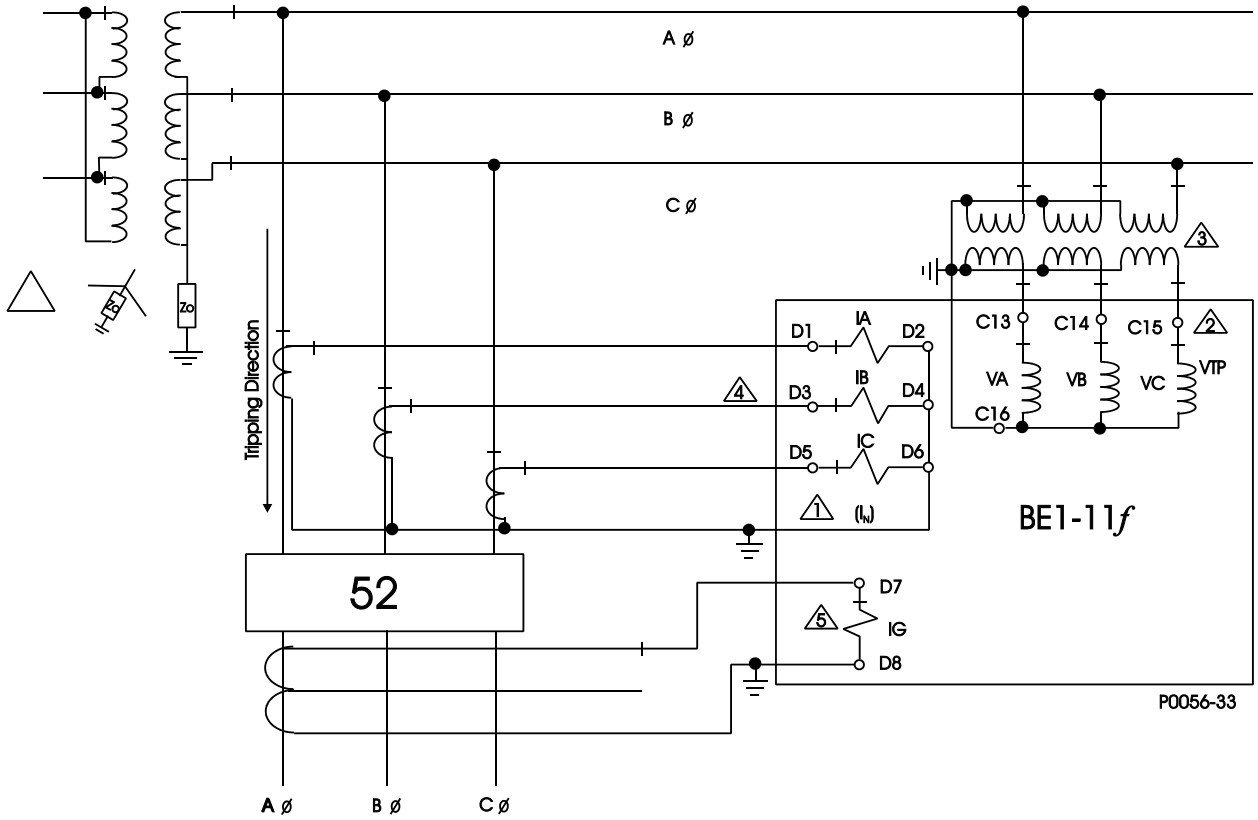


Figure 186. Overcurrent Protection of an Industrial Feeder (Radial Load) with Independent Ground (IG) connected to Core Balance CT for Sensitive Ground Fault Protection

Notes for Figure 186:

1. The neutral ground (IN) operates on internally calculated residual (3I0) current.
2. VTP connections shown are for H1 case.
3. 4-wire connection shown as typical. See the *Typical Connections* chapter for alternate VTP connections.
4. The polarity of metered watts and vars can be adjusted using BESTCOMS*Plus*.
5. Independent Ground Input (IG) supplied by a core balance CT, provides sensitive ground fault protection.

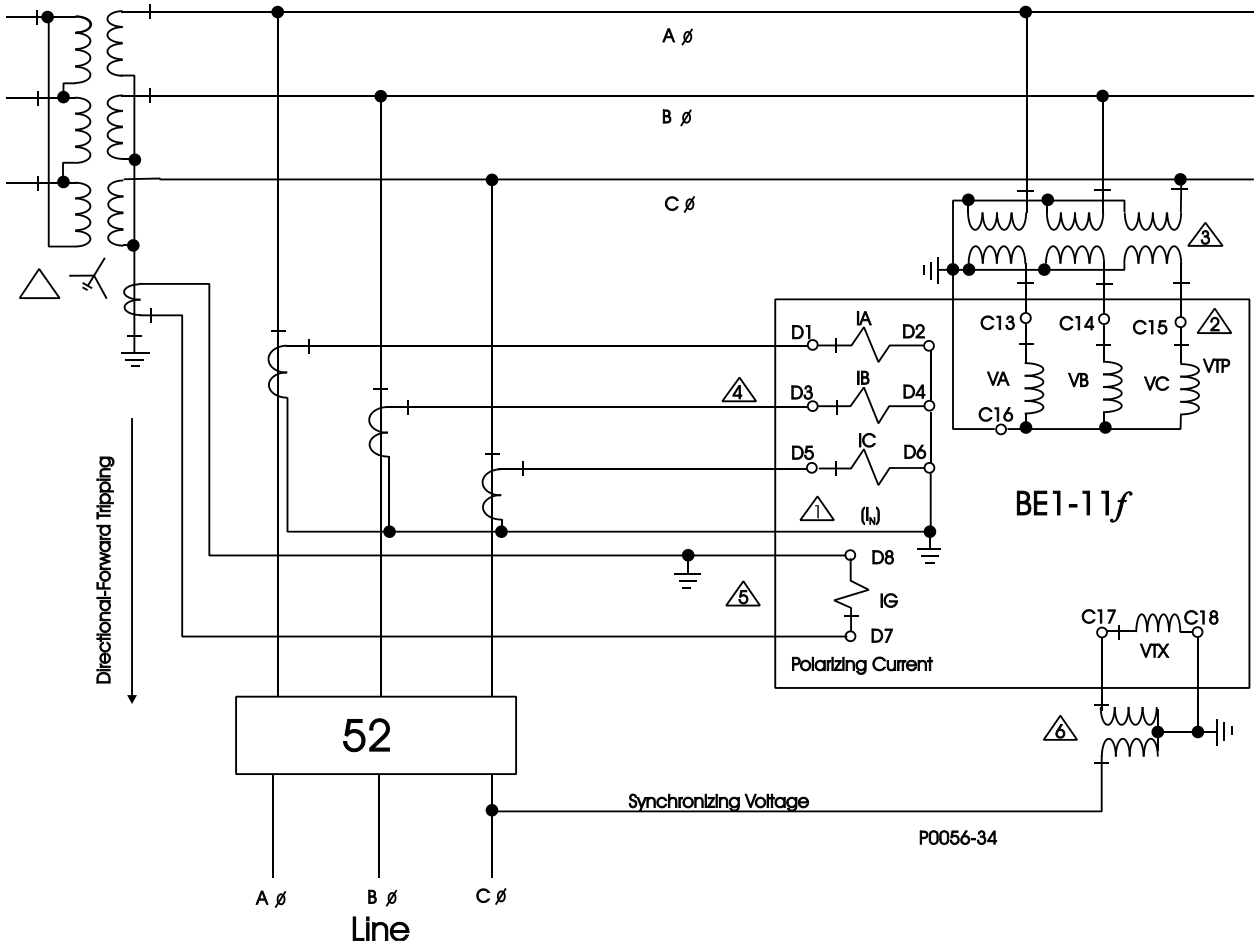


Figure 187. Directional Overcurrent Protection with Reclosing of a Transmission Line (Zero-Sequence Current Polarizing Source from Delta-Wye Transformer connected to IG)

Notes for Figure 187:

1. The neutral ground (IN) operates on internally calculated residual (3I0) current.
2. VTP connections shown are for H1 case.
3. 4-wire connection shown as typical. See the *Typical Connections* chapter for alternate VTP connections. The 4-wire connection provides negative- and zero-sequence voltage polarizing for ground faults; 3-wire connection provides negative-sequence voltage polarizing.
4. The polarity of metered watts and vars can be adjusted using BESTCOMS*Plus*.
5. Independent Ground Input (IG) connected to one CT inside the delta to protect an unloaded tertiary winding and provide backup protection for system ground faults.

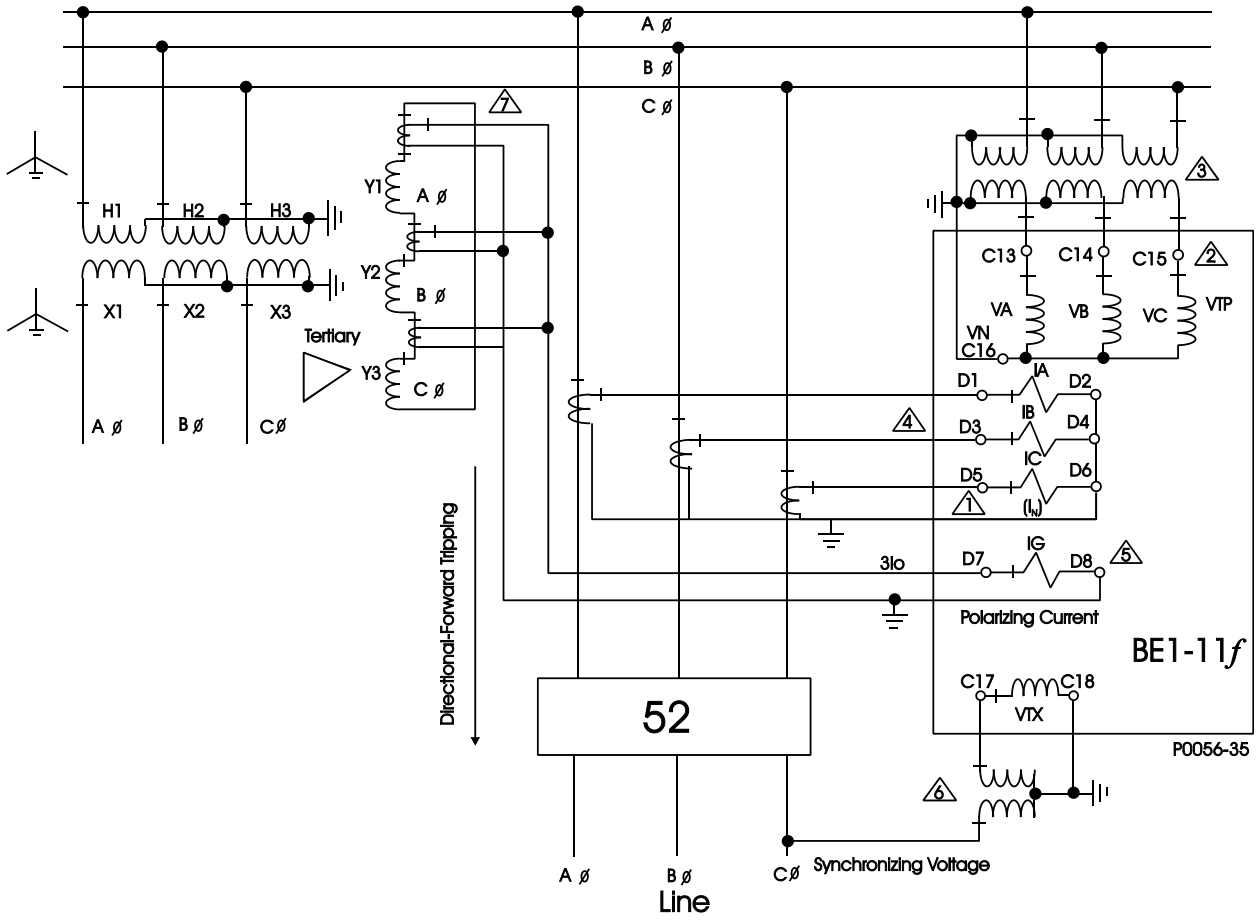


Figure 188. Directional Overcurrent Protection with Reclosing of a Transmission Line (Zero-Sequence Current Polarizing Source Delta Tertiary connected to (IG)

Notes for Figure 188:

1. The neutral ground (IN) operates on internally calculated residual (3I0) current.
2. VTP connections shown are for H1 case.
3. 4-wire connection shown as typical. See the *Typical Connections* chapter for alternate VTP connections. The 4-wire connection provides negative- and zero-sequence voltage polarizing for ground faults; 3-wire connection provides negative-sequence voltage polarizing.
4. The polarity of metered watts and vars can be adjusted using BESTCOMS*Plus*.
5. Independent Ground Input (IG) connected to one CT inside the delta to protect an unloaded tertiary winding and provide backup protection for system ground faults.
6. VTX can be connected A-N, B-N, C-N, or A-B, B-C, C-A. The relay automatically compensates for phase angle difference between VTP and VTX. Voltage magnitude between VTX and VTP must be matched external to the relay.
7. When tertiary is loaded, use 3 CT's inside Delta (3I0); when tertiary is unloaded, only 1 CT (I0) is required.

