SEL-700BT Motor Bus Transfer Relay

Comprehensive Motor Bus Transfer Protective Relay

Key Features

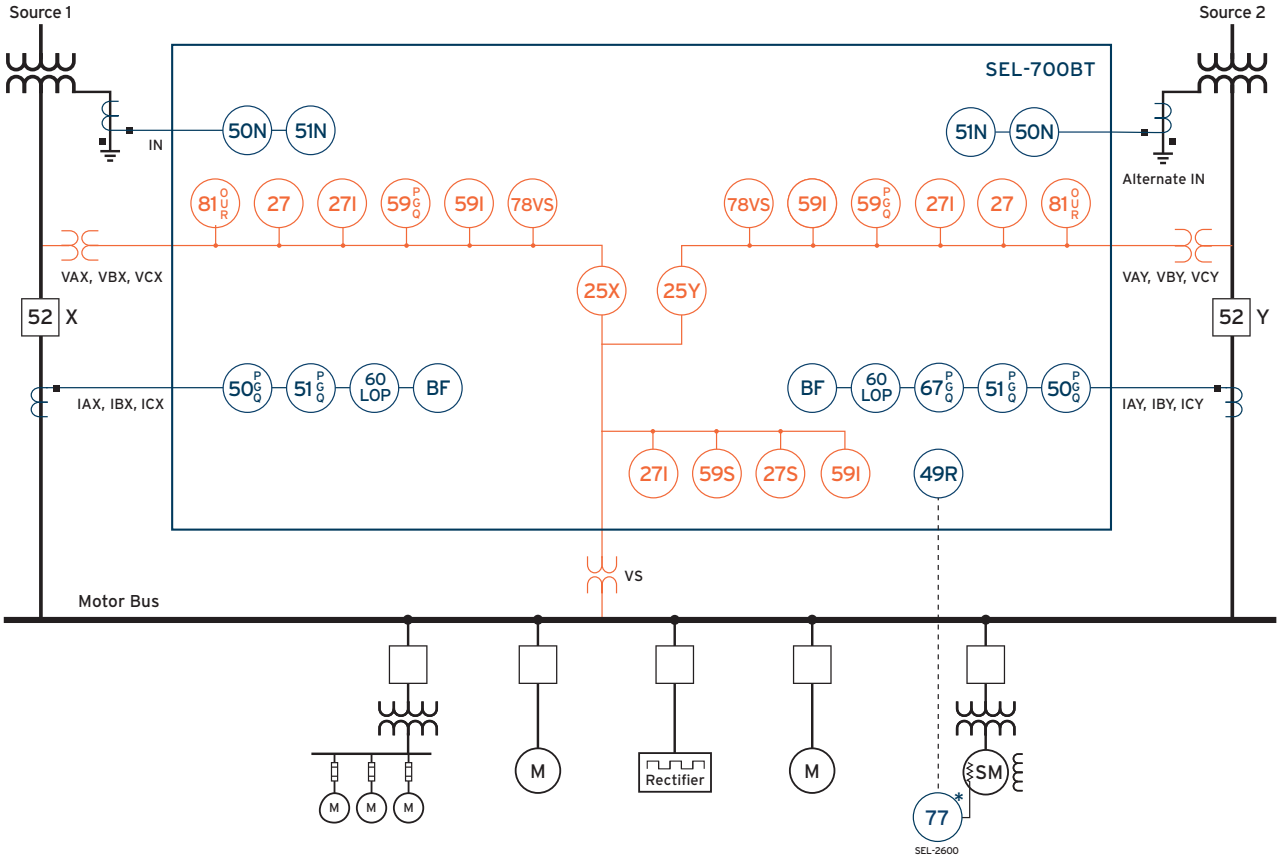
- Simple and economical motor bus transfer (MBT) solution.
- Ensure process continuity with one-way or bidirectional manual and automatic transfers.
- Expand the solution to accommodate main-tie-main configurations.
- Customize front-panel pushbuttons to enable manual or automatic MBT.
- Easily navigate screens, folders, and applications with the 5-inch, color, 800 x 480-pixel touchscreen. You can also view metered quantities and perform HMI functions, including viewing and editing settings, event summaries, target status, SER, etc. You can also customize as many as five bay screens.
- Simplify integration with Modbus RTU/TCP, DNP3 Serial, DNP3 LAN/WAN, IEC 61850 Edition 2, IEC 60870-5-103, EtherNet/IP, PRP, Rapid Spanning Tree Protocol (RSTP), SNTP, and IEEE 1588-2008 firmware-based precision time protocol (PTP).

