




# BE1-11<sup>t</sup> Transformer Protection System

*Instruction Manual*



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

# Preface

This instruction manual provides information about the installation and operation of the BE1-11*t* Transformer 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
- BESTCOMSP*lus*® software
- Communication and security
- Testing and troubleshooting procedures
- Specifications
- Time curve characteristics
- RTD module (optional)

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

- Modbus® communication protocol (Basler Electric part number 9424200774)
- Distributed Network Protocol (DNP) (Basler Electric part number 9424200773)
- IEC 61850 communication protocol (Basler Electric part number 9424200892)

## ***Conventions Used in this Manual***

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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*t*. Note all warnings, cautions, and notes in this manual as well as on the product. Keep this manual with the product for reference. Only qualified personnel should install, operate, or service this system. Failure to follow warning and cautionary labels may result in personal injury or property damage. Exercise caution at all times.

## Caution

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

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

For terms of service relating to this product and software, see the Commercial Terms of Products and Services document available at [www.basler.com/terms](http://www.basler.com/terms).

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

It is not the intention of this manual to cover all details and variations in equipment, nor does this manual provide data for every possible contingency regarding installation or operation. The availability and design of all features and options are subject to modification without notice. Over time, improvements and revisions may be made to this publication. Before performing any of the following procedures, contact Basler Electric for the latest revision of this manual.

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

# Revision History

A historical summary of the changes made to this instruction manual is provided below. Revisions are listed in reverse chronological order.

Visit [www.basler.com](http://www.basler.com) to download the latest hardware, firmware, and BESTCOMSPlus® revision histories.

## Instruction Manual Revision History

Manual Revision and Date	Change
AB, Jun-25	<ul style="list-style-type: none"> <li>Added FCC compliance statement</li> <li>Updated China RoHS compliance table</li> <li>Changed mentions of BESTwave to BESTdata</li> </ul>
AA, Sep-24	<ul style="list-style-type: none"> <li>Removed references to the product CD</li> <li>Removed language regarding plugin activation</li> <li>Corrected path to Driver Installer location</li> <li>Updated specifications</li> <li>Updated description of IG mode</li> <li>Updated BESTCOMSPlus system requirements</li> </ul>
Z, Dec-23	<ul style="list-style-type: none"> <li>Added China RoHS compliance</li> </ul>
Y, Feb-23	<ul style="list-style-type: none"> <li>Updated isolation specifications</li> <li>Added a note about recommended wire size and earth ground</li> <li>Updated procedure to download and install BESTCOMSPlus</li> </ul>
X, Feb-22	<ul style="list-style-type: none"> <li>Added UKCA Compliance to the BE1-11t and RTD Module</li> </ul>
W, Jul-21	<ul style="list-style-type: none"> <li>Removed the RTD Module's UL Recognition for use in Hazardous Locations</li> </ul>
V, Jul-21	<ul style="list-style-type: none"> <li>Added information on terminal strip kit and BE3-GPR adapter plate to the <i>Mounting</i> chapter</li> <li>Updated backup battery types</li> <li>Added descriptions for settings on Transformer Setup screen in the <i>Configuration</i> chapter</li> <li>Minor text edits throughout manual</li> </ul>
U, Sep-19	<ul style="list-style-type: none"> <li>Added support for BESTCOMSPlus version 4.00.00</li> <li>Removed Rev Letter from all pages</li> <li>Changed sequential numbering to sectional numbering</li> <li>Moved Instruction Manual Revision History into Preface</li> <li>Removed standalone <i>Revision History</i> chapter</li> <li>Minor text edits throughout manual</li> </ul>
T, Feb-19	<ul style="list-style-type: none"> <li>Added descriptions for settings in the <i>Power Quality</i> chapter</li> <li>Added RoHS 2 to the <i>Specifications</i> chapter</li> <li>Removed references to RTD module part numbers 944410103 and 944410104 from the <i>RTD Module</i> chapter</li> <li>Minor text edits throughout manual</li> </ul>
S1, Nov-18	<ul style="list-style-type: none"> <li>Added Prop 65 warning on back of cover page</li> </ul>
S, Aug-18	<ul style="list-style-type: none"> <li>Added description for DNP Time in UTC setting</li> <li>Other minor improvements</li> </ul>
R, Apr-18	<ul style="list-style-type: none"> <li>Corrected Power metering ranges listed in the <i>Metering</i> and <i>Specifications</i> chapters</li> <li>Added revision history for new versions of hardware, firmware, and software</li> </ul>
Q	<ul style="list-style-type: none"> <li>This revision letter not used</li> </ul>

Manual Revision and Date	Change
P, Nov-17	<ul style="list-style-type: none"> <li>• Updated description of Unbalance mode for 50 and 51 elements</li> <li>• Updated description of Pulse mode for 43 Virtual Control Switches</li> <li>• Updated 52 Trip Circuit Monitor circuit drawing and table for current draw</li> <li>• Added specifications for new RTD module part numbers 9444100103 and 9444100104</li> <li>• Other minor text edits</li> </ul>
O	<ul style="list-style-type: none"> <li>• This revision letter not used</li> </ul>
N, Jul-17	<ul style="list-style-type: none"> <li>• Added support for BE1-11<math>\tau</math> BESTCOMSPlus version 3.17.01</li> </ul>
M, May-17	<ul style="list-style-type: none"> <li>• Added support for BE1-11<math>\tau</math> firmware version 2.11.01 and BESTCOMSPlus version 3.17.00</li> <li>• Minor text edits throughout manual</li> </ul>
L, Feb-17	<ul style="list-style-type: none"> <li>• Added USB Driver Did Not Install Properly to the <i>Troubleshooting</i> chapter</li> <li>• Added caution statement about nonvolatile memory to the <i>BESTlogicPlus</i> chapter</li> <li>• Text edits throughout manual</li> </ul>
K, Jul-16	<ul style="list-style-type: none"> <li>• Added support for BE1-11<math>\tau</math> firmware version 2.10.00 and BESTCOMSPlus version 3.14.00</li> <li>• Minor text edits</li> </ul>
J, Dec-15	<ul style="list-style-type: none"> <li>• Added support for BE1-11<math>\tau</math> firmware version 2.09.00 and BESTCOMSPlus version 3.11.00</li> <li>• Replaced several BESTCOMSPlus settings screens showing primary and secondary values</li> <li>• Added Units of Selectable Parameters table in the <i>RTD Module</i> chapter</li> <li>• Added <i>BESTCOMSPlus Settings Loader Tool</i> chapter</li> <li>• Minor text edits</li> </ul>
I	<ul style="list-style-type: none"> <li>• This revision letter not used</li> </ul>
H, Sep-14	<ul style="list-style-type: none"> <li>• Added Conformal Coating to Option 2 in Figures 1 and 225</li> <li>• Corrected Figures 284 (A1 Curve), 295 (B1 Curve), and 300 (C1 Curve) in the <i>Time Curve Characteristics</i> chapter</li> <li>• Text edits throughout manual</li> </ul>
G, Apr-14	<ul style="list-style-type: none"> <li>• Added support for BE1-11<math>\tau</math> firmware version 2.08.00 and BESTCOMSPlus version 3.06.00</li> <li>• Added Step 2 and updated Step 3 under Element Operation, Control of Virtual Control Switches in the <i>Virtual Control Switches (43)</i> chapter</li> <li>• Added Offline Logic Simulator description in the <i>BESTlogicPlus</i> chapter</li> <li>• Changed the order of the Inverse Overcurrent (51) curves in the <i>Time Curve Characteristics</i> chapter</li> </ul>
F, Feb-14	<ul style="list-style-type: none"> <li>• Removed product registration information</li> </ul>
E, Dec-13	<ul style="list-style-type: none"> <li>• Added support for BE1-11<math>\tau</math> firmware version 2.07.00 and BESTCOMSPlus version 3.05.02</li> <li>• Moved revision history to the back of the manual</li> <li>• Added description of QR code in Table 2</li> <li>• Added QR code in Figures 2 and 23</li> <li>• Updated PC requirements for BESTCOMSPlus software</li> <li>• Moved Frequently Asked Questions from the <i>Troubleshooting</i> chapter into a new chapter</li> <li>• Corrected trip circuit monitor jumper illustration</li> </ul>

<b>Manual Revision and Date</b>	<b>Change</b>
D, Mar-13	<ul style="list-style-type: none"><li>• Added 10-Second Frequency description in the <i>Power Quality</i> chapter</li><li>• Added Figure 169, Single-Phase Current Sensing Connections in the <i>Typical Connections</i> chapter</li><li>• Added <i>Specifications - 25 Hz Operation</i> chapter</li><li>• Added <i>Digital Points</i> chapter</li></ul>
C, Jan-13	<ul style="list-style-type: none"><li>• Improved the 87N element equations and test procedure</li><li>• Added case overlap in Figure 157, J Type Case - Cutout and Drilling Dimensions in the <i>Mounting</i> chapter</li><li>• Added Storage statement in the <i>RTD Module</i> chapter</li></ul>
B, Nov-12	<ul style="list-style-type: none"><li>• Added Storage statement in the <i>Quick Start</i> chapter</li><li>• Minor text edits throughout manual</li></ul>
A, Sep-12	<ul style="list-style-type: none"><li>• Initial release</li></ul>



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# 1 • Introduction

The BE1-11 $\ell$  Transformer Protection System provides flexible, reliable, and economical transformer protection, control, monitoring, and measurement functions. The BE1-11 $\ell$  offers phase and neutral current differential, transformer monitor, distance, overexcitation (V/Hz), overcurrent, directional overcurrent, over/undervoltage, over/underfrequency, sync-check, recloser, RTD (Resistance Temperature Detector) with remote module, breaker failure protection, 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 BE1-11 $\ell$  front panel and through the BE1-11 $\ell$  communication ports. The capabilities of the BE1-11 $\ell$  make it well suited to provide comprehensive transformer protection. The system is suitable for mounting in OEM cubicle or retrofit switchgear applications. Suitable BE1-11 $\ell$  applications include transformers associated with generation step up transformers, intertie installations, network transformer, and distribution feeder step down transformer protection.

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

Front-panel features include a large, backlit alphanumeric display and LED indicators that display system parameters, BE1-11 $\ell$  settings, and BE1-11 $\ell$  status. Pushbuttons enable navigation through the display menu, changes to settings, resetting of targets (with password access), and direct access to virtual switches.

## Applications

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The capabilities of the BE1-11 $\ell$  make it ideally suited for applications with the following attributes:

- Transformer applications where differential protection is required
- Monitoring the through fault currents that may lead to transformer damage
- Complete control of the circuit breaker connecting the transformer to the distribution bus
- Applications where bus protection is provided by a high-speed overcurrent blocking scheme on the transformer bus mains instead of a dedicated bus differential circuit
- Isolation between the RTDs and the BE1-11 $\ell$  due to distance between the BE1-11 $\ell$  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

## Features

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The BE1-11 $t$  protection system 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 $t$  has a front-panel display and 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 BE1-11 $t$  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. Select Control Switch and Operate Control Switch pushbuttons provide a means to control the logic 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 or the communication ports.

Three free-form fields (Device ID, Station ID, and User ID) can be used to enter information to identify the BE1-11 $t$ . These fields are used by many of the reporting functions to identify the BE1-11 $t$  reporting the information. Examples of BE1-11 $t$  identification field uses include station name, circuit number, relay system, and purchase order, and others.

#### Device Security

Security settings affect read and write access. 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.

#### Setting Groups

Four setting groups allow adaptive relaying to be implemented to optimize BE1-11 $t$  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 $t$  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. BESTCOMSPlus is used to establish the priority of time reference sources available to the BE1-11t, IRIG-B, NTP, DNP, and RTC (real-time clock). The NTP address is set using BESTCOMSPlus.

## **Communications**

Three independent communication ports provide access to all BE1-11t 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 when RS-485 option is N (None). 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.

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.

## **Programmable Inputs and Outputs**

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

### Programmable Inputs

Either seven or 10 programmable contact sensing inputs with programmable signal conditioning provide a binary logic interface to the protection and control system. Refer to the style chart for I/O options. Each input function and label is programmable using BESTlogicPlus. 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.

### Programmable Outputs

Either eight or five programmable general-purpose contact outputs provide a binary logic interface to the protection and control system. Refer to the style chart for I/O options. One programmable, failsafe contact output serves as an alarm output. Each output function and label is programmable using BESTlogicPlus.

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.

## Reporting and Alarms

Several reporting and alarm functions provide fault reporting, differential 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 BE1-11 $\tau$  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 BESTlogicPlus.

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.

### Transformer Monitor (51TF)

The 51TF (through-fault) monitor measures the current flowing through a transformer and compares the current magnitude and duration to a damage characteristic defined by the user. When the current exceeds the threshold setting, a through-fault pickup counter increments to indicate the excessive current. If the duration of the current exceeds the damage characteristic, a through-fault duration counter increments. The pickup counter or duration counter can be used to trigger a 51TF through-fault alarm which would prompt inspection of the transformer. The number of counts for each counter is shown on the Transformer Damage Report screen in BESTCOMSPPlus.

### 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 BESTlogicPlus 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 $\tau$  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 $\tau$ . Both positive and negative values are reported in three-phase, primary units.

### General Status Reporting

The BE1-11 $t$  provides extensive general status reporting for monitoring, commissioning, and troubleshooting. Status reports are available from the front panel or 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 BE1-11 $t$  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 BESTdata that can read and plot binary or ASCII format files that are in the COMTRADE format. BESTdata software is free and available at [www.basler.com](http://www.basler.com).

### Sequence of Events Recorder

A Sequence of Events Recorder (SER) records and time stamps all BE1-11 $t$  inputs and outputs as well as all alarm conditions monitored by the BE1-11 $t$ . 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**

The BE1-11 $t$  includes protection elements that monitor voltage, current, power, phase angle, frequency, temperature, and more to provide protection against faults and abnormal operating conditions. Control elements make the BE1-11 $t$  capable of controlling complex distribution configurations. The following paragraphs describe each protection and control function.

### Overexcitation (24) Protection

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

### Sync-Check (25) Protection (style TxxxxxxxBxxxxx)

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 to operate when one, two, or three phases decrease below pickup level. 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.

### 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 monitor separately 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 or when 3V0 mode is selected to obtain calculated offset voltage from the phase quantities. The 27X is equipped with an undervoltage inhibit feature. Inverse or definite time can be selected.

### Frequency (81) Protection

Eight independent frequency elements can be set for over, under, or rate of change (81R) frequency operation. Each can be set separately 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 $t$  protection systems enabled for IEC-61850 communication (style Txxxx5xxxxxxx) 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 nine 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

Nine 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, four table curves, a fixed time curve, and a user programmable curve.

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 set separately 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.

### Note

BE1-11 $t$  protection systems enabled for IEC-61850 communication (style Txxxx5xxxxxxx) do not allow voltage controlled or restrained overcurrent elements. Blocking a 51 with an Undervoltage (27) element may allow control pending application requirements.

#### Distance (21) Protection (style TxxxxxxBxxxx)

Two distance protection elements provide backup protection in applications where the protected zone is connected to the transmission. Settings are provided to configure a zone of reach using a mho circle.

#### Phase Current Differential (87) Protection

One phase current differential element provides three-phase, percentage-restrained, differential protection with dual-slope.

#### Neutral Current Differential (87N) Protection

Two neutral current differential elements provide sensitive phase-to-ground fault differential protection for the wye winding of the transformer.

### Resistance Temperature Detector (49RTD) Protection

Fourteen resistance temperature detector elements provide over/undertemperature protection in applications where a remote RTD module is connected to the BE1-11 $\epsilon$  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.

### 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 misoperations of the 21, 24, 25, 27, 27X, 59, 59X, 67, 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 $\epsilon$  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.

Custom logic settings allow you to tailor the BE1-11 $\epsilon$  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 3<sup>rd</sup> harmonic)
- Frequency (phase and auxiliary)
- Primary and secondary currents (phase, ground, I1, I2, 3I0)
- Power (real, reactive, apparent)
- Power factor
- Synchronization
- Phase differential (Iop, Ir, 2<sup>nd</sup> Harmonic, 5<sup>th</sup> Harmonic)
- Neutral differential (Iop)
- Energy (total watthours and total varhours)

- Analog input and output values
- RTD input temperatures

## Model and Style Number Description

BE1-11*t* 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 BE1-11*t*, 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 1-1.

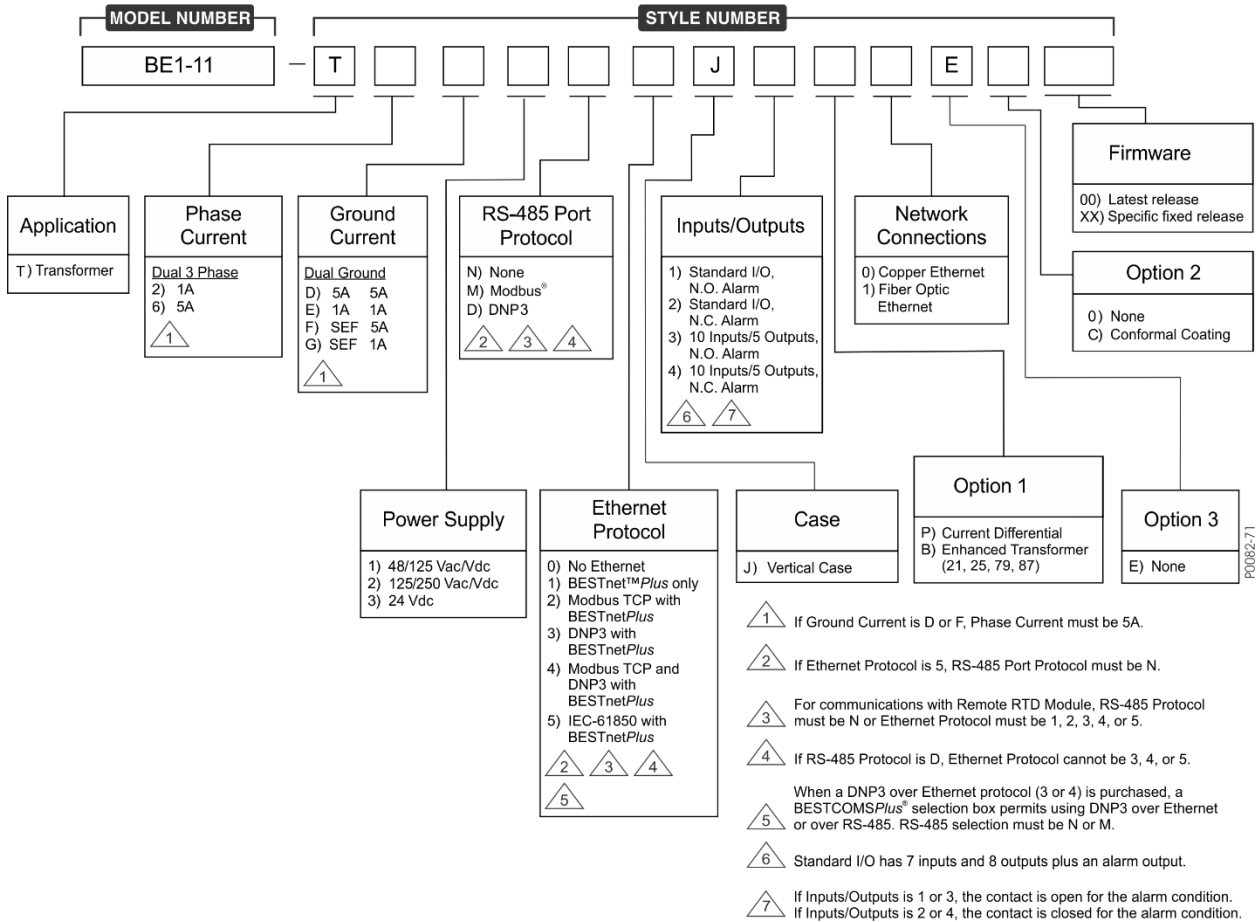


Figure 1-1. Style Chart

## 2 • Quick Start

This chapter provides basic installation and setup information about the BE1-11*t* Transformer Protection System. Upon receipt of the BE1-11*t*, 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*t* is not installed immediately, store it in the original shipping carton in a moisture- and dust-free environment.

### Note

Do not connect a USB cable between the PC and the BE1-11*t* until BESTCOMSP*lus* is installed. Connecting a USB cable before setup is complete may result in errors.

## Maintenance

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Preventive maintenance consists of periodic replacement of the backup battery and periodically checking that the connections between the BE1-11*t* and the system are clean and tight. The front cover should be removed only when replacing the backup battery for the real-time clock. Ensure that the BE1-11*t* is powered off and taken out of service before removing the front cover. BE1-11*t* 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

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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.

## Install BESTCOMSP*lus*® Software

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BESTCOMSP*lus* software is built on the Microsoft® .NET Framework. The setup utility that installs BESTCOMSP*lus* on your PC also installs the BE1-11 plugin and the required version of .NET Framework (if not already installed). BESTCOMSP*lus* operates with systems using Windows® 7 SP1, Windows 8.1, Windows 10, and Windows 11. System recommendations for the .NET Framework and BESTCOMSP*lus* are listed in Table 2-1.

**Table 2-1. System Recommendations for BESTCOMSPi.us and the .NET Framework**

System Type	Component	Recommendation
32/64 bit	Processor	2.0 GHz
32/64 bit	RAM	1 GB (minimum), 2 GB (recommended)
32 bit	Hard Drive	200 MB (if .NET Framework is already installed on PC)
		4.5 GB (if .NET Framework is not already installed on PC)
64 bit	Hard Drive	200 MB (if .NET Framework is already installed on PC)
		4.5 GB (if .NET Framework is not already installed on PC)

To install BESTCOMSPi.us, a Windows user must have Administrator rights.

1. Download BESTCOMSPi.us from [www.basler.com](http://www.basler.com).
2. Click the installation button for BESTCOMSPi.us. The setup utility installs the BESTCOMSPi.us, the .NET Framework (if not already installed), the USB driver, and the BE1-11 plugin for BESTCOMSPi.us on your PC.

When BESTCOMSPi.us 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 BESTCOMSPi.us when clicked.

## Connect and Power Up the BE1-11 Plug-In

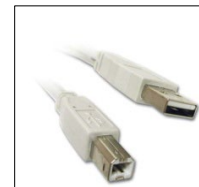
The BE1-11 plugin is a module that runs inside the BESTCOMSPi.us shell. The BE1-11 plugin contains specific operational and logic settings for only BE1-11 protection systems.

Note that if a BE1-11*t* 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 BESTCOMSPi.us installation and is installed automatically after powering the BE1-11*t*. 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*t* protection system. 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\USB Connect Driver\

If the USB driver does not install properly, refer to the *Troubleshooting* chapter.

### Apply Operating Power

The nominal power supply values are listed on the front-panel label. See Figure 2-1 for an example.



Figure 2-1. Front Panel Label Example

Connect rear terminals A6, A7, and A8 (ground) to a power supply. Figure 2-2 shows the rear terminals of the BE1-11 $t$  with standard I/O option. Apply operating power consistent with the nominal power supply values listed on the front-panel label. Wait until the boot sequence is complete.

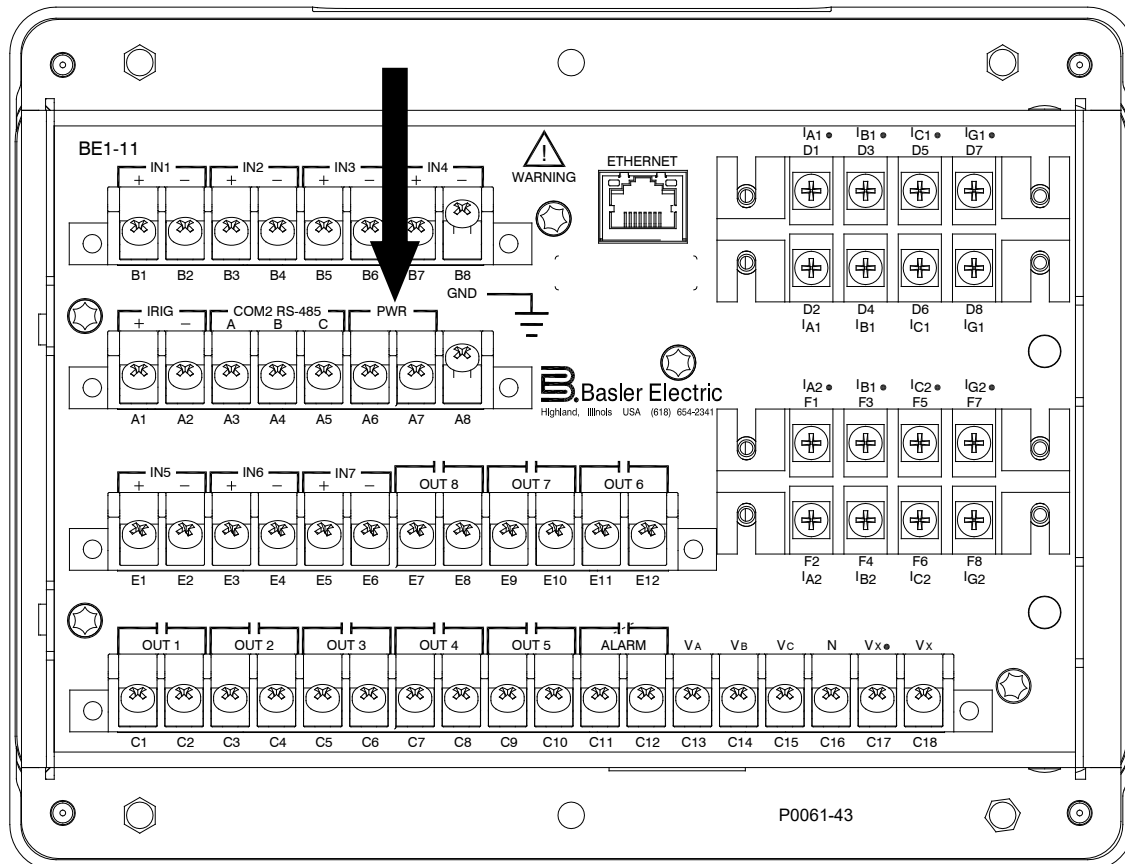
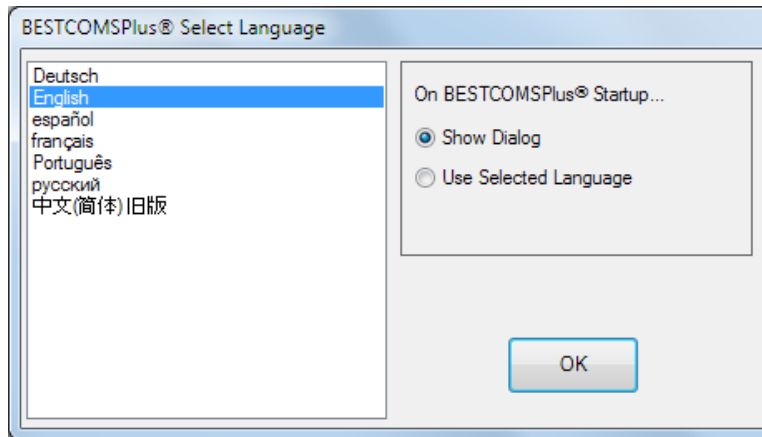


Figure 2-2. PWR Rear Terminals

### Start BESTCOMSPi<sup>us</sup>

To start BESTCOMSPi<sup>us</sup>, click the Start button, point to Programs, Basler Electric, and then click the BESTCOMSPi<sup>us</sup> icon. During initial startup, the BESTCOMSPi<sup>us</sup> Select Language screen is displayed (Figure 2-3). You can choose to have this screen displayed each time BESTCOMSPi<sup>us</sup> 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.



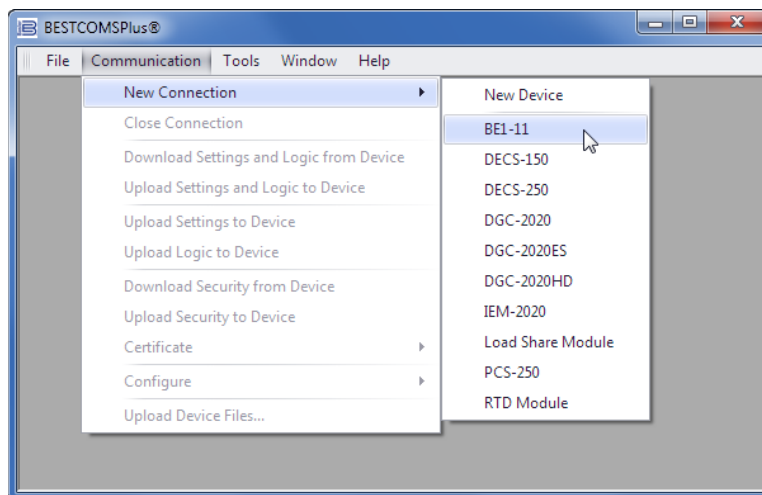
**Figure 2-3. BESTCOMSPlus Select Language Screen**

The BESTCOMSPlus splash screen is shown for a brief time. See Figure 2-4.



**Figure 2-4. BESTCOMSPlus Splash Screen**

The BESTCOMSPlus platform window opens. Select New Connection from the Communication pull-down menu and select BE1-11. See Figure 2-5.



**Figure 2-5. Communication Pull-Down Menu**

The BE1-11 Connection screen shown in Figure 2-6 appears. Select USB Connection and then click the Connect button.

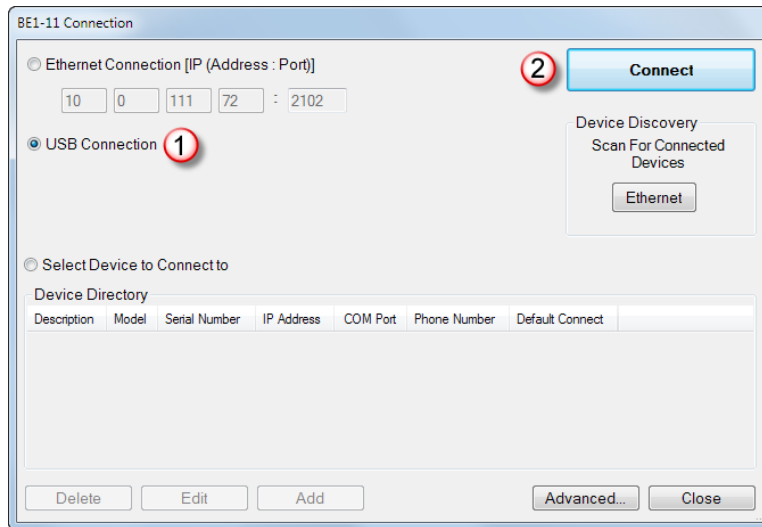


Figure 2-6. BE1-11 Connection Screen

## Programming the BE1-11t

This section contains an introduction to BESTCOMSPi<sup>us</sup>, explains summary screens, and gives an example of settings elements and programming logic.

### Introduction to BESTCOMSPi<sup>us</sup>®

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

BESTCOMSPi<sup>us</sup> provides the user with a point-and-click means to set and monitor the BE1-11t. The capabilities of BESTCOMSPi<sup>us</sup> make the configuration of one or several BE1-11t Transformer Protection Systems fast and efficient. A primary advantage of BESTCOMSPi<sup>us</sup> is that a settings scheme can be created, saved as a file, and then uploaded to the BE1-11t at the user's convenience.

The BE1-11 plugin opens inside the BESTCOMSPi<sup>us</sup> main shell. The same default logic scheme that is shipped with the BE1-11t is brought into BESTCOMSPi<sup>us</sup> by downloading settings and logic from the BE1-11t or by selecting application type "T" 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™Pi<sup>us</sup> Programmable Logic is used to program BE1-11t 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.

BESTCOMSPi<sup>us</sup> also allows for downloading industry-standard COMTRADE files for analysis of stored oscillography data. Detailed analysis of the oscillography files can be accomplished using BESTdata software. BESTdata software is free and available at [www.basler.com](http://www.basler.com).

Figure 2-7 illustrates the typical user interface components of the BE1-11 plugin with BESTCOMSPi<sup>us</sup>.

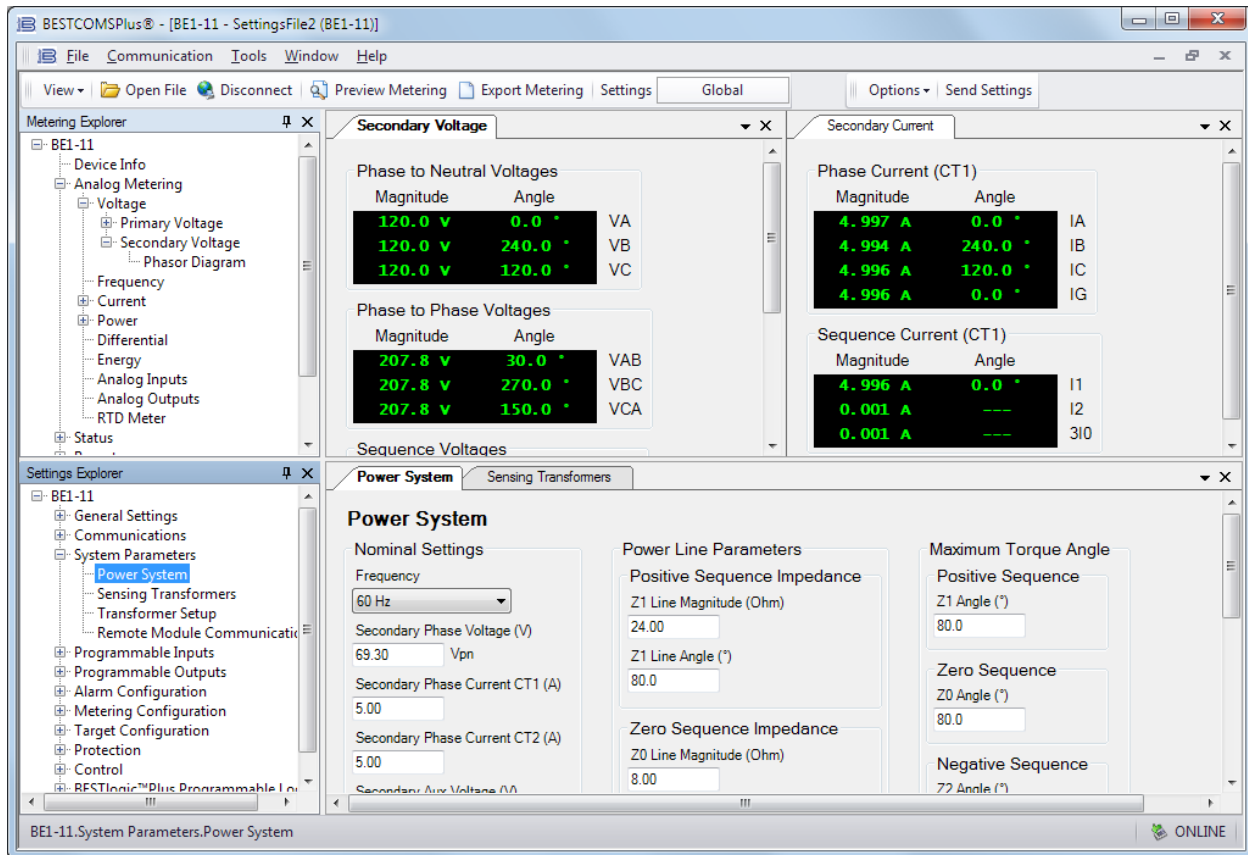


Figure 2-7. BESTCOMSPPlus Typical User Interface Components

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 2-8.

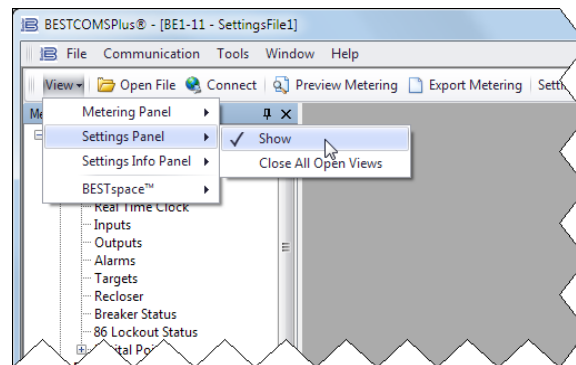


Figure 2-8. View Drop-Down Button

## 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 Protection Summary screen is available by clicking Protection in the Settings Explorer as shown in Figure 2-9. Summary screens are also available for General Settings, Alarm Configuration, and Control.

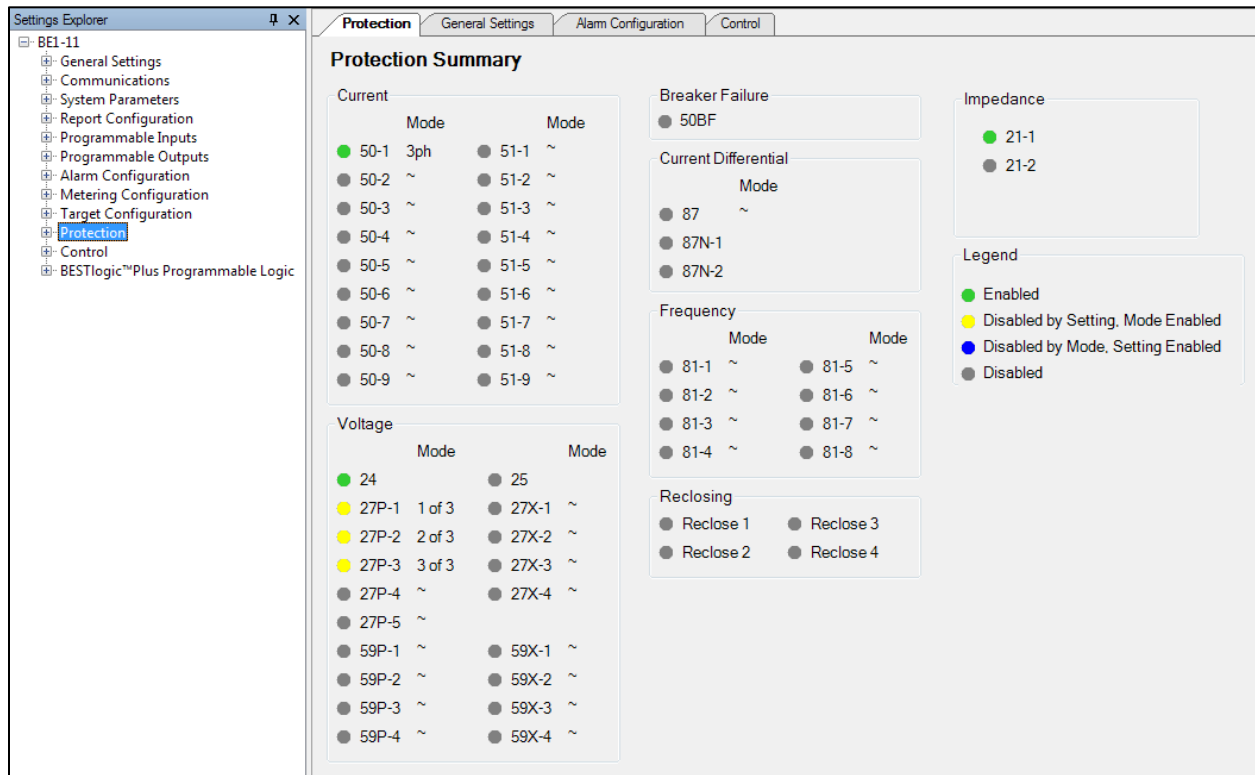


Figure 2-9. System Summary Screen

## 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 *BESTCOMSPi.us* and select New Connection, BE1-11 from the Communication pull-down menu to connect to the BE1-11*t*. See Figure 2-5.
- Step 2: The BE1-11 Connection screen appears. See Figure 2-6. 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*t* to *BESTCOMSPi.us*.
- Step 4: Click on the View drop-down button and de-select Show Metering Panel and Show Setting Information. See Figure 2-8. This maximizes the settings 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 2-10.
- Step 6: Under Nominal Settings, enter settings for Secondary Phase Voltage (69.3 V) and Secondary Phase Current (3.6 A).
- Step 7: In the Settings Explorer, expand Protection, Current and select the Instantaneous Overcurrent (50-3) screen. See Figure 2-11.
- Step 8: Select the Mode (3 Phase) and enter settings for Pickup (5.62 A) and Time Delay (30,000 ms).

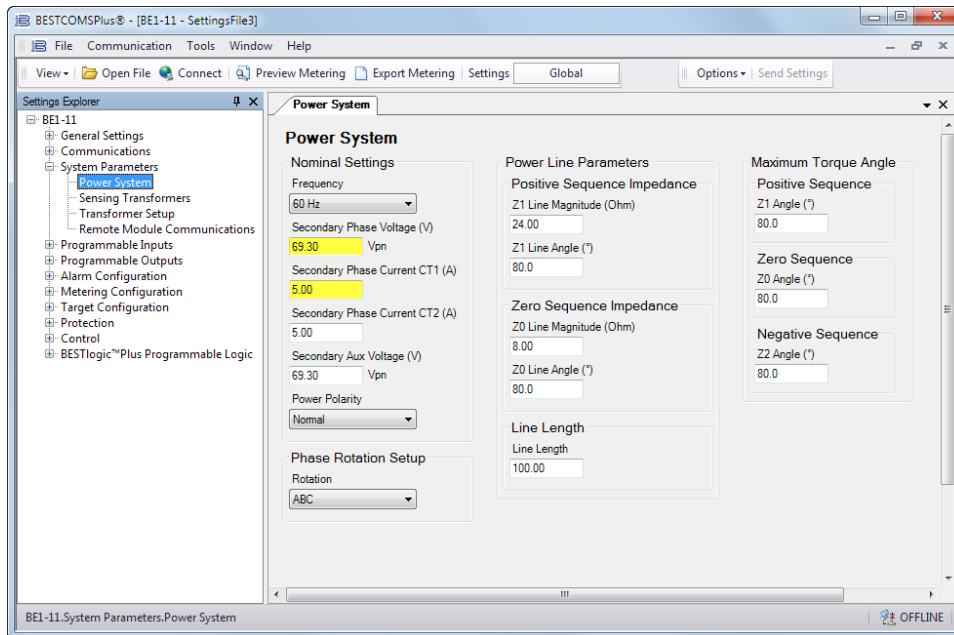


Figure 2-10. Power System Screen

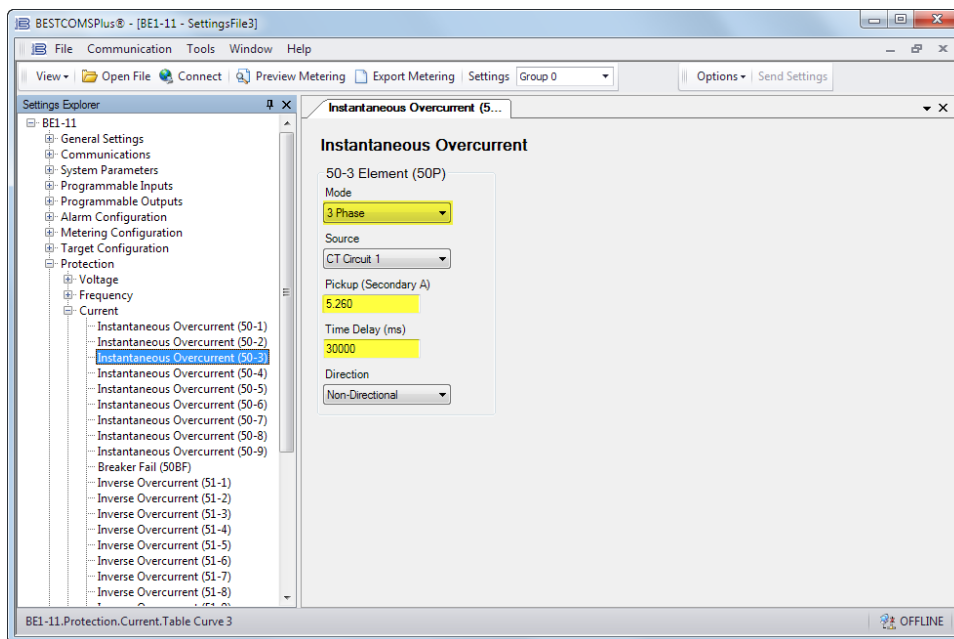


Figure 2-11. Instantaneous Overcurrent (50-3) Screen

Step 9: In the Settings Explorer, click BESTlogicPlus Programmable Logic to open the logic diagram. Click the Current tab. See Figure 2-12. 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 the Misc. Logic tab (Figure 2-13) 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 becomes an Off-Page Input (Figure 2-14). The Trip Bus Off-Page Input is connected to the Trip input of the Fault Trigger (FAULTTRIG) element to log a 50-3 target and to record fault current magnitudes at the time of trip.

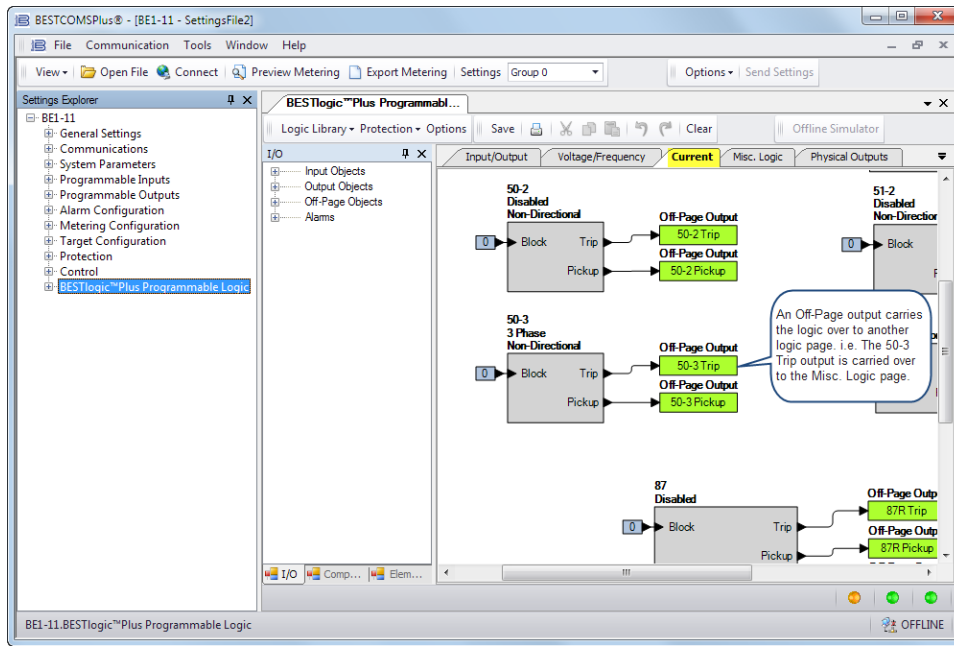


Figure 2-12. BESTlogicPlus Current Page

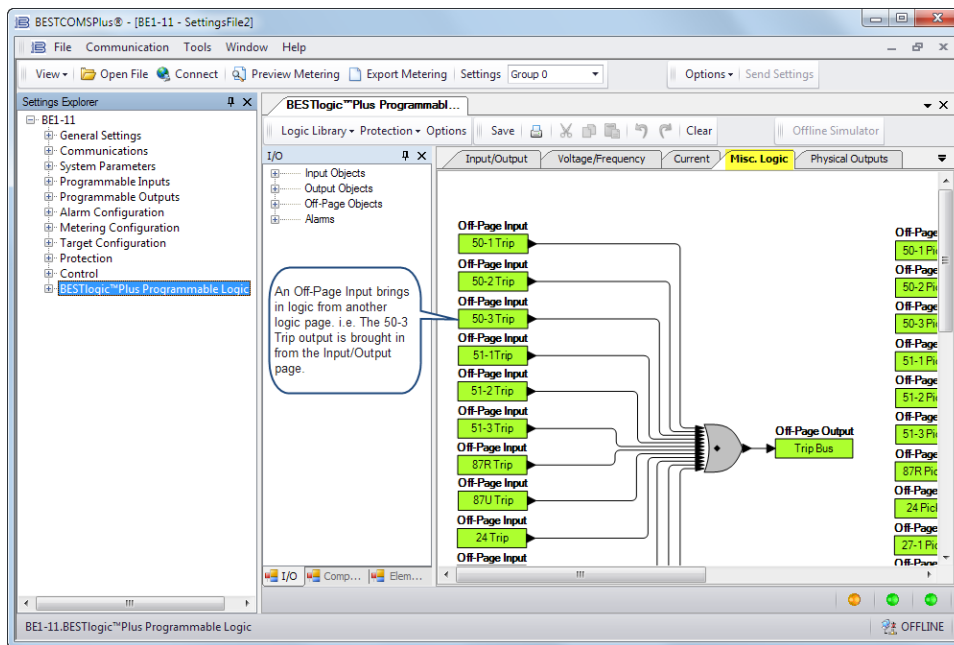


Figure 2-13. BESTlogicPlus Misc. Logic Page

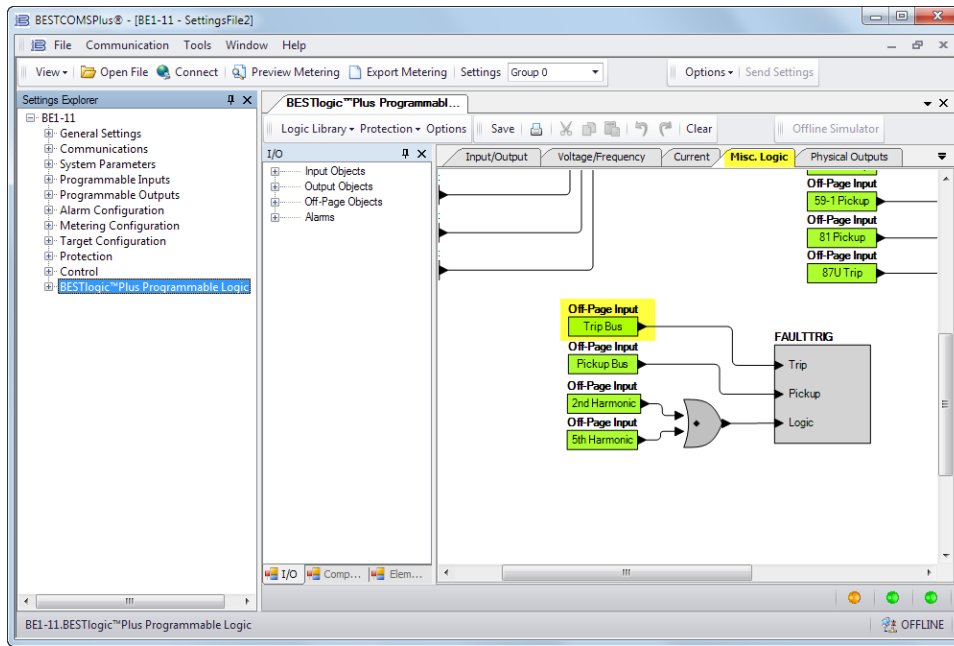


Figure 2-14. BESTlogicPlus Misc. Logic Page

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 Current 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 2-15.

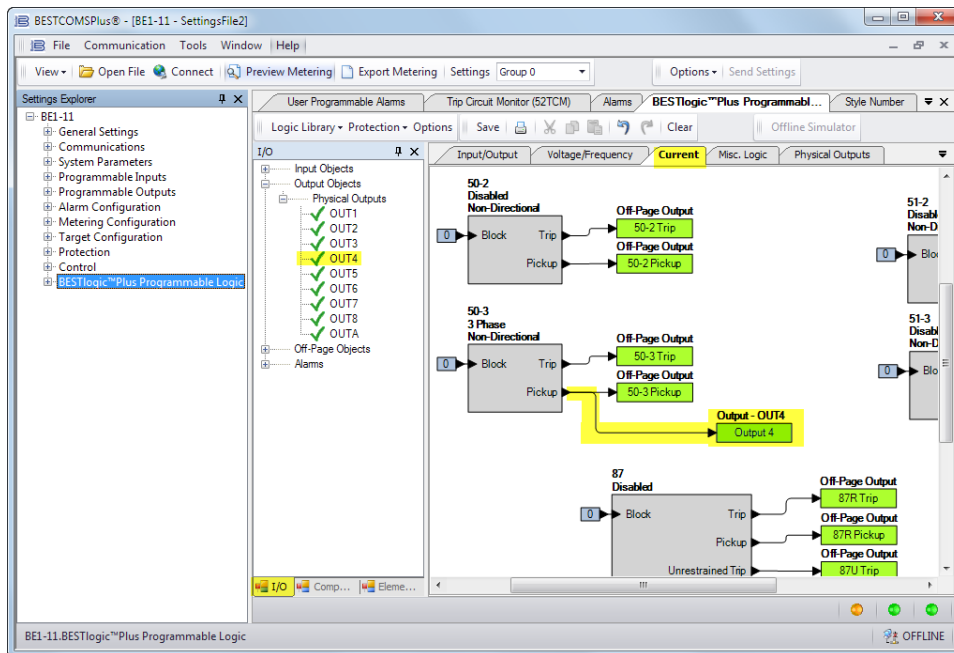
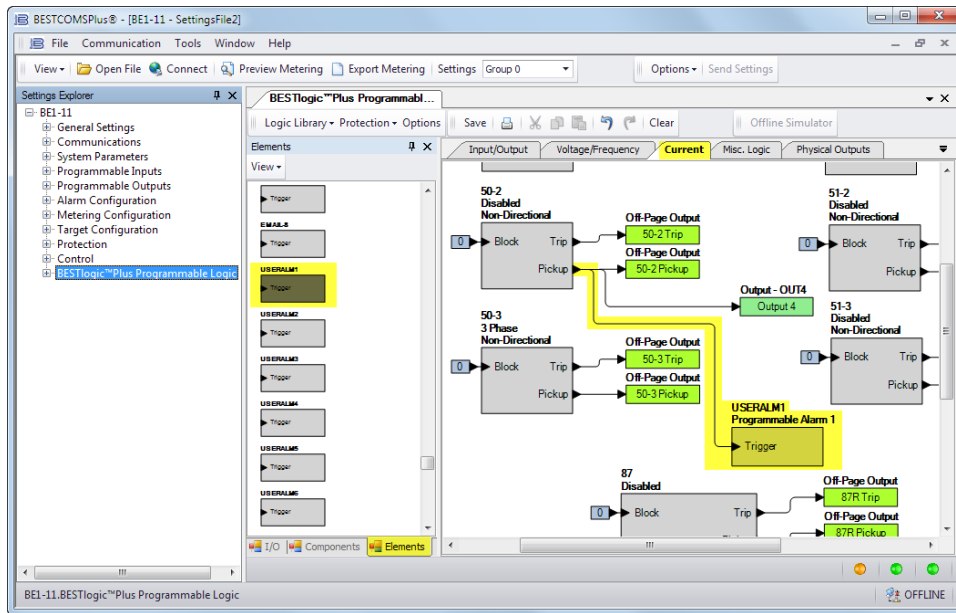


Figure 2-15. BESTlogicPlus Programming OUT4

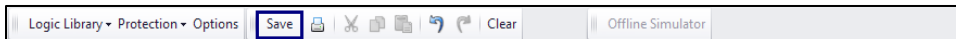
Step 11: In this step, the Pickup output of the 50-3 element is connected to User Alarm 1. When the Pickup output of the 50-3 element is true, the label of the user alarm is displayed on the Alarms screen on the front-panel display and in the fault report and/or sequence of events report. The label is named in Step 13. Click the Current 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 2-16.



**Figure 2-16. BESTlogicPlus Programming User Alarm 1**

Step 12: Click the Save button to save the logic to BESTCOMSPius memory for later inclusion in the settings file. See Figure 2-17.



**Figure 2-17. BESTlogicPlus Toolbar**

Step 13: In the Settings Explorer, expand Programmable Outputs, Contact Outputs, and name Output #4 (50-3 Pickup) as shown in Figure 2-18.

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 2-19.

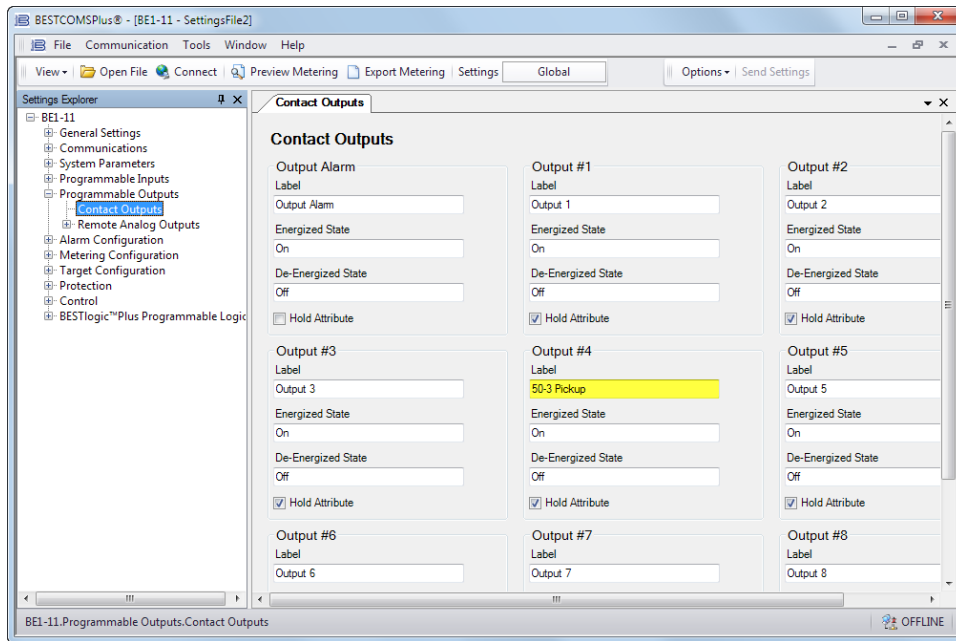


Figure 2-18. Contact Outputs Screen

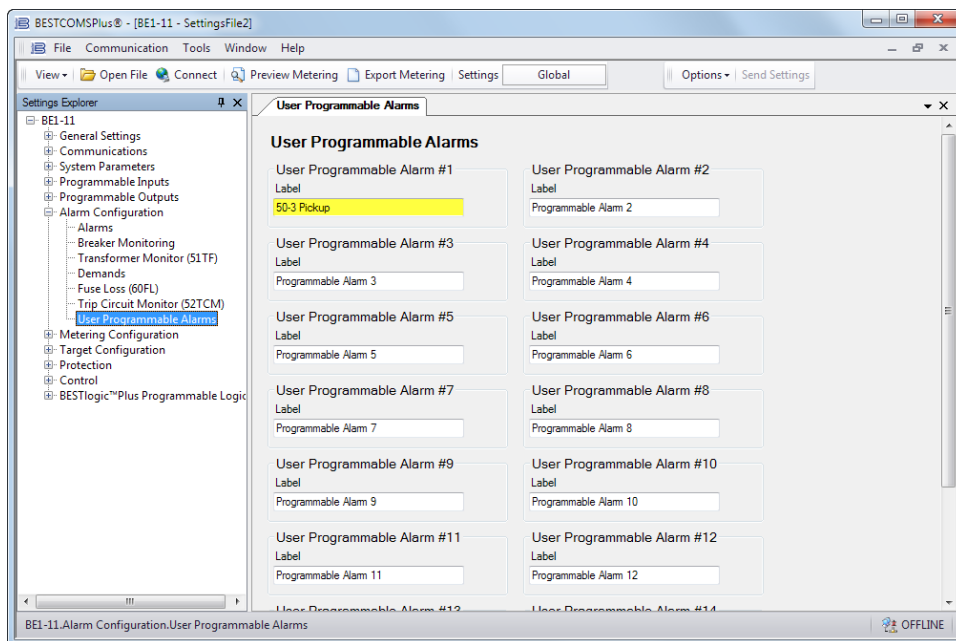
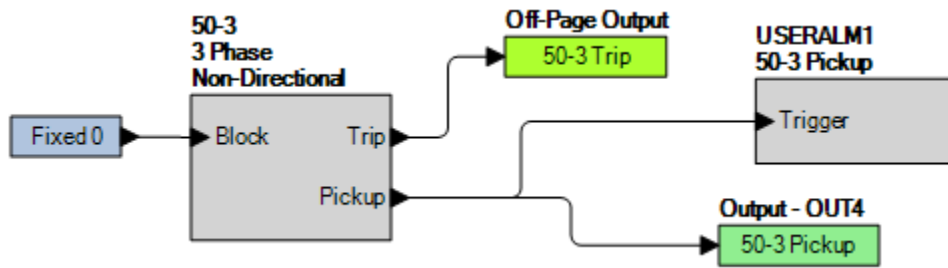


Figure 2-19. User Programmable Alarms Screen

Step 15: Figure 2-20 shows the user-defined labels of OUT4 and USERALM1 that were named in Step 13 and Step 14.



**Figure 2-20. 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 $t$ , select Upload Settings and Logic to Device from the Communication pull-down menu. Enter the username and password.



# 3 • Controls and Indicators

BE1-11<sub>t</sub> 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) is illustrated in Figure 3-1 and described in Table 3-1. The locators and descriptions of Table 3-1 correspond to the locators shown in Figure 3-1.

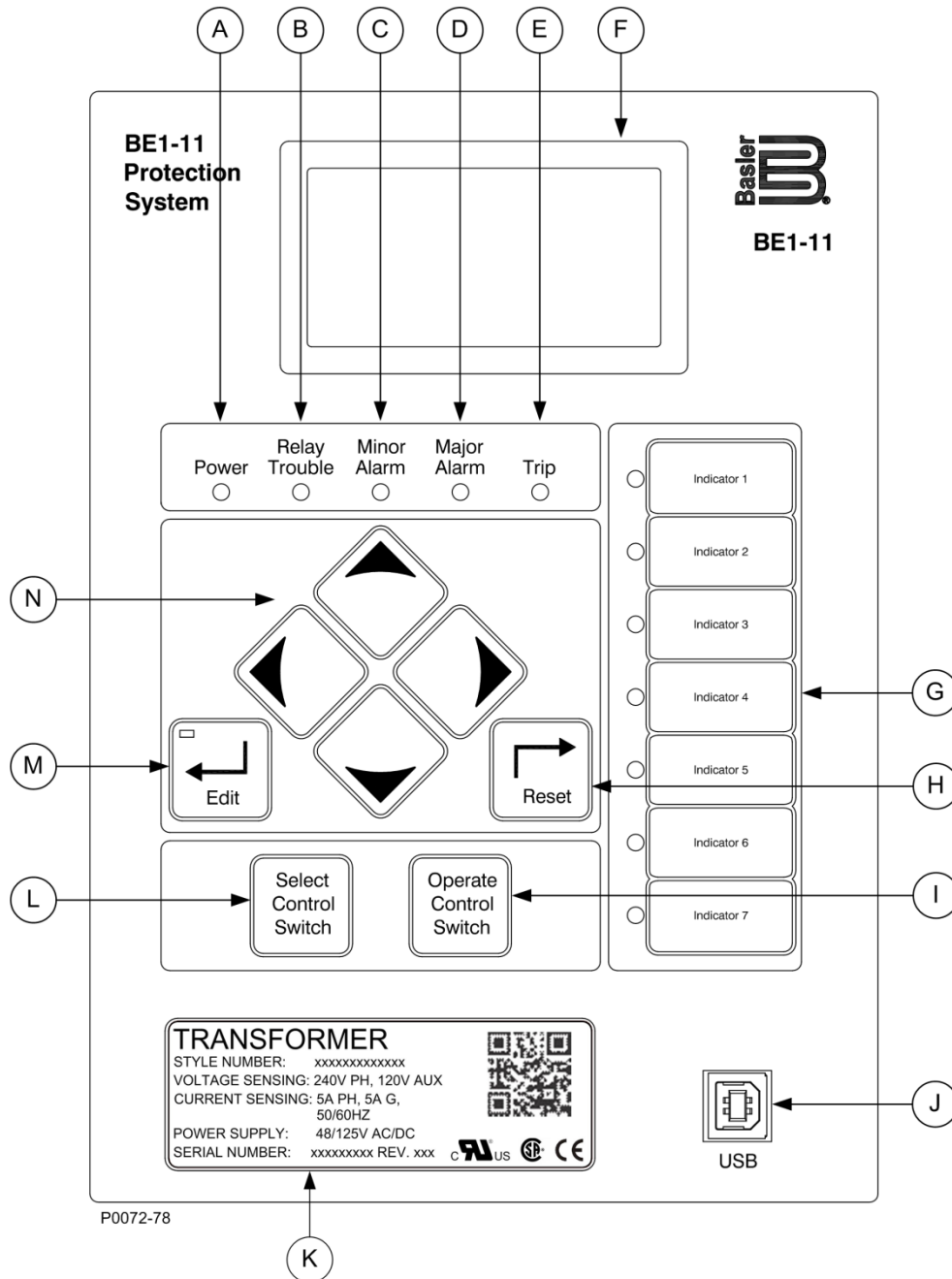


Figure 3-1. Front Panel

Table 3-1. Front Panel Descriptions

Locator	Description
A	Power Indicator – This green LED lights when operating power is applied to the BE1-11t.
B	Relay Trouble Indicator – This red LED lights momentarily during start-up and lights continuously when a BE1-11t failure is detected. The <i>Contact Inputs and Outputs</i> chapter provides a complete description of all BE1-11t 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 <i>Alarms</i> 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 BE1-11t or when locally setting the BE1-11t. 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 <i>BESTlogicPlus</i> chapter for information on assigning logic elements to LED indicators. Indicator status is also available through the Metering Explorer in BESTCOMSPlus®.
H	Reset Pushbutton – Pressing this button resets the Trip LED, sealed-in Trip Targets, and Alarms.
I	Operate Control Switch – This pushbutton operates a 43 virtual control switch after it has been selected using the <i>Select Control Switch (L)</i> . Refer to the <i>Virtual Control Switches (43)</i> chapter for more information about the control switches.
J	USB – This universal serial bus port is used to communicate with the BE1-11t using BESTCOMSPlus.
K	Identification Label – This label lists the style number, serial number, sensing input current and voltage range, and power supply input voltages. The QR (Quick Response) code is read by an imaging device, such as a camera on a mobile phone or tablet. If an internet connection is available, you will be directed to the BE1-11t mobile web page where you can access this instruction manual, frequently asked questions, and a basic troubleshooting guide. You can also contact technical support and subscribe to Basler Electric product email announcements.
L	Select Control Switch – This pushbutton selects an enabled 43 virtual control switch. The <i>Operate Control Switch (J)</i> operates the switch after it has been selected. Refer to the <i>Virtual Control Switches (43)</i> 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 BE1-11t 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.

## 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 3-2 illustrates the organization of the front-panel display menu tree structure.

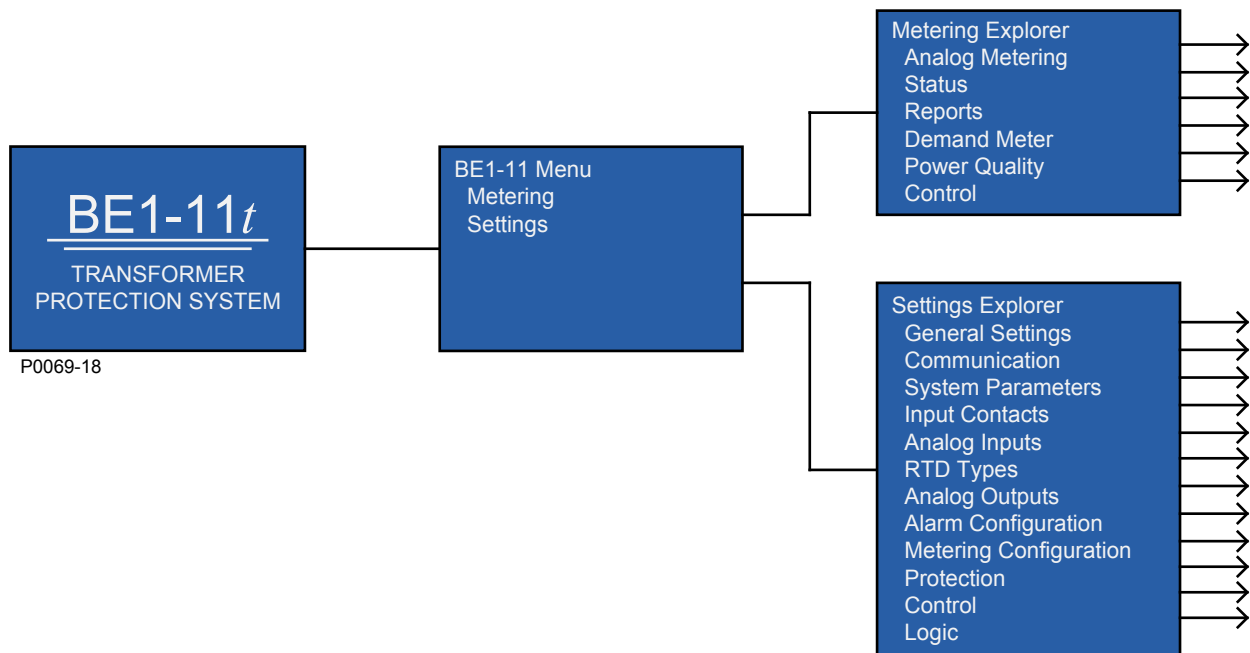


Figure 3-2. Front-Panel Display Menu Tree Layout

## Front Panel Operations

The following paragraphs describe how the front-panel interface is used to set and control BE1-11t 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 BE1-11 $\tau$  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 must be entered one character at a time. For example, to enter a 51-1 pickup as 7.3 amps, you would place the cursor in the Pickup 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 Curve Index field and then scroll through a list of available time characteristic 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 Settings > Control > Virtual Switch 43 > 43-1 and verify that the 43-1 is set for Switch/Pulse mode.
2. Use the scrolling pushbuttons to scroll to Metering > Control > Virtual Switches > 43-1 > Operate.
3. 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.
4. Press the UP or DOWN scrolling key to select the new state for the switch. The “Pulse” 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 “Reset” 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 “Reset” will function.

If the switch is set to Pulse mode, only the “Pulse” selection will function. If the switch is set to Switch/Pulse mode, any of the selections will function.

5. 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 Targets screen is displayed will reset the targets, 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

**BESTCOMSPlus Navigation Path:** Settings Explorer, General Settings, Front Panel HMI

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

Front-panel display settings are described in the following paragraphs. The BESTCOMSPlus Front Panel HMI screen is illustrated in Figure 3-3.

### LCD Setup

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 blue letters on a white background.

### Sleep Mode Setup

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 BESTCOMSPlus.

### Language Setup

The language can be set for English or Russian. Language changes will affect the front-panel LCD, sequence of events, fault reports, oscillography reports, load profile, and web pages.

### Screen Scrolling Setup

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. The Show Splash Screen setting allows the splash screen to be shown or hidden from screen scrolling. When screen scrolling is enabled and no screens are selected, the splash screen is displayed even if the Show Splash Screen setting is disabled. Scrolling screen items can only be selected in BESTCOMSPlus.

Targets and alarms are automatically displayed on the front-panel LCD when they become active if on the splash screen. After targets and alarms are reset, the BE1-11 $\iota$  returns to the main screen and begins scrolling if scrolling is enabled. Press the RIGHT navigation key to access the menu when targets and alarms are being displayed.

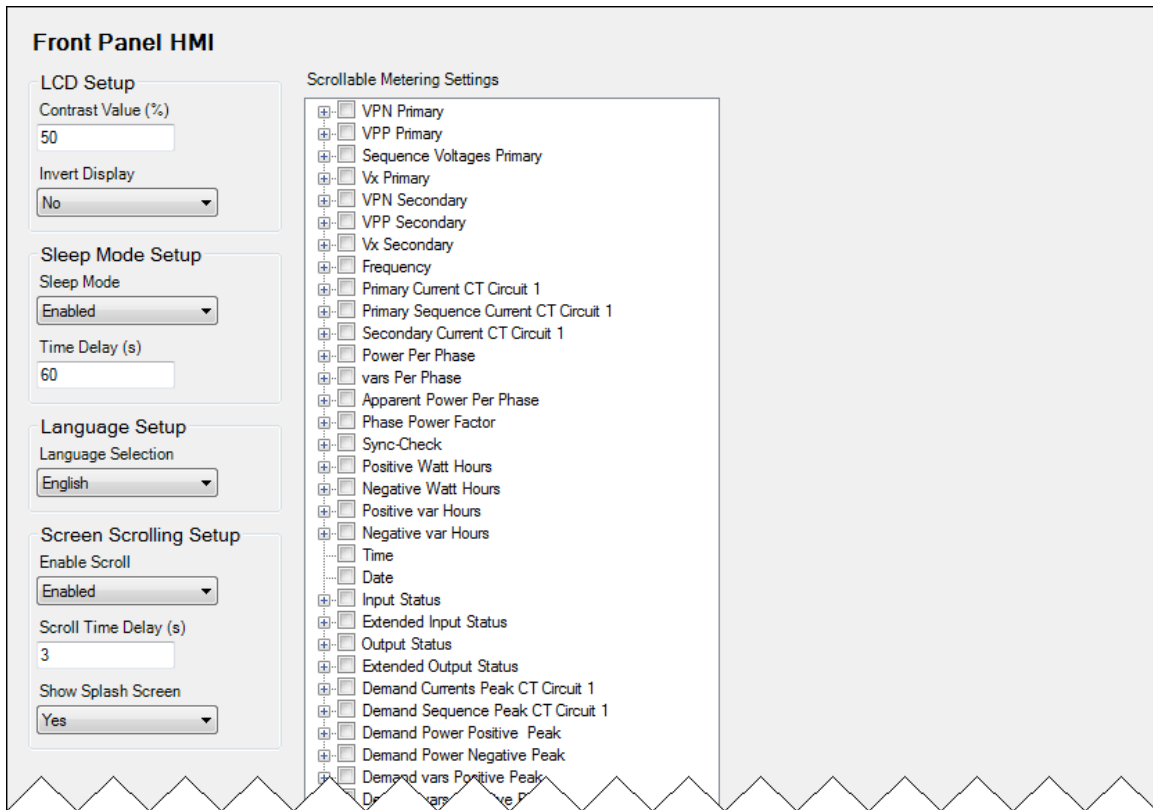


Figure 3-3. Front-Panel Display Setup Screen

## 4 • Contact Inputs and Outputs

BE1-11 $\ell$  Transformer Protection Systems provide seven contact inputs, 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

Either seven or 10 contact inputs are available to initiate BE1-11 $\ell$  protection system actions. Refer to the style chart for I/O options. Each isolated input requires an external wetting voltage. The nominal voltage(s) of the external dc source(s) must fall within the BE1-11 $\ell$  dc power supply input voltage range. To enhance user flexibility, the BE1-11 $\ell$  protection system 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 IN10. 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 $\ell$  protection system is delivered with the jumpers in the HIGH position. Read the following paragraphs before placing the BE1-11 $\ell$  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 4-1 for the contact-sensing turn-on voltages.

**Table 4-1. Contact-Sensing Turn-On Voltages**

Style Option	Nominal Input Voltage	Contact Sensing Turn-On Voltage *	
		Jumper Installed (Low Position)	Jumper Not Installed (High Position)
Txx1xxxxxxxxxx	48 Vdc or 125 Vac/dc	26 to 38 Vdc	69 to 100 Vdc 56 to 97 Vac
Txx2xxxxxxxxxx	125/250 Vac/dc	69 to 100 Vdc 56 to 97 Vac	138 to 200 Vdc 112 to 194 Vac
Txx3xxxxxxxxxx	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 $\ell$  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.

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

1. Remove the BE1-11 $\ell$  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 BE1-11t.

- 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 4-1 illustrates the location of the contact-sensing jumpers. The jumpers are shown in the HIGH position.
- 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.
- When all jumpers are positioned for operation in the desired control voltage range, reinstall the rear terminal block(s).
- Using a 7/64" hex tool, tighten the screws to 10 in-lbs (1.12 N•m).

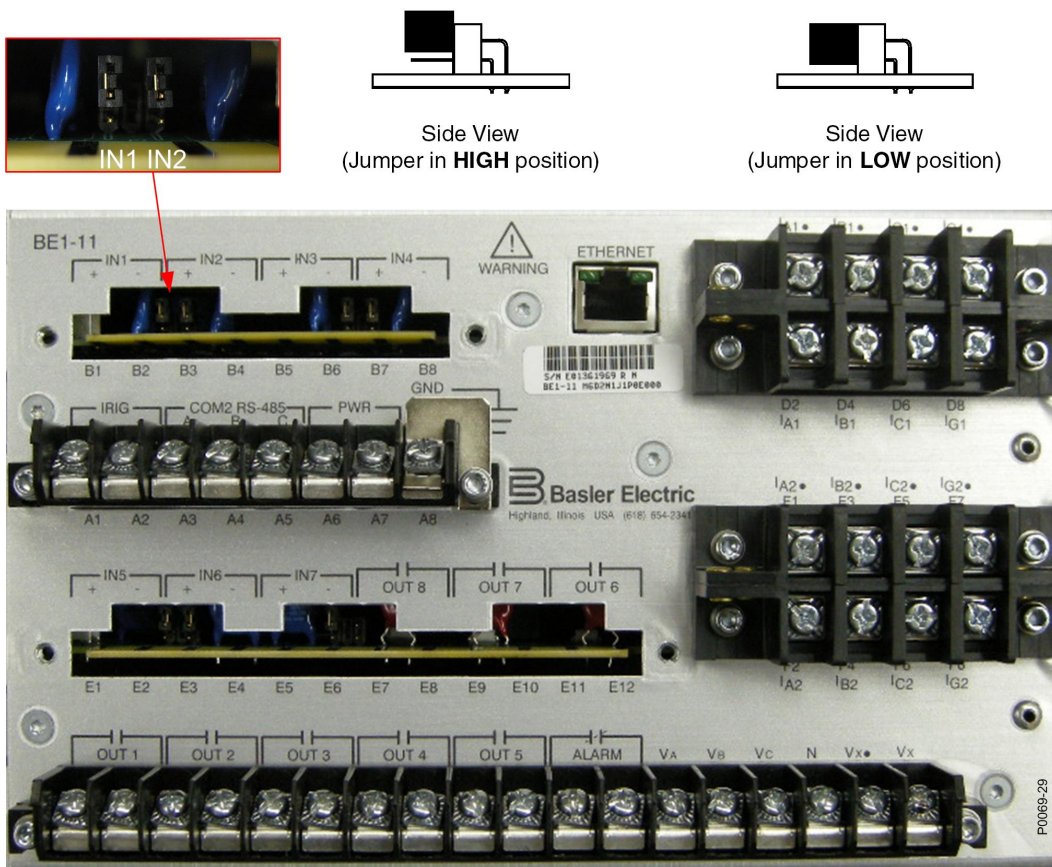


Figure 4-1. Contact-Sensing Jumper Locations (Standard I/O Option)

## 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 4-2.)

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.

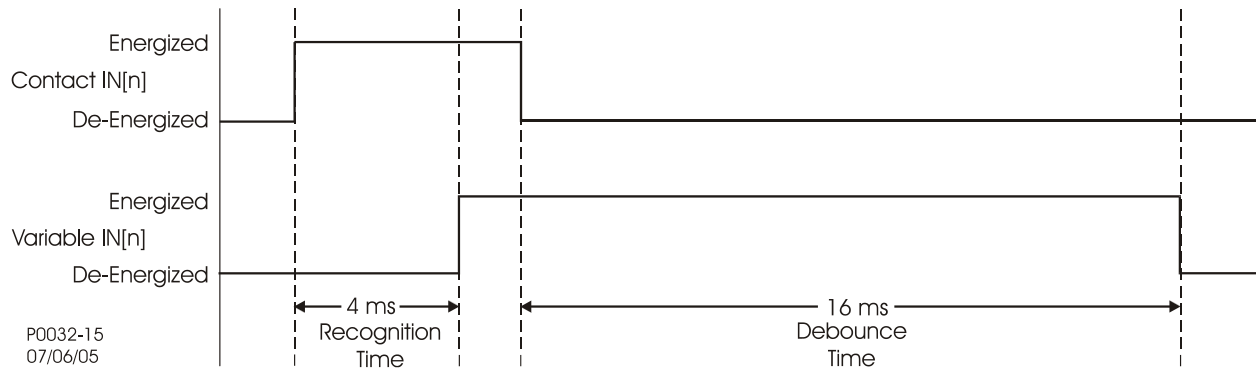


Figure 4-2. Digital Input Conditioning Timing Diagram

### Setting the Contact Inputs

**BESTCOMSPPlus Navigation Path:** Settings Explorer, Programmable Inputs, Contact Inputs

**HMI Navigation Path:** Settings Explorer, Contact Inputs

Settings and labels for the contact inputs are set using BESTCOMSPPlus®.

Each of the seven 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 BE1-11t'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 4-3.

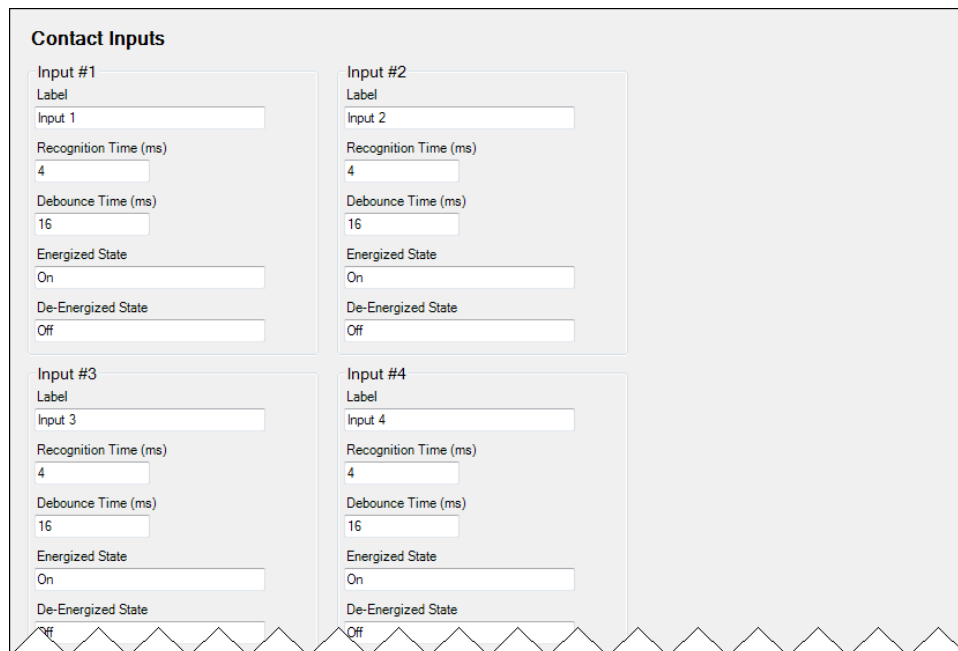


Figure 4-3. Contact Inputs Screen

See Table 4-2 for a list of settings and their defaults.

**Table 4-2. 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 *BESTCOMSPlus* by using the Metering Explorer to open the Status, Inputs tree branch. *BESTCOMSPlus* must be online with the BE1-11 $t$  to view contact input status. Alternately, status can be determined through the front-panel display by navigating to Metering > Status > Inputs.

## Contact Outputs

BE1-11 $t$  protection systems have either eight or five general-purpose contact outputs (OUT1 through OUT8/OUT5) and one failsafe, normally open or closed (when de-energized) alarm contact output (OUTA). Refer to the style chart for I/O options. 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 *BESTlogicPlus* 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.

*BESTlogicPlus* 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 4-4 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.

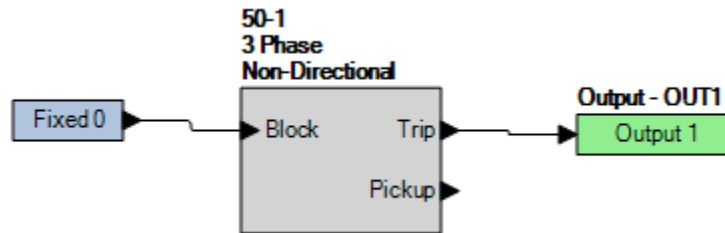


Figure 4-4. Output Logic, General Purpose Contact Outputs

Figure 4-5 illustrates the contact output logic for the failsafe alarm contact output when OUTA is normally closed (style xxxxxx2xxxxx). The OUTA relay closes when the 50-1 element is in a trip condition.

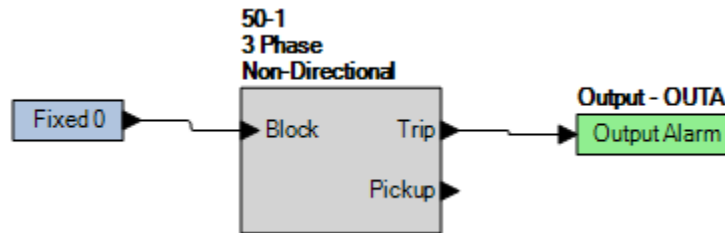


Figure 4-5. Output Logic, Failsafe Alarm Contact Output

### Relay Trouble Alarm Disable

All internal circuitry and software that affects how the BE1-11 $t$  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 4-3. 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 BE1-11 $t$  is taken offline. The relay trouble alarms function is not programmable.

Table 4-3. 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	BE1-11 $t$ not calibrated
Defaults Loaded	Defaults have been loaded
uP Overload	Microprocessor is busy
Power Supply	Input power is too low/failed

## Programmable Hold Timer—Hold Attribute

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 protection systems like the BE1-11*t*.

### Contact Output Seal-In Logic

To prevent the output relay contacts from opening prematurely, a hold timer (200 to 2,000 ms) can be set with *BESTCOMSPlus*. 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 4-6 provides a seal-in logic diagram.

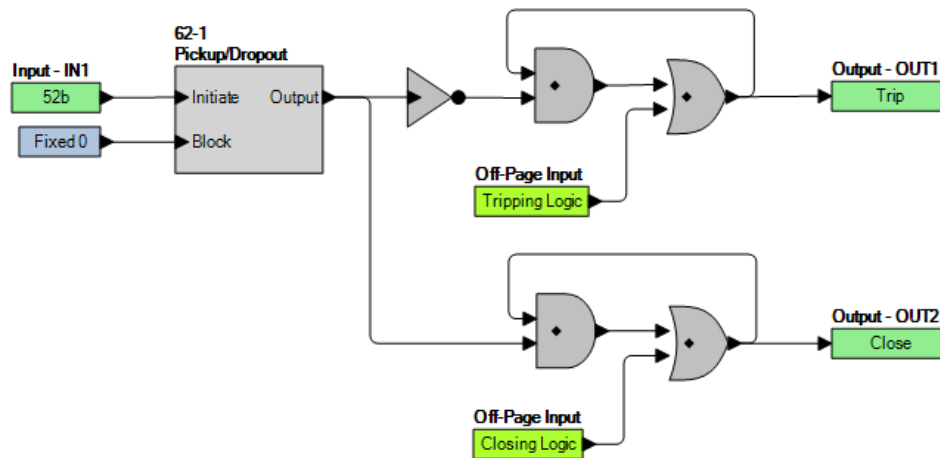


Figure 4-6. Contact Output Seal-In Logic Diagram

## Setting the Contact Outputs

**BESTCOMSPlus Navigation Path:** Settings Explorer, Programmable Outputs, Contact Outputs

**HMI Navigation Path:** Not available through the front panel

Settings and labels for the contact outputs are set using *BESTCOMSPlus*.

Each of the eight 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*t*'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 4-7.

The screenshot shows the 'Contact Outputs' configuration screen. It is divided into three columns for 'Output Alarm', 'Output #1', and 'Output #2'. Each column contains the following fields:

- Label:** A text input field containing 'Output Alarm', 'Output 1', and 'Output 2' respectively.
- Energized State:** A dropdown menu with 'On' selected.
- De-Energized State:** A dropdown menu with 'Off' selected.
- Hold Attribute:** A dropdown menu with 'Enabled' selected.
- Hold Time (ms):** A text input field containing '200'.

Figure 4-7. Contact Outputs Screen

## Contact Output Logic Override Control

**BESTCOMSPi.us Navigation Path:** Metering Explorer, Control, Output Override

**HMI 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 BESTCOMSPi.us. Use the Metering Explorer to open the Control, Output Override screen. Refer to Figure 4-8.

Output Label	Control	Status	Action	Output Status	Output Label
Output Alarm	Enabled	●	Set	●	Output Alarm
Output 1	Enabled	●	Reset	●	Output 1
Output 2	Disabled	●		●	Output 2
Output 3	Disabled	●		●	Output 3
Output 4	Disabled	●		●	Output 4
Output 5	Disabled	●		●	Output 5
Output 6	Disabled	●		●	Output 6
Output 7	Disabled	●		●	Output 7
Output 8	Disabled	●		●	Output 8

Figure 4-8. 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 BESTCOMSPi.us (Figure 4-8). 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 $\tau$  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 BESTCOMSP<sup>lus</sup> by using the Metering Explorer to open the Status/Outputs tree branch. BESTCOMSP<sup>lus</sup> must be online with the BE1-11<sup>t</sup> to view contact output status. Alternately, status can be determined through the front panel front-panel display by navigating to Metering > Status > Outputs.

## 5 • Overexcitation (24) Protection

The overexcitation (24) element monitors the volts per hertz ratio and protects transformers and generators from the adverse effects of excessive heating resulting from overexcitation. Overexcitation exists whenever the per unit volts per hertz exceeds the equipment design limitations.

Element logic connections are made on the BESTlogic™ *Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Overexcitation (24) settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

**BESTCOMS*Plus* Navigation Path:** Settings Explorer, Protection, Voltage, Overexcitation (24)

**HMI Navigation Path:** Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Voltage Protection, Overexcitation 24

### Element Operation

Overexcitation occurs when a generator or transformer magnetic core becomes saturated. When this happens, stray flux is induced in non-laminated components, causing overheating. The BE1-11*t* detects overexcitation conditions with a volts per hertz element that consists of one alarm setting, one inverse time characteristic with selectable exponents (3 sets of time curves), and two definite-time characteristics. This allows the user to select an individual inverse-time characteristic, a composite characteristic with inverse time, and one or two definite-time elements, or a dual-level, definite-time element.

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

The overexcitation element responds to the magnitude of voltage versus frequency where the measured voltage is phase to phase and includes the phase with the frequency measurement element.

### Sensing Configuration

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

Nominal voltage for the BE1-11*t* is defined as a phase-to-neutral quantity. Nominal V/Hz depends on the sensing voltage (VT) connection, nominal voltage, and nominal frequency settings. Nominal V/Hz is calculated as the nominal voltage divided by nominal frequency. For VT connections equal to 3W, 4W, AB, BC, CA, the nominal voltage (phase-neutral value) must be converted to a phase-phase value by multiplying by the square root of 3. No additional conversion is required for VT connections equal to AN, BN, or CN.

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

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

**Equation 5-1. V/Hz Measured (3W, 4W, AB, BC, or CA)**

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

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

**Equation 5-2. V/Hz Measured (AN, BN, or CN)**

## Trip and Reset Equations

Equation 5-3 and Equation 5-4 represent the trip time and reset time for a constant V/Hz level. Normally, the V/Hz pickup is set to a value greater than the V/Hz nominal. This ensures that V/Hz measured divided by V/Hz nominal is always greater than 1.000 throughout the pickup range. If the pickup is set less than nominal, then measured values above pickup and below nominal will result in the maximum time delay. The maximum time delay is determined by Equation 5-3 with (V/Hz measured / V/Hz nominal) set equal to 1.001. The overall inverse time delay range is limited to 1,000 seconds maximum and 0.2 seconds minimum.

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

Equation 5-3. Time to Trip

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

Equation 5-4. Time to Reset

where:

$T_T$  = Time to trip

$T_R$  = Time to reset

$D_T$  = Time dial, trip

$D_R$  = Time dial, reset

$E_T$  = Elapsed time

$n$  = Curve exponent (0.5, 1, 2)

FST = Full scale trip time ( $T_T$ )

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

## Pickup and Trip

The Pickup output occurs first, followed by the Trip output.

### Pickup

The Pickup output becomes true when the measured V/Hz increases above the V/Hz threshold established by the Pickup setting. In *BESTlogicPlus*, the Pickup output can be connected to other logic elements to annunciate the condition, control other elements in logic, and start the fault recorder (FAULTTRIG).

Assertion of the Pickup output initiates an inverse or definite timer that begins timing to a trip. The duration of the timer is established by the Time Dial (inverse time) or Time Delay (definite time) setting. A Time Delay or Time Dial setting of zero (0) makes the 24 element instantaneous with no intentional time delay.

If the monitored V/Hz is above both the calculated inverse time and definite time delay thresholds, the definite time delay has priority over the inverse time characteristic.

If the pickup condition subsides before the element 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 overexcitation. If inverse reset is chosen, the inverse trip timer will ramp down towards reset at a linear rate based on the Reset Dial setting. A Reset Dial setting of zero (0) makes the reset instantaneous with no intentional delay. See the *Time Curve Characteristics* chapter for details on each of the available time curves.

### Trip

The Trip output becomes true if an overexcitation pickup condition exists for the duration of the element Time Delay (definite time) or calculated inverse time. In *BESTlogicPlus*, the Trip output can be connected to other logic elements and to a physical relay output to annunciate the condition and to initiate corrective action. If a target is enabled for the element, the BE1-11t will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

## Programmable Alarm

A 24 Volts per Hz alarm occurs during overexcitation so that corrective action can be taken before the 24 function trips. The alarm appears on the front-panel display, web page interface, and on the Alarms metering screen in BESTCOMSP<sub>Plus</sub>. Refer to the *Alarms* chapter for information about programming alarms.

When the Alarm Pickup setting is exceeded, a timer is initiated and begins timing toward a trip. The duration of the timer is established by the alarm Time Delay setting. An alarm Time Delay setting of zero (0) makes the alarm instantaneous with no intentional time delay.

If the alarm pickup condition persists for the duration of the alarm Time Delay setting, the 24 Volts per Hz alarm becomes true. If the alarm pickup condition subsides before the alarm time delay expires, the timer is reset and no corrective action is taken.

## Element Blocking

### Fuse Loss

The fuse loss (60FL) element of the BE1-11<sub>t</sub> can be used to block 24 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.

Protective elements blocked by 60FL should be set so that trip times are 60 milliseconds or greater to assure proper coordination of blocking.

### Block Logic Input

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in BESTlogicP<sub>Plus</sub>. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## Logic Connections

Overexcitation element logic connections are made on the BESTlogicP<sub>Plus</sub> screen in BESTCOMSP<sub>Plus</sub>. The overexcitation element logic block is illustrated in Figure 5-1. Logic inputs and outputs are summarized in Table 5-1.

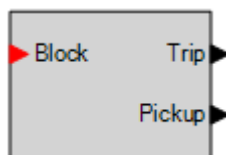


Figure 5-1. Overexcitation Element Logic Block

Table 5-1. Logic Inputs and Outputs

Name	Function	Purpose
Block	Input	Disables the 24 function when true
Trip	Output	True when the 24 element is in trip condition
Pickup	Output	True when the 24 element is in pickup condition

## Operational Settings

Overexcitation operational settings are configured on the Overexcitation (24) settings screen (Figure 5-2) in BESTCOMSP<sub>Plus</sub>.

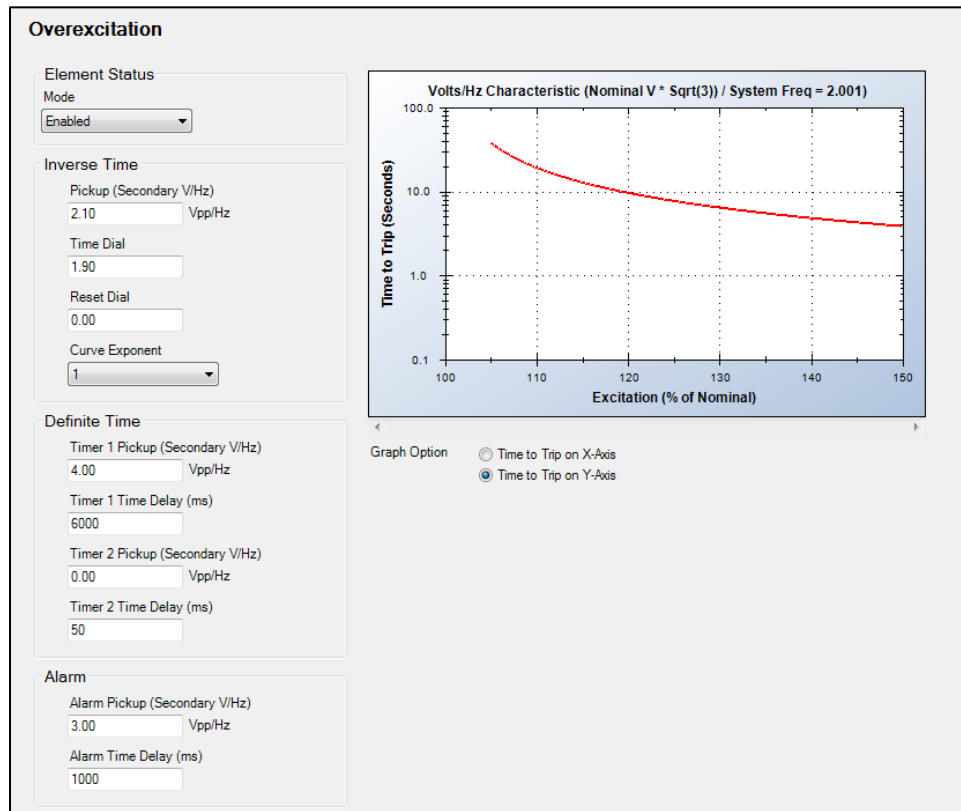


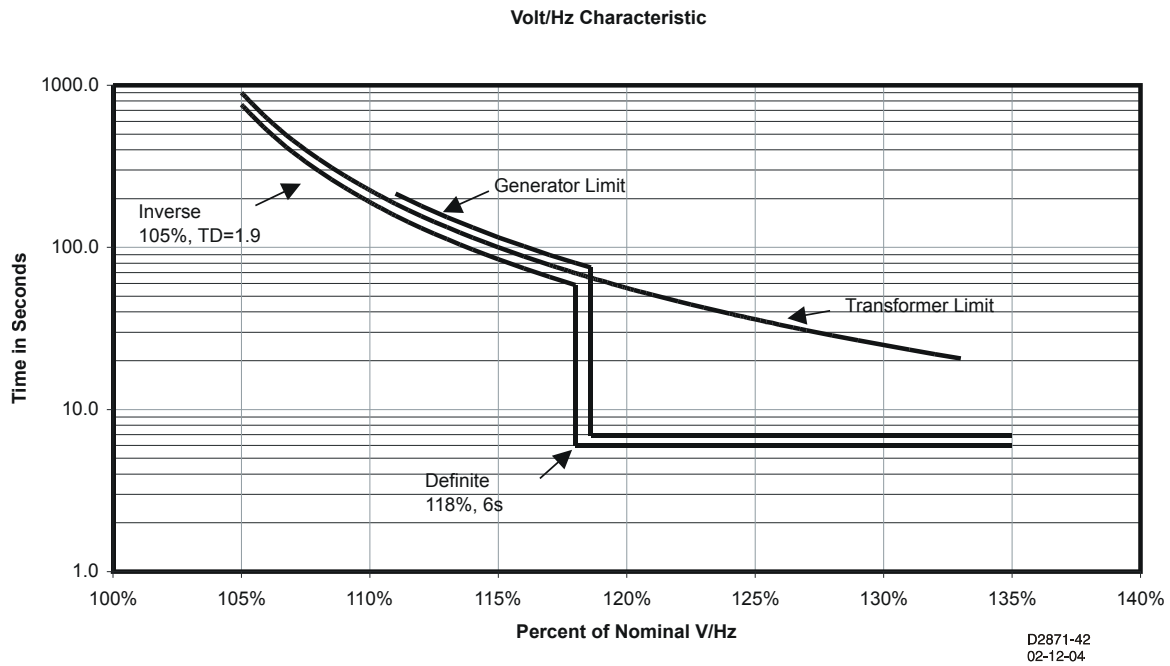
Figure 5-2. Overexcitation Settings Screen

## Settings Example

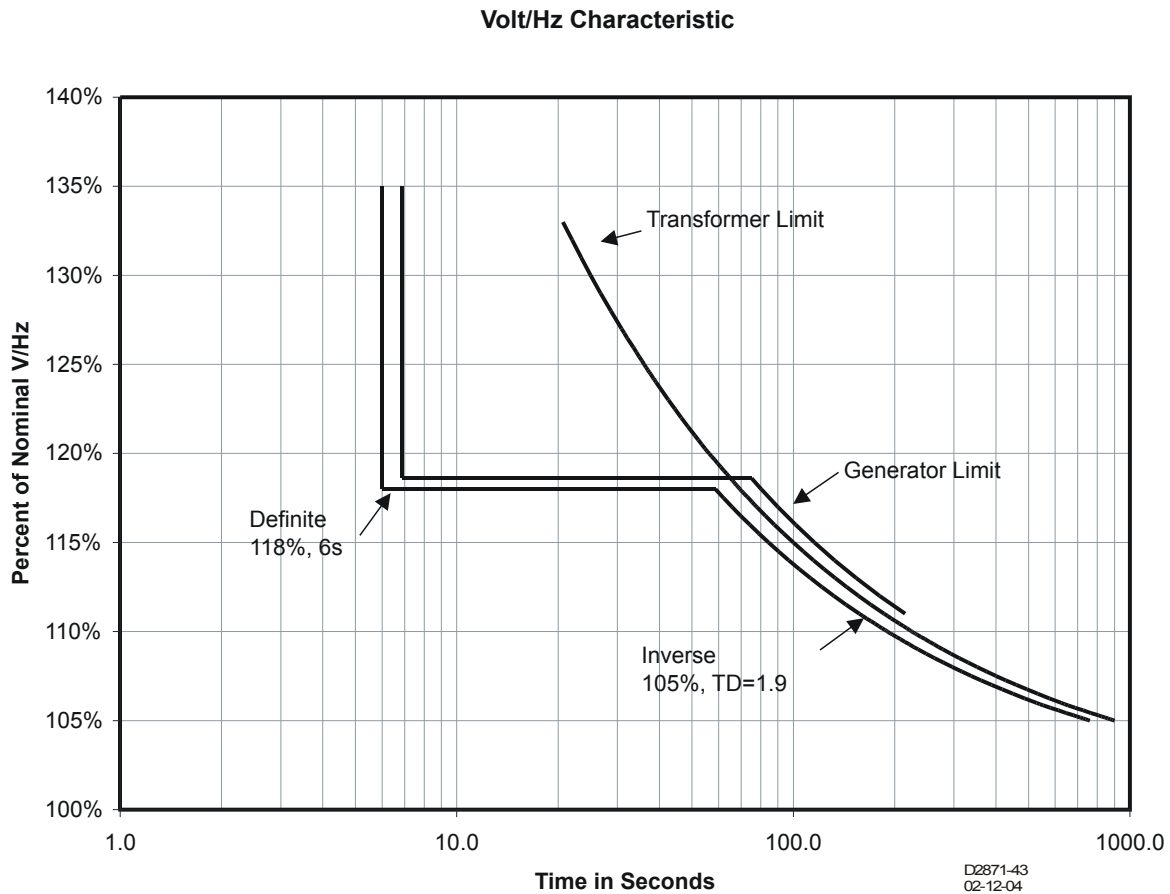
The overexcitation element is used to de-energize a generator or transformer that is experiencing an overexcitation condition. Therefore, the manufacturer's overexcitation limit curves are required to establish optimum protection. Figure 5-3 and Figure 5-4 show examples of a transformer and generator limit curve along with the optimum composite protection characteristic.

### Note

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



**Figure 5-3. Time Shown on Vertical Axis**



**Figure 5-4. Time Shown on Horizontal Axis**

Assuming a  $V_{nom}$  of 69.3 Vpn,  $1 \text{ pu volts/hertz} = (69.3 \cdot \sqrt{3}) / 60 = 2.00$ . Using IEEE Std C37.102-2006 - *IEEE Guide for AC Generator Protection* as a guide for setting overexcitation protection, the following

example demonstrates how to set the BE1-11 $t$  to provide a composite V/Hz characteristic for protection of a generator and a step-up transformer:

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

The reset rate is determined by the Reset Dial setting. A setting of zero (0) gives an instantaneous reset. Using the inverse squared characteristic, assume a trip time dial setting 2.0 and a pickup multiple of 1.2. The total time to trip will be 50 seconds. If this exists for 30 seconds before being corrected (60% elapsed time), what would the total reset time be for a reset dial setting of 5? Based on the reset equation (Equation 5-5), the calculation will be:

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

Equation 5-5. Time to Reset

If the overexcitation condition returns prior to total reset (i.e., less than 300 seconds), timing resumes from that point at the inverse square rate. For example, if this condition recurs after 150 seconds or 50% of the total reset time, then trip time from the second event will start at 30% instead of 0%, therefore tripping in 70% of the original trip time or 35 seconds. Figure 5-5 illustrates the inverse time delay and reset time.

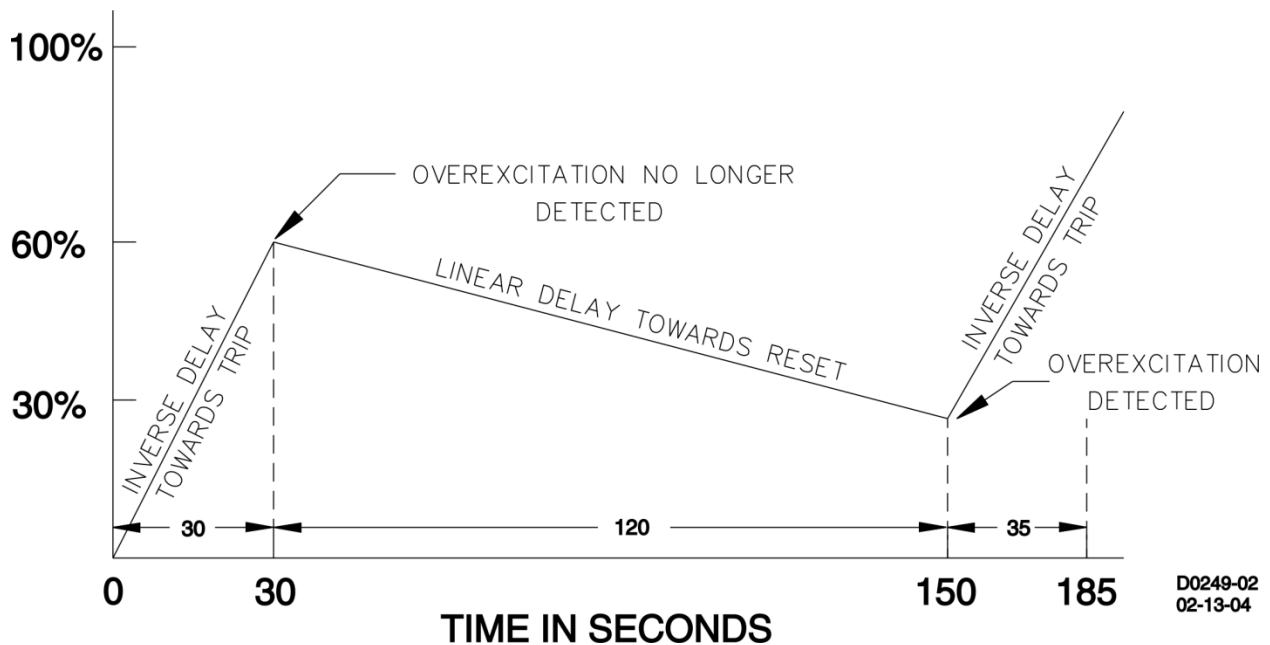


Figure 5-5. Inverse Time Delay and Reset Time

## 6 • Sync-Check (25) Protection

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. This element is available only in style TxxxxxxxBxxxx of the BE1-11t.

Element logic connections are made on the BESTlogic™ *Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Sync-Check settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appears 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 Sync output becomes true. In BESTlogic*Plus*, the Sync output can be connected to other logic elements to annunciate the condition or control other elements in logic. The Sync 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. Source Freq is the generator 3-phase connection and Destination Freq is the Aux connection.)
3. Voltage magnitude between sources is less than setting. (Note: The voltage used by the BE1-11t 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 Sync 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 a period of time). The moment that conditions 1, 2, and 3 (listed above) are met, the systems can be considered in synchronism, and the Sync 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.

### Caution

The Aux VT Connection must be properly selected on the Sensing Transformers screen in BESTCOMSP<sup>Plus</sup>. 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.

Common system and sensing transformer combinations are shown in Table 6-1. This table assumes no step-up or step-down transformer between the two measurement PTs. If the synchronizing zone includes a step-up or step-down transformer, change the nominal voltages accordingly.

**Table 6-1. Common System and Sensing Transformer Combinations**

Phase VT Connection	Phase Rotation	Aux VT Connection	Secondary Phase Voltage (Phase-Neutral)	Secondary Aux Voltage	Angle Compensation
3-wire	ABC	AB	69.3	120	0°
3-wire	ABC	BC	69.3	120	240°
3-wire	ABC	CA	69.3	120	120°
3-wire	ACB	AB	69.3	120	0°
3-wire	ACB	BC	69.3	120	120°
3-wire	ACB	CA	69.3	120	240°
4-wire	ABC	AN	69.3	69.3	0°
4-wire	ABC	BN	69.3	69.3	240°
4-wire	ABC	CN	69.3	69.3	120°
4-wire	ABC	AB	69.3	120	30°
4-wire	ABC	BC	69.3	120	270°
4-wire	ABC	CA	69.3	120	150°
4-wire	ACB	AN	69.3	69.3	0°
4-wire	ACB	BN	69.3	69.3	120°
4-wire	ACB	CN	69.3	69.3	240°
4-wire	ACB	AB	69.3	120	330°
4-wire	ACB	BC	69.3	120	90°
4-wire	ACB	CA	69.3	120	210°

Phase VT Connection	Phase Rotation	Aux VT Connection	Secondary Phase Voltage (Phase-Neutral)	Secondary Aux Voltage	Angle Compensation
AB	ABC	AB	69.3	120	0°
AB	ACB	AB	69.3	120	0°
BC	ABC	BC	69.3	120	0°
BC	ACB	BC	69.3	120	0°
AB	ABC	BC	69.3	120	240°
AB	ACB	BC	69.3	120	120°
AB	ABC	AN	69.3	69.3	330°
AB	ACB	AN	69.3	69.3	30°

## Voltage Monitoring

The sync-check element Sync logic output provides closing supervision for only the live line/live bus condition.

The Volt Monitor logic output is provided for conditions where the bus and/or the line are dead. In *BESTlogicPlus*, the Volt Monitor logic 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 equal to or above the live voltage threshold established by the Live Voltage setting. A dead condition for either phase voltage or auxiliary voltage is determined when the measured voltage on the respective input is equal to or below the dead voltage threshold established by the Dead Voltage setting. The Dropout Delay setting provides hysteresis for the Volt Monitor logic 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 Volt Monitor logic is illustrated in Figure 6-1. Any combination of logic settings can be selected for the Voltage Monitor Logic on the Sync-Check (25) settings screen in *BESTCOMSPlus*. When a logic combination is selected, the sync-check element closes the respective switch in Figure 6-1 associated with each of the outputs.

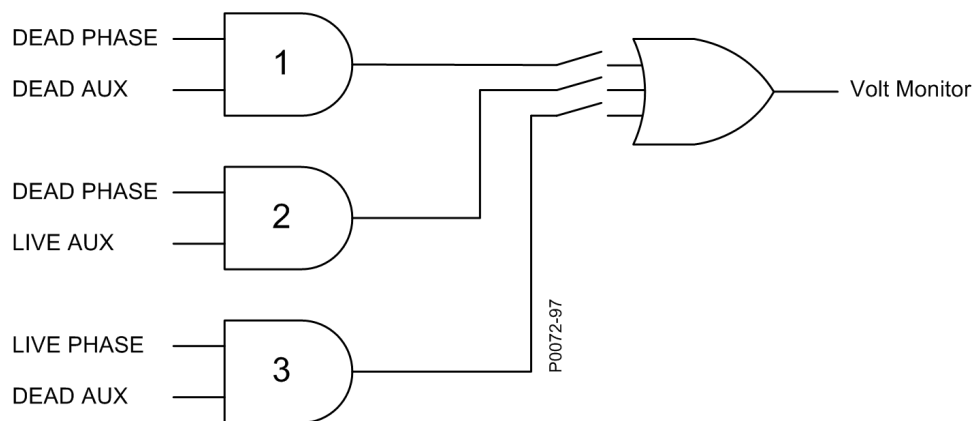


Figure 6-1. Voltage Monitor Logic

## Element Blocking

### Fuse Loss

The fuse loss (60FL) element of the BE1-11 $\tau$  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.

Protective elements blocked by 60FL should be set so that trip times are 60 milliseconds or greater to assure proper coordination of blocking.

### Block Logic Input

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the element outputs to logic 0. Connect the element Block input to the desired logic in *BESTlogicPlus*. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## **Logic Connections**

Sync-check element logic connections are made on the *BESTlogicPlus* screen in *BESTCOMSPlus*. The sync-check element logic block is illustrated in Figure 6-2. Logic inputs and outputs are summarized in Table 6-2.

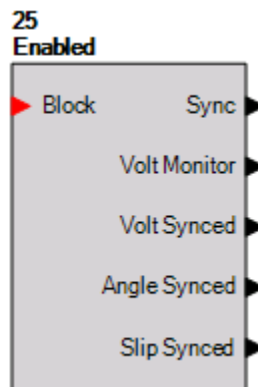


Figure 6-2. Sync-Check Element Logic Block

Table 6-2. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 25 function when true
Sync	Output	True when the monitored voltage between the sources meets angle, voltage, and slip criteria
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 6-3) in *BESTCOMSPlus*.

**Sync-Check**

25 Element

<p><b>25 Element Settings</b></p> <p>Mode Enabled</p> <p>Voltage Difference (%) 0</p> <p>Slip Angle (°) 10</p> <p>Slip Frequency (Hz) 0.01</p> <p>Source Freq &gt; Destination Freq Disabled</p>	<p><b>25 Voltage Monitoring</b></p> <p>Live Voltage (%) 0</p> <p>Dead Voltage (%) 0</p> <p>Drop Out Delay (ms) 50</p>
<p><b>25 Element Sensing Setup</b></p> <p>Angle Compensation (°) 0.0</p>	<p><b>25 Voltage Monitor Logic</b></p> <p>Dead Phase / Dead Aux Disabled</p> <p>Dead Phase / Live Aux Disabled</p> <p>Live Phase / Dead Aux Disabled</p>

Figure 6-3. Sync-Check Settings Screen



## 7 • Phase Undervoltage (27P) Protection

Five phase undervoltage (27P) elements monitor the sensing voltage applied to the BE1-11 $t$ . 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 appears 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.

#### **Timings**

The timing mode can be set for definite or inverse.

##### Inverse

When inverse timing is selected, a Curve setting is provided to select programmable or table curves. The user can select integrating reset timing to make the protective element use integrated reset and emulate an electromechanical induction disk reset characteristic. The undervoltage inverse time curve with default constants is shown in the *Time Curve Characteristics* chapter.

##### **Programmable Curves**

The programmable curve can be used to create a custom curve by selecting constants in the inverse time characteristic equation. When curve P is selected, the constants used in the equation are those defined by the user. Characteristics for trip and reset programmable curves are defined by Equation 7-1 and Equation 7-2. Definitions for these equations are provided in Table 7-1.

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

**Equation 7-1. Time Characteristics for Trip**

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

**Equation 7-2. Time Characteristics for Reset**

**Table 7-1. Definitions for Equation 7-1 and Equation 7-2**

<b>Parameter</b>	<b>Description</b>	<b>Explanation</b>
$T_T$	Time to trip	Time that the 27P-x function will take to time out and trip.
D	Time dial setting	Time dial setting for the 27P-x function.
M	Multiple of pickup	Measured current in multiples of pickup. The timing algorithm has a dynamic range of 0 to 1 times pickup.
A	Constant specific to selected curve	Affects the effective range of the time dial.
B	Constant specific to selected curve	Affects a constant term in the timing equation. Has greatest effect on curve shape at high multiples of tap.
C	Constant 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.
$T_R$	Time to reset	Relevant if 27P-x function is set for integrating reset.
R	Constant specific to selected curve	Affects the speed of reset when integrating reset is selected.

Curve constants are entered on the Undervoltage (27P) settings screen in *BESTCOMSPlus*. Programmable curve constants can be entered only when the P curve is chosen for the protection element from the Curve drop-down menu.

#### Table Curves

*BESTCOMSPlus* is used to set the 27P element Table Curves (T1, T2, T3, and T4). Using the Settings Explorer within *BESTCOMSPlus*, open the Protection, Voltage, Undervoltage Table Curves, Table Curve (1, 2, 3, or 4) tree branch and select the table curve to be modified. Refer to Figure 7-1. 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 27P-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.

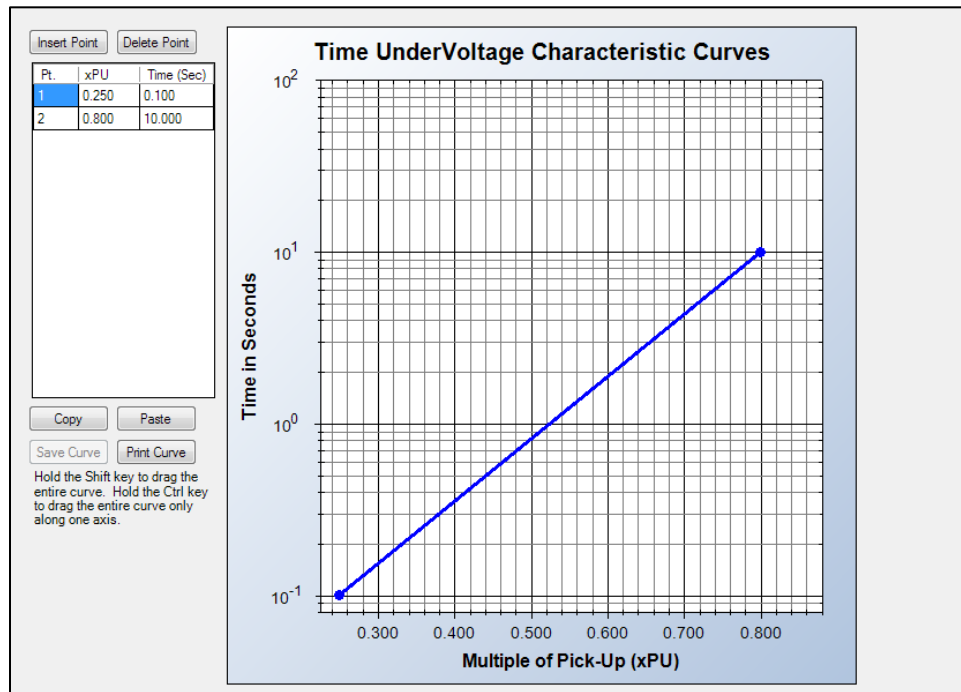


Figure 7-1. Time Undervoltage Characteristic Curves

## Pickup and Trip

The Pickup output occurs first, followed by the Trip output.

### Pickup

The Pickup output becomes true when the measured voltage decreases below the voltage threshold established by the Pickup setting. In *BESTlogicPlus*, the Pickup output can be connected to other logic elements to annunciate the condition, control other elements in logic, and start the fault recorder (logic element FAULTTRIG).

Assertion of the Pickup output initiates a timer that begins timing to a trip. 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 the pickup condition subsides before the element 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.

### Trip

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

## 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 *BESTCOMSPPlus*. 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  $V_{pn}$ . For three-wire or phase-to-phase sensing connections the inhibit level is expressed in  $V_{pp}$ .

## Element Blocking

### Fuse Loss

The fuse loss (60FL) element of the BE1-11 $t$  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.

Protective elements blocked by 60FL should be set so that trip times are 60 milliseconds or greater to assure proper coordination of blocking.

### Block Logic Input

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in BESTlogicPlus. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## Logic Connections

Phase undervoltage element logic connections are made on the BESTlogicPlus screen in BESTCOMSPPlus. The phase undervoltage element logic block is illustrated in Figure 7-2. Logic inputs and outputs are summarized in Table 7-2.

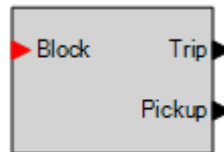


Figure 7-2. Phase Undervoltage Element Logic Block

Table 7-2. 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 7-3) in BESTCOMSPPlus.

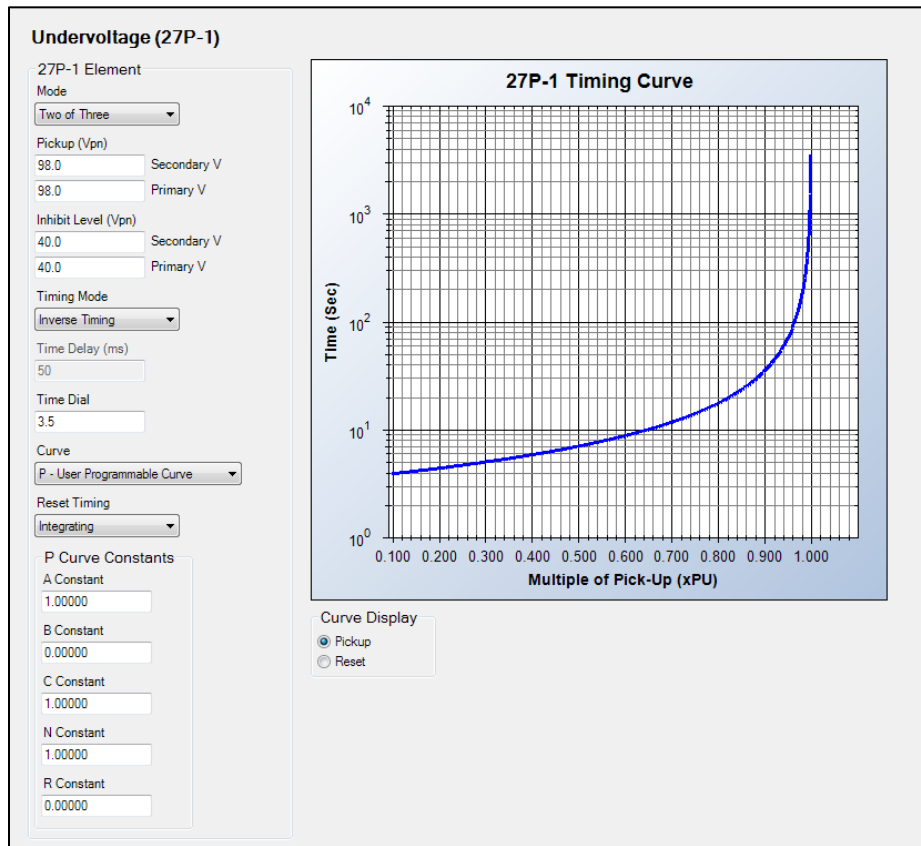


Figure 7-3. Phase Undervoltage Settings Screen



## 8 • Auxiliary Undervoltage (27X) Protection

Four auxiliary undervoltage (27X) elements monitor the phase and auxiliary voltage applied to the BE1-11 $t$ . 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 BESTCOMSP*Plus*® and element operational settings are configured on the Undervoltage (27X) settings screen in BESTCOMSP*Plus*. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

**BESTCOMSP*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***

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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 $t$ . 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

When using the Vx input, setting the Aux VT Connection parameter provides the correct labeling of settings and metering data found in BESTCOMSP<sup>Plus</sup> and fault reports. The Aux VT Connection parameter set to AB, for example, will display the metering data as AB in fault records and display the pickup setting as Vpp in BESTCOMSP<sup>Plus</sup>. See Table 8-1 for a full list of possible settings. The Aux VT Connection parameter is found on the System Parameters/Sensing Transformers settings screen in BESTCOMSP<sup>Plus</sup>. For more information on the auxiliary VT setup, see the *Configuration* chapter.

**Table 8-1. 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
Any	V1, V2, and 3V0	VPN

## Timings

The timing mode can be set for definite or inverse.

### Inverse

When inverse timing is selected, a Curve setting is provided to select programmable or table curves. The user can select integrating reset timing to make the protective element use integrated reset and emulate an electromechanical induction disk reset characteristic. The undervoltage inverse time curve with default constants is shown in the *Time Curve Characteristics* chapter.

### Programmable Curves

The programmable curve can be used to create a custom curve by selecting constants in the inverse time characteristic equation. When curve P is selected, the constants used in the equation are those defined by the user. Characteristics for trip and reset programmable curves are defined by Equation 8-1 and Equation 8-2. Definitions for these equations are provided in Table 8-2.

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

**Equation 8-1. Time Characteristics for Trip**

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

**Equation 8-2. Time Characteristics for Reset**

**Table 8-2. Definitions for Equation 8-1 and Equation 8-2**

Parameter	Description	Explanation
T <sub>T</sub>	Time to trip	Time that the 27X-x function will take to time out and trip.
D	Time dial setting	Time dial setting for the 27X-x function.
M	Multiple of pickup	Measured current in multiples of pickup. The timing algorithm has a dynamic range of 0 to 1 times pickup.
A	Constant specific to selected curve	Affects the effective range of the time dial.
B	Constant specific to selected curve	Affects a constant term in the timing equation. Has greatest effect on curve shape at high multiples of tap.
C	Constant 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.
T <sub>R</sub>	Time to reset	Relevant if 27X-x function is set for integrating reset.

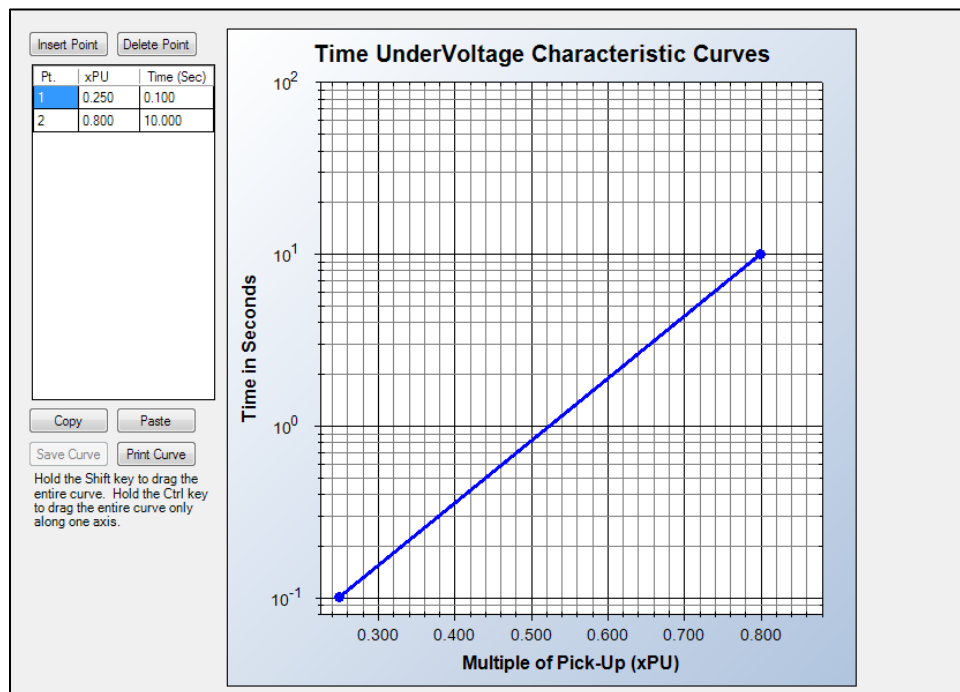
Parameter	Description	Explanation
R	Constant specific to selected curve	Affects the speed of reset when integrating reset is selected.

Curve constants are entered on the Undervoltage (27X) settings screen in *BESTCOMSPius*. Programmable curve constants can be entered only when the P curve is chosen for the protection element from the Curve drop-down menu.

### Table Curves

*BESTCOMSPius* is used to set the 27X element Table Curves (T1, T2, T3, and T4). Using the Settings Explorer within *BESTCOMSPius*, open the Protection, Voltage, Undervoltage Table Curves, Table Curve (1, 2, 3, or 4) tree branch and select the table curve to be modified. Refer to Figure 8-1. 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 27X-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 8-1. Time Undervoltage Characteristic Curves**

## Pickup and Trip

The Pickup output occurs first, followed by the Trip output.

### Pickup

The Pickup output becomes true when the measured voltage decreases below the voltage threshold established by the Pickup setting. In *BESTLogicPlus*, the Pickup output can be connected to other logic elements to annunciate the condition, control other elements in logic, and start the fault recorder (logic element FAULTTRIG).

Assertion of the Pickup output initiates a timer that begins timing to a trip. 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 the pickup condition subsides before the element 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.

### Trip

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

## **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 $t$  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.

Protective elements blocked by 60FL should be set so that trip times are 60 milliseconds or greater to assure proper coordination of blocking.

### Block Logic Input

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in *BESTlogicPlus*. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## **Logic Connections**

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Auxiliary undervoltage element logic connections are made on the *BESTlogicPlus* screen in *BESTCOMSPlus*. The auxiliary undervoltage element logic block is illustrated in Figure 8-2. Logic inputs and outputs are summarized in Table 8-3.

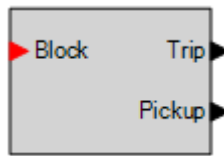


Figure 8-2. Auxiliary Undervoltage Element Logic Block

Table 8-3. 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 8-3) in BESTCOMSPUs.

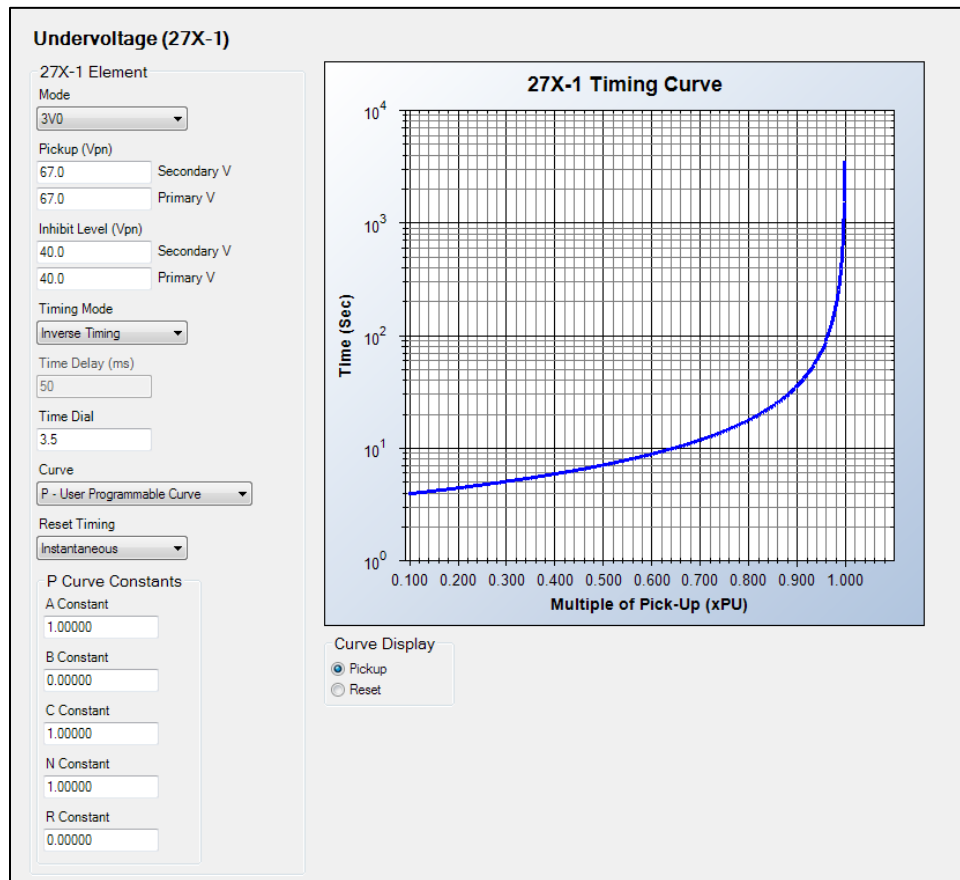


Figure 8-3. Auxiliary Undervoltage Settings Screen

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



## 9 • Negative-Sequence Voltage (47) Protection

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

Negative-sequence voltage protection is used to sense power-system imbalance. This situation occurs when a large single-phase load is switched onto the system, or when transformer-input fuses blow in only one or two phases. Negative-sequence voltage protection is good for detecting improper phasing when an oncoming generator is paralleled to the power system. All motor loads should be protected from the heating caused by unbalanced voltage (either on the bus or on each motor feeder). Industry standards state that the existence of unbalanced voltage feed results in 4 to 10 times the current imbalance. For a motor feeder, the negative-sequence voltage unbalances should not exceed 5 percent to avoid overheating and damage.



# 10 • Phase Overvoltage (59P) Protection

Four phase overvoltage (59P) elements monitor the sensing voltage applied to the BE1-11 $\iota$ . 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 BESTCOMSPlus® and element operational settings are configured on the Overvoltage settings screen in BESTCOMSPlus. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

**BESTCOMSPlus 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 BESTCOMSPlus. For more information on the VTP setup for PP or PN voltage response, see the *Configuration* chapter.

### Timings

The timing mode can be set for definite or inverse.

#### Inverse

When inverse timing is selected, a Curve setting is provided to select programmable or table curves. The user can select integrating reset timing to make the protective element use integrated reset and emulate an electromechanical induction disk reset characteristic. The overvoltage inverse time curve with default constants is shown in the *Time Curve Characteristics* chapter.

#### Programmable Curves

The programmable curve can be used to create a custom curve by selecting constants in the inverse time characteristic equation. When curve P is selected, the constants used in the equation are those defined by the user. Characteristics for trip and reset programmable curves are defined by Equation 10-1 and Equation 10-2. Definitions for these equations are provided in Table 10-1.

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

Equation 10-1. Time Characteristics for Trip

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

Equation 10-2. Time Characteristics for Reset

**Table 10-1. Definitions for Equation 10-1 and Equation 10-2**

Parameter	Description	Explanation
$T_T$	Time to trip	Time that the 59P-x function will take to time out and trip.
D	Time dial setting	Time dial setting for the 59P-x function.
M	Multiple of pickup	Measured current in multiples of pickup. The timing algorithm has a dynamic range of 1 to 3 times pickup.
A	Constant specific to selected curve	Affects the effective range of the time dial.
B	Constant specific to selected curve	Affects a constant term in the timing equation. Has greatest effect on curve shape at high multiples of tap.
C	Constant 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.
$T_R$	Time to reset	Relevant if 59P-x function is set for integrating reset.
R	Constant specific to selected curve	Affects the speed of reset when integrating reset is selected.

Curve constants are entered on the Overvoltage (59P) settings screen in *BESTCOMSPPlus*. Programmable curve constants can be entered only when the P curve is chosen for the protection element from the Curve drop-down menu.

#### Table Curves

*BESTCOMSPPlus* is used to set the 27P element Table Curves (T1, T2, T3, and T4). Using the Settings Explorer within *BESTCOMSPPlus*, open the Protection, Voltage, Overvoltage, Table Curves, Table Curve (1, 2, 3, or 4) tree branch and select the table curve to be modified. Refer to Figure 10-1. 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 59P-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.

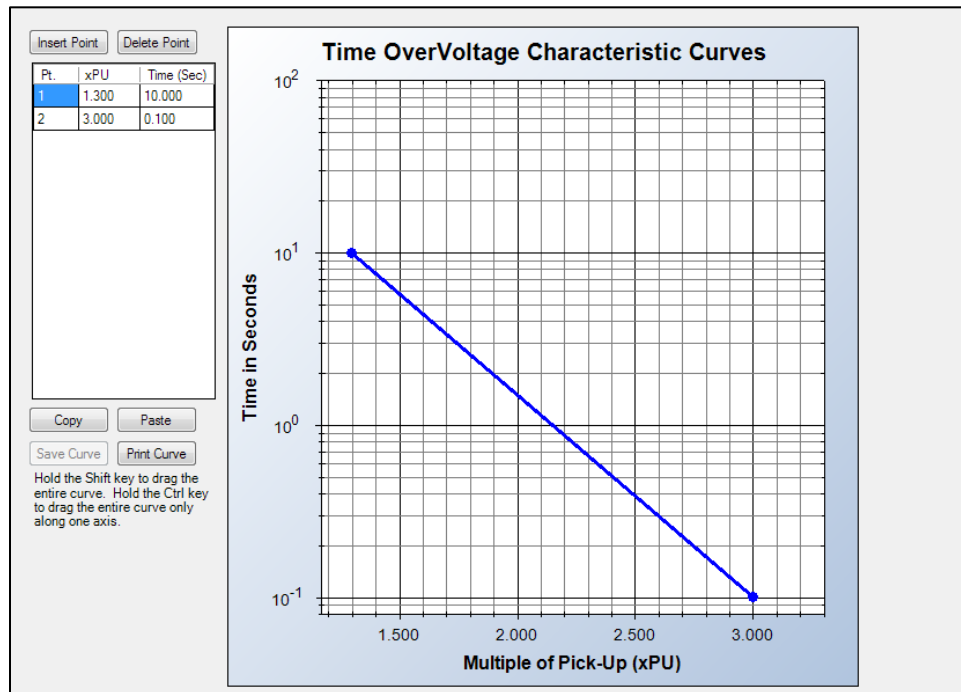


Figure 10-1. Time Overvoltage Characteristic Curves

## Pickup and Trip

The Pickup output occurs first, followed by the Trip output.

### Pickup

The Pickup output becomes true when the measured voltage increases above the voltage threshold established by the Pickup setting. In *BESTlogicPlus*, the Pickup output can be connected to other logic elements to annunciate the condition, control other elements in logic, and start the fault recorder (logic element FAULTTRIG).

Assertion of the Pickup output initiates a timer that begins timing to a trip. 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 the pickup condition subsides before the element 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.

### Trip

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

## Element Blocking

### Fuse Loss

The fuse loss (60FL) element of the BE1-11 $t$  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.

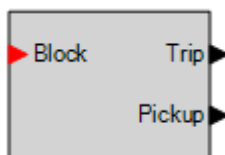
Protective elements blocked by 60FL should be set so that trip times are 60 milliseconds or greater to assure proper coordination of blocking.

### Block Logic Input

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in *BESTlogicPlus*. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## **Logic Connections**

Overvoltage element logic connections are made on the *BESTlogicPlus* screen in *BESTCOMSPlus*. The overvoltage element logic block is illustrated in Figure 10-2. Logic inputs and outputs are summarized in Table 10-2.



**Figure 10-2. Overvoltage Element Logic Block**

**Table 10-2. 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 10-3) in *BESTCOMSPlus*.

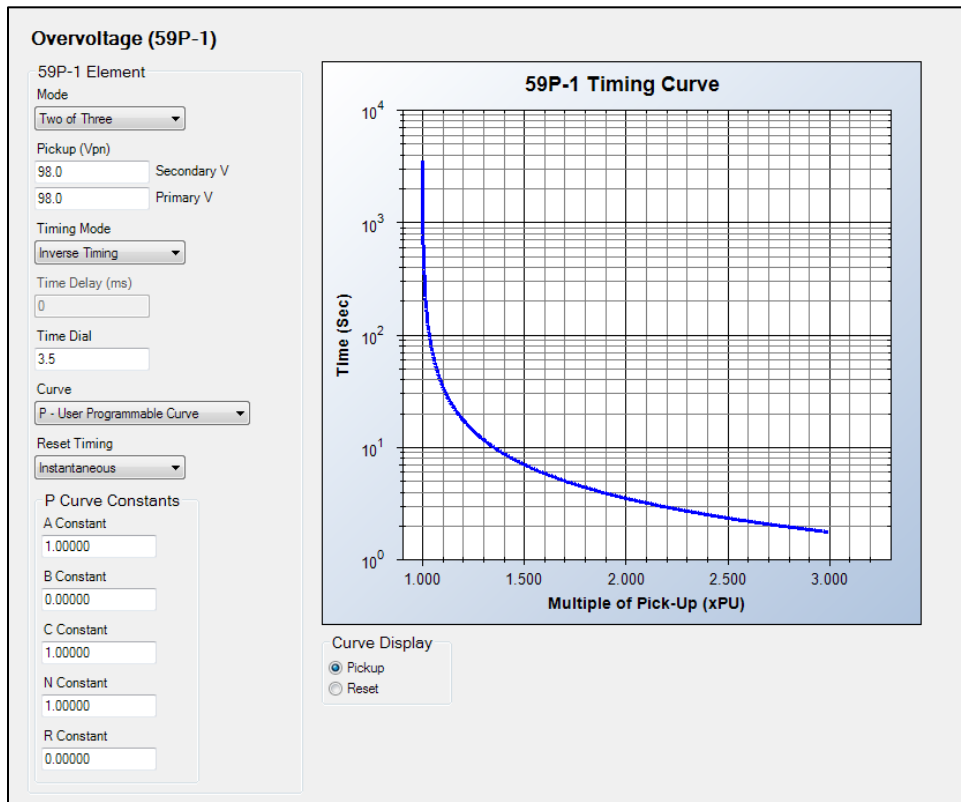


Figure 10-3. Overvoltage Settings Screen



# 11 • Auxiliary Overvoltage (59X) Protection

Four auxiliary overvoltage (59X) elements monitor the phase and auxiliary voltage applied to the BE1-11 $t$ . 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 BESTCOMSP*Plus*® and element operational settings are configured on the Overvoltage (59X) settings screen in BESTCOMSP*Plus*. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

**BESTCOMSP*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 $t$ . 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

When using the Vx input, setting the Aux VT Connection parameter provides the correct labeling of settings and metering data found in BESTCOMSP<sup>Plus</sup> and fault reports. The Aux VT Connection parameter set to AB, for example, will display the metering data as AB in fault records and display the pickup setting as Vpp in BESTCOMSP<sup>Plus</sup>. See Table 11-1 for a full list of possible settings. The Aux VT Connection parameter is found on the System Parameters/Sensing Transformers settings screen in BESTCOMSP<sup>Plus</sup>. For more information on the auxiliary VT setup, see the *Configuration* chapter.

**Table 11-1. 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
Any	V1, V2, and 3V0	VPN

## Timings

The timing mode can be set for definite or inverse.

### Inverse

When inverse timing is selected, a Curve setting is provided to select programmable or table curves. The user can select integrating reset timing to make the protective element use integrated reset and emulate an electromechanical induction disk reset characteristic. The overvoltage inverse time curve with default constants is shown in the *Time Curve Characteristics* chapter.

### Programmable Curves

The programmable curve can be used to create a custom curve by selecting constants in the inverse time characteristic equation. When curve P is selected, the constants used in the equation are those defined by the user. Characteristics for trip and reset programmable curves are defined by Equation 11-1 and Equation 11-2. Definitions for these equations are provided in Table 11-2.

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

**Equation 11-1. Time Characteristics for Trip**

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

**Equation 11-2. Time Characteristics for Reset**

**Table 11-2. Definitions for Equation 11-1 and Equation 11-2**

Parameter	Description	Explanation
T <sub>T</sub>	Time to trip	Time that the 59X-x function will take to time out and trip.
D	Time dial setting	Time dial setting for the 59X-x function.
M	Multiple of pickup	Measured current in multiples of pickup. The timing algorithm has a dynamic range of 1 to 3 times pickup.
A	Constant specific to selected curve	Affects the effective range of the time dial.
B	Constant specific to selected curve	Affects a constant term in the timing equation. Has greatest effect on curve shape at high multiples of tap.
C	Constant 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
$T_R$	Time to reset	Relevant if 59X-x function is set for integrating reset.
R	Constant specific to selected curve	Affects the speed of reset when integrating reset is selected.

Curve constants are entered on the Overvoltage (59X) settings screen in *BESTCOMSPPlus*. Programmable curve constants can be entered only when the P curve is chosen for the protection element from the Curve drop-down menu.

### Table Curves

*BESTCOMSPPlus* is used to set the 27P element Table Curves (T1, T2, T3, and T4). Using the Settings Explorer within *BESTCOMSPPlus*, open the Protection, Voltage, Overvoltage, Table Curves, Table Curve (1, 2, 3, or 4) tree branch and select the table curve to be modified. Refer to Figure 11-1. 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 59X-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.

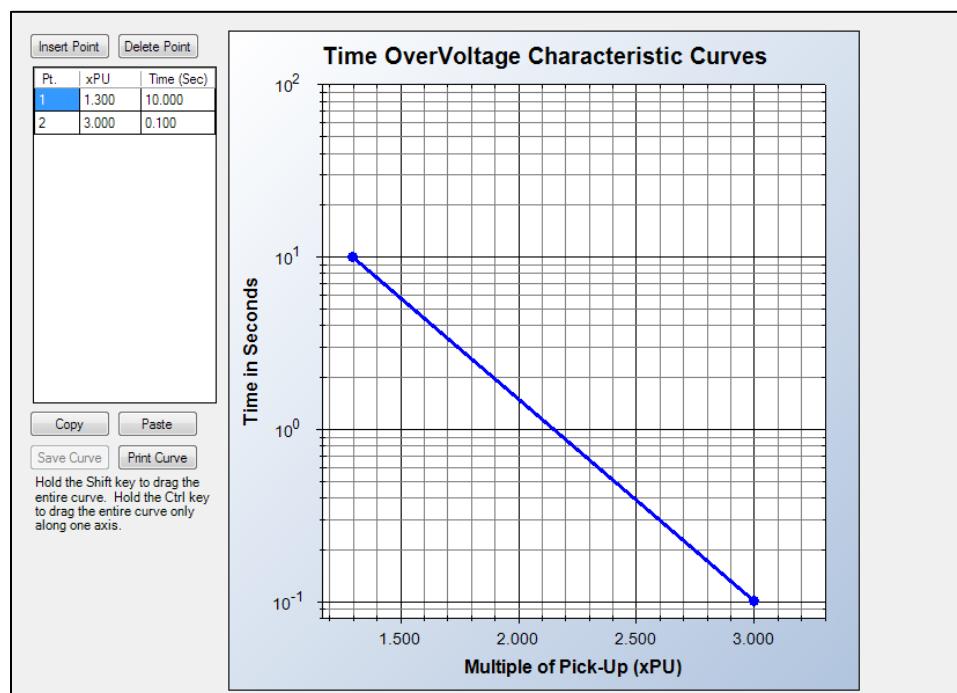


Figure 11-1. Time Overvoltage Characteristic Curves

## Pickup and Trip

The Pickup output occurs first, followed by the Trip output.

### Pickup

The Pickup output becomes true when the measured voltage increases above the voltage threshold established by the Pickup setting. In *BESTlogicPlus*, the Pickup output can be connected to other logic elements to annunciate the condition, control other elements in logic, and start the fault recorder (logic element FAULTTRIG).

Assertion of the Pickup output initiates a timer that begins timing to a trip. 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 the pickup condition subsides before the element 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.

### Trip

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

## Element Blocking

### Fuse Loss

The fuse loss (60FL) element of the BE1-11 $\iota$  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.

Protective elements blocked by 60FL should be set so that trip times are 60 milliseconds or greater to assure proper coordination of blocking.

### Block Logic Input

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in *BESTlogicPlus*. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## Logic Connections

Auxiliary overvoltage element logic connections are made on the *BESTlogicPlus* screen in *BESTCOMSPlus*. The auxiliary overvoltage element logic block is illustrated in Figure 11-2. Logic inputs and outputs are summarized in Table 11-3.

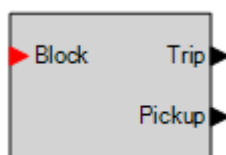


Figure 11-2. Auxiliary Overvoltage Element Logic Block

Table 11-3. 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 11-3) in *BESTCOMSPlus*.

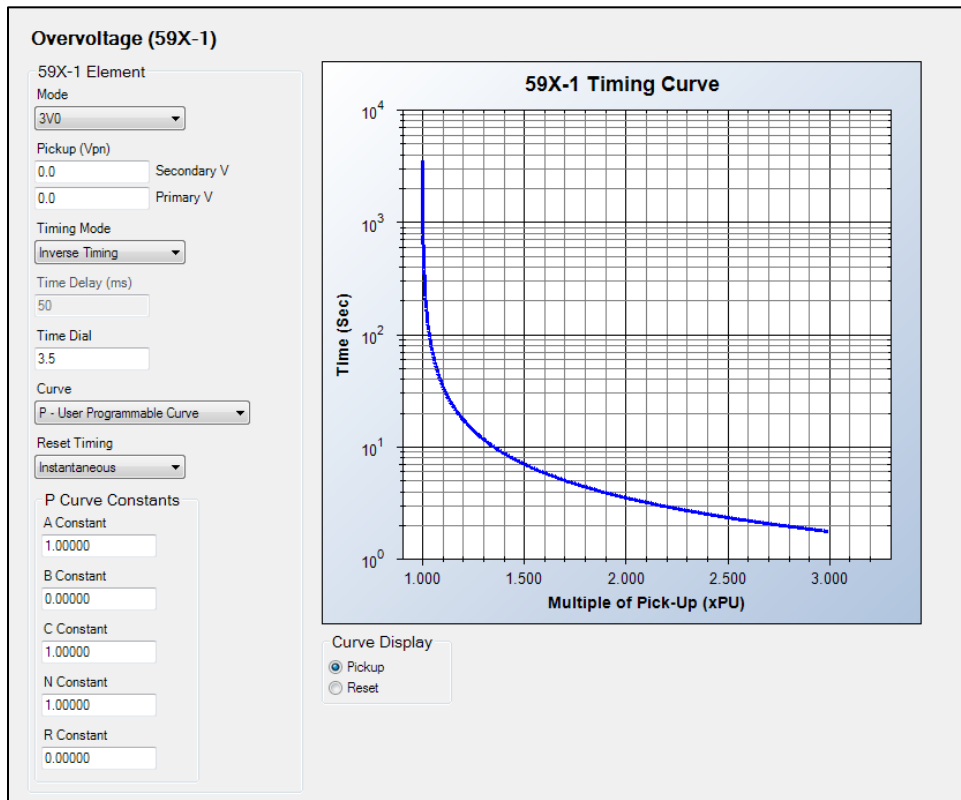
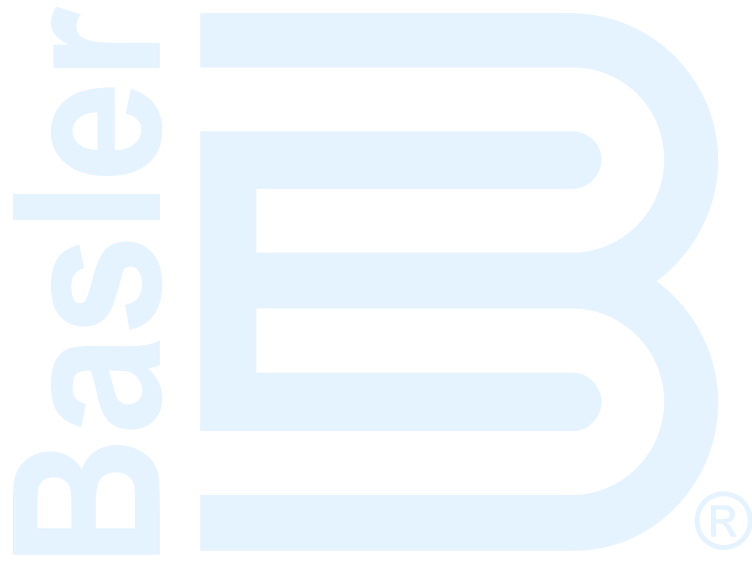


Figure 11-3. Auxiliary Overvoltage Settings Screen

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



## 12 • Frequency (81) Protection

Eight frequency (81) elements monitor the frequency of the sensing voltage applied to the BE1-11 $t$ . 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 $t$  protection systems enabled for IEC-61850 communication (style Txxxx5xxxxxxx) 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 $t$  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 $t$  auxiliary voltage (V $x$ ) sensing input. Refer to the *Typical Connections* chapter for information on voltage connections.

To measure frequency, the voltage sensed by the BE1-11 $t$  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 $t$  phase VT input or auxiliary VT (V $x$ ) 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 V $x$  input.

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

## Pickup and Trip

The Pickup output occurs first, followed by the Trip output.

### Pickup

The Pickup output becomes true 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. In *BESTlogicPlus*, the Pickup output can be connected to other logic elements to annunciate the condition, control other elements in logic, and start the fault recorder (logic element FAULTTRIG).

Assertion of the Pickup output initiates a timer that begins timing to 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 the pickup condition subsides before the element 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.

### Trip

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

## 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 *BESTCOMSPPlus* 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 V<sub>pn</sub>. For three-wire or phase-to-phase sensing connections the inhibit level is expressed in V<sub>pp</sub>.

## Element Blocking

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in *BESTlogicPlus*. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## ***Frequency Rate-of-Change Protection***

When a source of distributed generation 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 $t$  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 *BESTlogicPlus*, 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 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 *BESTlogicPlus*, 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 $t$  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 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

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 *BESTlogicPlus*.

## Logic Connections

Frequency element logic connections are made on the BESTlogicPlus screen in BESTCOMSPlus. The frequency element logic block is illustrated in Figure 12-1. Logic inputs and outputs are summarized in Table 12-1.

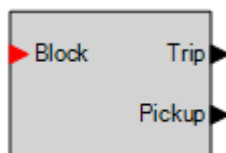


Figure 12-1. Frequency Element Logic Block

Table 12-1. 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 12-2) in BESTCOMSPlus.

Figure 12-2. Frequency Settings Screen

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.

## 13 • Negative-Sequence Overcurrent (46) Protection

Negative-sequence overcurrent protection is included as a mode of the 50 (Instantaneous Overcurrent) and the 51 (Inverse Overcurrent) elements. Refer to the chapters on *Instantaneous Overcurrent (50) Protection* and *Inverse Overcurrent (51) Protection* for information on how to set up and program the I2 (negative-sequence overcurrent) mode 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 (3I0) 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 (I2) current component.

### 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 13-1.

The phase-to-phase fault is made up of both positive and negative-sequence components as shown in Figure 13-2 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.

