



BE1-700

Digital Protective Relay

Instruction Manual
(Firmware Version 4.XX.XX)



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

Preface

This instruction manual provides information about the installation and operation of the BE1-700 Digital Protective Relay, which may also be referenced as the BE1-700V. To accomplish this, the following information is provided:

- General information
- Quick start
- Mounting and connections
- BESTCOMSP^lus[®] software
- Protection and control functions
- Reporting and alarms
- Communications and security
- Testing and troubleshooting
- Specifications

An optional *Modbus Protocol Instruction* manual (Basler Electric part number 9376700997) is available on the Basler Electric website.

Conventions Used in this Manual

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

Warning!

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

Caution

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

Note

Note boxes emphasize important information pertaining to installation or operation.



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Warning!

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

Caution

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

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

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

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

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

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

Hardware Versions

This instruction manual covers hardware version 4 of the BE1-700. For hardware versions 1, 2, and 3, refer to Basler Instruction Manual 9376700990. Differences between hardware versions are listed in the table below.

BE1-700 Version Differences

Hardware Differences		
Feature	Versions 1, 2, and 3*	Version 4
Front Panel Communications Port	RS-232	USB-C
Voltage and Current Sensing Inputs	Voltage or Current	Voltage Only
Firmware Differences		
Feature	Versions 1, 2, and 3*	Version 4
PC Software Interface	BESTCOMS™	BESTCOMSPi [®]
BESTnet™ Communication	Yes	No
Settings via ASCII Commands	Yes	No
Ethernet Port Supports Modbus [®] and BESTCOMSPi [®] Simultaneously	No	Yes
Modbus over Ethernet or RS-485	Selected by Style Number	Selected by User

*Versions 1, 2, and 3 are no longer available for ordering.

Identifying BE1-700 Version

BE1-700 relays with a front panel USB port are Version 4 while relays with a front panel RS-232 port are Versions 1, 2, or 3.

In BESTCOMSPi[®], the BE1-700 hardware version is found on the *Device Info* screen. Connect to the BE1-700 and download settings and logic. Using the *Settings Explorer*, open *General Settings, Device Info*. The hardware version of the BE1-700 is shown in the *Application Version* field. The application version number consists of five digits. The first digit is the hardware version number. Refer to the *BESTCOMSPi[®] Software* chapter for details on installing and using BESTCOMSPi[®].



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 to download the latest hardware, firmware, and BESTCOMSPlus® revision histories.

Instruction Manual Revision History

Manual Revision and Date	Change
B, Jun 2025	<ul style="list-style-type: none">• Replaced references to BESTwave™ software with BESTdata• Updated China RoHS compliance• Added FCC compliance
A, Aug 2024	<ul style="list-style-type: none">• Updated recommended RS-485 cable description in <i>Communications</i>• Added Shock, Vibration, Bump, and Seismic to <i>Specifications</i>• Added CE and UKCA Compliance to <i>Specifications</i>
—, Apr 2024	<ul style="list-style-type: none">• Initial release



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1 • Introduction

The BE1-700 Voltage-Only Digital Protective Relay is an economical, microprocessor based, multifunction system that is available in a panel mount, non-drawout case.

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

A front-panel USB port and optional rear Ethernet port enable local and remote communication between the BE1-700 and a PC operating with BESTCOMSP*lus*® software. BESTCOMSP*lus* software simplifies the commissioning process by providing a graphical interface for setting the BE1-700 and configuring a protection scheme for your application. Through BESTCOMSP*lus*, all BE1-700 settings and logic can be retained in a file for printing or uploading to other BE1-700 systems. Oscillography and sequential events records can be retrieved from a BE1-700, viewed, and printed.

Front-panel features include an LCD screen and LED indicators that display system parameters, BE1-700 settings, and BE1-700 status. The front-panel buttons enable navigation through the menu, changes to settings, resetting of targets (with password access), and direct access to controls and switches.

Applications

The BE1-700 is ideally suited for applications based on the following attributes:

- Highly reliable and proven over/undervoltage and over/underfrequency protection
- Power source health protection and monitoring
- The flexibility provided by wide setting ranges, multiple setting groups, and multiple functions in one unit
- The economy and space savings provided by a multifunction, multiphase unit
- High-speed Ethernet communications and protocol support
- The capabilities of a digital multifunction relay
- The small size and limited behind-panel projection facilitate modernizing protection and control
- Systems in existing equipment

Features

The BE1-700 system includes many features for the protection, monitoring, and control of power system equipment. These features include protection and control, metering, 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 inputs and outputs (I/O) and an advanced human-machine interface (HMI) provide easy access to the features provided.

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

General Features

- Secure device access settings
- Breaker automation and control with Trip Circuit Monitoring and Breaker Monitoring
- Three-Phase sensing with auxiliary input for circuit protection, monitoring, and control
- Contact input and output capabilities

- Four programmable contact-sensing inputs
- Five programmable general-purpose contact outputs
- One programmable fail-safe alarm output
- Encrypted and keyed field upgradable firmware
- IRIG-B synchronized clock
- USB, RS-485, and copper Ethernet (optional) ports with Modbus® protocol support
- Advanced recording
 - Targets and alarms
 - Oscillography (COMTRADE format) with Fault Summary
 - Sequence of Events (SoE)

Protection and Control

The BE1-700 includes protection elements that monitor voltage, frequency, breaker reclosing, fuse loss, and more to provide protection against faults and abnormal operating conditions. Setting groups and virtual control switches make up the control functions.

- Voltage - Overexcitation (24), Sync Check (25), Undervoltage (27), Negative-Sequence Overvoltage (47), Overvoltage (59)
- Frequency - Underfrequency (81U), Overfrequency (81O)
- Control - Breaker control (101), Virtual Switches (43), Fuse Loss (60FL), Logic Timers (62), Recloser (79)

BESTlogic™ Plus Programmable Logic

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

Each BE1-700 is shipped with a pre-defined logic scheme for over/undervoltage applications. Custom logic settings allow you to tailor the BE1-700 functionality to match the needs of the operation's practices and power system requirements.

Style Number

BE1-700 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 BE1-700, be sure to check the style number against the requisition and the packing list to ensure that they agree. The style chart is shown in Figure 1-1.

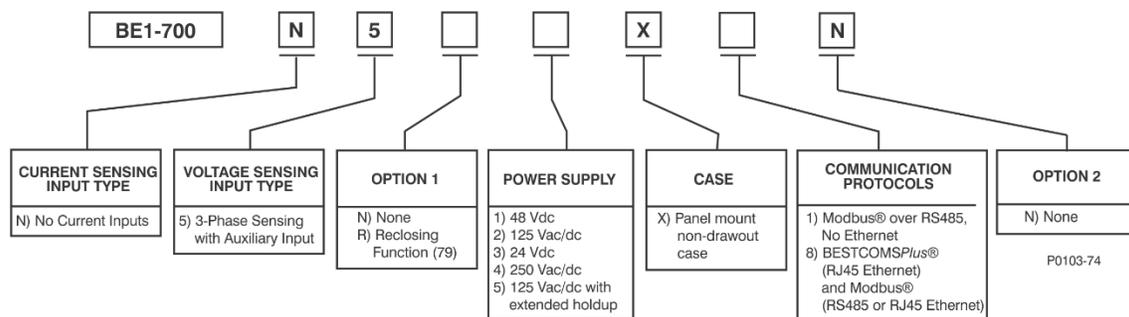


Figure 1-1. Style Chart

2 • Quick Start

This chapter provides basic installation and setup information about the BE1-700. BE1-700 protection systems are delivered with a BE1-700. Upon receipt of the BE1-700, 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 in Highland, Illinois.

If the BE1-700 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 BE1-700 until BESTCOMSP*lus* is installed. Connecting a USB cable before setup is complete may result in errors.

Maintenance

Preventive maintenance consists of periodically checking that the connections between the BE1-700 and the system are clean and tight. BE1-700 units are manufactured using state-of-the-art, surface-mount technology. As such, Basler Electric recommends that no repair procedures be attempted by anyone other than Basler Electric personnel.

Storage

This device contains long-life aluminum electrolytic capacitors. For devices that are not in service (spares in storage), the life of these capacitors can be maximized by energizing the device for 30 minutes once per year.

Install BESTCOMSP*lus*® Software

BESTCOMSP*lus* software is built on the Microsoft® .NET Framework. The setup utility that installs BESTCOMSP*lus* on your PC also installs the BE1-700 plugin and the required version of .NET Framework (if not already installed). BESTCOMSP*lus* operates with systems using Windows® 7 SP1, Windows 8.1, and Windows 10 version 1607 (Anniversary Edition) or later, and Windows 11. System recommendations for the .NET Framework and BESTCOMSP*lus* are listed in Table 2-1.

Table 2-1. 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)
32/64 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.

1. Download BESTCOMSP*lus* from www.basler.com.
2. Click the installation button for BESTCOMSP*lus*. The setup utility installs BESTCOMSP*lus*, the .NET Framework (if not already installed), the USB driver, and the BE1-700 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 and Power Up the BE1-700

The BE1-700 plugin is a module that runs inside the BESTCOMSP*lus* shell. The BE1-700 plugin contains specific operational and logic settings for only BE1-700 digital protective relays.

USB Connection

The USB driver was copied to your PC during BESTCOMSP*lus* installation and is installed automatically after powering the BE1-700. 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 BE1-700.

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

Apply operating power (per style chart in the *Introduction* chapter) to the BE1-700 at rear terminals A6 and A7. Wait until the boot sequence is complete.

Start BESTCOMSP*lus*[®]

To start BESTCOMSP*lus*, click the 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 2-1). 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.

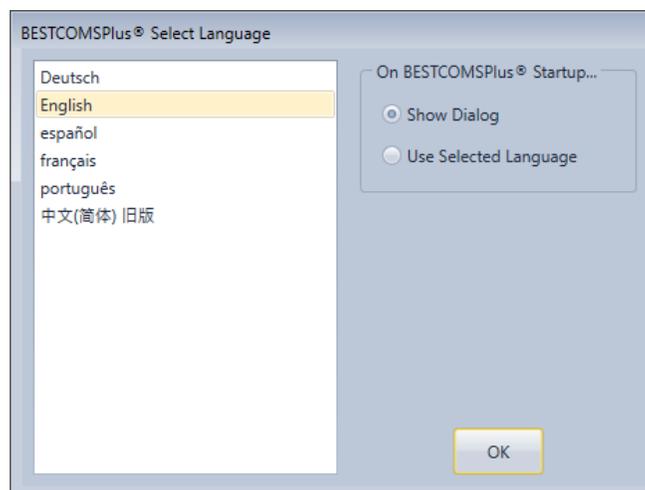


Figure 2-1. BESTCOMSP*lus* Select Language Screen

The BESTCOMSP_{Plus} platform window opens. Select New Connection from the Communication pull-down menu and select BE1-700. See Figure 2-2.

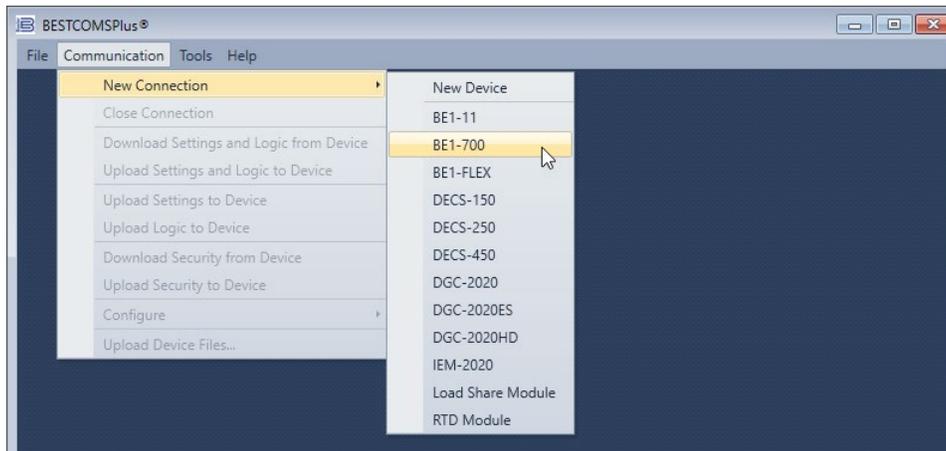


Figure 2-2. Communication Pull-Down Menu

The BE1-700 Connection screen shown in Figure 2-3 appears. Select USB Connection and then click the Connect button.

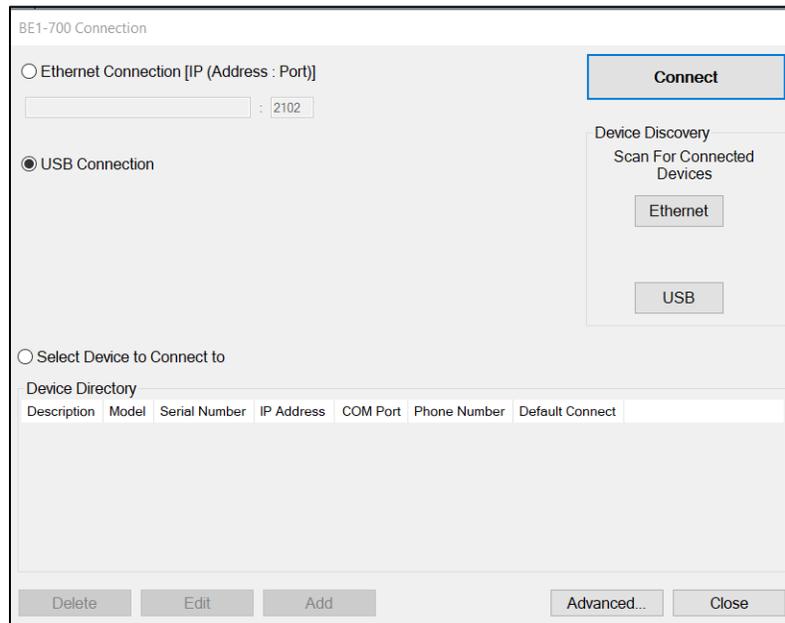


Figure 2-3. BE1-700 Connection Screen

Programming the BE1-700

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

Introduction to BESTCOMSP_{Plus}

BESTCOMSP_{Plus} is a Windows®-based, PC application that provides a user-friendly, graphical user interface (GUI) for use with Basler Electric communicating products. The name **BESTCOMSP_{Plus}** is an acronym that stands for **B**asler **E**lectric **S**oftware **T**ool for **C**ommunications, **O**perations, **M**aintenance, and **S**ettings.

BESTCOMSP_{Plus} provides the user with a point-and-click means to set and monitor the BE1-700. The capabilities of BESTCOMSP_{Plus} make the configuration of one or several BE1-700 Digital Protective

Relays fast and efficient. A primary advantage of BESTCOMSP $Plus$ is that a settings scheme can be created, saved as a file, and then uploaded to the BE1-700 at the user's convenience.

The BE1-700 plugin opens inside the BESTCOMSP $Plus$ main shell. The same default logic scheme that is shipped with the BE1-700 is brought into BESTCOMSP $Plus$ by opening a new settings file. 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 if the clear icon is then selected from the logic menu.

BESTlogic™ $Plus$ Programmable Logic is used to program BE1-700 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.

BESTCOMSP $Plus$ also allows for downloading industry-standard COMTRADE files for analysis of stored oscillography data. Detailed analysis of the oscillography files can be accomplished using BESTdata software. BESTdata software is free and available at www.basler.com.

Figure 2-4 illustrates the typical user interface components of the BE1-700 plugin with BESTCOMSP $Plus$.

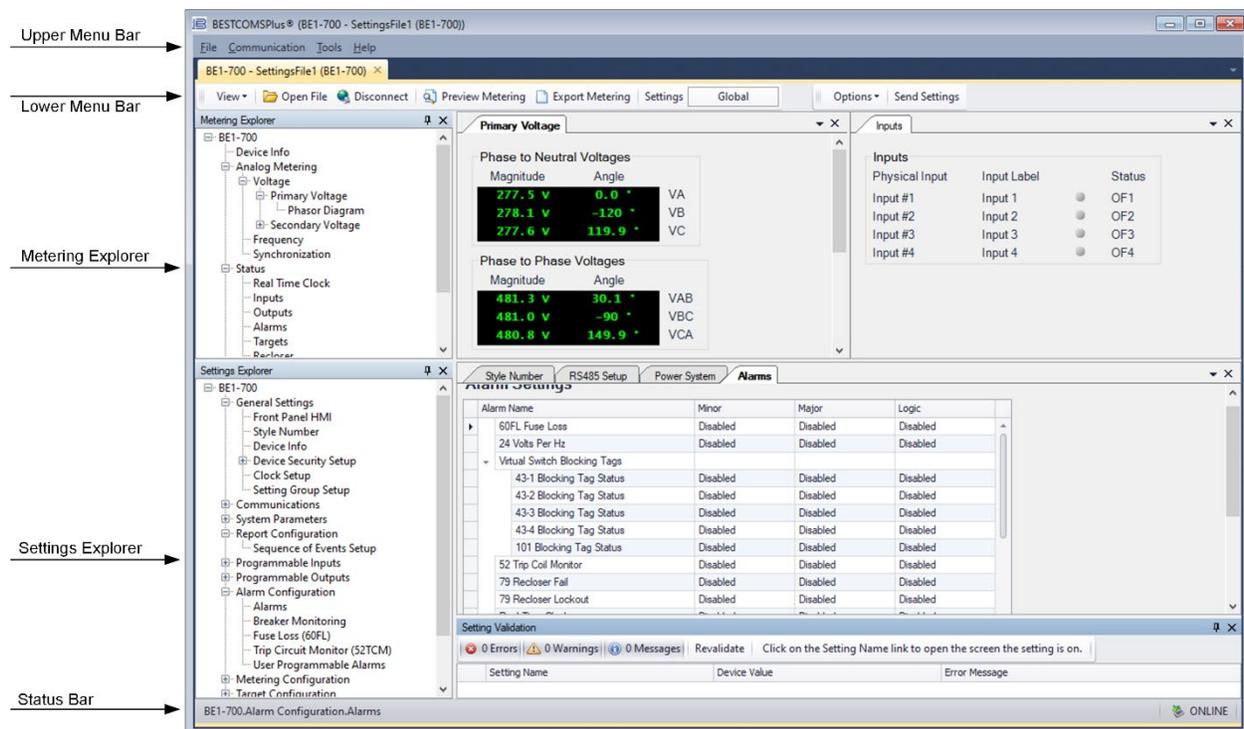


Figure 2-4. BESTCOMSP $Plus$ Typical User Interface Components

Click the View drop-down button to switch between the Settings Explorer and Metering Explorer or split the view between both. The Settings Info Panel displays settings ranges. A workspace can be opened, saved, or set as default. See Figure 2-5.

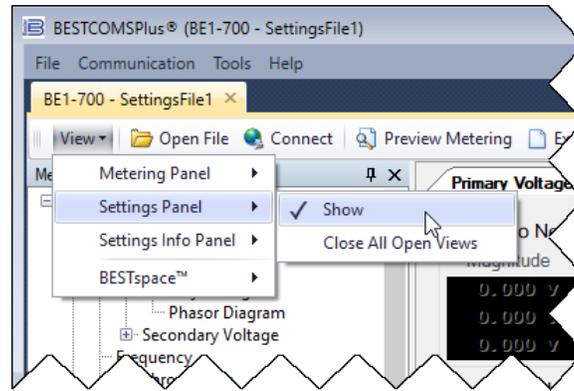


Figure 2-5. View Drop-Down Button

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 BE1-700 Summary screen is available by clicking BE1-700 in the Settings Explorer as shown in Figure 2-6. Summary screens are also available for General Settings, Alarm Configuration, Protection, and Control.

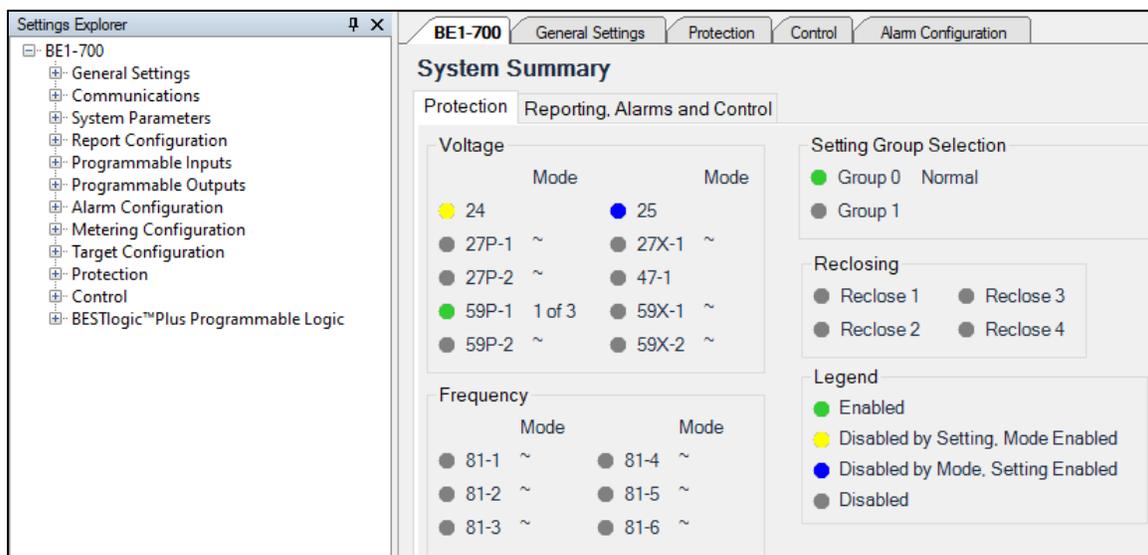


Figure 2-6. System Summary Screen

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 59P-1 overvoltage element. System nominal quantities are set to 69.3 volts phase-neutral. The 59P-1 element is set for a 105 volts pickup and a 500 ms time delay. Additionally, the element pickup output is logically wired to output 4 and a user alarm.

- Step 1: Start *BESTCOMSPPlus* and select New Connection, BE1-700 from the Communication pull-down menu to connect to the BE1-700. See Figure 2-2.
- Step 2: The BE1-700 Connection screen appears. See Figure 2-3. 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 BE1-700 to *BESTCOMSPPlus*.
- Step 4: Click on the View drop-down button and de-select Show Metering Panel and Show Setting Information. See Figure 2-5. This maximizes the settings workspace.
- Step 5: In the Settings Explorer, click the “+” next to BE1-700. This expands the sub menus in the tree. Now expand System Parameters and select the Power System screen. See Figure 2-7.
- Step 6: Under Nominal Settings, enter settings for Secondary Phase Voltage (69.3 V).

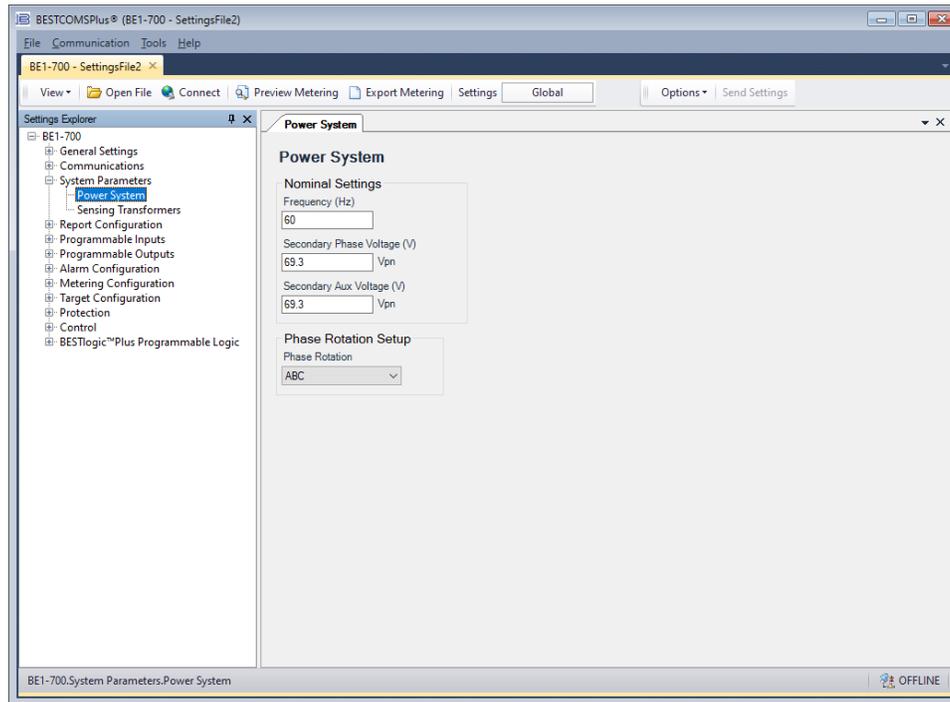


Figure 2-7. Power System Screen

- Step 7: In the Settings Explorer, expand Protection, Voltage and select the Overvoltage (59P-1) screen. See Figure 2-8.
- Step 8: Select the Mode (One of Three) and enter settings for Pickup (105 Vpn) and Time Delay (500 ms).
- Step 9: In the Settings Explorer, click *BESTlogicPlus* Programmable Logic to open the logic diagram. Click the Logic Page 1 tab. See Figure 2-9. Examine the 59P-1 element. The Logic 0 connected to the Block input indicates that the 59P-1 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 59P-1 Trip. This 59P-1 Trip Off-Page Output is carried over to Logic Page 2 (Figure 2-10) where it becomes an Off-Page Input. The 59P-1 Trip Off-Page Input and a settings disabled 27P-1 is OR gated to the Trip Bus Off-Page Output which is carried over to Logic Page 3 (Figure 2-11) where it becomes an Off-Page Input. The Trip Bus Off-Page Input in connected to physical Output 1 on the BE1-700. Therefore, the OUT1 contacts operate when the 59P-1 element is tripped.

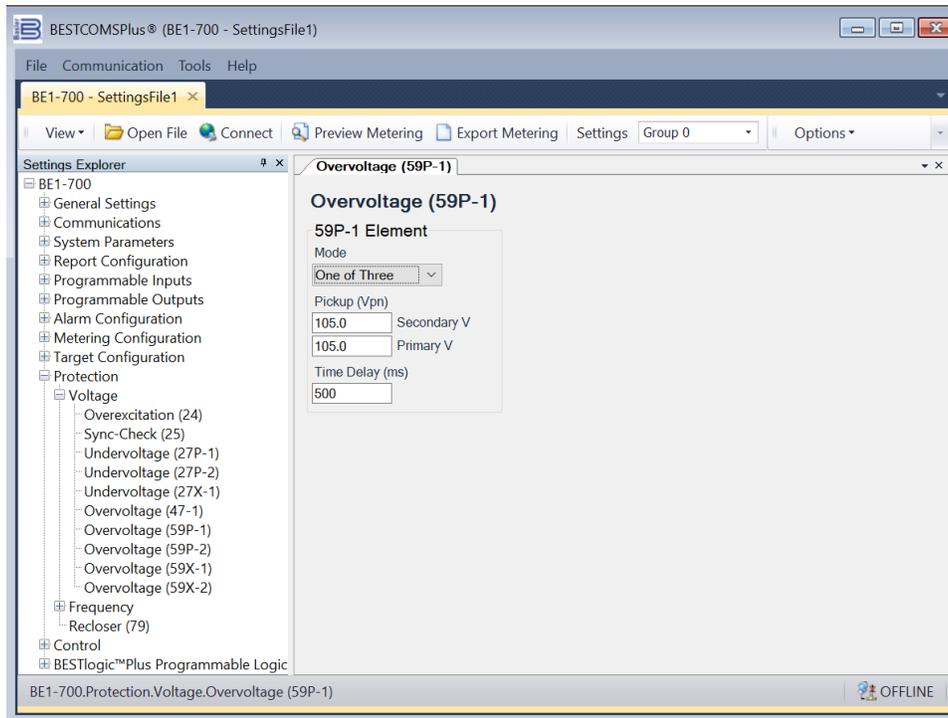


Figure 2-8. Overvoltage (59P-1) Screen

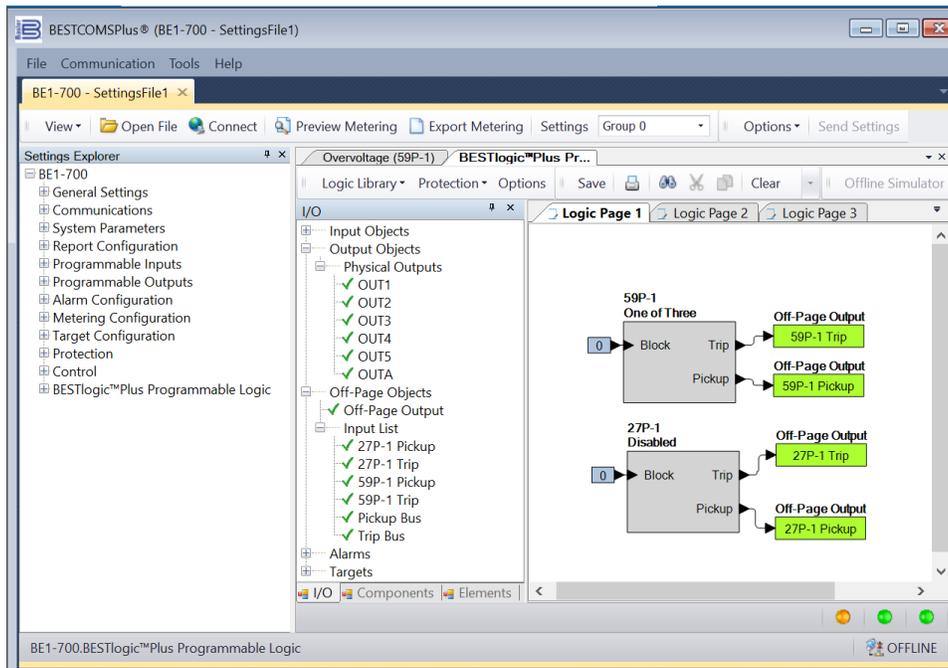


Figure 2-9. BESTlogicPlus Logic Page 1

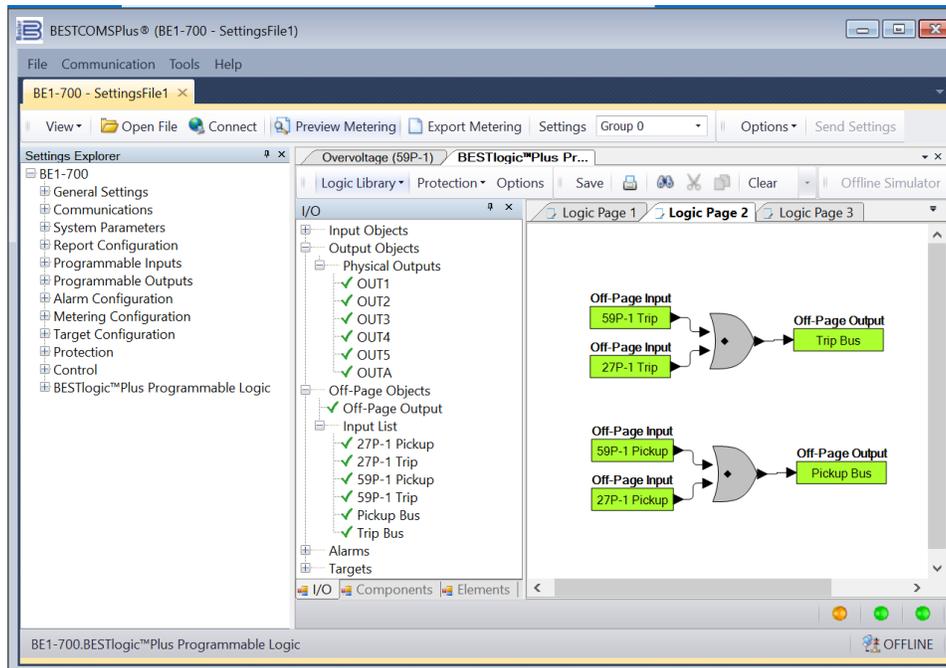


Figure 2-10. BESTlogicPlus Logic Page 2

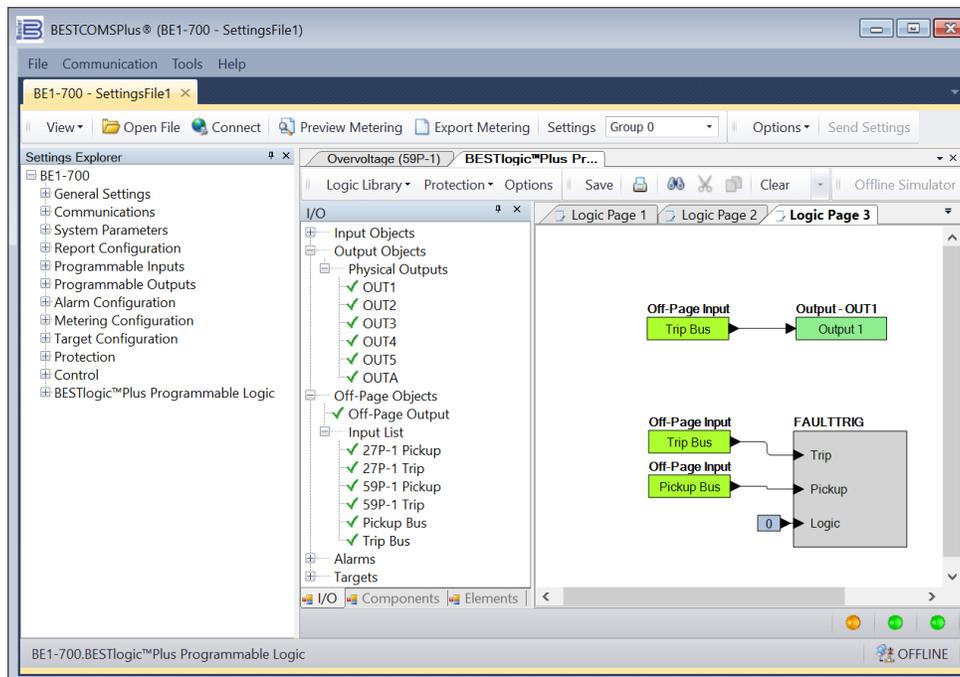


Figure 2-11. BESTlogicPlus Logic Page 3

Step 10: In this example step, the Pickup output of the 59P-1 element is connected to Output 4. When the Pickup output of the 59P-1 element is true, the label of Output 4 is displayed in the fault report and/or sequence of events report. The label is named in Step 12. Click the Logic Page 1 tab and then click the I/O tab at the bottom. Expand Output Objects and then Physical Outputs. Click and drag OUT4 over to the logic diagram. Click on the Pickup output of the 59P-1 element and drag it to the input of OUT4 to make a connection. Refer to Figure 2-12.

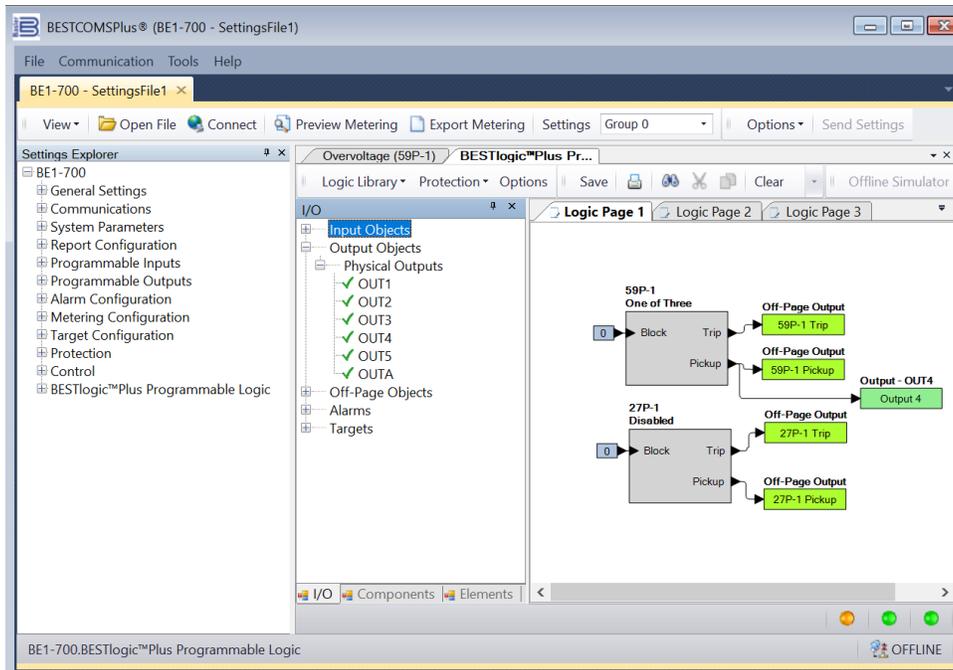


Figure 2-12. BESTlogicPlus Programming OUT4

Step 11: In this example step, the Pickup output of the 59P-1 element is connected to User Alarm 1. When the Pickup output of the 59P-1 element is true, the label of the user alarm is displayed on the Alarms screen on the front-panel display and in the fault report and/or sequence of events report. The label is named in Step 13. Click the Logic Page 1 tab and then click the Elements tab at the bottom. Locate the User Alarm 1 element. Click and drag USERALM1 over to the logic diagram. Click on the Pickup output of the 59P-1 element and drag to the input of USERALM1 to make a connection. Refer to Figure 2-13.

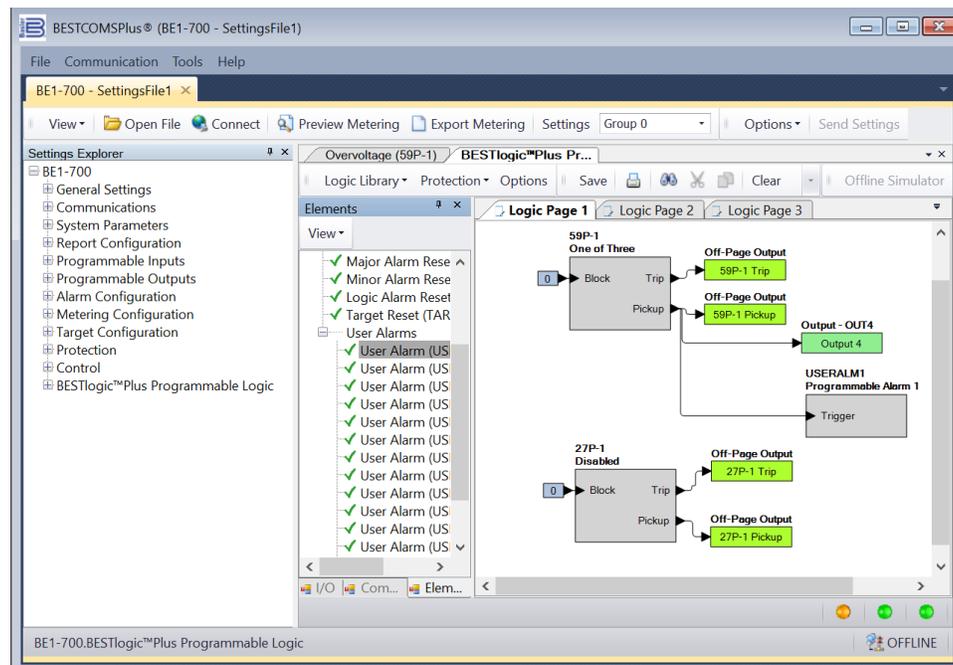


Figure 2-13. BESTlogicPlus Programming User Alarm 1

Step 12: Click the Save button to save the logic to BESTCOM*Plus* memory for later inclusion in the settings file. See Figure 2-14.



Figure 2-14. BESTlogic*Plus* Toolbar

Step 13: In the Settings Explorer, expand Programmable Outputs, Contact Outputs, and name Output #4 (59P-1 Pickup) as shown in Figure 2-15.

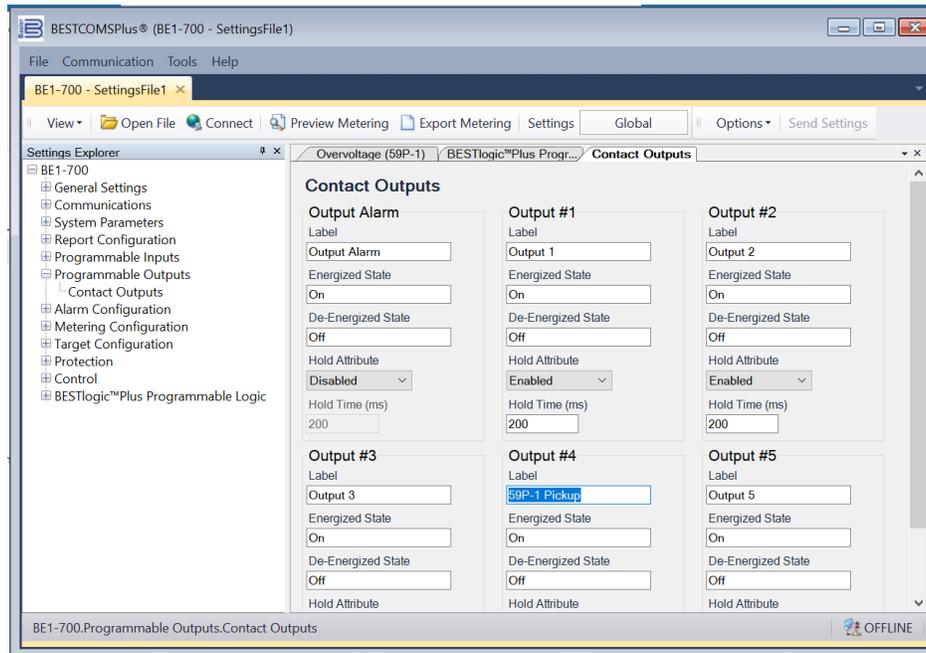


Figure 2-15. Contact Outputs Screen

Step 14: In the Settings Explorer, expand Alarm Configuration, User Programmable Alarms, and name User Programmable Alarm #1 (59P-1 Pickup) as shown in Figure 2-16.

Step 15: Select Save from the File pull-down menu to save your new settings file.

Step 16: To make your new settings active in the BE1-700, select Upload Settings and Logic to Device from the Communication pull-down menu. Enter the username and password.

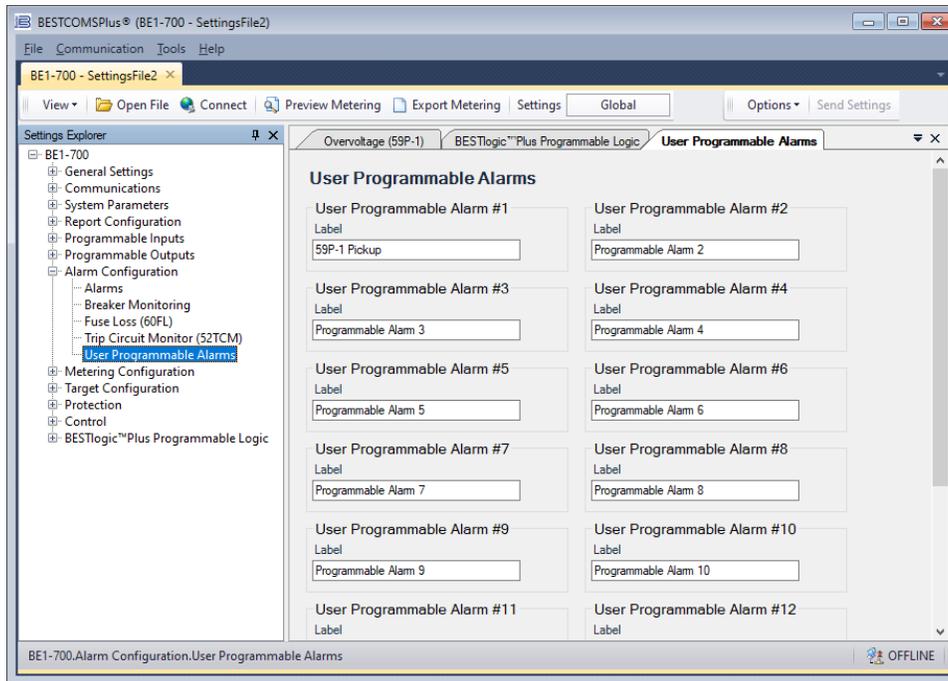


Figure 2-16. User Programmable Alarms Screen



3 • Mounting

BE1-700 Digital Protective Relays are supplied in a panel-mount, non-drawout case. A BE1-700 can be mounted at any convenient angle although the HMI does not rotate.

Case Dimensions

Case dimensions are shown in Figure 3-1, Figure 3-2, and Figure 3-3. Dimensions are shown in inches [millimeters].

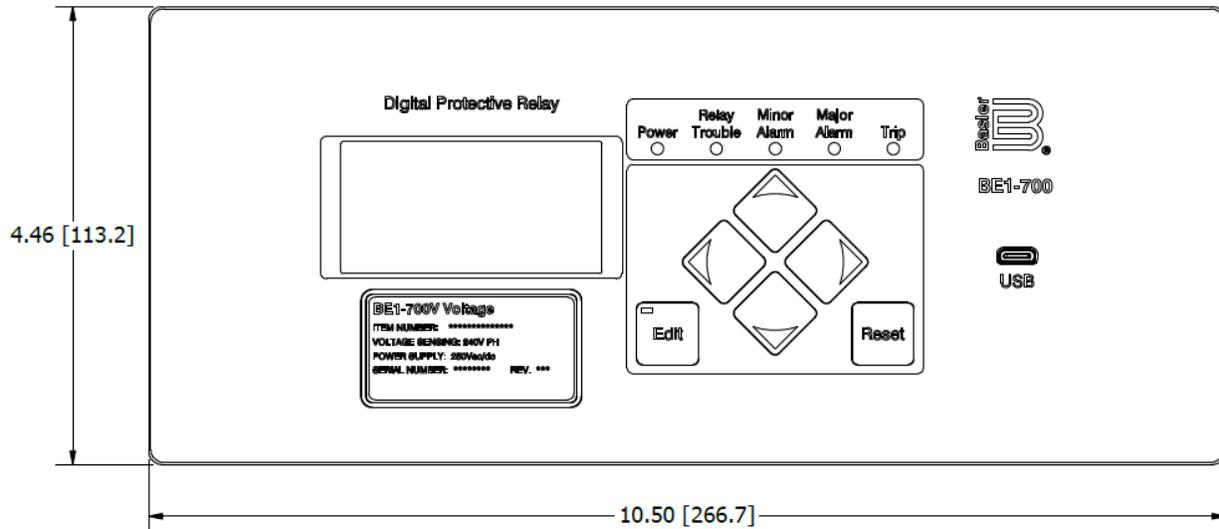


Figure 3-1. Case Front Dimensions

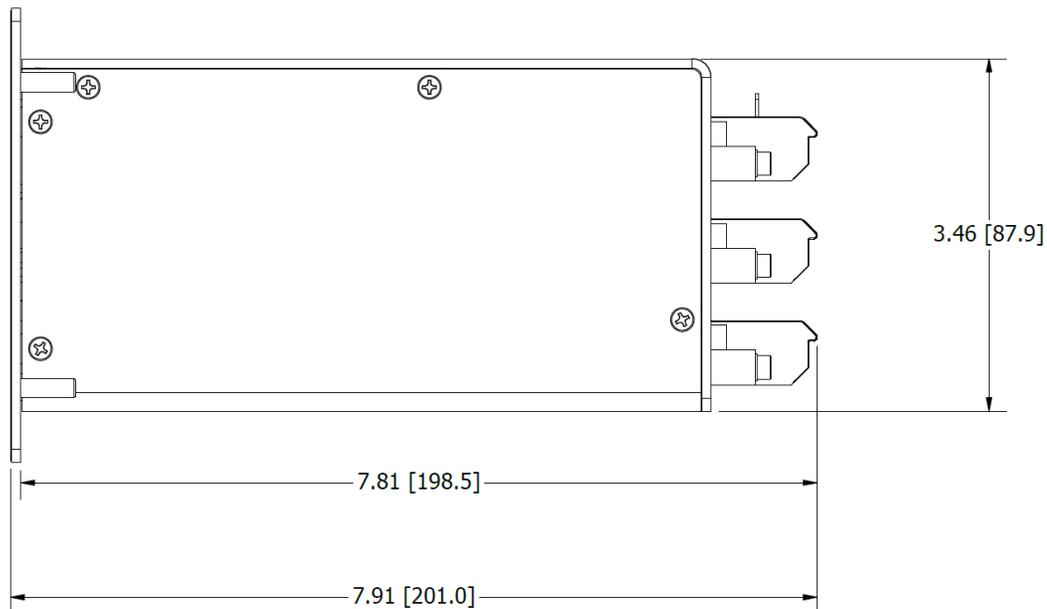


Figure 3-2. Case Side Dimensions

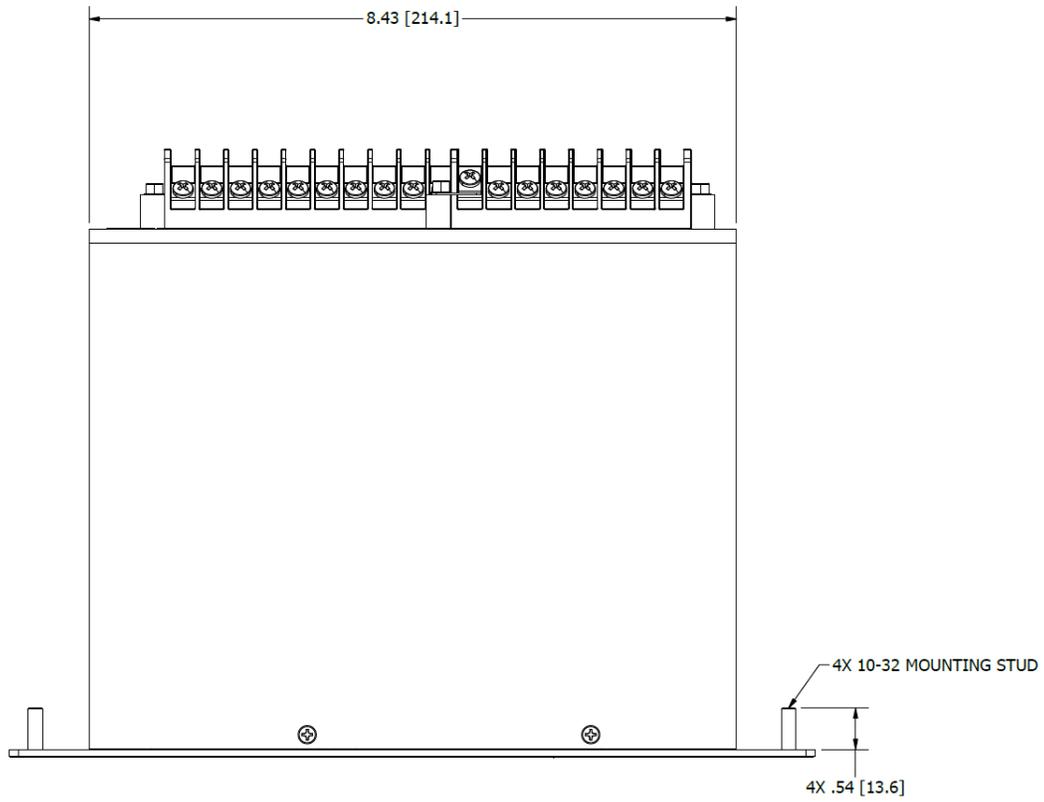


Figure 3-3. Case Top Dimensions

Panel Cutting and Drilling Dimensions

Panel cutting and drilling dimensions are shown in Figure 3-4. Dimensions are shown in inches (millimeters).