Major Features and Benefits

The SEL-700BT relay provides unsurpassed protection, integration, and control features in a flexible, compact, and cost-effective package.

- **Comprehensive Motor Bus Transfer Features.** Restore power before your motor slows down. The SEL-700BT supports sequential and simultaneous transfer modes. The relay is designed to support four methods of MBT: fast, in-phase, residual voltage, and fixed time. Initiate MBT manually or use the settings to select one of the automatic transfer modes. The relay automatically selects one of the transfer modes based on the system condition.
- **Basic Protection Features:** Phase, negative-sequence, residual-ground, and neutral-ground overcurrent elements; phase, negative-sequence, residual-ground, and neutral-ground time-overcurrent elements; directional phase, negative-sequence, and residual-ground overcurrent elements; breaker failure protection for three-pole breakers; under- and overvoltage elements; inverse-time over- and undervoltage elements; loss-of-potential elements; over- and underfrequency protection elements; rate-of-change-of-frequency elements; RTD protection (requires internal or external SEL-2600 RTD option).
- **Additional Protection Features:** Synchronism-check elements; synchronism-check under- and overvoltage elements; inverse-time over- and undervoltage elements; synchroscope; and vector shift elements for islanding detection.
- **Operator Controls.** Eight programmable front-panel pushbuttons each with two programmable tricolor LEDs allow for a wide variety of uses, including easy trip and close control and status indications for a breaker. Implement local and remote operator control schemes using 32 local and 32 remote control bits.
- **Integrated Web Server**. Log in to the built-in web server to view metering and monitoring data and to download events, Sequential Events Recorder (SER), etc. Use the web server to view relay settings and to perform relay firmware upgrades.
- **Relay and Logic Settings Software.** ACSELERATOR QuickSet® SEL-5030 Software reduces engineering costs for relay settings and logic programming. The tools in QuickSet make it easy to develop SELOGIC® control equations. Use the built-in phasor display to verify proper CT polarity and phasing. Use the synchroscope for synchronism-check elements.
- **Metering and Reporting.** Built-in metering functions eliminate separately mounted metering devices. Analyze SER reports and oscillographic event reports for rapid commissioning, testing, and post-fault diagnostics. Unsolicited SER protocol allows station-wide collection of binary SER messages.
- **Front-Panel HMI.** Navigate the relay HMI using a 5-inch, color, 800 x 480-pixel touchscreen display.
- **Additional Standard Features.** Includes Modbus® RTU, Event Messenger support, MIRRORED BITS® communications, built-in web server and communications, load profile report, 128 remote analogs, support for 12 external RTDs (SEL-2600 module), IRIG-B input, advanced SELOGIC, configurable labels, and fiber-optic serial port.
- **Optional Features.** Select from a wide offering of optional features, including SNTP (Simple Network Time Protocol), IEEE 1588-2008 firmware-based PTP, IEC 61850 Edition 2, Modbus® TCP/IP, EtherNet/IP, DNP3 LAN/WAN, DNP3 serial, IEC 60870-5-103, PRP, RSTP, 10 internal RTDs, additional EIA-232 or EIA-485 communications ports, and single or dual, copper wire or fiber-optic Ethernet ports. Several analog and digital I/O options are available. These include 4 AI/4 AO, 4 DI/4 DO, 8 DI, 8 DO, 3 DI/4 DO/1 AO, 4 DI/3 DO, and 14 DI. Conformal coating for chemically harsh and/or high-moisture environments is available as an option.
- **Language Support.** Choose English or Spanish for your serial ports, including the front-panel serial port. The standard relay front-panel overlay is in English; a Spanish overlay is available as an ordering option.

Functional Overview



- Sequential Events Recorder
- Event Reports
- Web Server
- SEL ASCII, Ethernet*, Modbus TCP*, SNTP*, IEEE 1588 firmware-based PTP* IEC 61850*, IEC 60870-5-103*, EtherNet/IP, RSTP*, PRP*, DNP3 LAN/WAN*, DNP3 Serial*, Modbus RTU, Telnet*, FTP*, and PTP*
- Eight Front-Panel Target LEDs, Six of Which Are Programmable
- Two Inputs and Three Outputs Standard
- I/O Expansion*—Additional Contact Inputs, Contact Outputs, Analog Inputs, Analog Outputs, and RTD Inputs
- Single or Dual Ethernet Copper or Fiber-Optic Communications Port*
- Battery-Backed Clock, IRIG-B Time Synchronization
- Instantaneous Metering, Demand Metering
- Eight Programmable Pushbuttons Each With Two Tricolor LEDs
- Advanced SELogic Control Equations
- 32 Programmable Display Messages
- Mirrored Bits Communications
- Breaker Wear Monitor
- Event Messenger Compatible
- Front-Panel HMI With 5-Inch, Color, 800 x 480-Pixel Touchscreen Display