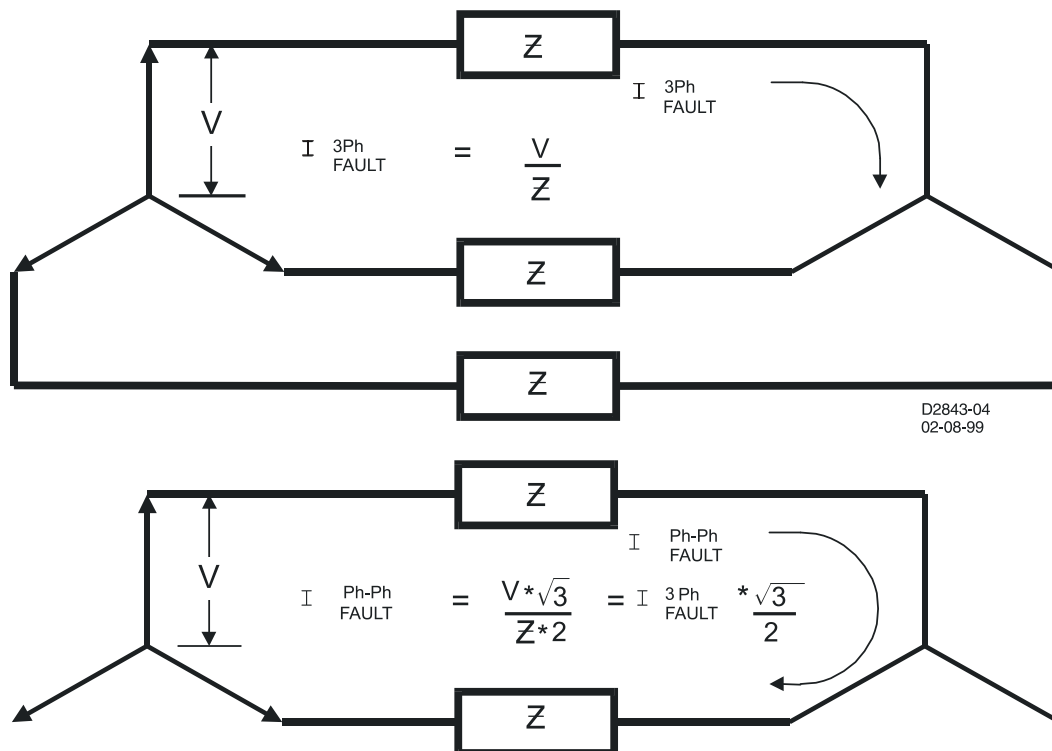


Figure 13-1. Phase-to-Phase Fault Magnitude

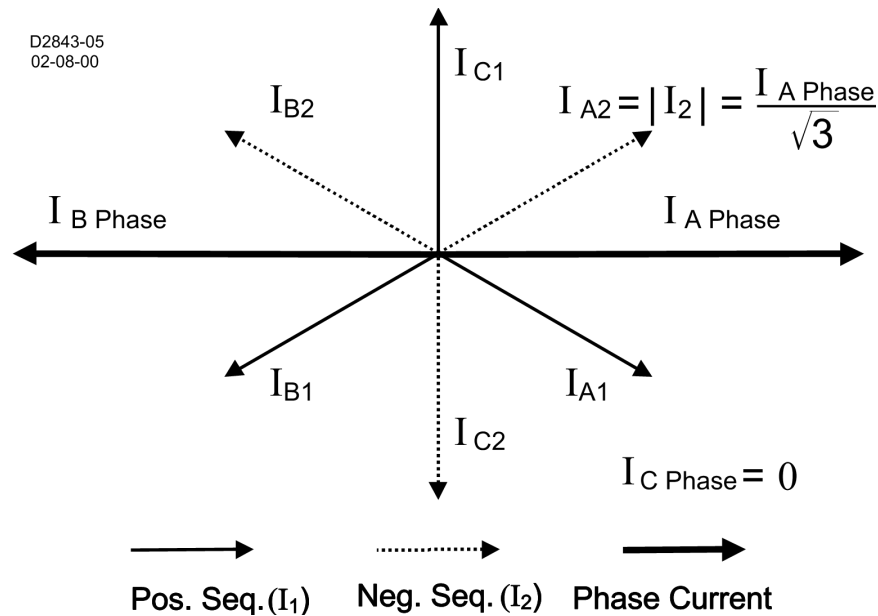


Figure 13-2. Sequence Components for an A-B Fault

## 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 13-1).

Table 13-1. Fault Type Multipliers

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

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

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

# 14 • Instantaneous Overcurrent (50) Protection

Nine instantaneous overcurrent (50) elements monitor the current applied to the BE1-11 $t$ . 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 nine, identical instantaneous overcurrent protection elements are designated 50-1, 50-2, 50-3, 50-4, 50-5, 50-6, 50-7, 50-8, and 50-9. 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 appears 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***

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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, one for each phase. Mode selection determines which phase pickup is required to activate protection.

#### *Three-Phase Mode*

The instantaneous overcurrent protection elements include three independent comparators, one for each phase. Protection is activated when any of the three phases increases 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. Refer to the *Negative-Sequence Overcurrent (46) Protection* chapter for more information.

#### *IG Mode*

IG mode provides measured ground fault protection from the Ground connection of a circuit.

#### *Unbalance Mode*

Unbalance mode provides unbalanced current 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. The unbalance is blocked if the average current of all three phases is below 25% of rated amps.

## CT Source

The CT Source setting configures an instantaneous overcurrent element to monitor CT circuit 1 or CT circuit 2. 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.

## Calculation Type

Two calculation methods are used to detect the pickup value, fundamental and peak detect. When set to Fundamental, the magnitude of current is calculated by using the first harmonic of current from the Discrete Fourier Transform (DFT). When set to Peak Detect, the magnitude of current is calculated by determining the fundamental equivalent of the highest sample value.

## Direction

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

### Directional Source

The Directional Source setting selects the directional element (67-1 or 67-2) to be used when making directional decisions. The CT source of the directional source selection (67-1 or 67-2) should match the CT source selection of the instantaneous overcurrent (50) element.

## Pickup and Trip

The Pickup output occurs first, followed by the Trip output.

### Pickup

The Pickup output becomes true when the measured current increases above the current threshold established by the Pickup setting. In *BESTlogicPlus*, the Pickup output can be connected to other logic elements to annunciate the condition, control other elements in logic, and start the fault recorder (logic element FAULTTRIG).

Assertion of the Pickup output initiates a timer that begins timing to 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 the pickup condition subsides before the element delay expires, the Pickup output is reset and a reset timer is initiated. The duration of the reset timer is established by the Reset Delay setting. A Reset Delay of zero (0) makes the reset instantaneous with no intentional reset delay. If there is no pickup for the duration of the element Reset Delay setting, the timer is reset to zero (0), no corrective action is taken, and the element is rearmed for any other occurrences of overcurrent. If the 50 element picks up again before the Reset Delay expires, the timer will continue timing to a trip.

### Trip

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

## Element Blocking

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in *BESTlogicPlus*. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## Logic Connections

Instantaneous overcurrent element logic connections are made on the BESTlogicPlus screen in BESTCOMSPPlus. The instantaneous overcurrent element logic block is illustrated in Figure 14-1. Logic inputs and outputs are summarized in Table 14-1.

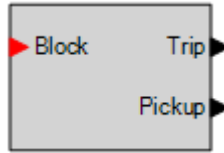


Figure 14-1. Instantaneous Overcurrent Element Logic Block

Table 14-1. 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 14-2) in BESTCOMSPPlus.

Figure 14-2. Instantaneous Overcurrent Settings Screen



# 15 • Breaker Failure (50BF) Protection

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

Element logic connections are made on the BESTlogic™ *Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Breaker Fail (50BF) settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appears 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 uses two methods to determine when the breaker has failed to open. The first method uses the breaker status (52a or 52b input) to determine if the breaker has successfully opened. The second method uses the monitored current to detect if the breaker has successfully opened.

In the first method, the breaker is closed when the Breaker Status (BRKSTAT) logic element is true. The 52BFI logic input is used to signal the breaker to open. When the BRKSTAT logic element and the 52BFI logic input are true, a delay timer is initiated to allow time for the breaker to transition. If the time delay expires and the BRKSTAT logic element and the 52BFI logic input are still true, the Trip output becomes true, signaling that the breaker has failed to trip.

In the second method, monitored current is used to determine if the breaker is closed. The 50BFI logic input of the Breaker Failure logic block is used to signal the breaker to open. When current is present and the 50BFI logic input is true, a timer is initiated to allow time for the fault to clear. If the time delay expires and current is still present, the Trip output becomes true, signaling that the breaker has failed to open. A control timer specifies the duration the breaker can remain closed before a Breaker Fail alarm will occur.

In both methods above, a Breaker Fail Retrip (BFRT) will be true while the delay timer is true. A breaker fail trip indicates a failed breaker. The Trip signal can be used 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 to the Breaker Failure logic element. There are two possible initiating signals. The 52 Breaker Fail Initiate (52BFI) signal is the initiation signal when breaker status is used to determine a breaker failure. The 50 Breaker Fail Initiate (50BFI) is the initiation signal when current is used to determine a breaker failure. These initiate inputs can be driven by other relays through BE1-11*t* contact inputs or GOOSE over IEC 61850. Alternately, they can come from trip signals from other protective elements within the BE1-11*t*. Breaker status input is provided by the BRKSTAT logic element.

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 Trip output when the 50BFI logic input is used to signal the breaker to open. 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.

## ReTrip and Trip

The adjustable delay timer allows time for current to clear or the breaker status to transition after signaling the breaker to trip. 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.

### ReTrip

The ReTrip output is true when the delay timer is actively timing. The delay timer can be stopped by several methods depending on the timer initiate source. When initiated by a 50BFI signal, the timer is stopped when current decreases below the pickup setting, when the fast current dropout detector detects that current has dropped out, or when the control timer expires. When initiated by a 52BFI signal, the timer is stopped when the BRKSTAT logic element indicates that the breaker is open. Regardless of initiate method, asserting the Block logic input also stops the timer. In *BESTlogicPlus*, the ReTrip output can be connected to other logic elements to annunciate the condition, control other elements in logic, and start the fault recorder (logic element FAULTTRIG).

### Trip

The Trip output becomes true when the delay timer expires. In *BESTlogicPlus*, the Trip output can be connected to other logic elements and to a physical relay output to annunciate the condition and to initiate corrective action. If a target is enabled for the element, the BE1-11 $\iota$  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. 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 *BESTCOMSPlus*. Refer to the *Alarms* chapter for information on how to program alarms.

## Element Blocking

The Block input provides logic-supervision control of the element. Element blocking is a useful feature to prevent inadvertent backup tripping during testing.

When true, the Block input disables the element by forcing the Trip and ReTrip outputs to logic 0 and resetting the element timers. Connect the element Block input to the desired logic in *BESTlogicPlus*. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## Logic Connections

Breaker failure element logic connections are made on the BESTlogicPlus screen in BESTCOMSPPlus. The breaker failure element logic block is illustrated in Figure 15-1. Logic inputs and outputs are summarized in Table 15-1.

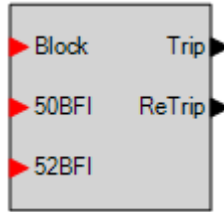


Figure 15-1. Breaker Failure Element Logic Block

Table 15-1. 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 after the 50BF Delay Timer expires
ReTrip	Output	True when the 50BF Delay Timer is actively timing

## Operational Settings

Breaker failure element operational settings are configured on the Breaker Fail (50BF) settings screen (Figure 15-2) in BESTCOMSPPlus.

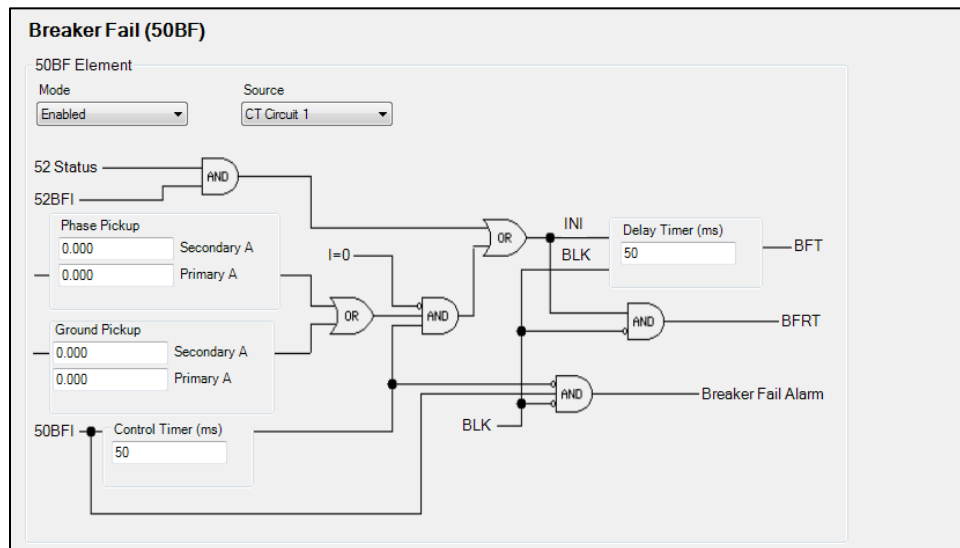


Figure 15-2. Breaker Fail Settings Screen



# 16 • Inverse Overcurrent (51) Protection

Nine inverse overcurrent (51) elements monitor the current applied to the BE1-11 $t$ . 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 nine, identical inverse overcurrent protection elements are designated 51-1, 51-2, 51-3, 51-4, 51-5, 51-6, 51-7, 51-8, and 51-9. 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 appears at the end of this chapter.

**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***

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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*

The inverse overcurrent protection elements include three independent comparators, one for each phase. Protection is activated when any of the three phases increases 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. Refer to the *Negative-Sequence Overcurrent (46) Protection* chapter for more information.

#### *IG Mode*

IG mode provides measured ground fault protection from the Ground connection of a circuit.

#### *Unbalance Mode*

Unbalance mode provides unbalanced current 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. The unbalance is blocked if the average current of all three phases is below 25% of rated amps.

## CT Source

The CT Source setting configures an inverse overcurrent element to monitor CT circuit 1 or CT circuit 2. 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 (67) Protection* chapter for more information.

### Directional Source

The Directional Source setting selects the directional element (67-1 or 67-2) to be used when making directional decisions. The CT source of the directional source selection (67-1 or 67-2) should match the CT source selection of the inverse overcurrent (51) element.

## Timings

Each inverse overcurrent element has a Curve setting. The following paragraphs describe the available timing curves. The user can select integrating reset timing to make the protective element use integrated reset and emulate an electromechanical induction disk reset characteristic.

### Standard Curves

There are 22 standard curves available including standard inverse, short inverse, moderately inverse, long inverse, very inverse, and extremely inverse. Refer to the *Time Curve Characteristics* chapter for specific information on each curve.

### Programmable Curves

An available programmable curve can be used to create a custom curve by selecting coefficients in the inverse time characteristic equation. When inverse time overcurrent characteristic curve P is selected, the coefficients used in the equation are those defined by the user. Inverse overcurrent characteristics for trip and reset programmable curves are defined by Equation 16-1 and Equation 16-2. These equations comply with IEEE Std C37.112-1996 - *IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays*. Definitions for these equations are provided in Table 16-1. The curve-specific coefficients are defined for the standard curves as listed in the *Time Curve Characteristics* chapter.

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

Equation 16-1. Time OC Characteristics for Trip

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

Equation 16-2. Time OC Characteristics for Reset

Table 16-1. Definitions for Equation 16-1 and Equation 16-2

Parameter	Description	Explanation
T <sub>T</sub>	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 1 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.

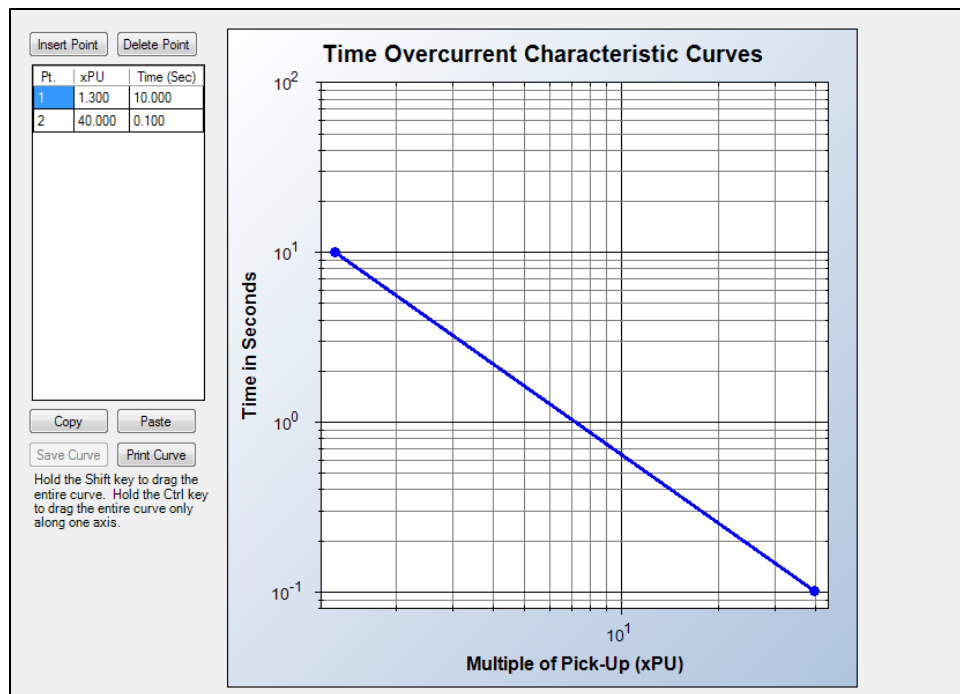
Parameter	Description	Explanation
N	Exponent specific to selected curve	Affects how inverse the characteristics are. Has greatest effect on curve shape at low to medium multiples of tap.
K	Constant	Characteristic minimum delay term.
T <sub>R</sub>	Time to reset	Relevant if 51-x function is set for integrating 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 *BESTCOMSPPlus*. 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

*BESTCOMSPPlus* is used to set the 51 element Table Curves (T1, T2, T3, and T4). Using the Settings Explorer within *BESTCOMSPPlus*, open the Protection, Current, Table Curve (1, 2, 3, or 4) tree branch and select the table curve to be modified. Refer to Figure 16-1. 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 16-1. Inverse Overcurrent Table Curve**

### 46 Curve

The 46 curve is a special curve designed to emulate the  $I_2^2t$  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 BE1-11 $t$  setting for nominal current.

## Pickup and Trip

The Pickup output occurs first, followed by the Trip output.

### Pickup

The Pickup output becomes true when the measured current increases above the current threshold established by the Pickup setting. In *BESTlogicPlus*, the Pickup output can be connected to other logic elements to annunciate the condition, control other elements in logic, or start the fault recorder (logic element FAULTTRIG).

Assertion of the Pickup output initiates a timer that begins timing to 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 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.

### Trip

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

## 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.

### Note

BE1-11 $t$  protection systems enabled for IEC-61850 communication (style Txxxx5xxxxxxx) do not allow voltage controlled or restrained overcurrent elements. Blocking a 51 with an Undervoltage (27) element may allow control pending application requirements.

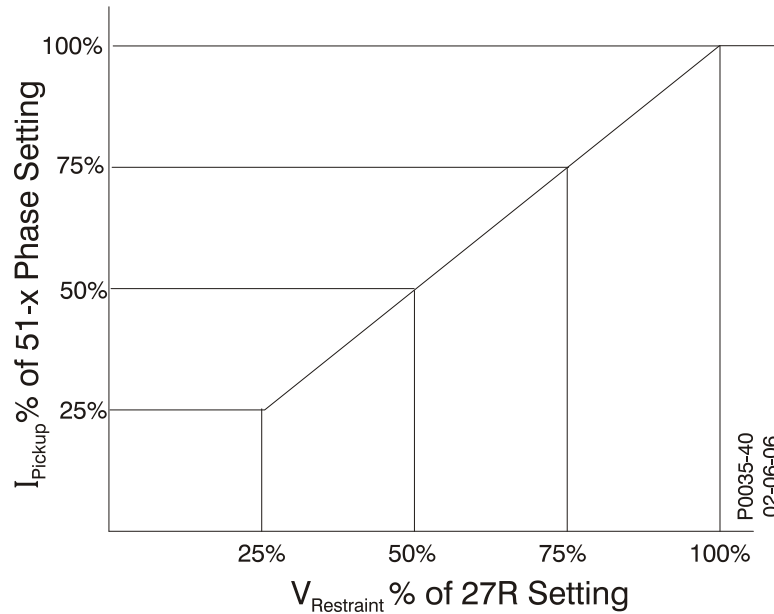
### Control Mode

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 16-2 shows how the 51 Pickup setting is adjusted in response to the measured voltage level. Equation 16-3 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 16-2. 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 16-3. Restraint Pickup Level**

#### Phase VT Configuration

The 51/27R function can be set to monitor either V<sub>pp</sub> or V<sub>pn</sub> depending upon the Phase VT Connection settings. See the *Configuration* chapter for details on how to set the phase VT connections. Table 16-2 shows which voltage measurements are used by each 51 element for each possible phase VT connection and 51/27 voltage monitoring mode setting.

**Table 16-2. Phase VT Connection Cross Reference**

Phase VT Connection	51/27 Mode	51A	51B	51C
4W	V <sub>pp</sub>	V <sub>ab</sub>	V <sub>bc</sub>	V <sub>ca</sub>
4W	V <sub>pn</sub>	V <sub>an</sub>	V <sub>bn</sub>	V <sub>cn</sub>
3W	V <sub>pp</sub>	V <sub>ab</sub>	V <sub>bc</sub>	V <sub>ca</sub>
AN	V <sub>pn</sub>	V <sub>an</sub>	V <sub>bn</sub> *	V <sub>cn</sub> *
BN	V <sub>pn</sub>	V <sub>an</sub> *	V <sub>bn</sub>	V <sub>cn</sub> *
CN	V <sub>pn</sub>	V <sub>an</sub> *	V <sub>bn</sub> *	V <sub>cn</sub>
AB	V <sub>pp</sub>	V <sub>ab</sub>	V <sub>bc</sub> *	V <sub>ca</sub> *
BC	V <sub>pp</sub>	V <sub>ab</sub> *	V <sub>bc</sub>	V <sub>ca</sub> *
CA	V <sub>pp</sub>	V <sub>ab</sub> *	V <sub>bc</sub> *	V <sub>ca</sub>

\* Calculated value. See the *Configuration* chapter for more information.

## 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 misoperation 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.

Protective elements blocked by 60FL should be set so that trip times are 60 milliseconds or greater to assure proper coordination of blocking.

### Block Logic Input

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in *BESTlogicPlus*. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## Logic Connections

Inverse overcurrent element logic connections are made on the *BESTlogicPlus* screen in *BESTCOMSPlus*. The inverse overcurrent element logic block is illustrated in Figure 16-3. Logic inputs and outputs are summarized in Table 16-3.

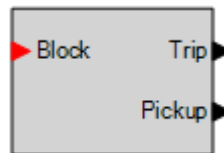


Figure 16-3. Inverse Overcurrent Element Logic Block

Table 16-3. 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 16-4) in BESTCOMSPlus.

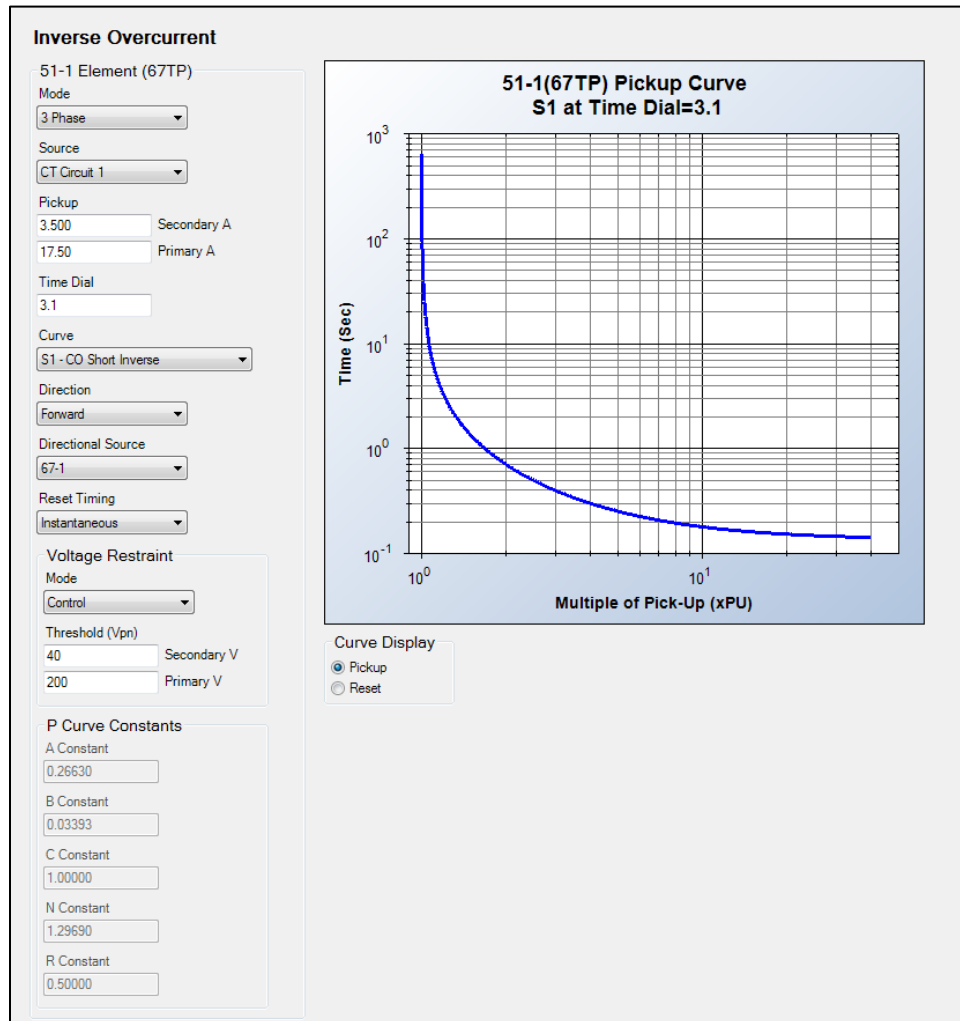


Figure 16-4. Inverse Overcurrent Settings Screen



# 17 • Directional Overcurrent (67) Protection

The 67 element provides directional supervision for the overcurrent tripping elements. Two reference quantities for each polarizing method are compared to establish directional signals for controlling operation of the phase, ground, and negative-sequence overcurrent elements. Directionality is derived from a comparison between internally calculated sequence voltages  $V_1$ ,  $V_2$ ,  $V_0$  (magnitude and angle) and calculated values of  $I_1$ ,  $I_2$ ,  $3I_0$ ,  $I_0$ , (magnitude and angle) and measured  $I_G$  (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 ( $I_1$ ,  $I_2$ ,  $3I_0/I_N$ ,  $I_0$ ,  $I_G$  operate) will change based on the direction of fault current flow.

The directional element can monitor CT circuit 1 or CT circuit 2. The CT source is selected on the Directional settings screen (Figure 17-1) in BESTCOMSPPlus®.

## Polarization Methods

The polarization methods are as follows:

- Positive-Sequence Polarization – Forward direction is detected is when the apparent  $Z_1$  angle (angle of  $V_1/I_1$ ) is equal to the positive-sequence maximum torque angle (MTA),  $\pm 90^\circ$ .
- 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),  $\pm 90^\circ$ . (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),  $\pm 90^\circ$ . (See Note 1.) However, the BE1-11t 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 protection system'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 ( $I_G$ ) is in phase with the calculated  $I_0$ ,  $\pm 90^\circ$ .

Each of the four internal polarization methods has designated internal bits that are used in the BE1-11t 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 BE1-11t 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 $t$  maintains memory voltage for 20 cycles to allow tripping for close in faults. When using memory voltage polarization, the BE1-11 $t$  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, or VXIG). The neutral overcurrent elements can be set to operate on either calculated  $I_0$  or independent ground input  $I_G$ . The four types of zero-sequence polarization methods were described above. Typical ac connections for external sources of  $V_0$  (a broken delta VT) are provided in 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 BE1-11 $t$ . 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 17-1) in BESTCOMSPi $us$ .

**BESTCOMSPi $us$  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

The screenshot shows the 'Directional (67-1)' settings screen. It includes a dropdown for '67-1 CT Selection' set to 'CT Circuit 1'. Under '67N-1 Polarization Method(s)', three checkboxes are checked: 'Zero Sequence Current Polarization (IG)', 'Negative Sequence Polarization (Q)', and 'Zero Sequence Voltage Polarization (V)'. The 'Modes' section contains four radio button options: 'Calculated Zero Sequence Volt compared to Calculated Zero Sequence Current (V0IN)' (selected), 'Calculated Zero Sequence Volt compared to Measured Ground Current (V0IG)', 'Measured 3V0-VX Input compared to Calculated Zero Sequence Current (VXIN)', and 'Measured 3V0-VX Input compared to Measured Ground Current (VXIG)'.

**Figure 17-1. Directional Settings Screen**

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 $t$  using BESTCOMSP $l$ us. 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  $\pm 90^\circ$  from the nominal line angle. A similar argument applies for the reverse direction with the current  $180^\circ$  out of phase from the voltage. The angle of  $Z_1$  is used during positive-sequence directional test and the angle of  $Z_2$  is used during negative-sequence directional test. Likewise, the angle of  $Z_0$  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 $t$  also uses several constant limits to determine if the system levels are adequate to perform reliable directional tests and set directional bits. See Table 17-1.

**Table 17-1. Internal Constants**

Internal Constant	Purpose	Value
Positive-Sequence Current	Minimum I1 current threshold for Positive-Sequence test	0.50 A for 5A CTs and 0.1 A for 1A CTs
Zero-Sequence Current	Minimum 3I0 current threshold for Current Polarization test	0.25 A for 5A CTs and 0.05 A for 1A CTs
Ground current (IG)	Minimum Ground (IG) current threshold for Current Polarization test	0.50 A for 5A CTs and 0.1 A for 1A CTs
Negative-Sequence Voltage	Minimum V2 voltage threshold for Negative-Sequence test	1.2% of V nominal
Zero-Sequence Voltage	Minimum V0 voltage threshold for Zero-Sequence test	0.75% 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 I1 and I2 for Negative-Sequence test	9%
Zero-Sequence Ratio	Minimum ratio between I1 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 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 BE1-11t uses the angle of maximum torque to prevent tripping for unusual load flow.

For directional decisions, a BE1-11t 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  $\pm 90$  degrees as forward (or reverse, depending on the BE1-11t setup). Suppose a radial single source condition exists relative to the BE1-11t 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 17-1. Note this equation is true independent of the fault type or the faulted phase.

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

**Equation 17-1. Local Substation Voltage**

The impedance seen by the BE1-11t is calculated in Equation 17-2:

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

**Equation 17-2. Impedance Seen by the BE1-11t**

If  $V_{0,Source}$  and  $V_{2,Source}$  are very small (Equation 17-3):

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

**Equation 17-3. Impedance with Small  $V_0$  and  $V_2$  Source Voltages**

The calculations in the BE1-11t account for the negative factor in the above equation and hence a  $180^\circ$  phase shift is implemented in the BE1-11t firmware so that a correct forward/reverse decision is made.

The positive-sequence impedance as seen by the BE1-11t 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 17-4):

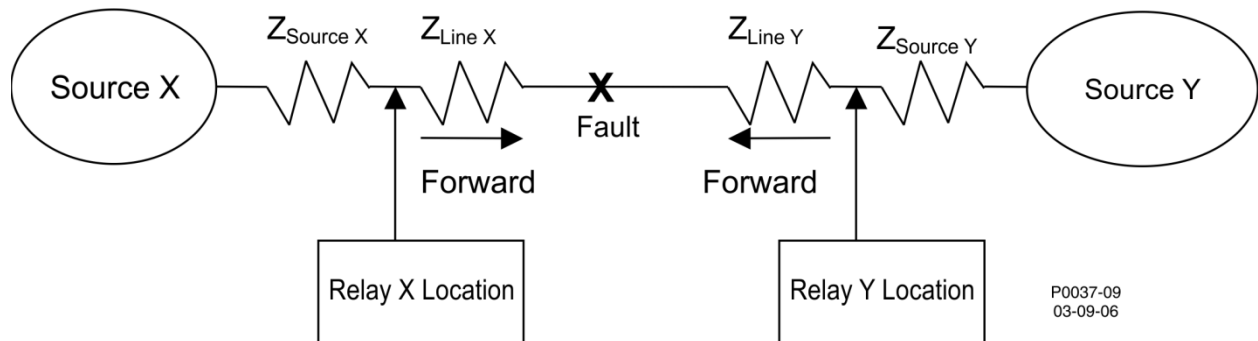
$$Z_{1,Relay,3phase} = \frac{V_{1,Source}}{\frac{V_{1,Source}}{Z_{1,Source} + Z_{1,Line}}} - Z_{1,Source} = Z_{1,Line}$$

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

**Equation 17-4. 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 17-2, a profile of sequence voltages in the system will show  $V_0$  and  $V_2$  at either source.  $V_0$  and  $V_2$  will still be negligible in normal operation, and show up only 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 BE1-11 $\tau$  will still be dependent on  $V_{Relay} = V_{Source} - Z_{Source} I_{Source}$ . The BE1-11 $\tau$  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 BE1-11 $\tau$  will sense the positive-sequence impedance in the line between the BE1-11 $\tau$  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  $\pm 90^\circ$  from the MTA is being utilized for directional decisions, the direction decision is not highly sensitive to zero-sequence coupling effects.

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>).



**Figure 17-2. Directional Overcurrent Relaying**



# 18 • Phase Current Differential (87) Protection

The phase-current differential (87) element monitors the differential current and provides primary protection for power transformers.

Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMSP*Plus*®, and element operational settings are configured on the Phase Current Differential (87) settings screen in BESTCOMSP*Plus*. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

**BESTCOMSP*Plus* Navigation Path:** Settings Explorer, Protection, Current, Phase Differential (87)

**HMI Navigation Path:** Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Current Protection, Differential 87

## ***Element Operation***

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The phase-current differential element compares the currents entering and leaving the protected transformer. If a fault is detected, the BE1-11*t* initiates a trip signal to isolate the power transformer. This action limits damage to the transformer and minimizes impact on the power system.

### **Functional Description**

Figure 18-1 shows a detailed functional diagram of one phase of the phase differential protection function. These functions and comparators are duplicated for each phase.

The measured currents are phase, zero-sequence, and tap compensated. The *Configuration* chapter describes the setup of the BE1-11*t* for phase and zero-sequence compensation. Setup of the tap adjustment compensation is described later in this chapter. The restraint current function uses the compensated current to calculate the restraint current magnitude (in multiples of tap). Depending on the setting, it calculates the maximum or average restraint current. The Operating Current function determines the magnitude of the fundamental, second, and fifth harmonic differential current as the phasor sum of those components of the compensated currents.

Figure 18-2 shows the characteristic of the phase current differential protection element. This comparator has two slope settings and a minimum pickup setting. The slope settings are the ratios of delta operating current to delta restraint current. The slope settings should be set above the maximum mismatch caused by excitation losses, tap mismatch, and load tap changers. The minimum pickup setting determines the minimum sensitivity of the restrained element.

### **Pickup and Trip**

The Pickup output occurs first, followed by the Trip output.

#### ***Pickup***

The Pickup output becomes true when the ratio of operating current to restraint current increases above the slope setting. The operate current is above the Minimum Restrained Pickup setting for any of the three phases. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition, control other elements in logic, and start the fault recorder (logic element FAULTTRIG).

Assertion of the Pickup output initiates a timer that begins timing to a trip. The duration of the timer is established by the Time Delay setting.

If the pickup condition subsides before the element delay expires, the timer and Restrained Pickup output are reset, no corrective action is taken, and the element is rearmed for any other fault conditions.

### Trip

The Trip output becomes true when a restrained pickup condition persists for the duration of the element Time Delay setting. In *BESTlogicPlus*, the Trip output can be connected to other logic elements and to a physical relay output to announce the condition and to initiate corrective action. If the target is enabled for the element, the BE1-11 $t$  will record a target when either the Trip or Unrestrained Trip outputs become true. See the *Fault Reporting* chapter for more information about target reporting.

### **Transient Monitor**

A transient monitor detects the effects of CT saturation during a through fault. The 87 element monitors the change in restraint current versus the change in operate current. For an internal fault, the restraint current and operate current will experience a step increase at the same time. For an external fault, there should be no operate current. If CT saturation occurs during a through fault, the operate current will increase at some time after the restraint current increases. In this case, a two-cycle delay is added to the restrained differential output to enhance security.

### **Harmonics**

The second and fifth harmonic functions check the ratio of the second and fifth harmonic operate currents to the fundamental operate current. Traditional harmonic restraint units operate on the ratio of harmonic current to total operate current versus the ratio to only the fundamental operate current used by the BE1-11 $t$ . For this reason, the BE1-11 $t$  will provide greater security for inrush and overexcitation with the same harmonic inhibit ratio settings used with traditional differential relays. When either of these two comparators is above the threshold, the percentage-restrained output is blocked from setting the Restrained Trip logic output. If the second or fifth harmonic inhibit comparators are picked up for any of the three phases, the Second Harmonic Inhibit and Fifth Harmonic Inhibit logic outputs respectively are also set.

In many cases, the second harmonic content of the inrush current may show up primarily in only one or two phases, which can cause one or two phases to not be inhibited. The BE1-11 $t$  allows the second harmonic currents to be shared between the three phases. When second harmonic sharing is enabled, the magnitude of the second harmonic operating current is summed from all three phases and this magnitude is used by the second harmonic comparator for each phase instead of the second harmonic operate current for only that phase. This is superior to other methods of cross blocking since each phase element operates independently in its comparison of operating current to harmonic current. Thus, security is enhanced without sacrificing dependability because a faulted phase will not be restrained by inrush on unfaulted phases as is the case with cross blocking schemes.

### **Unrestrained Tripping**

The 87 element provides high-speed tripping for high-grade faults inside the zone of protection. If the operate current is above the Unrestrained Tripping threshold for any of the three phases, the Unrestrained Trip logic output becomes true. The transient monitor function also enhances security for this function by doubling the pickup threshold when CT saturation is detected. The minimum setting for the Unrestrained Tripping threshold should be the maximum inrush current with a small margin.

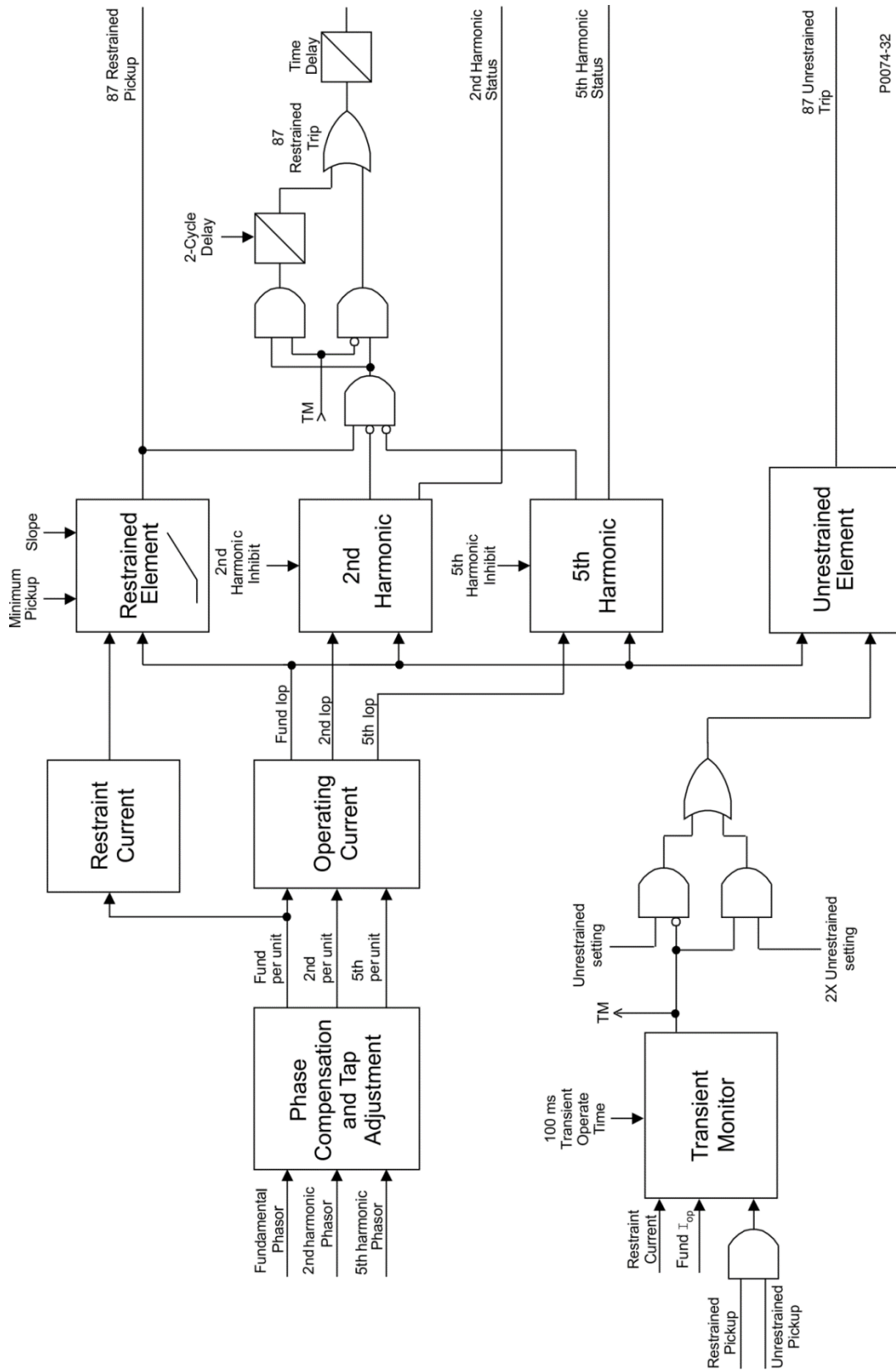
### **Programmable Alarm**

An 87 Alarm condition is indicated when the percentage restrained differential protection is nearing a trip condition on load. This alarm triggers a diagnostic routine that attempts to determine the source of the mismatch that is causing the differential unbalance.

The alarm appears on the front-panel display, web page interface, and on the Alarms metering screen in *BESTCOMSPPlus*. Refer to the *Alarms* chapter for information on how to program alarms.

### **Element Blocking**

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in *BESTlogicPlus*. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.



P0074-32

Figure 18-1. 87 Phase Differential Protection Functional Block Diagram

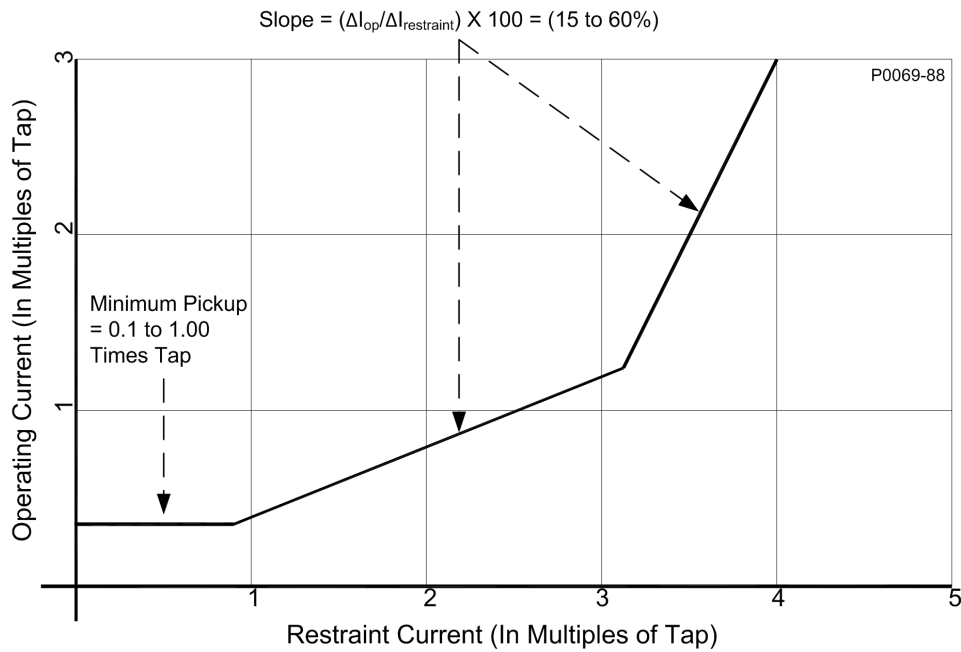


Figure 18-2. Percentage Restrained Differential Characteristic

### Logic Connections

Phase current differential element logic connections are made on the BESTlogicPlus screen in BESTCOMSPlus. The phase current differential element logic block is illustrated in Figure 18-3. Logic inputs and outputs are summarized in Table 18-1.

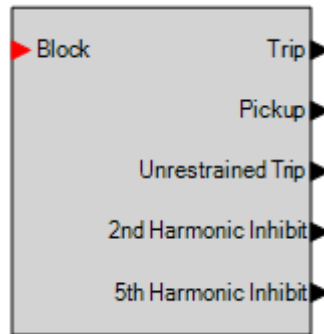


Figure 18-3. Phase Current Differential Element Logic Block

Table 18-1. Logic Inputs and Outputs

Name	Function	Purpose
Block	Input	Disables the 87 function when true
Trip	Output	True when the 87 element is in a trip condition
Pickup	Output	True when the 87 element is in a pickup condition
Unrestrained Trip	Output	True when the 87 element is in an unrestrained trip condition
2 <sup>nd</sup> Harmonic Inhibit	Output	True when the 87 is inhibited by 2 <sup>nd</sup> harmonic ratio
5 <sup>th</sup> Harmonic Inhibit	Output	True when the 87 is inhibited by 5 <sup>th</sup> harmonic ratio

## Settings

### Tap Compensation Settings

The measured currents must be tap adjusted to eliminate magnitude mismatch prior to being used by the Current Differential Protection (87) element. The tap adjust factors can be manually calculated per Equation 18-1. Or, the user can enter the MVA and kV base parameters (Table 18-2) and the BE1-11t will calculate the tap-adjust factors using CT Ratio (CTR) and Compensation Factor (COMP) parameters from the current measurement input function settings. For a transformer application, the mismatch will be at a minimum if the actual transformer voltage ratings are used, taking the no-load tap changer into consideration. If the transformer has a load tap changer, the voltage rating at the middle of the adjustment range should be used. This is generally at neutral.

$$TAPn = \frac{MVA \times 1000 \times COMPn}{\sqrt{3} \times kVn \times CTRn}$$

**Equation 18-1. Calculate Tap Adjust Factors**

**Table 18-2. MVA and kVn Base Parameters**

Parameter	Description	Explanation
Tapn	Restraint winding	The BE1-11t has 2 restraint windings (2 taps).
MVA	MVA base	Full load MVA or top rating of the protected equipment.
kVn	kV base for CT input n	L-L Voltage in kV for each CT input circuit.
CTRn	CT ratio for CT input n	Actual ratio not effective ratio.
COMPn	Phase compensation adjustment factor for CT input n	$\sqrt{3}$ if CTs are connected in Delta (CTcon = DAB or DAC). 1 in all other cases. See the <i>Configuration</i> chapter.

The input currents can be tap adjusted up to a spread ratio of 10:1. If the ratio between TAP1 and TAP2 is greater than ten, it will be necessary to adjust the CT ratios to bring the tap factors closer together. When the auto-tap calculation feature is used, the BE1-11t will give an error message if the spread ratio is greater than ten.

If one of the calculated taps is outside the acceptable range (2 to 20 for 5 ampere units or 0.4 to 4 for 1 ampere units), the auto-tap calculation feature will select the nearest acceptable tap and calculate the other tap (two at a time) so that the correct spread ratio is maintained. If the user is manually calculating the taps, the same adjustment should be made.

BESTCOMSP<sub>Plus</sub> is used to provide auto tap calculation by filling in the appropriate fields on the Transformer Setup screen and pressing the calculate button or manual tap values can be entered.

### Operational Settings

The settings for restrained minimum pickup and unrestrained trip are set in multiples of tap. If the ideal taps calculated by Equation 18-1 fell within the acceptable range, the sensitivity settings will be in Per Unit on the MVA Base used in the equation. For example, a 100 MVA, 115 kV transformer has a full load (1 per unit) current of 500 amperes. A pickup setting of 10 times tap for the unrestrained output pickup (URO) element is equivalent to 5,000 primary amperes of differential current.

If the taps had to be adjusted upwards or downwards to fit within the acceptable range, the sensitivity settings for these protective elements should be adjusted as well. Equation 18-2 gives the adjustment factor. The definitions for the variables in Equation 18-2 are the same as those for Equation 18-1. For example, the ideal taps (TAP<sub>n</sub>) were calculated using Equation 18-2 and Equation 18-3 to be 1.6 and 5.0. They had to be adjusted upwards so that the actual taps (TAP<sub>nA</sub>) are 2.0 and 6.25. Per Equation 18-2,

$X = 0.8$ . It is desired that the minimum pickup of the restrained element be 0.35 per unit on the circuit base. The actual setting should be  $0.35 * 0.8 = 0.28$  to achieve the same sensitivity.

The pickup settings in Times Tap can be related to primary amps by Equation 18-3. Minpu is the minimum pickup setting in Times Tap. The definitions for the remaining variables in Equation 18-3 are the same as those for Equation 18-1.

$$X = \frac{TAPn_l}{TAPn_A} = \frac{MVA \times 1000 \times COMPn}{TAPn_A \times \sqrt{3} \times KVn \times CTRn}$$

Equation 18-2. Tap Adjustment Equation

$$I_{pri} = \frac{Minpu \times TAPn \times CTRn}{COMPn}$$

Equation 18-3. Calculate Primary Amps

**% of Maximum** - The maximum of the compensated input currents is used. For example, the restraint current for phase A would be  $I_{RA} = \max(I_{AxCOMP})$  where  $x = 2$  for two current inputs.

**% of Average** - The average of the compensated input currents is used. For example, the restraint current for phase A would be given by Equation 18-4.

$$I_{RA} = \frac{\text{Sum of } I_{AxCOMP}}{\text{Number of Inputs}}$$

Equation 18-4. Calculate Restraint Current for Phase A, % of Average

Phase current differential element operational settings are configured on the Phase Current Differential (87) settings screen (Figure 18-4) in BESTCOMSP<sup>Plus</sup>. A legend for the chart (Figure 18-5) is shown by clicking the Help button on this screen.

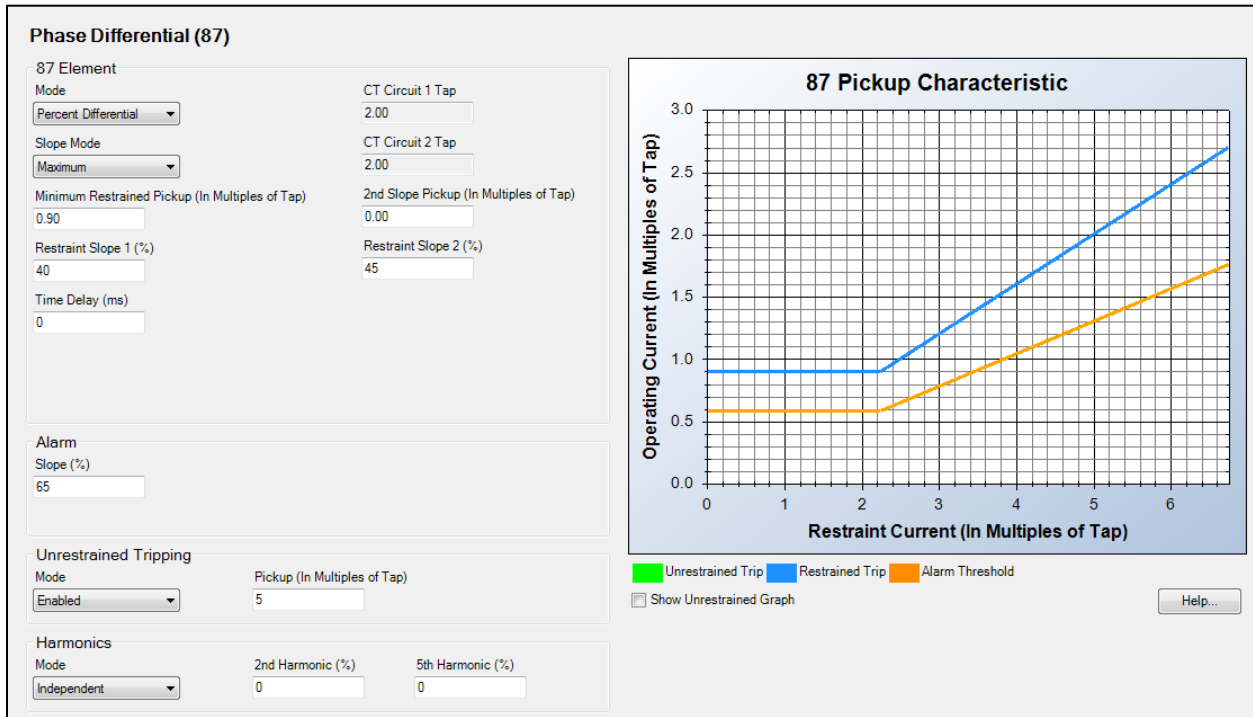


Figure 18-4. Phase Current Differential Settings Screen

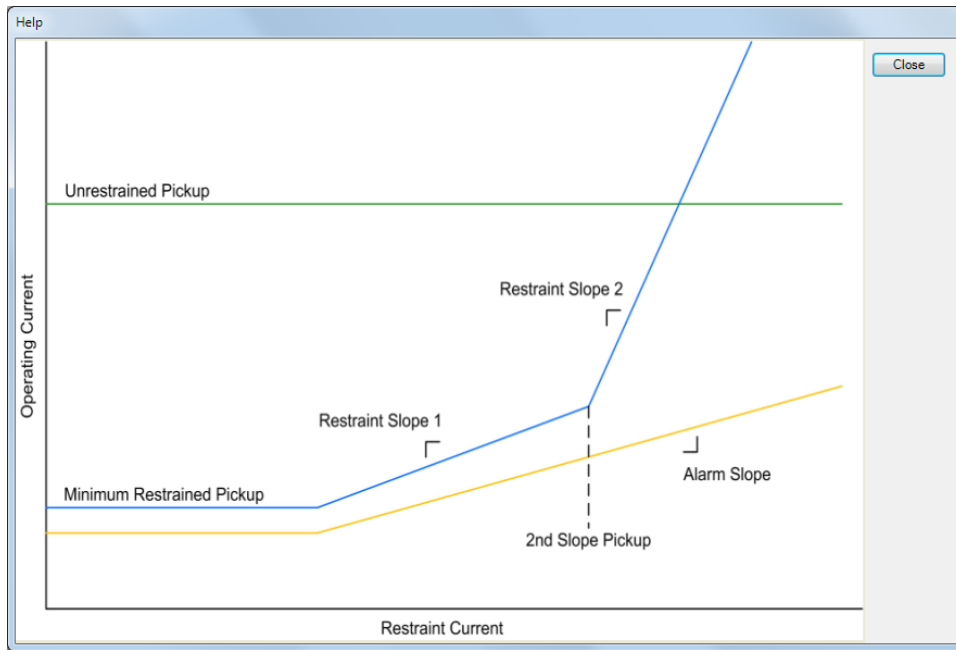


Figure 18-5. Phase Current Differential Operation Chart



# 19 • Neutral Current Differential (87N) Protection

Two neutral current differential (87N) elements provide sensitive differential protection from phase-to-ground faults in the Y-connected winding. On impedance grounded systems, ground fault levels may be reduced below the sensitivity of the phase differential protection. The result is that ground faults within the protected zone have to be cleared by time delayed backup overcurrent protection if sensitive differential protection is not available.

The two, identical neutral current differential protection elements are designated 87N-1 and 87N-2. Element logic connections are made on the BESTlogic™ *Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Neutral Current Differential (87N) settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

**BESTCOMS*Plus* Navigation Path:** Settings Explorer, Protection, Current, Neutral Differential (87N)

**HMI Navigation Path:** Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Current Protection, Neutral Differential 87N

## ***Element Operation***

---

The 87N element detects an imbalance between the neutral current (3I0) and ground current (IG).

### **CT Flip**

For a legacy CT with an auxiliary CT installed, the CT Flip setting will correct the polarity of the 3I0. Setting the CT Flip to true will introduce a 180° phase shift internally in the 3I0 calculation.

### **CT Source**

The CT Source setting configures the neutral current differential element to monitor the ground CT in either CT circuit 1 or CT Circuit 2. CT circuit 1 ground terminals are designated D7 and D8 and CT Circuit 2 terminals are designated F7 and F8. For an illustration, refer to the *Terminals and Connectors* chapter.

### **Overcorrection Coefficient**

The 87N element is directionally supervised by making a comparison of two vectors, the calculated IOP vector and the current present on the relay IG input terminals. First, the magnitude of the vector (IopMag) is checked by the equation  $IopMag = 3I0 + IG$  to determine if it is above the user defined pickup setting. Second, the IG quantity, as seen at the relay terminals, is used as the polarizing quantity to determine directionality (IopDir) by the equation  $IopDir = IG + (OVCR * 3I0)$ . The overcorrection coefficient (OVCR) is used to add security to the directional element in the previous equation. For the IopDir check, OVCR is used to offset the 3I0 measurement by the quantity determined in the Overcorrection Coefficient setting, which at low levels of 3I0 and IG, will provide greater confidence that the directional criterion is met. The decision to trip will be made only when IopMag is above the user defined pickup setting and IopDir is within  $\pm 90^\circ$  of the current present on the IG relay terminals.

### **Transient Delay**

A user-defined transient delay time provides security from misoperation on false residual caused by CT saturation during a through fault. If the transient monitor function from the phase current differential (87) function detects CT saturation, the 87N Trip logic output is routed through a timer. The timer should be set longer than the normal clearing time for a fault just outside the zone of protection to allow it to ride-through until the external fault is cleared.

## Pickup Calculations

The differential value is calculated as shown in Equation 19-1 and Equation 19-2 and displayed in BESTCOMSP<sup>Plus</sup> metering and on the front-panel display.

$$\text{If CT Flip Setting} = \text{Yes, then } I_{op} = I_{sec} - \left( \frac{\text{Phase CT Ratio}}{\text{round CT Ratio}} \times 3I_{0_{sec}} \right)$$

**Equation 19-1. I<sub>op</sub> Calculation when CT Flip Setting = Yes**

$$\text{If CT Flip Setting} = \text{No, then } I_{op} = I_{sec} + \left( \frac{\text{Phase CT Ratio}}{\text{round CT Ratio}} \times 3I_{0_{sec}} \right)$$

**Equation 19-2. I<sub>op</sub> Calculation when CT Flip Setting = No**

An Overcorrection Coefficient setting is provided to further improve the security of the 87N element by preventing false directional tripping. This setting is not intended to be used for CT ratio correction.

## Pickup and Trip

The Pickup occurs first, followed by the Trip output.

### Pickup

The Pickup output becomes true when the Minimum I<sub>op</sub> setting is exceeded. In BESTlogic<sup>Plus</sup>, the Pickup output can be connected to other logic elements to annunciate the condition, control other elements in logic, and start the fault recorder (logic element FAULTTRIG).

Assertion of the Pickup output initiates a timer that begins timing to a trip. The duration of the timer is established by the Time Delay setting. A Time Delay setting of zero (0) makes the 87N element instantaneous with no intentional time delay.

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

### Trip

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

## Current-Polarized Directional Scheme

Figure 19-1 shows the current-polarized directional scheme. The CT Flip setting is “YES” for this scheme. With the assumed positive current direction, 3I<sub>0</sub> and IG are in phase for an internal fault and are out of phase for an external fault.

## Element Blocking

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in BESTlogic<sup>Plus</sup>. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

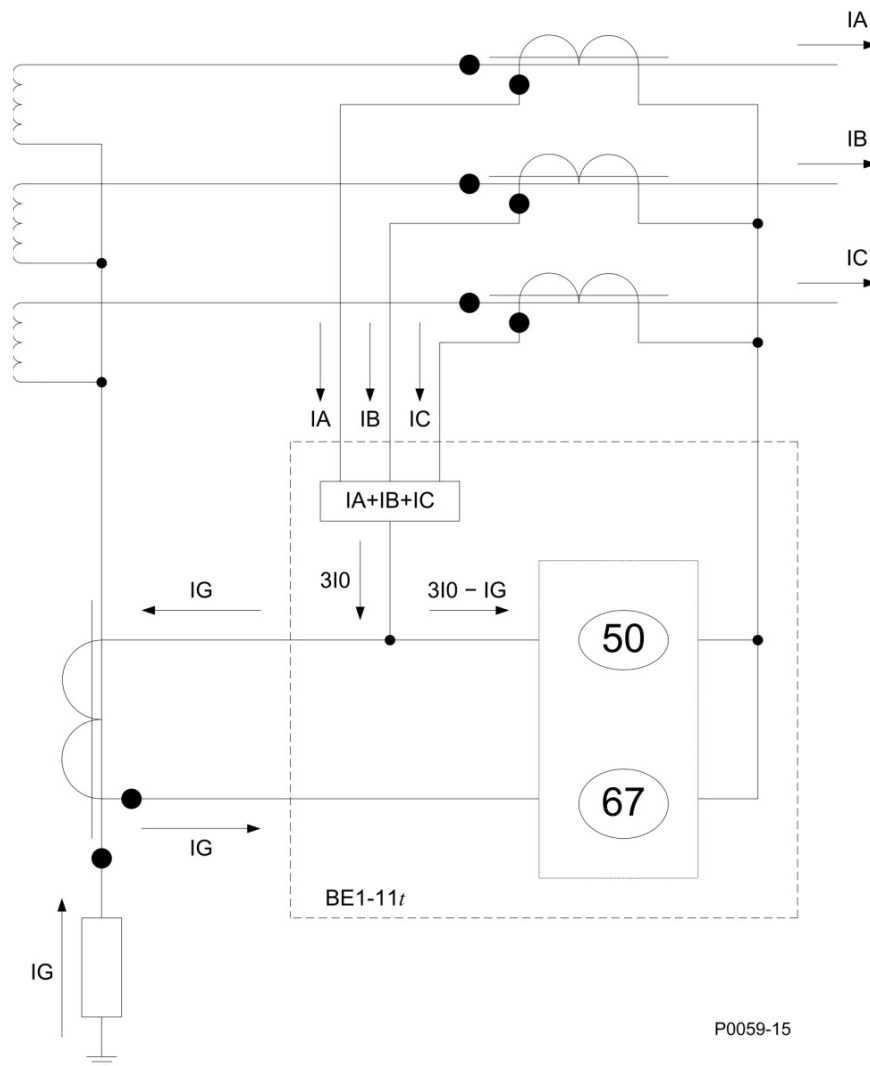


Figure 19-1. Current-Polarized Directional Scheme for BE1-11r CT Connection

## Logic Connections

Neutral current differential element logic connections are made on the BESTlogicPlus screen in BESTCOMSPUs. The neutral current differential element logic block is illustrated in Figure 19-2. Logic inputs and outputs are summarized in Table 19-1.

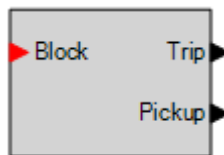


Figure 19-2. Neutral Current Differential Element Logic Block

Table 19-1. Logic Inputs and Outputs

Name	Function	Purpose
Block	Input	Disables the 87N function when true
Trip	Output	True when the 87N element is in trip condition
Pickup	Output	True when the 87N element is in pickup condition

## Operational Settings

Neutral current differential element operational settings are configured on the Neutral Current Differential (87N) settings screen (Figure 19-3) in BESTCOMSPlus.



**Neutral Differential**

87N-1 Element

Mode  
Enabled

Iop Minimum (A)  
0.00

Time Delay (ms)  
0

Overcorrection Coefficient  
1.10

CT Flip  
Yes

CT Source  
CT1, IG1

Transient Delay Time (ms)  
0

Figure 19-3. Neutral Current Differential Settings Screen

## 20 • Distance (21) Protection

A core principal of power system protection is to use a device to provide primary protection for the immediate area or zone as well as providing backup protection for the next closest zone. The transformer is the primary zone of protection for the BE1-11 $t$ . It may be desirable to also provide backup protection for the transmission and distribution systems that connect to the transformer. An important part of providing backup protection is coordinating to allow the primary protection to respond first. Using a distance (21) element to back up the transmission makes it easier to coordinate the backup protection with the transmission line's primary protection which is most commonly also distance elements. Two distance (21) elements are available only in style TxxxxxxBxxxx of the BE1-11 $t$ .

Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOM*SPlus*® and element operational settings are configured on the Distance (21) settings screen in BESTCOM*SPlus*. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

**BESTCOM*SPlus* Navigation Path:** Settings Explorer, Protection, Impedance, Distance (21)

**HMI Navigation Path:** Settings Explorer, Protection, Settings Group x (where x = 0 to 3), Impedance Protection, Distance 21

### ***Element Operation***

The zone of protection for the distance element may be set (using a mho circle) to include the generator-step-up transformer and the lines that connect the generator to the system. The time delay of the generator backup distance element must be coordinated with the associated primary zones of protection to ensure proper operation.

To include the generator in the distance (21) backup zone of protection, use CTs located on the neutral side of the generator. If neutral CTs are not provided, the BE1-11 $t$  may be connected to CTs located at the generator terminals. With this connection, the generator is not included in the protection system's zone of protection, but system backup protection is provided.

### **Bus CT Configuration**

The 21 element can monitor CT circuit 1 or CT circuit 2. The CT source is selected on the Sensing Transformers settings screen in BESTCOM*SPlus*.

### **Delta/Wye Compensation**

For installations where the generator is connected to the system through a delta/wye step-up transformer, delta/wye compensation is enabled to provide compensation for the differences in the current components on the wye and the delta side of the step-up transformer.

### **Torque Angle**

A Torque Angle (or characteristic angle) setting represents the angle between voltage and fault current on a zero (0) ohm fault. The torque angle is used for impedance calculations.

### **Pickup and Trip**

The Pickup output occurs first, followed by the Trip output.

#### Pickup

The Pickup output becomes true when the calculated impedance falls within the zone established by the mho circle. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition, control other elements in logic, and start the fault recorder (logic element FAULTTRIG).

Assertion of the Pickup output initiates a timer that begins timing to a trip. The duration of the timer is established by the Time Delay setting. A Time Delay setting of zero (0) makes the 21 element instantaneous with no intentional time delay.

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

### Trip

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

## Element Blocking

### Fuse Loss

The fuse loss (60FL) element of the BE1-11 $t$  can be used to block 21 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 Impedance is enabled, all functions that use impedance measurements are blocked. See the *Fuse Loss (60FL)* chapter for more information on the 60FL function.

Protective elements blocked by 60FL should be set so that trip times are 60 milliseconds or greater to assure proper coordination of blocking.

### Block Logic Input

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in *BESTlogicPlus*. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## Logic Connections

Distance element logic connections are made on the *BESTlogicPlus* screen in *BESTCOMSPPlus*. The distance element logic block is illustrated in Figure 20-1. Logic inputs and outputs are summarized in Table 20-1.

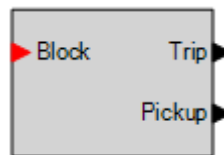


Figure 20-1. Distance Element Logic Block

Table 20-1. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 21 function when true
Trip	Output	True when the 21 element is in a trip condition
Pickup	Output	True when the 21 element is in a pickup condition

## Operational Settings

Distance element operational settings are configured on the Distance (21) settings screen (Figure 20-2) in *BESTCOMSPPlus*.

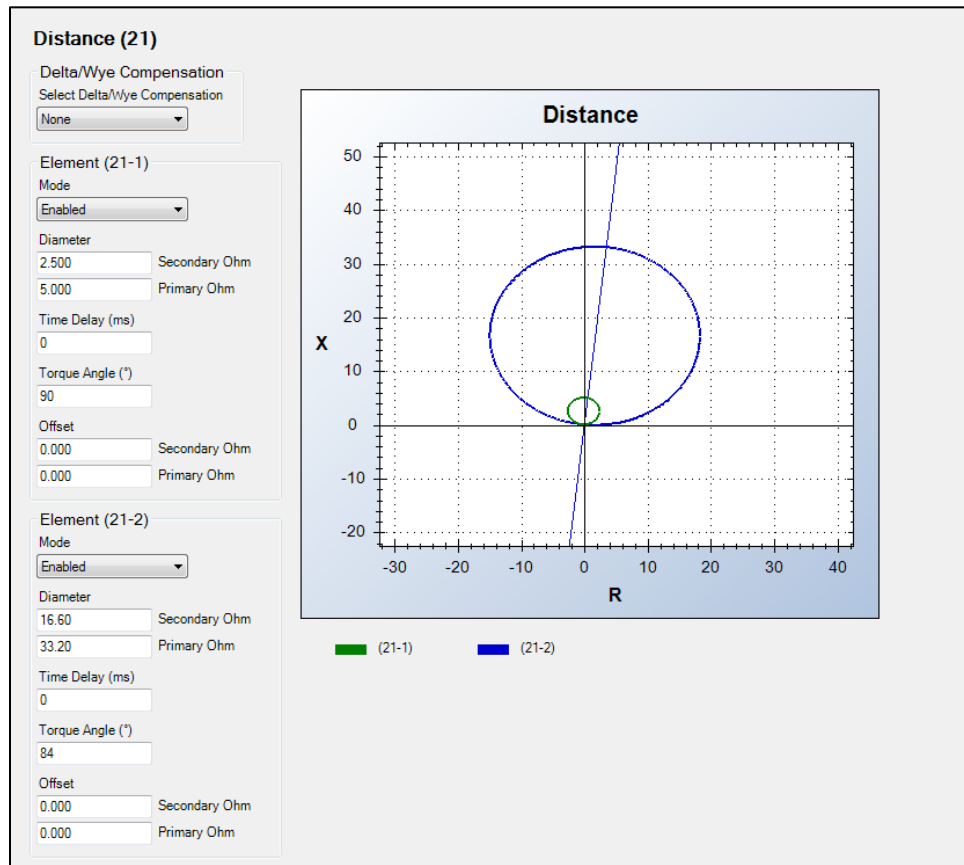


Figure 20-2. Distance Settings Screen



# 21 • Resistance Temperature Detector (49RTD) Protection

Fourteen resistance temperature detector (49RTD) elements provide over/undertemperature protection in applications when a remote RTD module is connected via Ethernet or RS-485. There are 12 physical RTD sensors per RTD module. Each element can be set to monitor a single physical RTD sensor or a group of them. Refer to the *RTD Module* chapter for information on mounting, connections, communication setup, and specifications.

The fourteen, identical remote RTD protection elements are designated 49RTD-1 through 49RTD-14. 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 appears 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**

The Pickup output occurs first, followed by the Trip output.

#### Pickup

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

Assertion of the Pickup output initiates a timer that begins timing to 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 the pickup condition subsides before the element delay expires, the timer and Pickup output are reset and no corrective action is taken.

### Trip

The Trip output becomes true if a pickup condition persists for the duration of the element Time Delay. In *BESTlogicPlus*, the Trip output can be connected to other logic elements and to a physical relay output to annunciate the condition and to initiate corrective action. If a target is enabled for the element, the BE1-11<sub>t</sub> will record a target when the Trip output becomes true. See the *Fault Reporting* chapter for more information about target reporting.

### 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

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in *BESTlogicPlus*. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## Logic Connections

Remote RTD input element logic connections are made on the *BESTlogicPlus* screen in *BESTCOMSPlus*. The remote RTD input element logic block is illustrated in Figure 21-1. Logic inputs and outputs are summarized in Table 21-1.

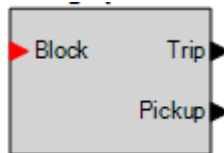


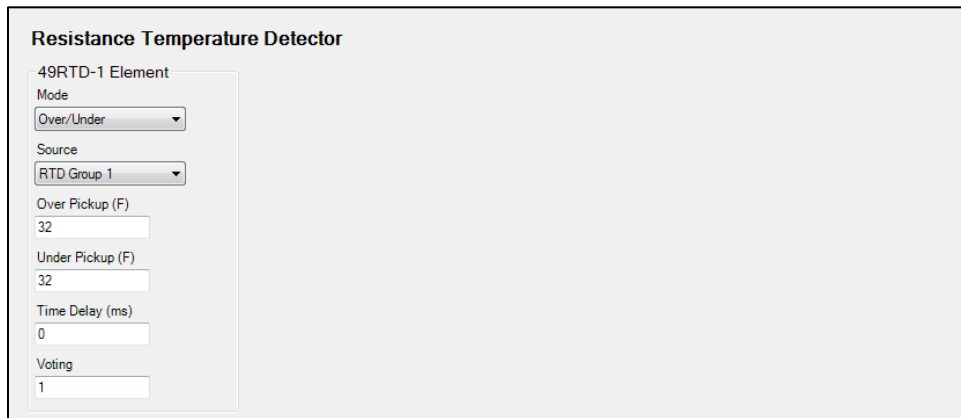
Figure 21-1. Remote RTD Input Element Logic Block

Table 21-1. 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 21-2) in *BESTCOMSPlus*.



**Resistance Temperature Detector**

49RTD-1 Element

Mode  
Over/Under

Source  
RTD Group 1

Over Pickup (F)  
32

Under Pickup (F)  
32

Time Delay (ms)  
0

Voting  
1

**Figure 21-2. Resistance Temperature Detector Settings Screen**

## ***Remote RTD Metering***

RTD metering values are obtained through BESTCOMSP*lus* by using the Metering Explorer to open the Analog Metering, RTD Meter tree branch. BESTCOMSP*lus* must be online with the BE1-11*t* 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.



## 22 • Recloser (79) Protection

The recloser (79) element automatically recloses circuit breakers, which have been tripped by protective relays or other devices in power transmission and distribution systems. This element is available only in style TxxxxxxxBxxxxx of the BE1-11t.

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 appears 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. 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 BE1-11t goes to lockout after power is restored.

##### Power Up to Reclose

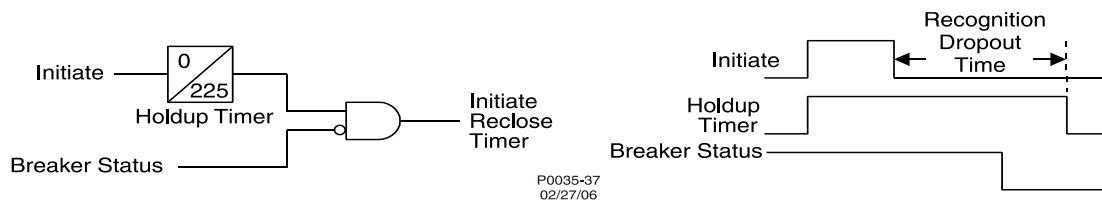
When power is lost during a reset condition, the BE1-11t initiates a first programmed reclose after power is restored if the breaker is open (52b) and the Initiate input of the 79 element is true.

#### **Inputs**

Recloser element logic inputs are described in the following paragraphs.

##### Initiate

The Initiate input is used with the Breaker Status (BRKSTAT) 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 and BRKSTAT must be false. 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 22-1 illustrates the recognition dropout logic and timing relationship.



**Figure 22-1. 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 $t$  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 device (BE1-11 $t$ ) senses that a downstream device has interrupted fault current, the BE1-11 $t$  will increment the trip/reclose sequence by one operation. This occurs because the BE1-11 $t$  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:

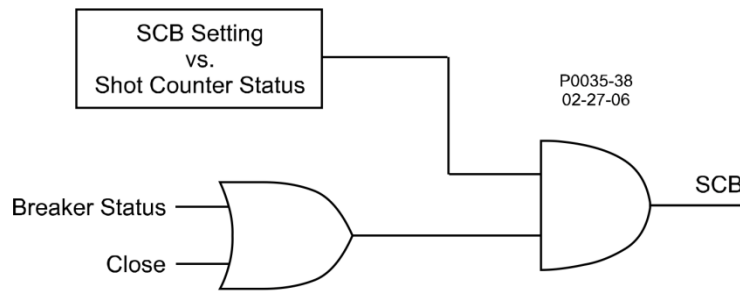
- More than the maximum number of programmed recloses is initiated before the recloser returns to the Reset state.
- The DTL input is true.
- The Reclose Fail (79F) is true.
- The maximum reclose cycle time is exceeded.

### 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 22-2 illustrates SCB logic.



**Figure 22-2. 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 BE1-11t 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 BESTCOMSPlus.

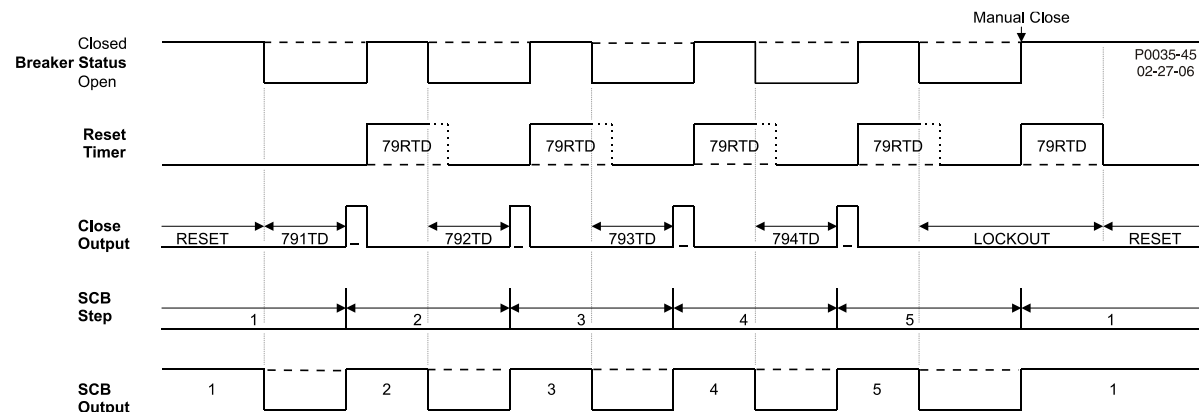
**Maximum Cycle Timer (MAX Cycle)**

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 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 not desired, the Max Cycle timer can be disabled by setting it at zero (0). The Wait input does not pause the Max Cycle timer. The maximum cycle time is set on the Recloser screen in BESTCOMSPlus.

**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 BESTCOMSPlus by checking the appropriate Trip box.

Figure 22-3 shows a logic timing diagram showing all possible sequence controlled blocks enabled (true). In Figure 22-4, 79RTD is the reclose reset time delay and 79#TD is the reclose time delay where # is the reclose shot number.



**Figure 22-3. SCB=1/2/3/4/5 Logic Timing Diagram**

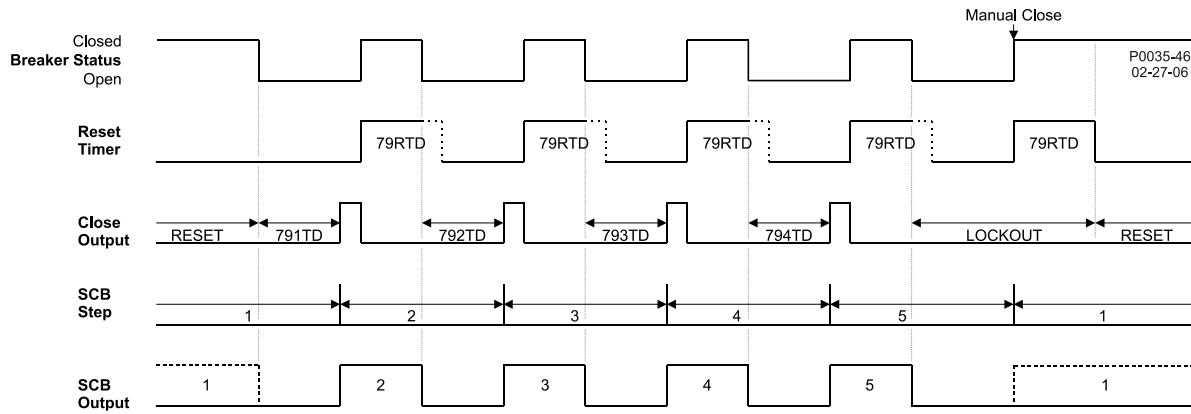


Figure 22-4. SCB=2/3/4/5 Logic Timing Diagram

### 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 BE1-11t setting groups can be found in the *Setting Groups* chapter.

### Logic Connections

Recloser element logic connections are made on the BESTLogicPlus screen in BESTCOMSPPlus. The recloser element logic block is illustrated in Figure 22-5. Logic inputs and outputs are summarized in Table 22-1.

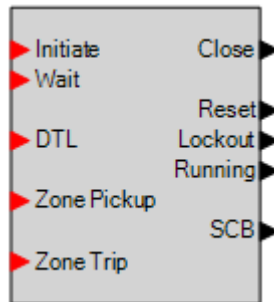


Figure 22-5. Recloser Element Logic Block

Table 22-1. 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
Lockout	Output	True when the recloser is in the Lockout state

Name	Logic Function	Purpose
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 22-6) in BESTCOMSPi.us.

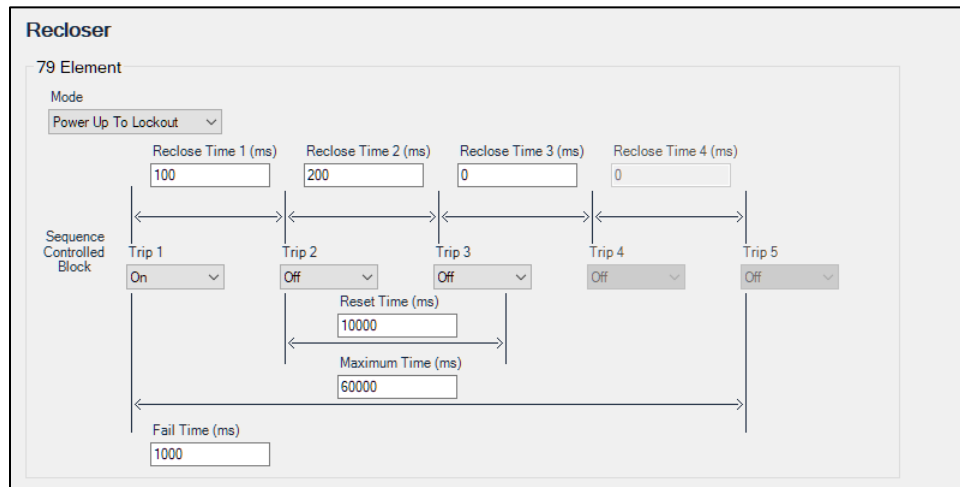
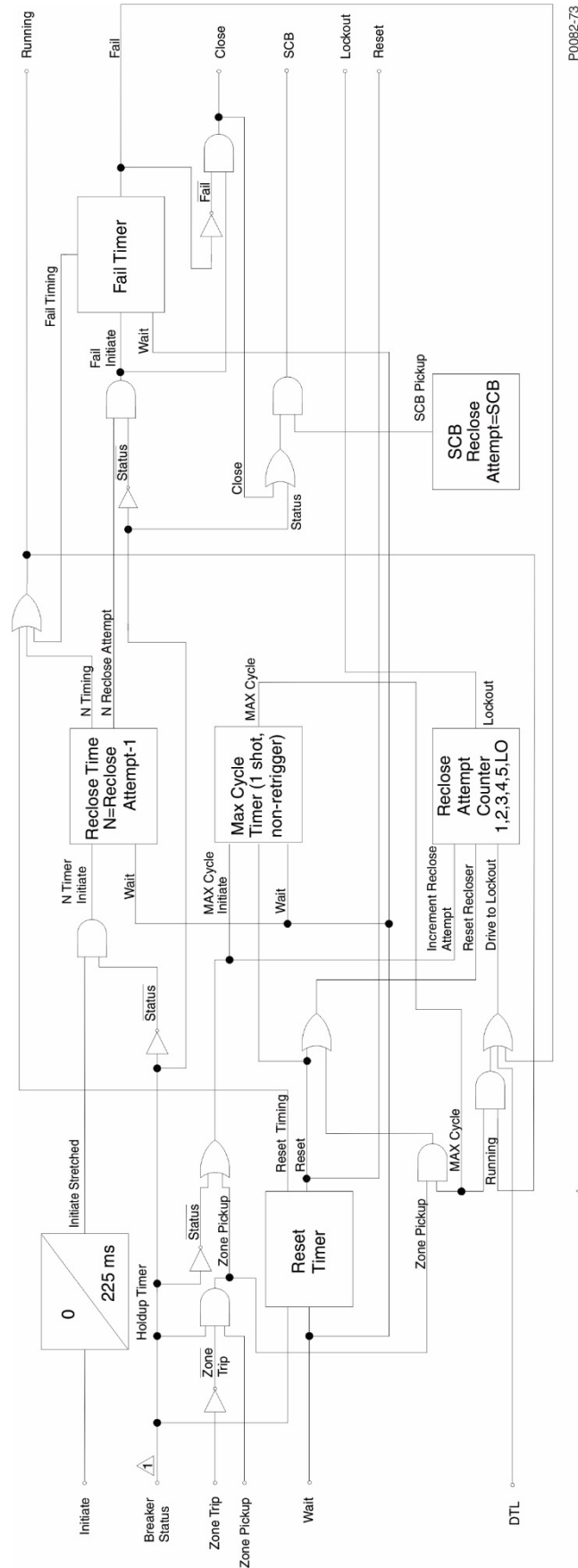


Figure 22-6. Recloser Settings Screen

## Logic Diagram

Figure 22-7 illustrates an overall logic diagram for the recloser element.



P0082-73

Configured by the Breaker Status Logic element. Refer to Section 8, Breaker Monitoring.

Figure 22-7. Overall Logic Diagram for Reclosing

## 23 • Analog Input Protection

Eight analog input 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 BESTCOMSP*Plus*® and element operational settings are configured on the Remote Analog Input settings screen in BESTCOMSP*Plus*. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

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

**HMI Navigation Path:** Settings Explorer, Protection, Analog Protection

### ***Element Operation***

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#### **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**

The Pickup output occurs first, followed by the Trip output.

##### Pickup

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

Assertion of the Pickup output initiates a timer that begins timing to 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 the pickup condition subsides before the element delay expires, the timer and Pickup output are reset and no corrective action is taken.

##### Trip

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

#### **Inhibit**

When enabled, 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

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the Trip and Pickup outputs to logic 0 and resetting the element timer. Connect the element Block input to the desired logic in BESTlogicPlus. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## Logic Connections

Remote analog input element logic connections are made on the BESTlogicPlus screen in BESTCOMSPPlus. The remote analog input element logic block is illustrated in Figure 23-1. Logic inputs and outputs are summarized in Table 23-1.

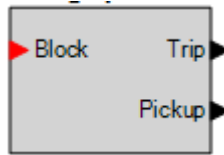


Figure 23-1. Remote Analog Input Element Logic Block

Table 23-1. 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 23-2) in BESTCOMSPPlus.

Figure 23-2. Remote Analog Input Settings Screen

## Remote Analog Input Metering

Analog input metering values are obtained through BESTCOMSPPlus by using the Metering Explorer to open the Analog Metering, Analog Inputs tree branch. BESTCOMSPPlus must be online with the BE1-11t 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.

## 24 • 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 appears 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 BE1-11*t* or in series with the ground trip output of the BE1-11*t*. 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 modes of operation are available: Switch/Pulse, Switch, and Pulse. Because switch status information is saved in nonvolatile memory, the BE1-11*t* powers up with the switches in the same state as when the BE1-11*t* 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 virtual output from its current state to the opposite state for 200 ms then back to the original state. An additional Hold Time can be set when the virtual output is connected to a physical output in BESTlogic*Plus*. See the *Contact Inputs and Outputs* chapter for more information.

##### 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 virtual output from its current state to the opposite state for 200 ms and then back to the original state. An additional Hold Time can be set when the virtual output is connected to a physical output in BESTlogic*Plus*. See the *Contact Inputs and Outputs* chapter for more information.

#### **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 BESTCOMSPi.us when the connection state is active. Using select-before-operate, perform the following steps to control a switch using BESTCOMSPi.us:

1. Use the Metering Explorer to open the Control/Virtual Switches tree branch (Figure 24-1).
2. If Switch/Pulse mode is selected on the Virtual Control Switches (43) settings screen in BESTCOMSPi.us, use the drop-down box to select either Switch or Pulse.
3. Click the 43-# button to **select** it. Login may be required. The On or Off indicator (current state) will begin to flash.
4. Click on the 43-# button a second time to **operate** it. The On or Off indicator (previous state) will stop flashing and the Off or On indicator (current/new state) will light.

### Note

If Step 4 is not performed within 30 seconds of Step 3, the LED will stop flashing and the 43-# button will have to be selected again.

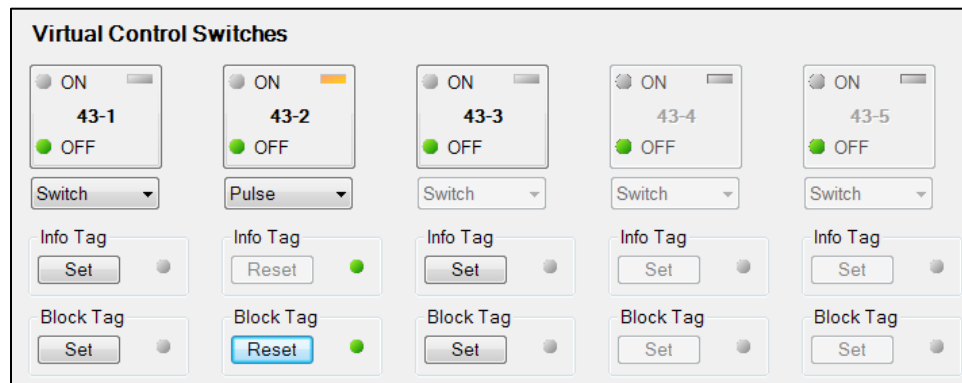


Figure 24-1. Virtual Switches Control Screen

## 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 BESTCOMSPi.us. Use the Metering Explorer in BESTCOMSPi.us 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 24-1.

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 BESTCOMSPi.us, it can be removed only through BESTCOMSPi.us. 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 BESTlogicPlus screen in BESTCOMSPPlus. The virtual control switch element logic block is illustrated in Figure 24-2. Logic inputs and outputs are summarized in Table 24-1.

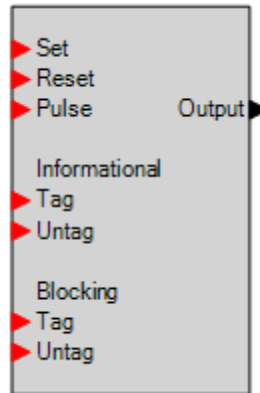


Figure 24-2. Virtual Control Switch Element Logic Block

Table 24-1. 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 24-3) in BESTCOMSPPlus.

**Virtual Control Switches (43)**

<p>43-1</p> <p>Mode</p> <p>Switch/Pulse</p> <p>Name Label</p> <p>43-1</p> <p>On Label</p> <p>On</p> <p>Off Label</p> <p>Off</p>	<p>43-2</p> <p>Mode</p> <p>Switch/Pulse</p> <p>Name Label</p> <p>43-2</p> <p>On Label</p> <p>On</p> <p>Off Label</p> <p>Off</p>
<p>43-3</p> <p>Mode</p> <p>Switch</p> <p>Name Label</p> <p>43-3</p> <p>On Label</p> <p>On</p> <p>Off Label</p> <p>Off</p>	<p>43-4</p> <p>Mode</p> <p>Disabled</p> <p>Name Label</p> <p>43-4</p> <p>On Label</p> <p>On</p> <p>Off Label</p> <p>Off</p>
<p>43-5</p> <p>Mode</p> <p>Disabled</p> <p>Name Label</p> <p>43-5</p> <p>On Label</p> <p>On</p> <p>Off Label</p> <p>Off</p>	

Figure 24-3. Virtual Control Switches Settings Screen

## 25 • 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 BESTCOMSPlus® and element operational settings are configured on the Logic Timers (62) settings screen in BESTCOMSPlus. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

**BESTCOMSPlus 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 BESTlogicPlus, 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<sub>t</sub> 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-Retriggerable, One-Shot/Retriggerable, 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 25-1. 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.

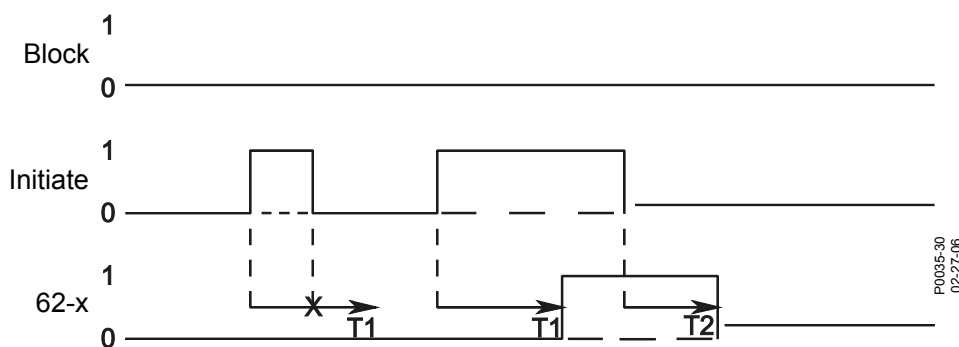


Figure 25-1. Pickup/Dropout Mode

##### 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 25-2. 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.

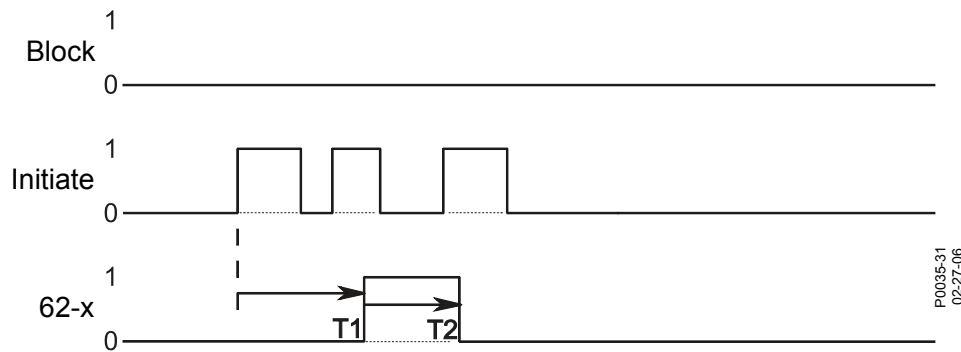


Figure 25-2. One-Shot/Non-Retriggerable Mode

### One-Shot/Retriggerable Mode

The one-shot retriggerable timer starts its timing sequence when the Initiate input changes from false to true. See Figure 25-3. 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.

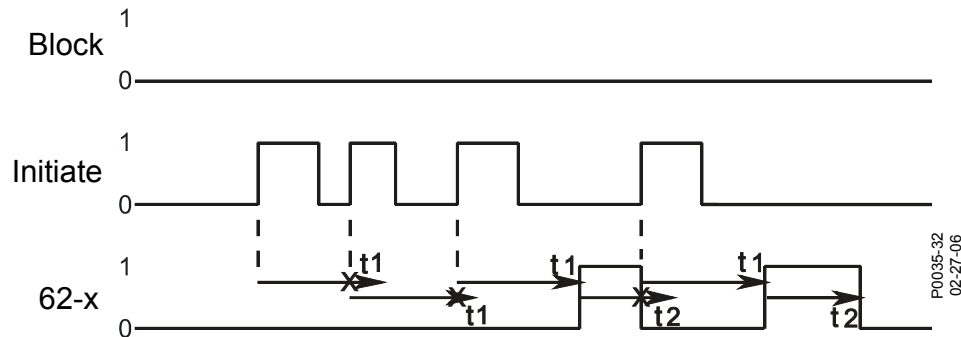


Figure 25-3. One-Shot/Retriggerable Mode

### Oscillator Mode

In this mode, the Initiate input is ignored. See Figure 25-4. 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.

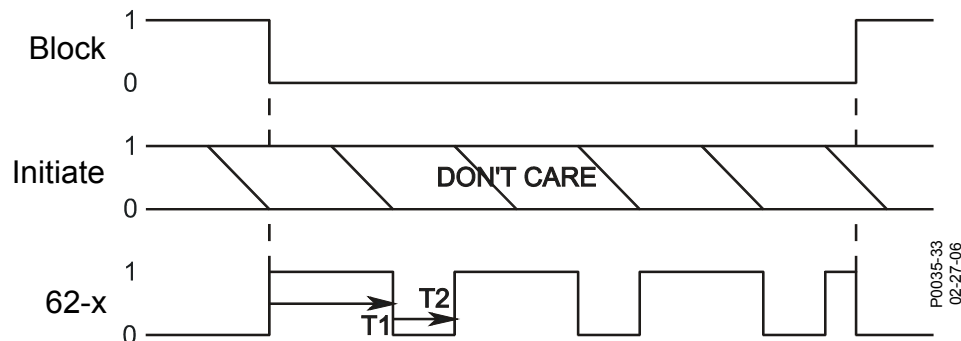


Figure 25-4. Oscillator Mode

### 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 25-5, 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.

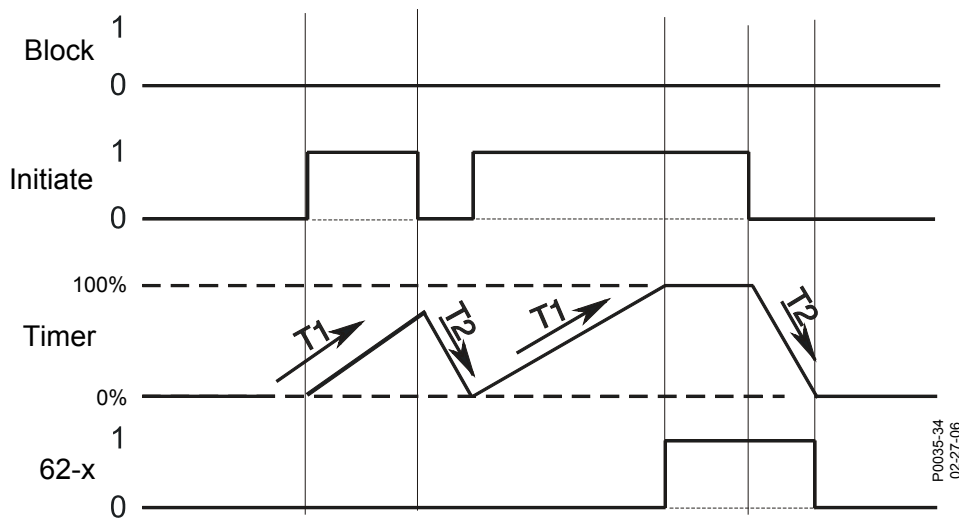


Figure 25-5. Integrating Timer Mode

#### 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 25-6.

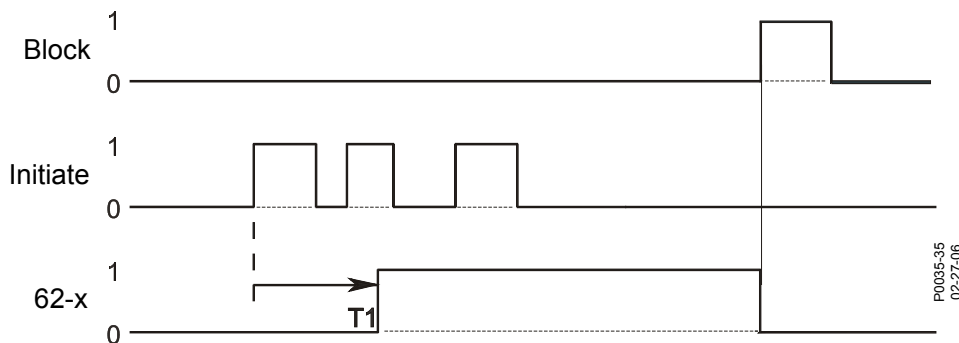


Figure 25-6. Latched Mode

#### **Element Blocking**

The Block input provides logic-supervision control of the element. When true, the Block input disables the element by forcing the element output to logic 0 and resetting the element timer. Connect the element

Block input to the desired logic in BESTLogicPlus. When the element is initially selected from the Elements view, the default condition of the Block input is a logic 0.

## Logic Connections

Logic timer element logic connections are made on the BESTLogicPlus screen in BESTCOMSPlus. The logic timer element logic block is illustrated in Figure 25-7. Logic inputs and outputs are summarized in Table 25-1.

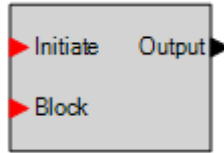


Figure 25-7. Logic Timer Element Logic Block

Table 25-1. 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 25-8) in BESTCOMSPlus.

Figure 25-8. Logic Timers Settings Screen

## 26 • 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 appears 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 26-1. Logic inputs and outputs are summarized in Table 26-1.

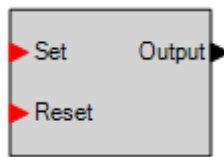


Figure 26-1. Lockout Function Element Logic Block

Table 26-1. 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 26-2) in BESTCOMS*Plus*.



Figure 26-2. Lockout Functions Settings Screen

## ***Retrieving Lockout Status from the BE1-11t***

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

To view 86 lockout status using BESTCOMSP*lus*, use the Metering Explorer to open the Status, 86 Lockout Status screen shown in Figure 26-3. To view lockout status from the front-panel display, navigate to Metering Explorer, Status, 86 Lockout Status.



**Figure 26-3. 86 Lockout Status Screen**

## 27 • 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 BESTCOMSP*Plus*® and element operational settings are configured on the Breaker Control Switch settings screen in BESTCOMSP*Plus*. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

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

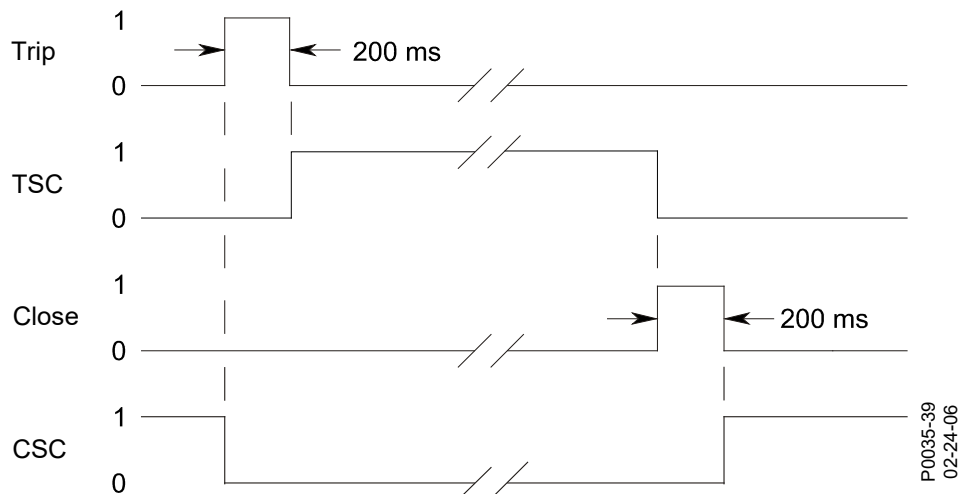
**HMI Settings Navigation Path:** Settings Explorer, Control, Breaker Switch 101

**BESTCOMSP*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 27-1 shows the state of the TSC and CSC logic outputs with respect to the state of the Trip and Close outputs.



**Figure 27-1. 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 then 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 BE1-11*t* will power up with the contact in the same state as when the BE1-11*t* was powered down.

### Control of Breaker Control Switch

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

1. Use the Metering Explorer to open the Control/Breaker Control Switch tree branch (Figure 27-2).
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 light.

### 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.

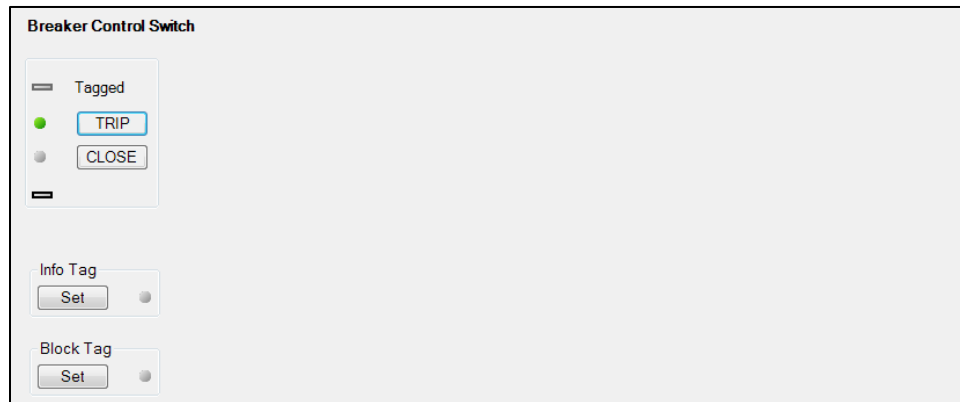


Figure 27-2. Breaker Control Switch Control Screen

## 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 LED on this screen.

Tagging of the breaker control switch can be accomplished through the front panel and through BESTCOMSPi.us. Use the Metering Explorer in BESTCOMSPi.us 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 LED to the right of the Set button will light.

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 BESTCOMSPi.us, it can be removed only through BESTCOMSPi.us. 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 BESTlogicPlus screen in BESTCOMSPi.us. The breaker control element logic block is illustrated in Figure 27-3. All logic inputs use rising-edge detection for recognition. Logic inputs and outputs are summarized in Table 27-1.

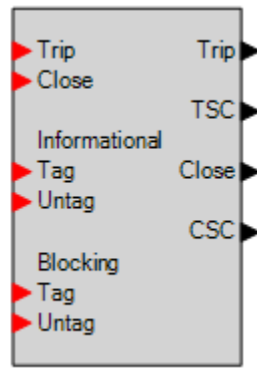


Figure 27-3. Breaker Control Element Logic Block

Table 27-1. 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 27-4) in BESTCOMSPlus.



Figure 27-4. Breaker Control Switch Settings Screen



## 28 • 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 appears 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 outputs.

#### 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 SGACTIVE 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*t* 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*t* off line. When a setting group changes according to current level (Phase, 3I0, or I2), and the optional 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*t* will power up using the same setting group that was active when it was powered down. To prevent the BE1-11*t* from changing settings while a fault condition is in process, setting group changes are blocked when the BE1-11*t* is in a picked-up state. Since the BE1-11*t* 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*t* stays in that group regardless of the state of the manual logic control conditions.

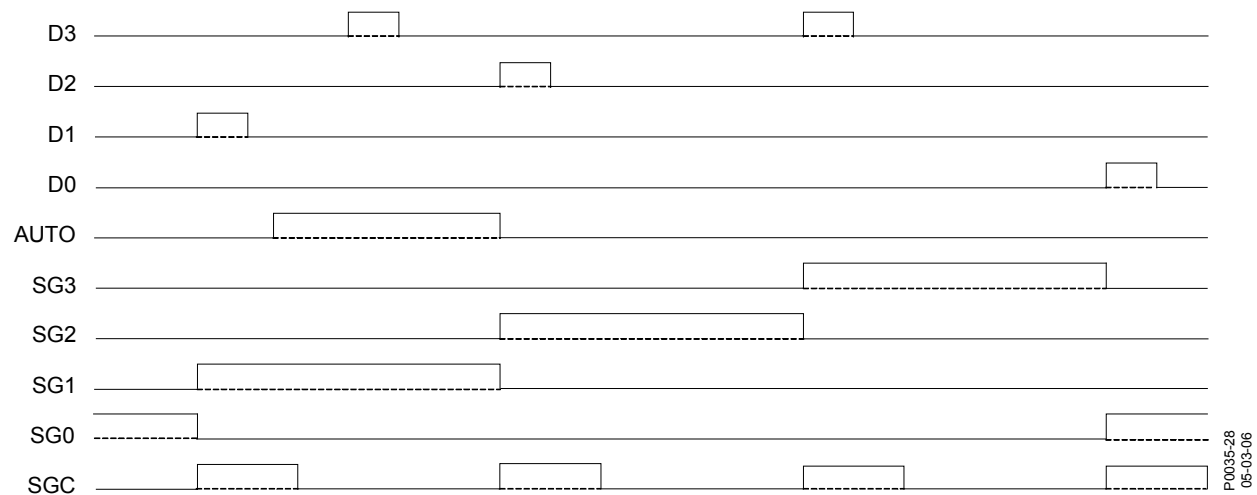
Manual (logic) selection reads the status of the logic inputs to the setting group selection function block to determine what setting group should be active. **For the logic inputs to determine which setting group**

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 28-3.

### 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. 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 28-1 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 28-1. Input Control Discrete Inputs**

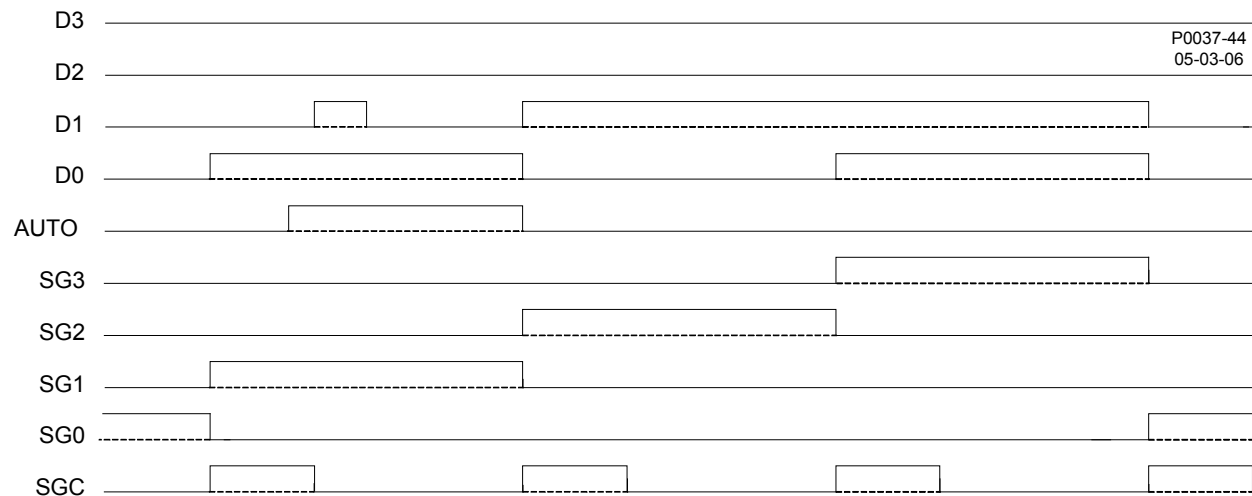
### Binary Inputs

When the setting group selection function block is enabled for Binary Inputs, the inputs on D0 and D1 are read as binary encoded (Table 28-1). 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 28-1. 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 28-2 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 28-2. Input Control Binary Inputs**

### CT Source

The CT Source setting configures the setting group selection function to monitor CT circuit 1 or CT circuit 2. 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.

### 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 $\iota$  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 $\iota$  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 BE1-11 $\iota$ . Another method is based upon the status of the optional 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 BE1-11 $\iota$  to change to settings that will automatically compensate for cold-load pickup conditions. For instance, if the BE1-11 $\iota$  senses current drop below a very small threshold for a period of time indicating an open breaker, then the BE1-11 $\iota$  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 BE1-11 $\iota$  returns to the normal settings. Another application is to prevent the BE1-11 $\iota$  from seeing an overload condition as a fault. If the BE1-11 $\iota$  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 BE1-11 $\iota$  will move to an alternate setting group that can accommodate the condition. The BE1-11 $\iota$  can be set to alarm for this condition using the programmable logic alarms.

The BE1-11 $\ell$  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 BE1-11 $\ell$  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 BE1-11 $\ell$  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 BE1-11 $\ell$  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 BE1-11 $\ell$  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 BE1-11 $\ell$  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 BE1-11 $\ell$  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 BE1-11 $\ell$  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 current is being monitored, then the BE1-11 $\ell$  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 Switch Time, a Return Threshold and Return Time, and a Monitor Setting. The Switch and Return thresholds are set in amps. If you wish to switch settings based upon loading, you could set the Monitor Setting to Max Phase Current. If you wish to switch settings based upon unbalance, you could set it to Neutral Current, or Negative-Sequence Current.

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 BE1-11 $\ell$  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 BE1-11 $\ell$  steps through an automatic reclose operation, the BE1-11 $\ell$  can be instructed to change to an appropriate setting group. If the monitored element is 1<sup>st</sup> reclose, 2<sup>nd</sup> reclose, 3<sup>rd</sup> reclose, or 4<sup>th</sup> reclose, the switch time, switch threshold, return time, and return threshold are ignored.

When setting group changes are made, the BE1-11 $\ell$  will stay in the last group selected until the BE1-11 $\ell$  returns to a reset condition. Upon the return to a reset condition, the BE1-11 $\ell$  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. Refer to Figure 28-3.

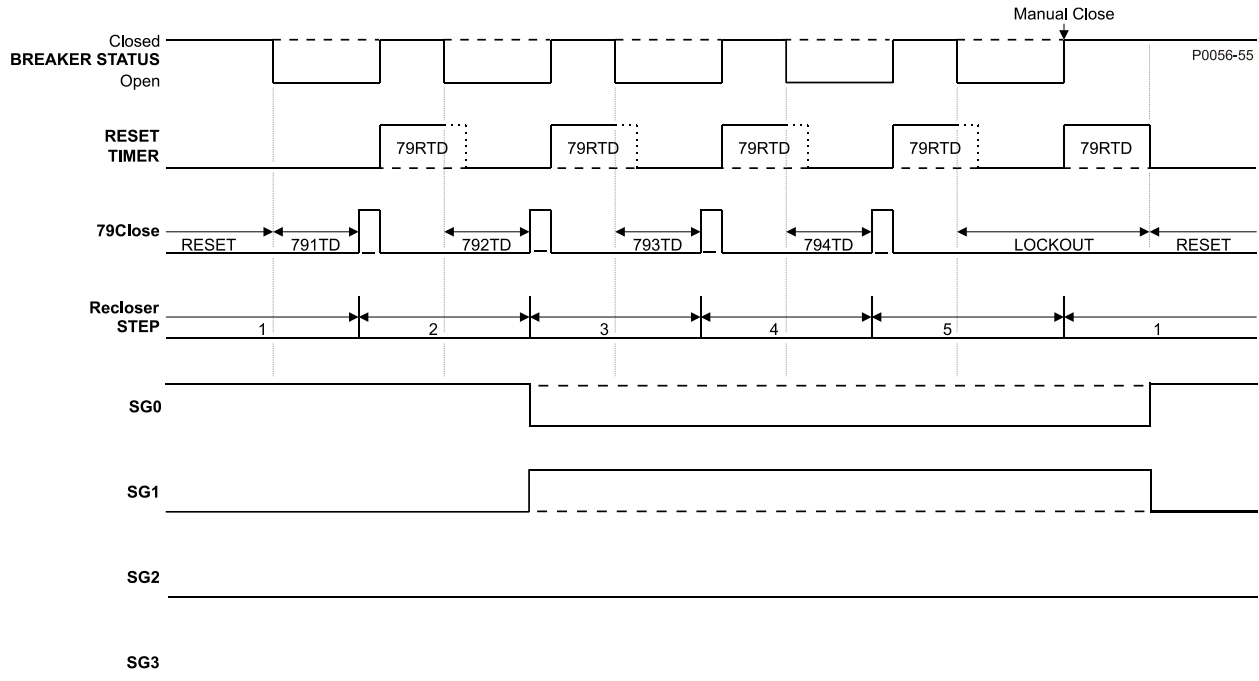


Figure 28-3. Change Group on Recloser Shot

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 BE1-11<sub>t</sub> 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 BESTlogicPlus screen in BESTCOMSPlus. The setting group logic block is illustrated in Figure 28-4. Logic inputs and outputs are summarized in Table 28-2.

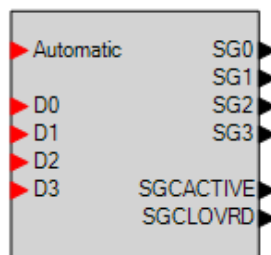


Figure 28-4. Setting Group Logic Block

**Table 28-2. 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
SGACTIVE	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 28-5) in BESTCOMSPi<sup>us</sup>. Setting ranges and defaults are summarized in Table 28-3.

**Setting Group Setup**

Element Status  
Mode: Discrete Inputs  
Source: CT1, IG1

**Setting Group 1**  
 Switch Threshold: 4.00 (Secondary A), 4.00 (Primary A)  
 Return Threshold: 3.00 (Secondary A), 3.00 (Primary A)  
 Switch Time (min): 0  
 Return Time (min): 0  
 Monitor Setting: Ground Current

**Setting Group 2**  
 Switch Threshold (Secondary A): 0.00  
 Return Threshold (Secondary A): 0.00  
 Switch Time (min): 0  
 Return Time (min): 0  
 Monitor Setting: Fuse Loss

**Setting Group 3**  
 Switch Threshold (Secondary A): 0.00  
 Return Threshold (Secondary A): 0.00  
 Switch Time (min): 0  
 Return Time (min): 0  
 Monitor Setting: Disabled

Setting Group Change (SGC) Alarm Timer (s)  
SGC Alarm Timer (s): 5

**Figure 28-5. Setting Group Setup Screen**

**Table 28-3. 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

Setting	Range	Purpose	Default
Source	CT Circuit 1 or CT Circuit 2	n/a	n/a
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, secondary amps.)	0
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
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, secondary amps.)	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
Monitor Setting	Disable, IP, IG, I2, 3I0, 60FL, First - Fourth Recloser Shot	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 or a Recloser Shot 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

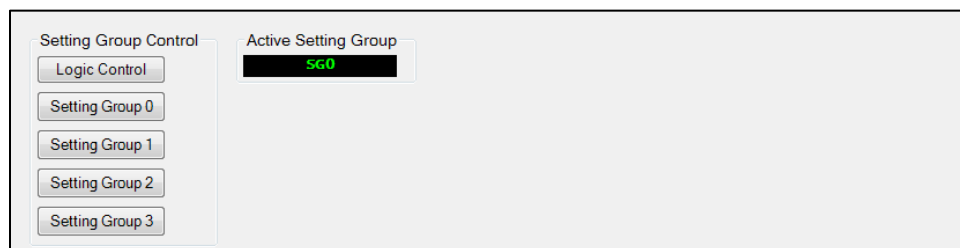
## Logic Override of the Setting Group Selection Function

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

**BESTCOMSPlus Navigation Path:** Metering Explorer, Control, Setting Group Control

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

Use the Metering Explorer in BESTCOMSPlus to open the Control, Setting Group Control tree branch as shown in Figure 28-6. Select a setting group to change to or return to logic control. The Active Setting Group is also displayed on this screen.



**Figure 28-6. 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.




## 29 • Metering

The BE1-11 $t$  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 BESTCOMSP $Plus$ ® 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 29-1. Table 29-1 explains the call-outs in Figure 29-1.

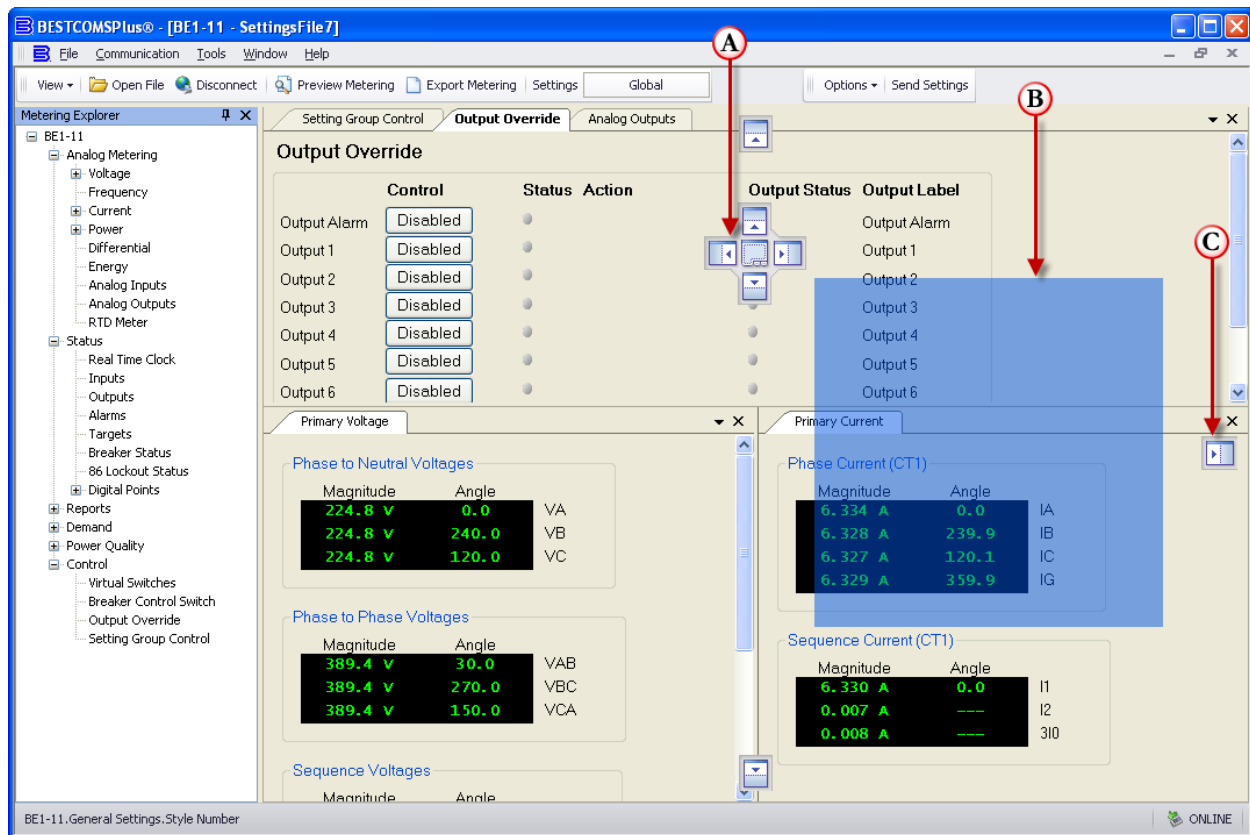



Figure 29-1. Metering, Docking Options

**Table 29-1. Explanation of Figure 29-1 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 $\tau$  analog metering functions include voltage, frequency, current, power, differential, and energy. Metered values are viewed through the Metering Explorer in BESTCOMSPlus, the front-panel display, or the web page interface on Ethernet equipped protection systems. 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 $\tau$  automatically scales metered values. Table 29-2 illustrates the ranges for each value metered.

**Table 29-2. 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 $\tau$  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 3<sup>rd</sup> harmonic auxiliary voltage (Vx 3<sup>rd</sup> 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 BESTCOMSPlus (Figure 29-2) and on the Metering > Analog Metering > Voltage screen of the front-panel display. A phasor diagram is also provided in BESTCOMSPlus.

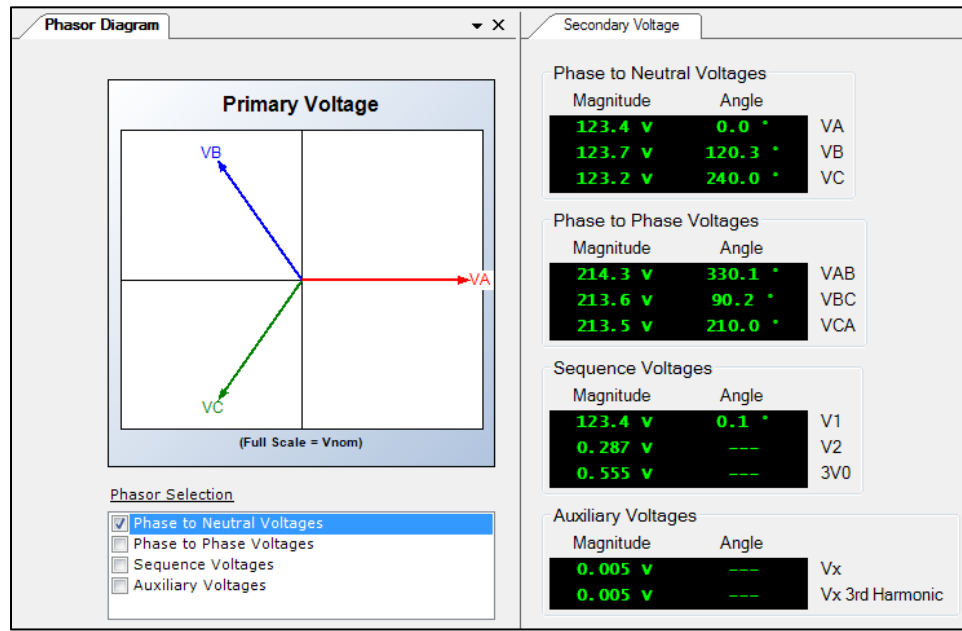


Figure 29-2. Analog Metering, Voltage Screen

### 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.

Primary and secondary current metering data is found in BESTCOMSPi.us (Figure 29-3) and on the Metering > Analog Metering > Current screen of the front-panel display. A phasor diagram is also provided in BESTCOMSPi.us.

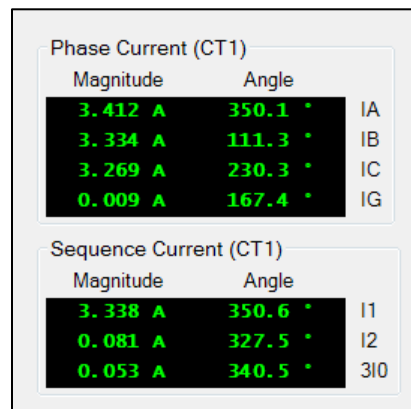


Figure 29-3. Analog Metering, Current Screen

### Power

Power metering data is found in BESTCOMSPi.us (Figure 29-4) and on the Metering > Analog Metering > Power screen of the front-panel display. A phasor diagram is also provided in BESTCOMSPi.us.

#### Real Power

Real power is metered over a range of -4,500 kilowatts to +4,500 kilowatts on five-ampere nominal systems. One-ampere nominal systems meter real power over a range of -900 watts to +900 watts. Phases A, B, C, and total phase are included.

### Reactive Power

Reactive power is metered over a range of –4,500 kilovars to +4,500 kilovars on five ampere nominal systems. One ampere systems meter reactive power over a range of –900 kilovars to +900 kilovars. Phases A, B, C, and total phase are included.

### Apparent Power

Metered apparent power is displayed over a range of –4,500 kilovoltamperes to +4,500 kilovoltamperes on five-ampere nominal systems. One-ampere nominal systems meter reactive power over a range of –900 kilovoltamperes to +900 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.

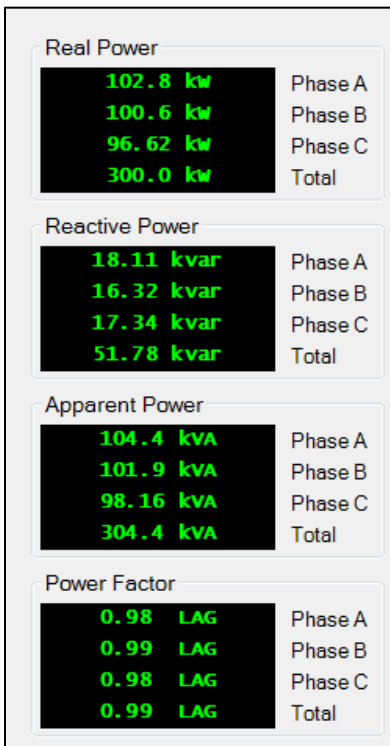


Figure 29-4. Analog Metering, Power Screen

## 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 BE1-11*t*. 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 BESTCOMSP*lus* (Figure 29-5) and on the Metering > Analog Metering > Frequency screen of the front-panel display.

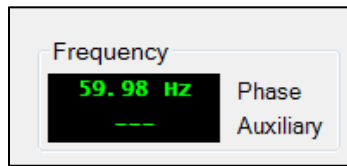


Figure 29-5. Analog Metering, Frequency Screen

**Differential**

The differential value is calculated as shown in the following equations:

If 87 Mode = Phase Differential and Slope Mode = Maximum, then  $IOP A = |I_{COMPA1} + I_{COMPA2}|$

where:  $I_{COMPA1} = \frac{IA_1}{TAP_1}$  and  $I_{COMPA2} = \frac{IA_2}{TAP_2}$

**Equation 29-1. IOP A Calculation when 87 Mode = Phase Differential**

If 87 Mode = Phase Differential, then  $IR A = \max (IRA_1, IRA_2)$

**Equation 29-2. IR A Calculation when 87 Mode = Phase Differential and Slope Mode = Maximum**

If 87 Mode = Phase Differential and Slope Mode = Average, then  $IR A = \text{avg} (IRA_1, IRA_2)$

**Equation 29-3. IR A Calculation when 87 Mode = Phase Differential and Slope Mode = Average**

Differential metering data is found in BESTCOMSP*lus* (Figure 29-6) and on the Metering > Analog Metering > Differential screen of the front-panel display.

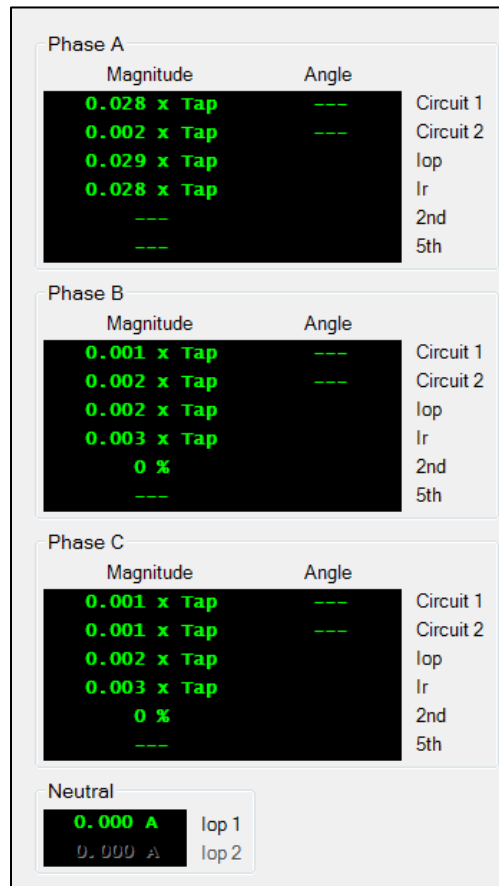


Figure 29-6. Analog Metering, Differential Screen

## Energy

Energy is metered for positive and negative watthours and varhours. Watthour and varhour values are calculated per minute as shown in Equation 29-4.

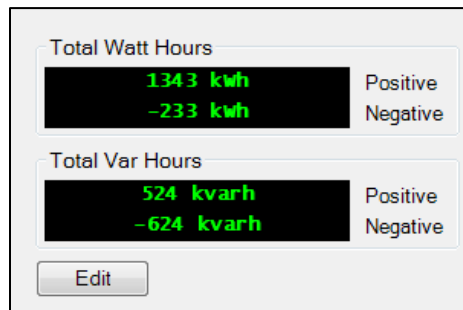
$$\frac{\text{Primary VT Ratio} \times \text{Primary CT Ratio}}{60 \text{ minutes}} \times \text{Secondary Watts or Vars}$$

**Equation 29-4. 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 BESTCOMSPUs (Figure 29-7) and on the Metering > Analog Metering > Energy screen of the front-panel display.



**Figure 29-7. Analog Metering, Energy Screen**

Click the Edit button to change the values. The Meter Energy Editor screen appears as shown in Figure 29-8. 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 29-8. Meter Energy Editor Screen**

## Analog Inputs and Outputs

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

The Analog Inputs screen is shown in Figure 29-9 and the Analog Outputs screen is shown in Figure 29-10.

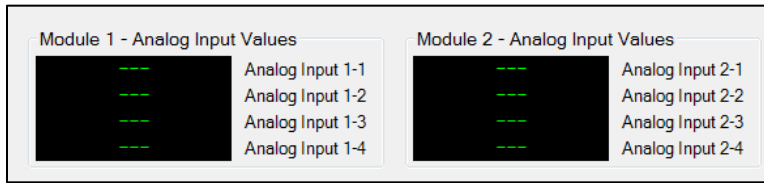


Figure 29-9. Analog Metering, Analog Inputs Screen

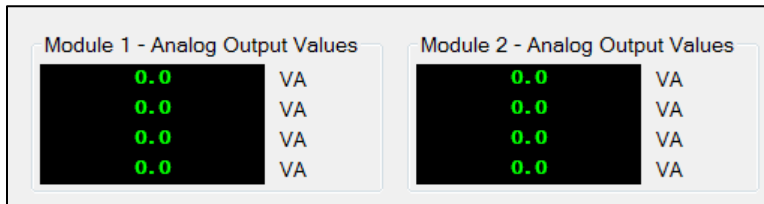


Figure 29-10. Analog Metering, Analog Outputs Screen

### RTD Meter

Figure 29-11 illustrates the RTD Meter screen. Temperatures are displayed from the optional RTD modules.

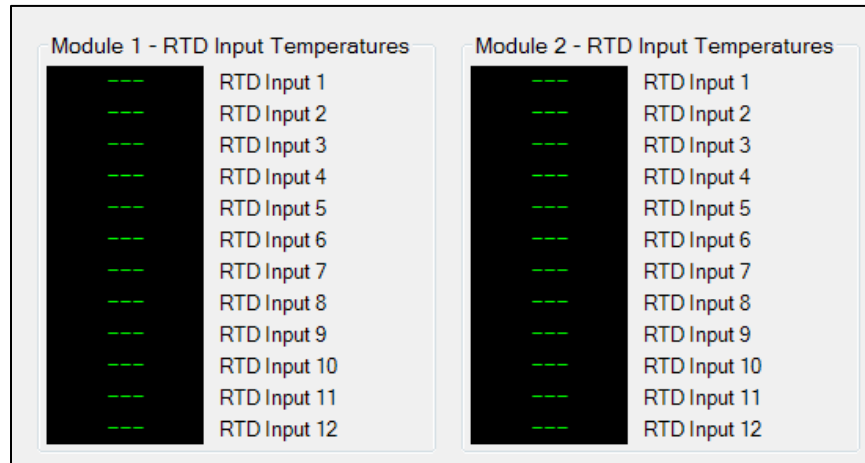
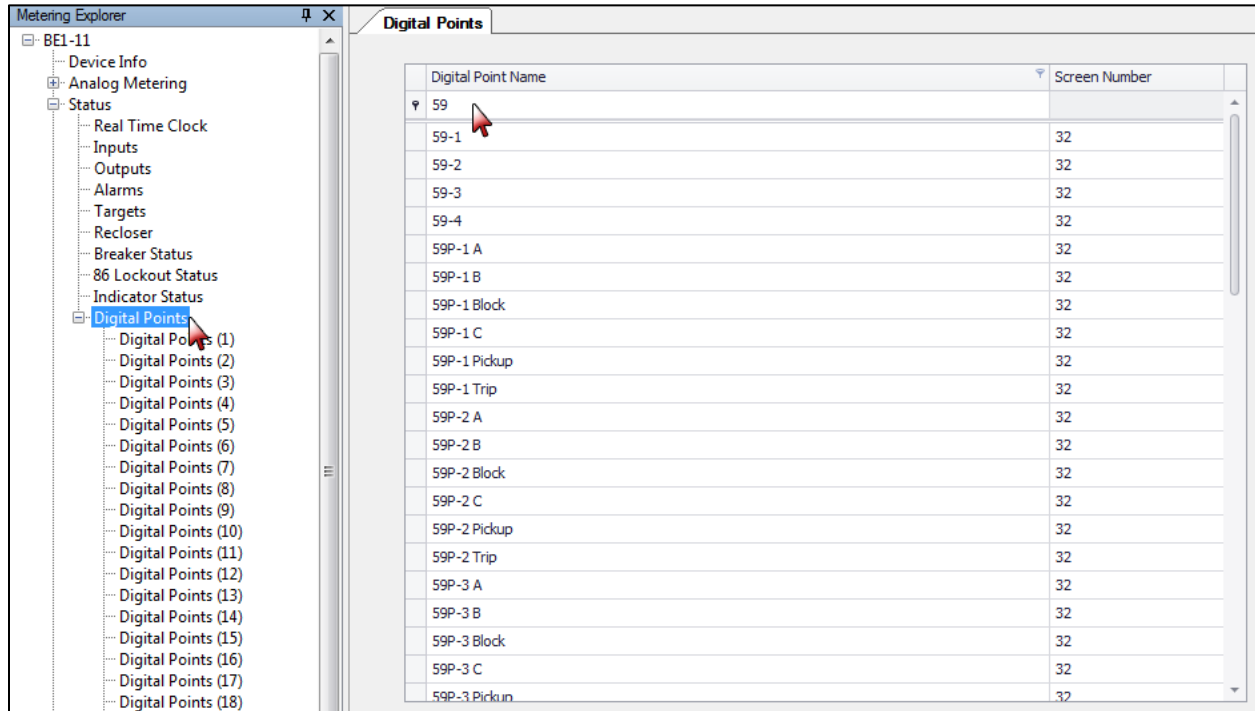


Figure 29-11. RTD Meter Screen



## 30 • Digital Points

BE1-11t digital points are shown in BESTCOMSPlus under *Metering Explorer, Status, Digital Points*. The user can search for points by scrolling through a grid of all points or by entering the point name in the top filter row. Clicking on the point name will open the corresponding monitor screen. The Search screen is available by clicking the Digital Points tree as shown in Figure 30-1. One of the digital points monitor screens is shown in Figure 30-2.



Digital Point Name	Screen Number
59	
59-1	32
59-2	32
59-3	32
59-4	32
59P-1 A	32
59P-1 B	32
59P-1 Block	32
59P-1 C	32
59P-1 Pickup	32
59P-1 Trip	32
59P-2 A	32
59P-2 B	32
59P-2 Block	32
59P-2 C	32
59P-2 Pickup	32
59P-2 Trip	32
59P-3 A	32
59P-3 B	32
59P-3 Block	32
59P-3 C	32
59P-3 Pickup	32

Figure 30-1. Digital Points – Search Screen



Figure 30-2. Digital Points – Monitor Screen

## 31 • 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 BE1-11 $\tau$ . 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 $\tau$  protection systems have three 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 *BESTCOMSPiPlus® Software* chapter for information on BE1-11 $\tau$  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 31-1.

**Table 31-1. 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.)

### **Sequence of Events Setup**

The Sequence of Events Setup screen is shown in Figure 31-1. Select events to be recorded in the Sequence of Events Log. All events are enabled by default.

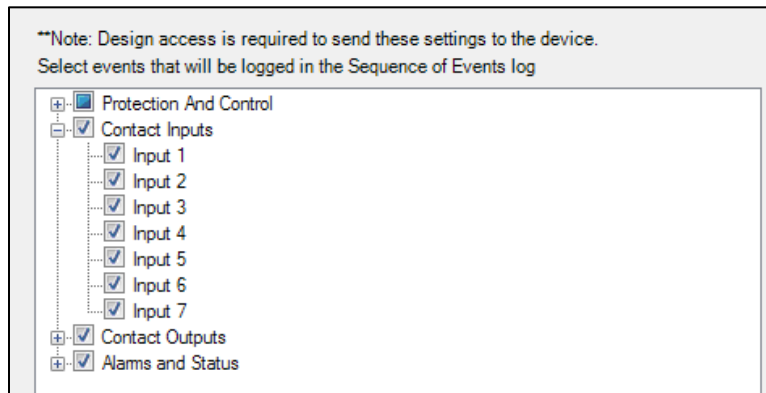


Figure 31-1. Sequence of Events Setup Screen

## Retrieving SER Information

Sequence of events data can be obtained through BESTCOMSP<sup>Plus</sup> and the web page interface.

### Viewing and Downloading SER Data through BESTCOMSP<sup>Plus</sup>®

Use the Metering Explorer to open the Reports, Sequence of Events screen. If an active connection to a BE1-11<sup>t</sup> is present, the sequence of events will automatically download. Using the Options button, you can copy, print, or save the Sequence of Events. The Refresh button is used to refresh/update the list of events. The Clear button will clear all events. The Toggle Sorting button enables sorting. Click on a column header to sort. See Figure 31-2.

Time Stamp	Sync	Device ID	Type	Num	Description	Status
2007-12-31 23:03:33.656	RTC	BE1-11	ALRM	0064	Fuse Loss	On
2008-01-01 22:45:33.200	RTC	BE1-11	ALRM	0064	Fuse Loss	Off
2008-01-01 22:45:33.268	RTC	BE1-11	PROT	0160	27P-1-Block	On
2008-01-02 18:31:26.200	RTC	BE1-11	PROT	0160	27P-1-Block	Off
2008-01-02 18:31:26.268	RTC	BE1-11	PROT	0160	27P-1-Block	On
2008-01-01 22:45:33.268	RTC	BE1-11	PROT	0832	50-4-Block	On
2008-01-02 18:31:26.200	RTC	BE1-11	PROT	0832	50-4-Block	Off
2008-01-02 18:31:26.268	RTC	BE1-11	PROT	0832	50-4-Block	On
2008-01-01 22:45:33.268	RTC	BE1-11	PROT	0864	50-5-Block	On
2008-01-02 18:31:26.200	RTC	BE1-11	PROT	0864	50-5-Block	Off
2008-01-02 18:31:26.268	RTC	BE1-11	PROT	0864	50-5-Block	On
2008-01-02 01:39:51.786	RTC	BE1-11	ALRM	1577	43-2-TagB Status	On
2008-01-02 18:31:26.200	RTC	BE1-11	ALRM	1577	43-2-TagB Status	Off
2008-01-02 18:31:26.276	RTC	BE1-11	ALRM	1577	43-2-TagB Status	On
2008-01-02 01:39:48.770	RTC	BE1-11	PROT	1578	43-2-TagI Status	On

Figure 31-2. 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.

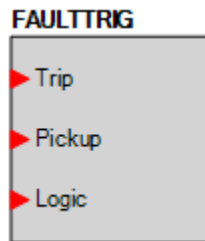
## 32 • Fault Reporting

The fault reporting function records and reports information about faults that have been detected by the BE1-11 $t$ . The BE1-11 $t$  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 BESTCOMSP $Plus$ <sup>®</sup>.

Figure 32-9 illustrates how each of these logic expressions is used by the various BE1-11 $t$  functions. Fault trigger logic connections are made on the BESTlogic<sup>™</sup>Plus screen in BESTCOMSP $Plus$ . The *BESTlogicPlus* chapter provides information about using BESTlogicPlus to program the BE1-11 $t$ . Figure 32-1 illustrates the fault reporting trigger logic block.



**Figure 32-1. 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 light 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.

#### **Pickup**

Pickup expressions are used by the fault reporting function to time-stamp the fault summary record, time the length of the fault from pickup to dropout (fault clearing time), and to control the recording of oscillographic data. The pickup expression is used to flash 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 BE1-11 $t$  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 32-9 and Table 32-3, call-out B). Table 32-1 lists targets as displayed. All targets are enabled by default.

Table 32-1. Targets as Displayed

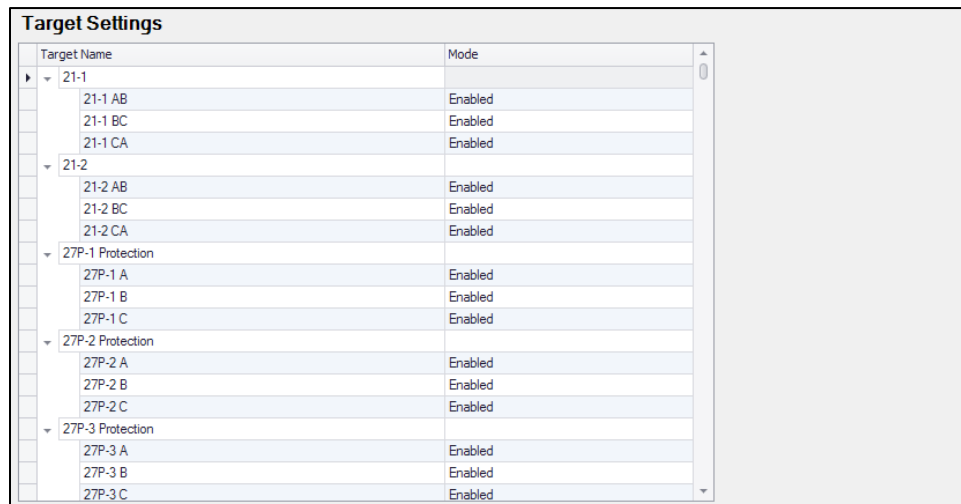
Target	Description
21-#-AB	Distance, AB
21-#-BC	Distance, BC
21-#-CA	Distance, CA
24	Overexcitation
27P-#-A/B/C	Phase Undervoltage, A, B, or C
27X-#-3V0	Auxiliary Undervoltage, 3V0-3ph VT
27X-#-V1	Auxiliary Undervoltage, Positive-Sequence
27X-#-V2	Auxiliary Undervoltage, Negative-Sequence
27X-#-AUX	Auxiliary Undervoltage, Fundamental VX
27X-#-3RD	Auxiliary Undervoltage, 3 <sup>rd</sup> Harmonic VX
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
51TF	Transformer Monitor
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, 3 <sup>rd</sup> Harmonic VX

Target	Description
60FL	Fuse Loss Detection
62-#	Timer Output
81-#-Over	Frequency, Over
81-#-Under	Frequency, Under
81-#-ROC	Frequency, Rate of Change
86-#	Lockout Function
87-A/B/C	Differential Current, Phase A, B, or C
87-Unrestrained A/B/C	87 Unrestrained, Phase A, B, or C
87N-#	Neutral Current Differential
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 BE1-11 $t$  is programmed to define which protective functions log targets.

### Target Settings

Targets are enabled using *BESTCOMSPlus*. 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 32-2.



Target Name	Mode
21-1	
21-1 AB	Enabled
21-1 BC	Enabled
21-1 CA	Enabled
21-2	
21-2 AB	Enabled
21-2 BC	Enabled
21-2 CA	Enabled
27P-1 Protection	
27P-1 A	Enabled
27P-1 B	Enabled
27P-1 C	Enabled
27P-2 Protection	
27P-2 A	Enabled
27P-2 B	Enabled
27P-2 C	Enabled
27P-3 Protection	
27P-3 A	Enabled
27P-3 B	Enabled
27P-3 C	Enabled

Figure 32-2. Target Settings Screen

### User Programmable Targets

**BESTCOMSPlus Navigation Path:** Settings Explorer, Target Configuration, User Programmable Targets

**HMI Navigation Path:** Not available through the front panel

Twelve user programmable targets are available. *BESTlogicPlus* Programmable Logic is used to set up target logic. User target labels are programmed on the User Programmable Targets screen (Figure 32-3) under Target Configuration. When active, the label of a user target is displayed on the front-panel display, in the fault report, and in the sequence of events report.

The screenshot displays a window titled "User Programmable Targets" containing eight individual configuration boxes for targets #1 through #8. Each box is organized as follows:

- Header:** "User Programmable Target #X" (where X is the target number).
- Label:** A text field labeled "Label".
- Target Name:** A text field labeled "Programmable Target X".

The boxes are arranged in two columns of four. The bottom edge of the window has a decorative, jagged border.

**Figure 32-3. User Programmable Targets Screen**

### Grouped Targets

A grouped target is announced when any target in the group is active. The group targets in Table 32-2 can be enabled or disabled on the Target Settings screen in BESTCOMSPi.us.

**Table 32-2. Grouped Targets**

Target	Targets in Group
Phase A	27P A 59P A 50 A 50 67 A 51 A 51 67 A 87 A 21 AB/CA
Phase B	27P B 59P B 50 B 50 67 B 51 B 51 67 B 87 B 21 AB/BC
Phase C	27P C 59P C 50 C 50 67 C 51 C 51 67 C 87 C 21 BC/CA
Phase G	50 G 50 67 G 51 G 51 67 G

Target	Targets in Group
Phase N	27X 3V0 27X Aux 59X 3V0 59X Aux 50 3I0 50 67 3I0 51 3I0 51 67 3I0 87N
Phase G/N	All G and N
Positive Sequence	27X V1 59X V1 50 I1 50 67 I1 51 I1 51 67 I1
Negative Sequence	27X V2 59X V2 50 I2 50 67 I2 51 I2 51 67 I2

### Retrieving Target Information and Resetting Targets

To view targets at the front-panel display, navigate to Metering > Status > Targets. The BE1-11 $t$  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 Metering > Status > Targets.

To view target status using BESTCOMSP $lus$ , use the Metering Explorer to open the Status, Targets screen shown in Figure 32-4.

Targets can also be viewed through the web page interface. Refer to the *BESTnet™Plus* chapter.

Targets can be cleared through BESTCOMSP $lus$  or by pressing the front-panel Reset button while viewing the Targets screen. Targets cannot be reset through the web page interface.

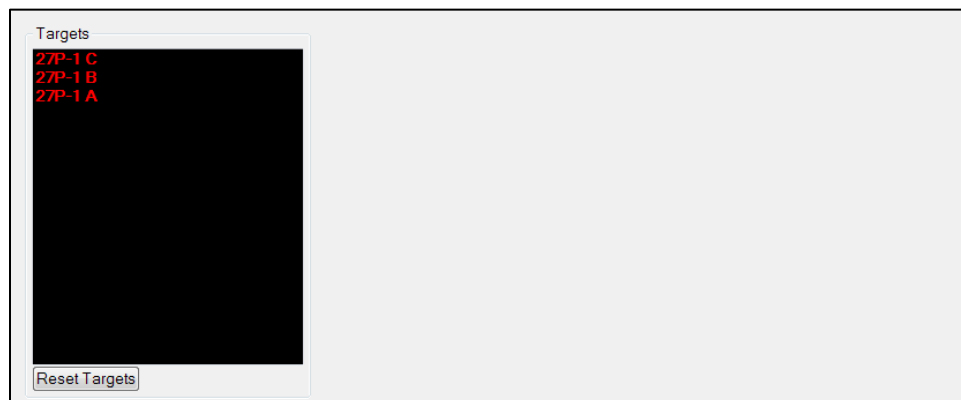
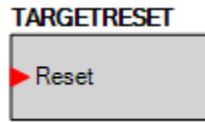


Figure 32-4. Targets Screen

A BESTlogicPlus expression can be used to reset the targets. Use the Settings Explorer within BESTCOMSP $lus$  to open the BESTlogicPlus 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 32-5.



**Figure 32-5. 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 *BESTlogicPlus*. Refer to the *BESTlogicPlus* chapter for more information.

## ***Fault Reports***

The BE1-11 $\ell$  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 BE1-11 $\ell$  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 BE1-11 $\ell$ . After event number 255 has been assigned, the numbering starts over at 1.

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

BE1-11 $\ell$  protection systems have three 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 Software* chapter for information on BE1-11 $\ell$  identification settings.

### **Viewing and Downloading Fault Data through BESTCOMSPlus®**

To view fault summary reports using *BESTCOMSPlus*, use the Metering Explorer to open the Reports, Fault Records screen shown in Figure 32-6. 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.

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 32-6) that are available to view/download. The Reset button resets new faults. The Trigger button manually triggers a fault.

Select the Fault Record to:

View All  
 View New  
 View Fault Details  
 View Fault Sequence of Events

#	Date	Time	Event Type	Osc
008	2007-12-31	23:28:13.797	Forced Trigger	1
007	2007-12-31	23:28:05.893	Forced Trigger	1
006	2007-12-31	23:27:10.804	Forced Trigger	1
005	2007-12-31	23:26:43.247	Forced Trigger	1
004	2007-12-31	23:26:42.047	Forced Trigger	1
003	2007-12-31	23:26:40.664	Forced Trigger	1
002	2007-12-31	23:26:39.255	Forced Trigger	1
001	2007-12-31	23:26:34.209	Forced Trigger	1

```

Product Name           : BE1-11T
Application Version    : 2.10.00
Station ID            : Station ID
Device ID             : BE1-11
User ID              : User ID
Relay Address(es)    :
IP                   : 10.0.111.72
Modbus Serial        : 1
Settings File Name   : DefaultSettingsFileName

Fault Time            : 2007-12-31 23:28:05.893
Fault Number         : 7
Event Type           : Forced Trigger
Event Trigger        : None
Active Group         : SG0
Recloser State       : Off

Fault Type           : NF
Targets              : None
Distance To Fault    : NA
Fault Clearing Time  : NA
Breaker Operate Time : NA
Oscillographic Record : RO-7B1

VAN : 119.98 V @ 0.0 *
VBN : 119.98 V @ 240.0 *
VCN : 119.99 V @ 120.0 *
VO  : 0.01 V @ NA
V1  : 119.98 V @ 0.0 *
V2  : 0.00 V @ NA
IA  : 5.00 A @ 360.0 *
IB  : 4.99 A @ 240.0 *
IC  : 5.00 A @ 120.0 *
IG  : 5.00 A @ 360.0 *
3I0 : 0.00 A @ NA
I1  : 5.00 A @ 0.0 *
I2  : 0.00 A @ NA
IA Circuit 2 : 0.00 A @ NA
IB Circuit 2 : 86.65 A @ 348.8 *
  
```

Figure 32-6. 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 *BESTCOMSPlus* 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 32-9 and Table 32-3, call-out A.

### Fault Number

This line reports the sequential number (from 1 to 255) assigned to the report by the BE1-11 $\ell$ .

### 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 BE1-11 $\ell$  tripped to clear the fault.
2. Pickup: A fault was detected as defined by the pickup expression but the BE1-11 $\ell$  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 BESTCOMSP $\ell$  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 32-9 and Table 32-3, 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 32-9 and Table 32-3, call-out F.

### Fault Clearing Time

This line reports the time from when the BE1-11 $\ell$  detected the fault until the BE1-11 $\ell$  detected that the fault had cleared. Refer to Figure 32-9 and Table 32-3, call-out C.

- If the fault report was triggered through the BESTCOMSP $\ell$  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 triggered 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 32-9 and Table 32-3, call-out E. Recording of oscillographic records is described later in this chapter.

### VA, IA, IA Circuit 2, VB, IB, IB Circuit 2, VC, IC, IC Circuit 2

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 BE1-11 $t$  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 32-9 and Table 32-3, 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 BE1-11 $t$  tripping, the recorded fault voltages are for the power system cycle two cycles prior to the end of the fault. Refer to Figure 32-9 and Table 32-3, call-out F.

### IG, IG Circuit 2

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 BE1-11 $t$  tripping, the recorded fault current is for the power system cycle two cycles prior to the end of the fault. Refer to Figure 32-9 and Table 32-3, call-out F.

### 3I0, 3I0 Circuit 2, I1, I1 Circuit 2, I2, I2 Circuit 2

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 BE1-11 $t$  tripping, the recorded fault currents are for the power system cycle two cycles prior to the end of the fault. Refer to Figure 32-9 and Table 32-3, 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 32-9 and Table 32-3, 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 BE1-11 $t$  tripping, the recorded fault voltages are for the power system cycle two cycles prior to the end of the fault. Refer to Figure 32-9 and Table 32-3, 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 BE1-11 $t$  can store up to 2,048 cycles of data at 8 samples per cycle or 512 cycles of data at 32 samples per cycle.