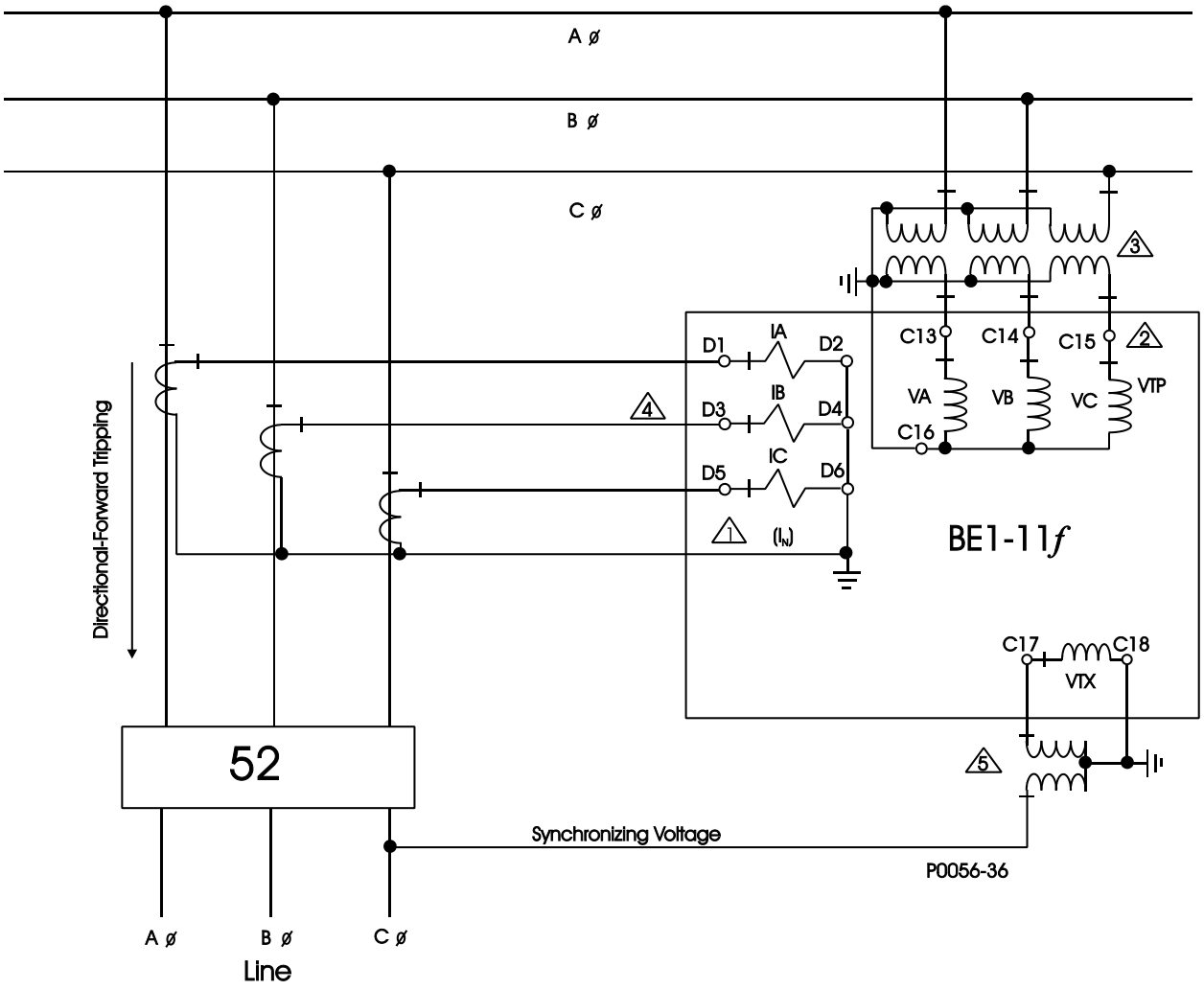


Figure 189. Directional Overcurrent Protection with Reclosing of a Transmission Line (Potential Polarized)

Notes for Figure 189:

1. The neutral ground (IN) operates on internally calculated residual (3I0) current.
2. VTP connections shown are for H1 case.
3. 4-wire connection shown as typical. See the *Typical Connections* chapter for alternate VTP connections. The 4-wire connection provides negative- and zero-sequence voltage polarizing for ground faults; 3-wire connection provides negative-sequence voltage polarizing.
4. The polarity of metered watts and vars can be adjusted using BESTCOMS*Plus*.
5. VTX can be connected A-N, B-N, C-N, or A-B, B-C, C-A. The relay automatically compensates for phase angle difference between VTP and VTX. Voltage magnitude between VTX and VTP must be matched external to the relay.

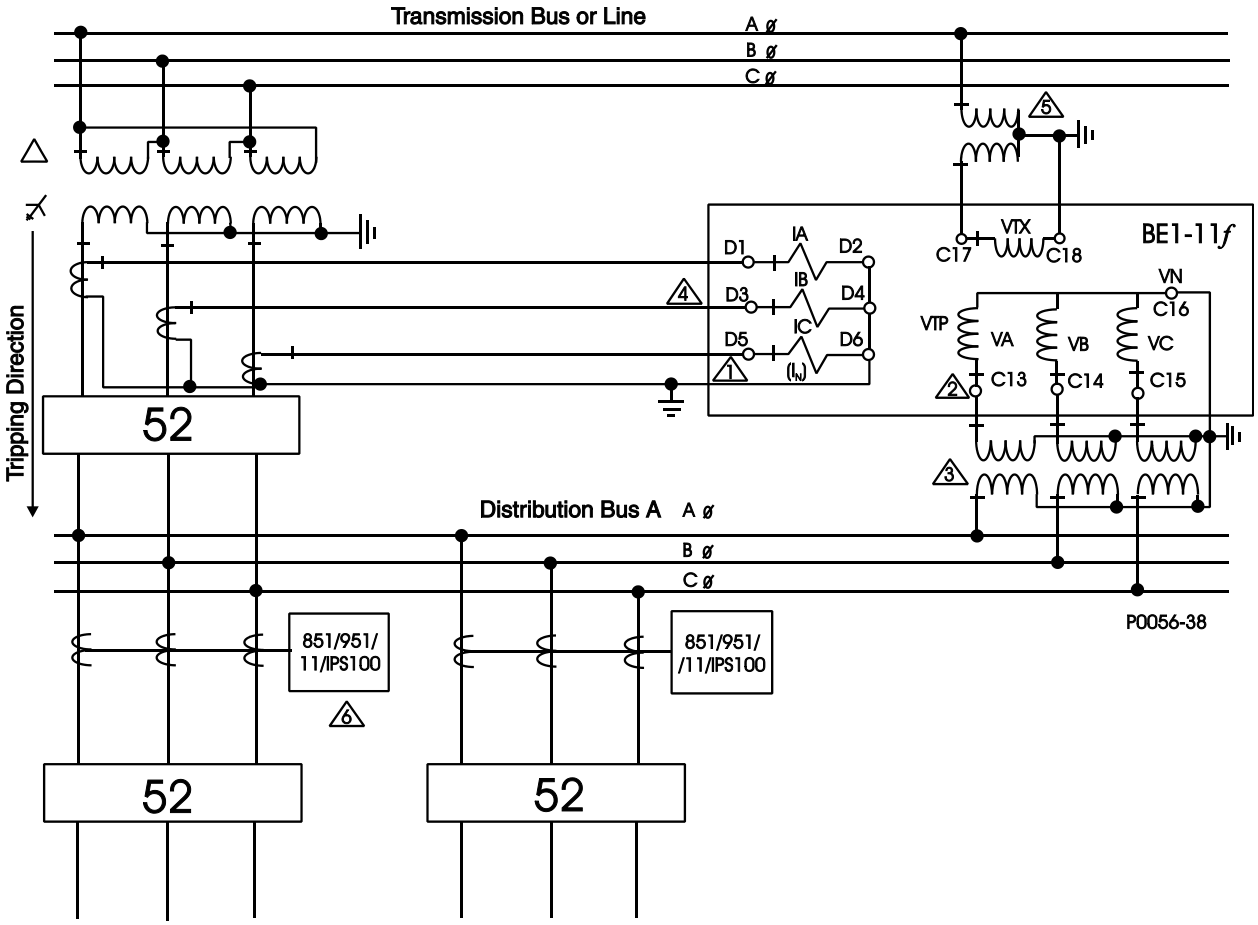


Figure 190. Dual Voltage Source UF Load Shed Using VTX Input; Overcurrent Bus-Protection (Including High Speed Bus Interlocking)

Notes for Figure 190:

1. The neutral ground (IN) operates on internally calculated residual (3I0) current.
2. VTP connections shown are for H1 case.
3. 4-wire connection shown as typical. See the *Typical Connections* chapter for alternate VTP connections. Note that the 81 voltage inhibit function for 4-wire and single-phase L-N systems monitor A-N voltage. 3-wire and single-phase L-L systems monitor A-B voltage.
4. The polarity of metered watts and vars can be adjusted using BESTCOMS*Plus*.
5. VTX can be connected A-N, B-N, C-N, or A-B, B-C, C-A. For the VTP connection shown, VTX input can be A-N, B-N, or C-N. If a 3-wire VTP system is connected, use A-B, B-C, or C-A for VTX input. Voltage magnitude between VTX and VTP must be matched external to the relay.
6. BE1-851, BE1-951, BE1-11*f*, or BE1-IPS100 is required on each circuit to implement high speed bus interlocking scheme.

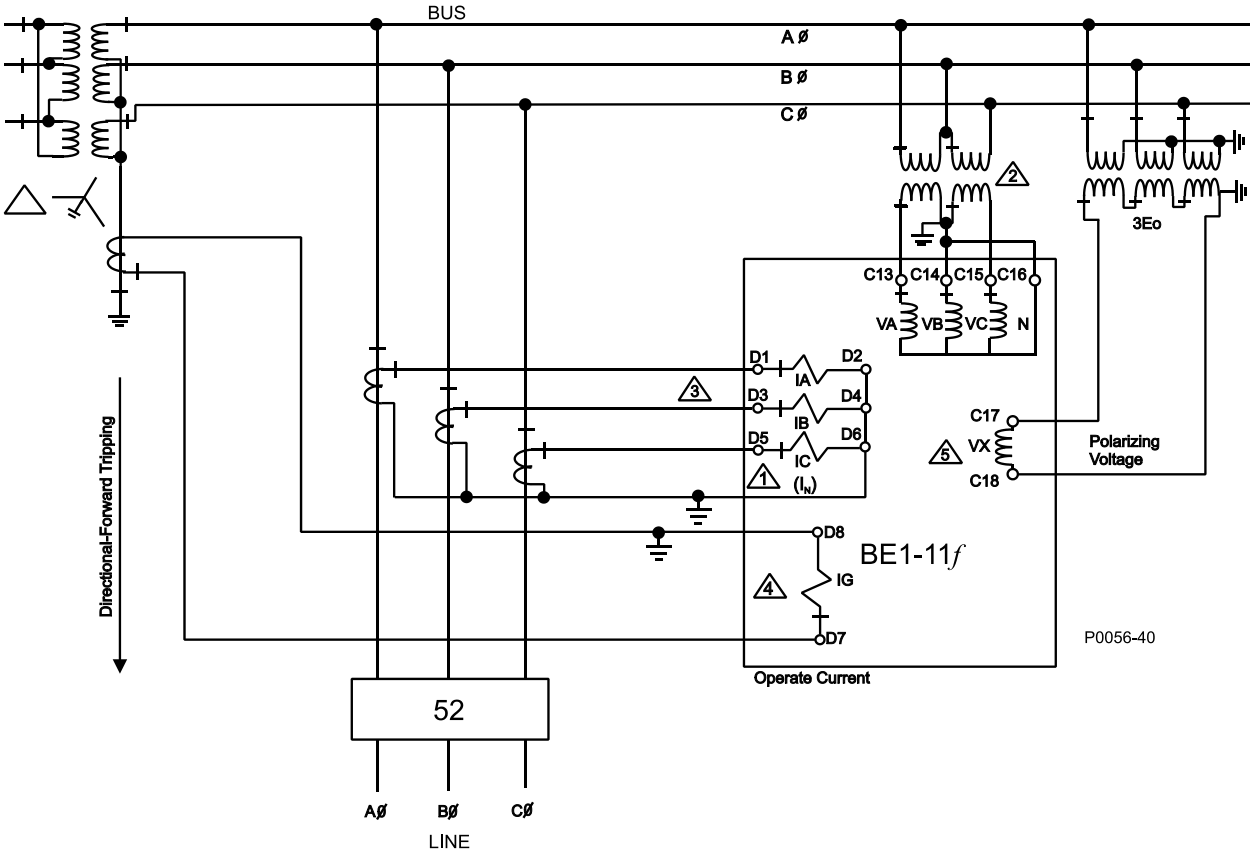


Figure 191. Directional Ground Overcurrent Protection using External Source of Zero-Sequence Polarizing Voltage (VTX) Compared to Ground Current (IG) Up the Neutral of a Delta-Wye Grounded Transformer

Notes for Figure 191:

1. The neutral ground (IN) operates on internally calculated residual (3I0) current.
2. VTP connections shown are for H1 case.
3. 4-wire connection shown as typical. See the *Typical Connections* chapter for alternate VTP connections. The 4-wire connection provides negative-sequence, and if selected (VOIN or VOIG), zero-sequence voltage polarizing for ground faults; 3-wire connection provides negative-sequence voltage polarizing.
4. The polarity of metered watts and vars can be adjusted using BESTCOMS*Plus*.
5. IG input is ground fault operating quantity compared VX polarizing input (VXIG).
6. VTX connected to external source of 3V0 polarizing voltage.