*Optional

Figure 1 SEL-700BT Motor Bus Transfer Relay

Protection Features

AC Analog Inputs

The SEL-700BT has 14 analog inputs. All analog inputs are recorded for event reporting and oscillography. *Table 1* shows the current and voltage inputs for the relay.

Table 1 Current (ACI) and Voltage (AVI) Card Selection for SEL-700BT

Model[a]	Description	Slot Z Card (MOT Digits)	Slot Z Inputs	Slot E Card (MOT Digits)	Slot E Inputs
700BT	Motor bus transfer relay	4 ACI/3 AVI (81, 82, 85, 86)	IAX, IBX, ICX, IN, VAX, VBX, VCX	3 ACI/4 AVI (71, 75)	IAY, IBY, ICY, VS, VAY, VBY, VCY

[a] For ordering options, refer to the SEL-700BT MOT.

The SEL-700BT offers an extensive variety of protection features, depending on the model and options selected. *Table 2* shows the protection features available in the SEL-700BT.

Table 2 SEL-700BT Protection Elements (Sheet 1 of 2)

Protection Elements	
49RTD	RTDs
78VS	Vector Shift
51_X	X-Side Phase Time-Overcurrent (P, Q, G)[a]
51_Y	Y-Side Phase Time-Overcurrent (P, Q, G)[a]
51N	Neutral Time-Overcurrent[a]
50_X	X-Side Phase Overcurrent (P, Q, G)[a]
50_Y	Y-Side Phase Overcurrent (P, Q, G)[a]
67_Y	Y-Side Directional Phase Overcurrent (P, Q, G)[a]
50N	Neutral Overcurrent
27X	Undervoltage
27Y	Undervoltage
27S	Synchronism Undervoltage
27I	Inverse-Time Undervoltage[b]
59X	Overvoltage (P, Q, G)[a]
59Y	Overvoltage (P, Q, G)[a]
59S	Synchronism Overvoltage
59I	Inverse-Time Overvoltage[c]
81X	Over/Underfrequency
81Y	Over/Underfrequency
81RX	Rate-of-Change of Frequency
81RY	Rate-of-Change of Frequency
BFX	Breaker Failure

Table 2 SEL-700BT Protection Elements (Sheet 2 of 2)

Protection Elements	
BFY	Breaker Failure
60LOPX	Loss of Potential
60LOPY	Loss of Potential
25X	Synchronism Check
25Y	Synchronism Check
	Motor Bus Transfer

[a] P = phase, Q = negative sequence, and G = residual ground.
[b] Two elements are available (select X- and/or Y-side phase, phase-to-phase, positive sequence, or synchronism voltage VS).
[c] Two elements are available (select X- and/or Y-side phase, phase-to-phase, residual, positive sequence, negative sequence or synchronism voltage VS).

Motor Bus Transfer (MBT)

The SEL-700BT relay has built-in logic for MBT. MBT allows users to quickly transfer load to an auxiliary feeder from the primary feeder during faults to the primary feeder. This instantaneous transfer of load allows users to keep processes running without requiring a cold start. Refer to *Applications* for more details.

Overcurrent Protection

The SEL-700BT provides complete overcurrent protection with as many as two sets of three-phase CTs and one neutral CT input. Phase overcurrent protection is provided for both three-phase inputs. The following overcurrent elements are provided.

Instantaneous Overcurrent Elements

The following instantaneous overcurrent elements are provided in the SEL-700BT as shown in *Table 2*. All instantaneous overcurrent elements provide torque control and definite-time delay settings.

- As many as six instantaneous phase overcurrent elements (50P) with peak detection algorithms to enhance element sensitivity during high-fault current conditions where severe CT saturation may occur.
- As many as two instantaneous negative-sequence overcurrent (50Q) elements.
- As many as two residual-ground instantaneous overcurrent (50G) elements. These elements use calculated residual (3I0) current levels.
- As many as two neutral instantaneous overcurrent elements (50N).