All channels are recorded (IA, IA Circuit 2, IB, IB Circuit 2, IC, IC Circuit 2, IG, IG Circuit 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 $t$  protection systems have three 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 *BESTCOMSPPlus Software* chapter for information on BE1-11 $t$  identification settings.

### Oscillographic Records Settings

The oscillographic records settings are programmed through BESTCOMSPPlus. Use the Settings Explorer to open the Metering Configuration, Fault Records screen as shown in Figure 32-7. Enter the values for Sample Resolution, Number of Records to Store, and Prefault Cycles.

The screenshot shows a configuration window titled "Fault Records". Inside, there is a sub-section "Oscillographic Fault Record Setup" with the following settings:

- Sample Resolution: 32 Samples/cycle
- Number of Records to Store: 32 Records
- Cycles Per Record: 16
- Prefault Cycles: 2 Cycles

Figure 32-7. Fault Records Screen

### Retrieving Oscillographic Records

Oscillographic records can be downloaded through the Reports, Fault Reports screen in BESTCOMSPPlus (Figure 32-6). 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 $t$  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 BESTCOMSPPlus or the front-panel interface.

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 BESTCOMSP<sup>Plus</sup>, 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 32-8.

**Figure 32-8. Power System Screen**

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<sub>t</sub> 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  $\pm 300\%$  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

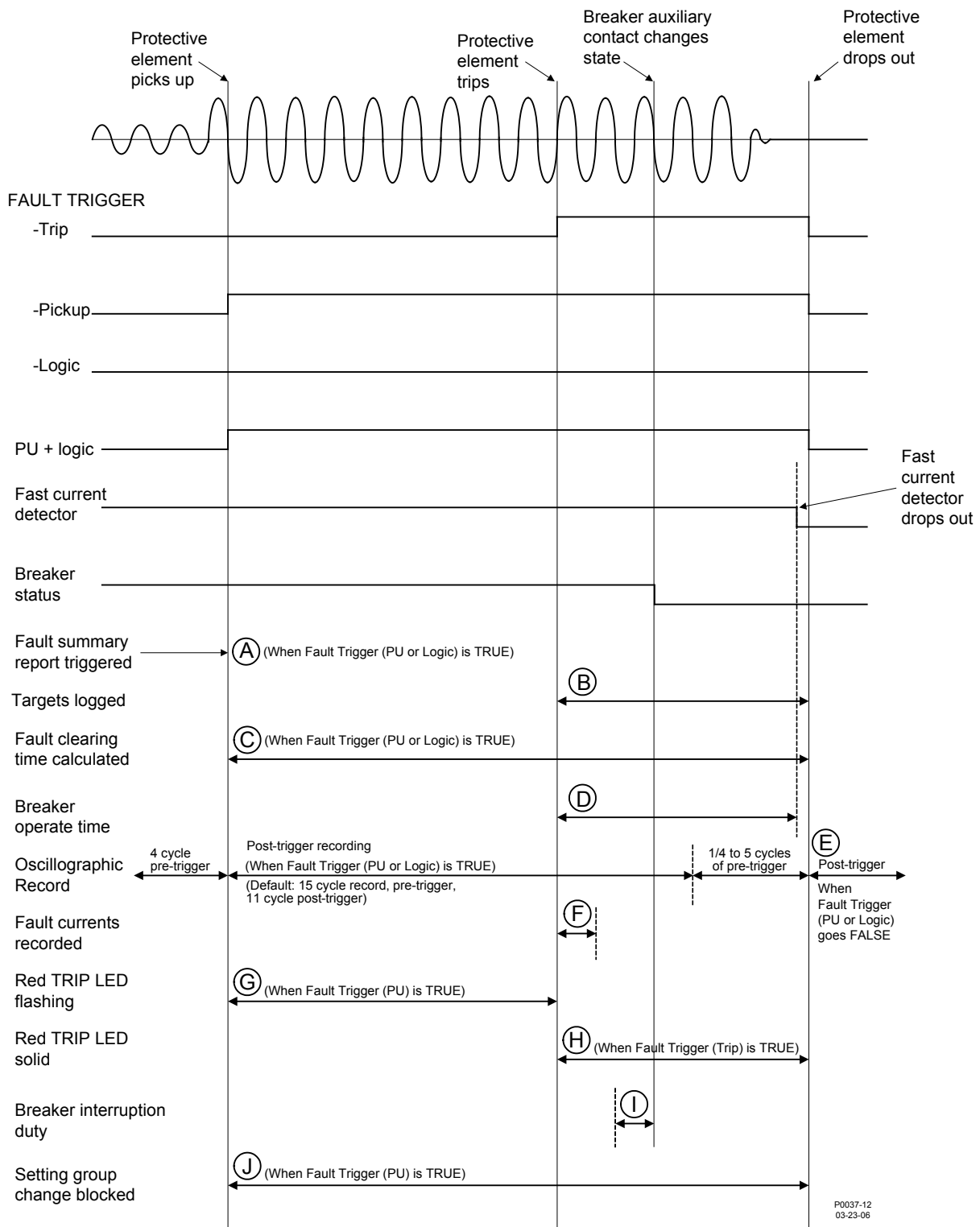


Figure 32-9. Protective Fault Analysis

Table 32-3. Legend for Figure 32-9

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 <i>BESTCOMSPlus</i> .
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 downstream 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 <i>BESTCOMSPlus</i> .
G	During the time that the Pickup expression is true, the red Trip LED on the front panel flashes indicating that the BE1-11 $\iota$ 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 BE1-11 $\iota$ 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.



## 33 • Alarms

The BE1-11 $\ell$  monitors internal systems, external interfaces, and power system equipment and annunciates an alarm when one of these components fails. An alarm can be configured as latching or non-latching with a status of major or minor. It can also be used as an input to other logic blocks in BESTlogic™*Plus*. Latching alarms are stored in nonvolatile memory and are retained even when BE1-11 $\ell$  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 BE1-11 $\ell$  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 BE1-11 $\ell$  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 33-1.

**Table 33-1. Available Alarms**

Name	Description
101 Blocking Tag Status	101 breaker control switch block tag is set
24 Volts Per Hz	Overexcitation
310 Demand	Neutral current unbalance demand
43-1 Blocking Tag Status	43-1 virtual switch block tag set
43-2 Blocking Tag Status	43-2 virtual switch block tag set
43-3 Blocking Tag Status	43-3 virtual switch block tag set
43-4 Blocking Tag Status	43-4 virtual switch block tag set
43-5 Blocking Tag Status	43-5 virtual switch block tag set
51TF Through Fault	Transformer Monitor
87 Alarm	Current Differential
Analog	Analog-to-digital converter error
Breaker Fail	Breaker failure
Breaker Monitor 1	Breaker alarm 1 threshold exceeded
Breaker Monitor 2	Breaker alarm 2 threshold exceeded
Breaker Monitor 3	Breaker alarm 3 threshold exceeded
Changes Lost	Password access lost. Read only
Date Time Set	The date/time was set by the user
Default Cal Loaded	Error reading the RTD module nonvolatile calibration settings which forces default calibration settings to be loaded. This alarm is set by the remote RTD module.
Defaults Loaded	Error reading the RTD module nonvolatile settings which forces default settings to be loaded. This alarm is set by the remote RTD module.
DNP Polls Error	DNP polling failure
Ethernet Excessive Traffic	Local network overloaded
Ethernet Link Lost	Ethernet communication lost

Name	Description
Fault Report Timeout	True if fault event trigger lasts longer than 60 seconds
Firmware Change	Firmware has been changed
Flash Failure	Error reading the RTD module nonvolatile settings (FLASH READ FAIL) or error writing the RTD module nonvolatile settings (FLASH WRITE FAIL). This alarm is set by the remote RTD module.
Freq Out Of Range	Frequency is out of range
Fuse Loss	One or more phases of voltage lost
I2 Demand	Negative-sequence current unbalance demand
IG Demand	Ground current demand
IP Demand	Phase current demand
IRIG Sync Lost	IRIG failed to synchronize
Logic Equal None	Active logic = NONE
No User Setting	User settings do not exist
NTP Sync Lost	Network Time Protocol (NTP) sync lost
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 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
Output Alarm Override Control	Override enabled on Output Alarm
Output Override	One or more output contacts have logic output override condition
Power Loss Alarm	Operating power lost
Programmable Alarm 1	Programmable alarm 1 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
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

Name	Description
Programmable Alarm 9	Programmable alarm 9 is true
Real Time Clock	Real-time clock not set
Recloser Fail	Reclose fail timer timed out before breaker closed
Recloser Lockout	Recloser went through sequence without success
RTD Comm Receive Fail	BE1-11 $t$ cannot communicate with the RTD module. This alarm is set by the BE1-11 $t$ .
RTD Comm Send Fail	RTD module cannot communicate with the BE1-11 $t$ . This alarm is set by the remote RTD module.
RTD Out of Range	RTD out of range. See the <i>RTD Module</i> chapter for acceptable range.
S Demand	Apparent power (VA) demand maximum exceeded
Setting Change	Setting change made by user
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
SGC Active	Active setting group changed
SGC Logic Override	Setting group control was overridden by logic
Trip Coil Monitor	Monitored trip circuit open
uP Reset Alarm	Microprocessor watchdog circuit timed out
Var Negative Demand	Negative var demand maximum exceeded
Var Positive Demand	Positive var demand maximum exceeded
Watt Forward Demand	Forward watt demand maximum exceeded
Watt Reverse Demand	Reverse watt demand maximum exceeded

## Alarm Settings

**BESTCOMSPlus Navigation Path:** Settings Explorer, Alarm Configuration, Alarms

**HMI Navigation Path:** Not available through the front panel

Alarms are enabled using BESTCOMSPlus. Use the Settings Explorer to open the Alarm Configuration, Alarms tree branch. Configure alarms by selecting Disabled, Latching, or Non-Latching from the Minor, Major, and Logic drop-down menus next to the alarms. Refer to Figure 33-1.

Alarm Settings				
Alarm Name	Minor	Major	Logic	
60FL Fuse Loss	Disabled	Disabled	Disabled	
24 Volts Per Hz	Disabled	Disabled	Disabled	
Virtual Switch Blocking Tags				
43-1 Blocking Tag Status	Disabled	Disabled	Disabled	
43-2 Blocking Tag Status	Disabled	Disabled	Disabled	
43-3 Blocking Tag Status	Disabled	Disabled	Disabled	
43-4 Blocking Tag Status	Disabled	Disabled	Disabled	
43-5 Blocking Tag Status	Disabled	Disabled	Disabled	
101 Blocking Tag Status	Disabled	Disabled	Disabled	
79 Recloser Fail	Disabled	Disabled	Disabled	
79 Recloser Lockout	Disabled	Disabled	Disabled	
50BF Breaker Fail	Disabled	Disabled	Disabled	
52 Trip Coil Monitor	Disabled	Disabled	Disabled	
Demands (CT Circuit 1)				
IP Demand	Disabled	Disabled	Disabled	
3I0 Demand	Disabled	Disabled	Disabled	
I2 Demand	Disabled	Disabled	Disabled	
IG Demand	Disabled	Disabled	Disabled	
Demands (CT Circuit 2)				
IP Demand	Disabled	Disabled	Disabled	

Figure 33-1. Alarm Settings Screen

## User Programmable Alarms

**BESTCOMSPPlus Navigation Path:** Settings Explorer, Alarm Configuration, User Programmable Alarms

**HMI Navigation Path:** Not available through the front panel

Sixteen user programmable alarms are available. BESTLogicPlus Programmable Logic is used to set up alarm logic. User alarm labels are programmed on the User Programmable Alarms screen (Figure 33-2) 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.

User Programmable Alarms	
User Programmable Alarm #1 Label Programmable Alarm 1	User Programmable Alarm #2 Label Programmable Alarm 2
User Programmable Alarm #3 Label Programmable Alarm 3	User Programmable Alarm #4 Label Programmable Alarm 4
User Programmable Alarm #5 Label Programmable Alarm 5	User Programmable Alarm #6 Label Programmable Alarm 6
User Programmable Alarm #7 Label Programmable Alarm 7	User Programmable Alarm #8 Label Programmable Alarm 8

Figure 33-2. User Programmable Alarms Screen

## Retrieving Alarm Information

**BESTCOMSPPlus Navigation Path:** Metering Explorer, Status, Alarms

**HMI Navigation Path:** Metering Explorer, Status, Alarms

Major and Minor alarms can be viewed through BESTCOMSPPlus, 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 Metering > Status > Alarms. 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 *BESTCOMSPi*, use the Metering Explorer to open the Status, Alarms screen shown in Figure 33-3. Alarms can be reset by clicking the Reset Alarms button under the appropriate column.

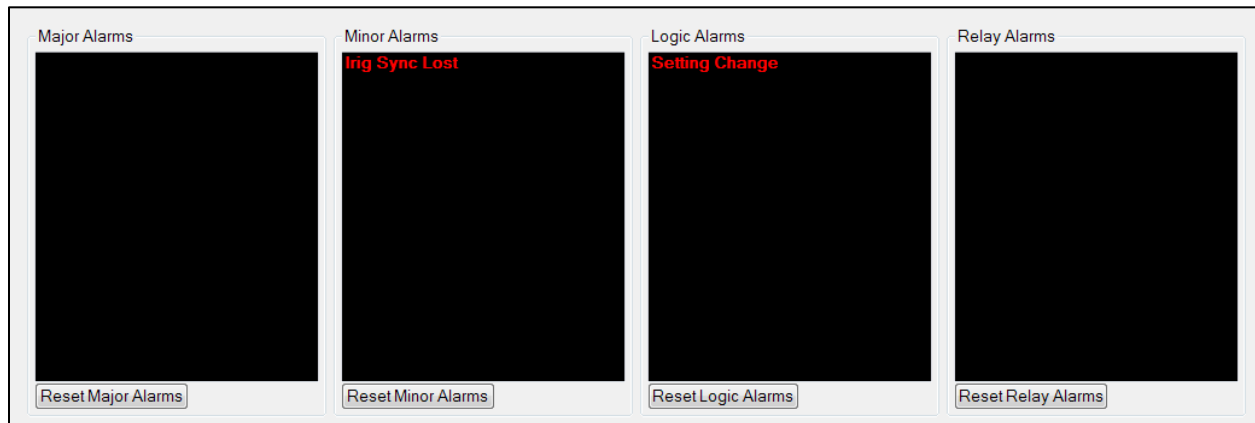


Figure 33-3. Alarms Screen

## Resetting Alarms

A *BESTlogicPlus* expression can be used to reset the alarms. Use the Settings Explorer within *BESTCOMSPi* to open the *BESTlogicPlus* Programmable Logic tree branch. Select the Major Alarm Reset, Minor Alarm Reset, or Logic 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. The Logic Alarm Reset will reset all logic 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 33-4.

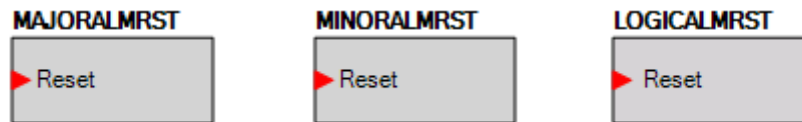


Figure 33-4. Alarm Reset Logic Block

Major and Minor alarms can be cleared by pressing the Reset button on the front-panel interface while the Alarms screen is being displayed or through *BESTCOMSPi*. 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, as long as no other port has access higher than Read. 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 is available as a status input in *BESTlogicPlus*. Refer to the *BESTlogicPlus* chapter for more information.



## 34 • Differential Reporting

The BE1-11*t* records information about the phase current differential (87) status of the BE1-11*t* and creates a differential report. Only one report is stored in nonvolatile memory. When a new report is generated, the BE1-11*t* discards the old report and replaces it with the new one.

To view differential reports using BESTCOMSP*lus*®, use the Metering Explorer to open the Reports, Differential Report screen shown in Figure 34-1.

From this screen, you can choose to Download the latest differential report into BESTCOMSP*lus*, Save the latest differential report to a file, or Trigger a new differential report.

Download
Save To File...
Trigger

```

BE1-11 DIFFERENTIAL CHECK RECORD
PRODUCT NAME       :BE1-11T
APPLICATION VERSION :2.08.05
STATION ID         :Station ID
DEVICE ID          :BE1-11
USER ID            :User ID
RELAY ADDRESS (ES) :
IP                 :10.0.111.72
MODBUS ETHERNET    :1
SETTINGS FILE NAME :DefaultSettingsFileName
REPORT DATE TIME   :2007-12-31 23:21:19.144
ACTIVE GROUP       :SGO

PHASE 87 SETTINGS  CTR   CT CON  TX CON  GROUNDED  ABC SWAP  180 Comp  DIFF CKT
CT CKT1            1     WYE    WYE     NO        ABC       NO        PRI
CT CKT2            1     WYE    WYE     NO        ABC       NO        PRI

MINPU              0 * TAP
SECPU              0
SLOPE1             45 %
SLOPE2             45 %
ALARM SLOPE        0 %

COMPENSATION        ANGLE  ROTATE  ABC SWAP  GROUND  TAP
CT CKT1            DAB    NA     NO        NO       2.00
CT CKT2            DAB    NA     NO        NO       2.00

ALARMS              PHASE A      PHASE B      PHASE C
DIFFERENTIAL       OK           OK           OK
POLARITY           ALARM       ALARM       ALARM
ANGLE COMP         OK           OK           OK
MISMATCH           OK           OK           OK

MEASUREMENTS       PHASE A      PHASE B      PHASE C
PRIMARY
CT CKT1            0.001 @ 232.4  0.001 @ 16.5  0.001 @ 205.4
CT CKT2            0.002 @ 224.1  0.002 @ 1.5   0.001 @ 76.5

SECONDARY
CT CKT1            0.001 @ 232.4  0.001 @ 16.5  0.001 @ 205.4
CT CKT2            0.002 @ 224.1  0.002 @ 1.5   0.001 @ 76.5

COMPENSATED
CT CKT1            0.000 @ 0.0   0.000 @ 0.0   0.000 @ 0.0
CT CKT2            0.000 @ 0.0   0.000 @ 0.0   0.000 @ 0.0

IOP                0.00 * TAP    0.00 * TAP    0.00 * TAP
IR                 0.00 * TAP    0.00 * TAP    0.00 * TAP
SLOPE RATIO 1     ---          ---          ---
SLOPE RATIO 2     ---          ---          ---

```

Figure 34-1. Differential Report Screen



## 35 • 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 79 function, and the 52TCM function. The breaker status logic block is shown in Figure 35-1.

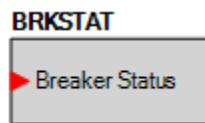


Figure 35-1. Breaker Status Logic Block

### BESTlogic™ Plus Settings for Breaker Status

Since the BE1-11 $\iota$  is completely programmable, it is necessary to program which logic variable will monitor breaker status. Breaker status is programmed using BESTCOMSPPlus®. Use the Settings Explorer to open the BESTlogicPlus 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 BESTlogicPlus programmable logic.

Table 35-1 summarizes the BESTlogicPlus settings for Breaker Status.

Table 35-1. BESTlogicPlus 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

**BESTCOMSPPlus Navigation Path:** Metering Explorer, Status, Breaker Status

**HMI Navigation Path:** Metering Explorer, Status, Breaker Status

Breaker status can be viewed through BESTCOMSPPlus, the front-panel display, and the web page interface.

To view breaker status using BESTCOMSPPlus, use the Metering Explorer to open the Status, Breaker Status screen shown in Figure 35-2. To view breaker status at the front-panel display, navigate to Metering Explorer, Status, Breaker Status.



Figure 35-2. 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 BE1-11 $\iota$  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. To view the breaker status using BESTCOMSP<sup>Plus</sup>, 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 35-3 illustrates breaker status during a fault and protective trip. Table 35-2 serves as a legend for the call-outs of Figure 35-3.

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 BE1-11 $t$  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 BE1-11 $t$  by injecting currents into the BE1-11 $t$ , the values in the duty registers should be read and recorded prior to the start of testing. Once testing is complete and the BE1-11 $t$  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.

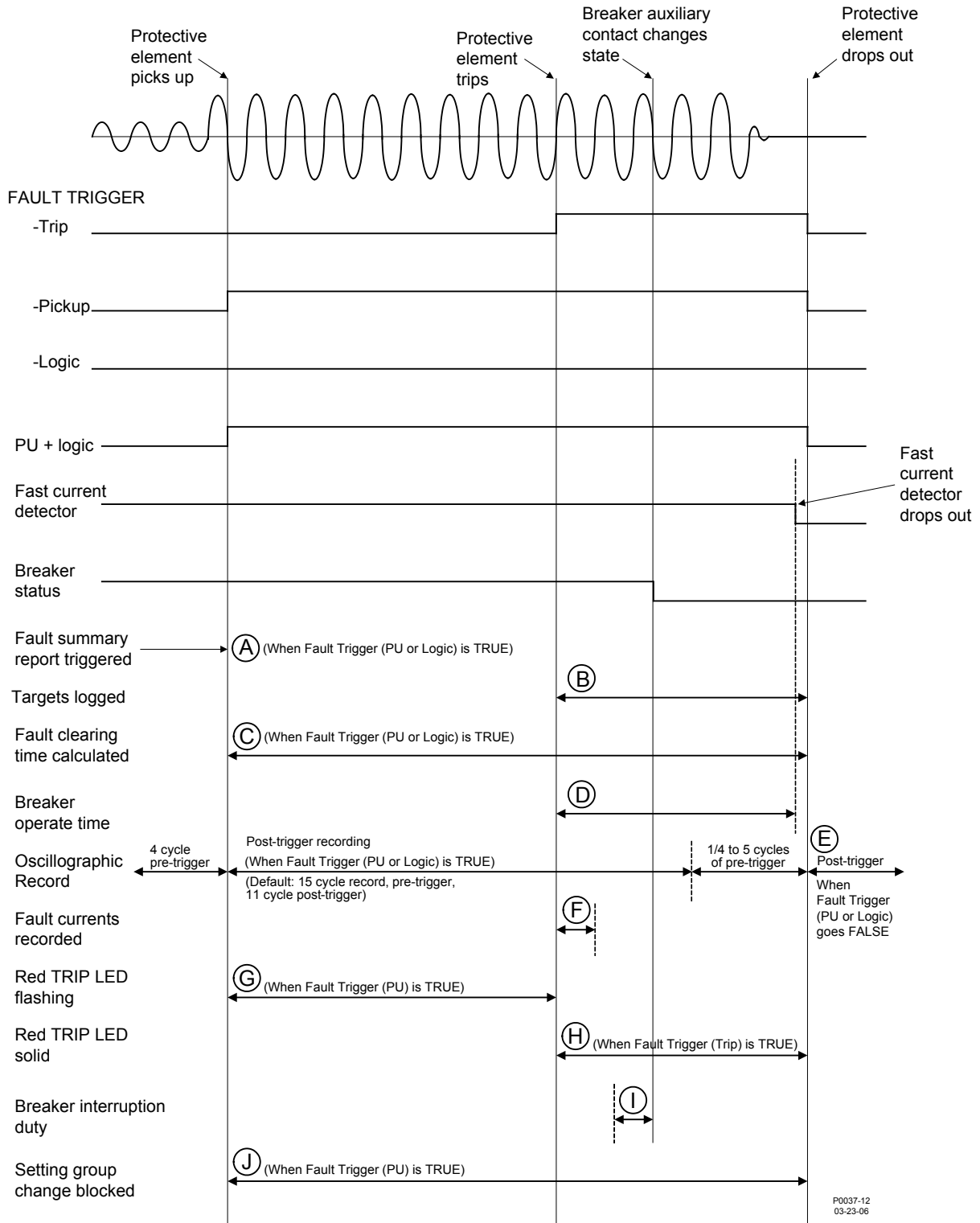


Figure 35-3. Protective Fault Analysis

Table 35-2. Legend for Figure 35-3

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 <i>BESTCOMSPPlus</i> .
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 downstream 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 <i>BESTCOMSPPlus</i> .
G	During the time that the Pickup expression is true, the red Trip LED on the front panel flashes indicating that the BE1-11 $\tau$ 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 BE1-11 $\tau$ 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

**BESTCOMSPPlus Navigation Path:** Settings Explorer, Alarm Configuration, Breaker Monitoring

**HMI Navigation Path:** Settings Explorer, Alarm Configuration, Breaker Monitor

Breaker Duty Monitoring settings are made using *BESTCOMSPPlus*. Use the Settings Explorer to open the Alarm Configuration, Breaker Monitoring tree branch shown in Figure 35-4.

Using the pull-down menus and settings boxes, make the application-appropriate settings to the breaker duty monitoring function.

Figure 35-4. Breaker Monitoring Screen

To connect the Block logic input, use the Settings Explorer within *BESTCOMSPlus* to open the *BESTlogicPlus* 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 *BESTlogicPlus* programmable logic.

The breaker monitor logic block is shown in Figure 35-5.

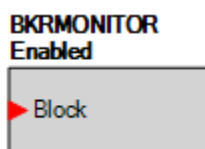


Figure 35-5. Breaker Monitor Logic Block

Table 35-3 summarizes the Breaker Duty Monitoring settings.

Table 35-3. 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 <u>not</u> counted.	0

## Retrieving Breaker Duty Information

**BESTCOMSPlus 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 *BESTCOMSPi*us. Use the Metering Explorer to open the Reports, Breaker Monitor screen shown in Figure 35-6.



Figure 35-6. 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

**BESTCOMSPi us Navigation Path:** Settings Explorer, Alarm Configuration, Breaker Monitoring

**HMI Navigation Path:** Settings Explorer, Alarm Configuration, Breaker Monitor

Settings are made using *BESTCOMSPi us*. Use the Settings Explorer to open the Alarm Configuration, Breaker Monitoring tree branch shown in Figure 35-4.

Using the pull-down menus and settings boxes, make the application-appropriate settings to the breaker alarms.

## 36 • 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 $t$  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 Circuit 1, IA Circuit 2, IB Circuit 1, IB Circuit 2, IC Circuit 1, IC Circuit 2), neutral current (3I0 Circuit 1, 3I0 Circuit 2), negative-sequence current (I2 Circuit 1, I2 Circuit 2), and ground current (IG Circuit 1, IG Circuit 2).

### Demand Current Reporting Settings

**BESTCOMSP $Plus$  Navigation Path:** Settings Explorer, Alarm Configuration, Demands

**HMI Navigation Path:** Settings Explorer, Alarm Configuration, Demands

Settings are made using BESTCOMSP $Plus$ <sup>®</sup>. 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 36-1.

The screenshot shows the 'Demands' configuration screen with the following sections and settings:

- Interval:**
  - Phase (min): 15.0
  - Neutral/Ground (min): 15.0
  - Negative Sequence (min): 15.0
- Current Thresholds (CT Circuit 1):**
  - Phase: 0.00 (Secondary A), 0.00 (Primary A)
  - Neutral/Ground: 0.00 (Secondary A), 0.00 (Primary A)
  - Negative Sequence: 0.00 (Secondary A), 0.00 (Primary A)
- Current Thresholds (CT Circuit 2):**
  - Phase: 0.00 (Secondary A), 0.00 (Primary A)
  - Neutral/Ground: 0.00 (Secondary A), 0.00 (Primary A)
  - Negative Sequence: 0.00 (Secondary A), 0.00 (Primary A)
- Real Power Thresholds:**
  - Forward: 0.0 (Secondary W), 0.0 (Primary W)
  - Reverse: 0.0 (Secondary W), 0.0 (Primary W)
- Reactive Power Thresholds:**
  - Forward: 0.0 (Secondary var), 0.0 (Primary var)
  - Reverse: 0.0 (Secondary var), 0.0 (Primary var)
- Apparent Power Thresholds:**
  - Threshold: 0.0 (Secondary VA), 0.0 (Primary VA)

Figure 36-1. Demands Screen

### 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

**BESTCOMSPi.us Navigation Path:** Settings Explorer, Alarm Configuration, Demands

**HMI Navigation Path:** Settings Explorer, Alarm Configuration, Demands

Settings are made using BESTCOMSPi.us. 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 36-1.

## Retrieving Demand Reporting Information

**BESTCOMSPi.us 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 BESTCOMSPi.us, 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 BESTCOMSPi.us, use the Metering Explorer to open the Demand tree branch and select Demand Current (Figure 36-2), Demand Power (Figure 36-3), Demand Reactive Power, or Demand Apparent Power. The Demand Reactive Power and Demand Apparent Power screens are similar.

Demand Current			
Peak	Peak Time	Present	
4.997 A	2014-03-06 14:22	4.997 A	IA
4.996 A	2014-03-06 14:43	4.995 A	IB
4.996 A	2014-03-06 14:24	4.995 A	IC
4.996 A	2014-03-06 14:38	4.996 A	IG

Demand Sequence Current			
Peak	Peak Time	Present	
4.976 A	2014-03-06 14:45	4.976 A	I2
9.869 A	2014-03-06 14:39	0.091 A	3I0

Edit

Figure 36-2. Demand Current Screen

Positive Real Power Demands			
Peak	Peak Time	Present	
0.599 kw	2014-03-06 14:23	0.510 kw	Phase A
0.599 kw	2014-03-06 14:40	0.502 kw	Phase B
0.599 kw	2014-03-06 14:24	0.510 kw	Phase C
1.80 kw	2014-03-06 14:24	1.52 kw	Total

Negative Real Power Demands			
Peak	Peak Time		
-0.300 kw	2014-03-06 14:43		Phase A
-0.385 kw	2014-03-06 14:42		Phase B
-0.300 kw	2014-03-06 14:42		Phase C
-0.985 kw	2014-03-06 14:42		Total

Edit

Figure 36-3. Demand Power Screen

---

Refer to the *BESTnet™Plus* chapter for information on viewing the demands through the web page interface.



## 37 • 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.

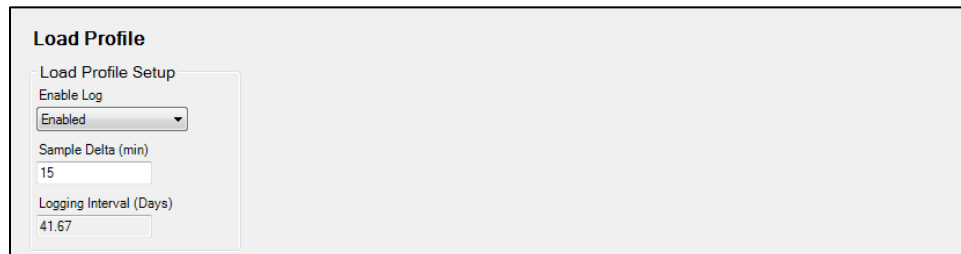
### ***Setting the Load Profile Recording Function***

**BESTCOMSPlus 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 BESTCOMSPlus®. Use the Settings Explorer to open the Load Profile screen under Metering Configuration.

The BESTCOMSPlus Load Profile screen is illustrated in Figure 37-1.



The screenshot shows the 'Load Profile' configuration screen. It includes the following fields and controls:

- Load Profile Setup** (Section Header)
- Enable Log**: A dropdown menu currently set to 'Enabled'.
- Sample Delta (min)**: A text input field containing the value '15'.
- Logging Interval (Days)**: A text input field containing the value '41.67'.

**Figure 37-1. Load Profile Screen**

### ***Retrieving Load Profile Recorded Data***

**BESTCOMSPlus Navigation Path:** Metering Explorer, Reports, Load Profile

**HMI Navigation Path:** Not available through the front panel

Recorded load profile data can be downloaded through BESTCOMSPlus on the Load Profile screen under Reports of the Metering Explorer.



## 38 • Power Quality

The BE1-11 $t$  offers class B power quality measurement performance as defined by IEC 610004-30. Power quality data consists of voltage, distortion, dips/swells, and harmonics. Power quality is reported through BESTCOMSPlus®, 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.

### Operation

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A dip event begins when any one phase decreases below the dip threshold and ends when all phases return above the dip threshold and dip hysteresis. A swell event begins when any one phase increases above the swell threshold and ends when all phases return below the swell threshold and swell hysteresis. A dip event reports dip duration and the residual voltage measured during the dip event. A swell event reports swell duration and the maximum voltage measured during the swell event. It is possible for a dip or swell event to begin on one phase and end on another. It is also possible for a dip and a swell to occur at the same time on different phases.

### Reference Mode

In Sliding mode, dip and swell thresholds are calculated based on the sliding average voltage, which changes over time. In Fixed mode, dip and swell thresholds are calculated based on the system rated voltage.

### Dip Hysteresis

This setting determines the hysteresis of the dip threshold. For example, a value of 1.02 sets the hysteresis to 2% of the dip threshold.

### Dip Ratio

This setting determines the dip threshold. For example, a value of 0.90 sets the dip threshold to 90% of the reference voltage.

### Swell Hysteresis

This setting determines the hysteresis of the swell threshold. For example, a value of 0.98 sets the hysteresis to 2% of the swell threshold.

### Swell Ratio

This setting determines the swell threshold. For example, a value of 1.10 sets the swell threshold to 110% of the reference voltage.

### Settings

---

**BESTCOMSPlus Navigation Path:** Settings Explorer, Metering Configuration, Power Quality

**HMI Navigation Path:** Settings Explorer, Metering Configuration, Power Quality

Settings are made using BESTCOMSPlus. Use the Settings Explorer to open the Metering Configuration, Power Quality tree branch. The Power Quality screen is illustrated in Figure 38-1.

Figure 38-1. Metering Configuration, Power Quality Screen

## Metering

**BESTCOMSPlus Navigation Path:** Metering Explorer, Power Quality

**HMI Navigation Path:** Metering Explorer, Power Quality

Power quality data can be viewed using BESTCOMSPlus, through the front-panel interface, and through the web page interface. To view data using BESTCOMSPlus, use the Metering Explorer to open the Power Quality tree branch.

## Voltage

Figure 38-2 illustrates the Power Quality, Voltage screen.

Frequency				
<b>60.00 Hz</b>		FREQ 10S		
Primary Voltage				
200 ms	3 sec	10 min	2 hour	
<b>120.0 v</b>	<b>120.0 v</b>	<b>120.0 v</b>	<b>120.0 v</b>	VA
<b>120.0 v</b>	<b>120.0 v</b>	<b>120.0 v</b>	<b>120.0 v</b>	VB
<b>120.0 v</b>	<b>120.0 v</b>	<b>120.0 v</b>	<b>120.0 v</b>	VC
---	---	---	---	VAB
---	---	---	---	VBC
---	---	---	---	VCA
Voltage Unbalance				
200 ms	3 sec	10 min	2 hour	
<b>102 %</b>	<b>102 %</b>	<b>102 %</b>	<b>11 %</b>	U0
---	---	---	<b>37 %</b>	U2

Figure 38-2. Power Quality, Voltage Screen

### 10-Second Frequency

A 10-second average of the frequency is calculated using Equation 38-1.

$$\frac{\text{Number of Integral Cycles}}{\text{Total Duration of Integer Cycles}}$$

Equation 38-1. 10-Second Frequency Calculation

### Example

Number of integral cycles: 501 cycles over 10 s

Total duration of the 501 cycles: 9.998 s

10-Second Frequency =  $501/9.998 = 50.1100$  Hz

### Distortion

The voltage during a dip is often distorted. This distortion may be important for understanding the effect of the dip on the system. The BE1-11 $t$  calculates distortion using Equation 38-2.

$$THD\% = \frac{\sqrt{V_{total}^2 - V_1^2}}{V_1} \times 100$$

**Equation 38-2. Distortion Calculation**

Figure 38-3 illustrates the Power Quality, Distortion screen.

Distortion				
200 ms	3 sec	10 min	2 hour	
1.5 %	1.5 %	1.5 %	1.5 %	Phase A
1.5 %	1.5 %	1.5 %	1.5 %	Phase B
1.4 %	1.4 %	1.4 %	1.5 %	Phase C

**Figure 38-3. Power Quality, Distortion Screen**

### Dip/Swell

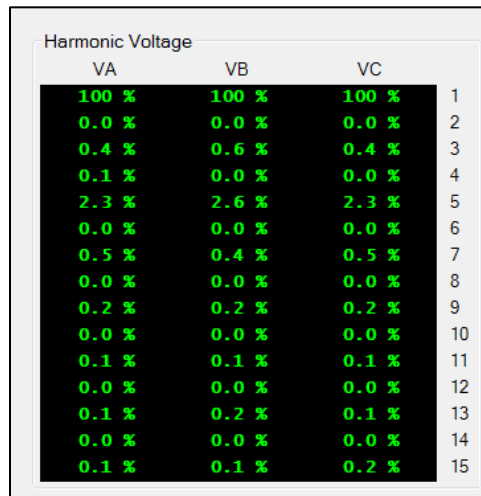
Figure 38-4 illustrates the Power Quality, Dip/Swell screen. A green LED indicates that the threshold specified in Power Quality Settings has been exceeded.

Dip/Swell		
● Dip Status		
69.30 v	Primary Residual Voltage	
69.30 v	Residual Voltage	
0 ms	Dip Duration	
● Swell Status		
69.30 v	Primary Swell Voltage	
69.30 v	Swell Voltage	
0 ms	Swell Duration	

**Figure 38-4. Power Quality, Dip/Swell Screen**

### Harmonics

Figure 38-5 illustrates the Power Quality, Harmonic Voltage screen. The Harmonic Current screen is similar.



Harmonic Voltage			
VA	VB	VC	
100 %	100 %	100 %	1
0.0 %	0.0 %	0.0 %	2
0.4 %	0.6 %	0.4 %	3
0.1 %	0.0 %	0.0 %	4
2.3 %	2.6 %	2.3 %	5
0.0 %	0.0 %	0.0 %	6
0.5 %	0.4 %	0.5 %	7
0.0 %	0.0 %	0.0 %	8
0.2 %	0.2 %	0.2 %	9
0.0 %	0.0 %	0.0 %	10
0.1 %	0.1 %	0.1 %	11
0.0 %	0.0 %	0.0 %	12
0.1 %	0.2 %	0.1 %	13
0.0 %	0.0 %	0.0 %	14
0.1 %	0.1 %	0.2 %	15

**Figure 38-5. Power Quality, Harmonic Voltage Screen**

Refer to the *BESTnetPlus* chapter for information on viewing power quality data through the web page interface.

## 39 • 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 appears 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. This contact is used in all of the preprogrammed logic schemes as the main trip output. The detector circuit across OUT1 is not polarity sensitive because the optical isolator used for detecting continuity is connected across a full wave bridge. See Figure 39-1.

The amount of current drawn through the optical isolator circuit depends on the total input impedance for each power supply voltage rating (see Table 39-1).

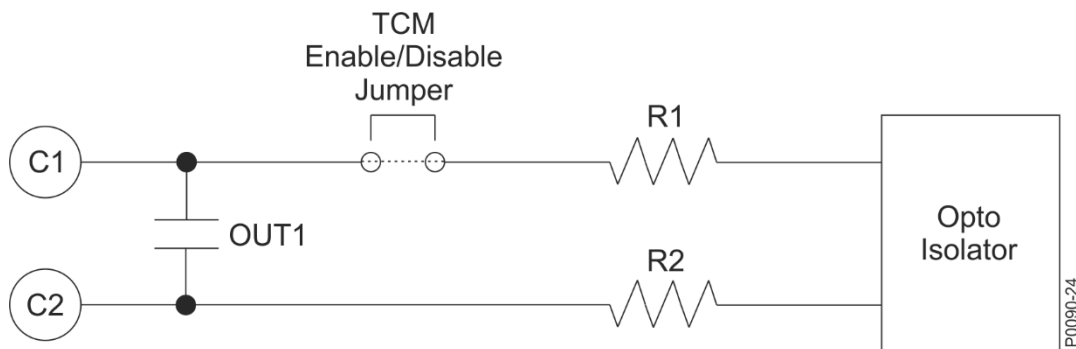


Figure 39-1. Trip Detector Circuit

Table 39-1. Current Draw for each Power Supply Voltage Rating

Power Supply Voltage Rating	R1	R2	R Total	Optical Isolator	
				Off (25% V)	On (80% V)
24 Vdc	9.4 k $\Omega$	6.8 k $\Omega$	16.2 k $\Omega$	6.0 V (0.370 mA)	19.2 V (1.19 mA)
48/125 Vdc	9.4 k $\Omega$	24 k $\Omega$	33.4 k $\Omega$	12.0 V (0.359 mA)	38.4 V (1.15 mA)
125/250 Vdc	9.4 k $\Omega$	82 k $\Omega$	91.4 k $\Omega$	31.2 V (0.342 mA)	100 V (1.09 mA)

Figure 39-2 illustrates typical trip circuit monitor connections for the BE1-11 $\iota$ .

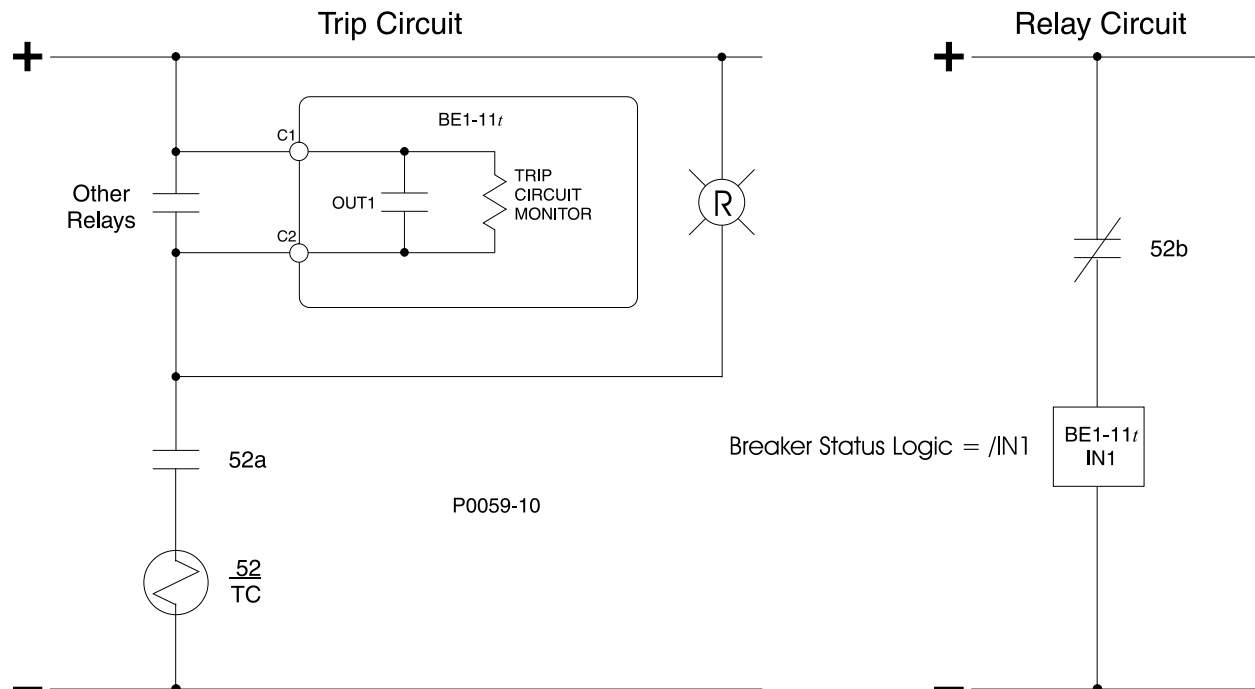


Figure 39-2. Trip Circuit Voltage and Continuity Monitor

### 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 $\iota$  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 $\iota$  to use one of the other output relays for tripping. In this situation, the trip circuit monitor function will not be available.

In Figure 39-3, 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 39-3 to isolate the TCM circuit from the effects of 62X.

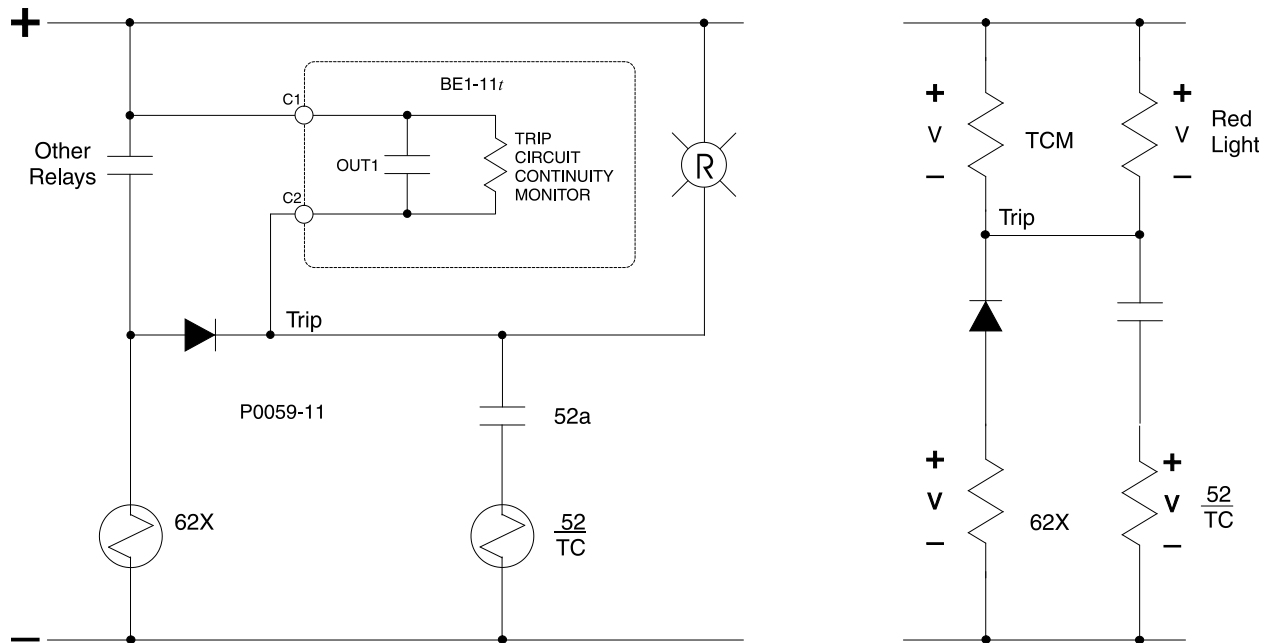


Figure 39-3. TCM with Other Devices

Trip Circuit Monitor (52TCM) Enable/Disable Jumper

**Note**

A BE1-11t in a J type case is delivered with the trip circuit monitor enabled (TCM jumper connected). Read the following paragraphs before placing the BE1-11t in service.

The trip circuit monitor draws a small amount of current, even when the contact is open. See Table 39-1 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 BE1-11t.
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 39-4 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.

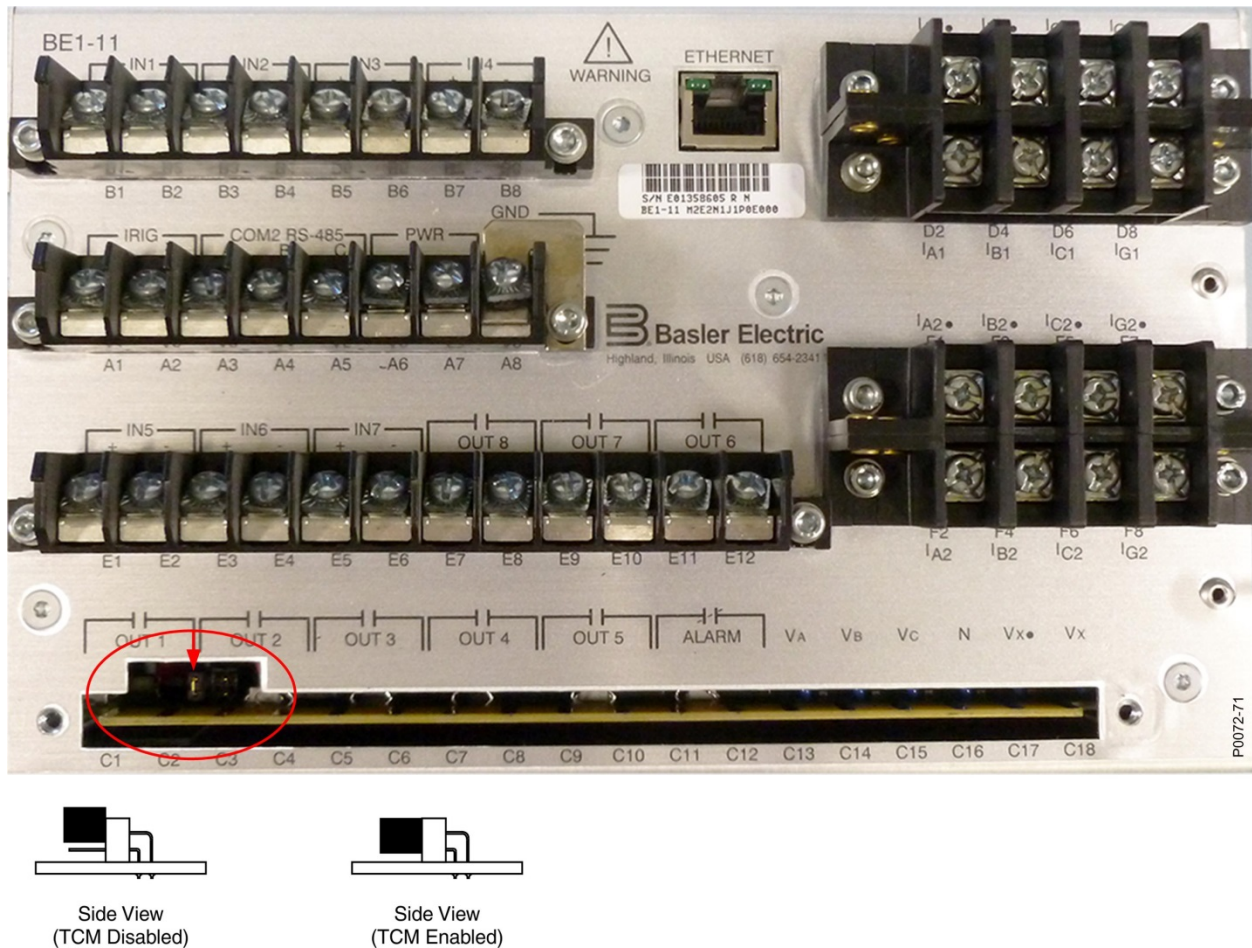


Figure 39-4. Trip Circuit Monitor Enable/Disable Jumper Location

### Logic Connections

Trip circuit monitor logic connections are made on the BESTlogicPlus screen in BESTCOMSPlus. The trip circuit monitor element logic block is illustrated in Figure 39-5. The logic output is summarized in Table 39-2.

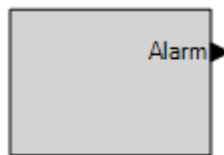


Figure 39-5. Trip Circuit Monitor Element Logic Block

Table 39-2. 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 39-6) in BESTCOMSPlus.



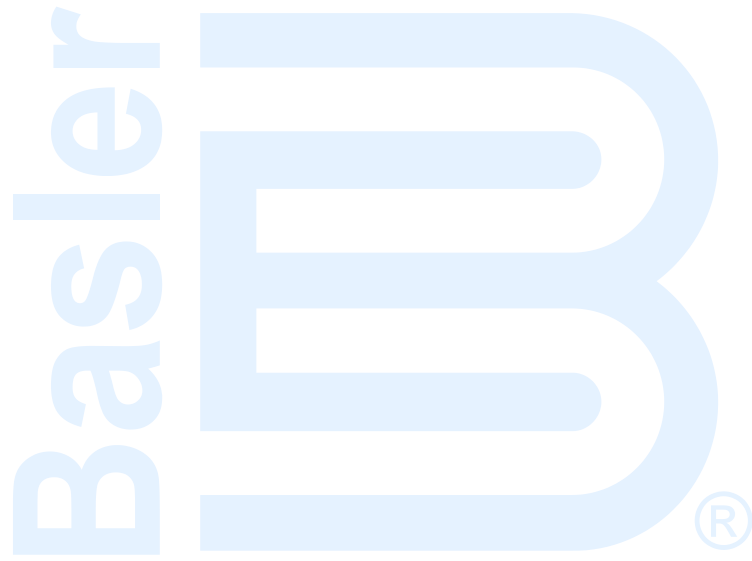
**Trip Circuit Monitor**

52TCM Element

Mode

Enabled

**Figure 39-6. Trip Circuit Monitor Settings Screen**



## 40 • 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 appears 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 40-1. Logic parameters are shown in Table 40-1.

Trip Logic:  $60FL \text{ Trip} = (A * C * G * J * P) + (E * F * G * J)$  (See Table 40-1.)

Reset Logic:  $60FL \text{ Reset} = H * /K * /L$  (See Table 40-1.)

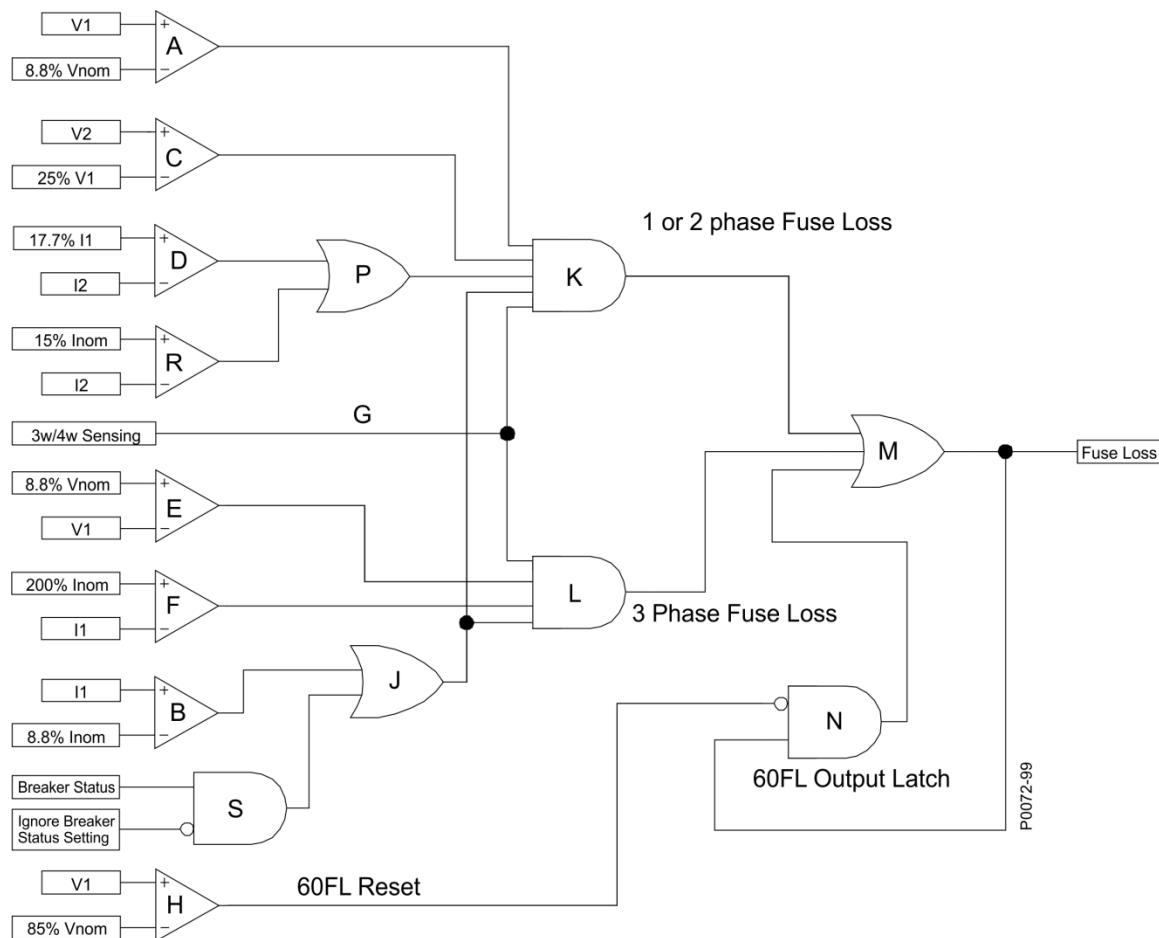


Figure 40-1. Fuse Loss Element Logic

Table 40-1. 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 + S); Detects breaker position and nominal current condition.
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.
S	Breaker Status is configured by the Breaker Status logic block. Information on setting up the breaker status logic can be found in the <i>Breaker Monitoring</i> chapter. The Ignore Breaker Status setting is found on the 60FL settings screen. (Enabled = 1, Disabled = 0)

## Function Blocking

User selectable block settings determine how the 51/27R, 24, 25, 27, 59, 27X, 59X, 21, and 67 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.

### Note

Protective elements blocked by 60FL should be set so that trip times are 60 milliseconds or greater to assure proper coordination of blocking.

## 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:  $60FL=FALSE \ \& \ 3P4W=TRUE \ \& \ (IN > \text{minimum}) \ \& \ (IN > I1*8\%) \ \& \ (V0 > \text{minimum})$
- V0IG inputs:  
Test:  $60FL=FALSE \ \& \ 3P4W=TRUE \ \& \ (IG > \text{minimum}) \ \& \ (V0 > \text{minimum})$
- VXIN inputs:  
Test:  $(IG > \text{minimum}) \ \& \ (IN > I1*8\%) \ \& \ (VX > \text{minimum})$
- VXIG inputs:  
Test:  $(IG > \text{minimum}) \ \& \ (VX > \text{minimum})$

## Programmable Alarm

The BE1-11 $t$  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 BESTCOMSP $lus$ . 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 BESTCOMSP $lus$ . The fuse loss element logic block is illustrated in Figure 40-2. The logic output is summarized in Table 40-2.

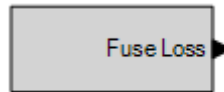


Figure 40-2. Fuse Loss Element Logic Block

Table 40-2. 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 40-3) in BESTCOMSP $lus$ . Settings are summarized in Table 40-3.

**Fuse Loss (60FL)**

60FL Element

- Block Voltage Control (51/27)
- Block Phase/V1 Voltage Elements (24, 27, 59)
- Block 3V0 Voltage Elements (27,59)
- Block V2 Voltage Elements (27,59)
- Block Power/Power Factor Elements
- Block Impedance Elements (21,40Z)
- Ignore Breaker Status

Figure 40-3. Fuse Loss Settings Screen

Table 40-3. 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.

<b>Setting</b>	<b>Purpose</b>
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. (24, 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 Impedance Elements	All functions that use the impedance measurement are blocked when the 60FL logic is true. (21)
Ignore Breaker Status	When enabled, breaker status is ignored.

# 41 • Transformer Monitor (51TF)

The transformer monitor (51TF) element implements a through-fault counter which allows the user to schedule wear-based maintenance instead of time-based maintenance.

Element logic connections are made on the BESTlogic™ *Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Transformer Monitor (51TF) settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings appears at the end of this chapter.

**BESTCOMS*Plus* Navigation Path:** Settings Explorer, Alarm Configuration, Transformer Monitor (51TF)

**HMI Navigation Path:** Settings Explorer, Alarm Configuration, Transformer Monitor 51TF

## Element Operation

The 51TF element uses time characteristic curves to monitor the pickup count and report the through-faults of a transformer.

### Time Curve

The time current characteristic curve is the combination of up to three time curves each with their own operating threshold and own curve constants. The curve being used is determined by current Threshold Setting 1, Threshold Setting 2, and Threshold Setting 3. When the current is above Threshold Setting 1, timing will be determined by TF<sub>1</sub>. If current increases above Threshold Setting 2 or 3, timing will be determined by TF<sub>2</sub> or TF<sub>3</sub> respectively. Threshold Setting 3 has priority over Threshold Setting 2. Threshold Setting 2 has priority over Threshold Setting 1.

$$TF_1 = \frac{K1}{(M - 1)^{N1}} \quad TF_2 = \frac{K2}{(M - 1)^{N2}} \quad TF_3 = \frac{K3}{(M - 1)^{N3}}$$

TF<sub>x</sub> = Time to Trip when M ≥ Threshold Setting x

M = Multiple of Transformer Base Current Setting

K, N = Constants for the particular curve

### Pickup and Trip

When the measured current increases above the lowest of three threshold settings established by the curve Threshold settings, the element Pickup output becomes true and the pickup counts are incremented. When picked up, the element is timing towards the increment of the through-fault counter. In BESTlogic*Plus*, the Pickup output can be connected to other logic elements to annunciate the condition or control other elements in logic.

The through-fault counter will increment when the timing characteristic curve has been exceeded and the Trip output will become 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.

### CT Source

The CT Source setting configures the transformer monitor element to monitor CT circuit 1 or CT circuit 2. 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.

### Alarm

A 51TF Through-Fault alarm indicates an alarm condition when the Through-Fault counts exceed the Alarm Count setting. The alarm appears on the front-panel display, web page interface, and on the

Alarms metering screen in *BESTCOMSPlus*. Refer to the *Alarms* chapter for information on how to program alarms.

The alarm count can be preset and reset through the front-panel interface or *BESTCOMSPlus*.

## Element Blocking

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

The transformer monitor element has a Block logic input which when true, disables the 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 *BESTlogicPlus*.

## Logic Connections

Transformer monitor element logic connections are made on the *BESTlogicPlus* screen in *BESTCOMSPlus*. The transformer monitor element logic block is illustrated in Figure 41-1. Logic inputs and outputs are summarized in Table 41-1.



Figure 41-1. Transformer Monitor Element Logic Block

Table 41-1. Logic Inputs and Outputs

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

## Operational Settings

Transformer monitor element operational settings are configured on the Transformer Monitor (51TF) settings screen (Figure 41-2) in *BESTCOMSPlus*.

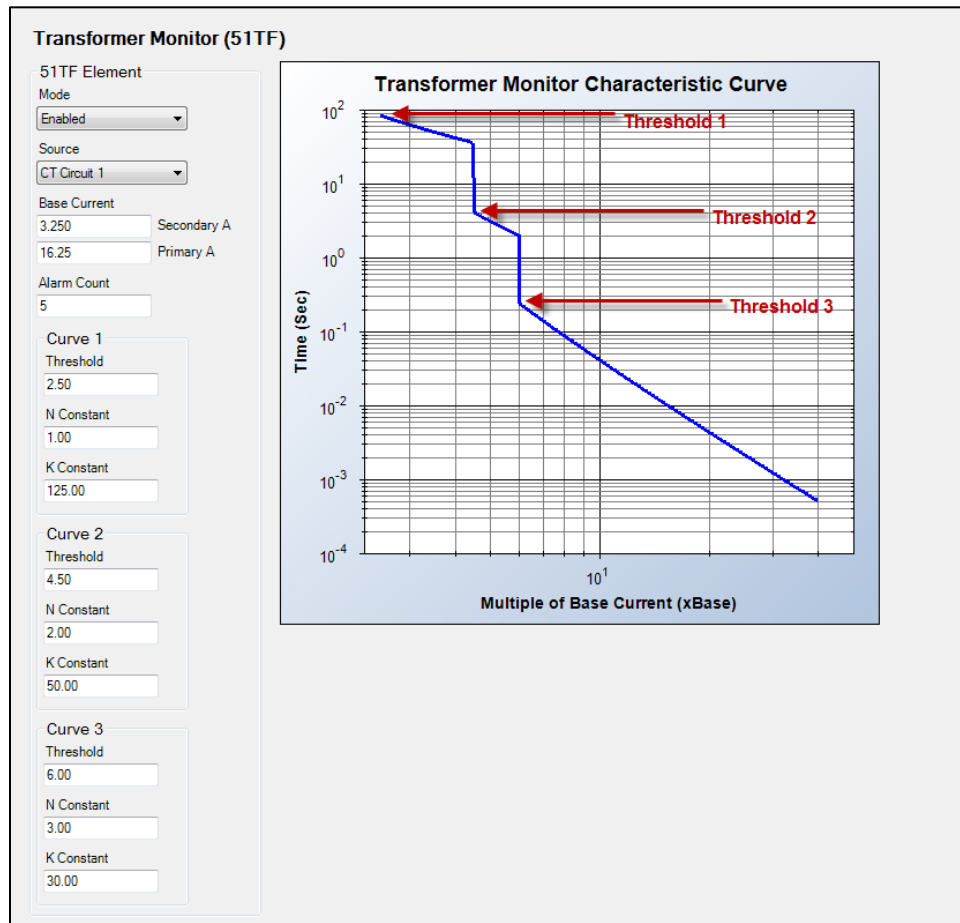


Figure 41-2. Transformer Monitor (51TF) Screen

## Transformer Damage Report

**BESTCOMSPlus Navigation Path:** Metering Explorer, Reports, Transformer Damage

**HMI Navigation Path:** Metering Explorer, Reports, Transfmr Damage Report

Transformer damage report values can be read at the front-panel display. Values can be changed by using the front-panel Edit key. Write access to reports is required to edit transformer damage report values. Values can also be read or changed through the communication ports using BESTCOMSPlus. Use the Metering Explorer to open the Transformer Damage Report screen shown in Figure 41-3.



Figure 41-3. Transformer Damage Report Screen



## 42 • BESTnet™ Plus

BE1-11 $t$  Transformer Protection Systems with an Ethernet port have a web page interface that can be used to view BE1-11 $t$  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 $t$  to communicate through the Ethernet port. Verify that Enable Web Pages is selected on the Settings, Communications, Ethernet screen in the Settings Explorer of BESTCOMSPPlus® or on the Settings > Communication > Ethernet screen of the front-panel display. Using a web browser, enter the IP Address of your BE1-11 $t$  in the address bar. The protection system's IP address is found on the front-panel display under Settings > Communication > Ethernet. Figure 42-1 shows an example for a BE1-11 $t$  with an IP address of 10.0.129.101.



Figure 42-1. Address Bar of Web Browser

### Status Page

Figure 42-2 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 lights to indicate an energized state for inputs and outputs.

 The screenshot shows the "BE1-11t" status page. On the left is a navigation menu with links: Status, Real Time Data, Demand Data, Faults, Sequence of Events, and Power Quality. The main content area features a "Status" table and two rows of indicator lights.
 

Status	
Station ID	Station ID
Device ID	BE1-11
User ID	User ID
Firmware Version	2.11.01
Breaker Status	Closed
Lockout Status 1	Off
Lockout Status 2	Off
Major Alarm Status	No Alarm
Minor Alarm Status	No Alarm
Logic Alarm Status	No Alarm
Relay Alarm Status	No Alarm
Targets	No Targets


  

Local Inputs							Local Outputs								
1	2	3	4	5	6	7	A	1	2	3	4	5	6	7	8

Figure 42-2. Status Page (Home Page)

### Real Time Data

Figure 42-3 illustrates the Real Time Data page. Values for currents, frequency, voltages, and power are shown on this page.



**Status**  
**Real Time Data**  
**Demand Data**  
**Faults**  
**Sequence of Events**  
**Power Quality**

## BE1-11t

Real Time Data			
Current			
IA Circuit 1	4.997A $\angle 0.0^\circ$	I1 Circuit 1	4.996A $\angle 0.0^\circ$
IB Circuit 1	4.994A $\angle 240.0^\circ$	I2 Circuit 1	0.001A $\angle ---^\circ$
IC Circuit 1	4.996A $\angle 120.0^\circ$	3I0 Circuit 1	0.001A $\angle ---^\circ$
IG Circuit 1	4.996A $\angle 0.0^\circ$		
IA Circuit 2	0.000A $\angle ---^\circ$	I1 Circuit 2	28.90A $\angle 237.9^\circ$
IB Circuit 2	0.000A $\angle ---^\circ$	I2 Circuit 2	28.90A $\angle 117.9^\circ$
IC Circuit 2	86.69A $\angle 357.9^\circ$	3I0 Circuit 2	86.69A $\angle 357.9^\circ$
IG Circuit 2	86.23A $\angle 357.6^\circ$		
Frequency			
Phase	60.00Hz	Aux	60.00Hz
Voltages			
VA	120.0V $\angle 0.0^\circ$	V1	120.0V $\angle 0.0^\circ$
VB	120.0V $\angle 240.0^\circ$	V2	0.002V $\angle ---^\circ$
VC	120.0V $\angle 120.0^\circ$	3V0	0.012V $\angle ---^\circ$
VAB	207.8V $\angle 30.0^\circ$	VX	120.0V $\angle 0.0^\circ$
VBC	207.8V $\angle 270.0^\circ$	VX3	0.007V $\angle ---^\circ$
VCA	207.8V $\angle 150.0^\circ$		
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 42-3. Real Time Data Page

## Demand Data

Figure 42-4 illustrates the Demand Data page. Present and peak demand values are shown on this page.

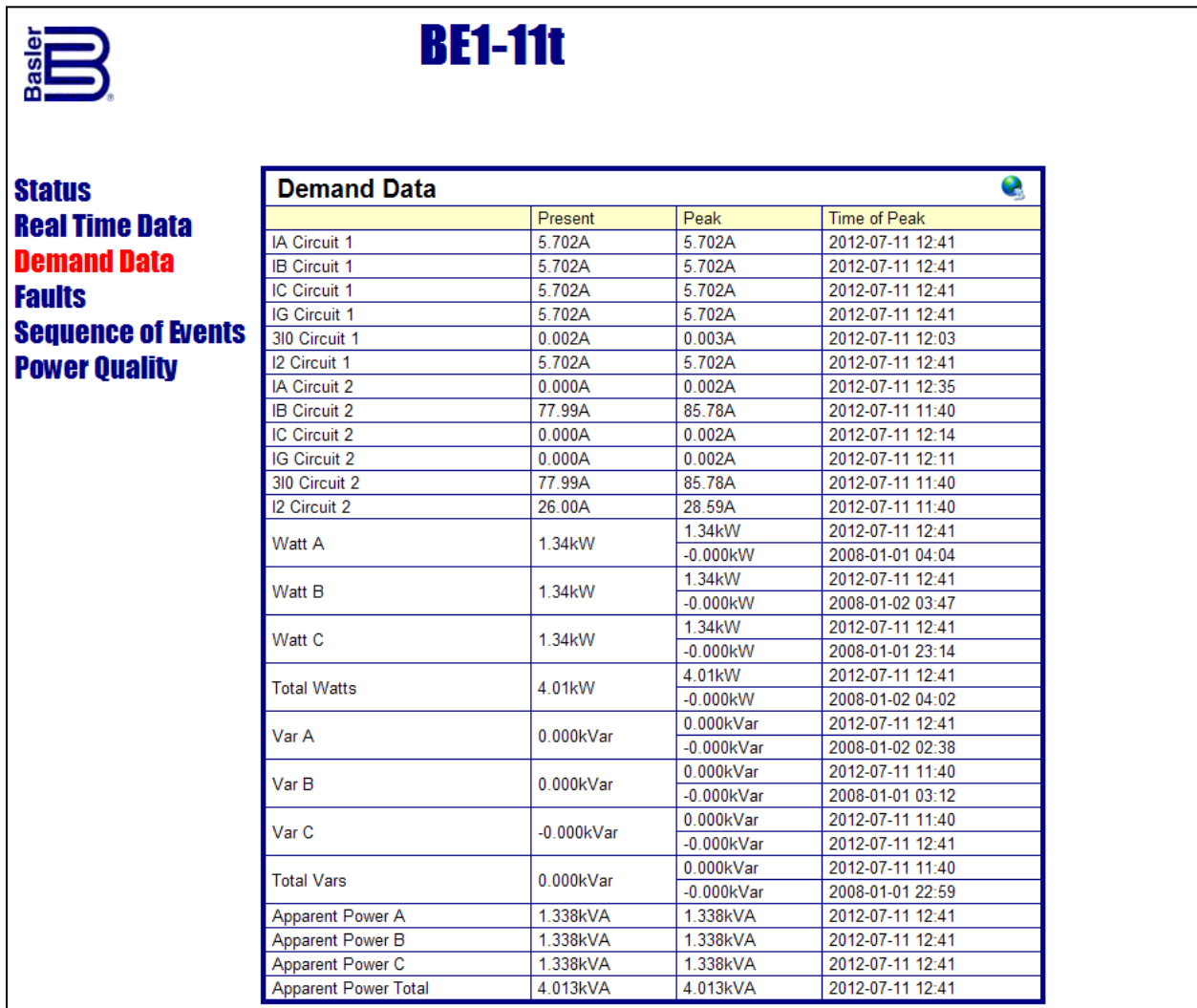


Figure 42-4. Demand Data Page

## Faults

### Fault Summary

Figure 42-5 illustrates the Fault Summary page. To view fault details and download oscillography files, click on a fault in the fault summary list.

**Basler**

# BE1-11t

- Status
- Real Time Data
- Demand Data
- Faults**
- Sequence of Events
- Power Quality

### Fault Summary

#	DATE	TIME	EVENT TYPE	OSC
014	2012-04-19	09:26:07.312	Trip	1
013	2012-04-18	14:37:10.122	Trip	1
012	2012-04-18	14:36:48.700	Trip	2
011	2012-04-18	12:59:53.588	Trip	1
010	2012-04-18	12:52:59.554	Trip	1
009	2012-04-18	11:07:36.521	Trip	2
008	2012-04-18	11:06:28.313	Trip	2
007	2012-04-18	11:06:16.434	Trip	2
006	2012-04-18	11:06:11.576	Trip	2

Figure 42-5. Fault Summary Page

## Fault Details

Figure 42-6 illustrates the Fault Details page. Use the buttons to download oscillography files.

**Basler**

# BE1-11t

- Status
- Real Time Data
- Demand Data
- Faults**
- Sequence of Events
- Power Quality

### Fault Details

Product Name : BE1-11T  
 Application Version : 2.10.00  
 Station ID : Station ID  
 Device ID : BE1-11  
 User ID : User ID  
 Relay Address(es) :  
 IP : 10.0.111.72  
 Modbus Serial : 1  
 Settings File Name : DefaultSettingsFileName

Fault Time : 2007-12-31 23:28:13.797  
 Fault Number : 8  
 Event Type : Forced Trigger  
 Event Trigger : None  
 Active Group : SGO  
 Recloser State : Off

Fault Type : NF  
 Targets : None  
 Distance To Fault : NA  
 Fault Clearing Time : NA  
 Breaker Operate Time : NA  
 Oscillographic Record : PO-881

[Download Osc #1](#) [Back to All Faults](#)

Figure 42-6. Fault Details Page

## Sequence of Events

Figure 42-7 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.

**Basler**

**BE1-11t**

**Status**  
**Real Time Data**  
**Demand Data**  
**Faults**  
**Sequence of Events**  
**Power Quality**

Sequence of Events Summary						
Time Stamp	Sync	Device ID	Type	Num	Description	Status
2012-04-19 09:28:11.552	RTC	BE1-11	PROT	0001	FREQ VALID	Off
2012-04-19 09:28:11.552	RTC	BE1-11	PROT	0003	FREQ VALID	Off
2012-04-19 09:28:11.544	RTC	BE1-11	PROT	0151	50-1-Pickup	Off
2012-04-19 09:28:11.544	RTC	BE1-11	PROT	0152	50-1-Trip	Off
2012-04-19 09:28:11.544	RTC	BE1-11	STAT	0635	Output 1	Off
2012-04-19 09:28:11.544	RTC	BE1-11	STAT	0653	Output 1 Logic State	Off
2012-04-19 09:28:11.544	RTC	BE1-11	PROT	0675	Pickup Logic	Off
2012-04-19 09:28:11.544	RTC	BE1-11	PROT	0676	Trip Logic	Off
2012-04-19 09:28:11.544	RTC	BE1-11	PROT	0889	Unbalance Block	On
2012-04-19 09:28:11.544	RTC	BE1-11	PROT	1153	87-Pickup	Off
2012-04-19 09:28:11.540	RTC	BE1-11	PROT	0887	Unbalance Block	On
2012-04-19 09:28:11.535	RTC	BE1-11	PROT	0002	Fast Current Detected	Off
2012-04-19 09:28:11.535	RTC	BE1-11	PROT	0886	Fast Current Detected	Off
2012-04-19 09:27:07.403	RTC	BE1-11	ALRM	0713	Fault Report Timeout	On
2012-04-19 09:26:07.718	RTC	BE1-11	ALRM	0005	Fuse Loss	Off
2012-04-19 09:26:07.718	RTC	BE1-11	TRGT	0010	60FL	Off
2012-04-19 09:26:07.500	RTC	BE1-11	ALRM	0698	Freq Out Of Range	Off
2012-04-19 09:26:07.379	RTC	BE1-11	ALRM	0005	Fuse Loss	On
2012-04-19 09:26:07.379	RTC	BE1-11	TRGT	0010	60FL	On

View New View Protection View Alarms View Targets Download

Figure 42-7. Sequence of Events Summary Page

## Power Quality

Figure 42-8 illustrates the Power Quality page.



# BE1-11t

**Status**  
**Real Time Data**  
**Demand Data**  
**Faults**  
**Sequence of Events**  
**Power Quality**


Power Quality 				
10sec Avg	60.00Hz			
	200 ms	3 sec	10 min	2 hour
VA THD	1.1%	1.1%	0.0%	0.0%
VB THD	1.2%	1.1%	0.0%	0.0%
VC THD	1.2%	1.2%	---%	0.0%
VA	234.6V	234.6V	0.000V	0.000V
VB	234.6V	234.6V	0.000V	0.000V
VC	234.6V	234.6V	0.057V	0.000V
VAB	---V	---V	---V	---V
VBC	---V	---V	---V	---V
VCA	---V	---V	---V	---V
VA Pri	234.6V	234.6V	0.000V	0.000V
VB Pri	234.6V	234.6V	0.000V	0.000V
VC Pri	234.6V	234.6V	0.057V	0.000V
VAB Pri	---V	---V	---V	---V
VBC Pri	---V	---V	---V	---V
VCA Pri	---V	---V	---V	---V
U0	123%	163%	102%	0.0%
U2	---%	---%	100%	0.0%
	Status	Voltage (Primary)	Voltage (Secondary)	Duration
Dip	Off	69.30V	69.30V	0ms
Swell	Off	69.30V	69.30V	0ms

Figure 42-8. Power Quality Page

## 43 • Mounting

BE1-11 $t$  protection systems are supplied in a non-drawout, S1 size case (J option) that fits in a standard S1 case opening. J case terminal strips are removable via two 7/64" hex screws. Extra terminal strip kits (Figure 43-1) are available as part number 9424226100. Adapter plates are sold separately. A BE1-11 $t$  can be mounted at any convenient angle.

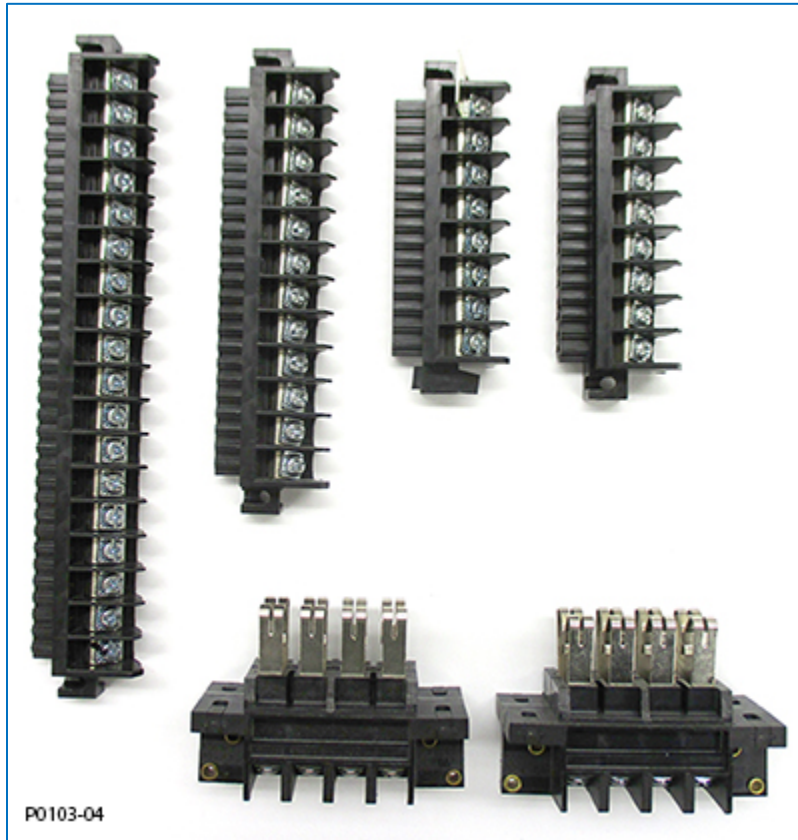


Figure 43-1. J Case Terminal Strip Kit, Part Number 9424226100

### Note

Case mounting studs are carbon steel #10-32. The torque applied to the provided nuts should be 25 to 35 inch-pounds (2.82 to 3.95 N•m).

## Case Cutouts and Dimensions

Front dimensions are shown in Figure 43-2 and side dimensions are shown in Figure 43-3. Dimensions are shown in inches [millimeters].

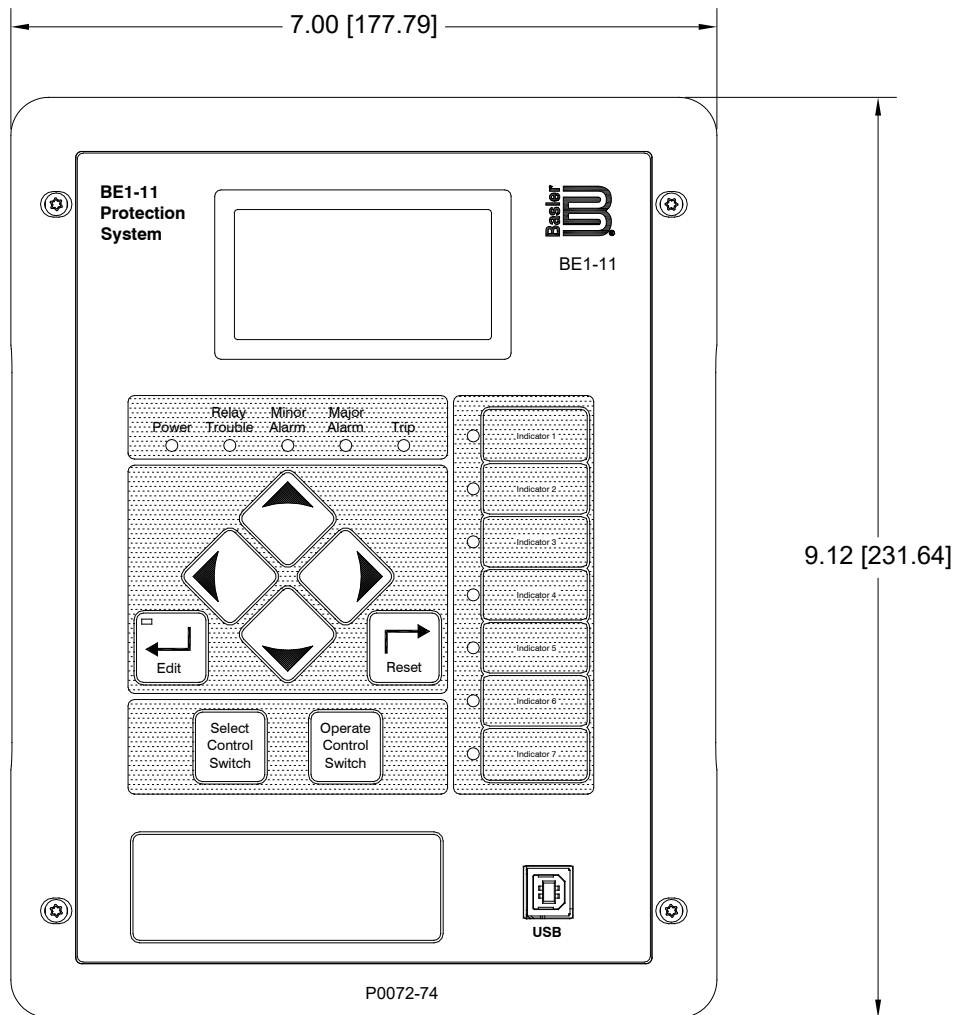


Figure 43-2. Case Front Dimensions

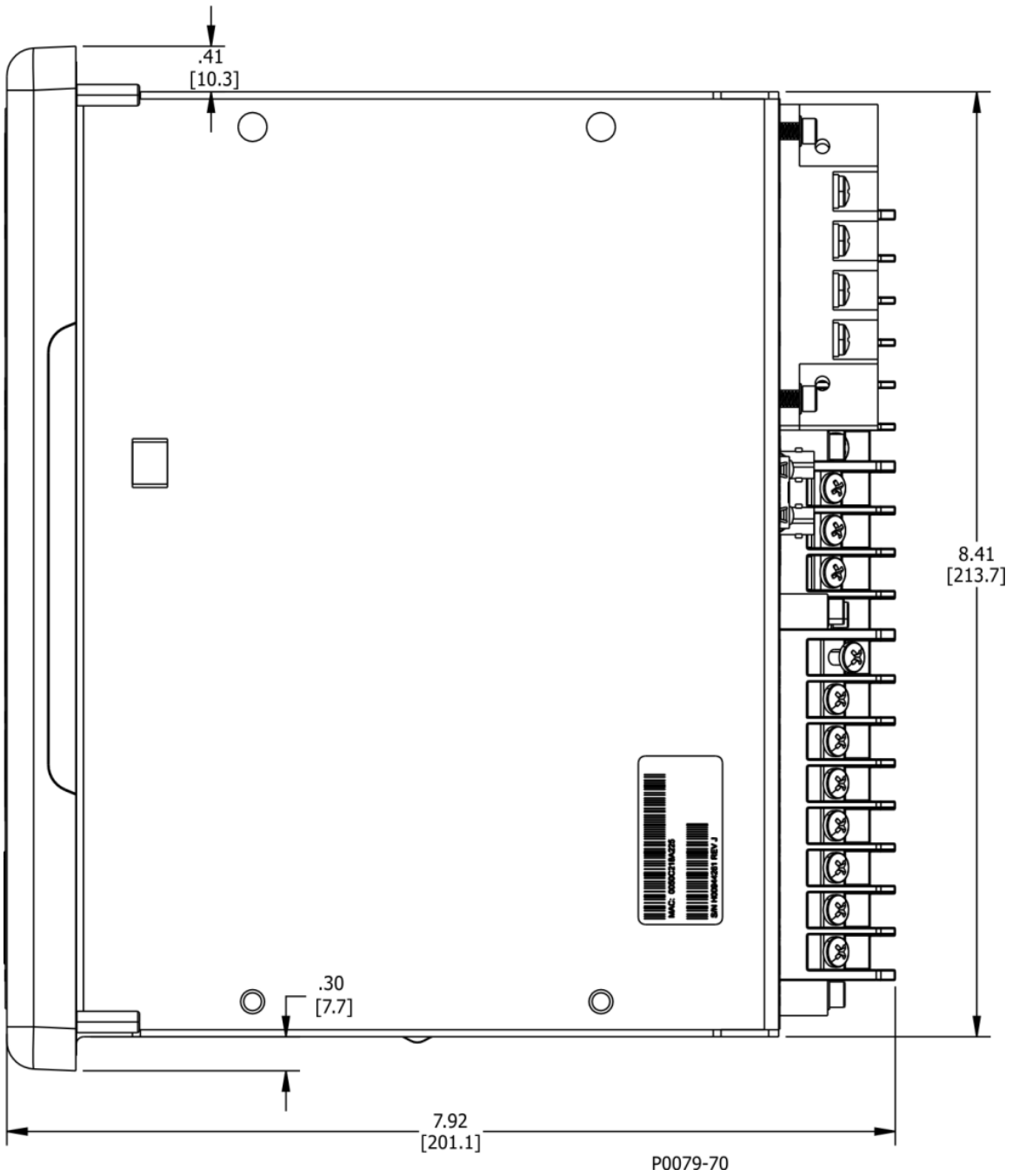
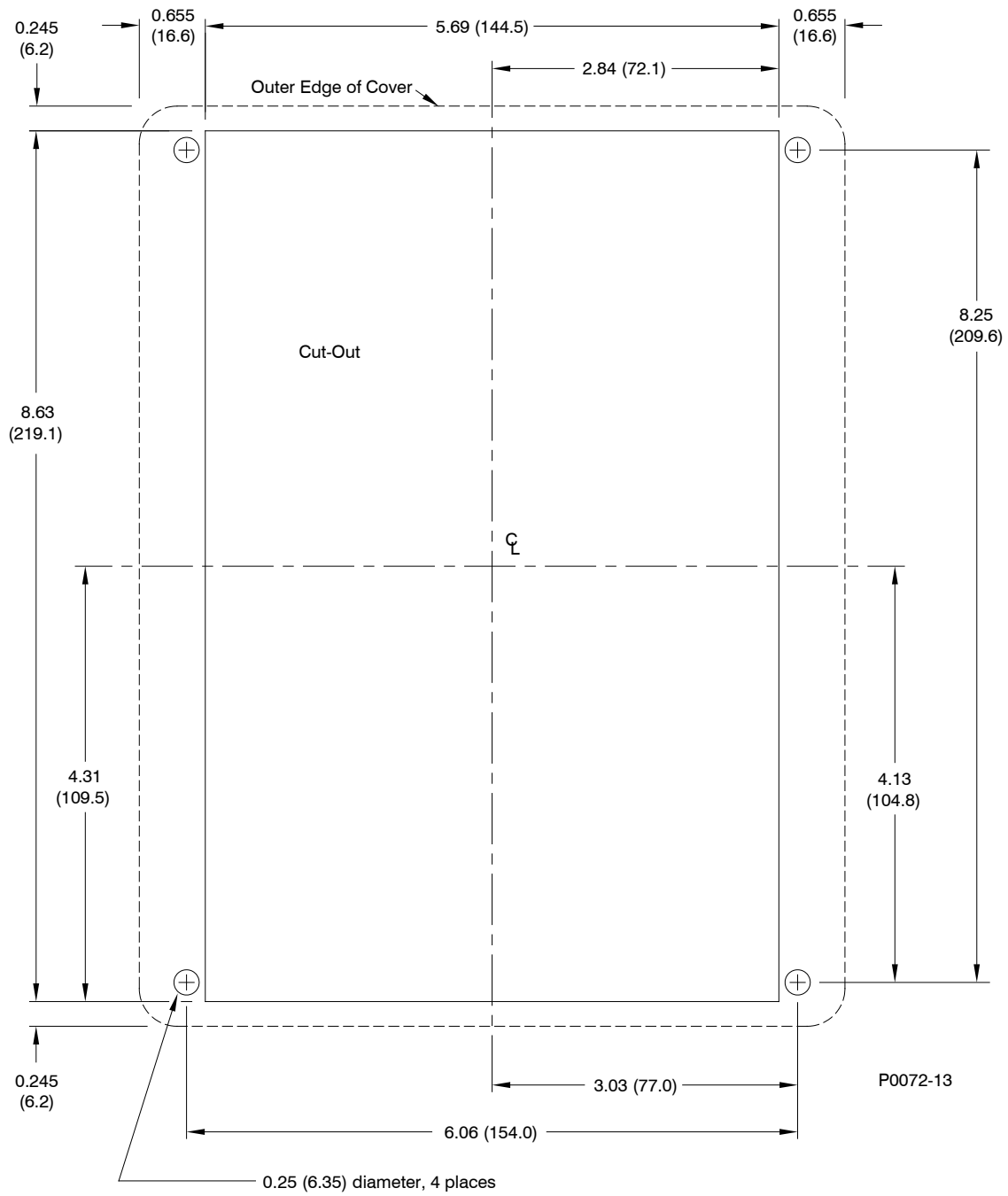


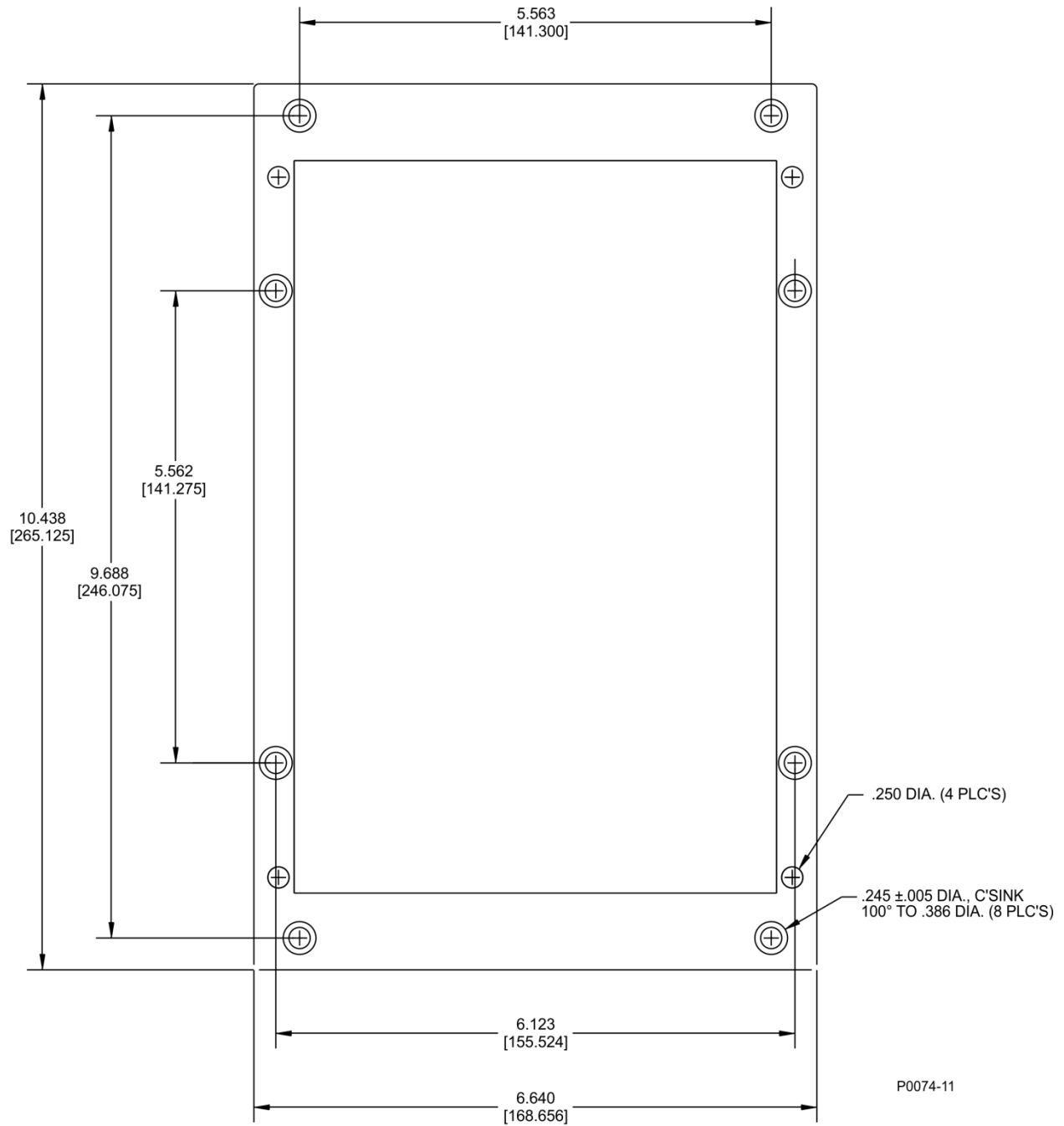
Figure 43-3. Case Side Dimensions

Case cutout and drilling dimensions are shown in Figure 43-4.



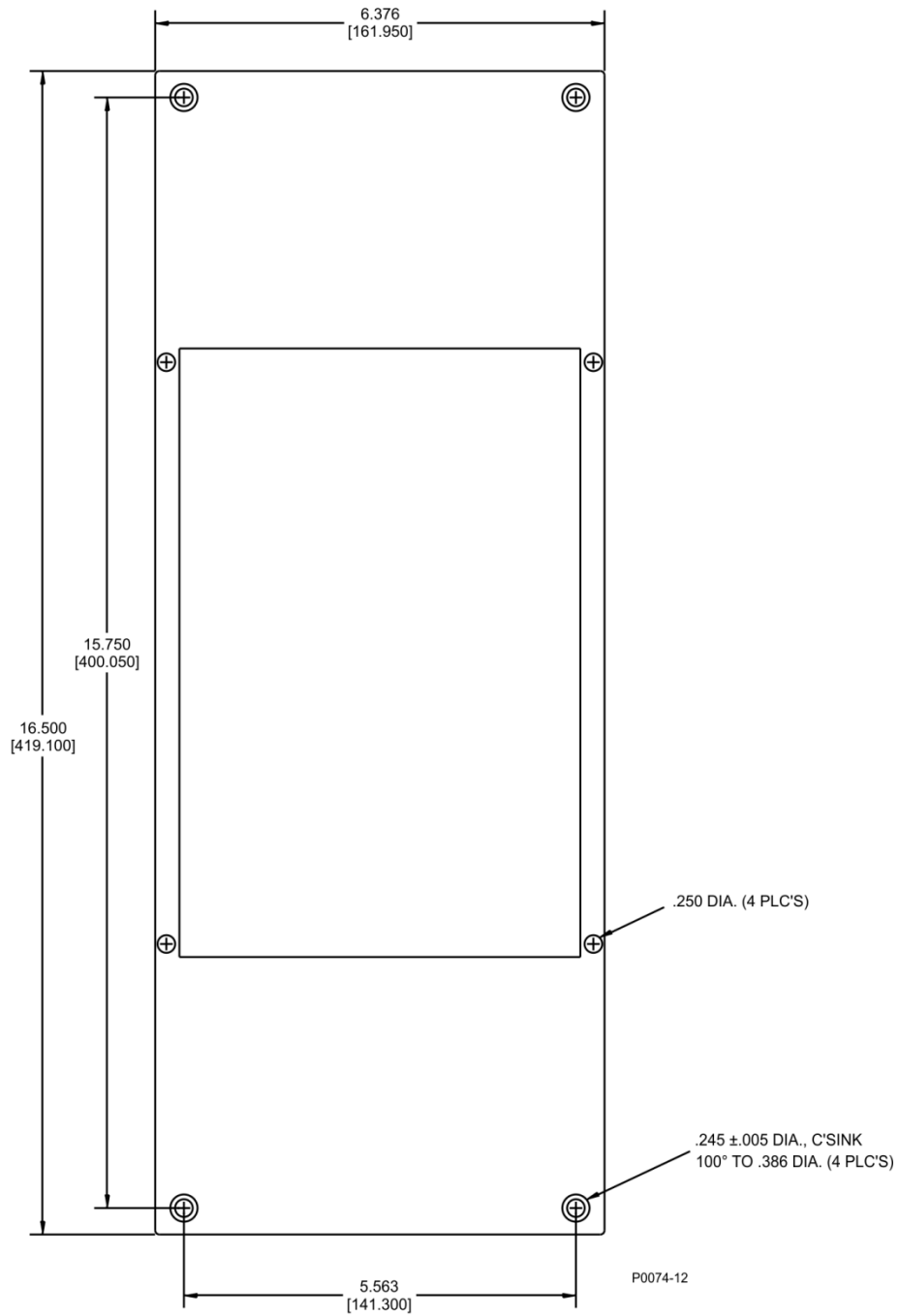
**Figure 43-4. Case Cutout and Drilling Dimensions**

An adapter plate to mount a J case in a GE S2 or ABB FT-21 cutout is shown in Figure 43-5. Order Basler part number 9108551021.



**Figure 43-5. Adapter Plate (Basler P/N: 9108551021)**

An adapter plate to mount a J case in a ABB FT-31/FT-32 cutout is shown in Figure 43-6. Order Basler part number 9108551022.



**Figure 43-6. Adapter Plate (Basler P/N: 9108551022)**

An adapter plate to mount a J case in a GE M1/M2 cutout or Basler M1 cutout is shown in Figure 43-7. Order Basler part number 9108551029.

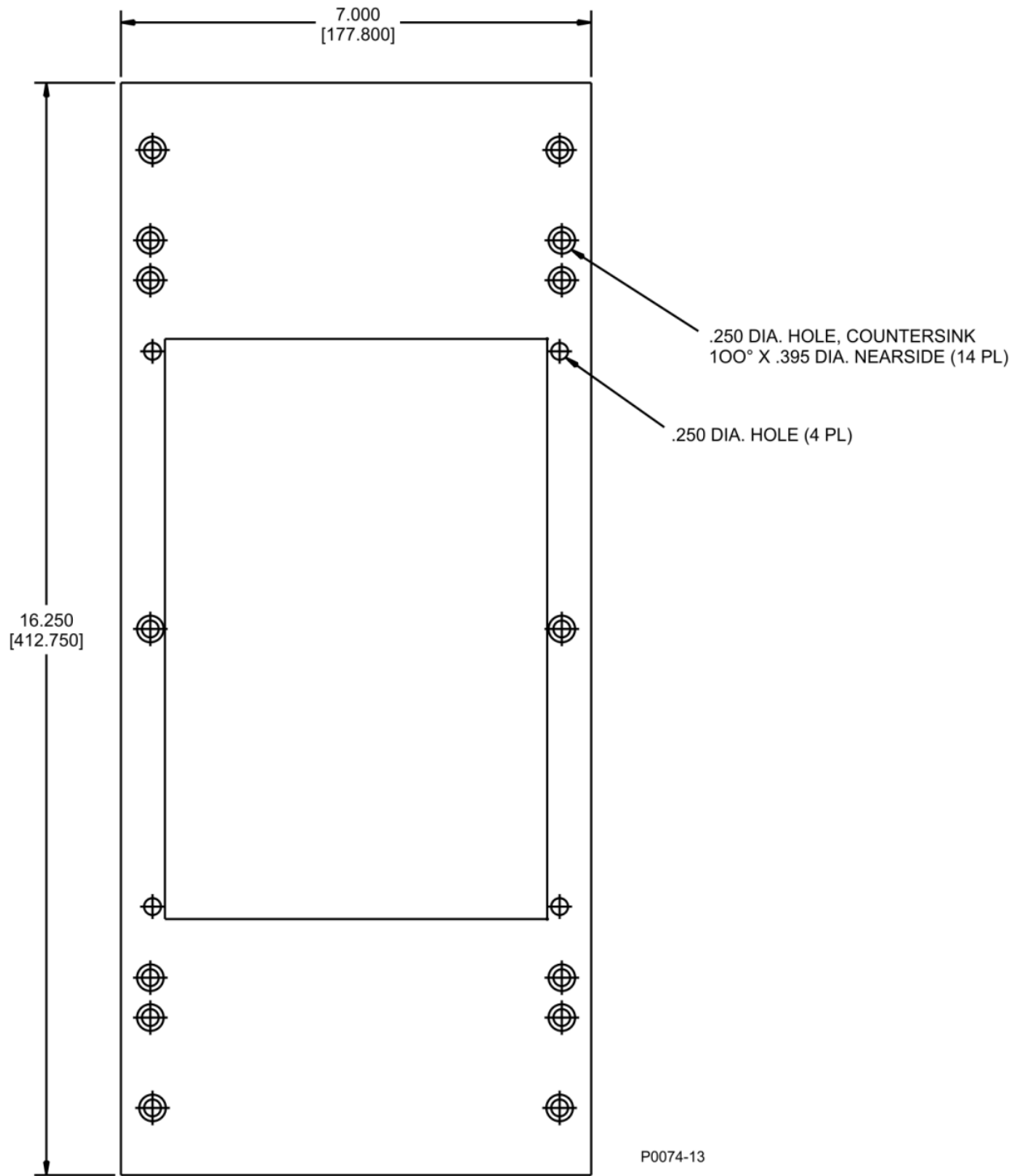
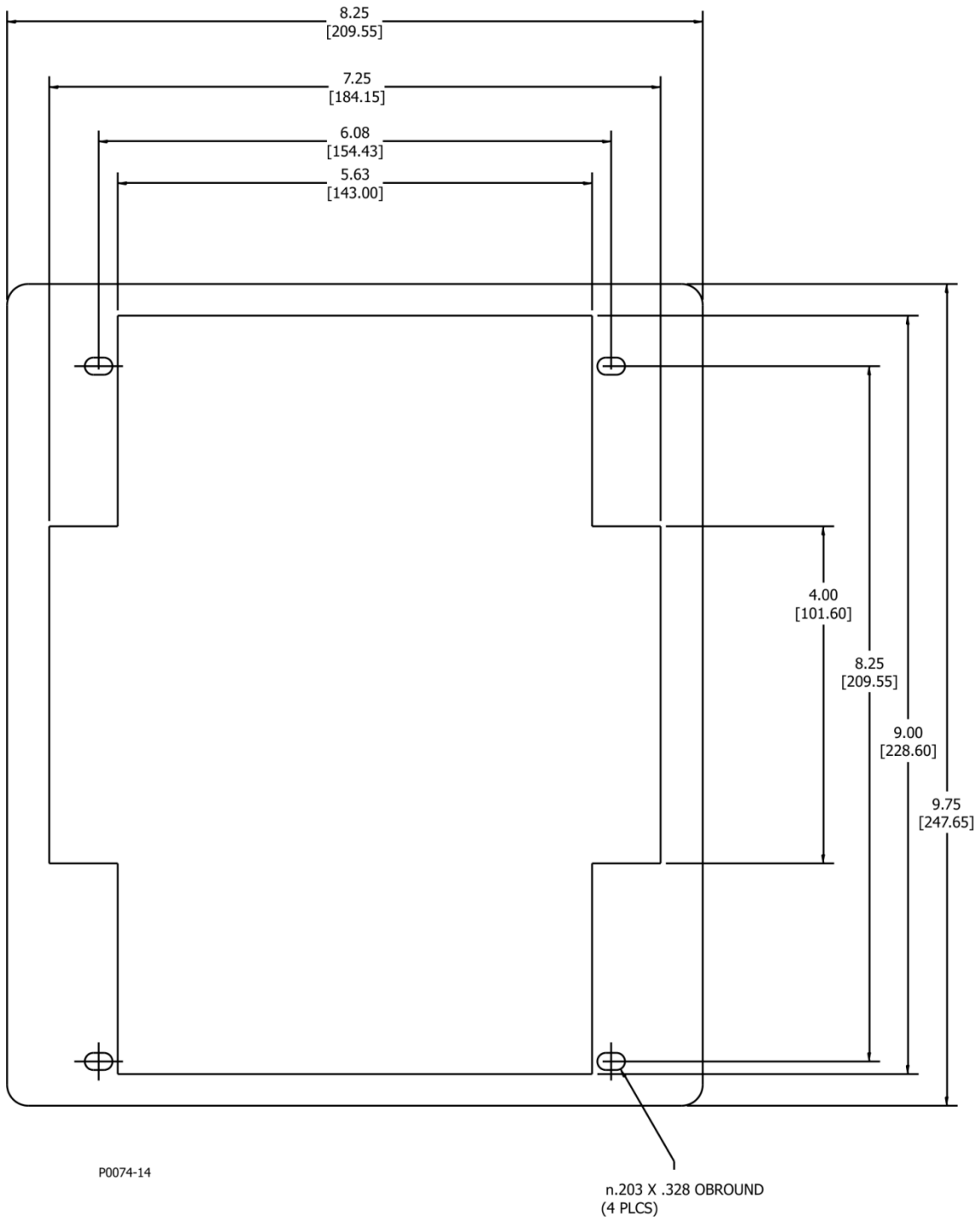
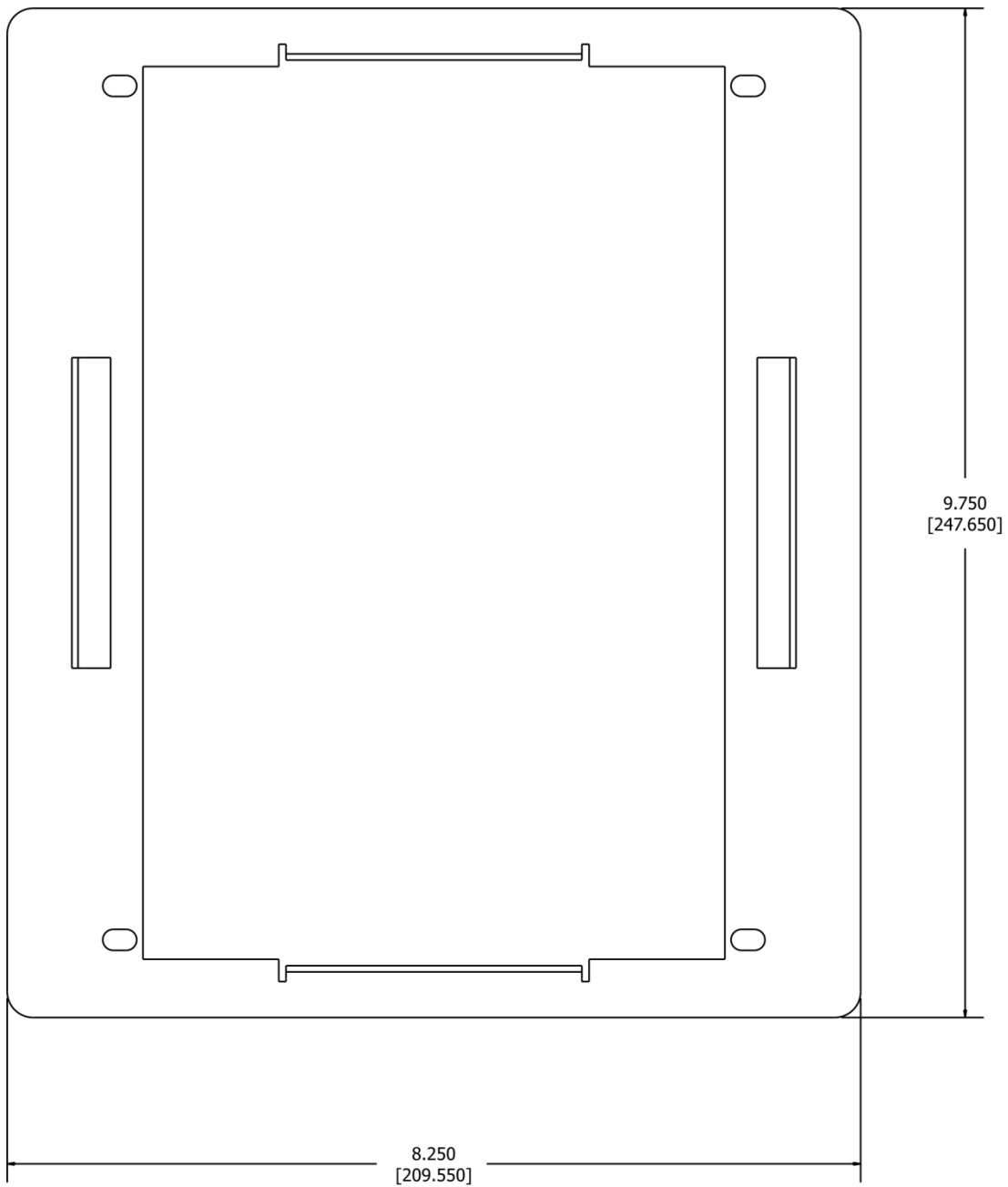


Figure 43-7. Adapter Plate (Basler P/N: 9108551029)

A J case retrofit mounting plate for the Multilin 345/745 consists of two parts. See Figure 43-8 and Figure 43-9. Order Basler part number 9424226101.



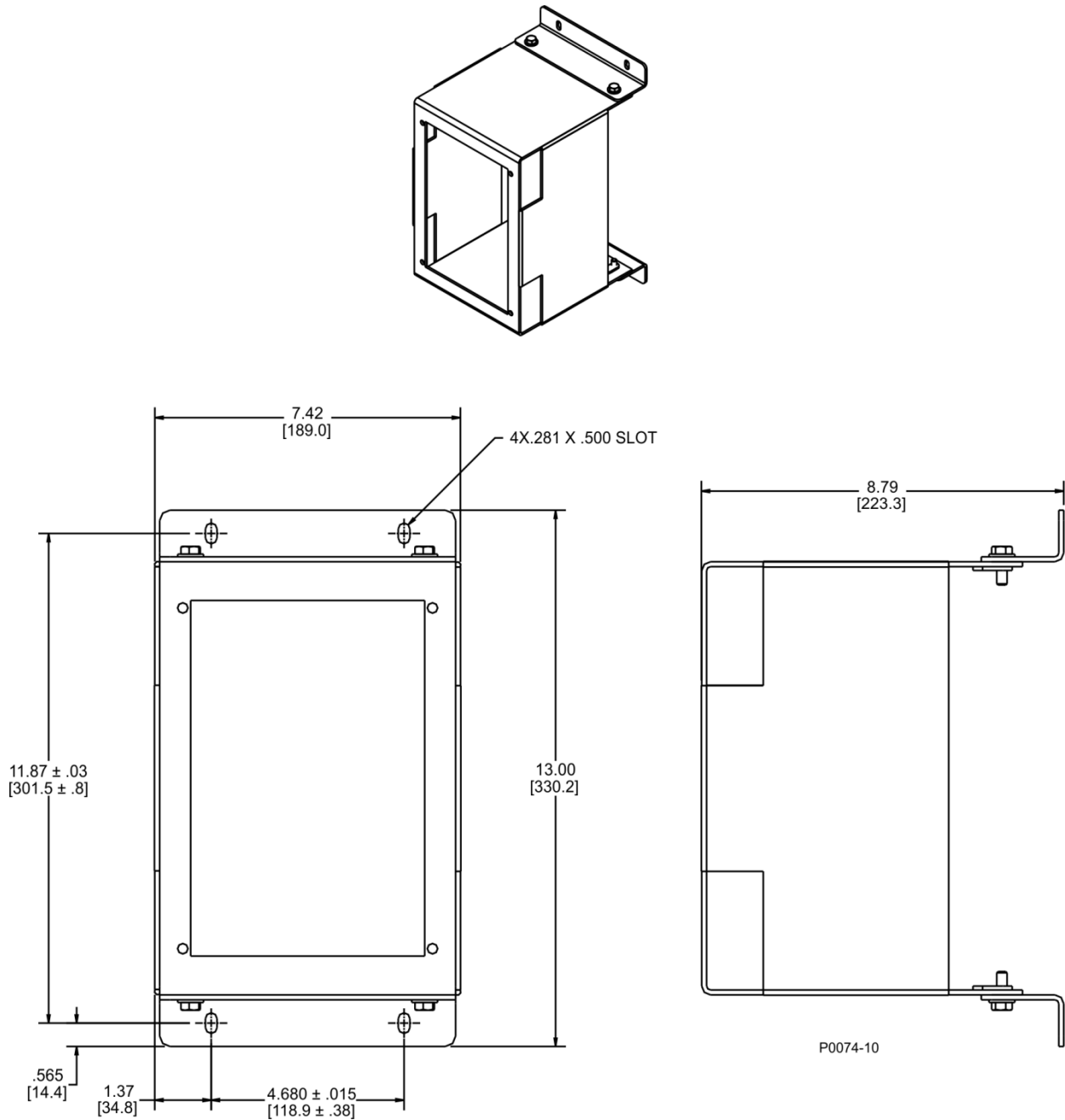
**Figure 43-8. Retrofit Mounting Plate (Basler P/N: 9424226101) – Part 1**



P0074-15

**Figure 43-9. Retrofit Mounting Plate (Basler P/N: 9424200073) – Part 2**

A pivoting projection-mounting kit for a J case is shown in Figure 43-10. When installed, this kit provides rear access to connections by allowing the BE1-11 $t$  to swing left or right. Order Basler part number 9424226101.



**Figure 43-10. Pivoting Projection-Mounting Kit (Basler P/N: 9424226101)**

## 44 • Terminals and Connectors

Connections to the BE1-11*t* are dependent on the application and logic scheme selected by the user. As a result, some BE1-11*t* inputs and outputs may not be used for a given application. Before energizing a BE1-11*t*, make sure the connections match the options associated with the model and style number found on the BE1-11*t* 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 BE1-11*t*.

### Notes

Connections to the BE1-11*t* voltage inputs, contact inputs, power supply inputs, and contact outputs should be made with a minimum wire size of 14 AWG (2.08 mm<sup>2</sup>).

Connections to the BE1-11*t* current inputs and ground terminal should be made with a minimum wire size of 12 AWG (3.31 mm<sup>2</sup>).

When the BE1-11*t* is configured in a system with other protective devices, a separate ground bus lead is recommended for each BE1-11*t*.

It is recommended in all applications where contact outputs drive relay coils that a reverse biased diode be implemented in parallel with the relay coil for EMI suppression.

Rear panel connections are shown in Figures 44-1 through 44-4.

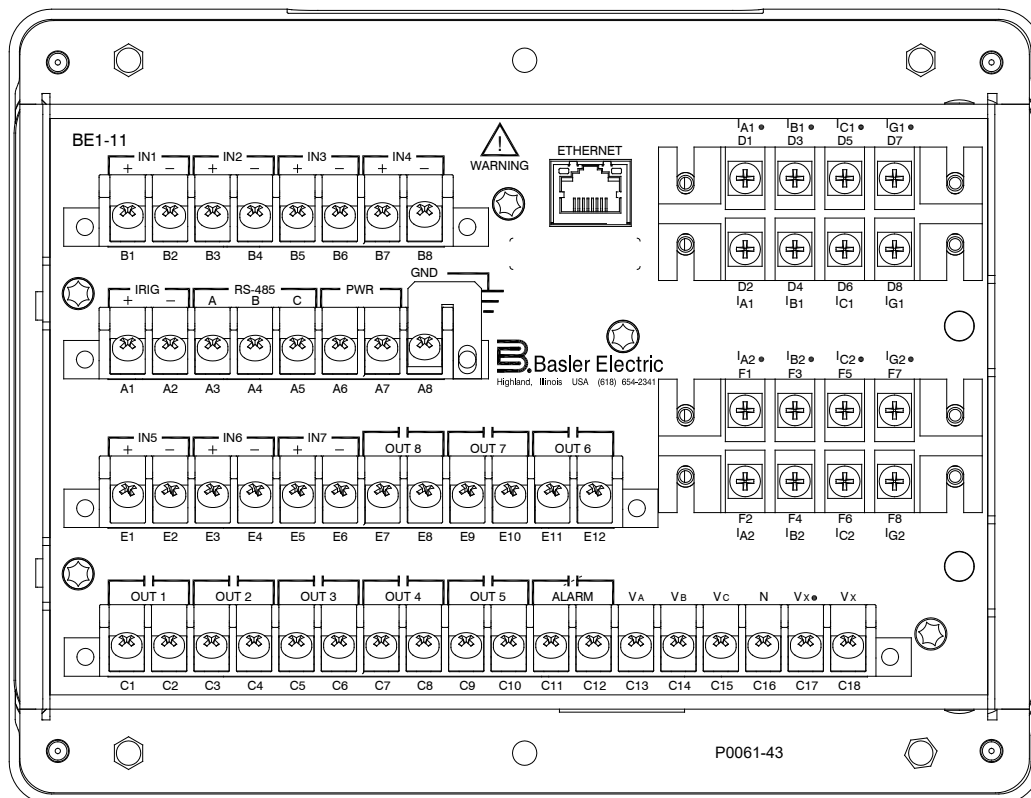


Figure 44-1. Rear Panel Connections with RJ45 Ethernet (7 Inputs and 8 Outputs Option)

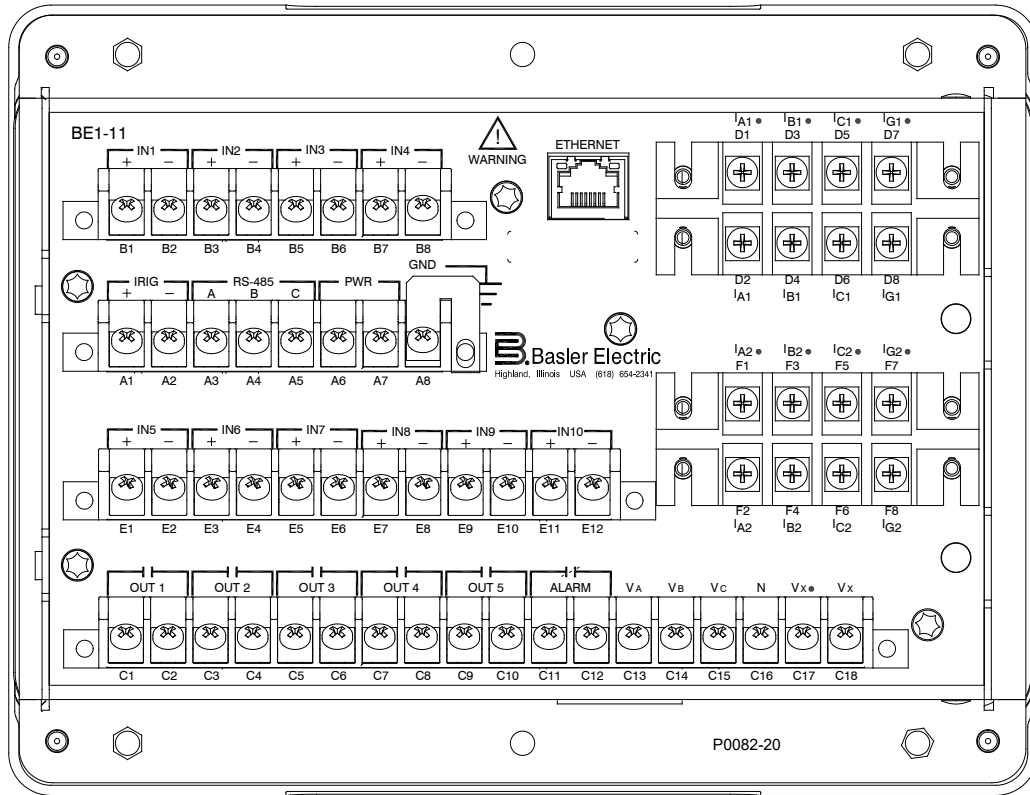


Figure 44-2. Rear Panel Connections with RJ45 Ethernet (10 Inputs and 5 Outputs Option)

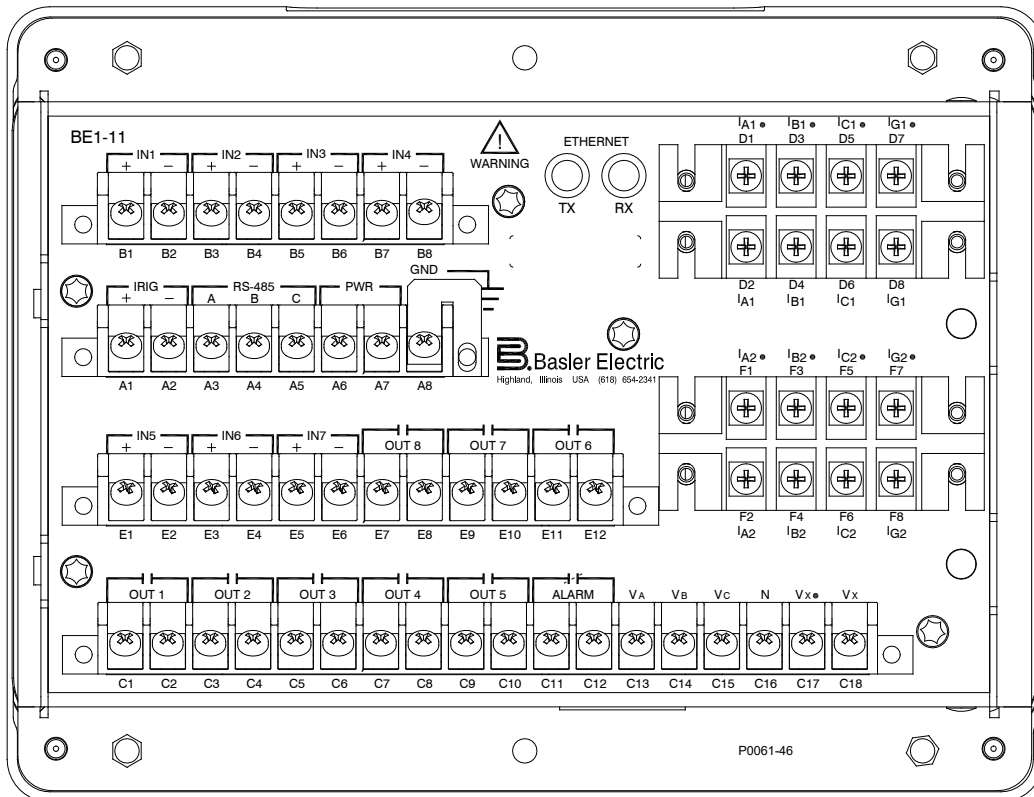


Figure 44-3. Rear Panel Connections with Fiber Optic Ethernet (7 Inputs and 8 Outputs Option)

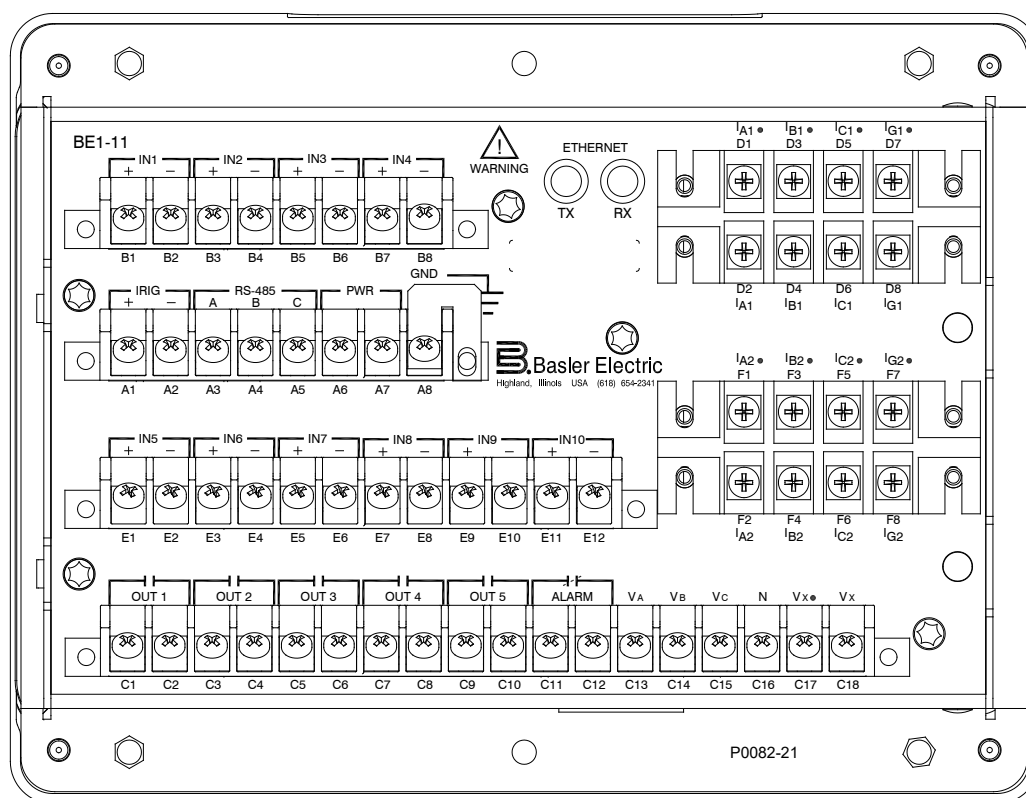


Figure 44-4. Rear Panel Connections with Fiber Optic Ethernet (10 Inputs and 5 Outputs Option)

## Terminal Blocks

J style cases use two sizes of terminal blocks.

The terminal blocks used for current sensing connections use #8-32 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 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 BE1-11t. The following provides fundamental information on CT polarity and protection systems.

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 44-5 and Figure 44-6).

## Circuit Breaker

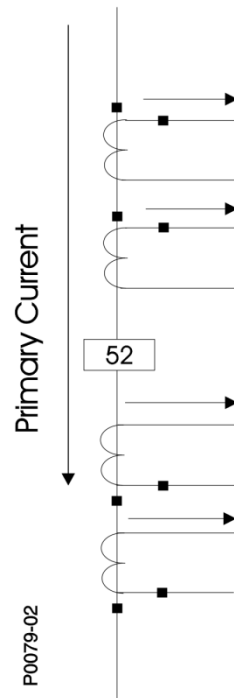


Figure 44-5. Standard CT Polarity

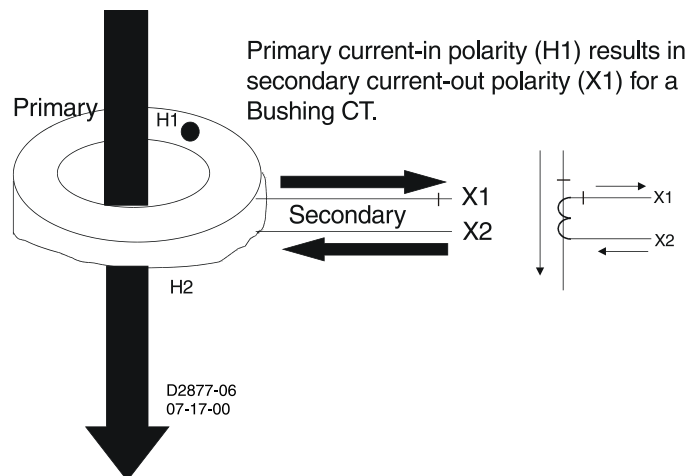


Figure 44-6. Current Transformer Action

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 44-7). 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 BE1-11t.

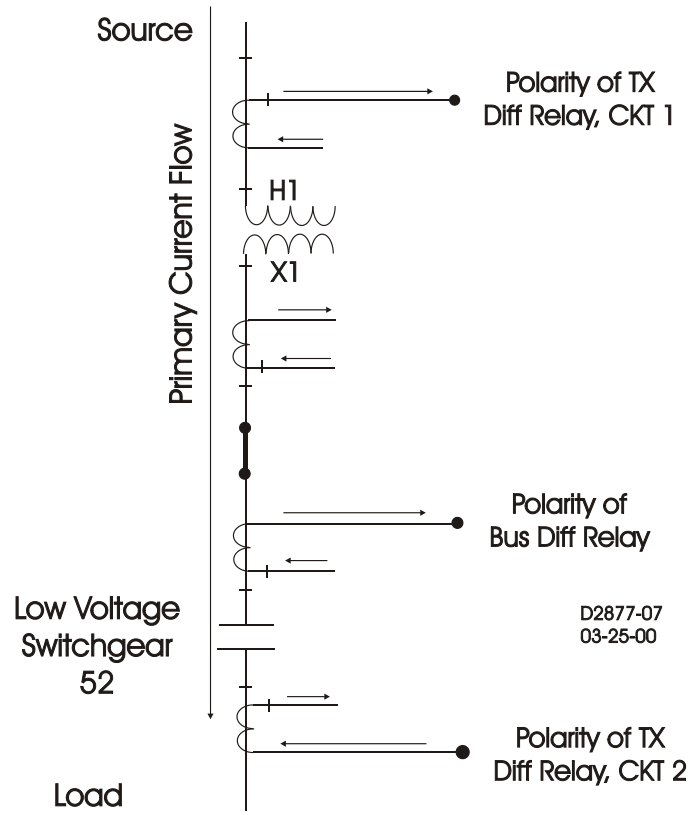


Figure 44-7. Example of Reversed CT Polarity

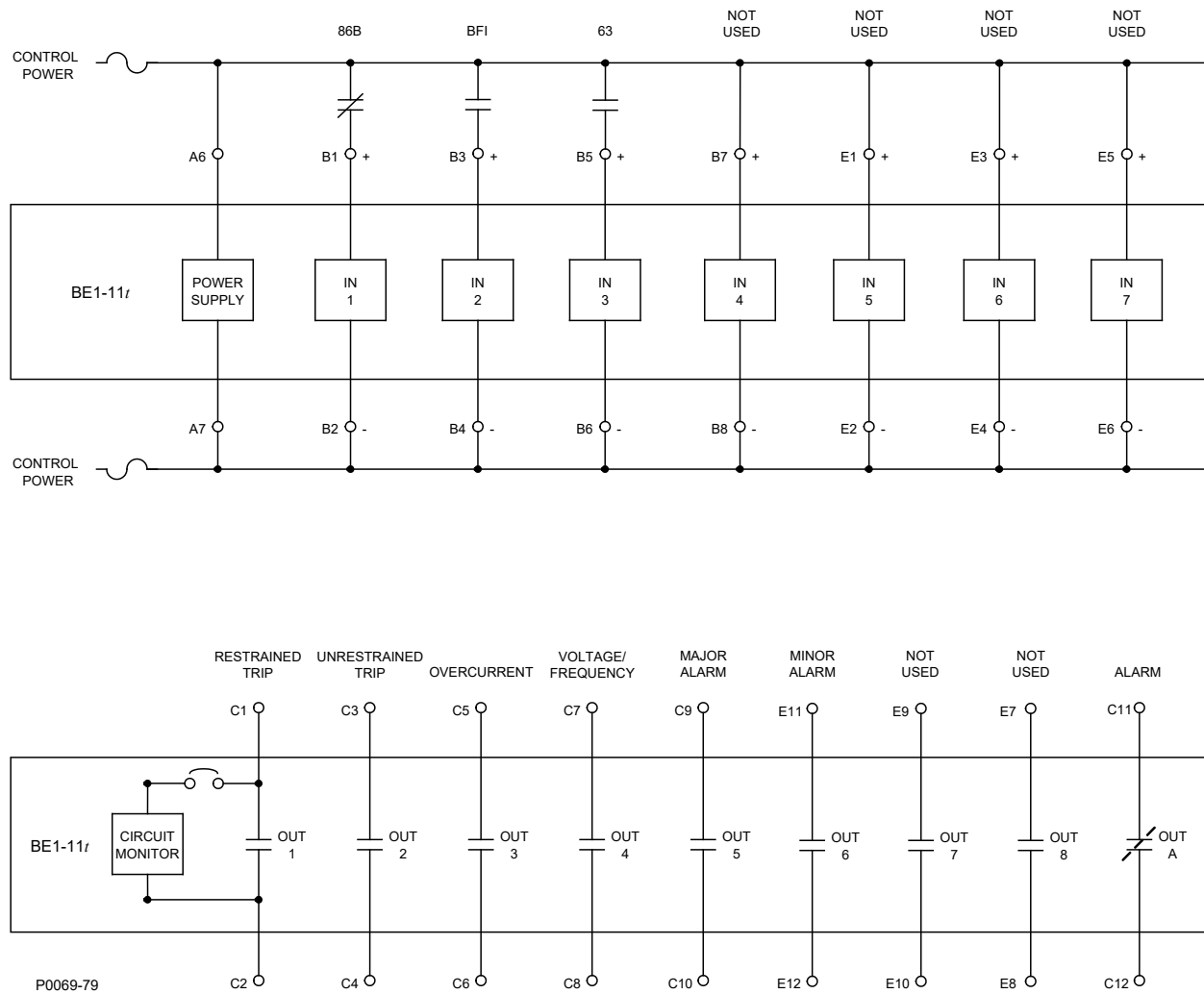


# 45 • Typical Connections

**Note**

The relay should be hard-wired to earth ground with no smaller than 12 AWG (4 mm<sup>2</sup>) copper wire attached to the rear ground terminal of the relay case. When the relay is configured in a system with other protective devices, a separate ground bus lead is recommended for each relay.

Typical external dc connections for the BE1-11r are shown in Figure 45-1.



**Figure 45-1. Typical External DC Connections**

Typical external ac connections for the BE1-11*t* are shown in Figure 45-2.

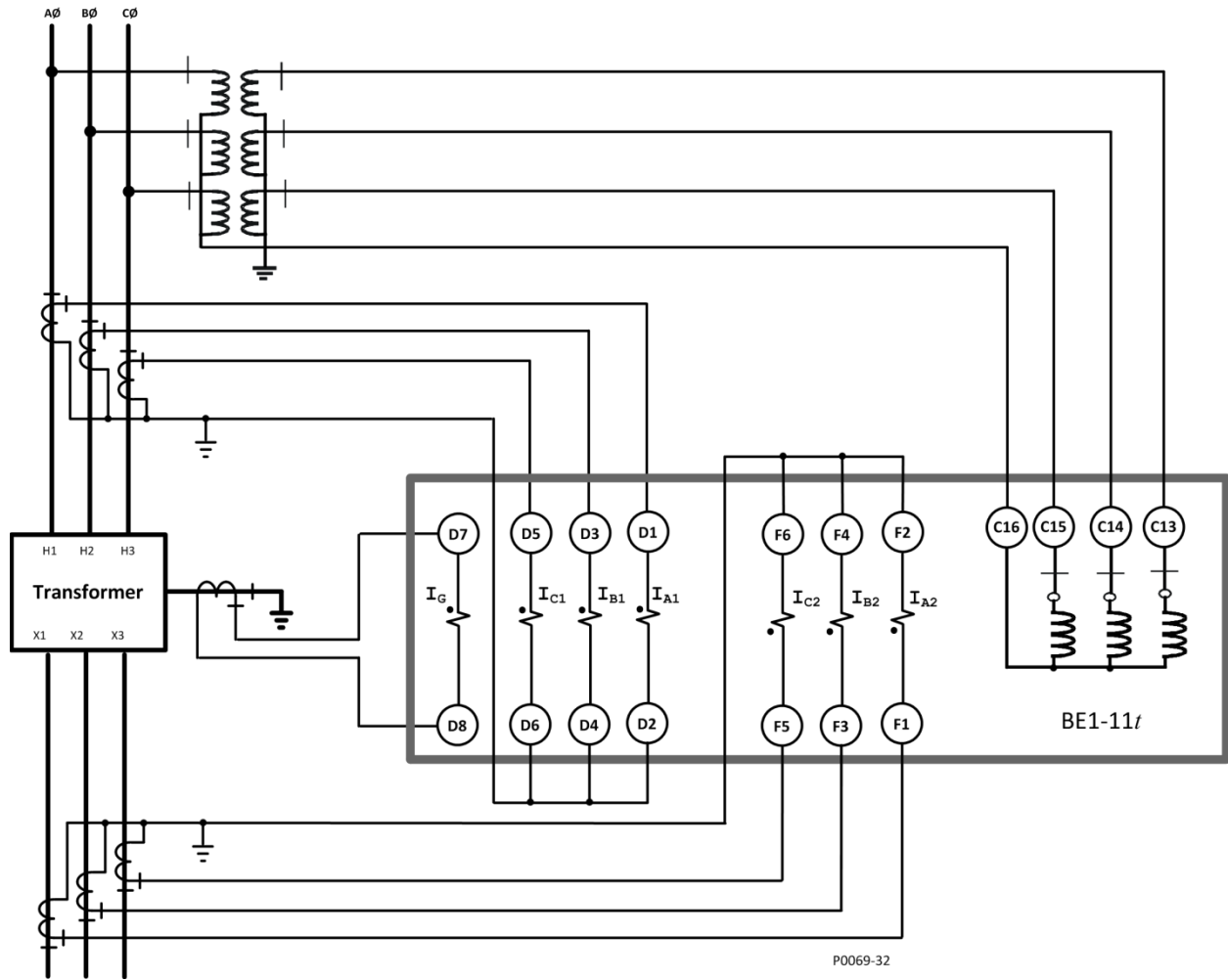
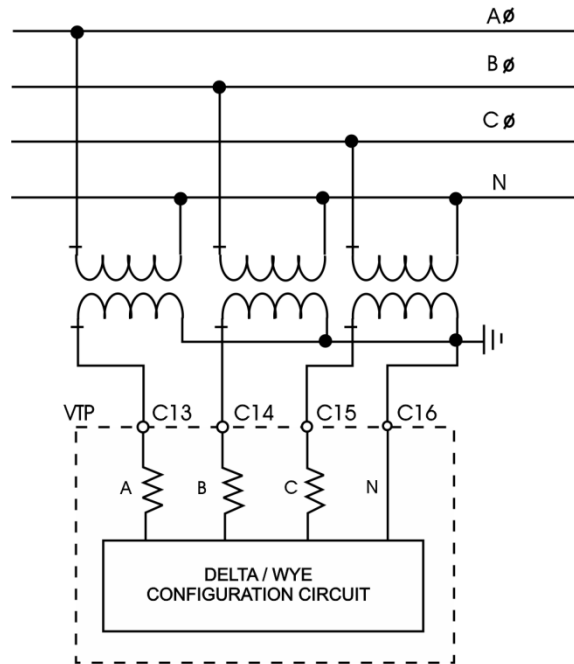


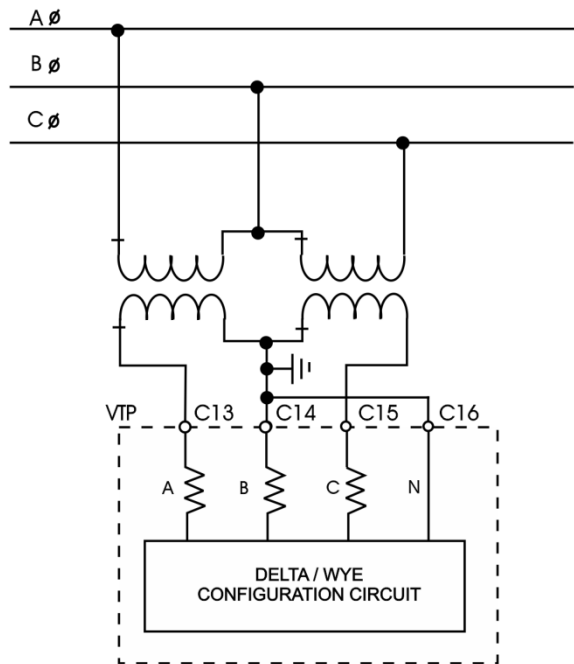
Figure 45-2. Typical AC Connections

Three-phase voltage sensing, alternate VT inputs are shown in Figure 45-3.



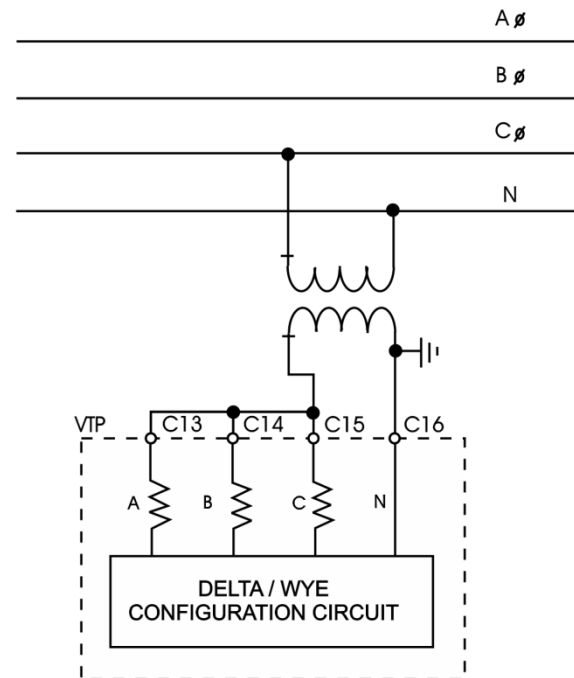
**A) Three Phase VTs; 4-Wire Connection**

Provides three-element metering. Elements 27P and 59P can be p-n or p-p. Provides negative- and zero-sequence polarizing for ground faults (67N).



**B) Three Phase VTs; 3-Wire Connection**

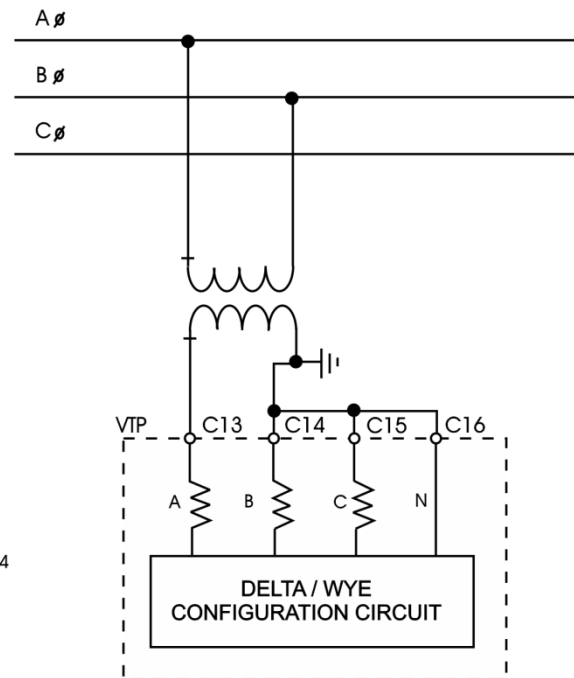
Provides two-element metering. Elements 27P and 59P are p-p. Element 59N (3V0) is disabled. Provides negative-sequence polarizing for ground faults (67N). Note relay B-to-N connection.



**C) One Phase VT; P-N Connection**

VT primary can be connected to any phase A-N, B-N, or C-N. One-element metering. Elements 47 (V2) and 59N (3V0) are disabled. Elements 27P and 59P are p-n.

P0074-54

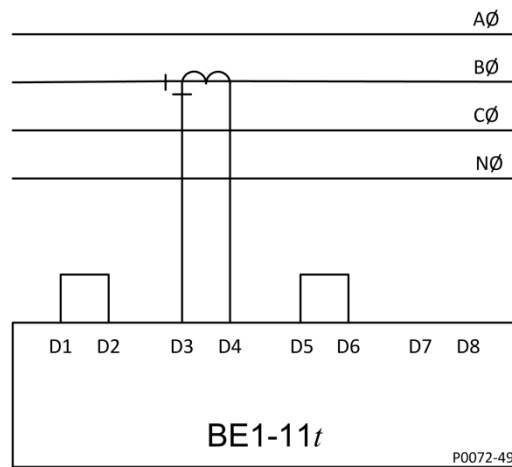


**D) One Phase VT; P-P Connection**

VT primary can be connected to any phase A-B, B-C, or C-A. One-element metering (30° shift). Elements 47 (V2) and 59N (3V0) are disabled. Elements 27P and 59P are p-p.

**Figure 45-3. Three-Phase Voltage Sensing, Alternate VTP Inputs**

Single-phase current sensing connections are shown in Figure 45-4.



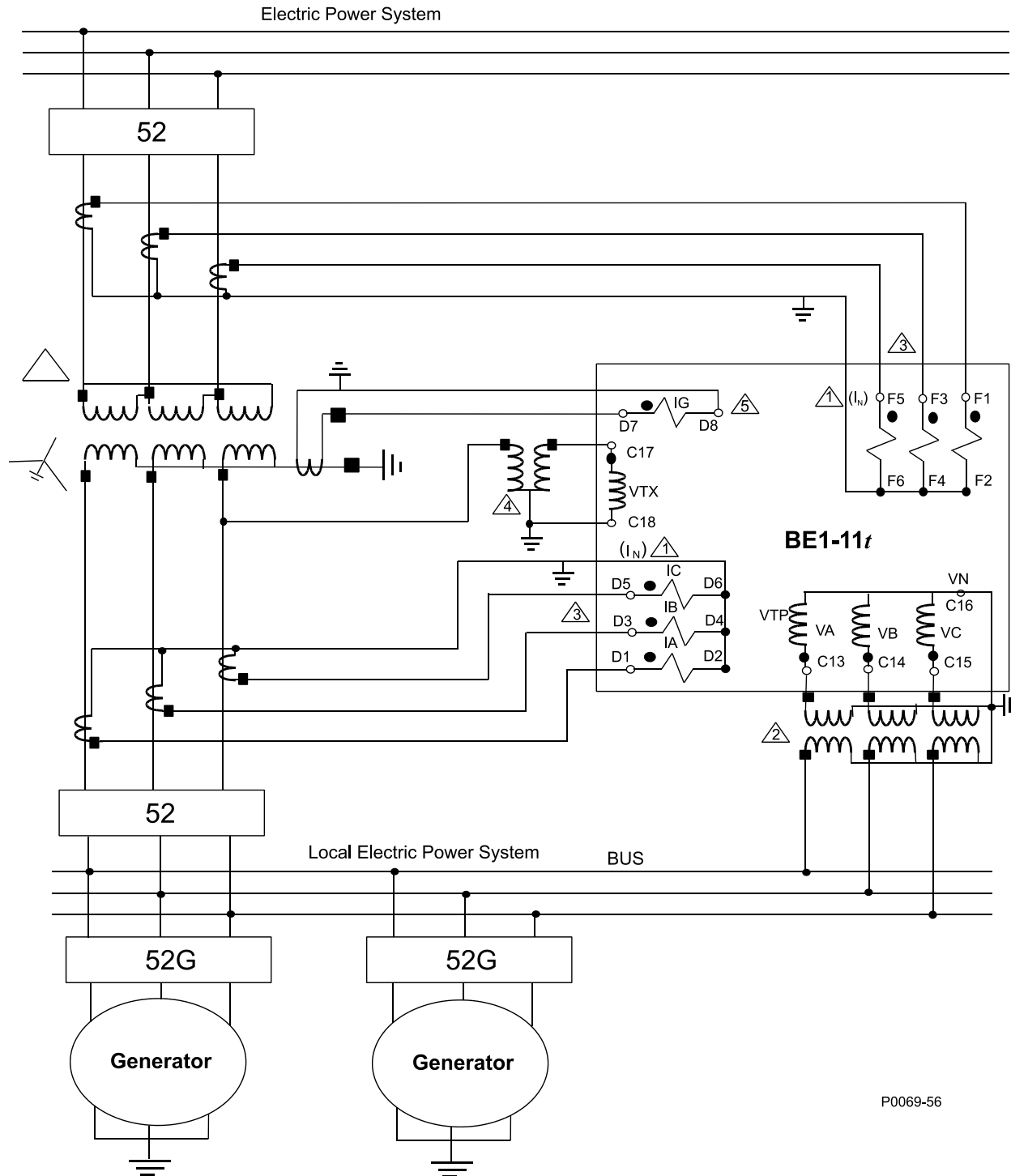
**Figure 45-4. Single-Phase Current Sensing Connections**

**Note**

Some elements may not function properly in certain modes when using single-phase current sensing.

# 46 • Power System Applications

The following figures show examples of the applications that can be served by the Basler Electric BE1-11*t* Transformer 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*f* Feeder Protection System, the BE1-11*g* Generator Protection System, or any other member of the BE1-11 family of protection systems.

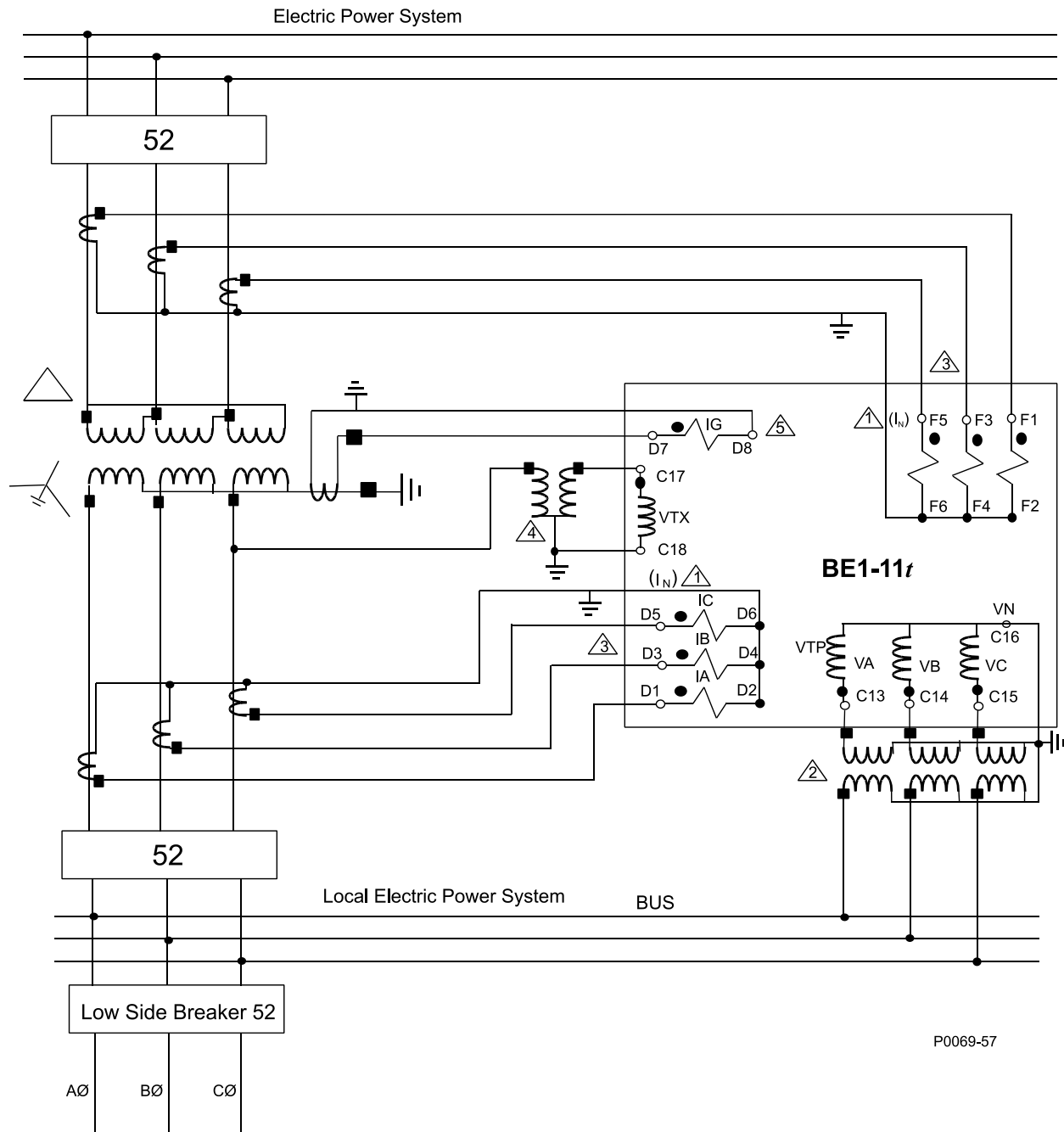


P0069-56

Figure 46-1. Complete Transformer Protection for Step-Up Transformers

## Notes for Figure 46-1:

1. The neutral ground (IN) operates on internally calculated residual (3I0) current.
2. 4-wire connection shown is 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.
3. The polarity of metered watts and vars can be adjusted using BESTCOMSP<sup>Plus</sup>®.
4. VTX can be connected A-N, B-N, C-N, or A-B, B-C, C-A. Refer to the *Typical Connections* chapter. The BE1-11 $\epsilon$  has settings for matching phase angle and voltage magnitude between VTX and VTP.
5. Independent Ground Input (IG) connected to detect Low Side ground faults and Transformer Ground Differential Protection.