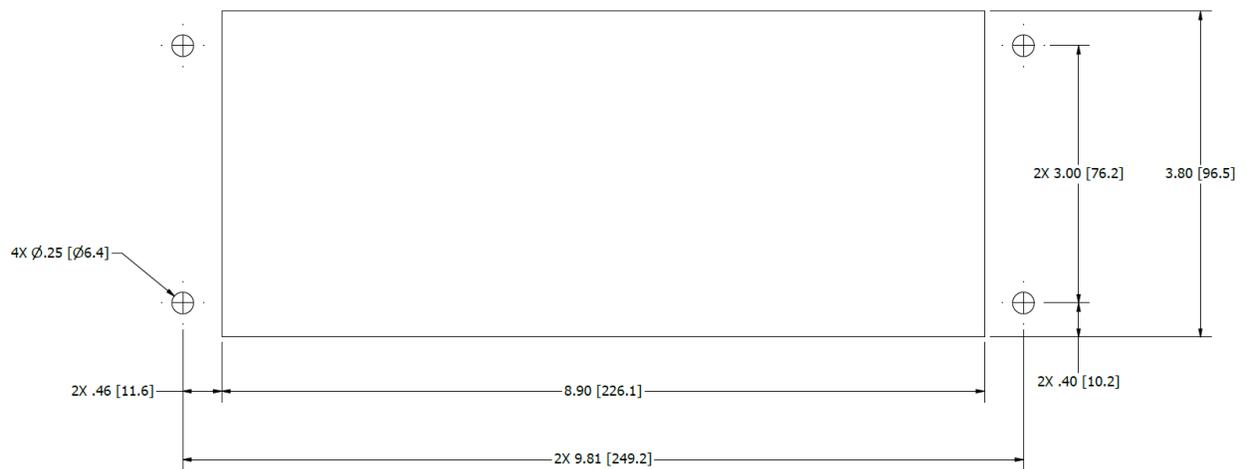


Figure 3-4. Panel Cutting and Drilling Dimensions

4 • Contact Inputs and Outputs

The BE1-700 provides four contact inputs, five general-purpose contact outputs, and one dedicated fail-safe alarm contact output. Each input and output is isolated and terminated at separate terminals. This chapter describes the function and setup of each input and output.

Contact-Sensing Inputs

BE1-700 relays have four contact-sensing inputs to initiate BE1-700 relay actions. These inputs are isolated and require an external wetting voltage. Nominal voltage(s) of the external dc source(s) must fall within the relay dc power supply input voltage range. To enhance user flexibility, the BE1-700 relay uses wide-range ac/dc power supplies that cover several common control voltage ratings. To further enhance flexibility, the input circuits are designed to respond to voltages at the lower end of the control voltage range while not overheating at the high end of the control voltage range.

Energizing levels for the contact-sensing inputs operate at a minimum of approximately 5 Vdc for 24 Vdc nominal sensing voltages, 26 Vdc for 48 Vdc nominal sensing voltages, 69 Vdc for 125 Vdc nominal sensing voltages, or 138 Vdc for 250 Vdc nominal sensing voltages. See Table 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 †
xxx1xxx	48 Vdc	26 to 38 Vdc
xxx2xxx	125 Vac/dc	69 to 100 Vdc 56 to 97 Vac
xxx3xxx	24 Vdc	Approx. 5 Vdc
xxx4xxx	250 Vac/dc	138 to 200 Vdc 112 to 194 Vac
xxx5xxx	125 Vac/dc *	69 to 100 Vdc 56 to 97 Vac

* Extended holdup option.

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

Relay Connections

Connections to the relay are dependent on the application and logic scheme selected by the user. As a result, not all of the relay's inputs and outputs may be used for a given application. Before energizing a relay, make sure the connections match the options associated with the style number found on the relay nameplate. Refer to the style number identification charts in Figure 1-1 for available options. Be sure to use the correct input power for the specified power supply. Incorrect wiring may result in damage to the relay.

Figure 4-1 shows the rear panel connections.

Note

It is recommended in all applications where contact outputs drive relay coils that a reverse biased diode be implemented in parallel with the relay coil for EMI suppression.

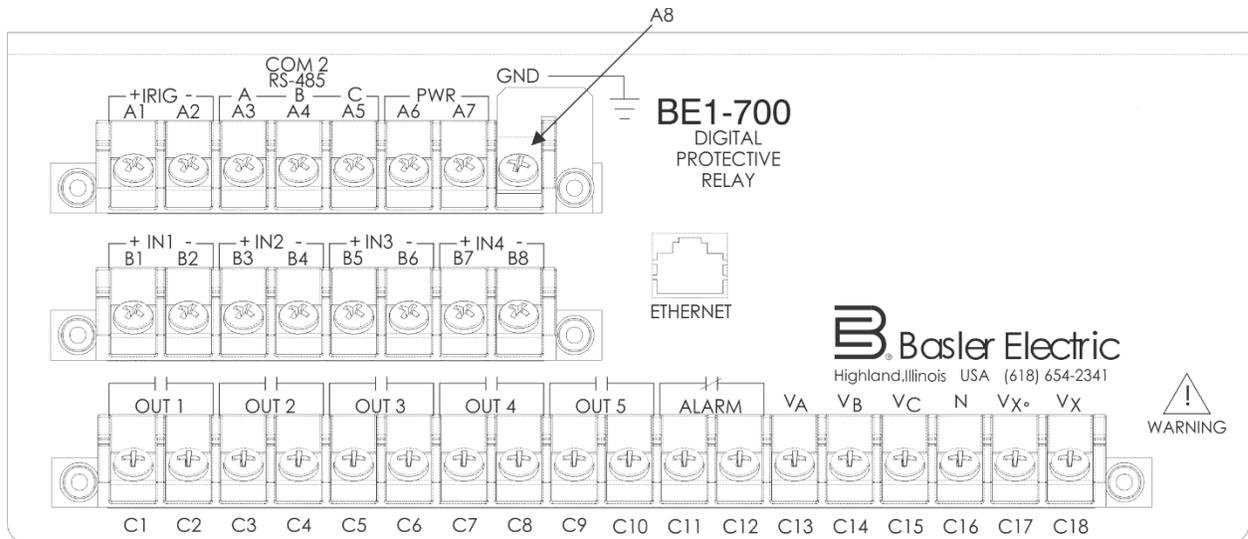


Figure 4-1. Rear Panel Terminal Connections, BE1-700

Digital Input Conditioning Function

Status of the contact sensing inputs is checked every millisecond. (See Figure 4-2.) User-settable digital contact recognition and debounce timers condition the signals applied to the inputs. These parameters can be adjusted to obtain the optimum compromise between speed and security for a specific application. Digital input conditioning is evaluated every quarter cycle.

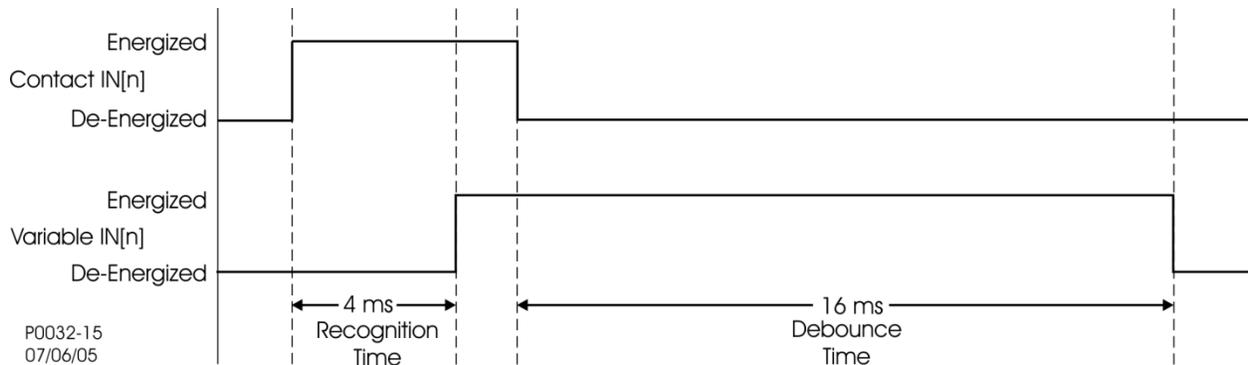


Figure 4-2. Digital Input Conditioning Timing Diagram

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

Setting the Contact Inputs

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

Front Panel Navigation Path: Settings Explorer, Contact Inputs

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

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

The screenshot shows a software interface titled "Contact Inputs" with a tab labeled "Contact Inputs". It contains four input configuration panels, labeled "Input #1" through "Input #4". Each panel has the following fields:

- Label:** A text box containing "Input 1" (for Input #1), "Input 2" (for Input #2), "Input 3" (for Input #3), and "Input 4" (for Input #4).
- Recognition Time (ms):** A numeric input box with the value "4".
- Debounce Time (ms):** A numeric input box with the value "16".
- Energized State:** A dropdown menu with "On" selected.
- De-Energized State:** A dropdown menu with "Off" selected.

Figure 4-3. Contact Inputs Screen

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

Table 4-2. Digital Input Conditioning Settings

Setting	Range	Increment	Unit of Measure	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 contact's energized state. Used by the reporting function to give meaningful identification to the state of the input contact. This label may be up to 64 characters long.			
De-Energized State	User programmable label for the contact's de-energized state. Used by the reporting function to give meaningful identification to the state of the input contact. This label may be up to 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 for greater than one-half of the power system cycle period. This will take advantage of the half-wave rectification provided by the input circuitry.

If an ac wetting voltage is used, the recognition time can be set to less than one-half of the power system cycle period and the debounce timer can be set to greater than one-half of the power system cycle

period. The extended debounce time will keep the input energized during the negative half-cycle. The default settings of 4 and 16 milliseconds are compatible with ac wetting voltages.

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

See the *Terminals and Typical Connections* 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 BESTCOMSPi.us by using the Metering Explorer to open the Status, Inputs tree branch. BESTCOMSPi.us must be online with the BE1-700 to view contact input status. Alternately, status can be determined through the front-panel display by navigating to Metering > Status > Inputs.

Contact Outputs

BE1-700 relays have five general-purpose output contacts (OUT1 through OUT5) and one fail-safe, normally closed (when de-energized), alarm output contact (OUTA). Each output is isolated and rated for tripping duty. OUT1 through OUT5 are Form A (normally open) and OUTA is Form B (normally closed). A trip coil monitoring circuit is hardwired across OUT1. See the *Trip Circuit Monitor (52TCM)* chapter for details.

Contact outputs OUT1 through OUT5 and OUTA are driven by BESTlogicPi.us expressions for OUT1 through OUT5 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 *BESTlogicPi.us* chapter has more information about programming output expressions in your programmable logic schemes.

BESTlogicPi.us expressions for OUT1 through OUT5 and OUTA drive contact outputs OUT1 through OUT5 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 or Output Override function overrides an output.

Figure 4-4 shows a diagram of the contact output logic for the general-purpose contact outputs. The OUT1 relay closes when the 59P-1 element is in a trip condition.

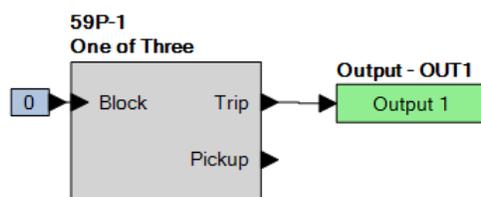


Figure 4-4. Output Logic, General Purpose Contact Outputs

Figure 4-5 illustrates the contact output logic for the failsafe alarm contact output OUTA, which is normally closed. The OUTA relay closes when the 59P-1 element is in a trip condition.

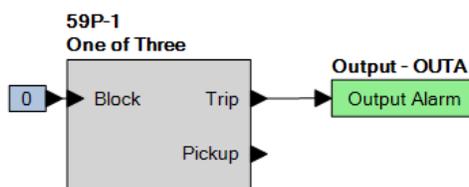


Figure 4-5. Output Logic, Failsafe Alarm Contact Output

Relay Trouble Alarm Disable

When the BE1-700 self-diagnostics function detects a relay problem, an internal alarm condition (RELAY TROUBLE) is set. This alarm condition disables the outputs and de-energizes the OUTA relay, closing the OUTA contact. For more details about this function see the *Fault Reporting* and *Alarms* chapters.

All internal circuitry and software that affects how the BE1-700 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 the OUTA contact, the front-panel Relay Trouble LED lights, all output relays are disabled, logic OUTA is set, and the BE1-700 is taken offline. The relay trouble alarms function is not programmable.

Table 4-3. Relay Trouble Alarms

Name	Description
uP Reset	Repetitive reboot
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 may not have significant closing torque for a low resistance connection. A third purpose is to prevent the relay contact from dropping out until the current has been interrupted by a 52a contact in series with the trip coil. If the tripping contact opens before the dc current is interrupted, the contact may be damaged. Of the three items, only item three is an issue for electronic relays like the BE1-700.

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 BESTCOMSP $Plus$ as shown in Figure 4-7.

If the protection engineer desires seal-in logic with feedback from the breaker position logic, they 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.

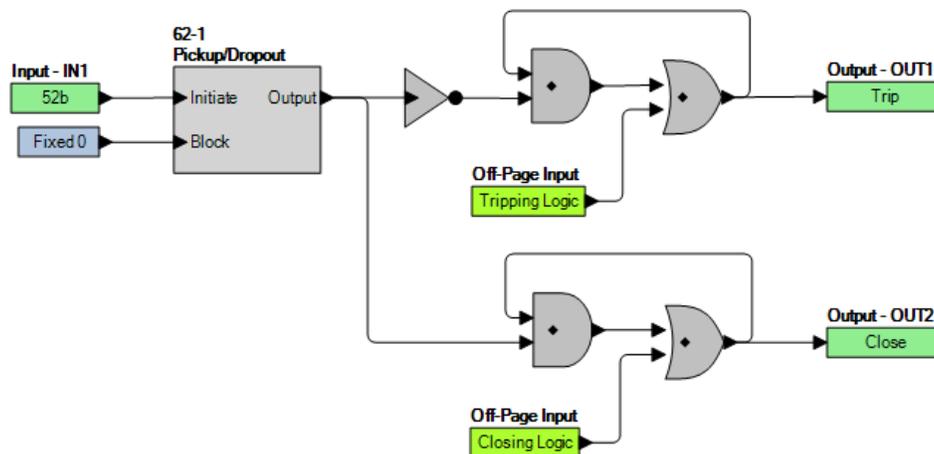


Figure 4-6. Contact Output Seal-In Logic Diagram

Setting the Contact Outputs

BESTCOMSPi.us Navigation Path: Settings Explorer, Programmable Outputs, Contact Outputs

Front Panel Navigation Path: Not available through the front panel

Settings and labels for the contact outputs are set using BESTCOMSPi.us®.

Each of the outputs has one setting and three labels. The setting consists of a Hold Attribute. The labels include a label to describe the output, a label to describe the Energized State, and a label to describe the De-Energized State. Labels are used by the BE1-700 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 displays the 'Contact Outputs' configuration window. It features a tabbed interface with 'Contact Inputs' and 'Contact Outputs' tabs. The 'Contact Outputs' tab is active, showing a grid of six configuration panels. The first panel is for 'Output Alarm', and the others are for 'Output #1' through 'Output #5'. Each panel contains the following fields:

- Label:** A text input field. For 'Output Alarm', the value is 'Alarm'. For 'Output #1' through '#5', the values are 'Output 1' through 'Output 5'.
- Energized State:** A text input field. For 'Output Alarm', the value is 'On'. For 'Output #1' through '#5', the values are 'On'.
- De-Energized State:** A text input field. For 'Output Alarm', the value is 'Off'. For 'Output #1' through '#5', the values are 'Off'.
- Hold Attribute:** A dropdown menu. For 'Output Alarm', the value is 'Disabled'. For 'Output #1' through '#5', the value is 'Enabled'.
- Hold Time (ms):** A text input field. For 'Output Alarm', the value is '200'. For 'Output #1' through '#5', the values are '200'.

Figure 4-7. Contact Output Screens

Contact Output Logic Override Control

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

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

Contact Output Override control disables Logic control of the selected output until override is disabled. 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 typically 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 Override						
	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

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. It can only be enabled through BESTCOMSP^{Plus} (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 BE1-700 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), Reset (logic 0 or false) or Pulse (pulsed logic 1) 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 Typical Connections* chapter for an illustration of the programmable output terminals. Contact output electrical ratings are listed in the *Specifications* chapter.

Retrieving Output Logic Override Status

Output status is determined through BESTCOMSP^{Plus} by using the Metering Explorer to open the Status, Outputs tree branch. BESTCOMSP^{Plus} must be online with the BE1-700 to view contact output status. Alternately, status can be determined through the front-panel display by navigating to Metering > Status > Outputs.



5 • Terminals and Typical Connections

Connections to the relay are dependent on the application and logic scheme selected by the user. As a result, not all of the relay's inputs and outputs may be used for a given application. Before energizing a relay, make sure the connections match the options associated with the model and style number found on the relay nameplate. Refer to the style identification chart in the *Introduction* chapter, for available options. Be sure to use the correct input power for the specified power supply. Incorrect wiring may result in damage to the relay.

Notes

Connections to the BE1-700 voltage inputs, contact inputs, power supply inputs, and contact outputs should be made with a minimum wire size of 14 AWG (2.08 mm²).

Connections to the BE1-700 ground terminal should be made with a minimum wire size of 12 AWG (3.31 mm²).

When the BE1-700 is configured in a system with other protective devices, a separate ground bus lead is recommended for each BE1-700.

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 Terminals

Figure 5-1 shows the BE1-700 rear panel connections.

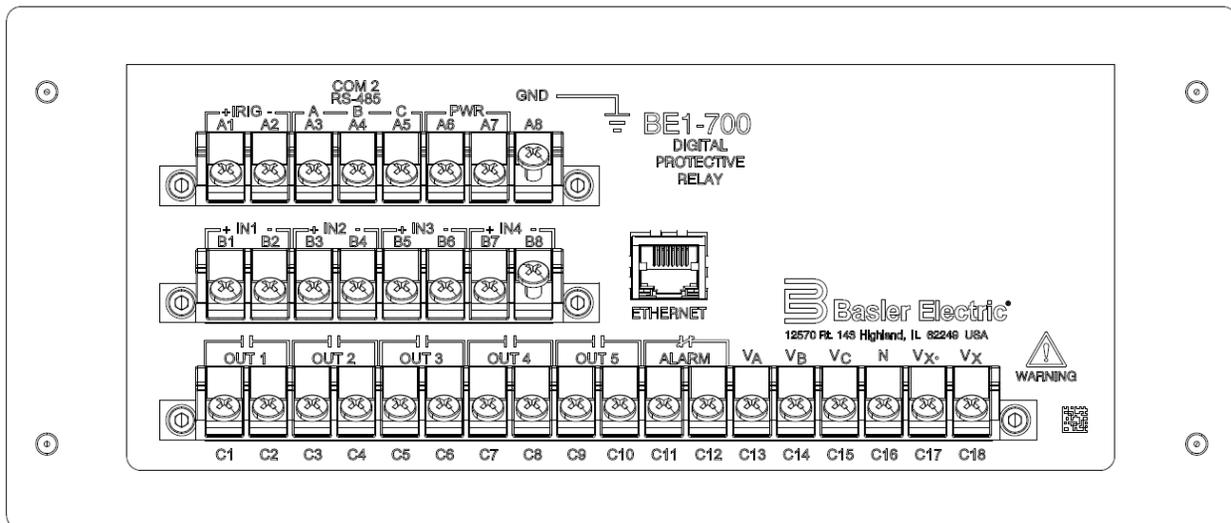


Figure 5-1. Rear Panel Terminal Connections

Terminal Blocks

The terminal blocks use 6/32-inch slot Phillips head screws with no washer.

The maximum wire lug width accommodated by the input-output block on the case is 0.320 inches (8.1 mm).

Typical Connections

Typical external contact I/O connections for the BE1-700 are shown in Figure 5-2. Contact inputs are polarity sensitive when used with dc control power.

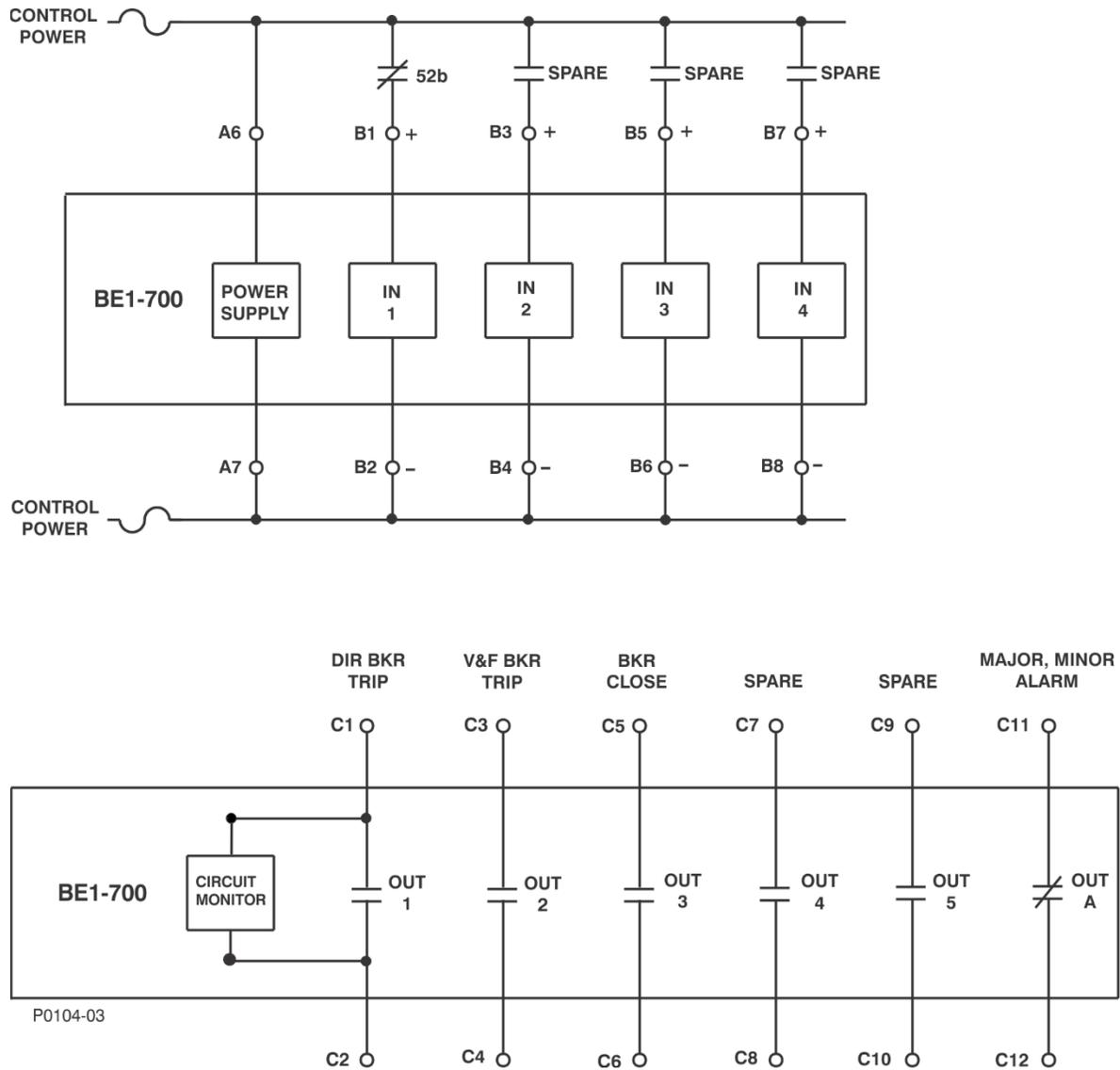
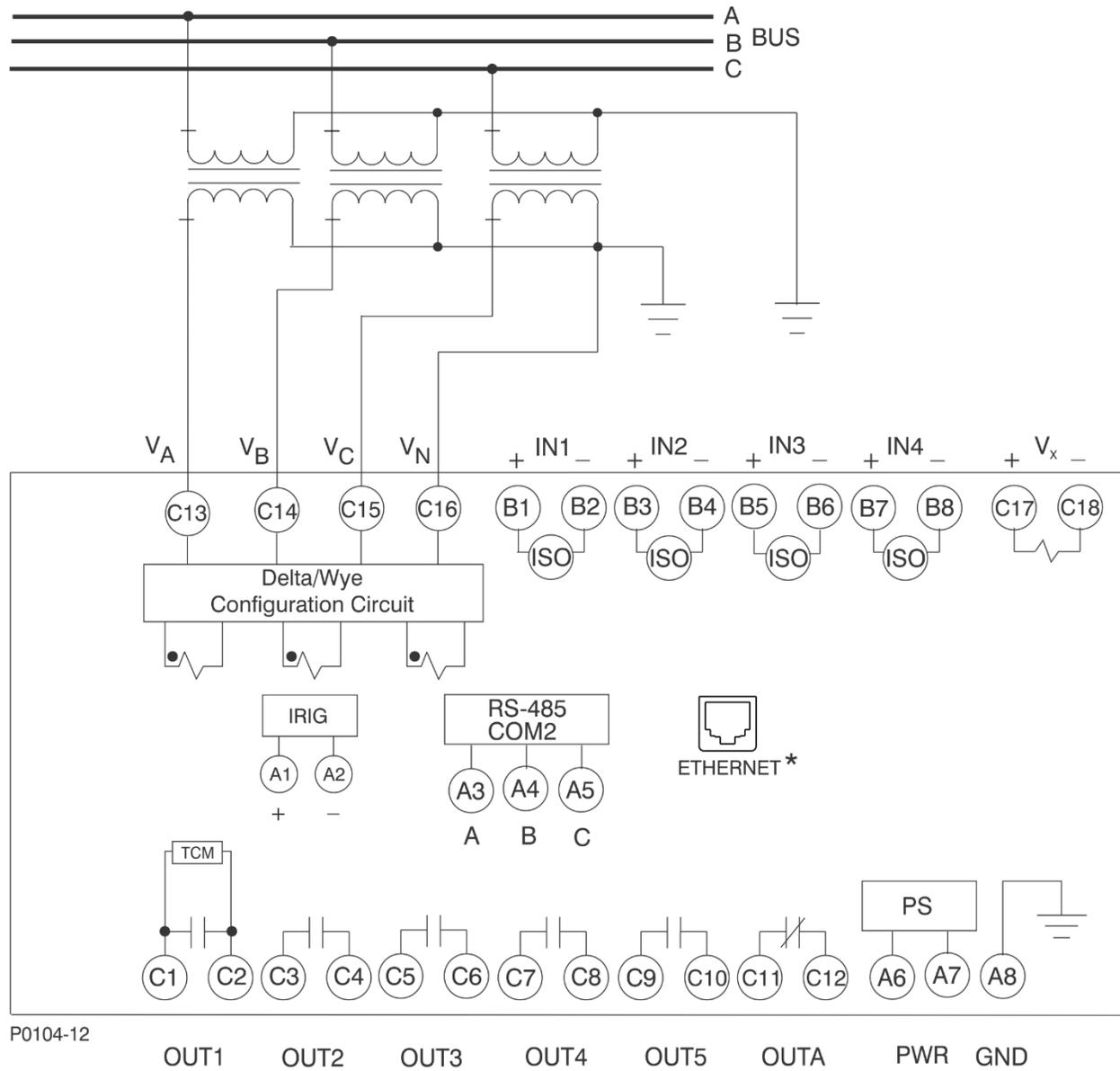


Figure 5-2. Typical External DC Connections

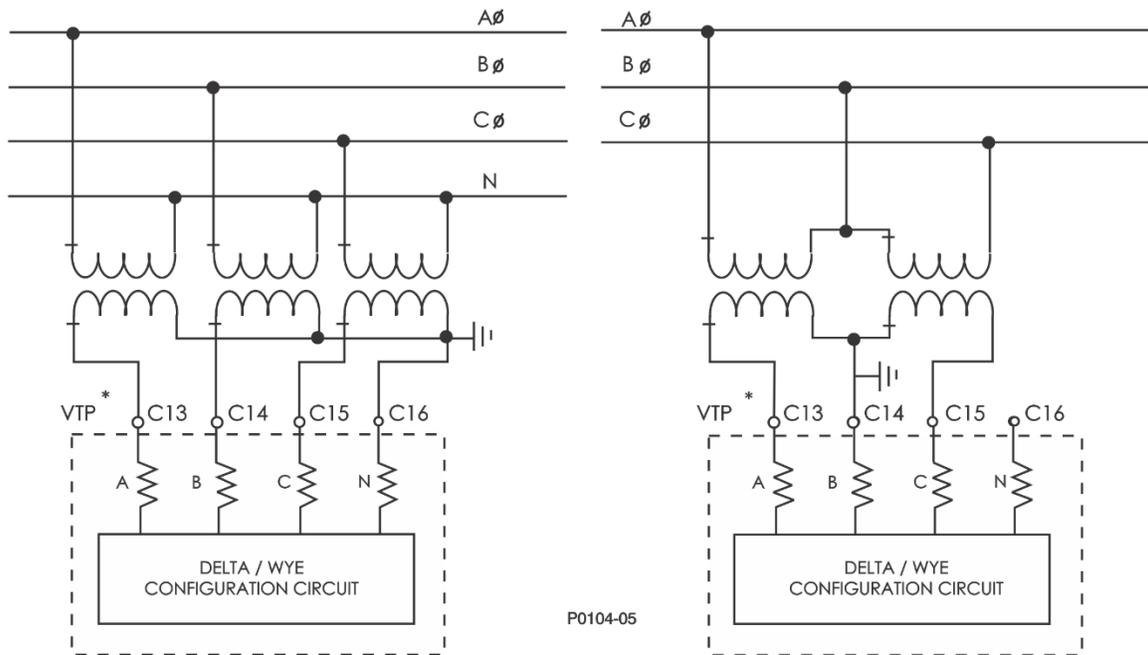
Typical external power system connections for the BE1-700 are shown in Figure 5-3.



* Ethernet Port (RJ45) is included with Communication Protocol Option 8.

Figure 5-3. Typical External AC Connections

Three-phase voltage sensing, alternate VT inputs are shown in Figure 5-4.



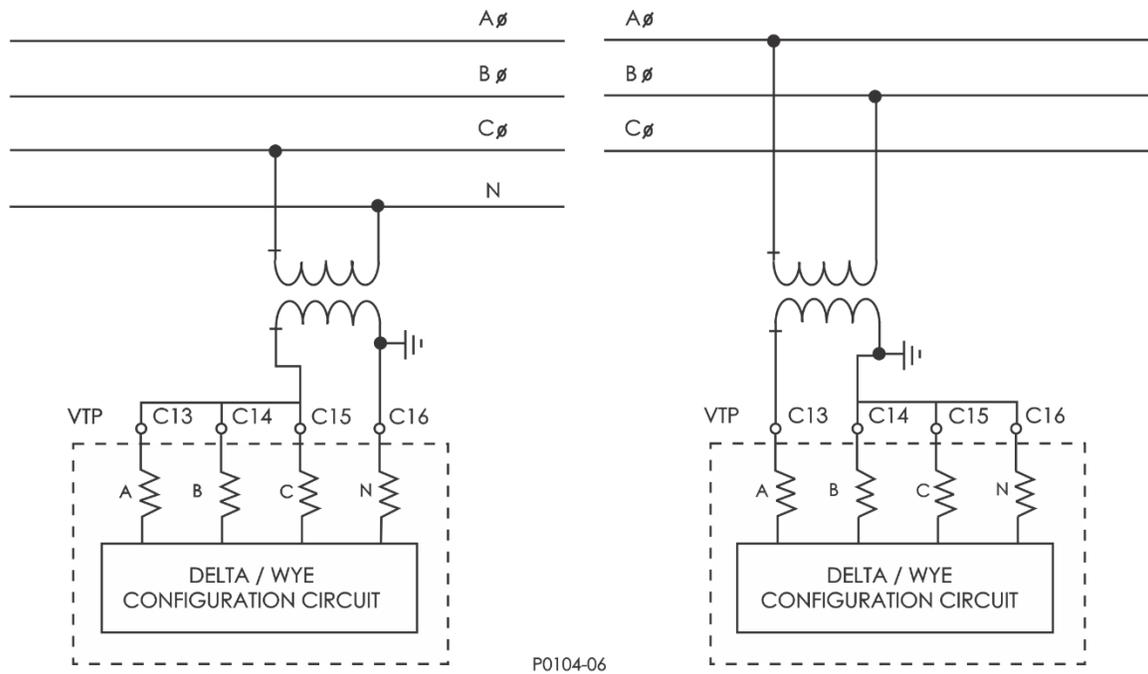
P0104-05

A) 3 Phase VT 4 Wire Connection

Provides 3 element metering; 27P and 59P can be P-N or P-P.

B) 3 Phase VT 3 Wire Connection

Provides 2 element metering; 27P and 59P are P-P; 59N (3V0) is disabled.



P0104-06

C) 1 Phase VT L-N Connection

VT primary can be connected to any phase, A-N, B-N, C-N. One element metering; 47 (V2) and 59N (3V0) disabled. 27P and 59P are P-N.

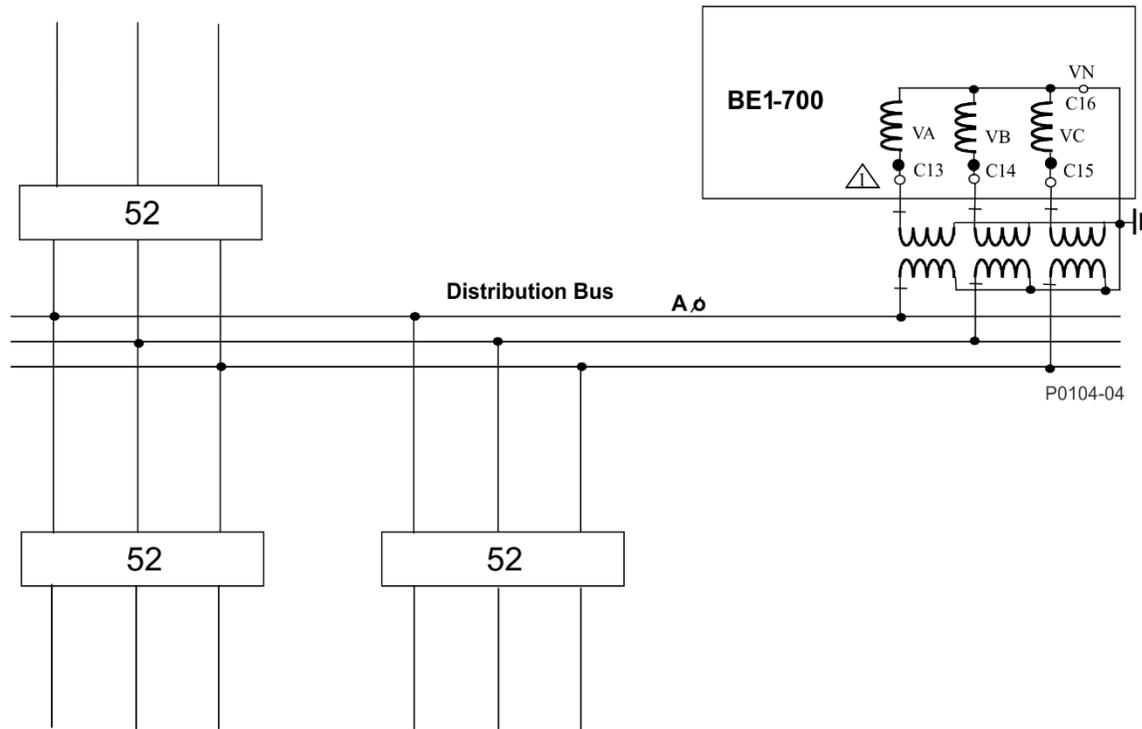
D) 1 Phase VT L-L Connection

VT primary can be connected to any phase, A-B, B-C, C-A. One element metering (-30 degrees); 47 (V2) and 59N (3V0) disabled; 27P and 59P are P-P.

Figure 5-4. Voltage Sensing

6 • Power System Applications

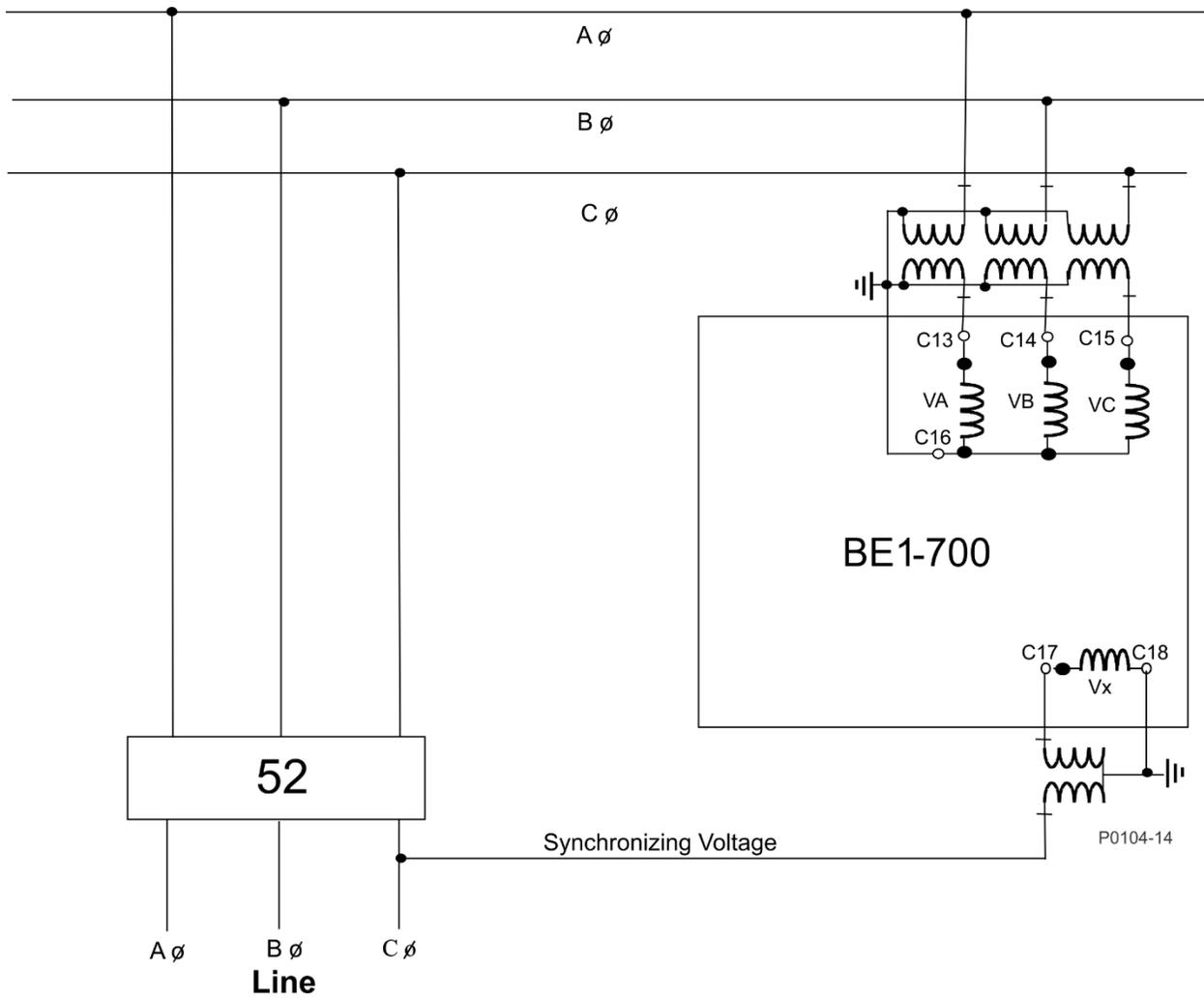
The following figures show examples of the applications that can be served by the Basler Electric BE1-700 Digital Protective Relay. These applications can be used in concert with other Basler systems such as the BE1-FLEX Protection, Automation and Control System.



Notes: Δ

1. Potentials used for 24, 25, 27, 47, 59, 81, and 3V0 detection. Four-wire connection is shown as typical. See the *Terminals and Typical Connections* chapter for example VTP connections.

Figure 6-1. BE1-700 Bus Voltage Protection including UF Load Shed



Notes: Δ

1. This application requires the optional 79 function.

Figure 6-2. BE1-700 Network Reclosing Application

7 • Human-Machine Interface (HMI)

This chapter describes the BE1-700 Digital Protective Relay human-machine interface (HMI) and illustrates the front panel display menu tree branches.

Front Panel Display

Figure 7-1 shows the HMI components of a BE1-700 in a fixed, horizontal, non-drawout case. The locators and descriptions of Table 7-1 correspond to the locators shown in Figure 7-1.

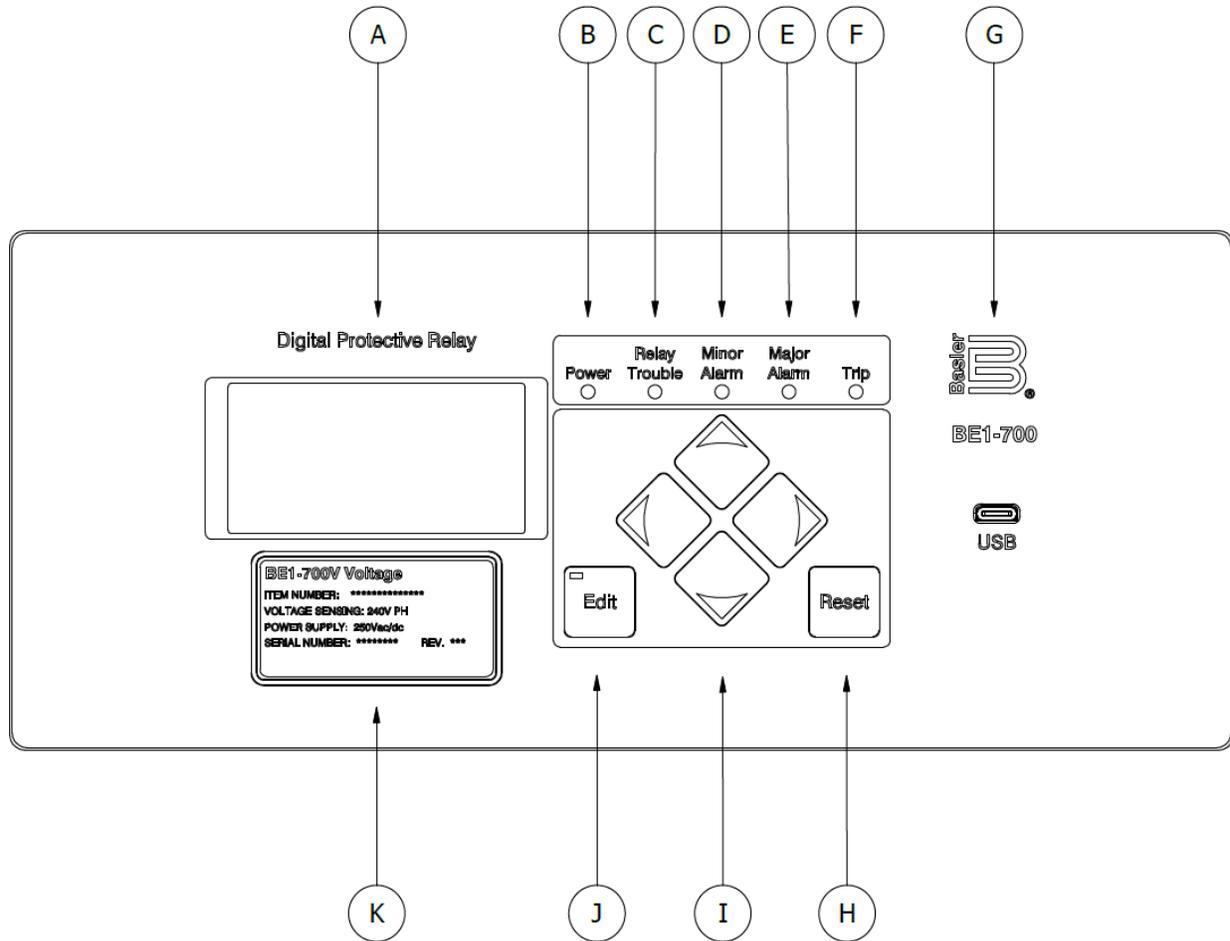


Figure 7-1. Front Panel

Table 7-1. Front Panel HMI Descriptions

Locator	Description
A	Display – 64 x 128 dot pixels liquid crystal display (LCD) with backlighting. The LCD is the primary source for obtaining information from the BE1-700 or when locally setting the BE1-700. Information such as targets, metering values, demand values, communication parameters, and diagnostic information is provided by the LCD. Information and settings are displayed in a menu.
B	Power Indicator – This green LED lights when operating power is applied to the relay.

Locator	Description
C	Relay Trouble Indicator – This red LED lights momentarily during start-up and lights continuously when a relay failure is detected. The <i>Alarms</i> chapter provides a complete description of all relay failure alarm diagnostics.
D, E	Minor Alarm, Major Alarm Indicators – These red LEDs light to indicate that a programmable alarm has been set. Each indicator can be programmed to annunciate one or more conditions. The <i>Alarms</i> chapter provides detailed information about programming alarms.
F	Trip Indicator – A flashing red Trip LED indicates that a protective element with a target and fault recording enabled is picked up. A continuously lit LED is asserted when a protective elements trip output has closed. This red LED is sealed in if a protective trip has occurred and targets are displayed.
G	USB-C – This universal serial bus port can be used to communicate with the BE1-700 using BESTCOMSP ^{Plus} ®.
H	Reset Pushbutton – Pressing this button resets the Trip LED, sealed-in Trip Targets, and Alarms.
I	Scrolling Pushbuttons – Use these four switches to navigate (<i>UP/DOWN/LEFT/RIGHT</i>) through the LCD menu tree. When in Edit mode, the <i>LEFT</i> and <i>RIGHT</i> scrolling pushbuttons select the variable to be changed. The <i>UP</i> and <i>DOWN</i> scrolling pushbuttons change the variable.
J	Edit Pushbutton – Settings changes can be 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 <i>Edit</i> switch is pressed again, the switch light turns off to indicate that your settings changes have been saved. If changes are not completed and saved within five minutes, the relay will automatically exit the Edit mode without saving any changes and announce an Access Error.
K	Identification Label – This label lists the style number, serial number, sensing input voltage range, and power supply input voltages.