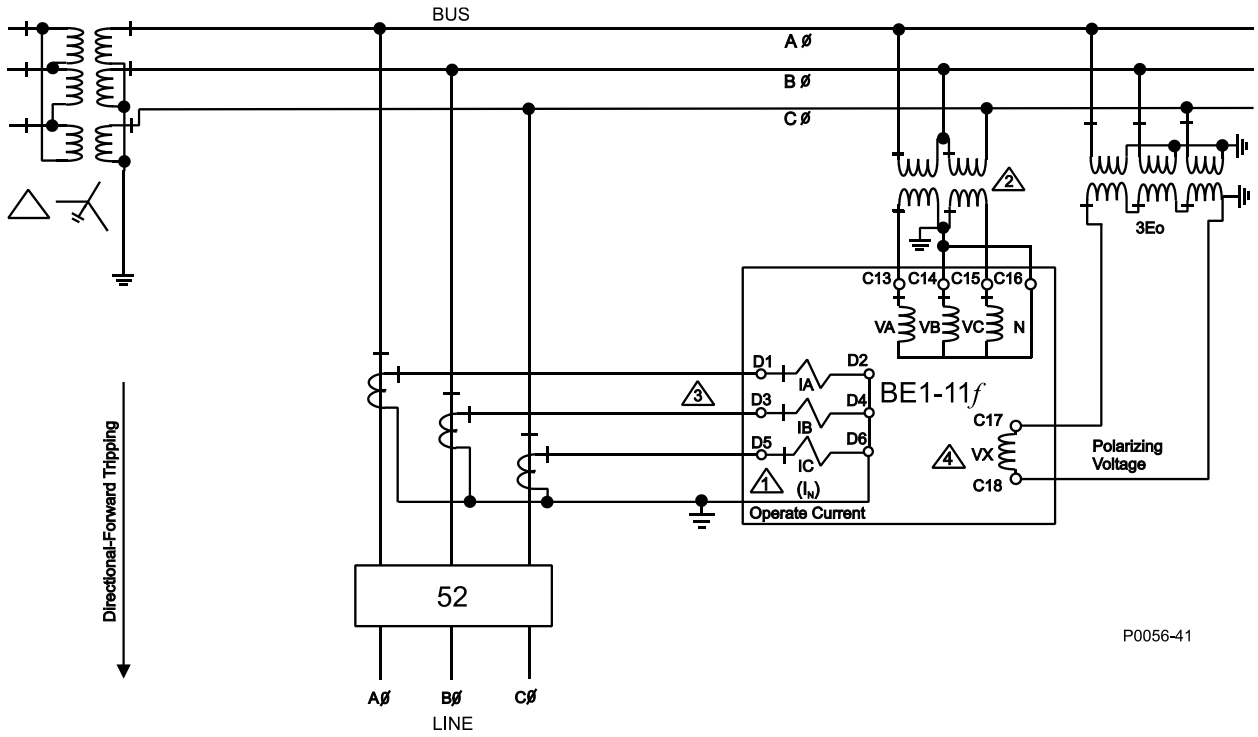


Figure 192. Directional Ground Overcurrent Protection using External Source of Zero-Sequence Polarizing Voltage (VX) Compared to Calculated Residual (3I0) (IN)

Notes for Figure 192:

1. The neutral ground (IN) operates on internally calculated residual (3I0) current.
2. VTP connections shown are for H1 case.
3. 4-wire connection shown as typical. See the *Typical Connections* chapter for alternate VTP connections. The 4-wire connection provides negative-sequence and, if selected, zero-sequence voltage polarizing (VOIN or VOIG) for ground faults; 3-wire connection provides negative-sequence voltage polarizing.
4. The polarity of metered watts and vars can be adjusted using BESTCOMS*Plus*.
5. VX connected to external source of 3V0 polarizing voltage.

BESTCOMS*Plus*® Software

BESTCOMS*Plus* is a Windows®-based, PC application that provides a user-friendly, graphical user interface (GUI) for use with Basler Electric communicating products. The name BESTCOMS*Plus* is an acronym that stands for Basler Electric Software Tool for Communications, Operations, Maintenance, and Settings.

BESTCOMS*Plus* provides the user with a point-and-click means to set and monitor the BE1-11*f*. The capabilities of BESTCOMS*Plus* make the configuration of one or several BE1-11*f* Feeder Protection Systems fast and efficient. A primary advantage of BESTCOMS*Plus* is that a settings scheme can be created, saved as a file, and then uploaded to the BE1-11*f* at the user's convenience.

BESTCOMS*Plus* uses plugins allowing the user to manage several different Basler Electric products. The BE1-11 plugin must be activated before use. The plugin can be activated automatically by connecting to a BE1-11*f* or activated manually by requesting an activation key from Basler Electric.

The BE1-11 plugin opens inside the BESTCOMS*Plus* main shell. The same default logic scheme that is shipped with the BE1-11*f* is brought into BESTCOMS*Plus* by downloading settings and logic from the relay or by selecting application type "F" on the Style Number screen. This gives the user the option of developing a custom setting file by modifying the default logic scheme or by building a unique scheme from scratch.

BESTlogic™*Plus* Programmable Logic is used to program BE1-11*f* logic for protection elements, inputs, outputs, alarms, etc. This is accomplished by the drag-and-drop method. The user can drag elements, components, inputs, and outputs onto the program grid and make connections between them to create the desired logic scheme.

BESTCOMS*Plus* also allows for downloading industry-standard COMTRADE files for analysis of stored oscillography data. Detailed analysis of the oscillography files can be accomplished using BESTwave™ software.

Figure 193 illustrates the typical user interface components of the BE1-11 plugin with BESTCOMS*Plus*.

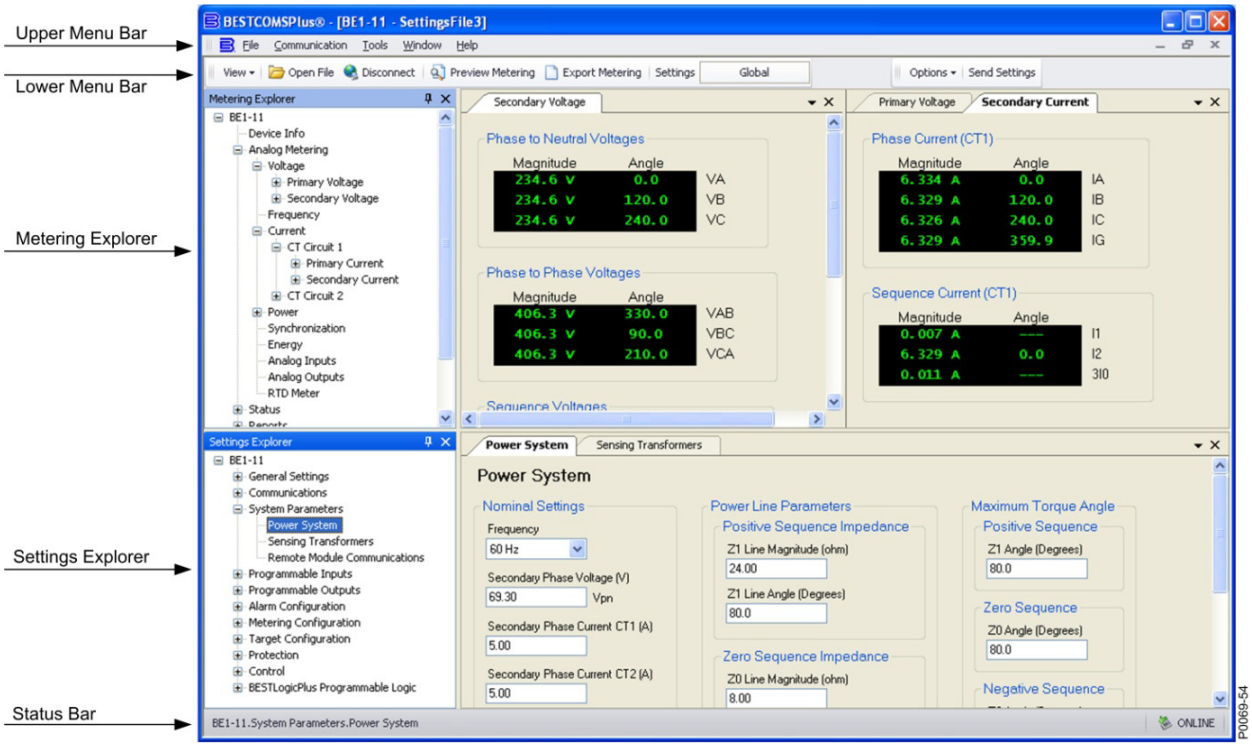


Figure 193. Typical User Interface Components

Installation

BESTCOMS*Plus* software is built on the Microsoft® .NET Framework. The setup utility that installs BESTCOMS*Plus* on your PC also installs the BE1-11 plugin and the required version of .NET Framework (if not already installed). BESTCOMS*Plus* operates with systems using Windows® XP 32-bit SP3, Windows Vista 32-bit SP1 (all editions), Windows 7 32-bit (all editions), and Windows 7 64-bit (all editions). System recommendations for the .NET Framework and BESTCOMS*Plus* are listed in Table 75.

Table 75. System Recommendations for BESTCOMS*Plus* and the .NET Framework

System Type	Component	Recommendation
32/64 bit	Processor	1.0 GHz
32/64 bit	RAM	512 MB (minimum)
32 bit	Hard Drive	75 MB (if .NET Framework is already installed on PC)
		925 MB (if .NET Framework is not already installed on PC)
64 bit	Hard Drive	75 MB (if .NET Framework is already installed on PC)
		2.1 GB (if .NET Framework is not already installed on PC)

To install BESTCOMS*Plus*, a Windows user must have Administrator rights.

Install BESTCOMS*Plus*®

Note

Do not connect a USB cable until setup completes successfully. Connecting a USB cable before setup is complete may result in unwanted or unexpected errors.

1. Insert the BE1-11 product CD into the PC CD-ROM drive.
2. When the BE1-11 Product CD menu appears, click the installation button for BESTCOMS*Plus*. The setup utility installs BESTCOMS*Plus*, the .NET Framework (if not already installed), the USB driver, and the BE1-11 plugin for BESTCOMS*Plus* on your PC.

When BESTCOMS*Plus* installation is complete, a Basler Electric folder is added to the Windows programs menu. This folder is accessed by clicking the Windows Start button and then accessing the Basler Electric folder in the Programs menu. The Basler Electric folder contains an icon that starts BESTCOMS*Plus* when clicked.

Activate the BE1-11 Plugin for BESTCOMSPlus®

The BE1-11 plugin is a module that runs inside the BESTCOMS*Plus* shell. The BE1-11 plugin contains specific operational and logic settings for only the BE1-11*f*. Uploading settings to the BE1-11*f* is possible only after activating the BE1-11 plugin.

The BE1-11 plugin can be activated automatically or manually. Automatic activation is achieved by using a USB cable to establish communication between the BE1-11*f* and BESTCOMS*Plus*. Manual activation is initiated by contacting Basler Electric for an activation key and entering the key into BESTCOMS*Plus*. Manual activation is useful if you want to create a settings file prior to receiving your relay. Note that if a relay is not connected, you will not be able to configure certain Ethernet settings. Ethernet settings can be changed only when an active USB or Ethernet connection is present. Refer to the *Communication* chapter.

Connect a USB Cable

The USB driver was copied to your PC during BESTCOMS*Plus* installation and is installed automatically after powering the BE1-11*f*. USB driver installation progress is shown in the Windows taskbar area. Windows will notify you when installation is complete.

Connect a USB cable between the PC and your BE1-11*f*. Apply operating power (per style chart in the *Introduction* chapter) to the BE1-11*f* at rear terminals A6 and A7. Wait until the boot sequence is complete.

Start BESTCOMS*Plus*® and Activate BE1-11 Plugin Automatically

To start BESTCOMS*Plus*, click the Start button, point to Programs, Basler Electric, and then click the BESTCOMS*Plus* icon. During initial startup, the BESTCOMS*Plus* Select Language screen is displayed (Figure 194). You can choose to have this screen displayed each time BESTCOMS*Plus* is started, or you can select a preferred language and this screen will be bypassed in the future. Click OK to continue. This screen can be accessed later by selecting Tools and Select Language from the menu bar.

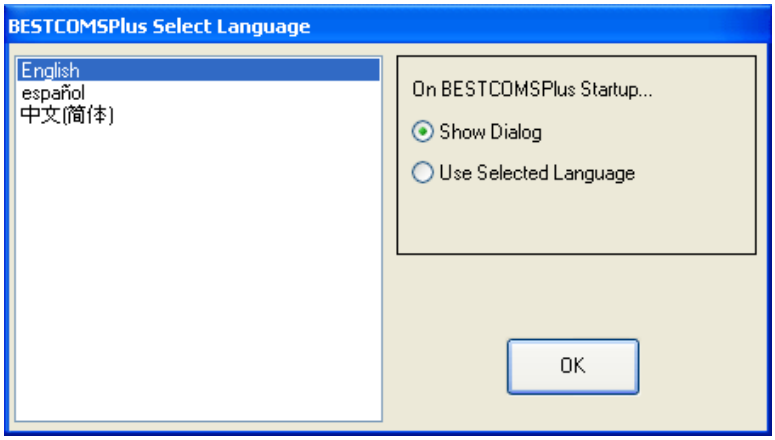


Figure 194. BESTCOMS*Plus* Select Language Screen

The BESTCOMS*Plus* splash screen is shown for a brief time. See Figure 195.