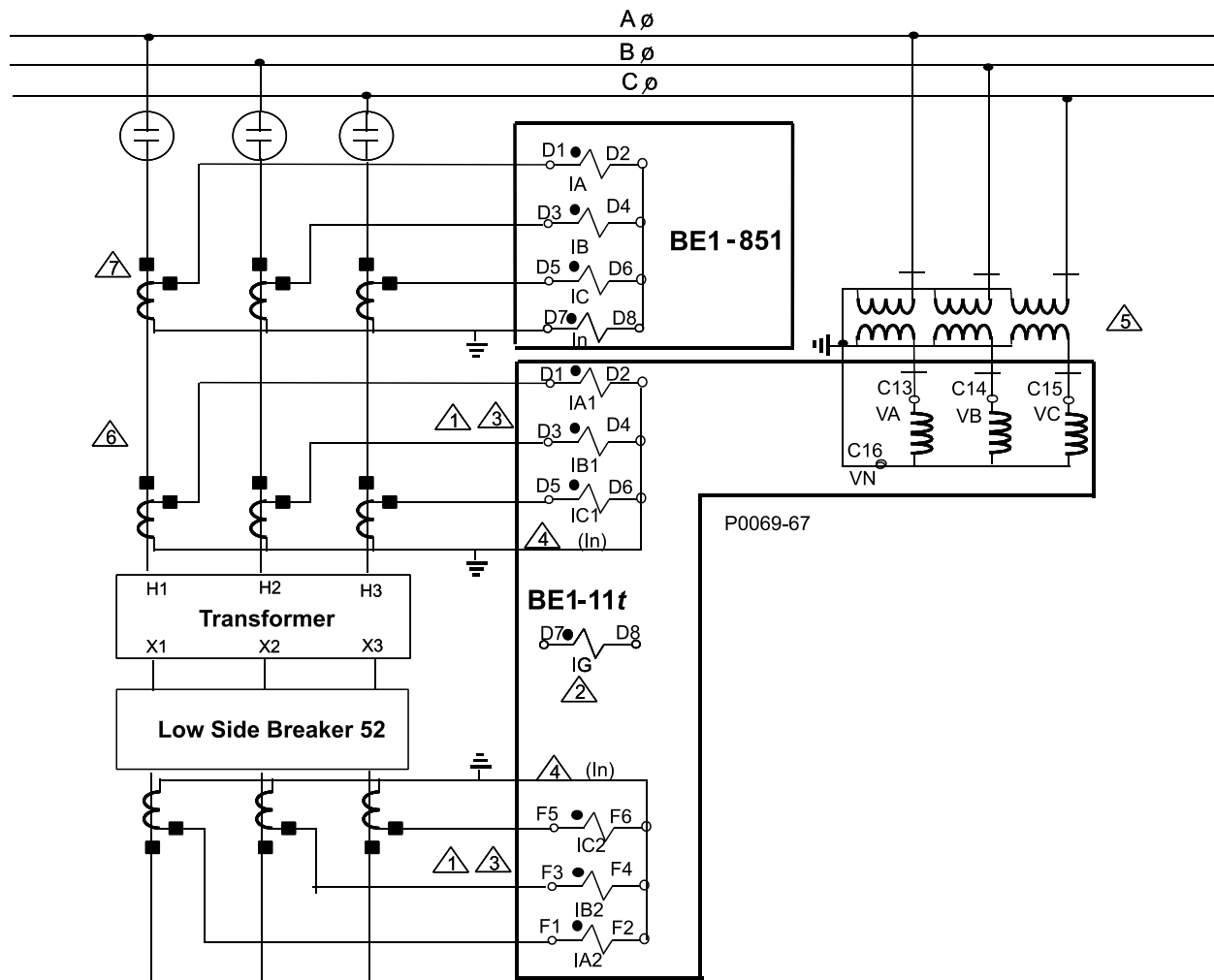


P0069-57

**Figure 46-2. Complete Transformer Protection for Network or Radial Transformer Applications**

Notes for Figure 46-2:

1. The neutral ground (IN) operates on internally calculated residual (3I<sub>0</sub>) current.
2. 4-wire connection shown is typical. See the *Typical Connections* chapter for alternate VTP connections.
3. The polarity of metered watts and vars can be adjusted using BESTCOMSP<sub>Plus</sub>.
4. VTX can be connected A-N, B-N, C-N, or A-B, B-C, C-A. Refer to the *Typical Connections* chapter. The BE1-11t has settings for matching phase angle and voltage magnitude between VTX and VTP.
5. Independent Ground Input (IG) connected to detect Low Side ground faults.



**Figure 46-3. BE1-11t Connected for Primary Protection, BE1-851 Connected for Independent Backup**

Notes for Figure 46-3:

1. With the appropriate transformer and CT connection information, the BE1-11t can automatically determine the required compensation. The BE1-11t can accommodate any combination of transformer and CT connection (wye, delta AB, or Delta AC). For more information, refer to the *Configuration* chapter.
2. Independent ground input ( $I_G$ ) can be connected for overcurrent or neutral differential protection.
3. Phase, residual, and  $I_2$  overcurrent elements can be connected to any CT circuit for backup protection.
4. Overcurrent neutral ground ( $I_N$ ) operates on internally calculated residual (3I<sub>0</sub>) current.
5. A four-wire connection is shown as typical. For more information on VTP connections, refer to the *Typical Connections* chapter.
6. The polarity of metered watts and vars can be adjusted using *BESTCOMSPUs*.
7. Shown with separate, overlapping CT for independent backup protection.

## 47 • BESTCOMSPPlus® Software

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

BESTCOMSPPlus provides the user with a point-and-click means to set and monitor the BE1-11t. The capabilities of BESTCOMSPPlus make the configuration of one or several BE1-11t Transformer Protection Systems fast and efficient. A primary advantage of BESTCOMSPPlus is that a settings scheme can be created, saved as a file, and then uploaded to the BE1-11t at the user's convenience.

BESTCOMSPPlus uses plugins allowing the user to manage several different Basler Electric products. The BE1-11 plugin opens inside the BESTCOMSPPlus main shell. The same default logic scheme that is shipped with the BE1-11t is brought into BESTCOMSPPlus by downloading settings and logic from the BE1-11t or by selecting application type "T" 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 BE1-11t 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.

BESTCOMSPPlus also allows for downloading industry-standard COMTRADE files for analysis of stored oscillography data. Detailed analysis of the oscillography files can be accomplished using BESTdata software. BESTdata software is free and available at [www.basler.com](http://www.basler.com).

Figure 47-1 illustrates the typical user interface components of the BE1-11 plugin with BESTCOMSPPlus.

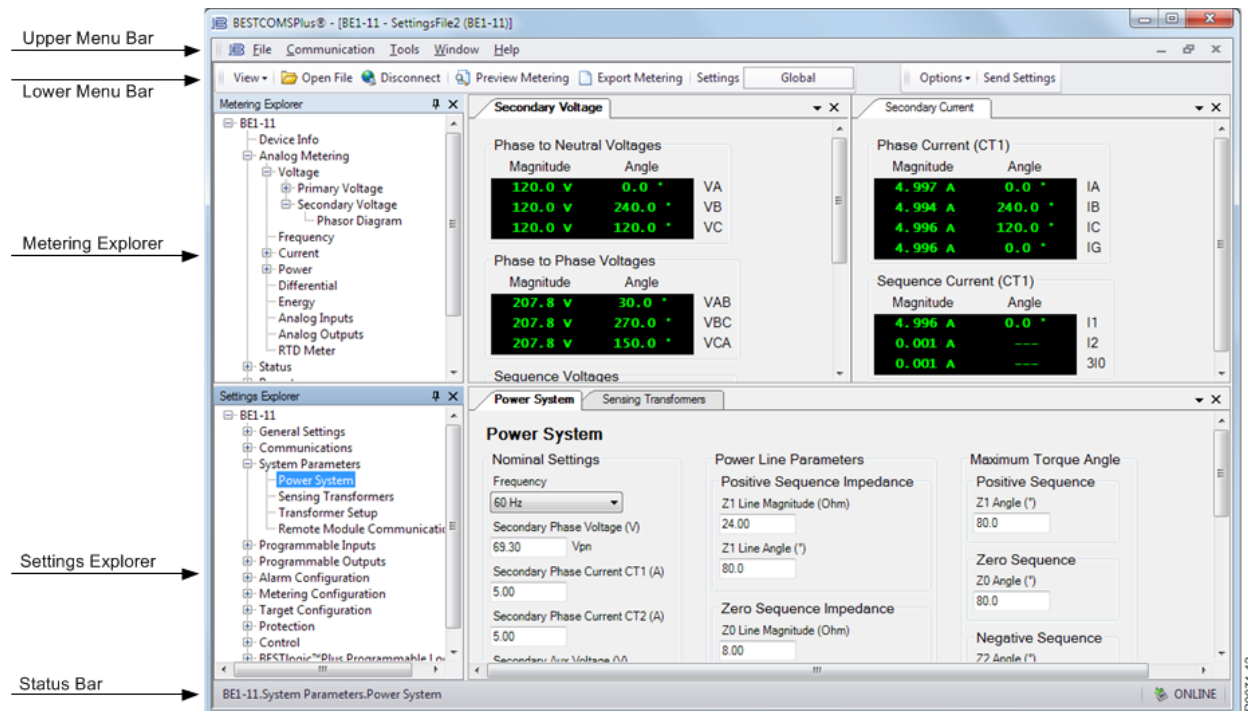


Figure 47-1. Typical User Interface Components

## System Recommendations

BESTCOMSP*lus* software is built on the Microsoft® .NET Framework. The setup utility that installs BESTCOMSP*lus* on your PC also installs the BE1-11 plugin and the required version of .NET Framework (if not already installed). BESTCOMSP*lus* operates with systems using Windows® 7 SP1, Windows 8.1, Windows 10, and Windows 11. System recommendations for the .NET Framework and BESTCOMSP*lus* are listed in Table 47-1.

**Table 47-1. System Recommendations for BESTCOMSP*lus* and the .NET Framework**

System Type	Component	Recommendation
32/64 bit	Processor	2.0 GHz
32/64 bit	RAM	1 GB (minimum), 2 GB (recommended)
32 bit	Hard Drive	200 MB (if .NET Framework is already installed on PC)
		4.5 GB (if .NET Framework is not already installed on PC)
64 bit	Hard Drive	200 MB (if .NET Framework is already installed on PC)
		4.5 GB (if .NET Framework is not already installed on PC)

To install BESTCOMSP*lus*, a Windows user must have Administrator rights.

## Installation

### 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.

Run the setup file for the BESTCOMSP*lus* application. The setup utility installs BESTCOMSP*lus*, the .NET Framework (if not already installed), the USB driver, and the BE1-11 plugin for BESTCOMSP*lus* on your PC.

When BESTCOMSP*lus* 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 BESTCOMSP*lus* when clicked.

## Connect the BE1-11 and Start BESTCOMSP*lus*®

The BE1-11 plugin is a module that runs inside the BESTCOMSP*lus* shell. The BE1-11 plugin contains specific operational and logic settings for only the BE1-11*t*.

### Connect a USB Cable

The USB driver was copied to your PC during BESTCOMSP*lus* installation and is installed automatically after powering the BE1-11*t*. 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*t*. Apply operating power (per style chart in the *Introduction* chapter) to the BE1-11*t* at rear terminals A6 and A7. Wait until the boot sequence is complete.

### 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\USB Connect Driver\

If the USB driver does not install properly, refer to the *Troubleshooting* chapter.

### Start BESTCOMSPPlus®

To start BESTCOMSPPlus, click the Start button, point to Programs, Basler Electric, and then click the BESTCOMSPPlus icon. During initial startup, the BESTCOMSPPlus Select Language screen is displayed (Figure 47-2). You can choose to have this screen displayed each time BESTCOMSPPlus 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.

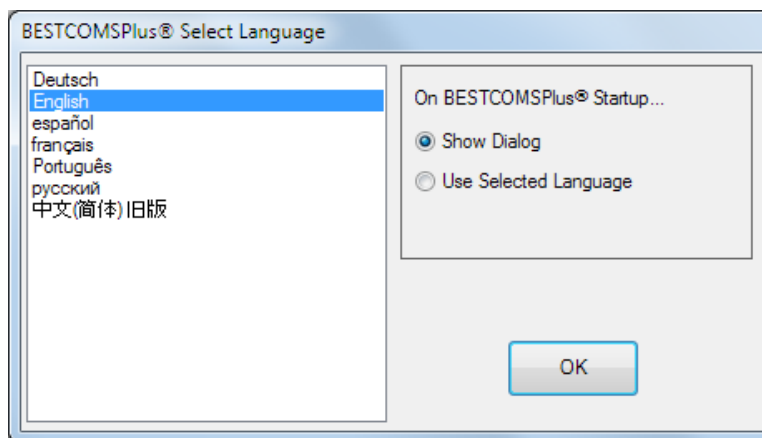


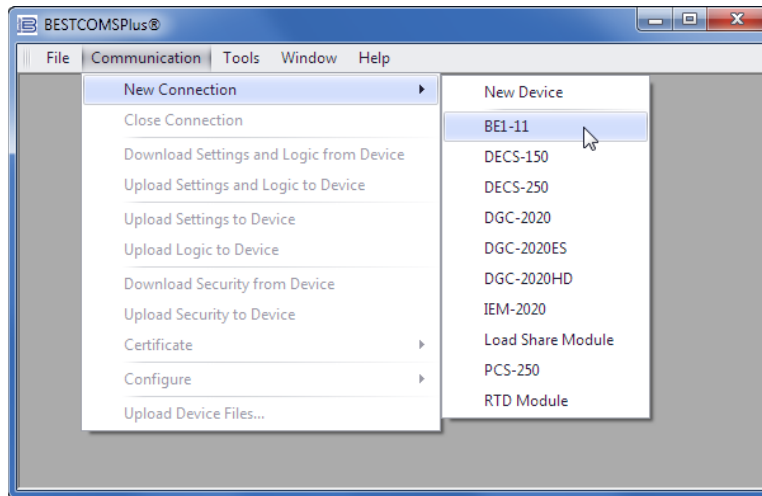
Figure 47-2. BESTCOMSPPlus Select Language Screen

The BESTCOMSPPlus splash screen is shown for a brief time. See Figure 47-3.



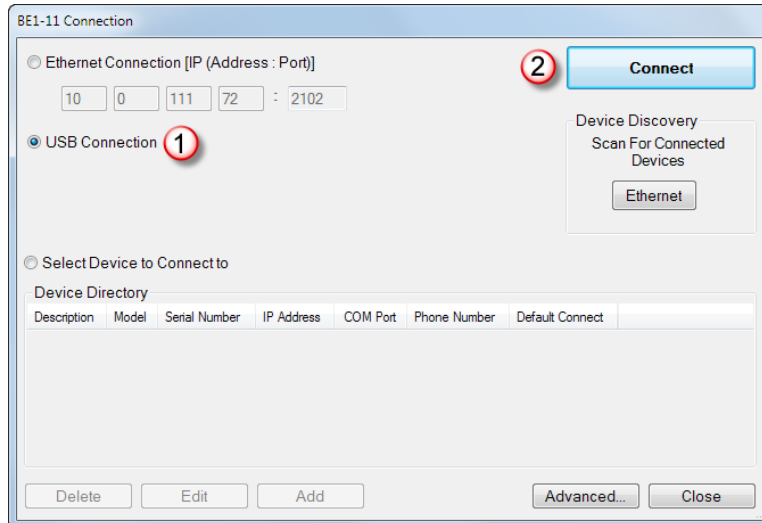
Figure 47-3. BESTCOMSPPlus Splash Screen

The BESTCOMSPPlus platform window opens. Select New Connection from the Communication pull-down menu and select BE1-11. See Figure 47-4.

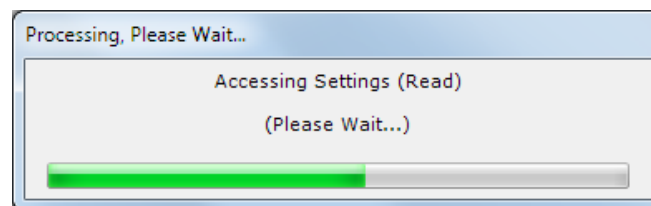


**Figure 47-4. Communication Pull-Down Menu**

The BE1-11 Connection screen shown in Figure 47-5 appears. Select USB Connection and then click the Connect button.



**Figure 47-5. BE1-11 Connection Screen**



**Figure 47-6. 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 47-7.

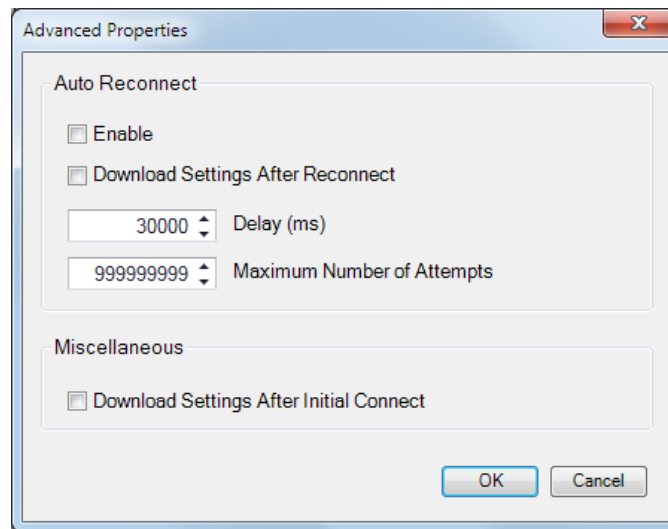


Figure 47-7. Advanced Properties Dialog

## Menu Bars

The menu bars are located near the top of the BESTCOMSP*lus* screen (see Figure 47-1). 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 BESTCOMSP*lus* 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 (BESTCOMSP*lus*® Shell)

Upper menu bar functions are listed and described in Table 47-2.

Table 47-2. Upper Menu Bar (BESTCOMSP*lus* Shell)


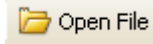
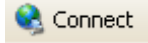
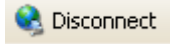

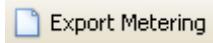
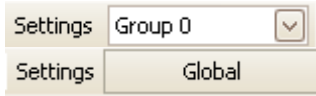


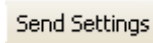
Menu Item	Description
<i>File</i>	
New	Create a new settings file
Open	Open an existing settings file
Close	Close settings file
Save	Save settings file
Save As	Save settings file with a different name
Export To File	Save settings as a *.csv file
Print	Print, export, or send a settings file
Properties	View properties of a settings file
History	View history of a settings file
Recent Files	Open a previously opened file
Exit	Close BESTCOMSP <i>lus</i> program
<i>Communication</i>	
New Connection	Choose new device or BE1-11
Close Connection	Close communication between BESTCOMSP <i>lus</i> and BE1-11
Download Settings and Logic from Device	Download operational and logic settings from the device

<b>Menu Item</b>	<b>Description</b>
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
Certificate - Upload Certificate to Device	Upload certificate to the device
Certificate - Remove Certificate from Device	Remove certificate from the device
Reset to Factory Defaults	Reset factory defaults in the BE1-11t (Available only when the device does not contain default settings. Administrator access level required.)
Upload Settings, Logic and Security	Upload operational, logic, and security settings to the device (Available only when the device contains default settings. No password required.)
Configure	Ethernet settings
Upload Device Files	Upload firmware to the device
Upgrade Style Number	Upload a style upgrade file supplied by Basler Electric
<b>Tools</b>	
Select Language	Select BESTCOMSPi+ language
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 at a user-defined interval
Launch BEST61850™	Opens BEST61850 (if installed)
Event Log - View	View the BESTCOMSPi+ event log
Event Log - Verbose Logging	Enable/disable verbose logging
Event Log - Verbose Communication Logging	Enable/disable verbose communication logging
Set Default Shell	Select the default shell for BESTCOMSPi+
Generate Certificate	Generate a certificate
Accepted Devices	View and delete accepted devices
<b>Help</b>	
Check for Updates	Check for BESTCOMSPi+ 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 47-3.

**Table 47-3. Lower Menu Bar (BE1-11 Plugin)**

Menu Button	Description
	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.
	Opens a saved settings file.
	Opens the BE1-11 Connection screen which enables you to connect to the BE1-11 <i>t</i> via USB or Ethernet. This button appears only when a BE1-11 <i>t</i> is not connected.
	Used to disconnect a connected BE1-11 <i>t</i> . This button appears only when a BE1-11 <i>t</i> is connected.
	Displays the Print Preview screen where a preview of the Metering printout is shown. Click on the printer button to send to a printer.
	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 BESTCOMSP <i>lus</i> is not operating in Live Mode. Click this button after making a setting change to send the modified setting to the BE1-11 <i>t</i> .

## Settings Explorer

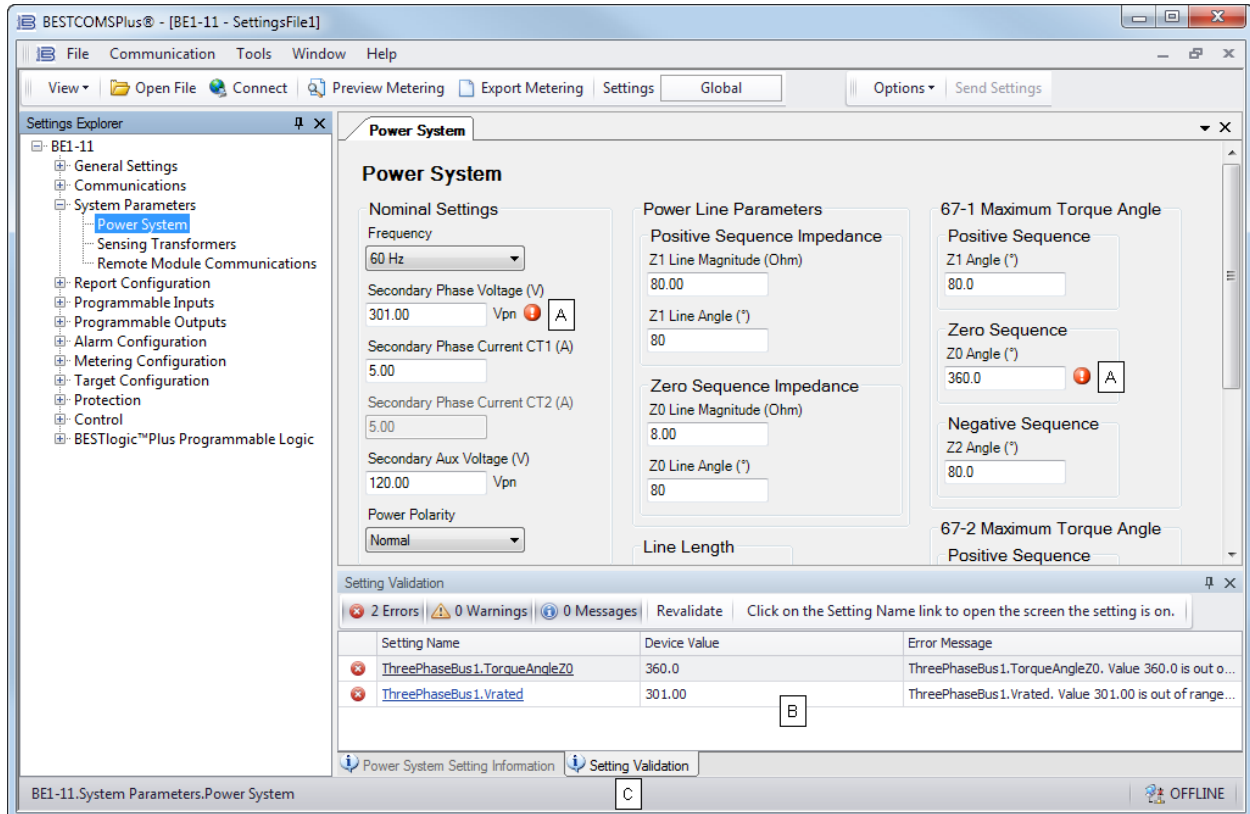
The Settings Explorer is a convenient tool within BESTCOMSP*lus* used to navigate through the various settings screens of the BE1-11 plugin. Descriptions of these configuration settings are organized as follows:

- 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.

## Settings Entry

When entering settings in *BESTCOMSPPlus*, each setting is validated against prescribed limits. Entered settings that do not conform with the prescribed limits are accepted but flagged as noncompliant. Figure 47-8 illustrates an example of flagged, noncompliant settings (locator A) and the Setting Validation window (locator B) used to diagnose faulty settings.



**Figure 47-8. Flagged, Noncompliant Settings and the Setting Validation Window**

The Setting Validation window, viewed by selecting the Setting Validation tab (locator C), displays three types of annunciations: errors, warnings, and messages. An error describes a problem such as a setting that is out of range. A warning describes a condition where supporting settings are invalid, causing other settings to be noncompliant with the prescribed limits. A message describes a minor setting issue that was automatically resolved by *BESTCOMSPPlus*. An example of a condition triggering a message is entry of a settings value with a resolution that exceeds the limit imposed by *BESTCOMSPPlus*. In this situation, the value is automatically rounded and a message is triggered. Each annunciation lists a hyperlinked name for the noncompliant setting and an error message describing the issue. Clicking the hyperlinked setting name takes you to the setting screen with the offending setting. Right-clicking the hyperlinked setting name will restore the setting to its default value.

### Note

It is possible to save a BE1-11 settings file in *BESTCOMSPPlus* with noncompliant settings. However, it is not possible to upload noncompliant settings to the BE1-11.

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## ***Metering Explorer***

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The Metering Explorer is described in the *Metering* chapter.

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## ***Settings File Management***

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A settings file contains all BE1-11*t* settings including logic.

A settings file created in BESTCOMSP*lus* will have one of two file extensions. Settings files created in version 4.00.00 and later are given an extension of “bst4”. Settings files created in versions prior to 4.00.00 will have an extension of “bstx”.

It is possible to save only the BE1-11*t* logic displayed on the BESTLogicP*lus* Programmable Logic screen as a separate logic library file. This ability is helpful when similar logic is required for several BE1-11*t* systems. The file extension of a logic file created in BESTCOMSP*lus* will be either “bsl4” (version 4.00.00 and later) or “bslx” (versions prior to 4.00.00).

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 BESTLogicP*lus* chapter.

### **Opening a Settings File**

To open a BE1-11*t* settings file with BESTCOMSP*lus*, pull down the **F**ile 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 BESTCOMSP*lus* instance will be overwritten with the settings of the opened file.

### **Saving a Settings File**

Select Save or Save As from the **F**ile 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*t*, open the file or create a new file through BESTCOMSP*lus*. Then pull down the **C**ommunication 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.

### **Upload Settings, Logic, and Security to Device**

This function is available only when the device contains default settings. A password is not required. To upload settings, logic, and security to the BE1-11*t*, pull down the Communication menu and select Upload Settings, Logic, and Security.

### **Download Settings and Logic from Device**

To download settings and logic from the BE1-11*t*, pull down the **C**ommunication menu and select Download Settings and Logic from Device. If the settings in BESTCOMSP*lus* 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. BESTCOMSP*lus* reads all settings and logic from the BE1-11*t* and loads them into BESTCOMSP*lus* memory. See Figure 47-9.

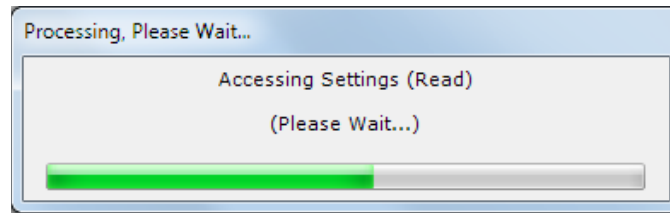


Figure 47-9. Processing, Please Wait...

## Printing a Settings File

To view a preview of the settings printout, select Print Preview from the **F**ile 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 **F**ile 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

BESTCOMSP*lus* has the ability to compare two settings files. To compare files, pull down the **T**ools menu and select Compare Settings Files. The BESTCOMSP*lus* Settings Compare Setup dialog box appears (Figure 47-10). 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 from a unit, click the Download settings from unit button to set up the communication port. Click the Compare button to compare the selected settings files.

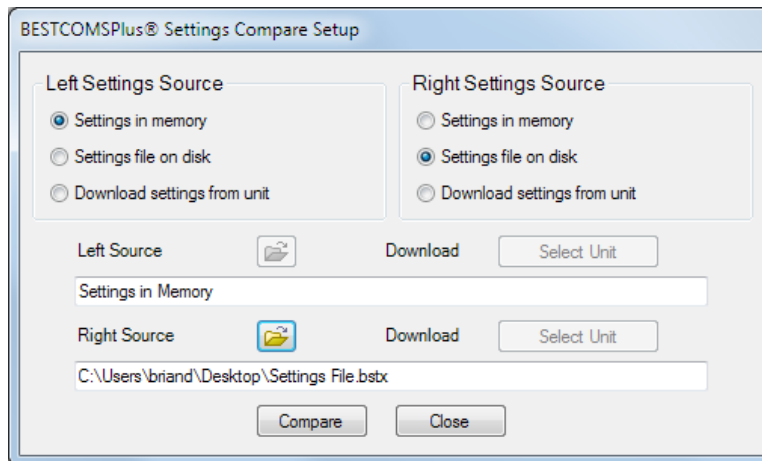


Figure 47-10. BESTCOMSP*lus* Settings Compare Setup

A dialog box will appear and notify you if any differences were found. The BESTCOMSP*lus* Settings Compare dialog box (Figure 47-11) is displayed where you can select to 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 BE1-11*t*, the BE1-11*t* 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.

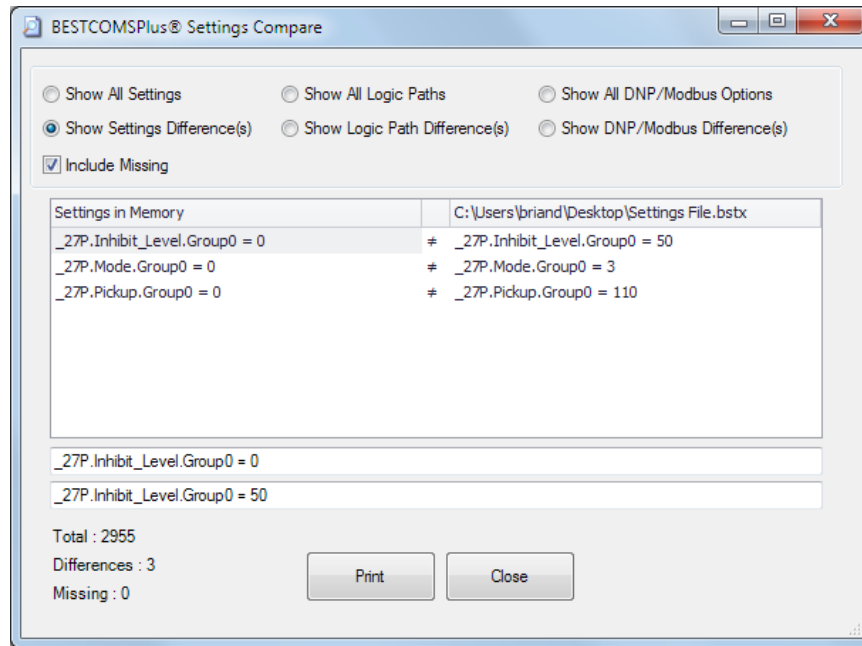


Figure 47-11. BESTCOMSPPlus Settings Compare

## 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 47-12 illustrates the Auto Export Metering screen.

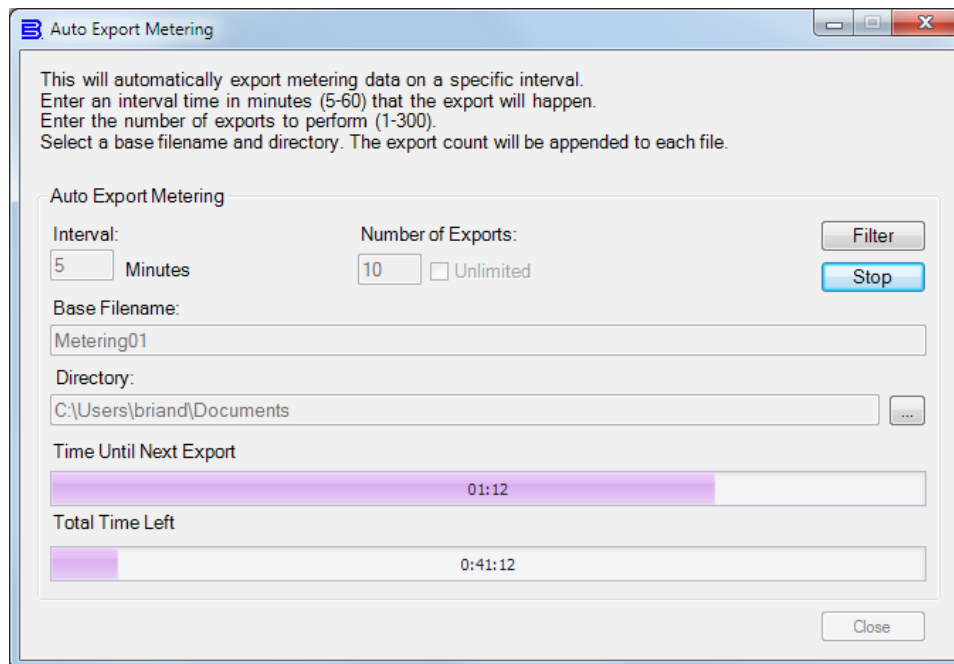


Figure 47-12. Auto Export Metering

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## ***BESTCOMSPi<sup>®</sup> Updates***

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Ongoing BE1-11*t* functionality enhancements may make future BE1-11*t* firmware updates desirable. Enhancements to BE1-11*t* firmware typically coincide with enhancements to the BE1-11 plugin for BESTCOMSPi<sup>®</sup>. When a BE1-11*t* is updated with the latest version of firmware, the latest version of BESTCOMSPi<sup>®</sup> should also be obtained.

- You can download the latest version of BESTCOMSPi<sup>®</sup> by visiting [www.basler.com](http://www.basler.com).
- BESTCOMSPi<sup>®</sup> automatically checks for updates when Check Automatically is selected on the Check for Updates User Settings screen. This screen is accessed under the Help drop-down menu. (An internet connection is required.)
- You can use the manual “check for updates” function in BESTCOMSPi<sup>®</sup> to ensure that the latest version is installed by selecting Check for Updates in the Help drop-down menu. (An internet connection is required.)

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## ***Firmware Updates***

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For information on updating firmware, refer to the *Device Information* chapter.

## 48 • BESTlogic™ Plus

BESTlogicPlus Programmable Logic is a programming method used for managing the input, output, protection, control, monitoring, and reporting capabilities of Basler Electric's BE1-11t Transformer Protection System. Each BE1-11t 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 BESTlogicPlus. BESTlogicPlus equations entered and saved in the BE1-11t 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 BE1-11t is called a logic scheme.

One default active logic scheme is preloaded into the BE1-11t. This scheme is configured for a typical transformer application and virtually eliminates the need for "start-from-scratch" programming. BESTCOMSPUs® can be used to open a logic scheme that was previously saved as a file and upload it to the BE1-11t. The default logic scheme can also be customized to suit your application.

BESTlogicPlus 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 BE1-11t. Detailed information about operating settings is provided in each chapter of the various protection and control functions.

### Caution

This product contains one or more *nonvolatile memory* devices. Nonvolatile memory is used to store information (such as settings) that needs to be preserved when the product is power-cycled or otherwise restarted. Established nonvolatile memory technologies have a physical limit on the number of times they can be erased and written. In this product, the limit is 100,000 erase/write cycles. During product application, consideration should be given to communications, logic, and other factors that may cause frequent/repeated writes of settings or other information that is retained by the product. Applications that result in such frequent/repeated writes may reduce the useable product life and result in loss of information and/or product inoperability.

### Overview of BESTlogic™ Plus

BESTlogicPlus settings are made through BESTCOMSPUs. Use the Settings Explorer to open the BESTlogicPlus Programmable Logic tree branch as shown in Figure 48-1.

The BESTlogicPlus Programmable Logic screen contains a logic library for opening and saving logic files, tools for creating and editing logic documents, and protection settings.

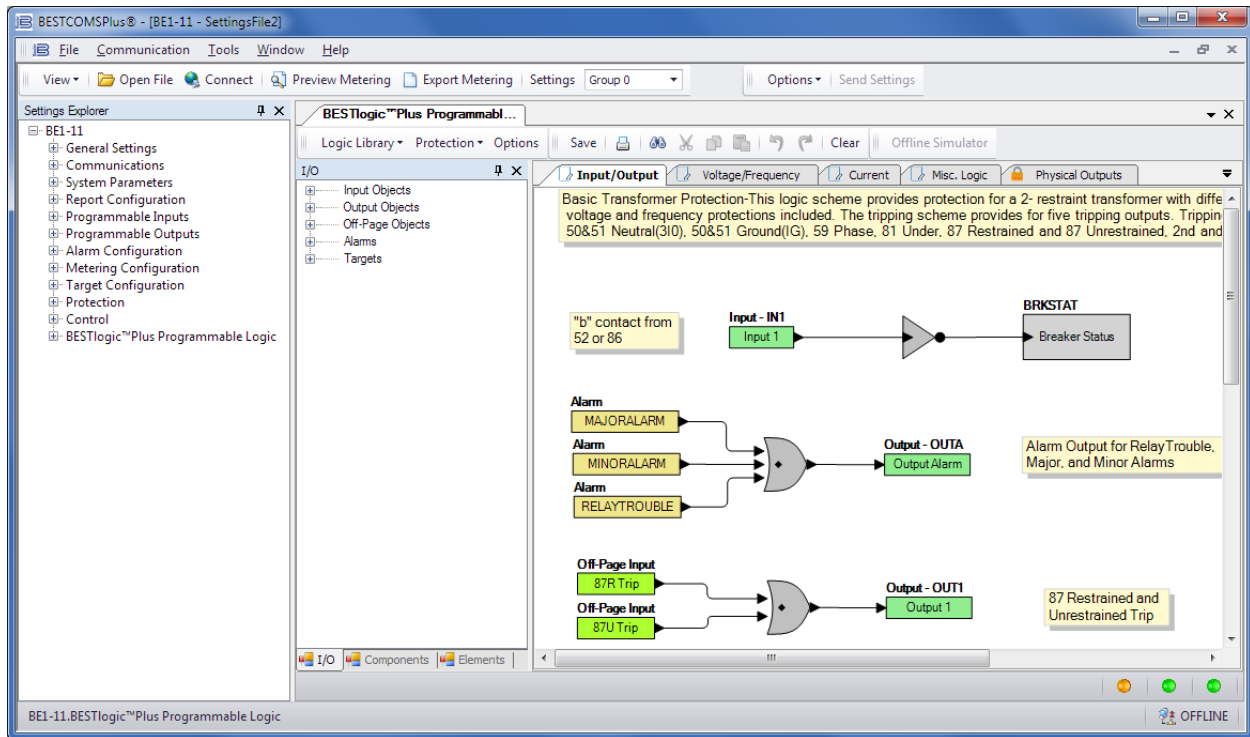


Figure 48-1. BESTlogicPlus Programmable Logic Tree Branch

### BESTlogic™Plus Composition

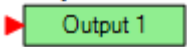
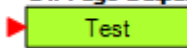
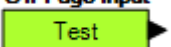
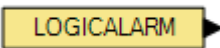
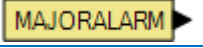
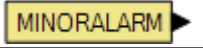
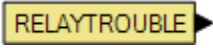
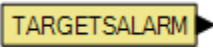
There are three main groups of objects used for programming BESTlogicPlus. These groups are I/O, Components, and Elements. For details on how these objects are used to program BESTlogicPlus, see the paragraphs on *Programming BESTlogicPlus*.

#### 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 48-1 lists the names and descriptions of the objects in the I/O group.

Table 48-1. I/O Group, Names and Descriptions

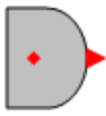
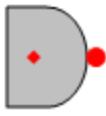
Name	Description	Symbol
<b>Input Objects</b>		
Logic 0	Always false (Low). Double-click or right-click on the object to change the fixed state from 0 to 1.	
Logic 1	Always true (High). Double-click or right-click on the object to change the fixed state from 1 to 0.	
Physical Inputs IN1 – IN10	True when Physical Input x is active.	
Status Inputs Alarm Reset	The Alarm Reset status input goes momentarily high when the Major, Minor, and Logic alarms are cleared.	
Status Inputs CT Circuit 1 and CT Circuit 2 Current Detected	The CT Circuit 1 Current Detected status input goes high when ac current is greater than 5% of nominal as determined by the fast current detector.	
Status Inputs Target Reset	The Target Reset status input goes momentarily high when the targets are cleared.	



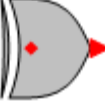


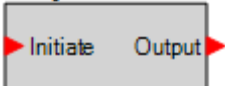
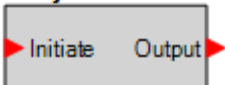
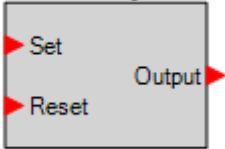
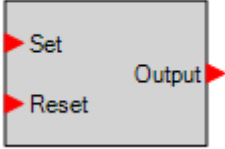
Name	Description	Symbol
<b>Output Objects</b>		
Physical Outputs OUT1 – OUT8 and OUTA	Physical Outputs 1 through 8 and A.	<b>Output - OUT1</b> 
<b>Off-Page Objects</b>		
Off-Page Output	Used in conjunction with the Off-Page Input to transform an output on one logic page into an input on another logic 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.	<b>Off-Page Output</b> 
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.	<b>Off-Page Input</b> 
<b>Alarms</b>		
Logic Alarm	True when the Logic Alarm is true. Refer to the <i>Alarms</i> chapter for more information.	<b>Alarm</b> 
Major Alarm	True when the Major Alarm is true. Refer to the <i>Alarms</i> chapter for more information.	<b>Alarm</b> 
Minor Alarm	True when the Minor Alarm is true. Refer to the <i>Alarms</i> chapter for more information.	<b>Alarm</b> 
Relay Trouble Alarm	True when a Relay Trouble alarm is active. Refer to the <i>Alarms</i> chapter for more information.	<b>Alarm</b> 
Targets	True when targets are active. Refer to the <i>Fault Reporting</i> chapter for more information.	<b>Alarm</b> 

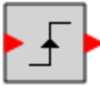
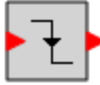
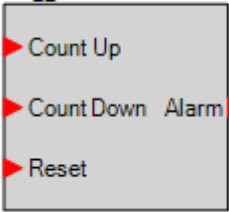
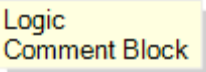
Components

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 48-2 lists the names and descriptions of the objects in the Components group.

**Table 48-2. Components Group, Names and Descriptions**

Name	Description	Symbol										
<b>Logic Gates</b>												
AND	<table border="1"> <thead> <tr> <th>Input</th> <th>Output</th> </tr> </thead> <tbody> <tr> <td>0 0</td> <td>0</td> </tr> <tr> <td>0 1</td> <td>0</td> </tr> <tr> <td>1 0</td> <td>0</td> </tr> <tr> <td>1 1</td> <td>1</td> </tr> </tbody> </table>	Input	Output	0 0	0	0 1	0	1 0	0	1 1	1	
Input	Output											
0 0	0											
0 1	0											
1 0	0											
1 1	1											
NAND	<table border="1"> <thead> <tr> <th>Input</th> <th>Output</th> </tr> </thead> <tbody> <tr> <td>0 0</td> <td>1</td> </tr> <tr> <td>0 1</td> <td>1</td> </tr> <tr> <td>1 0</td> <td>1</td> </tr> <tr> <td>1 1</td> <td>0</td> </tr> </tbody> </table>	Input	Output	0 0	1	0 1	1	1 0	1	1 1	0	
Input	Output											
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Name	Description	Symbol										
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NOT (INVERTER)	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Input</th> <th>Output</th> </tr> </thead> <tbody> <tr><td>0</td><td>1</td></tr> <tr><td>1</td><td>0</td></tr> </tbody> </table>	Input	Output	0	1	1	0					
Input	Output											
0	1											
1	0											
<b>Pickup and Dropout Timers</b>												
Pick 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 <i>Programming BESTlogicPlus, Pickup and Dropout Timers</i> . Double-click or right-click on the logic timer to select from timers 1 through 16.	<b>Pick Up Timer (1)</b> <b>TIMER_1</b> <b>Delay = 1</b> 										
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 <i>Programming BESTlogicPlus, Pickup and Dropout Timers</i> . Double-click or right-click on the logic timer to select from timers 1 through 16.	<b>Drop Out Timer (1)</b> <b>TIMER_1</b> <b>Delay = 1</b> 										
<b>Latches</b>												
Reset Priority Latch	The latch is set when the Set input is true and the Reset input is false. The latch is cleared when the Reset input is true.	<b>Reset Priority Latch</b> 										
Set Priority Latch	The latch is set when the Set input is true. The latch is cleared when the Set input is false and the Reset input is true.	<b>Set Priority Latch</b> 										


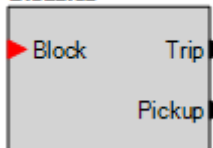
Name	Description	Symbol
<b>Triggers</b>		
Rising Edge	The output of a rising edge trigger pulses true when the input goes from logic 0 to logic 1. Double-click or right-click on the logic trigger to change the type.	
Falling Edge	The output of a falling edge trigger pulses true when the input goes from logic 1 to logic 0. Double-click or right-click on the logic trigger to change the type.	
<b>Logic Counters</b>		
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.	<p data-bbox="1159 527 1338 604"><b>Counter (1)</b> <b>Counter_1</b> <b>Trigger Count = 1</b></p> 
<b>Other</b>		
Logic Comment Block	The logic comment block is used to place notes on the logic.	

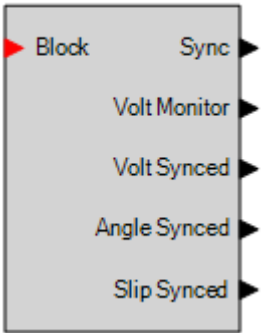
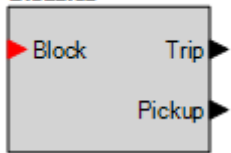
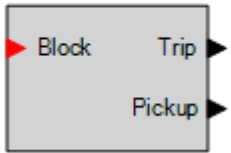
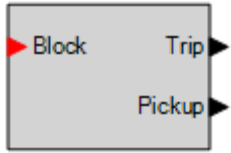
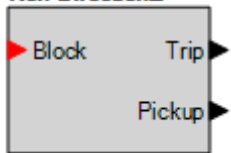
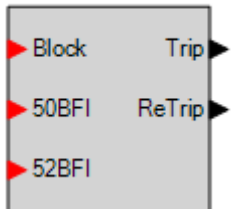
Elements

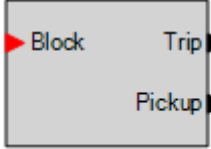
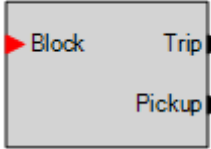
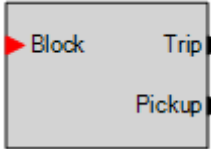
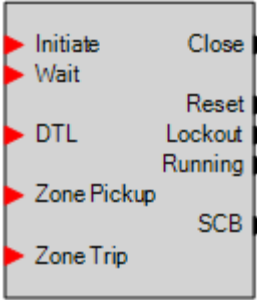
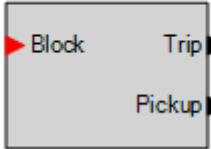
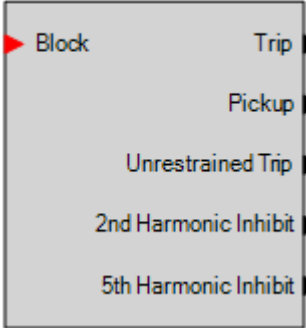
This group contains elements for the 21, 24, 25, 27P, 27X, 43, 49RTD, 50, 50BF, 51, 51TF, 59P, 59X, 60FL, 62, 79, 81, 86, 87, 87N, and 101. It also contains elements for 52TCM, Breaker Monitor, Breaker Status, Fault Trigger, Email Trigger, Setting Group Control, Analog Inputs 1-8, User Programmable Alarms 1-16, User Programmable Targets 1-12, Logic Labels 1-12, Indicators 1-7, Major Alarm Reset, Minor Alarm Reset, Logic Alarm Reset, and Target Reset.

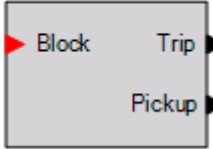
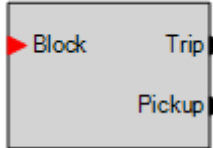
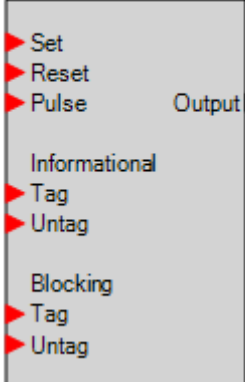
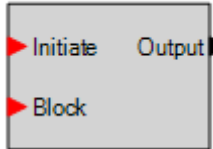
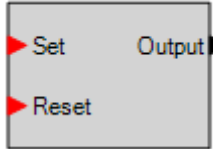
Table 48-3 lists the names and descriptions of the elements in the Elements group.

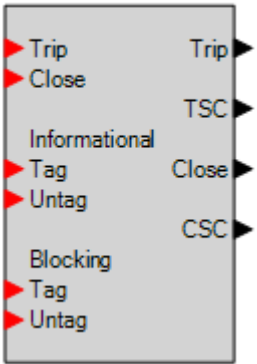
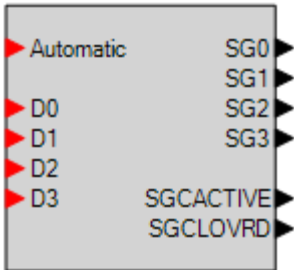
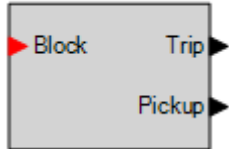
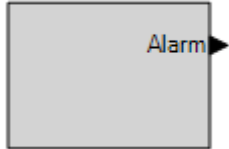
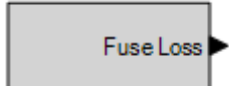
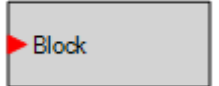
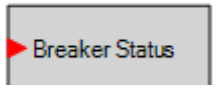
**Table 48-3. Elements Group, Names and Descriptions**


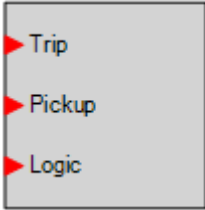
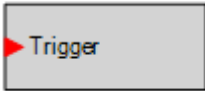
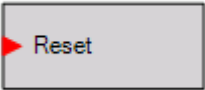
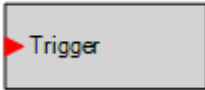

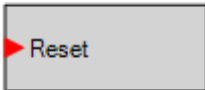
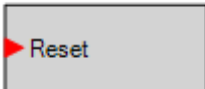
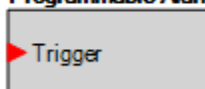
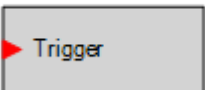
Name	Description	Symbol
<b>Protection</b>		
21	Distance Protection. Refer to the <i>Distance (21) Protection</i> chapter.	<p data-bbox="1133 1394 1224 1444"><b>21-1</b> <b>Disabled</b></p> 
24	Overexcitation Protection. Refer to the <i>Overexcitation (24) Protection</i> chapter.	<p data-bbox="1133 1617 1224 1667"><b>24</b> <b>Disabled</b></p> 

Name	Description	Symbol
25	Sync-Check Protection. Refer to the <i>Sync-Check (25) Protection</i> chapter.	<p><b>25</b> <b>Disabled</b></p> 
27P-x	Phase Undervoltage Protection. Refer to the <i>Phase Undervoltage (27P) Protection</i> chapter.	<p><b>27P-1</b> <b>Disabled</b></p> 
27X-x	Auxiliary Undervoltage Protection. Refer to the <i>Auxiliary Undervoltage (27X) Protection</i> chapter.	<p><b>27X-1</b> <b>Disabled</b></p> 
49RTD	Resistance Temperature Detector Protection. For use when an optional RTD module is connected. Refer to the <i>Resistance Temperature Detector (49RTD) Protection</i> chapter.	<p><b>49RTD-1</b> <b>Disabled</b></p> 
50-x	Instantaneous Overcurrent Protection. Refer to the <i>Instantaneous Overcurrent (50) Protection</i> chapter.	<p><b>50-1</b> <b>Disabled</b> <b>Non-Directional</b></p> 
50BF	Breaker Fail Protection. Refer to the <i>Breaker Fail (50BF) Protection</i> chapter.	<p><b>50BF</b> <b>Disabled</b></p> 

Name	Description	Symbol
51-x	Inverse Overcurrent Protection. Refer to the <i>Inverse Overcurrent (51) Protection</i> chapter.	<p><b>51-1</b> <b>Disabled</b> <b>Non-Directional</b></p> 
59P-x	Phase Overvoltage Protection. Refer to the <i>Phase Overvoltage (59P) Protection</i> chapter.	<p><b>59P-1</b> <b>Disabled</b></p> 
59X-x	Auxiliary Overvoltage Protection. Refer to the <i>Auxiliary Overvoltage (59X) Protection</i> chapter.	<p><b>59X-1</b> <b>Disabled</b></p> 
79	Recloser Protection. Refer to the <i>Recloser (79) Protection</i> chapter.	<p><b>79</b> <b>Disabled</b></p> 
81-x	Frequency Protection. Refer to the <i>Frequency (81) Protection</i> chapter.	<p><b>81-1</b> <b>Disabled</b> <b>Phase VT</b></p> 
87	Current Differential Protection. Refer to the <i>Current Differential (87) Protection</i> chapter.	<p><b>87</b> <b>Disabled</b></p> 

Name	Description	Symbol
87N-x	Neutral Current Differential Protection. Refer to the <i>Neutral Current Differential (87N) Protection</i> chapter.	<p><b>87N-1</b> <b>Disabled</b></p> 
ANALOG-x	Analog Input 1 through 8. Refer to the <i>RTD Module</i> chapter.	<p><b>ANALOG-1</b> <b>Disabled</b> <b>Analog Input 1-1</b></p> 
<b>Control</b>		
43-x	Virtual Control Switches. Refer to the <i>Virtual Control Switches (43)</i> chapter.	<p><b>43-1</b> <b>43-1</b> <b>Disabled</b></p> 
62-x	Logic Timers. Refer to the <i>Logic Timers (62)</i> chapter.	<p><b>62-1</b> <b>Disabled</b></p> 
86-x	Lockout Functions. Refer to the <i>Lockout Functions (86)</i> chapter.	<p><b>86-1</b> <b>Disabled</b></p> 

Name	Description	Symbol
101	Breaker Control Switch. Refer to the <i>Breaker Control Switch (101)</i> chapter.	<p><b>101</b> <b>Disabled</b></p> 
SETTINGGROUP	Setting Group Control. Refer to the <i>Setting Groups</i> chapter.	<p><b>SETTINGGROUP</b> <b>Disabled</b></p> 
<b>Reporting and Alarms</b>		
51TF	Transformer Monitor. Refer to the <i>Transformer Monitor (51TF)</i> chapter.	<p><b>51TF</b> <b>Disabled</b></p> 
52TCM	Trip Circuit Monitor. Refer to the <i>Trip Circuit Monitor (52TCM)</i> chapter.	<p><b>52TCM</b> <b>Disabled</b></p> 
60FL	Fuse Loss. Refer to the <i>Fuse Loss (60FL)</i> chapter.	<p><b>60FL</b></p> 
BKRMONITOR	Breaker Monitor. Refer to the <i>Breaker Monitoring</i> chapter.	<p><b>BKRMONITOR</b> <b>Disabled</b></p> 
BRKSTAT	Breaker Status. Refer to the <i>Breaker Monitoring</i> chapter.	<p><b>BRKSTAT</b></p> 

Name	Description	Symbol
EMAIL-x	Email Trigger 1 through 8. Refer to the <i>Communication</i> chapter.	<b>EMAIL-1</b> 
FAULTTRIG	Fault Trigger. Refer to the <i>Fault Reporting</i> chapter.	<b>FAULTTRIG</b> 
INDICATORx	Indicators 1 through 7. Refer to the <i>Controls and Indicators</i> chapter. The indicator is displayed in the sequence of events and the corresponding indicator on the front panel is lit when the Trigger input is true. To name indicators, use the Settings Explorer in <i>BESTCOMSPPlus</i> to expand the <i>BESTlogicPlus</i> Programmable Logic tree branch and select Front Panel Indicator Labels.	<b>INDICATOR1</b> <b>Indicator 1</b> 
LOGICALMRST	Logic Alarm Reset. The Reset input is positive-edge triggered. Refer to the <i>Alarms</i> chapter.	<b>LOGICALMRST</b> 
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 <i>BESTCOMSPPlus</i> to expand the <i>BESTlogicPlus</i> Programmable Logic tree branch and select Logic Labels.	<b>LOGICLABEL1</b> <b>Logic Label 1</b> 
MAJORALMRST	Major Alarm Reset. The Reset input is positive-edge triggered.  Refer to the <i>Alarms</i> chapter.	<b>MAJORALMRST</b> 
MINORALMRST	Minor Alarm Reset. The Reset input is positive-edge triggered.  Refer to the <i>Alarms</i> chapter.	<b>MINORALMRST</b> 
TARGETRESET	Target Reset. The Reset input is positive-edge triggered.  Refer to the <i>Fault Reporting</i> chapter.	<b>TARGETRESET</b> 
USERALARMx	User Programmable Alarms 1 through 16. Refer to the <i>Alarms</i> chapter.	<b>USERALM1</b> <b>Programmable Alarm 1 Name</b> 
USERTARGx	User Programmable Targets 1 through 12. Refer to the <i>Targets</i> chapter.	<b>USERTARG1</b> <b>59N</b> 

## Logic Schemes

A logic scheme is a group of logic variables that defines the operation of a BE1-11 $\ell$ . 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 $\ell$  protection systems 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 $\ell$  in service.

*Details of Default Logic Scheme* describes the characteristics of the logic scheme and how it combines to create a protection system for a two-winding transformer. A detailed description of the default scheme is also provided.

The default logic scheme is designed to accommodate most common transformer protection 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 BESTlogicPlus allows the protection engineer to create a custom scheme that exactly meets the requirements of the application.

### Caution

Always remove the BE1-11 $\ell$  from service prior to changing or modifying the active logic scheme. Attempting to modify a logic scheme while the BE1-11 $\ell$  is in service could generate unexpected or unwanted outputs.

Modifying a logic scheme in BESTCOMSPPlus does not automatically make that scheme active in the BE1-11 $\ell$ . The modified scheme must be uploaded into the BE1-11 $\ell$ . 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 BESTCOMSPPlus.

### Overview of Default Logic Scheme

The default logic is shown in Figures 2 through 6 and described in the following paragraphs. The default logic scheme provides transformer protection. The default logic includes elements and features available in the base option of the BE1-11 $\ell$ .

Restraint based differential protection (87) is available as well as voltage and current protection elements. Included protective elements are 24, 27P-1, 59P-1, 81-1, 4, 50-1, 50-2, 50-3, 51-1, 51-2, 51-3, and 87 for

transformer protection functions such as differential protection, short-circuit, ground fault, unbalance, undervoltage, overvoltage, overexcitation, and overcurrent.

Functions such as breaker failure and virtual breaker control features are not enabled in this scheme. However, these features can be activated through *BESTCOMSPlus*.

Inputs/Outputs

Figure 48-2 illustrates the default logic on the Inputs/Outputs tab in *BESTlogicPlus*.

Basic Transformer Protection-This logic scheme provides protection for a 2-restraint transformer with differential, time and instantaneous overcurrent, voltage and frequency protections included. The tripping scheme provides for five tripping outputs. Tripping functions include 24, 27 Phase, 50&51 Phase, 50&51 Neutral(3I0), 50&51 Ground(IG), 59 Phase, 81 Under, 87 Restrained and 87 Unrestrained, 2nd and 5th Harmonic Logic Trigger.

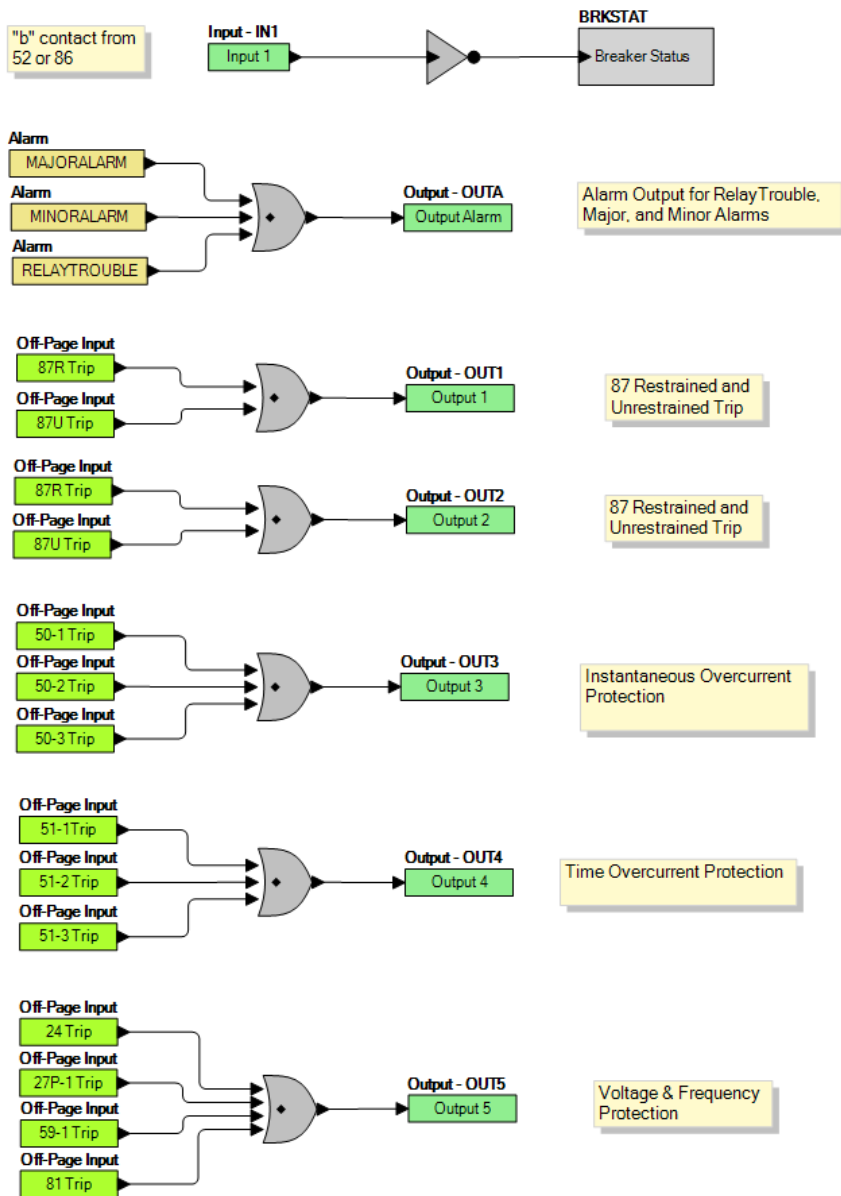


Figure 48-2. Inputs/Outputs Tab for Default Logic

Voltage/Frequency

Figure 48-3 illustrates the default logic on the Voltage/Frequency tab in BESTlogicPlus.

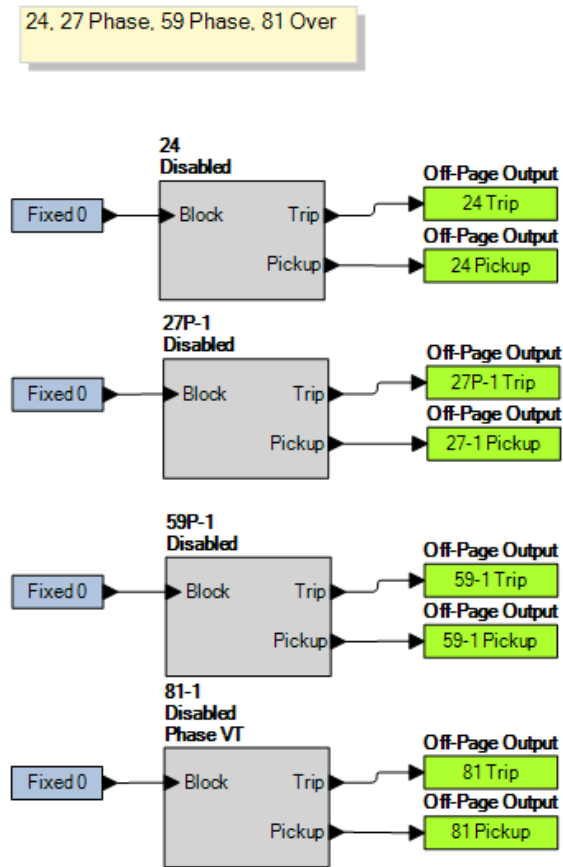


Figure 48-3. Voltage/Frequency Tab for Default Logic

Current

Figure 48-4 illustrates the default logic on the Current tab in BESTlogicPlus.

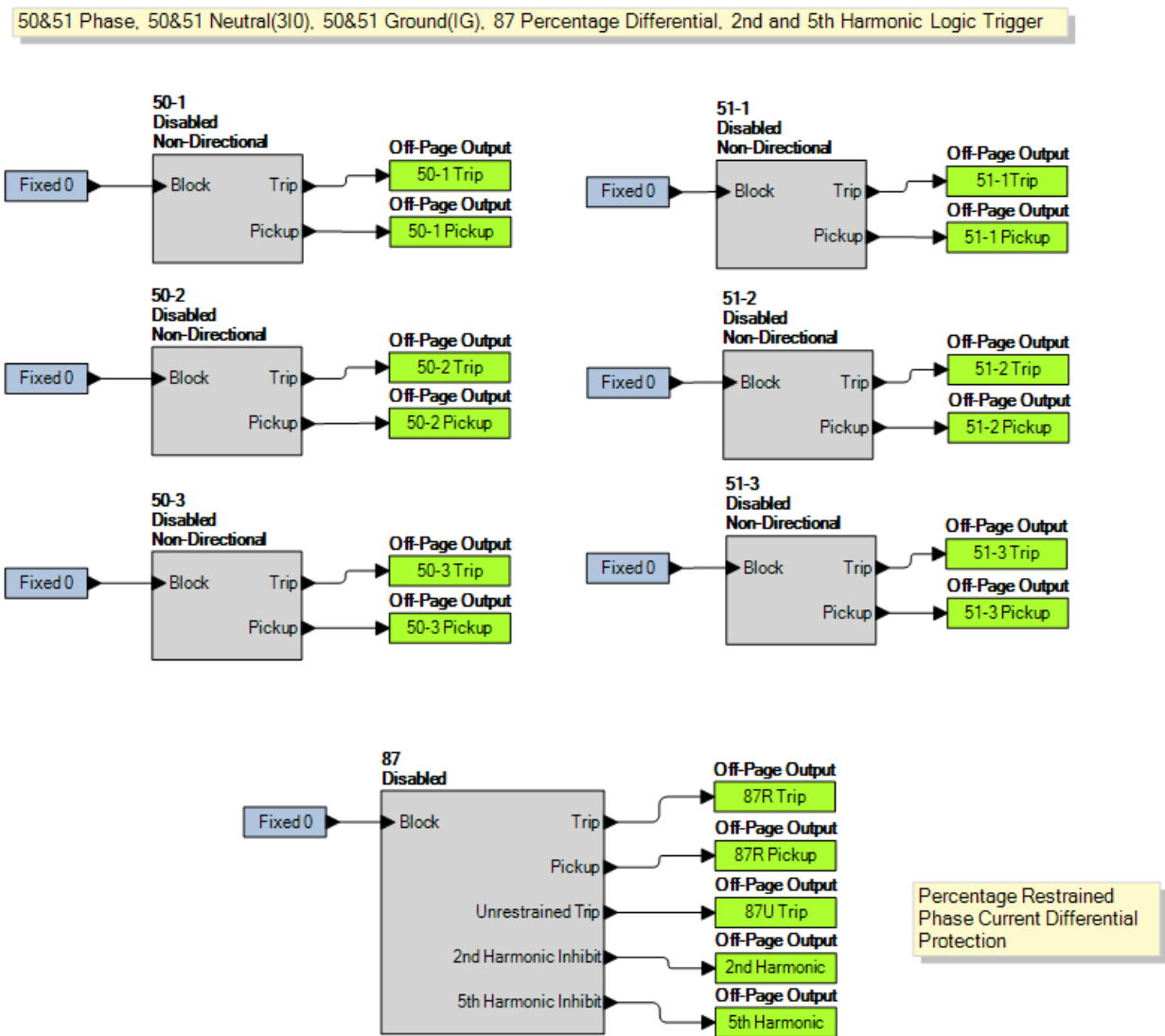


Figure 48-4. Current Tab for Default Logic

Miscellaneous Logic

Figure 48-5 illustrates the default logic on the Miscellaneous Logic tab in BESTlogicPlus.

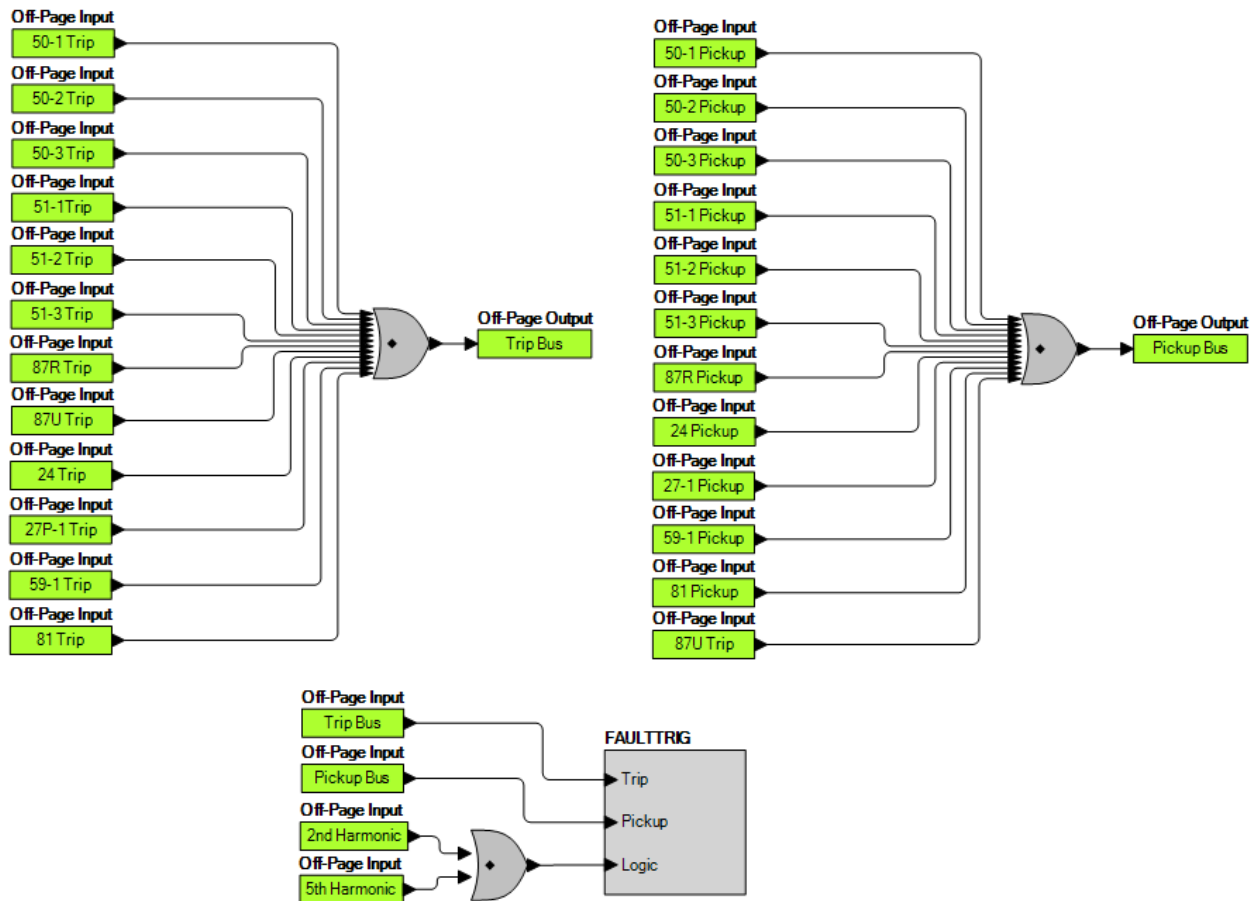
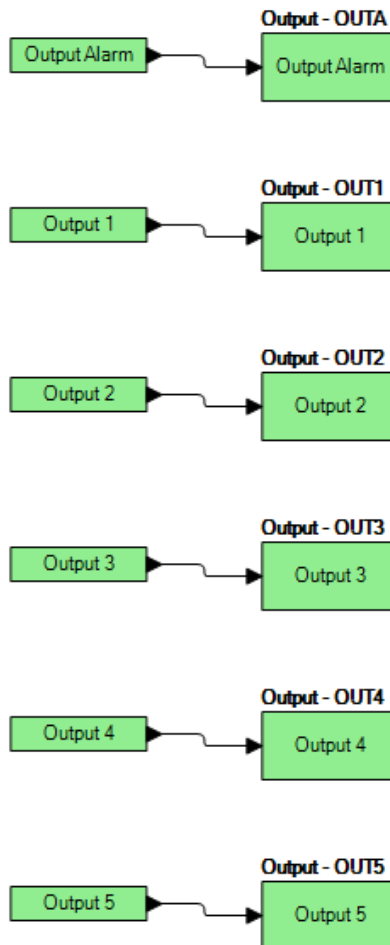


Figure 48-5. Miscellaneous Logic Tab for Default Logic

### Physical Outputs

Figure 48-6 illustrates the default logic on the Physical Outputs tab in BESTlogicPlus.



**Figure 48-6. Physical Outputs Tab 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 BESTCOMSPPlus 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 BE1-11t**

To retrieve settings from the BE1-11t, the BE1-11t must be connected to a computer through a communications port. Once the necessary connections are made, settings can be downloaded from the BE1-11t by selecting Download Settings and Logic from Device on the Communication pull-down menu.

### **Sending a Logic Scheme to the BE1-11t**

To send settings to the BE1-11t, the BE1-11t must be connected to a computer through a communications port. Once the necessary connections are made, settings can be uploaded to the BE1-11t by selecting Upload Settings and Logic to Device or Upload Logic to Device on the Communication pull-down menu.

## Programming BESTlogic™Plus

BESTCOMSPPlus is used to program BESTlogicPlus. Using BESTCOMSPPlus is analogous to physically attaching wire between discrete BE1-11t terminals. To program BESTlogicPlus, use the Settings Explorer within BESTCOMSPPlus to open the BESTlogicPlus Programmable Logic tree branch as shown in Figure 48-1.

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 BESTCOMSPPlus will allow logic to be uploaded to the BE1-11t:

- 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 elements in series.
- A maximum of 256 logic elements per diagram.

Three status indicators are located in the lower right corner of the BESTlogicPlus window. These indicators show the Logic Save Status, Logic Diagram Status, and Logic Layer Status. Table 48-4 defines the colors for each indicator.

**Table 48-4. Status Indicators**

Indicator	Color	Definition
Logic Save Status (Left Indicator)	● Amber	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 48-7.

To program logic timer settings, use the Settings Explorer within BESTCOMSPPlus to open the BESTlogicPlus 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 BESTlogicPlus 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.

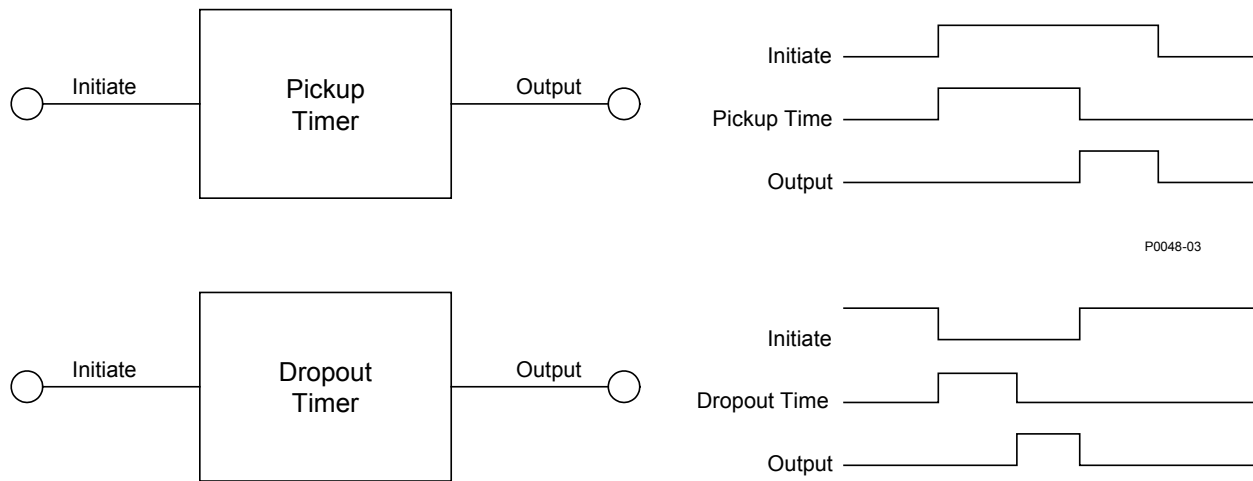


Figure 48-7. Pickup and Dropout Timer Logic Blocks

## Offline Logic Simulator

You can use the offline logic simulator to test your custom logic before placing it in operation. The state of various logic elements can be toggled to verify that the logic states travel through the system as expected.

Before running the logic simulator, you must click the Save button on the BESTlogicPlus toolbar to save the logic to memory. Changes to the logic (other than changing the state) are disabled when the simulator is enabled. Colors are selected by clicking the Options button on the BESTlogicPlus toolbar. By default, Logic 0 is red and Logic 1 is green. Using your mouse, double-click on a logic element to change its state.

An example of the offline logic simulator is shown in Figure 48-8. Output 1 is Logic 0 (red) when Input 1 is Logic 0 (red) and Fixed 1 is Logic 1 (green).

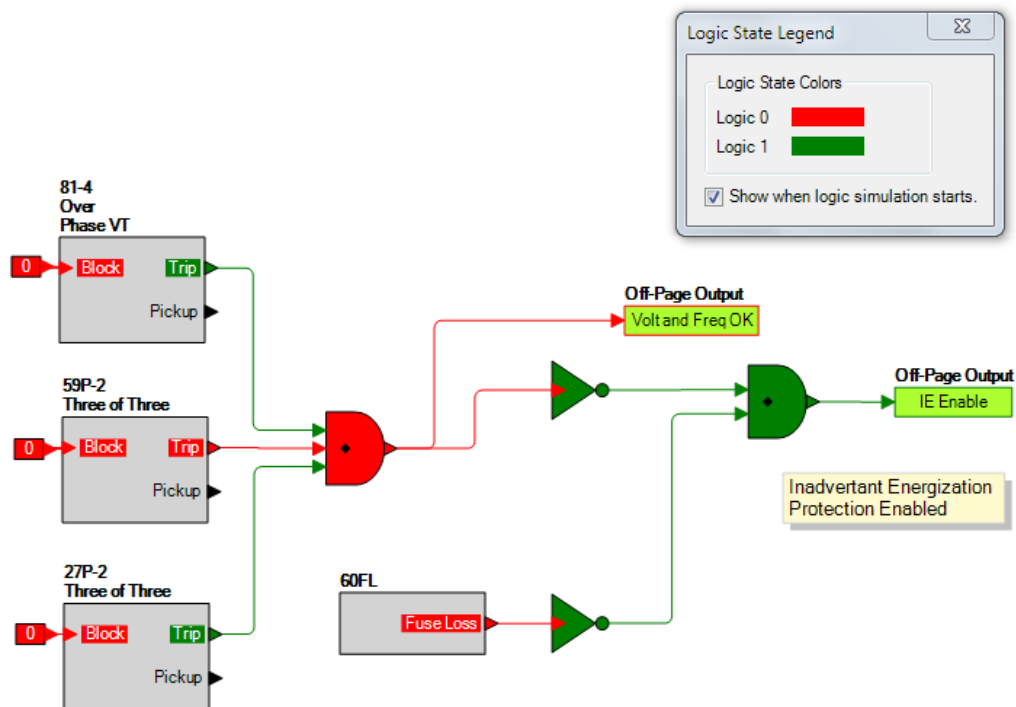


Figure 48-8. Offline Logic Simulator Example

## BESTlogic™Plus File Management

To manage BESTlogicPlus files, use the Settings Explorer to open the BESTlogicPlus Programmable Logic tree branch. The BESTlogicPlus Programmable Logic toolbar is used to manage BESTlogicPlus files. Refer to Figure 48-9. For information on Settings Files management, refer the *BESTCOMSPlus Software* chapter.

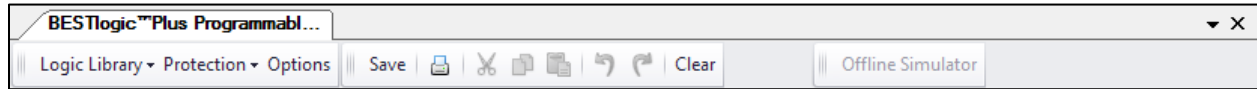


Figure 48-9. BESTlogicPlus Programmable Logic Toolbar

### Saving a BESTlogic™Plus File

After programming BESTlogicPlus settings, click on the Save button to save the settings to memory.

Before the new BESTlogicPlus settings can be uploaded to the BE1-11t, you must select Save from the File pull-down menu located at the top of the BESTCOMSPlus main shell. This step will save both the BESTlogicPlus settings and the operating settings to a file.

The user also has the option to save the BESTlogicPlus settings to a unique file that contains only BESTlogicPlus 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 BESTlogicPlus file, click on the Logic Library drop-down button on the BESTlogicPlus 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 BESTlogicPlus file to the BE1-11t, you must first open the file through BESTCOMSPlus or create the file using BESTCOMSPlus. Then pull down the Communication menu and select Upload Logic to Device.

### Downloading a BESTlogic™Plus File

To download a BESTlogicPlus file from the BE1-11t, you must pull down the Communication menu and select Download Settings and Logic from Device. If the logic in your BESTCOMSPlus 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 BESTlogicPlus 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 BESTlogicPlus 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 BESTlogicPlus 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 48-10 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.

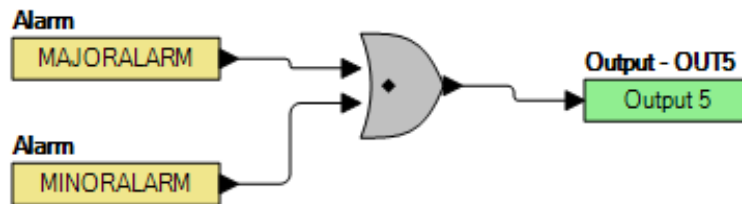


Figure 48-10. Example 1 - OR Gate Connections

### Example 2 - Inverse Overcurrent Logic Diagram

Figure 48-11 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.

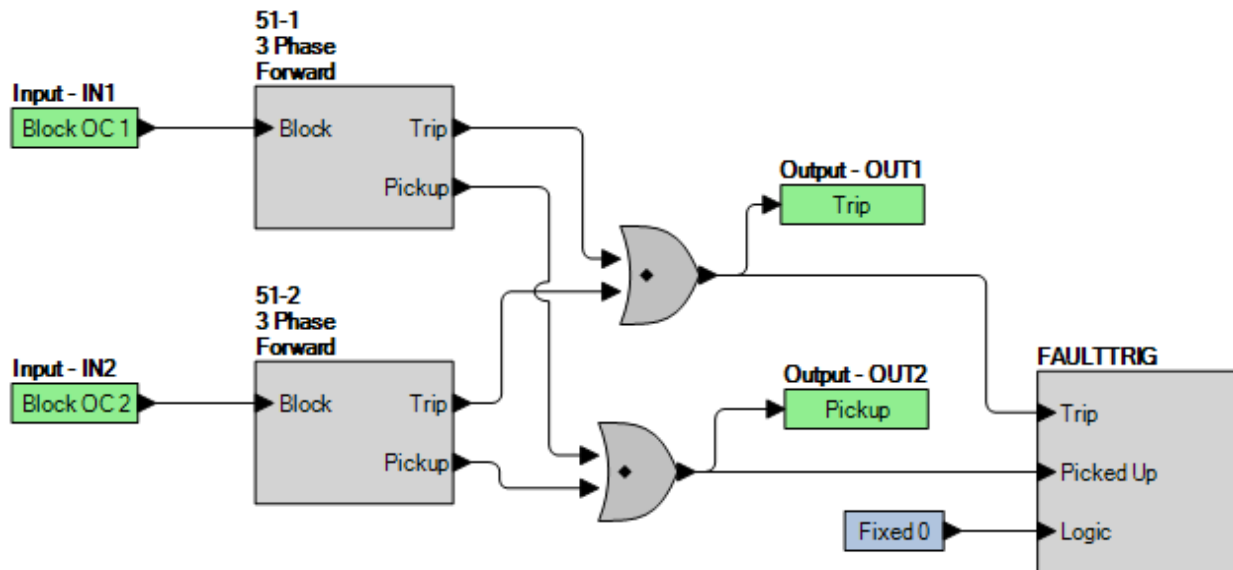


Figure 48-11. Example 2 - Inverse Overcurrent Logic Diagram

## 49 • Communication

This chapter describes the connections and settings for BE1-11*t* communication. In addition to standard USB, RS-485, and optional Ethernet communication, the BE1-11*t* is capable of sending email messages to a selected recipient with details about a user-selected condition. The configuration of email notifications is described later in this chapter.

Available ports for communicating with the BE1-11*t* include USB, RS-485, and Ethernet. DHCP (Dynamic Host Configuration Protocol) is enabled by default allowing the BE1-11*t* to send a broadcast request for configuration information. The DHCP server receives the request and responds with configuration information. Settings for Ethernet must be made through the front-panel USB port if not using DHCP.

### Connections

The following paragraphs describe the communication connections for the BE1-11*t*. Refer to the *Terminals and Connectors* chapter for views of the communication ports.

#### USB Connection

A front-panel B-type USB connector provides local communication with a PC operating BESTCOMSP*lus*® software.

#### Ethernet Connection

BE1-11*t* protection systems with style numbers xxxxx1xxxxxxx, xxxxx2xxxxxxx, xxxxx3xxxxxxx, xxxxx4xxxxxxx, and xxxxx5xxxxxxx have a rear-panel Ethernet port. For style number xxxxxxxx0xxxx (Copper Ethernet Connection), a 10BASE-T/100BASE-TX port is an eight-pin RJ45 connector that connects to shielded, twisted-pair, Category 5 copper wire media. For style number xxxxxxxx1xxxx (Fiber Optic Ethernet Connection), a 100BASE-FX ST type connector port uses a 1300 nanometer near-infrared (NIR) light wavelength transmitted via two strands of multimode optical fiber, one for receive (RX) and the other for transmit (TX).

#### RS-485 Connections

RS-485 connections are made at a three-position terminal block connector that mates with a standard communication cable. A twisted-pair cable is recommended. Shield and ground on both ends to common ground potential as recommended by industry standards. Connector pin numbers, functions, names, and signal directions are shown in Table 49-1. An RS-485 connection diagram is provided in Figure 49-1.

Table 49-1. RS-485 Pinouts

Terminal	Function	Name	Direction
A	Send/Receive A	(SDA/RDA)	In/Out
B	Send/Receive B	(SDB/RDB)	In/Out
C	Signal Ground	(GND)	n/a

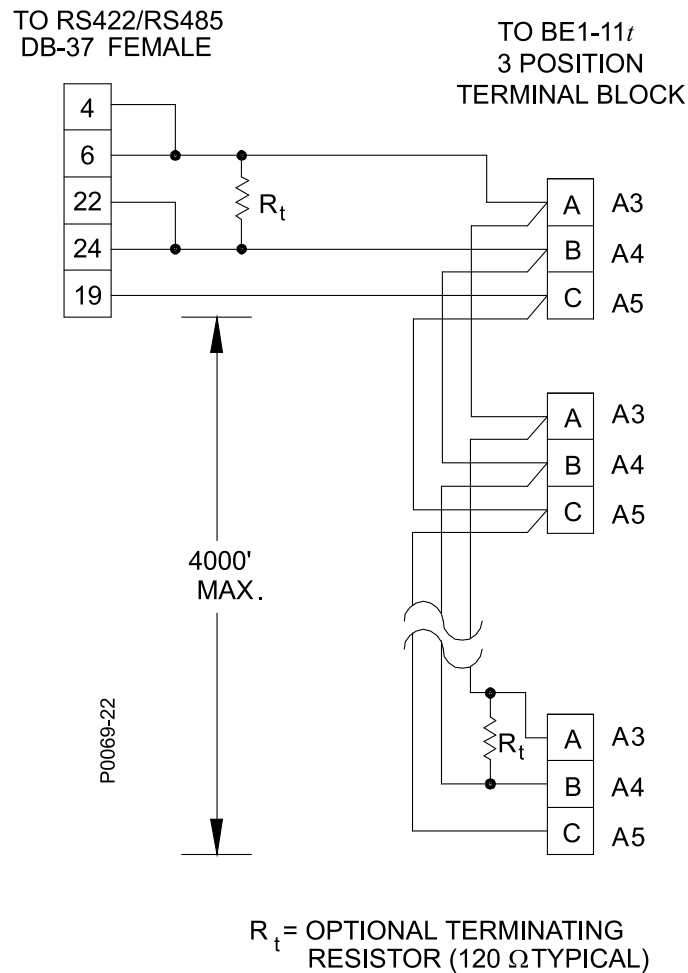


Figure 49-1. RS-485 DB-37 to BE1-11t

## Ethernet Setup

Located on the rear panel, the optional Ethernet communication port provides dynamic addressing (DHCP), Web pages (HTTP), email alerts (SMTP), as well as communication with a PC running BESTCOMSPi.us, Modbus®, or DNP software. Additional Ethernet settings are illustrated in Figure 49-2.

The Enable Web Pages box must be checked to enable viewing of BE1-11t web pages. Refer to the *BESTnet™Plus* chapter for more information on viewing web pages.

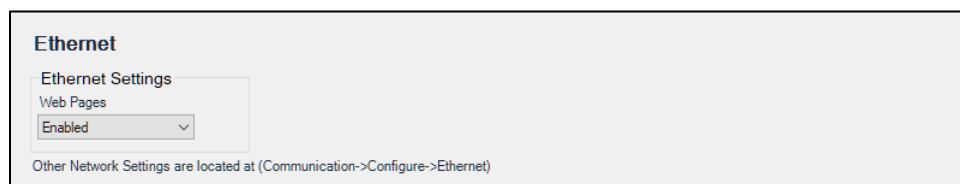


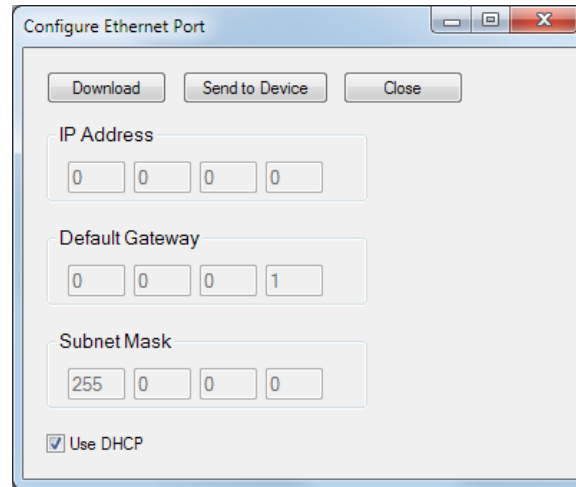
Figure 49-2. Ethernet Screen

## Ethernet Port Configuration

Initially you must use a USB connection on the front panel to configure communications.

1. Connect an Ethernet cable between the BE1-11t and your network.
2. Connect a USB cable between the BE1-11t and your PC.
3. Apply operating power to the BE1-11t and wait until the boot sequence is complete.

4. Use BESTCOMSPi.us to connect to the BE1-11*t* through the USB port.
5. Select Configure, Ethernet from the Communication pull-down menu. If the BE1-11*t* is connected properly, the Configure Ethernet Port screen shown in Figure 49-3 will appear.



**Figure 49-3. Configure Ethernet Port**

DHCP (Dynamic Host Configuration Protocol) is enabled by default and allows the BE1-11*t* to send a broadcast request for configuration information. The DHCP server receives the request and responds with configuration information. Use one of the following methods to locate the Active IP address of the BE1-11*t*:

- Use the Device Discovery function on the BE1-11 Connection screen in BESTCOMSPi.us.
- Navigate to Settings > Communication > Ethernet on the front panel of the BE1-11*t*.

If DHCP is not being used, use BESTCOMSPi.us to configure the Ethernet port as described in the following paragraphs.

Configurable Ethernet options include:

<i>IP Address:</i>	Internet Protocol Address to be used by the BE1-11 <i>t</i> .
<i>Default Gateway:</i>	Default host to send data destined for a host not on the network subnet.
<i>Subnet Mask:</i>	Mask used to determine the range of the current network subnet.
<i>Use DHCP:</i>	When this box is checked, the IP Address, Default Gateway, and Subnet Mask are automatically configured via DHCP. This can be used only if the Ethernet network has a properly configured DHCP server running. The BE1-11 <i>t</i> does not act as a DHCP server.

6. Obtain the values for these options from the site administrator if the BE1-11*t* is intended to share the network with other devices.
7. If the BE1-11*t* is operating on an isolated network, the IP address can be chosen from one of the following ranges as listed in IETF publication RFC 1918, *Address Allocation for Private Networks*.
  - 10.0.0.0 - 10.255.255.255
  - 172.16.0.0 - 172.31.255.255
  - 192.168.0.0 - 192.168.255.255

If the BE1-11*t* is operating on an isolated network, the Subnet Mask can be left at 0.0.0.0 and the Default Gateway can be chosen as any valid IP address from the same range as the BE1-11*t* IP address.

### Note

The PC running BESTCOMSP*lus* software must be configured correctly to communicate with the BE1-11*t*. The PC must have an IP address in the same subnet range as the BE1-11*t* if the BE1-11*t* is operating on a private, local network.

Otherwise, the PC must have a valid IP address with access to the network and the BE1-11*t* must be connected to a properly configured router. The network settings of the PC depend on the operating system installed. Refer to the operating system manual for instructions.

On most Microsoft Windows based PCs, the network settings can be accessed through the Network Connections icon located inside the Control Panel.

8. Click the Send to Device button located on the Configure Ethernet Port screen. A confirmation pop-up will indicate that the BE1-11*t* will reboot after settings are sent. Click the Yes button to allow settings to be sent. After the unit has rebooted and the power-up sequence is complete, the BE1-11*t* is ready to be used on a network.
9. If desired, BE1-11*t* settings can be verified by selecting Download Settings and Logic from Device from the Communication pull-down menu. Active settings will be downloaded from the BE1-11*t*. Verify that the downloaded settings match the previously sent settings.

## Email Setup

The BE1-11*t* is capable of sending email alerts when triggered by chosen logic. A maximum of eight circumstances can be established for sending email alerts. Setup of email notifications is made on the BESTCOMSP*lus* Email Setup screen (Settings Explorer, Communications, Email Setup) illustrated in Figure 49-4. A notification is configured by entering the SMTP email server address, mail from domain, and the email address of the intended recipients. One email address can be entered in the “To” field and one email address can be entered in the “Cc” field. The “Subject” field accepts up to 64 characters for describing the condition triggering the notification email.

Figure 49-4. Email Setup Screen

### BESTlogic™*Plus* Settings for Email

BESTlogic*Plus* settings are made using BESTCOMSP*lus*. To program the BESTlogic*Plus* settings, use the Settings Explorer within BESTCOMSP*lus* to open the BESTlogic*Plus* Programmable Logic tree branch and select the email logic block from the list of Elements. The email logic block is shown in Figure

49-5. 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 *BESTlogicPlus* programmable logic.

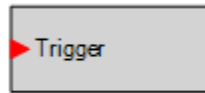


Figure 49-5. Email Logic Block

Table 49-2 lists the *BESTlogicPlus* settings for email.

Table 49-2. *BESTlogicPlus* Settings for Email

Name	Function	Purpose	Default
Trigger	Input	Triggers an email message.	0

## RS-485 Setup

The RS-485 communication port is located on the rear panel and provides communication with a PC operating Modbus® or DNP software. The Baud Rate is the rate at which the BE1-11 $t$  will communicate. Bits Per Character can be 8 Bits or 7 Bits. Parity can be None, Odd, or Even. Stop Bits can be set to 1 or 2. The *BESTCOMSPlus* RS485 Setup screen is illustrated in Figure 49-6.

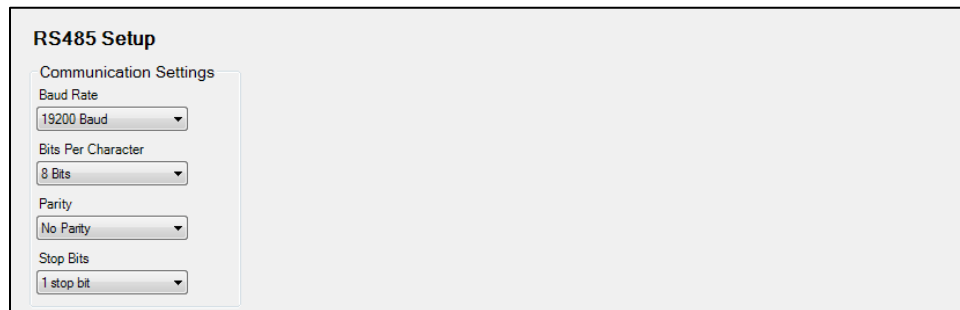


Figure 49-6. RS485 Setup Screen

## DNP Setup

Settings for DNP are made by using the Settings Explorer to open the Communications, DNP tree branch. Settings can be made for DNP Analog Points Mapping, DNP Binary Points Mapping, DNP Analog Input Scaling, and DNP Analog Output Scaling. A list of DNP data objects accessible by a master station can be found in Basler Electric publication 9424200773, *Distributed Network Protocol (DNP3) Instruction Manual*.

### DNP Settings

The Communications, DNP, DNP Settings tree branch contains screens for miscellaneous DNP settings, unsolicited response support, and default variations.

#### Miscellaneous Settings

The Miscellaneous Settings screen (Figure 49-7) is used to configure the physical port, type of Ethernet endpoint, local Ethernet port number, client IP address, UDP endpoint, listening end point, link layer, time sync support, application layer, alarm mask, and DNP time in UTC.

#### Alarm Mask

The Alarm Mask setting allows active alarms that are not enabled in an alarm list to be annunciated in DNP.

#### DNP Time In UTC

The DNP Time in UTC setting, when enabled, sets the DNP time base to UTC.

### Note

Physical Port Selection (Ethernet or RS-485) is available only for Ethernet Protocol options 3 and 4 and only when RS-485 port protocol option is N (None). RTD module communication over RS-485 is not available when the physical port for DNP communication is RS-485.

The screenshot shows the 'Miscellaneous Settings' screen for DNP configuration. It is divided into several sections:

- Port:** Physical Port Selection is set to 'Over Ethernet'.
- Ethernet:** Type of End Point is 'UDP Datagram'. Local Port Number is 20,000. Client IP Address is 0.0.0.0.
- Listening End Point:** TCP Keep Alive Timer (ms) is 300,000.
- Time Sync Support:** Time Sync Period (ms) is 0 (Disabled).
- UDP End Point:** Port for Initial Unsolicited Null Response is 20,000.
- Destination UDP Port For Other Responses:** Option is 'Use Source Port Number (0)', Port Number is 0. Datagram Association Timeout (ms) is 300,000.
- Link Layer:** Device Address is 1. Data Confirmation is 'Never'.
- Application Layer:** Response Fragment Size is 2,048. Confirm Timeout (ms) is 5,000.
- Alarm Mask:**  Use Alarm Mask.
- DNP Time in UTC:**  Enable.

Figure 49-7. DNP Settings, Miscellaneous Settings Screen

### Unsolicited Response Support

The Unsolicited Response Support screen (Figure 49-8) configures BE1-11t unsolicited responses over a DNP network and selects the classes of events that trigger the responses.

The screenshot shows the 'Unsolicited Response Support' screen. It contains the following settings:

- Unsolicited Response Support:** Support is set to 'Disabled'.
- Master Data Link Address:** 5.
- Confirmation Timeout (ms):** 0.
- Number of Retries:** 2.
- Off-Line Interval (ms):** 10,000.
- Trigger Conditions:**
  - Number of Class 1 Events: 1
  - Number of Class 2 Events: 1
  - Number of Class 3 Events: 1

Figure 49-8. DNP Settings, Unsolicited Response Support Screen

### Default Variations

The Default Variations screen (Figure 49-9) is used to configure the binary and analog inputs and analog output status.

Figure 49-9. Default Variations Screen

## DNP Analog Points Mapping

Analog points can be mapped to any of the available analog user map registers. Use the Settings Explorer in BESTCOMSPPlus to open the Communications, DNP, DNP Analog Points Mapping tree branch as shown in Figure 49-10.

To map an Analog Point to the Analog User Map:

1. Select an analog point in the left-hand column.
2. Click on the Add >> button to add the analog point to the analog user map list.
3. Use the Move Up or Move Down buttons above the analog user map list to arrange the analog user maps.
4. Click on the orange Save button to save the settings to BESTCOMSPPlus memory. This button changes to white indicating that the settings have been saved to BESTCOMSPPlus memory.

Upload settings to the device by selecting Communication from the top pull-down menu and then Upload Settings to Device.

Figure 49-10. DNP Analog Points Mapping Screen

## DNP Binary Points Mapping

Binary points can be mapped to any of the available binary user map registers. Use the Settings Explorer in BESTCOMSPPlus to open the Communications, DNP, DNP Binary Points Mapping tree branch as shown in Figure 49-11.

To map a Binary Point to the Binary User Map:

1. Select a binary point in the left-hand column.
2. Click on the Add >> button to add the binary point to the binary user map list.
3. Use the Move Up or Move Down buttons above the binary user map list to arrange the binary user maps.
4. Click on the orange Save button to save the settings to BESTCOMSPi.us memory. This button changes to white indicating that the settings have been saved to BESTCOMSPi.us memory.
5. Upload settings to the device by selecting Communication from the top pull-down menu and then Upload Settings to Device.

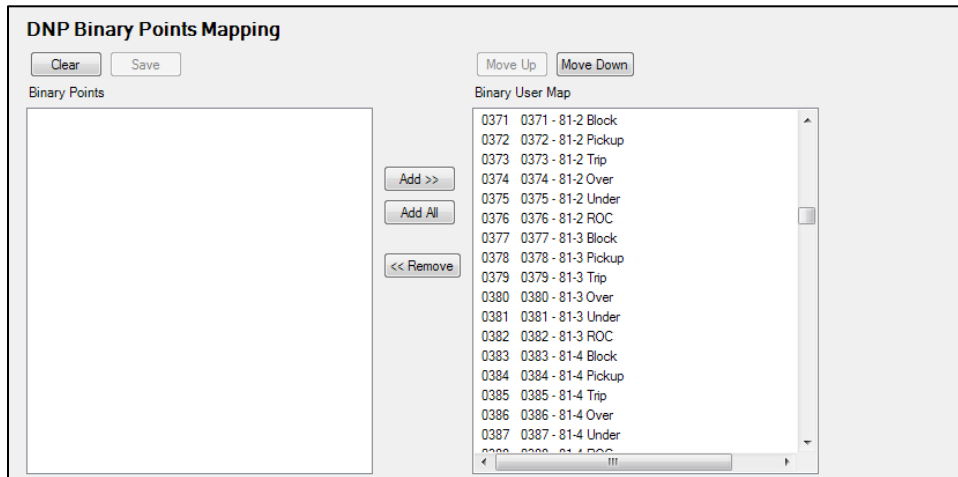


Figure 49-11. DNP Binary Points Mapping Screen

## DNP Analog Input and Output Scaling

Individual BE1-11t analog inputs and outputs can be scaled to maintain value readability and resolution. Analog input point scaling is adjusted on the DNP Analog Input Scaling screen (shown in Figure 49-12) and analog output point scaling is adjusted on the DNP Analog Output Scaling screen. On each screen, individual points can be selected and assigned a scaling factor of 0.001 to 1,000,000,000. A scaling factor of 1.000 is the default value for all analog input and output points.

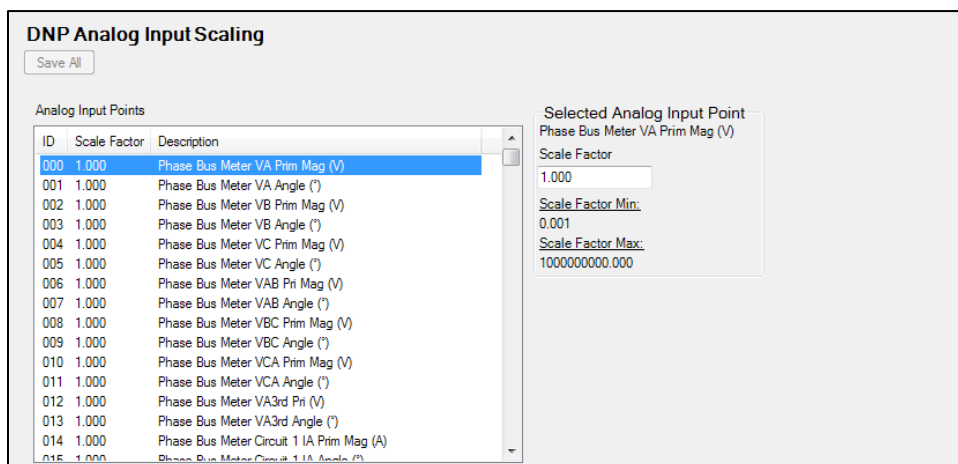


Figure 49-12. DNP Analog Input Scaling Screen

## Modbus® Setup

Settings for Modbus are made by using the Settings Explorer to open the Communications, Modbus tree branch. Settings can be made for Modbus mapping. A list of Modbus registers can be found in Basler Electric publication 9424200774, *Modbus Protocol Instruction Manual*.

### Miscellaneous Modbus® Settings

The Miscellaneous Modbus Settings screen is shown in Figure 49-13. Settings are provided for Modbus over RS485 and Ethernet. When Auto Save is enabled, group saves are performed to reduce write times.

Figure 49-13. Miscellaneous Modbus Settings

### Modbus® Mapping

Source registers can be mapped to any of 125 available poll block registers ranging from 9875 to 9999. Use the Settings Explorer in BESTCOMSPi<sub>us</sub> to open the Communications, Modbus, Modbus Mapping tree branch as shown in Figure 49-14.

To map a Source Register to Poll Block Registers:

1. Select a source register in the left-hand column. The category, register information, and description of the selected source register are shown in the lower left-hand corner of the screen.
2. Click the Add >> button to add the source register to the poll block register list.
3. Use the Move Up or Move Down buttons above the poll block register list to arrange the poll block registers.
4. Click on the orange Save button to save the settings to BESTCOMSPi<sub>us</sub> memory. This button changes to white indicating that the settings have been saved to BESTCOMSPi<sub>us</sub> memory.
5. Upload settings to the device by selecting Communication from the top pull-down menu and then Upload Settings to Device.

### Modbus Mapping

Clear Save
Move Up Move Down

Source Registers

- 12124 Demand Meter VARSC\_Present
- 12126 Demand Meter VARSTOTAL\_Present
- 12128 Demand Meter SA\_Present
- 12130 Demand Meter SB\_Present
- 12132 Demand Meter SC\_Present
- 12134 Demand Meter STOTAL\_Present
- 12172 Demand Meter IA Peak Time
- 12184 Demand Meter IB Peak Time
- 12196 Demand Meter IC Peak Time
- 12208 Demand Meter IG Peak Time
- 12220 Demand Meter 3I0 Peak Time
- 12232 Demand Meter I2 Peak Time
- 12244 Demand Meter Watts A Peak Time
- 12256 Demand Meter Watts B Peak Time
- 12268 Demand Meter Watts C Peak Time
- 12280 Demand Meter Watts Total Peak Time
- 12328 Demand Meter Vars Total Peak Time

Add >>

<< Remove

Poll Block Registers

- 9902 12311 - Demand Meter Vars B Peak Time
- 9903 12312 - Demand Meter Vars B Peak Time
- 9904 12313 - Demand Meter Vars B Peak Time
- 9905 12314 - Demand Meter Vars B Peak Time
- 9906 12315 - Demand Meter Vars B Peak Time
- 9907 12316 - Demand Meter Vars C Peak Time
- 9908 12317 - Demand Meter Vars C Peak Time
- 9909 12318 - Demand Meter Vars C Peak Time
- 9910 12319 - Demand Meter Vars C Peak Time
- 9911 12320 - Demand Meter Vars C Peak Time
- 9912 12321 - Demand Meter Vars C Peak Time
- 9913 12322 - Demand Meter Vars C Peak Time
- 9914 12323 - Demand Meter Vars C Peak Time
- 9915 12324 - Demand Meter Vars C Peak Time
- 9916 12325 - Demand Meter Vars C Peak Time
- 9917 12326 - Demand Meter Vars C Peak Time
- 9918 12327 - Demand Meter Vars C Peak Time
- 9919 [Empty]

CATEGORY:  
Expanded Demand Data

REGISTER INFORMATION (ID, Size, Type):  
12328, 12, String

DESCRIPTION:  
Demand Meter Vars Total Peak Time

Figure 49-14. Modbus Mapping Screen

## 50 • Security

Multiple levels of BE1-11 $t$  security give personnel the level of access appropriate for the tasks they routinely perform while securing critical settings from unauthorized access.

### Note

The BE1-11 $t$  does not support factory password reset in the field and will need to be returned to Basler Electric for service if all Admin passwords are lost or expired.

### Access Levels

Passwords provide access security for six distinct functional access areas: Read, Control, Operator, Settings, Design, and Administrator (Admin). Each functional area can be assigned a unique password or one password can be assigned to multiple areas. Functional areas are not independent of one another. For example, an Admin password is used to access levels 6, 5, 4, 3, 2, and 1; a Design password is used to access levels 5, 4, 3, 2, and 1. Table 50-1 lists the access levels and descriptions.

**Table 50-1. Access Levels and Descriptions**

Access Level	Description
6 - Admin (highest)	Create, edit, and delete users and device security.
5 - Design	Create or change programmable logic and reboot device.
4 - Settings	Change all settings values. Logic equations cannot be created or changed.
3 - Operator	Set date and time, reset accumulated metering values, and erase event data.
2 - Control	Operate real-time controls.
1 - Read	Read all system parameters. No changes or operation allowed.
0 - None	All access denied.

Additional security is provided by controlling the functional areas that can be accessed through a particular communication port. For example, security can be configured so that front panel access is permitted at a lower access level than BESTCOMSP $Plus$ <sup>®</sup> or Modbus access.

The communication ports and password parameters act as a two-dimensional control to limit changes. The entered password must be correct and the command must be entered through a valid port. Only one port at a time can be in use with higher than Read access. For example, if a user gains Settings access at the front-panel USB port, users at other areas (rear Ethernet and front panel) will be able to gain Read access only after the user with Settings access at the front-panel USB port disconnects from the device. Read access is always allowed for all simultaneous users with access level 1 or higher.

If a port holding higher than Read access sees no activity for the duration of the Access Timeout setting, access privileges will automatically be lowered to Read access. This feature ensures that password protection cannot be accidentally left in a state where access privileges are enabled for one area and other areas locked out for an indefinite period.

### Username Setup

1. Use the Settings Explorer in BESTCOMSP $Plus$  to select Username Setup under General Settings, Device Security Setup. The Login dialog box appears. See Figure 50-1. An administrator access level is required to set up usernames and passwords.

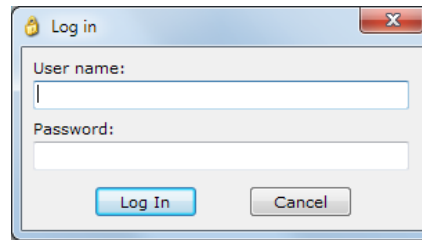


Figure 50-1. Login Screen

2. Enter the username and password of the administrator and then click the Log In button. The default Administrator username is “A” and the default Password is “A”.
3. Only an administrator can modify usernames and passwords on the Username Setup screen (Figure 50-2). Complex usernames and passwords up to 16 characters in length are accepted. Acceptable characters include uppercase letters, lowercase letters, numbers, and certain special characters.

### Note

BE1-11r firmware versions from 2.09.00 and beyond support at least this set of characters in passwords:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

a b c d e f g h i j k l m n o p q r s t u v w x y z

0 1 2 3 4 5 6 7 8 9

` ~ ! @ # \$ % ^ & ( ) \_ + - = { } [ ] \ : " ; ' < > ? . / ,

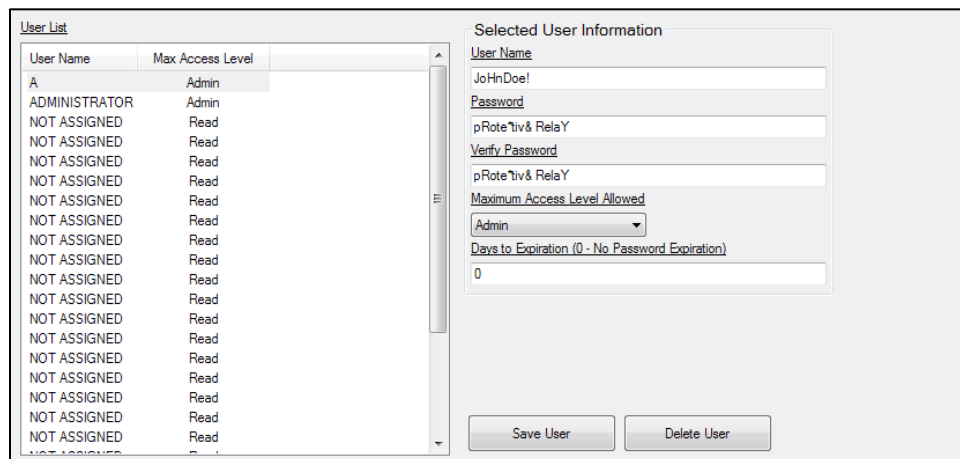


Figure 50-2. Username Setup Screen

4. In the left-hand column, highlight any username labeled NOT ASSIGNED or highlight a specific username to change it.
5. On the right side of the screen, enter a username.
6. Enter a password for the user.
7. Re-enter the password to verify it.
8. Using Table 50-1 as a reference, enter the maximum access level allowed for the user.
9. Enter the number of days to expiration of the password or leave at default (0) for no expiration.

10. Click the Save User button to save to the settings to BESTCOMSPPlus memory.
11. Pull down the Communication menu and select Upload Security to Device. The Login dialog box pops up. An administrator level is required to upload security settings to the device.
12. Enter the username and password of the administrator and then click the Log In button. The default administrator username is “A” and the default password is “A”. BESTCOMSPPlus notifies you when the upload is successful.

## Port Access Setup

1. Use the Settings Explorer in BESTCOMSPPlus to select Port Access Setup under General Settings, Device Security Setup. The Port List screen is shown in Figure 50-3.

Port	Unsecured Access	Secured Access
ASCII via Ethernet	Read	Admin
BESTCOMSPPlus® via Ethernet	Read	Admin
BESTCOMSPPlus® via USB	Read	Admin
DNP via Ethernet	Read	Admin
DNP via Serial	Read	Admin
HMI	Read	Admin
Modbus via Ethernet	Read	Admin
Modbus via Serial	Read	Admin

**Selected Port Information**

Unsecured Access Level: Read

Secured Access Level: Admin

Save Port

Figure 50-3. Port List Screen

2. The Login dialog box pops up. See Figure 50-1. An administrator access level is required to set up port access. Enter the username and password of the administrator and then click the Log In button. The default administrator username is “A” and the default Password is “A”.
3. In the side column, highlight a port to change.
4. On the right side of the screen, use the drop-down menus to select the Unsecured Access Level and Secured Access Level for the highlighted port. The Unsecured Access Level setting sets the max level of access which can be gained without entering a username/password. The Secured Access Level setting sets the max level of access which can be gained with a password.

### Caution

Setting the Secured Access Level to None on any port will make that port unusable. If the Secured Access Level is set to None on all available ports, the BE1-11t must be returned to Basler Electric for repair.

5. Click the Save Port button to save to the settings to BESTCOMSPPlus memory.
6. Pull down the Communication menu and select Upload Security to Device. The Login dialog box pops up. An administrator level is required to upload security to the device.
7. Enter the username and password of the administrator and then click the Log In button. The default administrator username is “A” and the default password is “A”. BESTCOMSPPlus notifies you when the upload is successful.

## Access Control

The Access Timeout setting defines the amount of time before access expires. The timer resets every time a setting is changed. If a username and/or password is entered incorrectly more than x times (Login Attempts) in y seconds (Login Time Window), then access is prohibited for z seconds (Login Lockout Time).

When the HMI Login Required Reset setting is disabled, target and alarm reset can be set outside of security control, allowing reset without logging in.

The BESTCOMSP*lus* Access Control screen is illustrated in Figure 50-4.

**Figure 50-4. Access Control Screen**

1. Use the Settings Explorer in BESTCOMSP*lus* to select Access Control under General Settings, Device Security Setup. The Access Control screen is shown in Figure 50-4.
2. Configure the Access Timeout and Login Failure settings.
3. Pull down the Communication menu and select Upload Security to Device. The Login dialog box pops up. An administrator level is required to upload security to the device.
4. Enter the username and password of the administrator and then click the Log In button. The default administrator username is “A” and the default password is “A”. BESTCOMSP*lus* notifies you when the upload is successful.

## Viewing the Security Log

**BESTCOMSP*lus* Navigation Path:** Metering Explorer, Reports, Security Log

**HMI Navigation Path:** Not available through the front panel

The BE1-11*t* records information about user logins including the port used to log in, the access level granted, the type of action performed, and the time of logout and creates security logs. A log will also be triggered when a user attempts to log in, but fails due to an invalid username or incorrect password.

A maximum of 200 entries are stored in nonvolatile memory. When a new entry is generated, the BE1-11*t* discards the oldest of the 200 entries and replaces it with a new one.

Use the Metering Explorer to open the Reports, Security Log screen. If an active connection to a BE1-11*t* is present, the security log will automatically download. Using the Options button, you can copy, print, or save the security log. The Refresh button is used to refresh/update the security log. The Clear button clears the security log. The Toggle Sorting button enables sorting. Click on a column header to sort. See Figure 50-5.

Port	Username	Access Level	Login Time	Logout Time	Action
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:00:24.000	2008-01-01 00:05:29.672	Activate
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:00:37.000	NA	None
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:00:37.418	NA	None
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:00:59.826	NA	None
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:01:00.537	NA	None
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:01:03.131	NA	None
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:01:04.993	NA	None
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:01:05.111	2008-01-01 00:13:38.352	Save
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:01:11.961	2008-01-01 00:36:08.238	Save
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:06:02.839	2008-01-01 00:16:07.411	Save
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:13:08.943	2008-01-01 00:13:53.707	Save
HMI Local	A	Read Access	2008-01-01 00:16:00.434	NA	None
HMI Local	A	Admin Access	2008-01-01 00:16:13.569	NA	None
Bestcoms Via Ethernet	A	Read Access	2008-01-01 00:17:29.641	NA	None
Bestcoms Via Ethernet	A	Admin Access	2008-01-01 00:14.417	2008-01-01 00:43.18	Save

Figure 50-5. Security Log

## Authenticity and Encryption

The BE1-11*t* supports authentication and encryption of communications with BESTCOMSP*lus*. This is done using the Transport Layer Security protocol, version 1.2 (TLS 1.2). To enable this mode, an X.509 certificate and private key must be uploaded to the BE1-11*t*.

In TLS 1.2, a certificate is used to verify the authenticity of the server (BE1-11*t*). The supported certificate formats are Standard PEM, DER/Binary, and PFX (PKCS#12). The BE1-11*t* supports RSA encryption up to 8192 bit keys. The recommended key length is 2048 as longer keys will slow the initial connection. DER and PEM formats commonly have the private key stored in a separate file. If this is the case, you will be asked for an additional file containing the key. If a password is required for the key, you will also need to enter it into the form. It is recommended that certificates be uploaded over a trusted connection or through the USB port.

### Generate a Certificate

BESTCOMSP*lus* is used to generate a self-signed X.509 certificate for use in identifying a connected device. In order for the certificate to work, the common name must match the domain name or the IP address of the device. Alternate names can be used if multiple domain names match the device. The valid dates specify how long the certificate may be used. A new certificate should be issued after one expires.

To generate a certificate, click on the **Tools** drop-down menu in BESTCOMSP*lus* and select **Generate Certificate**. Fill in all applicable fields. A password is optional. Click **Save** to generate a .pfx file which is the certificate and the private key required to upload to the BE1-11*t*.

Self-signed certificates can be less secure than using a Certificate Authority to sign the certificate for the device. It will allow encryption from end to end. Use caution when choosing this method. Distribution of the generated file compromises security.

Generate Certificate

Use this form to generate self signed certificates  
The only required field is Common Name. Empty field will not be added

Country: US United States of America

State or Province: SomeState

Locality (City): TheCity

Organization: MyCorp

Organizational Unit: Engineering

Common Name (IP Address): 10.0.0.1

Email: email@email.email

Alternate Names (each name new line)

Valid Dates

From: Wednesday, April 19, 2017

To: Wednesday, April 19, 2017

Password (Leave blank for none)

Confirm Password

Save

Cancel

Figure 50-6. Generate Certificate Screen

### Upload a Certificate to the Device

To upload a security certificate, click on the Communication drop-down menu in BESTCOMSP*lus* and select Certificate > Upload Certificate to Device. Then, select the certificate type, browse for the certificate file, and click the Upload button. See Figure 50-7.

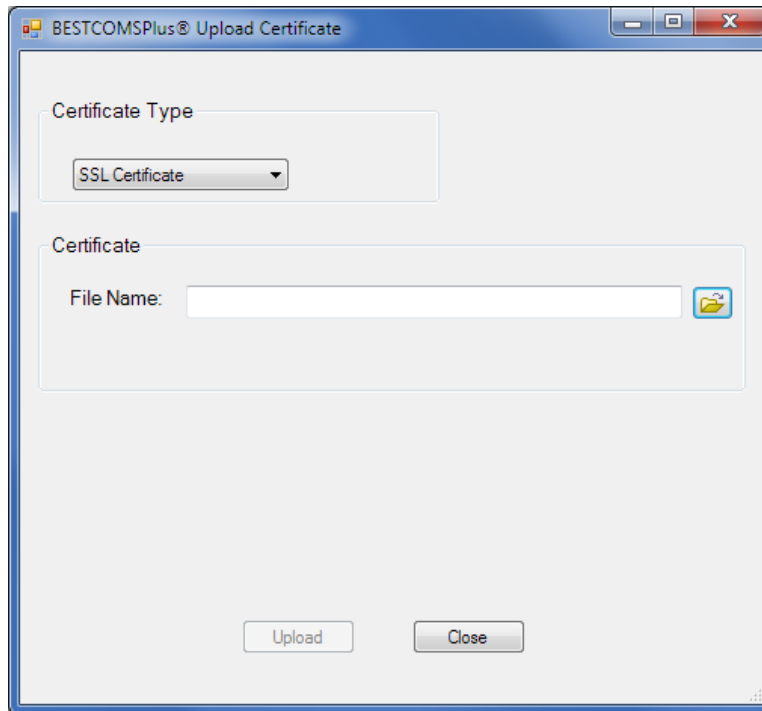


Figure 50-7. Upload Certificate Screen

### Remove a Certificate from the Device

To remove a security certificate, click on the Communication drop-down menu in *BESTCOMSPi.us* and select Certificate > Remove Certificate from Device.

### Authenticate a Certificate

Two methods for authenticating certificates are available. In the first method, a built-in Windows® mechanism verifies that the certificate chain is signed by a trusted root certificate authority. If you upload a certificate chain to the BE1-11t with a root trusted by Windows, it will automatically authenticate and connect. If it is not trusted, there is a second option to manually accept the certificate. All information about the certificate is displayed. The certificate can be accepted once (temporarily) or permanently. See Figure 50-8. If the certificate changes in any way, the prompt to manually accept the certificate is shown again.

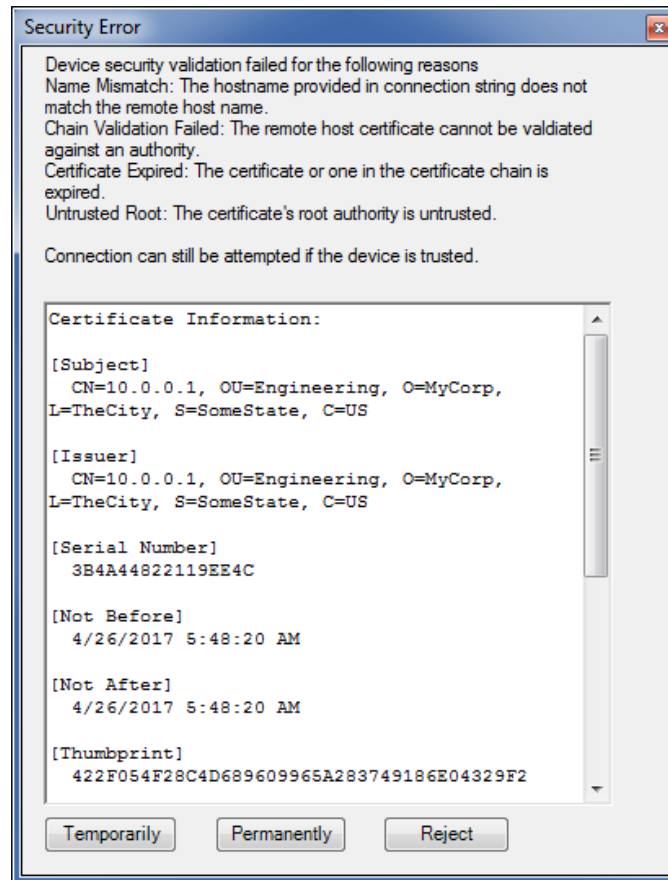
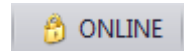


Figure 50-8. Security Error Screen

A lock symbol in the lower status bar of BESTCOMSP*lus* means the connection is secure.



## Remove Accepted Device

To remove a previously accepted device, click on the Tools drop-down menu in BESTCOMSP*lus* and select Accepted Certificates. See Figure 50-9.

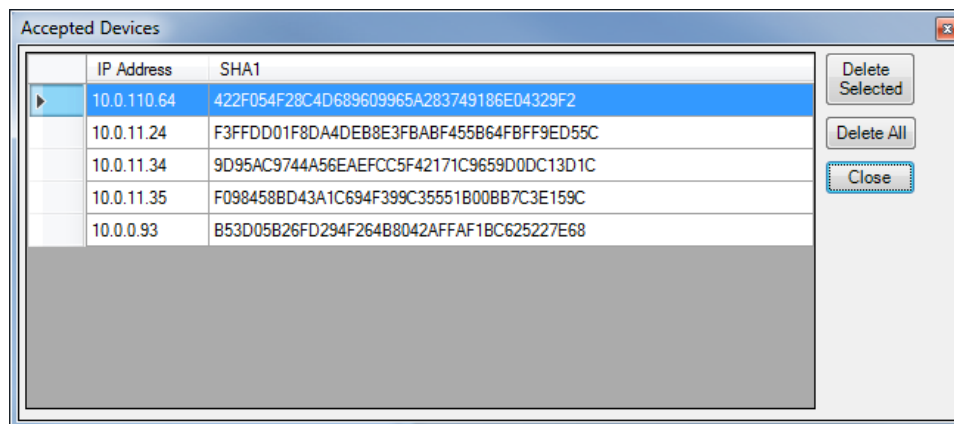


Figure 50-9. Accepted Devices

# 51 • Timekeeping

The BE1-11*t* provides a real-time clock with capacitor backup that is capable of operating the clock for up to 24 hours after power is removed from the BE1-11*t*. As the capacitor nears depletion, an internal backup battery takes over and maintains timekeeping. The backup battery is standard and will maintain the clock for more than five years depending on conditions.

The clock is used by the demand reporting function, the fault reporting function, the oscillography recording function, and the sequence of events recorder function to time-stamp events. The clock function records the year in two-digit format.

## **Clock Setup**

---

**BESTCOMSP*Plus* Navigation Path:** Settings Explorer, General Settings, Clock Setup

**HMI Navigation Path:** Settings Explorer, General Settings, Clock Setup

Clock settings are made through the communication ports using BESTCOMSP*Plus*® or through the front-panel interface. Write access to ports is required to program the clock. An alarm point is provided in the programmable alarms to detect when the BE1-11*t* has powered up and the clock has not been set.

The clock settings are made through BESTCOMSP*Plus* by selecting Clock Setup under General Settings. The BESTCOMSP*Plus* Clock Setup screen is illustrated in Figure 51-1.

The local time zone is configured on this screen. The Time Zone Offset is the local offset to UTC (Coordinated Universal Time). The Time Zone Offset is required if NTP or IRIG-B is used for time synchronization or when the Start/End Time Reference is set to UTC (Coordinated Universal Time). The Start/End Time Reference is set to UTC time if required by local daylight savings time rules. The Start/End Hour/Minute settings determine the time when the DST will go into effect. The Bias setting is the amount of time that the clock moves forward or backward. The default settings are configured for the Central Time Zone in the United States as shown in Figure 51-1. Using these settings, the clock would move forward 1 hour at 2:00 a.m. on the second Sunday in March and move backward 1 hour at 2:00 a.m. on the first Sunday in November. DST can also be configured for a specific day of the month by selecting Fixed Dates under DST Configuration.

## **Time Priority Setup**

There are three available protocols (NTP, IRIG-B, and DNP), which can be assigned priorities to update the date and time. Double-click on an available item to move it to the Enabled box. Use the arrow buttons to set the priority of the selected item. If all three protocols are disabled, the date and time will not be updated automatically.

The NTP (Network Time Protocol) synchronizes the real-time clock to a network time server when an Ethernet cable is connected. An address of a valid NTP server must be entered when NTP is selected in the Time Priority Setup, Enabled box. If using a named server, use the Additional NTP Sources and leave the NTP Address at 0.0.0.0.

## **IRIG Decoding**

The IRIG Decoding signal defines whether or not to decode the year field in the IRIG signal. Refer to the manufacturer of your equipment to determine if the year field is being sent to the BE1-11*t*.

**Clock Setup**

**Time Zone Offset Setup**  
 Time Zone Hour Offset: -6  
 Time Zone Minute Offset: 0

**Clock Display Setup**  
 Time Format: 24 Hour  
 Date Format: YYYY-MM-DD

**Daylight Saving Time Setup**  
 DST Configuration: Floating Dates  
 Start/End Time Reference:  
 Respective to Local Time  
 Respective to UTC Time

**Start Day**  
 Month: March  
 Occurrence of Day: Second  
 Weekday: Sunday  
 Hour: 2  
 Minute: 0

**End Day**  
 Month: November  
 Occurrence of Day: First  
 Weekday: Sunday  
 Hour: 2  
 Minute: 0

**Bias Setup**  
 Hour: 1  
 Minute: 0

**Time Priority Setup**  
 Disabled: [Empty Box]  
 Enabled: IrigB, Ntp, Dnp  
 Double-click on an item to move to next Box

**Irig Decoding**  
 IRIG without Year  
 IRIG with Year

**NTP Address**  
 0 0 0 0

**Additional NTP Sources**  
 NTP Server 1: [Empty Box]  
 NTP Server 2: [Empty Box]  
 NTP Server 3: [Empty Box]

Figure 51-1. Clock Setup Screen

## Setting the Time and Date

**BESTCOMSPiplus Navigation Path:** Metering Explorer, Status, Real Time Clock

**HMI Navigation Path:** Metering Explorer, Status, Real Time Clock

Time and date settings can be made through BESTCOMSPiplus on the Real Time Clock screen (Figure 51-2) under the Status branch of the Metering Explorer. Setting can also be made through the front panel.

Real Time Clock

15:02:22 Time  
 2014-03-10 Date

Edit

Figure 51-2. Status, Real Time Clock Screen

## IRIG Port

IRIG time code signal connections are located on the rear panel. When a valid time code signal is detected at the port, it is used to synchronize the clock function. Note that the IRIG time code signal received from older IRIG receivers does not contain year information. If this is the case, it will be necessary to enter the date manually. Year information is stored in nonvolatile memory so that when operating power is restored after an outage and the clock is re-synchronized the current year is restored.

When the clock rolls over to a new year, the year is automatically incremented in nonvolatile memory. An alarm bit is included in the programmable alarm function for loss of IRIG signal. The alarm point monitors for IRIG signal loss once a valid signal is detected at the IRIG port.

## Connections

IRIG connections are located on a terminal block shared with the RS-485 and input power terminals. Terminal designations and functions are shown in Table 51-1.

**Table 51-1. IRIG Terminal Assignments**

Terminal	Function
A1	(+) Signal
A2	(-) Reference

## Specifications

Interface supports IRIG Standard 200-04, Format B006.

Input Signal ..... Demodulated dc. Level-shifted, digital signal

Input Voltage Range .....  $\pm 10$  Vdc maximum

Input Resistance ..... Nonlinear, approximately 4 k $\Omega$  at 3.5 Vdc,  
approximately 3 k $\Omega$  at 20 Vdc

### Logic Voltage Threshold

High ..... 3.5 Vdc minimum

Low ..... 0.5 Vdc maximum

## Real-Time Clock Specifications

Resolution ..... 1 s

Accuracy .....  $\pm 1.73$  s/d at 77°F (25°C)

### Clock Holdup

Capacitor Holdup Time ..... Up to 24 hours depending on conditions

Battery Holdup Time ..... Greater than 5 years depending on conditions

Battery Type ..... BR2032 or CR2032, coin-type, 3 Vdc, 195 mAh  
Basler Electric P/N 38526

## Backup Battery for the Real-Time Clock

The backup battery for the real time clock is a standard feature of the BE1-11*t*. A battery is used to maintain clock function during loss of power supply voltage. In mobile substation and line-powered applications, the voltage that supplies the BE1-11*t* power supply may be disconnected for extended periods (weeks, months) between uses. Without battery backup for the real time clock, clock functions will cease if battery input power is removed.

The backup battery has a life expectancy of greater than five years depending on conditions. After this time, you should contact Basler Electric to order a new battery, Basler Electric P/N 38526.

**Caution**

Replacement of the backup battery for the real-time clock should be performed only by qualified personnel.  
Do not short-circuit the battery, reverse battery polarity, or attempt to recharge the battery. Observe polarity markings on the battery socket when inserting a new battery. The battery polarity must be correct in order to provide backup for the real-time clock.

**Note**

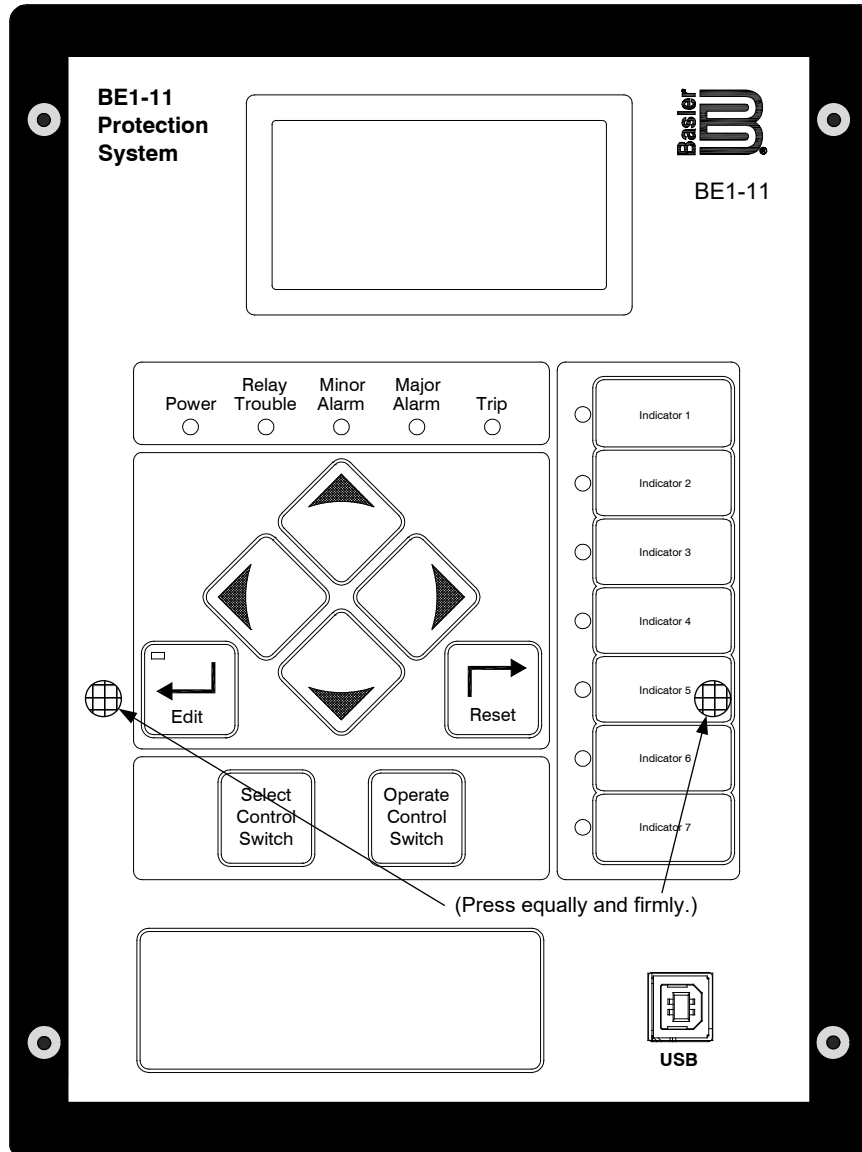
Failure to replace the battery with Basler Electric P/N 38526 may void the warranty.

**Battery Replacement Procedure**

Battery access is located behind the front cover of the BE1-11*t* on the front-panel circuit board. See Figure 51-3.

- Step 1: Remove the BE1-11*t* from service.
- Step 2: Use a 7/64" hex tool to remove the front cover screws and remove the cover.
- Step 3: Locate the battery holder attached to the rear of the cover. Remove the old battery. Consult your local ordinance for proper battery disposal.
- Step 4: Insert the new battery so that the polarity markings on the battery match the polarity markings on the battery holder and circuit board.
- Step 5: Reattach the front cover by pressing equally and firmly on both sides as shown in Figure 51-4. Using a 7/64" hex tool, tighten the front cover screws to 10 in-lbs (1.12 N•m).
- Step 6: Return the BE1-11*t* to service.





P0072-79

Figure 51-4. Re-Attaching the Front Cover

## 52 • Device Information

BE1-11 $\iota$  identification labels, firmware version, serial number, and style number are found on the Device Info screen in BESTCOMSP $\iota$ lus®.

### Style Number

The model number, together with the style number, describes the options included in a specific device and appears on labels located on the front panel and inside the case.

The style number of the BE1-11 $\iota$  is displayed on the BESTCOMSP $\iota$ lus Style Number screen after downloading settings from the device. When configuring BE1-11 $\iota$  settings off-line, the style number for the unit to be configured can be entered into BESTCOMSP $\iota$ lus to enable configuration of the required settings. The BESTCOMSP $\iota$ lus Style Number screen is illustrated in Figure 52-1.

**Style Number**

BE1-11 Style Number  
**BE1-11** T - 6 D 1 N 1 J 1 P 0 E 0 00

BE1-11 Style Number Options

T	Application Option	F) Feeder I) Intertie G) Generator <b>T) Transformer</b> M) Motor
6	Phase CT Option	<b>6) CT1 - 5 Amp Nominal / CT2 - 5 Amp Nominal</b> 2) CT1 - 1 Amp Nominal / CT2 - 1 Amp Nominal
D	Ground CT Option	<b>D) CT1 - 5 Amp Nominal / CT2 - 5 Amp Nominal</b> E) CT1 - 1 Amp Nominal / CT2 - 1 Amp Nominal F) CT1 - 0.01 - 7.5 Amp (SEF) / CT2 - 5 Amp Nominal G) CT1 - 0.01 - 7.5 Amp (SEF) / CT2 - 1 Amp Nominal
1	Power Supply Option	<b>1) 48/125 Vac/dc</b> 2) 125/250 Vac/dc 3) 24Vdc
N	RS-485 Port Protocol	<b>N) None</b> M) Modbus™ D) DNP 3.0
1	Ethernet Protocol	0) No Ethernet <b>1) BESTnet™Plus Only</b> 2) Modbus™/TCP with BESTnet™Plus 3) DNP 3.0 with BESTnet™Plus 4) Modbus™/TCP and DNP 3.0 with BESTnet™Plus 5) IEC 61850 with BESTnet™Plus
J	Case Option	<b>J) Vertical Case</b>
1	Inputs/Outputs Option	<b>1) Standard I/O. N.O. Alarm</b> 2) Standard I/O. N.C. Alarm 3) 10 Inputs / 5 Outputs. N.O. Alarm 4) 10 Inputs / 5 Outputs. N.C. Alarm
P	Option 1	<b>P) Current Differential</b> B) Enhanced Transformer (21, 25, 79, 87)
0	Network Connections	<b>0) Copper</b> 1) Fiber
E	Option 3	<b>E) None</b>
0	Option 2	<b>0) None</b> C) Conformal Coating
00	Firmware Option	<b>00) Latest Release</b>

Figure 52-1. Style Number Screen

### Device Info

Information about a BE1-11 $\iota$  communicating with BESTCOMSP $\iota$ lus can be obtained on the Device Info screen of BESTCOMSP $\iota$ lus after downloading settings from the device.

The application version must be selected when configuring BE1-11 $t$  settings off-line. When on-line, read-only information includes the application version, application part number, application build date, boot code version, model number, style number, serial number, language module version, and language module part number.

BE1-11 $t$  protection systems have three identification fields: Device ID, Station ID, and User ID. These fields are used in the header information lines of the Fault Reports, Oscillograph Records, and Sequence of Events Records.

The BESTCOMSP $l$ us Device Info screen is illustrated in Figure 52-2.

Figure 52-2. Device Info Screen

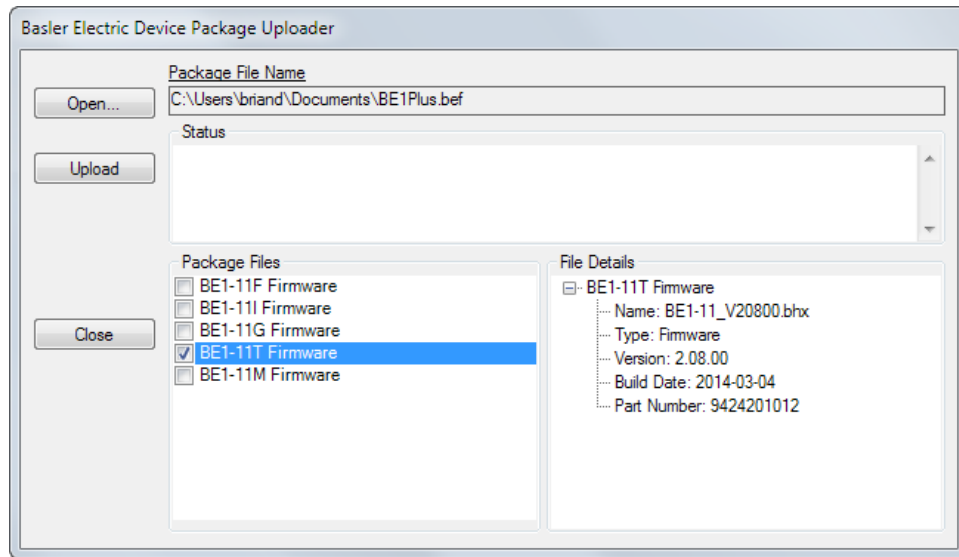
## Firmware Updates

### Caution

Default settings will be loaded into the BE1-11 $t$ , reports and events will be cleared, and the BE1-11 $t$  will reboot when firmware is updated. BESTCOMSP $l$ us can be used to download settings and save the settings in a file so that they can be restored after updating firmware. Refer to *Settings File Management* for help with saving a settings file.

Maintaining the latest version of BE1-11 $t$  firmware ensures worry-free operation using the latest features and functions. If you have obtained a package file containing an updated firmware file for your device, you can upload it by selecting Upload Device Files from the Communication pull-down menu on the main screen in BESTCOMSP $l$ us. The Basler Electric Device Package Uploader screen will appear. See Figure 52-3.

Use the Open button to browse for the device file that you obtained from Basler Electric. Place a checkmark next to the file you want to upload. Click the Upload button. The BE1-11 $t$  will reboot automatically after the firmware upload is complete.



**Figure 52-3. Basler Electric Device Package Uploader**

After rebooting, the Relay Trouble LED on the front panel is lit and Defaults Loaded is displayed on the Relay Alarms screen. To reset the alarm, use the Metering Explorer in *BESTCOMSPi* to navigate to the Status, Alarms screen (Figure 52-4) and click the Reset Relay Alarms button. This alarm can also be reset through the front panel by navigating to Metering > Status > Alarms > Relay Alarms and pressing the Reset button. Admin access is required to reset the Defaults Loaded alarm. The default username is “A” and the default password is “A”. Alarm reset can also be set outside of security control, allowing reset without logging in. Refer to the *Security* chapter for more information. Restore your settings file.



**Figure 52-4. BESTCOMSPi Alarms Screen**



## 53 • Configuration

BE1-11 $t$  inputs consist of two sets of three-phase current inputs and ground, three-phase voltage inputs, and one auxiliary voltage input. Each input is isolated and terminated at separate terminal blocks. This section describes the function and setup of each input, and provides the equations that the BE1-11 $t$  uses for calculating the power quantities.

### ***Power System Measurements***

---

Power system inputs, as described in the introduction, are sampled 32 times per cycle by the BE1-11 $t$ . The BE1-11 $t$  measures the voltage and current from these samples and uses those measurements to calculate other quantities. Frequency is measured from a zero-crossing detector. Measured inputs are then recorded every quarter-cycle. If the applied voltage is greater than 10 volts, the BE1-11 $t$  measures the frequency and varies the sampling rate to maintain 32 samples per cycle. Frequency compensation applies to all power system measurements. Power system inputs are described in the paragraphs under the following headings: *Current Measurement*, *Voltage Measurement*, *Frequency Measurement*, and *Power Measurement*.

#### **Current Measurement**

Secondary current from power system equipment CTs is applied to current transformers inside the BE1-11 $t$ . These internal transformers provide isolation and reduce the monitored current to levels compatible with BE1-11 $t$  circuitry. Secondary current from each internal CT is converted to a voltage signal and then filtered by an analog, low-pass, anti-aliasing filter.

##### *Current Measurement Functions*

Input waveforms are sampled by an analog-to-digital converter (ADC) at 32 samples per cycle. The BE1-11 $t$  extracts the magnitude and angle of the fundamental components of each three-phase current input and the magnitude and angle of the independent ground current input.

##### *Positive-Sequence, Neutral and Negative-Sequence Current Measurement*

Positive-sequence (I1), neutral (3I0), and negative-sequence (I2) components are calculated from the fundamental component of the three-phase current inputs. The BE1-11 $t$  can be set to accommodate ABC or ACB phase-sequence when calculating the positive- or negative-sequence component.

##### *Fast Current Detector*

A separate, fast current measurement algorithm is used by the breaker failure function and the breaker trip-speed monitoring function. This measurement algorithm has a sensitivity of 5% of the CT rating (5A or 1A depending on style number) and detects current interruption in the circuit breaker much more quickly than the regular current measurement functions. This measurement algorithm monitors only the phase current.

#### **Voltage Measurement**

Three-phase voltage inputs are reduced to internal signal levels by a precision resistor divider network. If the BE1-11 $t$  is set for single-phase or four-wire VT operation, the measuring elements are configured in wye. If the BE1-11 $t$  is set for three-wire VT operation, the measuring elements are configured in delta.

##### *Voltage Measurement Functions*

Input waveforms are sampled by an analog-to-digital converter (ADC) at 32 samples per cycle. The BE1-11 $t$  extracts the magnitude and angle of the fundamental components of each three-phase voltage input and the magnitude of the auxiliary voltage input.

##### *VT Connections*

When four-wire VT connections are used, the BE1-11 $t$  measures the three-phase to neutral voltages and calculates the phase voltage quantities. Overvoltage and undervoltage functions (27/59) can be set to

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

### Neutral-Shift Voltage

When four-wire VT connections are used, the BE1-11 $\tau$  calculates the neutral-shift voltage (3V0). Neutral-shift voltage measurement is not available when single-phase or three-wire VT connections are used. The 27X and 59X can be set to monitor the neutral-shift voltage.

### Negative-Sequence Voltage

Negative-sequence voltage (V2) is calculated from the fundamental component of the three-phase voltage inputs. It is available only on three-phase, three-wire, or three-phase, four-wire systems. V2 is calibrated to the phase-to-neutral base. Negative-sequence measurements accommodate either an ABC or ACB phase-sequence.

### Positive-Sequence Voltage

Positive-sequence voltage (V1) is calculated from the fundamental component of the three-phase voltage inputs. It is available only on three-phase, three-wire, or three-phase, four-wire systems. V1 is calibrated to the phase-to-neutral base. Positive-sequence measurements can accommodate either ABC or ACB phase-sequence.

## Frequency Measurement

Power system frequency is monitored on the A-phase voltage input or the AB voltage input when in three-wire mode. When the applied voltage is greater than 10 volts, the BE1-11 $\tau$  measures the frequency. The measured frequency is used by the 81 function and applies to all measurements and calculations.

### Frequency Compensation

After measuring the frequency, the BE1-11 $\tau$  varies the sampling rate to maintain 32 samples per cycle over a frequency of 10 to 125 hertz. If the voltage is too low for accurate frequency measurement or if the measured frequency is out of range, the analog-to-digital converter (ADC) defaults to a sampling rate appropriate for the BE1-11 $\tau$  nominal frequency setting. The sampling rate is adjusted every 50 milliseconds (3 cycles).

### Nominal Frequency

Nominal frequency ( $F_{nom}$ ) can be set for 25-, 50-, 60-, or 100-hertz power systems. When the voltage and current are too low for reliable frequency measurement, the ADC sample rate defaults to operation at the nominal frequency setting. Nominal frequency is also used in the volts/hertz (24) overexcitation calculation.

## Power Measurement

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

### For Sensing Type: Four-wire

$$\text{Watts}_A = V_{AN}I_A \cos(\phi_A)$$

$$\text{Watts}_B = V_{BN}I_B \cos(\phi_B)$$

$$\text{Watts}_C = V_{CN}I_C \cos(\phi_C)$$

$$\text{Watts}_{3\phi} = W_A + W_B + W_C$$

$$\text{Vars}_A = V_{AN}I_A \sin(\phi_A)$$

$$\text{Vars}_B = V_{BN}I_B \sin(\phi_B)$$

$$\text{Vars}_{CA} = V_{CN}I_C \sin(\phi_C)$$

$$\text{Vars}_{3\phi} = \text{Vars}_A + \text{Vars}_B + \text{Vars}_C$$

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

### For Sensing Type: Three-wire

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

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

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

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

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

#### *ABC Rotation*

$$\text{AN Sensing: } V_{BN} = V_{AN} \cdot 1\angle -120^\circ \quad V_{CN} = V_{AN} \cdot 1\angle 120^\circ$$

$$\text{BN Sensing: } V_{AN} = V_{BN} \cdot 1\angle 120^\circ \quad V_{CN} = V_{BN} \cdot 1\angle -120^\circ$$

$$\text{CN Sensing: } V_{AN} = V_{CN} \cdot 1\angle -120^\circ \quad V_{BN} = V_{CN} \cdot 1\angle 120^\circ$$

$$\text{AB Sensing: } V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -30^\circ \quad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -150^\circ \quad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 90^\circ$$

$$\text{BC Sensing: } V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 90^\circ \quad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -30^\circ \quad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -150^\circ$$

$$\text{CA Sensing: } V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -150^\circ \quad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 90^\circ \quad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -30^\circ$$

#### *ACB Rotation*

$$\text{AN Sensing: } V_{BN} = V_{AN} \cdot 1\angle 120^\circ \quad V_{CN} = V_{AN} \cdot 1\angle -120^\circ$$

$$\text{BN Sensing: } V_{AN} = V_{BN} \cdot 1\angle -120^\circ \quad V_{CN} = V_{BN} \cdot 1\angle 120^\circ$$

$$\text{CN Sensing: } V_{AN} = V_{CN} \cdot 1\angle 120^\circ \quad V_{BN} = V_{CN} \cdot 1\angle -120^\circ$$

$$\text{AB Sensing: } V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 30^\circ \quad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 150^\circ \quad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -90^\circ$$

$$\text{BC Sensing: } V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -90^\circ \quad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 30^\circ \quad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 150^\circ$$

$$\text{CA Sensing: } V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 150^\circ \quad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -90^\circ \quad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 30^\circ$$

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

## Power System Settings

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The BE1-11 $\ell$  requires information about the power system to provide metering, fault reporting, fault location, and protective relaying.

Power system settings are configured on the Power System settings screen in BESTCOMSP $\ell$ us $\text{\textcircled{R}}$ . A summary of the settings appear at the end of this section.

**BESTCOMSP $\ell$ us $\text{\textcircled{R}}$  Navigation Path:** Settings Explorer, System Parameters, Power System

**HMI Navigation Path:** Settings Explorer, System Parameters, Power System

### Nominal Settings

#### Frequency

Nominal Frequency can be set for 25-, 50-, 60-, or 100-hertz power systems.

#### Phase Voltage

The nominal Secondary Phase Voltage setting is used by the 24, 25, 60FL, and 67 elements. The nominal secondary phase voltage is defined as the secondary phase-neutral voltage for all sensing connections. That is, even if the user has selected 3-wire, AB, BC, or CA phase-phase sensing connections, the nominal secondary phase voltage must be set for the phase-neutral equivalent. For example, if a 3-wire open delta voltage source with a phase-phase voltage rating of 120 volts is connected, the nominal secondary phase voltage must be set at  $120/\sqrt{3}$  or 69.3 volts.

#### Auxiliary Voltage

The nominal Secondary Auxiliary Voltage setting is used by the 25 element. The nominal secondary auxiliary voltage is defined as the secondary phase-phase or phase-neutral voltage as defined by the Aux VT Connection setting on the Sensing Transformers screen in BESTCOMSP $\ell$ us $\text{\textcircled{R}}$ .

#### Current

The nominal Secondary Phase Current ( $I_{nom}$ ) setting is used by the 60FL function, directional calculations for the 67 elements, and DNP3 analog event reporting functions.  $I_{nom}$  is also used in the volts/hertz (24) calculation and in the 46 time curve calculation (K factor) of the negative-sequence current (51-x) element.