Menu Navigation

A menu tree with a Metering branch and a Settings branch can be accessed through the front-panel controls and display. A greater level of detail in a menu branch is accessed using the right scrolling pushbutton. The left scrolling pushbutton is used to return to the top of the menu branch. Figure 7-2 illustrates the organization of the front-panel display menu tree structure.

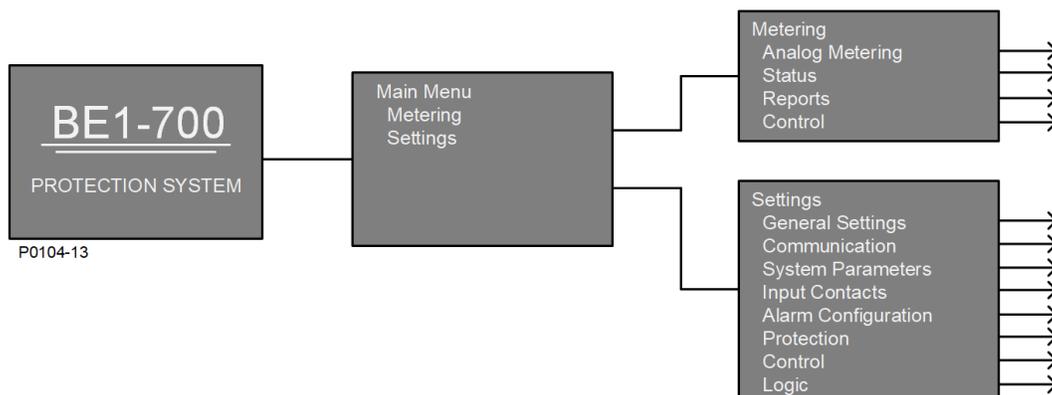


Figure 7-2. Front Panel Display Menu Tree Layout

Front Panel Operations

The following paragraphs describe how the front-panel interface is used to set and control a BE1-700 relay.

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 BE1-700 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 59-1 pickup as 89 volts, you would place the cursor in the Pickup field and press the UP pushbutton until the 9 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.

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

Front Panel Navigation Path: Settings Explorer, 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 7-3.

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.

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 *BESTCOMSPi*us.

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. Scrolled screens include Primary Voltage Metering, Secondary Voltage Metering, Frequency Metering, Synchronize Metering (25 function), Targets, and Alarms.

The screenshot displays the 'Front Panel HMI' configuration interface. It is organized into three distinct sections, each with a title and a set of controls:

- LCD Setup:** Contains a 'Contrast Value (%)' label and a text input field containing the value '75'.
- Sleep Mode Setup:** Contains a 'Sleep Mode' label and a dropdown menu currently set to 'Enabled', and a 'Time Delay (s)' label with a text input field containing '60'.
- Screen Scrolling Setup:** Contains an 'Enable Scroll' label and a dropdown menu currently set to 'Disabled', and a 'Scroll Time Delay (s)' label with a text input field containing '3'.

Figure 7-3. Front-Panel Display Setup Screen



8 • BESTCOMSPi^{us}® Software

BESTCOMSPi^{us} 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^{us} is an acronym that stands for Basler Electric Software Tool for Communications, Operations, Maintenance, and Settings.

BESTCOMSPi^{us} provides the user with a point-and-click means to set and monitor the in-service relay or relays under test. The capabilities of BESTCOMSPi^{us} make the configuration of one or several BE1-700 Digital Protective Relay Systems fast and efficient. A primary advantage of BESTCOMSPi^{us} is that a settings scheme can be created, saved as a file, and then uploaded to the BE1-700 at the user's convenience.

BESTCOMSPi^{us} uses plugins allowing the user to manage several different Basler Electric products. The BE1-700 plugin opens inside the BESTCOMSPi^{us} main shell. The same default logic scheme that is shipped with the BE1-700 is brought into BESTCOMSPi^{us} by downloading settings and logic from the BE1-700. 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^{us} Programmable Logic is used to program BE1-700 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^{us} 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.

Figure 8-1 illustrates the typical user interface components of the BE1-700 plugin with BESTCOMSPi^{us}.

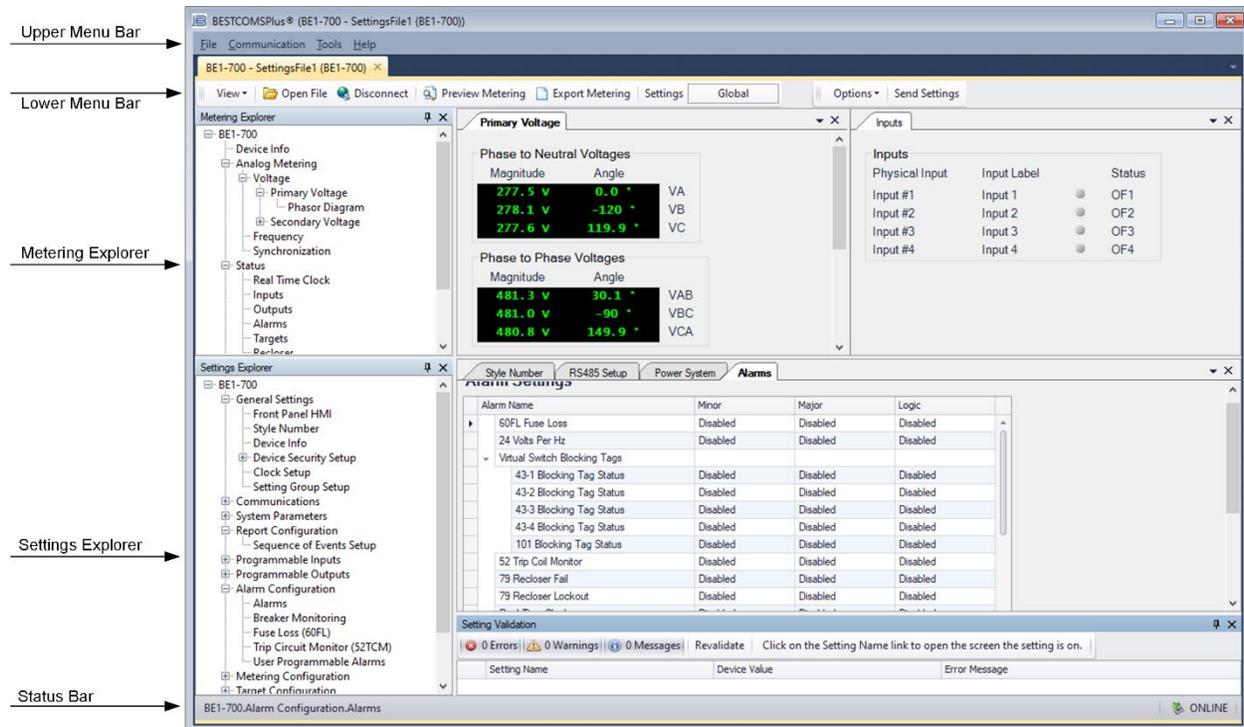


Figure 8-1. Typical User Interface Components

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 BE1-700 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 version 1607 (Anniversary Edition) or later, and Windows 11. System recommendations for the .NET Framework and BESTCOMSP*lus* are listed in Table 8-1.

Table 8-1. 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)
32/64 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.

1. Download BESTCOMSP*lus* from www.basler.com.
2. Click the installation button for BESTCOMSP*lus*. The setup utility installs BESTCOMSP*lus*, the .NET Framework (if not already installed), the USB driver, and the BE1-700 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 BE1-700 and Start BESTCOMSP*lus*®

The BE1-700 plugin is a module that runs inside the BESTCOMSP*lus* shell. The BE1-700 plugin contains specific operational and logic settings for only the BE1-700.

Connect a USB Cable and apply Control Power

The USB driver was copied to your PC during BESTCOMSP*lus* installation and is installed automatically after powering the BE1-700. 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 BE1-700. Apply operating power (per style chart in the *Introduction* chapter) to the BE1-700 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 8-2). 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.

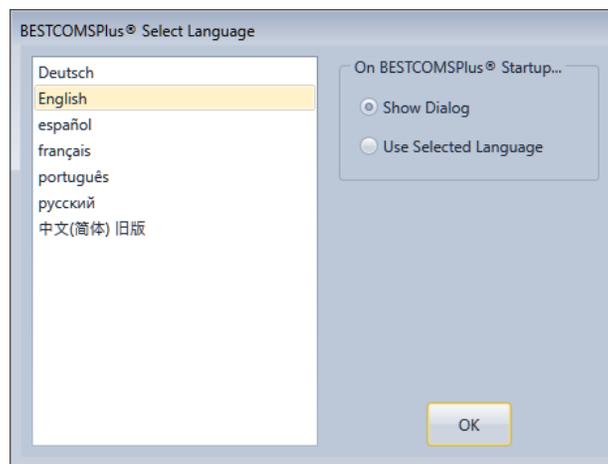


Figure 8-2. BESTCOMSPPlus Select Language Screen

The BESTCOMSPPlus platform window opens. Select New Connection from the Communication pull-down menu and select BE1-700. See Figure 8-3.

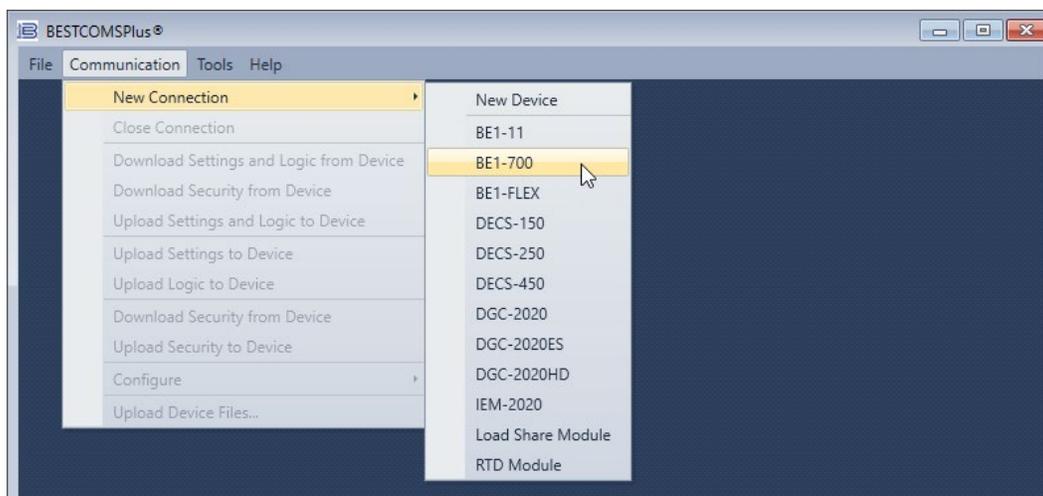


Figure 8-3. Communication Pull-Down Menu

The BE1-700 Connection screen shown in Figure 8-4 appears. Select USB Connection and then click the Connect button.

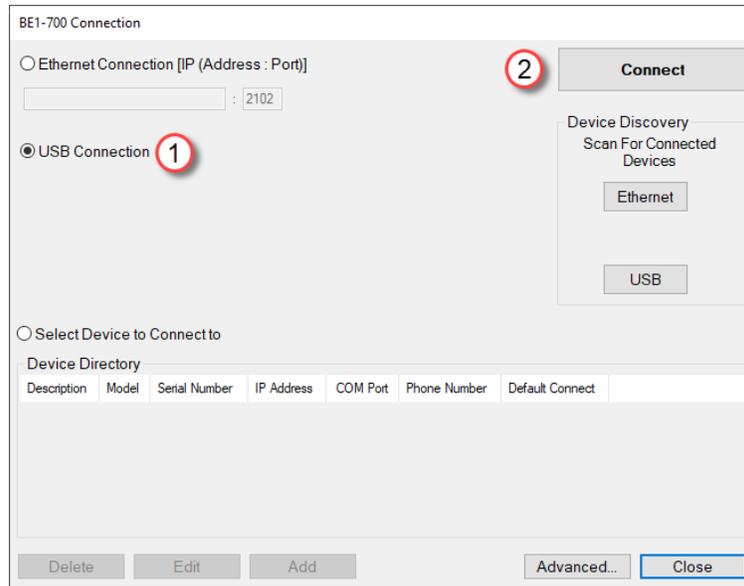


Figure 8-4. BE1-700 Connection Screen

Establishing Communication

Communication between BESTCOMSP*lus* and the BE1-700 is established by clicking on the Connect button on the BE1-700 Connection screen (see Figure 8-4) or by clicking on the Connect button on the lower menu bar of the main BESTCOMSP*lus* screen (Figure 8-1). If you receive an “Unable to Connect to Device” error message, verify that communications are configured properly. Only one Ethernet connection to BESTCOMSP*lus* is allowed at one time. Download all settings and logic from the BE1-700 by selecting Download Settings and Logic from the Communication pull-down menu. BESTCOMSP*lus* will read all settings and logic from the BE1-700 and load them into BESTCOMSP*lus* memory. A confirmation (Figure 8-5) will appear when complete.

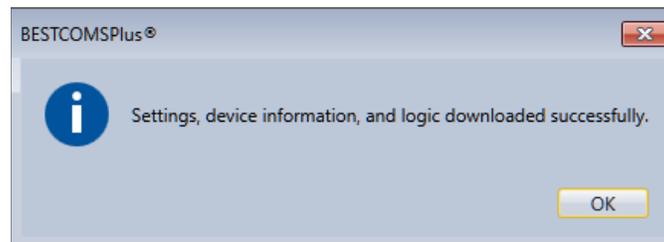


Figure 8-5. Downloaded Successfully

Advanced Properties

Click the Advanced button on the Connection screen to display the Advanced Properties dialog. Default settings are shown in Figure 8-6.

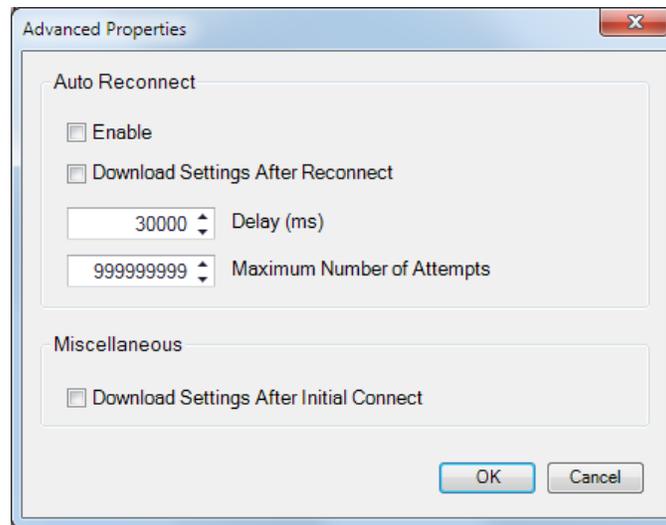


Figure 8-6. Advanced Properties Dialog

Menu Bars

The menu bars are located near the top of the BESTCOMS*Plus* screen (see Figure 8-1). The upper menu bar has four pull-down menus. With the upper menu bar, it is possible to manage settings files, configure communication settings, upload and download settings/security files, and compare settings files. The lower menu bar consists of clickable icons. The lower menu bar is used to change BESTCOMS*Plus* views, open a settings file, connect/disconnect, preview metering printout, export metering, switch to live mode, and send settings after a change is made when not in live mode.

Upper Menu Bar (BESTCOMS*Plus*® Shell)

Upper menu bar functions are listed and described in Table 8-2.

Table 8-2. Upper Menu Bar (BESTCOMS*Plus*® 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 BESTCOMS <i>Plus</i> program
<i>Communication</i>	
New Connection	Choose new device or BE1-700
Close Connection	Close communication between BESTCOMS <i>Plus</i> and BE1-700
Download Settings and Logic from Device	Download operational and logic settings from the device

Menu Item	Description
Upload Settings and Logic to Device	Upload operational and logic settings to the device
Upload Settings to Device	Upload operational settings to the device
Upload Logic to Device	Upload logic settings to the device
Download Security from Device	Download security settings from the device
Upload Security to Device	Upload security settings to the device
Configure	Ethernet settings
Upload Device Files	Upload firmware to the device
Tools	
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
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
Help	
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 (BE1-700 Plugin)

Lower menu bar functions are listed and described in Table 8-3.

Table 8-3. Lower Menu Bar (BE1-700 Plugin)

Menu Button	Description
View	Enables you to show/hide the Metering Panel, Settings Panel, or Settings Info Panel. Opens and saves workspaces. Customized workspaces make switching between tasks easier and more efficient.
Open File	Opens a saved settings file.
Connect	Opens the BE1-700 Connection screen which enables you to connect to the BE1-700 via USB or Ethernet. This button appears only when a BE1-700 is not connected.
Disconnect	Used to disconnect a connected BE1-700. This button appears only when a BE1-700 is connected.
Preview Metering	Displays the Print Preview screen where a preview of the Metering printout is shown. Click on the printer button to send to a printer.
Export Metering	Enables all metering values to be exported into a *.csv (comma-separated values) file.
Settings	A pull-down menu allowing group selection is available when making protection settings. The settings can be applied to Group 0 or 1. If a global setting is being changed, Global will appear in place of the drop-down menu.

Menu Button	Description
Options	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. Logic and security are not included in Live mode changes and needs to be uploaded from the Communication menu.
Save (Live Mode Only)	Saves all device settings to non-volatile memory. This button appears only when operating in Live mode.
Send Settings	Sends settings to the BE1-700 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 BE1-700.

Settings Explorer

The Settings Explorer is a convenient tool within BESTCOMSP*lus* used to navigate through the various settings screens of the BE1-700 plugin. Descriptions of these configuration settings are organized as follows:

- General Settings
- Communications
- System Parameters
- Report Configuration
- 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 BESTlogic*Plus* chapter.

Settings Entry

When entering settings in BESTCOMSP*lus*, each setting is validated against prescribed limits. Entered settings that do not conform with the prescribed limits are accepted but flagged as noncompliant. Figure 8-7 illustrates an example of flagged, noncompliant settings (locator A) and the Setting Validation window (locator B) used to diagnose faulty settings.

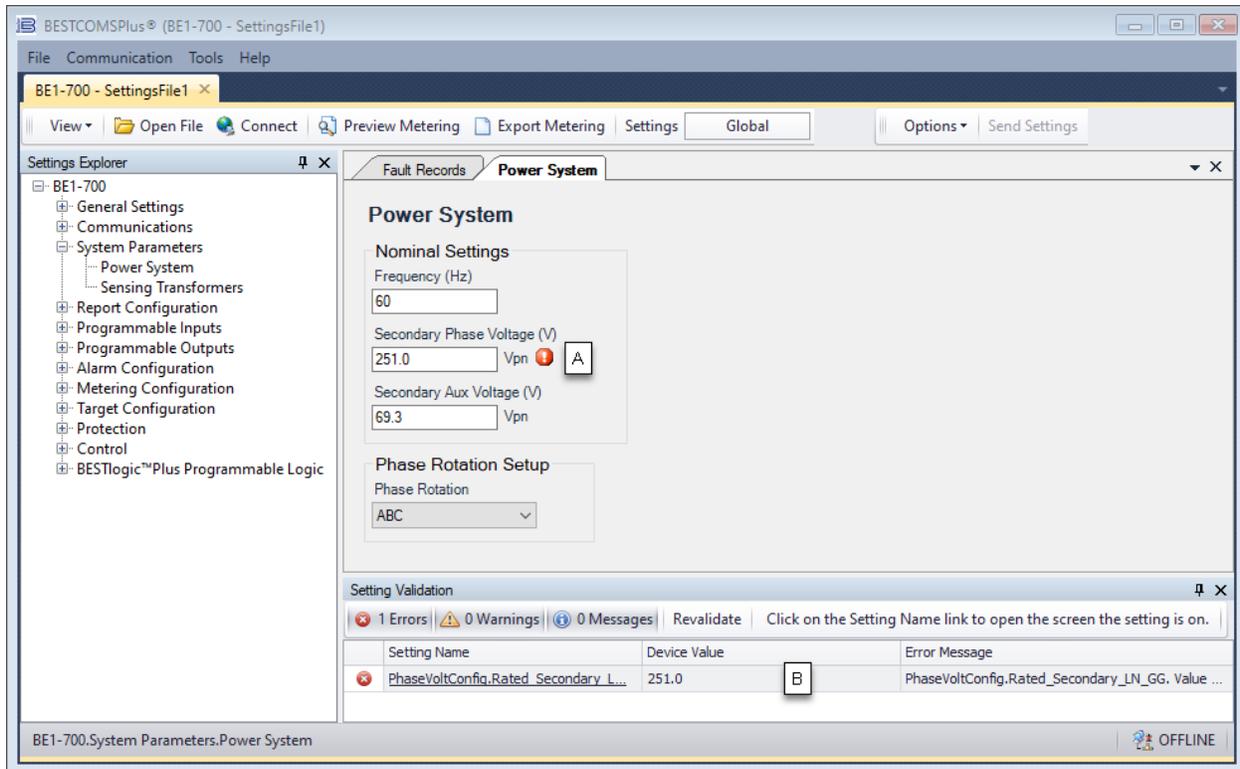


Figure 8-7. Flagged, Noncompliant Settings and the Setting Validation Window

The Setting Validation window, viewed by selecting the Setting Validation tab (locator B), 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 BESTCOMSPi.us. An example of a condition triggering a message is entry of a settings value with a resolution that exceeds the limit imposed by BESTCOMSPi.us. 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 BE1-700 settings file in BESTCOMSPi.us with noncompliant settings. However, it is not possible to upload noncompliant settings to the BE1-700.

Metering Explorer

The Metering Explorer is described in the *Metering* chapter.

Settings File Management

A settings file contains all BE1-700 settings including logic.

A settings file created in BESTCOMSPi.us will be given an extension of “bst4”.

It is possible to save only the BE1-700 logic displayed on the BESTlogicPi.us Programmable Logic screen as a separate logic library file. This ability is helpful when similar logic is required for several BE1-700 systems. The file extension of a logic file created in BESTCOMSPi.us will be “bsl4”.

It is important to note that settings and logic can be uploaded to the device separately or together but are always downloaded together. For more information on logic files, refer to the *BESTlogicPlus* chapter.

Opening a Settings File

To open a BE1-700 settings file with *BESTCOMSPi.us*, 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 the *BESTCOMSPi.us* 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 BE1-700, open the file or create a new file through *BESTCOMSPi.us*. 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.

Download Settings and Logic from Device

To download settings and logic from the BE1-700, pull down the **C**ommunication menu and select Download Settings and Logic from Device. If the settings in *BESTCOMSPi.us* 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. *BESTCOMSPi.us* reads all settings and logic from the BE1-700 and loads them into *BESTCOMSPi.us* memory. See Figure 8-8.

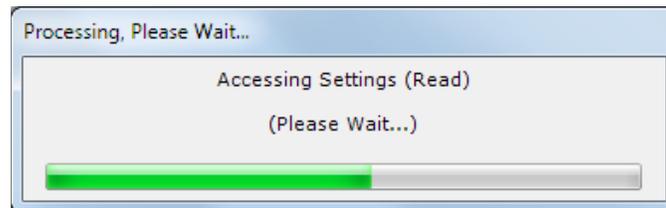


Figure 8-8. Processing, Please Wait...

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 the printer. Execute this command, as necessary, and then select Print.

Comparing Settings Files

BESTCOMSPi.us has the ability to compare two settings files. To compare files, pull down the **T**ools menu and select Compare Settings Files. The *BESTCOMSPi.us* Settings Compare Setup dialog box appears (Figure 8-9). 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.

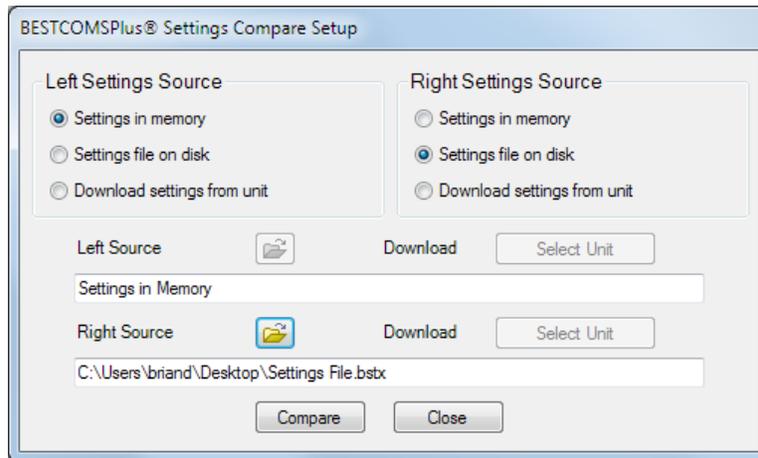


Figure 8-9. BESTCOMSPPlus Settings Compare Setup

A dialog box will appear and notify you if any differences were found. The BESTCOMSPPlus Settings Compare dialog box (Figure 8-10) is displayed where you can select to view all settings, settings differences, all logic paths, logic path differences, all Modbus options, or Modbus differences. If a settings file based on an older version of firmware was uploaded into the BE1-700, the BE1-700 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.

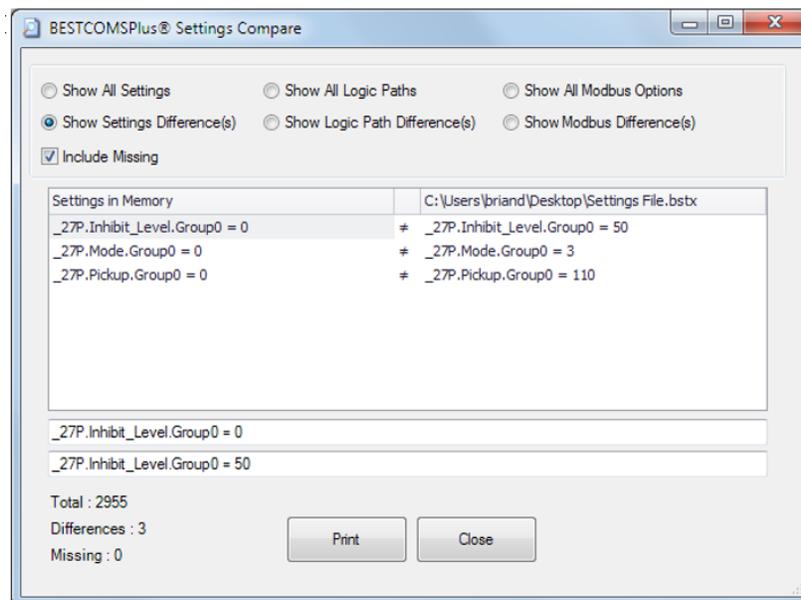


Figure 8-10. BESTCOMSPPlus Settings Compare

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 8-11 illustrates the Auto Export Metering screen.

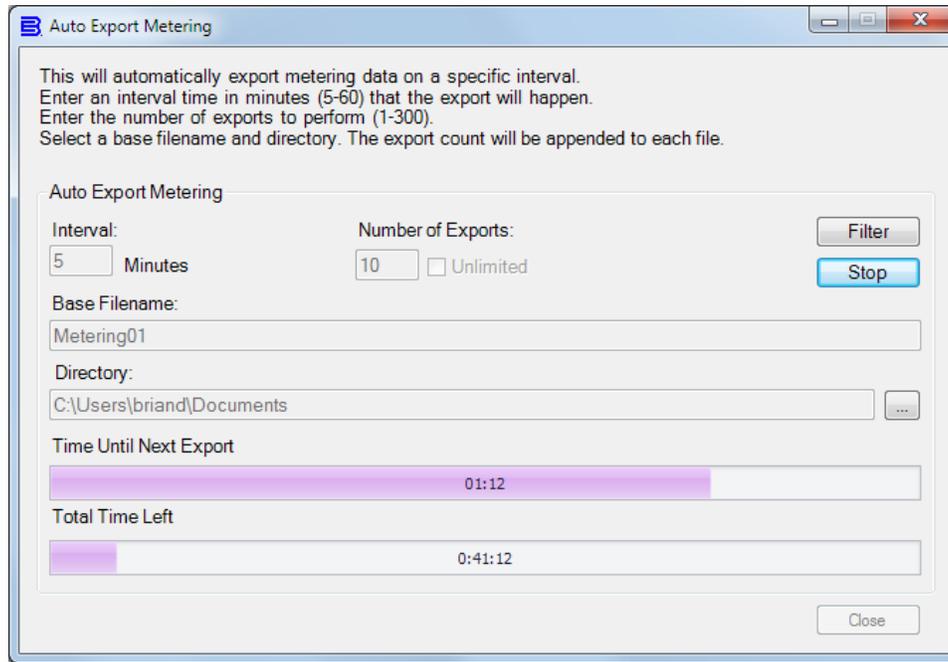


Figure 8-11. Auto Export Metering

BESTCOMSPi[®] Updates

Ongoing BE1-700 functionality enhancements may make future BE1-700 firmware updates desirable. Enhancements to BE1-700 firmware typically coincide with enhancements to the BE1-700 plugin for BESTCOMSPi[®]. When a BE1-700 is updated with the latest version of firmware, the latest version of BESTCOMSPi[®] should also be obtained.

- Download the latest version of BESTCOMSPi[®] by visiting www.basler.com.
- BESTCOMSPi[®] 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.)
- Use the manual “check for updates” function in BESTCOMSPi[®] to ensure that the latest version is installed by selecting Check for Updates in the Help drop-down menu. (An internet connection is required.)

Firmware Updates

For information on updating firmware, refer to the *Device Information* chapter.



9 • Security

In this chapter, security, in the form of multilevel password protection, is discussed along with the information required for protecting specific function groups and user interface components against unauthorized access.

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 9-1 lists the access levels and descriptions.

Table 9-1. 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 BESTCOMSPi^{us}® 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 BESTCOMSPi^{us} to select Username Setup under General Settings, Device Security Setup. The Login dialog box appears. See Figure 9-1. An administrator access level is required to set up usernames and passwords.

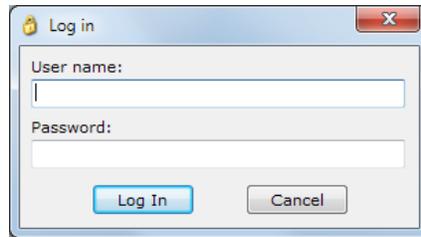


Figure 9-1. Login Screen

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 9-2). 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
BE1-700 firmware supports 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
` ~ ! @ # \$ % ^ & () _ + - = { } [] \ : " ; ' < > ? . / ,

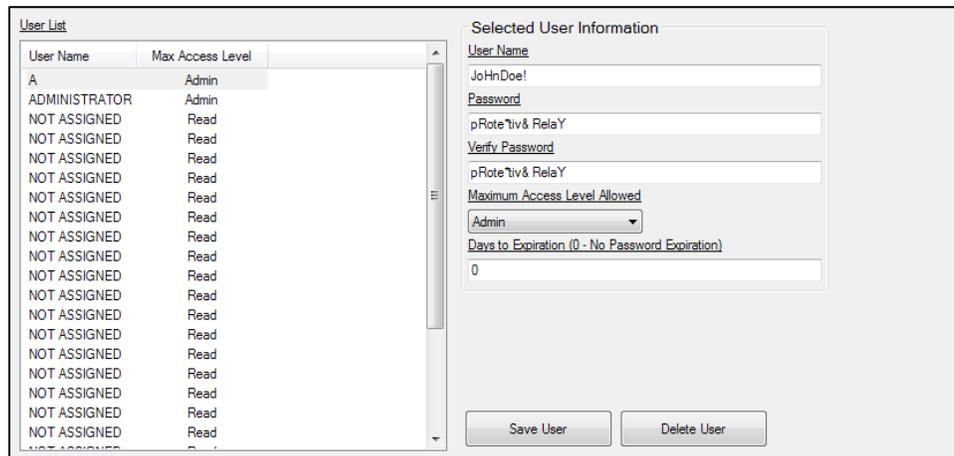


Figure 9-2. Username Setup Screen

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 9-1 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 BESTCOMSP*lus* 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”. BESTCOMSP*lus* notifies you when the upload is successful.

Port Access Setup

1. Use the Settings Explorer in BESTCOMSP*lus* to select Port Access Setup under General Settings, Device Security Setup. The Port List screen is shown in Figure 9-3.

Port	Unsecured Access	Secured Access
BESTCOMSP <i>lus</i> ® via Ethernet	Read	Admin
BESTCOMSP <i>lus</i> ® via USB	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 9-3. Port List Screen

2. The Login dialog box pops up. See Figure 9-1. 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 BE1-700 must be returned to Basler Electric for repair.

5. Click the Save Port button to save to the settings to BESTCOMSP*lus* 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”. BESTCOMSP*lus* 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 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 9-4.

Access Control

Access Timeout
Delay (s)
300

Login Failure
Login Attempts
1
Login Time Window (s)
1
Login Lockout Time (s)
1

HMI Login Required
Alarm Reset
Required
Target Reset
Required

Figure 9-4. Access Control Screen

1. Use the Settings Explorer in BESTCOMSPi.us to select Access Control under General Settings, Device Security Setup.
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". BESTCOMSPi.us notifies you when the upload is successful.

10 • Power System Configuration

BE1-700 inputs consist of three-phase voltage inputs and a single-phase auxiliary voltage input. This chapter describes the function and setup of voltage sensing and provides the equations that the BE1-700 uses for calculating the power quantities.

Power System Inputs

Power system inputs as described in the introduction, are sampled 32 times per cycle by the BE1-700. The BE1-700 measures the voltage from these samples and uses those measurements to calculate other quantities. Frequency is measured from a zero crossing detector. Measured inputs are then recorded every quarter cycle. If the applied voltage is greater than 10 volts, the BE1-700 measures the frequency and varies the sampling rate to maintain 32 samples per cycle. Frequency compensation applies to all power system measurements. Power system inputs are broken down in the following paragraphs into *Voltage Measurement*, *Frequency Measurement*, and *Measurement Functions Setup*.

Voltage Measurement

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

Voltage Measurement Functions

Input waveforms are sampled by an analog-to-digital converter (ADC) at 32 samples per cycle. The relay extracts the magnitude and angle of the fundamental components of each three-phase voltage input and the magnitude of the auxiliary voltage input.

VT Connections

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

Zero-Sequence (V_0) Voltage

When four-wire VT connections are used, the BE1-700 calculates the zero-sequence voltage ($3V_0$). Zero-sequence voltage measurement is not available when single-phase or three-wire VT connections are used. The 27X and 59X can be set to monitor the zero-sequence voltage.

Negative-Sequence (V_2) Voltage

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

Frequency Measurement

Power system frequency is monitored on the A-phase voltage input or the AB voltage input when in three-wire mode. When the applied voltage is greater than 10 volts, the BE1-700 measures the frequency. The measured frequency is used by the 81 function and applies to all measurements and calculations.

Frequency Compensation

After measuring the frequency, the BE1-700 varies the sampling rate to maintain 32 samples per cycle over a frequency of 10 to 75 hertz. If the voltage is too low for accurate frequency measurement or if the measured frequency is out of range, the ADC defaults to a sampling rate appropriate for the relay nominal frequency setting. The sampling rate is adjusted every 50 milliseconds.

Nominal Frequency

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

Measurement Functions Setup

The BE1-700 requires information about the power system and its and voltage transformers to provide metering, fault reporting, and protective relaying. This information is entered using BESTCOMSPPlus®. A summary of these settings appears at the end of this chapter. Alternately, it may be entered at the HMI (see the *Human-Machine Interface (HMI)* chapter).

BESTCOMSPPlus Navigation Path: Settings Explorer, System Parameters, Power System

HMI Navigation Path: Settings Explorer, System Parameters, Power System

Nominal Settings

Power System Settings

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

Nominal Secondary Voltage V_{nom} are used by the 60FL function. V_{nom} is also used in the volts/hertz (24) calculation.

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

In BESTCOMSPPlus for the BE1-700, under *General Operation* screen *Power System* tab, are settings for Nominal Voltage. Nominal Voltage (V_{nom}) is the nominal voltage rating corresponding to 1 pu volts and is configured as a phase-neutral secondary value.

The *Power System* settings panel is illustrated in Figure 10-1.

Figure 10-1. Power System Settings

Sensing Transformer Settings

The BE1-700 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 BESTCOMSPPlus. A summary of the settings appears at the end of this chapter.

BESTCOMSPPlus Navigation Path: Settings Explorer, System Parameters, Sensing Transformers

HMI Navigation Path: Settings Explorer, System Parameters, Sensing Transformers

Figure 10-2. VT Setup

Phase VT Setup

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

Auxiliary VT Setup

VTX Setup, VTX Ratio. The auxiliary voltage input (VX) connection can be set for any voltage combination VA, VB, VC, VAB, VBC, or VCA. Alternately, the VX input connection can be set to Ground. This setting is used when the VX input is connected to a source of ground unbalance voltage or residual voltage such as a generator grounding resistor, broken delta VT connection, or capacitor bank star point.

Table 10-1 lists the measurement function's settings.

Table 10-1. Measurement Functions Settings

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

Retrieving Output Logic Override Status

Output status is determined through BESTCOMSP*lus* by using the Metering Explorer to open the Status/Outputs tree branch. BESTCOMSP*lus* must be online with the BE1-700 to view contact output status. Alternately, status can be determined through the front-panel display by navigating to Metering > Status > Outputs.

11 • Device Information

BE1-700 identification labels, firmware version, serial number, and style number are found on the Device Info screen in BESTCOMSPi.us®.

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 BE1-700 is displayed on the BESTCOMSPi.us Style Number screen after downloading settings from the device. When configuring BE1-700 settings off-line, the style number for the unit to be configured can be entered into BESTCOMSPi.us to enable configuration of the required settings. The BESTCOMSPi.us Style Number screen is illustrated in Figure 11-1.

Option	Option Name	Description
N	Option C	None
5	Voltage Sensing Input Type	3-Phase Sensing with Auxiliary Input - Enhanced
R	Option 1	Reclosing Function (79) Added
2	Power Supply Option	125 Vac/dc
X	Case Option	Half-Rack Fixed Case
8	Comms Protocol Option	BESTCOMSPi.us (RJ45 Ethernet) and Modbus® (RS485 or RJ45 Ethernet)
N	Option 2	None

Figure 11-1. Style Number Screen

Device Info

Information about a BE1-700 communicating with BESTCOMSPi.us can be obtained on the Device Info screen of BESTCOMSPi.us after downloading settings from the device.

The application version must be selected when configuring BE1-700 settings off-line. When later attempting upload, BESTCOMSPi.us will prompt the user to update the application version if the settings do not match the firmware in the BE1-700. This does not update the firmware in the BE1-700. Some functions may be enabled or disabled pending availability in the selected firmware. When online, read-only information includes the application version, application part number, application build date, boot code version, model number, style number, and serial number.

BE1-700 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 BESTCOMSPi.us Device Info screen is illustrated in Figure 11-2.

The screenshot displays the 'Device Info' screen, which is divided into two main sections: 'Device Info' and 'Identification'. The 'Device Info' section contains several input fields and a dropdown menu. The 'Identification' section contains three input fields.

Device Info	
Application Version (dropdown)	Model Number
>= 1.00.00	BE1-700
Application Version	Style Number
4.00.01	BE1-700-N5N2X8N
Application Part Number	Serial Number
9376700044	H03275259
Application Build Date	
03/11/24	
Boot Code Version	
5.00.00	

Identification	
Device ID	BE1-700
Station ID	Station ID
User ID	User ID

Figure 11-2. Device Info Screen

Firmware Updates

Caution

Default settings will be loaded into the BE1-700, reports and events will be cleared, and the BE1-700 will reboot when firmware is updated. BESTCOMSPi.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* in the BESTCOMSPi.us Software chapter for help with saving a settings file.

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 BESTCOMSPi.us. The Basler Electric Device Package Uploader screen will appear. See Figure 11-3.

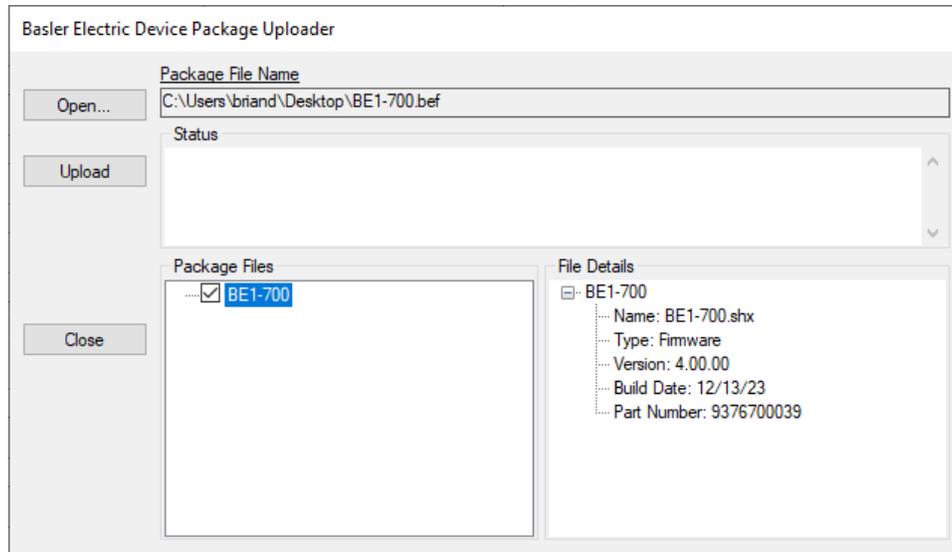


Figure 11-3. Basler Electric Device Package Uploader

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 BE1-700 will reboot automatically after the firmware upload is complete.

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 11-4) 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 11-4. BESTCOMSPi+ Alarms Screen



12 • Timekeeping

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

Clock Setup

BESTCOMSPlus® 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 BESTCOMSPlus 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 BE1-700 has powered up and the clock has not been set.

The clock settings are made through BESTCOMSPlus by selecting Clock Setup under General Settings. The BESTCOMSPlus Clock Setup screen is illustrated in Figure 12-1.

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 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 12-1. 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.

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 BE1-700.

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

Irig Decoding
 No
 Yes

Figure 12-1. Clock Setup Screen

Setting the Time and Date

BESTCOMSPi.us 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 BESTCOMSPi.us on the Real Time Clock screen (Figure 12-2), under the Status branch of the Metering Explorer. Settings can also be made through the front panel.



Figure 12-2. 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 12-1.

Table 12-1. IRIG Terminal Assignments

Terminal	Function
A1	(+) Signal
A2	(-) Reference

13 • Setting Groups

Two 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 two setting groups are designated Setting Group 0 and Setting Group 1. 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 and D1 and changes the active setting group according to the status of these inputs. These inputs can be connected to logic expressions such as contact sensing outputs.

Logic Outputs

The function logic has two logic variable outputs, SG0 and SG1. The appropriate variable is asserted when each setting group is active. These logic variables can be used in programmable logic to modify the logic based upon which setting group is active.

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 BE1-700 switches to a new setting group, all functions are reset and initialized with the new operating parameters. The settings change occurs instantaneously so at no time is the BE1-700 off line. The active setting group is saved in nonvolatile memory so that the BE1-700 will power up using the same setting group that was active when it was powered down. To prevent the BE1-700 from changing settings while a fault condition is in process, setting group changes are blocked when the BE1-700 is in a picked-up state. Since the BE1-700 is completely programmable, the fault condition is defined by the pickup logic expression in the fault reporting functions. See 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 BE1-700 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 13-2.

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. 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. 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.

Binary Inputs

The Binary Input mode on the BE1-700 operates the same as the Discrete Input mode as 0 and 1 have the same numerical value in both modes.

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 BE1-700 switches from one setting group to another. The Setting Change alarm bit is asserted for the SGC alarm time setting. This output can be used in the programmable alarms function if it is desired to monitor when the BE1-700 changes to a new setting group. See the *Alarms* chapter for more information on setting up alarms.

The SGC alarm 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 SGC alarm 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 BESTCOMSP^{Plus}®.

Automatic Setting Group Selection

The setting group element has the built-in ability to automatically change setting groups based upon the 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.

Group Control by Monitoring Recloser or Fuse Loss Status

The active setting group can also be controlled by the status of the Recloser (79) or fuse loss function (60FL). The

BE1-700 can be instructed to change to Setting Group 1. If the monitored element is a recloser shot or 60FL, the switch threshold, return time, and return threshold are ignored.

Logic Connections

Setting group logic connections are made on the BESTlogic^{Plus} screen in BESTCOMSP^{Plus}. The setting group logic block is illustrated in Figure 13-2. Logic inputs and outputs are summarized in Table 13-1.

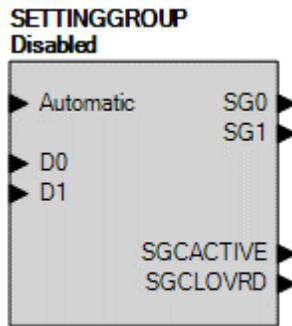


Figure 13-1. Setting Group Logic Block

Table 13-1. 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	Inputs	Meaning depends upon the Mode setting
SG0, SG1	Outputs	True for the active setting group
SGCACTIVE	Output	True when Setting Group Control is Active
SGCLOVRD	Output	True when Setting Group Control is overridden by logic

Operational Settings

Setting group operational settings are configured on the Setting Group Setup screen (Figure 13-3) in BESTCOMSP^{lus}. Setting ranges and defaults are summarized in Table 13-2.

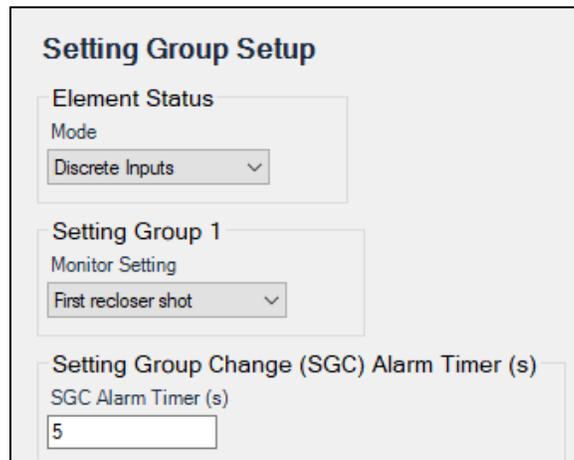


Figure 13-2. Setting Group Setup Screen

Table 13-2. 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
Monitor Setting	Disable, First-Fourth Recloser Shot, 60FL	Determines when automatic setting group changes occur. Recloser state (79) and Fuse Loss (60FL) can be used to switch setting groups.	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 13-4. If enabled, select a setting group to change to or return to logic control. The Active Setting Group is also displayed on this screen.

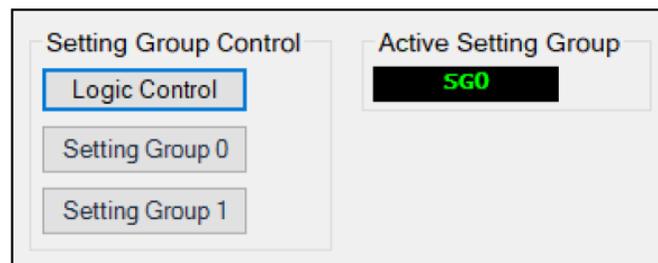


Figure 13-3. Setting Group Control Screen

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

14 • Metering

The BE1-700 measures the voltage 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 BESTCOMSPPlus® that contains analog metering, status, reports, 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, 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 14-1. Table 14-1 explains the call-outs in Figure 14-1.