Directional Instantaneous Overcurrent Elements

The following directional overcurrent elements are available in the SEL-700BT with directional control (see *Table 2*).

- As many as two directional phase overcurrent elements (67P).
- As many as two directional negative-sequence overcurrent elements (67Q).
- As many as two directional residual-ground overcurrent elements (67G).

Time-Overcurrent Elements

The SEL-700BT provides the time-overcurrent elements listed in *Table 2*. These time-overcurrent elements support the IEC and US (IEEE) time-overcurrent characteristics. Electromechanical disc reset capabilities are provided for all time-overcurrent elements.

- As many as two phase time-overcurrent (51P) elements are provided. These phase elements operate on the maximum of phase currents. One 51P element has directional control.
- As many as two negative-sequence time-overcurrent (51Q) elements are provided. These elements operate on the calculated negative-sequence current for each set of three-phase inputs. One 51Q element has directional control.
- As many as two residual time-overcurrent (51G) elements are provided. These elements use calculated residual (3I0) current levels. Both 51G elements have directional control.
- One neutral time-overcurrent (51N) element is provided with directional control.

Synchronism Check Elements (25X and 25Y)

The SEL-700BT has a synchronism-check function on both the X-side and the Y-side that provides the closing window for the breaker when connecting to the utility system.

Synchroscope

The touchscreen display comes with a built-in Synchroscope application in the Monitor folder, which displays a graphical representation of the phasor difference between the bus and the feeder, as shown in *Figure 2*.

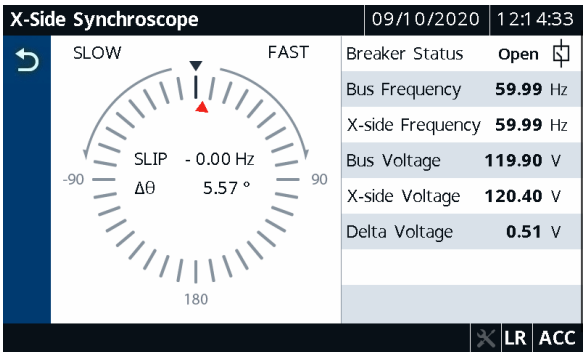


Figure 2 Synchroscope Application

Over- and Undervoltage Protection (27, 59)

Phase, phase-to-phase, and positive-sequence undervoltage (27), overvoltage (59), residual overvoltage (59G) and negative-sequence overvoltage (59Q) elements help you create protection and control schemes, such as undervoltage load shedding, or standby generation start/stop commands.

- Phase and phase-to-phase undervoltage elements operate with the minimum of the measured voltage magnitudes; these elements operate when any single measurement falls below the set thresholds.
- Phase and phase-to-phase overvoltage elements operate with the maximum of the measured voltage magnitudes.
- The positive-sequence undervoltage elements operate when the calculated positive-sequence voltage V1 drops below the set thresholds.
- The positive-sequence overvoltage elements operate when the calculated positive-sequence voltage V1 exceeds the set thresholds.
- The negative-sequence overvoltage elements operate when the calculated negative-sequence voltage V2 exceeds set thresholds.

- The residual-ground voltage element operates when the zero-sequence voltage 3V0 exceeds the set point.
- Inverse-time overvoltage (59I) and inverse-time undervoltage (27I) elements that operate on the measure phase-to-neutral voltages, phase-to-phase voltages, or VS channel voltage, depending on the relay part number.

All voltage elements provide definite-time delay settings.

Loss-of-Potential Logic (60LOP)

Relay functions that use phase voltages or symmetrical component voltages rely on valid inputs to make the correct decisions. The LOP logic detects open voltage transformer fuses or other conditions that cause a loss of relay secondary voltage input. The SEL-700BT with voltage inputs includes loss-of-potential logic that detects one, two, or three potentially blown fuses. This patented logic is unique and is universally applicable. It also offers a SELOGIC setting to block the LOP logic under user-defined conditions. The LOP feature allows for the blocking of protection elements to add security during fuse failure.

Breaker Failure Protection (BF)

The SEL-700BT offers breaker failure protection for up to two three-pole breakers. Use the breaker failure detection to issue re-trip commands to the failed breaker, or to trip adjacent breakers using the contact output logic of the relay or communications-based tripping schemes.

Frequency Protection (81)

Six levels of over- or underfrequency elements detect abnormal frequency operating conditions. Use the independently time-delayed output of these elements to trip or alarm. Phase undervoltage supervision prevents undesired frequency element operation during start-up, shutdown, and faults, and while the field is de-energized. SEL-700BT frequency elements have high accuracy (less than 0.01 Hz).