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

#### Power Polarity

This setting defines the polarity of metering and protection functions.

### Phase Rotation Setup

Normal phase rotation can be set for either ABC rotation or ACB rotation.

### Power Line Parameters

Power line parameters are used for fault location and distance to fault. For more information on distance to fault and the power line parameters, see the *Fault Reporting* chapter.

### Maximum Torque Angle

Maximum Torque Angle (MTA) is used by the directional overcurrent (67) element to provide directional supervision of the overcurrent tripping elements. The MTA for the phase and ground polarizing elements is normally derived from the line impedance angles (power line parameters) but there are applications

requiring MTA's different from the line impedance angles. Settings are provided for the 67-1 and 67-2 elements. For more information on setting MTA for different applications, see the *Directional Overcurrent (67) Protection* chapter.

## Settings

Power system settings are configured on the Power System settings screen (Figure 53-1) in BESTCOMSPi.us.

**Power System**

**Nominal Settings**

Frequency  
60 Hz

Secondary Phase Voltage (V)  
69.30 Vpn

Secondary Phase Current CT1 (A)  
5.00

Secondary Phase Current CT2 (A)  
5.00

Secondary Aux Voltage (V)  
69.30 Vpn

Power Polarity  
Normal

**Phase Rotation Setup**

Rotation  
ABC

**Power Line Parameters**

**Positive Sequence Impedance**

Z1 Line Magnitude (Ohm)  
24.00

Z1 Line Angle (°)  
80.0

**Zero Sequence Impedance**

Z0 Line Magnitude (Ohm)  
8.00

Z0 Line Angle (°)  
80.0

**Line Length**

Line Length  
100.00

**67-1 Maximum Torque Angle**

**Positive Sequence**

Z1 Angle (°)  
80.0

**Zero Sequence**

Z0 Angle (°)  
80.0

**Negative Sequence**

Z2 Angle (°)  
80.0

**67-2 Maximum Torque Angle**

**Positive Sequence**

Z1 Angle (°)  
80.0

**Zero Sequence**

Z0 Angle (°)  
80.0

**Negative Sequence**

Z2 Angle (°)  
80.0

Figure 53-1. Power System Settings Screen

## Sensing Transformers Settings

The BE1-11 $t$  requires information about the current and voltage transformers to provide metering, fault reporting, fault location, and protective relaying.

Sensing transformer settings are configured on the Sensing Transformers settings screen in BESTCOMSPi.us. A summary of the settings appear at the end of this section.

**BESTCOMSPi.us Navigation Path:** Settings Explorer, System Parameters, Sensing Transformers

**HMI Navigation Path:** Settings Explorer, System Parameters, Sensing Transformers

### CT Setup

The BE1-11 $t$  requires setting information on the CT ratios. This setting is used by the metering and fault reporting functions to display measured quantities in primary units.

#### Unbalanced Calculation Method

Unbalanced overcurrent protection is provided by the 50 and 51 elements. Two methods are available to calculate unbalanced current.

#### Method 1 (I2/I1)

$$I_{Unbalance} = \frac{I_2}{I_1} \times \text{MIN}$$

where:

$$\text{MIN} = \frac{I_{\text{Average}}}{I_{\text{Rated}}} \text{ or } 1, \text{ whichever is less}$$

### Method 2 (Average)

$$I_{\text{Unbalance}} = \frac{(\text{MAXp} - I_{\text{Average}}) \text{ or } (I_{\text{Average}} - \text{MINp}), \text{ whichever is greater}}{I_{\text{Average}}} \times \text{MIN}$$

where:

$$\text{MIN} = \frac{I_{\text{Average}}}{I_{\text{Rated}}} \text{ or } 1, \text{ whichever is less}$$

MAXp = maximum of all three phases

MINp = minimum of all three phases

### Connection

This setting defines how the sensing CTs are connected for differential metering.

### Phase VT Setup

The BE1-11 $\ell$  requires setting information about the VT ratio, the phase connections, and the operating modes for the 27/59 and 27R functions. These settings are used by the metering and fault reporting functions to display measured quantities in primary units. The voltage input circuit settings also determine which power measurement calculations are used. Most of these connections such as 3W-D, 4W-Y, AN, or AB are self-explanatory.

### Auxiliary VT Setup

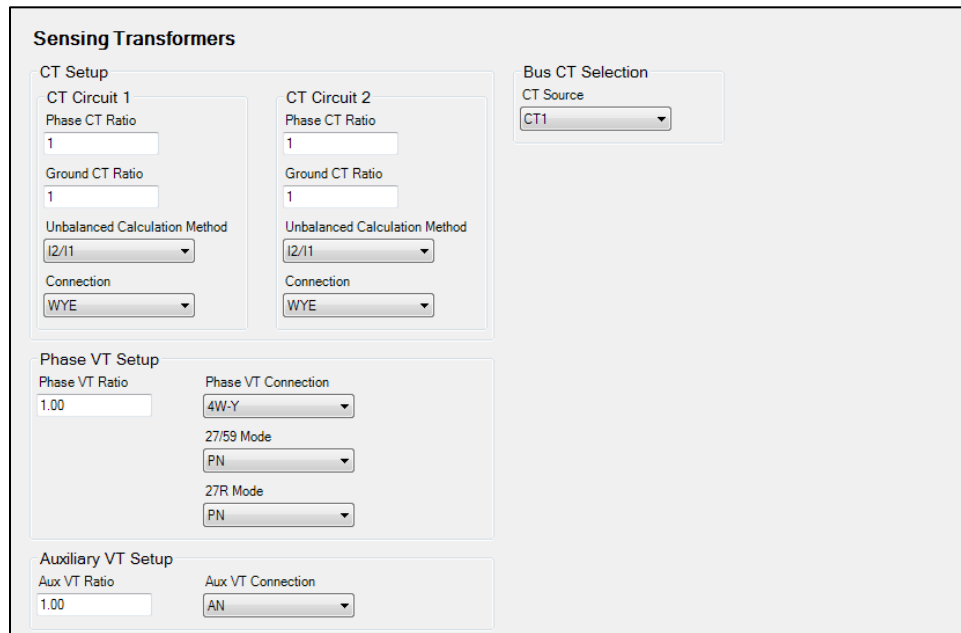
The auxiliary voltage input (Vx) connection can be set for AB, BC, CA, AN, BN, CN, or Ground. When set for one of the phase voltages, the sync-check function can be set to compensate for the phase angle difference relative to the reference voltage measured at the three-phase voltage inputs. The Vx input connection is set to Ground when connected to a source of ground unbalance voltage or residual voltage such as a generator grounding resistor, broken delta VT connection, or capacitor bank star point.

### Bus CT Selection

The CT Source setting selects the Bus CT to use in calculations for metering, fuse loss (60FL), and distance (21) protection.

### Settings

Sensing transformers settings are configured on the Sensing Transformers settings screen (Figure 53-2) in BESTCOMSP $\ell$ us.



The image shows a software interface titled "Sensing Transformers". It is divided into several sections:

- CT Setup:** Contains two columns for "CT Circuit 1" and "CT Circuit 2". Each column has input fields for "Phase CT Ratio" (both set to 1) and "Ground CT Ratio" (both set to 1). Below these are dropdown menus for "Unbalanced Calculation Method" (both set to I2/I1) and "Connection" (both set to WYE).
- Bus CT Selection:** A dropdown menu labeled "CT Source" set to CT1.
- Phase VT Setup:** Includes a "Phase VT Ratio" input field set to 1.00, and three dropdown menus: "Phase VT Connection" (set to 4W-Y), "27/59 Mode" (set to PN), and "27R Mode" (set to PN).
- Auxiliary VT Setup:** Includes an "Aux VT Ratio" input field set to 1.00 and a dropdown menu for "Aux VT Connection" set to AN.

Figure 53-2. Sensing Transformers Settings Screen

## Transformer Setup

The BE1-11 $t$  requires information about the transformer windings to provide differential metering and differential protection. See the *Phase Current Differential (87) Protection* chapter for more information.

Transformer setup is accomplished on the Sensing Transformers settings screen (Figure 53-3) in BESTCOMSP $lus$ .

**BESTCOMSP $lus$  Navigation Path:** Settings Explorer, System Parameters, Transformer Setup

**HMI Navigation Path:** Settings Explorer, System Parameters, Transformer Setup

### Transformer Connection

This setting identifies which side of the protected transformer the circuit is located. For example, if the circuit is on the delta side of a Delta/Wye transformer, set to DAB or DAC depending on how the delta of the transformer is constructed. Set to WYE if the circuit is on the wye side of the transformer. Set to NA when there is no transformer in the protected zone.

### Ground Compensation

If there is a ground source within the protected zone, the user can apply a numerical, zero-sequence trap to remove the zero-sequence components from the current to prevent misoperation on external ground faults when a ground bank is in the zone of protection. This setting is optional. It is not required to enter a ground source setting of 1 to describe a grounded wye transformer connection. Even though not all grounded wye transformer connections are ground sources, the BE1-11 $t$  always assumes that a wye transformer connection is a ground source so that it is secure. Zero-sequence current unbalance can occur in three legged core transformers due to the phantom tertiary effect. In all cases, the BE1-11 $t$  chooses delta compensation for a wye transformer connection so that the zero-sequence components are blocked.

### Differential Circuit

This identifies if the circuit is on the source (Primary) or load (Secondary) side of the power transformer. This setting does not affect protection. This setting is used by the differential report as part of its evaluation of the differential configuration.

## Polarity

This will typically be set to Normal. In some applications, the secondary side of the transformer may be wired 180 degrees instead of 0. If this is the case, then set to Reverse.

## Phase Relationship

This will typically be A. In some cases, two circuits will be connected such that A on one side of the transformer is in the same electrical location as B on the other side. In this situation, the second side phase relationship would be set to B

## IEC Setup

This provides an alternate way to set Phase and Polarity based on IEC nomenclature if it is available on the transformer. If IEC Setup is used, BESTCOMSP<sup>lus</sup> will set the Polarity and Phase Relationship based on the IEC Setup configuration.

## Tap Calculations

When Manual is selected, the user will set the taps for Circuit 1 and 2. This is often used when replacing an existing relay and wanting to use existing understood settings. When set to Auto, BESTCOMSP<sup>lus</sup> uses the MVA rating, kV rating, Transformer Connection, and CT ratios to calculate the tap settings.

## MVA Rating

This is the Volt Amp rating in millions of VA. This is used as part of the auto tap to scale tap settings to an appropriate level.

## kV Rating

This setting is used with CT ratios and Transformer connection to provide a correct ratio between Circuit 1 and Circuit 2 taps.

## CT Connection

This is set on the Sensing Transformers page and displayed here for information.

## Phase CT Ratio

This is set on the Sensing Transformers page and displayed here for information.

The screenshot displays the 'Transformer Setup' interface, which is divided into several sections:

- Transformer Circuits:** This section is split into two columns for 'Circuit 1' and 'Circuit 2'. Each column contains dropdown menus for 'Transformer Connection' (set to 'WYE'), 'Ground Compensation' (set to 'No'), 'Differential Circuit' (set to 'Primary'), 'Polarity' (set to 'Normal'), and 'Phase Relationship' (set to 'A').
- IEC Transformer Setup:** A button labeled 'IEC Setup' is located at the bottom left of the circuit configuration area.
- Transformer Taps:** This section includes a 'Tap Calculation Mode' dropdown set to 'Manual'. Below it is an 'MVA Rating' input field with the value '1.00' and a 'Calculate Taps' button. Two columns, 'Circuit 1' and 'Circuit 2', each have 'kV Rating' and 'Tap' input fields, both with the value '2.00'.
- CT Settings (Set on Sensing Transformers View):** This section at the bottom has two columns, 'Circuit 1' and 'Circuit 2'. Each column has a 'CT Connection' dropdown set to 'WYE' and a 'Phase CT Ratio' input field with the value '1'.

Figure 53-3. Transformer Setup Screen

## Connection Settings for Current Differential

When the zone of protection includes a transformer, it may be necessary to provide phase angle and zero sequence compensation to the currents used by the Phase Current Differential Protection (87) element. See Figure 53-4 and Figure 53-5. For each input circuit, a setting is provided to enter the transformer connections associated with that input.

### Determining the Transformer Connection Parameters

**Wye and Autotransformer Windings.** The transformer connection for a CT input circuit that is connected to either a wye or autotransformer winding should be classified as a wye winding.

**Delta Transformer Windings.** The transformer connection for a CT input circuit that is connected to a delta winding could be classified as one of two delta connections: Delta IA-IB (DAB) or Delta IA-IC (DAC). A delta configuration is defined by the currents that flow in the primary phases connected to the delta. The wye winding phase connections are used as the point of reference since the current that flows in the wye winding is the same as the current in the wye side primary phases. Figure 53-4 shows an example of a transformer with a DAB connection. Figure 53-5 shows an example of the same transformer with the phases reconnected to provide a DAC connection. If there is no wye winding to use as reference, as is the case with a delta/delta transformer, the definition of the delta configuration is not important.

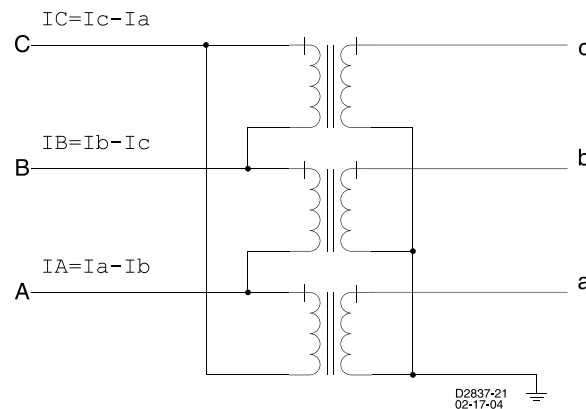


Figure 53-4. DAB Delta

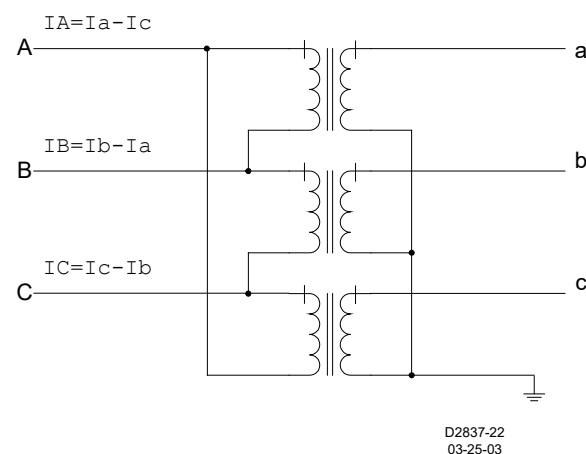


Figure 53-5. DAC Delta

With the appropriate CT and transformer connection information, the BE1-11 $\epsilon$  can automatically determine the correct compensation required. Normally, all circuits are compensated to obtain their equivalent delta currents. If all transformer windings and CTs are connected in wye, a special case exists and no compensation is required. For this case, wye currents can be used directly.

Total compensation is accomplished by summing the appropriate phasors from each of the CT inputs prior to using them in the differential function. For a WYE to DAB connection, the WYE CT phasors must first be phase-compensated to match the DAB circuit's 30° shift. This is done using the DAB compensator, which provides a phasor sum of  $I_a + I_b$  to form  $I'a$  for comparison to the DAB's  $I_a$  CT current. A similar operation is used to form  $I'b$  and  $I'c$ .

Total compensation uses six phase compensation factors: DAB, DAC, REV, Rotation Factors R1 and R2, WYE, and Double Delta DDAB. The compensation factors are used in various combinations to compensate for the  $\pm 30^\circ$ ,  $\pm 60^\circ$ ,  $\pm 90^\circ$ ,  $\pm 120^\circ$ ,  $\pm 150^\circ$ , and  $\pm 180^\circ$  phase shifts that are possible in transformers and sensing CT configurations.

Mathematically, the compensation factors provide the following:

Note: A  $1/(\text{square root of } 3)$  factor is missing from the compensation equations. See Table 53-5 for the net compensation equations.

$$\text{DAB: } \hat{I}'a = \hat{I}a - \hat{I}b, \quad \hat{I}'b = \hat{I}b - \hat{I}c, \quad \hat{I}'c = \hat{I}c - \hat{I}a \quad (+30)$$

$$\text{DAC: } \hat{I}'a = \hat{I}a - \hat{I}c, \quad \hat{I}'b = \hat{I}b - \hat{I}a, \quad \hat{I}'c = \hat{I}c - \hat{I}b \quad (-30)$$

$$\text{REV: } \hat{I}'a = -\hat{I}a, \quad \hat{I}'b = -\hat{I}b, \quad \hat{I}'c = -\hat{I}c \quad (+180)$$

$$\text{R1: } \hat{I}'a = \hat{I}c, \quad \hat{I}'b = \hat{I}a, \quad \hat{I}'c = \hat{I}b \quad (+120)$$

$$\text{R2: } \hat{I}'a = \hat{I}b, \quad \hat{I}'b = \hat{I}c, \quad \hat{I}'c = \hat{I}a \quad (+240)$$

$$\text{DDAB: } \hat{I}''a = \hat{I}'a - \hat{I}'b, \quad \hat{I}''b = \hat{I}'b - \hat{I}'c, \quad \hat{I}''c = \hat{I}'c - \hat{I}'a \quad (0 \text{ or } +60)$$

The net effect of DDAB compensation is as follows:

$$\hat{I}''a = \hat{I}'a - 2 \cdot \hat{I}'b + \hat{I}'c \quad \hat{I}''b = \hat{I}'a + \hat{I}'b - 2 \cdot \hat{I}'c \quad \hat{I}''c = -2 \cdot \hat{I}'a + \hat{I}'b + \hat{I}'c$$

$$\text{WYE: } \hat{I}'a = \hat{I}a, \quad \hat{I}'b = \hat{I}b, \quad \hat{I}'c = \hat{I}c \quad (\text{no compensation})$$

The following tables illustrate how the various phase compensation factors are applied to different winding and CT configurations.

The BE1-11t can also compensate for phase "mismatch". That is, if A phase of the incoming system is connected to the transformer primary H1 and A phase of the secondary system is connected to X2, the phases can be matched at the BE1-11t with this feature. Phase matching can be set with the Phase Relationship setting through BESTCOMSPPlus on the System Parameters, Transformer Setup screen.

Settings for the current measurement functions are provided in the following tables. These tables indicate the transformer circuit, CT settings, and type of phase compensation applied for various transformer applications. The settings are indicated on a per circuit basis. A circuit consists of one of the transformer's three-phase windings and its corresponding set of three-phase CT's.



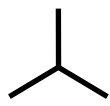

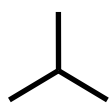
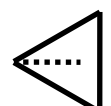
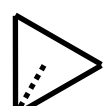
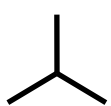
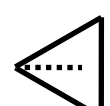
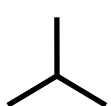
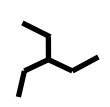
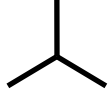
Table 53-2 and Table 53-3 are applied when a combination of delta and wye connections are present in the transformer and CT circuits. Table 53-2 is applied when only one type of delta connection is present in the transformer and CT circuits, such as DAB or DAC. This table is used for the majority of applications. If the application requires a combination of delta circuits, such as both DAB and DAC connections being present, Table 53-3 is applied. The only exceptions are when all CT and winding connections are wye as indicated above. Or, when one or more of the individual transformer windings are connected in delta or zigzag and has its corresponding CTs connected in delta. Table 53-4 is applied when one or more of the individual transformer windings is connected in delta or zigzag and has its corresponding CTs connected in delta. The special connection can require up to two delta compensations for the other windings depending on the circuit's configuration.

**Table 53-1. CT Input Circuit Settings for Non-transformer or Wye-only Application**

Transformer Connection	CT Input Connection	BE1-11 $t$ Settings		Compensation Applied	
		TX	CT	Phase	Rotation
N/A	WYE	NA	WYE	WYE	NONE
	DAB	NA	DAB	WYE	NONE
	DAC	NA	DAC	WYE	NONE
All WYE *	All WYE *	WYE	WYE	DAB	NONE

\* Special case where all transformer windings and all CTs are connected in wye.

**Table 53-2. CT Input Circuit Settings 1 for Delta/Wye Circuit Applications**

Transformer Connection	CT Input Connection	BE1-11 $t$ Settings		Compensation Applied	
		TX	CT	Phase	Rotation
WYE 	WYE 	WYE	WYE	DAB for DAB connections DAC for DAC connections	NONE
WYE 	DAB 	WYE	DAB		WYE
WYE 	DAC 	WYE	DAC	WYE	NONE
DAB 	WYE 	DAB	WYE	WYE	NONE
DAC 	WYE 	DAC	WYE	WYE	NONE
ZAB 	WYE 	ZAB	WYE	WYE	NONE


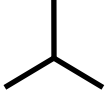
Transformer Connection	CT Input Connection	BE1-11r Settings		Compensation Applied	
		TX	CT	Phase	Rotation
ZAC 	WYE 	ZAC	WYE	WYE	R2

Table 53-3. CT Input Circuit Settings 2 for Delta/Wye Circuit Applications



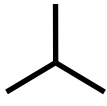




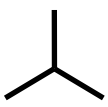
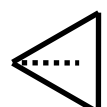

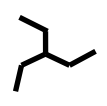
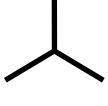
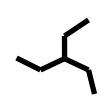
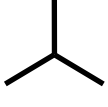
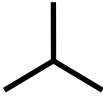
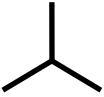
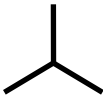

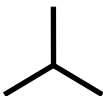

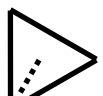
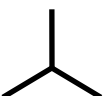





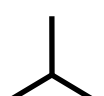




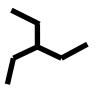
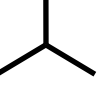
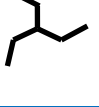

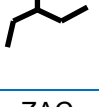


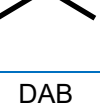




Transformer Connection	CT Input Connection	BE1-11r Settings		Compensation Applied	
		TX	CT	Phase	Rotation
WYE 	WYE 	WYE	WYE	DAB	NONE
WYE 	DAB 	WYE	DAB	WYE	NONE
WYE 	DAC 	WYE	DAC	WYE	R2
DAB 	WYE 	DAB	WYE	WYE	NONE
DAC 	WYE 	DAC	WYE	WYE	R2
ZAB 	WYE 	ZAB	WYE	WYE	NONE
ZAC 	WYE 	ZAC	WYE	WYE	R2

Table 53-4. CT Input Circuit Settings 3 for Delta/Wye Circuit Applications

Transformer Connection	CT Input Connection	BE1-11 <sub>t</sub> Settings		Compensation Applied	
		TX	CT	Phase	Rotation
WYE 	WYE 	WYE	WYE	DDAB	NONE
WYE 	DAB 	WYE	DAB	DAB	NONE
WYE 	DAC 	WYE	DAC	DAB	R2
DAB 	WYE 	DAB	WYE	DAB	NONE
DAB 	DAB 	DAB	DAB	WYE	NONE
DAB 	DAC 	DAB	DAC	WYE	R2
DAC 	WYE 	DAC	WYE	DAB	R2
DAC 	DAB 	DAC	DAB	WYE	R2

Transformer Connection	CT Input Connection	BE1-11 $t$ Settings		Compensation Applied	
		TX	CT	Phase	Rotation
DAC 	DAC 	DAC	DAC	WYE	R1
ZAB 	WYE 	ZAB	WYE	DAB	NONE
ZAB 	DAB 	ZAB	DAB	WYE	NONE
ZAB 	DAC 	ZAB	DAC	WYE	R2
ZAC 	WYE 	ZAC	WYE	DAB	R2
ZAC 	DAB 	ZAC	DAB	WYE	R2
ZAC 	DAC 	ZAC	DAC	WYE	R1

### Note

The CT input circuit settings are used by the auto-tap calculation function to calculate the correct tap adjustment factor for the differential functions. When entering these settings via the ASCII command interface, the validation routine and auto-tap calculation is performed on exit after all parameters have been entered.

When entering these settings using the front panel, the validation routine and auto-tap calculation is performed on exit of each screen. This may cause an Out of Range error message from the auto-tap calculation function. The user is advised to enter valid CT input circuit settings on the Sensing Transformers screen prior to entering the auto-tap calculation settings. If the user has previously set the auto-tap calculation settings and needs to change the CT input circuit settings, it may be necessary to temporarily change the auto-tap function setting to Manual on the Transformer Setup screen in order to enter the new CT settings.

See the *Phase Current Differential (87) Protection* chapter for more information on the auto-tap calculation function.

Figure 53-6 shows how the currents will be calculated for each set of current inputs for use by the Current Differential Protection (87) element. The calculation is dependent upon the phase compensation chosen as shown in the previous tables and the ground source setting.

**Table 53-5. Internal Compensation Chart**

Compensation	Ground Compensation	A Phase	B Phase	C Phase
Wye (none)	0 = No	$I_A$	$I_B$	$I_C$
Wye (none)	1 = Yes	$I_A - I_0$	$I_B - I_0$	$I_C - I_0$
DAB	0 = No or 1 = Yes	$(I_A - I_B) / \sqrt{3}$	$(I_B - I_C) / \sqrt{3}$	$(I_C - I_A) / \sqrt{3}$
DAC	0 = No or 1 = Yes	$(I_A - I_C) / \sqrt{3}$	$(I_B - I_A) / \sqrt{3}$	$(I_C - I_B) / \sqrt{3}$
DDAB	0 = No or 1 = Yes	$(I_A - 2I_B + I_C) / 3$	$(I_A + I_B - 2I_C) / 3$	$(-2I_A + I_B + I_C) / 3$

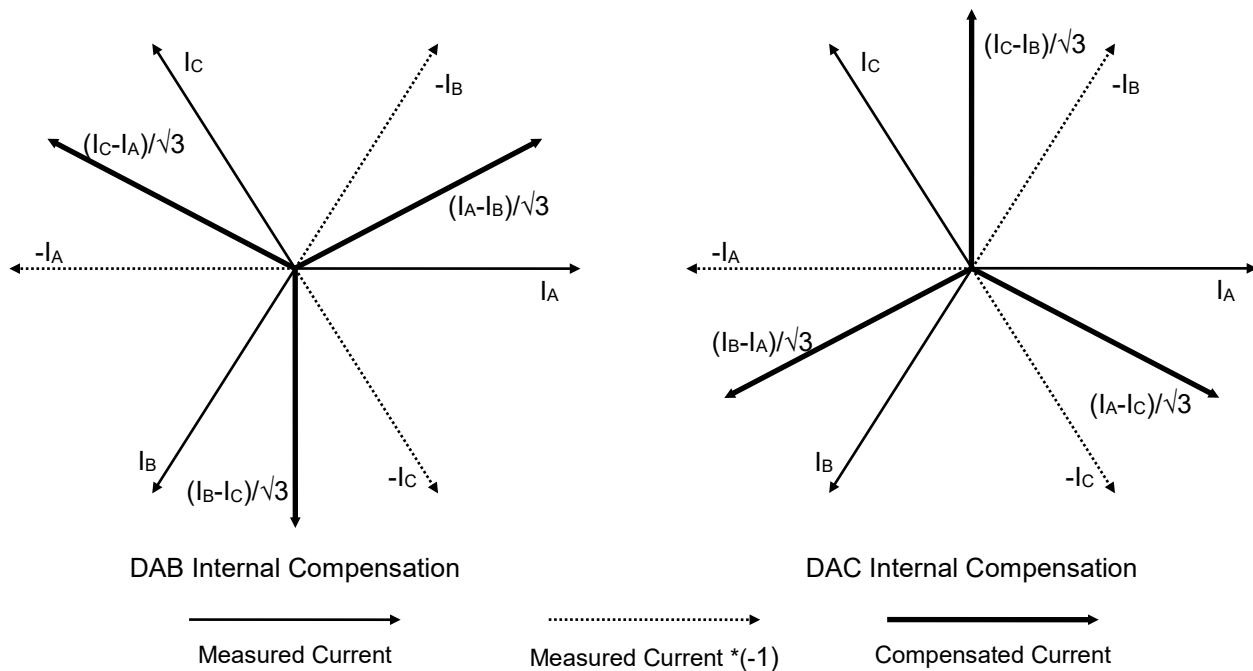


Figure 53-6. Internal Phase and Zero-Sequence Compensation

### IEC Transformer Setup

The IEC setup table is aimed at describing transformers that use phase shifts and winding designs that are more commonly found outside the US market. As can be found in the IEC standards, phase and bushing names of U, V, W, will be used generally, rather than A, B, and C, or H and X. Specifying phase shift and transformer connection is accomplished with the D-Y-Z + clock method. For instance, a transformer connection will be Dy1 rather than a DAB/Y, though some dual designations will be used for clarity. The number associated with the winding (Dy1) can be almost any hour of the clock, hence the term “around the clock” phase shifting.

In transformer standards such as IEEE C57.12.00 and IEC-60076-1, there will be many variations on the nomenclature and figures used to show how the phases are identified in a three-phase system. For details on IEC transformer connections, go to [www.basler.com](http://www.basler.com) and download the technical paper titled *Three Phase Transformer Winding Configurations and Differential Relay Compensation*, which was presented at the 2004 Western Protective Relay Conference.

Use BESTCOMSP<sub>Plus</sub> to open the System Parameters, Transformer Setup screen and select the IEC Setup button. On this screen (Figure 53-7), you can setup Windings 1 and 2. Press the OK button when finished.

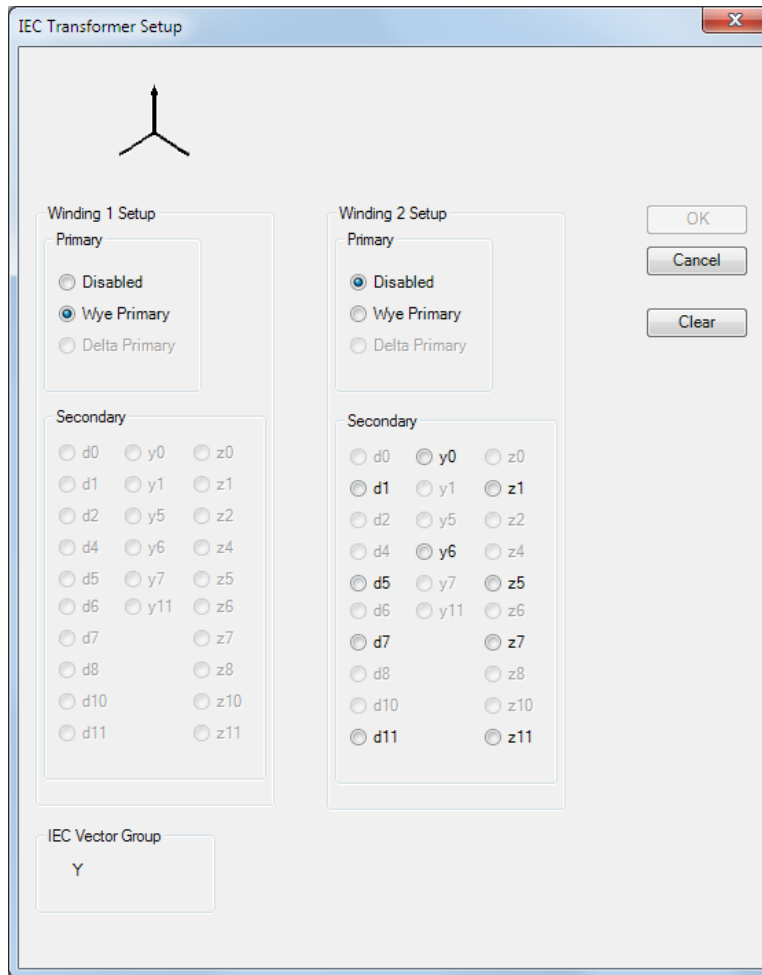


Figure 53-7. IEC Transformer Setup Screen

## Display Units

The Display Units screen is shown in Figure 53-8.

### System Units

This setting configures the BE1-11t to display and report temperature in English or metric units of measure.



Figure 53-8. Display Units Screen



## 54 • Introduction to Testing

The need to test protection systems to confirm performance as designed by manufacturers has always existed. However, numeric system design is changing the industry testing paradigms that have been in use since the first protective relay was built. Each time a fault occurs, the numeric protection system is tested, and because of its fault and event recording capability, the test is documented. In the unlikely event of a protection system problem, continuous monitoring along with remote communications capability provide for removing the affected device from service, auto switching to backup systems, and immediate notification of an attended facility. These features have virtually eliminated the need for periodic maintenance. Simple acceptance tests that verify the integrity of the BE1-11 $t$  measuring circuits and commissioning tests that verify the BE1-11 $t$  “electronic wiring” (control logic) are Basler Electric’s recommended pre-installation tests.

The testing chapters provide guidelines for performing these tests and others. For assistance in conducting BE1-11 $t$  self-tests and troubleshooting using internal diagnostics, contact Basler Electric Technical Support Services.

### **Testing Philosophies**

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Testing is generally divided into the following categories:

- Acceptance
- Commissioning
- Periodic (user scheduled maintenance)
- Functional

While all types of tests can be performed, all users do not generally perform these tests. Likewise, the degree to which you will conduct each type of test depends on need, economics, and perceived system value.

#### **Acceptance Testing**

Acceptance testing confirms that a particular BE1-11 $t$  delivered to a customer meets published specifications. Because this is a numerical device whose characteristics are defined by software, Basler Electric does not require the user to test each operational setting in the BE1-11 $t$ . Successful completion of the Acceptance Test verifies proper response of the protection system’s input and output circuits as well as its response to all external sensing input quantities (voltage, current, frequency).

Basler Electric performs detailed acceptance testing on all devices to verify all functions meet published specifications. All products are packaged and shipped with the strictest standards. The BE1-11 $t$  is a microprocessor-based device whose operating characteristics will not change over time. The BE1-11 $t$  will also not experience any change in operating characteristics during transit. However, it remains important that the user perform these acceptance tests to verify the device has not suffered any degradation in transit. Basler Electric warrants all products against any decay in performance outside of the published specified tolerances that result from problems created during transit.

#### **Commissioning Testing**

Commissioning testing verifies all physical connections and functional aspects of the BE1-11 $t$  for a new installation. This includes a thorough review and documentation of the operational settings to verify that the users calculated values match the actual values on each enabled protection element of the BE1-11 $t$ . All of the following connections or functions can be verified during commissioning tests:

- Proper connection and sensing of current and voltage signals as applicable
- Connections of I/O contacts
- I/O sensing versus virtual sensing

- Setting validation
- Proper operation of equipment (main or auxiliary)
- Proper alarming (to SCADA) and/or targeting

### Periodic Testing

Periodic testing can be performed at regularly scheduled intervals or upon an indication of problems or questionable operations within the BE1-11 $t$ . Verifying the integrity of the protection system's performance, short of playback of recorded events, may be necessary by performing certain tests similar to those accomplished in the *Acceptance Testing* chapter. Verification that the BE1-11 $t$  is measuring signals faithfully, that BE1-11 $t$  logic is appropriate, and that protective elements and equipment (main or auxiliary) operate correctly are goals that can be achieved during this type of testing.

Basler Electric recommends that all captured fault records and sequence of event records be analyzed and kept on file as in-service periodic test results for this particular device. This is an indication that all protective elements and the associated equipment are operating satisfactorily.

It is not the intent of this manual to elaborate on every conceivable test possible because this would encroach on individual preferences, techniques, and philosophies. It is the intent to pursue relevant testing methods to verify this BE1-11 $t$  meets published design specifications and applicability.

### Functional Testing

Functional (or application) testing is significantly more comprehensive in nature and tests suitability for a particular application. Functional testing also provides a means to familiarize the user with the logic and operation of this device. Test setups are generally more involved and often include ancillary equipment beyond voltage or current source type equipment. While economics may at times prohibit full functional testing, it is recommended that some functional testing be performed when published specifications lack appropriate detail to satisfy application testing requirements.

Basler Electric performs a thorough and comprehensive functional test of all protection systems before shipping. This ensures that this device is within specified tolerances, measures accurately, and operates correctly as designed.

## Testing and Troubleshooting Aids

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Under test or in-service, the BE1-11 $t$  provides several ways to check operations, targets, or events. The status of the system is monitored by a continuous self-test. The most basic reporting function is targets. Targets can be viewed through BESTCOMSP $Plus$ <sup>®</sup> or the front-panel display. Fault Summary Reports, Sequence of Events Recorder (SER) Reports, and Oscillographic Records yield more detail.

Each time a system disturbance occurs in or around this BE1-11 $t$  zone of protection, it is a test of the BE1-11 $t$  performance during the fault. If a questionable operation results in the need for troubleshooting, you have several ways in which to troubleshoot the BE1-11 $t$ , the installation, and overall application.

### Performance Testing

Performance testing can be accomplished through the capture and playback of system fault records. In actual applications, this type of test realizes further confirmation of faithful BE1-11 $t$  responses during system disturbances. For specific power system disturbances, protection systems can be subjected to a re-creation of captured events with the aid of equipment capable of replicating COMTRADE record files. In these instances, there is significant merit in testing protection systems in this manner to assess BE1-11 $t$  performance. Correct response of BE1-11 $t$  action in a performance test is supplemental verification of the conclusions drawn from functional (or application) tests.

This type of testing verifies not only whether the device operated correctly for a particular system disturbance but also offers additional confirmation of your protection philosophy in this application. It is beyond the scope of this manual to develop performance tests for this device. For assistance in developing these types of tests, please consult Basler Electric and your test equipment.

## BE1-11 $t$ Self-Test

All internal circuitry and software that affect the BE1-11 $t$  core functionality are monitored by the continuous self-test diagnostics. For specific relay trouble alarms, the self-test diagnostics force the microprocessor to reset and try to correct the problem. If unsuccessful, OUTA operates, the Relay Trouble LED on the front panel turns ON, all of the output relays are disabled, internal logic point ALMREL is set, and the BE1-11 $t$  is taken off line. For more information on self-test diagnostics and relay trouble alarms, see the *Contact Inputs and Outputs* chapter.

## Status Reporting Features

Status reporting is available by using the Metering Explorer in BESTCOMSP $lus$ . This report assembles all of the information required to determine the BE1-11 $t$  status.

Fault reporting and target data is dependent on the proper setting of trip, pickup, and logic trigger expressions (via BESTlogic™*Plus* Programmable Logic) and the assignment of protective elements to be logged as targets (via BESTCOMSP $lus$ ).

While the design of the BE1-11 $t$  facilitates obtaining and verifying targets and event data, it is not always necessary to use the BE1-11 $t$  functions to determine if the device operated while testing. You can simply use an ohmmeter or continuity tester to monitor the output contact status.

The following is a summary of where target and event data can be viewed in BESTCOMSP $lus$ :

- Fault records in memory - Metering Explorer/Reports/Fault Records
- Target data - Metering Explorer/Status/Targets
- Sequence of events (SOE) records - Metering Explorer/Reports/Sequence of Events

For more information on front-panel display menu trees, see the *Controls and Indicators* chapter.

## Event Reporting Features

The SOE function of the BE1-11 $t$  records protective element output changes, overcurrent element pickup or dropout, input/output contact state changes, logic triggers, setting group changes, and setting changes. For more information on event reporting, see the *Sequence of Events* chapter.

The following summarizes the reporting capabilities of the BE1-11 $t$  through the front-panel display:

- Trip LED (Flashing): flashes during pickup of protective elements based on the pickup logic expression set in BESTlogic $Plus$  Programmable Logic.
- Trip LED (Sealed-In): stays lit after trip logic becomes true based on the trip logic expression set in BESTlogic $Plus$  Programmable Logic.
- TARGETS: Metering > Status > Targets screen provides target data.
- ALARMS: Metering > Status > Alarms screen provides alarm data.
- FAULT REPORTS: Metering > Fault Reports screen indicates new fault reports.



## 55 • Acceptance Testing

Although Basler Electric performs detailed acceptance testing on all new protection systems, it is generally recommended that you perform each of the following acceptance test steps before installation. The following steps test each function of the BE1-11*t* to validate that it was manufactured properly and that no degradation of performance occurred because of shipping.

### Test Equipment

Suitable test equipment requires a minimum of two current sources, two voltage sources, and a contact wetting voltage. Test equipment should also have the capability of varying the frequency and the angle of the voltage and current sources. A PC with BESTCOMS*Plus*® installed and configured for communication with the BE1-11*t* is also required.

### Power Up

*Purpose:* To verify that the BE1-11*t* performs the power-up sequence.

Step 1: Apply voltage to input power terminals A6 and A7. Table 55-1 shows the appropriate input voltage for each BE1-11*t* style.

**Table 55-1. Input Voltages**

Style Number	Voltage Input
Txx1xxxxxxxxxx	48/125 Vac/dc
Txx2xxxxxxxxxx	125/250 Vac/dc
Txx3xxxxxxxxxx	24 Vdc

Step 2: Verify that the Power LED is ON, and that characters are displayed on the front panel. Upon power-up, the BE1-11*t* will perform a brief self-test. During this brief test, ~~all front panel LEDs flash momentarily~~, the display indicates each step of the self-test; Performing BIOS Tests..., Loading Application..., Initializing Protection..., and then the default display screen. Contact Basler Electric Technical Support Services if anything appears out of the ordinary or if an LCD error message appears.

### Communications

*Purpose:* To verify that the BE1-11*t* communicates through the USB and optional Ethernet port.

Step 1: Use BESTCOMS*Plus* to connect to the BE1-11*t* through the front-panel USB port and through the optional rear panel Ethernet port. Refer to the *Communication* chapter.

### Style Number and Serial Number Verification

*Purpose:* To verify that the BE1-11*t* style number and serial number matches the unit and unit labels.

Step 1: Connect to the BE1-11*t* through BESTCOMS*Plus*.

Step 2: Use the Settings Explorer to open the General Settings, Style Number screen and verify that the style number matches the unit labels.

Step 3: Use the Settings Explorer to open the General Settings, Device Info screen and verify that the serial number matches the unit labels.

## IRIG Verification (if used)

*Purpose:* To verify that the BE1-11 $\iota$  acquires and updates IRIG time and date information.

- Step 1: Connect a suitable IRIG source to BE1-11 $\iota$  terminals A1 (+) and A2 (-).
- Step 2: Upon receiving the IRIG signal, the BE1-11 $\iota$  clock will be updated with the current time, day, and month. Verify this on the Metering > Status > Real Time Clock screen on the front-panel display.

## Contact Sensing Inputs

*Purpose:* To verify that the BE1-11 $\iota$  senses hardware input status.

- Step 1: Apply an external voltage source within the range of the voltages listed in Table 55-2 to contact sensing inputs IN1 (B1/B2), IN2 (B3/B4), IN3 (B5/B6), IN4 (B7/B8), IN5 (E1/E2), IN6 (E3/E4), and IN7 (E5/E6).

**Table 55-2. Contact Sensing Turn-On Voltages**

Style Option	Nominal Input Voltage	Contact Sensing Turn-On Voltage*	
		Jumper Installed (Low Position)	Jumper Not Installed (High Position)
Txx1xxxxxxxxxx	48 Vdc or 125 Vac/dc	26 to 38 Vdc	69 to 100 Vdc 56 to 97 Vac
Txx2xxxxxxxxxx	125/250 Vac/dc	69 to 100 Vdc 56 to 97 Vac	138 to 200 Vdc 112 to 194 Vac
Txx3xxxxxxxxxx	24 Vdc	n/a	Approx. 5 Vdc

\* For information on setting contact-sensing input jumpers, refer to the [Contact Inputs and Outputs](#) chapter.

- Step 2: To verify that all inputs have been detected, use the Metering Explorer in BESTCOMSPlus to open the Status, Inputs screen.

## Control Outputs

*Purpose:* To verify that the BE1-11 $\iota$  senses hardware output status.

- Step 1: Connect to the BE1-11 $\iota$  through BESTCOMSPlus.
- Step 2: Use the Metering Explorer to open the Control, Output Override screen.
- Step 3: Click on the Disabled button for Output #1. The button changes to Enabled indicating that the output control override capability of the relay is enabled.
- Step 4: Select Set from the Action drop-down menu and click on the green arrow button to energize Output #1. Verify that the Output #1 Status LED, located on the Output Override screen of BESTCOMSPlus, turns on. Navigate to Metering > Status > Outputs on the front-panel display and verify that Output #1 changes state.
- Step 5: Select Reset from the Action drop-down menu and click on the green arrow button to de-energize Output #1. Verify that the Output #1 Status LED, located on the Output Override screen of BESTCOMSPlus, turns off. Navigate to Metering > Status > Outputs on the front-panel display and verify that Output #1 changes state.
- Step 6: Verify that the sequence of events recorder logged the events by using the Metering Explorer in BESTCOMSPlus to open the Reports, Sequence of Events screen.

- Step 7: Use the Metering Explorer in BESTCOMSP*lus* to return to the Control, Output Override screen and click on the Enabled button for Output #1. The button changes to Disabled indicating that the output control override capability of the relay is disabled.
- Step 8: Repeat Steps 3 through 7 for all desired output contacts.

## Current Circuit Verification

### CT Circuit 1

- Step 1: To verify 3I0, I1, and I2, connect an ac current source to Terminals D1 and D2.
- Step 2: Apply the appropriate current values in Table 55-3 to the BE1-11*t*. Measured 3I0 should correspond to values in Table 55-3 while I1 and I2 should be 1/3 the applied value  $\pm 1.5\%$  (For example, if the applied value equals 2 amps,  $I2 = 2/3 = 0.667$  amps  $\pm 1.5\%$  or  $\pm 0.01$  amps.) Verify current measuring accuracy by opening the Analog Metering, Current, CT Circuit 1, Secondary Current screen inside the Metering Explorer of BESTCOMSP*lus*. 3I0, I1, and I2 current measurements can also be verified on the Metering > Analog Metering > Current > Current Circuit 1 > Secondary Current screen of the front-panel display.

**Table 55-3. Current Circuit Verification Values**

Sensing Type	Applied Current	Measured Current	
		Lower Limit	Upper Limit
5 A	1 amps	0.99 A	1.01 A
	5 amps	4.95 A	5.05 A
	10 amps	9.90 A	10.10 A
	15 amps	14.85 A	15.15 A
	20 amps	19.80 A	20.20 A
1 A	0.25 amps	0.2475 A	0.2525 A
	1 amps	0.99 A	1.01 A
	2 amps	1.98 A	2.02 A
	3 amps	2.97 A	3.03 A
	4 amps	3.96 A	4.04 A

- Step 3: To verify IA1, IB1, IC1, and IG1, connect the four current inputs in series by connecting suitably sized jumper wires between terminals D2 and D3, D4 and D5, and D6 and D7. Then connect an ac current source to terminals D1 and D8.
- Step 4: Apply the appropriate current values in Table 55-3 to the BE1-11*t*. Verify current measuring accuracy on the Analog Metering, Current, CT Circuit 1, Secondary Current screen inside the Metering Explorer of BESTCOMSP*lus*. IA1, IB1, IC1, and IG1 current measurements can also be verified on the Metering > Analog Metering > Current > Current Circuit 1 > Secondary Current screen of the front-panel display.
- Step 5: Leave current circuit connected and de-energized. These test connections will be used later when verifying power readings.

### CT Circuit 2

- Step 1: To verify 3I0, I1, and I2, connect an ac current source to Terminals F1 and F2.
- Step 2: Apply the appropriate current values in Table 55-3 to the BE1-11*t*. Measured 3I0 should correspond to values in Table 55-3 while I1 and I2 should be 1/3 the applied value  $\pm 1.5\%$  (For example, if the applied value equals 2 amps,  $I2 = 2/3 = 0.667$  amps  $\pm 1.5\%$  or  $\pm 0.01$  amps.) Verify current measuring accuracy by opening the Analog Metering, Current, CT Circuit 2, Secondary Current screen inside the Metering Explorer of BESTCOMSP*lus*. 3I0, I1, and I2

current measurements can also be verified on the Metering > Analog Metering > Current > Current Circuit 2 > Secondary Current screen of the front-panel display.

- Step 3: To verify IA2, IB2, IC2, and IG2, connect the four current inputs in series by connecting suitably sized jumper wires between terminals F2 and F3, F4 and F5, and F6 and F7. Then connect an ac current source to terminals F1 and F8.
- Step 4: Apply the appropriate current values in Table 55-3 to the BE1-11*t*. Verify current measuring accuracy on the Analog Metering, Current, CT Circuit 2, Secondary Current screen inside the Metering Explorer of BESTCOMSP*lus*. IA2, IB2, IC2, and IG2 current measurements can also be verified on the Metering > Analog Metering > Current > Current Circuit 2 > Secondary Current screen of the front-panel display.
- Step 5: Leave current circuit connected and de-energized. These test connections will be used later when verifying power readings.

### Three-Phase Voltage Circuit Verification

- Step 1: Connect an ac voltage source at nominal frequency between BE1-11*t* Terminals C13 (A-phase) and C16 (Neutral terminal). Apply 100 volts and verify voltage-measuring accuracy by using the Metering Explorer in BESTCOMSP*lus* to open the Analog Metering, Secondary Voltage screen. Readings should be: VA = 100 volts  $\pm 0.5\%$ , VAB = 100 volts  $\pm 0.5\%$ , VCA = 100 volts  $\pm 0.5\%$ , 3V0 = 100 volts  $\pm 0.75\%$ , V1 = 33.4 volts  $\pm 0.75\%$  (applied divided by 3), and V2 = 33.4 volts  $\pm 0.75\%$  (applied divided by 3). The Metering > Analog Metering > Voltage > Secondary Voltage screen of the front-panel display can also be monitored to verify voltage measurements.
- Step 2: Connect an ac voltage source at nominal frequency between BE1-11*t* Terminals C14 (B-phase) and C16 (Neutral Terminal). Apply 100 volts and verify voltage-measuring accuracy by using the Metering Explorer in BESTCOMSP*lus* to open the Analog Metering, Voltage, Secondary Voltage screen. Readings should be: VB = 100 volts  $\pm 0.5\%$ , VAB = 100 volts  $\pm 0.5\%$ , VBC = 100 volts  $\pm 0.5\%$ , 3V0 = 100 volts  $\pm 0.75\%$ , V1 = 33.4 volts  $\pm 0.75\%$  (applied divided by 3), and V2 = 33.4 volts  $\pm 0.75\%$  (applied divided by 3). The Metering > Analog Metering > Voltage > Secondary Voltage screen of the front-panel display can also be monitored to verify voltage measurements.
- Step 3: Connect an ac voltage source at nominal frequency between BE1-11*t* Terminals C15 (C-phase) and C16 (Neutral Terminal). Apply 100 volts and verify voltage-measuring accuracy by using the Metering Explorer in BESTCOMSP*lus* to open the Analog Metering, Voltage, Secondary Voltage screen. Readings should be: VC = 100 volts  $\pm 0.5\%$ , VBC = 100 volts  $\pm 0.5\%$ , VCA = 100 volts  $\pm 0.5\%$ , 3V0 = 100 volts  $\pm 0.75\%$ , V1 = 33.4 volts  $\pm 0.75\%$  (applied divided by 3), and V2 = 33.4 volts  $\pm 0.75\%$  (applied divided by 3). The Metering > Analog Metering > Voltage > Secondary Voltage screen of the front-panel display can also be monitored to verify voltage measurements.
- Step 4: Connect BE1-11*t* Terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Connect an ac voltage source at nominal frequency to the three jumpered terminals and the Neutral Terminal (C16).
- Step 5: Apply the voltage values listed in Table 55-4 and verify voltage-measuring accuracy by using the Metering Explorer in BESTCOMSP*lus* to open the Analog Metering, Voltage, Secondary Voltage screen. The Metering > Analog Metering > Voltage > Secondary Voltage screen of the front-panel display can also be monitored to verify voltage measurements.

**Table 55-4. Voltage Circuit Verification Values**

Applied Voltage	Measured Voltage	
	Lower Limit	Upper Limit
80 volts	79.6 V	80.4 V
100 volts	99.5 V	100.5 V
120 volts	119.4 V	120.6 V

Applied Voltage	Measured Voltage	
	Lower Limit	Upper Limit
140 volts	139.3 V	140.7 V
160 volts	159.2 V	160.8 V

## Power Reading Verification

Step 1: Use the same voltage connections as in the previous test, polarity voltage jumpered to C13, 14, and 15, neutral tied to C16. Use the same current connection as in Steps 3 and 4 of *Current Circuit Verification, CT Circuit 1*; that is, polarity current in D1 out D8 with D2 and D3, D4 and D5, D6 and D7 jumpered together. Note: Be sure that CT1 is selected for the *Bus CT Selection* setting found on the System Parameters, Sensing Transformers screen in BESTCOMSPPlus.

### Note

Power readings in this procedure are based on a 5 amp BE1-11t; for 1 amp values, divide by 5.

- Step 2: Apply 100 volts at angle 0 degrees and 5 amps to the BE1-11t. Verify the accuracy of the power reading by using the Metering Explorer in BESTCOMSPPlus to open the Analog Metering, Power screen. Power should be 1.5 kW  $\pm 1.0\%$  and reactive should read near 0 vars. The Metering > Analog Metering > Power/Watts > Vars screen of the front-panel display can also be monitored to verify power and reactive readings. The apparent power should be 1.5 kVA  $\pm 1.0\%$  at unity power factor. The Metering > Analog Metering > Power > VA/PF screen of the front-panel display can also be monitored to verify apparent power.
- Step 3: Reverse the current polarity and apply the same values as in Step 2. Note that the power reading is  $-1.5$  kW, which indicates “power in” to the zone being protected.
- Step 4: Return the current polarity back to Step 1 position. Apply 100 volts at angle 0 degrees and 5 amps at angle  $-90$  degrees (I lags E by  $90^\circ$ ) to the BE1-11t, and verify reactive power accuracy by using the Metering Explorer in BESTCOMSPPlus to open the Analog Metering, Power screen. Power should be nearly 0 kW, and reactive should read 1.5 kvar  $\pm 1.0\%$ . The Metering > Analog Metering > Power screen of the front-panel display can also be monitored to verify power and reactive values. Note power factor reads near 0 with a negative sign indicating a lagging power factor angle.
- Step 5: Reverse the current polarity and apply the same values as in Step 4. Note that the reactive power reading is  $-1.5$  kvar, which indicates reactive power in to the device being protected. Also note that the power factor angle is a positive value near zero. A positive power factor angle indicates leading power factor.
- Step 6: Repeat Steps 2 and 4 for current values of 10 and 20 amps. Corresponding power reading should be 3 kW/kvar and 6 kW/kvar  $\pm 1.0\%$ .

## Auxiliary Voltage Input Verification - VX and VX 3<sup>rd</sup> (Fundamental and Third Harmonic)

- Step 1: Connect BE1-11t terminals C17 (polarity) and C18 to a 60 hertz ac voltage source.
- Step 2: Apply the voltage values listed in Table 55-5 and verify voltage-measuring accuracy by using the Metering Explorer in BESTCOMSPPlus to open the Analog Metering, Voltage, Secondary Voltage screen. The Metering > Analog Metering > Voltage > Secondary Voltage screen of the front-panel display can also be monitored to verify voltage measurements. Accuracy is  $\pm 0.5\%$ .
- Step 3: Connect BE1-11t Terminals C17 (polarity) and C18 to a 180 Hz (third harmonic) ac voltage source.

- Step 4: Apply the voltage values listed in Table 55-5 and verify voltage-measuring accuracy by using the Metering Explorer in BESTCOMSP*lus* to open the Analog Metering, Voltage, Secondary Voltage screen. The Metering > Analog Metering > Voltage > Secondary Voltage screen of the front-panel display can also be monitored to verify voltage measurements. Accuracy is  $\pm 0.5\%$ .

**Table 55-5. Aux Voltage Circuit Verification VX & VX 3<sup>rd</sup> Values**

Applied Voltage	Measured Voltage	
	Lower Limit	Upper Limit
30 volts	29.85 V	30.15 V
50 volts	49.75 V	50.25 V
70 volts	69.65 V	70.35 V
90 volts	89.55 V	90.45 V
110 volts	109.45 V	110.55 V

## Frequency Verification

- Step 1: Connect BE1-11*t* Terminals C13 (polarity) and C16 (A to Neutral of the three-phase voltage input) to a 60 hertz ac voltage source (line voltage).
- Step 2: Connect BE1-11*t* Terminals C17 (polarity) and C18 (Auxiliary Voltage Input) to a second 60-hertz ac voltage source (bus voltage).
- Step 3: Apply 115 volts at 0 degrees and 60 hertz to both sources. Verify the measuring accuracy of the line and bus frequency by using the Metering Explorer in BESTCOMSP*lus* to open the Analog Metering, Frequency screen. The Metering > Analog Metering > Frequency screen of the front-panel display can also be monitored to verify frequency measurements.

# 56 • Commissioning Testing

Special precautions should be taken to ensure that all tests are performed with safety as the greatest concern. Any CT circuit signals routed through this device as part of a protection scheme, including discrete relays or as a stand-alone device, should be shorted and isolated from this BE1-11 $t$  during these tests.

If this BE1-11 $t$  is being installed in an existing installation, be aware of the equipment monitoring features of this device, especially if the monitoring logic will be utilized. Make note of any pretest operation levels, duty levels, etc. on existing equipment (e.g., breakers or transformers). As the user, you can make the determination of what values the BE1-11 $t$  should have as initial monitoring values when the BE1-11 $t$  is placed in service.

It may on occasion be necessary to temporarily disable some of the protective elements while testing the BE1-11 $t$  to isolate testing of individual functions. Always remember to enable these functions before placing the BE1-11 $t$  in service.

To assist you in the commissioning testing of this BE1-11 $t$ , you can refer to the related reporting and alarms chapters.

Please refer to the related protection and control chapters of the instruction manual for assistance on any particular functions of the BE1-11 $t$ . If you require further assistance, contact Basler Electric field application personnel or the factory.

## ***Digital I/O Connection Verification***

### **Contact Sensing Inputs**

**Purpose:** To verify operation, labels, and logic settings of the contact sensing inputs.

**Chapter Reference:** Contact Inputs and Outputs

- Step 1: Use the Settings Explorer in BESTCOMSP $lus$ ® to open the Programmable Inputs, Contact Inputs screen and verify the Input 1 through Input 10 user-defined name, recognition time, debounce time, energized state label, and de-energized state label. Refer to the style chart for I/O options.
- Step 2: Use the Metering Explorer in BESTCOMSP $lus$  to open the Status, Inputs screen. Verify the status of Input 1. From the actual field device, energize (or de-energize) the specific contact that supplies BE1-11 $t$  Input 1. While maintaining contact position, verify that Input 1 has changed state on the Status, Inputs screen of BESTCOMSP $lus$  or the front-panel display. Return the field contact to its original state, verifying that Input 1 returns to its original state. Use the Metering Explorer in BESTCOMSP $lus$  to open the Reports, Sequence of Events screen. Click on the Download button and review the events associated with the field contact change.
- Step 3: Repeat Step 2 for each connected input.

### **Output Contacts**

**Purpose:** To verify operation, labels, and logic settings of the output contacts.

**Chapter Reference:** Contact Inputs and Outputs

- Step 1: Use the Settings Explorer in BESTCOMSP $lus$  to open the Programmable Output, Output Contacts screen and verify the output 1 through output 8, and output A label, energized state label, de-energized state label, and hold attribute. Refer to the style chart for I/O options.
- Step 2: Use the Metering Explorer in BESTCOMSP $lus$  to open the Control, Output Override screen. Verify the status of OUT1 through OUT8. Use the procedure outlined under *Acceptance Testing, Control Outputs* to actuate selected output contacts (OUT1 through OUT8) and actually trip or close the connected field device (circuit breaker, lockout, etc.). Verify that the selected output has changed state on the Control, Output Override screen of BESTCOMSP $lus$  or the

front-panel display. Return the output to its original state, verifying that the output returns to its original state. Use the Metering Explorer in *BESTCOMSPlus* to open the Reports, Sequence of Events screen. Click on the Download button and review the events associated with the output contact change.

Step 3: Repeat Step 2 to verify that operation of the alarm output relay (OUTA) initiates the appropriate alarm response.

## **Virtual Selector Switches**

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**Purpose:** To verify operation, labels, and logic settings of the 43 switches.

**Chapter Reference:** Virtual Control Switches (43)

- Step 1: Use the Settings Explorer in *BESTCOMSPlus* to open the Control, Virtual Control Switches screen and verify the 43-1 through 43-5 mode, name label, on label, and off label.
- Step 2: Use the Metering Explorer in *BESTCOMSPlus* to open the Control, Virtual Switches screen and obtain the position of the five virtual selector switches. Alternately, the virtual selector switch positions can be obtained on the Metering > Control > Virtual Switches screen of the front-panel display.
- Step 3: Obtain write access to the BE1-11 $t$ . For each virtual selector switch enabled in your logic scheme, change the switch position by following the procedure described in the *Virtual Control Switches (43)* chapter.
- Step 4: Verify each switch position change on the Control, Virtual Switches screen of *BESTCOMSPlus* or on the front-panel display.
- Step 5: Return each virtual selector switch to the original position.
- Step 6: Use the Metering Explorer in *BESTCOMSPlus* to open the Reports, Sequence of Events screen. Click on the Download button and review the events associated with the virtual switch activities.

## **Virtual Control Switch**

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**Purpose:** To verify operation and logic setting for the 101 switch.

**Chapter Reference:** Breaker Control Switch (101)

- Step 1: Use the Settings Explorer in *BESTCOMSPlus* to open the Control, Breaker Control Switch screen and verify the 101 element mode.
- Step 2: Use the Metering Explorer in *BESTCOMSPlus* to open the Control, Breaker Control Switch screen and obtain the position of the breaker control switch. Alternately, the breaker control switch position can be obtained on the Metering, Control, 101 Breaker Control SW screen of the front-panel display.
- Step 3: Obtain write access to the BE1-11 $t$ . Change the switch position by following the procedure described in the *Breaker Control Switch (101)* chapter.
- Step 4: Verify the switch position change on the Control, Breaker Control Switch screen of *BESTCOMSPlus* or on the front-panel display.
- Step 5: Return the breaker control switch to the original position.
- Step 6: Use the Metering Explorer in *BESTCOMSPlus* to open the Reports, Sequence of Events screen. Click on the Download button and review the events associated with the breaker control switch.

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## ***Protection and Control Function Verification***

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Before placing the BE1-11 $t$  in service, the user should ensure that all system ac and dc connections are correct, that the BE1-11 $t$  functions as intended with user settings applied, and that all equipment external to the BE1-11 $t$  operates as intended. All connected or monitored inputs and outputs, and polarity and phase rotation of ac connections should be tested. Verify that:

- Power supply voltages and contact wetting voltages are correct.
- User desired protection and control functions are enabled and connected to the correct CT and VT input circuits.
- The programmable logic settings (electronic wiring) provide the proper interconnection of these functions with the I/O of the BE1-11 $t$ .

Simple user-designed fault tests should be used to verify that the operational settings are correct, that the proper output relays are actuated and proper targeting occurs. It is not necessary to test every protection element, timer, and function in these tests.

Use of the fault and event recording capability of the BE1-11 $t$  will aid in the verification of the protection and control logic. Use the Metering Explorer in BESTCOMSP $lus$  to open the Reports, Sequence of Events screen. In addition, it is helpful to click on the Clear button prior to starting a test. This allows the user to review only those operations recorded since the sequence of events was last cleared. Refer to the *Sequence of Events* chapter for more detail.

It may be necessary to disable protection elements or change setting logic to verify a specific function. To guard against placing the BE1-11 $t$  in service with unwanted operational or logic settings, it is good practice to save a copy of the original setting file before the testing process begins. When testing is complete, compare the copy of the saved settings to the actual settings as a final verification.

Use the settings compare feature in BESTCOMSP $lus$  to compare setting files. Refer to the *BESTCOMSP $lus$  Software* chapter for more information.

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## ***Verify Other Setpoints as Appropriate***

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Consult the individual functional testing chapters for guidelines on testing and verifying setpoints of other protection and control functions.

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## ***Reporting and Alarm Functions***

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Just prior to placing the BE1-11 $t$  in service, the following reporting and alarm functions should be reset and/or verified.

### **Clock Display**

**BESTCOMSP $lus$  Navigation Path:** Metering Explorer, Status, Real Time Clock

**HMI Navigation Path:** Metering Explorer, Status, Real Time Clock

**Chapter Reference:** Timekeeping

Set the real time clock to the current date and time. If an IRIG signal or NTP server is used, day, time, and year are automatically synchronized with the source. Note that the time code signal from older IRIG time code generating equipment does not contain the current year information thus necessitating the entry of the year.

### **Energy Data and Demand**

**BESTCOMSP $lus$  Navigation Path:** Metering Explorer, Demand

**HMI Navigation Path:** Metering Explorer, Demand Meter

**Chapter Reference:** Demands

Read, change, or reset KWH and KVARH records. Use the following to reset the peak current, watt, and var demand registers to “0” or a pre-existing value:

### Breaker Monitoring

**BESTCOMSPlus Navigation Path:** Metering Explorer, Reports, Breaker Monitor

**HMI Navigation Path:** Metering Explorer, Reports, Breaker Report

**Chapter Reference:** Breaker Monitoring

If the Breaker Monitoring features of the BE1-11t are enabled, use the following to reset the counter and the duty registers to “0” or a pre-existing value:

### Relay Trouble Alarms

**BESTCOMSPlus Navigation Path:** Metering Explorer, Status, Alarms

**HMI Navigation Path:** Metering Explorer, Status, Alarms

**Chapter Reference:** Alarms

Reset and verify that the relay trouble alarm is not lit. If required, alarm information can be read by using the Metering Explorer in BESTCOMSPlus to open the Status, Alarms screen. To attempt clearing a Relay Trouble Alarm, press the Reset Relay Alarms button or navigate to Metering > Status > Alarms > Relay Alarms on the front-panel display and press the front-panel Reset button. Refer to the *Alarms* chapter for setting details.

### Major/Minor Programmable Alarms

**BESTCOMSPlus Navigation Path:** Metering Explorer, Status, Alarms

**HMI Navigation Path:** Metering Explorer, Status, Alarms

**Chapter Reference:** Alarms

Reset and verify that the programmable alarms, Major and Minor, as set to meet user needs, are not lit or asserted. If required, alarm information can be read by using the Metering Explorer in BESTCOMSPlus to open the Status, Alarms screen. To reset a Major/Minor alarm, press the Reset Major, Minor Alarms button or navigate to Metering > Status > Alarms > Major or Minor Alarms on the front-panel display and press the front-panel Reset button. Refer to the *Alarms* chapter for settings details.

### Targets

**BESTCOMSPlus Navigation Path:** Metering Explorer, Status, Targets

**HMI Navigation Path:** Metering Explorer, Status, Targets

**Chapter Reference:** Fault Reporting

Reset any active targets and verify that they clear. Targets are reset by navigating to Metering > Status > Targets on the front-panel display and pressing the Reset button or by using the Metering Explorer in BESTCOMSPlus to open the Status, Targets screen and clicking on the Reset Targets button. Write access is required to reset targets through BESTCOMSPlus. Refer to the *Fault Reporting* chapter for setting details.

### Fault Summary Reports

**BESTCOMSPlus Navigation Path:** Metering Explorer, Reports, Fault Records

**HMI Navigation Path:** Metering Explorer, Reports, Fault Reports

**Chapter Reference:** Fault Reporting

Reset “new” fault summary directory records to “0” by using the Metering Explorer in BESTCOMSPlus to open the Reports, Fault Records screen and clicking on the Reset button. Write access is required. Verify

the new faults are “0” by clicking on the Refresh button. Refer to the *Fault Reporting* chapter for setting details.

### **Sequence of Events Recorder (SER)**

**BESTCOMSPlus Navigation Path:** Metering Explorer, Reports, Sequence of Events

**HMI Navigation Path:** Not available through the front panel

**Chapter Reference:** Sequence of Events

Reset the “new” SER records counter to “0” by using the Metering Explorer in BESTCOMSPlus to open the Reports, Sequence of Events screen and clicking on the Clear button. Write access is required. Verify that the new records are “0” by clicking on the Download button. Refer to the *Sequence of Events* chapter setting details.

### **Just Prior to Energizing - Report Documentation**

After completing the previous steps, use the Metering Explorer in BESTCOMSPlus to open the Status tree branch. Capture and save the information for Inputs, Outputs, Alarms, Targets, and Digital Points. This report should be kept in a permanent record file of the device so the data can be used for comparison in future maintenance procedures.

Also, save the entire settings record for future reference by using BESTCOMSPlus and selecting Download Settings and Logic from the Communication pull-down menu. After settings and logic are downloaded into BESTCOMSPlus memory, select Save from the File pull-down menu. Use this record during the maintenance cycle or during the analysis of an operation to verify that the “as found” settings are exactly as left during the commissioning process.

Refer to the related reporting and alarms chapters and the *BESTCOMSPlus Software* chapter.

### **In Service Readings**

After energizing the equipment, use the Metering Explorer in BESTCOMSPlus to verify the following analog metering values.

- Secondary voltage and current to verify VT and CT ratios.
- Polarity of energy readings to verify polarity of VT and CT connections.
- I2 and V2 to verify proper phase-sequence connections.
- Anything else that the user may find helpful.

Save this record along with the status record mentioned earlier for future reference.



## 57 • Periodic Testing

Because the BE1-11 $t$  has extensive internal test capabilities, periodic testing of the protection system can be greatly reduced. BE1-11 $t$  operating characteristics are a function of programming instructions that do not drift over time. Thus, the user may wish to verify items that the protection system's self-testing features cannot completely determine. Periodic testing may consist of the following settings and function checks:

- Verify that the setpoints that were proven during commissioning have not been changed.
- Verify proper interfacing between the inputs and outputs and the rest of the protection and control system.
- Verify that the power system analog parameters used by the protection and control functions are measured accurately.

### ***Settings Verification***

Verification of the BE1-11 $t$  digital I/O connections can be accomplished in different ways. The method used depends on your preferences and practices. You may choose to use either of the following two methods:

- Repeat the digital I/O connection and label verification under commissioning tests.
- Monitor SER, status, and fault reports for proper sensing of digital signals and proper output tripping during normal operation.

#### **Note**

In redundant protection systems where multiple relays will trip a given breaker or other device for a fault, fault record monitoring may not indicate a failed output contact. The BE1-11 $t$  may report that it energized an output when tripping was actually accomplished by the redundant relay. In this situation, testing the contact is recommended.

### ***Analog Circuit Verification***

Verification of BE1-11 $t$  analog measurement circuits can be accomplished in multiple ways and depends on your preferences and practices. Either of the two following methods may be used:

- Repeat the acceptance tests by injecting test quantities into the BE1-11 $t$ .
- Use the BE1-11 $t$  metering functions to compare the protection system's measurements with those made by similar devices that are measuring the same signals. Redundant protection systems or metering devices can provide this independent confirmation of measured signals. If the BE1-11 $t$  is connected to an integration system, this verification can even be automated and done on a semi-continuous basis.

**Note**

If verifying the analog measurement circuits by comparison to independent devices is used, you should ensure that the two devices use similar measurement algorithms. For example, the measurements of a fundamental sensing relay cannot be compared with the measurements of an rms sensing device.

Functional testing is NOT required for this device. It is necessary only when performing a comprehensive assessment to determine suitability for an application.

## 58 • Overexcitation (24) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11*t* measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11*t* is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP*lus*® to open the BESTlogic™*Plus* Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogic*Plus* settings are made, click the Save button located on the toolbar to compile BESTlogic*Plus*. Upload BESTlogic*Plus* settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Overexcitation (24) Protection* chapter for more information on this function.

### Functional Test Procedure

#### Alarm, Inverse Time Pickup, and Definite Time Pickup Verification

The BE1-11*t* detects overexcitation conditions with a volts/hertz element that consist of one alarm setting, one inverse time characteristic with selectable exponents (3 sets of time curves as shown in the *Time Curve Characteristics* chapter) and two definite time characteristics. Note that V/Hz nominal is calculated using Equation 58-1.

$$V/Hz_{\text{Nom}} = \frac{\sqrt{3} \times V_{\text{Nom}}}{\text{Hz}_{\text{Nom}}} = \frac{\sqrt{3} \times 69.3}{60} = 2.001$$

Equation 58-1. V/Hz Nominal Calculation

That is, at nominal voltage and frequency (60 Hz system) 1 pu V/Hz = 2.001.

Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 58-1 to the BE1-11*t*. Reset all targets.

Table 58-1. Operational Settings

Setting	Value	BESTCOMSP <i>lus</i> Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
Nominal Phase Voltage	69.3 V	System Parameters, Power System	Sets nominal phase voltage to 69.3 V

Setting	Value	BESTCOMSP <sub>Plus</sub> Screen	Description
Element Mode	Enabled	Protection, Voltage, Overexcitation	Enables 24 function
24	Enabled	Target Configuration, Targets	Enables target for 24
24 Volts Per Hertz	Major/Non-Latching	Alarm Configuration, Alarms	Enables alarm for 24

Step 2: Use BESTCOMSP<sub>Plus</sub> to configure the BESTlogic<sub>Plus</sub> programmable logic shown in Figure 58-1.

- Blocking is disabled.
- OUT1 closes for 24 Trip.
- OUT2 closes for 24 Pickup.

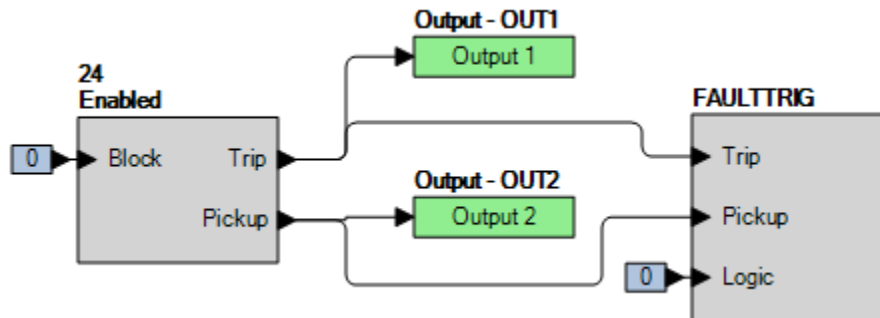


Figure 58-1. BESTlogic<sub>Plus</sub> Settings

Step 3: Use BESTCOMSP<sub>Plus</sub> to open the Protection, Voltage, Overexcitation (24) screen and send the test settings in Table 58-2 to the BE1-11<sub>t</sub>.

Table 58-2. Alarm and Inverse Time Pickup Test Settings

Setting	Value	Description
Inverse Time Pickup	2.1	Sets Inverse Time Pickup at 1.05% of nominal (2.10 V/Hz)
Inverse Time Dial	0	Sets Inverse Time Dial at minimum
Inverse Reset Dial	0	Sets Inverse Reset Dial at minimum
Curve Exponent	2	Sets Curve Exponent to 2
Definite Timer 1 Pickup	0	Disables Definite Timer 1 Pickup
Definite Timer 2 Pickup	0	Disables Definite Timer 2 Pickup
Alarm Pickup	2.05	Sets Alarm at 1.025% of nominal (2.05 V/Hz)

- Step 4: Prepare to monitor the operation of the 24 Alarm and Trip functions. Alarm operation can be verified by monitoring the Major Alarm LED on the protection system's front panel. Operation of the 24 Trip can be verified by monitoring OUT1.
- Step 5: Connect a three-phase, 100 Vac/50-Hz or 120 Vac/60-hertz voltage source (depending on user's nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral).
- Step 6: Apply A-phase voltage at nominal frequency and slowly increase until the Major Alarm LED lights ( $V/H \text{ PU} \times \text{Freq} \times \% \text{ Alarm} = \text{PU}$ ) and record the alarm pickup. Slowly decrease the A-phase voltage until the Major Alarm LED extinguishes and record the dropout.
- Step 7: Apply A-phase voltage at nominal frequency and slowly increase until OUT2 closes ( $V/H \text{ Trip} \times \text{Freq} = \text{PU}$ ) and record the pickup. Verify that there is a 24 target on the front-panel display. Slowly decrease the A-phase voltage until OUT2 opens and record the dropout.
- Step 8: (Optional.) Repeat steps 1 through 7 for higher and lower alarm and pickup settings.

- Step 9: (Optional.) Repeat steps 1 through 8 for frequencies other than nominal.
- Step 10: (Optional.) Repeat steps 1 through 9 for the B-phase and C-phase voltage inputs.
- Step 11: (Optional.) Repeat steps 1 through 10 for settings group 1, 2, and 3.
- Step 12: Use BESTCOMSP*lus* to open the Protection, Voltage, Overexcitation (24) screen and send the test settings in Table 58-3 to the BE1-11*t*.

**Table 58-3. Definite Time Pickup Test Settings**

Setting	Value	Description
Inverse Time Pickup	0	Disables Inverse Time Pickup
Definite Timer 1 Pickup	2.36	Sets Definite Timer 1 Pickup at 118% of nominal (2.36 V/Hz)
Definite Timer 1 Time Delay	50	Sets Definite Timer 1 Time Delay at 50 ms (minimum)
Definite Timer 2 Pickup	0	Disables Definite Timer 2 Pickup
Alarm Pickup	0	Disables Alarm Pickup

- Step 13: Prepare to monitor the operation of the Definite Timer 1 Pickup. Pickup operation can be verified by monitoring OUT2. Operation of the Definite Timer 1 Trip can be verified by monitoring OUT1.
- Step 14: Connect a three-phase, 100 Vac/50-Hz or 120 Vac/60-hertz voltage source (depending on user's nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral).
- Step 15: Apply A-phase voltage at nominal frequency and slowly increase until OUT2 closes (V/H Trip x Freq = PU) and record the pickup. Verify that there is a 24 target on the front-panel display. Slowly decrease the A-phase voltage until OUT2 opens and record the dropout.
- Step 16: (Optional.) Repeat steps 12 through 15 for higher and lower pickup settings.
- Step 17: (Optional.) Repeat steps 12 through 16 for frequencies other than nominal.
- Step 18: (Optional.) Repeat steps 12 through 17 for the B-phase and C-phase voltage inputs.
- Step 19: (Optional.) Repeat steps 12 through 18 for settings group 1, 2, and 3.
- Step 20: (Optional.) Set Definite Timer 1 Pickup to 0 and Definite Timer 2 Pickup to 2.36 V/Hz and repeat steps 12 through 19 for Definite Timer 2 Pickup.

### Inverse Time Verification

The following test uses the (M-1)<sup>2</sup> time curve.

- Step 1: Use BESTCOMSP*lus* to open the Protection, Voltage, Overexcitation (24) screen and send the test settings in Table 58-4 to the BE1-11*t*.

**Table 58-4. Inverse Time Verification Test Settings**

Setting	Value	Description
Inverse Time Pickup	2.1	Sets Inverse Time Pickup at 1.05% of nominal (2.10 V/Hz)
Inverse Time Dial	0.5	Sets Inverse Time Dial at 0.5
Inverse Reset Dial	0	Sets Inverse Reset Dial at minimum
Curve Exponent	2	Sets Curve Exponent to 2
Definite Timer 1 Pickup	0	Disables Definite Timer 1 Pickup
Definite Timer 2 Pickup	0	Disables Definite Timer 2 Pickup
Alarm Pickup	0	Disables Alarm Pickup

- Step 2: Connect and apply 120 Vac, three-phase, 60-hertz voltage source to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral).

- Step 3: All inverse timing tests are based on % of nominal Volts/Hertz (1 PU value). Refer to the *Time Curve Characteristics* chapter. Step the A-phase voltage to a value that equals the V/Hz % of nominal shown in Table 58-5 for Time Dial 0.5. Measure the time between the increase of voltage and the closure of OUT1. Record the results.

**Table 58-5. Inverse Time Verification Trip Times**

Percent of Nominal V/Hz	Step Voltage	Time Dial 0.5	Time Dial 1.0	Time Dial 2.0
110%	132 V	50 seconds	100 seconds	200 seconds
120%	144 V	12.5 seconds	25 seconds	50 seconds
140%	168 V	3.1 seconds	6.3 seconds	12.5 seconds

- Step 4: Repeat the test for Time Dial 1.0 and 2.0. Record the results.
- Step 5: (Optional.) Repeat steps 1 through 4 for the B-phase and C-phase voltage inputs.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.

### Inverse Time Reset Verification

- Step 1: Use BESTCOMSP*lus* to open the Protection, Voltage, Overexcitation (24) screen and send the test settings in Table 58-6 to the BE1-11*t*.

**Table 58-6. Inverse Time Reset Verification Test Settings**

Setting	Value	Description
Inverse Time Pickup	2.1	Sets Inverse Time Pickup at 1.05% of nominal (2.10 V/Hz)
Inverse Time Dial	0.5	Sets Inverse Time Dial at 0.5
Inverse Reset Dial	0.2	Sets Inverse Reset Dial at 0.2
Curve Exponent	2	Sets Curve Exponent to 2
Definite Timer 1 Pickup	0	Disables Definite Timer 1 Pickup
Definite Timer 2 Pickup	0	Disables Definite Timer 2 Pickup
Alarm Pickup	0	Disables Alarm Pickup

- Step 2: Connect and apply 120 Vac, three-phase, 60-hertz voltage source to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral).
- Step 3: Step the A-phase voltage to 144 V (120% of nominal V/Hz). OUT1 should close in approximately 12.5 seconds. Remove the test voltage (step back down to 120 V) and reapply (step back up to 144 V) after 5 seconds has elapsed. Measure the time from when the test voltage is reapplied until OUT1 closes. Record the result.
- Note: With a Reset Time Dial setting of 0.2, the total time to reset, after trip is removed, will be approximately 10 seconds. (See the *Overexcitation (24) Protection* chapter for more details.) Reapplying the test voltage after 5 seconds will yield a trip time of approximately ½ its original value or 6.25 seconds for Trip Time Dial 0.5 verifying that the reset time delay is working.
- Step 4: Repeat step 3 for Trip Time Dial 1.0 and 2.0 (½ trip time is approximately 12.5 seconds for Time Dial 1.0, and 25 seconds for Time Dial 2.0. (Still reapply voltage after 5 seconds as reset time dial is still 0.2.) Record the results.
- Step 5: (Optional.) Repeat steps 1 through 4 for the B-phase and C-phase voltage inputs.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.

### Definite Time Verification

- Step 1: Use BESTCOMSP*lus* to open the Protection, Voltage, Overexcitation (24) screen and send the test settings in Table 58-7 to the BE1-11*t*.

Table 58-7. Definite Time Verification Test Settings

Setting	Value	Description
Inverse Time Pickup	0	Disables Inverse Time Pickup
Definite Timer 1 Pickup	2.36	Sets Definite Timer 1 Pickup at 118% of nominal (2.36 V/Hz)
Definite Timer 1 Time Delay	500	Sets Definite Timer 1 Time Delay at 500 ms
Alarm Pickup	0	Disables Alarm Pickup

- Step 2: Connect and apply 120 Vac, three-phase, 60-hertz voltage source to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral).
- Step 3: Step the A-phase voltage to 142.2 V (118.5% or 2.37 V/Hz). Measure the time between the increase in voltage and the closure of OUT1. Record the result.
- Step 4: Repeat steps 1 through 3 for Time Delays of 1 second and 5 seconds. Record the results.
- Step 5: (Optional.) Repeat steps 1 through 4 for the B-phase and C-phase voltage inputs.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Set Definite Timer 1 Pickup to 0 and Definite Timer 2 Pickup to 2.36 V/Hz and repeat steps 1 through 6 for Definite Timer 2.

## Functional Test Report

### Alarm Verification

Alarm Setting Range = 0.5 to 6 V/Hz

Alarm Accuracy =  $\pm 2\%$  or  $\pm 0.05$  V/Hz, whichever is greater

Alarm/Reset Ratio = 98%  $\pm 1\%$

Step	Alarm Setting	Low	Actual Alarm	High	Low*	Actual Reset	High*	Pass/Fail
6	2.05	2.00 V/Hz		2.10 V/Hz	1.94 V/Hz		1.98 V/Hz	P / F

\* Reset range is calculated from the alarm setting and may need adjusted based on actual alarm.

### Inverse Time Pickup Verification

Pickup Setting Range = 0.5 to 6 V/Hz

Pickup Accuracy =  $\pm 2\%$  or  $\pm 0.05$  V/Hz, whichever is greater

Dropout/Pickup Ratio = 98%  $\pm 1\%$

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
7	2.10	2.05 V/Hz		2.15 V/Hz	2.037 V/Hz		2.079 V/Hz	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Definite Time Pickup Verification

Pickup Setting Range = 0.5 to 6 V/Hz

Pickup Accuracy =  $\pm 2\%$  or  $\pm 0.05$  V/Hz, whichever is greater

Dropout/Pickup Ratio = 98%  $\pm 1\%$

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
15	2.36	2.31 V/Hz		2.41 V/Hz	2.289 V/Hz		2.336 V/Hz	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Inverse Time Verification

Time Dial Range = 0.0 to 9.9

Timing Accuracy =  $\pm 5\%$  or  $\pm 50$  ms, whichever is greater

Step	Time Dial Setting	Percent of Nominal V/Hz	Step Voltage	Low	Actual Timing	High	Pass/Fail
3	0.5	110%	132 V	47.5 sec		52.5 sec	P / F
3	0.5	120%	144 V	11.875 sec		13.125 sec	P / F
3	0.5	140%	168 V	2.945 sec		3.255 sec	P / F
4	1.0	110%	132 V	95 sec		105 sec	P / F
4	1.0	120%	144 V	23.75 sec		26.25 sec	P / F
4	1.0	140%	168 V	5.985 sec		6.615 sec	P / F
4	2.0	110%	132 V	190 sec		210 sec	P / F
4	2.0	120%	144 V	47.5 sec		52.5 sec	P / F
4	2.0	140%	168 V	11.875 sec		13.125 sec	P / F

### Inverse Time Reset Verification

Time Dial Range = 0.0 to 9.9

Timing Accuracy =  $\pm 5\%$  or  $\pm 50$  ms, whichever is greater

Step	Time Dial Setting	Low	Actual Timing	High	Pass/Fail
3	0.5	5.937 sec		6.562 sec	P / F
4	1.0	11.875 sec		13.125 sec	P / F
4	2.0	23.75 sec		26.25 sec	P / F

### Definite Time Verification

Time Dial Range = 0 to 600,000

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 50$  ms, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
3	500 ms	450 ms		550 ms	P / F
4	1,000 ms	950 ms		1,050 ms	P / F
4	5,000 ms	4,950 ms		5,050 ms	P / F

## 59 • Sync-Check (25) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $\ell$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $\ell$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $\ell$ us<sup>®</sup> to open the BESTlogic $\text{TM}$ Plus Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogicPlus settings are made, click the Save button located on the toolbar to compile BESTlogicPlus. Upload BESTlogicPlus settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Sync-Check (25) Protection* chapter for more information on this function.

### Functional Test Procedure

#### VTP and VTX Live Voltage, Dead Voltage Pickup Test (25 Voltage Monitor)

Step 1: Use BESTCOMSP $\ell$ us to send the operational settings in Table 59-1 to the BE1-11 $\ell$ . Reset all targets.

Table 59-1. Operational Settings (25)

Setting	Value	BESTCOMSP $\ell$ us Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to phase-neutral
Aux VT Ratio	1	System Parameters, Sensing Transformers	Sets auxiliary VT ratio to 1
Aux VT Connection	AN	System Parameters, Sensing Transformers	Sets auxiliary VT connection to AN
Nominal Phase Voltage	100 V	System Parameters, Power System	Sets nominal phase voltage to 100 V
Nominal Aux Voltage	100 V	System Parameters, Power System	Sets nominal auxiliary voltage to 100 V
Element Mode	Enabled	Protection, Voltage, Sync-Check	Enables 25 function

Step 2: Use BESTCOMSPPlus to configure the BESTlogicPlus Programmable Logic shown in Figure 59-1.

- Blocking is disabled.
- OUT1 closes for 25.
- OUT2 closes for 25 Voltage Monitor.

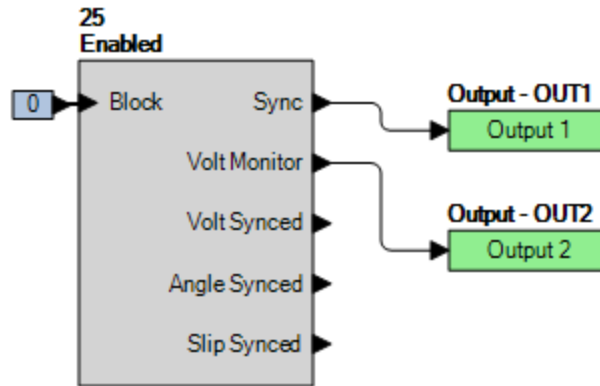


Figure 59-1. BESTlogicPlus Settings (25)

Step 3: Use BESTCOMSPPlus to open the Protection/Voltage/Sync-Check (25) screen and send the test settings in Table 59-2 to the BE1-11t.

Table 59-2. Time Pickup Test Settings (25VM)

Setting	Value	Description
25 Voltage Monitor Live Voltage	90%	Sets live voltage to 90 V (90% of nominal, nominal = 100 V)
25 Voltage Monitor Dead Voltage	55%	Sets dead voltage to 55 V (55% of nominal, nominal = 100 V)
25 Voltage Monitoring Drop Out Delay	0	Sets drop out delay to 0
25 Voltage Monitor Logic	Enable as shown in Figure 59-2.	Enable: Dead Phase/Dead Aux, Dead Phase/Live Aux, Live Phase/Dead Aux

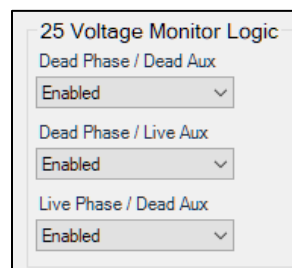


Figure 59-2. BESTCOMSPPlus Sync-Check Screen, 25 Voltage Monitor Logic

- Step 4: Prepare to monitor the 25VM function operation. Operation can be verified by monitoring OUT2.
- Step 5: Connect BE1-11t terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Apply a single phase, 0 Vac, 50 or 60-hertz ac voltage source (Line VTP) to the three jumpered terminals and the neutral terminal (C16). OUT2 should be closed.
- Step 6: Slowly increase the line voltage until OUT2 opens (55 volts). Record the result.
- Step 7: Increase the voltage until OUT2 closes (90 volts). Record the result.
- Step 8: Remove voltage source 1. Connect a second single-phase 50 or 60-hertz voltage source (Auxiliary VTX) to BE1-11t terminals C17 (polarity) and C18 (non-polarity). Apply 0 Vac. OUT2 should be closed.

Step 9: Slowly increase the Auxiliary voltage until OUT2 opens (55 volts). Record the result.

Step 10: Increase the voltage until OUT2 closes (90 volts). Record the result.

Step 11: (Optional.) Repeat steps 3 through 10 for settings group 1, 2, and 3.

### Live/Dead Dropout Timing Verification (25 Voltage Monitor)

Step 1: Use BESTCOMSP*lus* to open the Protection/Voltage/Sync-Check (25) screen and send the first row of test settings in Table 59-3 to the BE1-11*t*.

**Table 59-3. Live/Dead Dropout Time Test Settings (25VM)**

25VM Live Voltage	25VM Dead Voltage	25VM Drop Out Delay	25VM Logic
90%	55%	50 ms	Check boxes as shown in Figure 59-2.
90%	55%	2,000 ms	Check boxes as shown in Figure 59-2.
90%	55%	5,000 ms	Check boxes as shown in Figure 59-2.

Step 2: Prepare to monitor the 25 Voltage Monitor Live/Dead timing. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT2 opening.

Step 3: Connect BE1-11*t* terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Apply a 50 Vac, 50 or 60-hertz ac voltage source (Line VTP) to the three jumpered terminals and the neutral terminal (C16).

Step 4: Step the voltage up to 60 volts. Measure the time delay and verify the accuracy of the dead dropout time delay setting. Record the result.

Step 5: Set the ac voltage at 95 volts. Step the voltage down to 85 volts. Measure the time delay and verify the accuracy of the Live dropout delay setting. Record the result.

Step 6: Repeat steps 5 and 6 for the middle and upper time delay settings of Table 59-3.

Step 7: Remove phase voltage (Line VTP) and connect a second single-phase 50 or 60-hertz voltage source (Auxiliary VTX) to BE1-11*t* terminals C17 (polarity) and C18 (non-polarity). Repeat steps 4 through 6.

Step 8: (Optional.) Repeat steps 2 through 7 for settings group 1, 2, and 3.

### Output Test (25 Voltage Monitor)

Step 1: With no voltage applied to either the Line or Auxiliary voltage sources, OUT2 should be closed. This verifies the DEAD-LINE, DEAD AUX output of 25 Voltage Monitor.

Step 2: Slowly raise the volts ac to the line voltage input (VTP). Output 2 will open as the voltage is increased above the DEAD-LINE setting and close again when voltage exceeds the LIVE-LINE setting. This verifies the LIVE-LINE, DEAD-AUX output of 25VM. Remove voltage source 1.

Step 3: Slowly raise the volts ac to the auxiliary voltage input (VTX). Output 2 will open as the voltage is increased above the DEAD-LINE setting and close again when voltage exceeds the LIVE-LINE setting. This verifies the DEAD-LINE, LIVE-AUX output of 25 Voltage Monitor. Remove voltage source 2.

Step 4: (Optional.) Repeat steps 1 through 3 for settings group 1, 2, and 3.

### Sync-Check Verification (25)

Step 1: Use BESTCOMSP*lus* to open the Protection/Voltage/Sync-Check (25) screen and send the test settings in Table 59-4 to the BE1-11*t*.

**Table 59-4. Inverse Time and Definite Time Pickup Test Settings (25)**

Setting	Value	Description
Voltage Difference	10%	Sets voltage difference to 10 V (10% of nominal, nominal = 100 V). Nominal Settings are defined on the System Parameters, Power System screen in BESTCOMSPPlus
Slip Angle	10°	Sets slip angle to 10 degrees
Slip Frequency	0.3 Hz	Sets slip frequency to 0.3 Hz

- Step 2: Prepare to monitor the 25 function operation. Operation can be verified by monitoring OUT1.
- Step 3: As in the previous test, connect BE1-11 $\iota$  terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Apply a 120 Vac, 50 or 60 hertz ac, 0 degree voltage source (Line VTP) to the three jumpered terminals and the neutral terminal (C16).
- Step 4: Apply a second 120 Vac, 50 or 60-hertz ac, 0 degree voltage source (Auxiliary VTX) to C17 and C18. OUT1 should close verifying the 25 output for a Slip Angle of 0 degrees, 0 Voltage Difference, and 0 Slip Frequency.
- Step 5: Decrease the Auxiliary voltage input (VTX) until OUT1 opens. Slowly increase the voltage until OUT1 closes. Record the result.
- Step 6: Repeat step 5 for the Line voltage input (VTP). Return voltage inputs to 120 Vac, 50 or 60-hertz, 0 degrees. Record the result.
- Step 7: Swing the angle between voltage source 1 and 2 until the OUT1 opens. Slowly decrease the angle until OUT1 closes. Pickup should occur on the leading and lagging side of 0 degrees. Dropout should occur on the leading and lagging side of 0 degrees. Record the results.
- Step 8: With the Auxiliary Voltage set at nominal frequency, step change the frequency of the Line voltage input by  $-0.25$  hertz (59.75 on a 60-hertz BE1-11 $\iota$ ). Note that OUT1 is closing and opening based on a slip rate of 0.25 hertz. Decrease the frequency until OUT1 stays open. Record the result. Also, check on the fast side (60.25 for a 60-hertz BE1-11 $\iota$ ). Record the result.
- Step 9: Repeat step 8 for the Auxiliary Voltage input. Record the results.
- Step 10: (Optional.) Repeat steps 3 through 9 for settings group 1, 2, and 3.

## Functional Test Report

### VTP and VTX Live Voltage, Dead Voltage Pickup Test (25 Voltage Monitor)

Accuracy =  $\pm 2\%$

Step	Setting	Low	Actual	High	Pass/Fail
6	VTP - Dead V Dropout - 55.0 V	53.9 V		56.1 V	P / F
7	VTP - Live V Pickup - 90.0 V	89.2 V		91.8 V	P / F
9	VTX - Dead V Dropout - 55.0 V	53.9 V		56.1 V	P / F
10	VTX - Live V Pickup - 90.0 V	89.2 V		91.8 V	P / F

### Live/Dead Dropout Timing Verification (25 Voltage Monitor)

Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Dropout Delay Setting	Low	Actual Timing	High	Pass/Fail
4	VTP - Dead V Dropout Delay - 50 ms	18 ms		82 ms	P / F
5	VTP - Live V Dropout Delay - 50 ms	18 ms		82 ms	P / F
6	VTP - Dead V Dropout Delay - 2,000 ms	1,968 ms		2,032 ms	P / F
6	VTP - Live V Dropout Delay - 2,000 ms	1,968 ms		2,032 ms	P / F
6	VTP - Dead V Dropout Delay - 5,000 ms	4,968 ms		5,032 ms	P / F

Step	Dropout Delay Setting	Low	Actual Timing	High	Pass/Fail
6	VTP - Live V Dropout Delay - 5,000 ms	4,968 ms		5,032 ms	P / F
7	VTX - Dead V Dropout Delay - 50 ms	18 ms		82 ms	P / F
7	VTX - Live V Dropout Delay - 50 ms	18 ms		82 ms	P / F
7	VTX - Dead V Dropout Delay - 2,000 ms	1,968 ms		2,032 ms	P / F
7	VTX - Live V Dropout Delay - 2,000 ms	1,968 ms		2,032 ms	P / F
7	VTX - Dead V Dropout Delay - 5,000 ms	4,968 ms		5,032 ms	P / F
7	VTX - Live V Dropout Delay - 5,000 ms	4,968 ms		5,032 ms	P / F

### Sync-Check Verification (25)

Voltage Difference Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

Step	Voltage Difference Setting	Low	Actual Pickup	High	Actual Dropout	Pass/Fail
5	VTX - Voltage Difference = 10%	107.8 V		112.2 V		P / F
6	VTP - Voltage Difference = 10%	107.8 V		112.2 V		P / F

Slip Angle Accuracy =  $\pm 1^\circ$

Step	Slip Angle Setting	Low	Actual Pickup	High	Actual Dropout	Pass/Fail
7	Slip Angle = $+10^\circ$	$9^\circ$		$11^\circ$		P / F
7	Slip Angle = $-10^\circ$	$-9^\circ$		$-11^\circ$		P / F

Slip Frequency Accuracy =  $\pm 0.01$  Hz

Step	Slip Frequency Setting	Low	Actual Pickup	High	Actual Dropout	Pass/Fail
8	VTP - Slip Frequency = 59.70 Hz	58.50 Hz		60.89 Hz		P / F
8	VTP - Slip Frequency = 60.30 Hz	59.09 Hz		61.50 Hz		P / F
9	VTX - Slip Frequency = 59.70 Hz	58.50 Hz		60.89 Hz		P / F
9	VTX - Slip Frequency = 60.30 Hz	59.09 Hz		61.50 Hz		P / F



## 60 • Phase Undervoltage (27P) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this relay measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the relay is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSPPlus® to open the BESTlogic™Plus Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogicPlus settings are made, click the Save button located on the toolbar to compile BESTlogicPlus. Upload BESTlogicPlus settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Phase Undervoltage (27P) Protection* chapter for more information on this function.

### Functional Test Procedure

#### Pickup Verification

Step 1: Use BESTCOMSPPlus to send the operational settings in Table 60-1 to the BE1-11t. Reset all targets.

Table 60-1. Operational Settings

Setting	Value	BESTCOMSPPlus Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to phase-neutral
Element Mode	1 of 3	Protection, Voltage, Undervoltage (27P-1)	Enables 27P-1 function for one of three mode
Inhibit Level	10 V	Protection, Voltage, Undervoltage (27P-1)	Sets inhibit level to 10 V
Timing Mode	Definite	Protection, Voltage, Undervoltage (27P-1)	Selects definite timings
27P-1 A	Enabled	Target Configuration, Targets	Enables phase A target for 27P-1

Step 2: Use BESTCOMSPi.us to configure the BESTlogicPi.us programmable logic shown in Figure 60-1.

- Blocking is disabled.
- OUT1 closes for 27P-1 Trip.
- OUT2 closes for 27P-1 Pickup.
- Fault recording is enabled.

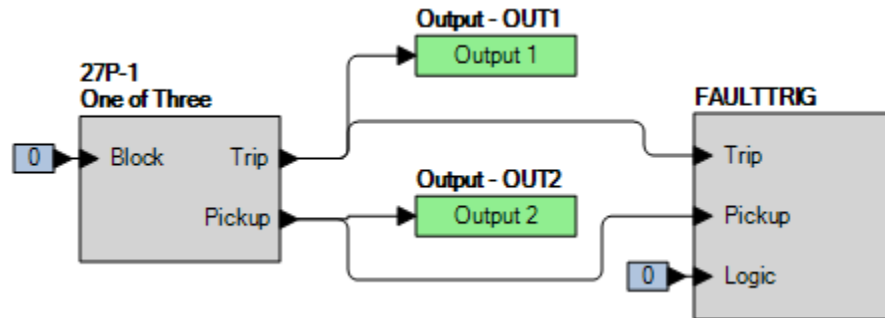


Figure 60-1. BESTlogicPi.us Settings

Step 3: Use BESTCOMSPi.us to open the Protection, Voltage, Undervoltage (27P-1) screen and send the first row of test settings in Table 60-2 to the BE1-11t.

Table 60-2. Pickup Test Settings

Pickup Setting	Time Delay
235 V	50 ms
115 V	50 ms
65 V	50 ms

Step 4: Prepare to monitor the 27P-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 60-1).

Step 5: Connect and apply a 240 Vac, three-phase voltage source to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral).

Step 6: Slowly decrease the A-phase voltage until OUT2 closes and record the pickup. Verify that there is a 27P-1-A target on the front-panel display. Slowly increase the A-phase voltage until OUT2 opens and record the reset. Reset the target.

Step 7: Verify the pickup and reset accuracy at 120 Vac for a pickup setting of 115 V and 70 Vac for a pickup setting of 65 V as listed in Table 60-2. Record the results.

Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs. Note: Be sure to enable proper target for each phase being tested.

Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.

Step 10: (Optional.) Repeat steps 1 through 9 for 27P-2, 27P-3, 27P-4, and 27P-5.

### Timing Verification

Step 1: Use BESTCOMSPi.us to open the Protection, Voltage, Undervoltage (27P-1) screen and send the first row of test settings in Table 60-3 to the BE1-11t for settings group 0.

Table 60-3. Timing Test Settings

Pickup Setting	Time Delay
115 V	2,000 ms
115 V	5,000 ms
115 V	10,000 ms

- Step 2: Prepare to monitor the 27P-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 120 Vac, three-phase voltage source to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral).
- Step 4: Step the A-phase voltage down to 110 volts. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delays of Table 60-3. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for the B-phase and C-phase voltage inputs. Note: Be sure to enable proper target for each phase being tested.
- Step 7: (Optional.) Repeat steps 1 through 6 through 6 for settings group 1, 2, and 3.
- Step 8: (Optional.) Repeat steps 1 through 7 for 27P-2, 27P-3, 27P-4, and 27P-5.

## Functional Test Report

### Pickup Verification

Pickup Setting Range = 1 to 300 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

Reset/Pickup Ratio =  $102\% \pm 1\%$

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Reset	High*	Pass/Fail
6	235.0 V	230.3 V		239.7 V	237.3 V		242.0 V	P / F
7	115.0 V	112.7 V		117.3 V	116.1 V		118.4 V	P / F
7	65.0 V	63.7 V		61.2 V	65.6 V		66.9 V	P / F

\* Reset range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Timing Verification

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F



## 61 • Auxiliary Undervoltage (27X) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $\iota$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $\iota$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $\text{Plus}$ ® to open the BESTlogic™ $\text{Plus}$  Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogic $\text{Plus}$  settings are made, click the Save button located on the toolbar to compile BESTlogic $\text{Plus}$ . Upload BESTlogic $\text{Plus}$  settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Auxiliary Undervoltage (27X) Protection* chapter for more information on this function.

### Functional Test Procedure

#### Pickup Verification (3V0 Mode)

3V0 mode is used to monitor a three-phase system for unbalanced voltages. The 3V0 measurement increases as the three-phase voltages become unbalanced. For simplicity, this test will force a system imbalance by increasing only the A-phase voltage. For example, for a 3V0 pickup setting of 115 V, a 3V0 trip would occur after VA was raised from 0 to 115 V while VB and VC remained at 0 V.

Step 1: Use BESTCOMSP $\text{Plus}$  to send the operational settings in Table 61-1 to the BE1-11 $\iota$ . Reset all targets.

**Table 61-1. Operational Settings (3V0 Mode)**

Setting	Value	BESTCOMSP $\text{Plus}$ Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to phase-neutral
Element Mode	3V0	Protection, Voltage, Undervoltage (27X-1)	Enables 27X-1 function for 3V0 mode
Inhibit Level	10 V	Protection, Voltage, Undervoltage (27X-1)	Sets inhibit level to 10 V

Setting	Value	BESTCOMSPPlus Screen	Description
Timing Mode	Definite	Protection, Voltage, Undervoltage (27X-1)	Selects definite timings
27X-1 3V0	Enabled	Target Configuration, Targets	Enables 3V0 target for 27X-1

Step 2: Use BESTCOMSPPlus to configure the BESTlogicPlus programmable logic shown in Figure 61-1.

- Blocking is disabled.
- OUT1 closes for 27X-1 Trip.
- OUT2 closes for 27X-1 Pickup.
- Fault recording is enabled.

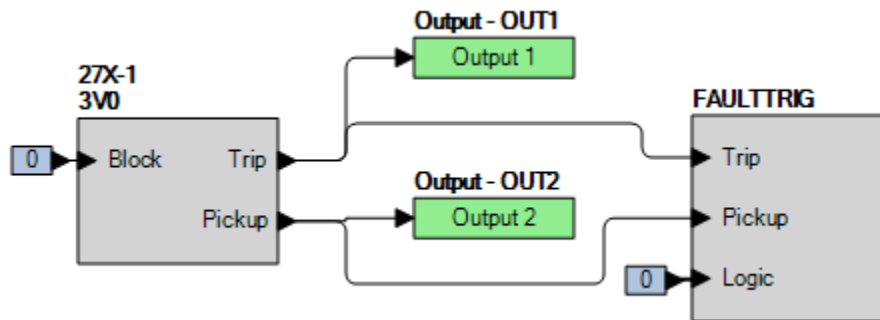


Figure 61-1. BESTlogicPlus Settings (3V0 Mode)

Step 3: Use BESTCOMSPPlus to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 61-2 to the BE1-11t.

Table 61-2. Pickup Test Settings (3V0 Mode)

Pickup Setting	Time Delay
115 V	50 ms
65 V	50 ms
20 V	50 ms

- Step 4: Prepare to monitor the 27X-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 61-1).
- Step 5: Connect and apply a 120 Vac, a single-phase voltage source to terminals C13 (A-phase) and C16 (Neutral). Reset the target.
- Step 6: Slowly decrease the voltage until OUT2 closes and record the pickup. Verify that there is a 27X-1-3V0 target on the front-panel display. Slowly increase the A-phase voltage until OUT2 opens and record the reset. Reset the target.
- Step 7: Verify the pickup and dropout accuracy at a pickup setting of 65 V and 20 V as listed in Table 61-2. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.
- Step 10: (Optional.) Repeat steps 1 through 9 for 27X-2, 27X-3, and 27X-4.

### Timing Verification (3V0 Mode)

- Step 1: Use BESTCOMSPPlus to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 61-3 to the BE1-11t for settings group 0.
- Step 2: Prepare to monitor the 27X-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.

**Table 61-3. Timing Test Settings (3V0 Mode)**

Pickup Setting	Time Delay
65 V	2,000 ms
65 V	5,000 ms
65 V	10,000 ms

- Step 3: Connect and apply a 75 Vac, single-phase voltage source to terminals C13 (A-phase) and C16 (Neutral).
- Step 4: Step the voltage down to 55 volts. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 61-3. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 and 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 27X-2, 27X-3, and 27X-4.

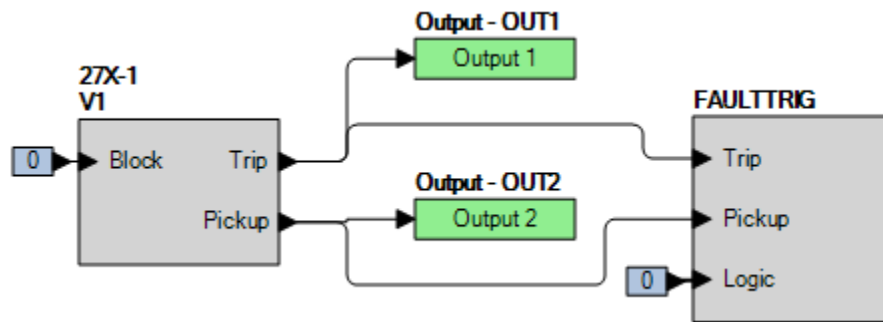
### Pickup Verification (V1 Mode)

- Step 1: Use *BESTCOMSPi* to send the operational settings in Table 61-4 to the BE1-11 $\epsilon$ . Reset all targets.

**Table 61-4. Operational Settings (V1 Mode)**

Setting	Value	BESTCOMSPi Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to phase-neutral
Element Mode	V1	Protection, Voltage, Undervoltage (27X-1)	Enables 27X-1 function for V1 mode
Inhibit Level	10 V	Protection, Voltage, Undervoltage (27X-1)	Sets inhibit level to 10 V
Timing Mode	Definite	Protection, Voltage, Undervoltage (27X-1)	Selects definite timings
27X-1 V1	Enabled	Target Configuration, Targets	Enables V1 target for 27X-1

- Step 2: Use *BESTCOMSPi* to configure the *BESTlogicPi* programmable logic shown in Figure 61-2.
- Blocking is disabled.
  - OUT1 closes for 27X-1 Trip.
  - OUT2 closes for 27X-1 Pickup.
  - Fault recording is enabled.



**Figure 61-2. BESTLogicPlus Settings (V1 Mode)**

Step 3: Use BESTCOMSP<sub>lus</sub> to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 61-5 to the BE1-11<sub>t</sub>.

**Table 61-5. Pickup Test Settings (V1 Mode)**

Pickup Setting	Time Delay
78 V	50 ms
38 V	50 ms
22 V	50 ms

- Step 4: Prepare to monitor the 27X-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 61-2).
- Step 5: Connect and apply a 240 Vac, single-phase voltage source to terminals C13 (A-phase) and C16 (neutral). For a single-phase input test,  $V1 = \text{A-phase voltage} / 3$ . Therefore, the BE1-11<sub>t</sub> should pick up at a value of three times the setting value when applying only a single-phase input. For example, to determine the pickup voltage value required for a BE1-11<sub>t</sub> with a pickup setting of 78, it would require 78 times 3 or 234 volts of input voltage.
- Step 6: Slowly decrease the A-phase voltage until OUT2 closes and record the pickup. Verify that there is a 27X-1-V1 target on the front-panel display. Slowly increase the voltage until OUT2 opens and record the reset. Reset the target.
- Step 7: Verify the pickup and reset accuracy at 120 Vac for a pickup setting of 38 V (114 Vac on test set) and 70 Vac for a pickup setting of 22 V (66 Vac on test set) as listed in Table 61-5. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.
- Step 10: (Optional.) Repeat steps 1 through 9 for 27X-2, 27X-3, and 27X-4.

### Timing Verification (V1 Mode)

Step 1: Use BESTCOMSP<sub>lus</sub> to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 61-6 to the BE1-11<sub>t</sub> for settings group 0.

**Table 61-6. Timing Test Settings (V1 Mode)**

Pickup Setting	Time Delay
38 V	2,000 ms
38 V	5,000 ms
38 V	10,000 ms

- Step 2: Prepare to monitor the 27X-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 120 Vac, single-phase voltage source to terminals C13 (A-phase) and C16 (neutral).

- Step 4: Step the voltage down to 110 volts. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 61-6. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 27X-2, 27X-3, and 27X-4.

### Pickup Verification (V2 Mode)

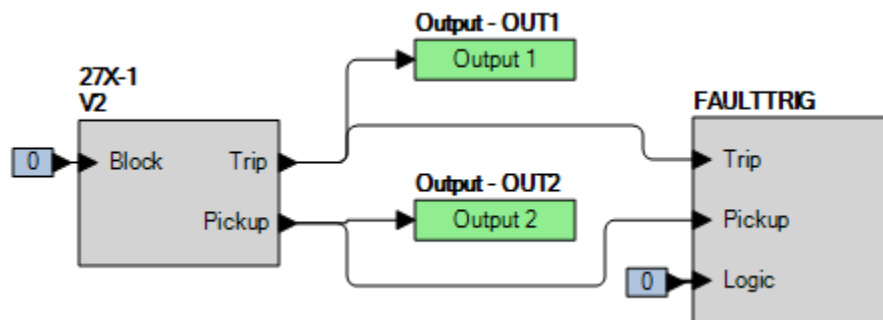
- Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 61-7 to the BE1-11*t*. Reset all targets.

**Table 61-7. Operational Settings (V2 Mode)**

Setting	Value	BESTCOMSP <i>lus</i> Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to phase-neutral
Element Mode	V2	Protection, Voltage, Undervoltage (27X-1)	Enables 27X-1 function for V2 mode
Inhibit Level	10 V	Protection, Voltage, Undervoltage (27X-1)	Sets inhibit level to 10 V
Timing Mode	Definite	Protection, Voltage, Undervoltage (27X-1)	Selects definite timings
27X-1 V2	Enabled	Target Configuration, Targets	Enables V2 target for 27X-1

- Step 2: Use BESTCOMSP*lus* to configure the BESTlogicP*lus* programmable logic shown in Figure 61-3.

- Blocking is disabled.
- OUT1 closes for 27X-1 Trip.
- OUT2 closes for 27X-1 Pickup.
- Fault recording is enabled.



**Figure 61-3. BESTlogicPlus Settings (V2 Mode)**

- Step 3: Use BESTCOMSP*lus* to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 61-8 to the BE1-11*t*.
- Step 4: Prepare to monitor the 27X-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 61-3).

**Table 61-8. Pickup Test Settings (V2 Mode)**

Pickup Setting	Time Delay
78 V	50 ms
38 V	50 ms
22 V	50 ms

- Step 5: Connect and apply a 240 Vac, single-phase voltage source to terminals C13 (A-phase) and C16 (neutral). For a single-phase input test,  $V2 = \text{A-phase voltage} / 3$ . Therefore, the BE1-11 $\iota$  should pick up at a value of three times the setting value when applying only a single-phase input. For example, to determine the pickup voltage value required for a BE1-11 $\iota$  with a pickup setting of 78, it would require 78 times 3 or 234 volts of input voltage.
- Step 6: Slowly decrease the A-phase voltage until OUT2 closes and record the pickup. Verify that there is a 27X-1-V2 target on the front-panel display. Slowly increase the voltage until OUT2 opens and record the reset. Reset the target.
- Step 7: Verify the pickup and reset accuracy at 120 Vac for a pickup setting of 38 V (114 Vac on test set) and 70 Vac for a pickup setting of 22 V (66 Vac on test set) as listed in Table 61-8. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.
- Step 10: (Optional.) Repeat steps 1 through 9 for 27X-2, 27X-3, and 27X-4.

### Timing Verification (V2 Mode)

- Step 1: Use BESTCOMSP $lus$  to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 61-9 to the BE1-11 $\iota$  for settings group 0.

**Table 61-9. Timing Test Settings (V2 Mode)**

Pickup Setting	Time Delay
38 V	2,000 ms
38 V	5,000 ms
38 V	10,000 ms

- Step 2: Prepare to monitor the 27X-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 120 Vac, single-phase voltage source to terminals C13 (A-phase) and C16 (neutral).
- Step 4: Step the voltage down to 110 volts. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 61-9. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 27X-2, 27X-3, and 27X-4.

### Pickup Verification (Vx Fundamental Mode)

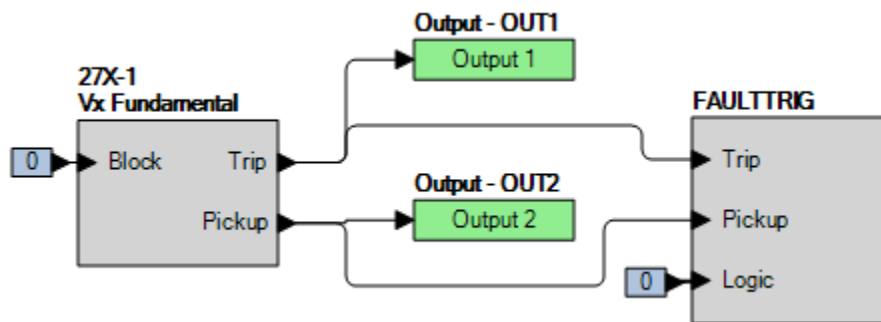
- Step 1: Use BESTCOMSP $lus$  to send the operational settings in Table 61-10 to the BE1-11 $\iota$ . Reset all targets.

**Table 61-10. Operational Settings (Vx Fundamental Mode)**

Setting	Value	BESTCOMSPi <sup>us</sup> Screen	Description
Aux VT Ratio	1	System Parameters, Sensing Transformers	Sets auxiliary VT ratio to 1
Aux VT Connection	AN	System Parameters, Sensing Transformers	Sets auxiliary VT connection to AN
Element Mode	Vx Fundamental	Protection, Voltage, Undervoltage (27X-1)	Enables 27X-1 function for Vx Fundamental mode
Inhibit Level	10 V	Protection, Voltage, Undervoltage (27X-1)	Sets inhibit level to 10 V
Timing Mode	Definite	Protection, Voltage, Undervoltage (27X-1)	Selects definite timings
27X-1 AUX	Enabled	Target Configuration, Targets	Enables Vx Fundamental target for 27X-1

Step 2: Use BESTCOMSPi<sup>us</sup> to configure the BESTlogicPi<sup>us</sup> programmable logic shown in Figure 61-4.

- Blocking is disabled.
- OUT1 closes for 27X-1 Trip.
- OUT2 closes for 27X-1 Pickup.
- Fault recording is enabled.

**Figure 61-4. BESTlogicPi Settings (Vx Fundamental Mode)**

Step 3: Use BESTCOMSPi<sup>us</sup> to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 61-11 to the BE1-11t.

**Table 61-11. Pickup Test Settings (Vx Fundamental Mode)**

Pickup Setting	Time Delay
115 V	50 ms
65 V	50 ms
20 V	50 ms

Step 4: Prepare to monitor the 27X-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 61-4).

Step 5: Connect and apply a 120 Vac, single-phase voltage source to the Vx input, terminals C17 (polarity) and C18 (non-polarity).

Step 6: Slowly decrease the voltage until OUT2 closes and record the pickup. Verify that there is a 27X-1-AUX target on the front-panel display. Slowly increase the voltage until OUT2 opens and record the reset. Reset the target.

Step 7: Verify the pickup and reset accuracy at 70 Vac for a pickup setting of 65 V and 25 Vac for a pickup setting of 20 V as listed in Table 61-11. Record the results.

Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs.

Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.

Step 10: (Optional.) Repeat steps 1 through 9 for 27X-2, 27X-3, and 27X-4.

### Timing Verification (Vx Fundamental Mode)

Step 1: Use *BESTCOMSPPlus* to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 61-12 to the BE1-11*t* for settings group 0.

**Table 61-12. Timing Test Settings (Vx Fundamental Mode)**

Pickup Setting	Time Delay
115 V	2,000 ms
115 V	5,000 ms
115 V	10,000 ms

Step 2: Prepare to monitor the 27X-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.

Step 3: Connect and apply a 120 Vac, single-phase voltage source to terminals C17 (polarity) and C18 (non-polarity).

Step 4: Step the voltage down to 110 volts. Measure the time delay and record the result.

Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 61-12. Record the results.

Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.

Step 7: (Optional.) Repeat steps 1 through 6 for 27X-2, 27X-3, and 27X-4.

### Pickup Verification (Vx Third Harmonic Mode)

Step 1: Use *BESTCOMSPPlus* to send the operational settings in Table 61-13 to the BE1-11*t*. Reset all targets.

**Table 61-13. Operational Settings (Vx Third Harmonic Mode)**

Setting	Value	BESTCOMSPPlus Screen	Description
Aux VT Ratio	1	System Parameters, Sensing Transformers	Sets auxiliary VT ratio to 1
Aux VT Connection	AN	System Parameters, Sensing Transformers	Sets auxiliary VT connection to AN
Element Mode	Vx Third Harmonic	Protection, Voltage, Undervoltage (27X-1)	Enables 27X-1 function for Vx Third Harmonic mode
Inhibit Level	10 V	Protection, Voltage, Undervoltage (27X-1)	Sets inhibit level to 10 V
Timing Mode	Definite	Protection, Voltage, Undervoltage (27X-1)	Selects definite timings
27X-1 3RD	Enabled	Target Configuration, Targets	Enables Vx Third Harmonic target for 27X-1

Step 2: Use *BESTCOMSPPlus* to configure the *BESTlogicPlus* programmable logic shown in Figure 61-4.

- Blocking is disabled.
- OUT1 closes for 27X-1 Trip.
- OUT2 closes for 27X-1 Pickup.
- Fault recording is enabled.

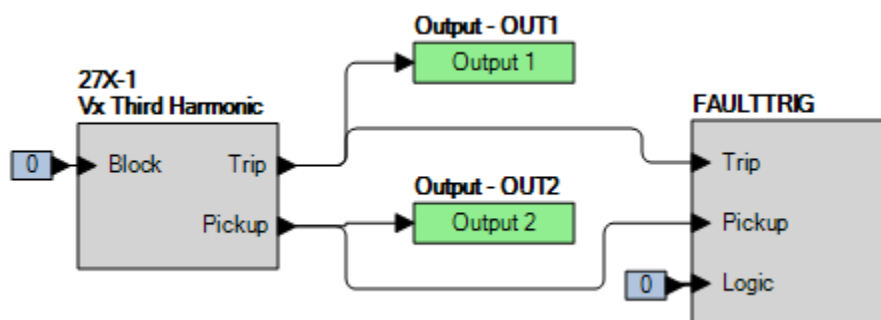


Figure 61-5. BESTlogicPlus Settings (Vx Third Harmonic Mode)

Step 3: Use BESTCOMSPiplus to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 61-14 to the BE1-11t.

Table 61-14. Pickup Test Settings (Vx Third Harmonic Mode)

Pickup Setting	Time Delay
115 V	50 ms
65 V	50 ms
20 V	50 ms

- Step 4: Prepare to monitor the 27X-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 61-5).
- Step 5: Connect and apply a single-phase, 120 Vac, 3<sup>rd</sup> harmonic voltage source to the Vx input, terminals C17 (polarity) and C18 (non-polarity).
- Step 6: Slowly decrease the voltage until OUT2 closes and record the pickup. Verify that there is a 27X-1-3RD target on the front-panel display. Slowly increase the voltage until OUT2 opens and record the reset. Reset the target.
- Step 7: Verify the pickup and reset accuracy at 70 Vac for a pickup setting of 65 V and 25 Vac for a pickup setting of 25 V as listed in Table 61-14. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.
- Step 10: (Optional.) Repeat steps 1 through 9 for 27X-2, 27X-3, and 27X-4.

### Timing Verification (Vx Third Harmonic Mode)

Step 1: Use BESTCOMSPiplus to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 61-15 to the BE1-11t for settings group 0.

Table 61-15. Timing Test Settings (Vx Third Harmonic Mode)

Pickup Setting	Time Delay
115 V	2,000 ms
115 V	5,000 ms
115 V	10,000 ms

- Step 2: Prepare to monitor the 27X-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 120 Vac, single-phase, 3<sup>rd</sup> harmonic voltage source to terminals C17 (polarity) and C18 (non-polarity).
- Step 4: Step the voltage down to 110 volts. Measure the time delay and record the result.

Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 61-15. Record the results.

Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.

Step 7: (Optional.) Repeat steps 1 through 6 for 27X-2, 27X-3, and 27X-4.

## Functional Test Report

### Pickup Verification (3V0 Mode)

Pickup Setting Range = 1 to 150 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

Reset/Pickup Ratio = 102%  $\pm 1\%$

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Reset	High*	Pass/Fail
6	115.0 V	112.7 V		117.3 V	116.2 V		118.4 V	P / F
7	65.0 V	63.7 V		66.3 V	65.7 V		66.9 V	P / F
7	20.0 V	19.0 V		21.0 V	20.2 V		20.6 V	P / F

\* Reset range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Timing Verification (3V0 Mode)

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F

### Pickup Verification (V1 Mode)

Pickup Setting Range = 1 to 150 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

Reset/Pickup Ratio = 102%  $\pm 1\%$

Step	Pickup Setting		Low		Actual Pickup	High		Low*		Actual Reset	High*		Pass/Fail
	V1	VA	V1	VA		V1	VA	V1	VA		V1	VA	
6	78.0	234.0	76.4	229.2		79.5	238.5	78.7	236.1		80.3	240.9	P / F
7	38.0	114.0	37.0	111.0		39.0	117.0	38.3	114.9		39.1	117.3	P / F
7	22.0	66.0	21.0	63.0		23.0	69.0	22.2	66.6		22.6	67.8	P / F

\* Reset range is calculated from the pickup setting and may need adjusted based on actual pickup.

**Timing Verification (V1 Mode)**

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F

**Pickup Verification (V2 Mode)**

Pickup Setting Range = 1 to 150 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greaterReset/Pickup Ratio =  $102\% \pm 1\%$ 

Step	Pickup Setting		Low		Actual Pickup	High		Low*		Actual Reset	High*		Pass/Fail
	V1	VA	V1	VA		V1	VA	V1	VA		V1	VA	
6	78.0	234.0	76.4	229.2		79.5	238.5	78.7	236.1		80.3	240.9	P / F
7	38.0	114.0	37.0	111.0		39.0	117.0	38.3	114.9		39.1	117.3	P / F
7	22.0	66.0	21.0	63.0		23.0	69.0	22.2	66.6		22.6	67.8	P / F

\* Reset range is calculated from the pickup setting and may need adjusted based on actual pickup.

**Timing Verification (V2 Mode)**

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F

**Pickup Verification (Vx Fundamental Mode)**

Pickup Setting Range = 1 to 150 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greaterReset/Pickup Ratio =  $102\% \pm 1\%$ 

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Reset	High*	Pass/Fail
6	115.0 V	112.7 V		117.3 V	116.1 V		118.4 V	P / F
7	65.0 V	63.7 V		66.3 V	65.6 V		66.9 V	P / F
7	20.0 V	19.0 V		21.0 V	20.2 V		20.6 V	P / F

\* Reset range is calculated from the pickup setting and may need adjusted based on actual pickup.

**Timing Verification (Vx Fundamental Mode)**

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F

**Pickup Verification (Vx Third Harmonic Mode)**

Pickup Setting Range = 1 to 150 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greaterReset/Pickup Ratio = 102%  $\pm 1\%$ 

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Reset	High*	Pass/Fail
6	115.0 V	112.7 V		117.3 V	116.1 V		118.4 V	P / F
7	65.0 V	63.7 V		66.3 V	65.6 V		66.9 V	P / F
7	20.0 V	19.0 V		21.0 V	20.2 V		20.6 V	P / F

\* Reset range is calculated from the pickup setting and may need adjusted based on actual pickup.

**Timing Verification (Vx Third Harmonic Mode)**

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F

## 62 • Phase Overvoltage (59P) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $\iota$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $\iota$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $\iota$  to open the BESTlogic $\text{TM}$ Plus Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogicPlus settings are made, click the Save button located on the toolbar to compile BESTlogicPlus. Upload BESTlogicPlus settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Phase Overvoltage (59P) Protection* chapter for more information on this function.

### Functional Test Procedure

#### Pickup Verification

Step 1: Use BESTCOMSP $\iota$  to send the operational settings in Table 62-1 to the BE1-11 $\iota$ . Reset all targets.

Table 62-1. Operational Settings

Setting	Value	BESTCOMSP $\iota$ Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to phase-neutral
Element Mode	1 of 3	Protection, Voltage, Overvoltage (59P-1)	Enables 59P-1 function for one of three mode
Timing Mode	Definite	Protection, Voltage, Overvoltage (59P-1)	Selects definite timings
59P-1 A	Enabled	Target Configuration, Targets	Enables phase A target for 59P-1

Step 2: Use BESTCOMSPi.us to configure the BESTlogicPi.us programmable logic shown in Figure 62-1.

- Blocking is disabled.
- OUT1 closes for 59P-1 Trip.
- OUT2 closes for 59P-1 Pickup.
- Fault recording is enabled.

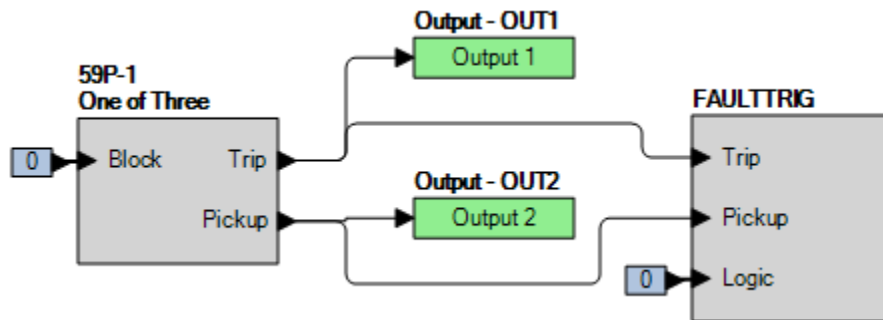


Figure 62-1. BESTlogicPi.us Settings

Step 3: Use BESTCOMSPi.us to open the Protection, Voltage, Overvoltage (59P-1) screen and send the first row of test settings in Table 62-2 to the BE1-11t.

Table 62-2. Pickup Test Settings

Pickup Setting	Time Delay
245 V	50 ms
125 V	50 ms
75 V	50 ms

Step 4: Prepare to monitor the 59P-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 62-1).

Step 5: Connect and apply a 240 Vac, three-phase voltage source to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral).

Step 6: Slowly increase the A-phase voltage until OUT2 closes and record the pickup. Verify that there is a 59P-1-A target on the front-panel display. Slowly decrease the A-phase voltage until OUT2 opens and record the dropout. Reset the target.

Step 7: Verify the pickup and dropout accuracy at 120 Vac for a pickup setting of 125 V and 70 Vac for a pickup setting of 75 V as listed in Table 62-2. Record the results.

Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs. Note: Be sure to enable proper target for each phase being tested.

Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.

Step 10: (Optional.) Repeat steps 1 through 9 for 59P-2, 59P-3, and 59P-4.

### Timing Verification

Step 1: Use BESTCOMSPi.us to open the Protection, Voltage, Overvoltage (59P-1) screen and send the first row of test settings in Table 62-3 to the BE1-11t for settings group 0.

Table 62-3. Timing Test Settings

Pickup Setting	Time Delay
125 V	2,000 ms
125 V	5,000 ms
125 V	10,000 ms

- Step 2: Prepare to monitor the 59P-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 120 Vac, three-phase voltage source to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral).
- Step 4: Step the A-phase voltage up to 130 volts. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 62-3. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for the B-phase and C-phase voltage inputs. Note: Be sure to enable proper target for each phase being tested.
- Step 7: (Optional.) Repeat steps 1 through 6 for settings group 1, 2, and 3.
- Step 8: (Optional.) Repeat steps 1 through 7 for 59P-2, 59P-3, and 59P-4.

## Functional Test Report

### Pickup Verification

Pickup Setting Range = 1 to 300 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

Dropout/Pickup Ratio =  $98\% \pm 1\%$

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
6	245.0 V	240.1 V		249.9 V	237.6 V		242.5 V	P / F
7	125.0 V	122.5 V		127.5 V	121.3 V		123.8 V	P / F
7	75.0 V	73.5 V		76.6 V	72.8 V		74.3 V	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Timing Verification

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,50 ms		10,050 ms	P / F



## 63 • Auxiliary Overvoltage (59X) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $\iota$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $\iota$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $\iota$  to open the BESTlogic $\text{TM}$ Plus Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogicPlus settings are made, click the Save button located on the toolbar to compile BESTlogicPlus. Upload BESTlogicPlus settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Auxiliary Overvoltage (59X) Protection* chapter for more information on this function.

### Functional Test Procedure

#### Pickup Verification (3V0 Mode)

Step 1: Use BESTCOMSP $\iota$  to send the operational settings in Table 63-1 to the BE1-11 $\iota$ . Reset all targets.

Table 63-1. Operational Settings (3V0 Mode)

Setting	Value	BESTCOMSP $\iota$ Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to phase-neutral
Element Mode	3V0	Protection, Voltage, Overvoltage (59X-1)	Enables 59X-1 function for 3V0 mode
Timing Mode	Definite	Protection, Voltage, Overvoltage (59X-1)	Selects definite timings
59X-1 3V0	Enabled	Target Configuration, Targets	Enables 3V0 target for 59X-1

Step 2: Use BESTCOMSPi.us to configure the BESTlogicPlus programmable logic shown in Figure 63-1.

- Blocking is disabled.
- OUT1 closes for 59X-1 Trip.
- OUT2 closes for 59X-1 Pickup.
- Fault recording is enabled.

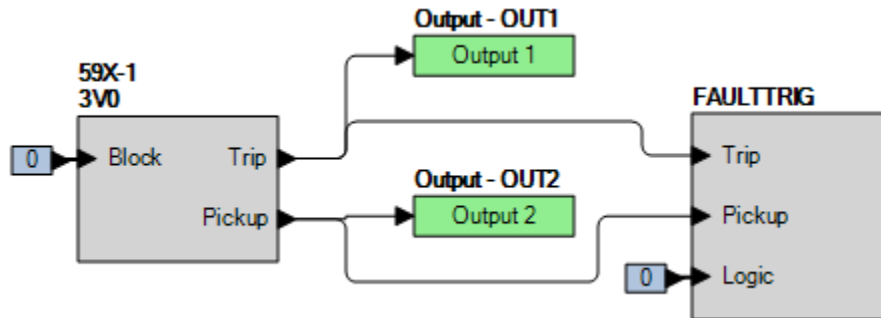


Figure 63-1. BESTlogicPlus Settings (3V0 Mode)

Step 3: Use BESTCOMSPi.us to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 63-2 to the BE1-11t.

Table 63-2. Pickup Test Settings (3V0 Mode)

Pickup Setting	Time Delay
115 V	50 ms
65 V	50 ms
20 V	50 ms

Step 4: Prepare to monitor the 59X-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 63-1).

Step 5: Connect and apply a 150 Vac, three-phase voltage source to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral).

Step 6: Slowly increase the A-phase voltage until OUT2 closes around 265 volts (150 Vac nominal + 115 V 3V0 pickup setting) and record the pickup. Verify that there is a 59X-1-3V0 target on the front-panel display. Slowly decrease the A-phase voltage until OUT2 opens and record the dropout. Reset the target.

Step 7: Verify the pickup and dropout accuracy at a pickup setting of 65 V and 20 V as listed in Table 63-2. Record the results.

Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs.

Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.

Step 10: (Optional.) Repeat steps 1 through 9 for 59X-2, 59X-3, and 59X-4.

### Timing Verification (3V0 Mode)

Step 1: Use BESTCOMSPi.us to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 63-3 to the BE1-11t for settings group 0.

Table 63-3. Timing Test Settings (3V0 Mode)

Pickup Setting	Time Delay
65 V	2,000 ms
65 V	5,000 ms
65 V	10,000 ms

- Step 2: Prepare to monitor the 59X-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 150 Vac, three-phase voltage source to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral).
- Step 4: Step the A-phase voltage up to 215 volts. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 63-3. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 59X-2, 59X-3, and 59X-4.

### Pickup Verification (V1 Mode)

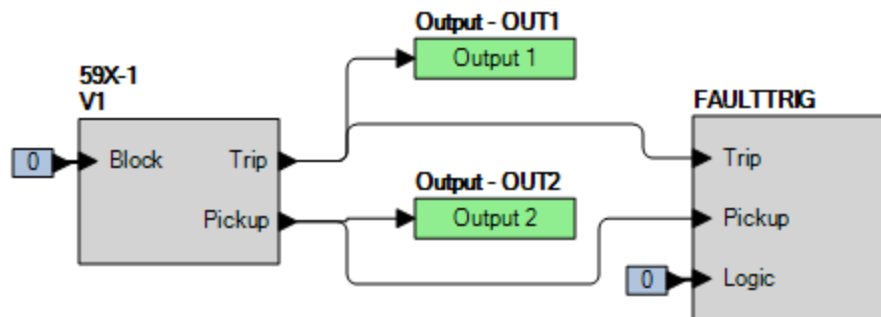
- Step 1: Use BESTCOMSPPlus to send the operational settings in Table 63-4 to the BE1-11 $\iota$ . Reset all targets.

**Table 63-4. Operational Settings (V1 Mode)**

Setting	Value	BESTCOMSPPlus Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to phase-neutral
Element Mode	V1	Protection, Voltage, Overvoltage (59X-1)	Enables 59X-1 function for V1 mode
Timing Mode	Definite	Protection, Voltage, Overvoltage (59X-1)	Selects definite timings
59X-1 V1	Enabled	Target Configuration, Targets	Enables V1 target for 59X-1

- Step 2: Use BESTCOMSPPlus to configure the BESTlogicPlus programmable logic shown in Figure 63-2.

- Blocking is disabled.
- OUT1 closes for 59X-1 Trip.
- OUT2 closes for 59X-1 Pickup.
- Fault recording is enabled.



**Figure 63-2. BESTlogicPlus Settings (V1 Mode)**

- Step 3: Use BESTCOMSPPlus to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 63-5 to the BE1-11 $\iota$ .

**Table 63-5. Pickup Test Settings (V1 Mode)**

Pickup Setting	Time Delay
82 V	50 ms
42 V	50 ms
25 V	50 ms

- Step 4: Prepare to monitor the 59X-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 63-2).
- Step 5: Connect and apply a 240 Vac, single-phase voltage source to terminals C13 (A-phase) and C16 (neutral). For a single-phase input test,  $V1 = \text{A-phase voltage} / 3$ . Therefore, the BE1-11 $\epsilon$  should pick up at a value of three times the setting value when applying only a single-phase input. For example, to determine the pickup voltage value required for a BE1-11 $\epsilon$  with a pickup setting of 82, it would require 82 times 3 or 246 volts of input voltage.
- Step 6: Slowly increase the voltage until OUT2 closes and record the pickup. Verify that there is a 59X-1-V1 target on the front-panel display. Slowly decrease the voltage until OUT2 opens and record the dropout. Reset the target.
- Step 7: Verify the pickup and dropout accuracy at 120 Vac for a pickup setting of 42 V (126 Vac on test set) and 70 Vac for a pickup setting of 25 V (75 Vac on test set) as listed in Table 63-5. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.
- Step 10: (Optional.) Repeat steps 1 through 9 for 59X-2, 59X-3, and 59X-4.

### Timing Verification (V1 Mode)

- Step 1: Use BESTCOMSP $Plus$  to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 63-6 to the BE1-11 $\epsilon$  for settings group 0.

**Table 63-6. Timing Test Settings (V1 Mode)**

Pickup Setting	Time Delay
42 V	2,000 ms
42 V	5,000 ms
42 V	10,000 ms

- Step 2: Prepare to monitor the 59X-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 120 Vac, single-phase voltage source to terminals C13 (A-phase) and C16 (neutral).
- Step 4: Step the voltage up to 130 volts. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 63-6. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 59X-2, 59X-3, and 59X-4.

### Pickup Verification (V2 Mode)

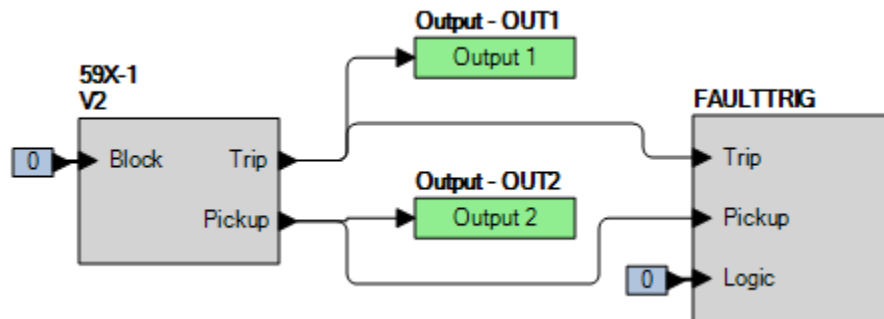
- Step 1: Use BESTCOMSP $Plus$  to send the operational settings in Table 63-7 to the BE1-11 $\epsilon$ . Reset all targets.

**Table 63-7. Operational Settings (V2 Mode)**

Setting	Value	BESTCOMSPi+ Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to phase-neutral
Element Mode	V2	Protection, Voltage, Overvoltage (59X-1)	Enables 59X-1 function for V2 mode
Timing Mode	Definite	Protection, Voltage, Overvoltage (59X-1)	Selects definite timings
59X-1 V2	Enabled	Target Configuration, Targets	Enables V2 target for 59X-1

Step 2: Use BESTCOMSPi+ to configure the BESTlogicPi+ programmable logic shown in Figure 63-3.

- Blocking is disabled.
- OUT1 closes for 59X-1 Trip.
- OUT2 closes for 59X-1 Pickup.
- Fault recording is enabled.

**Figure 63-3. BESTlogicPi+ Settings (V2 Mode)**

Step 3: Use BESTCOMSPi+ to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 63-8 to the BE1-11t.

**Table 63-8. Pickup Test Settings (V2 Mode)**

Pickup Setting	Time Delay
82 V	50 ms
42 V	50 ms
25 V	50 ms

Step 4: Prepare to monitor the 59X-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 63-3).

Step 5: Connect and apply a 240 Vac, single-phase voltage source to terminals C13 (A-phase) and C16 (neutral). For a single-phase input test,  $V2 = A\text{-phase voltage} / 3$ . Therefore, the BE1-11t should pick up at a value of three times the setting value when applying only a single-phase input. For example, to determine the pickup voltage value required for a BE1-11t with a pickup setting of 82, it would require 82 times 3 or 246 volts of input voltage.

Step 6: Slowly increase the voltage until OUT1 closes and record the pickup. Verify that there is a 59X-1-V2 target on the front-panel display. Slowly decrease the voltage until OUT1 opens and record the dropout. Reset the target.

- Step 7: Verify the pickup and dropout accuracy at 120 Vac for a pickup setting of 42 V (126 Vac on test set) and 70 Vac for a pickup setting of 25 V (75 Vac on test set) as listed in Table 63-8. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.
- Step 10: (Optional.) Repeat steps 1 through 9 for 59X-2, 59X-3, and 59X-4.

### Timing Verification (V2 Mode)

- Step 1: Use BESTCOMSP*lus* to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 63-9 to the BE1-11*t* for settings group 0.

**Table 63-9. Timing Test Settings (V2 Mode)**

Pickup Setting	Time Delay
42 V	2,000 ms
42 V	5,000 ms
42 V	10,000 ms

- Step 2: Prepare to monitor the 59X-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 120 Vac, single-phase voltage source to terminals C13 (A-phase) and C16 (neutral).
- Step 4: Step the voltage up to 130 volts. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 63-9. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 59X-2, 59X-3, and 59X-4.

### Pickup Verification (Vx Fundamental Mode)

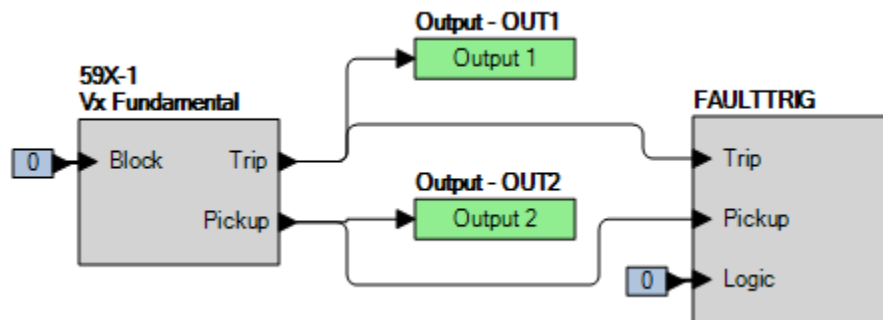
- Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 63-10 to the BE1-11*t*. Reset all targets.

**Table 63-10. Operational Settings (Vx Fundamental Mode)**

Setting	Value	BESTCOMSP <i>lus</i> Screen	Description
Aux VT Ratio	1	System Parameters, Sensing Transformers	Sets auxiliary VT ratio to 1
Aux VT Connection	AN	System Parameters, Sensing Transformers	Sets auxiliary VT connection to AN
Element Mode	Vx Fundamental	Protection, Voltage, Overvoltage (59X-1)	Enables 59X-1 function for Vx Fundamental mode
Timing Mode	Definite	Protection, Voltage, Overvoltage (59X-1)	Selects definite timings
59X-1 AUX	Enabled	Target Configuration, Targets	Enables Vx Fundamental target for 59X-1

- Step 2: Use BESTCOMSP*lus* to configure the BESTlogic*Plus* programmable logic shown in Figure 63-4.
- Blocking is disabled.
  - OUT1 closes for 59X-1 Trip.
  - OUT2 closes for 59X-1 Pickup.

- Fault recording is enabled.



**Figure 63-4. BESTlogicPlus Settings (Vx Fundamental Mode)**

Step 3: Use BESTCOMSPPlus to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 63-11 to the BE1-11t.

**Table 63-11. Pickup Test Settings (Vx Fundamental Mode)**

Pickup Setting	Time Delay
125 V	50 ms
75 V	50 ms
30 V	50 ms

- Step 4: Prepare to monitor the 59X-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 63-4).
- Step 5: Connect and apply a 120 Vac, single-phase voltage source to the Vx input, terminals C17 (polarity) and C18 (non-polarity).
- Step 6: Slowly increase the voltage until OUT2 closes and record the pickup. Verify that there is a 59X-1-AUX target on the front-panel display. Slowly decrease the voltage until OUT2 opens and record the dropout. Reset the target.
- Step 7: Verify the pickup and dropout accuracy at 70 Vac for a pickup setting of 75 V and 25 Vac for a pickup setting of 30 V as listed in Table 63-11. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.
- Step 10: (Optional.) Repeat steps 1 through 9 for 59X-2, 59X-3, and 59X-4.

### Timing Verification (Vx Fundamental Mode)

Step 1: Use BESTCOMSPPlus to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 63-12 to the BE1-11t for settings group 0.

**Table 63-12. Timing Test Settings (Vx Fundamental Mode)**

Pickup Setting	Time Delay
125 V	2,000 ms
125 V	5,000 ms
125 V	10,000 ms

- Step 2: Prepare to monitor the 59X-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 120 Vac, single-phase voltage source to terminals C17 (polarity) and C18 (non-polarity).
- Step 4: Step the voltage up to 130 volts. Measure the time delay and record the result.

Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 63-12. Record the results.

Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.

Step 7: (Optional.) Repeat steps 1 through 6 for 59X-2, 59X-3, and 59X-4.

### Pickup Verification (Vx Third Harmonic Mode)

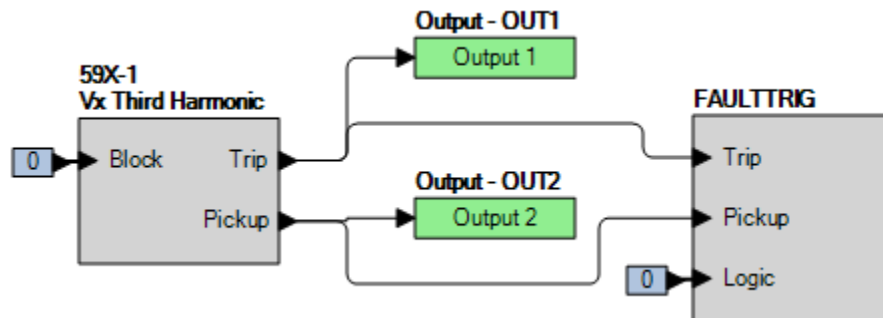
Step 1: Use *BESTCOMSPPlus* to send the operational settings in Table 63-13 to the BE1-11*t*. Reset all targets.

**Table 63-13. Operational Settings (Vx Third Harmonic Mode)**

Setting	Value	BESTCOMSPPlus Screen	Description
Aux VT Ratio	1	System Parameters, Sensing Transformers	Sets auxiliary VT ratio to 1
Aux VT Connection	AN	System Parameters, Sensing Transformers	Sets auxiliary VT connection to AN
Element Mode	Vx Third Harmonic	Protection, Voltage, Overvoltage (59X-1)	Enables 59X-1 function for Vx Third Harmonic mode
Timing Mode	Definite	Protection, Voltage, Overvoltage (59X-1)	Selects definite timings
59X-1 3RD	Enabled	Target Configuration, Targets	Enables Vx Third Harmonic target for 59X-1

Step 2: Use *BESTCOMSPPlus* to configure the *BESTLogicPlus* programmable logic shown in Figure 63-5.

- Blocking is disabled.
- OUT1 closes for 59X-1 Trip.
- OUT2 closes for 59X-1 Pickup.
- Fault recording is enabled.



**Figure 63-5. BESTLogicPlus Settings (Vx Third Harmonic Mode)**

Step 3: Use *BESTCOMSPPlus* to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 63-14 to the BE1-11*t*.

**Table 63-14. Pickup Test Settings (Vx Third Harmonic Mode)**

Pickup Setting	Time Delay
125 V	50 ms
75 V	50 ms
30 V	50 ms

Step 4: Prepare to monitor the 59X-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 63-5).

- Step 5: Connect and apply a single-phase, 120 Vac, 3<sup>rd</sup> harmonic voltage source to the V<sub>x</sub> input, terminals C17 (polarity) and C18 (non-polarity).
- Step 6: Slowly increase the voltage until OUT2 closes and record the pickup. Verify that there is a 59X-1-3RD target on the front-panel display. Slowly decrease the voltage until OUT2 opens and record the dropout. Reset the target.
- Step 7: Verify the pickup and dropout accuracy at 70 Vac for a pickup setting of 75 V and 25 Vac for a pickup setting of 30 V as listed in Table 63-14. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for the B-phase and C-phase voltage inputs.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.
- Step 10: (Optional.) Repeat steps 1 through 9 for 59X-2, 59X-3, and 59X-4.

### Timing Verification (V<sub>x</sub> Third Harmonic Mode)

- Step 1: Use BESTCOMSP<sub>Plus</sub> to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 63-15 to the BE1-11<sub>r</sub> for settings group 0.

**Table 63-15. Timing Test Settings (V<sub>x</sub> Third Harmonic Mode)**

Pickup Setting	Time Delay
125 V	2,000 ms
125 V	5,000 ms
125 V	10,000 ms

- Step 2: Prepare to monitor the 59X-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 120 Vac, single-phase, 3<sup>rd</sup> harmonic voltage source to terminals C17 (polarity) and C18 (non-polarity).
- Step 4: Step the voltage up to 130 volts. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 63-15. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 59X-2, 59X-3, and 59X-4.

## Functional Test Report

### Pickup Verification (3V0 Mode)

Pickup Setting Range = 1 to 150 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

Dropout/Pickup Ratio =  $98\% \pm 1\%$

Step	Pickup Setting		Low		Actual Pickup	High		Low*		Actual Dropout	High*		Pass/Fail
	3V0	VA	3V0	VA†		3V0	VA†	3V0	VA†		3V0	VA†	
6	115.0	265.0	112.7	262.7		117.3	267.3	111.6	261.6		113.9	263.9	P / F
7	65.0	215.0	63.7	213.7		66.3	216.3	63.1	213.1		64.4	214.4	P / F
7	20.0	170.0	19.0	169.0		21.0	171.0	19.4	169.4		19.8	169.8	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

† VA Low and High values are calculated as  $VA=3V_0+150$  V nominal.

### Timing Verification (3V0 Mode)

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F

### Pickup Verification (V1 Mode)

Pickup Setting Range = 1 to 150 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

Dropout/Pickup Ratio =  $98\% \pm 1\%$

Step	Pickup Setting		Low		Actual Pickup	High		Low*		Actual Dropout	High*		Pass/Fail
	V1	VA	V1	VA		V1	VA	V1	VA		V1	VA	
6	82.0	246.0	80.3	240.9		83.6	250.8	82.8	248.4		84.4	253.2	P / F
7	42.0	126.0	41.0	123.0		43.0	129.0	42.4	127.2		43.2	129.6	P / F
7	25.0	75.0	24.0	72.0		26.0	78.0	25.2	75.6		25.7	77.1	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Timing Verification (V1 Mode)

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F

### Pickup Verification (V2 Mode)

Pickup Setting Range = 1 to 150 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

Dropout/Pickup Ratio =  $98\% \pm 1\%$

Step	Pickup Setting		Low		Actual Pickup	High		Low*		Actual Dropout	High*		Pass/Fail
	V1	VA	V1	VA		V1	VA	V1	VA		V1	VA	
6	82.0	246.0	80.3	240.9		83.6	250.8	82.8	248.4		84.4	253.2	P / F
7	42.0	126.0	41.0	123.0		43.0	129.0	42.4	127.2		43.2	129.6	P / F
7	25.0	75.0	24.0	72.0		26.0	78.0	25.2	75.6		25.7	77.1	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Timing Verification (V2 Mode)

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F

### Pickup Verification (Vx Fundamental Mode)

Pickup Setting Range = 1 to 150 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

Dropout/Pickup Ratio =  $98\% \pm 1\%$

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
6	125.0 V	122.5 V		127.5 V	121.3 V		123.8 V	P / F
7	75.0 V	73.5 V		76.6 V	72.8 V		74.3 V	P / F
7	30.0 V	29.0 V		31.0 V	29.1 V		29.7 V	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Timing Verification (Vx Fundamental Mode)

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F

### Pickup Verification (Vx Third Harmonic Mode)

Pickup Setting Range = 1 to 150 V

Pickup Accuracy =  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

Dropout/Pickup Ratio =  $98\% \pm 1\%$

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
6	125.0 V	122.5 V		127.5 V	121.3 V		123.8 V	P / F
7	75.0 V	73.5 V		76.6 V	72.8 V		74.3 V	P / F
7	30.0 V	29.0 V		31.0 V	29.1 V		29.7 V	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Timing Verification (Vx Third Harmonic Mode)

Time Delay Range = 50 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,968 ms		2,032 ms	P / F
5	5,000 ms	4,968 ms		5,032 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F



## 64 • Frequency (81) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11*r* measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11*r* is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP*lus*® to open the BESTlogic™*Plus* Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogic*Plus* settings are made, click the Save button located on the toolbar to compile BESTlogic*Plus*. Upload BESTlogic*Plus* settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Frequency (81) Protection* chapter for more information on this function.