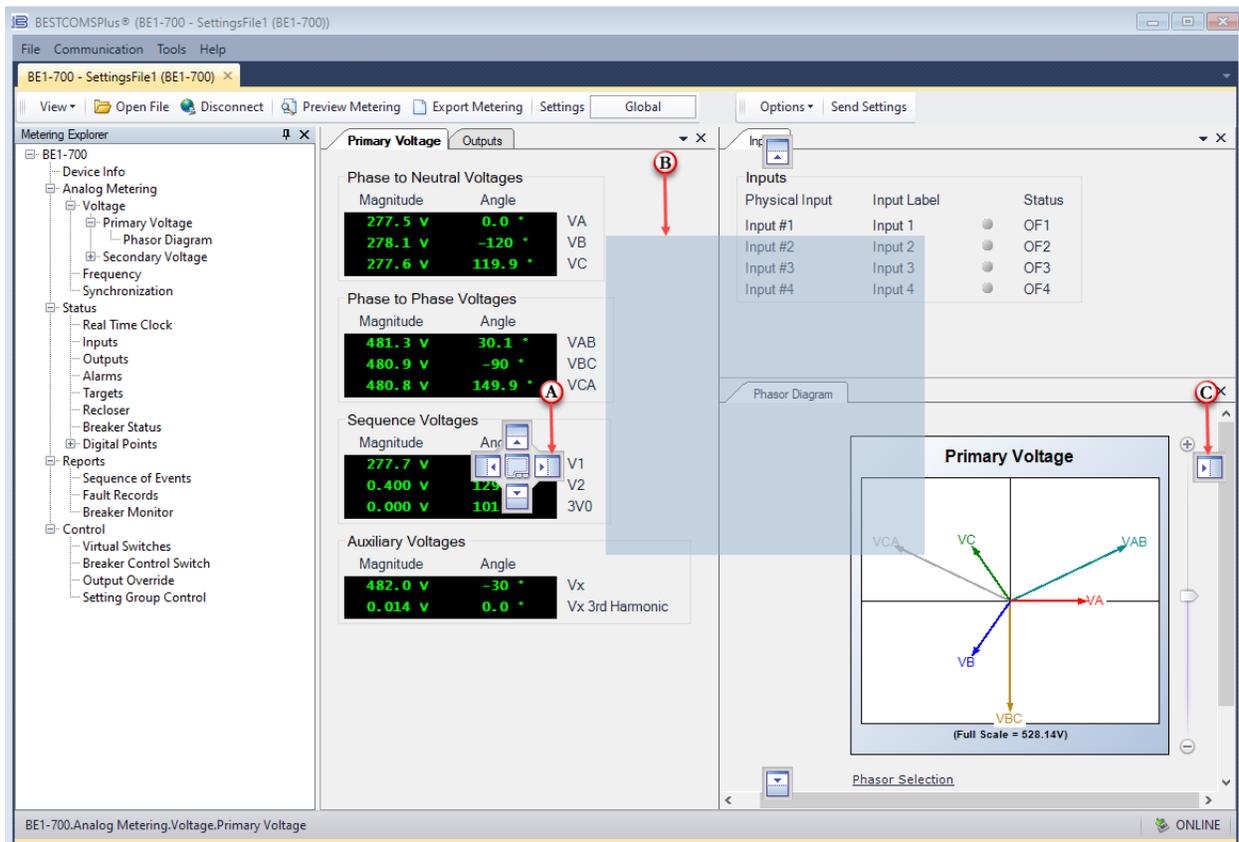


Figure 14-1. Metering, Docking Options

Table 14-1. Explanation of 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

BE1-700 analog metering functions include voltage, frequency, and synchronization. Metered values are viewed through the Metering Explorer in BESTCOMS*Plus* and the front-panel display. Metering functions are summarized in the following paragraphs.

Auto Ranging

The BE1-700 automatically scales metered values. Table 14-2 illustrates the ranges for each value metered.

Table 14-2. Auto Ranging Scales for Metered Values

Metered Value	Unit Display Ranges			
	Whole Units	Kilo Units	Mega Units	Giga Units
Voltage	0 V to 999 V	0 kV to 999 kV	n/a	n/a
Frequency	10 to 75 Hz	n/a	n/a	n/a

Voltage - Primary and Secondary

The BE1-700 meters primary and secondary phase-to-neutral voltages (VA, VB, VC), phase-to-phase voltages (VAB, VBC, VCA), positive-sequence voltage (V1), negative-sequence voltage (V2), neutral-shift voltage (3V0), auxiliary voltage (Vx), and 3rd harmonic auxiliary voltage (Vx 3rd Harmonic). The Phase VT connection determines what is measured. The auxiliary voltage input is user selectable. Refer to the *Power System Configuration* chapter for more information on configuring Phase VT and AUX VT.

Primary and secondary voltage metering data is found in BESTCOMS*Plus* (Figure 14-2) and on the Metering > Analog Metering > Voltage screen of the front-panel display. A phasor diagram is also provided in BESTCOMS*Plus*.

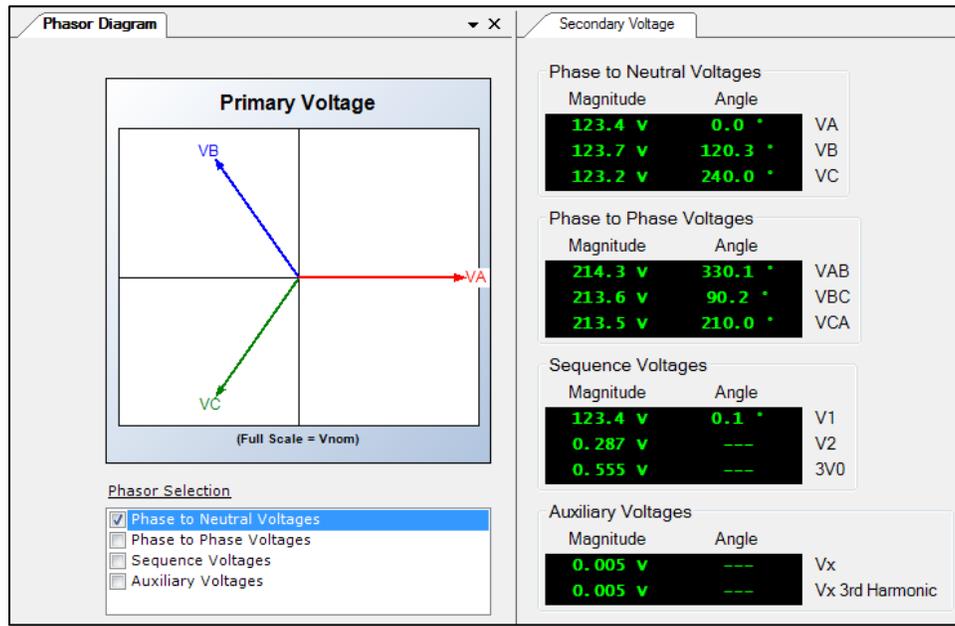


Figure 14-2. Analog Metering, Voltage Screen

Frequency

Frequency is metered over a range of 10 to 75 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 BE1-700. Refer to the *Terminals and 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 BESTCOMSPi.us (Figure 14-3) and on the Metering > Analog Metering > Frequency screen of the front-panel display.



Figure 14-3. Analog Metering, Frequency Screen

Synchronization

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

Synchronization metering data is found in BESTCOMSPi.us (Figure 14-4) and on the Metering > Analog Metering > Synchronization screen of the front-panel display.



Figure 14-4. Analog Metering, Synchronization Screen



15 • Overexcitation (24)

The overexcitation (24) element monitors the volts per hertz ratio and protects transformers from the adverse effects of excessive heating resulting from overexcitation. Distribution systems are becoming more complex with the addition of distributed generation throughout the distribution network. Systems that were once well defined with power flowing from the utility to the customer loads now may have power flowing back to the utility or from one customer to another at any moment. This change in power flow has made it difficult for the existing transformer load tap changers to keep voltage at a proper level. The overexcitation element can be used to protect the transformer during these conditions.

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 or 1), Voltage Protection, Overexcitation 24

Element Operation

Overexcitation occurs when a transformer magnetic core becomes saturated. When this happens, stray flux is induced in non-laminated components, causing overheating. The BE1-700 detects overexcitation conditions with a volts 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 *Power System Configuration* chapter.

Nominal voltage for the BE1-700 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:

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

Equation 15-1. 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 15-2. V/Hz Measured (AN, BN, or CN)

Trip and Reset Equations

Equation 15-3 and Equation 15-4 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 15-3 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 15-3. Time to Trip

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

Equation 15-4. 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 (logic element 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 *Overexcitation (24) Inverse Time Curves* 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 BE1-700 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 and on the Alarms metering screen in *BESTCOMSPlus*. 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

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

Overexcitation element logic connections are made on the *BESTlogicPlus* screen in *BESTCOMSPlus*. The overexcitation element logic block is illustrated in Figure 15-1. Logic inputs and outputs are summarized in Table 15-1.

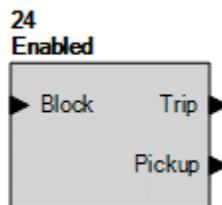


Figure 15-1. Overexcitation Element Logic Block

Table 15-1. Logic Inputs and Outputs

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

Operational Settings

Overexcitation operational settings are configured on the Overexcitation (24) settings screen (Figure 15-2) in BESTCOMSPlus.

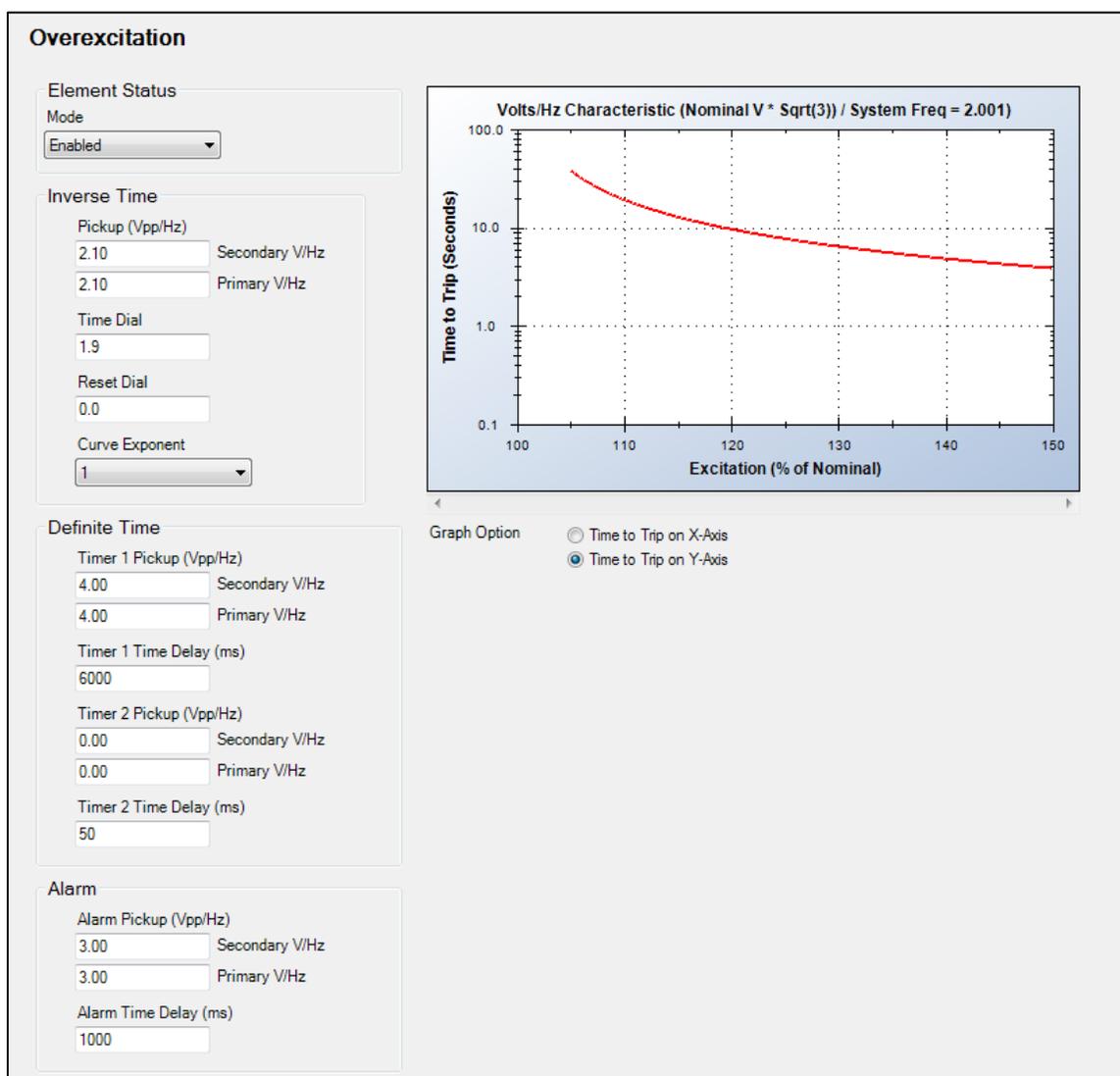


Figure 15-2. Overexcitation Settings Screen

Settings Example

The overexcitation element is used to de-energize a transformer that is experiencing an overexcitation condition. Therefore, the manufacturer's overexcitation limit curves are required to establish optimum protection. Figure 15-3 and Figure 15-4 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.

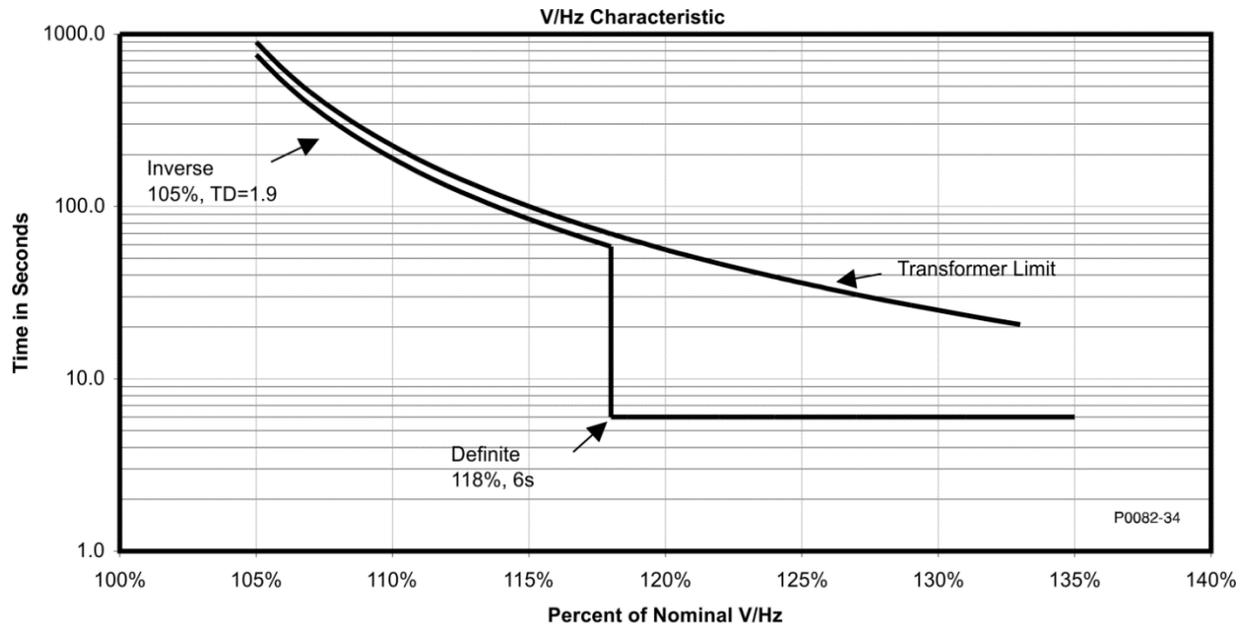


Figure 15-3. Time Shown on Vertical Axis

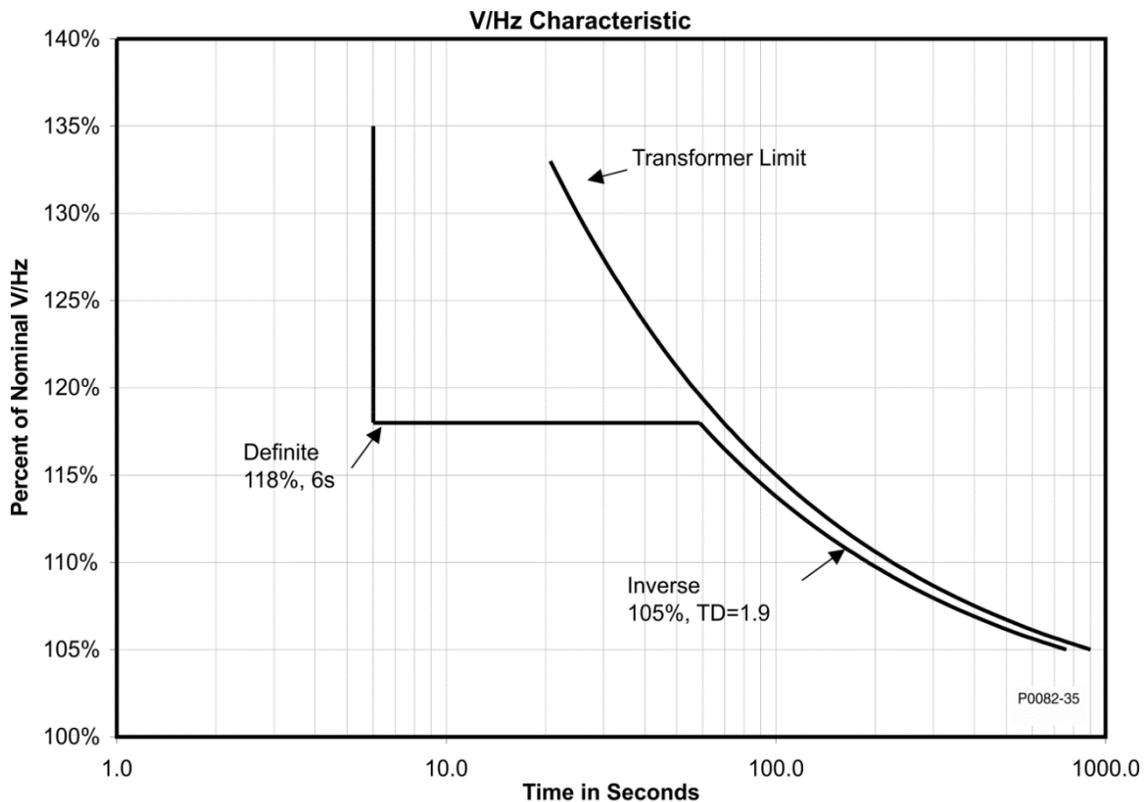


Figure 15-4. Time Shown on Horizontal Axis

Assuming a V_{nom} of 69.3 Vpn, 1 pu volts/hertz = $(69.3 * \sqrt{3}) / 60 = 2.00$. Using the transformer limit curve in Figure 15-4, the following example demonstrates how to set the BE1-700 to provide a composite V/Hz characteristic for protection of a step-up transformer:

- Alarm = 105% @ 1 second time delay; V/Hz = $2 * 1.05 = 2.10$
- Inverse time pickup = 105%; Time Dial = 1.9; Inverse Trip Curve = $(M-1)^2$; V/Hz = $2 * 1.05 = 2.10$

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 15-5), 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 15-5. 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 15-6 illustrates the inverse time delay and reset time.

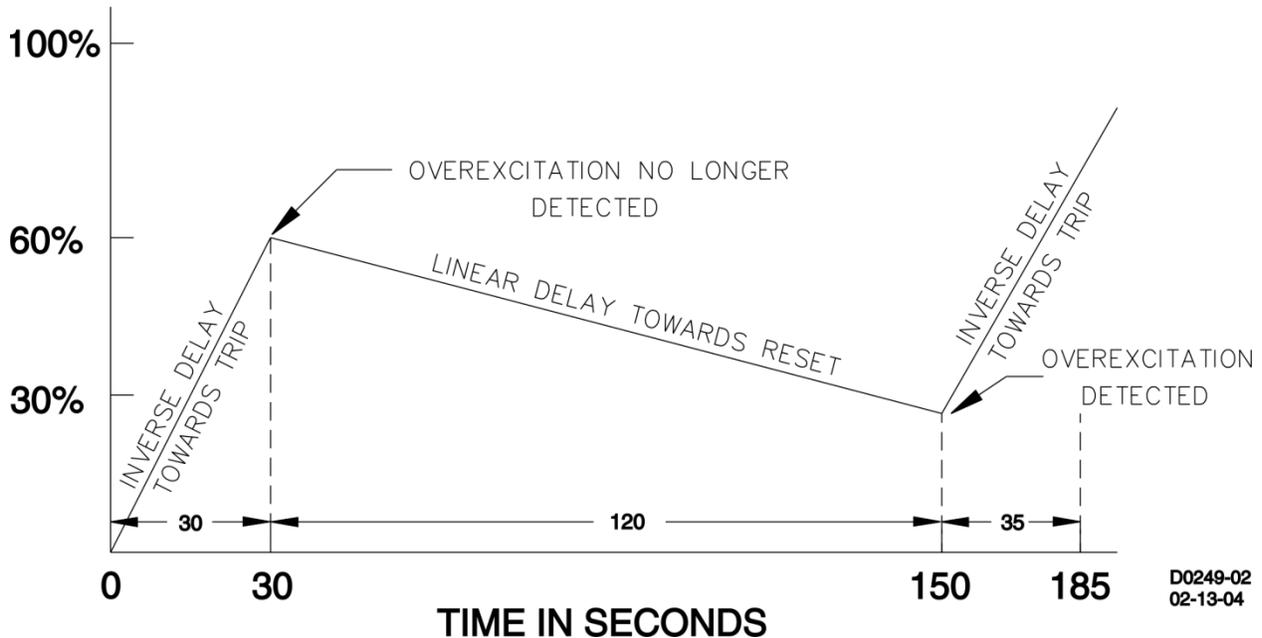


Figure 15-5. Inverse Time Delay and Reset Time

16 • Sync-Check (25)

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

Element logic connections are made on the BESTlogic™ *Plus* screen in BESTCOMS*Plus*® and element operational setting are configured on the Sync-Check settings screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs and operational settings 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 or 1), 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 dropdown is enabled, 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 BE1-700 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 utilized for residual voltage input (59N).

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 typically 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 *Terminals and 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^{Plus}. Refer to the *Configuration* chapter for more information on this setting.

Angle Compensation

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

Common system and sensing transformer combinations are shown in Table 16-1. 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 16-1. 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 16-1. 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 16-1 associated with each of the outputs.

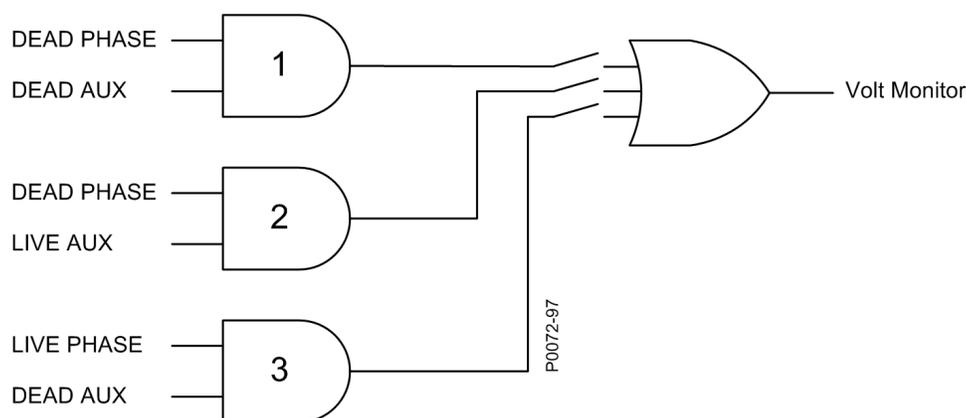


Figure 16-1. Voltage Monitor Logic

Element Blocking

Fuse Loss

The fuse loss (60FL) element of the BE1-700 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 Voltage Elements 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 16-2. Logic inputs and outputs are summarized in Table 16-2.

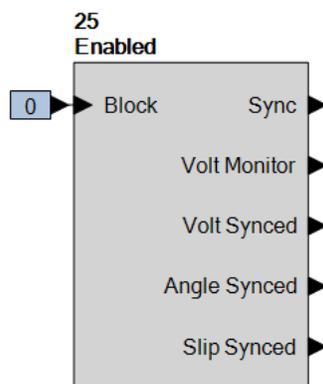


Figure 16-2. Sync-Check Element Logic Block

Table 16-2. 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 16-3) in BESTCOMSPlus.

Sync-Check

25 Element Settings

Mode
Enabled ▾

Voltage Difference (%)
0

Slip Angle (°)
10

Slip Frequency (Hz)
0.01

Source Freq > Destination Freq
Enabled ▾

25 Voltage Monitoring

Live Voltage (%)
0

Dead Voltage (%)
0

Drop Out Delay (ms)
50

25 Voltage Monitor Logic

Dead Phase / Dead Aux
Disabled ▾

Dead Phase / Live Aux
Disabled ▾

Live Phase / Dead Aux
Disabled ▾

25 Element Sensing Setup

Angle Compensation (°)
0.0

Figure 16-3. Sync-Check Settings Screen



17 • Phase Undervoltage (27P)

Two phase undervoltage (27P) elements monitor the sensing voltage applied to the BE1-700. An element can be configured to protect against undervoltage when the phase voltage decreases below a defined level.

The two phase undervoltage protection elements are designated 27P-1 and 27P-2. 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 or 1), 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. Undervoltage protection can also be utilized as an indication of power system stability.

Fault Recorder

When the Fault Recorder setting is enabled, recording starts when the Pickup output becomes true. Pre-fault cycles are included per the fault recording settings described in the *Fault Reporting* chapter.

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.

Sensing Configuration

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 VT setting setup for PP or PN voltage response, see the *Power System Configuration* chapter.

Pickup and Trip

Pickup

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

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. A Time Delay setting of zero (0) makes the 27P element instantaneous with no intentional time delay.

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 future events.

Trip

The Trip output becomes true when an undervoltage 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 BE1-700 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 and secondary voltage and Vpn, or Vpp, depending on the 27/59 Mode parameter of the phase VT connections found on the System Parameters/Sensing Transformers settings screen in *BESTCOMSPlus*. Its unit of measure depends upon the phase VT connection setting.

Element Blocking

Fuse Loss

The fuse loss (60FL) element of the BE1-700 can be used to block Undervoltage (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 Voltage Elements 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

Undervoltage element logic connections are made on the *BESTLogicPlus* screen in *BESTCOMSPlus*. The phase undervoltage element logic block is illustrated in Figure 17-1. Logic inputs and outputs are summarized in Table 17-1.

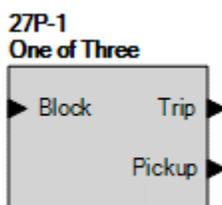


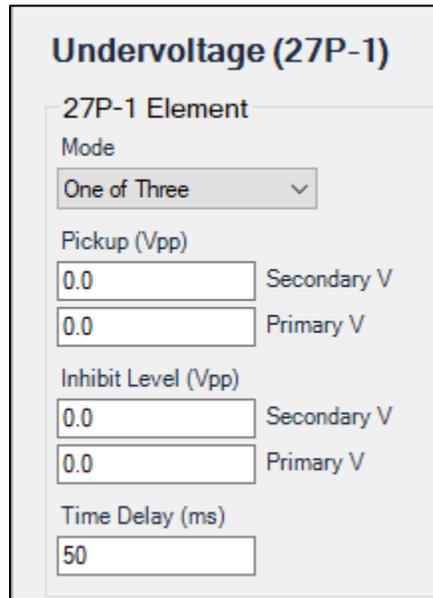
Figure 17-1. Phase Undervoltage Element Logic Block

Table 17-1. 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 17-2) in BESTCOMSPlus.



Undervoltage (27P-1)

27P-1 Element

Mode
One of Three ▾

Pickup (Vpp)

0.0 Secondary V

0.0 Primary V

Inhibit Level (Vpp)

0.0 Secondary V

0.0 Primary V

Time Delay (ms)

50

Figure 17-2. Phase Undervoltage Settings Screen



18 • Auxiliary Undervoltage (27X)

The auxiliary undervoltage (27X) element monitors the phase and auxiliary voltage applied to the BE1-700. The element can be configured to protect against undervoltage by monitoring zero sequence voltage on the phase sensing or be set to monitor the fundamental or 3rd harmonic voltage on the Vx input.

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

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

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 or 1), Voltage Protection, Undervoltage 27X

Element Operation

Auxiliary undervoltage protection can be used to protect equipment from damage caused by phase failure or phase unbalance.

Fault Recorder

When the Fault Recorder setting is enabled, recording starts when the Pickup output becomes true. Pre-fault cycles are included per the fault recording settings described in the *Fault Reporting* chapter.

Modes of Protection

Three modes of protection are available: 3V0, Vx Fundamental, and Vx Third Harmonic.

3V0 Mode

3V0 mode measures the neutral offset for ungrounded systems. The 3V0 measurement typically increases as the three-phase voltages become unbalanced. To use 3V0 mode, the VTP connection cannot be single-phase.

Vx Fundamental Mode

Vx Fundamental mode measures the fundamental frequency voltage of the Vx hardware.

Vx Third Harmonic Mode

Vx Third Harmonic mode measures the 3rd harmonic frequency voltage of the Vx hardware and is commonly used in generator protection applications.

Connections

Connections are made on the rear of the BE1-700. The phase VT inputs (Va, Vb, Vc) are used when 3V0 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 Typical Connections* 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 BESTCOMS*Plus* 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 BESTCOMS*Plus*. See Table 18-1 for a full list of possible settings. The Aux VT Connection parameter is found on the System Parameters/Sensing Transformers settings screen in BESTCOMS*Plus*. For more information on the auxiliary VT setup, see the *Power System Configuration* chapter.

Table 18-1. 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

Pickup and Trip

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 and control other elements in logic.

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. A Time Delay setting of zero (0) makes the 27X element instantaneous with no intentional time delay.

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 future events.

Trip

The Trip output becomes true if an undervoltage 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 BE1-700 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.

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 3V0 mode of the 27X element.

Element Blocking

Fuse Loss

The fuse loss (60FL) element of the BE1-700 can be used to block Auxiliary Undervoltage (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 3V0 Voltage Elements 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

Auxiliary undervoltage element logic connections are made on the BESTlogicPlus screen in BESTCOMSPlus. The auxiliary undervoltage element logic block is illustrated in Figure 18-1.

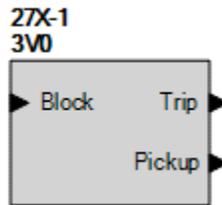


Figure 18-1. Auxiliary Undervoltage Element Logic Block

Table 18-2. 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 18-2) in BESTCOMSPlus.

Figure 18-2. Auxiliary Undervoltage Settings Screen



19 • Negative-Sequence Overvoltage (47)

A negative-sequence overvoltage (47) element monitors the phase voltage applied to the BE1-700.

This element is designated 47-1. Element logic connections are made on the BESTlogic™*Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Overvoltage (47) 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, Overvoltage (47)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 or 1), Voltage Protection, Overvoltage 47

Element Operation

Negative-sequence overvoltage protection can be used to protect equipment from damage caused by reversed phase sequence and voltage unbalance.

Fault Recorder

When the Fault Recorder setting is enabled, recording starts when the Pickup output becomes true. Pre-fault cycles are included per the fault recording settings described in the *Fault Reporting* chapter.

Connections

Connections are made at the phase VT inputs (Va, Vb, Vc) on the rear of the BE1-700. For an illustration of terminals, refer to the *Terminals and Typical Connections* chapter.

Sensing Configuration

The overvoltage element can be set to monitor VPP or VPN. This is determined by the 27/59 Mode parameter of the phase VT connections found on the System Parameters/Sensing Transformers settings screen in BESTCOMS*Plus*. For more information on the VT settings for PP or PN voltage response, see the *Power System Configuration* chapter. Negative-sequence overvoltage protection is not available for single-phase connections.

Pickup and Trip

Pickup

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

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. A Time Delay setting of zero (0) makes the 47 element instantaneous with no intentional time delay.

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 future events.

Trip

The Trip output becomes true if the 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 BE1-700 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 BE1-700 can be used to block 47 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 V2 Voltage Elements is enabled, the 47 function will be 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

Negative-sequence overvoltage element logic connections are made on the BESTlogicPlus screen in BESTCOMSPlus. The negative-sequence overvoltage element logic block is illustrated in Figure 19-1. Logic inputs and outputs are summarized in Table 19-1.

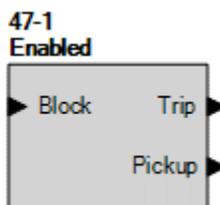


Figure 19-1. Negative-Sequence Overvoltage Element Logic Block

Table 19-1. Logic Inputs and Outputs

Name	Logic Function	Purpose
Block	Input	Disables the 47 function when true
Trip	Output	True when the 47 element is in a trip condition
Pickup	Output	True when the 47 element is in a pickup condition

Operational Settings

Negative-sequence overvoltage element operational settings are configured on the Negative Sequence Overvoltage (47) settings screen (Figure 19-2) in BESTCOMSPlus.

Negative Sequence Overvoltage (47-1)

47-1 Element

Mode
Enabled

Pickup (Vpn)
0.0 Secondary V
0.0 Primary V

Time Delay (ms)
50

Figure 19-2. Negative-Sequence Overvoltage Settings Screen



20 • Phase Overvoltage (59P)

Two phase overvoltage (59P) elements monitor the sensing voltage applied to the BE1-700. An element can be configured to protect against overvoltage when the phase voltage increases above a defined level.

The two overvoltage protection elements are designated 59P-1 and 59P-2. Element logic connections are made on the BESTlogic™ *Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Overvoltage (59P) 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, Overvoltage (59P)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 or 1), Voltage Protection, Overvoltage 59P

Element Operation

Overvoltage protection can be used to prevent transformers and downstream equipment damage when an overvoltage condition exists. For example, an overvoltage condition could occur when the tap changing control fails. Overvoltage protection can also be utilized as an indication of power system stability.

Fault Recorder

When the Fault Recorder setting is enabled, recording starts when the Pickup output becomes true. Pre-fault cycles are included per the fault recording settings described in the *Fault Reporting* chapter.

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.

Sensing Configuration

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

Pickup and Trip

Pickup

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

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. A Time Delay setting of zero (0) makes the 59P element instantaneous with no intentional time delay.

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

Trip

The Trip output becomes true if an overvoltage 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 BE1-700 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 BE1-700 can be used to block Overvoltage (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 Voltage Elements 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 20-1. Logic inputs and outputs are summarized in Table 20-1.

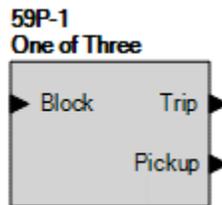


Figure 20-1. Overvoltage Element Logic Block

Table 20-1. 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 (59) settings screen (Figure 20-2) in *BESTCOMSPlus*.

Overvoltage (59P-1)

59P-1 Element

Mode
One of Three

Pickup (Vpp)
0.0 Secondary V
0.0 Primary V

Time Delay (ms)
50

Figure 20-2. Overvoltage Settings Screen



21 • Auxiliary Overvoltage (59X)

Two auxiliary overvoltage (59X) elements monitor the phase and auxiliary voltage applied to the BE1-700. An element can be configured to protect against overvoltage by monitoring neutral-shift voltage, fundamental voltage on the Vx input, or third-harmonic voltage on the Vx input.

The two auxiliary overvoltage protection elements are designated 59X-1 and 59X-2. Element logic connections are made on the BESTlogic™ *Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Auxiliary Overvoltage (59X) 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, Auxiliary Overvoltage (59X)

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 or 1), Voltage Protection, Auxiliary Overvoltage 59X

Element Operation

Auxiliary overvoltage protection can be used to protect equipment from damage caused by phase failure, phase unbalance or ground faults.

Fault Recorder

When the Fault Recorder setting is enabled, recording starts when the Pickup output becomes true. Pre-fault cycles are included per the fault recording settings described in the *Fault Reporting* chapter.

Modes of Protection

Three modes of protection are available: 3V0, 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. To use 3V0 mode, the VTP connection cannot be single-phase.

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 BE1-700. The phase VT inputs (Va, Vb, Vc) are used when 3V0 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 Typical Connections* 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 BESTCOMS*Plus* 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 BESTCOMS*Plus*. See Table 21-1 for a full list of possible settings. The Aux VT Connection parameter is found on the System Parameters/Sensing Transformers settings screen in BESTCOMS*Plus*. For more information on the auxiliary VT setup, see the *Power System Configuration* chapter.

Table 21-1. 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	3V0	VPN

Pickup and Trip

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 and control other elements in logic.

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. A Time Delay setting of zero (0) makes the 59X element instantaneous with no intentional time delay.

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 future events.

Trip

The Trip output becomes true if an overvoltage 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 BE1-700 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 BE1-700 can be used to block Auxiliary Overvoltage (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 3V0 Voltage Elements 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 *BESTCOMSPPlus*. The auxiliary overvoltage element logic block is illustrated in Figure 21-1. Logic inputs and outputs are summarized in Table 21-2.

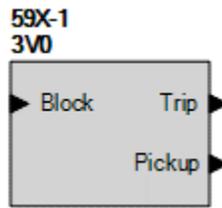


Figure 21-1. Auxiliary Overvoltage Element Logic Block

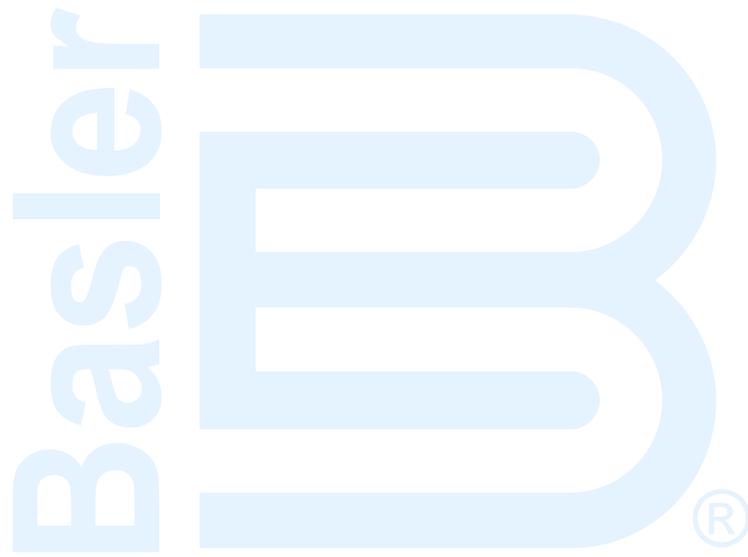
Table 21-2. Logic Inputs and Outputs

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 21-2) in BESTCOMSPlus.

Figure 21-2. Auxiliary Overvoltage Settings Screen



22 • Frequency (81)

Six frequency (81) elements monitor the frequency of the sensing voltage applied to the BE1-700. An element can be configured to protect against underfrequency or overfrequency.

The six, identical frequency protection elements are designated 81-1, 81-2, 81-3, 81-4, 81-5 and 81-6. 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.

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

HMI Navigation Path: Settings Explorer, Protection, Settings Group x (where x = 0 or 1), Frequency Protection 81

Frequency Measurement

For four-wire or single-phase sensing connections, the power system frequency is measured through the BE1-700 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 BE1-700 auxiliary voltage (Vx) sensing input. Refer to the *Terminals and Typical Connections* chapter for information on voltage connections.

To measure frequency, the voltage sensed by the BE1-700 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 unhealthy power sources, 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 case of a load-to-generation match). This makes frequency measurement an excellent method for detecting an island condition.

Any of the six 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 BE1-700 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

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 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 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 BE1-700 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 and its unit of measure depends upon the phase VT connection setting. For four-wire or phase-to-neutral sensing connections the inhibit level is expressed in Vpn. For three-wire or phase-to-phase sensing connections the inhibit level is expressed in Vpp.

Element Blocking

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

Frequency element logic connections are made on the *BESTlogicPlus* screen in *BESTCOMSPlus*. The frequency element logic block is illustrated in Figure 22-1. Logic inputs and outputs are summarized in Table 22-1.

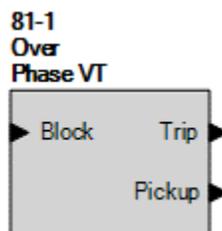


Figure 22-1. Frequency Element Logic Block

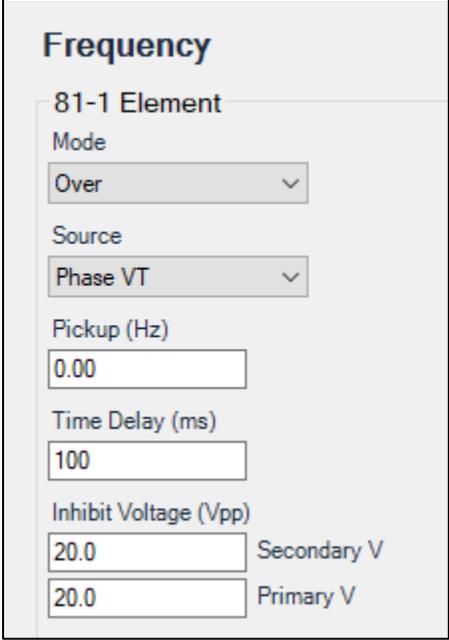
Table 22-1. Logic Inputs and Outputs

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 22-2) in BESTCOMSPlus.

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



Frequency

81-1 Element

Mode
Over

Source
Phase VT

Pickup (Hz)
0.00

Time Delay (ms)
100

Inhibit Voltage (Vpp)
20.0 Secondary V
20.0 Primary V

Figure 22-2. Frequency Settings Screen



23 • Virtual Control Switch (43)

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

The four, identical virtual control switch elements are designated 43-1, 43-2, 43-3, and 43-4. 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 BE1-700 or in series with the ground trip output of the BE1-700. Instead, a virtual control switch can be used to reduce costs with the added benefit of being able to operate the switch both locally through the front panel and remotely from a substation computer or through an Ethernet connection to a remote operator's console.

Mode

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

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 23-1).
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.

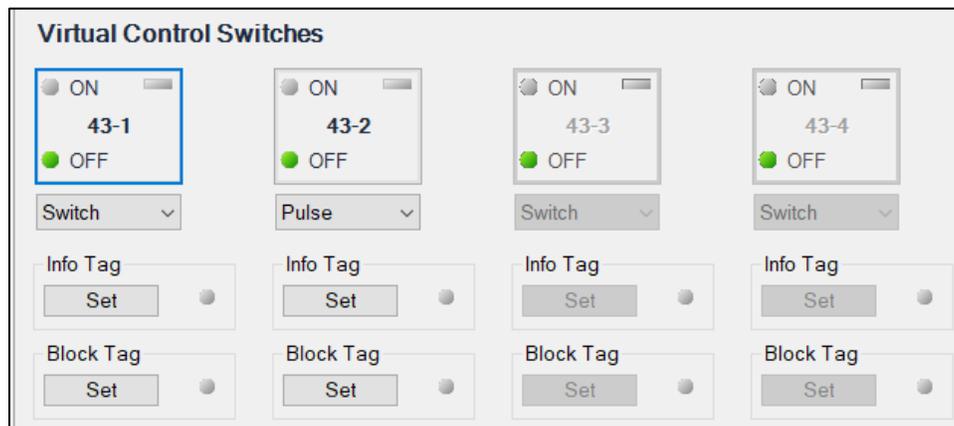


Figure 23-1. Virtual Switches Control Screen

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 23-1.

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 BESTlogic™ *Plus* screen in BESTCOMSP*lus*®. The virtual control switch element logic block is illustrated in Figure 23-2. Logic inputs and outputs are summarized in Table 23-1.

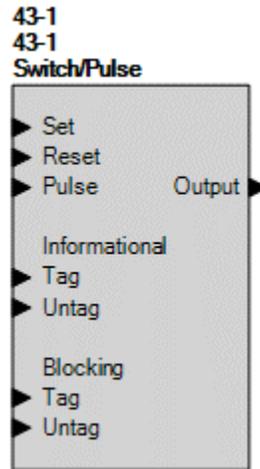


Figure 23-2. Virtual Control Switch Element Logic Block

Table 23-1. 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 23-3) in BESTCOMSP*lus*®.

Virtual Control Switches (43)

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

Figure 23-3. Virtual Control Switches Settings Screen

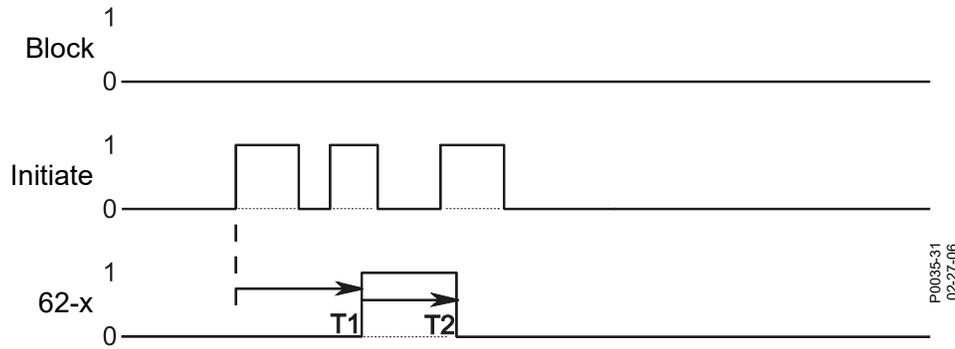


Figure 24-2. One-Shot/Non-Retriggerable Mode

One-Shot/Retriggerable Mode

The one-shot retriggerable timer starts its timing sequence when the Initiate input changes from false to true. See Figure 24-3. 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.

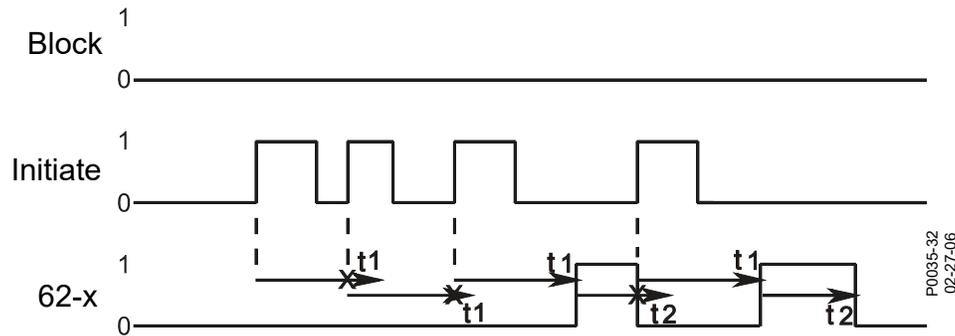


Figure 24-3. One-Shot/Retriggerable Mode

Oscillator Mode

In this mode, the Initiate input is ignored. See Figure 24-4. 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.

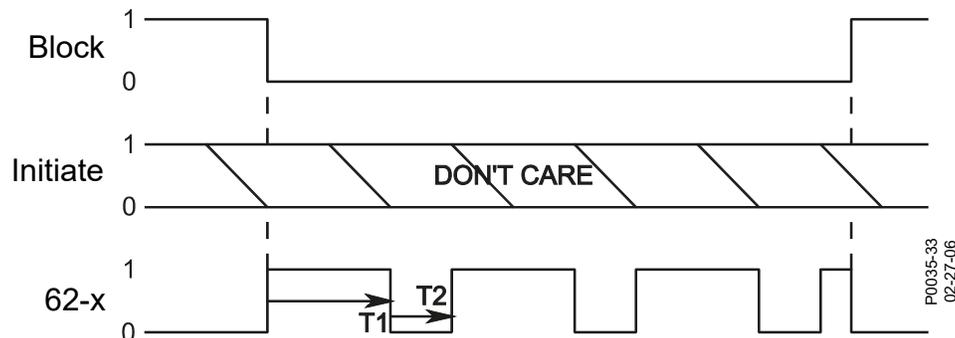


Figure 24-4. Oscillator Mode

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 24-5, 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 overvoltage (59) element could be used to monitor the voltage level. Thus, if the voltage 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. The BE1-700 protective elements require signals to be several percent from pickup to reset. This avoids the necessity to use integrating timers for many applications. See the *Specifications* chapter for reset characteristics.

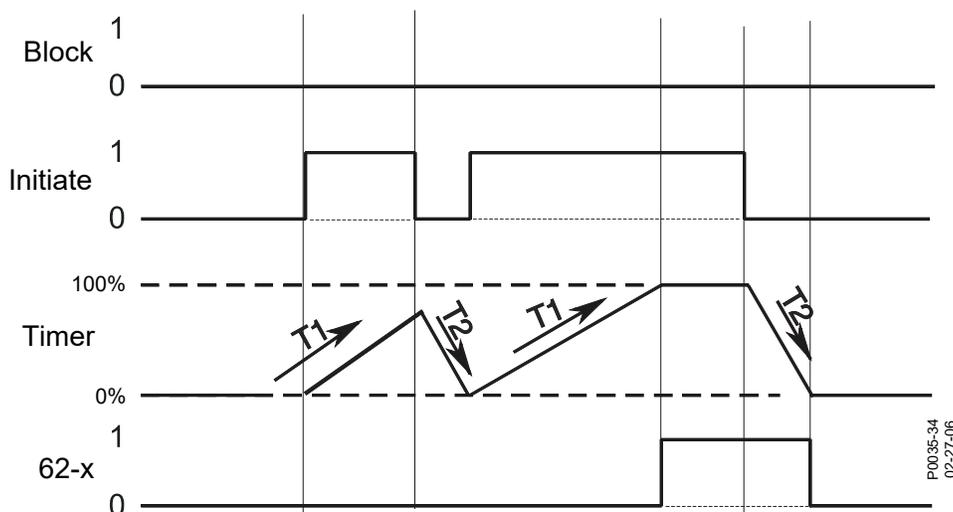


Figure 24-5. Integrating Timer Mode

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 24-6. Latched timers reset if control power is cycled.