Figure 195. BESTCOMS*Plus* Splash Screen

The BESTCOMS*Plus* platform window opens. Select New Connection from the Communication pull-down menu and select BE1-11. See Figure 196. The BE1-11 plugin is activated automatically after connecting to a BE1-11*f*.

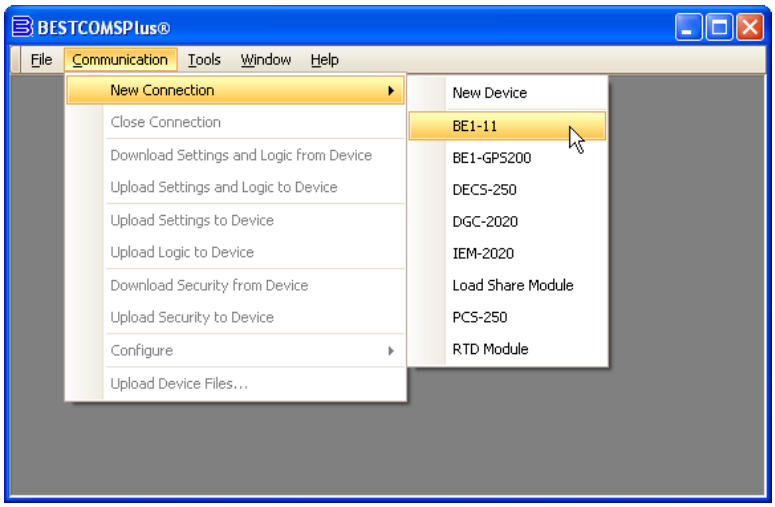


Figure 196. Communication Pull-Down Menu

The BE1-11 Connection screen shown in Figure 197 appears. Select USB Connection and then click the Connect button.

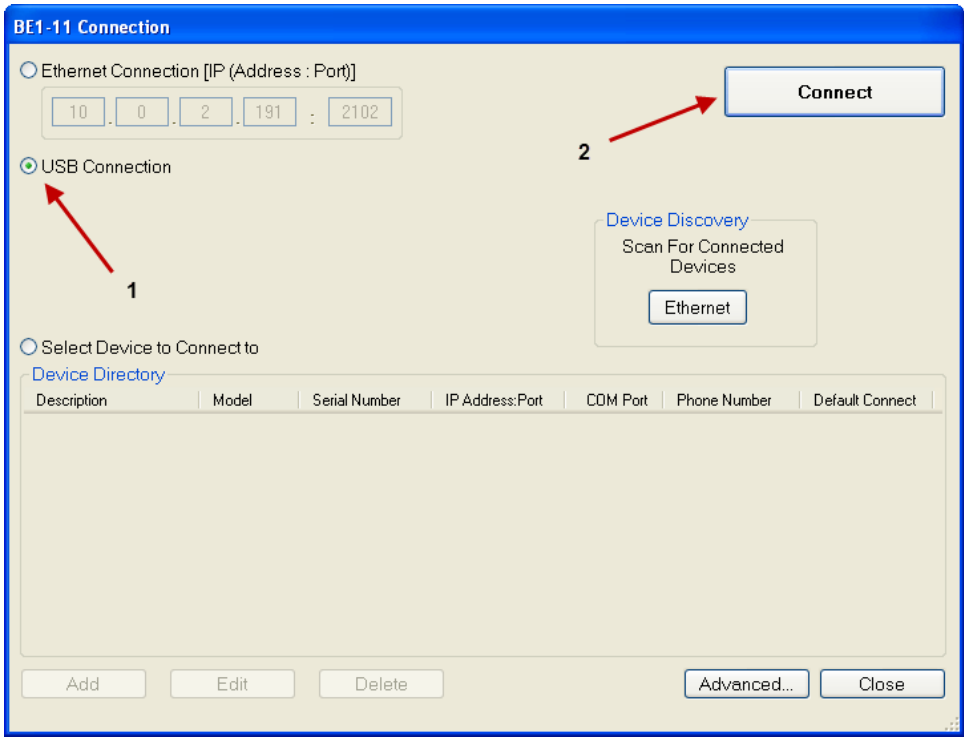


Figure 197. BE1-11 Connection Screen

The BE1-11 plugin opens indicating that activation was successful. You can now configure the BE1-11*f* communication ports and other BE1-11*f* settings.

Manual Activation of the BE1-11 Plugin

Manual activation of the BE1-11 plugin is required only if your initial use of BESTCOMS*Plus* will be on a PC that is not connected to a BE1-11*f*. Manual activation is described in the following paragraphs.

Requesting an Activation Key

When initially running the BE1-11 plugin, the Activate Device Plugin pop-up appears. You must contact Basler Electric for an activation key before you can activate the BE1-11 plugin. You can request an activation key through email or the Basler Electric website. Click either the Website or Email button. Click

the Activate button when you are ready to enter the activation key you received from Basler Electric. The Activate Device Plugin pop-up appears. Refer to Figure 198.

Entering an Activation Key

Select BE1-11 from the *Device* pull-down menu. Enter your Email Address and Activation Key provided by Basler Electric. If you received an email containing the Activation Key, you can select all of the text in the email and copy it to the Windows clipboard using normal Windows techniques. The Get Data button extracts the Device, Email Address, and Activation Key from the Windows clipboard and pastes it into the appropriate fields. Click the Activate button to continue. The Activate Device Plugin screen is also found by selecting Activate Device from the Tools pull-down menu of the BESTCOMS*Plus* main screen.

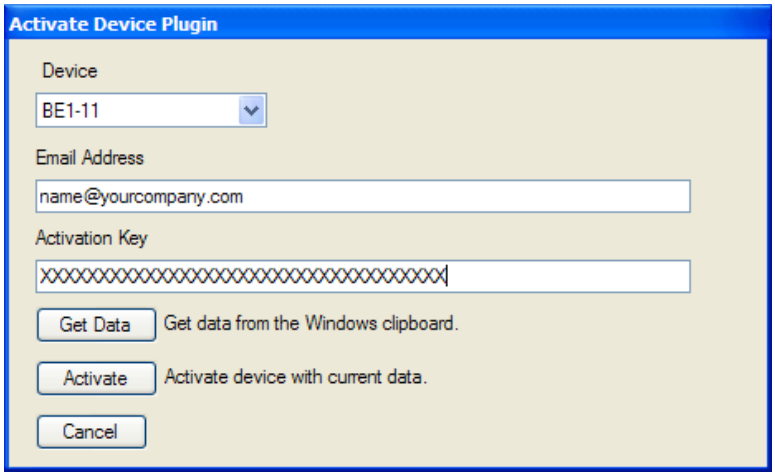


Figure 198. Activate Device Plugin

Establishing Communication

Communication between BESTCOMS*Plus* and the BE1-11*f* is established by clicking on the Connect button on the BE1-11 Connection screen (see Figure 197) or by clicking on the Connect button on the lower menu bar of the main BESTCOMS*Plus* screen (Figure 193). If you receive an "Unable to Connect to Device" error message, verify that communications are configured properly. Only one Ethernet connection is allowed at one time. Download all settings and logic from the relay by selecting Download Settings and Logic from the Communication pull-down menu. BESTCOMS*Plus* will read all settings and logic from the BE1-11*f* and load them into BESTCOMS*Plus* memory. See Figure 199.

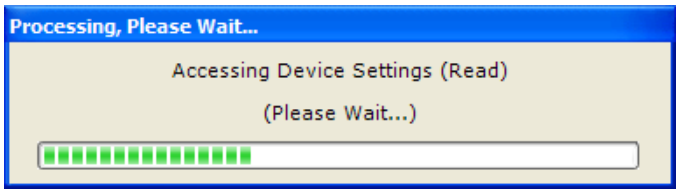


Figure 199. Processing, Please Wait…

Advanced Properties

Click the Advanced button on the Connection screen to display the Advanced Properties dialog. Default settings are shown in Figure 200.

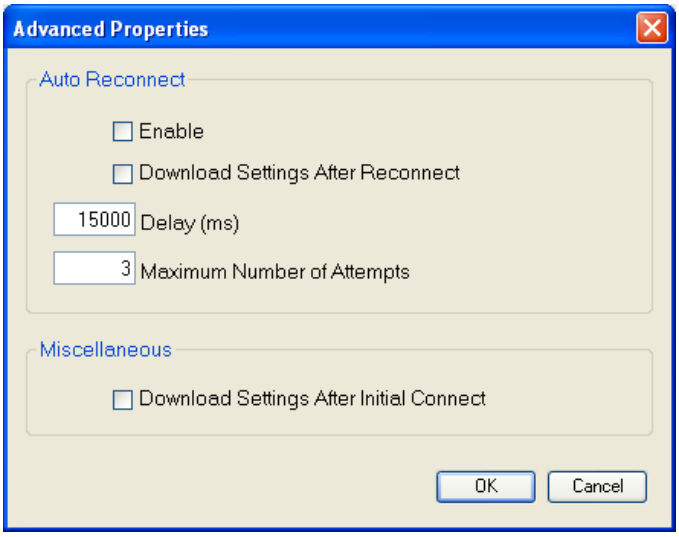


Figure 200. Advanced Properties Dialog

Menu Bars

The menu bars are located near the top of the BESTCOMS*Plus* screen (see Figure 193). The upper menu bar has five pull-down menus. With the upper menu bar, it is possible to manage settings files, configure communication settings, upload and download settings/security files, and compare settings files. The lower menu bar consists of clickable icons. The lower menu bar is used to change BESTCOMS*Plus* views, open a settings file, connect/disconnect, preview metering printout, export metering, switch to live mode, and send settings after a change is made when not in live mode.

Upper Menu Bar (BESTCOMS*Plus*® Shell)

Upper menu bar functions are listed and described in Table 76.

Table 76. Upper Menu Bar (BESTCOMS*Plus*® Shell)

Menu Item	Description
File	
New	Create a new settings file
Open	Open an existing settings file
Open File As Text	Generic file viewer for *.csv, *,txt, etc. files
Close	Close settings file
Save	Save settings file
Save As	Save settings file with a different name
Export To File	Save settings as a *.csv file
Print	Print, export, or send a settings file
Properties	View properties of a settings file
History	View history of a settings file
Recent Files	Open a previously opened file
Exit	Close BESTCOMS*Plus* program
Communication	
New Connection	Choose new device or BE1-11
Close Connection	Close communication between BESTCOMS*Plus* and BE1-11

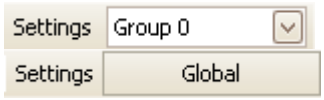
Menu Item	Description
Download Settings and Logic from Device	Download operational and logic settings from the device
Upload Settings and Logic to Device	Upload operational and logic settings to the device
Upload Settings to Device	Upload operational settings to the device
Upload Logic to Device	Upload logic settings to the device
Download Security from Device	Download security settings from the device
Upload Security to Device	Upload security settings to the device
Configure	Ethernet settings
Upload Device Files	Upload firmware to the device
Upgrade Style Number	Upload a style upgrade file supplied by Basler Electric
Tools	
Select Language	Select BESTCOMS*Plus* language
Activate Device	Activate the BE1-11 plugin
Set File Password	Password protect a settings file
Compare Settings Files	Compare two settings files
Copy Settings Group	Copy Settings from Group to Group
Auto Export Metering	Exports metering data on a user-defined interval
Launch BEST61850	Opens BEST61850 (if installed)
Event Log - View	View the BESTCOMS*Plus* event log
Event Log - Clear	Clear the BESTCOMS*Plus* event log
Event Log - Set New File Name	Set a new file name for event log
Window	
Cascade All	Cascade all windows
Tile	Tile horizontally or vertically
Maximize All	Maximize all windows
Help	
Check for Updates	Check for BESTCOMS*Plus* updates via the internet
Check for Update Settings	Enable or change automatic checking for updates
About	View general, detailed build, and system information

Lower Menu Bar (BE1-11 Plugin)

Lower menu bar functions are listed and described in Table 77.

Table 77. Lower Menu Bar (BE1-11 Plugin)

Menu Button	Description
View ▾	Enables you to show/hide the Metering Panel, Settings Panel, or Settings Info Panel. Opens and saves workspaces. Customized workspaces make switching between tasks easier and more efficient.
Open File	Opens a saved settings file.
Connect	Opens the BE1-11 Connection screen which enables you to connect to the BE1-11*f* via USB or Ethernet. This button appears only when a BE1-11*f* is not connected.
Disconnect	Used to disconnect a connected BE1-11*f*. This button appears only when a BE1-11*f* is connected.
Preview Metering	Displays the Print Preview screen where a preview of the Metering printout is shown. Click on the printer button to send to a printer.

Menu Button	Description
	Enables all metering values to be exported into a *.csv (comma-separated values) file.
	A pull-down menu allowing group selection is available when making protection settings. The settings can be applied to Group 0, 1, 2, or 3. If a global setting is being changed, Global will appear in place of the drop-down menu.
	Displays a drop-down list entitled Live Mode Settings which enables Live mode where settings are automatically sent to the device in real time as they are changed. The changed device settings are saved to non-volatile memory by clicking on the Save button.
	Saves all device settings to non-volatile memory. This button appears only when operating in Live mode.
	Sends settings to the BE1-11 when BESTCOMS*Plus* is not operating in Live Mode. Click this button after making a setting change to send the modified setting to the BE1-11*f*.

Settings Explorer

The Settings Explorer is a convenient tool within BESTCOMS*Plus* used to navigate through the various settings screens of the BE1-11 plugin. Descriptions of these configuration settings are organized as follows:

- General Settings
- Communications
- System Parameters
- Programmable Inputs
- Programmable Outputs
- Alarm Configuration
- Metering Configuration
- Target Configuration
- Protection
- Control
- BESTlogic*Plus* Programmable Logic

Logic setup will be necessary after making certain setting changes. For more information, refer to the *BESTlogicPlus* chapter.