### Note

Testing the 81 Rate of Change (ROC) mode requires a voltage source capable of smoothly sweeping the frequency of the applied voltage for a variable positive and negative rate of change. Frequency step changes at 1 millisecond intervals (maximum) are required to support the accuracy requirement of the element.

## Functional Test Procedure

### Overfrequency Pickup Verification

Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 64-1 to the BE1-11*r*. Reset all targets.

**Table 64-1. Operational Settings (Overfrequency)**

Setting	Value	BESTCOMSP <i>lus</i> Screen	Description
Element Mode	Over	Protection, Frequency (81-1)	Enables 81-1 function for Over mode
Source	Phase VT	Protection, Frequency (81-1)	Sets source to Phase VT
Voltage Inhibit	40 V	Protection, Frequency (81-1)	Sets voltage inhibit pickup to 40 V
81-1 Over	Enabled	Target Configuration, Targets	Enables Over target for 81-1

Step 2: Use *BESTCOMSPPlus* to configure the *BESTlogicPlus* programmable logic shown in Figure 64-1.

- Blocking is disabled.
- OUT1 closes for 81-1 Trip.
- OUT2 closes for 81-1 Pickup.
- Fault recording is enabled.

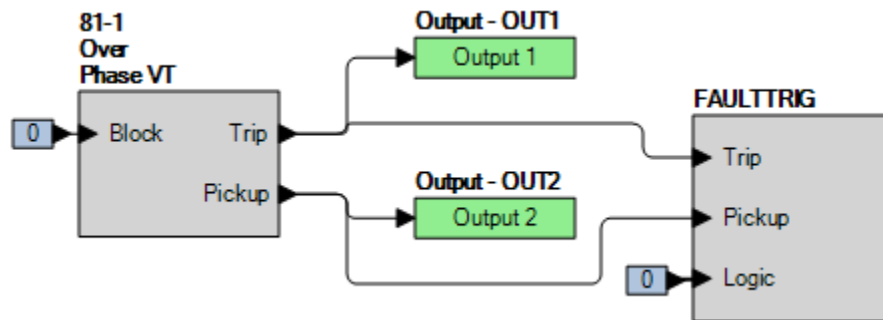


Figure 64-1. *BESTlogicPlus* Settings (Overfrequency)

Step 3: Use *BESTCOMSPPlus* to open the Protection, Frequency, Frequency (81-1) screen and send the first row of test settings in Table 64-2 to the BE1-11*t*.

Table 64-2. Pickup Test Settings (Overfrequency)

Pickup Setting	Time Delay
65 Hz	0 ms
67 Hz	0 ms
69 Hz	0 ms

Step 4: Prepare to monitor the 81-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 64-1).

Step 5: Connect and apply a 120 Vac, 60-hertz voltage source to terminals C13 (A-phase) and C16 (neutral).

Step 6: Slowly increase the frequency of the applied voltage until OUT2 closes and record the pickup. Verify that there is an 81-1-Over target on the front-panel display. Slowly decrease the frequency until OUT2 opens and record the dropout.

Step 7: Repeat step 6 for the 67 Hz and 69 Hz pickup settings listed in Table 64-2. Record the results.

Step 8: (Optional.) Repeat steps 1 through 7 for settings groups 1, 2, and 3.

Step 9: (Optional.) Repeat steps 1 through 8 for 81-2, 81-3, 81-4, 81-5, 81-6, 81-7, and 81-8.

### Underfrequency Pickup Verification

Step 1: Use *BESTCOMSPPlus* to send the operational settings in Table 64-3 to the BE1-11*t*. Reset all targets.

Table 64-3. Operational Settings (Underfrequency)

Setting	Value	<i>BESTCOMSPPlus</i> Screen	Description
Element Mode	Under	Protection, Frequency (81-1)	Enables 81-1 function for Under mode
Source	Phase VT	Protection, Frequency (81-1)	Sets source to Phase VT
Voltage Inhibit	40 V	Protection, Frequency (81-1)	Sets voltage inhibit pickup to 40 V
81-1 Under	Enabled	Target Configuration, Targets	Enables Under target for 81-1

Step 2: Use BESTCOMSP<sup>lus</sup> to configure the BESTlogicP<sup>lus</sup> programmable logic shown in Figure 64-2.

- Blocking is disabled.
- OUT1 closes for 81-1 Trip.
- OUT2 closes for 81-1 Pickup.
- Fault recording is enabled.

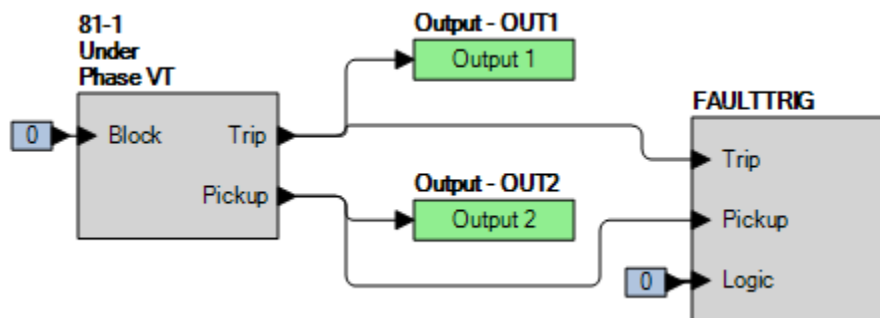


Figure 64-2. BESTlogicPlus Settings (Underfrequency)

Step 3: Use BESTCOMSP<sup>lus</sup> to open the Protection, Frequency, Frequency (81-1) screen and send the first row of test settings in Table 64-4 to the BE1-11 $\iota$ .

Table 64-4. Pickup Test Settings (Underfrequency)

Pickup Setting	Time Delay
42 Hz	0 ms
46 Hz	0 ms
48 Hz	0 ms

Step 4: Prepare to monitor the 81-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 64-2).

Step 5: Connect and apply a 120 Vac, 60-hertz voltage source to terminals C13 (A-phase) and C16 (neutral).

Step 6: Slowly decrease the frequency of the applied voltage until OUT2 closes and record the pickup. Verify that there is an 81-1-Under target on the front-panel display. Slowly increase the frequency until OUT2 opens and record the dropout.

Step 7: Repeat step 6 for the 46 Hz and 48 Hz pickup settings listed in Table 64-4. Record the results.

Step 8: (Optional.) Repeat steps 1 through 7 for settings groups 1, 2, and 3.

Step 9: (Optional.) Repeat steps 1 through 8 for 81-2, 81-3, 81-4, 81-5, 81-6, 81-7, and 81-8.

### Time Delay Verification

Step 1: Use BESTCOMSP<sup>lus</sup> to open the Protection, Frequency, Frequency (81-1) screen and send the first row of test settings in Table 64-5 to the BE1-11 $\iota$ . Commands entered in Table 64-3 should be retained for this test.

Table 64-5. Timing Test Settings

Pickup Setting	Time Delay
57.50 Hz	2,000 ms
57.50 Hz	5,000 ms
57.50 Hz	10,000 ms

Step 2: Prepare to monitor the 81-1 timings. Timing accuracy is verified by measuring the elapsed time between a frequency change and OUT1 closing.

- Step 3: Connect and apply a 120 Vac, 60-hertz voltage source to terminals C13 (A-phase) and C16 (neutral).
- Step 4: Step the frequency of the applied voltage down to 55-hertz. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delays listed in Table 64-5. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings groups 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 81-2, 81-3, 81-4, 81-5, 81-6, 81-7, and 81-8.

### Pickup Verification (ROC Frequency)

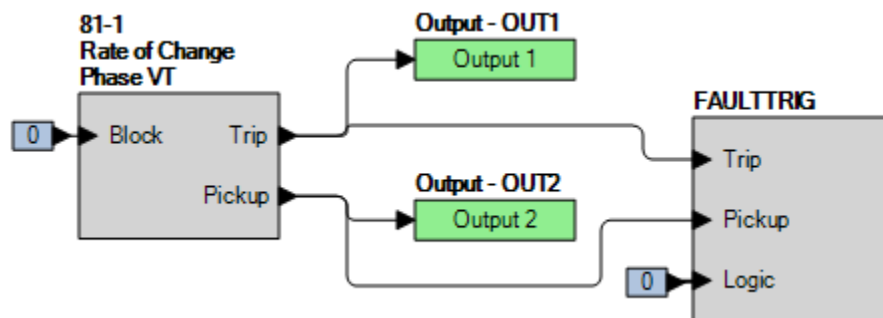
- Step 1: Use *BESTCOMSPPlus* to send the operational settings in Table 64-6 to the BE1-11*t*. Reset all targets.

**Table 64-6. Operational Settings (ROC Frequency)**

Setting	Value	BESTCOMSPPlus Screen	Description
Element Mode	Rate of Change	Protection, Frequency (81-1)	Enables 81-1 function for Rate of Change mode
Source	Phase VT	Protection, Frequency (81-1)	Sets source to Phase VT
Pickup	10 Hz/sec	Protection, Frequency (81-1)	Sets pickup to 10 Hz/sec
Voltage Inhibit	40 V	Protection, Frequency (81-1)	Sets voltage inhibit pickup to 40 V
Over Frequency Inhibit	64 Hz	Protection, Frequency (81-1)	Sets over frequency inhibit to 64 Hz
Under Frequency Inhibit	46 Hz	Protection, Frequency (81-1)	Sets under frequency inhibit to 46 Hz
81-1 ROC	Enabled	Target Configuration, Targets	Enables ROC target for 81-1

- Step 2: Use *BESTCOMSPPlus* to configure the *BESTlogicPlus* programmable logic shown in Figure 64-3.

- Blocking is disabled.
- OUT1 closes for 81-1 Trip.
- OUT2 closes for 81-1 Pickup.
- Fault recording is enabled.



**Figure 64-3. BESTlogicPlus Settings (ROC Frequency)**

- Step 3: Prepare to monitor the 81-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 64-3).

- Step 4: Connect a 120 Vac voltage source capable of smoothly sweeping the frequency from 35 Hz to 75 Hz to terminals C13 (A-phase) and C16 (neutral).
- Step 5: Set the ramp rate at 0.001 seconds/step (max level, lower if possible) and set the total number steps at 1,000 (one second total for the sweep test).
- Step 6: Set the frequency range of the sweep (ramp) for 55.0 to 64.7 Hz. This equates to a ROC of 9.7 Hz/sec (3.0% below the 10.0 Hz/sec pickup setting).
- Step 7: Initiate the sweep (ramp) which simultaneously applies voltage to the BE1-11 $\ell$  and note that there is no operation of OUT2.
- Step 8: Increase the rate of change in increments of 1% (9.8, 9.9 Hz/sec) up to 9.9 Hz/sec and 0.5% thereafter until OUT2 closes and record the pickup.
- Step 9: Repeat steps 3 through 8 with the pickup value set at 2 Hz/sec. Begin the test by applying a rate of change value 8% below pickup (1.84 Hz/sec or a frequency sweep range of 59 to 60.84 Hz). Increase the rate of change in 1% increments until OUT2 closes and record the pickup.
- Step 10: (Optional.) Repeat steps 1 through 9 in Positive ROC mode. Additionally, verify that a sweep from a high to low frequency does not cause an operation.
- Step 11: (Optional.) Repeat steps 1 through 9 in Negative ROC mode by reversing the sweep rate from high to low to simulate negative rate of change. Additionally, verify that a sweep from a low to high frequency does not cause an operation.
- Step 12: (Optional.) Repeat steps 1 through 11 for settings group 1, 2, and 3.
- Step 13: (Optional.) Repeat steps 1 through 12 for 81-2, 81-3, 81-4, 81-5, 81-6, 81-7, and 81-8.

### Time Delay Verification (ROC Frequency)

Time delay verification is not necessary for the ROC mode as the same timers are used as in the over/underfrequency timing tests. Timing starts when the 81 Pickup goes high whether the cause is over, under, or rate of change.

### Inhibit Quantities (ROC Inhibit)

Operation in the rate of change mode can be inhibited by sensing voltage, negative-sequence voltage, and frequency limits or range, the latter of which creates a “frequency window” of operation. The sensing voltage inhibit is the same feature used for the over/underfrequency elements and has already been tested. The following tests verify the negative-sequence and frequency limit inhibits.

- Step 1: Use the Settings Explorer in BESTCOMSP $\ell$  to open the Protection, Frequency, Frequency (81-1) screen and send the operational settings in Table 64-7 to the BE1-11 $\ell$ .

**Table 64-7. Operational Settings (ROC Inhibit)**

Setting	Value	Description
Element Mode	Rate of Change	Enables 81-1 function for Rate of Change mode
Source	Phase VT	Sets source to Phase VT
Pickup	2 Hz/sec	Sets pickup to 2 Hz/sec
Time Delay	0 ms	Sets time delay to minimum
Voltage Inhibit	40 V	Sets voltage inhibit pickup to 40 V
Over Frequency Inhibit	64 Hz	Sets overfrequency inhibit to 64 Hz
Under Frequency Inhibit	46 Hz	Sets underfrequency inhibit to 46 Hz
Negative Sequence Inhibit	20%	Sets negative-sequence inhibit to 20%

Step 2: Use BESTCOMSP<sub>Plus</sub> to configure the BESTlogic<sub>Plus</sub> programmable logic shown in Figure 64-4.

- Blocking is disabled.
- OUT1 closes for 81-1 Trip.
- OUT2 closes for 81-1 Pickup.
- Fault recording is enabled.

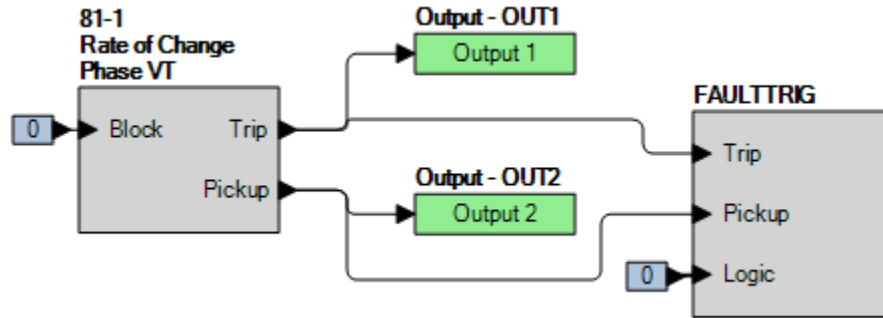


Figure 64-4. BESTlogic<sub>Plus</sub> Settings (ROC Inhibit)

- Step 3: To test the negative-sequence inhibit, connect a three-phase voltage source with 120 degrees between phases. The negative-sequence quantity is based on phase to neutral nominal voltage (69.3 or 120). The negative-sequence inhibit setting is a percent of nominal voltage. Assuming a 4-wire connection and a nominal voltage of 120 volts phase-to-neutral, 208 phase-to-phase, a 20% of nominal setting equates to a negative-sequence voltage of 24 volts.
- Step 4: Set the rate of change (sweep or ramp) for 3 Hz/s (BE1-11<sub>t</sub> set to trip at 2 Hz/sec), initiate the sweep, and note that OUT2 operates. While monitoring Metering of the BE1-11<sub>t</sub>, reduce the C-phase voltage to 55 volts and note the negative-sequence voltage. Continue to reduce the C-phase voltage in 1-volt increments repeating the sweep test after each reduction until OUT2 **does not** operate. Inhibit should occur at 24 volts negative-sequence. Record the result.
- Step 5: Set the Negative Sequence Inhibit setting to 0%.
- Step 6: To test the frequency limit inhibit function, connect a 120 Vac voltage source capable of smoothly sweeping the frequency from 35 Hz to 75 Hz to terminals C13 (A-phase) and C16 (neutral). With a ROC setting of 2 Hz/sec, initiate a 3 Hz/sec sweep (frequency range set 60 Hz to 57 Hz) and note that OUT2 operates.
- Step 7: Set the Overfrequency Inhibit setting to 59.7 Hz and the Underfrequency Inhibit setting to 59.5 Hz. Repeat step 6 and note that OUT2 does not operate. Pickup accuracy for over and underfrequency limit is  $\pm 0.01$  Hz.

## Functional Test Report

### Overfrequency Pickup Verification

Pickup Setting Range = 15 to 110 Hz

Pickup Accuracy =  $\pm 0.01$  Hz

Dropout = 0.02 Hz  $\pm 0.01$  Hz of the actual pickup value

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
6	65 Hz	64.99 Hz		65.01 Hz	64.97 Hz		64.99 Hz	P / F
7	67 Hz	66.99 Hz		67.01 Hz	66.97 Hz		66.99 Hz	P / F
7	69 Hz	68.99 Hz		69.01 Hz	68.97 Hz		68.99 Hz	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Underfrequency Pickup Verification

Pickup Setting Range = 15 to 110 Hz

Pickup Accuracy =  $\pm 0.01$  Hz

Reset = 0.02 Hz  $\pm 0.01$  Hz of the actual pickup value

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
6	42 Hz	41.99 Hz		42.01 Hz	41.97 Hz		41.99 Hz	P / F
7	46 Hz	45.99 Hz		46.01 Hz	45.97 Hz		45.99 Hz	P / F
7	48 Hz	47.99 Hz		48.01 Hz	47.97 Hz		47.99 Hz	P / F

\* Reset range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Time Delay Verification

Time Delay Range = 0 to 600,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 1$  cycle, whichever is greater + 3 cycles recognition time for time delay settings < 50 ms

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,983 ms		2,017 ms	P / F
5	5,000 ms	4,975 ms		5,025 ms	P / F
5	10,000 ms	9,950 ms		10,050 ms	P / F

### Pickup Verification (ROC Frequency)

ROC Pickup Setting Range = 0.2 to 20 Hz/sec

Accuracy =  $\pm 2\%$  or  $\pm 0.1$  Hz/sec, whichever is greater

Step	Setting	Low	Pickup	High	Pass/Fail
8	10 Hz/sec	9.8 Hz/sec		10.2 Hz/sec	P / F
9	2 Hz/sec	1.9 Hz/sec		2.1 Hz/sec	P / F



## 65 • Instantaneous Overcurrent (50) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $\iota$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $\iota$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $\textit{Plus}$ ® to open the BESTlogic™ $\textit{Plus}$  Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogic $\textit{Plus}$  settings are made, click the Save button located on the toolbar to compile BESTlogic $\textit{Plus}$ . Upload BESTlogic $\textit{Plus}$  settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Instantaneous Overcurrent (50) Protection* chapter for more information on this function.

### Functional Test Procedure

#### Pickup Verification (Phase Mode)

Step 1: Use BESTCOMSP $\textit{Plus}$  to send the operational settings in Table 65-1 to the BE1-11 $\iota$ . Reset all targets.

Table 65-1. Operational Settings (Phase Mode)

Setting	Value	BESTCOMSP $\textit{Plus}$ Screen	Description
Phase CT Ratio	1	System Parameters, Sensing Transformers	Sets phase CT ratio to 1
Element Mode	IA	Protection, Current, Instantaneous Overcurrent (50-1)	Enables 50-1 function for IA mode
Source	CT Circuit 1	Protection, Current, Instantaneous Overcurrent (50-1)	Selects CT circuit 1 as the source
50-1 A	Enabled	Target Configuration, Targets	Enables phase A target for 50-1

Step 2: Use BESTCOMSP $\textit{Plus}$  to configure the BESTlogic $\textit{Plus}$  programmable logic shown in Figure 65-1.

- Blocking is disabled.
- OUT1 closes for 50-1 Trip.
- OUT2 closes for 50-1 Pickup.
- Fault recording is enabled.

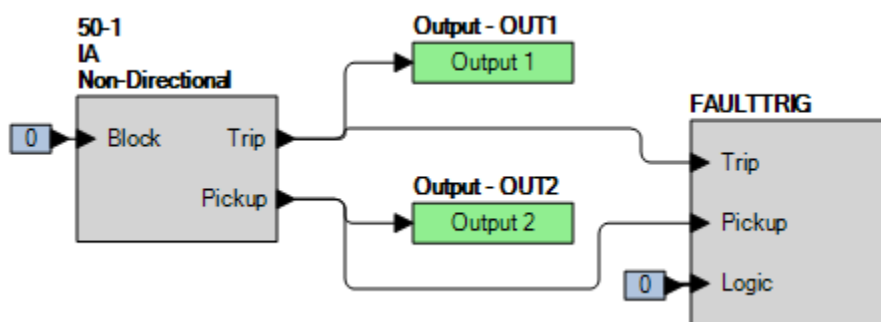


Figure 65-1. BESTlogicPlus Settings (Phase Mode)

Step 3: Use BESTCOMSPPlus to open the Protection, Current, Instantaneous Overcurrent (50-1) screen and send the low range test settings (minimum pickup setting) to the BE1-11t for your sensing input type in Table 65-2.

Table 65-2. Pickup Test Settings (Phase Mode)

Sensing Input Type	Range	Pickup Setting	Time Delay
5 A	Low	0.5 A	0 ms
	Middle	5.0 A	0 ms
	High	20.0 A	0 ms
1 A	Low	0.1 A	0 ms
	Middle	1.0 A	0 ms
	High	4.0 A	0 ms

- Step 4: Prepare to monitor the 50-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 65-1).
- Step 5: Connect a current source to terminals D1 and D2 (A-phase). Note that mode can be set for IA, IB, IC, or 3 phases. Test is conducted on IA.
- Step 6: Slowly increase the A-phase current until OUT2 closes and record the pickup. Verify that there is a 50-1-A target on the front-panel display. Slowly decrease the applied current until OUT2 opens and record the dropout.
- Step 7: Repeat step 6 for the middle and high range pickup settings for your sensing input type. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for phase B and phase C. Note: Be sure to change Element Mode and enable proper target for each phase being tested.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.
- Step 10: (Optional.) Repeat steps 1 through 9 for 50-2, 50-3, 50-4, 50-5, 50-6, 50-7, 50-8, and 50-9.
- Step 11: (Optional.) Repeat steps 1 through 10 with CT Circuit 2 as the source. In step 5, replace D1 with F1, D2 with F2, etc.

### Timing Verification (Phase Mode)

- Step 1: Use BESTCOMSPPlus to open the Protection, Current, Instantaneous Overcurrent (50-1) screen and send the first row of test settings in Table 65-3 to the BE1-11t for settings group 0.
- Step 2: Prepare to monitor the 50-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing current change and OUT1 closing.
- Step 3: Connect and apply 0.45 A to BE1-11t terminals D1 and D2 (A-phase).
- Step 4: Step the A-phase current up to 0.75 A. Measure the time delay and record the result.

**Table 65-3. Timing Test Settings (Phase Mode)**

Pickup Setting	Time Delay
0.5 A	2,000 ms
0.5 A	5,000 ms
0.5 A	10,000 ms

- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 65-3. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for the B-phase and C-phase current inputs.
- Step 7: (Optional.) Repeat steps 1 through 6 for settings group 1, 2, and 3.
- Step 8: (Optional.) Repeat steps 1 through 7 for 50-2, 50-3, 50-4, 50-5, 50-6, 50-7, 50-8, and 50-9.
- Step 9: (Optional.) Repeat steps 1 through 8 with CT Circuit 2 as the source. In step 3, replace D1 with F1, D2 with F2, etc.

### Pickup Verification (3I0 Mode)

- Step 1: Use *BESTCOMSPi* to send the operational settings in Table 65-4 to the BE1-11 $\iota$ . Reset all targets.

**Table 65-4. Operational Settings (3I0 Mode)**

Setting	Value	BESTCOMSPi Screen	Description
Phase CT Ratio	1	System Parameters, Sensing Transformers	Sets phase CT ratio to 1
Element Mode	3I0	Protection, Current, Instantaneous Overcurrent (50-1)	Enables 50-1 function for 3I0 mode
Source	CT Circuit 1	Protection, Current, Instantaneous Overcurrent (50-1)	Selects CT circuit 1 as the source
50-1 Residual	Enabled	Target Configuration, Targets	Enables residual target for 50-1

- Step 2: Use *BESTCOMSPi* to configure the *BESTlogicPi* programmable logic shown in Figure 65-2.
- Blocking is disabled.
  - OUT1 closes for 50-1 Trip.
  - OUT2 closes for 50-1 Pickup.
  - Fault recording is enabled.
- Step 3: Use *BESTCOMSPi* to open the Protection, Current, Instantaneous Overcurrent (50-1) screen and send the low range test settings (minimum pickup setting) to the BE1-11 $\iota$  for your sensing input type in Table 65-5.

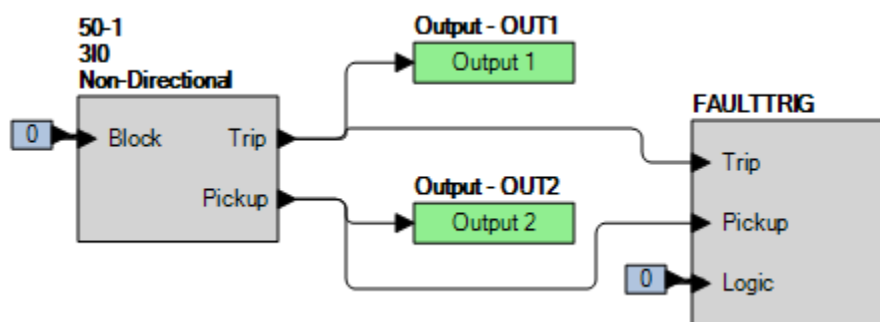


Figure 65-2. BESTlogicPlus Settings (3I0 Mode)

Table 65-5. Pickup Test Settings (3I0 Mode)

Sensing Input Type	Range	Pickup Setting	Time Delay
5 A	Low	0.5 A	0 ms
	Middle	5.0 A	0 ms
	High	20.0 A	0 ms
1 A	Low	0.1 A	0 ms
	Middle	1.0 A	0 ms
	High	4.0 A	0 ms

- Step 4: Prepare to monitor the 50-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 65-2).
- Step 5: Connect a current source to terminals D1 and D2 (A-phase).
- Step 6: Slowly increase the A-phase current until OUT2 closes and record the pickup. Verify that there is a 50-1-Residual target on the front-panel display. Slowly decrease the applied current until OUT2 opens and record the dropout.
- Step 7: Repeat step 6 for the middle and high range pickup settings for your sensing input type. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for settings group 1, 2, and 3.
- Step 9: (Optional.) Repeat steps 1 through 8 for 50-2, 50-3, 50-4, 50-5, 50-6, 50-7, 50-8, and 50-9.
- Step 10: (Optional.) Repeat steps 1 through 9 with CT Circuit 2 as the source. In step 5, replace D1 with F1, D2 with F2, etc.

### Timing Verification (3I0 Mode)

- Step 1: Use BESTCOMSPPlus to open the Protection, Current, Instantaneous Overcurrent (50-1) screen and send the first row of test settings in Table 65-6 to the BE1-11t for settings group 0.

Table 65-6. Timing Test Settings (3I0 Mode)

Pickup Setting	Time Delay
0.5 A	2,000 ms
0.5 A	5,000 ms
0.5 A	10,000 ms

- Step 2: Prepare to monitor the 50-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing current change and OUT1 closing.
- Step 3: Connect and apply 0.45 A to BE1-11t terminals D1 and D2 (A-phase).

- Step 4: Step the A-phase current up to 0.55 A. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 65-6. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 50-2, 50-3, 50-4, 50-5, 50-6, 50-7, 50-8, and 50-9.
- Step 8: (Optional.) Repeat steps 1 through 7 with CT Circuit 2 as the source. In step 5, replace D1 with F1, D2 with F2, etc.

**Pickup Verification (I2 Mode)**

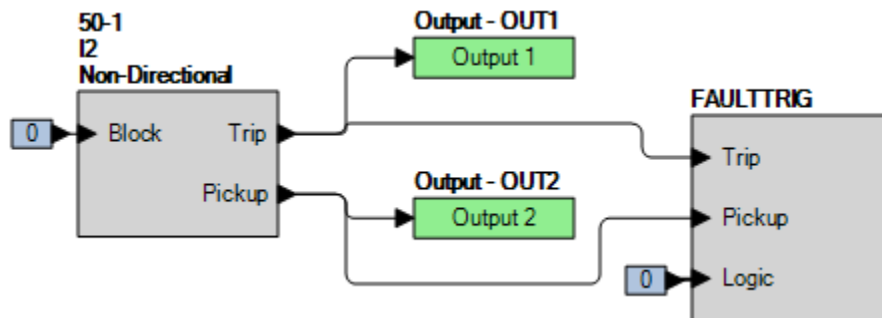
Step 1: Use BESTCOMSPi<sub>us</sub> to send the operational settings in Table 65-7 to the BE1-11<sub>t</sub>. Reset all targets.

**Table 65-7. Operational Settings (I2 Mode)**

Setting	Value	BESTCOMSPi <sub>us</sub> Screen	Description
Phase CT Ratio	1	System Parameters, Sensing Transformers	Sets phase CT ratio to 1
Element Mode	I2	Protection, Current, Instantaneous Overcurrent (50-1)	Enables 50-1 function for I2 mode
Source	CT Circuit 1	Protection, Current, Instantaneous Overcurrent (50-1)	Selects CT circuit 1 as the source
50-1 Neg SEQ	Enabled	Target Configuration, Targets	Enables Neg SEQ target for 50-1

Step 2: Use BESTCOMSPi<sub>us</sub> to configure the BESTlogicPi<sub>us</sub> programmable logic shown in Figure 65-3.

- Blocking is disabled.
- OUT1 closes for 50-1 Trip.
- OUT2 closes for 50-1 Pickup.
- Fault recording is enabled.



**Figure 65-3. BESTlogicPi<sub>us</sub> Settings (I2 Mode)**

Step 3: Use BESTCOMSPi<sub>us</sub> to open the Protection, Current, Instantaneous Overcurrent (50-1) screen and send the low range test settings (minimum pickup setting) to the BE1-11<sub>t</sub> for your sensing input type in Table 65-8.

**Table 65-8. Pickup Test Settings (I2 Mode)**

Sensing Input Type	Range	Pickup Setting	Time Delay
5 A	Low	0.5 A	0 ms
	Middle	5.0 A	0 ms
	High	9.0 A	0 ms

Sensing Input Type	Range	Pickup Setting	Time Delay
1 A	Low	0.1 A	0 ms
	Middle	1.0 A	0 ms
	High	1.8 A	0 ms

- Step 4: Prepare to monitor the 50-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 65-3).
- Step 5: Connect a current source to terminals D1 and D2 (A-phase). For a single-phase input test,  $I_2 = I_a / 3$ . Therefore, the BE1-11 $\tau$  should pick up at a value of three times the setting value when applying only a single-phase input. For example, to determine the pickup current value required for a 1 A BE1-11 $\tau$  with a pickup setting of 0.1, it would require 0.1 times 3 or 0.3 amperes of input current.
- Step 6: Slowly increase the A-phase current until OUT2 closes and record the pickup. Verify that there is a 50-1-Neg SEQ target on the front-panel display. Slowly decrease the applied current until OUT2 opens and record the dropout.
- Step 7: Repeat step 6 for the middle and high range pickup settings for your sensing input type. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for settings group 1, 2, and 3.
- Step 9: (Optional.) Repeat steps 1 through 8 for 50-2, 50-3, 50-4, 50-5, 50-6, 50-7, 50-8, and 50-9.
- Step 10: (Optional.) Repeat steps 1 through 9 with CT Circuit 2 as the source. In step 5, replace D1 with F1, D2 with F2, etc.

### Timing Verification (I2 Mode)

- Step 1: Use BESTCOMSP $Plus$  to open the Protection, Current, Instantaneous Overcurrent (50-1) screen and send the first row of test settings in Table 65-9 to the BE1-11 $\tau$  for settings group 0.

**Table 65-9. Timing Test Settings (I2 Mode)**

Pickup Setting	Time Delay
0.5 A	2,000 ms
0.5 A	5,000 ms
0.5 A	10,000 ms

- Step 2: Prepare to monitor the 50-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing current change and OUT1 closing.
- Step 3: Connect and apply 1.45 A to BE1-11 $\tau$  terminals D1 and D2 (A-phase). For a single-phase input test,  $I_2 = I_a / 3$ . Therefore, the BE1-11 $\tau$  should pick up at a value of three times the setting value when applying only a single-phase input. For example, to determine the pickup current value required for a 1 A BE1-11 $\tau$  with a pickup setting of 0.1, it would require 0.1 times 3 or 0.3 amperes of input current.
- Step 4: Step the A-phase current up to 1.55 A. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 65-9. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 50-2, 50-3, 50-4, 50-5, 50-6, 50-7, 50-8, and 50-9.
- Step 8: (Optional.) Repeat steps 1 through 7 with CT Circuit 2 as the source. In step 5, replace D1 with F1, D2 with F2, etc.

## Pickup Verification (IG Mode)

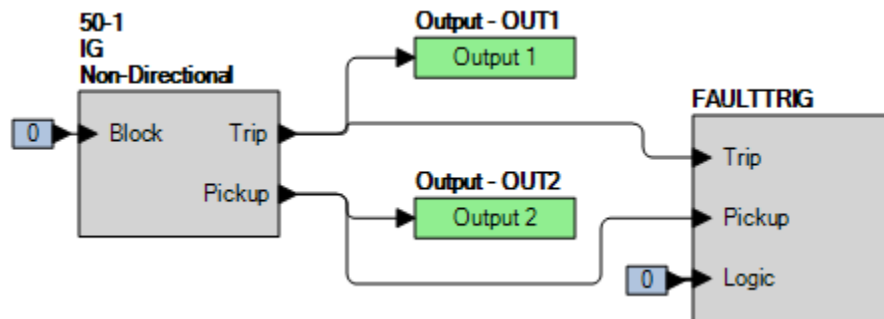
Step 1: Use *BESTCOMSPi* to send the operational settings in Table 65-10 to the BE1-11 $\tau$ . Reset all targets.

**Table 65-10. Operational Settings (IG Mode)**

Setting	Value	BESTCOMSPi Screen	Description
Ground CT Ratio	1	System Parameters, Sensing Transformers	Sets ground CT ratio to 1
Element Mode	IG	Protection, Current, Instantaneous Overcurrent (50-1)	Enables 50-1 function for IG mode
Source	CT Circuit 1	Protection, Current, Instantaneous Overcurrent (50-1)	Selects CT circuit 1 as the source
50-1 IND GND	Enabled	Target Configuration, Targets	Enables IND GND target for 50-1

Step 2: Use *BESTCOMSPi* to configure the *BESTlogicPi* programmable logic shown in Figure 65-4.

- Blocking is disabled.
- OUT1 closes for 50-1 Trip.
- OUT2 closes for 50-1 Pickup.
- Fault recording is enabled.



**Figure 65-4. BESTlogicPi Settings (IG Mode)**

Step 3: Use *BESTCOMSPi* to open the Protection, Current, Instantaneous Overcurrent (50-1) screen and send the low range test settings (minimum pickup setting) to the BE1-11 $\tau$  for your sensing input type in Table 65-11.

**Table 65-11. Pickup Test Settings (IG Mode)**

Sensing Input Type	Range	Pickup Setting	Time Delay
5 A	Low	0.5 A	0 ms
	Middle	5.0 A	0 ms
	High	10.0 A	0 ms
1 A or SEF	Low	0.1 A	0 ms
	Middle	1.0 A	0 ms
	High	2.0 A	0 ms

Step 4: Prepare to monitor the 50-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 65-4).

Step 5: Connect a current source to terminals D7 and D8 (IG).

- Step 6: Slowly increase the ground current until OUT2 closes and record the pickup. Verify that there is a 50-1-IND GND target on the front-panel display. Slowly decrease the applied current until OUT2 opens and record the dropout.
- Step 7: Repeat step 6 for the middle and high range pickup settings for your sensing input type. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for settings group 1, 2, and 3.
- Step 9: (Optional.) Repeat steps 1 through 8 for 50-2, 50-3, 50-4, 50-5, 50-6, 50-7, 50-8, and 50-9.
- Step 10: (Optional.) Repeat steps 1 through 9 with CT Circuit 2 as the source. In step 5, replace D1 with F1, D2 with F2, etc.

### Timing Verification (IG Mode)

- Step 1: Use BESTCOMSP<sup>lus</sup> to open the Protection, Current, Instantaneous Overcurrent (50-1) screen and send the first row of test settings in Table 65-12 to the BE1-11 $\tau$  for settings group 0.

**Table 65-12. Timing Test Settings (IG Mode)**

Pickup Setting	Time Delay
0.5 A	2,000 ms
0.5 A	5,000 ms
0.5 A	10,000 ms

- Step 2: Prepare to monitor the 50-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing current change and OUT1 closing.
- Step 3: Connect and apply 0.45 A to BE1-11 $\tau$  terminals D7 and D8 (IG).
- Step 4: Step the ground current up to 0.55 A. Measure the time delay and record the result.
- Step 5: Repeat step 4 for the 5,000 ms and 10,000 ms time delay settings of Table 65-12. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 50-2, 50-3, 50-4, 50-5, 50-6, 50-7, 50-8, and 50-9.
- Step 8: (Optional.) Repeat steps 1 through 7 with CT Circuit 2 as the source. In step 3, replace D1 with F1, D2 with F2, etc.

## Functional Test Report

### Pickup Verification (Phase Mode)

Pickup Setting Range = 0.5 to 150 A for 5A sensing

0.1 to 30 A for 1A sensing

Pickup Accuracy =  $\pm 2\%$  or  $\pm 50$  mA, whichever is greater for 5A sensing

$\pm 2\%$  or  $\pm 10$  mA, whichever is greater for 1A sensing

Dropout should occur between 93-99% of the actual pickup value.

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
6	0.5 A (5A CT)	0.45 A		0.55 A	0.465 A		0.495 A	P / F
7	5.0 A (5A CT)	4.9 A		5.1 A	4.65 A		4.95 A	P / F
7	20.0 A (5A CT)	20.6 A		20.4 A	18.6 A		19.8 A	P / F
6	0.1 A (1A CT)	0.09 A		0.11 A	0.093 A		0.099 A	P / F
7	1.0 A (1A CT)	0.98 A		1.02 A	0.93 A		0.99 A	P / F
7	4.0 A (1A CT)	3.92 A		4.08 A	3.72 A		3.96 A	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

**Timing Verification (Phase Mode)**

Time Delay Range = 0 to 60,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm \frac{1}{2}$  cycle, whichever is greater + 3 cycles max for currents 1.5 x pickup

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,942 ms		2,058 ms	P / F
5	5,000 ms	4,927 ms		5,073 ms	P / F
5	10,000 ms	9,902 ms		10,098 ms	P / F

**Pickup Verification (3I0 Mode)**

Pickup Setting Range = 0.5 to 150 A for 5A sensing

0.1 to 30 A for 1A sensing

Pickup Accuracy =  $\pm 3\%$  or  $\pm 75$  mA, whichever is greater for 5A sensing $\pm 3\%$  or  $\pm 15$  mA, whichever is greater for 1A sensing

Dropout should occur between 93-99% of the actual pickup value.

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
6	0.5 A (5A CT)	0.425 A		0.575 A	0.465 A		0.495 A	P / F
7	5.0 A (5A CT)	4.85 A		5.15 A	4.65 A		4.95 A	P / F
7	20.0 A (5A CT)	19.4 A		20.6 A	18.6 A		19.8 A	P / F
6	0.1 A (1A CT)	0.085 A		0.115 A	0.093 A		0.099 A	P / F
7	1.0 A (1A CT)	0.97 A		1.03 A	0.93 A		0.99 A	P / F
7	4.0 A (1A CT)	3.88 A		4.12 A	3.72 A		3.96 A	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

**Timing Verification (3I0 Mode)**

Time Delay Range = 0 to 60,000 ms

Timing Accuracy =  $\pm 1\%$  or  $\pm \frac{1}{2}$  cycle, whichever is greater + 3 cycles max for currents 1.5 x pickup

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,942 ms		2,058 ms	P / F
5	5,000 ms	4,927 ms		5,073 ms	P / F
5	10,000 ms	9,902 ms		10,098 ms	P / F

**Pickup Verification (I2 Mode)**

Pickup Setting Range = 0.5 to 150 A for 5A sensing

0.1 to 30 A for 1A sensing

Pickup Accuracy =  $\pm 3\%$  or  $\pm 75$  mA, whichever is greater for 5A sensing $\pm 3\%$  or  $\pm 15$  mA, whichever is greater for 1A sensing

Dropout should occur between 93-99% of the actual pickup value.

Step	Pickup Setting		Low		Actual Pickup	High		Low*		Actual Dropout	High*		Pass/Fail
	I2	IA	I2	IA		I2	IA	I2	IA		I2	IA	
6	0.5 (5A CT)	1.5	0.42	1.26		0.57	1.71	0.46	1.38		0.49	1.47	P / F
7	5.0 (5A CT)	15.0	4.85	14.55		5.15	15.45	4.65	13.95		4.95	14.85	P / F
7	9.0 (5A CT)	27.0	8.73	26.19		9.27	27.81	8.37	25.11		8.91	26.73	P / F
6	0.1 (1A CT)	0.3	0.08	0.24		0.11	0.33	0.093	0.279		0.099	0.297	P / F
7	1.0 (1A CT)	3.0	0.97	2.91		1.03	3.09	0.93	2.79		0.99	2.97	P / F
7	1.8 (1A CT)	5.4	1.74	5.22		1.85	5.55	1.67	5.01		1.78	5.34	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Timing Verification (I2 Mode)

Time Delay Range = 0 to 60,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm \frac{1}{2}$  cycle, whichever is greater + 3 cycles max for currents  $1.5 \times$  pickup

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,942 ms		2,058 ms	P / F
5	5,000 ms	4,927 ms		5,073 ms	P / F
5	10,000 ms	9,902 ms		10,098 ms	P / F

### Pickup Verification (IG Mode)

Pickup Setting Range = 0.5 to 150 A for 5A sensing

0.1 to 30 A for 1A sensing

0.01 to 7.5 for SEF

Pickup Accuracy =  $\pm 2\%$  or  $\pm 50$  mA, whichever is greater for 5A sensing

$\pm 2\%$  or  $\pm 10$  mA, whichever is greater for 1A sensing

$\pm 2.5\%$  or  $\pm 2.5$  mA, whichever is greater for SEF

Dropout should occur between 93-99% of the actual pickup value.

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
6	0.5 A (5A CT)	0.45 A		0.55 A	0.465 A		0.495 A	P / F
7	5.0 A (5A CT)	4.9 A		5.1 A	4.65 A		4.95 A	P / F
7	20.0 A (5A CT)	20.6 A		20.4 A	18.6 A		19.8 A	P / F
6	0.1 A (1A CT)	0.09 A		0.11 A	0.093 A		0.099 A	P / F
7	1.0 A (1A CT)	0.98 A		1.02 A	0.93 A		0.99 A	P / F
7	2.0 A (1A CT)	1.96 A		2.04 A	1.86 A		1.98 A	P / F
6	0.1 A (SEF)	0.09 A		0.11 A	0.093 A		0.099 A	P / F
7	1.0 A (SEF)	0.85 A		1.15 A	0.93 A		0.99 A	P / F
7	2.0 A (SEF)	1.95 A		2.05 A	1.86 A		1.98 A	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

**Timing Verification (IG Mode)**

Time Delay Range = 0 to 60,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm \frac{1}{2}$  cycle, whichever is greater + 3 cycles max for currents 1.5 x pickup

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	2,000 ms	1,942 ms		2,058 ms	P / F
5	5,000 ms	4,927 ms		5,073 ms	P / F
5	10,000 ms	9,902 ms		10,098 ms	P / F



## 66 • Breaker Fail (50BF) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11*t* measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11*t* is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP*lus*® to open the BESTlogic™*Plus* Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogic*Plus* settings are made, click the Save button located on the toolbar to compile BESTlogic*Plus*. Upload BESTlogic*Plus* settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Breaker Fail (50BF) Protection* chapter for more information on this function.

### Functional Test Procedure

The BE1-11*t* has two types of Breaker Failure Initiates, one being contact only initiate, and the other being current supervised BE1-11*t* trip initiate. The following tests are for **Contact Only** initiate.

Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 66-1 to the BE1-11*t*. Reset all targets.

**Table 66-1. Operational Settings (BFI52 Contact Initiate)**

Setting	Value	BESTCOMSP <i>lus</i> Screen	Description
Element Mode	Enabled	Protection, Current, Breaker Fail (50BF)	Enables 50BF function
Phase Pickup	0	Protection, Current, Breaker Fail (50BF)	Sets phase pickup to 0
Ground Pickup	0	Protection, Current, Breaker Fail (50BF)	Sets ground pickup to 0
Control Timer	0	Protection, Current, Breaker Fail (50BF)	Sets control timer to 0
Delay Timer	100 ms	Protection, Current, Breaker Fail (50BF)	Sets delay timer to 100 ms
50BF	Enabled	Target Configuration, Targets	Enables target for 50BF

Step 2: Use BESTCOMSP*lus* to configure the BESTlogic*Plus* programmable logic shown in Figure 66-1.

- Blocking is disabled.
- 50BFI is disabled.
- 52BFI is initiated with IN2.
- OUT1 closes for 50BF Trip.
- OUT2 closes for 50BF ReTrip.

- Fault recording is enabled.
- Breaker Status is closed with /IN1.

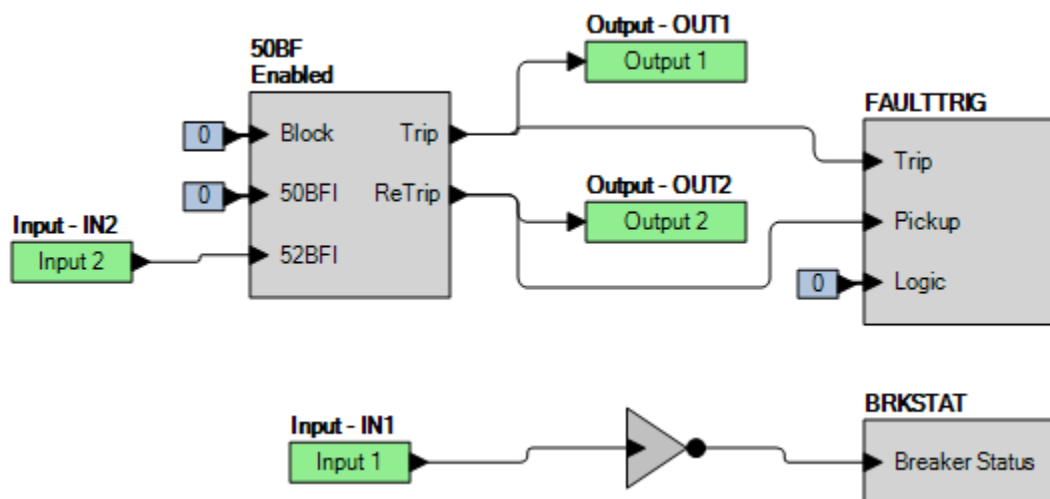


Figure 66-1. BESTlogicPlus Settings (BF152 Contact Initiate)

Step 3: IN1 is used to simulate breaker status as supplied by a “b” contact from the circuit breaker. With no wetting voltage applied to BE1-11 $t$  input IN1, the BE1-11 $t$  considers the breaker closed because of the /IN1 designation at the breaker status input of the breaker failure element. A switched wetting voltage at IN2 is used to simulate an external BF152 initiate contact for starting the Breaker Failure Timer. This input is also used to start the test set timer and OUT1 of the BE1-11 $t$  is used to stop the test set timer. OUT2 should be monitored to verify operation of the re-trip circuit upon breaker failure initiate.

Step 4: With no wetting voltage applied to BE1-11 $t$  input IN1, switch on the wetting voltage to IN2 and measure the operate time. Record the result.

Step 5: Apply wetting voltage to IN1 and repeat step 4. There should be no operation.

Step 6: Repeat step 3 with the delay timer set at 200 ms and 300 ms. Record the results.

The following tests are for **Current Supervised** BE1-11 $t$  trip initiates. Any or all BE1-11 $t$  trips can be used: 50 Trip, 51 Trip, etc. For ease of testing, the 50-1 Trip variable will be used in the following tests.

Step 7: Use BESTCOMSPlus to send the operational settings in Table 66-2 to the BE1-11 $t$ . Reset all targets.

Table 66-2. Operational Settings (BF150 Current Supervised BE1-11 $t$  Trip Initiate)

Setting	Value	BESTCOMSPlus Screen	Description
Element Mode	Enabled	Protection, Current, Breaker Fail (50BF)	Enables 50BF function
Phase Pickup	1 A	Protection, Current, Breaker Fail (50BF)	Sets phase pickup to 1 A
Ground Pickup	1 A	Protection, Current, Breaker Fail (50BF)	Sets ground pickup to 1 A
Control Timer	0	Protection, Current, Breaker Fail (50BF)	Sets control timer to 0
Delay Timer	100 ms	Protection, Current, Breaker Fail (50BF)	Sets delay timer to 100 ms
50BF	Enabled	Target Configuration, Targets	Enables target for 50BF
Breaker Fail	Minor, Non-Latching	Alarm Configuration, Alarms	Sets 50BF BFI alarm for Minor Alarm

Setting	Value	BESTCOMSPUs Screen	Description
Element Mode	IA	Protection, Current, Instantaneous Overcurrent (50-1)	Enables 50-1 function
Pickup	2 A	Protection, Current, Instantaneous Overcurrent (50-1)	Sets pickup to 2 A
Source	CT Circuit 1	Protection, Current, Instantaneous Overcurrent (50-1)	Selects CT circuit 1 as the source

Step 8: Use BESTCOMSPUs to configure the BESTlogicPlus programmable logic shown in Figure 66-2.

- 50BF Blocking is disabled.
- 50BFI is initiated with 50-1 Trip.
- 52BFI is disabled.
- OUT1 closes for 50BF Trip.
- OUT2 closes for 50BF ReTrip.
- OUT3 closes when minor alarm is true. (Minor Alarm = Breaker Fail)
- Fault recording is enabled.
- Breaker Status is disabled.
- 50-1 Blocking is disabled.

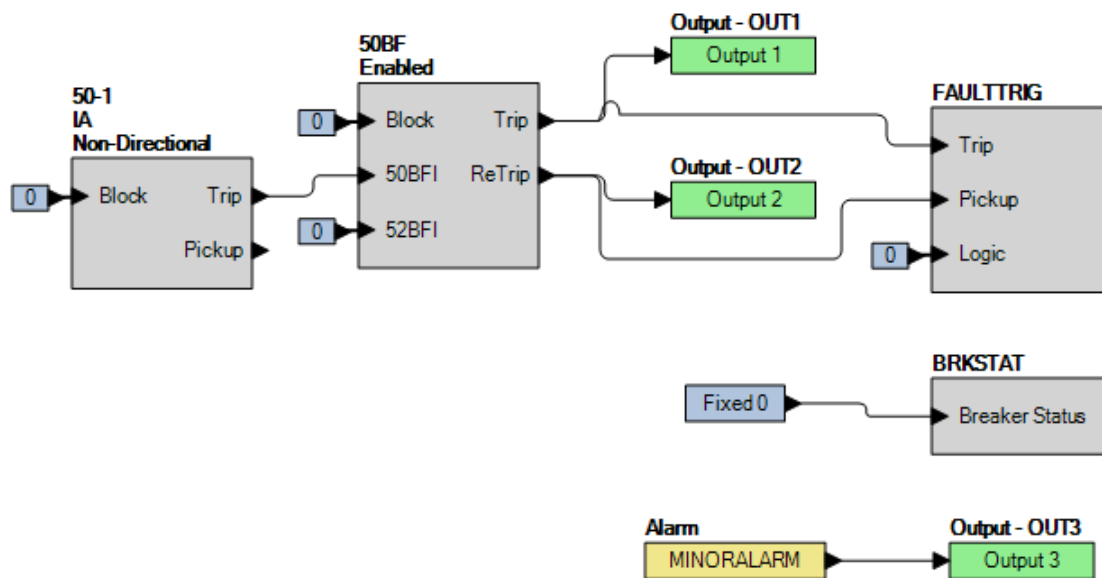


Figure 66-2. BESTlogicPlus Settings (BFI50 Current Supervised BE1-11r Trip Initiate)

- Step 9: Verify the BF time delay by applying pickup current (above 2 A) to phase A for at least 100 ms. A 50BF Trip should occur. Use BESTCOMSPUs to retrieve an SER report and verify that a 50BF Trip was logged 100 milliseconds  $\pm 0.5\%$  ( $1\frac{1}{4}$  cycles maximum for currents  $\geq 5$  times the pickup setting.  $1\frac{3}{4}$  cycles maximum for a current of 2 times pickup. Two cycles maximum for a current of 1.05 times the pickup setting) after application of pickup current.
- Step 10: (Optional.) Raise 50-1 Pickup setting to 10 amps and apply nominal current to the BE1-11r. Note that OUT1 and OUT2 do not operate. No initiate prevents operation of the breaker failure function, blocking the breaker fail logic.
- Step 11: Verify the Control Time function by using BESTCOMSPUs to send the settings in Table 66-3 to the BE1-11r.

**Table 66-3. Control Time Delay Settings**

Setting	Value	BESTCOMSPlus Screen	Description
Phase Pickup	1 A	Protection, Current, Breaker Fail (50BF)	Sets phase pickup to 1 A
Ground Pickup	1 A	Protection, Current, Breaker Fail (50BF)	Sets ground pickup to 1 A
Control Timer	100 ms	Protection, Current, Breaker Fail (50BF)	Sets control timer to 100 ms
Delay Timer	200 ms	Protection, Current, Breaker Fail (50BF)	Sets delay timer to 200 ms
Pickup	2 A	Protection, Current, Instantaneous Overcurrent (50-1)	Sets pickup to 2 A

Step 12: Connect a current source to terminals D1 and D2 (A-phase). Apply nominal current to the BE1-11 $\tau$  and note operation of OUT3 and no operation of OUT1 and OUT2. To verify control time, apply nominal current and start the test set timer. Use OUT3 to stop the timer. Record the result.

Step 13: (Optional.) Repeat steps 1 through 12 for the B and C phase elements. Note: Set 50-1 mode to IB for B-phase and IC for C-phase.

Step 14: (Optional.) Repeat steps 7 through 13 with CT Circuit 2 as the source. In step 12, replace D1 with F1, D2 with F2, etc.

## Functional Test Report

### Delay Timer Verification

Delay Timer Range = 50 to 999 ms

Delay Timer Accuracy =  $\pm 0.5\%$  or  $+1\%$ ,  $-0.5$  cycles, whichever is greater

Step	Delay Timer Setting	Low	Actual Timing	High	Pass/Fail
4	100 ms	92 ms		120 ms	P / F
6	200 ms	192 ms		220 ms	P / F
6	300 ms	292 ms		320 ms	P / F

### Control Timer Verification

Control Timer Range = 50 to 99 ms

Control Timer Accuracy =  $\pm 0.5\%$  or  $\frac{1}{2}$  cycle, whichever is greater

Step	Control Timer Setting	Low	Actual Timing	High	Pass/Fail
12	100 ms	92 ms		120 ms	P / F

## 67 • Inverse Overcurrent (51) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $\iota$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $\iota$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $\iota$  to open the BESTlogic $\text{TM}$ Plus Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogicPlus settings are made, click the Save button located on the toolbar to compile BESTlogicPlus. Upload BESTlogicPlus settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Inverse Overcurrent (51) Protection* chapter for more information on this function.

### Functional Test Procedure

#### Pickup Verification (Phase Mode)

Step 1: Use BESTCOMSP $\iota$  to send the operational settings in Table 67-1 to the BE1-11 $\iota$ . Reset all targets.

Table 67-1. Operational Settings (Phase Mode)

Setting	Value	BESTCOMSP $\iota$ Screen	Description
Phase CT Ratio	1	System Parameters, Sensing Transformers	Sets phase CT ratio to 1
Element Mode	IA	Protection, Current, Inverse Overcurrent (51-1)	Enables 51-1 function for IA mode
Source	CT Circuit 1	Protection, Current, Instantaneous Overcurrent (51-1)	Selects CT circuit 1 as the source
51-1 A	Enabled	Target Configuration, Targets	Enables phase A target for 51-1

Step 2: Use BESTCOMSP $\iota$  to configure the BESTlogicPlus programmable logic shown in Figure 67-1.

- Blocking is disabled.
- OUT1 closes for 51-1 Trip.
- OUT2 closes for 51-1 Pickup.
- Fault recording is enabled.

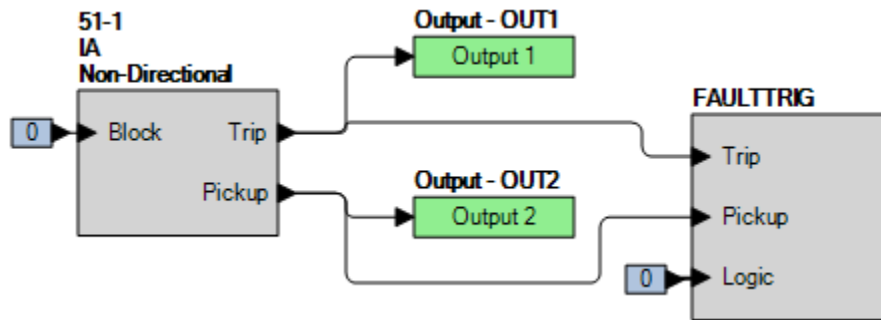


Figure 67-1. BESTlogicPlus Settings (Phase Mode)

Step 3: Use BESTCOMSPPlus to open the Protection, Current, Inverse Overcurrent (51-1) screen and send the low range test settings (minimum pickup setting) to the BE1-11t for your sensing input type in Table 67-2.

Table 67-2. Pickup Test Settings (Phase Mode)

Sensing Input Type	Range	Pickup Setting	Time Dial	Time Curve
5 A	Low	0.5 A	0	I2
	Middle	5.0 A	0	I2
	High	16.0 A	0	I2
1 A	Low	0.1 A	0	I2
	Middle	1.0 A	0	I2
	High	3.2 A	0	I2

- Step 4: Prepare to monitor the 51-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 67-1).
- Step 5: Connect a current source to terminals D1 and D2 (A-phase). Note that mode can be set for IA, IB, IC, or 3 phases. Test is conducted on IA.
- Step 6: Slowly increase the A-phase current until OUT2 closes and record the pickup. Verify that there is a 51-1-A target on the front-panel display. Slowly decrease the applied current until OUT2 opens and record the dropout.
- Step 7: Repeat step 6 for the middle and high range pickup settings for your sensing input type. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for phase B and phase C. Note: Be sure to change Element Mode and enable proper target for each phase being tested.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.
- Step 10: (Optional.) Repeat steps 1 through 9 for 51-2, 51-3, 51-4, 51-5, 51-6, 51-7, 51-8, and 51-9.
- Step 11: (Optional.) Repeat steps 1 through 10 with CT Circuit 2 as the source. In step 5, replace D1 with F1, D2 with F2, etc.

### Timing Verification (Phase Mode)

Step 1: Use BESTCOMSPPlus to open the Protection, Current, Inverse Overcurrent (51-1) screen and send the test settings in Table 67-3 to the BE1-11t for settings group 0.

Table 67-3. Timing Test Settings (Phase Mode)

Pickup Setting	Time Curve
0.5 A (5 A sensing), 0.1 A (1 A sensing or SEF)	I2

- Step 2: Prepare to monitor the 51-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing current change and OUT1 closing.
- Step 3: Connect a current source to BE1-11 $t$  terminals D1 and D2 (A-phase).
- Step 4: Using the values listed in Table 67-4, apply the appropriate current values, and measure the time between the application of current and the closure of OUT1. Record the results.
- Step 5: Repeat step 4 for all of the current and time dial settings for your current sensing type.
- Step 6: (Optional.) Repeat steps 1 through 5 for the B-phase and C-phase current inputs. Note: Be sure to enable proper target for each phase being tested.
- Step 7: (Optional.) Repeat steps 1 through 6 for settings group 1, 2, and 3.
- Step 8: (Optional.) Repeat steps 1 through 7 for 51-2, 51-3, 51-4, 51-5, 51-6, 51-7, 51-8, and 51-9.
- Step 9: (Optional.) Repeat steps 1 through 8 with CT Circuit 2 as the source. In step 3, replace D1 with F1, D2 with F2, etc.

**Table 67-4. Timing Test Settings (Phase Mode)**

Sensing Type	Time Dial	Applied Current
5 A	0.5	1.00 A
		2.50 A
		12.50 A
	5.0	1.00 A
		2.50 A
		12.50 A
	9.9	1.00 A
		2.50 A
		12.50 A
1 A	0.5	0.20 A
		0.50 A
		2.50 A
	5.0	0.20 A
		0.50 A
		2.50 A
	9.9	0.20 A
		0.50 A
		2.50 A

### Pickup Verification (3I0 Mode)

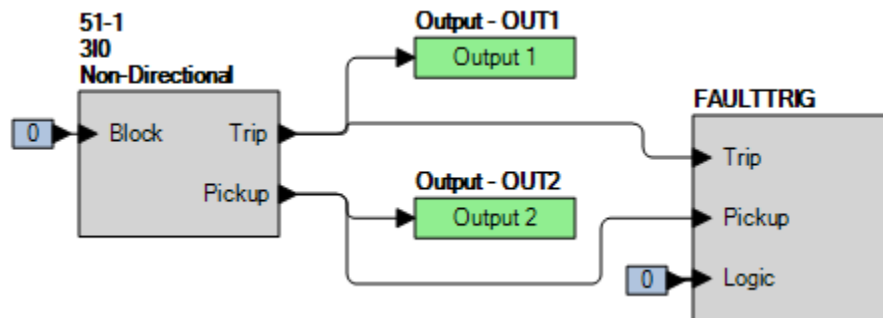
- Step 1: Use BESTCOMSP $lus$  to send the operational settings in Table 67-5 to the BE1-11 $t$ . Reset all targets.

**Table 67-5. Operational Settings (3I0 Mode)**

Setting	Value	BESTCOMSPi+ Screen	Description
Phase CT Ratio	1	System Parameters, Sensing Transformers	Sets phase CT ratio to 1
Element Mode	3I0	Protection, Current, Inverse Overcurrent (51-1)	Enables 51-1 function for 3I0 mode
Source	CT Circuit 1	Protection, Current, Instantaneous Overcurrent (51-1)	Selects CT circuit 1 as the source
51-1 Residual	Enabled	Target Configuration, Targets	Enables residual target for 51-1

Step 2: Use BESTCOMSPi+ to configure the BESTlogicPi+ programmable logic shown in Figure 67-2.

- Blocking is disabled.
- OUT1 closes for 51-1 Trip.
- OUT2 closes for 51-1 Pickup.
- Fault recording is enabled.

**Figure 67-2. BESTlogicPi+ Settings (3I0 Mode)**

Step 3: Use BESTCOMSPi+ to open the Protection, Current, Inverse Overcurrent (51-1) screen and send the low range test settings (minimum pickup setting) to the BE1-11t for your sensing input type in Table 67-6.

**Table 67-6. Pickup Test Settings (3I0 Mode)**

Sensing Input Type	Range	Pickup Setting	Time Dial
5 A	Low	0.5 A	0
	Middle	5.0 A	0
	High	16.0 A	0
1 A	Low	0.1 A	0
	Middle	1.0 A	0
	High	3.2 A	0

Step 4: Prepare to monitor the 51-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 67-2).

Step 5: Connect a current source to terminals D1 and D2 (A-phase).

Step 6: Slowly increase the A-phase current until OUT2 closes and record the pickup. Verify that there is a 51-1-Residual target on the front-panel display. Slowly decrease the applied current until OUT2 opens and record the dropout.

- Step 7: Repeat step 6 for the middle and high range pickup settings for your sensing input type. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for settings group 1, 2, and 3.
- Step 9: (Optional.) Repeat steps 1 through 8 for 51-2, 51-3, 51-4, 51-5, 51-6, 51-7, 51-8, and 51-9.
- Step 10: (Optional.) Repeat steps 1 through 9 with CT Circuit 2 as the source. In step 5, replace D1 with F1, D2 with F2, etc.

### Timing Verification (3I0 Mode)

- Step 1: Use BESTCOMSP*lus* to open the Protection, Current, Inverse Overcurrent (51-1) screen and send the test settings in Table 67-7 to the BE1-11*t* for settings group 0.

**Table 67-7. Timing Test Settings (3I0 Mode)**

Pickup Setting	Time Curve
0.5 A (5 A sensing), 0.1 A (1 A sensing)	I2

- Step 2: Prepare to monitor the 51-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing current change and OUT1 closing.
- Step 3: Connect a current source to BE1-11*t* terminals D1 and D2 (A-phase).
- Step 4: Using the values listed in Table 67-8, apply the appropriate current values, and measure the time between the application of current and the closure of OUT1. Record the results.
- Step 5: Repeat step 4 for all of the current and time dial settings for your current sensing type.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 51-2, 51-3, 51-4, 51-5, 51-6, 51-7, 51-8, and 51-9.
- Step 8: (Optional.) Repeat steps 1 through 7 with CT Circuit 2 as the source. In step 3, replace D1 with F1, D2 with F2, etc.

**Table 67-8. Timing Test Settings (3I0 Mode)**

Sensing Type	Time Dial	Applied Current
5 A	0.5	1.00 A
		2.50 A
		12.50 A
	5.0	1.00 A
		2.50 A
		12.50 A
	9.9	1.00 A
		2.50 A
		12.50 A
1 A	0.5	0.20 A
		0.50 A
		2.50 A
	5.0	0.20 A
		0.50 A
		2.50 A
	9.9	0.20 A
		0.50 A
		0.50 A

Sensing Type	Time Dial	Applied Current
		2.50 A

### Pickup Verification (I2 Mode)

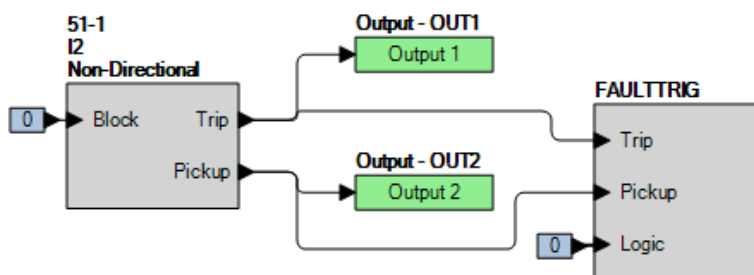
Step 1: Use *BESTCOMSPUs* to send the operational settings in Table 67-9 to the BE1-11 $\iota$ . Reset all targets.

**Table 67-9. Operational Settings (I2 Mode)**

Setting	Value	BESTCOMSPUs Screen	Description
Phase CT Ratio	1	System Parameters, Sensing Transformers	Sets phase CT ratio to 1
Element Mode	I2	Protection, Current, Instantaneous Overcurrent (51-1)	Enables 51-1 function for I2 mode
Source	CT Circuit 1	Protection, Current, Instantaneous Overcurrent (51-1)	Selects CT circuit 1 as the source
51-1 Neg SEQ	Enabled	Target Configuration, Targets	Enables Neg SEQ target for 51-1

Step 2: Use *BESTCOMSPUs* to configure the *BESTlogicPlus* programmable logic shown in Figure 67-3.

- Blocking is disabled.
- OUT1 closes for 51-1 Trip.
- OUT2 closes for 51-1 Pickup.
- Fault recording is enabled.



**Figure 67-3. BESTlogicPlus Settings (I2 Mode)**

Step 3: Use *BESTCOMSPUs* to open the Protection, Current, Inverse Overcurrent (51-1) screen and send the low range test settings (minimum pickup setting) to the BE1-11 $\iota$  for your sensing input type in Table 67-10.

**Table 67-10. Pickup Test Settings (I2 Mode)**

Sensing Input Type	Range	Pickup Setting	Time Dial	Time Curve
5 A	Low	0.5 A	0	I2
	Middle	5.0 A	0	I2
	High	9.0 A	0	I2
1 A	Low	0.1 A	0	I2
	Middle	1.0 A	0	I2
	High	1.8 A	0	I2

- Step 4: Prepare to monitor the 51-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 67-3).
- Step 5: Connect a current source to terminals D1 and D2 (A-phase). For a single-phase input test,  $I_2 = I_a / 3$ . Therefore, the BE1-11 $\epsilon$  should pick up at a value of three times the setting value when applying only a single-phase input. For example, to determine the pickup current value required for a 1 A BE1-11 $\epsilon$  with a pickup setting of 0.1, it would require 0.1 times 3 or 0.3 amperes of input current.
- Step 6: Slowly increase the A-phase current until OUT2 closes and record the pickup. Verify that there is a 51-1-Neg SEQ target on the front-panel display. Slowly decrease the applied current until OUT2 opens and record the dropout.
- Step 7: Repeat step 6 for the middle and high range pickup settings for your sensing input type. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for settings group 1, 2, and 3.
- Step 9: (Optional.) Repeat steps 1 through 8 for 51-2, 51-3, 51-4, 51-5, 51-6, 51-7, 51-8, and 51-9.
- Step 10: (Optional.) Repeat steps 1 through 9 with CT Circuit 2 as the source. In step 5, replace D1 with F1, D2 with F2, etc.

### Timing Verification (I2 Mode)

- Step 1: Use BESTCOMSP $\text{Plus}$  to open the Protection, Current, Inverse Overcurrent (51-1) screen and send the test settings in Table 67-11 to the BE1-11 $\epsilon$  for settings group 0.

**Table 67-11. Timing Test Settings (I2 Mode)**

Pickup Setting	Time Curve
0.5 A (5 A sensing), 0.1 A (1 A sensing)	I2

- Step 2: Prepare to monitor the 51-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing current change and OUT1 closing.
- Step 3: Connect a current source to BE1-11 $\epsilon$  terminals D1 and D2 (A-phase).
- Step 4: Using the values listed in Table 67-12, apply the appropriate current values, and measure the time between the application of current and the closure of OUT1. Record the results.

**Table 67-12. Timing Test Settings (I2 Mode)**

Sensing Type	Time Dial	Applied Current
5 A	0.5	3.00 A
		7.50 A
		27.00 A
	5.0	3.00 A
		7.50 A
		27.00 A
	9.9	3.00 A
		7.50 A
		27.00 A
1 A	0.5	0.45 A
		1.5 A
		7.5 A
	5.0	0.45 A

Sensing Type	Time Dial	Applied Current
		1.5 A
		7.5 A
	9.9	0.45 A
		1.5 A
		7.5 A

Step 5: Repeat step 4 for all of the current and time dial settings for your current sensing type.

Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.

Step 7: (Optional.) Repeat steps 1 through 6 for 51-2, 51-3, 51-4, 51-5, 51-6, 51-7, 51-8, and 51-9.

Step 8: (Optional.) Repeat steps 1 through 7 with CT Circuit 2 as the source. In step 3, replace D1 with F1, D2 with F2, etc.

### Pickup Verification (IG Mode)

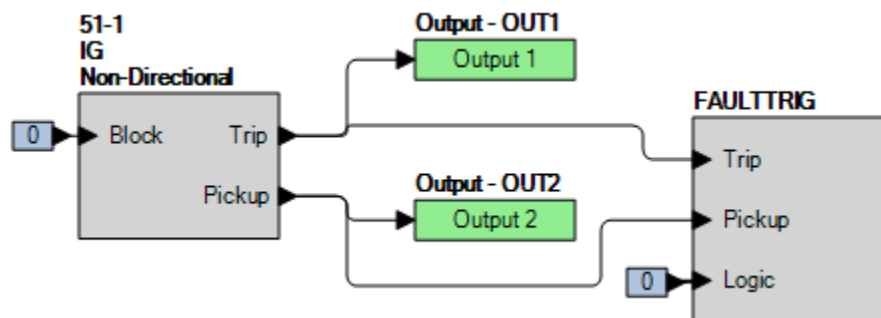
Step 1: Use *BESTCOMSPPlus* to send the operational settings in Table 67-13 to the BE1-11 $\iota$ . Reset all targets.

**Table 67-13. Operational Settings (IG Mode)**

Setting	Value	BESTCOMSPPlus Screen	Description
Ground CT Ratio	1	System Parameters, Sensing Transformers	Sets ground CT ratio to 1
Element Mode	IG	Protection, Current, Instantaneous Overcurrent (51-1)	Enables 51-1 function for IG mode
Source	CT Circuit 1	Protection, Current, Instantaneous Overcurrent (51-1)	Selects CT circuit 1 as the source
51-1 IND GND	Enabled	Target Configuration, Targets	Enables IND GND target for 51-1

Step 2: Use *BESTCOMSPPlus* to configure the *BESTlogicPlus* programmable logic shown in Figure 67-4.

- Blocking is disabled.
- OUT1 closes for 51-1 Trip.
- OUT2 closes for 51-1 Pickup.
- Fault recording is enabled.



**Figure 67-4. BESTlogicPlus Settings (IG Mode)**

Step 3: Use *BESTCOMSPPlus* to open the Protection, Current, Inverse Overcurrent (51-1) screen and send the low range test settings (minimum pickup setting) to the BE1-11 $\iota$  for your sensing input type in Table 67-14.

- Step 4: Prepare to monitor the 51-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 67-4).
- Step 5: Connect a current source to terminals D7 and D8 (IG).
- Step 6: Slowly increase the ground current until OUT2 closes and record the pickup. Verify that there is a 51-1-IND GND target on the front-panel display. Slowly decrease the applied current until OUT2 opens and record the dropout.
- Step 7: Repeat step 6 for the middle and high range pickup settings for your sensing input type. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for settings group 1, 2, and 3.

**Table 67-14. Pickup Test Settings (IG Mode)**

Sensing Input Type	Range	Pickup Setting	Time Dial	Time Curve
5 A	Low	0.5 A	0	I2
	Middle	5.0 A	0	I2
	High	16.0 A	0	I2
1 A	Low	0.1 A	0	I2
	Middle	1.0 A	0	I2
	High	3.2 A	0	I2
SEF	Low	0.01 A	0	I2
	Middle	0.5 A	0	I2
	High	0.8 A	0	I2

- Step 9: (Optional.) Repeat steps 1 through 8 for 51-2, 51-3, 51-4, 51-5, 51-6, 51-7, 51-8, and 51-9.
- Step 10: (Optional.) Repeat steps 1 through 9 with CT Circuit 2 as the source. In step 5, replace D1 with F1, D2 with F2, etc.

### Timing Verification (IG Mode)

- Step 1: Use BESTCOMSP*lus* to open the Protection, Current, Inverse Overcurrent (51-1) screen and send the test settings in Table 67-15 to the BE1-11*r*.

**Table 67-15. Timing Test Settings (IG Mode)**

Pickup Setting	Time Curve
0.5 A (5 A sensing), 0.1 A (1 A sensing)	I2

- Step 2: Prepare to monitor the 51-1 timings. Timing accuracy is verified by measuring the elapsed time between a sensing current change and OUT1 closing.
- Step 3: Connect a current source to BE1-11*r* terminals D7 and D8 (IG).
- Step 4: Using the values listed in Table 67-16, apply the appropriate current values, and measure the time between the application of current and the closure of OUT1. Record the results.
- Step 5: Repeat step 4 for all of the current and time dial settings for your current sensing type.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 51-2, 51-3, 51-4, 51-5, 51-6, 51-7, 51-8, and 51-9.
- Step 8: (Optional.) Repeat steps 1 through 7 with CT Circuit 2 as the source. In step 3, replace D1 with F1, D2 with F2, etc.

**Table 67-16. Timing Test Settings (IG Mode)**

Sensing Type	Time Dial	Applied Current
5 A	0.5	1.00 A
		2.50 A
		12.50 A
	5.0	1.00 A
		2.50 A
		12.50 A
	9.9	1.00 A
		2.50 A
		12.50 A
1 A	0.5	0.20 A
		0.50 A
		2.50 A
	5.0	0.20 A
		0.50 A
		2.50 A
	9.9	0.20 A
		0.50 A
		2.50 A
SEF	0.5	0.20 A
		0.50 A
		0.80 A
	5.0	0.20 A
		0.50 A
		0.80 A
	9.9	0.20 A
		0.50 A
		0.80 A

## ***Functional Test Report***

### **Pickup Verification (Phase Mode)**

Pickup Setting Range = 0.5 to 16 A for 5A sensing

0.1 to 3.2 A for 1A sensing

Pickup Accuracy =  $\pm 2\%$  or  $\pm 50$  mA, whichever is greater for 5A sensing

$\pm 2\%$  or  $\pm 10$  mA, whichever is greater for 1A sensing

Dropout should occur between 93-99% of the actual pickup value.

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
6	0.5 A (5A sensing)	0.45 A		0.55 A	0.46 A		0.49 A	P / F
7	5.0 A (5A sensing)	4.9 A		5.1 A	4.65 A		4.95 A	P / F
7	16.0 A (5A sensing)	15.68 A		16.32 A	14.88 A		15.84 A	P / F
6	0.1 A (1A sensing)	0.09 A		0.11 A	0.09 A		0.09 A	P / F
7	1.0 A (1A sensing)	0.98 A		1.02 A	0.93 A		0.99 A	P / F
7	3.2 A (1A sensing)	3.13 A		3.26 A	2.97 A		3.16 A	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Timing Verification (Phase Mode, 5A Sensing)

Time Dial Range = 0.0 to 9.9

Timing Accuracy =  $\pm 5\%$  or  $\pm 1\frac{1}{2}$  cycles, whichever is greater

Step	Time Dial	Time Curve	Applied Current	Low	Actual Timing	High	Pass/Fail
4	0.5	I2	1.00 A	0.444 sec		0.491 sec	P / F
4	0.5	I2	2.50 A	0.190 sec		0.240 sec	P / F
4	0.5	I2	12.50 A	0.100 sec		0.150 sec	P / F
4	5.0	I2	1.00 A	4.204 sec		4.647 sec	P / F
4	5.0	I2	2.50 A	1.798 sec		1.988 sec	P / F
4	5.0	I2	12.50 A	0.944 sec		1.044 sec	P / F
4	9.9	I2	1.00 A	8.300 sec		9.173 sec	P / F
4	9.9	I2	2.50 A	3.535 sec		3.907 sec	P / F
4	9.9	I2	12.50 A	1.844 sec		2.038 sec	P / F

### Timing Verification (Phase Mode, 1A Sensing)

Time Dial Range = 0.0 to 9.9

Timing Accuracy =  $\pm 5\%$  or  $\pm 1\frac{1}{2}$  cycles, whichever is greater

Step	Time Dial	Time Curve	Applied Current	Low	Actual Timing	High	Pass/Fail
4	0.5	I2	0.20 A	0.444 sec		0.491 sec	P / F
4	0.5	I2	0.50 A	0.190 sec		0.240 sec	P / F
4	0.5	I2	2.50 A	0.100 sec		0.150 sec	P / F
4	5.0	I2	0.20 A	4.204 sec		4.647 sec	P / F
4	5.0	I2	0.50 A	1.798 sec		1.988 sec	P / F
4	5.0	I2	2.50 A	0.944 sec		1.044 sec	P / F
4	9.9	I2	0.20 A	8.300 sec		9.173 sec	P / F
4	9.9	I2	0.50 A	3.535 sec		3.907 sec	P / F
4	9.9	I2	2.50 A	1.844 sec		2.038 sec	P / F

### Pickup Verification (3I0 Mode)

Pickup Setting Range = 0.5 to 16 A for 5A sensing

0.1 to 3.2 A for 1A sensing

Pickup Accuracy =  $\pm 3\%$  or  $\pm 75$  mA, whichever is greater for 5A sensing

$\pm 3\%$  or  $\pm 15$  mA, whichever is greater for 1A sensing

Dropout should occur between 93-99% of the actual pickup value.

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
6	0.5 A (5A sensing)	0.425 A		0.575 A	0.465 A		0.495 A	P / F
7	5.0 A (5A sensing)	4.85 A		5.15 A	4.65 A		4.95 A	P / F
7	16.0 A (5A sensing)	15.52 A		16.48 A	14.88 A		15.84 A	P / F
6	0.1 A (1A sensing)	0.085 A		0.115 A	0.093 A		0.099 A	P / F
7	1.0 A (1A sensing)	0.97 A		1.03 A	0.93 A		0.99 A	P / F
7	3.2 A (1A sensing)	3.104 A		3.296 A	2.976 A		3.168 A	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Timing Verification (3I0 Mode, 5A Sensing)

Time Dial Range = 0.0 to 9.9

Timing Accuracy =  $\pm 5\%$  or  $\pm 1\frac{1}{2}$  cycles, whichever is greater

Step	Time Dial	Time Curve	Applied Current	Low	Actual Timing	High	Pass/Fail
4	0.5	I2	1.00 A	0.444 sec		0.491 sec	P / F
4	0.5	I2	2.50 A	0.190 sec		0.240 sec	P / F
4	0.5	I2	12.50 A	0.100 sec		0.150 sec	P / F
4	5.0	I2	1.00 A	4.204 sec		4.647 sec	P / F
4	5.0	I2	2.50 A	1.798 sec		1.988 sec	P / F
4	5.0	I2	12.50 A	0.944 sec		1.044 sec	P / F
4	9.9	I2	1.00 A	8.300 sec		9.173 sec	P / F
4	9.9	I2	2.50 A	3.535 sec		3.907 sec	P / F
4	9.9	I2	12.50 A	1.844 sec		2.038 sec	P / F

### Timing Verification (3I0 Mode, 1A Sensing)

Time Dial Range = 0.0 to 9.9

Timing Accuracy =  $\pm 5\%$  or  $\pm 1\frac{1}{2}$  cycles, whichever is greater

Step	Time Dial	Time Curve	Applied Current	Low	Actual Timing	High	Pass/Fail
4	0.5	I2	0.20 A	0.444 sec		0.491 sec	P / F
4	0.5	I2	0.50 A	0.190 sec		0.240 sec	P / F
4	0.5	I2	2.50 A	0.100 sec		0.150 sec	P / F
4	5.0	I2	0.20 A	4.204 sec		4.647 sec	P / F
4	5.0	I2	0.50 A	1.798 sec		1.988 sec	P / F
4	5.0	I2	2.50 A	0.944 sec		1.044 sec	P / F
4	9.9	I2	0.20 A	8.300 sec		9.173 sec	P / F
4	9.9	I2	0.50 A	3.535 sec		3.907 sec	P / F
4	9.9	I2	2.50 A	1.844 sec		2.038 sec	P / F

### Pickup Verification (I2 Mode)

Pickup Setting Range = 0.5 to 16 A for 5A sensing

0.1 to 3.2 A for 1A sensing

Pickup Accuracy =  $\pm 3\%$  or  $\pm 75$  mA, whichever is greater for 5A sensing

$\pm 3\%$  or  $\pm 15$  mA, whichever is greater for 1A sensing

Dropout should occur between 93-99% of the actual pickup value.

Step	Pickup Setting		Low		Actual Pickup	High		Low*		Actual Dropout	High*		Pass/Fail
	I2	IA	I2	IA		I2	IA	I2	IA		I2	IA	
6	0.5 (5A CT)	1.50	0.42	1.26		0.57	1.71	0.46	1.38		0.49	1.47	P / F
7	5.0 (5A CT)	15.00	4.85	14.55		5.15	15.45	4.65	13.95		4.95	14.85	P / F
7	9.0 (5A CT)	27.00	8.73	26.19		9.27	27.81	8.37	25.11		8.91	26.73	P / F
6	0.1 (1A CT)	0.30	0.08	0.24		0.11	0.33	0.093	0.279		0.099	0.297	P / F
7	1.0 (1A CT)	3.00	0.97	2.91		1.03	3.09	0.93	2.79		0.99	2.97	P / F
7	1.8 (1A CT)	5.40	1.74	5.22		1.85	5.55	1.67	5.01		1.78	5.34	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

### Timing Verification (I2 Mode, 5A Sensing)

Time Dial Range = 0.0 to 9.9

Timing Accuracy =  $\pm 5\%$  or  $\pm 1\frac{1}{2}$  cycles, whichever is greater

Step	Time Dial	Time Curve	Applied Current	Low	Actual Timing	High	Pass/Fail
4	0.5	I2	3.00 A	0.444 sec		0.491 sec	P / F
4	0.5	I2	7.50 A	0.190 sec		0.240 sec	P / F
4	0.5	I2	27.00 A	0.094 sec		0.174 sec	P / F
4	5.0	I2	3.00 A	4.204 sec		4.647 sec	P / F
4	5.0	I2	7.50 A	1.798 sec		1.988 sec	P / F
4	5.0	I2	27.00 A	1.035 sec		1.145 sec	P / F
4	9.9	I2	3.00 A	8.300 sec		9.173 sec	P / F
4	9.9	I2	7.50 A	3.535 sec		3.907 sec	P / F
4	9.9	I2	27.00 A	2.023 sec		2.237 sec	P / F

### Timing Verification (I2 Mode, 1A Sensing)

Time Dial Range = 0.0 to 9.9

Timing Accuracy =  $\pm 5\%$  or  $\pm 1\frac{1}{2}$  cycles, whichever is greater

Step	Time Dial	Time Curve	Applied Current	Low	Actual Timing	High	Pass/Fail
4	0.5	I2	0.60 A	0.444 sec		0.491 sec	P / F
4	0.5	I2	1.50 A	0.190 sec		0.240 sec	P / F
4	0.5	I2	7.50 A	0.100 sec		0.150 sec	P / F
4	5.0	I2	0.60 A	4.204 sec		4.647 sec	P / F
4	5.0	I2	1.50 A	1.798 sec		1.988 sec	P / F
4	5.0	I2	7.50 A	0.944 sec		1.044 sec	P / F
4	9.9	I2	0.60 A	8.300 sec		9.173 sec	P / F
4	9.9	I2	1.50 A	3.535 sec		3.907 sec	P / F
4	9.9	I2	7.50 A	1.844 sec		2.038 sec	P / F

**Pickup Verification (IG Mode)**

Pickup Setting Range = 0.5 to 16 A for 5A sensing

0.1 to 3.2 A for 1A sensing

0.01 to 0.8 A for SEF

Pickup Accuracy =  $\pm 2\%$  or  $\pm 50$  mA, whichever is greater for 5A sensing $\pm 2\%$  or  $\pm 10$  mA, whichever is greater for 1A sensing $\pm 2.5\%$  or  $\pm 2.5$  mA, whichever is greater for SEF

Dropout should occur between 93-99% of the actual pickup value.

Step	Pickup Setting	Low	Actual Pickup	High	Low*	Actual Dropout	High*	Pass/Fail
6	0.5 A (5A sensing)	0.45 A		0.55 A	0.465 A		0.495 A	P / F
7	5.0 A (5A sensing)	4.90 A		5.10 A	4.65 A		4.95 A	P / F
7	16.0 A (5A sensing)	15.68 A		16.32 A	14.88 A		15.84 A	P / F
6	0.1 A (1A sensing)	0.09 A		0.11 A	0.09 A		0.09 A	P / F
7	1.0 A (1A sensing)	0.98 A		1.02 A	0.93 A		0.99 A	P / F
7	3.2 A (1A sensing)	3.13 A		3.26 A	2.97 A		3.16 A	P / F
6	0.1 A (SEF sensing)	0.0075A		0.0125 A	0.0093 A		0.0099 A	P / F
7	0.5 A (SEF sensing)	0.317 A		0.682 A	0.465 A		0.495 A	P / F
7	0.8 A (SEF sensing)	0.63 A		0.97 A	0.074 A		0.792 A	P / F

\* Dropout range is calculated from the pickup setting and may need adjusted based on actual pickup.

**Timing Verification (IG Mode, 5A Sensing)**

Time Dial Range = 0.0 to 9.9

Timing Accuracy =  $\pm 5\%$  or  $\pm 1\frac{1}{2}$  cycles, whichever is greater

Step	Time Dial	Time Curve	Applied Current	Low	Actual Timing	High	Pass/Fail
4	0.5	I2	1.00 A	0.444 sec		0.491 sec	P / F
4	0.5	I2	2.50 A	0.190 sec		0.240 sec	P / F
4	0.5	I2	12.50 A	0.100 sec		0.150 sec	P / F
4	5.0	I2	1.00 A	4.204 sec		4.647 sec	P / F
4	5.0	I2	2.50 A	1.798 sec		1.988 sec	P / F
4	5.0	I2	12.50 A	0.944 sec		1.044 sec	P / F
4	9.9	I2	1.00 A	8.300 sec		9.173 sec	P / F
4	9.9	I2	2.50 A	3.535 sec		3.907 sec	P / F
4	9.9	I2	12.50 A	1.844 sec		2.038 sec	P / F

**Timing Verification (IG Mode, 1A Sensing)**

Time Dial Range = 0.0 to 9.9

Timing Accuracy =  $\pm 5\%$  or  $\pm 1\frac{1}{2}$  cycles, whichever is greater

Step	Time Dial	Time Curve	Applied Current	Low	Actual Timing	High	Pass/Fail
4	0.5	I2	0.20 A	0.444 sec		0.491 sec	P / F
4	0.5	I2	0.50 A	0.190 sec		0.240 sec	P / F
4	0.5	I2	2.50 A	0.100 sec		0.150 sec	P / F
4	5.0	I2	0.20 A	4.204 sec		4.647 sec	P / F

4	5.0	I2	0.50 A	1.798 sec		1.988 sec	P / F
4	5.0	I2	2.50 A	0.944 sec		1.044 sec	P / F
4	9.9	I2	0.20 A	8.300 sec		9.173 sec	P / F
4	9.9	I2	0.50 A	3.535 sec		3.907 sec	P / F
4	9.9	I2	2.50 A	1.844 sec		2.038 sec	P / F

### Timing Verification (IG Mode, SEF)

Time Dial Range = 0.0 to 9.9

Timing Accuracy =  $\pm 5\%$  or  $\pm 1\frac{1}{2}$  cycles, whichever is greater

Step	Time Dial	Time Curve	Applied Current	Low	Actual Timing	High	Pass/Fail
4	0.5	I2	0.20 A	0.444 sec		0.491 sec	P / F
4	0.5	I2	0.50 A	0.190 sec		0.240 sec	P / F
4	0.5	I2	0.80 A	0.149 sec		0.197 sec	P / F
4	5.0	I2	0.20 A	4.204 sec		4.647 sec	P / F
4	5.0	I2	0.50 A	1.798 sec		1.988 sec	P / F
4	5.0	I2	0.80 A	1.401 sec		1.548 sec	P / F
4	9.9	I2	0.20 A	8.300 sec		9.173 sec	P / F
4	9.9	I2	0.50 A	3.535 sec		3.907 sec	P / F
4	9.9	I2	0.80 A	2.674 sec		3.111 sec	P / F



## 68 • Directional Overcurrent (67) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $\ell$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $\ell$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $\ell$ us<sup>®</sup> to open the BESTlogic $\text{TM}$ Plus Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogicPlus settings are made, click the Save button located on the toolbar to compile BESTlogicPlus. Upload BESTlogicPlus settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Directional Overexcitation (67) Protection* chapter for more information on this function.

### Functional Test Procedure

Step 1: Use BESTCOMSP $\ell$ us to send the operational settings in Table 68-1 to the BE1-11 $\ell$ . Reset all targets.

**Table 68-1. Operational Settings**

Setting	Value	BESTCOMSP $\ell$ us Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to PN
Aux VT Ratio	1	System Parameters, Sensing Transformers	Sets auxiliary VT ratio to 1
Aux VT Connection	AN	System Parameters, Sensing Transformers	Sets auxiliary VT connection to AN
Phase CT Ratio	1	System Parameters, Sensing Transformers	Sets phase CT ratio to 1
67-1 CT Source	CT 1	Protection, Current, Directional (67-1)	Selects the CT Source for 67-1
Maximum Torque Angle Positive Sequence	80°	System Parameters, Power System, 67-1 Maximum Torque Angle	Sets MTA Pos Seq to 80 degrees

Setting	Value	BESTCOMSPi.us Screen	Description
Maximum Torque Angle Negative Sequence	80°	System Parameters, Power System, 67-1 Maximum Torque Angle	Sets MTA Neg Seq to 80 degrees
Element Mode	IA	Protection, Current, Instantaneous Overcurrent (50-1)	Enables 50-1 function for IA mode
Source	CT 1	Protection, Current, Instantaneous Overcurrent (50-1)	Selects the CT source for 50-1
Direction	Forward	Protection, Current, Instantaneous Overcurrent (50-1)	Selects forward direction for 50-1
Directional Source	67-1	Protection, Current, Instantaneous Overcurrent (50-1)	Selects the directional source for the 50-1
Element Mode	3I0	Protection, Current, Instantaneous Overcurrent (50-2)	Enables 50-2 function for 3I0 mode
Source	CT 1	Protection, Current, Instantaneous Overcurrent (50-2)	Selects the CT source for 50-2
Direction	Forward	Protection, Current, Instantaneous Overcurrent (50-2)	Selects forward direction for 50-2
Directional Source	67-1	Protection, Current, Instantaneous Overcurrent (50-2)	Selects the directional source for the 50-2
Element Mode	I2	Protection, Current, Instantaneous Overcurrent (50-3)	Enables 50-3 function for I2 mode
Source	CT 1	Protection, Current, Instantaneous Overcurrent (50-3)	Selects the CT source for 50-3
Direction	Forward	Protection, Current, Instantaneous Overcurrent (50-3)	Selects forward direction for 50-3
Directional Source	67-1	Protection, Current, Instantaneous Overcurrent (50-3)	Selects the directional source for the 50-3
50-1 67 A	Enabled	Target Configuration, Targets	Enables phase A directional target for 50-1
50-2 67 Residual	Enabled	Target Configuration, Targets	Enables residual directional target for 50-2
50-3 67 Neg SEQ	Enabled	Target Configuration, Targets	Enables Neg SEQ directional target for 50-3

Step 2: Use BESTCOMSPi.us to configure the BESTlogicPi.us programmable logic shown in Figure 68-1.

- Blocking is disabled.
- OUT1 closes for 50-1 Trip.
- OUT2 closes for 50-2 Trip
- OUT3 closes for 30-3 Trip.
- Fault recording is enabled for 50-1, 50-2, and 50-3.

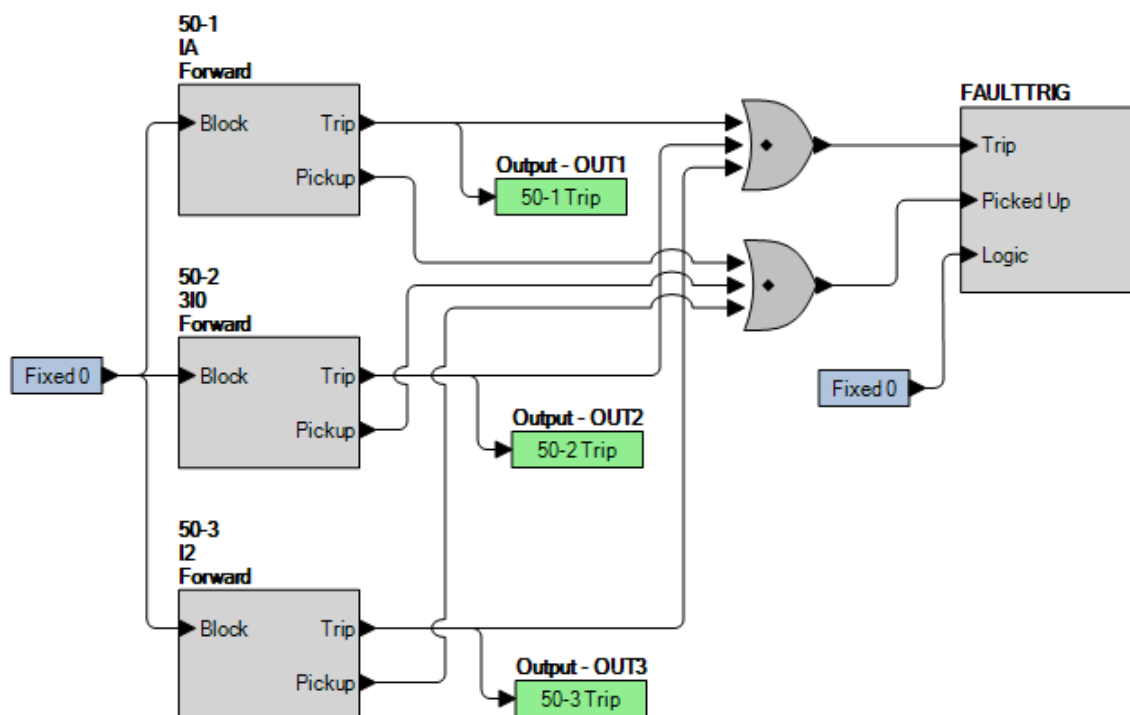


Figure 68-1. BESTlogicPlus Settings

Step 3: Using Table 68-2 as a guide, send the settings to the BE1-11 $t$ . Prior to each directional test, reset the BE1-11 $t$  targets from the previous test. Max Torque Angle setting, for positive and zero sequence impedance angles is continuously adjustable between 0 and 90°, the default setting of 80° is used in the test example.

Table 68-2. Negative-Sequence Polarization Operational Settings

Setting	Value	BESTCOMSPlus Screen	Description
Polarization Method	IG=unchecked Q=checked V=unchecked	Protection, Current, Directional (67-1)	Selects negative sequence polarization
Pickup	2.5 A	Protection, Current, Instantaneous Overcurrent (50-1)	Sets 50-1 pickup to 2.5 amps
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-2)	Sets 50-2 pickup to 0 amps
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-3)	Sets 50-3 pickup to 0 amps

### Positive-Sequence Voltage Polarizing, Phase Overcurrent Elements

- Step 4: Connect and apply a 120 Vac, three-phase voltage source at nominal frequency to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Connect a variable ac current source to terminals D1 (A-phase polarity) and D2 (A-phase non-polarity).
- Step 5: Set A-phase current source to 0 amps with an angle of 80 degrees lagging (positive-sequence torque angle) and slowly increase the current until OUT1 closes. Decrease A-phase current until OUT1 just drops out. Pickup will occur within  $\pm 2\%$  of the 50-1 pickup setting (2.45 A to 2.55A). Dropout will occur at approximately 95% of the actual pickup value. Verify that there is a 50-1-67-A target on the front-panel display.
- Step 6: With three-phase voltage still applied, increase the A-phase current until OUT1 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 80-degree

positive-sequence torque angle. Verify that OUT1 opens at approximately 170 degrees lagging and 350 degrees lagging. OUT1 should remain closed from 170 to 180, and continuing through 350 degrees lagging (defined as forward trip direction).

### Negative-Sequence Voltage Polarizing, Phase Overcurrent Elements

- Step 7: Apply a 120 Vac, three-phase voltage source at nominal frequency to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Reduce the A-phase voltage to 40 Vac. View the Metering screen on the front-panel display to verify that negative-sequence voltage is greater than 1 volt.
- Step 8: Set A-phase current source to 0 amps with an angle of 80 degrees lagging (same as negative-sequence torque angle) and slowly increase the current until OUT1 closes. Pickup will occur within  $\pm 2\%$  of the 50-1 pickup setting (2.45 A to 2.55A). Decrease A-phase current until OUT1 just drops out. Dropout will occur at approximately 95% of the actual pickup value. Verify that there is a 50-1-67-A target on the front-panel display.
- Step 9: With the same voltage still applied, increase the A-phase current until OUT1 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 80-degree negative-sequence torque angle. Verify that OUT1 opens at approximately 170 degrees lagging and 350 degrees lagging. OUT1 should remain closed from 170 to 180, and continuing through 350 degrees lagging (defined as forward trip direction).
- Step 10: (Optional.) Repeat steps 4 through 9 for B-phase current (D3 and D4) and C-phase current (D5 and D6).

### Negative-Sequence Voltage Polarizing, Negative-Sequence Overcurrent Elements

- Step 11: Using Table 68-3 as a guide, send the settings to the BE1-11t.

**Table 68-3. Directional, Negative-Sequence Operational Settings**

Setting	Value	BESTCOMSPiUS Screen	Description
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-1)	Sets 50-1 pickup to 0 amps
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-2)	Sets 50-2 pickup to 0 amps
Pickup	0.5 A	Protection, Current, Instantaneous Overcurrent (50-3)	Sets 50-3 pickup to 0.5 amps

- Step 12: Apply a 120 Vac, three-phase voltage source at nominal frequency to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Reduce the A-phase voltage to 40 Vac. View the Metering screen on the front-panel display to verify that negative-sequence voltage is greater than 1 volt.
- Step 13: Set A-phase current source to 0 amps with an angle of 80 degrees lagging (same as negative-sequence torque angle) and slowly increase the current until OUT3 closes (Negative-Sequence Pickup current will be approximately 1/3 the applied A-phase current value). Decrease A-phase current until OUT3 just drops out. Pickup will occur within  $\pm 2\%$  of the 50-3 pickup setting (0.4 A to 0.6 A). Dropout will occur at approximately 95% of the actual pickup value. Verify that there is a 50-3-67-Neg SEQ target on the front-panel display.
- Step 14: With the same voltage still applied, increase the A-phase current until OUT3 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 80-degree negative-sequence torque angle. Verify that OUT3 opens at approximately 170 degrees lagging and 350 degrees lagging. OUT3 should remain closed from 170 to 180, and continuing through 350 degrees lagging (defined as forward trip direction).
- Step 15: Using Table 68-4 as a guide, send the settings to the BE1-11t.

**Table 68-4. Directional, Neutral Operational Settings**

Setting	Value	BESTCOMSP <sup>Plus</sup> Screen	Description
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-1)	Sets 50-1 pickup to 0 amps
Pickup	2.0 A	Protection, Current, Instantaneous Overcurrent (50-2)	Sets 50-2 pickup to 2.0 amps
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-3)	Sets 50-3 pickup to 0 amps

Step 16: Apply a 120 Vac, three-phase voltage source at nominal frequency to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral). Reduce the A-phase voltage to 40 Vac. View the Metering screen on the front-panel display to verify that negative-sequence voltage is greater than 1 volt.

Step 17: Set A-phase current source to 0 amps with an angle of 80 degrees lagging (same as negative-sequence torque angle) and slowly increase the current until OUT2 closes. Decrease A-phase current until OUT2 just drops out. Pickup will occur within  $\pm 2\%$  of the 50-2 pickup setting (1.96 A to 2.04 A). Dropout will occur at approximately 95% of the actual pickup value. Verify that there is a 50-2-67-Residual target on the front-panel display.

Step 18: With the same voltage still applied, increase the A-phase current until OUT2 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 80-degree negative-sequence torque angle. Verify that OUT2 opens at approximately 170 degrees lagging and 350 degrees lagging. OUT2 should remain closed from 170 through 80 to 350 degrees lagging (defined as forward trip direction).

### Negative-Sequence Voltage Polarizing, Ground Overcurrent Elements

Step 19: Using Table 68-5 as a guide, send the settings to the BE1-11 $t$ .

**Table 68-5. Directional, Negative-Sequence Polarizing, Neutral Operational Settings**

Setting	Value	BESTCOMSP <sup>Plus</sup> Screen	Description
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-1)	Sets 50-1 pickup to 0 amps
Pickup	2.0 A	Protection, Current, Instantaneous Overcurrent (50-2)	Sets 50-2 pickup to 2.0 amps
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-3)	Sets 50-3 pickup to 0 amps

Step 20: Apply a 120 Vac, three-phase voltage source at nominal frequency to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral). Reduce the A-phase voltage to 40 Vac. View the Metering screen on the front-panel display to verify that negative-sequence voltage is greater than 1 volt.

Step 21: Set A-phase current source to 0 amps with an angle of 80 degrees lagging (same as torque-sequence line angle) and slowly increase the current until OUT2 closes. Decrease A-phase current until OUT2 just drops out. Pickup will occur within  $\pm 2\%$  of the 50-2 pickup setting (1.96 A to 2.04 A). Dropout will occur at approximately 95% of the actual pickup value. Verify that there is a 50-2-67-Residual target on the front-panel display.

Step 22: With the same voltage still applied, increase the A-phase current until OUT2 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 80-degree positive-sequence torque angle. Verify that OUT2 opens at approximately 170 degrees lagging and 350 degrees lagging. OUT2 should remain closed from 170 through 80 to 350 degrees lagging (defined as forward trip direction).

### Zero-Sequence Voltage Polarizing, Ground Overcurrent Elements

Step 23: Using Table 68-6 as a guide, send the settings to the BE1-11 $t$ .

**Table 68-6. Directional, Voltage Polarizing, Neutral Operational Settings**

Setting	Value	BESTCOMSP <sup>Plus</sup> Screen	Description
Polarization Method	IG=unchecked Q=unchecked V=checked	Protection, Current, Directional (67-1)	Selects negative sequence polarization
Zero Sequence Mode	VOIN	Protection, Current, Directional (67-1)	Selects VOIN for zero sequence mode
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-1)	Sets 50-1 pickup to 0 amps
Pickup	2.0 A	Protection, Current, Instantaneous Overcurrent (50-2)	Sets 50-2 pickup to 2.0 amps
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-3)	Sets 50-3 pickup to 0 amps

- Step 24: Apply a 120 Vac, three-phase voltage source at nominal frequency to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral). Reduce the A-phase voltage to 40 Vac. View the Metering screen on the front-panel display to verify that the zero sequence voltage is greater than 80 volts.
- Step 25: Set A-phase current source to 0 amps with an angle of 80 degrees lagging (zero sequence line angle) and slowly increase the current until OUT2 closes. Decrease A-phase current until OUT2 just drops out. Pickup will occur within  $\pm 2\%$  of the 50-2 pickup setting (1.96 A to 2.04 A). Dropout will occur at approximately 95% of the actual pickup value. Verify that there is a 50-2-67-Residual target on the front-panel display.
- Step 26: With the same voltage still applied, increase the A-phase current until OUT2 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 80-degree zero-sequence line angle. Verify that OUT2 opens at approximately 170 degrees lagging and 350 degrees lagging. OUT2 should remain closed from 170 through 80 to 350 degrees lagging (defined as forward trip direction). Steps 23 through 26 verify polarizing reference quantities VOIN, with 50-2 set to operate for calculated 3I0 as per Table 68-1. The 50-2 element can also be set to operate for measured ground current IG while still being polarized by VOIN. To verify, connect A-phase current in series with IG current. That is, polarity current should go in D1 out D2, in D7 out D8. Repeat steps 24 through 26 with 50-2 mode set for IG operate and 50-2 target set for 50-2-67-IND GND. Verify that there is a 50-2-67-IND GND target on the front-panel display.
- Step 27: Set Zero Sequence Mode to VOIG on the Protection, Current, Directional (67-1) screen. The polarizing reference quantities are V0 compared to IG measured. This compares calculated V0 to measured IG (independent ground input). Repeat steps 24 through 26 with A-phase current connected in series with IG current. That is, polarity current should go in D1 out D2, in D7 out D8. Verify that there is a 50-2-67-IND GND target on the front-panel display. Note that 50-2 can also be set to operate for calculated IN (3I0) while still being polarized by VOIG. Verify operation by repeating steps 24 through 26 with 50-2 set for 3I0 operate. Verify that there is a 50-2-67-Residual target on the front-panel display.
- Step 28: Set Zero Sequence Mode to VXIG on the Protection, Current, Directional (67-1) screen. Set 50-2 mode to IG on the Protection, Current, Instantaneous Overcurrent (50-2) screen. The polarizing reference quantities are an external source of 3V0 applied at the VX input compared to measured IG (independent ground input). Apply polarity of a single-phase voltage source (30 Vac at nominal frequency) to terminal C17 and non-polarity to C18 at an angle of 180 degrees lagging. An angle of 180 degrees is used to simulate a broken delta voltage where polarity to non-polarity is 180 degrees out of phase with, for example, the A-phase current during an A-phase to ground fault. The BE1-11<sub>t</sub> internally compensates for the 180 degree phase difference such that polarity voltage from the broken delta source connected to polarity of the BE1-11<sub>t</sub> results in a 0 degree condition for a Forward fault. To verify, connect A-phase current in series with IG current. That is, polarity current should go in D1 out D2, in D7 out D8. Repeat steps 25 and 26 with 50-2 set for IG operate. Verify that there is a 50-2-67-IND GND target on the front-

panel display. Note that 50-2 can also be set to operate for calculated IN (3I0) while still being polarized by VXIG. Verify operation by repeating steps 25 and 26 with 50-2 set for 3I0 operate. Verify that there is a 50-2-67-Residual target on the front-panel display.

- Step 29: Set Zero Sequence Mode to VXIN on the Protection, Current, Directional (67-1) screen. The polarizing reference quantities are an external source of 3V0 applied at the VX input compared to the calculated IN (3I0) quantity. Apply polarity of a single-phase voltage source (30 Vac at nominal frequency) to terminal C17 and non-polarity to C18 at an angle of 180 degrees lagging. An angle of 180 degrees is used to simulate a broken delta voltage where polarity to non-polarity is 180 degrees out of phase with, for example, the A-phase current during an A-phase to ground fault. The BE1-11 $\tau$  internally compensates for the 180 degree phase difference such that polarity voltage from the broken delta source connected to polarity of the BE1-11 $\tau$  results in a 0 degree condition for a Forward fault. To verify, connect A-phase current in series with IG current. That is, polarity current should go in D1 out D2 and in D7 out D8 if IG is available. Repeat steps 25 and 26 with 50-2 set for 3I0 operate. Verify that there is a 50-2-67-Residual target on the front-panel display. Note that 50-2 can also be set to operate for measured independent ground (IG) while still being polarized by VXIN. Verify operation by repeating steps 25 and 26 with 50-2 set for 3I0 operate. Verify that there is a 50-2-67-Residual target on the front-panel display.
- Step 30: Repeat steps 4 through 29 for "Reverse Polarization." BE1-11 $\tau$  operation will occur 180 degrees away from the Positive and Negative Sequence torque angle (both at 80 degrees or 260 degrees I lags E in our example). Verify that the output contacts remain closed from 170 through 260 to 350 degrees I lags E.
- Step 31: (Optional.) Repeat steps 4 through 30 for 50-4, 50-5, and 50-6. Setup commands and associated operational setting Tables must be modified accordingly.
- Step 32: (Optional.) Repeat steps 4 through 31 for settings group 1, 2, and 3.
- Step 33: (Optional.) Repeat steps 1 through 33 with CT Circuit 2 selected as the CT source for the instantaneous overcurrent (50) and directional overcurrent (67) elements, and 67-2 as the directional source. In Step 1, D7 with F7, D8 with F8.

## Zero-Sequence Current Polarization

Use setup commands in Table 68-1. Using Table 68-7 as a guide, send the settings to the BE1-11 $\tau$ .

**Table 68-7. Directional, Current-Polarizing, Neutral Operational Settings**

Setting	Value	BESTCOMSP $\text{Plus}$ Screen	Description
Polarization Method	IG=checked Q=unchecked V=unchecked	Protection, Current, Directional (67-1)	Selects zero sequence current polarization
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-1)	Sets 50-1 pickup to 0 amps
Pickup	2.0 A	Protection, Current, Instantaneous Overcurrent (50-2)	Sets 50-2 pickup to 2.0 amps
Pickup	0 A	Protection, Current, Instantaneous Overcurrent (50-3)	Sets 50-3 pickup to 0 amps

- Step 1: Apply 2 Aac current at 0 degrees to the independent ground input IG, terminals D7 (polarity) and D8 (non-polarity). No ac voltage is required for this test.
- Step 2: From a second current source, apply 0 amp A-phase current at an angle of 0 degrees and slowly increase the current until OUT2 closes. Decrease A-phase current until OUT2 just drops out. Pickup will occur within  $\pm 2\%$  of the 50-2 pickup setting (1.96 A to 2.04 A). Dropout will occur at approximately 95% of the actual pickup value. Verify that there is a 50-2-67-Residual target on the front-panel display.
- Step 3: With the same polarizing current applied, increase the A-phase current until OUT2 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 0. Verify

that OUT2 opens at approximately 90 degrees lagging and 270 degrees lagging. OUT2 should remain closed from 90 through 0 to 270 degrees lagging (defined as forward trip direction).

- Step 4: Repeat steps 1 through 4 for "Reverse Polarization by selecting Reverse direction on the Protection, Current, Instantaneous Overcurrent (50-2) screen. BE1-11 $t$  operation will occur at 180 degrees lagging. Swing the angle of the applied current +90 degrees and –90 degrees away from the 180 degrees. Verify that OUT2 opens at approximately 90 degrees lagging and 270 degrees lagging. OUT2 should remain closed from 90 through 180 to 270 degrees lagging (defined as reverse trip direction).
- Step 5: (Optional.) Repeat steps 1 through 5 for 50-4, 50-5, and 50-6. Setup commands in Table 68-1 and operational settings in Table 68-7 must be modified accordingly.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 with CT Circuit 2 selected as the CT source for the instantaneous overcurrent (50) and directional overcurrent (67) elements, and 67-2 as the directional source. In Step 1, D7 with F7, D8 with F8.

### ***Functional Test Report***

<b>Steps</b>	<b>Function</b>	<b>Pass/Fail</b>
4-6	Positive-Sequence Voltage Polarizing, Phase Overcurrent Elements	P / F
7-10	Negative-Sequence Voltage Polarizing, Phase Overcurrent Elements	P / F
11-18	Negative-Sequence Voltage Polarizing, Negative-Sequence Overcurrent Elements	P / F
19-22	Negative-Sequence Voltage Polarizing, Ground Overcurrent Elements	P / F
23-32	Zero-Sequence Voltage Polarizing, Ground Overcurrent Elements	P / F
1-6	Zero-Sequence Current Polarization	P / F

## 69 • Phase Current Differential (87) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $\iota$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $\iota$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $\iota$  to open the BESTlogic $\text{TM}$ Plus Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogicPlus settings are made, click the Save button located on the toolbar to compile BESTlogicPlus. Upload BESTlogicPlus settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Phase Current Differential (87) Protection* chapter for more information on this function.

### Restrained Functional Test Procedure

#### Pickup Verification (Maximum Restraint)

Step 1: Use BESTCOMSP $\iota$  to send the operational settings in Table 69-1. Reset all targets.

**Table 69-1. Operational Settings (87R - Maximum)**

Setting	Value	BESTCOMSP $\iota$ Screen	Description
Nominal Phase Voltage	69.3 V	System Parameters, Power System	Sets the nominal secondary sensing voltage to 69.3 V
Nominal Phase Current	5 A	System Parameters, Power System	Sets the nominal secondary sensing current to 5 A
Nominal Aux. Voltage	69.3 V	System Parameters, Power System	Sets the nominal secondary auxiliary voltage to 69.3 V
Phase CT 1 Ratio	1	System Parameters, Sensing Transformers	Sets the phase CT 1 ratio to 1
CT 1 Connection	WYE	System Parameters, Sensing Transformers	Sets the CT 1 connection to WYE
Phase CT 2 Ratio	1	System Parameters, Sensing Transformers	Sets the phase CT 2 ratio to 1
CT 2 Connection	WYE	System Parameters, Sensing Transformers	Sets the CT 2 connection to WYE

Setting	Value	BESTCOMSPPlus Screen	Description
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to phase-neutral
Circuit 1 Transformer Connection	N/A	System Parameters, Transformer Setup	Configures the primary side for a WYE connection
Circuit 1 Ground Compensation	No	System Parameters, Transformer Setup	Disables the primary winding zero sequence trap
(Optional) Circuit 1 Differential Circuit	Primary	System Parameters, Transformer Setup	Establishes circuit 1 on the primary side of the transformer. For report labeling purposes only.
Circuit 1 Polarity	Normal	System Parameters, Transformer Setup	Sets the phase rotation of circuit 1 for ABC
Circuit 1 Phase Relationship	A	System Parameters, Transformer Setup	Sets A-phase in circuit 1 equal to the phase relationship setting for circuit 2
Circuit 2 Transformer Connection	N/A	System Parameters, Transformer Setup	Configures the secondary side for a WYE connection
Circuit 2 Ground Compensation	No	System Parameters, Transformer Setup	Disables the secondary winding zero sequence trap
(Optional) Circuit 2 Differential Circuit	Secondary	System Parameters, Transformer Setup	Establishes circuit 2 on the secondary side of the transformer. For report labeling purposes only.
Circuit 2 Polarity	Normal	System Parameters, Transformer Setup	Sets the phase rotation of circuit 2 for ABC
Circuit 2 Phase Relationship	A	System Parameters, Transformer Setup	Sets A-phase in circuit 2 equal to the phase relationship setting for circuit 1
(Optional) IEC Setup Winding 1	Wye Primary	System Parameters, Transformer Setup, IEC Transformer Setup	Configures the primary side for a WYE connection
(Optional) IEC Setup Winding 2	y0 Secondary	System Parameters, Transformer Setup, IEC Transformer Setup	Configures the secondary side for a WYE connection with normal ABC phase rotation
Circuit 1 Tap	2.00	System Parameters, Transformer Setup	Sets the tap for circuit 1 to 2.00 A secondary
Circuit 2 Tap	2.00	System Parameters, Transformer Setup	Sets the tap for circuit 2 to 2.00 A secondary

Setting	Value	BESTCOMSP <sub>Plus</sub> Screen	Description
Mode	Percent Differential	Protection, Current, Phase Differential (87)	Sets the type of operation protection to traditional phase current differential
Slope Mode	Maximum	Protection, Current, Phase Differential (87)	Sets the element to operate using maximum restraint current
Min. Rest. Pickup (MOT)	0.10	Protection, Current, Phase Differential (87)	Sets the minimum amount of operate current required for a trip to 0.10x tap
Restraint Slope 1 (%)	20	Protection, Current, Phase Differential (87)	Sets the 1 <sup>st</sup> slope of the restraint characteristic to 20%
2 <sup>nd</sup> Slope Pickup (MOT)	3.00	Protection, Current, Phase Differential (87)	The 2 <sup>nd</sup> slope is active when the measured maximum restraint current is greater 3x tap
Restraint Slope 2 (%)	40	Protection, Current, Phase Differential (87)	Sets the 2 <sup>nd</sup> slope of the restraint characteristic to 40%
Time Delay (ms)	100	Protection, Current, Phase Differential (87)	Sets the trip time delay to 100 ms
(Optional) Harmonics Mode	Independent	Protection, Current, Phase Differential (87)	Sets the harmonic restraint for independent phase operation
(Optional) 2 <sup>nd</sup> Harmonic (%)	12	Protection, Current, Phase, Differential (87)	Sets the second harmonic restraint threshold to 12% of the fundamental
(Optional) 5 <sup>th</sup> Harmonic (%)	35	Protection, Current, Phase Differential (87)	Sets the fifth harmonic restraint threshold to 35% of the fundamental

Step 2: Use BESTCOMSP<sub>Plus</sub> to configure the BESTlogic<sub>Plus</sub> programmable logic shown in Figure 69-1.

- Blocking is disabled.
- OUT1 closes for 87 Trip.
- OUT2 closes for 87 Pickup.
- Fault recording is enabled.

Step 3: Prepare to monitor the 87R function operation. Operation can be verified by monitoring OUT2 (see Figure 69-1).

Step 4: To test the Minimum Restrained Pickup setting, connect two balanced three-phase current sources to the BE1-11<sub>r</sub> in ABC rotation: 0.5∠0°, 0.5∠-120°, 0.5∠120° amps to terminals D1 through D6 and 0.5∠180°, 0.5∠60°, 0.5∠-60° amps to terminals F1 through F6 (0.25x tap).

Step 5: Slowly increase the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 0.70 A ±0.05 A. Verify that there is an 87A target on the front-panel display.

Step 6: Slowly decrease the A-phase current in CT circuit 1 or 2 until OUT2 reopens and record the dropout. See the functional test report for acceptable ranges.

Step 7: Reset to the current levels in step 4 and reset all targets.

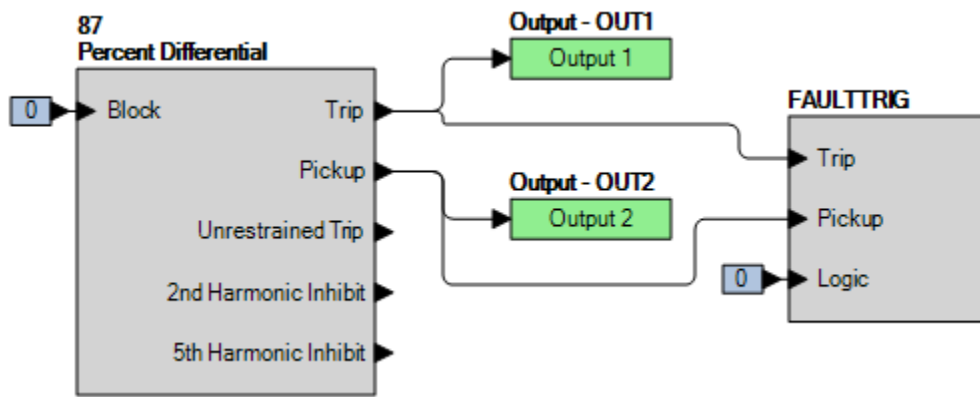


Figure 69-1. BESTlogicPlus Settings (87R)

- Step 8: Slowly decrease the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 0.30 A  $\pm$ 0.05 A. Verify that there is an 87A target on the front-panel display.
- Step 9: Slowly increase the A-phase current in CT circuit 1 or 2 until OUT2 reopens and record the dropout. See the functional test report for acceptable ranges.
- Step 10: To test the Restraint Slope 1 setting, connect two balanced three-phase current sources to the BE1-11 $\tau$  in ABC rotation: 3.0 $\angle$ 0°, 3.0 $\angle$ -120°, 3.0 $\angle$ 120° amps to terminals D1 through D6 and 3.0 $\angle$ 180°, 3.0 $\angle$ 60°, 3.0 $\angle$ -60° amps to terminals F1 through F6 (1.5x tap).
- Step 11: Slowly increase the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 3.75 A  $\pm$ 0.08 A. Verify that there is an 87A target on the front-panel display.
- Step 12: Reset to the current levels in step 10 and reset all targets.
- Step 13: Slowly decrease the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 2.40 A  $\pm$ 0.05 A. Verify that there is an 87A target on the front-panel display.
- Step 14: To test the Restraint Slope 2 setting, connect two balanced three-phase current sources to the BE1-11 $\tau$  in ABC rotation: 6.5 $\angle$ 0°, 6.5 $\angle$ -120°, 6.5 $\angle$ 120° amps to terminals D1 through D6 and 6.5 $\angle$ 180°, 6.5 $\angle$ 60°, 6.5 $\angle$ -60° amps to terminals F1 through F6 (3.25x tap).
- Step 15: Slowly increase the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 8.83 A  $\pm$ 0.18 A. Verify that there is an 87A target on the front-panel display.
- Step 16: Reset to the current levels in step 14 and reset all targets.
- Step 17: Slowly decrease the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 5.10 A  $\pm$ 0.10 A. Verify that there is an 87A target on the front-panel display.
- Step 18: (Optional.) Repeat steps 1 through 17 for the B-phase and C-phase current inputs.
- Step 19: (Optional.) Repeat steps 1 through 18 for settings group 1, 2, and 3.

### Pickup Verification (Average Restraint)

Step 1: Use BESTCOMSP $\mu$ s to send the operational settings in Table 69-2. Reset all targets.

Table 69-2. Operational Settings (87R - Average)

Setting	Value	BESTCOMSP $\mu$ s Screen	Description
Nominal Phase Voltage	69.3 V	System Parameters, Power System	Sets the nominal secondary sensing voltage to 69.3 V

Setting	Value	BESTCOMSP <sup>Plus</sup> Screen	Description
Nominal Phase Current	5 A	System Parameters, Power System	Sets the nominal secondary sensing current to 5 amps
Nominal Aux. Voltage	69.3 V	System Parameters, Power System	Sets the nominal secondary auxiliary voltage to 69.3 V
Phase CT 1 Ratio	1	System Parameters, Sensing Transformers	Sets the phase CT ratio to 1
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Phase VT Connection	4W-Y	System Parameters, Sensing Transformers	Sets phase VT connection to 4W-Y
27/59 Mode	PN	System Parameters, Sensing Transformers	Sets 27/59 mode to phase-neutral
Circuit 1 Transformer Connection	WYE	System Parameters, Transformer Setup	Configures the primary side for a WYE connection
Circuit 1 Ground Compensation	No	System Parameters, Transformer Setup	Disables the primary winding zero sequence trap
(Optional) Circuit 1 Differential Circuit	Primary	System Parameters, Transformer Setup	Establishes circuit 1 on the primary side of the transformer. For report labeling purposes only.
Circuit 1 Polarity	Normal	System Parameters, Transformer Setup	Sets the phase rotation of circuit 1 for ABC
Circuit 1 Phase Relationship	A	System Parameters, Transformer Setup	Sets A-phase in circuit 1 equal to the phase relationship setting for circuit 2
Circuit 2 Transformer Connection	WYE	System Parameters, Transformer Setup	Configures the secondary side for a WYE connection
Circuit 2 Ground Compensation	No	System Parameters, Transformer Setup	Disables the secondary winding zero sequence trap
(Optional) Circuit 2 Differential Circuit	Secondary	System Parameters, Transformer Setup	Establishes circuit 2 on the secondary side of the transformer. For report labeling purposes only.
Circuit 2 Polarity	Normal	System Parameters, Transformer Setup	Sets the phase rotation of circuit 2 for ABC
Circuit 2 Phase Relationship	A	System Parameters, Transformer Setup	Sets A-phase in circuit 2 equal to the phase relationship setting for circuit 1
(Optional) IEC Setup Winding 1	Wye Primary	System Parameters, Transformer Setup, IEC Transformer Setup	Configures the primary side for a WYE connection
(Optional) IEC Setup Winding 2	y0 Secondary	System Parameters, Transformer Setup, IEC Transformer Setup	Configures the secondary side for a WYE connection with normal ABC phase rotation

Setting	Value	BESTCOMSP <sup>Plus</sup> Screen	Description
Circuit 1 Tap	2.00	System Parameters, Transformer Setup	Sets the tap for circuit 1 to 2.00 A secondary
Circuit 2 Tap	2.00	System Parameters, Transformer Setup	Sets the tap for circuit 2 to 2.00 A secondary
Mode	Percent Differential	Protection, Current, Phase Differential (87)	Sets the type of operation protection to traditional phase current differential
Slope Mode	Average	Protection, Current, Phase Differential (87)	Sets the element to operate using average restraint current
Min. Rest. Pickup (MOT)	0.10	Protection, Current, Phase Differential (87)	Sets the minimum amount of operate current required for a trip to 0.10x tap
Restraint Slope 1 (%)	20	Protection, Current, Phase Differential (87)	Sets the 1 <sup>st</sup> slope of the restraint characteristic to 20%
2 <sup>nd</sup> Slope Pickup (MOT)	3.00	Protection, Current, Phase Differential (87)	The 2 <sup>nd</sup> slope is active when the measured maximum restraint current is greater 3x tap
Restraint Slope 2 (%)	40	Protection, Current, Phase Differential (87)	Sets the 2 <sup>nd</sup> slope of the restraint characteristic to 40%
(Optional) Unrestrained Tripping Mode	Enabled	Protection, Current, Phase Differential (87)	Enables the unrestrained element
(Optional) Unrestrained Tripping Pickup	2	Protection, Current, Phase Differential (87)	Sets the operate current pickup for unrestrained tripping to 2x tap
Time Delay (ms)	100	Protection, Current, Phase Differential (87)	Sets the trip time delay to 100 ms
(Optional) Harmonics Mode	Shared	Protection, Current, Phase Differential (87)	Sets the harmonic restraint for shared phase operation
(Optional) 2 <sup>nd</sup> Harmonic (%)	12	Protection, Current, Phase, Differential (87)	Sets the second harmonic restraint threshold to 12% of the fundamental
(Optional) 5 <sup>th</sup> Harmonic (%)	35	Protection, Current, Phase Differential (87)	Sets the fifth harmonic restraint threshold to 35% of the fundamental

- Step 2: Use BESTCOMSP<sup>Plus</sup> to configure the BESTlogic<sup>Plus</sup> programmable logic previously shown in Figure 69-1.
- Step 3: Prepare to monitor the 87R function operation. Operation can be verified by monitoring OUT2 (see Figure 69-1).
- Step 4: To test the Minimum Restrained Pickup setting, connect two balanced three-phase current sources to the BE1-11<sub>i</sub> in ABC rotation: 0.5∠0°, 0.5∠-120°, 0.5∠120° amps to terminals D1 through D6 and 0.5∠180°, 0.5∠60°, 0.5∠-60° amps to terminals F1 through F6 (0.25x tap).
- Step 5: Slowly increase the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 0.70 A ±0.05 A. Verify that there is an 87A target on the front-panel display.

- Step 6: Slowly decrease the A-phase current in CT circuit 1 or 2 until OUT2 reopens and record the dropout. See the functional test report for acceptable ranges.
- Step 7: Reset to the current levels in step 4 and reset all targets.
- Step 8: Slowly decrease the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 0.30 A  $\pm$ 0.05 A. Verify that there is an 87A target on the front-panel display.
- Step 9: Slowly increase the A-phase current in CT circuit 1 or 2 until OUT2 reopens and record the dropout. See the functional test report for acceptable ranges.
- Step 10: To test the Restraint Slope 1 setting, connect two balanced three-phase current sources to the BE1-11 $t$  in ABC rotation: 3.0 $\angle$ 0°, 3.0 $\angle$ -120°, 3.0 $\angle$ 120° amps to terminals D1 through D6 and 3.0 $\angle$ 180°, 3.0 $\angle$ 60°, 3.0 $\angle$ -60° amps to terminals F1 through F6 (1.5x tap).
- Step 11: Slowly increase the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 3.67 A  $\pm$ 0.07 A. Verify that there is an 87A target on the front-panel display.
- Step 12: Reset to the current levels in step 10 and reset all targets.
- Step 13: Slowly decrease the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 2.46 A  $\pm$ 0.05 A. Verify that there is an 87A target on the front-panel display.
- Step 14: To test the Restraint Slope 2 setting, connect two balanced three-phase current sources to the BE1-11 $t$  in ABC rotation: 6.5 $\angle$ 0°, 6.5 $\angle$ -120°, 6.5 $\angle$ 120° amps to terminals D1 through D6 and 6.5 $\angle$ 180°, 6.5 $\angle$ 60°, 6.5 $\angle$ -60° amps to terminals F1 through F6 (3.25x tap).
- Step 15: Slowly increase the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 8.25 A  $\pm$ 0.17 A. Verify that there is an 87A target on the front-panel display.
- Step 16: Reset to the current levels in step 14 and reset all targets.
- Step 17: Slowly decrease the A-phase current in CT circuit 1 or 2 until OUT2 closes and record the pickup. This should occur at 5.32 A  $\pm$ 0.11 A. Verify that there is an 87A target on the front-panel display.
- Step 18: (Optional.) Repeat steps 1 through 17 for the B-phase and C-phase current inputs.
- Step 19: (Optional.) Repeat steps 1 through 18 for settings group 1, 2, and 3.

### Timing Verification (Maximum or Average Restraint)

- Step 1: Use BESTCOMSP $Plus$  to verify the operational settings in Table 69-1 (Maximum) or 2 (Average) and logic in Figure 69-1. Reset all targets.
- Step 2: Prepare to monitor the 87 timings. Timing accuracy is verified by measuring the elapsed time between OUT2 (pickup) and OUT1 (trip) closing.
- Step 3: Connect two balanced three-phase current sources to the BE1-11 $t$  in ABC rotation: 3.0 $\angle$ 0°, 3.0 $\angle$ -120°, 3.0 $\angle$ 120° amps to terminals D1 through D6 and 3.0 $\angle$ 180°, 3.0 $\angle$ 60°, 3.0 $\angle$ -60° amps to terminals F1 through F6.
- Step 4: Slowly increase the A-phase current in CT circuit 1 or 2 until OUT2 closes. Record the time between OUT2 and OUT1 closing. This should be 100 ms  $\pm$  (50 ms + 2 cycles).
- Step 5: (Optional) Repeat steps 1 through 4 for settings group 1, 2, and 3.

## Unrestrained Functional Test Procedure

### Pickup Verification

Step 1: Use BESTCOMSP*lus* to verify the operational settings in Table 69-2 and logic in Figure 69-2. Reset all targets.

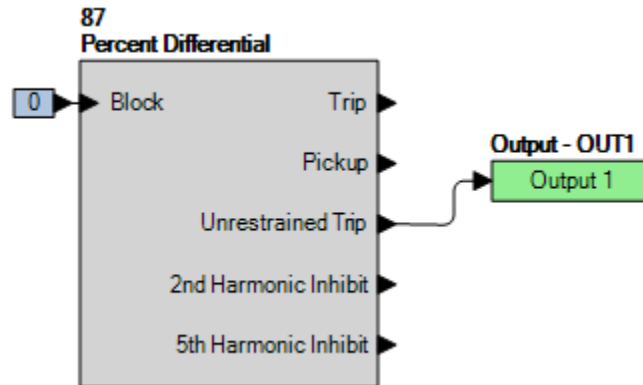


Figure 69-2. BESTlogicPlus Settings (87U)

- Step 2: Prepare to monitor the unrestrained 87 element. Operation can be verified by monitoring OUT1 (see Figure 69-2).
- Step 3: Connect a single-phase current source to terminals D1 (A-phase polarity) and D2 (A-phase non-polarity).
- Step 4: Slowly increase the current magnitude until OUT1 closes and record the pickup. This should occur at 4.0 A  $\pm$ 0.08 A. Verify that there is an 87 Unrestrained A target on the HMI screen.
- Step 5: (Optional.) Repeat steps 1 through 4 for B-phase (terminals D3 and D4) and C-phase (terminals D5 and D6).
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.

## Harmonic Restraint Functional Test Procedure

### Second Harmonic Restraint Verification (Independent)

- Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 69-1 and verify the logic in Figure 69-1. Reset all targets.
- Step 2: Connect in parallel an A-phase current source of 50 or 60-hertz and a second A-phase current source of twice the applied fundamental (100 or 120-hertz) to terminals D1 (A-phase polarity) and D2 (A-phase non-polarity).
- Step3: Apply 2 amps at 0° of the 50 or 60-hertz source. OUT2 should close immediately and OUT1 after the programmed time delay of 100 ms. Verify that there is an 87A target on the front-panel display screen.
- Step 4: Increase the second harmonic current source until OUT1 opens and record the magnitude of the second harmonic source.
- Step 5: To calculate the second-harmonic Restraint percentage, divide the second-harmonic current measured in step 4 by the current applied in step 3. (Divide the harmonic current by the fundamental current.). This should be 12% or 0.24 A  $\pm$ 0.05 A.
- Step 6: (Optional.) Repeat steps 1 through 5 for the B-phase (terminals D3 and D4) and C-phase (terminals D5 and D6) current inputs.
- Step 7: (Optional.) Repeat steps 1 through 6 for settings group 1, 2, and 3.

**Second-Harmonic Restraint Verification (Shared)**

- Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 69-2 and verify the logic in Figure 69-1. Reset all targets.
- Step 2: Connect in parallel a balanced, three-phase current source of 50 or 60-hertz and a second three-phase current source of twice the applied fundamental (100 or 120-hertz) to terminals D1 through D6.
- Step3: Apply 2 amps at 0° of the 50 or 60-hertz source. OUT2 should close immediately and OUT1 after the programmed time delay of 100 ms. Verify that there is an 87A, 87B, and 87C target on the front-panel display.
- Step 4: Increase the second-harmonic current source until OUT1 opens and record the magnitude of the second-harmonic source.
- Step 5: To calculate the second-harmonic restraint percentage, divide the second-harmonic current measured in step 4 by the current applied in step 3 and multiply the result by 3. This should be 12% or  $3 \times (0.08 \text{ A each phase}) \pm 0.05 \text{ A}$ .
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.

**Fifth-Harmonic Restraint Verification (Independent)**

- Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 69-1 and verify the logic in Figure 69-1. Reset all targets.
- Step 2: Connect in parallel an A-phase current source of 50 or 60-hertz and a second A-phase current source of five times the applied fundamental (250 or 300-hertz) to terminals D1 (A-phase polarity) and D2 (A-phase non-polarity).
- Step3: Apply 2 amps at 0° of the 50 or 60-hertz source. OUT2 should close immediately and OUT1 after the programmed time delay of 100 ms. Verify that there is an 87A target on the front-panel display.
- Step 4: Increase the fifth-harmonic current source until OUT1 opens and record the magnitude of the fifth-harmonic source.
- Step 5: To calculate the fifth-harmonic restraint percentage, divide the fifth-harmonic current measured in step 4 by the current applied in step 3. (Divide the harmonic current by the fundamental current.). This should be 35% or  $0.70 \text{ A} \pm 0.05 \text{ A}$ .
- Step 6: (Optional.) Repeat steps 1 through 5 for the B-phase (terminals D3 and D4) and C-phase (terminals D5 and D6) current inputs.
- Step 7: (Optional.) Repeat steps 1 through 6 for settings group 1, 2, and 3.

**Fifth-Harmonic Restraint Verification (Shared)**

- Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 69-2 and verify the logic in Figure 69-1. Reset all targets.
- Step 2: Connect in parallel a balanced, three-phase current source of 50 or 60-hertz and a second three-phase current source of five times the applied fundamental (250 or 300-hertz) to terminals D1 through D6.
- Step3: Apply 2 amps at 0° of the 50 or 60-hertz source. OUT2 should close immediately and OUT1 after the programmed time delay of 100 ms. Verify that there is an 87A, 87B, and 87C target on the front-panel display.
- Step 4: Increase the fifth-harmonic current source until OUT1 opens and record the magnitude of the fifth-harmonic source.
- Step 5: To calculate the fifth-harmonic restraint percentage, divide the fifth-harmonic current measured in step 4 by the current applied in step 3 and multiply the result by 3. This should be 35% or  $3 \times (0.233 \text{ A each phase}) \pm 0.05 \text{ A}$ .

Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.

## Functional Test Reports

### Restrained Pickup Verification (Maximum Restraint)

Pickup Accuracy =  $\pm 2\%$  or  $\pm 0.05A$ , whichever is greater.

Dropout =  $(1 - 0.1) * \text{pickup}$

Step	Pickup Setting	Low	Actual Pickup	High	Low	Actual Dropout	High	Pass/Fail
5/6 - MRPU	0.70 A	0.65 A		0.75 A	0.59 A		0.68 A	P / F
8/9 - MRPU	0.30 A	0.25 A		0.35 A	0.28 A		0.39 A	P / F
11 – Slope 1	3.75 A	3.68 A		3.83 A	N/A*	N/A*	N/A*	P / F
13 – Slope 1	2.40 A	2.35 A		2.45 A	N/A*	N/A*	N/A*	P / F
15 – Slope 2	8.83 A	8.66 A		9.00 A	N/A*	N/A*	N/A*	P / F
17 – Slope 2	5.10 A	5.00 A		5.20 A	N/A*	N/A*	N/A*	P / F

\* Dropout verified in previous steps.

### Restrained Pickup Verification (Average Restraint)

Pickup Accuracy =  $\pm 2\%$  or  $\pm 0.05A$ , whichever is greater.

Dropout =  $(1 - 0.1) * \text{pickup}$

Step	Pickup Setting	Low	Actual Pickup	High	Low	Actual Dropout	High	Pass/Fail
5/6 - MRPU	0.70 A	0.65 A		0.75 A	0.59 A		0.68 A	P / F
8/9 - MRPU	0.30 A	0.25 A		0.35 A	0.28 A		0.39 A	P / F
11 – Slope 1	3.67 A	3.59 A		3.74 A	N/A*	N/A*	N/A*	P / F
13 – Slope 1	2.46 A	2.41 A		2.51 A	N/A*	N/A*	N/A*	P / F
15 – Slope 2	8.25 A	8.09 A		8.42 A	N/A*	N/A*	N/A*	P / F
17 – Slope 2	5.32 A	5.21 A		5.42 A	N/A*	N/A*	N/A*	P / F

\* Dropout verified in previous steps.

### Restrained Timing Verification (Maximum or Average Restraint)

Time Delay Range = 0 to 60,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 1/2$  cycle, whichever is greater, plus  $1\frac{1}{4}$  cycles maximum for currents  $\geq 5$  times the pickup setting.  $1\frac{3}{4}$  cycles maximum for a current of 2 times pickup. Two cycles maximum for a current of 1.05 times the pickup setting.

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	100 ms	62.5 ms		163 ms	P / F

### Unrestrained Pickup Verification

Pickup Accuracy =  $\pm 2\%$  or  $\pm 0.05A$ , whichever is greater.

Step	Pickup Setting	Low	Actual Pickup	High	Pass/Fail
4	4.00 A	3.92 A		4.08 A	P / F

**2<sup>nd</sup> Harmonic Restraint Verification (Independent)**Pickup Accuracy =  $\pm 2\%$  or  $\pm 0.05A$ , whichever is greater.

Step	Pickup Setting	Low	Actual Pickup	High	Pass/Fail
5	0.24 A	0.19 A		0.29 A	P / F

**2<sup>nd</sup> Harmonic Restraint Verification (Shared)**Pickup Accuracy =  $\pm 2\%$  or  $\pm 0.05A$ , whichever is greater.

Step	Pickup Setting	Low	Actual Pickup	High	Pass/Fail
5	3 x (0.08) A	3x (0.06) A		3 x (0.10) A	P / F

**5<sup>th</sup> Harmonic Restraint Verification (Independent)**Pickup Accuracy =  $\pm 2\%$  or  $\pm 0.05A$ , whichever is greater.

Step	Pickup Setting	Low	Actual Pickup	High	Pass/Fail
5	0.24 A	0.19 A		0.29 A	P / F

**5<sup>th</sup> Harmonic Restraint Verification (Shared)**Pickup Accuracy =  $\pm 2\%$  or  $\pm 0.05A$ , whichever is greater.

Step	Pickup Setting	Low	Actual Pickup	High	Pass/Fail
5	3 x (0.23) A	3x (0.22) A		3 x (0.25) A	P / F



# 70 • Neutral Current Differential (87N) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $t$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $t$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $lus$ ® to open the BESTlogic™ $Plus$  Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogic $Plus$  settings are made, click the Save button located on the toolbar to compile BESTlogic $Plus$ . Upload BESTlogic $Plus$  settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Neutral Current Differential (87N) Protection* chapter for more information on this function.

## Functional Test Procedure

### Pickup Verification

Step 1: Use BESTCOMSP $lus$  to send the operational settings in Table 70-1. Reset targets.

**Table 70-1. Operational Settings**

Setting	Value	BESTCOMSP $lus$ Screen	Description
Nominal Phase Voltage	69.3 V	System Parameters, Power System	Sets the nominal secondary sensing voltage to 69.3 V
Nominal Phase Current	5 A	System Parameters, Power System	Sets the nominal secondary sensing current to 5 A
Nominal Aux. Voltage	69.3 V	System Parameters, Power System	Sets the nominal secondary auxiliary voltage to 69.3 V
Phase CT 1 Ratio	1	System Parameters, Sensing Transformers	Sets the phase CT ratio to 1
Ground CT 1 Ratio	1	System Parameters, Sensing Transformers	Sets the ground CT ratio to 1

Setting	Value	BESTCOMSPiplus Screen	Description
Circuit 1 Transformer Connection	WYE	System Parameters, Transformer Setup	Configures the primary side for a WYE connection
Circuit 1 Ground Compensation	No	System Parameters, Transformer Setup	Disables the primary winding zero sequence trap
(Optional) Circuit 1 Diff. Circuit	Primary	System Parameters, Transformer Setup	Establishes circuit 1 on the primary side of the transformer. For report labeling purposes only.
Circuit 1 Polarity	Normal	System Parameters, Transformer Setup	Sets the phase rotation of circuit 1 for ABC
Circuit 1 Phase Relationship	A	System Parameters, Transformer Setup	Sets A-phase in circuit 1 equal to the phase relationship setting for circuit 2
Mode	Enabled	Protection, Current, Neutral Differential (87N-1)	Enables the neutral differential element
Iop Minimum (A)	2.00	Protection, Current, Neutral Differential (87N-1)	Sets the minimum operate current required for pickup to 2 A
Time Delay (ms)	100	Protection, Current, Neutral Differential (87N-1)	Sets the time to trip after a pickup to 100 ms
Overcorrection Coefficient	1.30	Protection, Current, Neutral Differential (87N-1)	Sets the sensitivity of the directional sensing by using a factor of 1.30
CT Flip	No	Protection, Current, Neutral Differential (87N-1)	Stipulates that IG is in phase with 3I0 for internal faults
CT Source	CT1, IG1	Protection, Current, Neutral Differential (87N-1)	Sets the differential zone with CT1 and IG1

Step 2: Use BESTCOMSPiplus to configure the BESTlogicPiplus programmable logic shown in Figure 70-1.

- Blocking is disabled.
- OUT1 closes for 87N-1 Trip.
- OUT2 closes for 87N-1 Pickup.
- Fault recording is enabled.

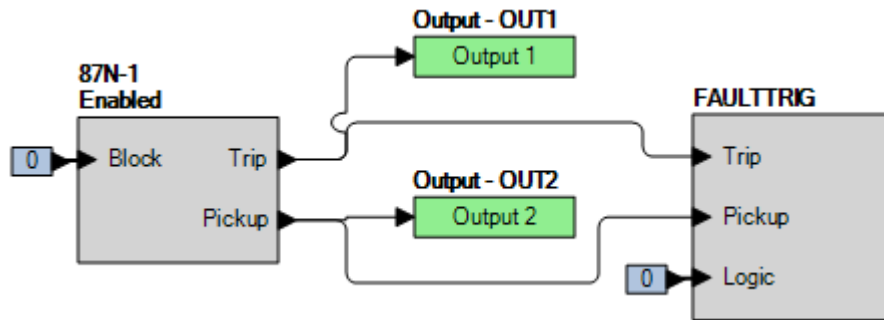


Figure 70-1. BESTlogicPlus Settings

- Step 3: Prepare to monitor the 87N-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 70-1).
- Step 4: Connect a single-phase 60-Hz current source to terminals D1 and D2 (CT1 A-phase): 3.0 A  $\angle 0^\circ$ . Connect a single-phase current source to terminals D7 and D8 (IG input): 3.0 A  $\angle 180^\circ$ . Verify that Iop is around zero amps.
- Step 5: Slowly increase the magnitude of the IG current input until OUT2 closes and record the pickup. This should occur at 5.0 A  $\pm 0.05$  A. Verify that there is an 87N-1 target on the front-panel display.
- Step 6: Reset the currents according to step 4. Reset all targets.
- Step 7: To verify directional blocking of the 87N-1 element, slowly increase the magnitude of the A-phase current input until the magnitude reaches 5.1 A. Verify that Iop is greater than 2.0 A and that OUT2 remains open.
- Step 8: To verify the operation of the directional bias and the overcorrection coefficient, slowly increase the angle of the A-phase current input until OUT2 closes. This should occur at approximately 64°.
- Step 9: Reset the currents according to step 4. Reset all targets.
- Step 10: Slowly decrease the magnitude of the A-phase current input until OUT2 closes and record the pickup. This should occur at 1.0 A  $\pm 0.05$  A. Verify that there is an 87N-1 target on the front-panel display.
- Step 11: (Optional.) Repeat steps 1 through 10 for CT input 2 and IG2.
- Step 12: (Optional.) Repeat steps 1 through 11 for settings group 1, 2, and 3.

### Timing Verification

- Step 1: Use BESTCOMSPPlus to verify the operational settings in Table 70-1 and logic in Figure 70-1. Reset all targets.
- Step 2: Prepare to monitor the 87 timings. Timing accuracy is verified by measuring the elapsed time between OUT2 (pickup) and OUT1 (trip) closing.
- Step 3: Connect a single-phase current source to terminals D1 and D2 (CT1 A-phase): 1.0 A  $\angle 0^\circ$ . Connect a single-phase current source to terminals D7 and D8 (IG input): 1.0 A  $\angle 180^\circ$ .
- Step 4: Step the IG current input to 4.0 A  $\angle 180^\circ$  and verify that OUT2 closes. Record the time between OUT2 and OUT1 closing. This should be 100 ms  $\pm 50$  ms.
- Step 5: Reset IG input to 1.0 A  $\angle 180^\circ$ . Reset all targets.
- Step 6: (Optional) Repeat steps 1 through 5 for settings group 1, 2, and 3.

## Functional Test Report

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### Pickup Verification

Pickup Setting Range = 0.1 - 5 A

Pickup Accuracy =  $\pm 0.05$  A

Step	Pickup Setting	Low	Actual Pickup	High	Pass/Fail
5	3.00 A	2.95 A		3.05 A	P / F
10	1.00 A	0.95 A		1.05 A	P / F

### Timing Verification

Time Delay Range = 50 to 60,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	100 ms	67 ms		133 ms	P / F

# 71 • Distance (21) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $\iota$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $\iota$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $\iota$  to open the BESTlogic™Plus Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogicPlus settings are made, click the Save button located on the toolbar to compile BESTlogicPlus. Upload BESTlogicPlus settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Distance (21) Protection* chapter for more information on this function.

## Pickup Verification

Step 1: Use BESTCOMSP $\iota$  to send the operational settings in Table 71-1 to the BE1-11 $\iota$ .

**Table 71-1. Operational Settings**

Setting	Value	BESTCOMSP $\iota$ Screen	Description
CT Circuit 1, Phase CT Ratio	1	System Parameters, Sensing Transformers	Sets phase CT ratio to 1
CT Connection	WYE	System Parameters, Sensing Transformers	Sets phase CT connection to WYE
Phase VT Ratio	1	System Parameters, Sensing Transformers	Sets phase VT ratio to 1
Element 21-1 Mode	Enabled	Protection, Impedance, Distance (21)	Enables 21-1 element
Use Delta/Wye Compensation	Unchecked	Protection, Impedance, Distance (21)	Disables Delta/Wye compensation
Diameter (ohm)	15.0	Protection, Impedance, Distance (21)	Sets the reach to 15 $\Omega$
Time Delay (ms)	100	Protection, Impedance, Distance (21)	Sets the definite time delay to 100 ms
Torque Angle (degrees)	45	Protection, Impedance, Distance (21)	Sets the characteristic angle of the system to 45°
Offset (ohm)	-5.0	Protection, Impedance, Distance (21)	Sets the offset to -5 $\Omega$

Step 2: Use BESTCOMSPPlus to configure the BESTlogicPlus programmable logic shown in Figure 71-1.

- Blocking is disabled.
- OUT1 closes for 21-1 Trip.
- OUT2 closes for 21-1 Pickup.
- Fault recording is enabled.

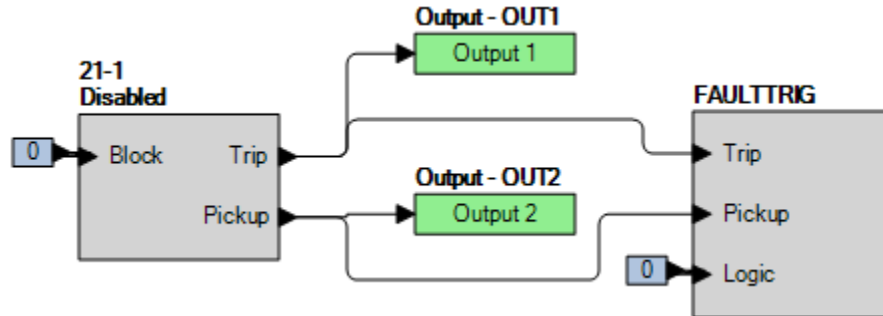


Figure 71-1. BESTlogicPlus Settings

Step 3: Use BESTCOMSPPlus to open the Protection, Impedance, Distance (21) screen and verify the first row of test settings in Table 71-2 for 21-1.

Table 71-2. Pickup Test Settings

Diameter (secondary $\Omega$ )	Time Delay	Torque Angle	Offset (secondary $\Omega$ )
15 $\Omega$	100 ms	45°	-5 $\Omega$
20 $\Omega$	60,000 ms	60°	+1 $\Omega$
5 $\Omega$	0 ms	80°	0 $\Omega$

- Step 4: Prepare to monitor the 21-1 function operation. Operation can be verified by monitoring OUT1 (see Figure 71-1).
- Step 5: Connect and apply a balanced three-phase current of 5 Aac to terminals D1 through D6 and a balanced three-phase voltage of 69.28 V phase-neutral voltage source to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral).
- Step 6: Gradually decrease the magnitude of all three phase voltages until OUT2 closes and record the pickup. This should occur at 45.282 V  $\pm$ 1.569 V. Gradually increase the voltage until OUT2 opens and record the reset. This should occur at approximately 47 V. Reset the target.
- Step 7: Verify the pickup and reset accuracy for all settings as listed in Table 71-2. Reference the functional test report below for the remaining voltage values to be used. Record the results. Pickup accuracy is  $\pm$ 2% or 0.1  $\Omega$  of the calculated trip point on the mho circle, whichever is greater. Impedance values for this test have been converted to measureable phase-neutral voltages.
- Step 8: (Optional.) Repeat steps 1 through 7 for settings group 1, 2, and 3.
- Step 9: (Optional.) Repeat steps 1 through 8 for 21-2.

## Timing Verification

- Step 1: Use BESTCOMSPPlus to open the Protection, Impedance, Distance (21) screen and send the first row of test settings in Table 71-2 to the 21-1 element for settings group 0.
- Step 2: Prepare to monitor the 21-1 timings. Timing accuracy is verified by measuring the elapsed time between OUT2 (pickup) and OUT1 (trip) closing.

- Step 3: Connect and apply balanced three-phase 5 A to terminals D1 through D6 and a balanced three-phase 69.28 V phase-neutral voltage source to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral).
- Step 4: Gradually decrease the magnitude of all three phase voltages until OUT2 closes. Record the time to trip (OUT1 closes). Verify that the 21-1-AB, 21-1-BC, and 21-1-CA targets are displayed on the front-panel display. Increase the voltage until OUT2 opens. Reset the target.
- Step 5: Repeat step 4 for the time delays in the second and third rows of Table 71-2. Record the results. Timing accuracy is 0.5% or 2 cycles, whichever is greater.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1, 2, and 3.
- Step 7: (Optional.) Repeat steps 1 through 6 for 21-2.

## Functional Test Report

### Pickup Verification Table 2 Row 1

Diameter Setting Range = 0 – 500 secondary  $\Omega$

Pickup Accuracy =  $\pm 2\%$  or  $\pm 0.1 \Omega$ , whichever is greater

Reset Hysteresis = 105% of the diameter setting

Reset Accuracy =  $\pm 2\%$  or  $\pm 0.1 \Omega$ , whichever is greater

Step	Pickup Setting	Low	Actual Pickup	High	Low	Actual Reset	High	Pass/Fail
6	45.28 Vpn	43.71 V		46.85 V	46.26 V		48.15 V	P / F

### Pickup Verification Table 2 Row 2

Step	Pickup Setting	Low	Actual Pickup	High	Low	Actual Reset	High	Pass/Fail
6	42.71 Vpn	41.23 V		44.19 V	48.72 V		50.44 V	P / F

### Pickup Verification Table 2 Row 3

Step	Pickup Setting	Low	Actual Pickup	High	Low	Actual Reset	High	Pass/Fail
6	4.34 Vpn	3.84 V		4.84 V	5.86 V		7.59 V	P / F

### Timing Verification

Time Delay Range = 0 to 300,000 ms

Timing Accuracy =  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Step	Time Delay Setting	Low	Actual Timing	High	Pass/Fail
4	100 ms	83.3 ms		117 ms	P / F
5	60,000 ms	57,000 ms		63,000 ms	P / F
5	0 ms	>0 ms		33.3 ms	P / F



## 72 • Virtual Control Switches (43) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $\iota$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $\iota$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $\iota$  to open the BESTlogic™Plus Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogicPlus settings are made, click the Save button located on the toolbar to compile BESTlogicPlus. Upload BESTlogicPlus settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Virtual Control Switches (43)* chapter for more information on this function.