Rate-of-Change-of-Frequency Protection (81R)

Four independent rate-of-change-of-frequency elements are provided with individual time delays for use when frequency changes occur, for example, when there is a sudden imbalance between generation and load. They call for control action or switching action such as network decoupling or load shedding. Each element includes logic to detect either increasing or decreasing frequency and above or below nominal frequency.

Vector Shift Protection (78VS)

When distributed generators (DG) are connected in the utility network, the vector shift element (78VS) is used to detect islanding conditions and trip the DG. Failure to trip islanded generators can lead to problems such as danger to personnel, out-of-synchronization reclosing, and degradation of power quality. Based on the change in the angle of the voltage waveform, the islanding condition can be detected by the vector shift function. Use the vector shift element with the 81RF element as a backup for fast and secure islanding detection. The vector shift element operates within three cycles, which is fast enough to prevent reclosing out-of-synchronism with the network feeders to avoid generator damage.

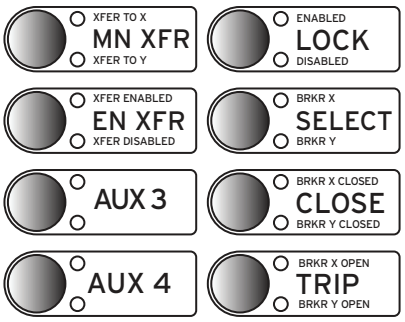
RTD Thermal Protection

When the SEL-700BT is equipped with either an optional 10 RTD input expansion card or an external SEL-2600 RTD Module with up to 12 RTD inputs, as many as 12 thermal elements in the relay can be programmed for two levels of thermal protection per element. Each RTD input provides an alarm and trip thermal pickup setting in degrees C, provides open and shorted RTD detection, and is compatible with the following three-wire RTD types:

- PT100 (100 Ω platinum)
- NI100 (100 Ω nickel)
- NI120 (120 Ω nickel)
- CU10 (10 Ω copper)

Operator Controls

Operator controls eliminate traditional panel control switches. Eight conveniently sized operator controls are located on the relay front panel (see *Figure 3*). The SER can be set to track operator controls. Change operator control functions using SELOGIC control equations.



NOTE: All text can be changed with the configurable labels kit.

Figure 3 Operator Controls

The following operator control descriptions are for factory-set logic for the model shown.

LOCK: The **LOCK** operator control blocks selected functions. Press it for at least three seconds to engage or disengage the lock function. While locked in position, the following operator controls cannot change state if pressed: TRIP and CLOSE.

AUX: The **AUX** operator control and LEDs are user programmable.

SELECT: Use the **SELECT** pushbutton to select **BRKR X** or **BRKR Y**. If **BRKR X** is selected, the **BRKR X** LED is on and if **BRKR Y** is selected, the **BRKR Y** LED is on. The **SELECT** pushbutton allows a breaker selection before the **CLOSE** or **TRIP** pushbutton is used.

CLOSE and TRIP: Use the **CLOSE** and **TRIP** operator controls to close and open the connected circuit breaker. They can be programmed with intentional time delays to support operational requirements for breaker-mounted relays. This allows the operator to press the **CLOSE** or **TRIP** pushbutton, then move to an alternate location before the breaker command is executed.

MN XFR: Use the **MN XFR** operator control pushbutton to initiate a manual transfer. The manual transfer will issue a trip to the closed breaker and then initiate the motor bus transfer logic to complete the transfer. The **XFER TO X** and **XFER TO Y** LEDs will indicate which terminal the logic will be/is transferring to. If neither is illuminated, then no action will be taken.

EN XFR: Use the **EN XFR** operator control pushbutton for one second to enable or disable the motor bus transfer. The **XFER ENABLED** and **XFER DISABLED** LEDs illuminate to reflect the status of the transfer enable function. While the **XFER DISABLED** LED is illuminated, both manual and automatic transfers are disabled.

With the touchscreen display, you can also use the front-panel operator control pushbuttons to jump to a specific screen while also using them for LOCK/CLOSE/TRIP operations, etc. You can program the selectable operator pushbutton screen settings under the Touchscreen settings category in QuickSet and map the button to a specific screen.