Metering Explorer

The Metering Explorer is described in the *Metering* chapter.

Settings File Management

A settings file contains all BE1-11*f* settings including logic. A settings file assumes a file extension of "*.bst" or "*.bstx". It is possible to save the logic only as a separate logic library file on the *BESTlogicPlus Programmable Logic* screen. This function is helpful when similar logic is required for several devices. A logic library file assumes a file extension of "*.bsl" or "*.bslx". It is important to note that settings and logic can be uploaded to the device separately or together, but are always downloaded together. For more information on logic files, refer to the *BESTlogicPlus* chapter.

Opening a Settings File

To open a BE1-11*f* settings file with BESTCOMS*Plus*, pull down the File menu and choose Open. 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 choose Open. You can also open a file by clicking on the Open File button on the lower menu bar. If connected to a device, you will be asked to upload the settings and logic from the file to the current device. If you choose Yes, the settings displayed in BESTCOMS*Plus* instance will be overwritten with the settings of the opened file.

Saving a Settings File

Select Save or Save As from the File pull-down menu. A dialog box pops up allowing you to enter a filename and location to save the file. Select the Save button to complete the save.

Upload Settings and/or Logic to Device

To upload a settings file to the BE1-11*f*, open the file or create a new file through BESTCOMS*Plus*. Then pull down the Communication menu and select Upload Settings and Logic to Device. If you want to upload operational settings without logic, select Upload Settings to Device. If you want to upload logic without operational settings, select Upload Logic to Device. You are prompted to enter the username and password. The default username is "**A**" and the default password is "**A**". If the username and password are correct, the upload begins and the progress bar is shown.

Download Settings and Logic from Device

To download settings and logic from the BE1-11*f*, pull down the Communication menu and select Download Settings and Logic from Device. If the settings in BESTCOMS*Plus* have changed, a dialog box will open asking if you want to save the current settings changes. You can choose Yes or No. After you have taken the required action to save or discard the current settings, downloading begins. BESTCOMS*Plus* reads all settings and logic from the BE1-11*f* and loads them into BESTCOMS*Plus* memory. See Figure 201.

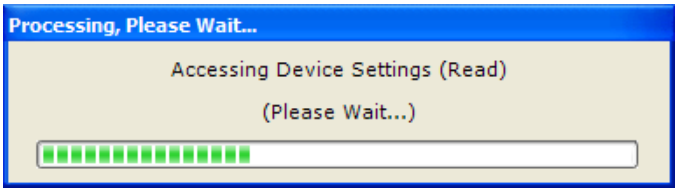


Figure 201. Processing, Please Wait…

Printing a Settings File

To view a preview of the settings printout, select Print Preview from the File pull-down menu. To print the settings, select the printer icon in the upper left corner of the Print Preview screen.

You can skip the print preview and go directly to print by pulling down the File menu and selecting Print. A Print dialog box opens with the typical Windows choice to setup the properties of printer. Execute this command, as necessary, and then select Print.

Comparing Settings Files

BESTCOMS*Plus* has the ability to compare two settings files. To compare files, pull down the Tools menu and select Compare Settings Files. The BESTCOMS*Plus* Settings Compare Setup dialog box appears (Figure 202). Select the location of the first file under Left Settings Source and select the location of the second file 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 Select Unit button to set up the communication port. Click the Compare button to compare the selected settings files.

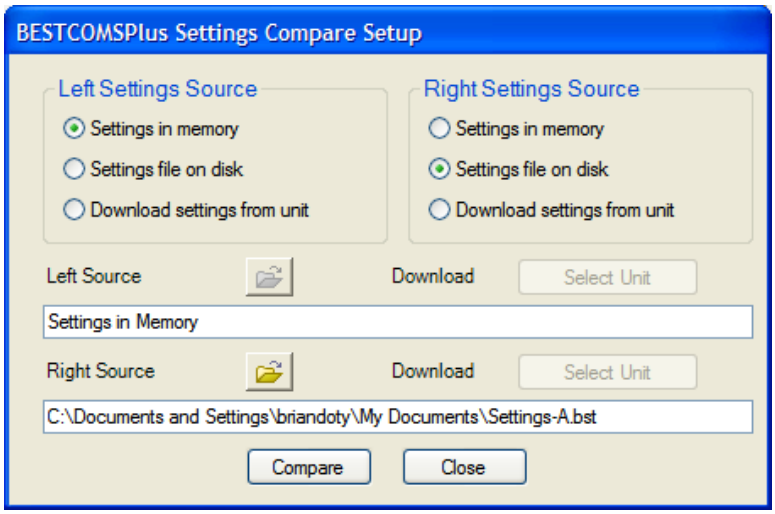


Figure 202. BESTCOMS*Plus* Settings Compare Setup

A dialog box will appear and notify you if any differences were found. The BESTCOMS*Plus* Settings Compare dialog box (Figure 203) is displayed where you can view all settings, settings differences, all logic paths, logic path differences, all DNP/Modbus options, or DNP/Modbus differences. If a settings file based on an older version of firmware was uploaded into the relay, the relay could contain additional settings that did not exist when the original settings file was created. The settings compare function detects these differences and displays them when the Include Missing box is checked. Uncheck this box to ignore differences due to the additional settings. Click Print to print a report or click Close to close the window.

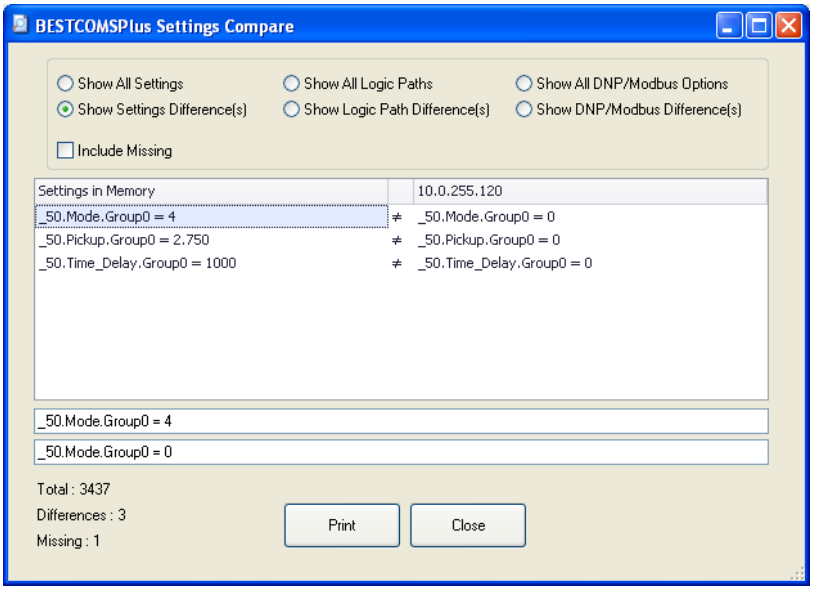


Figure 203. BESTCOMS*Plus* Settings Compare

Auto Export Metering

The auto export metering function automatically exports metering data over a user-defined period. The user specifies the Number of Exports and the Interval between each export. Enter a filename for the metering data and a folder in which to save. The first export is performed immediately after clicking the Start button. Click the Filter button to select specific metering screens. Figure 204 illustrates the Auto Export Metering screen.

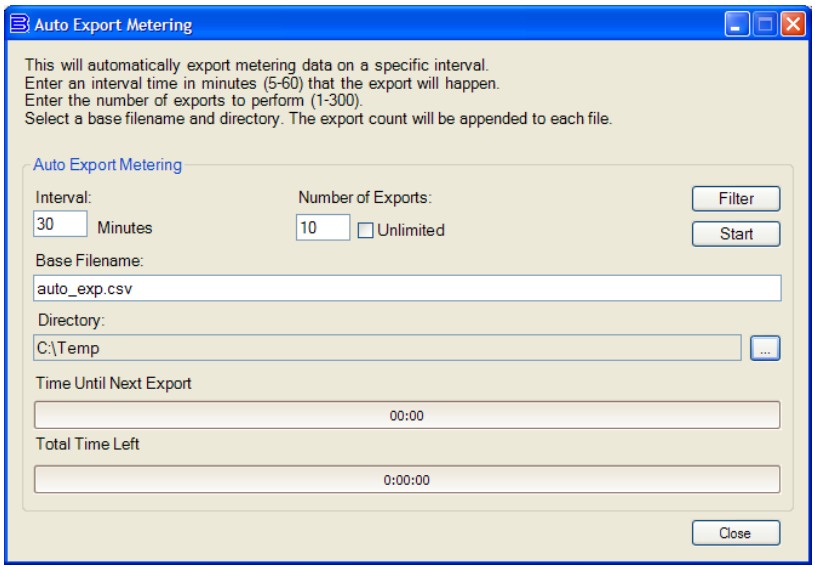


Figure 204. Auto Export Metering

BESTCOMSPlus® Updates

Ongoing BE1-11*f* functionality enhancements may make future BE1-11*f* firmware updates desirable. Enhancements to BE1-11*f* firmware typically coincide with enhancements to the BE1-11 plugin for BESTCOMS*Plus*. When a BE1-11*f* is updated with the latest version of firmware, the latest version of BESTCOMS*Plus* should also be obtained.

- If you obtained a CD-ROM containing a firmware update from Basler Electric, then that CD-ROM will also contain the corresponding version of BESTCOMS*Plus* software.
- You can check for BESTCOMS*Plus* updates by visiting www.basler.com. An online form can be completed to obtain a password for downloading the software.
- You can use the manual “check for updates” function in BESTCOMS*Plus* to ensure that the latest version is installed by selecting Check for Updates in the Help drop-down menu. (An internet connection is required.)

Firmware Updates

For information on updating firmware, refer to the *Device Information* chapter.

BESTlogic™*Plus*

BESTlogic*Plus* Programmable Logic is a programming method used for managing the input, output, protection, control, monitoring, and reporting capabilities of Basler Electric's BE1-11*f* Feeder Protection System. Each BE1-11*f* has multiple, self-contained logic blocks that have all of the inputs and outputs of its discrete component counterpart. Each independent logic block interacts with control inputs and hardware outputs based on logic variables defined with BESTlogic*Plus*. BESTlogic*Plus* equations entered and saved in the BE1-11*f* system's nonvolatile memory integrate (electronically wire) the selected or enabled protection and control blocks with control inputs and hardware outputs. A group of logic equations defining the logic of the BE1-11*f* is called a logic scheme.

One default active logic scheme is preloaded into the BE1-11*f*. This scheme is configured for a typical protection and control application and virtually eliminates the need for "start-from-scratch" programming. BESTCOMS*Plus*® can be used to open a logic scheme that was previously saved as a file and upload it to the BE1-11*f*. The default logic scheme can also be customized to suit your application.

BESTlogic*Plus* is not used to define the operating settings (modes, 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 BE1-11*f*. Detailed information about operating settings is provided in each chapter of the various protection and control functions.

Overview of BESTlogic™Plus

BESTlogic*Plus* settings are made through BESTCOMS*Plus*. Use the Settings Explorer to open the BESTlogic*Plus* Programmable Logic tree branch as shown in Figure 205.

The BESTlogic*Plus* Programmable Logic screen contains a logic library for opening and saving logic files, tools for creating and editing logic documents, and protection settings.

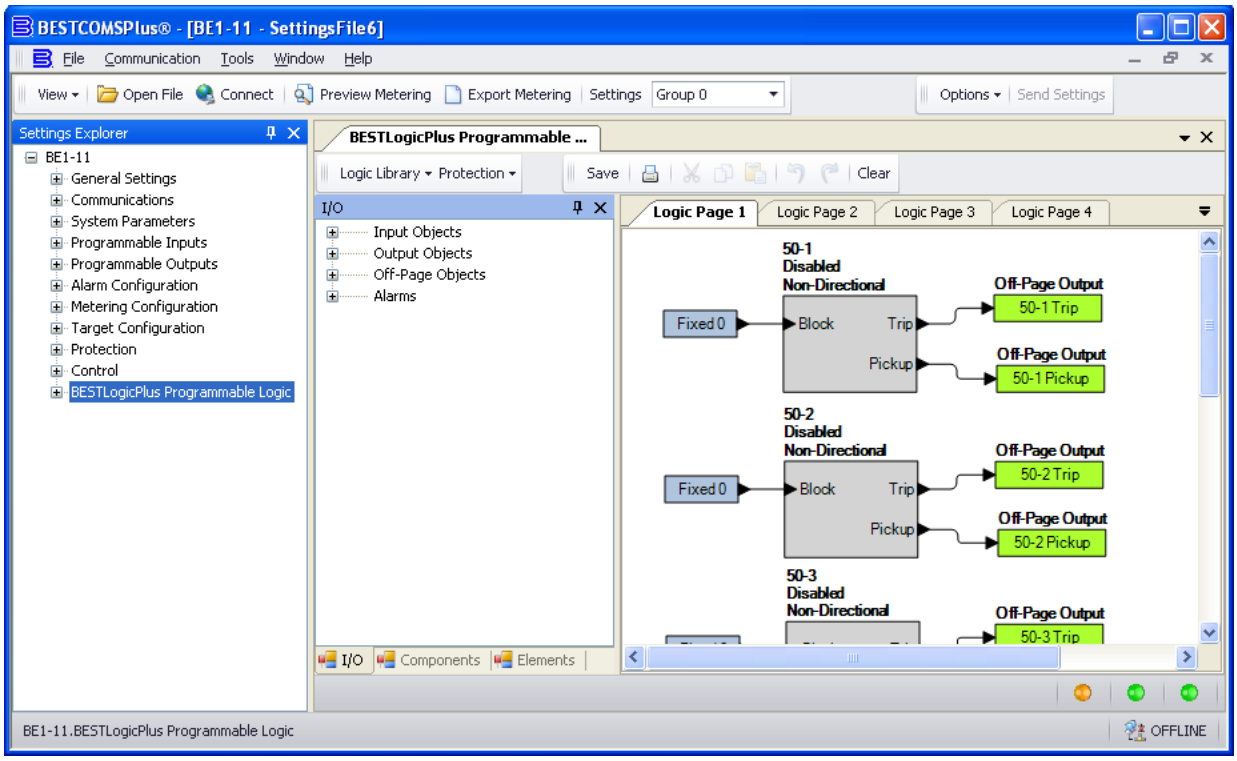


Figure 205. BESTlogic*Plus* Programmable Logic Tree Branch

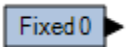
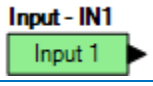
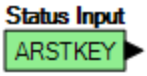
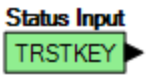
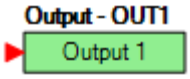
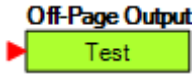
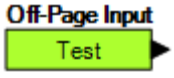
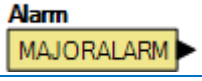
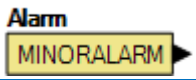
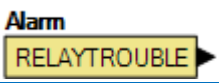
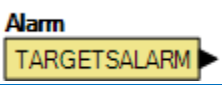
BESTlogic™*Plus* Composition