### Functional Test Procedure

#### Switch/Pulse Mode

Step 1: Use BESTCOMSP $\iota$  to send the operational settings in Table 72-1 to the BE1-11 $\iota$ .

Table 72-1. Operational Settings

Setting	Value	BESTCOMSP $\iota$ Screen	Description
43-1 Mode	Switch/Pulse	Control, Virtual Control Switches (43)	Sets 43-1 to Switch/Pulse mode
43-1 Name Label	Test	Control, Virtual Control Switches (43)	Names 43-1 Name label to "Test"
43-1 On Label	On	Control, Virtual Control Switches (43)	Names 43-1 On label to "On"
43-1 Off Label	Off	Control, Virtual Control Switches (43)	Names 43-1 Off label to "Off"

Step 2: Use BESTCOMSP $\iota$  to configure the BESTlogicPlus programmable logic shown in Figure 72-1.

- All inputs are set to logic 0.
- OUT1 closes when 43-1 output is true.

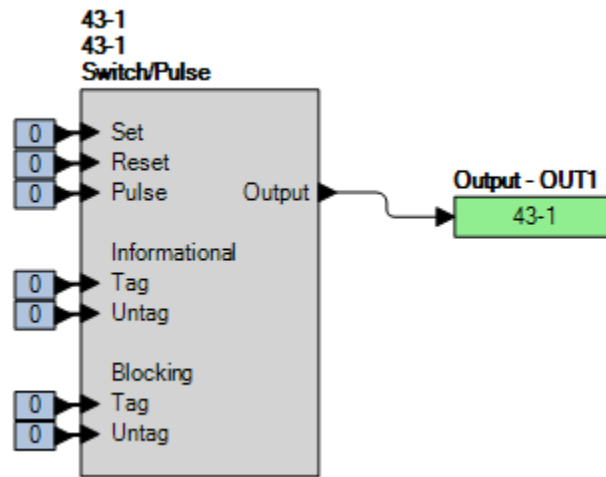


Figure 72-1. BESTlogicPlus Settings

- Step 3: Prepare to monitor the virtual switch operation. An ohmmeter or continuity tester can be used to monitor the contact status of OUT1.
- Step 4: Use the Metering Explorer of BESTCOMSPPlus to open the Control, Virtual Switches tree branch (Figure 72-2). Using select-before-operate, perform the following steps to control a virtual switch.

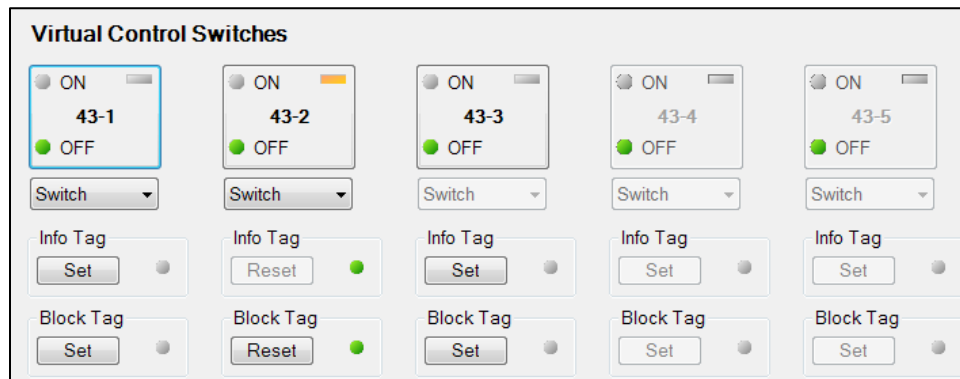


Figure 72-2. BESTCOMSPPlus Virtual Switches Control Screen

- Step 5: Click the 43-1 button to **select** it. Login may be required. The On or Off indicator (current state) will begin to flash.

### Note

If step 6 is not performed within 25 seconds of step 5, the indicator will stop flashing and the 43-1 button will have to be selected again.

- Step 6: Click on the 43-1 button a second time to **operate** it. After clicking Yes, the On or Off indicator (previous state) will stop flashing and the On or Off indicator (current/new state) will light.
- Step 7: Verify that OUT1 contact closes and remains closed.
- Step 8: Repeat steps 5 and 6 to change the state of the 43-1 switch to OFF. Verify that OUT1 contact opens and remains open.
- Step 9: (Optional.) Repeat steps 1 through 8 for 43-2, 43-3, 43-4, and 43-5.
- Step 10: (Optional.) Repeat steps 1 through 9 for settings group 1, 2, and 3.

## Switch Mode

- Step 1: Change the 43-1 element mode to Switch.
- Step 2: Prepare to monitor the virtual switch operation. An ohmmeter or continuity tester can be used to monitor the contact status of OUT1.
- Step 3: Use the Metering Explorer of BESTCOMSP*lus* to open the Control, Virtual Switches tree branch (Figure 72-2). Using select-before-operate, perform the following steps to control a virtual switch.
- Step 4: Click the 43-1 button to **select** it. Login may be required. The On or Off indicator (current state) will begin to flash.

### Note

If step 5 is not performed within 25 seconds of step 4, the indicator will stop flashing and the 43-1 button will have to be re-selected.

- Step 5: Click on the 43-1 button a second time to **operate** it. After clicking Yes, the On or Off indicator (previous state) will stop flashing and the On or Off indicator (current/new state) will light.
- Step 6: Verify that OUT1 contact closes and remains closed.
- Step 7: Repeat steps 4 and 5 to change the state of the 43-1 switch to OFF. Verify that OUT1 contact opens and remains open.
- Step 8: (Optional.) Repeat steps 1 through 7 for 43-2, 43-3, 43-4, and 43-5.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.

## Pulse Mode

- Step 1: Use BESTCOMSP*lus* to change the 43-1 element mode to Pulse.
- Step 2: Prepare to monitor the virtual switch operation. An ohmmeter or continuity tester can be used to monitor the contact status of OUT1.
- Step 3: Using the front-panel display, navigate to Metering > Control > Virtual Switches. Highlight the first switch (43-1) and press the Right key on the front panel to enter the 43-1 control screen. Use the Edit key to login. Highlight Operate and then press the Edit key to change the state of the 43-1. Using the Up/Down keys select PUL and then press the Edit key. Verify that OUT1 contact closes for 200 milliseconds and returns to the open state.
- Step 4: (Optional.) Repeat steps 1 through 3 for 43-2, 43-3, 43-4, and 43-5.
- Step 5: (Optional.) Repeat steps 1 through 4 for settings group 1, 2, and 3.

## Functional Test Report

Function	Pass/Fail
Switch/Pulse Mode	P / F
Switch Mode	P / F
Pulse Mode	P / F



## 73 • Logic Timers (62) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11 $\iota$  measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11 $\iota$  is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP $\iota$  to open the BESTlogic $\text{TM}$ Plus Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogicPlus settings are made, click the Save button located on the toolbar to compile BESTlogicPlus. Upload BESTlogicPlus settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Logic Timers (62)* chapter for more information on this function.

### Functional Test Procedure

#### Pickup/Dropout Mode

Step 1: Use BESTCOMSP $\iota$  to send the operational settings in Table 73-1 to the BE1-11 $\iota$ .

**Table 73-1. Operational Settings (Pickup/Dropout Mode)**

Setting	Value	BESTCOMSP $\iota$ Screen	Description
62-1 Mode	Pickup/Dropout	Control, Logic Timers (62)	Sets 62-1 to Pickup/Dropout mode
62-1 Time Delay 1 (T1)	400 ms	Control, Logic Timers (62)	Sets 62-1 pickup time delay to 400 ms
62-1 Time Delay 2 (T2)	2,000 ms	Control, Logic Timers (62)	Sets 62-1 dropout time delay to 2,000 ms
43-1 Mode	Switch	Control, Virtual Control Switches (43)	Sets 43-1 to Switch mode
62-1 Target	Enabled	Target Configuration, Targets screen.	Enables 62-1 target

Step 2: Use BESTCOMSP $\iota$  to configure the BESTlogicPlus programmable logic shown in Figure 73-1.

- Blocking is disabled.
- 62-1 initiates when 43-1 output is true.
- OUT1 closes when 62-1 output is true.

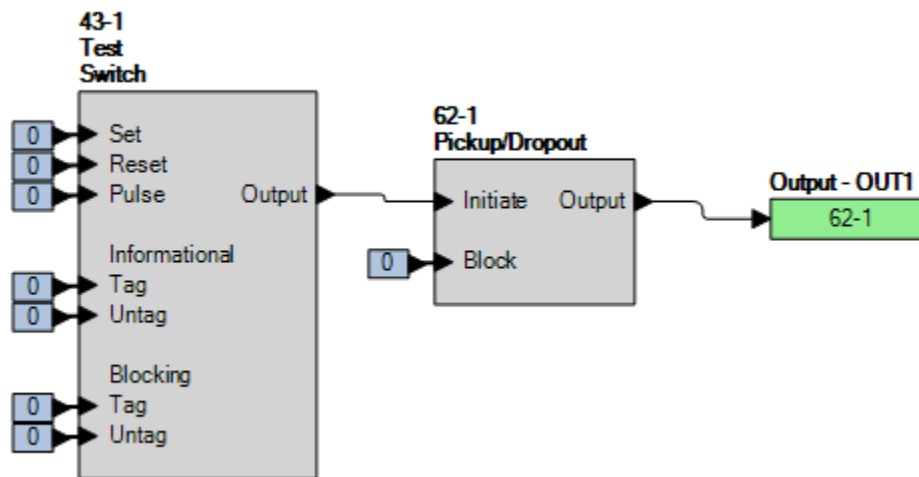


Figure 73-1. BESTlogicPlus Settings

- Step 3: Steps 4 through 6 will initiate the 62-1 timer by changing the 43-1 switch state to ON (logic 1). Once initiated, the 62-1 timer will force an output based on the 400 ms pickup time setting.
- Step 4: Use the Metering Explorer of BESTCOMSPiPlus to open the Control, Virtual Switches tree branch (Figure 73-2). Using select-before-operate, perform the following steps to control a virtual switch.

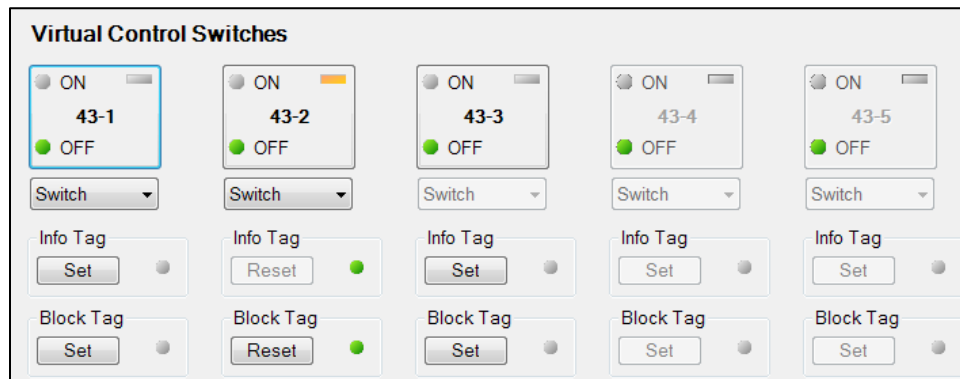


Figure 73-2. BESTCOMSPiPlus Virtual Switches Control Screen

- Step 5: Click the 43-1 button to **select** it. Login may be required. The On or Off indicator (current state) will begin to flash.

### Note

If step 6 is not performed within 25 seconds of step 5, the indicator will stop flashing and the 43-1 button will have to be selected again.

- Step 6: Click on the 43-1 button a second time to **operate** it. After clicking Yes, the On or Off indicator (previous state) will stop flashing and the On or Off indicator (current/new state) will light.
- Step 7: Repeat steps 5 and 6 to change the state of the 43-1 switch to open and remove the initiate input from the 62-1 timer.
- Step 8: Use the Metering Explorer in BESTCOMSPiPlus to open the Reports, Sequence of Events screen.
- Step 9: Verify that the 43-1 switch change to an ON state was logged and approximately 400 ms later, the 62-1 timer picked up. Then, sometime later, the 43-1 switch change to an OFF state was logged and the 62-1 timer dropped out approximately 2,000 ms later. The state of the 43-1

switch in the SER report uses the programmable name parameters applied to the switch. Figure 73-3 illustrates the timing relationship of the 43-1 switch and 62-1 timer.

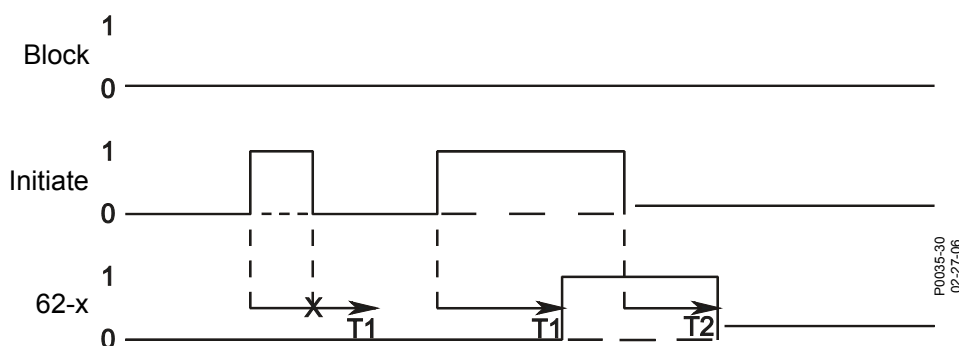


Figure 73-3. Pickup/Dropout Mode

Step 10: (Optional.) Repeat steps 1 through 9 for 62-1, 62-2, 62-3, 62-4, 62-5, 62-6, 62-7, and 62-8.

Step 11: (Optional.) Repeat steps 1 through 10 for settings group 1, 2, and 3.

### One-Shot/Non-Retriggerable Mode

Step 1: Use BESTCOMSPi.us to send the operational settings in Table 73-2 to the BE1-11t. Retain the logic settings from Figure 73-1.

Table 73-2. Operational Settings (One-Shot/Non-Retriggerable Mode)

Setting	Value	BESTCOMSPi.us Screen	Description
62-1 Mode	One-Shot/Non-Retriggerable	Control, Logic Timers (62)	Sets 62-1 to One-Shot/Non-Retriggerable mode
62-1 Time Delay 1 (T1)	400 ms	Control, Logic Timers (62)	Sets 62-1 pickup time delay to 400 ms
62-1 Time Delay 2 (T2)	20,000 ms	Control, Logic Timers (62)	Sets 62-1 dropout time delay to 20,000 ms
43-1 Mode	Pulse	Control, Virtual Control Switches (43)	Sets 43-1 to Pulse mode
62-1 Target	Enabled	Target Configuration, Targets screen.	Enables 62-1 target

Step 2: Step 4 supplies the 62-1 timer with a momentary initiate input by pulsing the 43-1 switch from an OFF state to an ON state and then back to an OFF state. You can view the state changes of the 43-1 switch at the Metering > Control > Virtual Switches screen on the front-panel display.

Step 3: Close communication with BESTCOMSPi.us.

#### Note

The 43-1 switch action is performed twice in this test. To illustrate the action of the timer mode, step 4 should be executed as quickly as possible. Ideally, this test should be repeated within 20 seconds. If this is a problem, try extending the dropout timer setting (Time Delay 2).

Step 4: Using the front-panel display, navigate to Metering > Control > Virtual Switches. Highlight the first switch (43-1) and press the Right key on the front panel to enter the 43-1 control screen. Use the Edit key to login. Highlight *Operate* and then press the Edit key to change the state of the 43-1. Using the Up/Down keys select PUL and then press the Edit key.

Step 5: Use the Metering Explorer in BESTCOMSPi.us to open the Reports, Sequence of Events screen. Verify that an OFF-ON-OFF pulse action was logged and that approximately 400 ms



### Note

The 43-1 switch action is performed three times in this test. To illustrate the action of the timer mode, step 4 should be executed as quickly as possible for the second 43-1 switch action (within 15 second duration of the pickup time delay). Perform step 4 again for the third 43-1 switch action after at least 15 seconds (the pickup timer setting) have elapsed but before the 20 second dropout time delay expires. This will illustrate the action of the timer mode. The time delay settings can be increased if difficulty is encountered with repeating the 43-1 switch actions.

Step 7: Use the Metering Explorer in BESTCOM*Plus* to open the Reports, Sequence of Events screen. Verify that approximately 15 seconds after the second 43-1 OFF to ON initiate signal, the 62-1 timer output went true. Verify that the timer output went false when the third OFF to ON initiate signal forced the 62-1 time delay 1 to restart. Figure 73-5 illustrates the timing relationship of the 43-1 switch and 62-1 timer.

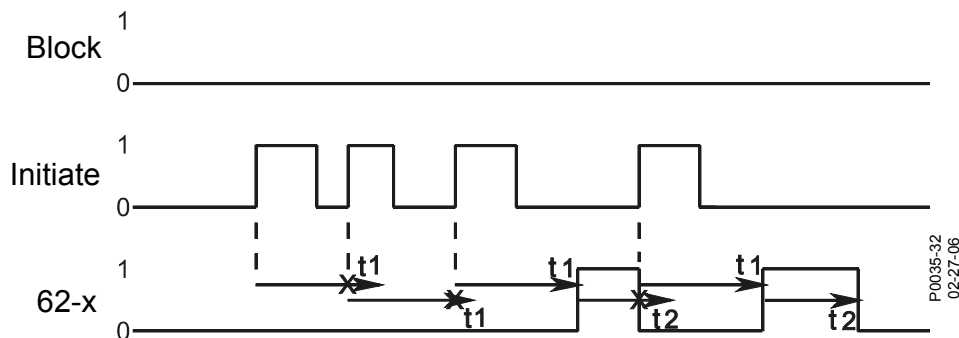


Figure 73-5. One-Shot/Retriggerable Mode

Step 8: (Optional.) Repeat steps 1 through 7 for 62-1, 62-2, 62-3, 62-4, 62-5, 62-6, 62-7, and 62-8.

Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1, 2, and 3.

### Oscillator Mode

Because this operating mode is not intended for general use, no testing procedure is available. Information about Oscillator mode is available in the *Logic Timers (62)* chapter.

### Integrating Timer Mode

Step 1: Use BESTCOM*Plus* to send the operational settings in Table 73-4 to the BE1-11*t*. Retain the logic settings from Figure 73-1.

Table 73-4. Operational Settings (Integrating Timer Mode)

Setting	Value	BESTCOM <i>Plus</i> Screen	Description
62-1 Mode	Integrating Timer	Control, Logic Timers (62)	Sets 62-1 to Integrating Timer mode
62-1 Time Delay 1 (T1)	15,000 ms	Control, Logic Timers (62)	Sets 62-1 pickup time delay to 15,000 ms
62-1 Time Delay 2 (T2)	5,000 ms	Control, Logic Timers (62)	Sets 62-1 dropout time delay to 5,000 ms
43-1 Mode	Switch	Control, Virtual Control Switches (43)	Sets 43-1 to Switch mode
62-1 Target	Enabled	Target Configuration, Targets screen.	Enables 62-1 target

- Step 2: Steps 3 through 5 supply the 62-1 timer with a block input by changing the 43-1 switch state to ON. You can view the state changes of the 43-1 switch at the Metering > Control > Virtual Switches screen on the front-panel display.

**Note**

The 43-1 switch action is performed three times in this test. Follow the timing sequence to illustrate timer mode action. The time delay settings can be increased if difficulty is encountered with repeating the 43-1 switch actions.

- Step 3: Use the Metering Explorer of BESTCOMSP*lus* to open the Control, Virtual Switches tree branch (Figure 73-2). Using select-before-operate, perform the following steps to control a virtual switch.
- Step 4: Click the 43-1 button to **select** it. Login may be required. The On or Off indicator (current state) will begin to flash.

**Note**

If step 5 is not performed within 25 seconds of step 4, the indicator will stop flashing and the 43-1 button will have to be selected again.

- Step 5: Click on the 43-1 button a second time to **operate** it. After clicking Yes, the On or Off indicator (previous state) will stop flashing and the On or Off indicator (current/new state) will light.
- Step 6: Wait no longer than 10 seconds to interrupt time delay 1.
- Step 7: Repeat steps 4 and 5 to change the state of the 43-1 switch to OFF and remove the initiate input from the 62-1 timer.
- Step 8: Wait at least 5 seconds for time delay 2 to reset.
- Step 9: Repeat steps 4 and 5 to change the state of the 43-1 switch to OFF and remove the initiate input from the 62-1 timer.
- Step 10: Use the Metering Explorer in BESTCOMSP*lus* to open the Reports, Sequence of Events screen. Verify that the 62-1 timer output remained false between the first 43-1 switch action (ON) and the second 43-1 switch action (ON), the 62-1 timer output went true after the second 43-1 switch action (ON), and the 62-1 timer output returned to an OFF state.

Figure 73-6 illustrates the timing relationship of the 43-1 switch and 62-1 timer.

- Step 11: (Optional.) Repeat steps 1 through 10 for 62-1, 62-2, 62-3, 62-4, 62-5, 62-6, 62-7, and 62-8.
- Step 12: (Optional.) Repeat steps 1 through 11 for settings group 1, 2, and 3.

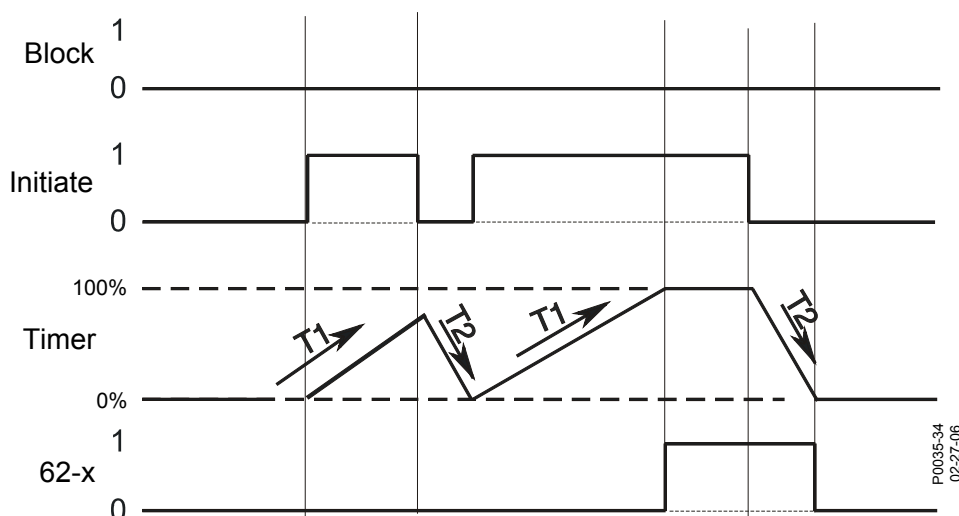


Figure 73-6. Integrating Timer Mode

### Latched Mode

Step 1: Use *BESTCOMSPi* to send the operational settings in Table 73-5 to the BE1-11 $\iota$ . Retain the logic settings from Figure 73-1.

Table 73-5. Operational Settings (Latched Mode)

Setting	Value	BESTCOMSPi Screen	Description
62-1 Mode	Latched	Control, Logic Timers (62)	Sets 62-1 to One-Shot/Retriggerable mode
62-1 Time Delay 1 (T1)	30,000 ms	Control, Logic Timers (62)	Sets 62-1 pickup time delay to 15,000 ms
62-1 Time Delay 2 (T2)	0	Control, Logic Timers (62)	Sets 62-1 dropout time delay to 0
43-1 Mode	Pulse	Control, Virtual Control Switches (43)	Sets 43-1 to Pulse mode
43-2 Mode	Pulse	Control, Virtual Control Switches (43)	Sets 43-2 to Pulse mode
62-1 Target	Enabled	Target Configuration, Targets screen.	Enables 62-1 target

Step 2: Use *BESTCOMSPi* to configure the *BESTlogicPi* programmable logic shown in Figure 73-7.

- 62-1 initiates when 43-1 output is true.
- 62-1 is blocked when 43-2 output is true.
- OUT1 closes when 62-1 output is true.

Step 3: Step 5 supplies the 62-1 timer with a latch input by pulsing the 43-1 switch from an OFF state to an ON state and then back to an OFF state. These commands also supply a block input when the 43-2 is ON. You can view the state changes of the 43-1 switch at the Metering > Control > Virtual Switches screen on the front-panel display.

Step 4: Close communication with *BESTCOMSPi*.

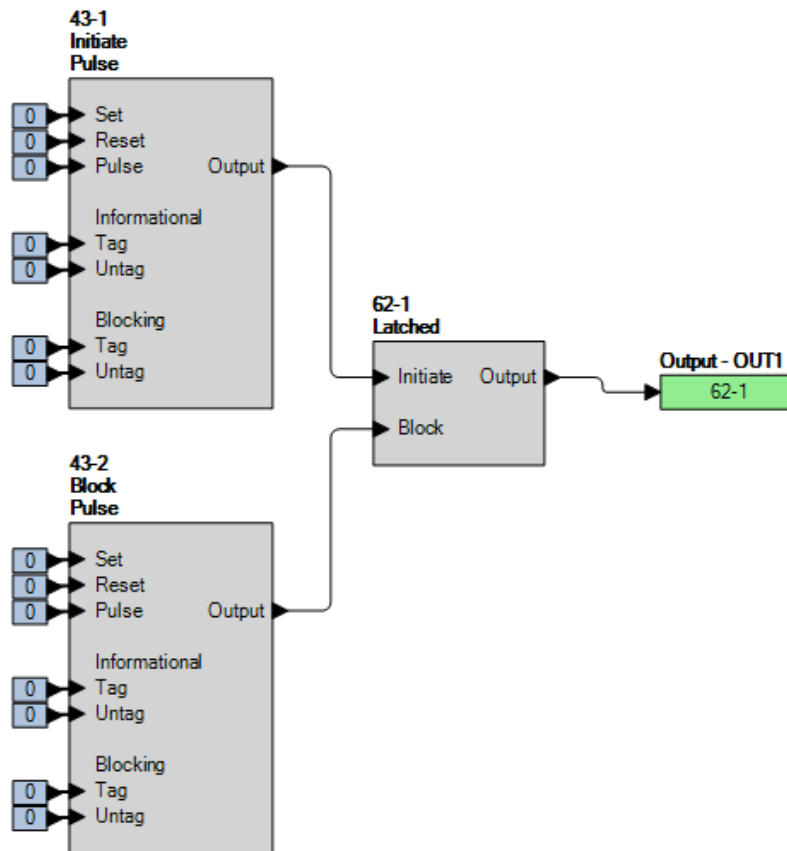


Figure 73-7. BESTlogicPlus Settings (Latched Mode)

### Note

The 43-1 switch action is performed twice in this test. The 43-2 switch action is performed once. Follow the timing sequence to illustrate time mode action. The time delay settings can be increased if difficulty is encountered with repeating the 43-1 and 43-2 switch actions.

- Step 5: Using the front-panel display, navigate to Metering > Control > Virtual Switches. Highlight the first switch (43-1) and press the Right key on the front panel to enter the 43-1 control screen. Use the Edit key to login. Highlight Operate and then press the Edit key to change the state of the 43-1. Using the Up/Down keys select PUL and then press the Edit key.
- Step 6: Repeat Step 5 within 30 seconds.
- Step 7: Wait at least 30 seconds (total elapsed time) before beginning Step 8.
- Step 8: Using the front-panel display, navigate to Metering > Control > Virtual Switches. Highlight the second switch (43-2) and press the Right key on the front panel to enter the 43-2 control screen. Use the Edit key to login. Highlight Operate and then press the Edit key to change the state of the 43-2. Using the Up/Down keys select PUL and then press the Edit key.
- Step 9: Use the Metering Explorer in BESTCOMSPi+ to open the Reports, Sequence of Events screen. Verify that the 62-1 timer output remained false after the first 43-1 switch action (ON), the 62-1 timer output went true 30 seconds after 43-1 switch action (ON), and 62-1 timer output returned to a false state with the 43-2 switch action (ON). Figure 73-8 illustrates the timing relationship of the 43-1/43-2 switches and 62-1 timer.
- Step 10: (Optional.) Repeat Steps 1 through 9 for 62-1, 62-2, 62-3, 62-4, 62-5, 62-6, 62-7, and 62-8.
- Step 11: (Optional.) Repeat Steps 1 through 10 for settings group 1, 2, and 3.

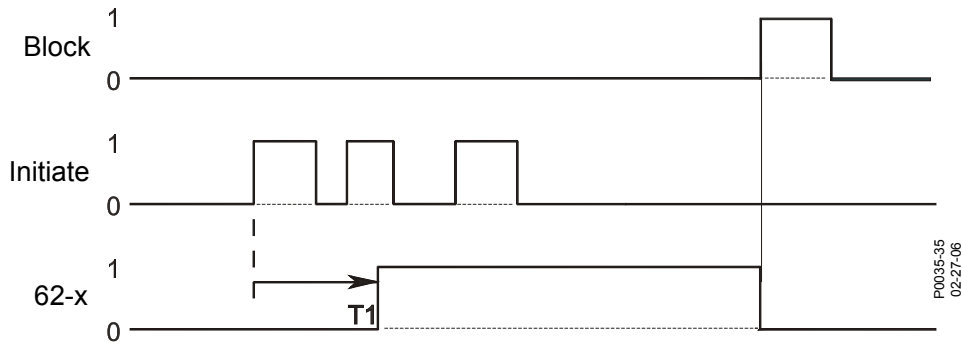


Figure 73-8. Latched Mode

### Functional Test Report

Function	Pass/Fail
Pickup/Dropout Mode	P / F
One-Shot Non-Retriggerable Mode	P / F
One-Shot/Retriggerable Mode	P / F
Oscillator Mode	P / F
Integrating Timer Mode	P / F
Latched Mode	P / F



## 74 • Lockout Functions (86) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11*t* measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11*t* is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP*lus*® to open the BESTlogic™*Plus* Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogic*Plus* settings are made, click the Save button located on the toolbar to compile BESTlogic*Plus*. Upload BESTlogic*Plus* settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Lockout Functions (86)* chapter for more information on this function.

### Functional Test Procedure

Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 74-1 to the BE1-11*t*.

Table 74-1. Operational Settings

Setting	Value	BESTCOMSP <i>lus</i> Screen	Description
86-1 Mode	Enabled	Control, Lockout Functions (86)	Enables 86-1 function

Step 2: Use BESTCOMSP*lus* to configure the BESTlogic*Plus* programmable logic shown in Figure 74-1.

- IN1 sets the 86-1.
- IN2 resets the 86-1.
- OUT1 closes when 86-1 output is true.

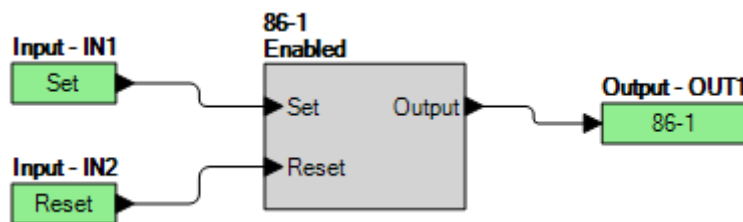


Figure 74-1. BESTlogic*Plus* Settings

Step 3: Prepare to monitor the 86-1 virtual lockout operations. Operation can be verified by monitoring OUT1 on the Metering > Status > Outputs front-panel display screen or monitoring OUT1 contacts between terminals C1 and C2.

- Step 4: Connect power supply to IN1 terminals.
- Step 5: Apply voltage to IN1. Verify that OUT1 closes and remains closed.
- Step 6: Power down the BE1-11 $\ell$  and verify that OUT1 opens. Wait 10 seconds and power up the BE1-11 $\ell$ . Verify that OUT1 closes. This verifies that the 86-1 position is stored in non-volatile memory. Remove voltage from IN1.
- Step 7: Connect power supply to IN2 terminals.
- Step 8: Apply voltage to IN2. Verify that OUT1 opens and remains open.
- Step 9: Apply voltage to both IN1 and IN2. OUT1 should close. This verifies that the Set input has priority over the Reset input.
- Step 10: Repeat steps 1 through 9 for the 86-2 element.
- Step 11: Repeat steps 1 through 10 for settings group 1, 2, and 3.

### ***Functional Test Report***

Pass/Fail
P / F

## 75 • Breaker Control Switch (101) Test

Functional testing is a way to assess this protection system's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that this BE1-11*t* measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the BE1-11*t* is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Connectors* chapter for terminal locations and connections.

Reset all targets prior to each test by navigating to the Metering > Status > Targets screen and pressing the front-panel Reset key. Enter the appropriate username and password if prompted. Clear all logic prior to each test by using the Settings Explorer in BESTCOMSP*lus*® to open the BESTlogic™*Plus* Programmable Logic screen and click the Clear button located on the toolbar. After new BESTlogic*Plus* settings are made, click the Save button located on the toolbar to compile BESTlogic*Plus*. Upload BESTlogic*Plus* settings by selecting Upload Logic to Device from the Communication pull-down menu. Operational settings can be sent by selecting Upload Settings to Device from the Communication pull-down menu or by clicking the Send Settings button on the toolbar.

The actual operating time of an output contact is equal to the recognition time plus the time delay setting (accuracy) plus 6 milliseconds. Output contact operating time depends upon the type of test set used and its operating characteristics.

A *Functional Test Report* is included at the end of this chapter. It should be used to record the results and verify pickup and timing accuracy.

Refer to the *Breaker Control Switch (101)* chapter for more information on this function.

### Functional Test Procedure

Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 75-1 to the BE1-11*t*.

**Table 75-1. Operational Settings**

Setting	Value	BESTCOMSP <i>lus</i> Screen	Description
101 Mode	Enabled	Control, Breaker Control Switch (101)	Enables 101 function

Step 2: Use BESTCOMSP*lus* to configure the BESTlogic*Plus* Programmable Logic shown in Figure 75-1.

- OUT1 closes when 101 Trip output is true.
- OUT2 closes when 101 TSC output is true.
- OUT3 closes when 101 Close output is true.
- OUT4 closes when 101 CSC output is true.

Step 3: Prepare to monitor the 101 breaker control switch operations. Operation can be verified by monitoring the programmed output contacts on the Metering > Status > Outputs front-panel display screen.

Step 4: Place the 101 in the TRIP position by using the Metering Explorer in BESTCOMSP*lus* to open the Control, Breaker Control Switch tree branch. Click on the TRIP button to **select** it. Login may be required. The green selection LED will begin to flash. Within 25 seconds, click on the TRIP button a second time to **operate** it. The green selection LED will stop flashing and the trip status LED will light.

Result: OUT1 closes for 200 ms and returns to the open state. OUT2 closes (TRIP state) and remains closed.

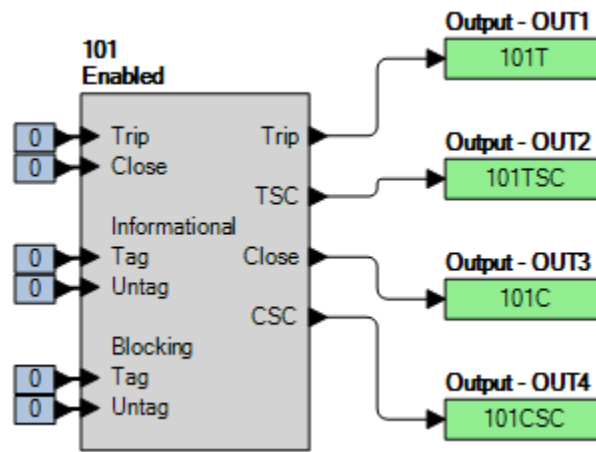


Figure 75-1. BESTlogicPlus Settings

Step 5: Place the 101 in the CLOSE position by using the Metering Explorer in BESTCOMSPPlus to open the Control, Breaker Control Switch tree branch. Click on the CLOSE button to **select** it. Login may be required. The green selection LED will begin to flash. Within 25 seconds, click on the CLOSE button a second time to **operate** it. The green selection LED will stop flashing and the close status LED will light.

Result: OUT3 closes for 200 ms and returns to the open state. OUT4 closes (CLOSE state) and remains closed.

Figure 75-2 illustrates the breaker control switch state diagram.

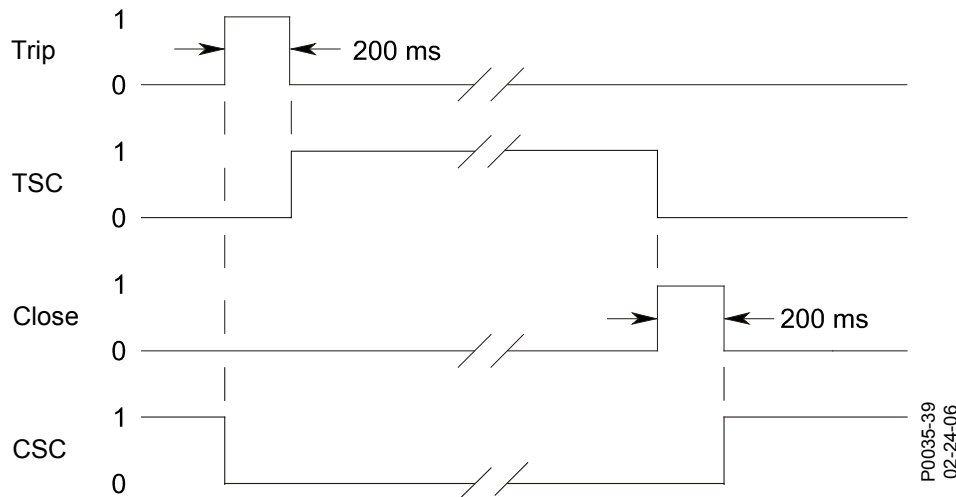


Figure 75-2. Breaker Control Switch State Diagram

## Functional Test Report

Pass/Fail
P / F

# 76 • Frequently Asked Questions (FAQ)

## ***Electrical/Connections***

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### **Is the power supply polarity sensitive?**

No, the power supply will accept either an ac or dc voltage input. Refer to the *Typical Connections* chapter.

### **Are the sensing contacts polarity sensitive?**

Yes, refer to the *Typical Connections* chapter for more information.

### **What voltage level is used to develop current flow through the contact sensing inputs?**

Voltage level is dependent on the power supply option (called out in the BE1-11*t* style chart). For additional information, refer to the *Contact Inputs and Outputs* chapter and the style chart in the *Introduction* chapter.

### **Can the IRIG signal be daisy-chained to multiple BE1-11*t* units?**

Yes, multiple BE1-11*t* units can use the same IRIG-B input signal by daisy-chaining the BE1-11*t* inputs. The burden data is nonlinear, approximately 4 k $\Omega$  at 3.5 Vdc and 3 k $\Omega$  at 20 Vdc. See the *Specifications* chapter for additional information.

## ***General Operation***

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### **Does the BE1-11*t* trip output contact latch after a fault?**

The answer to the question is yes and no. In general, once the fault goes away the output contacts open. The BE1-11*t* does offer an option to ensure that the contact will stay closed for at least 200 milliseconds. See the *Contact Inputs and Outputs* chapter for additional information on that function. Also, a Set Priority Latch in BESTlogic™*Plus* can keep the relay outputs closed as long as power is applied.

### **Can I make logic settings at the front panel?**

No, logic settings cannot be made at the front panel. Logic settings must be programmed using BESTCOMSP*Plus*® communication software.

### **Since the BE1-11*t* is a programmable device, what are the factory defaults?**

Default settings are shown with each function in the instruction manual. For input or output default settings see the *Contact Inputs and Outputs* chapter. For protection and control functions, see the appropriate chapters. The factory default logic scheme is defined in the BESTlogic*Plus* chapter.

### **Does the BE1-11*t* have a battery installed as the backup power source for the internal clock on loss of power?**

A ride-through capacitor, up to 24 hours, and a backup battery, greater than five years, are standard features of the BE1-11*t*. Refer to the *Timekeeping* chapter for more information on the backup battery including replacement.

### **How are reports and other information obtained from the BE1-11*t* saved in files for future use?**

BESTCOMSP*Plus* can be used to view sequence of events, fault records, security log, load profile, and breaker status. See the appropriate chapters for more information.

### **How can I check the version number of my BE1-11t?**

The application version can be found in four different ways: One, on the Settings > General Settings > Device Information screen of the front-panel display. Two, on the Settings Explorer, General Settings, Device Info screen of BESTCOMSP<sup>lus</sup>. Three, on the *Status* (home) page of the web page interface. Four, on the Metering Explorer, Device Info screen of BESTCOMSP<sup>lus</sup>.

## ***Features***

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### **How many overcurrent elements does the BE1-11t have available?**

The BE1-11t has nine instantaneous overcurrent and nine inverse overcurrent elements. Like any element, each element can be assigned to any output for building logic equations.

## ***Communications***

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### **Is the IRIG signal modulated or demodulated?**

The BE1-11t accepts an IRIG-B signal that is demodulated (dc level-shifted digital signal). See the *Specifications* chapter for additional information.

# 77 • Troubleshooting

Basler microprocessor-based protection systems are similar in nature to a panel of electromechanical or solid-state component relays. Both must be wired together with inputs and outputs, and have operating settings applied. Logic settings determine which protection elements are electronically wired to the inputs and outputs of the device. Operating settings determine the pickup thresholds and time delays.

The logic and operating settings should be tested by applying actual inputs and operating quantities and verifying proper output response. For more details, refer to the testing chapters. All of the following connections and functions should be verified during commissioning tests:

- Proper connection and sensing of current and voltage signals
- Input and output contact connections
- I/O sensing
- Settings validation
- Proper operation of equipment (main or auxiliary)
- Proper alarming (to SCADA) and/or targeting

If you do not get the results that you expect from the BE1-11 $t$ , first check the programmable settings for the appropriate function. Use the following troubleshooting procedures when difficulties are encountered in the operation of your BE1-11 $t$ .

## Warning!

Troubleshooting of the BE1-11 $t$  should be performed only by qualified personnel. High voltage may be present on the rear terminals of the BE1-11 $t$ .

## Communications

### Ethernet Port Does Not Operate Properly

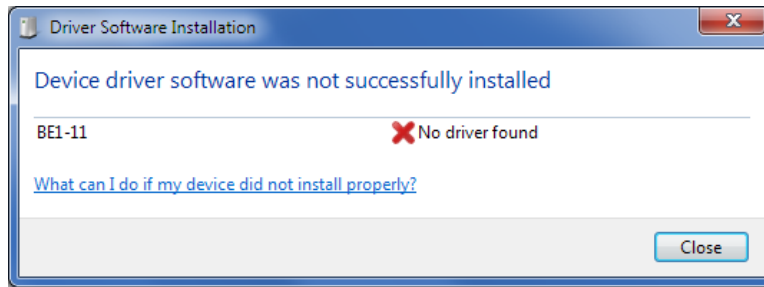
- Step 1. Verify that the proper port of your computer is being used. For more information, refer to the *Communication* chapter.
- Step 2. Verify that the network configuration of the BE1-11 $t$  is set up properly. For more information, refer to the *Communication* chapter.

### USB Port Does Not Operate Properly

Verify that the USB driver was installed properly. For more information, refer to the *BESTCOMSPlus Software* chapter.

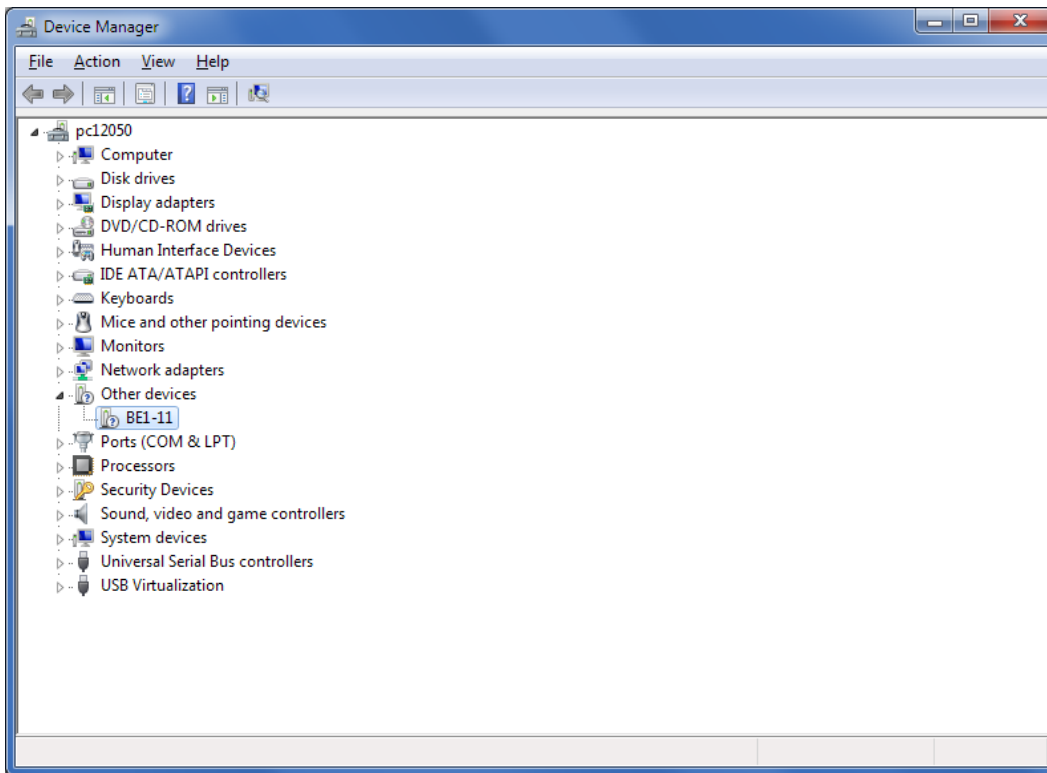
### USB Driver Did Not Install Properly on Windows® 7, 8, or 10

- Step 1. If the message in Figure 77-1 is shown, close all programs and restart the computer.



**Figure 77-1. Driver Software Installation**

- Step 2. Open the Windows® Device Manager as shown in Figure 77-2. Right-click on BE1-11 (or Unknown Device) under Other Devices and select Properties.



**Figure 77-2. Device Manager**

- Step 3. In the Properties windows, select the Driver tab and click Update Driver. See Figure 77-3.

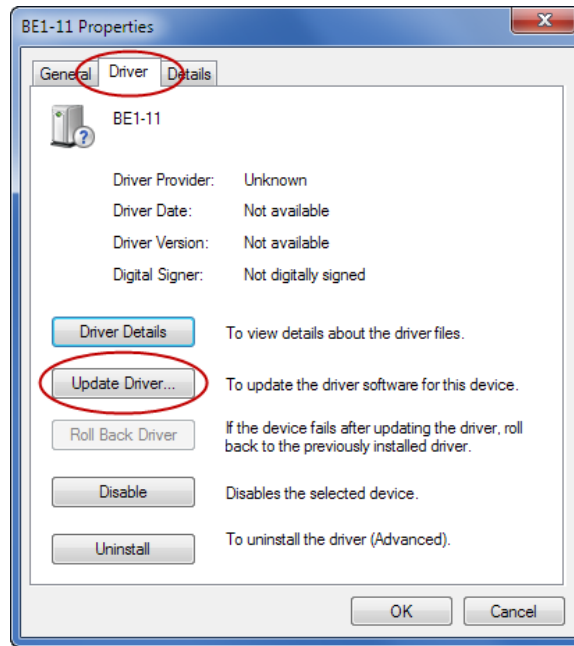


Figure 77-3. BE1-11 Properties

Step 4. Select Browse My Computer for Driver Software as shown in Figure 77-4.

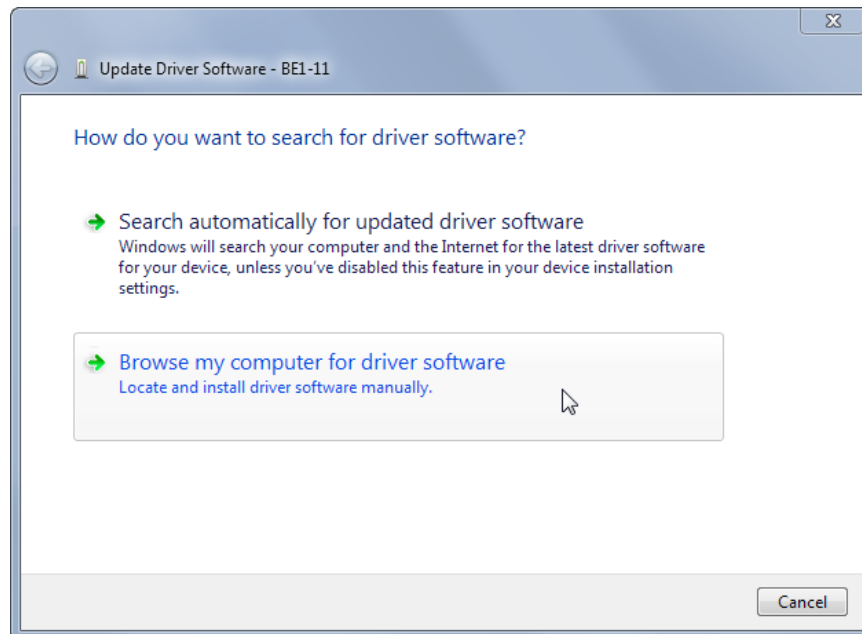
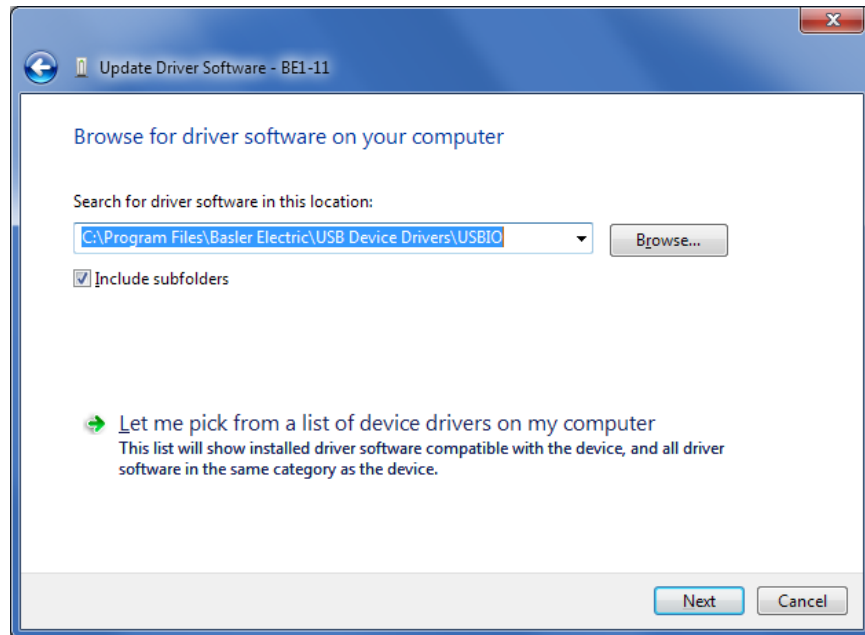


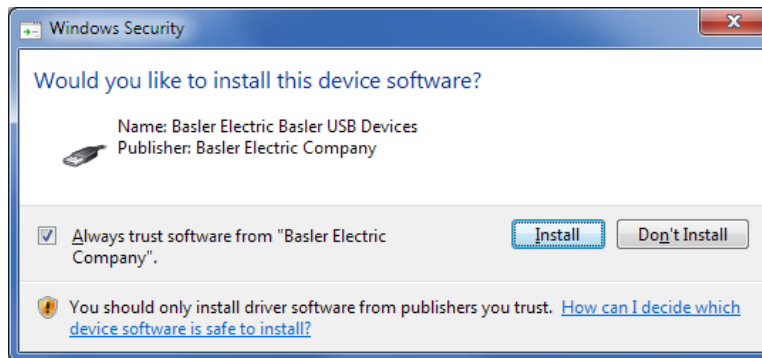
Figure 77-4. Update Driver Software - BE1-11

Step 5. Click Browse and navigate to C:\Program Files\Basler Electric\USB Device Drivers\USBIO. Click Next. See Figure 77-5.



**Figure 77-5. Update Driver Software - BE1-11**

Step 6. If a Windows Security window (Figure 77-6) appears, click Install.



**Figure 77-6. Windows Security**

Step 7. The window in Figure 77-7 appears if driver installation was successful.

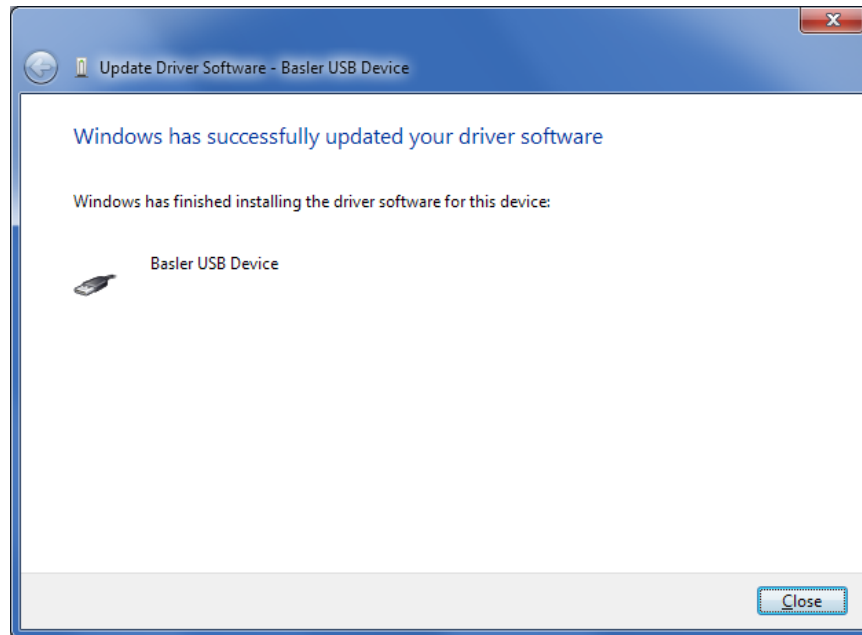


Figure 77-7. Driver Software Update Successful

### Why do I keep getting access conflict errors when I attempt communication with the BE1-11t?

If you try to gain access to more than one port at a time, an access conflict results. The BE1-11t has three communication ports: front-panel USB, rear panel optional Ethernet, and rear panel RS-485. Each communication method has its own access. For example, if you gain access through Modbus TCP, then you cannot gain access using BESTCOMSP*lus* over Ethernet. Access needs to be gained only when a write command to the BE1-11t is required (control or setting change or report reset).

When access is gained through a port, a user-defined access control timer starts counting down to zero. When port activity occurs, the timer resets to the user-defined access control timer setting and resumes counting down. If no activity is seen for the duration of the access control timer setting, access is withdrawn and any unsaved changes are lost. When activity at a port is no longer required, access should be terminated.

To close front panel access immediately, press the Reset button while any menu screen is displayed. The BE1-11t should flash “Read Only” on the LCD screen to indicate access through the front panel has been terminated.

Obtaining data or reports from the BE1-11t never requires password access. The security log is an exception, as it requires Administrator access.

### In Modbus<sup>®</sup> TCP/IP, the master cannot communicate with the BE1-11t, but can communicate over Modbus TCP/IP with other devices on the same network

- Step 1. Verify that there is no IP address or Modbus slave address conflict.
- Step 2. For some devices on an Ethernet network, only the IP address is required to communicate over Modbus TCP/IP. This is because each device must have a different IP address. With BE1-11t Transformer Protection Systems, in addition to the correct IP address, the master must also use the correct slave address.

### Why don't the BE1-11t security parameters get sent to the relay when I upload settings?

The security settings are not sent with the Upload Settings and Logic to Device or Upload Settings to Device commands found under the Communications drop-down menu in BESTCOMSP*lus*. The Upload Security to Device command must be used to send security parameters to the BE1-11t.

## Inputs and Outputs

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### Programmable Inputs Do Not Operate as Expected

- Step 1. Verify that all wiring is properly connected. Refer to the *Typical Connections* chapter.
- Step 2. Verify that the inputs are programmed properly.
- Step 3. Verify that the sensing input jumpers are in the correct position. Refer to the *Contact Inputs and Outputs* chapter.

### Programmable Outputs Do Not Operate as Expected

- Step 1. Verify that all wiring is properly connected. Refer to the *Typical Connections* chapter.
- Step 2. Verify that the outputs are programmed properly.
- Step 3. Verify that the output is not being set by other means. There can be more than one connection to an output (check the physical outputs tab in *BESTlogicPlus*). Also, check that the output override is not set for the output.

## Metering/Display

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### Incorrect Display of Current

- Step 1. Verify that all wiring is properly connected. Refer to the *Typical Connections* chapter.
- Step 2. Verify that the proper current is present at BE1-11 $\iota$  current sensing inputs IA1 (D1/D2), IB1 (D3/D4), IC1 (D5/D6), and IG1 (D7/D8). If the second set of CTs is being used, also verify proper current at IA2 (F1/F2), IB2 (F3/F4), IC2 (F5/F6), and IG2 (F7/F8).
- Step 3. Verify that the current transformer ratio and sensing configuration is correct.
- Step 4. Verify that the current sensing transformers are correct and properly installed.

### Incorrect Display of Voltage

- Step 1. Verify that all wiring is properly connected. Refer to the *Typical Connections* chapter.
- Step 2. Verify that the proper voltage is present at BE1-11 $\iota$  voltage sensing inputs VA (C13), VB (C14), VC (C15), and VN (C16).
- Step 3. Verify that the voltage transformer ratio and sensing configuration is correct.
- Step 4. Verify that the voltage sensing transformers are correct and properly installed.

## General Operation

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### Why won't the Trip LED reset when I press the Reset key on the front panel?

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

### Why won't the 60FL alarm or target reset when I press the Reset key on the front panel?

The only way to reset the Fuse Loss alarm or target is to apply more than 85% of rated positive-sequence voltage. Refer to the *Fuse Loss (60FL)* chapter for more information.

### Do I have to log in to reset the targets or alarms?

It depends on the security setup. You can reset the targets or alarms through a specific port without logging in if the Unsecured Access Level is set to Operator or higher on that port. Target and alarm reset can also be set outside of security control, allowing reset through the front-panel interface without logging in. Refer to the *Security* chapter for more information.

### Why don't the targets or trip LED work properly?

If a protective element is tripping at the desired level, but the targets aren't behaving as expected, use *BESTCOMSPPlus* to verify that the targets are enabled for the protective function. Refer to the *Fault Reporting* chapter for detailed information about targets.

Trip LED behavior depends on the pickup and trip expression of the protective function. When the functions pickup expression is true and the trip expression is false, the Trip LED flashes. In other words, a flashing LED means that a protection element is in a picked up state and is timing toward a trip. When both the pickup and trip expression is true, the Trip LED lights steadily. The Trip LED also lights steadily when neither expression is true but latched targets exist. When resetting a target, the Trip LED will not turn off if the fault is still present. The truth table of Table 77-1 serves as an aid to interpreting Trip LED indications.

**Table 77-1. Trip LED Truth Table**

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

### Why are voltage dependent elements (51/27, 24, 25, 27, 59, 21) not operating as expected when testing by secondary injections?

The BE1-11 $\ell$  has the ability to distinguish a loss of fuse from a loss of voltage. Check the sequence of events for a Fuse Loss alarm. If a Fuse Loss alarm is active, voltage dependent elements will not operate. Refer to the *Fuse Loss (60FL)* chapter for information on applying voltage and current so the BE1-11 $\ell$  does not detect a fuse loss. Fuse Loss protection can also be disabled for the protection element being tested.



## 78 • Specifications

BE1-11 $\tau$  protection systems used in 50 and 60 Hz systems have the following features and capabilities. For 25 Hz operational specifications, refer to the *Specifications - 25 Hz Operation* chapter.

### Operational Specifications

#### Metered Current Values and Accuracy

5 Aac Nominal Range .....	0.5 to 15 Aac
1 Aac Nominal Range .....	0.1 to 3.0 Aac
SEF Range.....	0.01 to 3.0 Aac
Phase Current Accuracy .....	$\pm 0.5\%$ of reading at nominal current $\pm 1\%$ of reading or $\pm 0.15\%$ of full range, whichever is greater at 77°F (25°C)
I1, I2, I0* Accuracy.....	$\pm 0.8\%$ of reading at nominal current $\pm 1.5\%$ of reading or $\pm 0.25\%$ of full range, whichever is greater at 77°F (25°C)
Temperature Dependence .....	$\leq \pm 0.02\%$ per °C

\* 3I0 displayed

#### Metered Voltage Values and Accuracy

3-wire Range.....	50 to 250 Vac
4-wire Range.....	50 to 250 Vac
Auxiliary Range.....	25 to 125 Vac
Phase/Auxiliary Accuracy.....	$\pm 0.5\%$ of reading or $\pm 0.1\%$ of full range whichever is greater at 77°F (25°C)
V1, V2, V0* Accuracy .....	$\pm 0.75\%$ of reading or $\pm 0.15\%$ of full range whichever is greater at 77°F (25°C)
Temperature Dependence .....	$\leq \pm 0.02\%$ per °C

\* 3V0 displayed

#### Metered Frequency Values and Accuracy

Range.....	10 to 125 Hz
Accuracy.....	$\pm 0.01$ Hz, $\pm 1$ least significant digit at 77°F (25°C) nominal
3-wire Sensing Input .....	Phase A – B
4-wire Sensing Input .....	Phase A – Neutral
Minimum Frequency Tracking Voltage .....	10 V rms

#### Calculated Values and Accuracy

##### Demand

Range.....	0.1 to 1.5 nominal
Type .....	Exponential
Accuracy.....	$\pm 1\%$ of reading $\pm 1$ digit at 77°F (25°C)
Temperature Dependence .....	$\leq \pm 0.02\%$ per °C
Interval.....	1 to 60 min

##### True Power

5 Ampere CT Range .....	-4,500 W to +4,500 W
1 Ampere CT Range .....	-900 W to +900 W
Accuracy.....	$\pm 1\%$ at unity power factor

Reactive Power

5 Ampere CT Range .....	-4,500 var to +4,500 var
1 Ampere CT Range .....	-900 var to +900 var
Accuracy.....	±1% at zero power factor

**Energy Data Reporting**

5 Ampere CT Range .....	1,000,000 kWhr or 1,000,000 kvarh
1 Ampere CT Range .....	1,000,000 kWhr or 1,000,000 kvarh
Units of Measure .....	kilo
Rollover Value of Registers.....	1,000,000 kWhr or 1,000,000 kvarh
Accuracy.....	±1% at unity power factor

**21 - Distance Protection (Optional)**Diameter

Setting Range .....	0 to 500 $\Omega$
5 Ampere CT Accuracy .....	±3% or ±0.2 $\Omega$ , whichever is greater from 0 to 100 $\Omega$
1 Ampere CT Accuracy .....	±3% or ±0.2 $\Omega$ , whichever is greater from 0 to 500 $\Omega$

Time Delay

Setting Range .....	0 to 300,000 ms
Accuracy.....	±0.5% or ±2 cycles, whichever is greater

Torque Angle

Setting Range .....	0 to 90 degrees
Accuracy.....	±1 degree

Offset

Setting Range .....	-500 to 500 $\Omega$
5 Ampere CT Accuracy .....	±3% or ±0.2 $\Omega$ , whichever is greater from -100 to 100 $\Omega$
1 Ampere CT Accuracy .....	±3% or ±0.2 $\Omega$ , whichever is greater from -500 to 500 $\Omega$

**24 - Overexcitation Protection**Inverse Time

Curve Exponent .....	0.5, 1, or 2
----------------------	--------------

Pickup

Setting Range .....	0.5 to 6 V/Hz
Accuracy.....	±2% or ±0.05 V/Hz, whichever is greater
Dropout/Pickup Ratio .....	98% ±1%

Time Dial

Setting Range .....	0.0 to 9.9
Accuracy.....	±5% or ±3 cycles, whichever is greater

Reset Dial

Setting Range .....	0.0 to 9.9
Accuracy.....	±5% or ±3 cycles, whichever is greater

Definite Time 1 and 2Pickup

Setting Range .....	0.5 to 6 V/Hz
Accuracy.....	±2% or ±0.05 V/Hz, whichever is greater

Time Delay

Setting Range .....	50 to 600,000 ms
Accuracy.....	±1.5% or ±3 cycles, whichever is greater

AlarmPickup

Setting Range .....	0.5 to 6 V/Hz
Accuracy.....	±2% or ±0.05 V/Hz, whichever is greater
Reset/Alarm Ratio .....	98% ±1%

Time Delay

Setting Range .....	50 to 600,000 ms
Accuracy.....	±0.5% or ±3 cycles, whichever is greater

**25 - Sync-Check Protection**SettingsVoltage Difference

Setting Range .....	0 to 50% of nominal
Accuracy.....	±2% or ±1 V, whichever is greater

Slip Angle

Setting Range .....	1 to 99°
Accuracy.....	±1°

Slip Frequency

Setting Range .....	0.01 to 0.50 Hz
Accuracy.....	±0.01 Hz

Sensing

Angle Compensation Setting Range.....	0 to 359.9°
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Voltage MonitoringLive/Dead Voltage

Setting Range .....	0 to 90%
Accuracy.....	±2%

Drop Out Delay

Setting Range .....	50 to 60,000 ms
Accuracy.....	±0.5% or ±2 cycles, whichever is greater

**27P - Phase Undervoltage Protection**Pickup

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

Inhibit Level

Setting Range .....	1 to 300 V
Accuracy.....	±2% or ±1 V, whichever is greater
Reset/Inhibit Ratio.....	102% ±1%

Timing ModeDefinite Timing

Setting Range .....	50 to 600,000 ms
Accuracy.....	±0.5% or ±2 cycles, whichever is greater

Inverse Timing

Setting Range .....	0 to 9.9
Accuracy.....	±5% or ±2 cycles, whichever is greater

## 27X - Auxiliary Undervoltage Protection

### Pickup

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

### Inhibit Level

Setting Range .....	1 to 150 V
Accuracy.....	±2% or ±1 V, whichever is greater
Reset/Inhibit Ratio.....	102% ±1%

### Timing Mode

#### Definite Timing

Setting Range .....	50 to 600,000 ms
Accuracy.....	±0.5% or ±2 cycles, whichever is greater

#### Inverse Timing

Setting Range .....	0 to 9.9
Accuracy.....	±5% or ±2 cycles, whichever is greater

## 46 - Negative-Sequence Current Protection

Negative-sequence current protection is available when a 50 or 51 element is configured in I2 mode. Refer to *Instantaneous Overcurrent* or *Inverse Overcurrent* for operational specifications.

## 47 - Negative-Sequence Voltage Protection

Negative-sequence voltage protection is available when a 27X or 59X element is configured in V2 mode. Refer to *Auxiliary Overvoltage* or *Auxiliary Undervoltage* for operational specifications.

## 49RTD - Resistance Temperature Device Protection (Optional)

### Pickup

Setting Range .....	32 to 482°F (0 to 250°C)
Accuracy.....	±2% or ±3.6°F (±2°C), whichever is greater
Reset/Pickup Ratio.....	105% / 95% ±1% (over / under) or 41°F (5°C) minimum

### Time Delay

Setting Range .....	0 to 600,000 ms
Accuracy.....	±1 s

## 50 - Instantaneous Overcurrent Protection

### Pickup

5 Ampere CT Setting Range .....	0.5 to 150 A
1 Ampere CT Setting Range.....	0.1 to 30 A
SEF Setting Range .....	0.01 to 7.5 A
Unbalanced Setting Range .....	2 to 100%
Dropout .....	93 to 99% of the actual pickup value

### 3Phase, IA, IB, IC, IG Accuracy

5 Ampere CT.....	±2% or ±50 mA, whichever is greater
1 Ampere CT.....	±2% or ±10 mA, whichever is greater
SEF (Pickup Setting of 0.01 to 4.99 A) .....	±(2.5% + 4.5 mA)
SEF (Pickup Setting of 5 to 7.5 A) .....	±(5% + 4.5 mA)

**3I0, I1, I2 Accuracy**

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

**Unbalanced Accuracy**

5 Ampere CT .....	±2% of pickup setting
1 Ampere CT .....	±2% of pickup setting

**Time Delay**

Setting Range .....	0 to 60,000 ms
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**Accuracy**

Phase & Ground .....	±0.5% or ±½ cycle, whichever is greater, plus trip time for instantaneous response (0.0 setting)*†
Residual .....	±0.5% or ±½ cycle, whichever is greater, plus trip time for instantaneous response (0.0 setting)*
* Trip Time for 0.0 Delay Setting .....	1¼ cycles maximum for currents ≥ 5 times the pickup setting. 1¾ cycles maximum for a current of 2 times pickup. Two cycles maximum for a current of 1.05 times the pickup setting.
† Peak Detect Time for 0.0 Delay Setting .....	1 cycle maximum for current ≥ 2 times the pickup setting when using high-speed outputs.

**50BF - Breaker Failure Protection****Phase & Ground Pickup**

5 Ampere CT Setting Range .....	0.25 to 10 A
1 Ampere CT Setting Range .....	0.05 to 2 A
SEF .....	0.01 to 0.5 A

**Accuracy**

5 Ampere CT .....	±2% or ±50 mA, whichever is greater
1 Ampere CT .....	±2% or ±10 mA, whichever is greater
SEF .....	±(2.5% + 2.5 mA)

**Time Delay & Control Time**

Setting Range .....	50 to 999 ms
Accuracy .....	±0.5% or +1¼, -0.5 cycles, whichever is greater

**51 - Inverse Overcurrent Protection****Pickup**

5 Ampere CT Setting Range .....	0.5 to 16 A
1 Ampere CT Setting Range .....	0.1 to 3.2 A
SEF Setting Range .....	0.01 to 0.8 A
Unbalanced Setting Range .....	2 to 100%
Dropout .....	93 to 99% of the actual pickup value

**3Phase, IA, IB, IC, IG Accuracy**

5 Ampere CT .....	±2% or ±50 mA, whichever is greater
1 Ampere CT .....	±2% or ±10 mA, whichever is greater
SEF .....	±(2.5% + 2.5 mA)

**3I0, I1, I2 Accuracy**

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

**Unbalanced Accuracy**

5 Ampere CT .....	±2% of pickup setting
1 Ampere CT .....	±2% of pickup setting

Time Current Characteristic Curves

Timing Accuracy (All 51 Functions) .....  $\pm 5\%$  or  $\pm 1\frac{1}{2}$  cycles, whichever is greater, for time dial settings greater than 0.1 and multiples of 2 to 40 times the pickup setting but not over 150 A for 5 A CT units or 30 A for 1 A CT units.  
Refer to the *Time Curve Characteristics* chapter for information on available timing curves.

Voltage Restraint

Control/Restraint Range ..... 30 to 250 V  
Accuracy .....  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

**51TF - Transformer Monitor**Base CurrentPickup

5 Ampere CT Setting Range ..... 0.5 to 16 A  
1 Ampere CT Setting Range ..... 0.1 to 3.2 A

Alarm Count

Setting Range ..... 1 to 99

Thresholds

Setting Range ..... 1 to 40 A

Accuracy

5 Ampere CT .....  $\pm 2\%$  or  $\pm 0.05$  A, whichever is greater  
1 Ampere CT .....  $\pm 2\%$  or  $\pm 0.01$  A, whichever is greater

N Constants

Setting Range ..... 0.5 to 3

K Constants

Setting Range ..... 1 to 3,000

**59P - Phase Overvoltage Protection**Pickup

Setting Range ..... 1 to 300 V  
Accuracy .....  $\pm 2\%$  or  $\pm 1$  V, whichever is greater  
Dropout/Pickup Ratio .....  $98\% \pm 1\%$

Timing ModeDefinite Timing

Setting Range ..... 50 to 600,000 ms  
Accuracy .....  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Inverse Timing

Setting Range ..... 0 to 9.9  
Accuracy .....  $\pm 5\%$  or  $\pm 2$  cycles, whichever is greater

**59X - Auxiliary Overvoltage Protection**Pickup

Setting Range ..... 1 to 150 V  
Accuracy .....  $\pm 2\%$  or  $\pm 1$  V, whichever is greater  
Dropout/Pickup Ratio .....  $98\% \pm 1\%$

Timing ModeDefinite Timing

Setting Range ..... 50 to 600,000 ms  
 Accuracy.....  $\pm 0.5\%$  or  $\pm 2$  cycles, whichever is greater

Inverse Timing

Setting Range ..... 0 to 9.9  
 Accuracy.....  $\pm 5\%$  or  $\pm 2$  cycles, whichever is greater

**60FL - Fuse Loss**

Time Delay ..... Fixed at 50 ms

**62 - Logic Timers**

Modes..... Pickup/Dropout, One-Shot/Non-Retriggerable,  
 One-Shot/Retriggerable, Oscillator, Integrating  
 Timer, Latched  
 Setting Range ..... 0 to 9,999,000 ms  
 Accuracy.....  $\pm 0.5\%$  or  $\pm 12$  ms, whichever is greater

**67/67N - Directional Current and Polarization Protection**

Modes..... Forward, Reverse, Non-directional  
 Maximum Torque Angle ..... 0 to 359.9°

Polarization Methods

- Zero Sequence Current Polarization (IG)
- Negative Sequence Polarization (Q)
- Zero Sequence Polarization (V)
  - VOIN - Calculated Zero Sequence Voltage compared to Calculated Zero Sequence Current.
  - VOIG - Calculated Zero Sequence Voltage compared to Measured Ground Current.
  - VXIN - Measured 3V0-VX Input compared to Calculated Zero Sequence Current.
  - VXIG - Measured 3V0-VX Input compared to Measured Ground Current.

**79 - Recloser Protection**Reclose (1st, 2nd, 3rd, 4th), Reset (79R), Max Cycle (79M), Reclose Fail (79F)

Setting Range ..... 100 to 600,000 ms  
 Accuracy.....  $\pm 0.5\%$  or  $+1\frac{3}{4}$ ,  $-0$  cycles, whichever is greater

**81 - Frequency Protection**O/UPickup

Setting Range ..... 15 to 110 Hz  
 Accuracy.....  $\pm 0.01$  Hz  
 Dropout..... 0.02 Hz  $\pm 0.01$  Hz of the actual pickup value

Time Delay

Setting Range ..... 0 to 600,000 ms  
 Accuracy.....  $\pm 0.5\%$  or  $\pm 1$  cycle, whichever is greater, plus 3  
 cycle recognition time for time delays < 50 ms

ROCPickup

Setting Range ..... 0.2 to 20 Hz/sec (positive, negative, or either)  
 Accuracy.....  $\pm 2\%$  or  $\pm 0.1$  Hz/sec of the setting, whichever is  
 greater  
 Dropout.....  $\pm 3\%$  of the actual pickup value

**Over/Underfrequency Inhibit**

Setting Range .....	15 to 110 Hz
Increment .....	0.01 Hz
Accuracy.....	±0.01 Hz

**Negative-Sequence Inhibit**

Setting Range .....	0 to 99% of nominal voltage
Accuracy.....	±0.5% or ±1 V, whichever is greater

**Time Delay**

Setting Range .....	0 to 600,000 ms
Accuracy.....	±0.5% or ±1 cycle, whichever is greater, plus recognition time*

\* Recognition time = 2 cycles for 0.57 > pickup, 4 cycles for 0.24 > pickup, 8 cycles for 0.08 > pickup, 16 cycles at pickup

**O/U/ROC Voltage Inhibit**

Setting Range .....	15 to 250 V
Accuracy.....	±2% or ±1 V, whichever is greater

**87 - Phase Current Differential Protection****Restrained Differential**

5 Ampere CT Pickup Accuracy .....	±4% or ±75 mA, whichever is greater
1 Ampere CT Pickup Accuracy .....	±4% or ±25 mA, whichever is greater
Response Time .....	<2 cycles at 5 times pickup <3 cycles at 1.5 times pickup

**TAP**

5 Ampere CT Setting Range .....	2.00 to 20.0 A
1 Ampere CT Setting Range .....	0.40 to 4.00 A

**Minimum Restraint Pickup ( $I_{op}$ )**

Setting Range .....	0.1 to 1.00 per unit
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**2<sup>nd</sup> Slope Pickup ( $I_{res}$ )**

Setting Range .....	0.1 to 20.0 per unit
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**Restraint Slope 1**

Setting Range .....	5 to 100%
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**Restraint Slope 2**

Setting Range .....	15 to 140%
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**Time Delay**

Setting Range .....	0 to 60,000 ms
Accuracy.....	±0.5% or ±½ cycle, whichever is greater, plus trip time for instantaneous response (0.0 setting)*

\* Trip Time for 0.0 Delay Setting ..... 1¼ cycles maximum for currents ≥ 5 times the pickup setting. 1¼ cycles maximum for a current of 2 times pickup. Two cycles maximum for a current of 1.05 times the pickup setting.

**87N - Neutral Current Differential Protection****I<sub>op</sub> Minimum Pickup****5 Ampere CT**

Setting Range .....	0.1 to 5 A
Accuracy.....	±3% or ±75 mA, whichever is greater

**1 Ampere CT**

Setting Range .....	0.02 to 1 A
Accuracy.....	5 A CT: $\pm 3\%$ or $\pm 15$ mA, whichever

**Overcorrection Coefficient**

Setting Range .....	1 to 1.3
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**Time Delay**

Setting Range .....	0 to 60,000 ms
Accuracy.....	$\pm 0.5\%$ or $\pm \frac{1}{2}$ cycle, whichever is greater, plus trip time for instantaneous response (0.0 setting)*

\* Trip Time for 0.0 Delay Setting .....  $1\frac{1}{4}$  cycles maximum for currents  $\geq 5$  times the pickup setting.  $1\frac{3}{4}$  cycles maximum for a current of 2 times pickup. Two cycles maximum for a current of 1.05 times the pickup setting.

**Automatic Setting Group Characteristics**

Number of Setting Groups .....	4
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**Control Modes**

Automatic .....	Cold-Load Pickup, Dynamic Load or Unbalance
External .....	Discrete Input Logic, Binary Input Logic

**Switch Threshold**

Range.....	0.1 to 25 A (5 A), 0.02 to 5 A (1 A)
Accuracy.....	$\pm 2\%$ or $\pm 0.05$ A (5 A), $\pm 2\%$ or $\pm 0.01$ A (1 A)

**Switch Time**

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

**BESTlogic™ Plus**

Update Rate .....	$\frac{1}{4}$ cycle
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**General Specifications****AC Current Inputs****5 Ampere CT**

Continuous Rating.....	20 A
One Second Rating.....	400 A

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

Begins to Clip (Saturate) .....	150 A
Burden.....	<10 m $\Omega$

**1 Ampere CT**

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

For other current levels, use the following formula:  $I = (K/t)^{\frac{1}{2}}$  where t = time in seconds, K = 6,400.

Begins to Clip (Saturate) .....	30 A
Burden.....	<10 m $\Omega$

**SEF**

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

Terminals (CT1)

IA1 .....	D1, D2
IB1 .....	D3, D4
IC1 .....	D5, D6
IN1 .....	D7, D8

Terminals (CT2)

IA2 .....	F1, F2
IB2 .....	F3, F4
IC2 .....	F5, F6
IN2 .....	F7, F8

**Phase AC Voltage Inputs**

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

Terminals

VA .....	C13
VB .....	C14
VC .....	C15
N .....	C16

**Auxiliary AC Voltage Input**

Continuous Rating .....	150 V, Line to Line
One Second Rating .....	600 V, Line to Neutral
Burden .....	<1 VA @ 150 Vac
Terminals .....	C17, C18

**Analog to Digital Converter**

Type .....	16-bit
Sampling Rate .....	32 samples per cycle, adjusted to input frequency (10 to 125 Hz)

**Power Supply**

Terminals .....	A6, A7
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Option 1 (48/125 Vac/dc)

DC Operating Range .....	35 to 150 Vdc
AC Operating Range .....	55 to 135 Vac

Option 2 (125/250 Vac/dc)

DC Operating Range .....	90 to 300 Vdc
AC Operating Range .....	90 to 270 Vac

Option 3 (24 Vdc)

Operating Range .....	17 to 32 Vdc (down to 8 Vdc momentarily)
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Frequency Range

Options 1 and 2 only .....	40 to 70 Hz
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Burden

Options 1, 2, and 3..... 12 W continuous, 14 W maximum with all outputs energized

**Output Contacts**

Make and Carry for Tripping Duty ..... 30 A, 250 Vdc for 0.2 seconds per IEEE Std C37.90-2005 - *IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus*; 7 A continuous AC or DC

Break Resistive or Inductive..... 0.3 A at 125 or 250 Vdc (L/R = 0.04 maximum)

Terminals

OUT 1..... C1, C2  
 OUT 2..... C3, C4  
 OUT 3..... C5, C6  
 OUT 4..... C7, C8  
 OUT 5..... C9, C10  
 OUT 6..... E11, E12  
 OUT 7..... E9, E10  
 OUT 8..... E7, E8  
 OUT A ..... C11, C12

**Contact-Sensing Inputs**

Maximum Input Voltage

The maximum input voltages are the highest voltage for each power-supply range listed under the *Power Supply* section.

Turn-On Voltage

Contact-sensing turn-on voltages are listed in Table 78-1.

**Table 78-1. Contact-Sensing Turn-On Voltages**

Style Option	Nominal Input Voltage	Contact-Sensing Turn-On Voltage*	
		Jumper Installed (Low Position) †	Jumper Not Installed (High Position) †
Txx1xxxxxxxxxx	48 Vdc or 125 Vac/dc	26 to 38 Vdc	69 to 100 Vdc 56 to 97 Vac
Txx2xxxxxxxxxx	125/250 Vac/dc	69 to 100 Vdc 56 to 97 Vac	138 to 200 Vdc 112 to 194 Vac
Txx3xxxxxxxxxx	24 Vdc	n/a	Approx. 5 Vdc

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

† Voltage ranges depend on jumper configurations. See the *Contact Inputs and Outputs* chapter for more information.

Input Burden

Burden values shown in Table 78-2 assume nominal value of input voltage applied.

**Table 78-2. Contact-Sensing Input Burden**

Style Option	Nominal Input Voltage	Burden	
		Jumper Installed (Low Position)	Jumper Not Installed (High Position)
Txx1xxxxxxxxxx	48 Vdc or 125 Vac/dc	22 kΩ	53 kΩ
Txx2xxxxxxxxxx	125/250 Vac/dc	66 kΩ	123 kΩ

Style Option	Nominal Input Voltage	Burden	
		Jumper Installed (Low Position)	Jumper Not Installed (High Position)
Txx3xxxxxxxxxx	24 Vdc	n/a	6 k $\Omega$

### Recognition Time

Programmable..... 4 to 255 ms

### Note

All timing specifications are for the worst-case response. This includes output contact operate times and standard *BESTlogicPlus* operation timing but excludes input debounce timing and nonstandard logic configurations. If a nonstandard logic scheme involves feedback, then one or more *BESTlogicPlus* update rate delays must be included to calculate the worst-case delay. An example of feedback is logic outputs driving logic inputs. For more information, see *BESTlogicPlus*.

### Terminals

IN1 ..... B1, B2  
 IN2 ..... B3, B4  
 IN3 ..... B5, B6  
 IN4 ..... B7, B8  
 IN5 ..... E1, E2  
 IN6 ..... E3, E4  
 IN7 ..... E5, E6  
 IN8 (Optional) ..... E7, E8  
 IN9 (Optional) ..... E9, E10  
 IN10 (Optional) ..... E11, E12

### **IRIG Interface**

Standard ..... 200-98, Format B002, and 200-04, Format B006  
 Input Signal ..... Demodulated (dc level-shifted signal)  
 Logic High Level ..... 3.5 Vdc, minimum  
 Logic Low Level ..... 0.5 Vdc, maximum  
 Input Voltage Range ..... -10 to +10 Vdc  
 Input Resistance ..... Nonlinear, approximately 4 k $\Omega$  at 3.5 Vdc,  
 3 k $\Omega$  at 20 Vdc  
 Response Time ..... <1 cycle  
 Terminals ..... A1, A2

### **Real-Time Clock**

Clock has leap year and selectable daylight saving time correction. Backup capacitor and standard backup battery sustain timekeeping during losses of BE1-11t operating power.

Resolution ..... 1 s  
 Accuracy .....  $\pm 1.73$  s/d at 77°F (25°C)

### Clock Holdup

Capacitor Holdup Time ..... Up to 24 hours depending on conditions  
 Battery Holdup Time ..... Greater than 5 years depending on conditions  
 Battery Type ..... BR2032 CR2032, coin-type, 3 Vdc, 195 mAh  
 Basler Electric P/N 38526

### Caution

Replacement of the backup battery for the real-time clock should be performed only by qualified personnel.  
Observe polarity markings on the battery socket while inserting a new battery. The battery polarity must be correct in order to provide backup for the real-time clock.

### Note

Failure to replace the battery with Basler Electric P/N 38526 may void the warranty.

## Communication Ports

Communication ports consist of USB, serial, and Ethernet connections.

### USB

A front-panel B-type USB connector provides local communication with a PC operating BESTCOMS*Plus*® software. Compatible with USB 2.0 specification.

Data Transfer Speed..... 12 MB/s (Full Speed)

### RS-485

Rear-panel RS-485 port (compression terminals) that supports Modbus and DNP3.

Port Speed (Baud) ..... Up to 115,200

### Terminals

A ..... A3  
B ..... A4  
C ..... A5

### Ethernet (Optional)

Either an RJ45 or a fiber optic Ethernet port is available. See style chart. These connectors provide dynamic addressing (DHCP), web pages (HTTP), e-mail alerts (SMTP), network time protocol (NTP) to synchronize the real-time clock, as well as communication with BESTCOMS*Plus* software. Modbus, DNP3, and IEC 61850 communication through Ethernet is optional.

### Copper Type (RJ45 Connector)

Version ..... 10BASE-T/100BASE-TX  
Maximum Length (One Network Segment)..... 328 ft (100 m)

### Fiber Optic Type (ST Connector)

Version ..... 100BASE-FX, multimode  
Maximum Length (Half-Duplex) ..... 1,310 ft (399 m)  
Maximum Length (Full-Duplex)..... 6,600 ft (2,011 m)

## Panel Display

64 by 128 dot pixels LCD with LED backlight.

Operating Temperature ..... –40 to 158°F (–40 to 70°C). Display contrast adjustment may be impaired below –4°F (–20°C).

## Temperature

Operating Temperature Range ..... –40 to 158°F (–40 to 70°C)\*  
Storage Temperature Range ..... –40 to 158°F (–40 to 70°C)

\* Display is inoperative below –4°F (–20°C)

## Isolation

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

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

\* Excludes communication ports.

## Standards

IEC Standards:

- IEC 60068-1 – *Environmental Testing Part 1: General and Guidance. Temperature Test*
- IEC 60068-2-1 – *Basic Environmental Testing Procedures, Part 2: Tests - Test Ad: Cold (Type Test)*
- IEC 60068-2-2 – *Basic Environmental Testing Procedures, Part 2: Tests - Test Bd: Dry Heat (Type Test)*
- IEC 60068-2-28 – *Environmental Testing Part 2: Testing-Guidance for Damp Heat Tests*
- IEC 60255-4 – *Single Input Energizing Quantity Measuring Relays with Dependent Specified Time*
- IEC 60255-5 – *Electrical Insulation Tests for Electrical Relays. Dielectric Test and Impulse Test*
- IEC 60255-6 – *Electrical Relays - Measuring Relays and Protection Equipment*
- IEC 60255-21-1 – *Vibration, Shock, Bump, and Seismic Tests on Measuring Relays and Protective Equipment (Section 1 - Vibration Test - Sinusoidal). Class 1*
- IEC 60255-21-2 – *Vibration, Shock, Bump, and Seismic Tests on Measuring Relays and Protective Equipment (Section 2 - Shock and Bump Test - Sinusoidal). Class 1*
- IEC 60255-21-3 – *Vibration, Shock, Bump, and Seismic Tests on Measuring Relays and Protective Equipment (Section 3 – Seismic Test). Class 1*

IEEE Standards:

- IEEE Std C37.90.1-2002 – *IEEE Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus*
- IEEE Std C37.90.2-2004 – *IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers*
- IEEE Std C37.90.3-2001 – *IEEE Standard Electrostatic Discharge Test for Protective Relays*

## CE and UKCA Compliance

This product has been evaluated and complies with the relevant essential requirements set forth by the EU legislation and UK Parliament.

EC Directives:

- LVD 2014/35/EU
- EMC 2014/30/EU
- RoHS 2 2011/65/EU as amended by (EU) 2015/863

Harmonized standards used for evaluation:

- IEC 60255-1:2010 – *Measuring Relays and Protection Equipment, Part 1: Common Requirements*
- IEC 60255-26:2014 – *Measuring Relays and Protection Equipment, Part 26: Electromagnetic Compatibility Requirements*
- IEC 60255-27:2014 – *Measuring Relays and Protection Equipment, Part 27: Product Safety Requirements*

## UL Recognition

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

Standard used for evaluation:

- UL 508

UL Recognition for Style xxxxxxxxxxxCxx

This product is recognized to applicable U.S. and Canadian safety standards and requirements by UL. Evaluation to Class 1, Div 2, Groups A, B, C, and D, Temperature Code T4 for Hazardous Location Service. Suitable for use in Class 1, Division 2, Groups A, B, C, and D hazardous locations only.

Standards used for evaluation:

- UL 508
- ISA 12.12.01
- CSA C22.2 No. 213-M1987

**Warning! - EXPLOSION HAZARD**

Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

Substitution of components may impair suitability for Class 1, Division 2.

Do not engage USB unless power has been switched off or the area is known to be non-hazardous.

**CSA Certification**

This product was tested and has met the certification requirements for industrial control equipment.

Standards used for evaluation:

- CSA C22.2 No. 14

**China RoHS**

The following table serves as the declaration of hazardous substances for China in accordance with PRC standard SJ/T 11364-2014. The EFUP (Environment Friendly Use Period) for this product is 40 years.

PRODUCT: BE1-11t		有害物质 Hazardous Substances								
零件名称 Part Name	铅 Lead (Pb)	汞 Mercury (Hg)	镉 Cadmium (Cd)	六价铬 Hexavalent Chromium (Cr <sup>6+</sup> )	多溴联苯 Polybrominated Biphenyls (PBB)	多溴二苯醚 Polybrominated Diphenyl Ethers (PBDE)	邻苯二甲酸二丁酯 Dibutyl Phthalate (DBP)	邻苯二甲酸丁苄酯 Benzyl butyl phthalate (BBP)	邻苯二甲酸二酯 Bis(2-ethylhexyl) phthalate (BEHP)	邻苯二甲酸二异丁酯 Diisobutyl phthalate (DIBP)
金属零件 Metal parts	○	○	○	○	○	○	○	○	○	○
聚合物 Polymers	○	○	○	○	○	○	○	○	○	○
电子产品 Electronics	X	○	○	○	○	○	○	○	○	○
电缆和互连配件 Cables & interconnect accessories	○	○	○	○	○	○	○	○	○	○
绝缘材料 Insulation material	○	○	○	○	○	○	○	○	○	○

本表格依据 SJ/T11364 的规定编制。

<b>PRODUCT:</b> BE1-11 <i>t</i>										
有害物质 Hazardous Substances										
零件名称 Part Name	铅 Lead (Pb)	汞 Mercury (Hg)	镉 Cadmium (Cd)	六价铬 Hexavalent Chromium (Cr <sup>6+</sup> )	多溴联苯 Polybrominated Biphenyls (PBB)	多溴二苯醚 Polybrominated Diphenyl Ethers (PBDE)	邻苯二甲 酸二丁酯 Dibutyl Phthalate (DBP)	邻苯二甲 酸丁苄酯 Benzyl butyl phthalate (BBP)	邻苯二甲 酸二酯 Bis(2- ethylhexyl) phthalate (BEHP)	邻苯二甲 酸二异丁 酯 Diisobutyl phthalate (DIBP)
<p>O: 表示该有害物质在该部件所有均质材料中的含量均在 GB/T 26572 规定的限量要求以下。</p> <p>X: 表示该有害物质至少在该部件的某一均质材料中的含量超出 GB/T 26572 规定的限量要求。</p> <p>This form was prepared according to the provisions of standard SJ/T11364.</p> <p>O: Indicates that the hazardous substance content in all homogenous materials of this part is below the limit specified in standard GB/T 26572.</p> <p>X: Indicates that the hazardous substance content in at least one of the homogenous materials of this part exceeds the limit specified in standard GB/T 26572.</p>										

## FCC Requirements

This product complies with FCC 47 CFR Part 15.

## HALT (Highly Accelerated Life Testing)

Basler Electric uses HALT to prove that our products will provide the user with many years of reliable service. HALT subjects the device to extremes in temperature, shock, and vibration to simulate years of operation, but in a much shorter period span. HALT allows Basler Electric to evaluate all possible design elements that will add to the life of this device. As an example of some of the extreme testing conditions, the BE1-11*t* was subjected to temperature extremes of  $-80^{\circ}\text{C}$  to  $+130^{\circ}\text{C}$ , vibration extremes of 5 to 45 G at  $+20^{\circ}\text{C}$ , and temperature/vibration extremes of 45 G over a temperature range of  $-60^{\circ}\text{C}$  to  $+110^{\circ}\text{C}$ . Combined temperature and vibration testing at these extremes proves that the BE1-11*t* is expected to provide long-term operation in a rugged environment. Note that the vibration and temperature extremes listed in this paragraph are specific to HALT and do not reflect recommended operation levels. These operational ratings are listed under *Temperature*.

## DNP Certification

DNP3-2009, V2.6 compliant, Subset Level 2, by Advanced Control Systems, Inc.

## IEC 61850 Certification

KEMA certified per IEC 61850 Certificate Level A.

## Physical

Weight ..... 5.1 lb (2.3 kg)  
 IP Class ..... IP50  
 Case Size ..... Refer to the *Mounting* chapter.

# 79 • Specifications - 25 Hz Operation

BE1-11 $\tau$  protection systems used in 25 Hz systems have the following features and capabilities.

## ***Operational Specifications***

### **Metered Current Values and Accuracy**

5 Aac Nominal Range .....	0.5 to 15 Aac
1 Aac Nominal Range .....	0.1 to 3.0 Aac
SEF Range.....	0.01 to 3.0 Aac
Phase Current Accuracy .....	$\pm 1.5\%$ of reading at nominal current $\pm 2.5\%$ of reading or $\pm 0.15\%$ of full range, whichever is greater at 77°F (25°C)
I1, I2, I0* Accuracy.....	$\pm 2\%$ of reading at nominal current $\pm 3\%$ of reading or $\pm 0.25\%$ of full range, whichever is greater at 77°F (25°C)
Temperature Dependence .....	$\leq \pm 0.02\%$ per °C
* 3I0 displayed	

### **Metered Voltage Values and Accuracy**

3-wire Range.....	50 to 250 Vac
4-wire Range.....	50 to 250 Vac
Auxiliary Range.....	25 to 125 Vac
Phase/Auxiliary Accuracy.....	$\pm 1\%$ of reading or $\pm 0.2\%$ of full range whichever is greater at 77°F (25°C)
V1, V2, V0* Accuracy .....	$\pm 1.5\%$ of reading or $\pm 0.3\%$ of full range whichever is greater at 77°F (25°C)
Temperature Dependence .....	$\leq \pm 0.02\%$ per °C
* 3V0 displayed	

### **Metered Frequency Values and Accuracy**

Range.....	10 to 125 Hz
Accuracy.....	$\pm 0.01$ Hz, $\pm 1$ least significant digit at 77°F (25°C) nominal
3-wire Sensing Input .....	Phase A – B
4-wire Sensing Input .....	Phase A – Neutral
Minimum Frequency Tracking Voltage .....	10 V rms

### **Calculated Values and Accuracy**

#### Demand

Range.....	0.1 to 1.5 nominal
Type .....	Exponential
Accuracy.....	$\pm 2\%$ of reading $\pm 1$ digit at 77°F (25°C)
Temperature Dependence .....	$\leq \pm 0.02\%$ per °C
Interval.....	1 to 60 min

#### True Power

5 Ampere CT Range .....	-4,500 W to +4,500 W
1 Ampere CT Range .....	-900 W to +900 W
Accuracy.....	$\pm 3\%$ at unity power factor

#### Reactive Power

5 Ampere CT Range .....	-4,500 var to +4,500 var
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1 Ampere CT Range ..... –900 var to +900 var  
 Accuracy..... ±3% at zero power factor

### Energy Data Reporting

5 Ampere CT Range ..... 1,000 GWh or 1,000 Gvarh  
 1 Ampere CT Range ..... 1,000 GWh or 1,000 Gvarh  
 Units of Measure ..... kilo  
 Rollover Value of Registers..... 1,000,000,000 kWhr or kvarhr  
 Accuracy..... ±3% at unity power factor

## 21 - Distance Protection

### Diameter

Setting Range ..... 0 to 500  $\Omega$   
 5 Ampere CT Accuracy ..... ±5% or ±0.4  $\Omega$ , whichever is greater from 0 to 100  $\Omega$   
 1 Ampere CT Accuracy ..... ±5% or ±0.4  $\Omega$ , whichever is greater from 0 to 500  $\Omega$

### Time Delay

Setting Range ..... 0 to 300,000 ms  
 Accuracy..... ±1.5% or ±4 cycles, whichever is greater

### Torque Angle

Setting Range ..... 0 to 90 degrees  
 Accuracy..... ±1 degree

### Offset

Setting Range ..... –500 to 500  $\Omega$   
 5 Ampere CT Accuracy ..... ±5% or ±0.4  $\Omega$ , whichever is greater from –100 to 100  $\Omega$   
 1 Ampere CT Accuracy ..... ±5% or ±0.4  $\Omega$ , whichever is greater from –500 to 500  $\Omega$

## 24 - Overexcitation Protection

### Inverse Time

Curve Exponent ..... 0.5, 1, or 2

### Pickup

Setting Range ..... 0.5 to 6 V/Hz  
 Accuracy..... ±2% or ±0.05 V/Hz, whichever is greater  
 Dropout/Pickup Ratio ..... 98% ±1%

### Time Dial

Setting Range ..... 0.0 to 9.9  
 Accuracy..... ±5% or ±3 cycles, whichever is greater

### Reset Dial

Setting Range ..... 0.0 to 9.9  
 Accuracy..... ±5% or ±3 cycles, whichever is greater

### Definite Time 1 and 2

#### Pickup

Setting Range ..... 0.5 to 6 V/Hz  
 Accuracy..... ±2% or ±0.05 V/Hz, whichever is greater

#### Time Delay

Setting Range ..... 50 to 600,000 ms  
 Accuracy..... ±1.5% or ±4 cycles, whichever is greater

AlarmPickup

Setting Range .....	0.5 to 6 V/Hz
Accuracy.....	±2% or ±0.05 V/Hz, whichever is greater
Reset/Alarm Ratio .....	98% ±1%

Time Delay

Setting Range .....	50 to 600,000 ms
Accuracy.....	±1.5% or ±4 cycles, whichever is greater

**25 - Sync-Check Protection**SettingsVoltage Difference

Setting Range .....	0 to 50% of nominal
Accuracy.....	±2% or ±1 V, whichever is greater

Slip Angle

Setting Range .....	1 to 99°
Accuracy.....	±1°

Slip Frequency

Setting Range .....	0.01 to 0.50 Hz
Accuracy.....	±0.01 Hz

Sensing

Angle Compensation Setting Range.....	0 to 359.9°
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Voltage MonitoringLive/Dead Voltage

Setting Range .....	0 to 90%
Accuracy.....	±2%

Drop Out Delay

Setting Range .....	50 to 60,000 ms
Accuracy.....	±1.5% or ±4 cycles, whichever is greater

**27P - Phase Undervoltage Protection**Pickup

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

Inhibit Level

Setting Range .....	1 to 300 V
Accuracy.....	±2% or ±1 V, whichever is greater
Reset/Inhibit Ratio.....	102% ±1%

Timing ModeDefinite Timing

Setting Range .....	50 to 600,000 ms
Accuracy.....	±1.5% or ±4 cycles, whichever is greater

Inverse Timing

Setting Range .....	0 to 9.9
Accuracy.....	±8% or ±4 cycles, whichever is greater

## 27X - Auxiliary Undervoltage Protection

### Pickup

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

### Inhibit Level

Setting Range .....	1 to 150 V
Accuracy.....	±2% or ±1 V, whichever is greater
Reset/Inhibit Ratio.....	102% ±1%

### Timing Mode

#### Definite Timing

Setting Range .....	50 to 600,000 ms
Accuracy.....	±1.5% or ±4 cycles, whichever is greater

#### Inverse Timing

Setting Range .....	0 to 9.9
Accuracy.....	±8% or ±4 cycles, whichever is greater

## 46 - Negative-Sequence Current Protection

Negative-sequence current protection is available when a 50 or 51 element is configured in I2 mode. Refer to *Instantaneous Overcurrent* or *Inverse Overcurrent* for operational specifications.

## 47 - Negative-Sequence Voltage Protection

Negative-sequence voltage protection is available when a 27X or 59X element is configured in V2 mode. Refer to *Auxiliary Overvoltage* or *Auxiliary Undervoltage* for operational specifications.

## 49RTD - Resistance Temperature Device Protection (Optional)

### Pickup

Setting Range .....	32 to 482°F (0 to 250°C)
Accuracy.....	±2% or ±3.6°F (±2°C), whichever is greater
Reset/Pickup Ratio.....	105% / 95% ±1% (over / under) or 41°F (5°C) minimum

### Time Delay

Setting Range .....	0 to 600,000 ms
Accuracy.....	±1 s

## 50 - Instantaneous Overcurrent Protection

### Pickup

5 Ampere CT Setting Range .....	0.5 to 150 A
1 Ampere CT Setting Range.....	0.1 to 30 A
SEF Setting Range .....	0.01 to 7.5 A
Unbalanced Setting Range .....	2 to 100%
Dropout .....	93 to 99% of the actual pickup value

### 3Phase, IA, IB, IC, IG Accuracy

5 Ampere CT.....	±4% or ±50 mA, whichever is greater
1 Ampere CT.....	±4% or ±10 mA, whichever is greater
SEF (Pickup Setting of 0.01 to 4.99 A) .....	±(5% + 4.5 mA)
SEF (Pickup Setting of 5 to 7.5 A) .....	±(10% + 4.5 mA)

**3I0, I1, I2 Accuracy**

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

**Unbalanced Accuracy**

5 Ampere CT .....	±3% of pickup setting
1 Ampere CT .....	±3% of pickup setting

**Time Delay**

Setting Range .....	0 to 60,000 ms
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**Accuracy**

Phase & Ground .....	±1% or ±3 cycles, whichever is greater, plus trip time for instantaneous response (0.0 setting)*
Residual .....	±2% or ±3 cycles, whichever is greater, plus trip time for instantaneous response (0.0 setting)*
* Trip Time for 0.0 Delay Setting .....	1¼ cycles maximum for currents ≥ 5 times the pickup setting. 1¾ cycles maximum for a current of 2 times pickup. Two cycles maximum for a current of 1.05 times the pickup setting.

**50BF - Breaker Failure Protection****Phase & Ground Pickup**

5 Ampere CT Setting Range .....	0.25 to 10 A
1 Ampere CT Setting Range .....	0.05 to 2 A
SEF .....	0.01 to 0.5 A

**Accuracy**

5 Ampere CT .....	±4% or ±50 mA, whichever is greater
1 Ampere CT .....	±4% or ±10 mA, whichever is greater
SEF .....	±(5% + 2.5 mA)

**Time Delay & Control Time**

Setting Range .....	50 to 999 ms
Accuracy .....	±1% or +3, -0.5 cycles, whichever is greater

**51 - Inverse Overcurrent Protection****Pickup**

5 Ampere CT Setting Range .....	0.5 to 16 A
1 Ampere CT Setting Range .....	0.1 to 3.2 A
SEF Setting Range .....	0.01 to 0.8 A
Unbalanced Setting Range .....	2 to 100%
Dropout .....	93 to 99% of the actual pickup value

**3Phase, IA, IB, IC, IG Accuracy**

5 Ampere CT .....	±4% or ±50 mA, whichever is greater
1 Ampere CT .....	±4% or ±10 mA, whichever is greater
SEF .....	±(5% + 2.5 mA)

**3I0, I1, I2 Accuracy**

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

**Unbalanced Accuracy**

5 Ampere CT .....	±3% of pickup setting
1 Ampere CT .....	±3% of pickup setting

Time Current Characteristic Curves

Timing Accuracy (All 51 Functions) .....  $\pm 8\%$  or  $\pm 4$  cycles, whichever is greater, for time dial settings greater than 0.1 and multiples of 2 to 40 times the pickup setting but not over 150 A for 5 A CT units or 30 A for 1 A CT units.  
Refer to the *Time Curve Characteristics* chapter for information on available timing curves.

Voltage Restraint

Control/Restraint Range ..... 30 to 250 V  
Accuracy .....  $\pm 2\%$  or  $\pm 1$  V, whichever is greater

**51TF - Transformer Monitor**Base CurrentPickup

5 Ampere CT Setting Range ..... 0.5 to 16 A  
1 Ampere CT Setting Range ..... 0.1 to 3.2 A

Alarm Count

Setting Range ..... 1 to 99

Thresholds

Setting Range ..... 1 to 40 A

Accuracy

5 Ampere CT .....  $\pm 4\%$  or  $\pm 0.05$  A, whichever is greater  
1 Ampere CT .....  $\pm 4\%$  or  $\pm 0.01$  A, whichever is greater

N Constants

Setting Range ..... 0.5 to 3

K Constants

Setting Range ..... 1 to 3,000

**59P - Phase Overvoltage Protection**Pickup

Setting Range ..... 1 to 300 V  
Accuracy .....  $\pm 2\%$  or  $\pm 1$  V, whichever is greater  
Dropout/Pickup Ratio .....  $98\% \pm 1\%$

Timing ModeDefinite Timing

Setting Range ..... 50 to 600,000 ms  
Accuracy .....  $\pm 1.5\%$  or  $\pm 2$  cycles, whichever is greater

Inverse Timing

Setting Range ..... 0 to 9.9  
Accuracy .....  $\pm 8\%$  or  $\pm 4$  cycles, whichever is greater

**59X - Auxiliary Overvoltage Protection**Pickup

Setting Range ..... 1 to 150 V  
Accuracy .....  $\pm 2\%$  or  $\pm 1$  V, whichever is greater  
Dropout/Pickup Ratio .....  $98\% \pm 1\%$

Timing ModeDefinite Timing

Setting Range ..... 50 to 600,000 ms  
 Accuracy.....  $\pm 1.5\%$  or  $\pm 4$  cycles, whichever is greater

Inverse Timing

Setting Range ..... 0 to 9.9  
 Accuracy.....  $\pm 8\%$  or  $\pm 4$  cycles, whichever is greater

**60FL - Fuse Loss**

Time Delay ..... Fixed at 50 ms

**62 - Logic Timers**

Modes..... Pickup/Dropout, One-Shot/Non-Retriggerable,  
 One-Shot/Retriggerable, Oscillator, Integrating  
 Timer, Latched  
 Setting Range ..... 0 to 9,999,000 ms  
 Accuracy.....  $\pm 0.5\%$  or  $\pm 12$  ms, whichever is greater

**67/67N - Directional Current and Polarization Protection**

Modes..... Forward, Reverse, Non-directional  
 Maximum Torque Angle ..... 0 to 359.9°

Polarization Methods

- Zero Sequence Current Polarization (IG)
- Negative Sequence Polarization (Q)
- Zero Sequence Polarization (V)
  - VOIN - Calculated Zero Sequence Voltage compared to Calculated Zero Sequence Current.
  - VOIG - Calculated Zero Sequence Voltage compared to Measured Ground Current.
  - VXIN - Measured 3V0-VX Input compared to Calculated Zero Sequence Current.
  - VXIG - Measured 3V0-VX Input compared to Measured Ground Current.

**79 - Recloser Protection**

*Reclose (1st, 2nd, 3rd, 4th), Reset (79R), Max Cycle (79M), Reclose Fail (79F)*

Setting Range ..... 100 to 600,000 ms  
 Accuracy.....  $\pm 0.5\%$  or  $+1\frac{3}{4}$ , -0 cycles, whichever is greater

**81 - Frequency Protection**O/UPickup

Setting Range ..... 15 to 110 Hz  
 Accuracy.....  $\pm 0.01$  Hz  
 Dropout..... 0.02 Hz  $\pm 0.01$  Hz of the actual pickup value

Time Delay

Setting Range ..... 0 to 600,000 ms  
 Accuracy.....  $\pm 1\%$  or  $\pm 2$  cycles, whichever is greater, plus 3  
 cycle recognition time for time delays < 50 ms

ROCPickup

Setting Range ..... 0.2 to 20 Hz/sec (positive, negative, or either)  
 Accuracy.....  $\pm 2\%$  or  $\pm 0.1$  Hz/sec of the setting, whichever is  
 greater  
 Dropout.....  $\pm 3\%$  of the actual pickup value

**Over/Underfrequency Inhibit**

Setting Range .....	15 to 110 Hz
Increment .....	0.01 Hz
Accuracy.....	±0.01 Hz

**Negative-Sequence Inhibit**

Setting Range .....	0 to 99% of nominal voltage
Accuracy.....	±0.5% or ±1 V, whichever is greater

**Time Delay**

Setting Range .....	0 to 600,000 ms
Accuracy.....	±0.5% or ±1 cycle, whichever is greater, plus recognition time*

\* Recognition time = 2 cycles for 0.57 > pickup, 4 cycles for 0.24 > pickup, 8 cycles for 0.08 > pickup, 16 cycles at pickup

**O/U/ROC Voltage Inhibit**

Setting Range .....	15 to 250 V
Accuracy.....	±2% or ±1 V, whichever is greater

**87 - Phase Current Differential Protection****Restrained Differential**

5 Ampere CT Pickup Accuracy .....	±5% or ±75 mA, whichever is greater
1 Ampere CT Pickup Accuracy .....	±5% or ±25 mA, whichever is greater
Response Time .....	<2 cycles at 5 times pickup <3 cycles at 1.5 times pickup

**TAP**

5 Ampere CT Setting Range .....	2.00 to 20.0 A
1 Ampere CT Setting Range .....	0.40 to 4.00 A

**Minimum Restraint Pickup ( $I_{op}$ )**

Setting Range .....	0.1 to 1.00 per unit
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**2<sup>nd</sup> Slope Pickup ( $I_{res}$ )**

Setting Range .....	0.1 to 20.0 per unit
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**Restraint Slope 1**

Setting Range .....	5 to 100%
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**Restraint Slope 2**

Setting Range .....	15 to 140%
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**Time Delay**

Setting Range .....	0 to 60,000 ms
Accuracy.....	±1% or ±1 cycle, whichever is greater, plus trip time for instantaneous response (0.0 setting)*

\* Trip Time for 0.0 Delay Setting ..... 1¼ cycles maximum for currents ≥ 5 times the pickup setting. 1¼ cycles maximum for a current of 2 times pickup. Two cycles maximum for a current of 1.05 times the pickup setting.

**87N - Neutral Current Differential Protection****I<sub>op</sub> Minimum Pickup****5 Ampere CT**

Setting Range .....	0.1 to 5 A
Accuracy.....	±5% or ±75 mA, whichever is greater

**1 Ampere CT**

Setting Range ..... 0.02 to 1 A  
 Accuracy.....  $\pm 3\%$  or  $\pm 15$  mA, whichever

**Overcorrection Coefficient**

Setting Range ..... 1 to 1.3

**Time Delay**

Setting Range ..... 0 to 60,000 ms  
 Accuracy.....  $\pm 1\%$  or  $\pm 1$  cycle, whichever is greater, plus trip time for instantaneous response (0.0 setting)\*  
 \* Trip Time for 0.0 Delay Setting .....  $1\frac{1}{4}$  cycles maximum for currents  $\geq 5$  times the pickup setting.  $1\frac{3}{4}$  cycles maximum for a current of 2 times pickup. Two cycles maximum for a current of 1.05 times the pickup setting.

**Automatic Setting Group Characteristics**

Number of Setting Groups ..... 4

**Control Modes**

Automatic ..... Cold-Load Pickup, Dynamic Load or Unbalance  
 External ..... Discrete Input Logic, Binary Input Logic

**Switch Threshold**

Range..... 0.1 to 25 A (5 A), 0.02 to 5 A (1 A)  
 Accuracy.....  $\pm 2\%$  or  $\pm 0.05$  A (5 A),  $\pm 2\%$  or  $\pm 0.01$  A (1 A)

**Switch Time**

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

**BESTlogic™ Plus**

Update Rate .....  $\frac{1}{4}$  cycle



# 80 • Time Curve Characteristics

This chapter provides time curve information for the inverse overcurrent (51), under/overvoltage (27/59), and overexcitation (24) functions of the BE1-11t.

## Inverse Overcurrent (51)

### General

The inverse overcurrent (51) time curves provided by the BE1-11t closely emulate most of the common electromechanical, induction-disk, overcurrent relays sold in North America. To further improve proper BE1-11t coordination, selection of integrated reset or instantaneous reset characteristics is also provided.

### Curve Specifications

Timing Accuracy (All 51 Functions): Within  $\pm 5\%$  or  $\pm 1\frac{1}{2}$  cycles, whichever is greater, for time dial settings greater than 0.1 and multiples of 2 to 40 times the pickup setting but not over 150 A for 5 A CT units or 30 A for 1 A CT units.

Twenty-two inverse time functions, one fixed time function, one 46 time function, one programmable time function, and four Table Curve functions can be selected. Characteristic curves for the inverse and definite time functions are defined by the following equations and comply with IEEE Std C37.112 - 1996 - *IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays*.

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

Equation 80-1

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

Equation 80-2

$T_T$  = Time to trip when  $M \geq 1$

$T_R$  = Time to reset if BE1-11t is set for integrating reset when  $M < 1$ . Otherwise, reset is 50 milliseconds or less

D = Time Dial setting (0.0 to 9.9)\*

M = Multiple of Pickup setting (0 to 40)

A, B, C, N, K = Constants for the particular curve

R = Constant defining the reset time.

\* Timing range is one second times the Time Dial setting when the F (fixed) curve is selected.

Table 80-1 lists time characteristic curve constants. See the figures after the tables for graphs of the characteristics.

Table 80-1. 51 Time Characteristic Curve Constants

Curve Selection	Curve Name	Trip Characteristic Constants					Reset *
		A	B	C	N	K	R
<b>S1</b>	CO Short Inverse	0.2663	0.03393	1	1.2969	0.028	0.5
<b>S2</b>	IAC Short Inverse	0.0286	0.0208	1	0.9844	0.028	0.094
<b>A</b>	Standard Inverse	0.01414	0	1	0.02	0.028	2
<b>A1</b>	IEC Inverse	0.14	0	1	0.02	0	2
<b>I1</b>	CO Inverse Time	8.9341	0.17966	1	2.0938	0.028	9

Curve Selection	Curve Name	Trip Characteristic Constants					Reset *
		A	B	C	N	K	R
I2	IAC Inverse Time	0.2747	0.10426	1	0.4375	0.028	0.8868
M	CO Moderately Inverse	0.3022	0.1284	1	0.5	0.028	1.75
D1	IEEE Moderately Inverse	0.0515	0.114	1	0.02	0	4.85
L1	CO Long Inverse	5.6143	2.18592	1	1	0.028	15.75
L2	IAC Long Inverse	2.3955	0	1	0.3125	0.028	7.8001
G	Long Time Inverse ( $I^2t$ )	12.1212	0	1	1	0.028	29
V1	CO Very Inverse	5.4678	0.10814	1	2.0469	0.028	5.5
V2	IAC Very Inverse	4.4309	0.0991	1	1.9531	0.028	5.8231
B	Very Inverse ( $I^2t$ )	1.4636	0	1	1.0469	0.028	3.25
B1	IEC Very Inverse	13.5	0	1	1	0	3.25
E3	IEEE Very Inverse	19.61	0.491	1	2	0	21.6
E1	CO Extremely Inverse	7.7624	0.02758	1	2.0938	0.028	7.75
E2	IAC Extremely Inverse	4.9883	0.0129	1	2.0469	0.028	4.7742
C	Extremely Inverse ( $I^2t$ )	8.2506	0	1	2.0469	0.028	8
C1	IEC Extremely Inverse	80	0	1	2	0	8
F1	IEEE Extremely Inverse	28.2	0.1217	1	2	0	29.1
D	CO Definite Time	0.4797	0.21359	1	1.5625	0.028	0.875
F	Fixed Time ‡	0	1	0	0	0	1
46	K Factor	†	0	0	2	0.028	100
P	User Programmable §	0 to 600	0 to 25	0 to 1	0.5 to 2.5	0.028	0 to 30
T1	User Table 1	n/a	n/a	n/a	n/a	n/a	n/a
T2	User Table 2	n/a	n/a	n/a	n/a	n/a	n/a
T3	User Table 3	n/a	n/a	n/a	n/a	n/a	n/a
T4	User Table 4	n/a	n/a	n/a	n/a	n/a	n/a

\* Instantaneous or integrating reset is selected on the Inverse Overcurrent setup screen in BESTCOMSPUs®.

† Constant A is variable for the 46 curve and is determined, as necessary, based on system full-load current setting, minimum pickup, and K factor settings.

‡ Curve F has a fixed delay of one second times the Time Dial setting.

§ The programmable curve allows for four significant digits after the decimal place for every variable.

|| There is a minimum of 2 and maximum of 40 points that can be entered for any one T curve. For information on setting T curves, refer to the *Inverse Overcurrent (51) Protection* chapter.

### Time Overcurrent Characteristic Curve Graphs

The figures after the tables illustrate the characteristic curves of the BE1-11*t*. Table 80-2 cross-references each curve to existing electromechanical relay characteristics. Equivalent time dial settings were calculated at a value of five times pickup.

Table 80-2. Characteristic Curve Cross-Reference

Curve	Curve Name	Similar To
S1	CO Short Inverse	ABB CO-2

Curve	Curve Name	Similar To
<b>S2</b>	IAC Short Inverse	GE IAC-55
<b>A</b>	Standard Inverse	Refer to BS 142
<b>A1</b>	IEC Inverse	Refer to IEC 60255-151 Ed. 1
<b>I1</b>	CO Inverse Time	ABB CO-8
<b>I2</b>	IAC Inverse Time	GE IAC-51
<b>M</b>	CO Moderately Inverse	ABB CO-7
<b>D1</b>	IEEE Moderately Inverse	Refer to IEC 60255-151 Ed. 1
<b>L1</b>	CO Long Inverse	ABB CO-5
<b>L2</b>	IAC Long Inverse	GE IAC-66
<b>G</b>	Long Time Inverse ( $I^2t$ )	Refer to BS 142
<b>V1</b>	CO Very Inverse	ABB CO-9
<b>V2</b>	IAC Very Inverse	GE IAC-53
<b>B</b>	Very Inverse ( $I^2t$ )	Refer to BS 142
<b>B1</b>	IEC Very Inverse	Refer to IEC 60255-151 Ed. 1
<b>E3</b>	IEEE Very Inverse	Refer to IEC 60255-151 Ed. 1
<b>E1</b>	CO Extremely Inverse	ABB CO-11
<b>E2</b>	IAC Extremely Inverse	GE IAC-77
<b>C</b>	Extremely Inverse ( $I^2t$ )	Refer to BS 142
<b>C1</b>	IEC Extremely Inverse	Refer to IEC 60255-151 Ed. 1
<b>F1</b>	IEEE Extremely Inverse	Refer to IEC 60255-151 Ed. 1
<b>D</b>	CO Definite Time	ABB CO-6
<b>F</b>	Fixed Time	n/a
<b>46</b>	K Factor	n/a
<b>P</b>	User Programmable	n/a
<b>T1, T2, T3, T4</b>	User Tables	n/a

#### Time Dial Setting Cross-Reference

Although the time characteristic curve shapes have been optimized for each BE1-11 $t$ , time dial settings of Basler Electric protection systems are not identical to the settings of electromechanical induction disk overcurrent relays. Table 80-3 helps you convert the time dial settings of induction disk relays to the equivalent setting for Basler Electric protection systems. Enter time dial settings using BESTCOMSP $Plus$ . For more information, refer to the *Inverse Overcurrent (51) Protection* chapter.

#### Using Table 80-3

Cross-reference table values were obtained by inspection of published electromechanical time current characteristic curves. The time delay for a current of five times tap was entered into the time dial calculator function for each time dial setting. The equivalent Basler Electric time dial setting was then entered into the cross-reference table.

If your electromechanical relay time dial setting is between the values provided in the table, it will be necessary to estimate the correct intermediate value between the electromechanical setting and the Basler Electric setting.

Basler Electric protection systems have a maximum time dial setting of 9.9. The Basler Electric equivalent time dial setting for the electromechanical maximum setting is provided in the cross-reference table even if it exceeds 9.9. This allows interpolation as noted above.

Basler Electric time current characteristics are determined by a linear mathematical equation. The induction disk of an electromechanical relay has a certain degree of non-linearity due to inertial and friction effects. For this reason, even though every effort has been made to provide characteristic curves with minimum deviation from the published electromechanical curves, slight deviations can exist between them.

In applications where the time coordination between curves is extremely close, we recommend that you choose the optimal time dial setting by inspection of the coordination study. In applications where coordination is tight, it is recommended that you retrofit your circuits with Basler Electric protection systems to ensure high timing accuracy.

**Table 80-3. Time Dial Setting Cross-Reference**

Curve	Equivalent To	Electromechanical Relay Time Dial Setting											
		0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0
		Basler Electric Equivalent Time Dial Setting											
<b>S1</b>	ABB CO-2	0.3	0.8	1.7	2.4	3.4	4.2	5.0	5.8	6.7	7.7	8.6	9.7
<b>S2</b>	GE IAC-55	0.2	1.0	2.0	3.1	4.0	4.9	6.1	7.2	8.1	8.9	9.8	n/a
<b>I1</b>	ABB CO-8	0.3	0.7	1.5	2.3	3.2	4.0	5.0	5.8	6.8	7.6	8.7	n/a
<b>I2</b>	GE IAC-51	0.6	1.0	1.9	2.7	3.7	4.8	5.7	6.8	8.0	9.3	n/a	n/a
<b>M</b>	ABB CO-7	0.4	0.8	1.7	2.5	3.3	4.3	5.3	6.1	7.0	8.0	9.0	9.8
<b>L1</b>	ABB CO-5	0.4	0.8	1.5	2.3	3.3	4.2	5.0	6.0	7.0	7.8	8.8	9.9
<b>L2</b>	GE IAC-66	0.4	0.9	1.8	2.7	3.9	4.9	6.3	7.2	8.5	9.7	n/a	n/a
<b>V1</b>	ABB CO-9	0.3	0.7	1.4	2.1	3.0	3.9	4.8	5.7	6.7	7.8	8.7	9.6
<b>V2</b>	GE IAC-53	0.4	0.8	1.6	2.4	3.4	4.3	5.1	6.3	7.2	8.4	9.6	n/a
<b>E1</b>	ABB CO-11	0.3	0.7	1.5	2.4	3.2	4.2	5.0	5.7	6.6	7.8	8.5	n/a
<b>E2</b>	GE IAC-77	0.5	1.0	1.9	2.7	3.5	4.3	5.2	6.2	7.4	8.2	9.9	n/a
<b>D</b>	ABB CO-6	0.5	1.1	2.0	2.9	3.7	4.5	5.0	5.9	7.2	8.0	8.9	n/a

## The 46 Curve

The 46 curve (Figure 80-23) is a special curve designed to emulate the  $(I_2)^2 t$  withstand ratings of generators using what is frequently referred to as the generator K factor.

### The 46 Curve Characteristics

#### 46 Pickup Current

Generators have a maximum continuous rating for negative sequence current. This is typically expressed as a percent of stator rating. When using the 46 curve, the user should convert the continuous  $I^2$  rating data to actual secondary current at the BE1-11t. This value (plus some margin, if appropriate) should be entered as the pickup setting. For example, if a generator's rated full-load current is 5 amperes, a pu setting of 0.5 A would allow 10% continuous  $I_2$ .

#### 46 Time Dial (= Generator K factor)

The amount of time that a generator can withstand a given level of unbalance is defined by Equation 80-3.

$$t = \frac{K}{(I_2)^2}$$

**Equation 80-3**

The K factor gives the time that a generator can withstand 1 per unit negative sequence current. For example, with a K factor of 20, since  $(I_2)^2$  becomes 1 at 1 per unit of current, the generator can withstand

the condition for 20 seconds. Typical values for generator K factors are in the 2 to 40 range. The BE1-11t uses the “nominal current” setting of the BE1-11t to determine what corresponds to 1 per unit current in the generator.

When curve 46 is selected, the BE1-11t changes the range of the allowed time dial to 1 to 99 (instead of the time dial range of 0.1 to 9.9 for all the other curves). The user should enter the “K” factor of the generator into the time dial field.

#### BE1-11t Equation

When the 46 function is used, the BE1-11t uses the K factor (i.e., 46 time dial setting), 46 minimum pickup setting and generator full-load current to create a constant Z (see Equation 80-4).

$$Z = 46 \text{ Time Dial} \left( \frac{I_{Nom \text{ Setting}}}{46 \text{ Pickup Setting}} \right)^2$$

**Equation 80-4**

The time to trip equation used in the BE1-11t is:

$$T_T = \frac{Z}{M^2} + 0.028 \text{ seconds}$$

**Equation 80-5**

where:

$$M = \frac{\text{Measured } I_2}{46 \text{ Pickup Setting}}$$

**Equation 80-6**

which, when  $M > 1$ , reduces to:

$$T_T = 46 \text{ Time Dial} \left( \frac{I_{Nom \text{ Setting}}}{I_2 \text{ Measured}} \right)^2$$

**Equation 80-7**

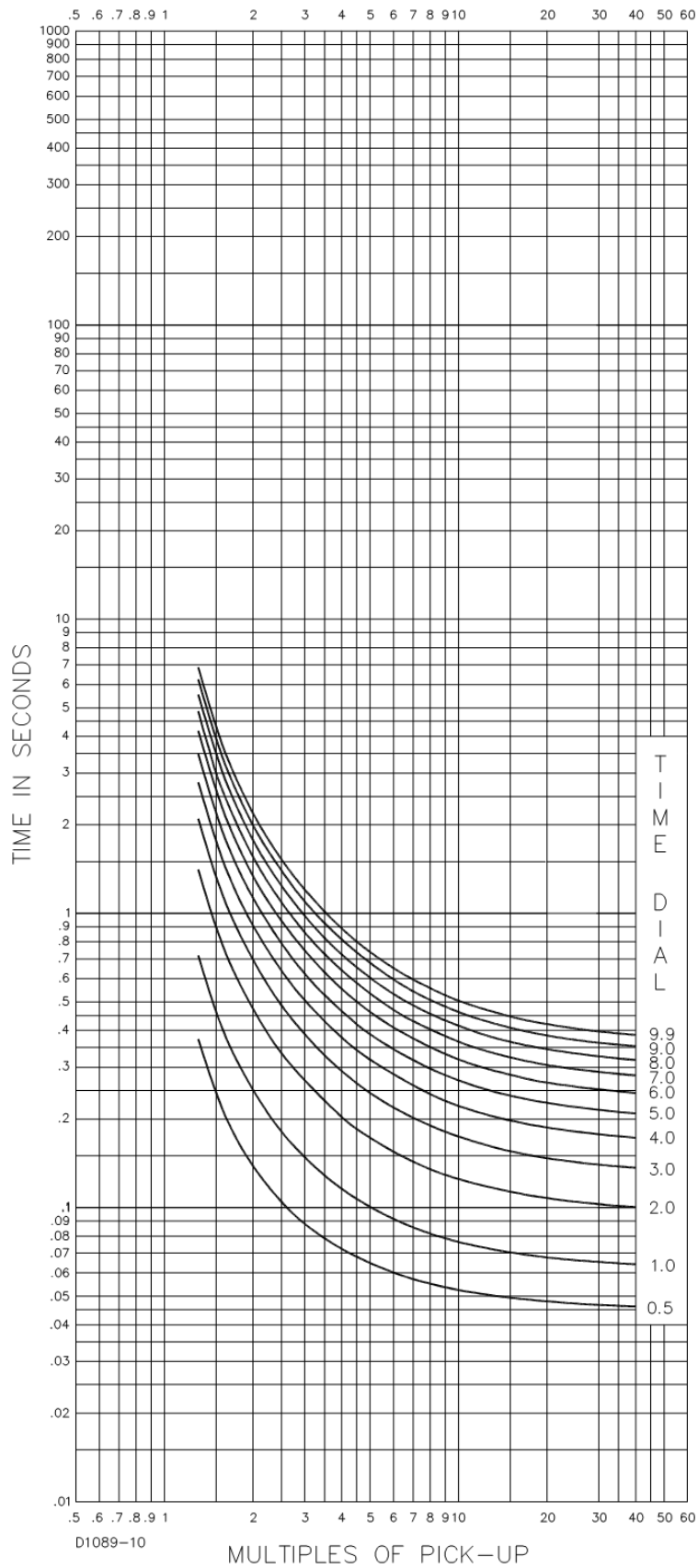


Figure 80-1. Time Characteristic Curve S1, Short Inverse (Similar to ABB CO-2)

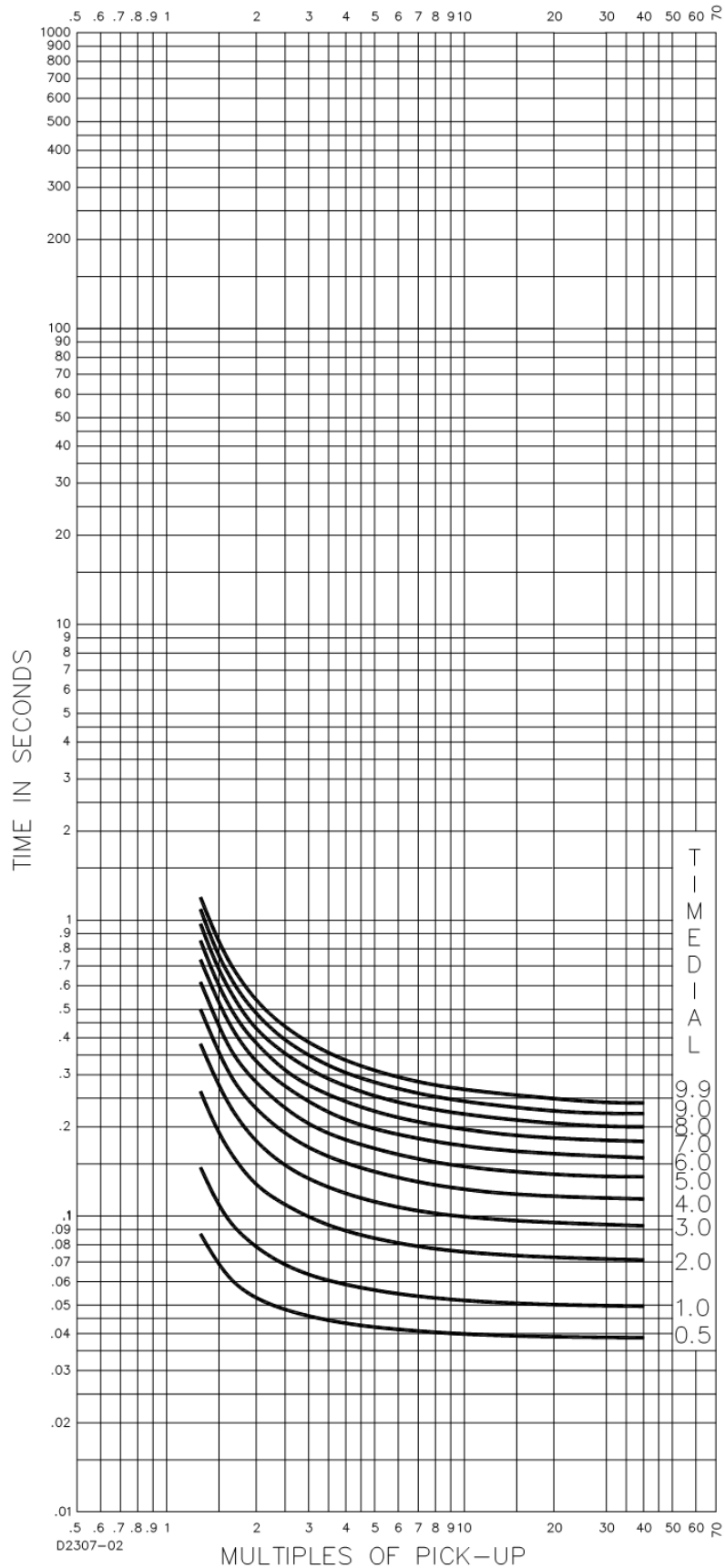


Figure 80-2. Time Characteristic Curve S2, Short Inverse (Similar To GE IAC-55)

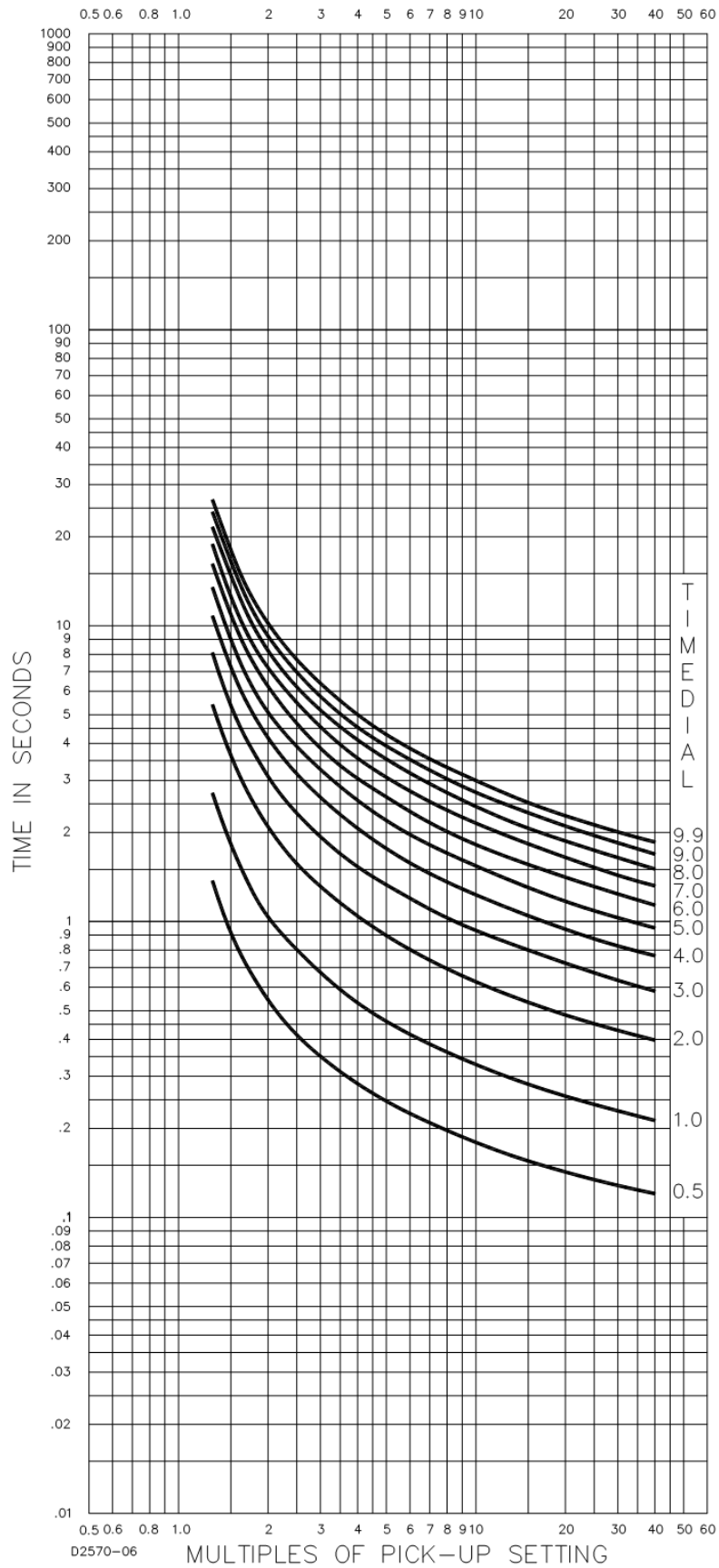


Figure 80-3. Time Characteristic Curve A, Standard Inverse (BS 142)

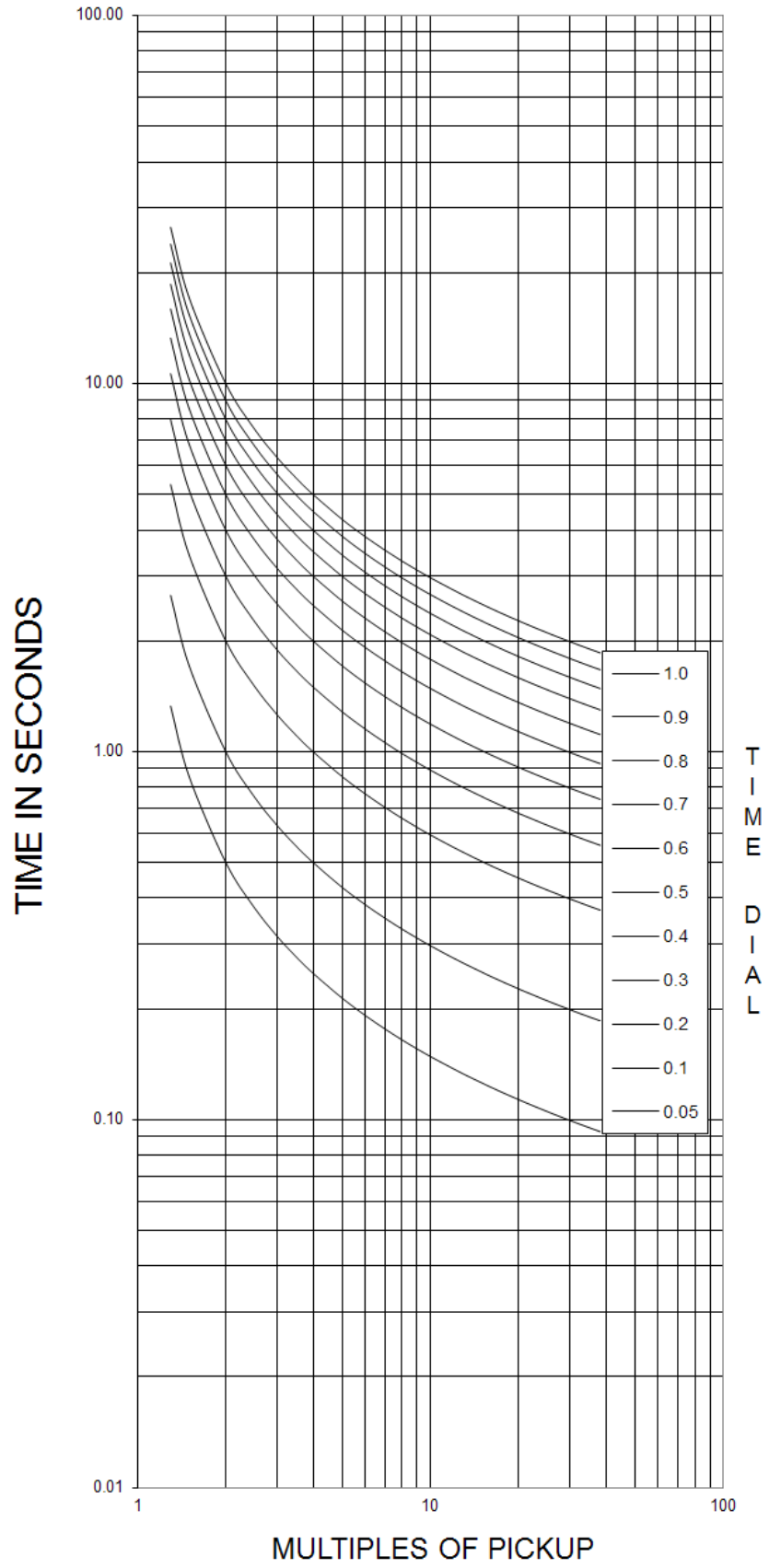


Figure 80-4. Time Characteristic Curve A1, Inverse (IEC 60255-151 Ed. 1)

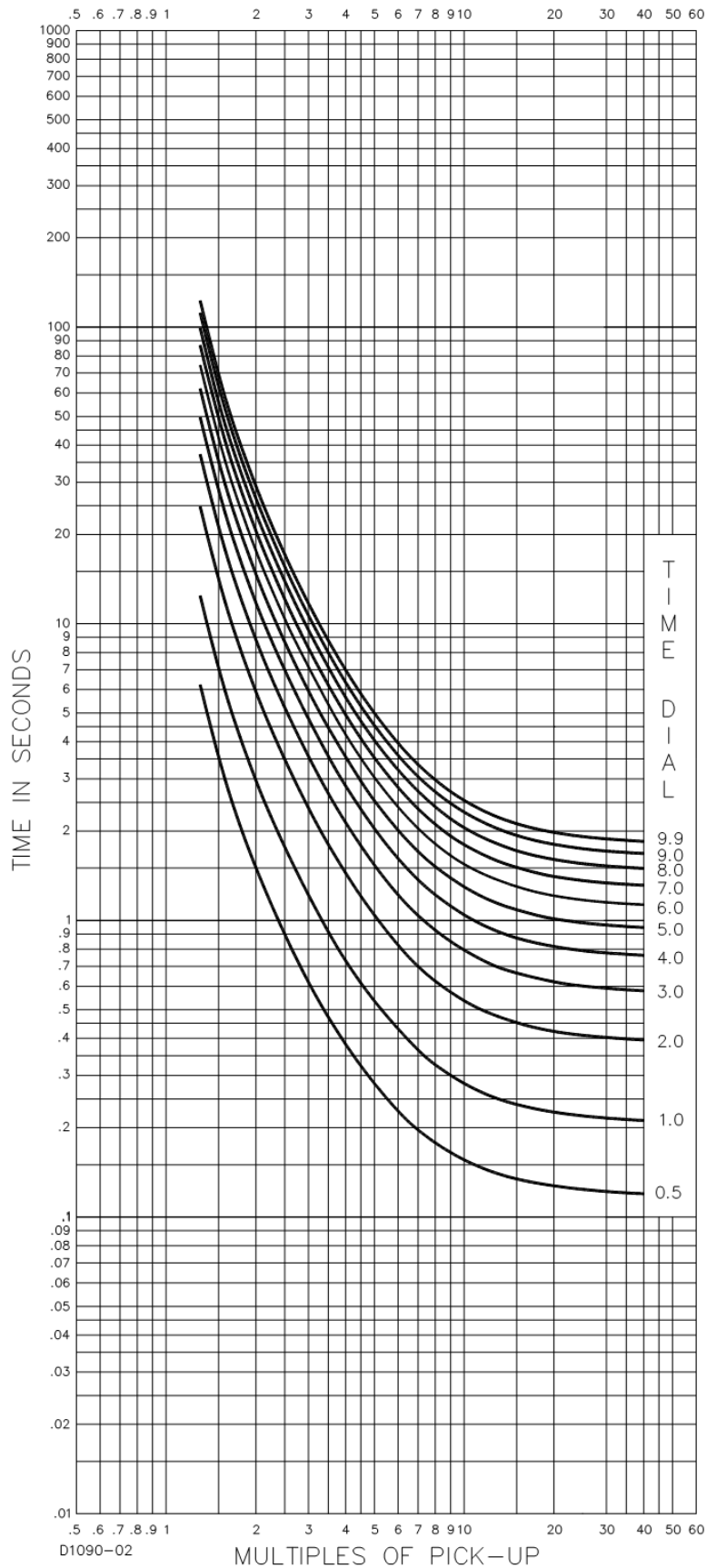


Figure 80-5. Time Characteristic Curve I1, Inverse Time (Similar to ABB CO-8)

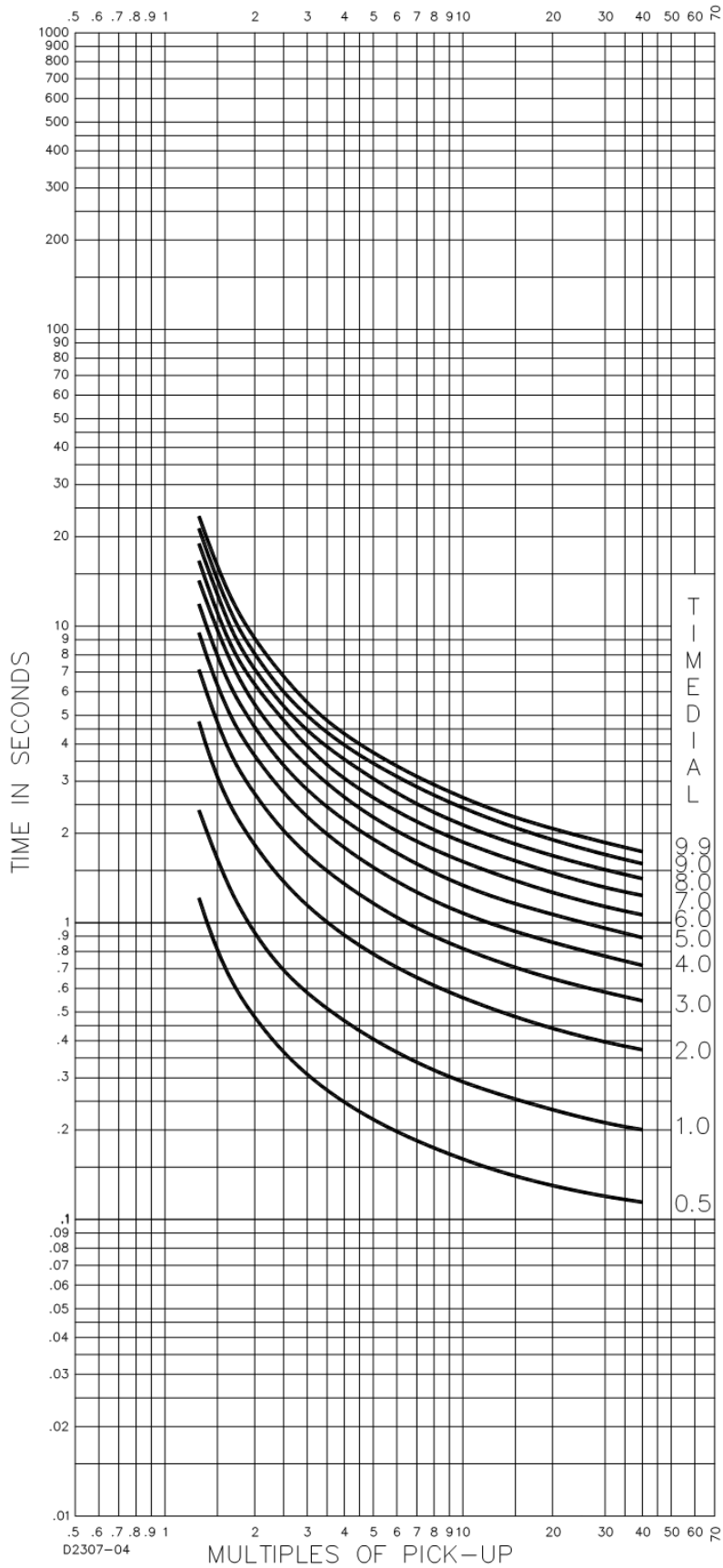


Figure 80-6. Time Characteristic Curve I2, Inverse Time (Similar to GE IAC-51)

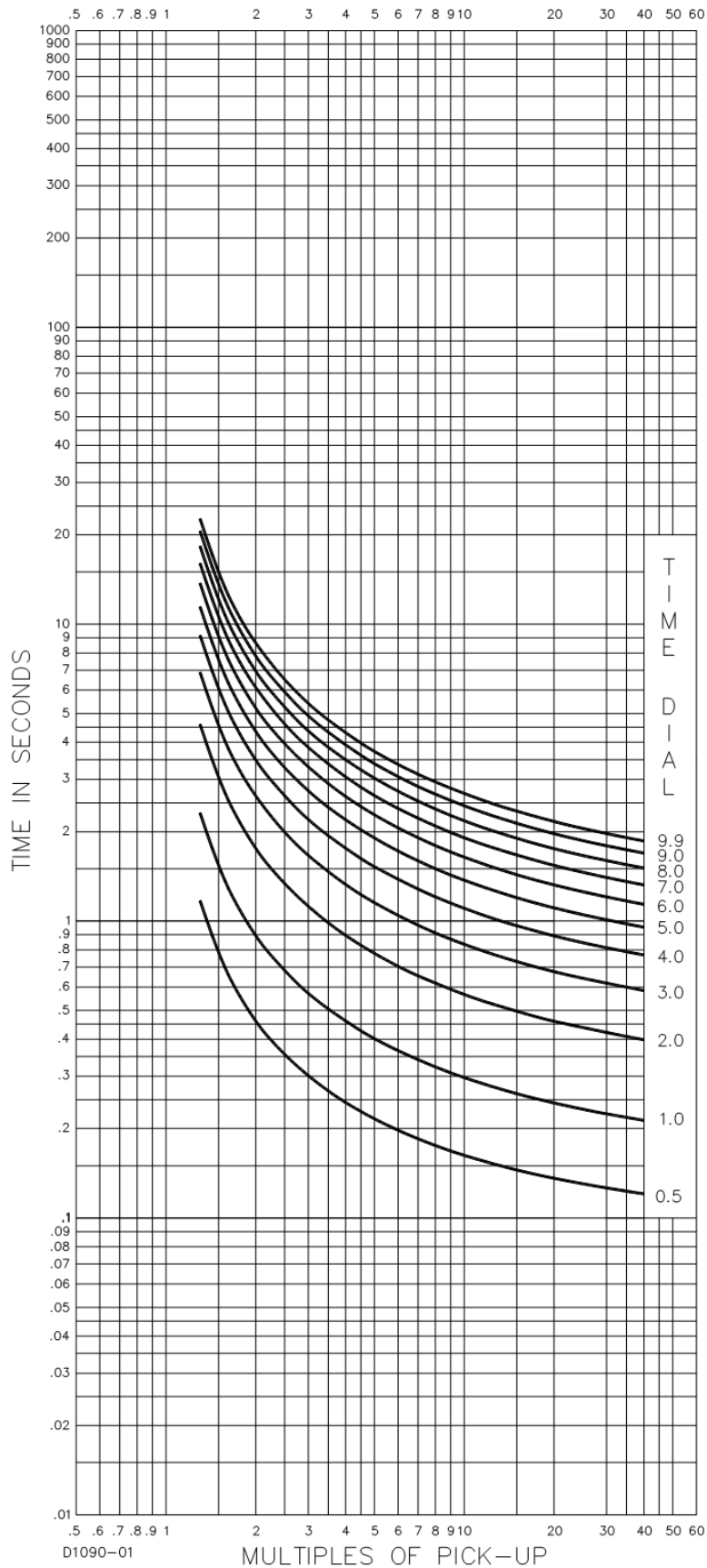


Figure 80-7. Time Characteristic Curve M, Moderately Inverse (Similar to ABB CO-7)

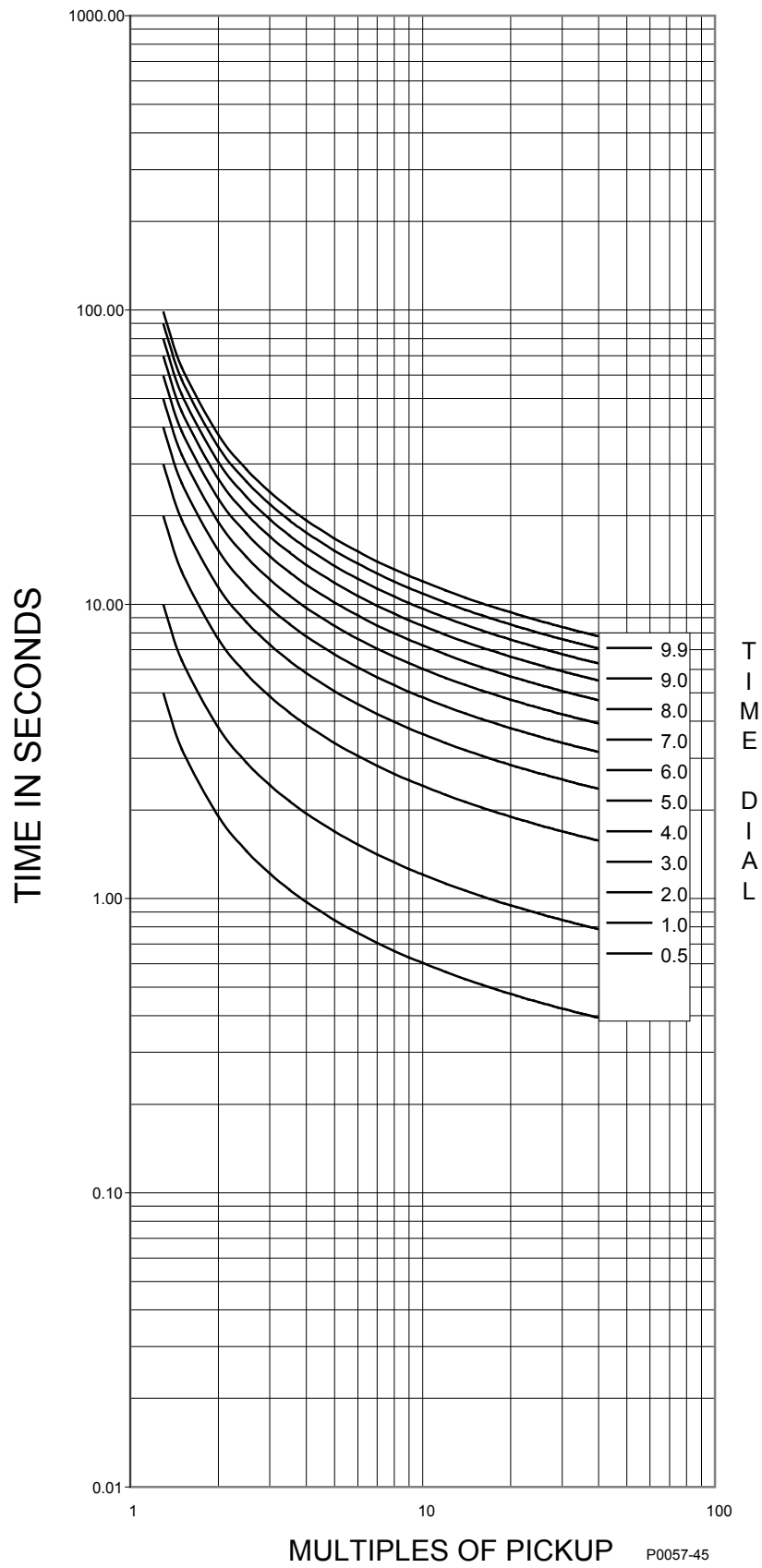


Figure 80-8. Time Characteristic Curve D1, Moderately Inverse (IEC 60255-151 Ed. 1)