Built-In Web Server

Every Ethernet-equipped SEL-700BT includes a built-in web server. Use any standard web browser to interface with the relay and perform the following actions:

- Log in with password protection.
- Safely read the relay settings.
- Verify the relay self-test status and view the relay configuration.
- Inspect meter reports.
- Download SER and event reports.
- Upload new firmware (firmware upgrade).

Figure 4 shows the fundamental metering screen that can be accessed by clicking **Meter > Fundamental**. Use the Meter menu to view all the available relay metering statistics.

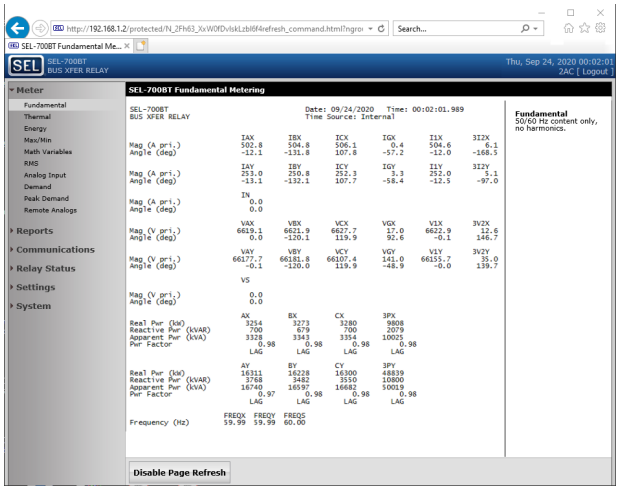


Figure 4 Fundamental Meter Report Webpage

Figure 5 shows the Group 1 settings webpage. You can view the settings of each relay settings class by selecting **Settings** and the respective relay settings class.

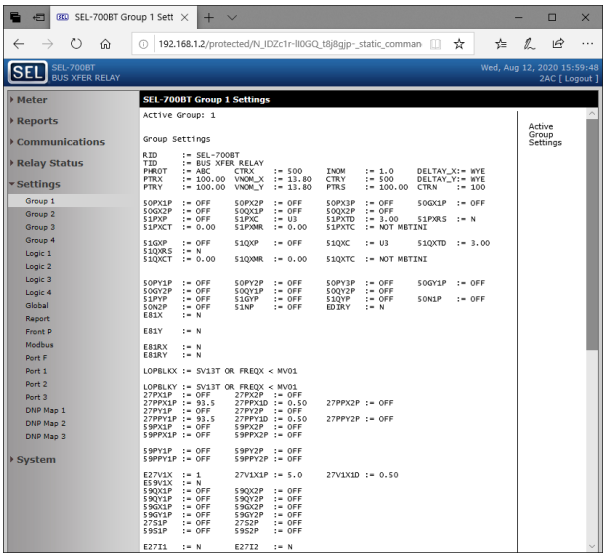


Figure 5 Group 1 Settings Webpage

You can upgrade the relay firmware through the relay web server by clicking **System > File Management** and selecting the firmware upgrade file. *Figure 6* shows the firmware upgrade webpage.

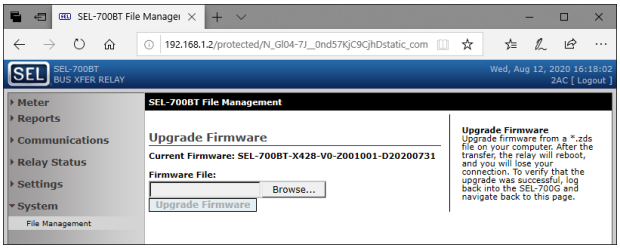


Figure 6 Upgrade the Relay Firmware From the File Management Webpage

Relay and Logic Settings Software

QuickSet Software simplifies settings and provides analysis support for the SEL-700BT. With QuickSet you have several ways to create and manage relay settings:

- Develop settings off-line with an intelligent settings editor that only allows valid settings.
- Create SELOGIC control equations with a drag-and-drop text editor.
- Configure proper settings using online help.
- Organize settings with the relay database manager.
- Load and retrieve settings using a simple PC communications link.

With QuickSet you can verify settings and analyze events; and analyze power system events with the integrated waveform and harmonic analysis tools.

The following features of QuickSet can monitor, commission, and test the SEL-700BT:

- The PC interface remotely retrieves power system data.
- The HMI monitors meter data, Relay Word bits, and output contacts status during testing. The control window allows resetting of metering quantities, and other control functions.
- Bay control allows you to design new bay screens and edit existing bay screens by launching ACSELERATOR Bay Screen Builder SEL-5036 Software for the touchscreen display.