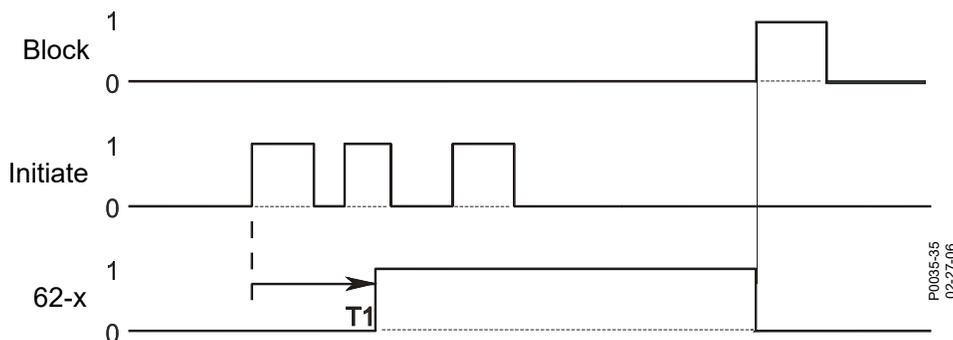


Figure 24-6. Latched Mode

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 24-7. Logic inputs and outputs are summarized in Table 24-1.

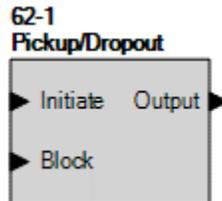


Figure 24-7. Logic Timer Element Logic Block

Table 24-1. 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 24-8) in *BESTCOMSPlus*.

Figure 24-8. Logic Timers Settings Screen

25 • Recloser (79)

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

Element logic connections are made on the BESTlogic™ *Plus* screen in BESTCOMS*Plus*® and element operational settings are configured on the Recloser (79) screen in BESTCOMS*Plus*. A summary of the logic inputs and outputs, operational settings, and an overall logic diagram 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 or 1), 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 BE1-700 goes to lockout after power is restored.

Power Up to Reclose

When power is lost during a reset condition, the BE1-700 initiates a first programmed reclose after power is restored if the breaker is open (Breaker Status is Open) and the Initiate input of the 79 element is true.

Inputs and Outputs

Logic inputs and Outputs are described in the following paragraphs.

Initiate Input

The Initiate input is used with the Breaker Status logic element to start the reclose timers at each step of the reclosing sequence. To start the automatic reclose timers, the Initiate input must be true and Breaker Status 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 25-1 illustrates the recognition dropout logic and timing relationship.



Figure 25-1. Recognition Dropout Timing

Wait Input

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) Input

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.

Pilot Initiate Input and Pilot Output

If the recloser is in the reset state upon receiving a pilot initiate input signal, the reclose logic issues a pilot output after the programmed time delay. The initiate logic shall be held for 100 ms to ensure that it will be there when the Breaker Status input and the Pilot Initiate input are compared. If the recloser is in the reset state and the Pilot Initiate and Initiate inputs are received simultaneously with the breaker status open, the pilot timer shall be initiated instead of the first reclose timer. After the pilot timer expires, only the Initiate input is monitored to start the delayed reclosing sequence if the Breaker Status input indicates that the breaker opened before the reset time has expired.

Upon a trip, when the recloser is in reset, the pilot time delay is non-zero, and the first reclose time delay is zero, a reclose initiate causes the relay to use the second reclose time delay instead of the first.

Zone Pickup and Zone Trip Inputs

To coordinate tripping and reclosing sequences with downstream protective relays and reclosers, the BE1-700 senses downstream faults when a user programmable logic of the Zone setting picks up and then drops out without a trip output. If the upstream device (BE1-700) senses that a downstream device has cleared a fault, the BE1-700 will increment the trip/reclose sequence by one operation.

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.

Close Output

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:

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

Reset Output

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

Lockout Output

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 is true.
- The maximum reclose cycle time is exceeded.

Running Output

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) Output

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 25-2 illustrates SCB logic.

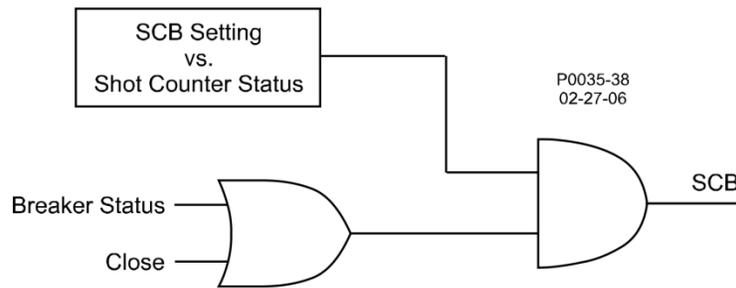


Figure 25-2. Sequence Control Blocking Logic

Reclosing Fail Timer

This timer begins when the Close output becomes true and continues counting until the Breaker Status becomes true. If the Fail Timer times out, the recloser function is driven to lockout and the Lockout output becomes true. The BE1-700 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 BESTCOMSPPlus.

Maximum Timer

Maximum Time 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 Maximum 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 Maximum timer can be disabled by setting it at zero (0). The Wait input does not pause the Maximum timer. The maximum time is set on the Recloser screen in BESTCOMSPPlus®.

Sequence Controlled Blocking (SCB)

The SCB output is true when breaker status is 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 BESTCOMSPPlus by checking the appropriate Trip box.

Figure 25-3 shows a logic timing diagram showing all possible sequence controlled blocks enabled (true). In Figure 25-4, 79RTD is the reclose reset time delay and 79#TD is the reclose time delay where # is the reclose shot number.

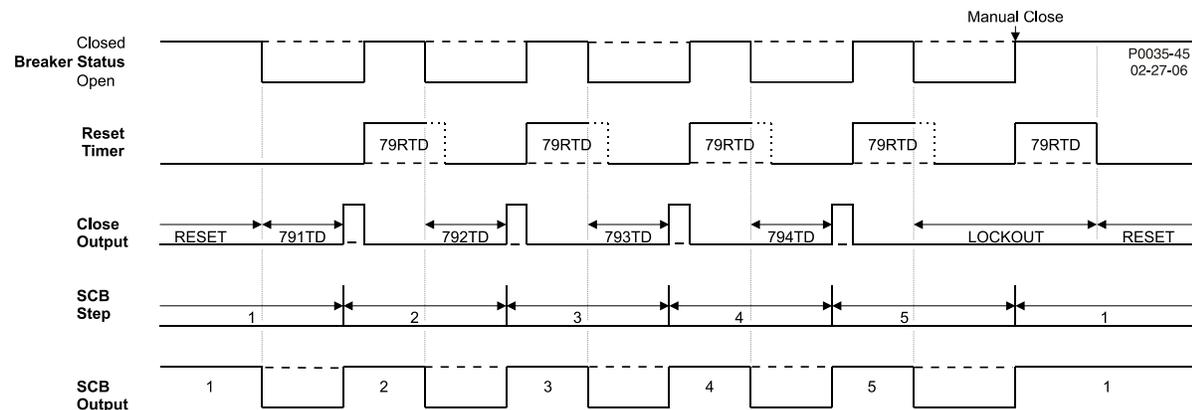


Figure 25-3. SCB=1/2/3/4/5 Logic Timing Diagram

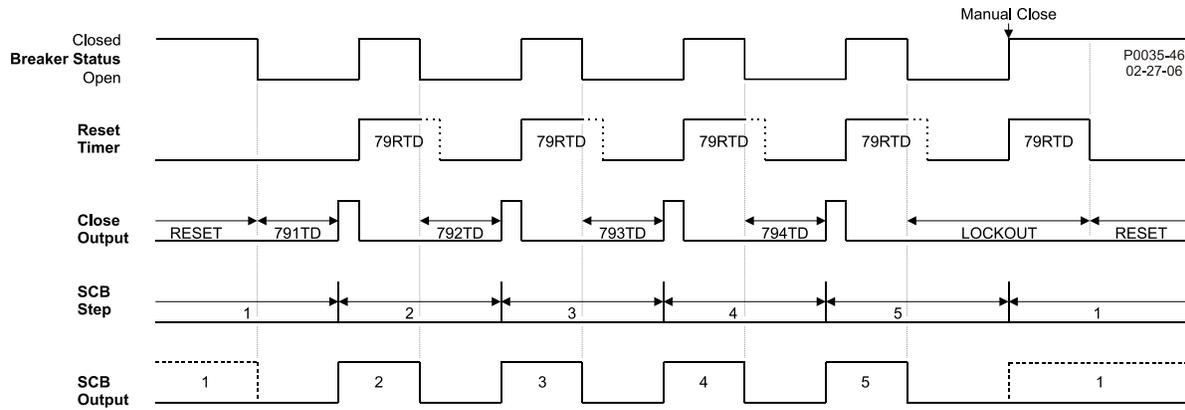


Figure 25-4. Sequence Control Blocking Timing Diagram

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. Detailed information about BE1-700 setting groups can be found in the *Setting Groups* chapter.

Logic Connections

Recloser element logic connections are made on the BESTlogicPlus screen in BESTCOMSPlus. The recloser element logic block is illustrated in Figure 25-5. Logic inputs and outputs are summarized in Table 25-1.

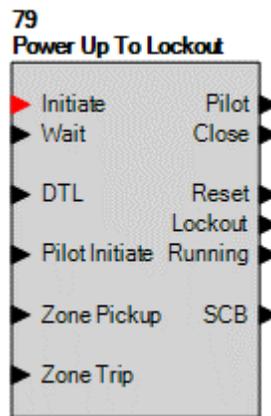


Figure 25-5. Recloser Element Logic Block

Table 25-1. 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)
Pilot Initiate	Input	Initiates the Pilot function
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

Name	Logic Function	Purpose
Pilot	Output	True after the Pilot time delay has expired
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
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 25-6) in BESTCOMSPi.us.

The screenshot shows the 'Recloser' settings screen for a '79 Element'. The settings are as follows:

- Mode: Power Up To Lockout (dropdown)
- Pilot Time (ms): 0
- Reclose 1 Time (ms): 100
- Reclose 2 Time (ms): 0
- Reclose 3 Time (ms): 0
- Reclose 4 Time (ms): 0
- Sequence Controlled Block: Trip 1 (Off), Trip 2 (Off), Trip 3 (Off), Trip 4 (Off), Trip 5 (Off) (dropdowns)
- Reset Time (ms): 10000
- Maximum Time (ms): 60000
- Fail Time (ms): 1000

Figure 25-6. Recloser Settings Screen

Logic Diagram

Figure 25-7 illustrates an overall logic diagram for the recloser element.

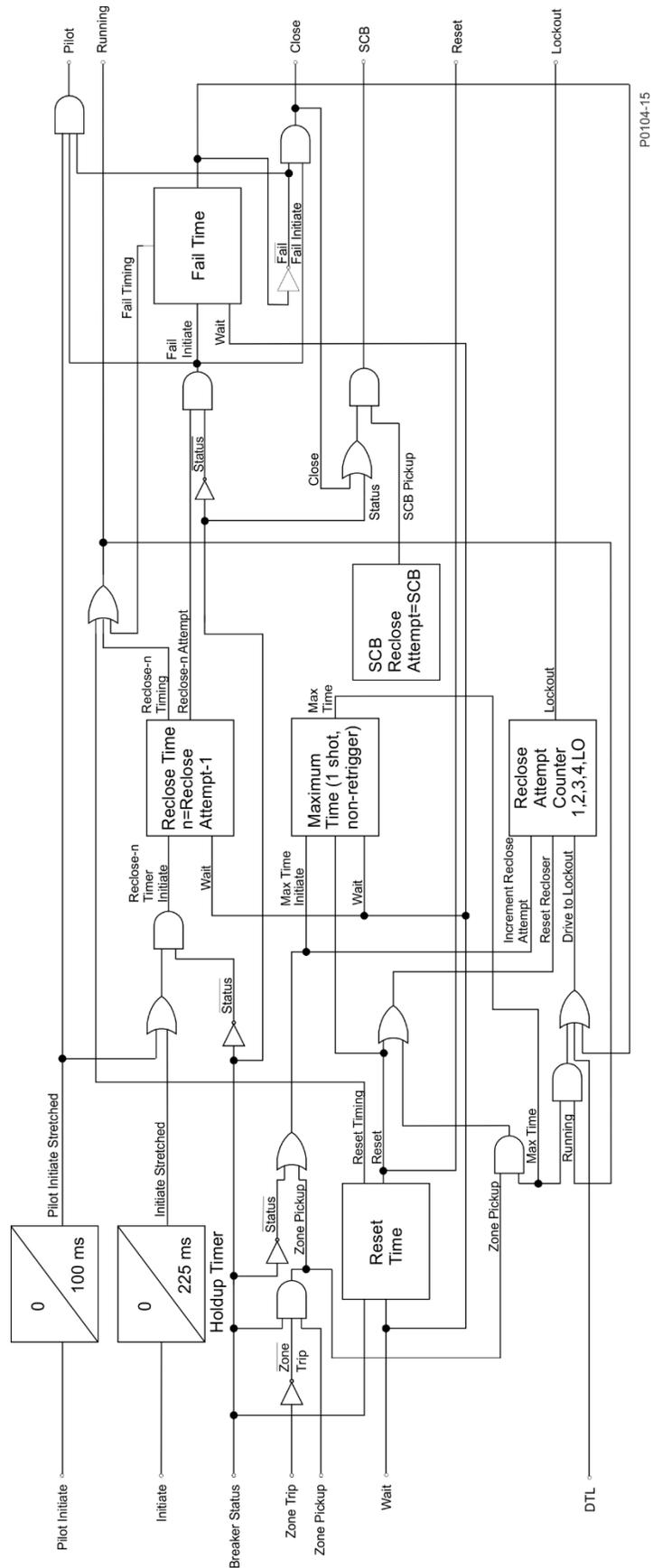


Figure 25-7. Overall Logic Diagram for Reclosing

26 • Breaker Control Switch (101)

The breaker control switch (101) element provides manual control of a circuit breaker or switch without using physical switches or interposing relays. Both local and remote control is possible. A virtual switch can be used instead of a physical switch to reduce costs with the added benefit that the virtual switch can be operated both locally from the front panel and remotely from a substation computer or Ethernet connection to an operator's console.

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

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

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

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

HMI Control Navigation Path: Metering Explorer, Control, 101 Breaker Ctrl Switch

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 26-1 shows the state of the TSC and CSC logic outputs with respect to the state of the Trip and Close outputs.

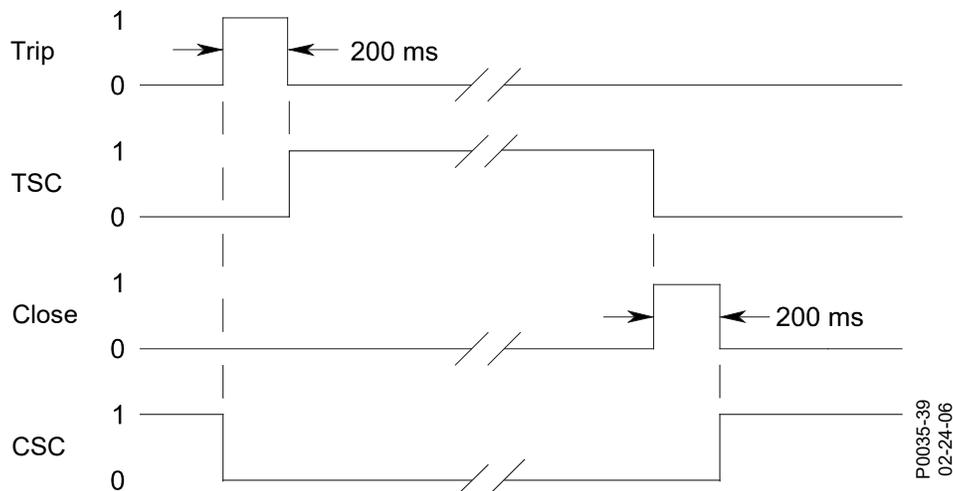


Figure 26-1. Breaker Control Switch State Diagram

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 BE1-700 will power up with the contact in the same state as when the BE1-700 was powered down.

Control of Breaker Control Switch

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

1. Use the Metering Explorer to open the Control/Breaker Control Switch tree branch (Figure 26-2).
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.

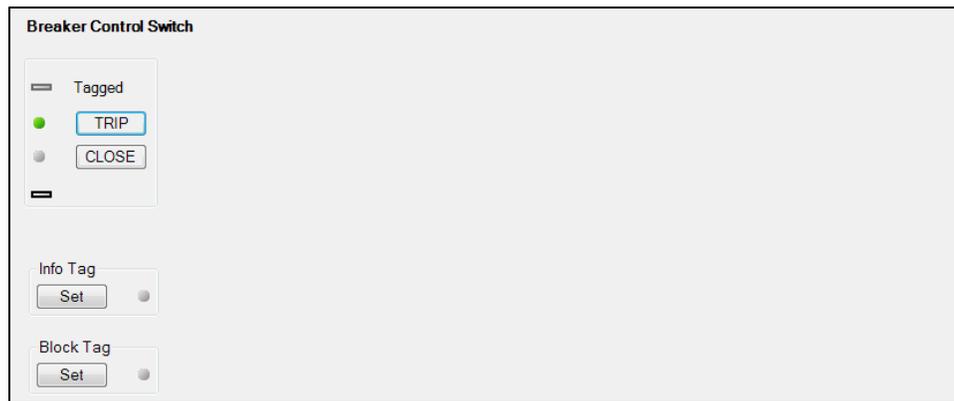


Figure 26-2. Breaker Control Switch Control Screen

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 indicator on this screen.

Tagging of the breaker control switch can be accomplished through the front panel and through BESTCOMSP*lus*. Use the Metering Explorer in BESTCOMSP*lus* to open the Control/Breaker Control Switch tree branch. Click on the Set button for Informational Tag, Blocking Tag, or both. If tagging is successful, a green indicator to the right of the Set button will 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 BESTCOMSP*lus*, it can be removed only through BESTCOMSP*lus*. It cannot be removed through the front panel. If a tag is placed through the front panel, it can be removed only through the front panel. This applies for all other forms of communication when placing tags.

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

Logic Connections

Breaker control element logic connections are made on the BESTLogic*Plus* screen in BESTCOMSP*lus*. The breaker control element logic block is illustrated in Figure 26-3. All logic inputs use rising-edge detection for recognition. Logic inputs and outputs are summarized in Table 26-1.

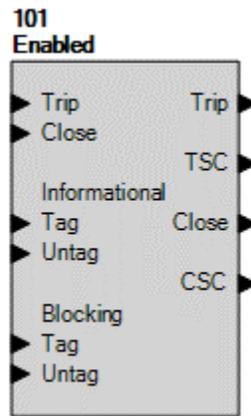


Figure 26-3. Breaker Control Element Logic Block

Table 26-1. 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 26-4) in BESTCOMSPlus.

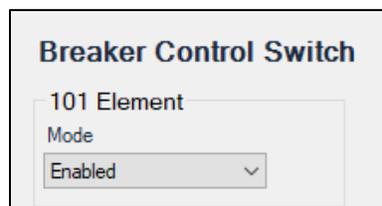


Figure 26-4. Breaker Control Switch Settings Screen



27 • 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 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 in parallel with the OUT1 contact. See Figure 27-1. This contact is used in the preprogrammed logic schemes as the main trip output. The detector circuit across OUT1 is not polarity sensitive because the optical isolator used for detecting continuity is connected across a full wave bridge.

The amount of current drawn through the optical isolator circuit depends on the total input impedance for each power supply voltage rating. See Table 27-1.

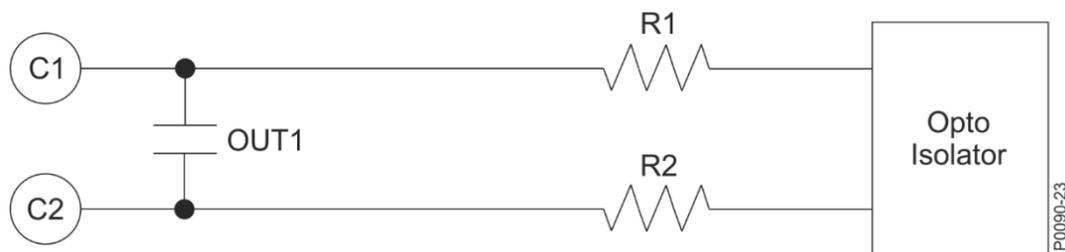


Figure 27-1. Trip Detector Circuit

Table 27-1. 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 kΩ	6.8 kΩ	16.2 kΩ	6.0 V (0.370 mA)	19.2 V (1.19 mA)
48/125 Vdc	9.4 kΩ	24 kΩ	33.4 kΩ	12.0 V (0.359 mA)	38.4 V (1.15 mA)
125/250 Vdc	9.4 kΩ	82 kΩ	91.4 kΩ	31.2 V (0.342 mA)	100 V (1.09 mA)

Figure 27-2 illustrates typical trip circuit monitor connections for the BE1-700.

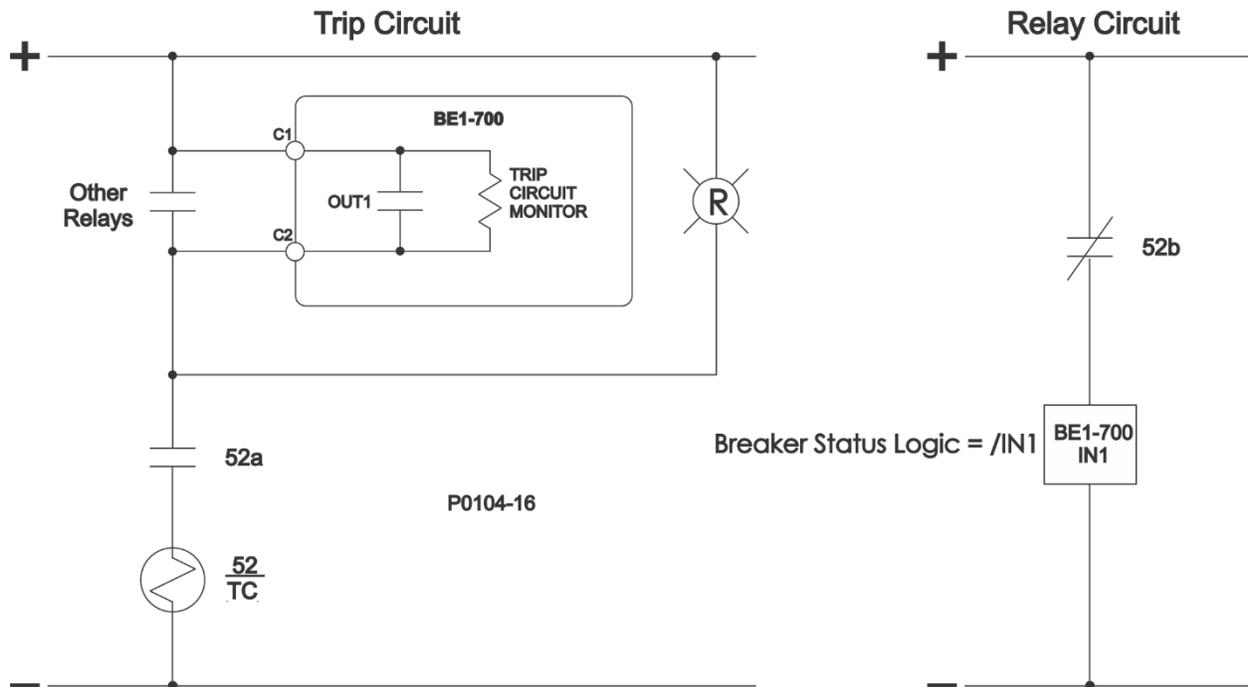


Figure 27-2. Typical trip Circuit Voltage and Continuity Monitor

Caution

Applications that place other device inputs in parallel with the breaker trip coil may not perform as desired. The connection of other devices in parallel with the trip coil causes a voltage divider to occur when the breaker or trip circuit is open. This may cause false tripping of the other devices and prevent the BE1-700 trip circuit monitor from reliably detecting an open circuit. Contact Basler Electric for advice on this application.

The circuit monitor sensing element has the same rating as the power supply voltage. If the trip circuit voltage is significantly greater than the power supply voltage (for example, when using a capacitor trip device), the user should program the BE1-700 to use one of the other output relays for tripping. In this situation, the trip circuit monitor function will not be available.

In Figure 27-3, 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 27-3 to isolate the TCM circuit from the effects of 62X.

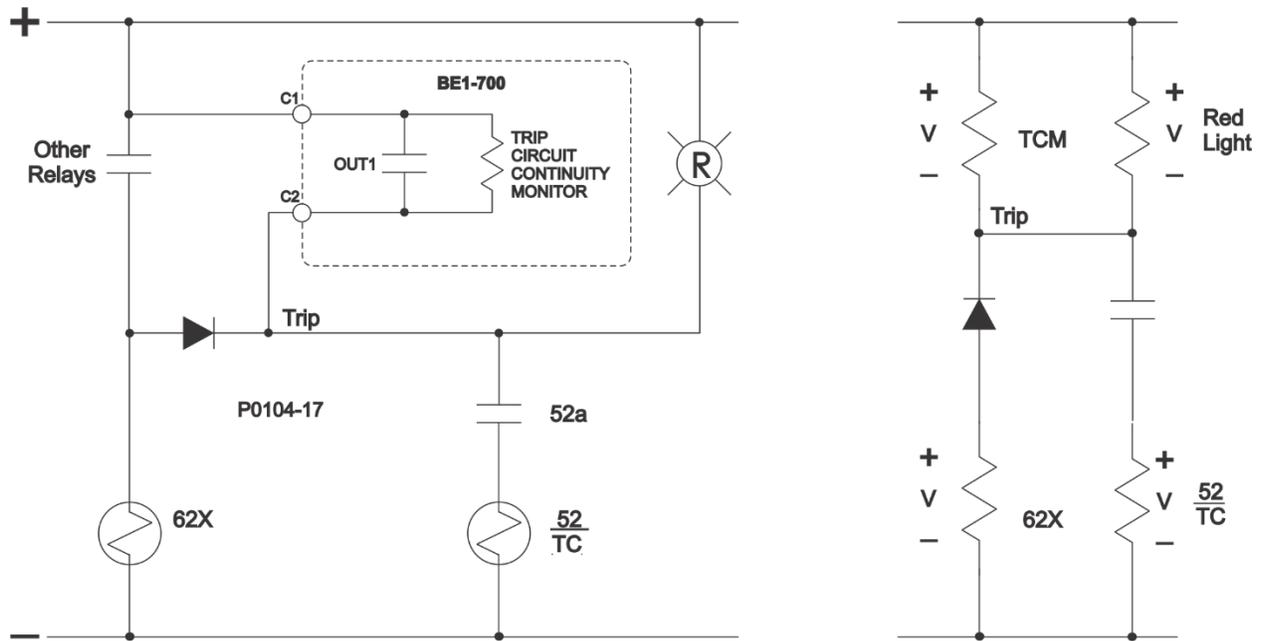


Figure 27-3. TCM with Other Devices

Logic Connections

Trip circuit monitor logic connections are made on the BESTlogicPlus screen in BESTCOMSPPlus. The trip circuit monitor element logic block is illustrated in Figure 27-4. The logic output is summarized in Table 27-2.

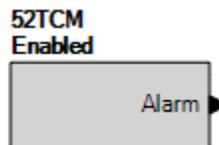


Figure 27-4. Trip Circuit Monitor Element Logic Block

Table 27-2. 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 27-5) in BESTCOMSPPlus.



Figure 27-5. Trip Circuit Monitor Settings Screen



28 • 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 thresholds that are expressed as a percentage of the nominal voltage values. See the *Power System Configuration* chapter for information on changing the nominal voltage values.

When the 60FL element logic becomes true, the Fuse Loss output becomes true. A logic diagram is shown in Figure 28-1. Logic parameters are shown in Table 28-1.

Trip Logic: $60FL \text{ Trip} = (A * C * G)$ (See Table 28-1.)

Reset Logic: $60FL \text{ Reset} = H * /K$ (See Table 28-1.)

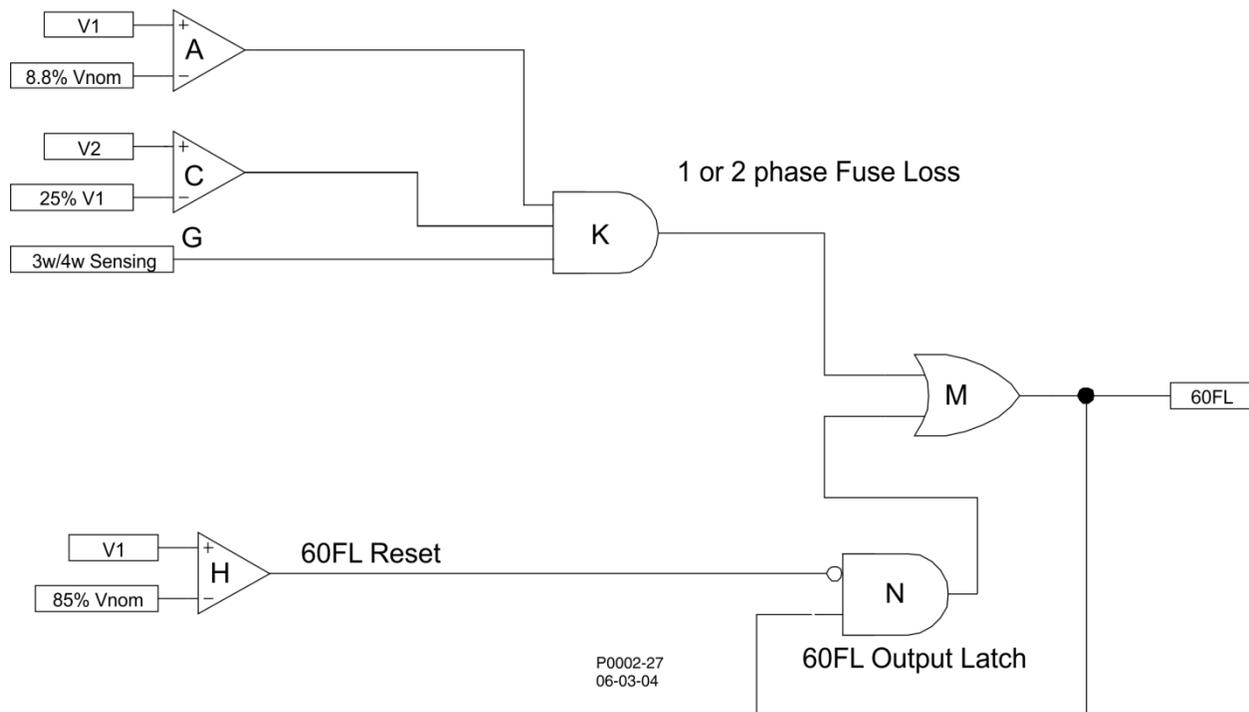


Figure 28-1. Fuse Loss Element Logic

Table 28-1. Fuse Loss Logic Parameters

Input	True Condition
A	Positive-sequence volts greater than 8.8% of the nominal voltage; Detects minimum voltage is applied.
C	Negative-sequence volts greater than 25% of the pos-seq volts; Detects loss of 1 or 2 phase voltages.
G	Three-wire or four-wire sensing selected.
H	Positive-sequence volts greater than 85% of nominal voltage; Detects a restored voltage condition.
K	(A * C * G * J * P); Detects when either one or two phases are lost.
M, N	Latches the 60FL output until the reset criteria are met.

Function Blocking

User selectable block settings determine how the 25, 27, 59, 27X, 59X, and 47 protection functions operate when a fuse loss condition exists. 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.

Programmable Alarm

The BE1-700 indicates an alarm condition when the 60FL element detects a fuse loss or loss of potential. The alarm appears on the front-panel display and on the Alarms metering screen in *BESTCOMSPi.us*. Refer to the *Alarms* chapter for information on how to program alarms.

Logic Connections

Fuse loss logic connections are made on the *BESTlogicPlus* screen in *BESTCOMSPi.us*. The fuse loss element logic block is illustrated in Figure 28-2. The logic output is summarized in Table 28-2.

**Figure 28-2. Fuse Loss Element Logic Block****Table 28-2. 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 28-3) in *BESTCOMSPi.us*. Settings are summarized in Table 28-3.

Fuse Loss (60FL)

60FL Element

Block Phase Voltage Elements (25,27P,59P)

Block 3V0 Voltage Elements (27X,59X)

Block V2 Voltage Elements (47)

Figure 28-3. Fuse Loss Settings Screen

Table 28-3. Operational Settings

Setting	Purpose
Block Phase Voltage Elements	All functions that use phase voltage (P) and positive-sequence voltage (V1) measurements are blocked when the 60FL logic is true. (25, 27P, and 59P)
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. (47)



29 • BESTlogic™ Plus

BESTlogic™ Plus Programmable Logic is a programming method used for managing the input, output, protection, control, monitoring, and reporting capabilities of the BE1-700. Each BE1-700 has multiple, self-contained logic blocks that have all of the inputs and outputs of its discrete component counterpart. Each independent logic block interacts with control inputs and hardware outputs based on logic variables defined with BESTlogic Plus. BESTlogic Plus equations entered and saved in the BE1-700 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 BE1-700 is called a logic scheme.

The BE1-700 contains basic default logic as shown in Figure 29-1. A modified logic scheme is often required before placing the BE1-700 in service. BESTCOMS Plus® can be used to open a logic scheme that was previously saved as a file and upload it to the BE1-700.

BESTlogic Plus is not used to define the operating settings (modes, pickup thresholds, and time delays) of the individual protection and control functions. Operating settings and logic settings are interdependent but separately programmed functions. Changing logic settings is similar to rewiring a panel and is separate and distinct from making the operating settings that control the pickup thresholds and time delays of a BE1-700. 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 20TBW (Terabytes Written). 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

BESTlogic Plus settings are made through BESTCOMS Plus. Use the Settings Explorer to open the BESTlogic Plus Programmable Logic tree branch as shown in Figure 29-1.

The BESTlogic Plus Programmable Logic screen contains a logic library for opening and saving logic files, tools for creating and editing logic documents, and protection and control settings.

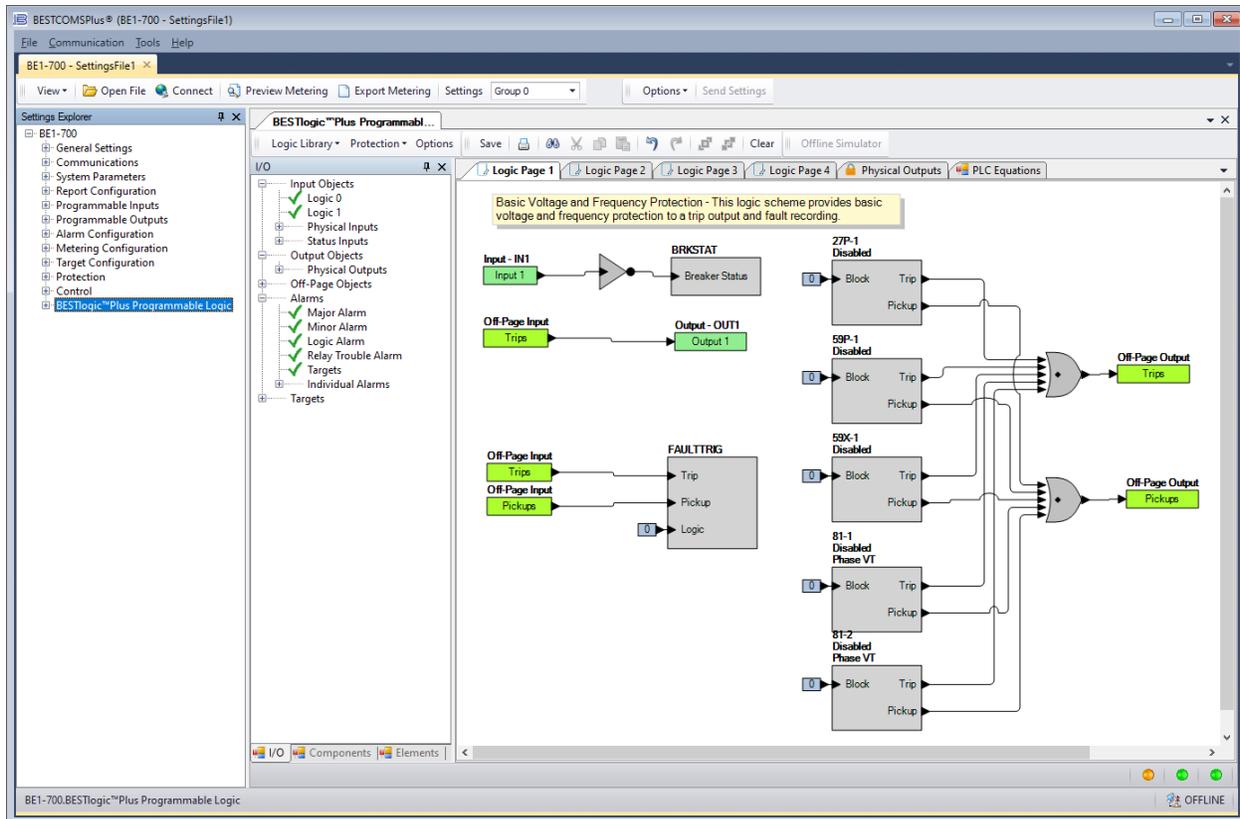


Figure 29-1. BESTlogicPlus Programmable Logic Tree Branch

BESTlogicPlus File Management

BESTlogicPlus files are a subset of the full settings files and can be managed separately if desired. 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 29-2. For information on Settings Files management, refer the *BESTCOMSPPlus Software* chapter.



Figure 29-2. BESTlogicPlus Programmable Logic Toolbar

Saving a BESTlogicPlus 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 BE1-700, you must select Save from the File pull-down menu located at the top of the BESTCOMSPPlus 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 BESTlogicPlus 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 BESTlogicPlus 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 BESTlogicPlus File

To upload a BESTlogicPlus file to the BE1-700, 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 BESTlogicPlus File

To download a BESTlogicPlus file from the BE1-700, 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 BESTlogicPlus File

To print or export the logic, click on the Print (🖨) icon located on the BESTlogicPlus Programmable Logic toolbar. From the Print screen, logic can be exported to file formats such as PDF, emailed, and printed.

Clearing the On-Screen Logic Diagram

Click the Clear button to clear the on-screen logic diagram on *all* logic pages and start over.

Programming BESTlogicPlus

BESTCOMSPlus is used to program BESTlogicPlus. Using BESTCOMSPlus is analogous to physically attaching wire between discrete BE1-700 terminals. To program BESTlogicPlus, use the Settings Explorer within BESTCOMSPlus to open the BESTlogicPlus Programmable Logic tree branch as shown in Figure 29-1.

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 input. Use OR and other gates if multiple conditions need to drive input points. Use OR and other gates if multiple conditions need to drive output points. If the proximity of the endpoint of the wire/link is not exact, it may attach to an unintended port.

The view of a Logic Page can be automatically arranged by clicking the right mouse button on the window and selecting Auto-Layout.

The following must be met before BESTCOMSP*Plus* will allow logic to be uploaded to the BE1-700:

- 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
- Cannot include functions not supported by the configuration
- Cannot include logic errors such as unlinked ports (shown as red arrows in logic diagram). Right click on the node and select remove unlinked ports if logic functions as desired.

The BESTlogic*Plus* processing sequence is performed in non-software selectable layers. Every protective, control, input, and alarm function is scanned in the first layer in a predefined sequence. This sequence is not strictly alphabetical. Feedback loops are processed only after all other functions have been run through the full logic sequence. A logic diagram, with elements 27X-1, 27P-2, 59P-1, and IN-3 for example, will process in that sequence regardless of where they are located in a graphical logic string. After every node's output is determined, it moves to the next layer and repeats the process. The physical position of any component and logic page do not impact the processing sequence.

Three status indicators are located in the lower right corner of the BESTlogic*Plus* window. These indicators show the Logic Save Status, Logic Diagram Status, and Logic Layer Status. Table 29-1 defines the colors for each indicator.

Table 29-1. 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 	Error or unlinked port exists on presently viewed tab
	Green 	Logic file does not contain any errors or unlinked ports
Logic Layer Status (Right Indicator)	Red 	Error or unlinked port exists on at least one tab
	Green 	Presently viewed tab does not contain any errors or unlinked ports

Pickup and Dropout Timers

Pickup and dropout timer logic blocks are shown in Figure 29-3. These simplified timers can be used in cooperation with or independently of 62 Element Logic timers, which include additional modes and features.

To program logic timer settings, use the Settings Explorer within BESTCOMSP*Plus* to open the BESTlogic*Plus* Programmable Logic, Logic Timers tree branch. Enter a Name label that you want to appear on the timer logic block. The Time Delay value range is 0.0 to 1800.0 seconds in 0.1-second increments.

Next, open the Components tab inside the BESTlogic*Plus* window and drag a timer onto the program grid. Right click on the timer to select the timer you want to use that was previously set on the Logic Timers tree branch. The Logic Timer Properties Dialog Box will appear. Select the timer you want to use.

Timing accuracy is ± 15 milliseconds.

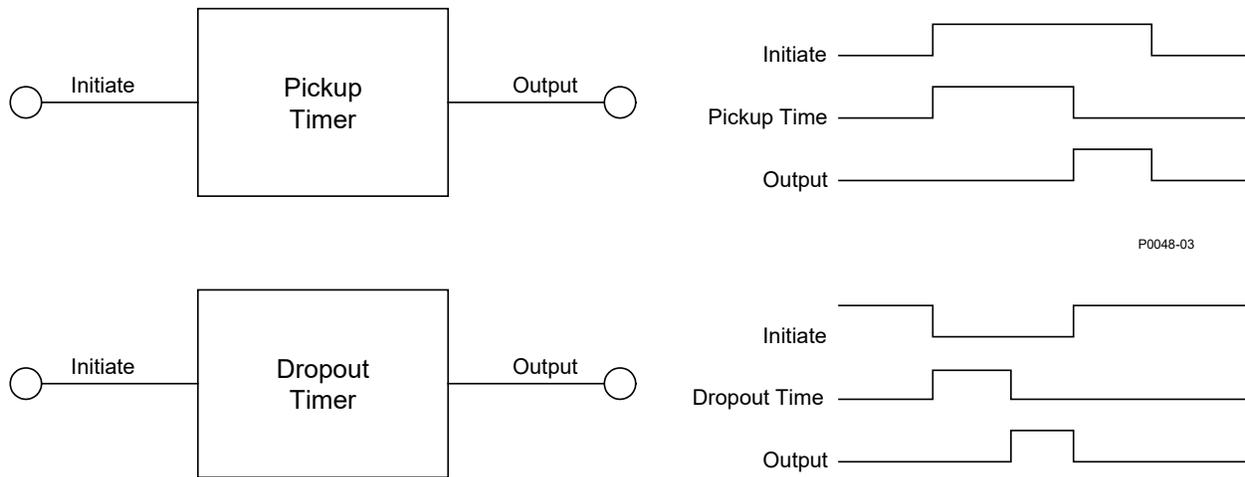


Figure 29-3. Pickup and Dropout Timer Logic Blocks

Offline Logic Simulator

You can use the offline logic simulator to test your custom logic before placing it in operation. The state of the 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 and all three logic status indicators must be green. 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. The offline simulator does not process protective and control element blocks so simulators must intentionally toggle input and output states as desired such as turning off a Trip output if the Block input is true. Simulation will process Boolean gates, simplified logic timers, latches, and counters.

An example of the offline logic simulator is shown in Figure 29-4.

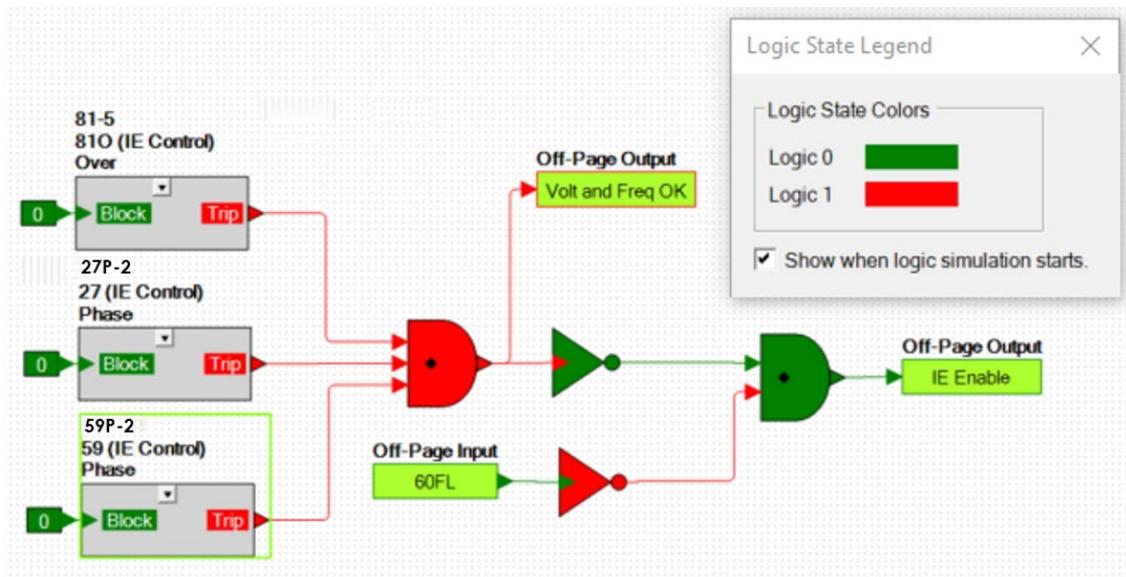


Figure 29-4. Offline Logic Simulator Example

BESTlogicPlus Composition

There are three main groups of objects used for programming BESTlogicPlus. These groups are I/O, Components, and Elements.

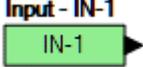
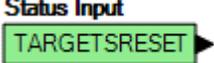
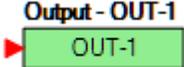
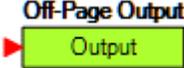
The logic workspace will expand automatically. Bring to Front and Send to Back buttons along the BESTlogicPlus menu bar allows intentional logic layering.

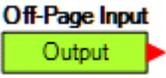
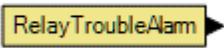
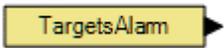
Logic can be created on any of the available four tabs. Right click on the workspace to rename logic tabs.

I/O

Input objects can be logically connected to any logic block input. Output objects can be logically connected to any logic block output. Table 29-2 lists the names and descriptions of the objects in the I/O group.

Table 29-2. I/O Group

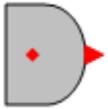
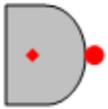
Name	Description	Symbol
Input Objects		
Logic 0 Fixed Bit	Always false (Low). Double-click or right-click on the object to change the fixed state from 0 to 1.	
Logic 1 Fixed Bit	Always true (High). Double-click or right-click on the object to change the fixed state from 1 to 0.	
Physical Inputs	True when a configured input instance 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 Targets Reset	The Target Reset status input goes momentarily high when the targets are cleared.	
Output Objects		
Physical Outputs	Closes a configured output instance when true. Form C outputs are configured by the normally open contact and the normally closed follows as the opposite state.	
Off-Page Objects		
Off-Page Output	Used in conjunction with the Off-Page Input to consolidate logic to a single status point and 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.	

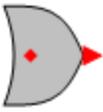
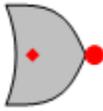
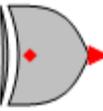
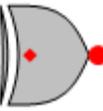
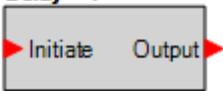
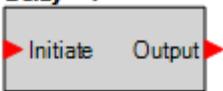
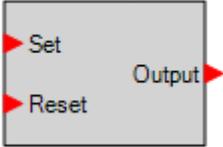
Name	Description	Symbol
Off-Page Input	Used in conjunction with the Off-Page Output to consolidate logic to a single status point and to transform an output on one logic page into an input on another logic page. Inputs can be renamed by right-clicking and selecting Rename Input. Right-clicking will also show pages that the corresponding outputs can be found on. Selecting the page will take you to that page.	
Alarms		
Logic	True when the Logic Alarm is true.	
Major	True when the Major Alarm is true.	
Minor	True when the Minor Alarm is true.	
Relay Trouble	True when a Relay Trouble alarm is active.	
Targets	True when targets are active.	
Targets		
Protection Targets	True when a protection element target is active. Target logic is available for all protection elements. The 24 element target logic is shown as an example.	