There are three main groups of objects used for programming BESTlogic*Plus*. These groups are I/O, Components, and Elements. For details on how these objects are used to program BESTlogic*Plus*, see the paragraphs on *Programming BESTlogicPlus.*

I/O

This group contains Input Objects, Output Objects, Off-Page Objects, and Alarms. Input objects can be logically connected to any logic block input. Output objects can be logically connected to any logic block output. Table 78 lists the names and descriptions of the objects in the I/O group.

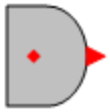
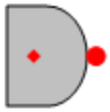
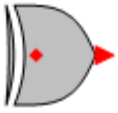
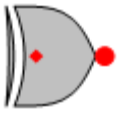
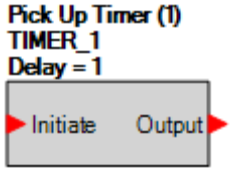
Table 78. I/O Group, Names and Descriptions

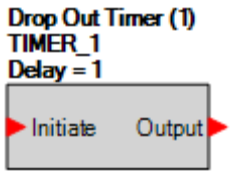
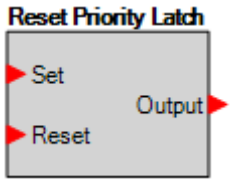
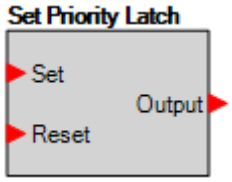
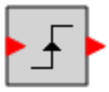
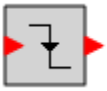
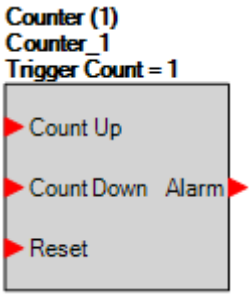
Name	Description	Symbol
Input Objects		
Logic 0	Always false (Low). Double-click or right-click on the object to change the fixed state from 0 to 1.	
Logic 1	Always true (High). Double-click or right-click on the object to change the fixed state from 1 to 0.	
Physical Inputs IN1 – IN7	True when Physical Input x is active.	
Status Inputs Alarm Reset Key	The Alarm Reset Key status input goes momentarily high when the Reset button on the front panel is pressed while viewing the alarms screen.	
Status Inputs Target Reset Key	The Target Reset Key status input goes momentarily high when the Reset button on the front panel is pressed while viewing the targets screen.	
Output Objects		
Physical Outputs OUT1 – OUT8 and OUTA	Physical Outputs 1 through 8 and A.	
Off-Page Objects		
Off-Page Output	Used in conjunction with the Off-Page Input to transform an output on one logic page into an input on another logic page. Outputs can be renamed by right-clicking and selecting Rename Output. Right-clicking will also show pages that the corresponding inputs can be found on. Selecting the page will take you to that page.	
Off-Page Input	Used in conjunction with the Off-Page Output to transform an output on one logic page into an input on another logic page. Inputs can be renamed by right-clicking and selecting Rename Input. Right-clicking will also show pages that the corresponding outputs can be found on. Selecting the page will take you to that page.	
Alarms		
Major Alarm	True when the Major Alarm is true. Refer to the *Alarms* chapter for more information.	
Minor Alarm	True when the Minor Alarm is true. Refer to the *Alarms* chapter for more information.	
Relay Trouble Alarm	True when a Relay Trouble alarm is active. Refer to the *Alarms* chapter for more information.	
Targets	True when targets are active. Refer to the *Fault Reporting* chapter for more information.	

Components

This group contains Logic Gates, Pickup and Dropout Timers, Latches, Logic Counters, and Comment Blocks. Double-click or right-click on a gate to change the type. Table 79 lists the names and descriptions of the objects in the Components group.

Table 79. Components Group, Names and Descriptions

Name	Description	Symbol
Logic Gates		
AND	Input Output 0 0 0 0 1 0 1 0 0 1 1 1	
NAND	Input Output 0 0 1 0 1 1 1 0 1 1 1 0	
OR	Input Output 0 0 0 0 1 1 1 0 1 1 1 1	
NOR	Input Output 0 0 1 0 1 0 1 0 0 1 1 0	
XOR	Input Output 0 0 0 0 1 1 1 0 1 1 1 0	
XNOR	Input Output 0 0 1 0 1 0 1 0 0 1 1 1	
NOT (INVERTER)	Input Output 0 1 1 0	
Pickup and Dropout Timers		
Pickup Up Timer	A pickup timer produces a true output when the elapsed time is greater than or equal to the Pickup Time setting after a false to true transition occurs on the Initiate input from the connected logic. Whenever the Initiate input status transitions to false, the output transitions to FALSE immediately. Refer to *Programming BESTlogicPlus, Pickup and Dropout Timers*. Double-click or right-click on the logic timer to select from timers 1 through 16.	

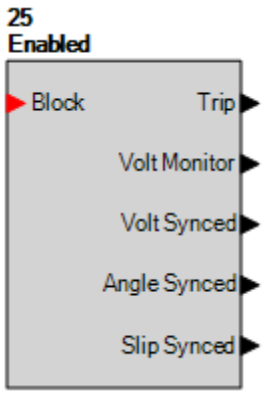
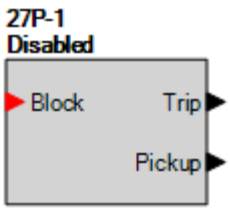
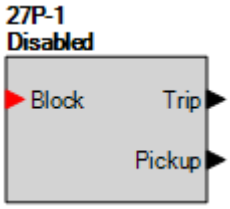
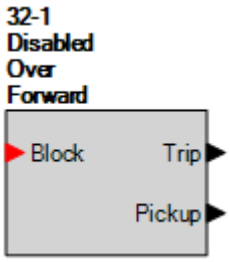
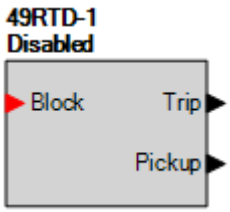
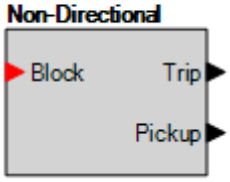
Name	Description	Symbol
Drop Out Timer	A drop out timer produces a true output when the elapsed time is greater than or equal to the Dropout Time setting after a true to false transition occurs on the Initiate input from the connected logic. Whenever the Initiate input transitions to true, the output transitions to false immediately. Refer to *Programming BESTlogicPlus, Pickup and Dropout Timers*. Double-click or right-click on the logic timer to select from timers 1 through 16.	
Latches		
Reset Priority Latch	A positive going edge on the Set input sets the latch, as long as the Reset input is false. A positive edge on the Reset input will clear the latch.	
Set Priority Latch	A positive going edge on the Set input sets the latch. A positive going edge on the Reset input will clear the latch, as long as the Set input is false.	
Triggers		
Rising Edge	The output of a rising edge trigger pulses true when the input goes from logic 0 to logic 1. Double-click or right-click on the logic trigger to change the type.	
Falling Edge	The output of a falling edge trigger pulses true when the input goes from logic 1 to logic 0. Double-click or right-click on the logic trigger to change the type.	
Logic Counters		
Logic Counters	A logic counter produces a true Alarm output when the elapsed count is greater than or equal to the Trigger Count setting after a false to true transition occurs on the Count Up input from the connected logic. A positive going edge on the Reset input will reset the counter. The count will be reduced by 1 each time a false to true transition occurs on the Count Down input. Double-click or right-click on the logic counter to select from counters 1 through 8.	
Other		
Logic Comment Block	The logic comment block is used to place notes on the logic.	

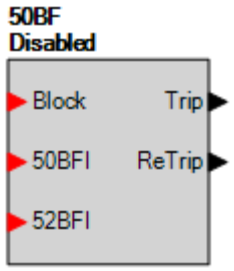
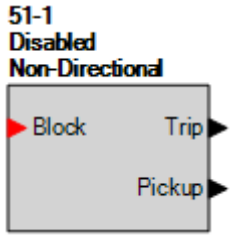
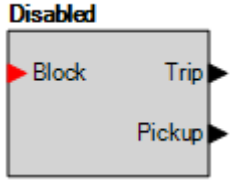
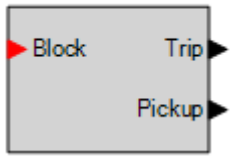
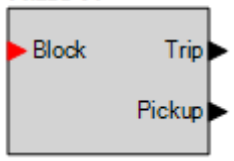
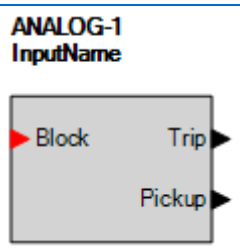
Elements

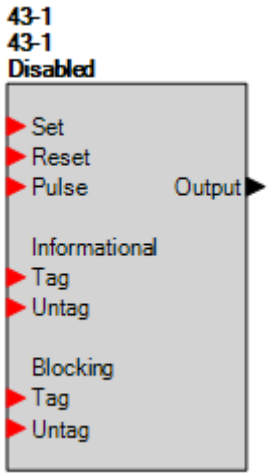
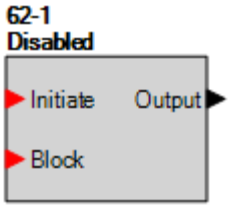
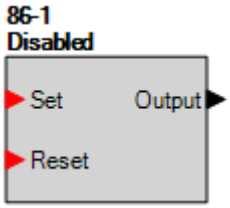
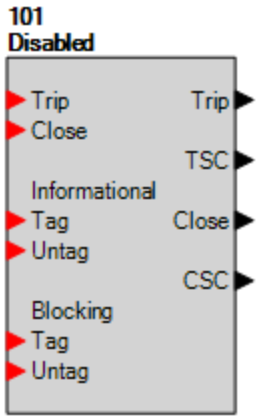
This group contains elements for the 25, 27P, 27X, 32, 43, 49RTD, 50, 50BF, 51, 59P, 59X, 60FL, 62, 81, 86, and 101. It also contains elements for 52TCM, Breaker Monitor, Breaker Status, Fault Trigger, Email Trigger, Setting Group Control, Analog Inputs 1-8, User Alarms 1-16, Logic Labels 1-12, Indicators 1-7, Major Alarm Reset, Minor Alarm Reset, and Target Reset.

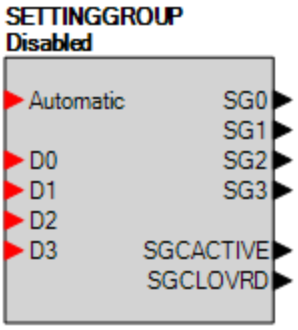
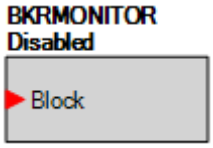
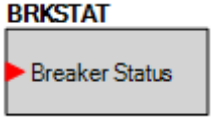
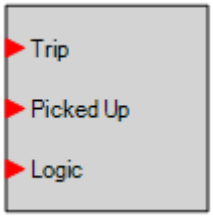
Table 80 lists the names and descriptions of the elements in the Elements group.

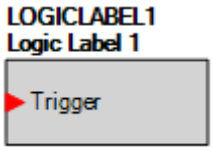
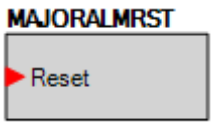
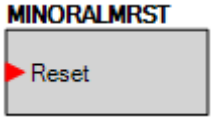
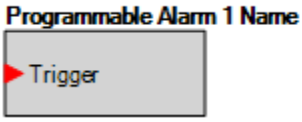
Table 80. Elements Group, Names and Descriptions

Name	Description	Symbol
Protection		
25	Sync-Check Protection. Refer to the *Sync-Check Protection (25)* chapter.	
27P-x	Phase Undervoltage Protection. Refer to the *Phase Undervoltage Protection (27P)* chapter.	
27X-x	Auxiliary Undervoltage Protection. Refer to the *Auxiliary Undervoltage Protection (27X)* chapter.	
32-x	Power Protection. Refer to the *Power Protection (32)* chapter.	
49RTD	Thermal Protection - Thermocouple. For use when an optional RTD module is connected. Refer to the *RTD Module* chapter.	
50-x	Instantaneous Overcurrent Protection. Refer to the *Instantaneous Overcurrent Protection (50)* chapter.	