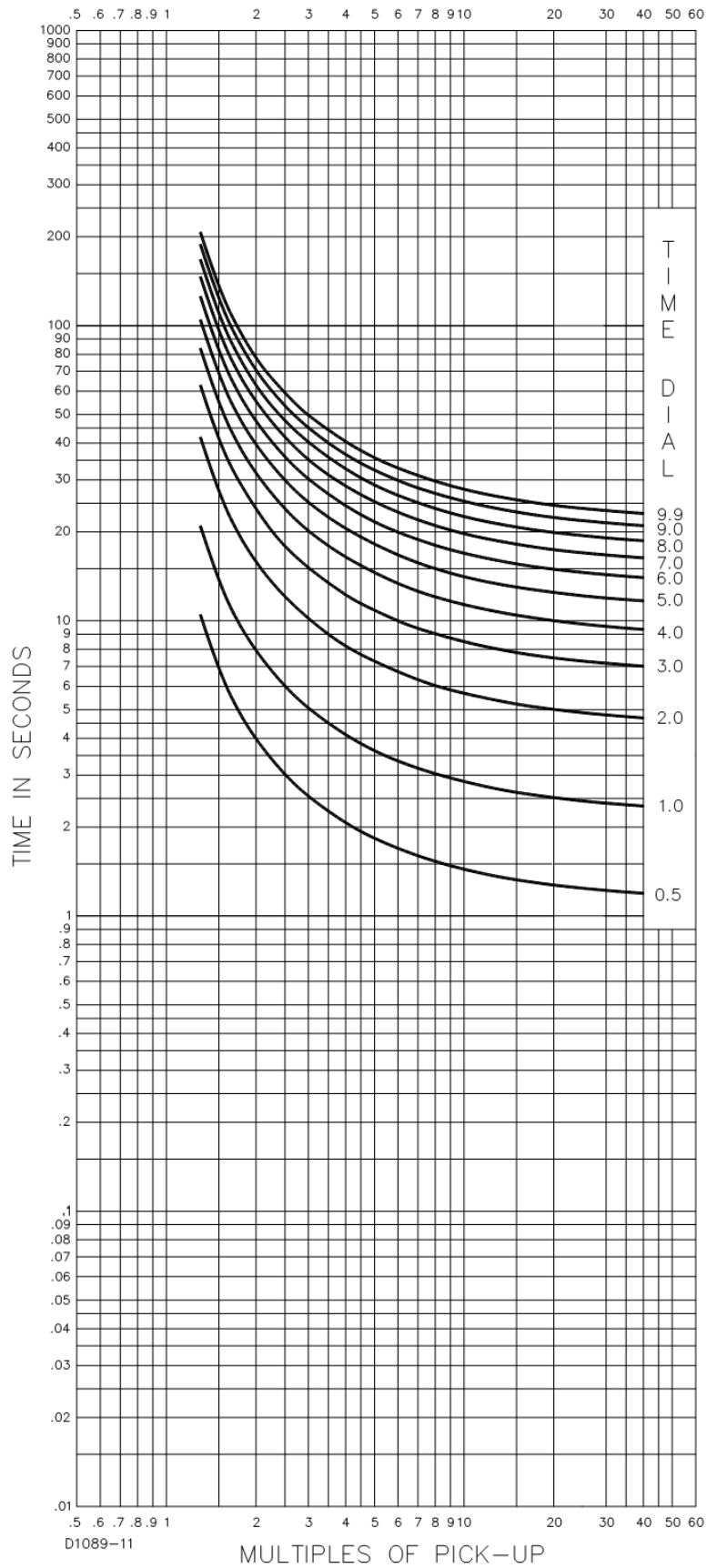


Figure 80-9. Time Characteristic Curve L1, Long Inverse (Similar to ABB CO-5)

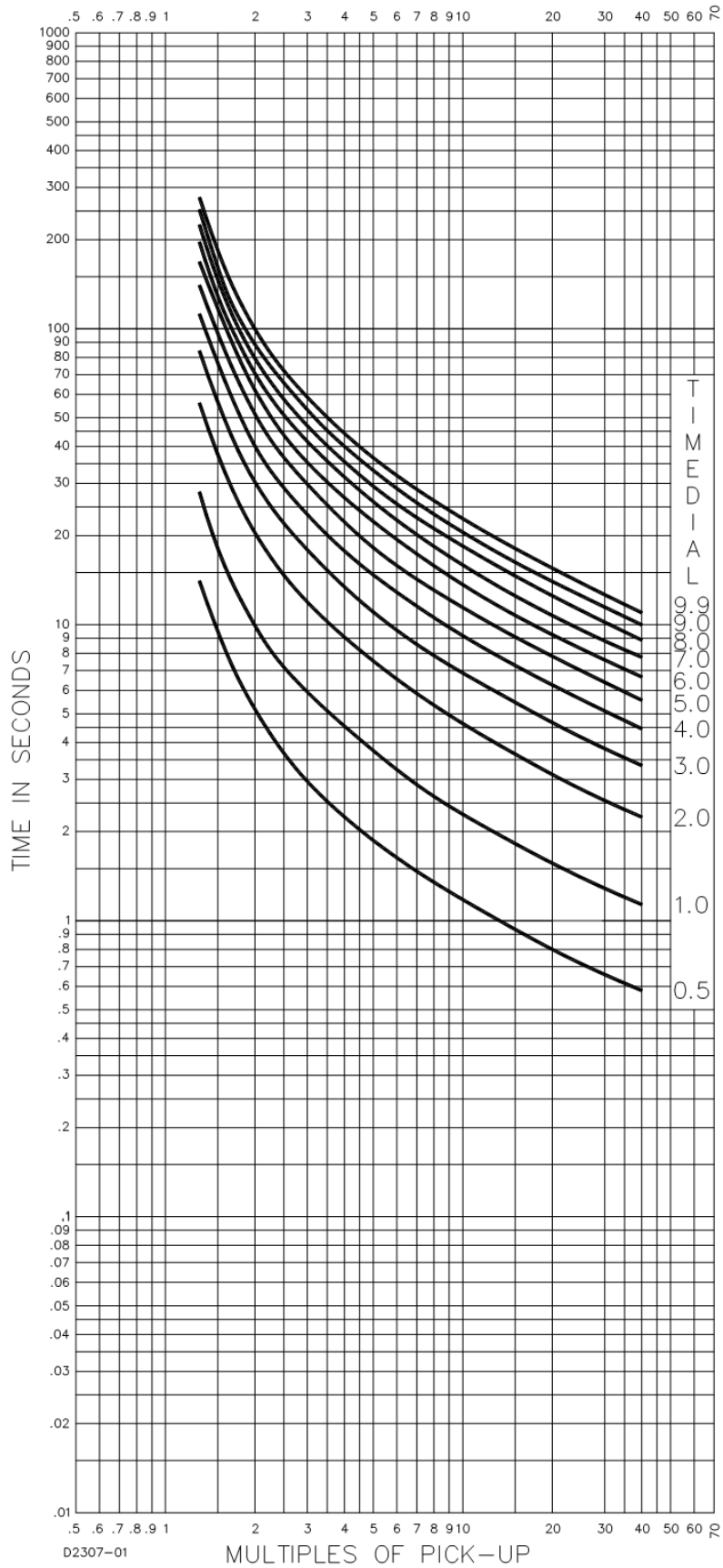


Figure 80-10. Time Characteristic Curve L2, Long Inverse (Similar To GE IAC-66)

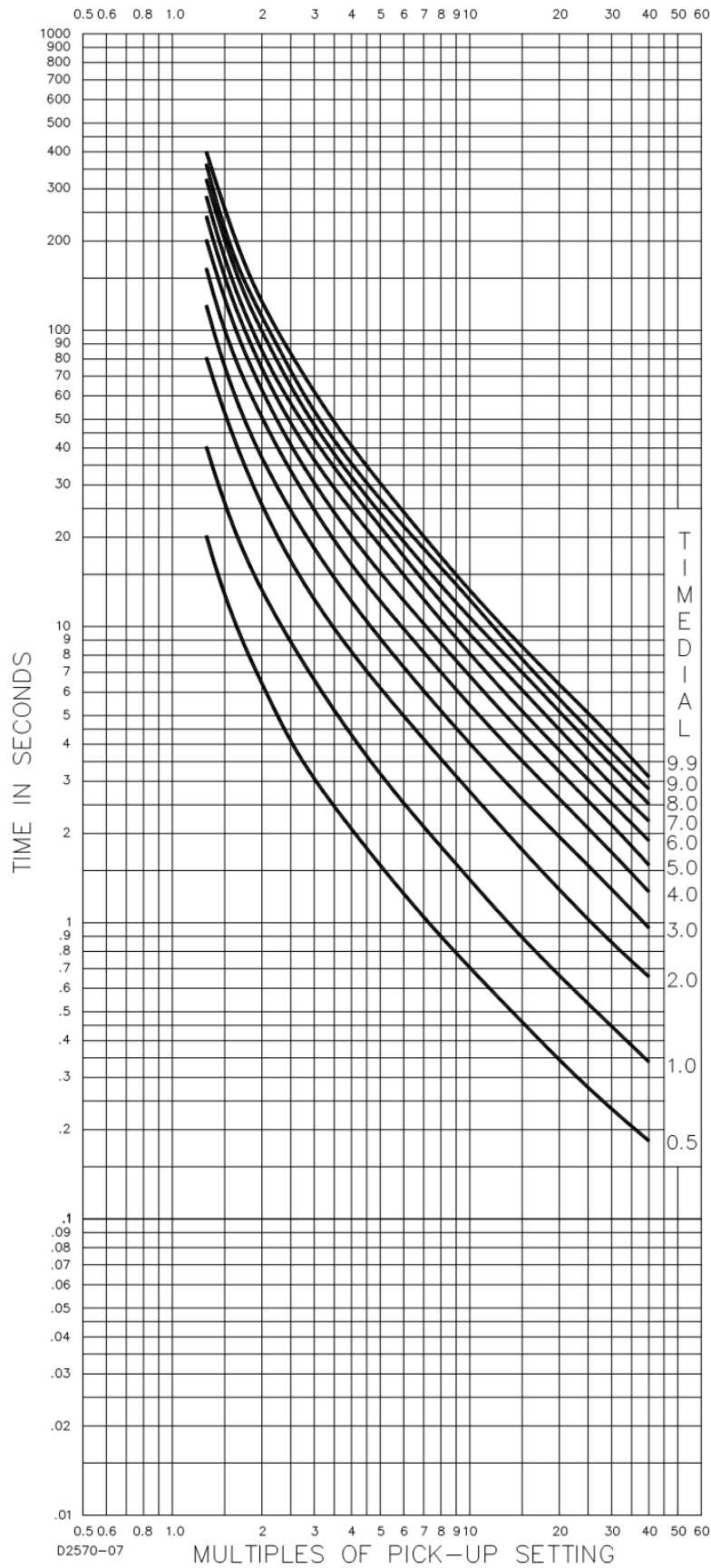


Figure 80-11. Time Characteristic Curve G, Long Time Inverse (BS 142)

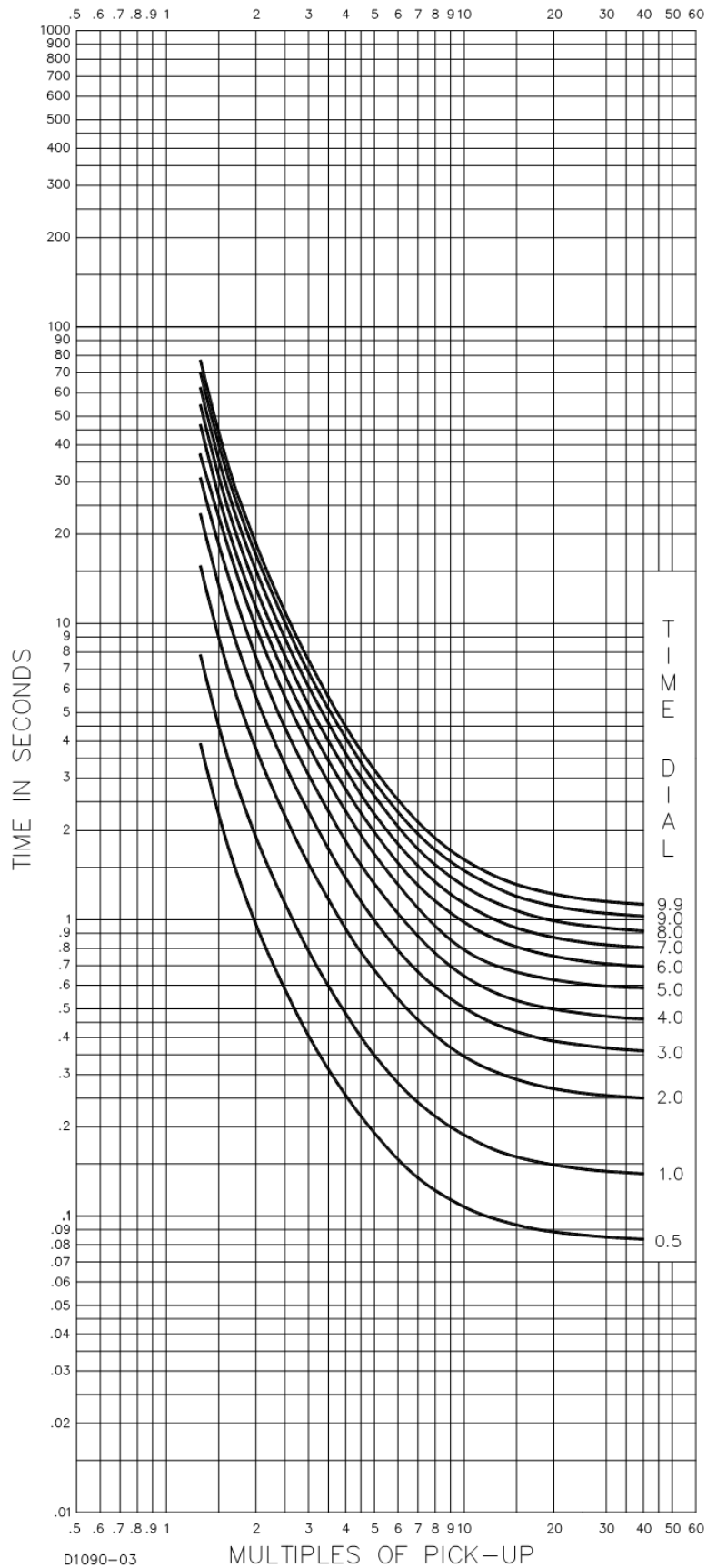


Figure 80-12. Time Characteristic Curve V1, Very Inverse (Similar to ABB CO-9)

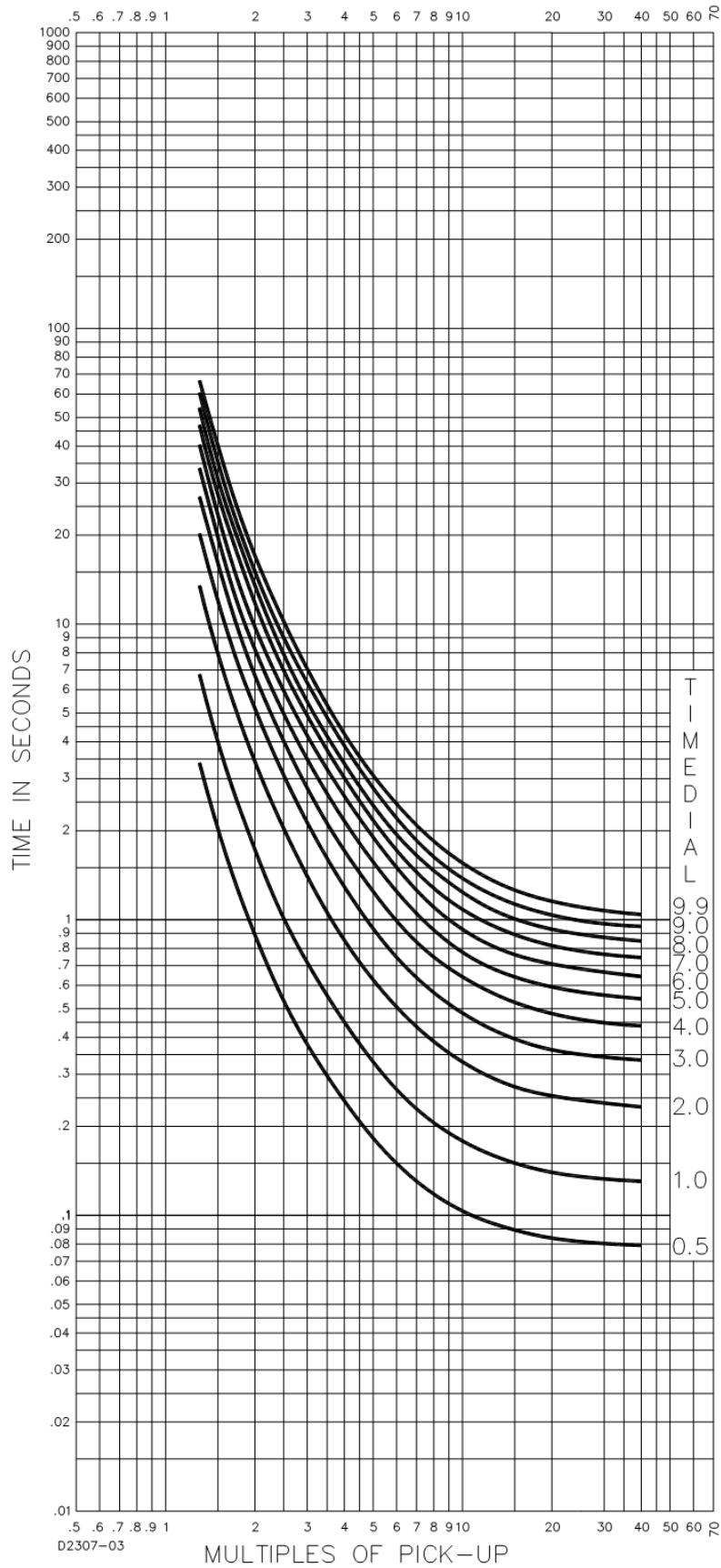


Figure 80-13. Time Characteristic Curve V2, Very Inverse (Similar to GE IAC-53)

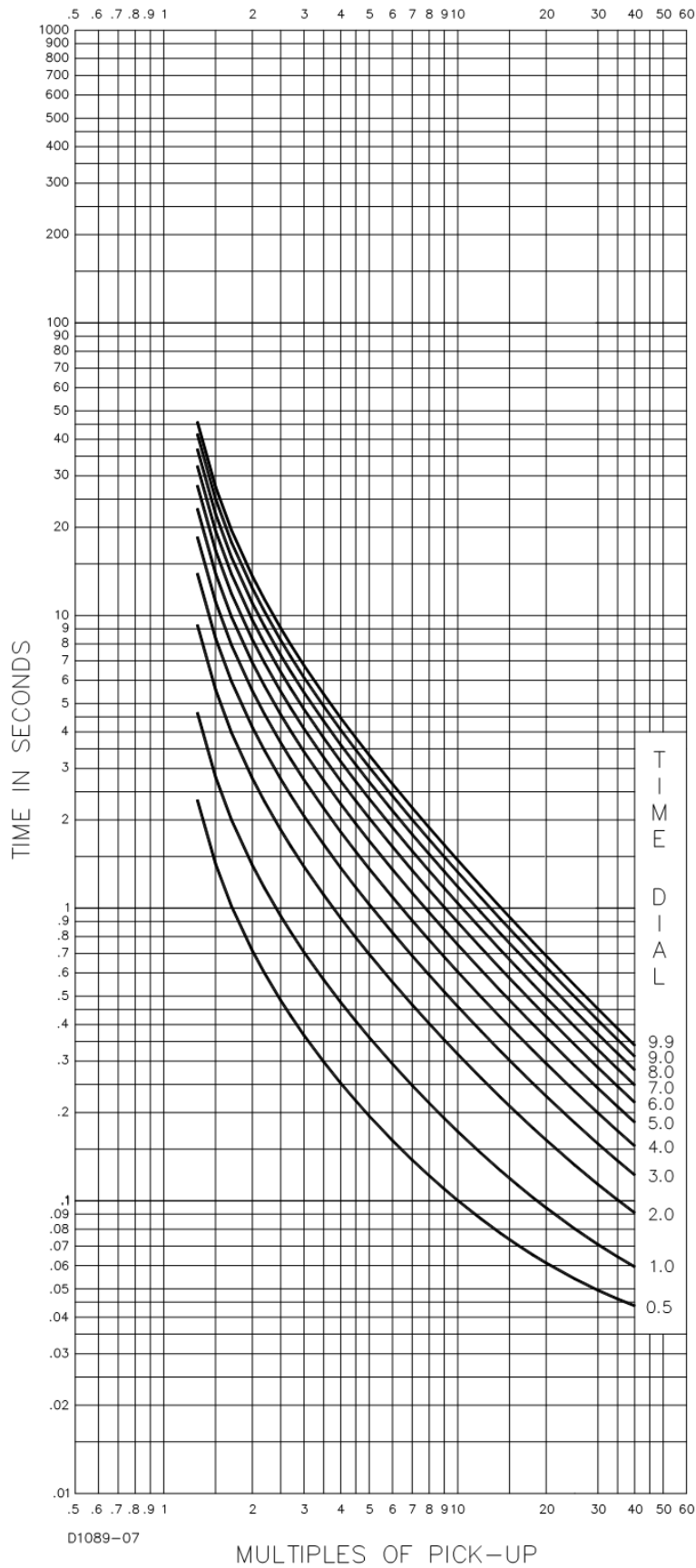


Figure 80-14. Time Characteristic Curve B, Very Inverse (BS 142)

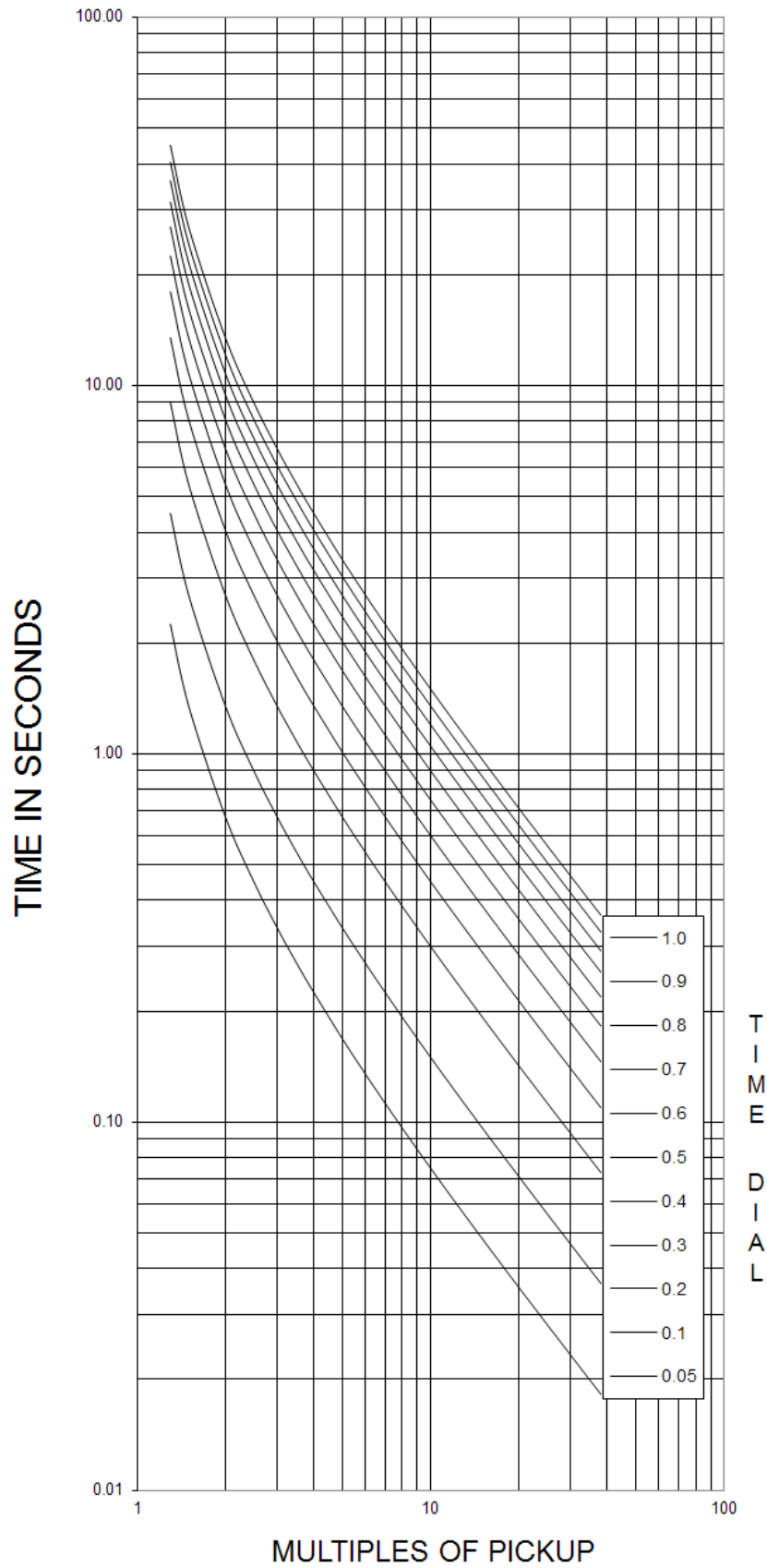


Figure 80-15. Time Characteristic Curve B1, Very Inverse (IEC 60255-151 Ed. 1)

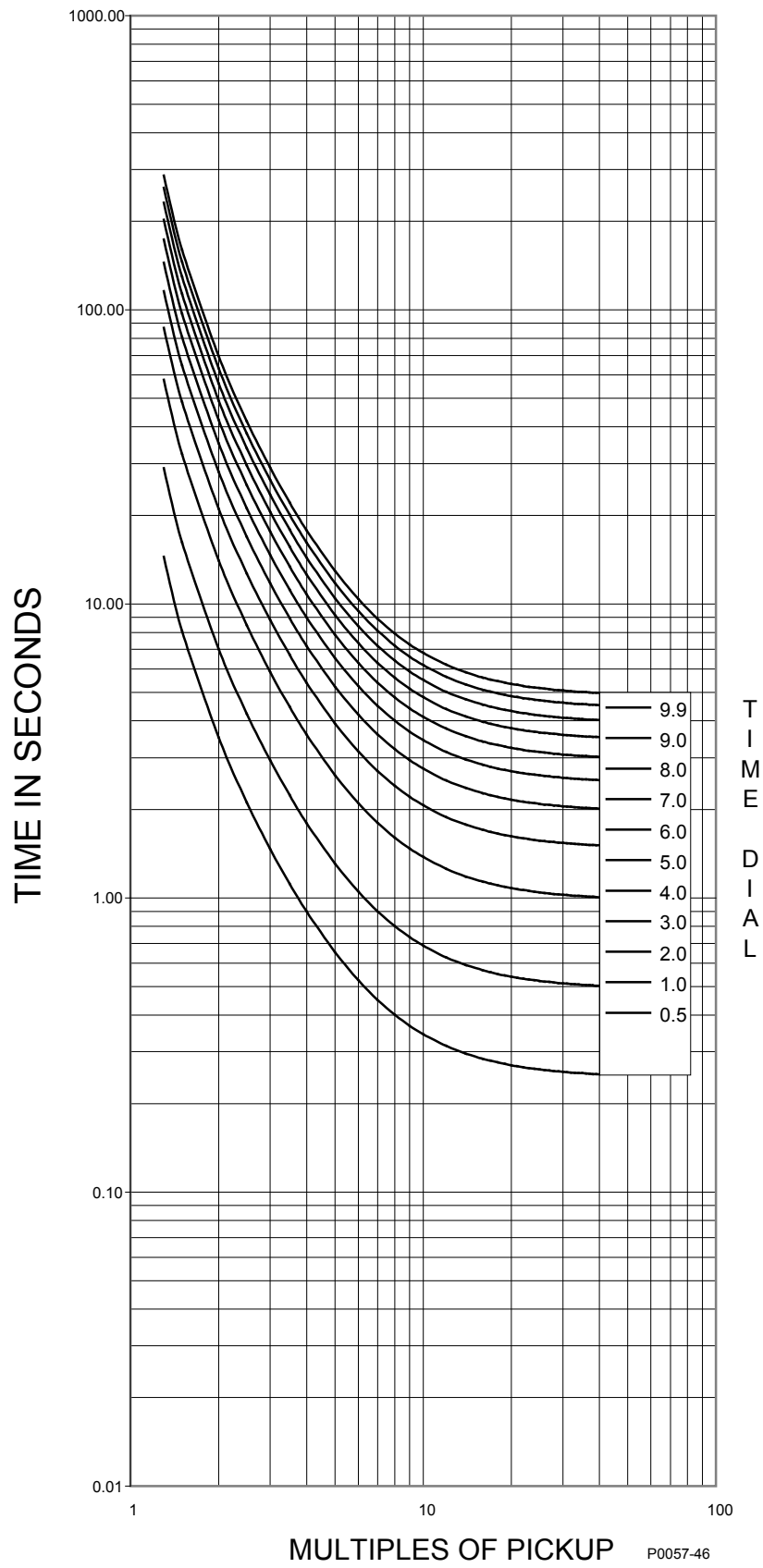


Figure 80-16. Time Characteristic Curve E3, Very Inverse (IEC 60255-151 Ed. 1)

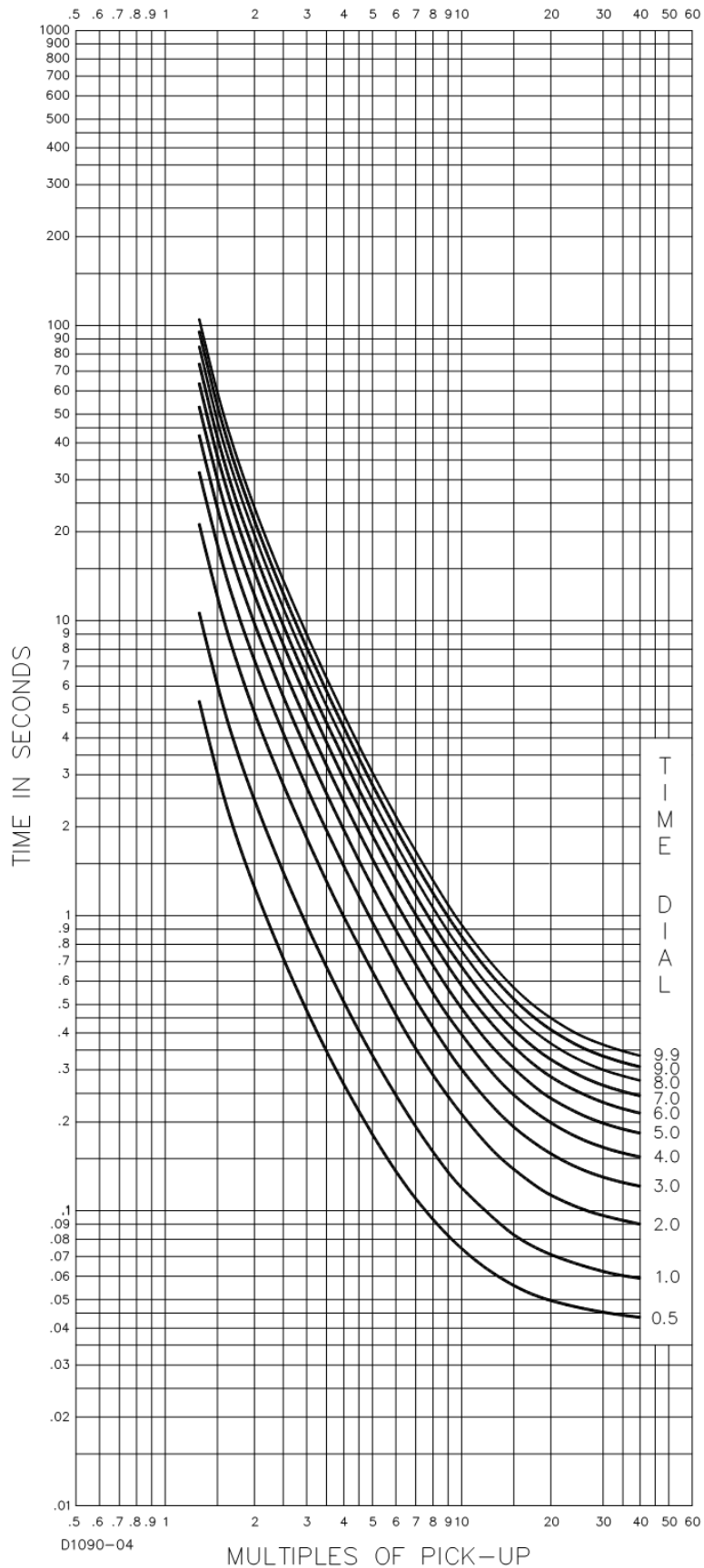


Figure 80-17. Time Characteristic Curve E1, Extremely Inverse (Similar to ABB CO-11)

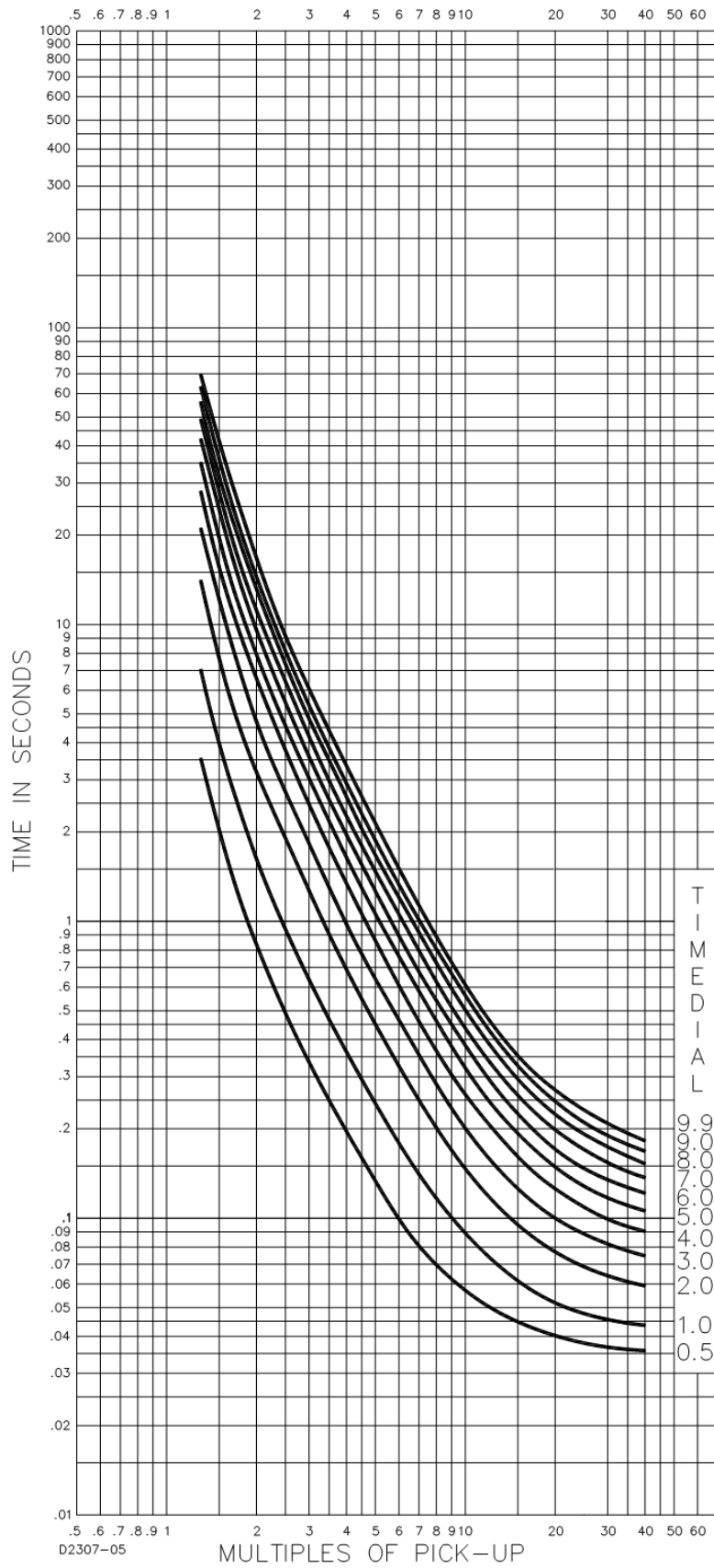


Figure 80-18. Time Characteristic Curve E2, Extremely Inverse (Similar to GE IAC-77)

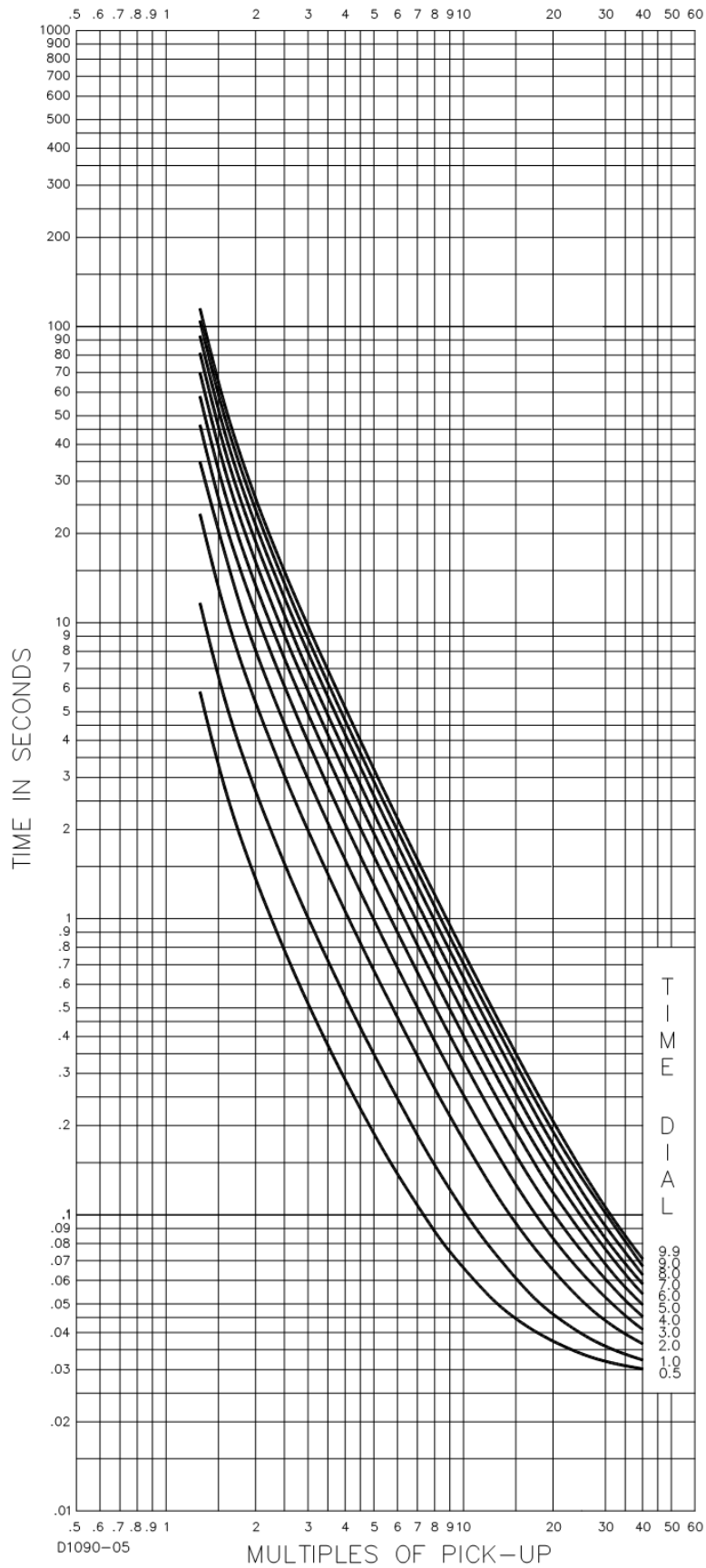


Figure 80-19. Time Characteristic Curve C, Extremely Inverse (BS 142)

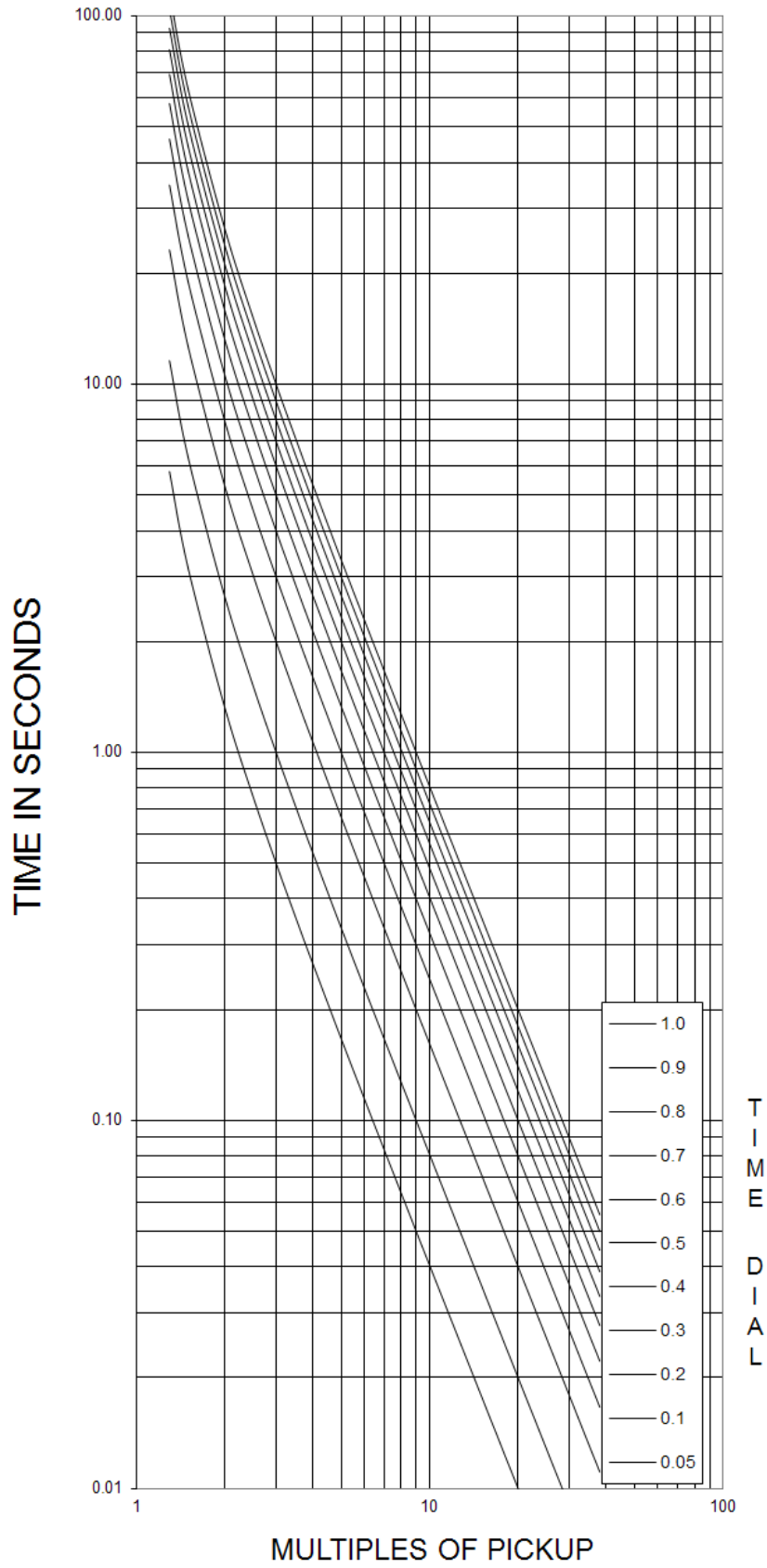


Figure 80-20. Time Characteristic Curve C1, Extremely Inverse (IEC 60255-151 Ed. 1)

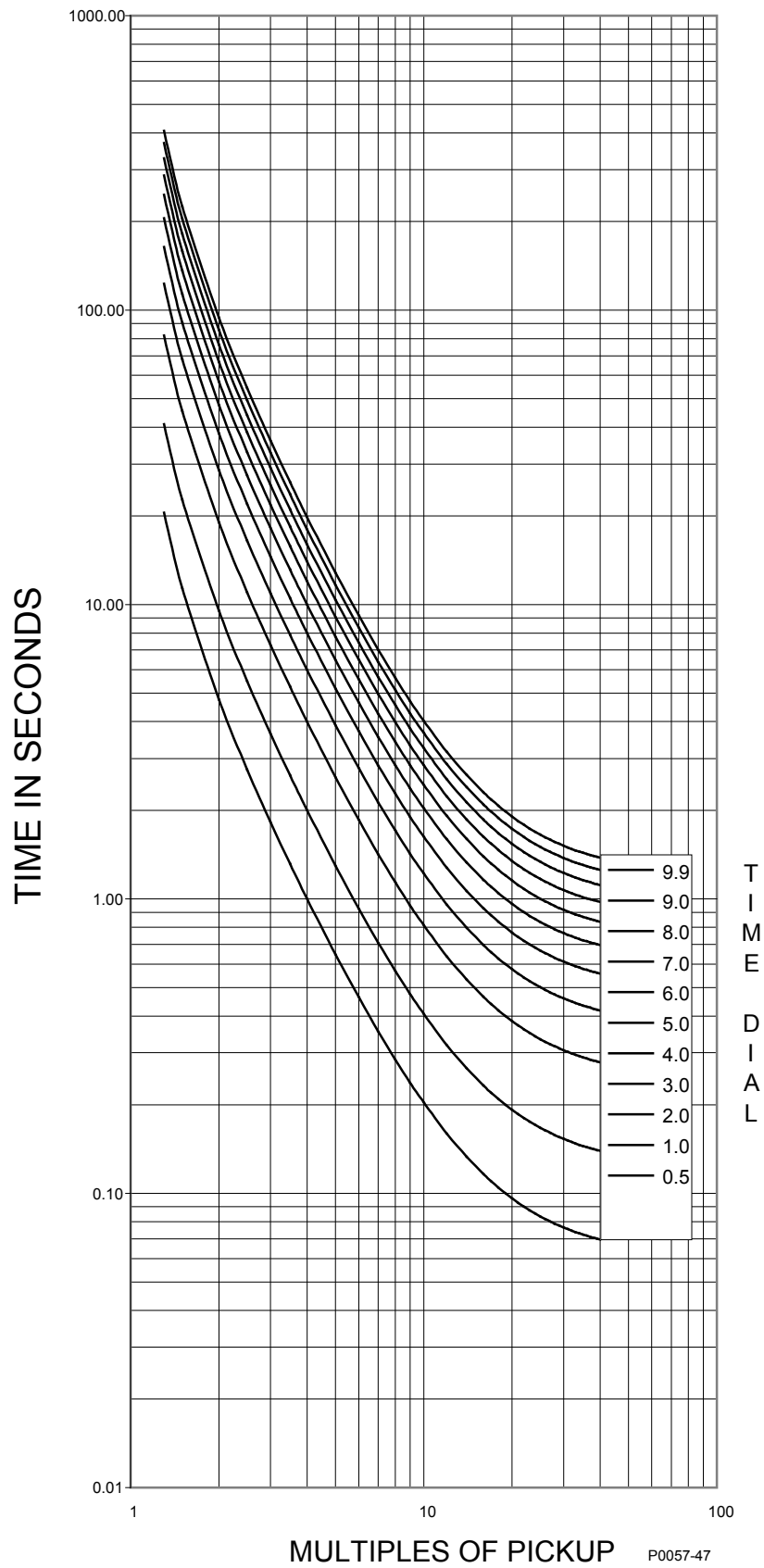


Figure 80-21. Time Characteristic Curve F1, Extremely Inverse (IEC 60255-151 Ed. 1)

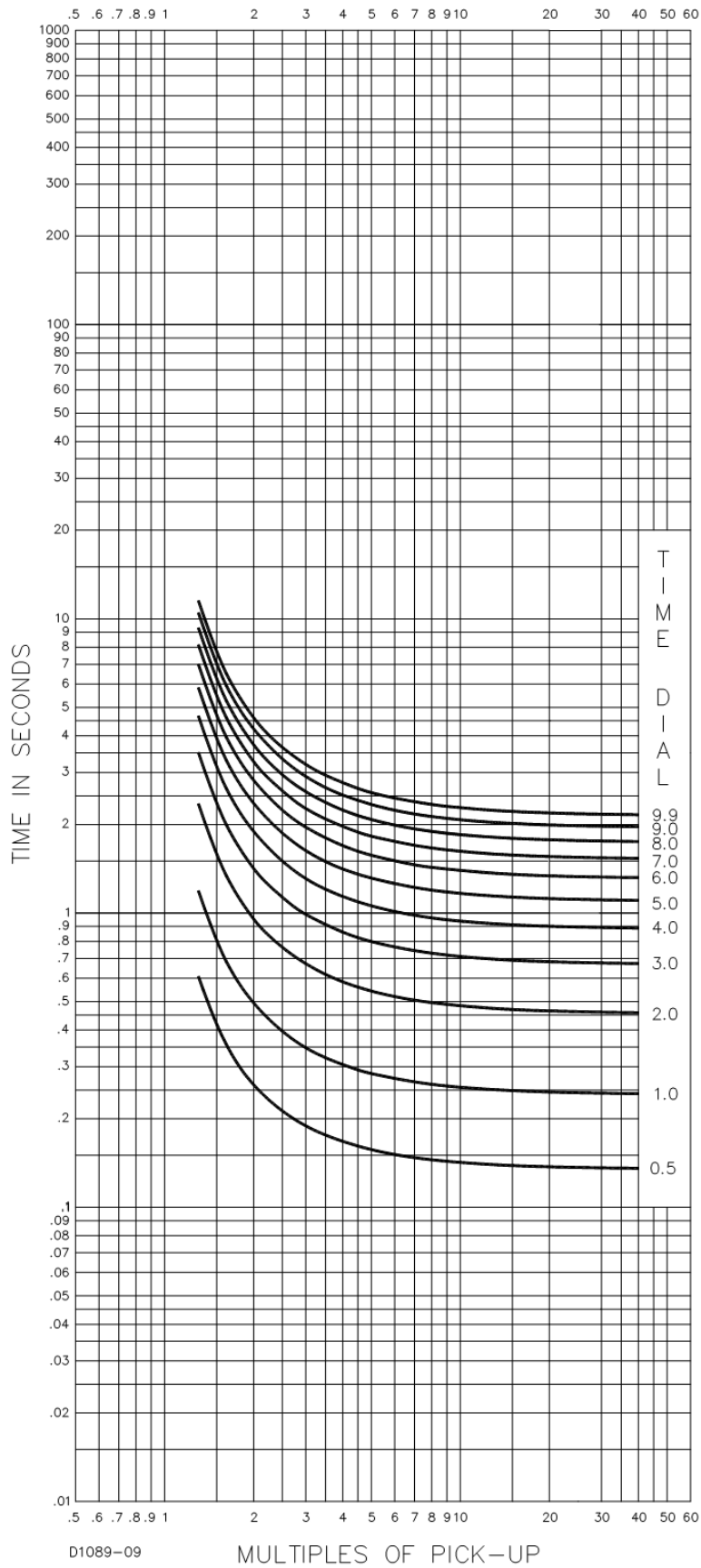
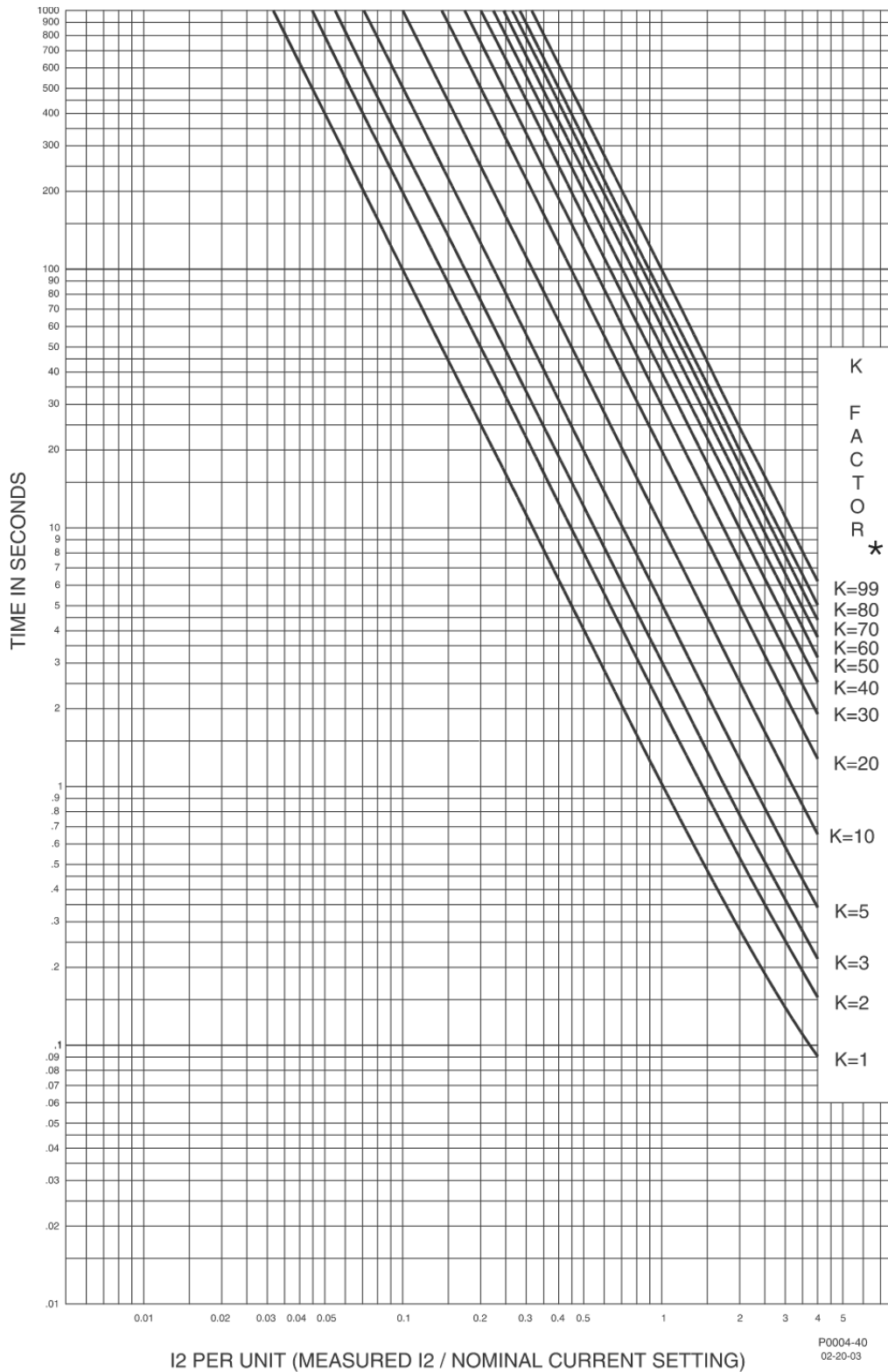


Figure 80-22. Time Characteristic Curve D, Definite Time (Similar To ABB CO-6)



★ The K factor is the time that a generator can withstand 1 per-unit I2, where 1 pu is the user's setting for full-load current

**Figure 80-23. 46 Time Characteristic Curve**

NOTE: Curves are shown as extending farther to the left than they will in practice. Curves stop at pickup level. For example, if the user selects 5A FLC and a pickup setting of 0.5A, the per-unit pickup is 0.1A. The BE1-11t will not pick up at less than 0.1 pu I2 for these settings.

## ***Under/Overvoltage (27/59)***

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The 27 and 59 elements have independent user defined definite and inverse time delays. The inverse time curves are defined below.

### **Undervoltage (27) Inverse Time Curve**

The undervoltage inverse time curve is defined by Equation 80-8. The undervoltage inverse time curve with default constants is shown in Figure 80-24.

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

**Equation 80-8**

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

**Equation 80-9**

$T_T$  = Time to trip when  $M \leq 1$

$T_R$  = Time to reset if BE1-11t is set for integrating reset when  $M > 1$ . Otherwise, reset is 50 milliseconds or less

D = Time Dial setting (0.0 to 9.9)

M = Multiple of Pickup setting

A, B, C, N = Constants for the particular curve

R = Constant defining the reset time.

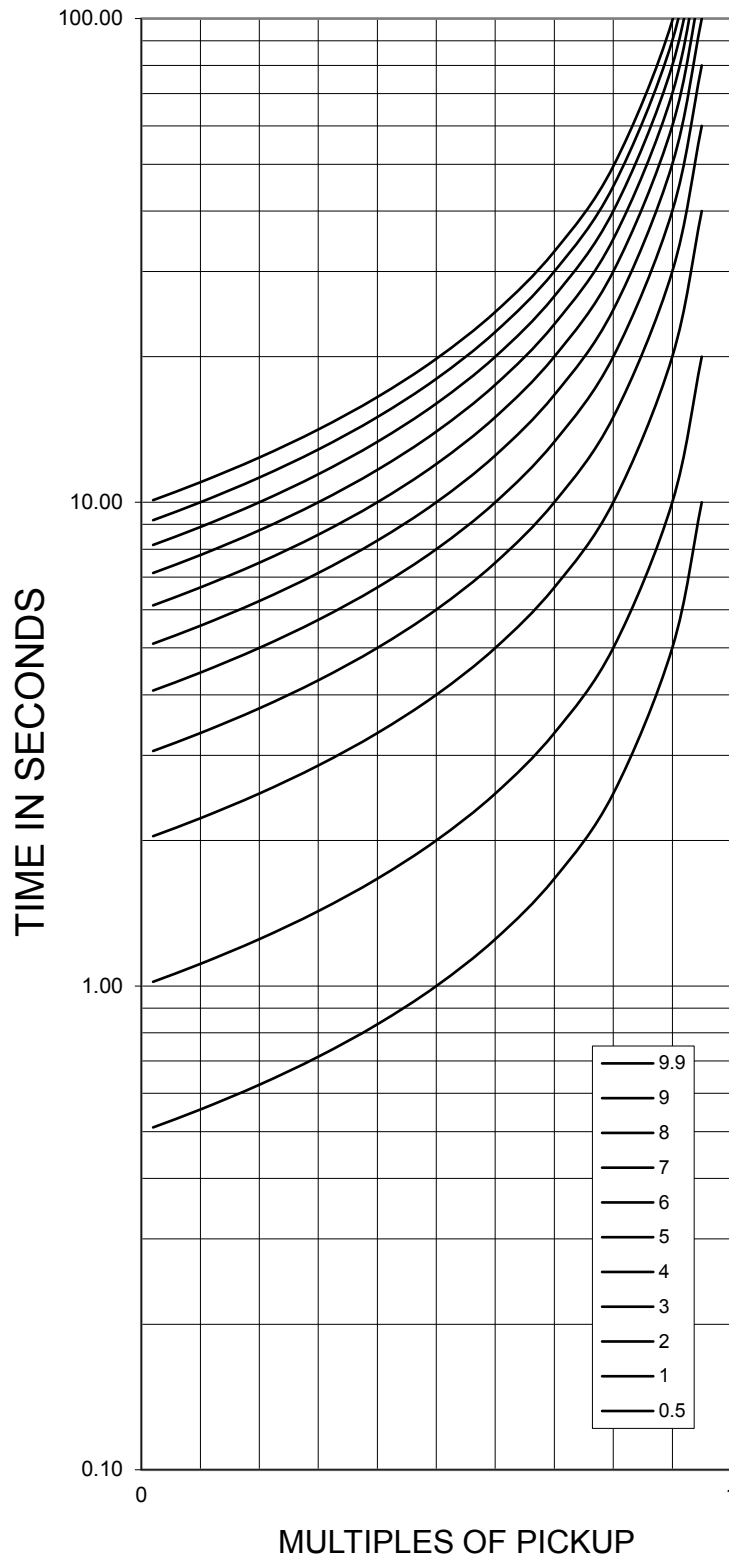


Figure 80-24. Undervoltage (27) Inverse Time Curve (Default Constants)

### Overvoltage (59) Inverse Time Curve

The undervoltage inverse time curve is defined by Equation 80-10. The undervoltage inverse time curve with default constants is shown in Figure 80-25.

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

Equation 80-10

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

Equation 80-11

$T_T$  = Time to trip when  $M \geq 1$

$T_R$  = Time to reset if BE1-11t is set for integrating reset when  $M < 1$ . Otherwise, reset is 50 milliseconds or less

D = Time Dial setting (0.0 to 9.9)

M = Multiple of Pickup setting

A, B, C, N = Constants for the particular curve

R = Constant defining the reset time.

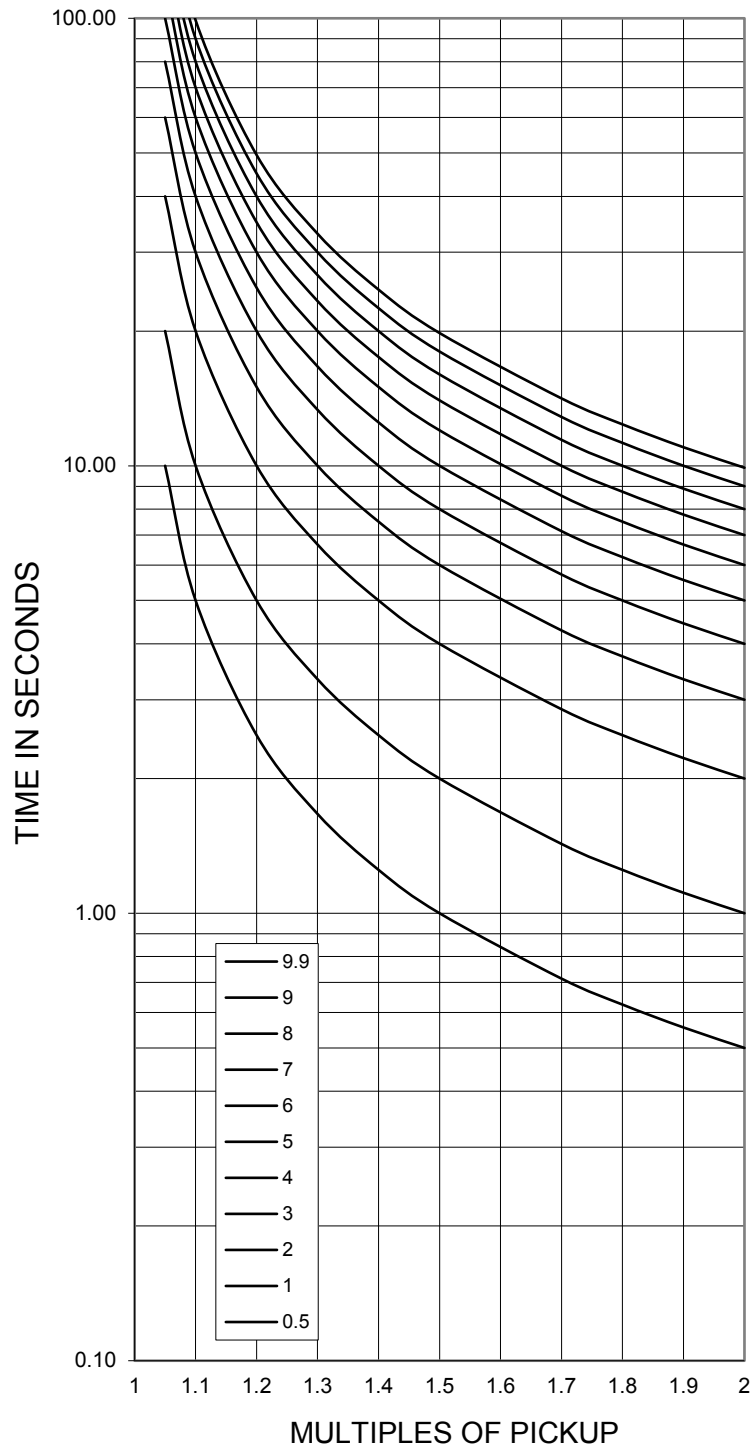


Figure 80-25. Overvoltage (59) Inverse Time Curve (Default Constants)

## Overexcitation (24)

### General

The inverse time curves for the overexcitation (24) element are defined below. Equation 80-12 and Equation 80-13 represent the trip time and reset time for constant volts per hertz level. Normally, the V/Hz pickup is set to a value greater than the V/Hz nominal. This ensures that V/Hz measured divided by V/Hz nominal is always greater than 1.000 throughout the pickup range.

### Curve Specifications

If the pickup is set less than nominal, then measured values above pickup and below nominal will result in the maximum time delay. The maximum time delay is determined by Equation 80-13 with (V/Hz measured / V/Hz nominal) set equal to 1.001. The overall inverse time delay range is limited to 1,000 seconds maximum and 0.2 seconds minimum.

$$T_T = \frac{D_T}{\left(\frac{V/Hz \text{ Measured}}{V/Hz \text{ Nominal}} - 1\right)^n}$$

Equation 80-12. Time to Trip

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

Equation 80-13. Time to Reset

where:

$T_T$  = Time to trip

$T_R$  = Time to reset

$D_T$  = Time dial trip

$D_R$  = Time dial, reset

$E_T$  = Elapsed time

$N$  = Curve exponent (0.5, 1, 2)

$FST$  = Full scale trip time ( $T_T$ )

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

When the measured V/Hz rises above a pickup threshold, the pickup element becomes true and an integrating or definite time timer starts. If the V/Hz remains above the pickup threshold and the integration continues for the required time interval as defined by the equations shown above and the set time dial, the trip output becomes true. If the measured V/Hz drops below pickup before timeout to trip, either an instantaneous or a time delayed integrating reset can be selected.

The following sets of curves are shown first with the time axis on the vertical and then on the horizontal for ease of use.

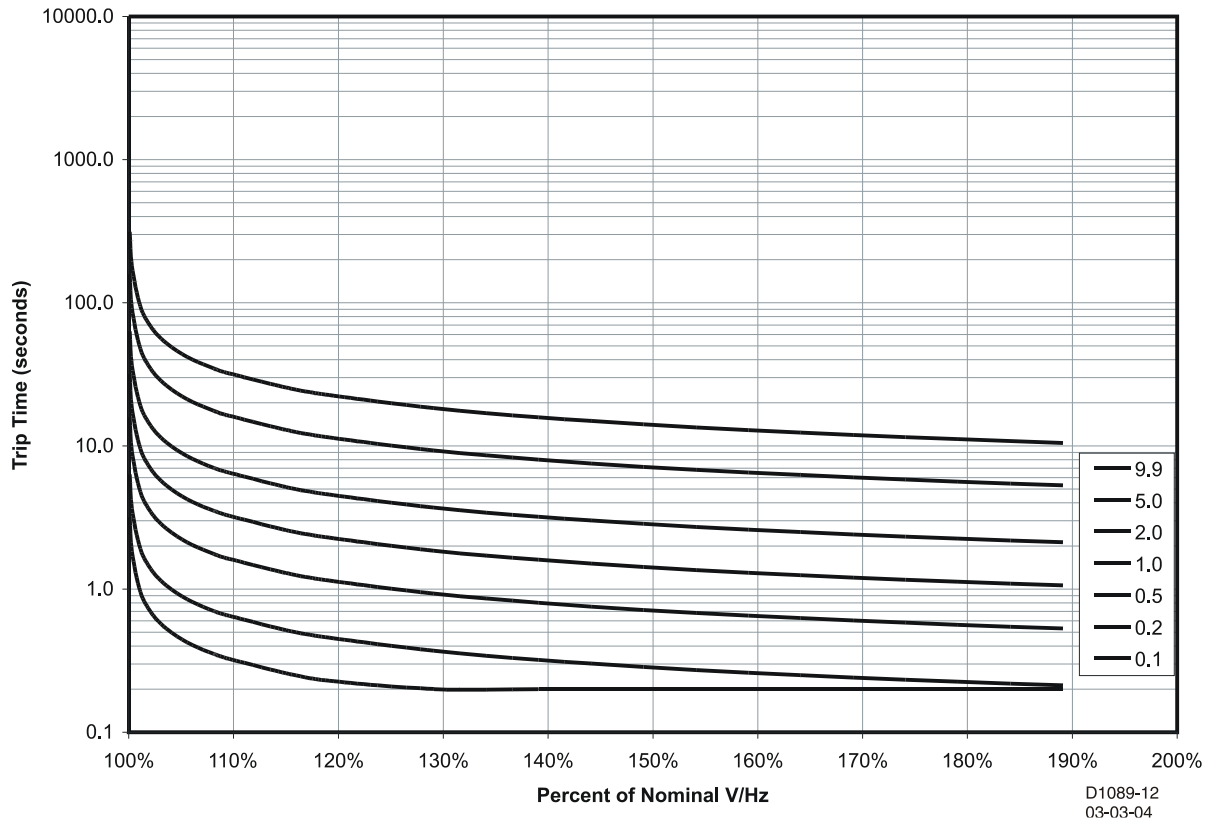


Figure 80-26. V/Hz Characteristic  $(M-1)^{0.5}$  – Time on Vertical Axis

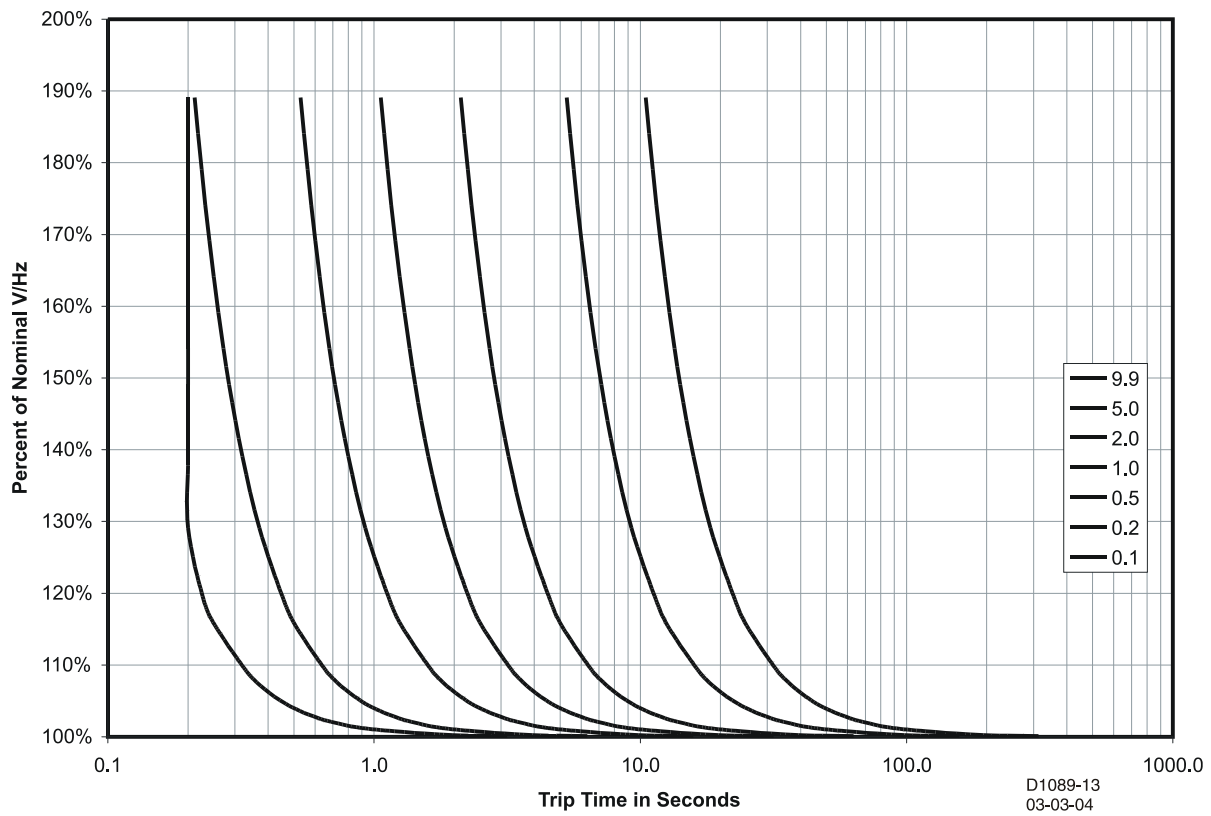


Figure 80-27. V/Hz Characteristic  $(M-1)^{0.5}$  – Time on Horizontal Axis

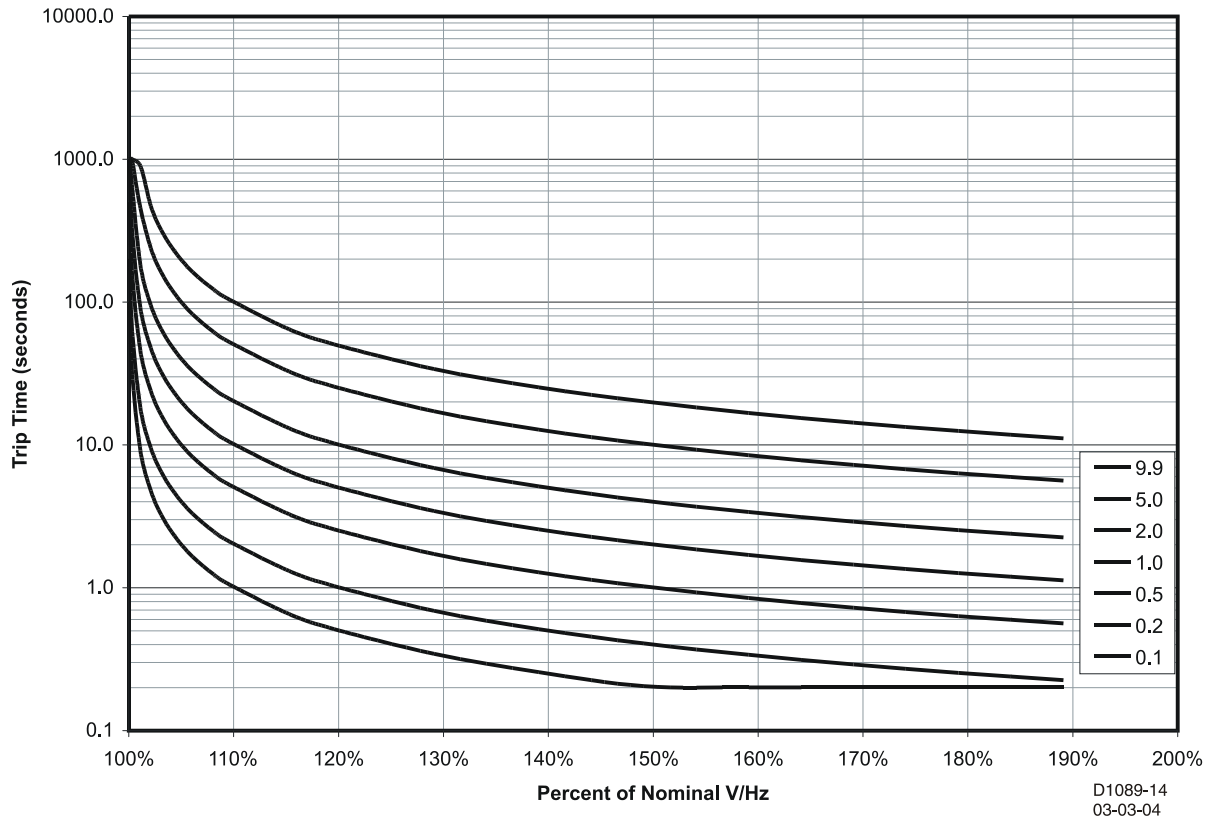


Figure 80-28. V/Hz Characteristic (M-1)<sup>1</sup> – Time on Vertical Axis

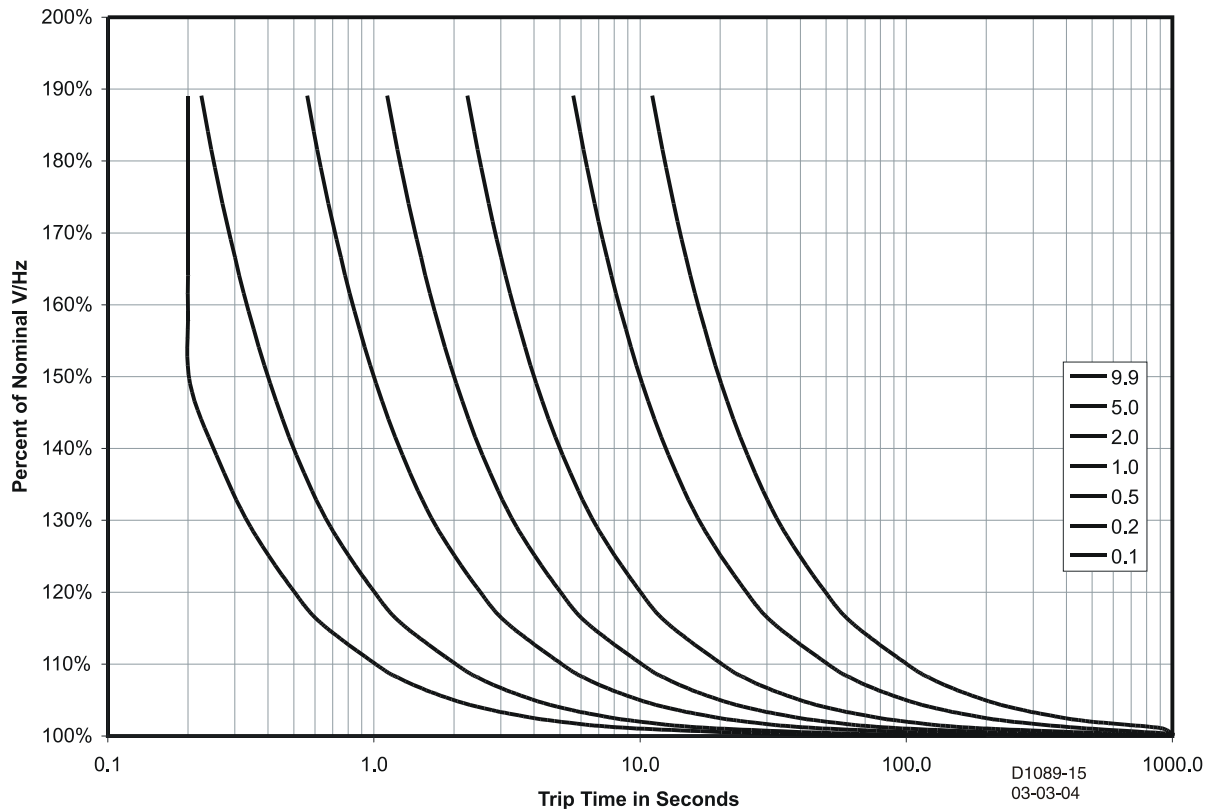


Figure 80-29. V/Hz Characteristic (M-1)<sup>1</sup> – Time on Horizontal Axis

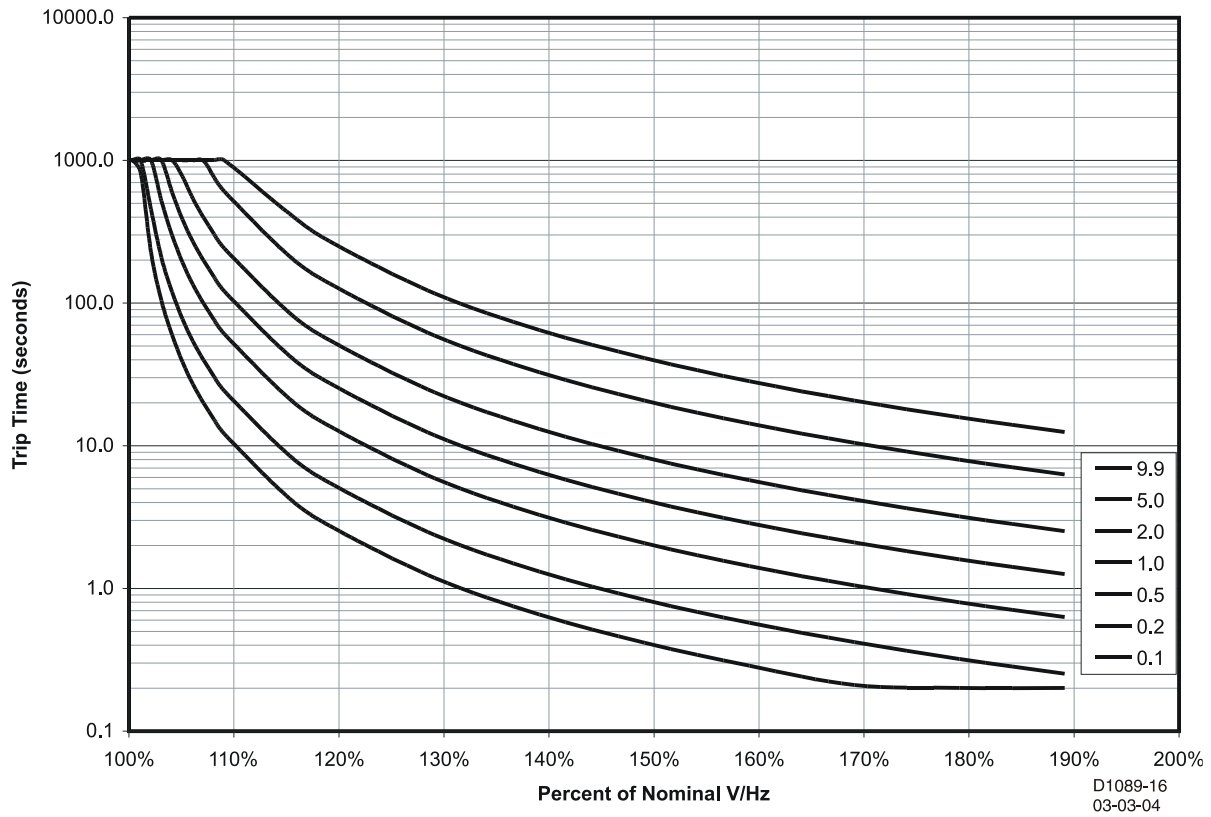


Figure 80-30. V/Hz Characteristic  $(M-1)^2$  – Time on Vertical Axis

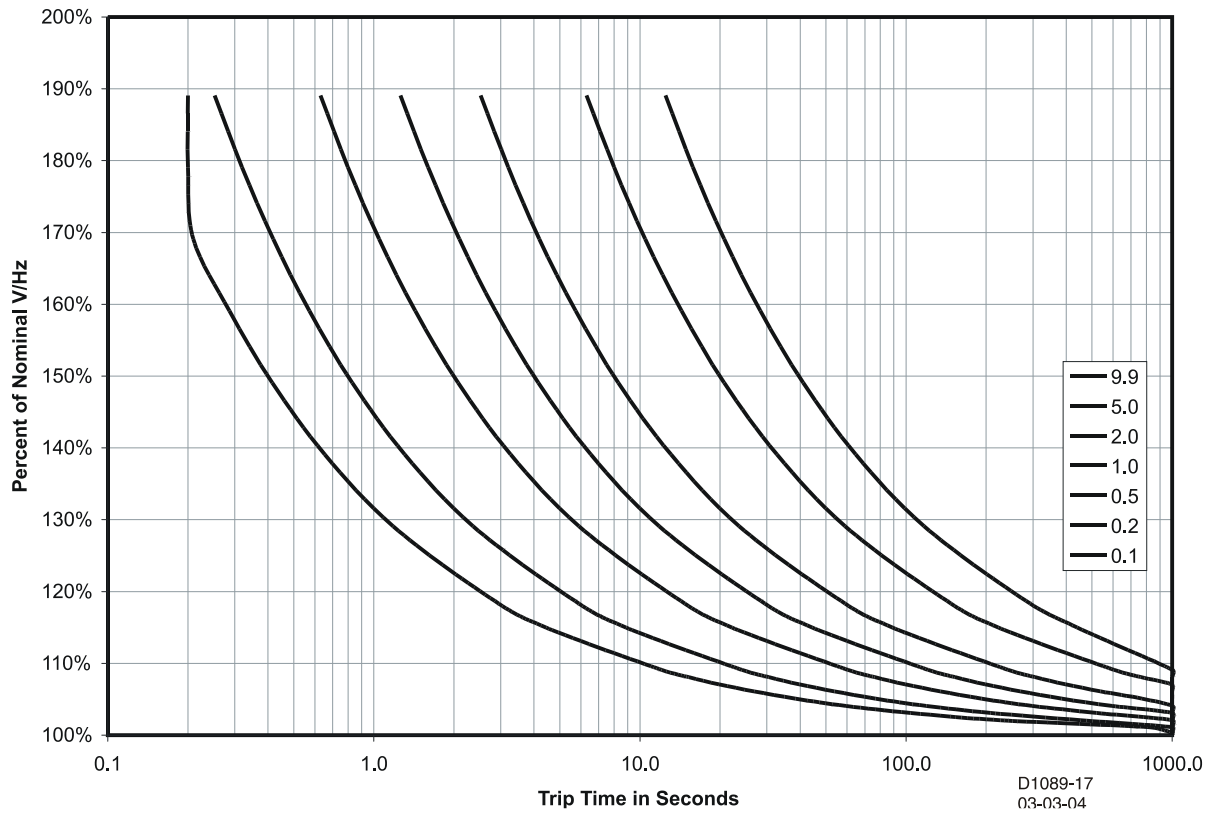


Figure 80-31. V/Hz Characteristic  $(M-1)^2$  – Time on Horizontal Axis

# 81 • RTD Module

The RTD (Resistance Temperature Detector) module is an optional remote device that provides RTD inputs, analog inputs, and analog outputs for transformer protection applications.

## Features

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RTD modules have the following features:

- 12 RTD Inputs
- 4 Analog Inputs
- 4 Analog Outputs
- Secured Read/Write Access\*
- Reporting and Alarm Functions
- Communications via Ethernet or RS-485

\* The default password for uploading settings to the RTD module is “**OEM**” in upper case letters.

## Functional Description

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A functional description of the RTD module's inputs and outputs is provided below.

### Analog Inputs

The RTD module provides four analog inputs that are user-selectable for 4 to 20 mAdc or 0 to 10 Vdc. Each analog input has under/over thresholds that when exceeded, trip an analog input protection element. RTD modules with firmware 1.01.01 and above limit measurements in relation to the 4 to 20 mAdc or 0 to 10 Vdc range. Firmware below 1.01.01 is not operational outside the ranges. The label text of each analog input is customizable.

### RTD Inputs

The RTD module provides 12 user-configurable RTD inputs for monitoring system temperatures. Each RTD input can be configured to protect against high or low temperature conditions. The label text of each RTD input is customizable.

### Analog Outputs

The RTD module provides four analog outputs that are user-selectable for 4 to 20 mAdc or 0 to 10 Vdc. A wide selection of parameters including BE1-11 $t$  metered voltages and currents, analog inputs, and RTD inputs can be configured as analog outputs. Refer to the Programmable Outputs, Remote Analog Outputs screen in BESTCOMSP $lus$ ® for a full list of parameter selections.

### Alarm Contact Functions

The RTD module provides form C (SPDT) alarm contacts that operate when an internal RTD module failure exists. The contacts also operate when operating power is cycled.

### Real-Time Status Functions

The RTD module is equipped with a multi-function LED with the following functions.

- Slow Flashing - Communications established
- Quick Flashing - Communications lost
- Steady On - Power applied

## Mounting

RTD modules are contained in a potted plastic case and may be mounted in any convenient position using UNC ¼-20 or equivalent screws. Hardware selection should be based on any expected shipping/transportation and operating conditions. The torque applied to the mounting hardware should not exceed 65 in-lb (7.34 N•m).

See Figure 81-1 for RTD module overall dimensions. All dimensions are shown in inches with millimeters in parenthesis.

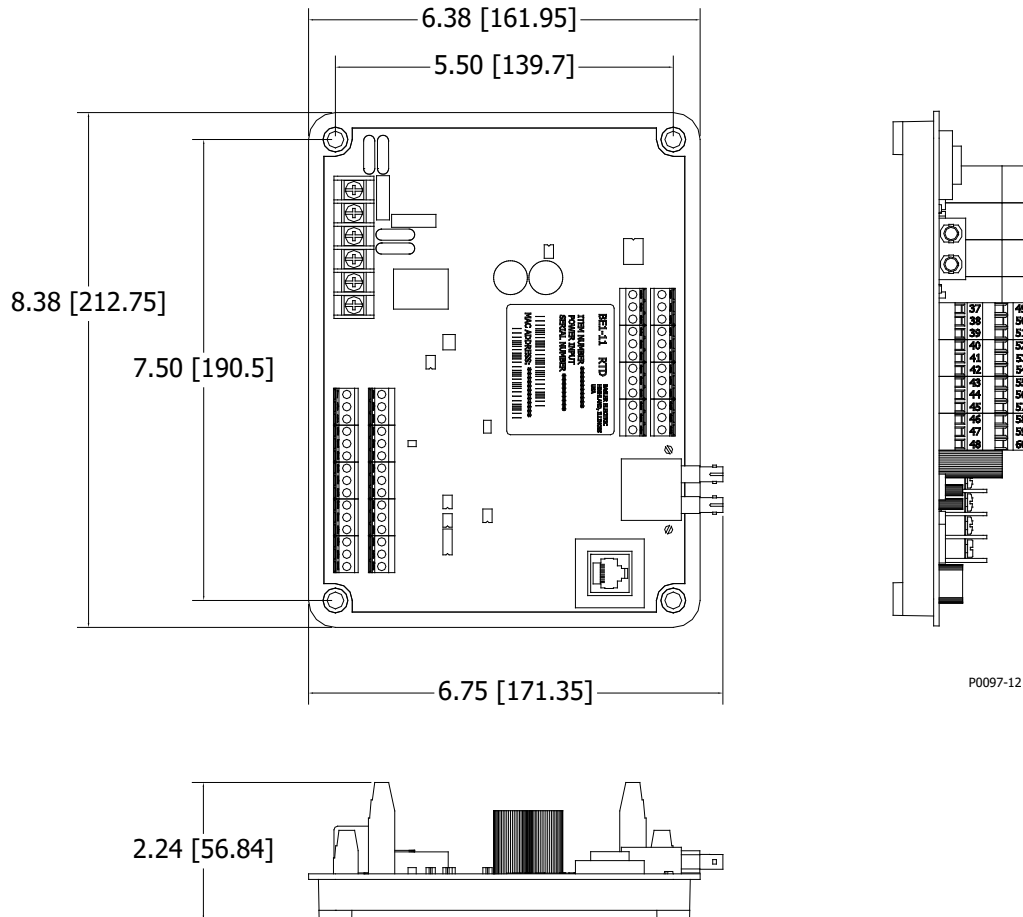


Figure 81-1. RTD Module Overall Dimensions

## Connections

RTD module connections are dependent on the application. Incorrect wiring may result in damage to the module.

### Note

Be sure that the RTD module is hard-wired to earth ground with no smaller than 12 AWG (3.31 mm<sup>2</sup>) copper wire attached to the chassis ground terminal on the module.

## Terminations

The terminal interface consists of permanently mounted connectors with screw-down compression terminals.

RTD module connections are made with one 6-position connector, two 12-position connectors, and two 15-position connectors. Connector screw terminals accept a maximum wire size of 12 AWG (3.31 mm<sup>2</sup>). Maximum screw torque is 5 inch-pounds (0.56 N•m) for the 12- and 15-position connectors. Maximum screw torque is 9 inch-pounds (1.01 N•m) for the 6-position connector.

### Operating Power

The RTD module operating power input accepts 125/250 Vac/dc and tolerates voltage over the range of 90 to 270 Vac or 90 to 300 Vdc. The operating power inputs are not polarity sensitive. Operating power terminals are listed in Table 81-1.

**Table 81-1. Operating Power Terminals**

Terminal	Description
TB1-1	Operating power input
TB1-2	Operating power input
TB1-3	Chassis ground connection

### Alarm Contacts

These terminals provide form C (SPDT) alarm contacts. Alarm contact terminals are listed in Table 81-2.

**Table 81-2. Alarm Contact Terminals**

Terminal	Description
TB1-4	Normally Open
TB1-5	Common
TB1-6	Normally Closed

### RTD Module Inputs and Outputs

Input and output terminals are shown in Figure 81-2 and listed in Table 81-3.

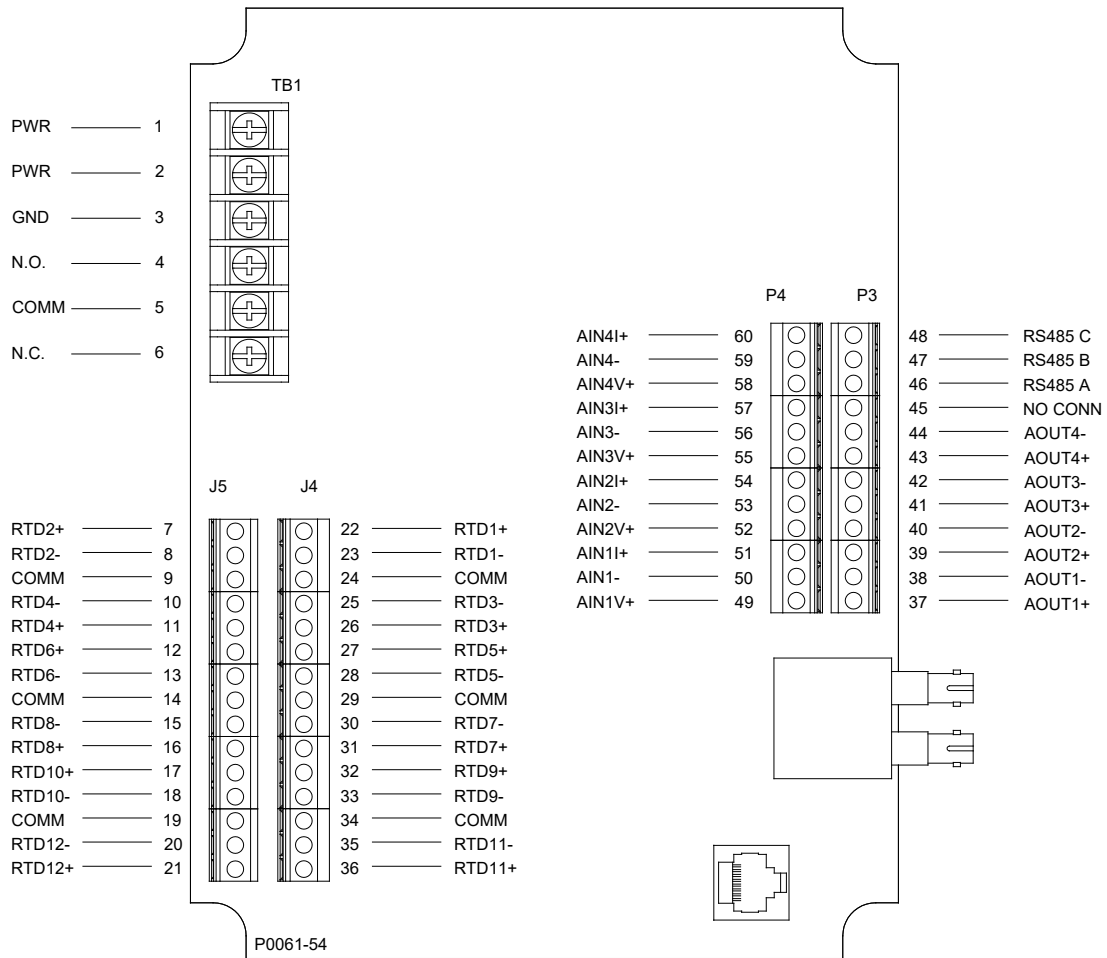


Figure 81-2. Input and Output Terminals

Table 81-3. Input and Output Terminals

Connector	Description
TB1	Operating Power and Alarm Contacts
J4	RTD Inputs 1, 3, 5, 7, 9, 11
J5	RTD Inputs 2, 4, 6, 8, 10, 12
P3	Analog Outputs 1 - 4 and RS485 Connection
P4	Analog Inputs 1 - 4

## External Analog Input Connections

Voltage input connections are shown in Figure 81-3 and current input connections are shown in Figure 81-4. When using the current input, AIN V+ and AIN I+ must be tied together.

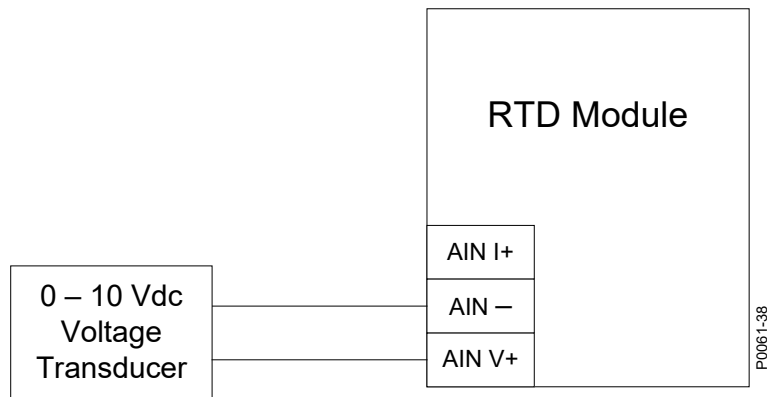


Figure 81-3. Analog Inputs - Voltage Input Connections

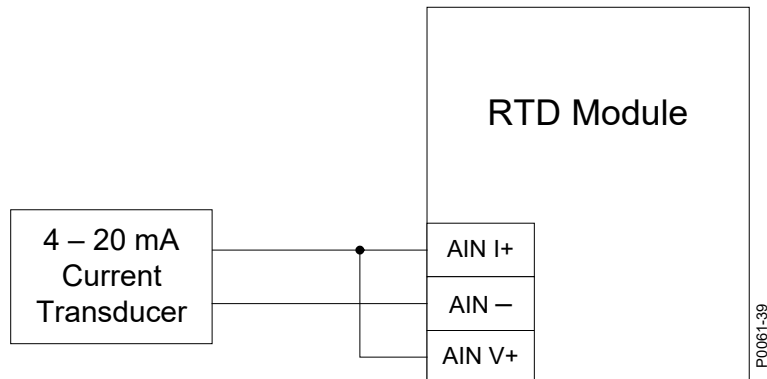


Figure 81-4. Analog Inputs - Current Input Connections

## External RTD Input Connections

External 2-wire RTD input connections are shown in Figure 81-5. Figure 81-6 shows external 3-wire RTD input connections.

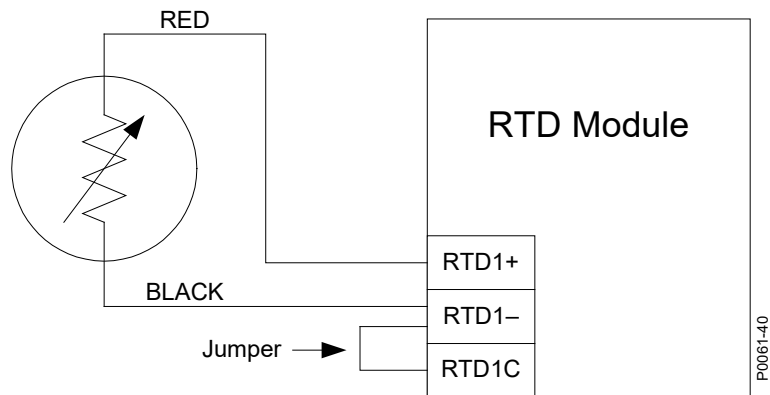


Figure 81-5. External Two-Wire RTD Input Connections

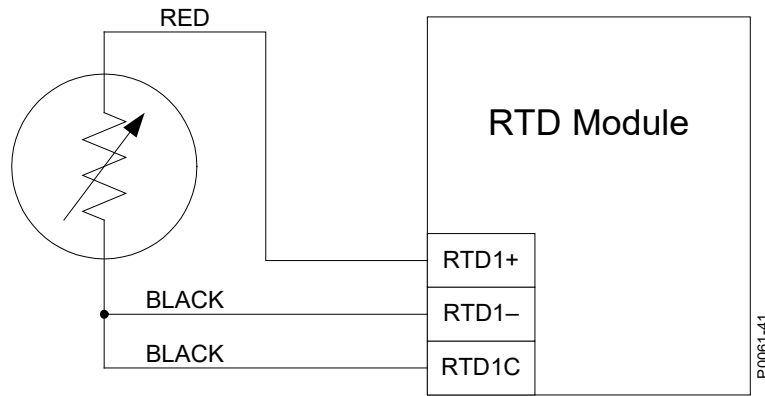


Figure 81-6. External Three-Wire RTD Input Connections

## RTD Module Communications Setup Procedure

Communication between the BE1-11 $t$  and the RTD module can be accomplished via Ethernet or RS-485. For RS-485 communication, RS-485 Port Protocol option must be “N”. Initial settings for the RTD module must be made via Ethernet.

An IP address is assigned to the RTD module in all cases even if the connection between the RTD module and the BE1-11 $t$  will be RS-485. Assigning an IP address to the RTD module gives the user the option to save a settings file and to view the serial number and firmware version of the RTD module using BESTCOMSP $lus$ .

Perform one of the following procedures to set up the RTD module. It is assumed that the BE1-11 $t$  is already connected to the PC or network.

### Procedure 1

The PC and BE1-11 $t$  are connected through a network or the PC is connected directly to the BE1-11 $t$  via Ethernet cable or USB cable. The RTD module connects to the BE1-11 $t$  via Ethernet or RS-485. See Figure 81-7.

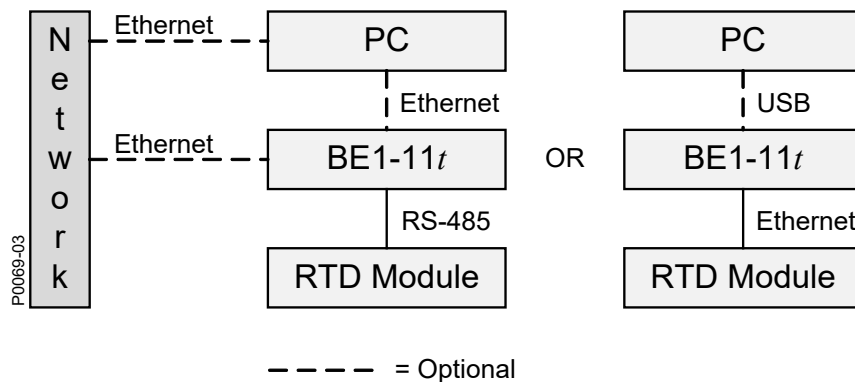


Figure 81-7. Procedure 1

### Connect to RTD Module

1. Connect an Ethernet cable directly between the PC and RTD module.
2. Apply operating power to the RTD module.
3. Determine the IP address, Subnet Mask, and Default Gateway of the PC Ethernet port for later use. Open a Windows® command prompt by clicking Start > Run. Type “cmd”, and click OK. Type “ipconfig” and press enter.

4. Record the IP address, Subnet Mask, and Default Gateway of the PC Ethernet port that is connected to the RTD module. Close the Windows command prompt window.
5. Open the RTD Module plugin in BESTCOMSP*lus*.
6. Pull down the Communication menu and select New Connection > RTD Module. The RTD Module Connection screen appears.
7. Under Device Discovery, click the Ethernet button to scan for connected devices.
8. After scanning for connected devices, the Device Discovery screen appears.
9. Use the computer mouse to highlight the desired RTD module and click the Configure button.
10. The Configure - RTD Module screen appears. The BE1-11*t* uses the Device Address (Remote Module ID) to communicate with the RTD module. The RTD module comes with a default address of 255 (module disabled). Enter the desired device address between 1 and 254.
11. Assign an IP Address to the RTD module by entering an address in the same range as the IP address of the PC recorded in Step 4. For example, if the IP address recorded in Step 4 was 169.254.153.248, you could enter 169.254.153.150 or 169.254.153.45. (The range is 1 to 255.)
12. The PC and RTD module must have the same Subnet Mask and Default Gateway. Assign the Subnet Mask and Default Gateway to the RTD module using the values of the PC recorded in Step 4.
13. Click Send to Device. A password is required. The default password is "OEM". Click Close.
14. Click Cancel on the Device Discovery screen.
15. Cycle power to the RTD module to activate the new IP address.

#### Verify RTD Module Communication and Save a Settings File

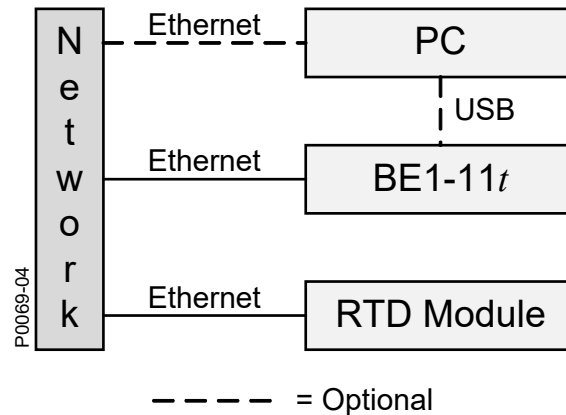
16. To verify that the IP address of the RTD module was correctly configured or to save a settings file for the RTD module, click the Ethernet button under Device Discovery to scan for connected devices.
17. After scanning for connected devices, the Device Discovery screen appears.
18. Use the computer mouse to highlight the desired RTD module and click the Connect button. If the connection was successful, BESTCOMSP*lus* will show **Online** in the lower right corner.
19. Review settings or save a settings file if desired.
20. Click the Disconnect button near the top of BESTCOMSP*lus* to close the RTD module connection.

#### Configure the BE1-11*t* to Communicate with the RTD Module

21. Connect an Ethernet or USB cable between the PC and BE1-11*t*.
22. Open the BE1-11 plugin in BESTCOMSP*lus* and connect to the BE1-11*t*.
23. Use the Settings Explorer to open the Remote Module Communications screen under System Parameters.
24. Set the *Status* to **Enabled**. Set Communication Type to **Ethernet** or **RS485**. Set Remote Module ID to match the remote module ID entered in Step 10.
25. Perform this step if the RTD Module is connected to the BE1-11*t* via a direct Ethernet connection. The BE1-11*t* communicates with the RTD Module only if its Active IP Address is a nonzero value. To confirm/set the IP Address, open the Ethernet screen under Communication, Configure and de-select the Use DHCP box. Then, enter any nonzero value for the IP Address. Click the Send to Device button to apply the settings to the BE1-11*t*.
26. Perform this step if the RTD module is connected to the BE1-11*t* via RS-485. The RTD Module communicates with the BE1-11*t* only at 19200 baud when using RS-485. Open the RS485 Setup screen under Communications and set Baud Rate to **19200 Baud**, Bits Per Character to **8 Bits**, Parity to **No Parity**, and Stop Bits to **1 stop bit**.
27. Use BESTCOMSP*lus* to send settings to the BE1-11*t*.

## Procedure 2

The PC, BE1-11*t*, and RTD module are connected through a network. See Figure 81-8.



**Figure 81-8. Procedure 2**

### Connect to RTD Module

1. Connect an Ethernet cable directly between the PC and RTD module.
2. Apply operating power to the RTD module.
3. Open the RTD Module plugin in *BESTCOMSPius*.
4. Pull down the Communication menu and select New Connection > RTD Module. The RTD Module Connection screen appears.
5. Under Device Discovery, click the Ethernet button to scan for connected devices.
6. After scanning for connected devices, the Device Discovery screen appears.
7. Use the computer mouse to highlight the desired RTD module and click the Configure button.
8. The Configure - RTD Module screen appears. The BE1-11*t* uses the Device Address (Remote Module ID) to communicate with the RTD module. The RTD module comes with a default address of 255 (module disabled). Enter the desired device address between 1 and 254.
9. DHCP (Dynamic Host Configuration Protocol) allows the RTD module to send a broadcast request for configuration information. The DHCP server receives the request and responds with configuration information. DHCP is disabled by default. To enable, check the DHCP box.

If DHCP is not being used, use *BESTCOMSPius* to configure the Ethernet port as described in the following paragraphs.

Configurable Ethernet options include:

<i>IP Address:</i>	Internet Protocol Address to be used by the RTD module.
<i>Default Gateway:</i>	Default host to send data destined for a host not on the network subnet.
<i>Subnet Mask:</i>	Mask used to determine the range of the current network subnet.
<i>Use DHCP:</i>	When this box is checked, the IP Address, Default Gateway, and Subnet Mask are automatically configured via DHCP. This can be used only if the Ethernet network has a properly configured DHCP server running. Uncheck the box if DHCP is not being used.

Obtain the values for these options from the site administrator if the RTD module is intended to share the network with other devices.

If the RTD module is operating on an isolated network, the IP address can be chosen from one of the following ranges as listed in IETF publication RFC 1918, *Address Allocation for Private Networks*.

- 10.0.0.0 - 10.255.255.255

- 172.16.0.0 - 172.31.255.255
  - 192.168.0.0 - 192.168.255.255
10. Click Send to Device. A password is required. The default password is “**OEM**”. Click Close.
  11. Click Cancel on the Device Discovery screen.
  12. Remove operating power from the RTD module. Connect the RTD module to the network. Apply operating power to the RTD module

#### Verify RTD Module Communication and Save a Settings File

13. Connect the PC to the same network as the RTD module.
14. To verify that the IP address of the RTD module was correctly configured or to save a settings file for the RTD module, click the Ethernet button under Device Discovery to scan for connected devices.
15. After scanning for connected devices, the Device Discovery screen appears.
16. Use the computer mouse to highlight the desired RTD module and click the Connect button. If the connection was successful, BESTCOMSP*lus* will show **Online** in the lower right corner.
17. Review settings or save a settings file if desired.
18. Click the Disconnect button near the top of BESTCOMSP*lus* to close the RTD module connection.

#### Configure the BE1-11*t* to Communicate with the RTD Module

19. Connect an Ethernet or USB cable between the PC and BE1-11*t*.
20. Open the BE1-11 plugin in BESTCOMSP*lus* and connect to the BE1-11*t*.
21. Use the Settings Explorer to open the Remote Module Communications screen under System Parameters.
22. Set the *Status* to **Enabled**. Set Communication Type to **Ethernet**. Set Remote Module ID to match the remote module ID entered in Step 8.
23. Use BESTCOMSP*lus* to send settings to the BE1-11*t*.

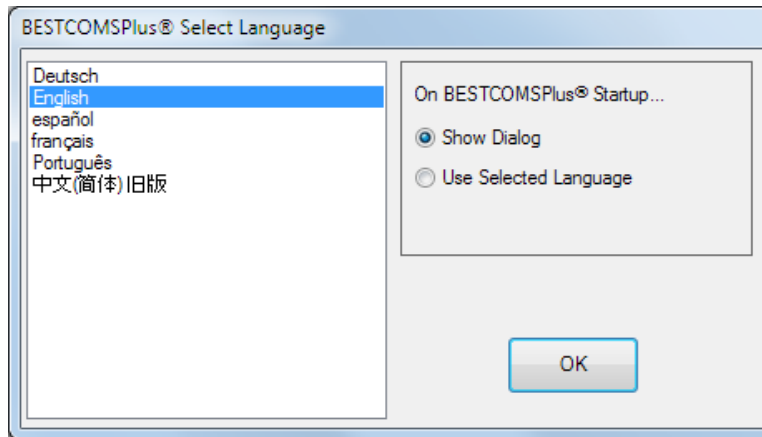
### **RTD Module Plugin for BESTCOMSP*lus***

The setup utility that installs BESTCOMSP*lus* on your PC also installs the RTD Module plugin. The RTD Module plugin is used to set the device address, set device security, and view device information such as firmware version and serial number. RTD Module operational settings such as metering and protective elements are found in the BE1-11 plugin for BESTCOMSP*lus*.

BESTCOMSP*lus* provides the user with a point-and-click means to set and monitor the RTD module. Installation and operation of BESTCOMSP*lus* is described in the *BESTCOMSP*lus* Software* chapter.

#### Automatic Startup

To start BESTCOMSP*lus*, click the Windows® Start button, point to Programs, Basler Electric, and then click the BESTCOMSP*lus* icon. During initial startup, the BESTCOMSP*lus* Select Language screen is displayed (Figure 81-9). You can choose to have this screen displayed each time BESTCOMSP*lus* 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.



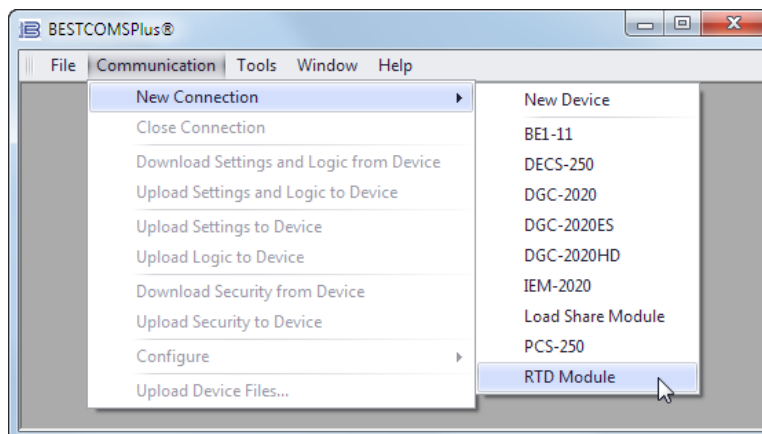
**Figure 81-9. BESTCOMSPPlus Select Language Screen**

The BESTCOMSPPlus splash screen is shown for a brief time. See Figure 81-10.



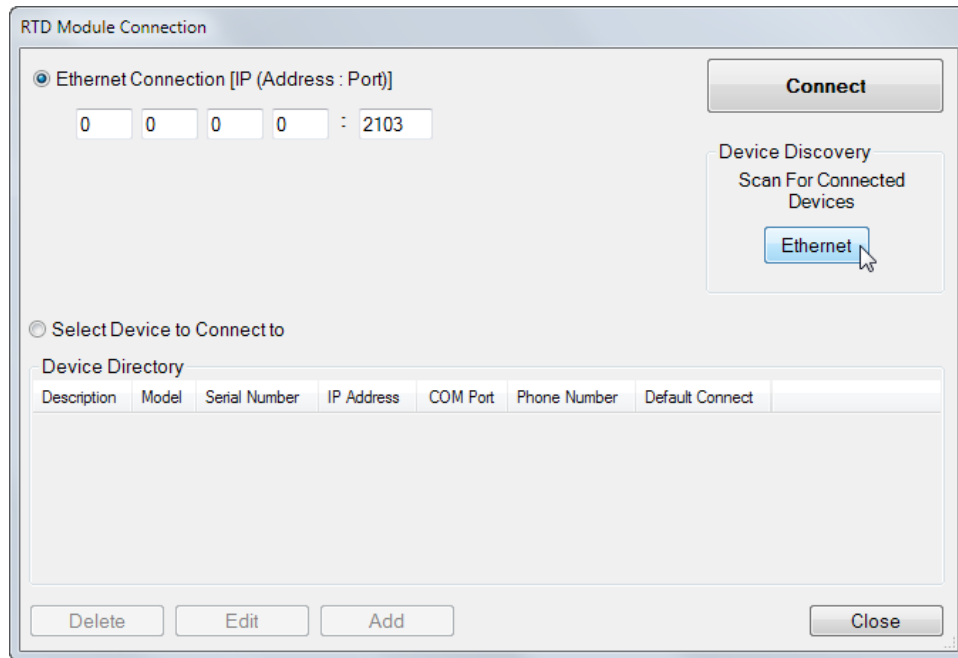
**Figure 81-10. BESTCOMSPPlus Splash Screen**

The BESTCOMSPPlus platform window opens. Select New Connection from the Communication pull-down menu and select RTD Module. See Figure 81-11.



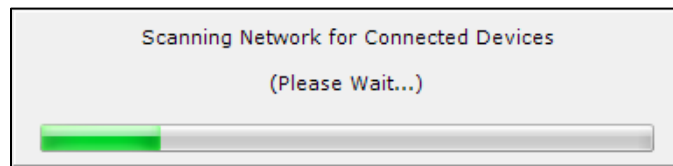
**Figure 81-11. Communication Pull-Down Menu**

The RTD Module Connection screen shown in Figure 81-12 appears. Under Device Discovery, click the Ethernet button.



**Figure 81-12. RTD Module Connection Screen**

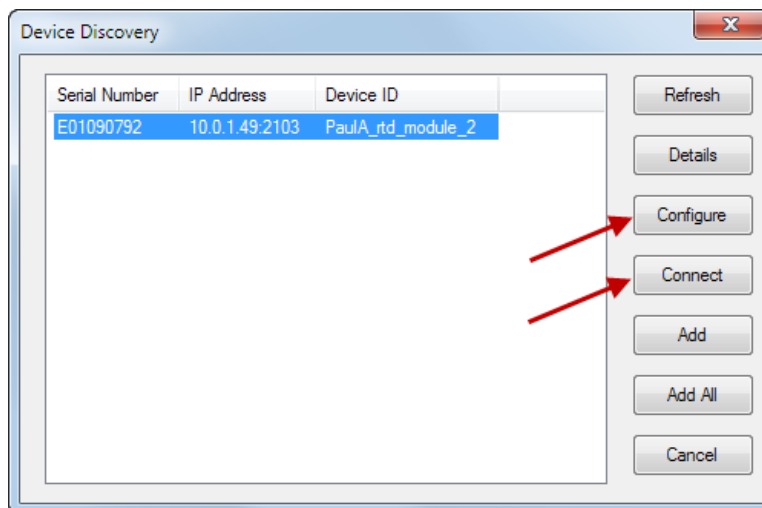
Wait until scanning is complete. See Figure 81-13.



**Figure 81-13. Scanning for Connected Devices**

The Device Discovery screen shown in Figure 81-14 appears. Use the computer mouse to highlight the desired RTD module and click the Connect button (or proceed to configure communications as explained in the next paragraph). The RTD Module plugin opens. You can now configure the RTD module settings.

Click the Configure button to change RTD module communication settings.



**Figure 81-14. Device Discovery Screen**

The Configure - RTD Module screen shown in Figure 81-15 appears. The BE1-11 $\ell$  uses the Device Address to communicate with the connected RTD module through Ethernet or RS-485. All other settings

are only for the Ethernet port. Program the desired settings and click Send to Device. A password is required. The default password is “**OEM**”. Click the Close button.

**Figure 81-15. Configure - RTD Module Screen**

The Device Discovery screen shown in Figure 81-14 re-appears. Click the Connect button. The RTD Module plugin opens. You can now configure the RTD module settings.

### Device Info

Information about an RTD module communicating with BESTCOMSP*lus* can be obtained on the Device Info screen of BESTCOMSP*lus*.

Select application version when configuring RTD module settings off-line. When on-line, read-only information includes application version, boot code version, application build date, serial number, application part number, and model number. A specific Device ID can be assigned by the user.

BESTCOMSP*lus* device information values and settings are illustrated in Figure 81-16.

**Figure 81-16. Device Info Screen**

### Remote Module ID

The default setting is 255 (communications disabled). Assign a remote module ID (1 to 254) to the RTD module. The BE1-11*t* uses this unique ID to communicate with the connected RTD module. To obtain metering values in BESTCOMSP*lus* or through the BE1-11*t* front panel, the same ID must be entered on the Remote Module Communications screen under System Parameters in the Settings Explorer of the BE1-11 plugin. The Device Address screen is shown in Figure 81-17.

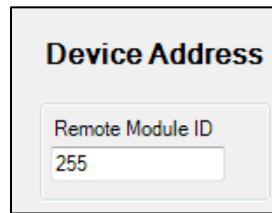


Figure 81-17. Device Address Screen

### Device Security Setup

Password protection guards against unauthorized changing of RTD module settings. Passwords are case sensitive. OEM Access is the only level of password protection available. This password level allows access to all settings made using the RTD Module plugin for BESTCOMSP $l$ us. The default, OEM-access password is “OEM”.

Passwords can be changed only after communication between the PC and RTD module is established. A change to the password is made through the Device Security Setup screen.

Use the Settings Explorer in BESTCOMSP $l$ us to select Device Security Setup under General Settings. The Login dialog box appears. See Figure 81-18.

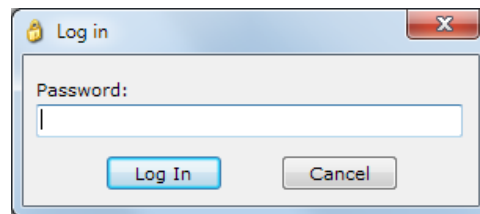


Figure 81-18. Login Screen

Enter the Password and then click the Log In button. The default password is “OEM”. The Device Security Setup screen shown in Figure 81-19 appears.

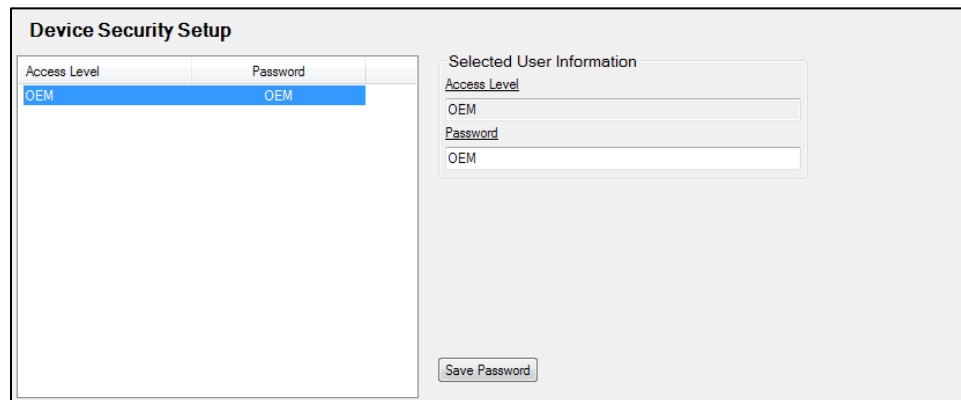


Figure 81-19. Device Security Setup Screen

A password is changed by clicking on the access level and entering the new password. Click the Save Password button to save the settings to BESTCOMSP $l$ us memory.

Pull down the Communication menu and select Upload Security to Device. The Login dialog box pops up. An OEM access level is required to upload security settings to the device.

Enter the password and then click the Log In button. The default password is “OEM”. BESTCOMSP $l$ us notifies you when the upload is successful.

## **Remote Analog Inputs Configuration**

The RTD module provides four analog inputs. The BE1-11 $t$  supports two RTD modules at once. To make identifying the analog inputs easier, a user-assigned name can be given to each input.

Protection settings for remote analog inputs are described in the *Analog Input Protection* chapter.

## Configuration Settings

**BESTCOMSPi.us Navigation Path:** Settings Explorer, Programmable Inputs, Remote Analog Inputs

**HMI Navigation Path:** Settings Explorer, Analog Inputs

Configuration settings are made using the BE1-11 plugin for BESTCOMSPi.us. To program the configuration settings, use the Settings Explorer to open the Programmable Inputs, Remote Analog Inputs tree branch and select the module and input to be modified. Refer to Figure 81-20. Use the drop-down menu under Type to select the type of configuration. The analog inputs are always monitored and their status is displayed on the appropriate metering screens.

Ranges must be set for the selected input type. Param Min correlates to Min Input Current or Min Input Voltage and Param Max correlates to Max Input Current or Max Input Voltage. Param Min and Param Max are scaled values of the Min/Max Voltage/Current settings that are used for protection.

RTD Module 1 Input #1		
Configuration		
Label	Type	
Analog Input 1-1	Voltage	
Ranges		
Param Min	Min Input Current (mA)	Min Input Voltage (V)
-99,999.9	4.00	0.00
Param Max	Max Input Current (mA)	Max Input Voltage (V)
99,999.9	20.00	10.00

Figure 81-20. Module 1 Input #1 Screen

## Remote Analog Outputs Configuration

The RTD module provides four analog outputs. The BE1-11*t* supports two RTD modules at once.

## Configuration Settings

**BESTCOMSPi.us Navigation Path:** Settings Explorer, Programmable Outputs, Remote Analog Outputs

**HMI Navigation Path:** Settings Explorer, Analog Outputs

Configuration settings are made using the BE1-11 plugin for BESTCOMSPi.us. To program the configuration settings, use the Settings Explorer to open the Programmable Outputs, Remote Analog Outputs tree branch and select the module and output to be modified. Refer to Figure 81-21. Use the drop-down menu under Param Selection to select a parameter. Select the Output Type. The analog outputs are always monitored and their status is displayed on the appropriate metering screens.

Ranges must be set for the selected output type. Param Min correlates to Min Output Current or Min Output Voltage and Param Max correlates to Max Output Current or Max Output Voltage.

RTD Module 1 Output #1		
Configuration		
Param Selection	Output Type	
VA	Voltage	
Ranges		
Param Min	Min Output Current (mA)	Min Output Voltage (V)
-99,999.9	4.00	0.00
Param Max	Max Output Current (mA)	Max Output Voltage (V)
99,999.9	20.00	10.00

Figure 81-21. Module 1 Output #1 Screen

Table 81-4 defines the units of selectable parameters.

Table 81-4. Units of Selectable Parameters

Parameter	Unit	Note
VA, VB, VC, VAB, VBC, VCA, 3V0, V1, V2, Vx, Vx 3 <sup>rd</sup> Harmonic	V (secondary)	
IA Circuit 1, IB Circuit 1, IC Circuit 1, 3I0 Circuit 1, I1 Circuit 1, I2 Circuit 1, IG Circuit 1	A (secondary)	
IA Circuit 2, IB Circuit 2, IC Circuit 2, 3I0 Circuit 2, I1 Circuit 2, I2 Circuit 2, IG Circuit 2	A (secondary)	
Phase Frequency, Aux Frequency	Hz	
Power Factor	Per unit	$PF = \frac{Watts}{VA}$
Real Power	kW (secondary)	In the metering screen, the power values are displayed in kW, kvar, and kVA primary. The analog output values are displayed in secondary. Secondary values must be calculated using the CT and VT ratio.
Reactive Power	kvar (secondary)	
Apparent Power	kVA (secondary)	
Analog Input 1-1 through 1-4	Scale entered for the analog input	When an analog output is used to repeat an analog input, the scaled value is used (not the raw 4-20 mA or 0-10 V signal).
Analog Input 2-1 through 2-4	Scale entered for the analog input	
RTD 1-1 through RTD 1-12	Degrees C or F (depends on System Units setting)	
RTD 2-1 through RTD 2-12	Degrees C or F (depends on System Units setting)	

### Remote Analog Output Metering

Analog output metering values are obtained through BESTCOMS*Plus* by using the Metering Explorer to open the Analog Metering, Analog Outputs tree branch. BESTCOMS*Plus* must be online with the BE1-11*t* to view analog output metering. Alternately, values can be obtained through the front-panel display by navigating to Metering > Analog Metering > Analog Output.

### Remote RTDs Configuration

The RTD module provides 12 RTD inputs. The BE1-11*t* supports two RTD modules at once. The RTDs are always monitored and their status is displayed on the appropriate metering screens.

Protection settings for remote RTDs are described in the *Resistance Temperature Detector (49RTD) Protection* chapter.

### Out of Range Alarm

The BE1-11*t* reports an Out of Range alarm when the resistance from an RTD has exceeded an expected range for a properly functioning RTD. Exceeding the range indicates that the RTD may be shorted or open and cannot be relied on to provide thermal detection. Table 81-5 defines the resistance and equivalent temperature levels that will result in an Out of Range alarm.

**Table 81-5. Out of Range Alarm Resistance/Temperature Levels**

RTD Type	Min. Ohms	Min. Temperature	Max. Ohms	Max. Temperature
10 Ω Cu	7 Ω	-61°C (-77.8°F)	20 Ω	261°C (501.8°F)
100 Ω Pt	76 Ω	-61°C (-77.8°F)	198 Ω	261°C (501.8°F)
100 Ω Ni	69 Ω	-61°C (-77.8°F)	224 Ω	181°C (357.8°F)
120 Ω Ni	79 Ω	-61°C (-77.8°F)	383 Ω	261°C (501.8°F)

## Configuration Settings

**BESTCOMSPlus Navigation Path:** Settings Explorer, Programmable Inputs, Remote RTD

**HMI Navigation Path:** Settings Explorer, RTD Types

Configuration settings are made using the BE1-11 plugin for BESTCOMSPlus. Before making configuration settings, remote module communications must be configured on the System Parameters, Remote Module Communications screen. To program the configuration settings, use the Settings Explorer to open the Programmable Inputs, Remote RTD, RTD Type Selection tree branch and select RTD Type Selection. Use the drop-down menu to select RTD Type. Refer to Figure 81-22.

**Figure 81-22. RTD Type Selection Screen**

Use the Settings Explorer to open the Programmable Inputs, Remote RTD, RTD Block Configuration tree branch and enter a user-defined name (up to 64 alphanumeric characters) for the RTD Configuration Block selected. Check the boxes next to the RTDs to include in each configuration group. See Figure 81-23.

The source for the 49RTD protection elements can be set for RTD Group 1, 2, 3, 4, 5, 6, or 7. Refer to the *Resistance Temperature Detector (49RTD) Protection* chapter for information on setting 49RTD protection elements.

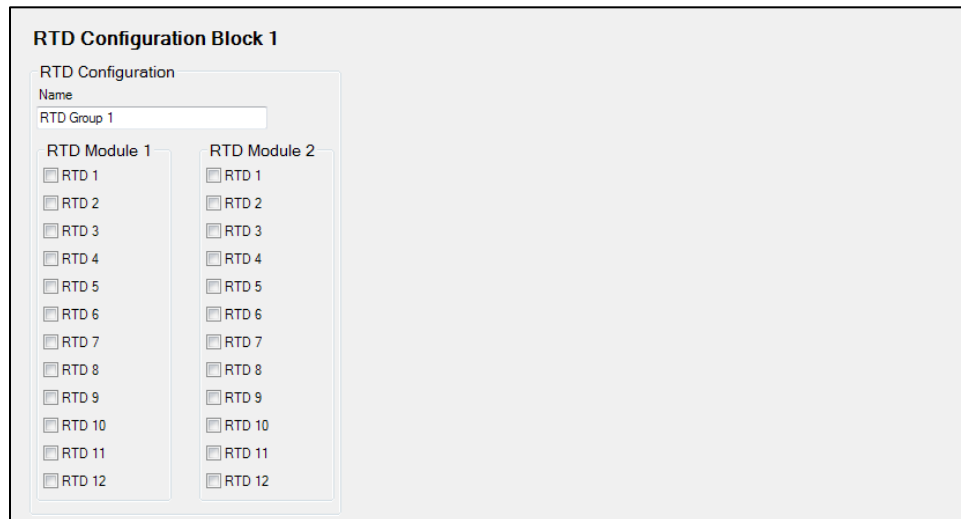


Figure 81-23. RTD Configuration Block Screen

## Specifications

### Operating Power

Nominal ..... 125/250 Vac/dc  
 Range ..... 90 to 270 Vac or 90 to 300 Vdc  
 Maximum Consumption ..... 9 W

### Analog Inputs

The RTD module contains four programmable analog inputs.  
 Rating ..... 4 to 20 mAdc or 0 to 10 Vdc (user-selectable)

### RTD Inputs

The RTD module contains 12 programmable RTD inputs.  
 User-Selectable Types ..... 100  $\Omega$  Platinum (DIN43760), 10  $\Omega$  Copper, 100  $\Omega$  Nickel, or 120  $\Omega$  Nickel  
 Range ..... -50 to 250°C (-58 to 482°F)  
 Accuracy .....  $\pm 2^\circ\text{C}$  (3.6°F)  
 Maximum Lead Length ..... 150 feet (45.72 m) with 22 AWG (0.326 mm<sup>2</sup>) wire  
 Sensing Current Level ..... 2.5 mA  
 Isolation ..... 35 Vpp

### Analog Outputs

The RTD module contains four programmable analog outputs.  
 Rating ..... 4 to 20 mAdc or 0 to 10 Vdc (user-selectable)

#### Current

Accuracy .....  $\pm 0.053\%$  of full scale (10 V) at 25°C  
 Temperature Dependence .....  $\pm 0.029\%$  drift per degree Celsius

#### Voltage

Accuracy .....  $\pm 0.055\%$  of full scale (20 mA) at 25°C  
 Temperature Dependence .....  $\pm 0.04\%$  drift per degree Celsius

### Alarm Contact

Type ..... Form C (SPDT)  
 Rating ..... 24/48/125/250 Vdc at:

- 30 A make for 0.2 seconds
- 7 A continuous
- 0.3 Adc Break (L/R = 0.04)

## Communication Interface

### Ethernet

An RTD module with part number 9444100101 is equipped with both fiber and copper Ethernet connections. An RTD module with part number 9444100100 is equipped with only a copper Ethernet connection.

#### Copper Type (RJ45 Connector)

Version ..... 10BASE-T/100BASE-TX  
 Maximum Length (One Network Segment)..... 328 ft (100 m)

#### Fiber Optic Type (ST Connector)

Version ..... 100BASE-FX, multimode  
 Maximum Length (Half-Duplex) ..... 1,310 ft (399 m)  
 Maximum Length (Full-Duplex)..... 6,600 ft (2,011 m)

### Serial

RS-485 19,200 baud

## Temperature

Operating Range ..... –40°C to 70°C (–40°F to 158°F)  
 Storage Range ..... –40°C to 70°C (–40°F to 158°F)

## Standards

- IEC 60068-1: *Environmental Testing Part 1: General and Guidance. Temperature Test*
- IEC 60068-2-1: *Basic Environmental Testing Procedures, Part 2: Tests - Test Ad: Cold (Type Test)*
- IEC 60068-2-2: *Basic Environmental Testing Procedures, Part 2: Tests - Test Bd: Dry Heat (Type Test)*
- IEC 60068-2-28: *Environmental Testing Part 2: Testing-Guidance for Damp Heat Tests*
- IEC 60255-4: *Single Input Energizing Quantity Measuring Relays with Dependent Specified Time*
- IEC 60255-5: *Electrical Insulation Tests for Electrical Relays. Dielectric Test and Impulse Test*
- IEC 60255-6: *Electrical Relays - Measuring Relays and Protection Equipment*
- IEC 60255-21-1: *Vibration, Shock, Bump, and Seismic Tests on Measuring Relays and Protective Equipment (Section 1 - Vibration Test - Sinusoidal). Class 1*
- IEC 60255-21-2: *Vibration, Shock, Bump, and Seismic Tests on Measuring Relays and Protective Equipment (Section 2 - Shock and Bump Test - Sinusoidal). Class 1*
- IEEE C37.90.1: *Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus*
- IEEE C37.90.2: *Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers*

## UL Approval

“cURus” recognized to UL Standard 508 & CSA Standard C22.2 No.14

## CSA Certification

CSA certified to Standard C22.2 No.14.

## CE and UKCA Compliance

This product has been evaluated and complies with the requirements set forth by the EU legislation and UK Parliament.

EC Directives:

- LVD 2014/35/EU
- EMC 2014/30/EU
- RoHS2 2011/65/EU

Harmonized Standards used for evaluation:

- EN 50178:1997 - *Electronic Equipment for use in Power Installations*
- EN 61000-6-4:2001 - *Electromagnetic Compatibility (EMC), Generic Standards, Emission Standard for Industrial Environments*
- EN 61000-6-2:2001 - *Electromagnetic Compatibility (EMC), Generic Standards, Immunity for Industrial Environments*
- EN 61000-4-2: *Electrostatic Discharge Immunity*
- EN 61000-4-3: *Radiated, Radio-Frequency, Electromagnetic Field Immunity*
- EN 61000-4-4: *EFT Immunity*
- EN 61000-4-5: *Surge Immunity*
- EN 61000-4-6: *Conducted Immunity*
- EN 61000-4-8: *Power Frequency Magnetic Field Immunity*
- EN 61000-4-11: *Voltage Dips and Interrupts*

## HALT (Highly Accelerated Life Testing)

Basler Electric uses HALT to prove that our products will provide the user with many years of reliable service. HALT subjects the device to extremes in temperature, shock, and vibration to simulate years of operation, but in a much shorter period span. HALT allows Basler Electric to evaluate all possible design elements that will add to the life of this device. As an example of some of the extreme testing conditions, the RTD module was subjected to temperature extremes of  $-80^{\circ}\text{C}$  to  $+130^{\circ}\text{C}$ , vibration extremes of 5 to 45 G at  $+20^{\circ}\text{C}$ , and temperature/vibration extremes of 45 G over a temperature range of  $-60^{\circ}\text{C}$  to  $+110^{\circ}\text{C}$ . Combined temperature and vibration testing at these extremes proves that the RTD module is expected to provide long-term operation in a rugged environment. Note that the vibration and temperature extremes listed in this paragraph are specific to HALT and do not reflect recommended operation levels. These operational ratings are listed under *Temperature*.

## Physical

Weight ..... 2.15 lb (0.975 kg)  
 IP Class ..... IP50  
 Size ..... Refer to *Mounting*.

## Repair

RTD modules 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.

Before returning the RTD module for repair, contact the Basler Electric Technical Services Department at 618-654-2341 for a return authorization number.

## Maintenance

Preventive maintenance consists of periodically checking that the connections between the RTD module and the system are clean and tight.

## ***Storage***

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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.

# 82 • BESTCOMSPi<sup>us</sup>® Settings Loader Tool

## Introduction

The BESTCOMSPi<sup>us</sup>® Settings Loader Tool is a software application which allows the user to instantly upload settings to Basler BESTCOMSPi<sup>us</sup>-compatible products by scanning a pre-registered bar code which promotes consistency, reduces potential errors, and saves time.

## Setup

The BESTCOMSPi<sup>us</sup> Settings Loader Tool software and a bar code reader (acquired separately) must be installed on the same PC.

## BESTCOMSPi<sup>us</sup> Settings Loader Tool Installation

### System Recommendations

The BESTCOMSPi<sup>us</sup>® Settings Loader Tool is bundled with BESTCOMSPi<sup>us</sup> software. BESTCOMSPi<sup>us</sup> software is built on the Microsoft® .NET Framework. The setup utility that installs BESTCOMSPi<sup>us</sup> on your PC also installs the BESTCOMSPi<sup>us</sup> Settings Loader Tool and the required version of .NET Framework (if not already installed). BESTCOMSPi<sup>us</sup> operates with systems using Windows® 7 SP1, Windows 8.1, Windows 10, and Windows 11. Microsoft Internet Explorer 5.01 or later must be installed on your PC before installing BESTCOMSPi<sup>us</sup>. System recommendations for the .NET Framework and BESTCOMSPi<sup>us</sup> are listed in Table 82-1.

**Table 82-1. System Recommendations for BESTCOMSPi<sup>us</sup> and the .NET Framework**

System Type	Component	Recommendation
32/64 bit	Processor	2.0 GHz
32/64 bit	RAM	1 GB (minimum), 2 GB (recommended)
32 bit	Hard Drive	200 MB (if .NET Framework is already installed on PC)
		4.5 GB (if .NET Framework is not already installed on PC)
64 bit	Hard Drive	200 MB (if .NET Framework is already installed on PC)
		4.5 GB (if .NET Framework is not already installed on PC)

### Download BESTCOMSPi<sup>us</sup>

Use the following procedure to download BESTCOMSPi<sup>us</sup> from the Basler Electric website.

1. Navigate to <https://www.basler.com/Downloads>.
2. Select BE1-11<sub>r</sub> from the model drop down menu.
3. Under the Software heading, click the download link for BESTCOMSPi<sup>us</sup>.
4. Sign in or create an account to continue with the download.

### Install BESTCOMSPi<sup>us</sup>

To install and run BESTCOMSPi<sup>us</sup>, a Windows user must have Administrator rights.

**Note**

Do not connect a USB cable until setup completes successfully. Connecting a USB cable before setup is complete may result in errors.

Run the setup file for the BESTCOMSP*lus* application. The setup utility installs BESTCOMSP*lus*, the .NET Framework (if not already installed), the USB driver, and the BESTCOMSP*lus* Settings Loader Tool on your PC.

When BESTCOMSP*lus* 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 the BESTCOMSP*lus* Settings Loader Tool.

**Bar Code Reader and Bar Codes**

The BESTCOMSP*lus* Settings Loader Tool is compatible with bar code readers which conform to UnifiedPOS specifications. Bar code readers and bar code labels are not provided and must be acquired separately. Refer to the bar code reader's documentation for installation instructions.

Any bar code compatible with your bar code reader may be used.

***BESTCOMSP*lus*® Settings Loader Tool Settings***

BESTCOMSP*lus* Settings Loader Tool settings are found on two main screens, the Loader Grid and Configuration screen. The Loader Grid contains management options for the product settings files and their associated bar codes. The Configuration screen contains product-specific options for the default behavior of the BESTCOMSP*lus* Settings Loader Tool. These settings are described in the following paragraphs.

**Loader Grid**

One entry, or row, in the Loader Grid contains all of the necessary data to associate a product settings file with a bar code. New entries can be added. Existing entries can be edited, deleted, and uploaded to a Basler product.

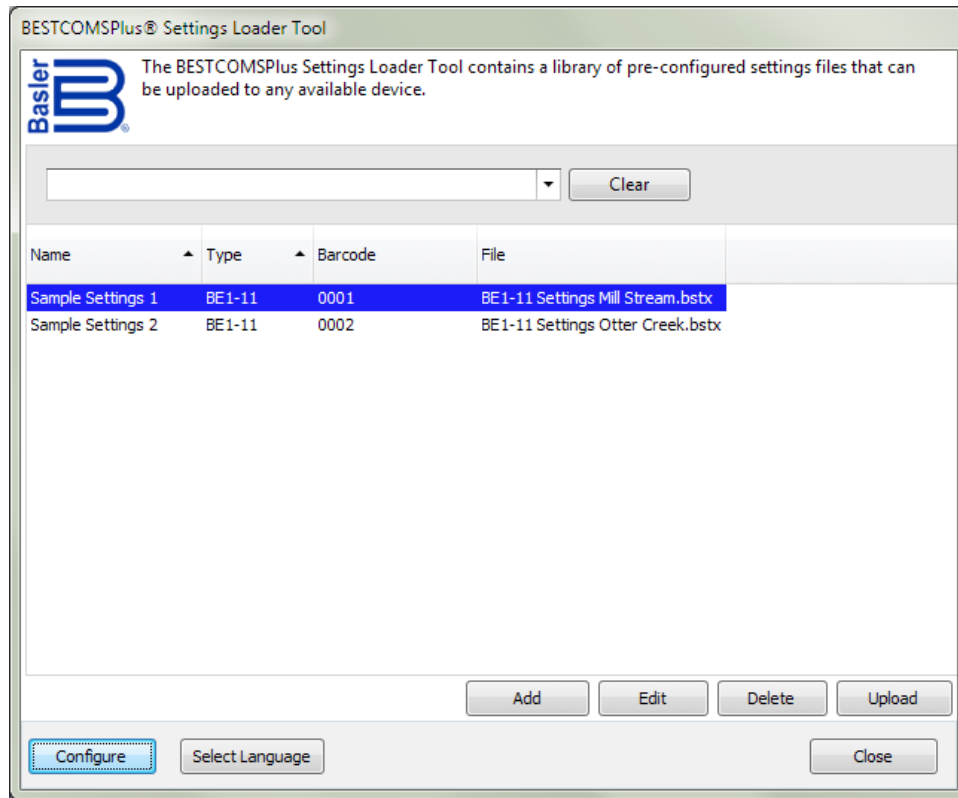


Figure 82-1. Loader Grid

### Scanning Bar Codes

Place the cursor in the text field, found at the top of the Loader Grid screen, and scan a bar code. If successful, the digits which comprise the bar code appear in the text field. The BESTCOMSPPlus Settings Loader Tool automatically searches for this bar code among the entries in the Loader Grid and displays the matching entry. Click Clear to remove the digits from the text field.

### Adding an Entry

Click Add to create an entry. The BESTCOMSPPlus® Settings Loader Tool: Add Device dialog box appears (Figure 82-2).

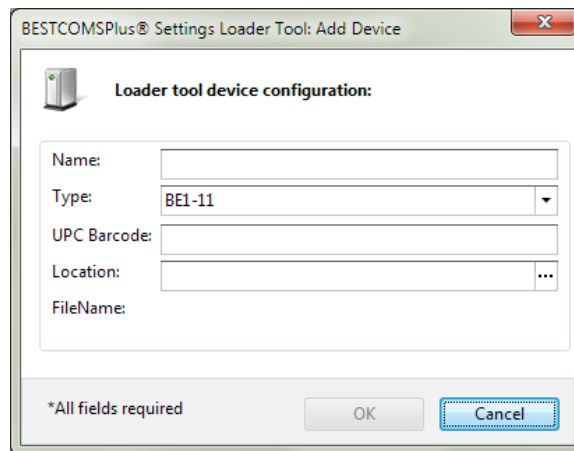


Figure 82-2. Add Device Screen

Enter the name of the entry in the Name field. This appears in the first column of the Loader Grid.

Select the product type from the Type drop-down menu. This appears in the second column of the Loader Grid.

Enter the bar code of the entry in the UPC Barcode field by placing the cursor in the UPC Barcode field and scanning the bar code.

To select the product settings file for the entry, click the browse (...) button in the Location field. Use standard Windows methods to navigate to the desired product settings file and click Open. Ensure that the selected product type in the Type field matches that of the product settings file specified in the Location field.

Click OK when finished.

### Editing an Entry

To Edit an existing entry, select the entry in the Loader Grid and click Edit. The BESTCOMSP*lus* Settings Loader Tool: Edit Device dialog box appears. The options are identical to those of the Add Device dialog. When the desired changes have been made, click OK.

### Deleting an Entry

To delete an entry from the Loader Grid, select the entry and click the Delete button. A prompt appears providing the option to confirm or cancel the deletion.

### Uploading an Entry

Select an entry and click Upload. A dialog appears which provides connection options for the appropriate type of device. Refer to the Basler product instruction manual for detailed connection information. Once a connection is established, the product settings associated with the entry are uploaded.

## Configuration Settings

For configuration settings, click the Configure button in the bottom left of the Loader Grid. The product tabs on the left represent the compatible Basler products. Each product tab contains tabs for Settings Files and Connection Options. The options on these tabs are described below.

### Setting Files Options

**Use Saved Path:** When enabled, the path specified in the Loader Grid entry is used when uploading the settings file.

**Single Folder:** When enabled, this specifies a single folder which contains all settings files for the product. The Windows filename specified in the Location field of the Loader Grid entry is searched for in the Single Folder location. For example, all settings files for a product are located in "C:\Files". The Location field in the Loader Grid entry for a device contains "C:\Documents\Settings\BE1-11 Settings.bstx". The BESTCOMSP*lus* Settings Loader Tool searches in "C:\Files" for the filename "BE1-11 Settings.bstx".

**Append Bar-Code to Location:** When enabled, the bar code is appended to the specified location when uploading the settings file. For example, an entry with the bar code "0002" is located in C:\Files\0002 and an entry with the bar code "0003" is located in C:\Files\0003.

**Logon:** If User Name and Password are specified, you will not be prompted for credentials when required.

**Save After Upload:** After uploading a settings file, the settings are downloaded from the connected device and saved to the specified location, when enabled.

**Upload Security:** When enabled, the security settings stored in the settings file are uploaded to the device. Credentials will be requested if not already specified.

Figure 82-3 illustrates the Setting Files tab.

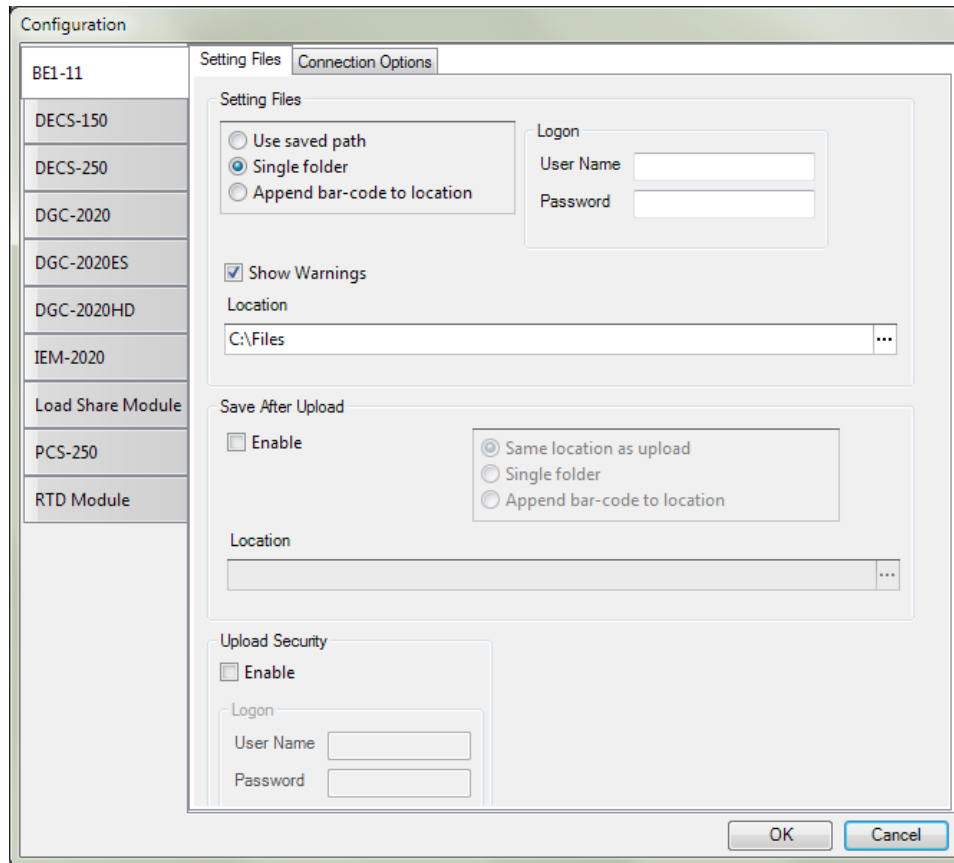


Figure 82-3. Configuration, Settings Files Tab

### Connection Options

Connection options consist of the three selections described below. Refer to the Basler product instruction manual for detailed connection information.

**Always Prompt for Connection:** When enabled, a dialog appears which provides connection options for the appropriate type of device each time a connection attempt is made.

**Ethernet Connection:** When enabled, the BESTCOMSPi<sup>us</sup> Settings Loader Tool automatically attempts to connect to the specified IP address before uploading settings.

**USB Connection:** When enabled, the BESTCOMSPi<sup>us</sup>® Settings Loader Tool automatically attempts to connect to the device via USB port before uploading settings.

Figure 82-4 illustrates the Connection Options tab.

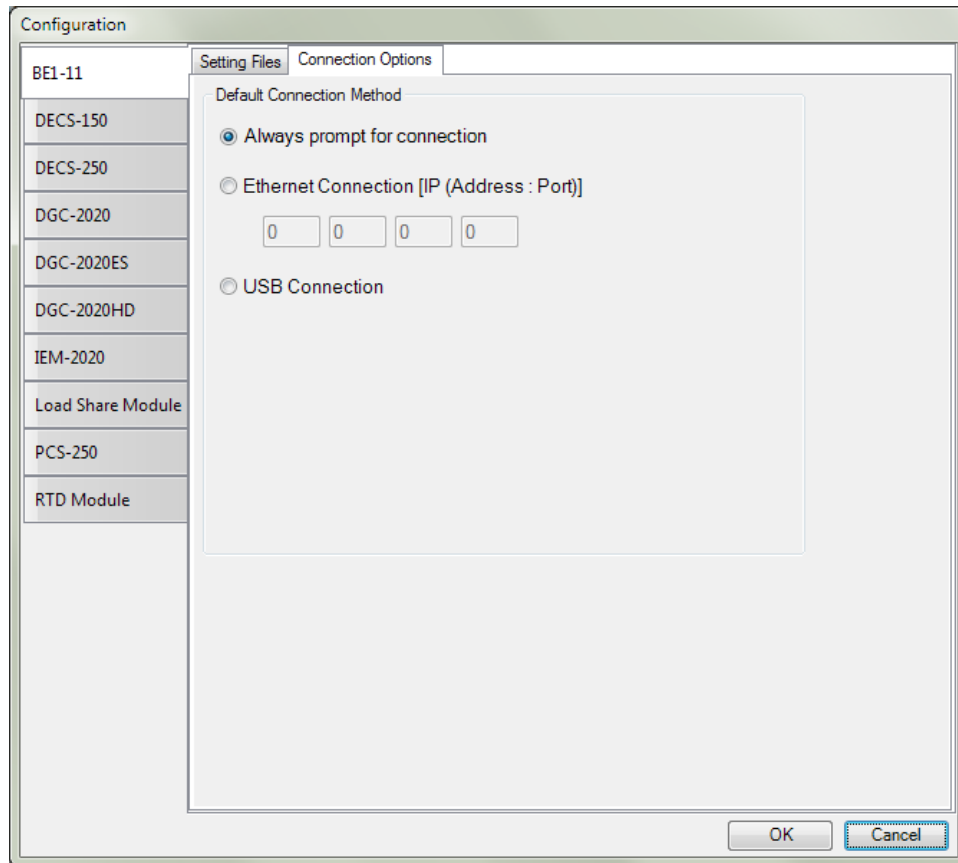


Figure 82-4. Configuration, Connection Options Tab

## General Operation

The steps listed below are provided as a general guideline for how to operate the BESTCOMS*Plus* Settings Loader Tool when the initial setup is complete and the settings files are associated with bar codes.

1. Power on the device which will receive the new settings. Ensure proper communication connections have been made between the device and the PC running BESTCOMS*Plus* Settings Loader Tool.
2. Run BESTCOMS*Plus* Settings Loader Tool.
3. Place cursor in search bar.
4. Scan bar code.
5. Settings file is automatically highlighted and isolated in the grid.
6. Click Upload.
7. BESTCOMS*Plus* Settings Loader Tool automatically connects to device and uploads settings. Device connection is automatic unless “Always prompt for connection” is enabled.





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