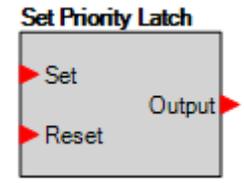
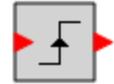
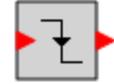
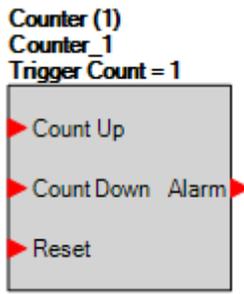
Components

Double-click or right-click on a gate to change the type. Table 29-3 lists the names and descriptions of the objects in the Components group.

Table 29-3. Components Group

Name	Description	Symbol										
Logic Gates												
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	
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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	
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1 1	0											

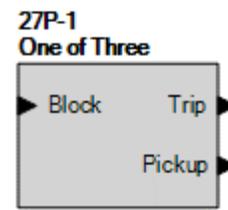
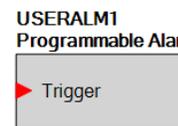
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NOT (INVERTER)	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Input</th> <th>Output</th> </tr> </thead> <tbody> <tr><td>0</td><td>1</td></tr> <tr><td>1</td><td>0</td></tr> </tbody> </table>	Input	Output	0	1	1	0					
Input	Output											
0	1											
1	0											
Pickup and Dropout Timers												
Pick Up Timer	<p>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 50.</p>	<p>Pick Up Timer (1) TIMER_1 Delay = 1</p> 										
Drop Out Timer	<p>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 50.</p>	<p>Drop Out Timer (1) TIMER_1 Delay = 1</p> 										
Latches												
Reset Priority Latch	<p>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.</p>	<p>Reset Priority Latch</p> 										

Name	Description	Symbol
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.	
Triggers		
Rising Edge	The output of a rising edge trigger pulses true when the input goes from logic 0 to logic 1. Double-click or right-click on the logic trigger to change the type.	
Falling Edge	The output of a falling edge trigger pulses true when the input goes from logic 1 to logic 0. Double-click or right-click on the logic trigger to change the type.	
Logic Counters		
Logic Counters	A logic counter produces a true Alarm output when the elapsed count is greater than or equal to the Trigger Count setting after a false to true transition occurs on the Count Up input from the connected logic. A positive going edge on the Reset input will reset the counter. The count will be reduced by 1 each time a false to true transition occurs on the Count Down input. Double-click or right-click on the logic counter to select from counters 1 through 30.	
Other		
Logic Comment Block	The logic comment block is used to place notes on the logic.	

Elements and Alarms

Table 29-4 provides an example of the names and descriptions of the elements in the Elements group and an example Alarm.

Table 29-4. Elements Group

Name	Symbol
Protection and Control	
<p>27P Phase Undervoltage Note: The 27P logic block is shown as an example. All other elements are shown in their respective chapters.</p>	
Reporting and Alarms	
<p>User Programmable Alarm Note: The UserAlarm1 logic block is shown as an example. All other elements are shown in their respective chapters.</p>	



30 • Communications

This chapter describes the connections and settings for BE1-700 communication, in addition to standard USB, RS-485, and optional Ethernet communication.

Available ports for communicating with the BE1-700 include USB, RS-485, and Ethernet. DHCP (Dynamic Host Configuration Protocol) is enabled by default allowing the BE1-700 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 BE1-700. Refer to the *Terminals and Typical Connections* chapter for views of the communication ports and the *BE1-700 Modbus® Protocol Instruction* manual for Modbus® specific information.

USB Connection

A front-panel USB-C connector provides local communication with a PC operating BESTCOMSPi^{us}® software.

Ethernet Connection

BE1-700 protection systems with Communication Protocol style option 8 have a rear-panel Ethernet port. The 10BASE-T/100BASE-TX port is an eight-pin RJ45 connector that connects to shielded, twisted-pair, Category 5 copper wire media.

RS-485 Connections

RS-485 connections are made at a three-position terminal block connector that mates with a standard communication cable. A twisted shielded-pair cable is recommended with the shield grounded at both ends to a common ground potential. Connector pin numbers, functions, names, and signal directions are shown in Table 30-1. An RS-485 connection diagram is provided in Figure 30-1.

Table 30-1. 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

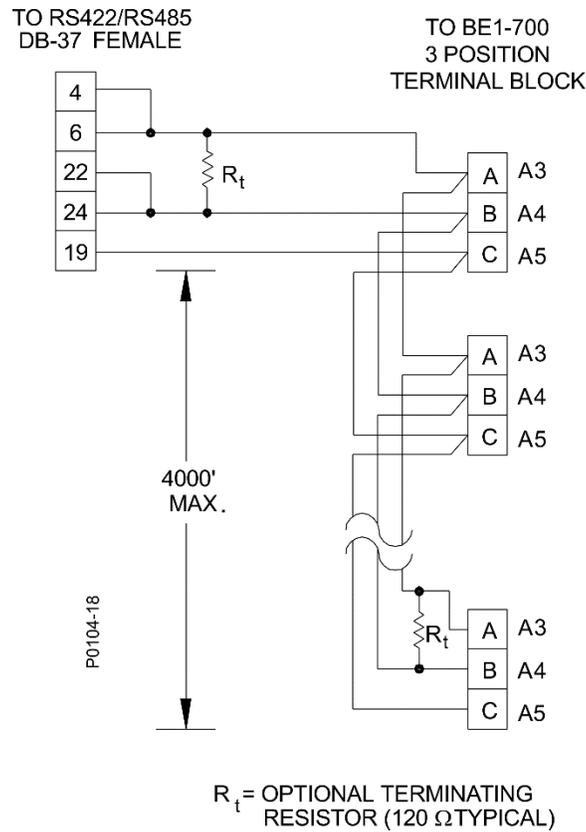


Figure 30-1. RS-485 DB-37 to BE1-700

Ethernet Setup

Located on the rear panel, the optional Ethernet communication port provides dynamic addressing (DHCP) as well as communication with a PC running BESTCOMSP*lus* and Modbus software. Additional Ethernet settings are illustrated in Figure 30-2.

Ethernet Port Configuration

Initially you must use a USB connection on the front panel to configure communications.

1. Connect an Ethernet cable between the BE1-700 and your network.
2. Connect a USB cable between the BE1-700 and your PC.
3. Apply operating power to the BE1-700 and wait until the boot sequence is complete.
4. Use BESTCOMSP*lus* to connect to the BE1-700 through the USB port.
5. Select Configure, Ethernet from the Communication pull-down menu. If the BE1-700 is connected properly, the Configure Ethernet Port screen shown in Figure 30-2 will appear.

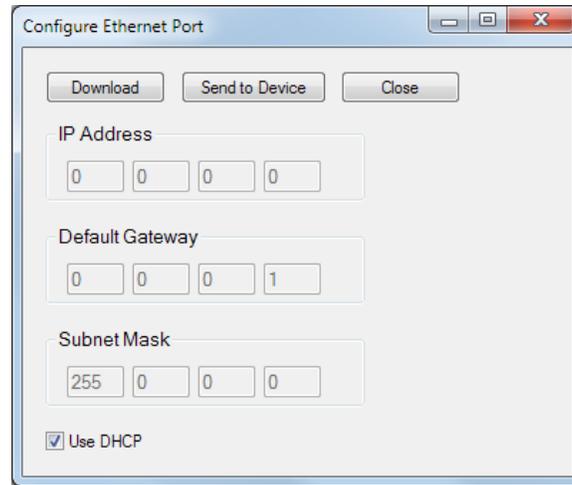


Figure 30-2. Configure Ethernet Port

DHCP (Dynamic Host Configuration Protocol) is enabled by default and allows the BE1-700 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 BE1-700.

- Use the Device Discovery function on the BE1-700 Connection screen in *BESTCOMSPiUs*.
- Navigate to Settings > Communication > Ethernet on the front panel of the BE1-700.

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 BE1-700.
<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 BE1-700 does not act as a DHCP server.

6. Obtain the values for these options from the site administrator if the BE1-700 is intended to share the network with other devices.
7. If the BE1-700 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 BE1-700 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 BE1-700 IP address.

Note

The PC running BESTCOMSP^{Plus} software must be configured correctly to communicate with the BE1-700. The PC must have an IP address in the same subnet range as the BE1-700 if the BE1-700 is operating on a private, local network.

Otherwise, the PC must have a valid IP address with access to the network and the BE1-700 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 BE1-700 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 BE1-700 is ready to be used on a network.
9. If desired, BE1-700 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 BE1-700. Verify that the downloaded settings match the previously sent settings.

RS-485 Setup

The RS-485 communication port is located on the rear panel and provides communication with a PC operating Modbus[®] software. The Baud Rate is the rate at which the BE1-700 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 BESTCOMSP^{Plus} RS-485 Setup screen is illustrated in Figure 30-3.

The screenshot shows the 'RS485 Setup' window with the following settings:

- Communication Settings:**
 - Baud Rate: 19200 Baud
 - Bits Per Character: 8 Bits
 - Parity: No Parity
 - Stop Bits: 1 stop bit

Figure 30-3. RS-485 Setup Screen

Modbus[®] Setup

Settings for Modbus are made by using the Settings Explorer to open the Communications, Modbus tree branch. Custom settings can be made for Modbus mapping if desired. A list of Modbus registers can be found in Basler Electric publication 9376700997, *BE1-700 Modbus Protocol Instruction Manual*.

Miscellaneous Modbus[®] Settings

The Miscellaneous Modbus Settings screen is shown in Figure 30-4. Settings are provided for Modbus over RS-485 and Ethernet. When Auto Save is enabled, group saves are performed to reduce write times.

Miscellaneous Modbus Settings

RS485 Settings Unit ID <input type="text" value="1"/> Response Delay (ms) <input type="text" value="10"/>	Ethernet Settings Unit ID <input type="text" value="1"/>
Auto Save Settings Auto Save <input type="text" value="Enabled"/>	

Figure 30-4. Miscellaneous Modbus Settings



31 • Fault Reporting

The fault reporting function records and reports information about faults that have been detected by the BE1-700. The BE1-700 provides many fault reporting features including 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 BESTCOMSPlus®.

Figure 31-1 illustrates how each of these logic expressions is used by the various BE1-700 functions. Fault trigger logic connections are made on the BESTlogic™Plus screen in BESTCOMSPlus. The *BESTlogicPlus* chapter provides information about using BESTlogicPlus to program the BE1-700. Figure 31-1 illustrates the fault reporting trigger logic block.

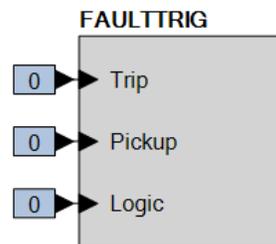


Figure 31-1. Fault Reporting Trigger Logic Block

Trip

Trip expressions are used by the fault reporting function to start logging targets for an event and to record voltage and frequency 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 BE1-700 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 31-7 and Figure 31-2, call-out B). Table 31-1 lists targets as displayed. All targets are enabled by default.

Table 31-1. Targets as Displayed

Target	Description
24	Overexcitation
27P-#-A/B/C	Phase Undervoltage, A, B, or C
27X-#-3V0	Auxiliary Undervoltage, 3V0-3ph VT
27X-#-AUX	Auxiliary Undervoltage, Fundamental VX
27X-#-3RD	Auxiliary Undervoltage, 3 rd Harmonic VX
47	Negative-Sequence Overvoltage
59P-#-A/B/C	Phase Overvoltage, A, B, or C
59X-#-3V0	Auxiliary Overvoltage, 3V0-3ph VT
59X-#-AUX	Auxiliary Overvoltage, Fundamental VX
59X-#-3RD	Auxiliary Overvoltage, 3 rd Harmonic VX
60FL	Fuse Loss Detection
62-#	Timer Output
81-#-Over	Frequency, Over
81-#-Under	Frequency, Under

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 BE1-700 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 31-2.

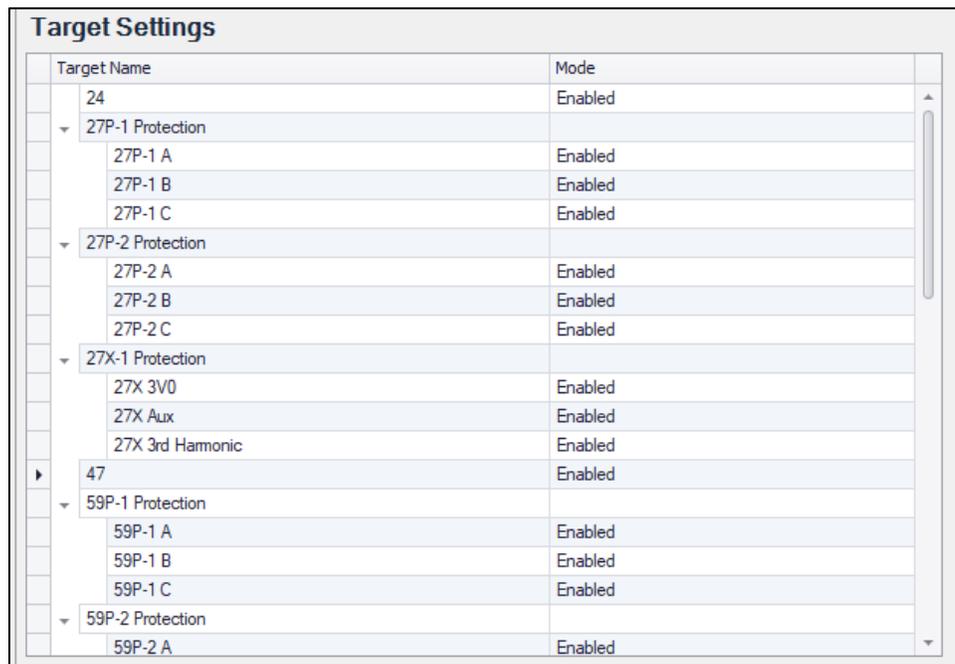


Figure 31-2. Target Settings Screen

Retrieving Target Information and Resetting Targets

To view targets at the front-panel display, navigate to Metering > Status > Targets. The BE1-700 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 BESTCOMSPi.us, use the Metering Explorer to open the Status, Targets screen shown in Figure 31-3.

Targets can be cleared through BESTCOMSPi.us or by pressing the front-panel Reset button while viewing the Targets screen.



Figure 31-3. Targets Screen

A BESTlogicPlus expression can be used to reset the targets. Use the Settings Explorer within BESTCOMSPi.us 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 31-4.



Figure 31-4. 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 BE1-700 records information about faults and creates fault summary reports. A maximum of 16 fault summary reports are stored in nonvolatile memory. When a new fault summary report is generated, the BE1-700 discards the oldest of the 16 events and replaces it with a new one. Each fault summary report is assigned a sequential number (from 1 to 16) by the BE1-700. After event number 16 has been assigned, the numbering starts over at 1.

Four different event types are generated by the BE1-700: Trip, Pickup, Logic, and Forced Trigger.

BE1-700 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 *BESTCOMSPPlus Software* chapter for information on BE1-700 identification settings.

Viewing and Downloading Fault Data through BESTCOMSPPlus®

To view fault summary reports using BESTCOMSPPlus, use the Metering Explorer to open the Reports, Fault Records screen shown in Figure 31-5. 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 31-5) 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
007	2024-02-14	11:09:41.711	Trip	0
006	2024-02-14	11:09:41.703	Pickup	0
005	2024-02-14	07:38:48.372	Trip	0
004	2024-02-14	11:38:12.042	Trip	0
003	2024-02-14	11:37:35.184	Pickup	0
002	2024-02-14	11:37:30.105	Trip	0
001	2024-02-14	11:36:54.123	Trip	0
016	2024-02-14	11:35:58.639	Trip	0
015	2024-02-12	13:50:39.271	Trip	0
014	2024-02-12	13:17:06.573	Trip	0
013	2024-02-12	11:46:45.519	Pickup	0
012	2024-02-12	11:46:45.411	Pickup	0
011	2024-02-12	11:46:45.365	Pickup	0
010	2024-02-12	11:46:39.038	Pickup	0
009	2024-02-12	11:06:40.301	Pickup	0
008	2024-02-12	11:06:40.280	Pickup	0

```

PRODUCT NAME           : BE1-700
STYLE NUMBER           : BE1-700-N5N2X8N
FIRMWARE VERSION       : 4.00.00
SERIAL NUMBER          : H03275259
STATION ID             : Station ID
RELAY ID               : BE1-700
USER ID                : User ID
RELAY ADDRESS(ES)     :
IP                     : 10.0.10.5
MODBUS ETHERNET        : 1
MODBUS SERIAL          : 1

Fault Number           : 6
Event Type             : Pickup
Fault Date             : 2024-02-14
Fault Time             : 11:09:41.703
Event Trigger          : 59P-1 Pickup
Active Group           : SGC D0
Recloser State         : off

Targets                : None

Fault clearing Time    : 0.004 SEC
Breaker Operate Time  : NA

Oscillographic Record : 0
VAN                   : 277.47 V @ 0.0 DEG
VBN                   : 278.12 V @ 239.9 DEG
VCN                   : 277.58 V @ 119.9 DEG
3V0                   : 0.00 V @ NA
V1                    : 277.72 V @ 359.9 DEG
V2                    : 0.40 V @ NA
VX-AB                 : 481.97 V @ 329.9 DEG
FP                    : 59.98 Hz
FX                    : 59.98 Hz
  
```

Figure 31-5. Fault Reports Screen

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 BESTCOMSPPlus 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 BESTCOMSP^{lus} 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 31-7 and Table 31-2, call-out A.

Fault Number

This line reports the sequential number (from 1 to 16) assigned to the report by the BE1-700.

Event Type

This line reports the type of event that occurred. There are four event categories:

1. Trip: A fault was detected as defined by the pickup expression and the BE1-700 tripped to clear the fault.
2. Pickup: A fault was detected as defined by the pickup expression but the BE1-700 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. Forced Trigger: A fault report was triggered through the BESTCOMSP^{lus} 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 31-7 and Table 31-2, call-out B.

Fault Clearing Time

This line reports the time from when the BE1-700 detected the fault until the BE1-700 detected that the fault had cleared. Refer to Figure 31-7 and Table 31-2, call-out C.

- If the fault report was triggered through the BESTCOMSP^{lus} 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.

Oscillographic Record

This line reports the number of oscillographic records that are stored in memory for this fault report. Refer to Figure 31-7 and Table 31-2, call-out E. Recording of oscillographic records is described later in this chapter.

VA, VB, VC

These lines report the phase voltage magnitudes and angles measured two power system cycles immediately following the trip trigger. If the fault is cleared prior to the BE1-700 tripping, the recorded fault voltages are for the power system cycle two cycles prior to the end of the fault. Refer to Figure 31-7 and Table 31-2, call-out F. The default two cycle pre-fault value can be edited in settings.

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 BE1-700 tripping, the recorded fault voltages are for the power system cycle two cycles prior to the end of the fault. Refer to Figure 31-7 and Table 31-2, 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 31-7 and Table 31-2, 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 BE1-700 tripping, the recorded fault voltages are for the power system cycle two cycles prior to the end of the fault. Refer to Figure 31-7 and Table 31-2, call-out F.

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 16 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 as 4, 8, or 16 records. The BE1-700 stores up to 4,096 cycles of data at 32 samples per cycle. As an example, 1,024 cycles of data is stored when the user selects 4 fault records.

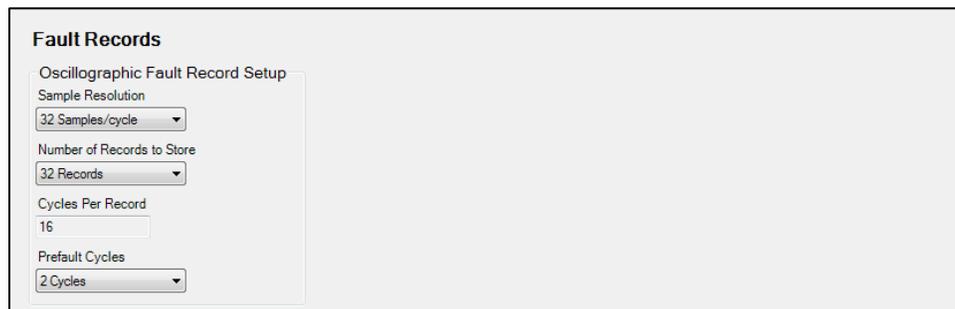
All channels are recorded (VA, VB, VC, VX, FP, and FX) as they happen in real time.

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.

BE1-700 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 BE1-700 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 31-6. Enter the values for Sample Resolution, Number of Records to Store, and Prefault Cycles.



Fault Records

Oscillographic Fault Record Setup

Sample Resolution
32 Samples/cycle

Number of Records to Store
32 Records

Cycles Per Record
16

Prefault Cycles
2 Cycles

Figure 31-6. Fault Records Screen

Retrieving Oscillographic Records

Oscillographic records can be downloaded through the Reports, Fault Reports screen in BESTCOMSPPlus (Figure 31-5). See *Fault Reports* earlier in this chapter.

Protective Fault Analysis

The below sample shows a fault record relative to time to demonstrate the variables associated with a protective relay trip event.

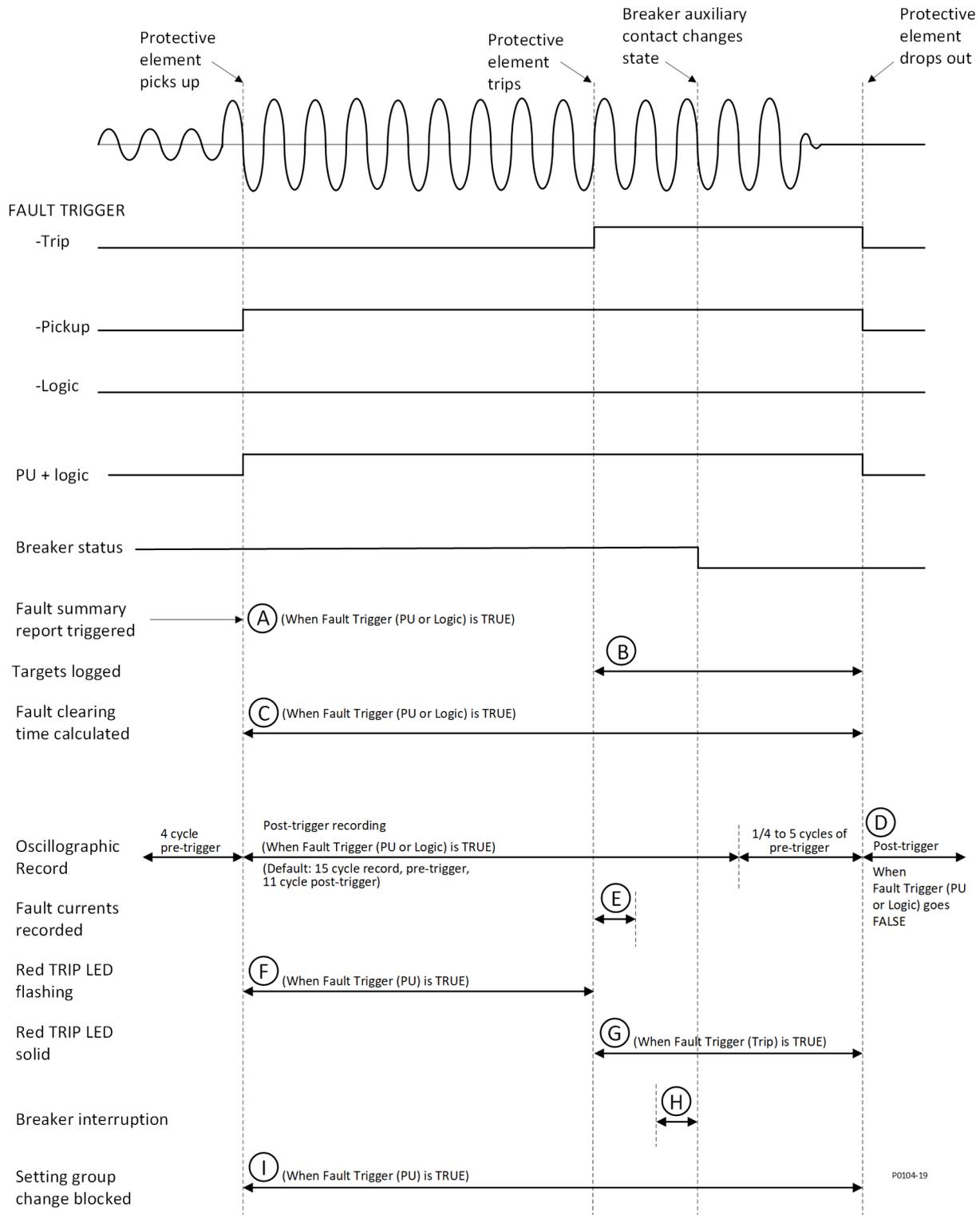


Figure 31-7. Protective Fault Analysis

Table 31-2. Legend for Figure 31-7

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	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.
E	Recorded fault voltages are displayed on the Targets screen of the front-panel display. The same information including phase voltage frequency, auxiliary voltage frequency, and voltage angles are recorded in the fault summary report. The magnitude and angle 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. If the Trip expression does not become true, the fault was cleared by a down-stream device. For these pickup-only events, fault voltage and angles are 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> .
F	During the time that the Pickup expression is true, the red Trip LED on the front panel flashes indicating that the BE1-700 is picked up.
G	During the time the Trip expression is true, the red Trip LED on the front panel lights steadily indicating that the BE1-700 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.
H	Breaker operations are driven by the breaker status function. The operations counter is incremented on breaker opening.
I	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.



32 • Breaker Monitoring

Breaker monitoring helps manage equipment inspection and maintenance expenses by providing monitoring and alarms for the circuit breaker. Breaker monitoring functions include breaker status and operations counter reporting. 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 79 function and the 52TCM function. The breaker status logic block is shown in Figure 32-1.



Figure 32-1. Breaker Status Logic Block

BESTlogic™ Plus Settings for Breaker Status

Since the BE1-700 is completely programmable, it is necessary to program which logic variable will monitor breaker status. Breaker status is programmed using BESTCOMSPlus®. 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 32-1 summarizes the BESTlogicPlus settings for Breaker Status.

Table 32-1. 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

BESTCOMSPlus Navigation Path: Metering Explorer, Status, Breaker Status

HMI Navigation Path: Metering Explorer, Status, Breaker Status

Breaker status can be viewed through BESTCOMSPlus and on the front-panel display.

To view breaker status using BESTCOMSPlus, use the Metering Explorer to open the Status, Breaker Status screen shown in Figure 32-2. To view breaker status at the front-panel display, navigate to Metering Explorer, Status, Breaker Status.



Figure 32-2. 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 BE1-700 counter value to be matched to an existing mechanical cyclometer on a breaker mechanism. Write access to the reports functions must be gained to edit this value at the front-panel display. To view the breaker status using BESTCOMSPlus, 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.

Setting the Breaker Monitoring Function

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

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

Breaker Duty Monitoring settings are made using BESTCOMSPi.us. Use the Settings Explorer to open the Alarm Configuration, Breaker Monitoring tree branch shown in Figure 32-3.

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

Figure 32-3. Breaker Monitoring Screen

To connect the Block logic input, use the Settings Explorer within BESTCOMSPi.us to open the BESTlogicPi.us 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 *BESTlogicPi.us* chapter for more information on setting BESTlogicPi.us programmable logic.

The breaker monitor logic block is shown in Figure 32-4.

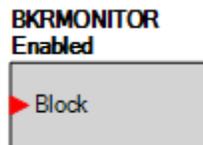


Figure 32-4. Breaker Monitor Logic Block

Table 32-2 summarizes the Breaker Duty Monitoring settings.

Table 32-2. Breaker Monitoring Settings

Function	Range/Purpose	Default
Mode	Disabled or Enabled	Disabled
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 operation counts can be read at the front-panel display. Operations can be changed by using the front-panel Edit key. Write access to reports is required to edit breaker operation values. Operation values can also be read or changed through the communication ports using BESTCOMSPlus. Use the Metering Explorer to open the Reports, Breaker Monitor screen shown in Figure 32-5.

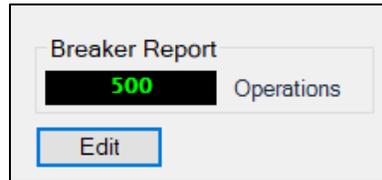


Figure 32-5. Breaker Report Screen

Breaker Alarms

Three alarm points are included in the programmable alarms for checking breaker monitoring functions.

Breaker Alarms Settings

BESTCOMSPlus Navigation Path: Settings Explorer, Alarm Configuration, Breaker Monitoring

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

Settings are made using BESTCOMSPlus. Use the Settings Explorer to open the Alarm Configuration, Breaker Monitoring tree branch shown in Figure 32-3.

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



33 • Alarms

The BE1-700 monitors internal systems, external interfaces, and power system equipment. An alarm is annunciated when a component 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 BE1-700 operating power is lost. Active alarms are displayed on the front-panel display and through BESTCOMSP*Plus*® until they are cleared. Non-latching alarms are cleared when BE1-700 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 BE1-700 the functionality of a local and remote alarm annunciator.

A detailed list of alarms is provided in Table 32-1.

Table 32-1. Available Alarms

Name	Description
60FL Fuse Loss	One or more phases of voltage lost
24 Volts Per Hertz	Overexcitation
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
101 Blocking Tag Status	101 breaker control switch block tag set
52 Trip Coil Monitor	Monitored trip circuit open
79 Recloser Fail	Reclose fail timer timed out before breaker closed
79 Recloser Lockout	Recloser went through sequence without success
Power Supply	Operating power lost
Changes Lost	Password access lost. Read only.
Real Time Clock	Real-time clock not set
Date Time Set	The date/time was set by the user
Firmware Change	Firmware has been changed
Freq Out of Range	Frequency is out of range
Ethernet Link Lost	Ethernet communication lost
Network Overload	Local network overloaded
USB Coms Alarm	USB communication error
IRIG Sync Lost	IRIG failed to synchronize
Logic Equal None	Active logic = NONE
No User Setting	User settings do not exist
Setting Change	Setting change made by user
Output Override	One or more output contacts have logic output override condition
Analog	Analog-to-digital converter error
uP Reset Alarm	Microprocessor watchdog circuit timed out

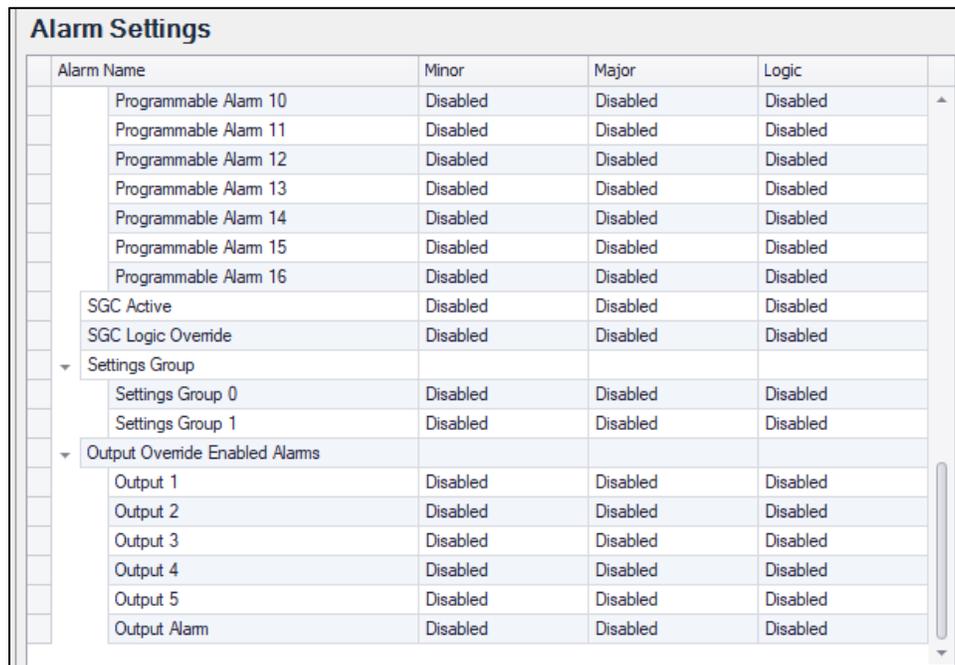
Name	Description
Fault Report Timeout	True if fault event trigger lasts longer than 60 seconds
Breaker Monitor 1	Breaker alarm 1 threshold exceeded
Breaker Monitor 2	Breaker alarm 2 threshold exceeded
Breaker Monitor 3	Breaker alarm 3 threshold exceeded
Programmable Alarms 1-16	Programmable alarm 1-16 is true
SGC Active	Active setting group changed
SGC Logic Override	Setting group control was overridden by logic
Settings Group 0	Setting group 0 is active
Settings Group 1	Setting group 1 is active
Output 1 Override Control	Override enabled on Output 1
Output 2 Override Control	Override enabled on Output 2
Output 3 Override Control	Override enabled on Output 3
Output 4 Override Control	Override enabled on Output 4
Output 5 Override Control	Override enabled on Output 5
Output Alarm Override Control	Override enabled on Alarm

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 32-1.



The screenshot shows the 'Alarm Settings' window with a table of configurations. The table has four columns: Alarm Name, Minor, Major, and Logic. The rows are grouped into sections: Programmable Alarms 10-16, SGC settings, Settings Group, and Output Override Enabled Alarms. All settings are currently set to 'Disabled'.

Alarm Name	Minor	Major	Logic
Programmable Alarm 10	Disabled	Disabled	Disabled
Programmable Alarm 11	Disabled	Disabled	Disabled
Programmable Alarm 12	Disabled	Disabled	Disabled
Programmable Alarm 13	Disabled	Disabled	Disabled
Programmable Alarm 14	Disabled	Disabled	Disabled
Programmable Alarm 15	Disabled	Disabled	Disabled
Programmable Alarm 16	Disabled	Disabled	Disabled
SGC Active	Disabled	Disabled	Disabled
SGC Logic Override	Disabled	Disabled	Disabled
Settings Group			
Settings Group 0	Disabled	Disabled	Disabled
Settings Group 1	Disabled	Disabled	Disabled
Output Override Enabled Alarms			
Output 1	Disabled	Disabled	Disabled
Output 2	Disabled	Disabled	Disabled
Output 3	Disabled	Disabled	Disabled
Output 4	Disabled	Disabled	Disabled
Output 5	Disabled	Disabled	Disabled
Output Alarm	Disabled	Disabled	Disabled

Figure 32-1. Alarm Settings Screen

User Programmable Alarms

BESTCOMSPiplus Navigation Path: Settings Explorer, Alarm Configuration, User Programmable Alarms

HMI Navigation Path: Not available through the front panel

Sixteen user programmable alarms are available. BESTlogicPiplus Programmable Logic is used to set up alarm logic. User alarm labels are programmed on the User Programmable Alarms screen (Figure 32-2) 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.

The screenshot displays a window titled "User Programmable Alarms" with eight individual configuration sections arranged in a 4x2 grid. Each section is labeled "User Programmable Alarm #1" through "User Programmable Alarm #8". Each section contains a "Label" field with a text input box. The input boxes for all eight sections contain the text "Programmable Alarm 1" through "Programmable Alarm 8" respectively.

Figure 32-2. User Programmable Alarms Screen

Retrieving Alarm Information

BESTCOMSPiplus Navigation Path: Metering Explorer, Status, Alarms

HMI Navigation Path: Metering Explorer, Status, Alarms

Major and Minor alarms can be viewed through BESTCOMSPiplus, the front-panel display and LED indicators, and Modbus interfaces. 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 BESTCOMSPiplus, use the Metering Explorer to open the Status, Alarms screen shown in Figure 32-3. Alarms can be reset by clicking the Reset Alarms button under the appropriate column.

The screenshot shows a screen with four columns, each representing a different alarm category. Each column has a title at the top and a "Reset" button at the bottom. The "Minor Alarms" column shows an active alarm "Irig Sync Lost" in red text. The "Logic Alarms" column shows an active alarm "Setting Change" in red text. The other columns are currently empty.

Major Alarms	Minor Alarms	Logic Alarms	Relay Alarms
	Irig Sync Lost	Setting Change	
Reset Major Alarms	Reset Minor Alarms	Reset Logic Alarms	Reset Relay Alarms

Figure 32-3. Alarms Screen

Resetting Alarms

A BESTlogicPlus expression can be used to reset the alarms. Use the Settings Explorer within BESTCOMSPPlus to open the BESTlogicPlus Programmable Logic tree branch. Select the Major Alarm Reset or Minor Alarm Reset logic block from the list of Elements. The Major Alarm Reset will reset all major alarms. The Minor Alarm Reset will reset all minor alarms. Use the drag-and-drop method to connect a variable or series of variables to the Reset input. The alarm reset logic blocks are shown in Figure 32-4.

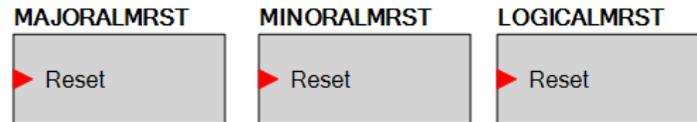


Figure 32-4. Alarm Reset Logic Block

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 BESTCOMSPPlus.

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 above 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 • Sequence of Events

A sequence of events recorder (SOE) report is very useful in reconstructing the exact sequence and timing of events during a power disturbance or even normal system operations. The SOE tracks over 100 data points by monitoring the internal and external status of the BE1-700. Data points are scanned every quarter-cycle. All changes of state that occur during each scan are time tagged to 1 millisecond resolution. Over 255 records are stored in nonvolatile memory; when the SOE memory becomes full, the oldest record is replaced by the latest one acquired.

The SOE monitors the following points and conditions:

- Single-state events such as resetting targets, changing settings, etc.
- Programmable logic variables
- Targets
- Relay trouble alarm variables
- Programmable alarm variables
- Output contact status
- Fault reporting trigger expressions

BE1-700 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 BE1-700 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 SOE report instead of the generic variable name and state names.

When a monitored event occurs or a monitored variable changes state, the SOE logs all event data listed in Table 34-1.

Table 34-1. 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
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 34-1. Select events to be recorded in the Sequence of Events Log. All events are enabled by default.

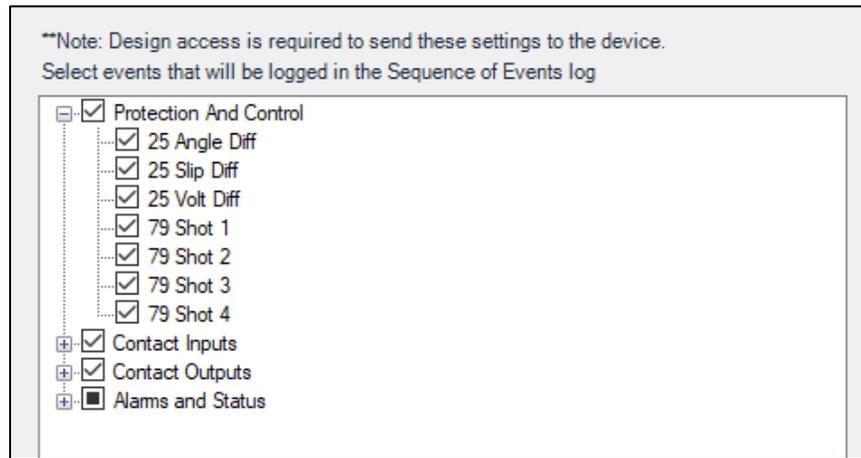


Figure 34-1. Sequence of Events Setup Screen

Retrieving SOE Information

Sequence of events data can be obtained through BESTCOMSPlus.

Viewing and Downloading SOE Data through BESTCOMSPlus

Use the Metering Explorer to open the Reports, Sequence of Events screen. If an active connection to a BE1-700 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 34-2.

Options	Refresh	Clear	Toggle Sorting	Sorting: Enabled
Time Stamp	Description	Status		
2024-02-14 11:36:35.948	Setting Change	Off		
2024-02-14 11:36:36.058	Setting Change	On		
2024-02-14 11:36:42.630	Setting Change	Off		
2024-02-14 11:36:42.634	Major Alarm	Off		
2024-02-14 11:36:54.123	59P-1 Pickup	On		
2024-02-14 11:36:54.123	Output 2 Logic State	On		
2024-02-14 11:36:54.123	Out 2	ON		
2024-02-14 11:36:54.123	System Data Pickup Logic	On		
2024-02-14 11:36:54.152	59P-1 Trip	On		
2024-02-14 11:36:54.152	Output 3 Logic State	On		
2024-02-14 11:36:54.152	Out 3	ON		

Figure 34-2. Sequence of Events Screen

35 • Overexcitation (24) Inverse Time Curves

This chapter contains the inverse time curves for the overexcitation element (24). Equation 35-1 and Equation 35-2 represent the trip time and reset time for constant volts per hertz level. Normally, the V/Hz pickup is set to a value greater than the V/Hz nominal. This ensures that V/Hz measured divided by V/Hz nominal is always greater than 1.000 throughout the pickup range.

Curve Specifications

If the pickup is set less than nominal, then measured values above pickup and below nominal will result in the maximum time delay. The maximum time delay is determined by Equation 35-1 with (V/Hz measured / V/Hz nominal) set equal to 1.001. The overall inverse time delay range is limited to 1,000 seconds maximum and 0.2 seconds minimum.

$$T_T = \frac{D_T}{\left(\frac{V/Hz \text{ Measured}}{V/Hz \text{ Nominal}} - 1\right)^n}$$

Equation 35-1. Time to Trip

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

Equation 35-2. Time to Reset

where:

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

When the measured V/Hz rises above a pickup threshold, the pickup element becomes true and an integrating or definite time timer starts. If the V/Hz remains above the pickup threshold and the integration continues for the required time interval as defined by the equations shown above and the set time dial, the trip output becomes True. If the measured V/Hz drops below pickup before timeout to trip, either an instantaneous or a time delayed integrating reset can be selected.

The following sets of curves (Figure 35-1 through Figure 35-6) are shown first with the time axis on the vertical and then on the horizontal for ease of use.