Bay Screen Builder

The SEL-700BT provides you the ability to design bay configuration screens to meet your system needs. You can display the bay configuration as a single-line diagram (SLD) on the touchscreen. You can use ANSI and IEC symbols, along with analog and digital labels, for the SLD to indicate the status and control of the breaker and two- or three-position disconnects, bus voltages, and power flow through the breaker. In addition to SLDs, you can design the screens to show the status of various relay elements via Relay Word bits or to show analog quantities for commissioning or day-to-day operations. You can design these screens with the help of Bay Screen Builder in conjunction with QuickSet. Bay Screen Builder provides an intuitive and powerful interface to design bay screens to meet your application needs.

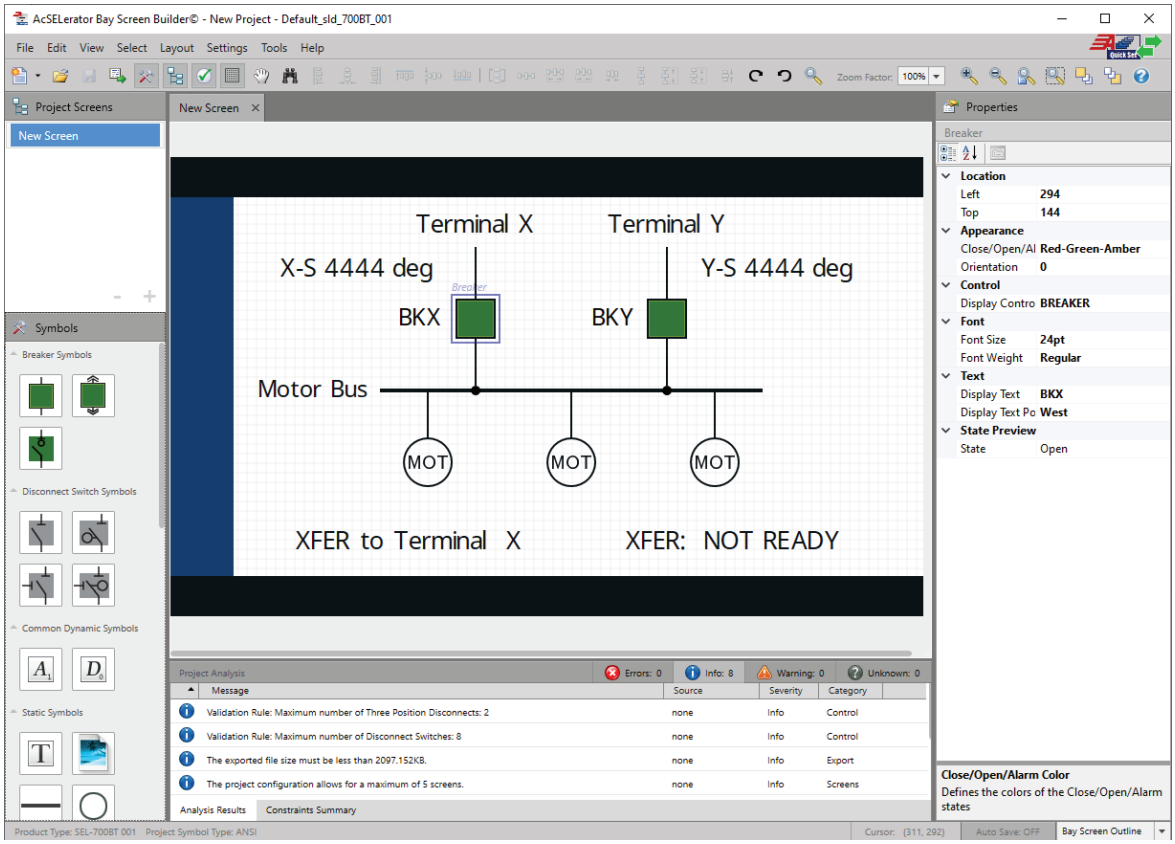


Figure 7 Bay Screen Builder

Metering and Monitoring

The SEL-700BT provides extensive metering capabilities. See *Specifications on page 21* for metering and power measurement accuracies. As shown in *Table 3*, metered quantities include voltages and currents; sequence voltages and currents; power, frequency, and energy; and maximum/minimum logging of selected quantities. The relay reports all metered quantities in primary quantities (current in A primary and voltage in V primary).