Name	Description	Symbol
50BF	Breaker Fail Protection. Refer to the *Breaker Fail Protection (50BF)* chapter.	
51-x	Inverse Overcurrent Protection. Refer to the *Inverse Overcurrent Protection (51)* chapter.	
59P-x	Phase Overvoltage Protection. Refer to the *Phase Overvoltage Protection (59P)* chapter.	
59X-x	Auxiliary Overvoltage Protection. Refer to the *Auxiliary Overvoltage Protection (59X)* chapter.	
81-x	Frequency Protection. Refer to the *Frequency Protection (81)* chapter.	
ANALOG-x	Analog Input 1 through 8. Refer to the *RTD Module* chapter.	

Name	Description	Symbol
Control		
43-x	Virtual Control Switches. Refer to the *Virtual Control Switches (43)* chapter.	
62-x	Logic Timers. Refer to the *Logic Timers (62)* chapter.	
86-x	Lockout Functions. Refer to the *Lockout Functions (86)* chapter.	
101	Breaker Control Switch. Refer to the *Breaker Control Switch (101)* chapter.	

Name	Description	Symbol
SETTINGGROUP	Setting Group Control. Refer to the *Setting Groups* chapter.	
Reporting and Alarms		
52TCM	Trip Circuit Monitor. Refer to the *Trip Circuit Monitor (52TCM)* chapter.	
60FL	Fuse Loss. Refer to the *Fuse Loss (60FL)* chapter.	
BKRMONITOR	Breaker Monitor. Refer to the *Breaker Monitoring* chapter.	
BRKSTAT	Breaker Status. Refer to the *Breaker Monitoring* chapter.	
EMAIL-x	Email Trigger 1 through 8. Refer to the *Communication* chapter.	
FAULTTRIG	Fault Trigger. Refer to the *Fault Reporting* chapter.	
INDICATORx	Indicators 1 through 7. Refer to the *Controls and Indicators* chapter. The indicator is displayed in the sequence of events and the corresponding indicator on the front panel is illuminated when the Trigger input is true. To name indicators, use the Settings Explorer in BESTCOMS*Plus* to expand the BESTlogic*Plus* Programmable Logic tree branch and select Front Panel Indicator Labels.	

Name	Description	Symbol
LOGICLABELx	Logic Label 1 through 12. The logic label is displayed in the sequence of events when the Trigger input is true. To name logic labels, use the Settings Explorer in BESTCOMS*Plus* to expand the BESTlogic*Plus* Programmable Logic tree branch and select Logic Labels.	
MAJORALMRST	Major Alarm Reset. Refer to the *Alarms* chapter.	
MINORALMRST	Minor Alarm Reset. Refer to the *Alarms* chapter.	
TARGETRESET	Target Reset. Refer to the *Fault Reporting* chapter.	
USERALARMx	User Alarms 1 though 16. Refer to the *Alarms* chapter.	

Logic Schemes

A logic scheme is a group of logic variables that defines the operation of a BE1-11*f*. Each logic scheme is given a unique name. This gives you the ability to select a specific scheme and be confident that the selected scheme is in operation. One logic scheme is configured for typical control applications and is the default active logic scheme. Only one logic scheme can be active at a given time. In most applications, preprogrammed logic schemes eliminate the need for custom programming. Preprogrammed logic schemes can provide more inputs, outputs, or features than are needed for a particular application. This is because a preprogrammed scheme is designed for a large number of applications with no special programming required. Unneeded logic block outputs can be left open to disable a function or a function block can be disabled through operating settings.

When a custom logic scheme is required, programming time is reduced by modifying the default logic scheme.

Default Logic Scheme

All BE1-11*f* relays are delivered with the default logic scheme pre-loaded in memory. 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 BE1-11*f* in service.

Details of Default Logic Scheme describes the characteristics of the logic scheme and how it combines to create an Overcurrent Protection System for a radial system substation. A detailed description of the default scheme is also provided.

The default logic scheme is designed to accommodate most common distribution or sub-transmission radial system overcurrent coordination schemes. The protection engineer can adapt it by changing the function block operation and settings. This eliminates the need to create a custom logic scheme.

It should be noted that the default logic scheme also illustrates typical ways of using or controlling various functions. The user can choose to create a custom logic scheme by mixing the logic from the default

scheme. The flexibility of BESTlogic*Plus* allows the protection engineer to create a custom scheme that exactly meets the requirements of the application.

Caution

Always remove the BE1-11*f* from service prior to changing or modifying the active logic scheme. Attempting to modify a logic scheme while the BE1-11*f* is in service could generate unexpected or unwanted outputs.

Modifying a logic scheme in BESTCOMS*Plus* does not automatically make that scheme active in the BE1-11*f*. The modified scheme must be uploaded into the BE1-11*f*. See the paragraphs on *Sending and Retrieving Logic Schemes.*

Operational settings are not included in the default logic scheme. Each element, target, pickup setting, timing setting, etc. will have to be enabled and programmed separately using the Settings Explorer in BESTCOMS*Plus*.

Overview of Default Logic Scheme

The default logic scheme provides basic time and instantaneous overcurrent protection. Included protective elements are 50-1, 50-2, 50-3, 51-1, 51-2, and 51-3. Functions such as breaker failure, virtual breaker control, and protective voltage features are not enabled in this scheme. However, these features can be activated through BESTCOMS*Plus*.

Details of Default Logic Scheme

The following paragraphs describe the default logic scheme in detail. Operation of the protection and control logic under normal conditions is described. The features of the logic scheme are broken down into functional groups and described in detail.

The default logic scheme is intended for applications requiring three-phase and neutral non-directional overcurrent protection. This logic scheme provides an excellent base on which to create a custom scheme for a specific application.

The components of the default logic are summarized in Table 81 and Table 82. Figure 206 shows a one-line drawing for the default logic scheme. A diagram of the default logic is shown in Figure 207.

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 setpoint at zero in each of the four setting groups. OUT1 will operate and trip the breaker. Contact outputs OUT2, OUT3, OUT4, and OUT5 are designated to specific function blocks. OUT2 operates for instantaneous phase overcurrent conditions, OUT3 trips for timed phase overcurrent situations, OUT4 operates for instantaneous neutral and negative-sequence overcurrent conditions, and OUT5 operates for timed neutral and negative-sequence overcurrent conditions. All contact sensing inputs are unassigned.

Operation - Setting Group Selection

A setting group can be selected automatically or by using the communication ports or the front-panel interface. 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 using BESTCOMS*Plus*. Setting group changes are not accommodated in this scheme.

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 on the front panel will light. OUTA will also close if relay operating power is lost. More information about alarms is provided in the *Alarms* chapter.

Table 81. Default Function Block Logic

Function	Purpose	BESTlogic*Plus* Inputs
50-1	Used for instantaneous phase overcurrent protection.	0
50-2	Used for instantaneous neutral overcurrent protection.	0
50-3	Used for instantaneous negative-sequence overcurrent protection.	0
51-1	Used for timed phase overcurrent protection.	0
51-2	Used for timed neutral overcurrent protection.	0
51-3	Used for timed negative-sequence overcurrent protection.	0
FAULT TRIGGER	Trip	Trip Bus
	Picked Up	Pickup Bus
	Logic	0

Table 82. Default Output Logic

Output	Purpose	Description	Label	State Labels	
				Energized	De-Energized
OUTA	Alarm Output Contact.	Alarm contact closes/opens (refer to style number) automatically when relay trouble alarm occurs.	Output Alarm	On	Off
OUT1	Breaker Trip Output.	Contact closes when protective trip expression is TRUE.	Output 1	On	Off
OUT2	Instantaneous Phase OC Auxiliary Contact.	Contact closes when instantaneous overcurrent (50-1) trip occurs.	Output 2	On	Off
OUT3	Timed Phase OC Auxiliary Contact.	Contact closes when inverse overcurrent (51-1) trip occurs.	Output 3	On	Off
OUT4	Instantaneous Neutral and Negative-Sequence OC.	Contact closes when instantaneous overcurrent (50-2 or 50-3) trip occurs.	Output 4	On	Off
OUT5	Timed Neutral and Negative-Sequence OC.	Contact closes when inverse overcurrent (51-2 or 51-3) trip occurs.	Output 5	On	Off

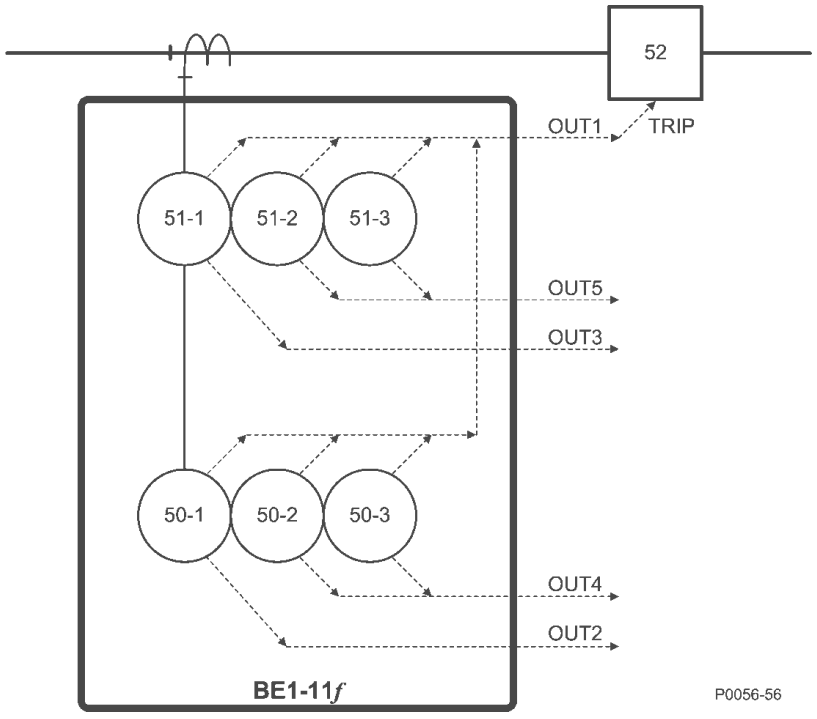


Figure 206. One-Line Drawing for Default Logic

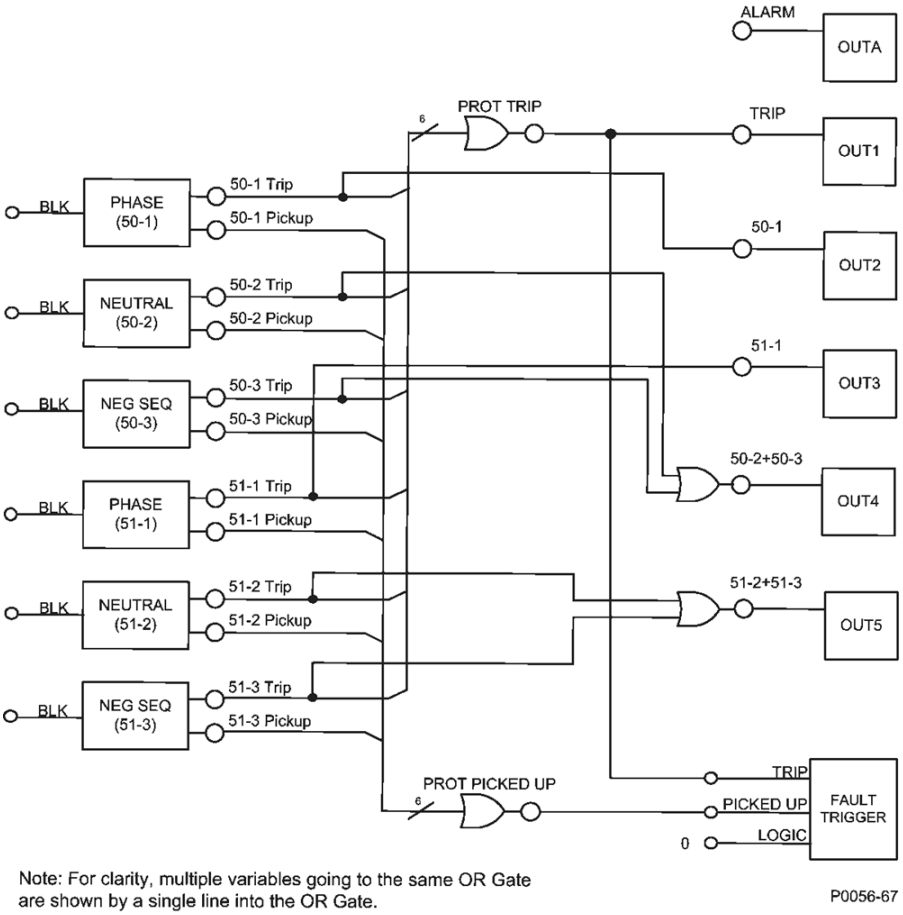


Figure 207. Logic Diagram for Default Logic

Copying and Renaming Preprogrammed Logic Schemes

Copying a saved logic scheme to the active logic (Logic Name) and assigning a unique name is accomplished by loading the saved logic scheme into BESTCOMS*Plus* and then typing over the logic scheme's name. Changes are not activated until the new settings have been saved and uploaded to the device.