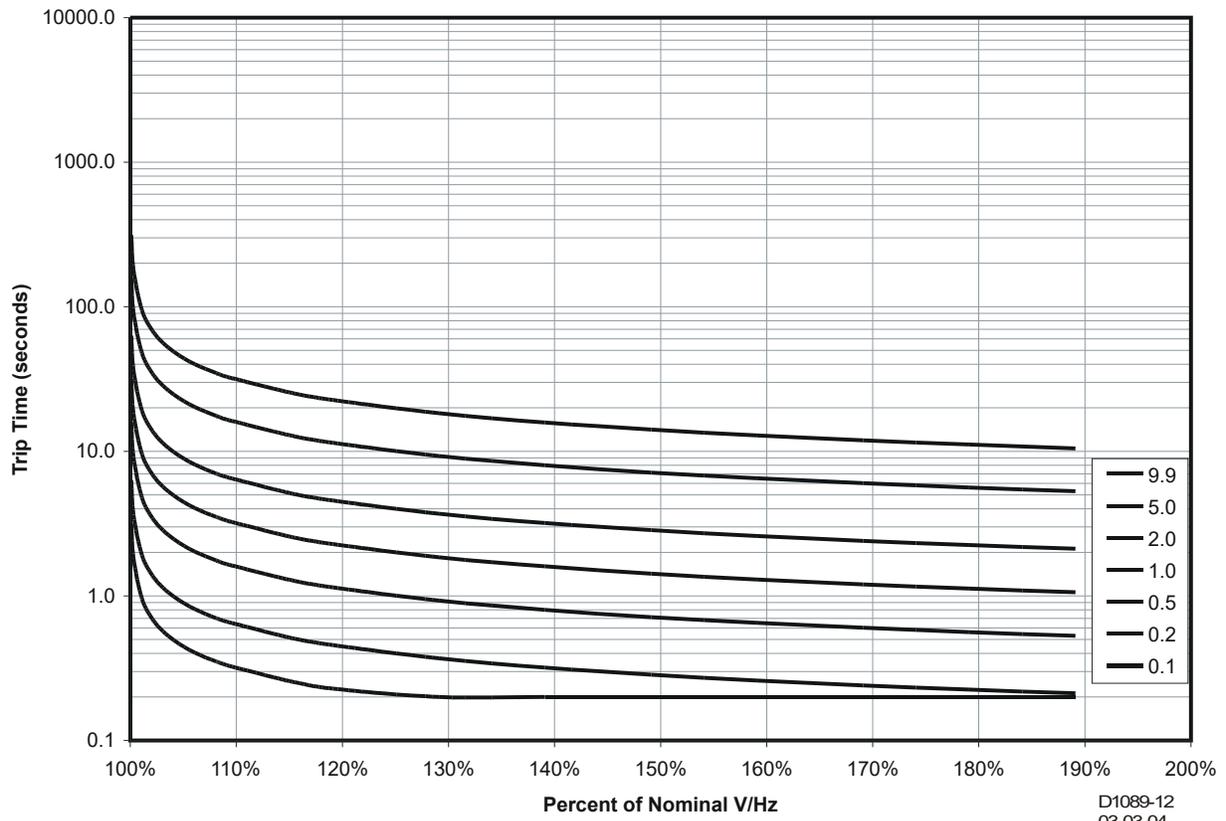


Figure 35-1. V/Hz Characteristic $(M-1)^{0.5}$ - Time on Vertical Axis

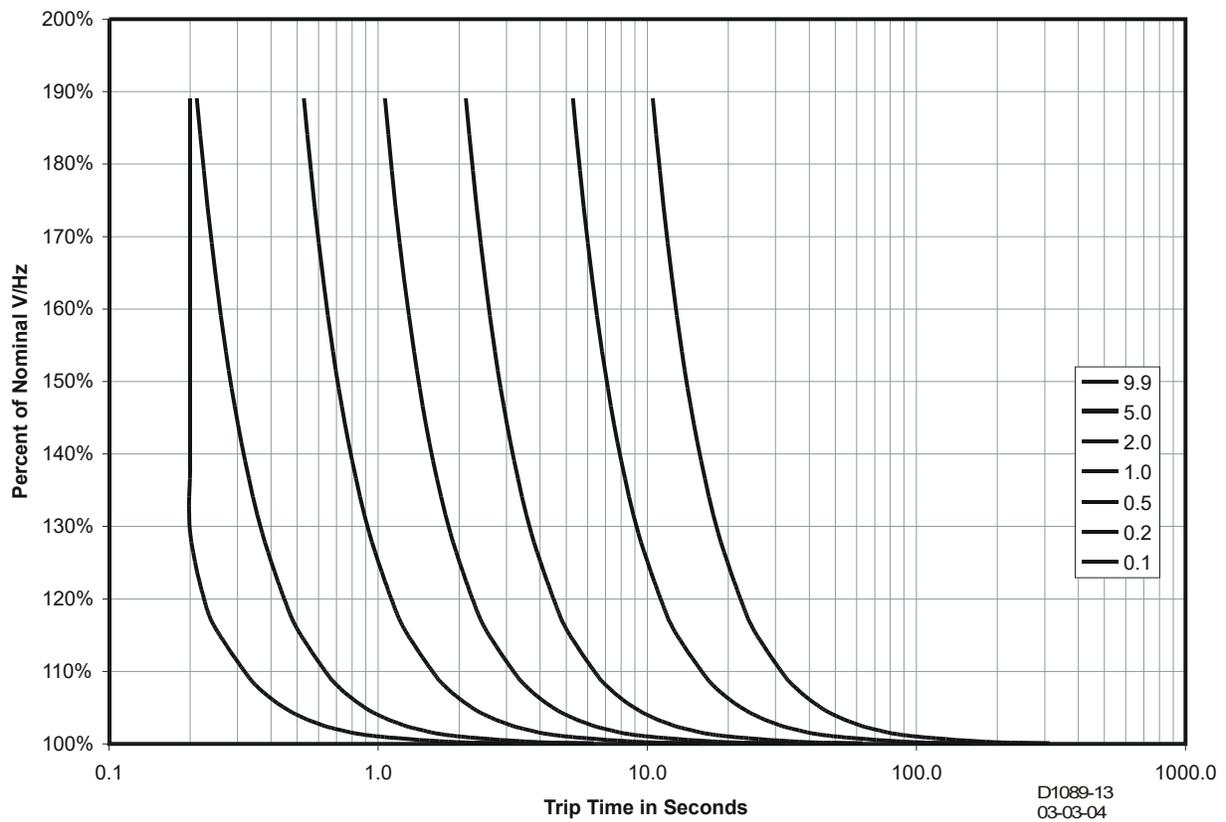


Figure 35-2. V/Hz Characteristic $(M-1)^{0.5}$ - Time on Horizontal Axis

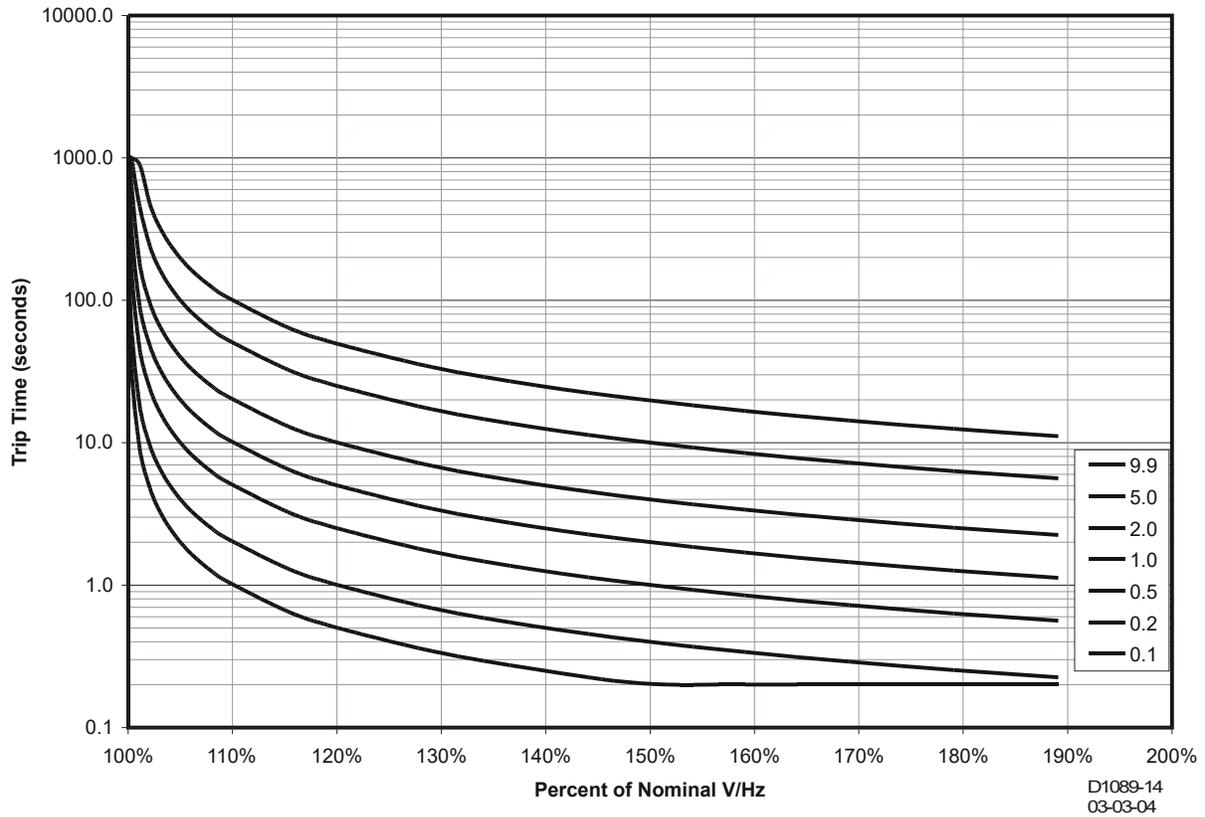


Figure 35-3. V/Hz Characteristic (M-1)¹ – Time on Vertical Axis

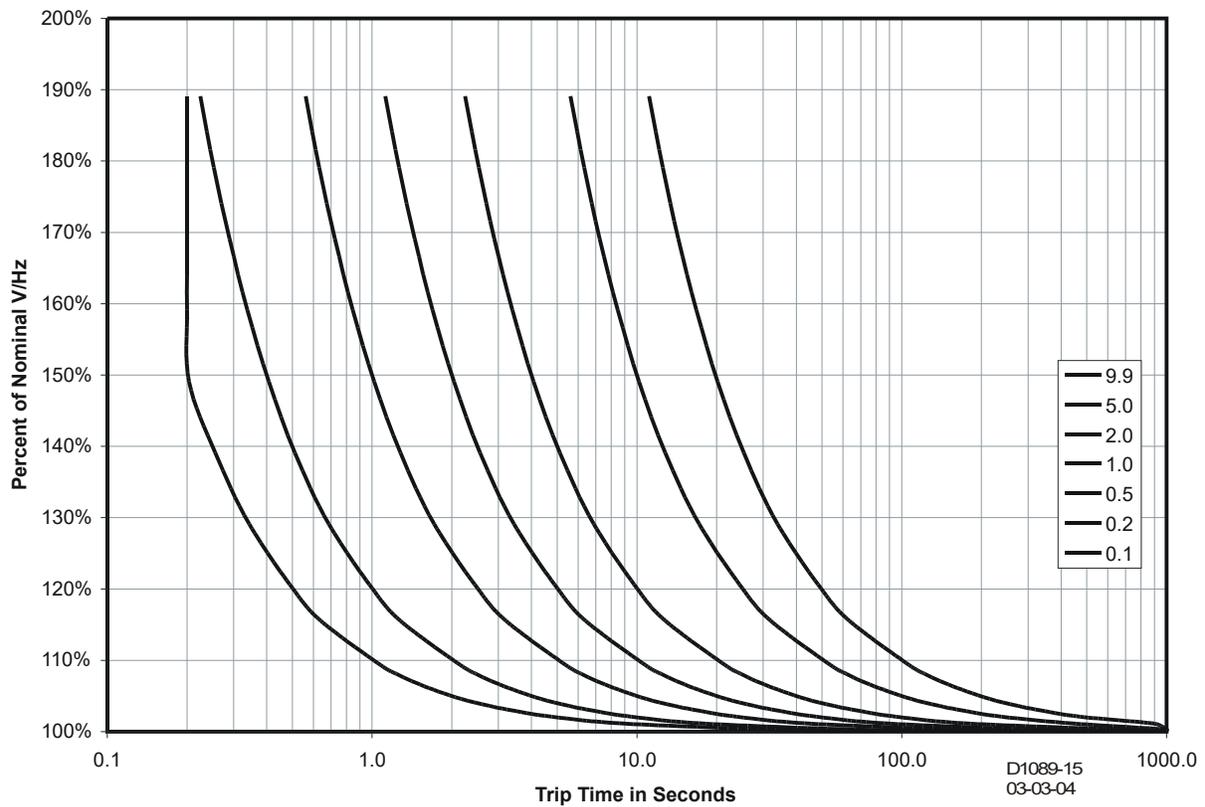


Figure 35-4. V/Hz Characteristic (M-1)¹ – Time on Horizontal Axis

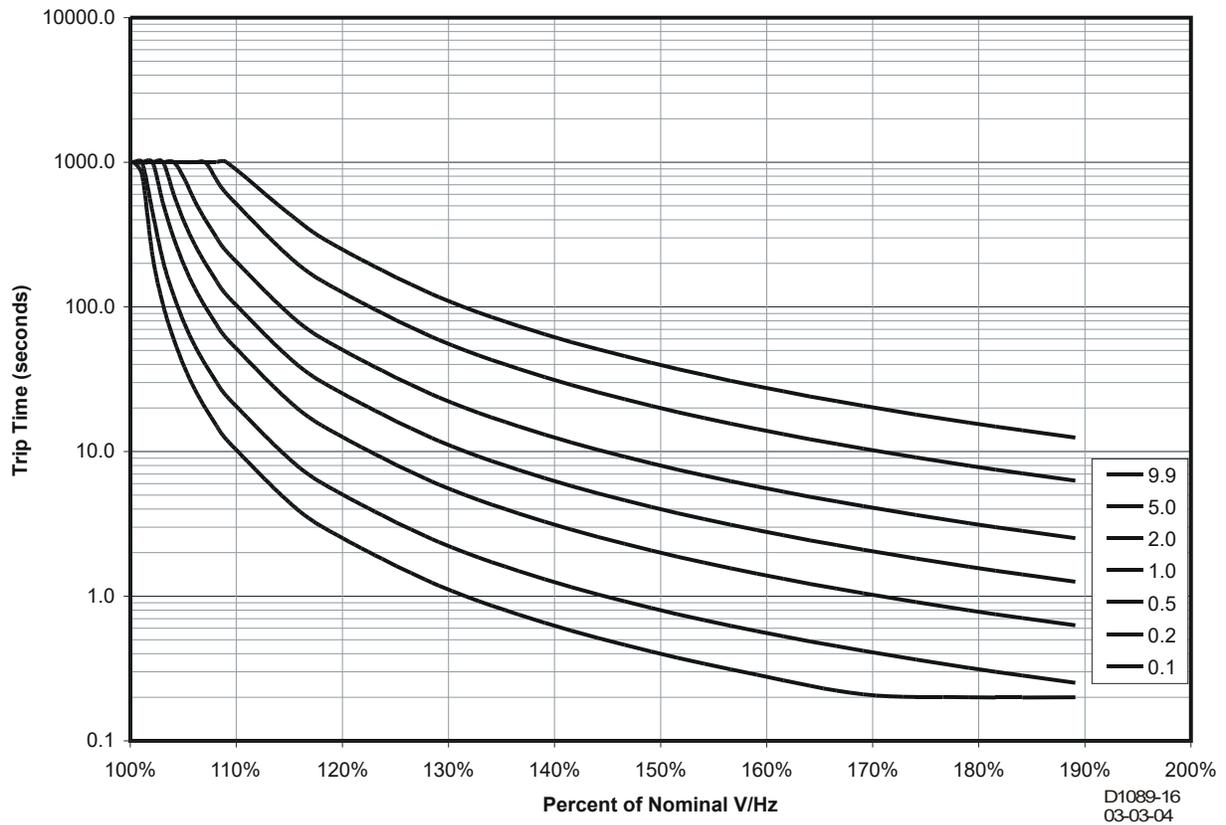


Figure 35-5. V/Hz Characteristic $(M-1)^2$ – Time on Vertical Axis

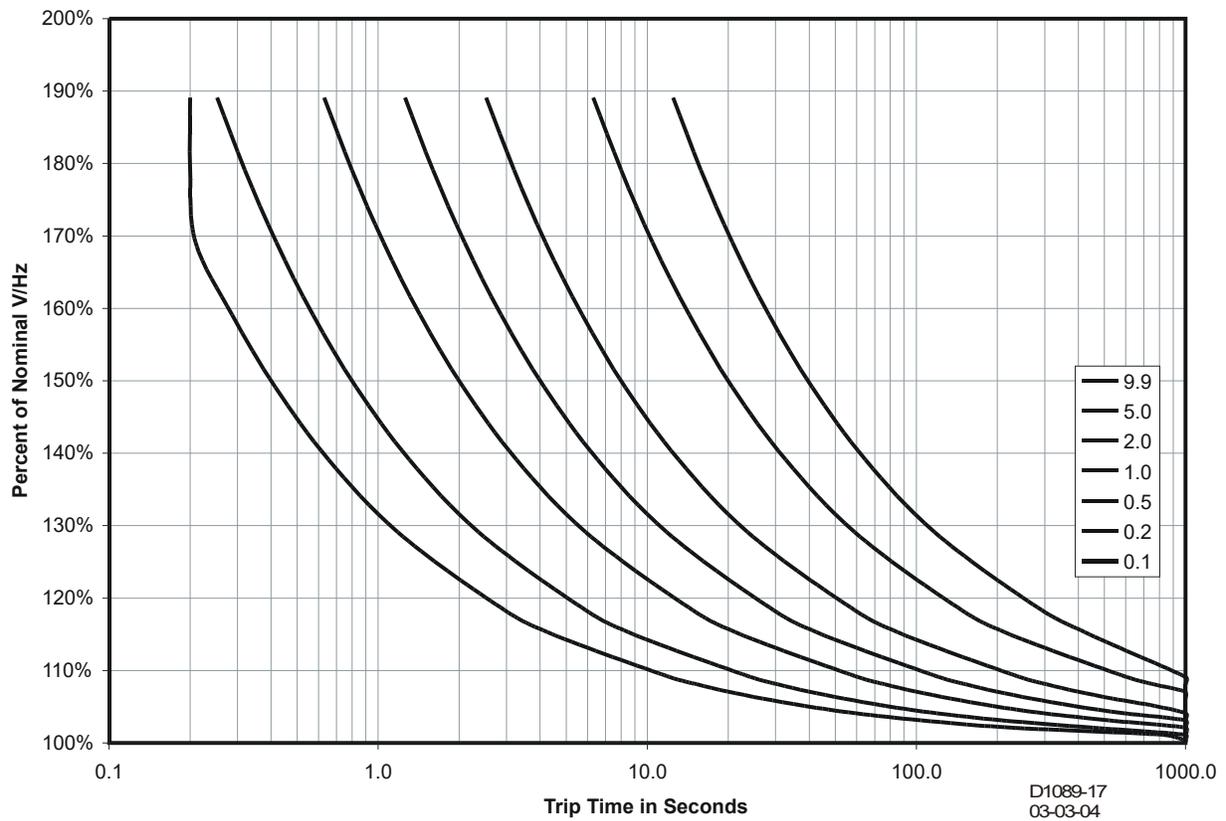


Figure 35-6. V/Hz Characteristic $(M-1)^2$ – Time on Horizontal Axis

36 • Introduction to Testing

The need to test protection systems to confirm performance as designed by manufacturers has always existed. However, digital 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 digital 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 reduced the need for periodic maintenance. Simple acceptance tests that verify the integrity of the BE1-700 measuring circuits and commissioning tests that verify the BE1-700 “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 BE1-700 self-tests and troubleshooting using internal diagnostics, contact Basler Electric Technical Support Services.

Testing Philosophies

Testing is generally divided into the following categories:

- Acceptance
- Commissioning
- Periodic (user scheduled maintenance)
- Functional

While all types of tests 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, criticality, economics, and perceived system value.

Acceptance Testing

Acceptance testing confirms that a particular BE1-700 delivered to a customer meets published specifications. Because this is a digital device whose characteristics are defined by internal software (firmware), Basler Electric does not require the user to test each operational setting in the BE1-700. 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 and 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 BE1-700 is a microprocessor-based device whose operating characteristics will not change over time. The BE1-700 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 damage in transit. Basler Electric warrants all products against any deviation 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 BE1-700 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 BE1-700. All of the following connections or functions can be verified during commissioning tests:

- Proper connection and sensing voltage signals
- Connections of I/O contacts
- 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 BE1-700. 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 BE1-700 is measuring signals faithfully, that BE1-700 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 BE1-700 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 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

Under test or in-service, the BE1-700 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}® or the front-panel display. Fault Summary Reports, Sequence of Events Recorder (SOE) Reports, and Oscillographic Records yield more detail.

Each time a system disturbance occurs in or around this BE1-700 zone of protection, it is a test of the BE1-700 performance during the fault. If a questionable operation results in the need for troubleshooting, you have several ways in which to troubleshoot the BE1-700, 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 BE1-700 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 BE1-700 performance. Correct response of BE1-700 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.

BE1-700 Self-Test

All internal circuitry and software that affect the BE1-700 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 Relay Trouble Alarm is set, and the BE1-700 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 BE1-700 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 BE1-700 facilitates obtaining and verifying targets and event data, it is not always necessary to use the BE1-700 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 BE1-700 records protective element output changes, 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 BE1-700 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.



37 • Acceptance Testing

Although Basler Electric performs detailed acceptance testing on all new relays, it is generally recommended that you perform each of the following acceptance test steps before installation. Performing these steps tests each function of the BE1-700 relay to validate that no degradation of performance occurred because of shipping and handling.

Test Equipment

Suitable test equipment requires a minimum of one voltage source element and a contact wetting voltage. Test equipment should also have the capability of varying the frequency and the angle of the voltage sources.

Power Up

Purpose: To verify that the relay performs the power-up sequence.

Step 1: Apply voltage to the input power Terminals A6 and A7. Table 37-1 shows the appropriate input voltage for each relay style.

Table 37-1. Input Voltages

Style Number	Voltage Input
BE1-700-xxx1xxN	48 Vdc
BE1-700-xxx2xxN	125 Vac/dc
BE1-700-xxx3xxN	24 Vdc
BE1-700-xxx4xxN	250 Vac/dc
BE1-700-xxx5xxN	125 Vac/dc *

* Extended holdup option.

Step 2: Verify that the Power LED is on and that characters are displayed on the HMI display. Upon power-up, the relay will perform a brief self-test.

During this brief test, all front panel LEDs flash momentarily, the display indicates each step of the self-test, the relay model, the software version, and then the default display screen. Contact Basler Electric, Technical Support Services if anything appears out of the ordinary or if an LCD error message appears.

Communications

Purpose: To verify that the BE1-700 communicates through the USB and optional Ethernet port.

Step 1: Use BESTCOMSP^lus[®] to connect to the BE1-700 through the front-panel USB port and through the optional rear panel Ethernet port. Refer to the *Communications* chapter.

Style Number and Serial Number Verification

Purpose: To verify that the BE1-700 style number and serial number matches the unit and unit labels.

Step 1: Connect to the BE1-700 through BESTCOMSP^lus.

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 BE1-700 acquires and updates IRIG time and date information.

- Step 1: Connect a suitable IRIG source to BE1-700 terminals A1 (+) and A2 (-).
- Step 2: Upon receiving the IRIG signal, the BE1-700 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 BE1-700 senses hardware input status.

- Step 1: Apply an external voltage source within the range of the voltages listed in Table 37-2 to contact sensing inputs IN1 (B1/B2), IN2 (B3/B4), IN3 (B5/B6), and IN4 (B7/B8).

Table 37-2. Contact Sensing Turn-On Voltages

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

* For information on setting contact-sensing input jumpers, refer to the *Contact Inputs and Outputs* chapter.

** Extended holdup option.

- 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 BE1-700 senses hardware output status.

- Step 1: Connect to the BE1-700 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 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.

Three-Phase Voltage Circuit Verification

- Step 1: Connect an ac voltage source at nominal frequency between BE1-700 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 BE1-700 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 BE1-700 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 BE1-700 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 37-3 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 37-3. 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
140 volts	139.3 V	140.7 V
160 volts	159.2 V	160.8 V

Auxiliary Voltage Input Verification - VX and VX 3rd (Fundamental and Third Harmonic)

- Step 1: Connect BE1-700 terminals C17 (polarity) and C18 to a 60 hertz ac voltage source.
- Step 2: Apply the voltage values listed in Table 37-4 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. Accuracy is $\pm 0.5\%$.
- Step 3: Connect BE1-700 Terminals C17 (polarity) and C18 to a 180 Hz (third harmonic) ac voltage source.
- Step 4: Apply the voltage values listed in Table 37-4 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. Accuracy is $\pm 0.5\%$.

Table 37-4. Aux Voltage Circuit Verification VX & VX 3rd 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 BE1-700 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 BE1-700 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.

38 • Commissioning Testing

Special precautions should be taken to ensure that all tests are performed with safety as the greatest concern.

If this BE1-700 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, etc. on existing equipment (e.g., breakers or transformers). As the user, you can make the determination of what values the BE1-700 should have as initial monitoring values when it is placed in service.

It may on occasion be necessary to temporarily disable some of the protective elements while testing the BE1-700 to isolate testing of individual functions. Always remember to enable these functions before placing the BE1-700 in service. Settings compare is available within BESTCOMSP^lus® to assist in ensuring the as found and as left settings are equal.

To assist you in the commissioning testing of this BE1-700, you can refer to the related reporting and alarms chapters.

Refer to the related protection and control chapters of the instruction manual for assistance on any particular functions of the BE1-700. 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 4 user-defined name, recognition time, debounce time, energized state label, and de-energized state label.
- 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 BE1-700 Input 1 with the appropriate level of energizing voltage. See the *Contact Inputs and Outputs* chapter. 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 5, and Output A label, energized state label, de-energized state label, and hold attribute.
- Step 2: Use the Metering Explorer in BESTCOMSP^lus to open the Control, Output Override screen. Verify the status of OUT1 through OUT5. Use the procedure outlined under *Acceptance Testing, Control Outputs* to actuate selected output contacts (OUT1 through OUT5) 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 BESTCOMSP^lus to open the Reports, Sequence of

Events screen. Click on the Download button and review the events associated with the output contact change. Failure to disable output override for an output will result in an output that does not follow protective trip and control logic.

- Step 3: Repeat Step 2 to verify that operation of the alarm output relay (OUTA) initiates the appropriate alarm response.

Virtual Selector Switches

Purpose: To verify operation, labels, and logic settings of the 43 switches.

Chapter Reference: Virtual Control Switch (43)

- Step 1: Use the Settings Explorer in BESTCOMSP^{Plus} to open the Control, Virtual Control Switches screen and verify the 43-1 and 43-2 mode, name label, on label, and off label.
- Step 2: Use the Metering Explorer in BESTCOMSP^{Plus} 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 BE1-700. For each virtual selector switch enabled in your logic scheme, change the switch position by following the procedure described in the *Virtual Control Switch (43)* chapter.
- Step 4: Verify each switch position change on the Control, Virtual Switches screen of BESTCOMSP^{Plus} or on the front-panel display.
- Step 5: Return each virtual selector switch to the original position.
- Step 6: Use the Metering Explorer in BESTCOMSP^{Plus} 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

Purpose: To verify operation and logic setting for the 101 switch.

Chapter Reference: Breaker Control Switch (101)

- Step 1: Use the Settings Explorer in BESTCOMSP^{Plus} to open the Control, Breaker Control Switch screen and verify the 101 element mode.
- Step 2: Use the Metering Explorer in BESTCOMSP^{Plus} 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 BE1-700. 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 BESTCOMSP^{Plus} or on the front-panel display.
- Step 5: Return the breaker control switch to the original position.
- Step 6: Use the Metering Explorer in BESTCOMSP^{Plus} to open the Reports, Sequence of Events screen. Click on the Download button and review the events associated with the breaker control switch.

Protection and Control Function Verification

Before placing the BE1-700 in service, the user should ensure that all system ac and dc connections are correct, that the BE1-700 functions as intended with user settings applied, and that all equipment external to the BE1-700 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 VT input circuits.
- The programmable logic settings (electronic wiring) provide the proper interconnection of these functions with the I/O of the BE1-700.

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 BE1-700 will aid in the verification of the protection and control logic. Use the Metering Explorer in *BESTCOMSPlus* 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 BE1-700 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 *BESTCOMSPlus* to compare setting files. Refer to the *BESTCOMSPlus Software* chapter for more information.

Verify Other Setpoints as Appropriate

Consult the individual functional testing chapters for guidelines on testing and verifying performance of other protection and control functions.

Reporting and Alarm Functions

Just prior to placing the BE1-700 in service, the following reporting and alarm functions should be reset and/or verified.

Clock Display

BESTCOMSPlus 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 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.

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 BE1-700 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 (SOE)

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” SOE 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 to verify VT ratios.
- V2 to verify proper phase-sequence connections. V2 is near 0 volts in a balanced 3 phase system
- Anything else that the user may find helpful.

Save this record along with the status record mentioned earlier for future reference.



39 • Periodic Testing

Periodic Testing

Because the BE1-700 has extensive internal test capabilities, periodic testing of the protection system can be greatly reduced. Relay operating characteristics are a function of programming instructions that do not drift over time. Thus, the user may wish to verify items that the relay's self-testing features cannot completely determine. Periodic testing might consist of the following settings and function checks:

- Verify that the setpoints that were proven during commissioning have not been changed.
- Verify that the inputs and outputs are interfacing properly with the rest of the protection and control system.
- Verify that the power system analog parameters used by the protection and control functions are being measured accurately.

Settings Verification

Verification of the relay digital I/O connections can be accomplished in different ways. The method used depends on your preferences and practices. You might choose to use either of the following two methods:

- Repeat the digital I/O connection and label verification under commissioning tests.
- Monitor SOE, Status, and Fault reports for proper sensing of digital signals and proper output tripping during normal operation.

Note

In redundant protection systems where multiple relays will trip a given breaker or other device for a fault, fault record monitoring may not indicate a failed output contact. The relay may report that it energized an output when tripping was actually accomplished by the redundant relay. In this situation, testing the contact is recommended.

Analog Circuit Verification

Verification of relay analog measurement circuits can be accomplished in multiple ways and depends on your preferences and practices. Either of the two following methods might be used:

- Repeat the acceptance tests by injecting test quantities into the relay.
- Use the relay metering functions to compare the relay's measurements with those made by similar devices that are measuring the same signals. Redundant relays or metering devices can provide this independent confirmation of measured signals. If the relay is connected to an integration system, this verification can even be automated and done on a semi-continuous basis.

Note

If verifying the analog measurement circuits by comparison to independent devices is used, you should ensure that the two devices use similar measurement algorithms and compensate for each device and instrumentation transformers specified accuracies. For example, the measurements of a fundamental sensing relay cannot be compared with the measurements of an RMS sensing device and accuracies may vary.

Care and Handling

The BE1-700 Digital Protective Relay requires no preventative maintenance. The fully digital design of the relay contains no internal jumpers or mechanical settings, and requires no circuit-board level calibration.

Repair of the assembly by replacement of individual circuit boards is not recommended. The printed circuit boards are constructed using surface-mount technology and are not intended to be field serviceable.

Before returning the assembly for repair, contact the Basler Electric, Technical Services Department at 618-654-2341 for a return authorization number.

Storage

This device contains long-life aluminum electrolytic capacitors. For devices that are not in service (spares in storage), the life of these capacitors can be maximized by energizing the device for 30 minutes once per year.

Updating Firmware and Software

Future enhancements to relay functionality may make a firmware update desirable. Enhancements to relay firmware typically coincide with enhancements to BESTCOMSP*lus*[®]. When a relay is updated with the latest version of firmware, the latest version of BESTCOMSP*lus* software should also be obtained.

Updating Relay Firmware

If a firmware upgrade is desired, contact Basler Electric technical support to request download access. Once the appropriate firmware is obtained, it can be uploaded to a relay using BESTCOMSP*lus*.

Updating BESTCOMSP*lus* Software

Firmware enhancements often include the addition of relay settings or the modification of existing settings. BESTCOMSP*lus* software is revised to accommodate the new or modified settings. When firmware is updated, the latest version of BESTCOMSP*lus* should also be obtained. BESTCOMSP*lus* can also be downloaded from www.basler.com.

40 • Volts per Hertz 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 BE1-700 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 BE1-700 is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Typical Connections* 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^{Plus}® 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.

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)* chapter for more information on this function.

Functional Test Procedure

Alarm, Inverse Time Pickup, and Definite Time Pickup Verification

The BE1-700 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 *Overexcitation (24) Inverse Time Curves* chapter) and two definite time characteristics. Note that V/Hz nominal is calculated using Equation 40-1.

$$V/Hz_{\text{Nom}} = \frac{\sqrt{3} \times V_{\text{Nom}}}{\text{Hz}_{\text{Nom}}} = \frac{\sqrt{3} \times 69.3}{60} = 2.001$$

Equation 40-1. V/Hz Nominal Calculation

That is, at nominal voltage and frequency (60 Hz system) 1 pu V/Hz = 2.001.

Step 1: Use BESTCOMSP^{Plus} to send the operational settings in Table 40-1 to the BE1-700. Reset all targets.

Table 40-1. Operational Settings

Setting	Value	BESTCOMSP ^{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
Nominal Phase Voltage	69.3 V	System Parameters, Power System	Sets nominal phase voltage to 69.3 V

Setting	Value	BESTCOMSP _{Plus} 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_{Plus} to configure the BESTlogic_{Plus} programmable logic shown in Figure 40-1.

- Blocking is disabled.
- OUT1 closes for 24 Trip.
- OUT2 closes for 24 Pickup.

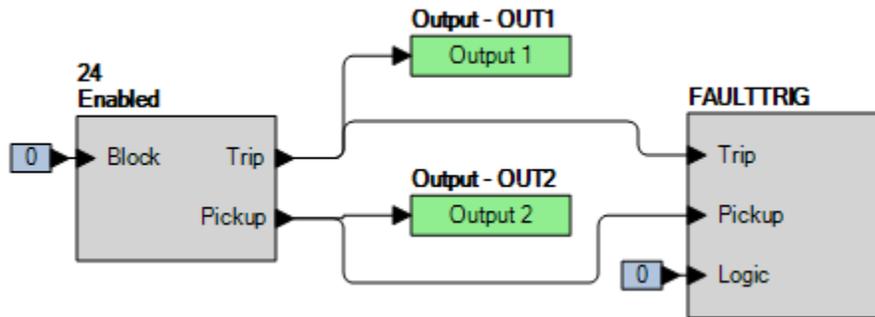


Figure 40-1. BESTlogic_{Plus} Settings

Step 3: Use BESTCOMSP_{Plus} to open the Protection, Voltage, Overexcitation (24) screen and send the test settings in Table 40-2 to the BE1-700.

Table 40-2. Alarm and Inverse Time Pickup Test Settings

Setting	Value	Description
Inverse Time Pickup	2.1	Sets Inverse Time Pickup at 105% 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 102.5% 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 40-3 to the BE1-700.

Table 40-3. 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.
- 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 $(M-1)^2$ time curve.

- Step 1: Use BESTCOMSP*lus* to open the Protection, Voltage, Overexcitation (24) screen and send the test settings in Table 40-4 to the BE1-700.

Table 40-4. Inverse Time Verification Test Settings

Setting	Value	Description
Inverse Time Pickup	2.1	Sets Inverse Time Pickup at 105% 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 *Overexcitation (24) Inverse Time Curves* chapter. Step the A-phase voltage to a value that equals the V/Hz % of nominal shown in Table 40-5 for Time Dial 0.5. Measure the time between the increase of voltage and the closure of OUT1. Record the results.

Table 40-5. 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.

Inverse Time Reset Verification

Step 1: Use BESTCOMSP*lus* to open the Protection, Voltage, Overexcitation (24) screen and send the test settings in Table 40-6 to the BE1-700.

Table 40-6. Inverse Time Reset Verification Test Settings

Setting	Value	Description
Inverse Time Pickup	2.1	Sets Inverse Time Pickup at 105% 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)* 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.

Definite Time Verification

Step 1: Use BESTCOMSP_{Plus} to open the Protection, Voltage, Overexcitation (24) screen and send the test settings in Table 40-7 to the BE1-700.

Table 40-7. 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.

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 ± 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 ± 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 ± 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 ± 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 ± 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 ± 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

41 • 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 BE1-700 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 BE1-700 is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Typical Connections* 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.

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)* 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 BESTCOMSPPlus to send the operational settings in Table 41-1 to the BE1-700. Reset all targets.

Table 41-1. Operational Settings (25)

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
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 .

- Blocking is disabled.
- OUT1 closes for 25.
- OUT2 closes for 25 Voltage Monitor.

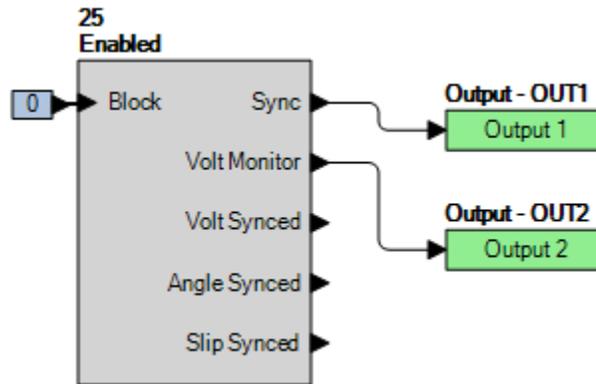


Figure 41-1. BESTlogicPlus Settings (25)

Step 3: Use BESTCOMSPPlus to open the Protection/Voltage/Sync-Check (25) screen and send the test settings in Table 41-2 to the BE1-700.

Table 41-2. 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 41-2.	Enable: Dead Phase/Dead Aux, Dead Phase/Live Aux, Live Phase/Dead Aux

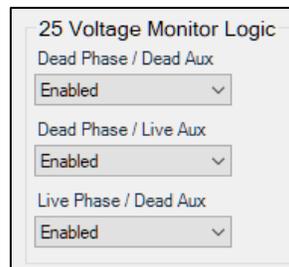


Figure 41-2. BESTCOMSPPlus Sync-Check Screen, 25 Voltage Monitor Logic

- Step 4: Prepare to monitor the 25VM function operation. Operation can be verified by monitoring OUT2.
- Step 5: Connect BE1-700 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 BE1-700 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.

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 41-3 to the BE1-700.

Table 41-3. 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 41-2.
90%	55%	2,000 ms	Check boxes as shown in Figure 41-2.
90%	55%	5,000 ms	Check boxes as shown in Figure 41-2.

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 BE1-700 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 41-3.

Step 7: Remove phase voltage (Line VTP) and connect a second single-phase 50 or 60-hertz voltage source (Auxiliary VTX) to BE1-700 terminals C17 (polarity) and C18 (non-polarity). Repeat steps 4 through 6.

Step 8: (Optional.) Repeat steps 2 through 7 for settings group 1.

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.

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 41-4 to the-BE1-700.

Table 41-4. 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 BESTCOMSPlus
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 BE1-700 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 BE1-700). 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 BE1-700). 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.

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 ± 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

Step	Dropout Delay Setting	Low	Actual Timing	High	Pass/Fail
6	VTP - Dead V Dropout Delay - 5,000 ms	4,968 ms		5,032 ms	P / F
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 ± 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°		11°		P / F
7	Slip Angle = -10°	-9°		-11°		P / F

Slip Frequency Accuracy = ± 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



42 • 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 BE1-700 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 BE1-700 is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Typical Connections* 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.

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)* chapter for more information on this function.

Functional Test Procedure

Pickup Verification

Step 1: Use BESTCOMSPPlus to send the operational settings in Table 41-1 to the BE1-700. Reset all targets.

Table 41-1. 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 BESTlogicPlus programmable logic shown in Figure 41-1.

- Blocking is disabled.
- OUT1 closes for 27P-1 Trip.
- OUT2 closes for 27P-1 Pickup.
- Fault recording is enabled.

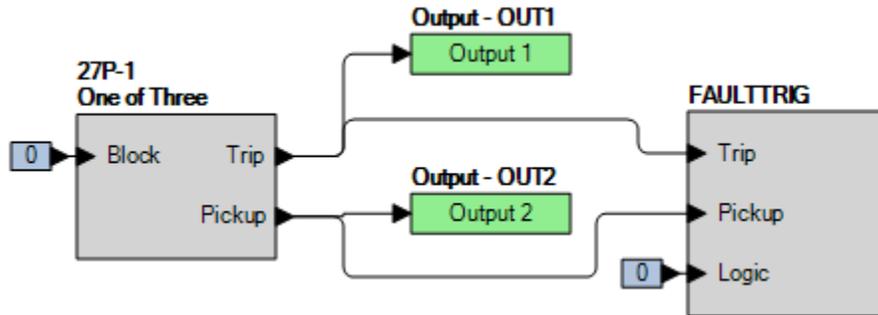


Figure 41-1. BESTlogicPlus Settings

Step 3: Use BESTCOMSPi.us to open the Protection, Voltage, Undervoltage (27P-1) screen and send the first row of test settings in Table 41-2 to the BE1-700.

Table 41-2. 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 41-1).

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 41-2. 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.

Step 10: (Optional.) Repeat steps 1 through 9 for 27P-2.

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 41-3 to the BE1-700 for settings group 0.

Table 41-3. 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 41-3. 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.
- Step 8: (Optional.) Repeat steps 1 through 7 for 27P-2.

Functional Test Report

Pickup Verification

Pickup Setting Range = 1 to 300 V

Pickup Accuracy = $\pm 2\%$ or ± 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 = 10 to 600,000 ms

Timing Accuracy = $\pm 0.5\%$ or ± 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



43 • 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 BE1-700 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 BE1-700 is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Typical Connections* 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.

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)* 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 BESTCOMSPPlus to send the operational settings in Table 42-1 to the BE1-700. Reset all targets.

Table 42-1. Operational Settings (3V0 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	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
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 BESTCOMSPi.us to configure the BESTlogicPlus programmable logic shown in Figure 42-1.

- Blocking is disabled.
- OUT1 closes for 27X-1 Trip.
- OUT2 closes for 27X-1 Pickup.
- Fault recording is enabled.

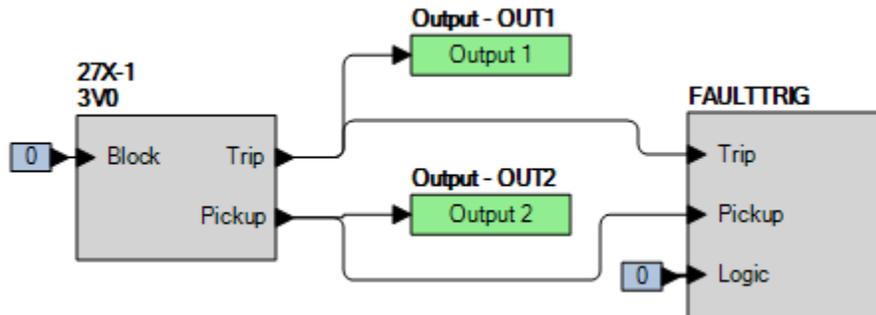


Figure 42-1. BESTlogicPlus Settings (3V0 Mode)

Step 3: Use BESTCOMSPi.us to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 42-2 to the BE1-700.

Table 42-2. 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 42-1).

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 reset accuracy at a pickup setting of 65 V and 20 V as listed in Table 42-2. 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.

Timing Verification (3V0 Mode)

Step 1: Use BESTCOMSPi.us to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 42-3 to the BE1-700 for settings group 0.

Table 42-3. 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 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 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 42-3. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1.

Pickup Verification (Vx Fundamental Mode)

- Step 1: Use *BESTCOMSPlus* to send the operational settings in Table 42-4 to the BE1-700. Reset all targets.

Table 42-4. Operational Settings (Vx Fundamental Mode)

Setting	Value	BESTCOMSPlus 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 *BESTCOMSPlus* to configure the *BESTlogicPlus* programmable logic shown in Figure 42-2.

- Blocking is disabled.
- OUT1 closes for 27X-1 Trip.
- OUT2 closes for 27X-1 Pickup.
- Fault recording is enabled.

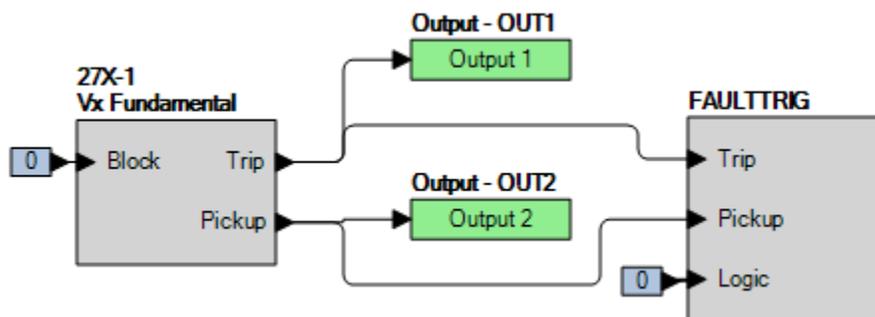


Figure 42-2. BESTlogicPlus Settings (Vx Fundamental Mode)

- Step 3: Use *BESTCOMSPi* to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 42-5 to the BE1-700.

Table 42-5. 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 42-4).
- 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 42-5. 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.

Timing Verification (Vx Fundamental Mode)

- Step 1: Use *BESTCOMSPi* to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 42-6 to the BE1-700 for settings group 0.

Table 42-6. 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 42-6. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1.

Pickup Verification (Vx Third Harmonic Mode)

- Step 1: Use *BESTCOMSPi* to send the operational settings in Table 42-7 to the BE1-700. Reset all targets.

Table 42-7. Operational Settings (Vx Third Harmonic Mode)

Setting	Value	BESTCOMSPi 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

Setting	Value	BESTCOMSPi+ Screen	Description
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 BESTCOMSPi+ to configure the BESTlogicPi+ programmable logic shown in Figure 42-3.

- Blocking is disabled.
- OUT1 closes for 27X-1 Trip.
- OUT2 closes for 27X-1 Pickup.
- Fault recording is enabled.

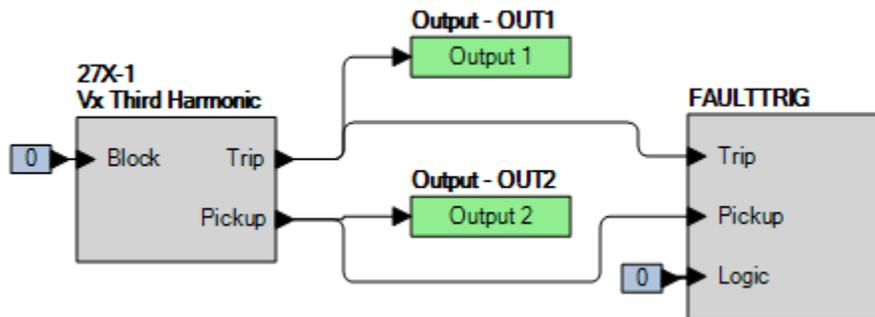


Figure 42-3. BESTlogicPi+ Settings (Vx Third Harmonic Mode)

Step 3: Use BESTCOMSPi+ to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 42-8 to the BE1-700.

Table 42-8. 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 42-3).
- Step 5: Connect and apply a single-phase, 120 Vac, 3rd 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 42-8. 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.

Timing Verification (Vx Third Harmonic Mode)

Step 1: Use BESTCOMSP_{Plus} to open the Protection, Voltage, Undervoltage (27X-1) screen and send the first row of test settings in Table 42-9 to the BE1-700 for settings group 0.

Table 42-9. 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, 3rd 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 42-9. Record the results.

Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1.

Functional Test Report

Pickup Verification (3V0 Mode)

Pickup Setting Range = 1 to 150 V

Pickup Accuracy = $\pm 2\%$ or ± 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 = 10 to 600,000 ms

Timing Accuracy = $\pm 0.5\%$ or ± 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 ± 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 ± 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 ± 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 ± 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



44 • Negative-Sequence Overvoltage (47) 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 BE1-700 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 BE1-700 is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Typical Connections* 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^{Plus}® 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.

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 *Negative-Sequence Overvoltage (47)* chapter for more information on this function.

Functional Test Procedure

Pickup Verification – Negative Sequence (47)

Step 1: Use BESTCOMSP^{Plus} to send the operational settings in Table 44-1. Reset all targets.

Table 44-1. Operational Settings

Setting	Value	BESTCOMSP ^{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	Enabled	Protection, Voltage, Overvoltage (47-1)	Enables the 47-1 function

Step 2: Use BESTCOMSP^{Plus} to configure the BESTlogic*Plus* programmable logic shown in Figure 44-1.

- Blocking is disabled.
- OUT1 closes for 47-1 Trip.
- OUT2 closes for 47-1 Pickup.
- Fault recording is enabled.

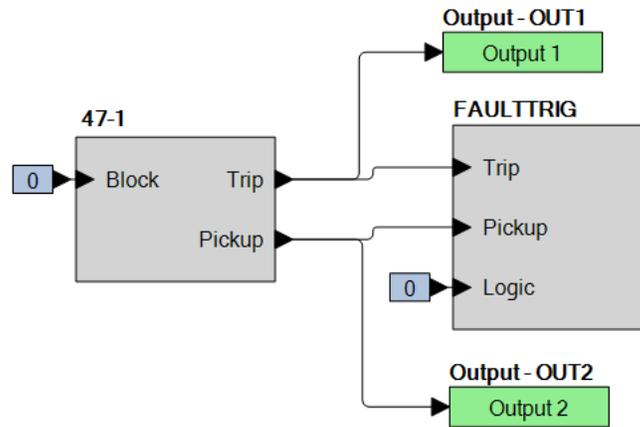


Figure 44-1. BESTlogicPlus Settings

- Step 3: Use BESTCOMSPi+ to open the Protection, Voltage, Negative Sequence Overvoltage (47-1) screen and send the first row of test settings in Table 44-2 to the BE1-700.

Table 44-2. Pickup Test Settings

Pickup Setting	Time Delay
82 V	50 ms
42 V	50 ms
25 V	50 ms

- Step 4: Prepare to monitor the 47-1 function operation. Operation can be verified by monitoring OUT2 (see Figure 44-1).
- 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, $V_2 = A\text{-phase voltage} / 3$. Therefore, the BE1-700 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 BE1-700 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 44-2. 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.

Timing Verification– Negative Sequence (47)

- Step 1: Use BESTCOMSPi+ to open the Protection, Voltage, Overvoltage (47-1) screen and send the first row of test settings in Table 44-3 to the BE1-700 for settings group 0.

Table 44-3. Timing Test Settings

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 47-1 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 44-3. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1.

Functional Test Report

Pickup Verification – Negative Sequence (47)

Pickup Setting Range = 1 to 300 V

Pickup Accuracy = $\pm 2\%$ or ± 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 – Negative Sequence (47)

Time Delay Range = 50 to 600,000 ms

Timing Accuracy = $\pm 0.5\%$ or ± 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



45 • 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 BE1-700 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 BE1-700 is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Typical Connections* 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.

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)* chapter for more information on this function.

Functional Test Procedure

Pickup Verification

Step 1: Use BESTCOMSPPlus to send the operational settings in Table 45-1 to the BE1-700. Reset all targets.

Table 45-1. 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, 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 45-1.

- Blocking is disabled.
- OUT1 closes for 59P-1 Trip.
- OUT2 closes for 59P-1 Pickup.
- Fault recording is enabled.

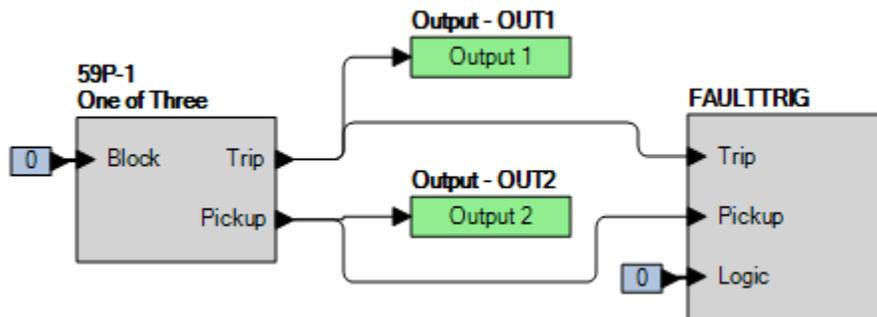


Figure 45-1. BESTlogicPi.us Settings

Step 3: Use BESTCOMSPi.us to open the Protection, Voltage, Overvoltage (59P-1) screen and send the first row of test settings in Table 45-2 to the BE1-700.

Table 45-2. 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 45-1).

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 45-2. 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.

Step 10: (Optional.) Repeat steps 1 through 9 for 59P-2.

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 45-3 to the BE1-700 for settings group 0.

Table 45-3. 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 45-3. 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.
- Step 8: (Optional.) Repeat steps 1 through 7 for 59P-2.

Functional Test Report

Pickup Verification

Pickup Setting Range = 1 to 300 V

Pickup Accuracy = $\pm 2\%$ or ± 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 = 10 to 600,000 ms

Timing Accuracy = $\pm 0.5\%$ or ± 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



46 • 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 BE1-700 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 BE1-700 is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Typical Connections* 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.

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)* chapter for more information on this function.

Functional Test Procedure

Pickup Verification (3V0 Mode)

Step 1: Use BESTCOMSPPlus to send the operational settings in Table 46-1 to the BE1-700. Reset all targets.

Table 46-1. Operational Settings (3V0 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	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+ to configure the BESTlogicPi+ programmable logic shown in Figure 46-1.

- Blocking is disabled.
- OUT1 closes for 59X-1 Trip.
- OUT2 closes for 59X-1 Pickup.
- Fault recording is enabled.

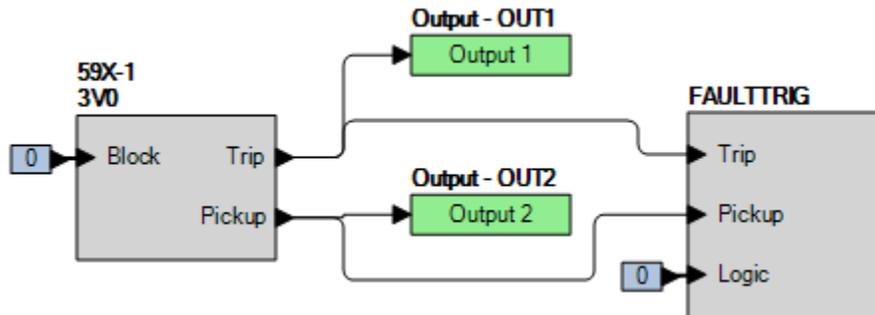


Figure 46-1. BESTlogicPi+ Settings (3V0 Mode)

Step 3: Use BESTCOMSPi+ to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 46-2 to the BE1-700.