Retrieving a Logic Scheme from the BE1-11*f*

To retrieve settings from the BE1-11*f*, the BE1-11*f* must be connected to a computer through a communications port. Once the necessary connections are made, settings can be downloaded from the BE1-11*f* by selecting Download Settings and Logic from Device on the Communication pull-down menu.

Sending a Logic Scheme to the BE1-11*f*

To send settings to the BE1-11*f*, the BE1-11*f* must be connected to a computer through a communications port. Once the necessary connections are made, settings can be uploaded to the BE1-11*f* by selecting Upload Settings and Logic to Device or Upload Logic to Device on the Communication pull-down menu.

Programming BESTlogicPlus

BESTCOMS*Plus* is used to program BESTlogic*Plus*. Using BESTCOMS*Plus* is analogous to physically attaching wire between discrete BE1-11*f* terminals. To program BESTlogic*Plus*, use the Settings Explorer within BESTCOMS*Plus* to open the BESTlogic*Plus* Programmable Logic tree branch as shown in Figure 205.

The drag-and-drop method is used to connect a variable or series of variables to the logic inputs, outputs, components, and elements. To draw a wire/link from port to port (triangles), use the primary mouse button to click on a port, pull the wire onto another port, and release the left mouse button. A red port indicates that a connection to the port is required or missing. A black port indicates that a connection to the port is not required. Drawing wires/links from input to input or output to output is not allowed. Only one wire/link can be connected to any one output. If the proximity of the endpoint of the wire/link is not exact, it may attach to an unintended port.

If an element is disabled by the style number, it will have a red X on it. To enable the element, configure the style number to include the element. Refer to the *Device Information* chapter for more details.

The view of Logic Page 1 through 4 and Physical Outputs can be automatically arranged by clicking the right mouse button on the window and selecting *Auto-Layout.*

Logic tabs can be renamed by clicking the right mouse button in the logic drawing area and selecting Rename Logic Tabs.

The following must be met before BESTCOMS*Plus* will allow logic to be uploaded to the BE1-11*f*:

- A minimum of two inputs and a maximum of 32 inputs on any multi-port (AND, OR, NAND, NOR, XOR, and XNOR) gate.
- A maximum of 32 logic levels for any particular path. A path being an input block or an output side of an element block through gates to an output block or an input side of an element block. This is to include any OR gates on the Physical Outputs page, but not the matched pairs of Physical Outputs blocks.
- A maximum of 256 gates per logic level with a maximum of 256 gates allowed per diagram. All output blocks and input sides of element blocks are at the maximum logic level of the diagram. All gates are pushed forward/upwards in logic levels and buffered to reach the final output block or element block if needed.

Three status indicators are located in the lower right corner of the BESTlogic*Plus* window. These indicators show the Logic Save Status, Logic Diagram Status, and Logic Layer Status. Table 83 defines the colors for each indicator.

Table 83. Status Indicators

Indicator	Color	Definition
Logic Save Status (Left Indicator)	Orange	Logic has changed since last save
	Green	Logic has NOT changed since last save
Logic Diagram Status (Center Indicator)	Red	Requirements NOT met as listed above
	Green	Requirements met as listed above
Logic Layer Status (Right Indicator)	Red	Requirements NOT met as listed above
	Green	Requirements met as listed above

Pickup and Dropout Timers

Pickup and dropout timer logic blocks are shown in Figure 208.

To program logic timer settings, use the Settings Explorer within BESTCOMS*Plus* to open the BESTlogic*Plus* Programmable Logic, Logic Timers tree branch. Enter a *Name* label that you want to appear on the timer logic block. The Time Delay value range is 0.0 to 1800.0 seconds in 0.1-second increments.

Next, open the *Components* tab inside the BESTlogic*Plus* window and drag a timer onto the program grid. Right click on the timer to select the timer you want to use that was previously set on the Logic Timers tree branch. The Logic Timer Properties Dialog Box will appear. Select the timer you want to use.

Timing accuracy is ±15 milliseconds.

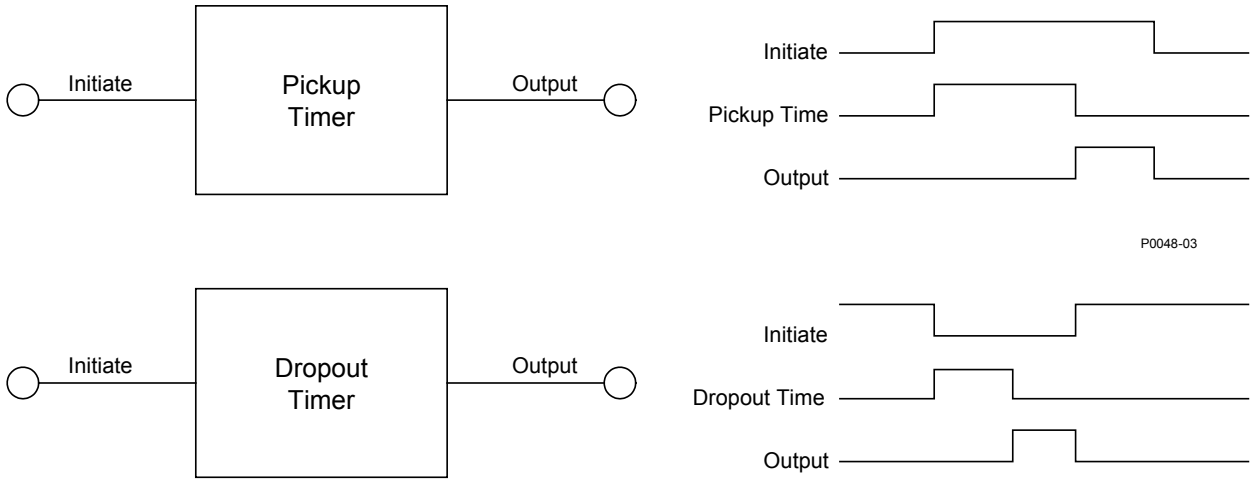


Figure 208. Pickup and Dropout Timer Logic Blocks

BESTlogic™Plus File Management

To manage BESTlogic*Plus* files, use the Settings Explorer to open the BESTlogic*Plus* Programmable Logic tree branch. The BESTlogic*Plus* Programmable Logic toolbar is used to manage BESTlogic*Plus* files. Refer to Figure 209. For information on Settings Files management, refer the *BESTCOMSPlus* chapter.

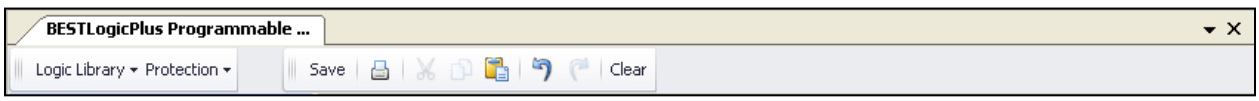


Figure 209. BESTlogic*Plus* Programmable Logic Toolbar

Saving a BESTlogic™*Plus* File

After programming BESTlogic*Plus* settings, click on the Save button to save the settings to memory.

Before the new BESTlogic*Plus* settings can be uploaded to the BE1-11*f*, you must select Save from the File pull-down menu located at the top of the BESTCOMS*Plus* main shell. This step will save both the BESTlogic*Plus* settings and the operating settings to a file.

The user also has the option to save the BESTlogic*Plus* settings to a unique file that contains only BESTlogic*Plus* settings. Click on the Logic Library drop-down button and select Save Logic Library File. Use normal Windows® techniques to browse to the folder where you want to save the file and enter a filename to save as.

Opening a BESTlogic™*Plus* File

To open a saved BESTlogic*Plus* file, click on the *Logic Library* drop-down button on the BESTlogic*Plus* Programmable Logic toolbar and select Open Logic Library File. Use normal Windows techniques to browse to the folder where the file is located.

Protecting a BESTlogic™*Plus* File

Objects in a logic diagram can be locked so that when the logic document is protected these objects cannot be changed. Locking and protecting is useful when sending logic files to other personnel to be modified. The locked object(s) cannot be changed. To view the lock status of the object(s), select Show Lock Status from the Protection drop-down menu. To lock object(s), use the mouse to select object(s) to be locked. Right click on the selected object(s) and select Lock Object(s). The gold colored padlock next to the object(s) will change from an open to a locked state. To protect a logic document, select Protect Logic Document from the Protection drop-down button. A password is optional.

Uploading a BESTlogic™*Plus* File

To upload a BESTlogic*Plus* file to the BE1-11*f*, you must first open the file through BESTCOMS*Plus* or create the file using BESTCOMS*Plus*. Then pull down the Communication menu and select Upload Logic to Device.

Downloading a BESTlogic™*Plus* File

To download a BESTlogic*Plus* file from the BE1-11*f*, you must pull down the Communication menu and select Download Settings and Logic from Device. If the logic in your BESTCOMS*Plus* has changed, a dialog box will open asking you if want to save the current logic changes. You can choose Yes or No. After you have taken the required action to save or not save the current logic, the downloading is executed.

Printing a BESTlogic™*Plus* File

To view a preview of the printout, click on the Print Preview icon located on the BESTlogic*Plus* Programmable Logic toolbar. If you wish to print, select the printer icon in the upper left corner of the Print Preview screen.

You can skip the print preview and go directly to print by clicking on the Printer icon on the BESTlogic*Plus* Programmable Logic toolbar. A dialog box, Select Views to Print opens allowing you to check which views you would like to print. Next, the Print dialog box opens with the typical Windows choice to setup the properties of printer. Execute this command, as necessary, and then select Print.

A *Page Setup* icon is also provided on the BESTlogic*Plus* Programmable Logic toolbar allowing you to select Paper Size, Paper Source, Orientation, and Margins.

Clearing the On-Screen Logic Diagram

Click the Clear button to clear the on-screen logic diagram on all logic pages and start over.

BESTlogic™Plus Examples

Example 1 - OR Gate Connections

Figure 210 illustrates a typical OR gate connection. In this example, OUT5 will become active when either the Major Alarm OR the Minor Alarm OR both is true.

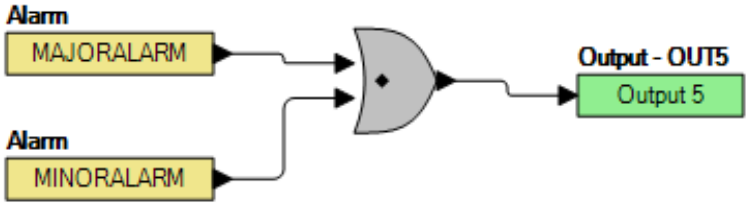


Figure 210. Example 1 - OR Gate Connections

Example 2 - Inverse Overcurrent Logic Diagram

Figure 211 illustrates a typical logic diagram of two inverse overcurrent elements set up to trip outputs and trigger fault reports. The 51-1 function is blocked when IN1 is true. The 51-1 function is blocked when IN2 is true. OUT1 is true when either the 51-1 or 51-2 is in a trip condition. OUT2 is true when either the 51-1 or 51-2 is in a pickup condition. The fault trigger logic block ensures that faults are recorded.

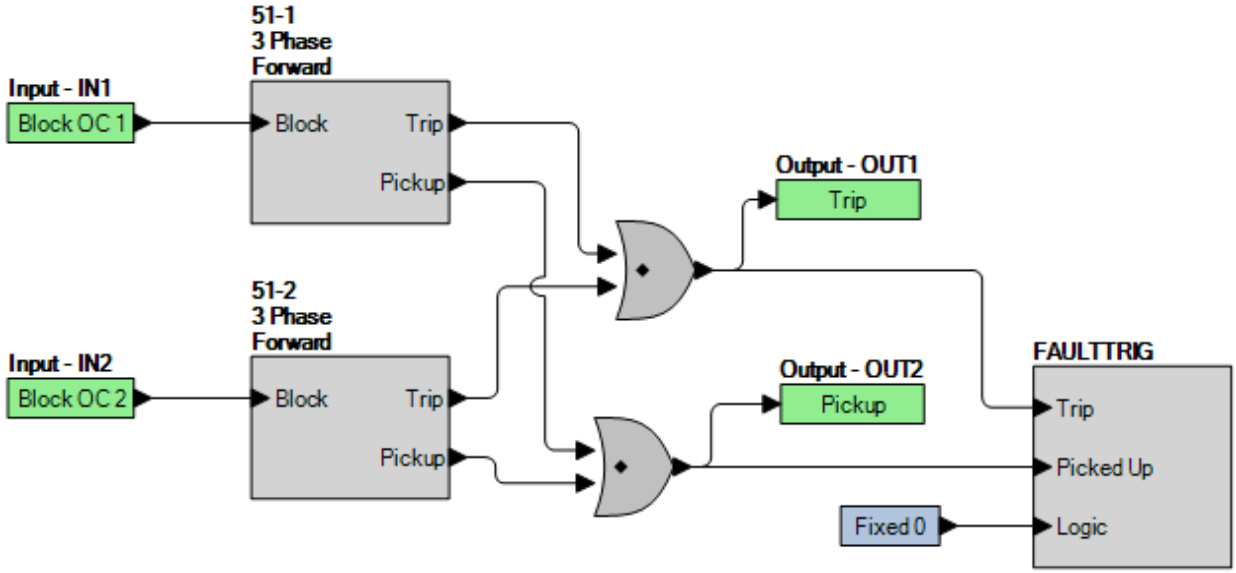


Figure 211. Example 2 - Inverse Overcurrent Logic Diagram