Table 46-2. 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 46-1).

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 46-2 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.

Step 10: (Optional.) Repeat steps 1 through 9 for 59X-2.

Timing Verification (3V0 Mode)

Step 1: Use BESTCOMSPi+ to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 46-3 to the BE1-700 for settings group 0.

Table 46-3. 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 46-3. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1.
- Step 7: (Optional.) Repeat steps 1 through 6 for 59X-2.

Pickup Verification (Vx Fundamental Mode)

- Step 1: Use BESTCOMSP*lus* to send the operational settings in Table 46-4 to the BE1-700. Reset all targets.

Table 46-4. 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 BESTlogicP*lus* programmable logic shown in Figure 46-2.

- Blocking is disabled.
- OUT1 closes for 59X-1 Trip.
- OUT2 closes for 59X-1 Pickup.
- Fault recording is enabled.

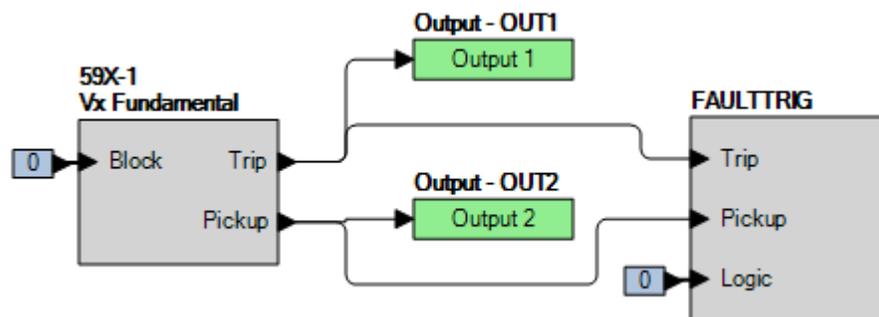


Figure 46-2. BESTlogicPlus Settings (Vx Fundamental Mode)

- Step 3: Use BESTCOMSP*lus* to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 46-5 to the BE1-700.

Table 46-5. 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 46-2).
- 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 46-5. Record 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.
- Step 10: (Optional.) Repeat steps 1 through 9 for 59X-2.

Timing Verification (Vx Fundamental 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 46-6 to the BE1-700 for settings group 0.

Table 46-6. 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 46-6. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1.
- Step 7: (Optional.) Repeat steps 1 through 6 for 59X-2.

Pickup Verification (Vx Third Harmonic Mode)

Step 1: Use *BESTCOMSPlus* to send the operational settings in Table 46-7 to the BE1-700. Reset all targets.

Table 46-7. Operational Settings (Vx Third Harmonic Mode)

Setting	Value	BESTCOMSPus 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 *BESTCOMSPus* to configure the *BESTlogicPlus* programmable logic shown in Figure 46-3. Blocking is disabled.

- OUT1 closes for 59X-1 Trip.
- OUT2 closes for 59X-1 Pickup.
- Fault recording is enabled.

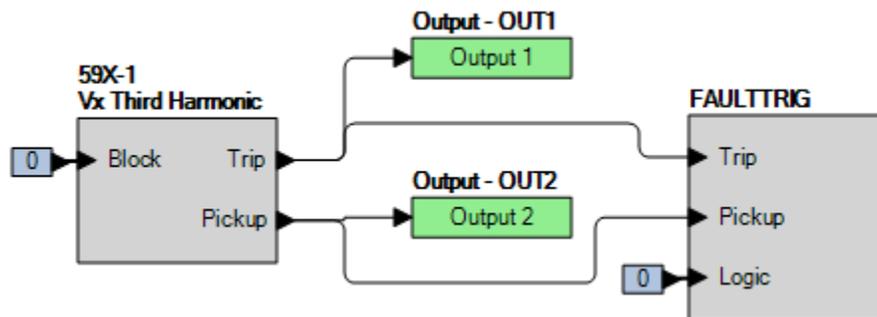


Figure 46-3. BESTlogicPlus Settings (Vx Third Harmonic Mode)

Step 3: Use *BESTCOMSPus* to open the Protection, Voltage, Overvoltage (59X-1) screen and send the first row of test settings in Table 46-8 to the BE1-700.

Table 46-8. 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 46-3).

Step 5: Connect and apply a single-phase, 120 Vac, 3rd harmonic 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-1-3RD 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 46-8. 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.
- Step 10: (Optional.) Repeat steps 1 through 9 for 59X-2.

Timing Verification (Vx Third Harmonic 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 46-9 to the BE1-700 for settings group 0.

Table 46-9. Timing Test Settings (Vx 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, 3rd 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 46-9. Record the results.
- Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1.
- Step 7: (Optional.) Repeat steps 1 through 6 for 59X-2.

Functional Test Report

Pickup Verification (3V0 Mode)

Pickup Setting Range = 1 to 150 V

Pickup Accuracy = $\pm 2\%$ or ± 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 $VA=3V0+150$ V nominal.

Timing Verification (3V0 Mode)

Time Delay Range = 10 to 600,000 ms

Timing Accuracy = $\pm 0.5\%$ or ± 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 ± 1 V, whichever is greaterDropout/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 ± 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 ± 1 V, whichever is greaterDropout/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 ± 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

47 • Over/Underfrequency (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 BE1-700 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 BE1-700 is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Typical Connections* 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.

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)* chapter for more information on this function.

Functional Test Procedure

Overfrequency Pickup Verification

Step 1: Use BESTCOMSPPlus to send the operational settings in Table 47-1 to the BE1-700. Reset all targets.

Table 47-1. Operational Settings (Overfrequency)

Setting	Value	BESTCOMSPPlus 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 47-1.

- Blocking is disabled.
- OUT1 closes for 81-1 Trip.
- OUT2 closes for 81-1 Pickup.
- Fault recording is enabled.

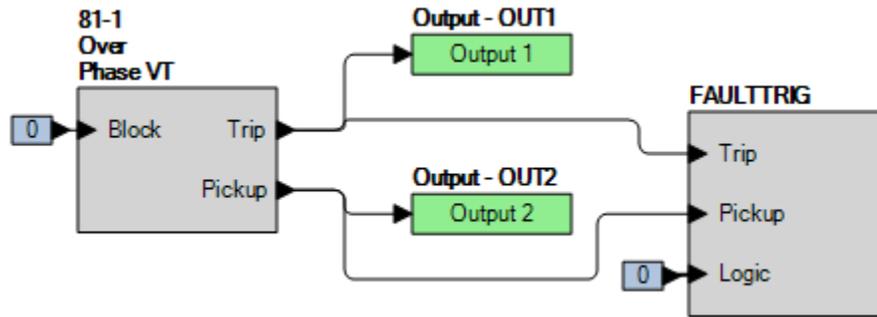


Figure 47-1. BESTlogicPlus Settings (Overfrequency)

Step 3: Use BESTCOMSPlus to open the Protection, Frequency, Frequency (81-1) screen and send the first row of test settings in Table 47-2 to the BE1-700.

Table 47-2. 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 47-1).
- 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 47-2. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for settings group 1.
- Step 9: (Optional.) Repeat steps 1 through 8 for 81-2, 81-3, 81-4, 81-5, and 81-6.

Underfrequency Pickup Verification

Step 1: Use BESTCOMSPlus to send the operational settings in Table 47-3 to the BE1-700. Reset all targets.

Table 47-3. Operational Settings (Underfrequency)

Setting	Value	BESTCOMSPlus 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 BESTCOMSPlus to configure the BESTlogicPlus programmable logic shown in Figure 47-2.
- Blocking is disabled.
 - OUT1 closes for 81-1 Trip.
 - OUT2 closes for 81-1 Pickup.
 - Fault recording is enabled.

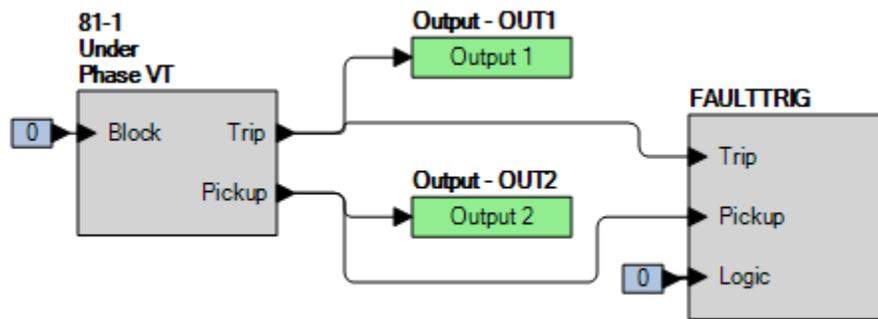


Figure 47-2. BESTlogicPlus Settings (Underfrequency)

Step 3: Use BESTCOMSP*lus* to open the Protection, Frequency, Frequency (81-1) screen and send the first row of test settings in Table 47-4 to the BE1-700.

Table 47-4. 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 47-2).
- 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 47-4. Record the results.
- Step 8: (Optional.) Repeat steps 1 through 7 for settings group 1.
- Step 9: (Optional.) Repeat steps 1 through 8 for 81-2, 81-3, 81-4, 81-5, and 81-6.

Time Delay Verification

Step 1: Use BESTCOMSP*lus* to open the Protection, Frequency, Frequency (81-1) screen and send the first row of test settings in Table 47-5 to the BE1-700. Commands entered in Table 47-3 should be retained for this test.

Table 47-5. 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 47-5. Record the results.

Step 6: (Optional.) Repeat steps 1 through 5 for settings group 1.

Step 7: (Optional.) Repeat steps 1 through 6 for 81-2, 81-3, 81-4, 81-5, and 81-6.

Functional Test Report

Overfrequency Pickup Verification

Pickup Setting Range = 20 to 70 Hz

Pickup Accuracy = ± 0.01 Hz

Dropout = 0.02 Hz ± 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 = 20 to 70 Hz

Pickup Accuracy = ± 0.01 Hz

Reset = 0.02 Hz ± 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 ± 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

48 • Virtual Control Switch (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 BE1-700 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 BE1-700 is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Typical Connections* 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.

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 Switch (43)* chapter for more information on this function.

Functional Test Procedure

Switch/Pulse Mode

Step 1: Use BESTCOMSPPlus to send the operational settings in Table 48-1 to the BE1-700.

Table 48-1. Operational Settings

Setting	Value	BESTCOMSPPlus 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 BESTCOMSPPlus to configure the BESTlogicPlus programmable logic shown in Figure 48-1.

- All inputs are set to logic 0.
- OUT1 closes when 43-1 output is true.

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 48-2). Using select-before-operate, perform the following steps to control a virtual switch.

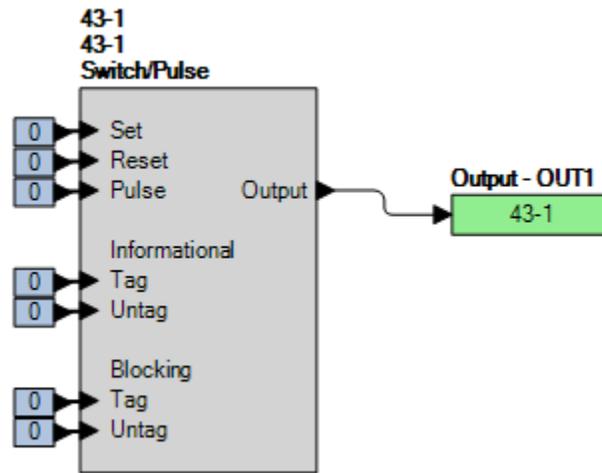


Figure 48-1. BESTlogicPlus Settings

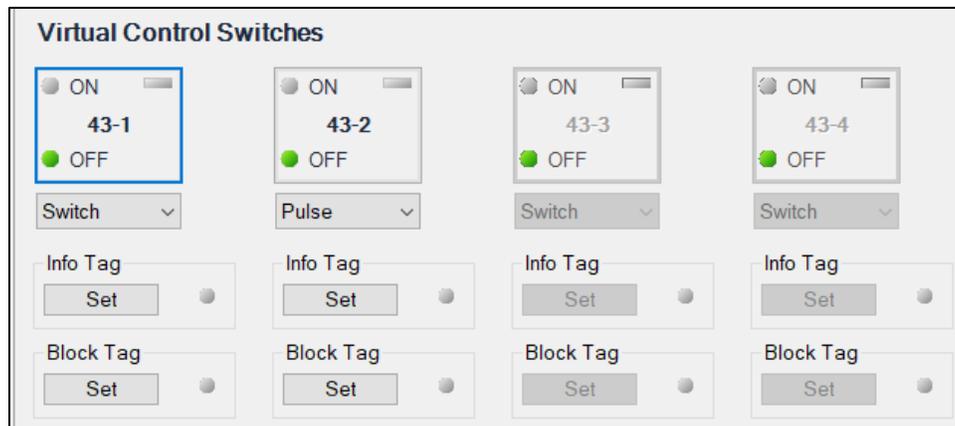


Figure 48-2. BESTCOMSPlus Virtual Switches Control Screen

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, and 43-4.

Step 10: (Optional.) Repeat steps 1 through 9 for settings group 1.

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 48-2). 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, and 43-4.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1.

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, and 43-4.
- Step 5: (Optional.) Repeat steps 1 through 4 for settings group 1.

Functional Test Report

Function	Pass/Fail
Switch/Pulse Mode	P / F
Switch Mode	P / F
Pulse Mode	P / F



49 • 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 BE1-700 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 BE1-700 is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Typical Connections* 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.

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 Timer (62)* chapter for more information on this function.

Functional Test Procedure

Pickup/Dropout Mode

Step 1: Use BESTCOMSPPlus to send the operational settings in Table 49-1 to the-BE1-700.

Table 49-1. Operational Settings (Pickup/Dropout Mode)

Setting	Value	BESTCOMSPPlus 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 BESTCOMSPPlus to configure the BESTlogicPlus programmable logic shown in Figure 49-1.

- Blocking is disabled.
- 62-1 initiates when 43-1 output is true.
- OUT1 closes when 62-1 output is true.

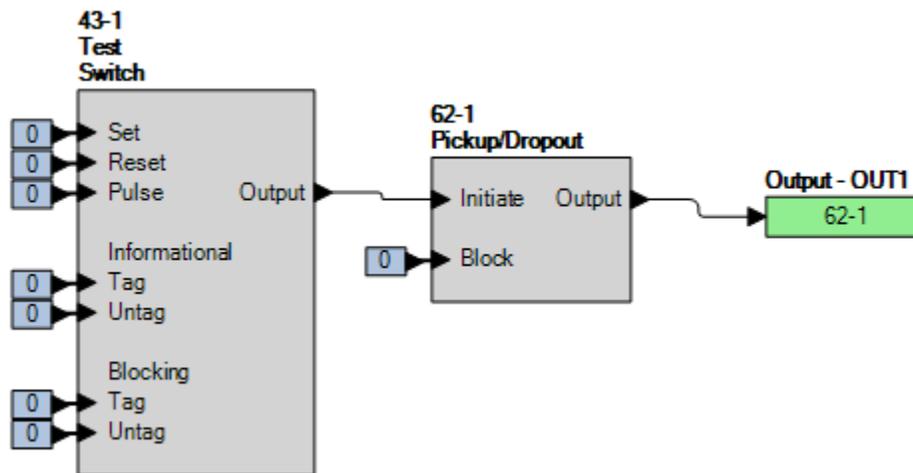


Figure 49-1. BESTlogicPlus Settings

- 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 BESTCOMSPPlus to open the Control, Virtual Switches tree branch (Figure 49-2). Using select-before-operate, perform the following steps to control a virtual switch.

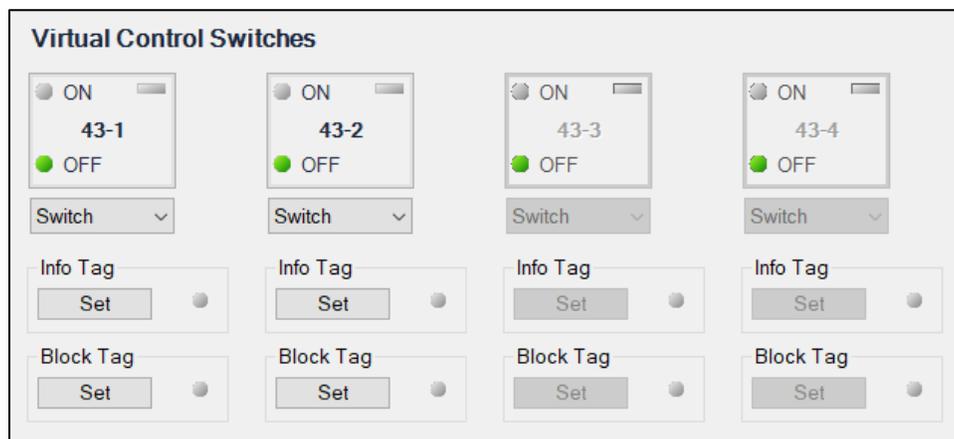


Figure 49-2. BESTCOMSPPlus Virtual Switches Control Screen

- 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: 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 BESTCOMSPPlus 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

- 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: Repeat step 4.
- Step 6: Wait at least 15 seconds (but no longer than 35 seconds) and then repeat step 4.
- Step 7: Use the Metering Explorer in BESTCOMSPi^{us} 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 49-5 illustrates the timing relationship of the 43-1 switch and 62-1 timer.

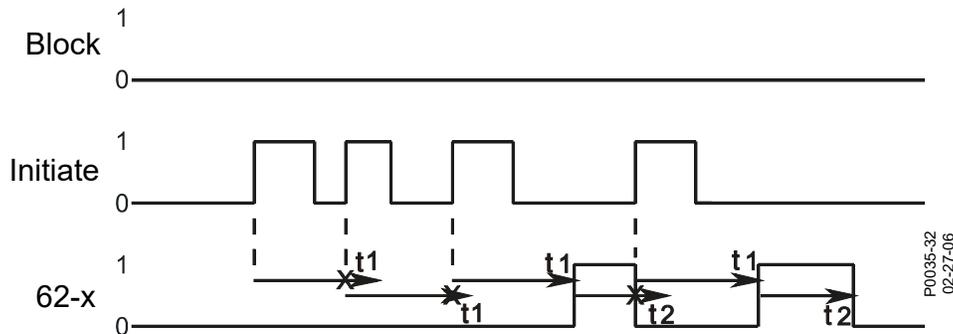


Figure 49-5. One-Shot/Retriggerable Mode

- Step 8: (Optional.) Repeat steps 1 through 7 for 62-2.
- Step 9: (Optional.) Repeat steps 1 through 8 for settings group 1.

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 Timer (62)* chapter.

Integrating Timer Mode

- Step 1: Use BESTCOMSPi^{us} to send the operational settings in Table 49-4 to the BE1-700. Retain the logic settings from Figure 49-1.

Table 49-4. Operational Settings (Integrating Timer Mode)

Setting	Value	BESTCOMSPi ^{us} 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.

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*Plus* to open the Control, Virtual Switches tree branch (Figure 49-2). 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*Plus* 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 49-6 illustrates the timing relationship of the 43-1 switch and 62-1 timer.

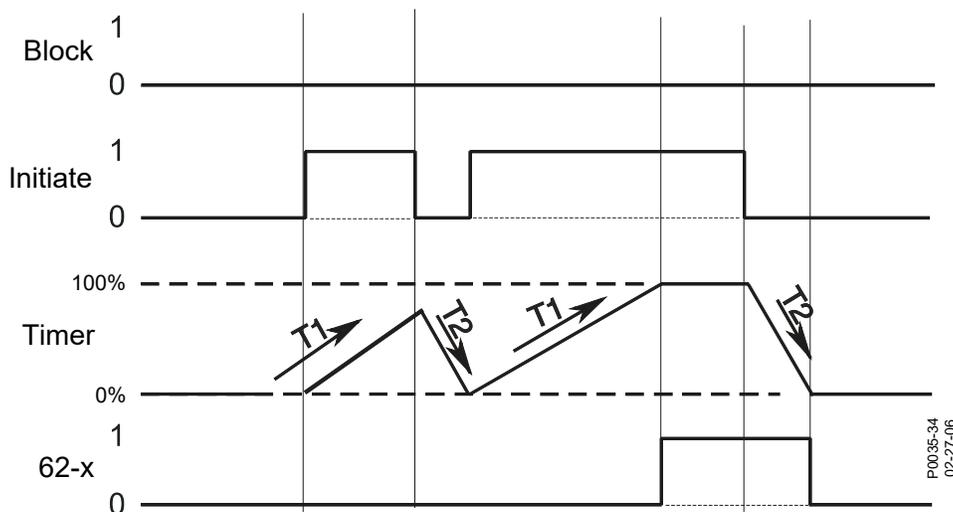


Figure 49-6. Integrating Timer Mode

- Step 11: (Optional.) Repeat steps 1 through 10 for 62-2.
- Step 12: (Optional.) Repeat steps 1 through 11 for settings group 1.

Latched Mode

Step 1: Use BESTCOMSPlus to send the operational settings in Table 49-5 to the BE1-700. Retain the logic settings from Figure 49-1.

Table 49-5. Operational Settings (Latched Mode)

Setting	Value	BESTCOMSPlus 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 BESTCOMSPlus to configure the BESTlogicPlus programmable logic shown in Figure 49-7.

- 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.

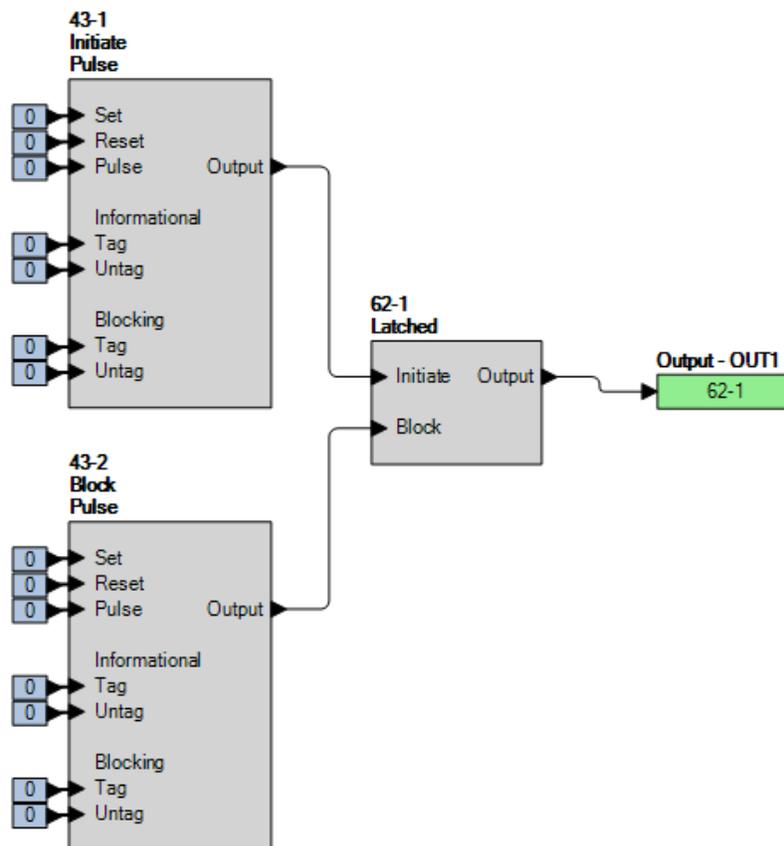


Figure 49-7. BESTlogicPlus Settings (Latched Mode)

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.

Step 4: Close communication with BESTCOMSPlus.

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 BESTCOMSPlus 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 49-8 illustrates the timing relationship of the 43-1/43-2 switches and 62-1 timer.

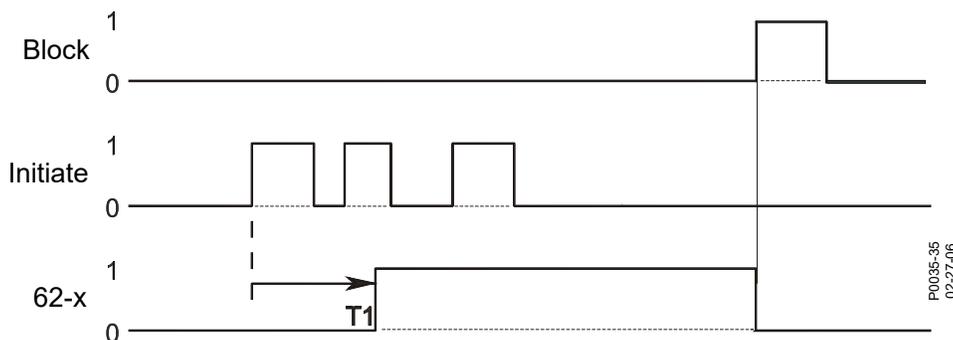


Figure 49-8. Latched Mode

Step 10: (Optional.) Repeat steps 1 through 9 for 62-2.

Step 11: (Optional.) Repeat steps 1 through 10 for settings group 1.

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



50 • 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 BE1-700 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 BE1-700 is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Sales Support.

Refer to the *Terminals and Typical Connections* 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.

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 BESTCOMSPPlus to send the operational settings in Table 50-1 to the BE1-700.

Table 50-1. Operational Settings

Setting	Value	BESTCOMSPPlus Screen	Description
101 Mode	Enabled	Control, Breaker Control Switch (101)	Enables 101 function

Step 2: Use BESTCOMSPPlus to configure the BESTlogicPlus Programmable Logic shown in Figure 50-1.

- 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 BESTCOMSPPlus 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.

51 • Frequently Asked Questions (FAQ)

Electrical/Connections

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

If a protective element is tripping at the desired level, but the targets and fault records aren't behaving as expected, two settings locations should be checked. Trip LED behavior is designed to flash when it is in a known pickup condition. And stay lit when there is a known trip condition. Status is dependent upon the pickup and trip status of the logic Fault Trigger block and targets. The truth table of Table 51-1 serves as an aid to interpreting Trip LED indications.

Table 51-1. Trip LED Truth Table

Fault Trigger Trip	Fault Trigger Pickup	Target	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

Are the power supply or contact inputs polarity sensitive?

No, the power supply will accept either an ac or dc voltage input. However, the contact sensing for the programmable inputs is polarity sensitive. Refer to the *Terminals and Typical Connections* chapter for interconnection diagrams.

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

Voltage level is dependent on the power supply option. For additional information, see the *Introduction* chapter.

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

Yes, multiple BE1-700 units can use the same IRIG-B input signal by daisy-chaining the BE1-700 inputs. The burden data is nonlinear, approximately 4 k Ω at 3.5 Vdc and 3 k Ω at 20 Vdc. See the *Specifications* chapter for additional information.

General Operation

Does the BE1-700 trip output contact latch after a fault?

The answer to the question is typically no. In general, once the fault goes away the output contacts open. The BE1-700 does offer an option to ensure that the contact will stay closed for at least 200 milliseconds. See 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.

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

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

Can I make logic settings at the front panel?

No, logic settings cannot be programmed at the front panel. Logic settings must be programmed using BESTCOMSPi^{us}® communication software.

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

The BE1-700 factory settings include general logic for voltage and frequency protection. Protection setpoints and modes are application specific and therefore set to 0 and disabled. 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. For protection and control functions see the appropriate protection and control chapters. The factory default logic scheme is defined in the BESTlogicPi^{us} chapter.

How are reports and other information obtained from the BE1-700 saved in files for future use?

BESTCOMSPi^{us} can be used to view sequence of events, fault records, and breaker status. See the appropriate chapters for more information.

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

The application version can be found in two different ways: One, the Settings > General Settings > Device Information screen of the front-panel display. And two, on the Settings Explorer, General Settings, Device Info screen of BESTCOMSPi^{us}.

Communications

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

If you try to gain access to a port with more than one interface, an access conflict can result. The BE1-700 has three communication ports: front-panel USB, rear panel optional Ethernet, and rear panel RS-485. USB and RS-485 are serial connections and therefore can only support one connection at a time. Ethernet can support multiple simultaneous interfaces, but only one of each protocol interface simultaneously. Additionally, each User is only allowed to access one port at a time so if logged in from the HMI, access will not be allowed if also trying to log in via USB with the same User credentials.

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.

Is the IRIG signal modulated or demodulated?

The BE1-700 accepts an IRIG-B signal that is demodulated (dc level-shifted digital signal). See the *Specifications* chapter for additional information.

52 • Troubleshooting

The BE1-700 protection system is similar in protection and control 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.

If you do not get the results that you expect from the BE1-700, first check the programmable settings for the appropriate function. Use the following troubleshooting procedures when difficulties are encountered in the operation of your BE1-700.

Warning!

Troubleshooting of the BE1-700 should be performed only by qualified personnel. High voltage may be present on the rear terminals of the BE1-700.

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 *Communications* chapter.
- Step 2. Verify that the network configuration of the BE1-700 is set up properly. For more information, refer to the *Communications* chapter.

USB Port Does Not Operate Properly

Verify that the USB driver was installed properly. For more information, refer to the *BESTCOMSPPlus Software* chapter.

USB Driver Did Not Install Properly on Windows® 7, 8, or 10

- Step 1. If the message in Figure 52-1 is shown, close all programs and restart the computer.

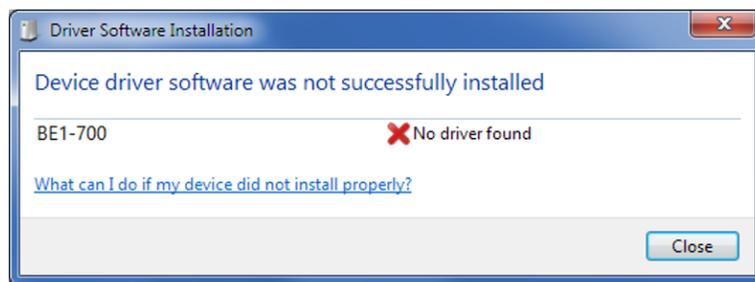


Figure 52-1. Driver Software Installation

- Step 2. Open the Windows® Device Manager as shown in Figure 52-2. Right-click on BE1-700 (or Unknown Device) under Other Devices and select Properties.

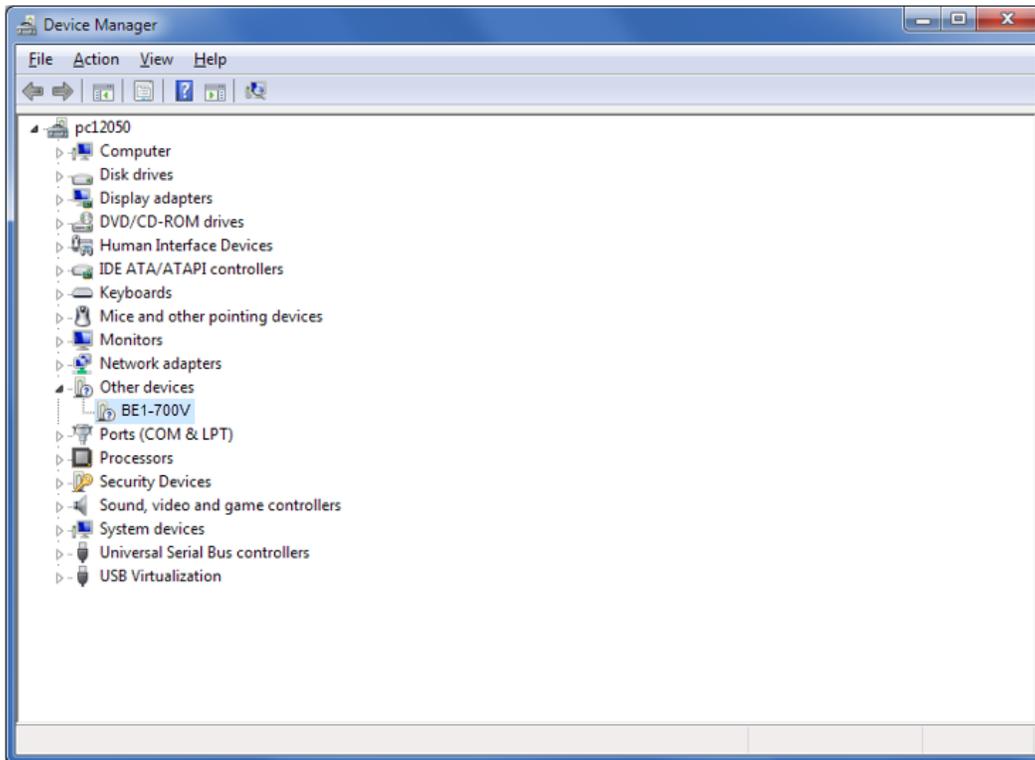


Figure 52-2. Device Manager

Step 3. In the Properties windows, select the Driver tab and click Update Driver. See Figure 52-3.

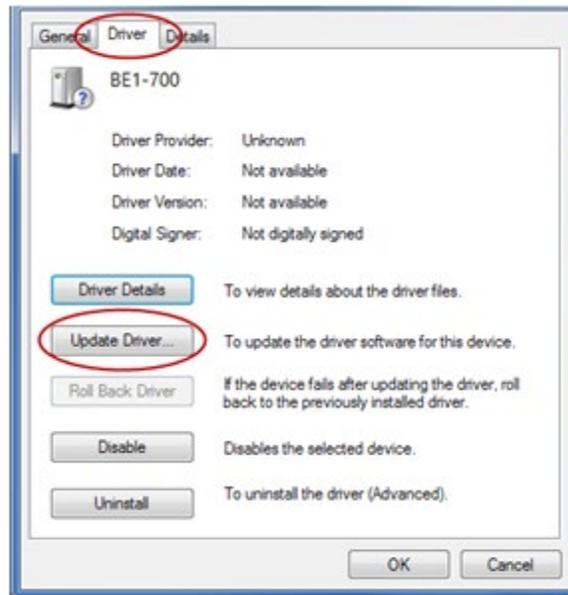


Figure 52-3. BE1-700 Properties

Step 4. Select Browse My Computer for Driver Software as shown in Figure 52-4.

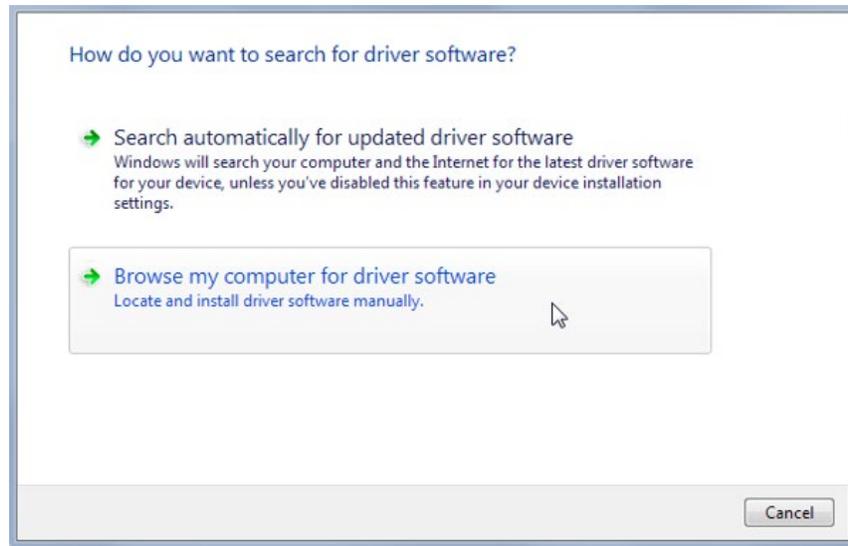


Figure 52-4. Update Driver Software - BE1-700

Step 5. Click Browse and navigate to C:\Program Files\Basler Electric\USB Connect Driver. Click Next. See Figure 52-5.

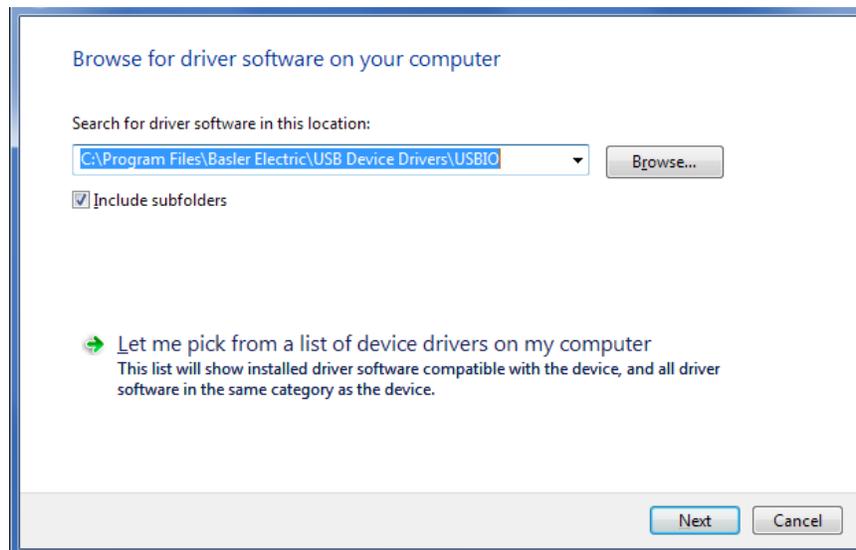


Figure 52-5. Update Driver Software - BE1-700

Step 6. If a Windows Security window (Figure 52-6) appears, click Install.



Figure 52-6. Windows Security

Step 7. The window in Figure 52-7 appears if driver installation was successful.

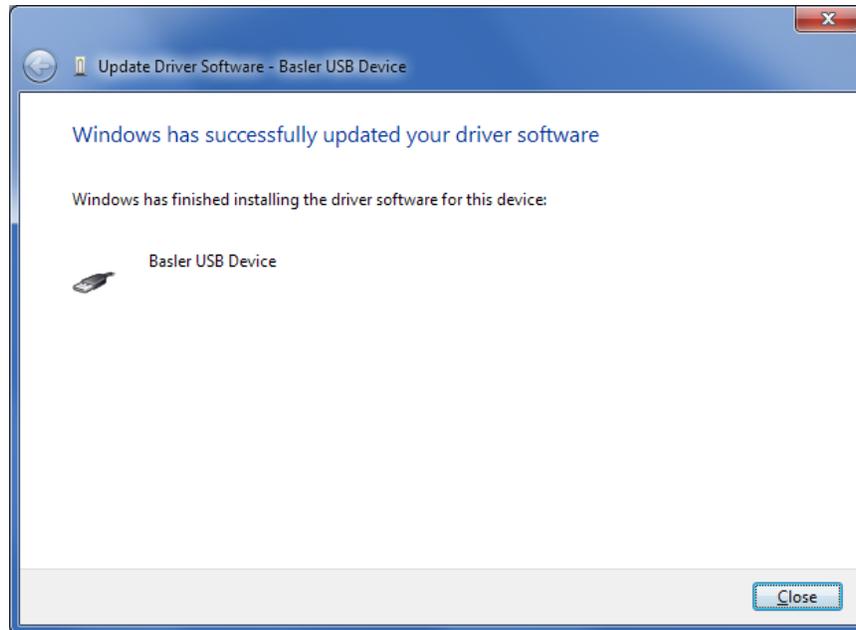


Figure 52-7. Driver Software Update Successful

In Modbus[®] TCP/IP, the client cannot communicate with the BE1-700, 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 BE1-700, in addition to the correct IP address, the client must also use the correct server address.

Why don't the BE1-700 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 BE1-700.

Communications cannot be established when using the USB-C port of the computer

USB-C to USB-C communications is not directly supported in the BE1-700. Several solutions are to utilize a different USB port type or USB-C to USB-A cable with USB-A to USB-C adapter or hub to communicate.

Inputs and Outputs

Programmable Inputs Do Not Operate as Expected

- Step 1. Verify that all wiring is properly connected. Refer to the *Terminals and Typical Connections* chapter.
- Step 2. Verify that the inputs are programmed properly.
- Step 3. Verify that the wetting voltage is correct. 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 *Terminals and 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

Incorrect Display of Voltage

- Step 1. Verify that all wiring is properly connected. Refer to the *Terminals and Typical Connections* chapter.
- Step 2. Verify that the proper voltage is present at BE1-700 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

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. It is also possible that the Trip condition remains and the LED asserts immediately again after reset.

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. 85% is determined by the V_{pn} nominal voltage setting. 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. Refer to the *Security* chapter for more information.

Why are the elements (25, 27, 47, 59) not operating as expected when testing by secondary injections?

The BE1-700 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 so the BE1-700 does not detect a fuse loss. Fuse Loss protection can also be disabled for the protection element being tested.



53 • Specifications

BE1-700 relays have the following specifications.

Operational Specifications

Metered Voltage Values and Accuracy

3-wire Range	50 to 250 Vac
4-wire Range	50 to 250 Vac
Auxiliary Range	25 to 150 Vac
Fundamental Phase/Auxiliary Accuracy	±0.5% of reading or ±0.1% of full range whichever is greater at 77°F (25°C)
3 rd Harmonic Accuracy	±1% of reading or ±0.1% of full range whichever is greater at 77°F (25°C)
V2, V0* Accuracy	±0.75% of reading or ±0.15% of full range whichever is greater at 77°F (25°C)
Temperature Dependence	≤ ±0.02% per °C

* 3V0 displayed

Metered Frequency Values and Accuracy

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

24 Overexcitation Protection

Pickup

Setting Range	0.5 to 6 V/Hz
Accuracy	±2%

Integrating Time Delay

Time Dial	0.0 to 9.9
Reset Dial	0.0 to 9.9
Curve Exponent	0.5, 1, or 2
Accuracy	5% or 4 cycles, whichever is greater

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

Time to Trip

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

Time to Reset

where:

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

Definite Time Delay

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

25 Sync-Check Protection

Settings

Voltage Difference

Setting Range 0 to 50% of nominal
 Accuracy..... $\pm 2\%$ or ± 1 V, whichever is greater

Slip Angle

Setting Range 1 to 99°
 Accuracy..... $\pm 1^\circ$

Slip Frequency

Setting Range 0.01 to 0.50 Hz
 Accuracy..... ± 0.01 Hz

Sensing

Angle Compensation Setting Range 0 to 359.9°

Voltage Monitoring

Live/Dead Voltage

Setting Range 0 to 90%
 Accuracy..... $\pm 2\%$

Drop Out Delay

Setting Range 0, 50 to 60,000 ms
 Accuracy..... $\pm 0.5\%$ or ± 2 cycles, whichever is greater

27P Phase Undervoltage Protection

Pickup

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

Time Delay

Setting Range 0, 10 to 600,000ms
 Accuracy..... $\pm 0.5\%$ or ± 2.5 cycles, whichever is greater

27X Auxiliary Undervoltage Protection

Pickup

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

Time Delay

Setting Range 0, 10 to 600,000ms
 Accuracy..... $\pm 0.5\%$ or ± 2.5 cycles, whichever is greater

47 Negative-Sequence Overvoltage ProtectionPickup

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

Time Delay

Setting Range 0, 10 to 600,000ms
 Accuracy..... $\pm 0.5\%$ or ± 2.5 cycles, whichever is greater

59P Phase Overvoltage ProtectionPickup

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

Time Delay

Setting Range 0, 10 to 600,000ms
 Accuracy..... $\pm 0.5\%$ or ± 2.5 cycles, whichever is greater

59X Auxiliary Overvoltage ProtectionPickup

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

Time Delay

Setting Range 0, 10 to 600,000ms
 Accuracy..... $\pm 0.5\%$ or ± 2.5 cycles, whichever is greater

60FL Fuse Loss

Time Delay Fixed at 50 ms

62 Logic Timers

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

79 Recloser Protection

Reclose (791, 792, 793, 794), Reset (79R), Max Cycle (79M), Reclose Fail (79F), Pilot (79P)
 Setting Range 100 ms to 600 s
 Accuracy..... $\pm 0.5\%$ or $\pm 1\%$, -0 cycles, whichever is greater

81 Over/Under Frequency Protection

Pickup

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

Time Delay

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

Voltage Inhibit

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

Automatic Setting Group Characteristics

Number of Setting Groups	2
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Control Modes

Automatic	Recloser Shot; Fuse Loss (60FL)
External	Discrete Input Logic, Binary Input Logic

BESTlogic™ Plus

Update Rate	¼ cycle
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General Specifications

Phase AC Voltage Inputs

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

Auxiliary AC Voltage Inputs

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

Analog to Digital Converter

Type	16-bit
Sampling Rate.....	32 samples per cycle, adjusted to input frequency (10 to 75 Hz)

Power Supply

Power supply ranges and holdup times are listed in Table 53-1.

Table 53-1. Power Supply Ranges and Holdup Times

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

† Operates down to 8 Vdc momentarily.

Frequency Range

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

Burden

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

Output Contacts

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

Break Resistive or Inductive 0.3 A at 125 or 250 Vdc (L/R = 0.04 maximum)

Contact-Sensing Inputs

Contact-sensing turn-on voltages and burdens are listed in Table 53-2. Burden values assume nominal value of input voltage applied.

Table 53-2. Contact-Sensing Turn-On Voltages and Burdens

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

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

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*.

IRIG

Supports IRIG Standard 200-98 and 200-04, Format B006

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

Real-Time Clock

Accuracy	1 second per day at 25°C (free running) or ±2 milliseconds (with IRIG synchronization)
Resolution	1 millisecond
Date and Time Setting Provisions	Front panel, communications port, and IRIG. Leap year and selectable daylight saving time correction provided.

Communication Ports

USB

A front-panel USB-C connector provides local communication with a PC operating *BESTCOMSPlus*® software.

Data Transfer Speed	12 MB/s (Full Speed)
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RS-485

Rear-panel RS-485 port (compression terminals) that supports Modbus..

Port Speed (Baud)	Up to 115,200
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Terminals

A	A3
B	A4
C	A5

Ethernet (Optional)

Optional RJ45 Ethernet port is available. This connector provide dynamic addressing (DHCP), as well as communication with *BESTCOMSPlus* software.

Copper Type (RJ45 Connector)

Version	10BASE-T/100BASE-TX
Maximum Length (One Network Segment)	328 ft (100 m)

Display

Type	64 by 128 dot pixels LCD with LED backlight.
------------	--

Temperature

Operating Temperature –40°C (–40°F) to +70°C (+158°F).
 Display contrast may be impaired at temperatures below –20°C (–4°F).

Isolation

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

Power Supply to Ground 1 min at 2,000 Vac
 Contact Sense to Ground..... 1 min at 2,000 Vac
 Contact Output to Ground 1 min at 2,000 Vac
 Voltage Sensing to Ground 1 min at 2,000 Vac
 IRIG, RS-485 to Ground..... 1 sec at 500 Vac
 RJ45 Ethernet Port..... 1 sec at 500 Vdc

Surge Withstand Capability

Oscillatory

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

Fast Transient

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

Radio Frequency Interference (RFI)

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

Electrostatic Discharge (ESD)

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

Shock, Vibration, Bump, and Seismic

IEC 255-21-1 – *Vibration, Shock, Bump and Seismic Tests on Measuring Relays and Protective Equipment (Section 1 - Vibration Test - Sinusoidal). Class 1*

IEC 255-21-2 – *Vibration, Shock, Bump and Seismic Tests on Measuring Relays and Protective Equipment (Section 2 - Shock and Bump Test). Class 1*

IEC 255-21-3 – *Vibration, Shock, Bump and Seismic Tests on Measuring Relays and Protective Equipment (Section 3 - Seismic Test). Class 1*

Environment

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)
 * Display is inoperative below –20°C

Humidity

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

CE 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 60255-27:2014 – *Measuring relays and Protection equipment – Part 27: Product Safety Requirements*
- IEC 60255-26:2014 – *Measuring relays and Protection equipment – Part 26: Electromagnetic Compatibility Requirements*

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.

Table 53-3. Declaration of Hazardous Substances

PRODUCT: BE1-700		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 ⁶⁺)	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	O	O	O	O	O	O	O	O	O	O
聚合物 Polymers	O	O	O	O	O	O	O	O	O	O
电子产品 Electronics	X	O	O	O	O	O	O	O	O	O
电缆和互连配件 Cables & interconnect accessories	O	O	O	O	O	O	O	O	O	O
绝缘材料 Insulation material	O	O	O	O	O	O	O	O	O	O

本表格依据 SJ/T11364 的规定编制。

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。

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。

This form was prepared according to the provisions of standard SJ/T11364.

O: Indicates that the hazardous substance content in all homogenous materials of this part is below the limit specified in standard GB/T 26572.

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.

UL Approval

This product is recognized to applicable Canadian and US safety standards and requirements by UL.
Standards used for evaluation:

- UL 508
- CSA C22.2-14

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

FCC Requirements

This product complies with FCC 47 CFR Part 15.

Physical

Weight 4.33 lb (1.96 kg) maximum

Case Size See Section 12, Installation.





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