Table 3 SEL-700BT Metered Values (Sheet 1 of 2)

Types of Metering		
Instantaneous	Max/Min	Analog Inputs
Remote Analogs	Math Variables	Thermal
Demand and Peak Demand	Energy	RMS

Quantities	**Description**
Currents: IA*n*, IB*n*, IC*n*, IG*n*, IN	Phase currents, calculated residual currents (IG = 3I0 = IA + IB + IC) and neutral current, for *n* = X and Y
Voltages: VA*n*, VB*n*, VC*n*	Wye-connected voltage inputs for *n* = X and Y
Voltages: VAB*n*, VBC*n*, VCA*n*	Delta-connected voltage inputs for *n* = X and Y
Voltage VS	Synchronism-check voltage input
Power kWA*n*, B*n*, C*n*, 3P*n* kVARA*n*, B*n*, C*n*, 3P*n* kVAA*n*, B*n*, C*n*, 3P*n*	Single and three-phase kilowatts, kilovars, and kilovolt-amps for *n* = X and Y

Table 3 SEL-700BT Metered Values (Sheet 2 of 2)

Quantities	Description
Energy MWhA*n*, B*n*, C*n*, 3P*n* MVARhA*n*, B*n*, C*n*, 3P*n* MVAhA*n*, B*n*, C*n*, 3P*n*	Single and three-phase real, reactive and apparent energy for *n* = X and Y
Power Factor PFA*n*, B*n*, C*n*, 3P*n*	Single and three-phase power factor for *n* = X and Y
Sequence I1*n*, 3I2*n*, 3I0*n*, V1*n*, 3V2*n*, 3V0*n*	Positive, negative and zero-sequence currents and voltages for *n* = X and Y
Frequency FREQ*n*, FREQS (Hz)	Instantaneous power system frequency for *n* = X and Y and for synchronism-check voltage input VS
AX*x*01–AX*x*04	Analog inputs
MV01–MV32	Math variables
RA001–RA128	Remote analogs
RTD*n* (*n* = 1 to 12)	RTD temperature measurement (degrees C)

Load Profile

The SEL-700BT features a programmable Load Profile (LDP) recorder that records as many as 17 metering quantities into nonvolatile memory at fixed time intervals. The LDP saves several days to several weeks of the most recent data depending on the LDP settings (9800 entries total).

Improve Situational Awareness

Event Reporting and SER

Event reports and the SER simplify post-fault analysis and improve understanding of simple and complex protective scheme operations. In response to a user-selected trigger, the voltage, current, frequency, and element status information contained in each event report confirms the relay scheme and system performance for every fault. Decide how much detail is necessary when you request an event report (e.g., 1/4-cycle or 1/32-cycle resolution, filtered or raw analog data, respectively).

The relay stores as many as 8 of the most recent 180-cycle event reports, 21 of the most recent 64-cycle event reports, or 44 of the most recent 15-cycle event reports in nonvolatile memory. The relay always appends relay settings at the time of the event to the bottom of each event report.

The following analog data formats are available:

- 1/4-cycle or 1/32-cycle resolution, filtered or unfiltered analog, ASCII or Compressed ASCII reports
- 1/32-cycle resolution COMTRADE reports

The relay SER feature stores the latest 1024 entries. Use this feature to gain a broad perspective at a glance. An SER entry helps to monitor input/output change-of-state occurrences and element pickup/dropout.

Synchronized Measurements

The IRIG-B time-code input synchronizes the SEL-700BT time to within ±5 ms of the time-source input. A convenient source for this time code is an SEL-2401 Satellite-Synchronized Clock, the SEL-3530 Real Time Automation Controller (RTAC), or the SEL-2032, SEL-2030, or SEL-2020 Communications Processor (via Serial Port 3 on the SEL-700BT).

IEC 61850 Test Mode

Test Mode allows you to test an in-service relay without accidentally operating control output contacts. Test Mode includes five different modes:

On: In On mode, the relay operates as normal; it reports IEC 61850 Mode/Behavior status as On and processes all inputs and outputs as normal. If the quality of the subscribed GOOSE messages satisfies the GOOSE processing, the relay processes the received GOOSE messages as valid.

Blocked: This mode is similar to On mode, except that the device does not trip any physical contact output.

Test: In Test mode, the relay processes valid incoming test signals and normal messages and operates physical contact outputs, if the outputs are triggered.

Test/Blocked: This is similar to Test mode, except that the device does not trip any physical contact outputs.

Off: The device does not process any incoming data or control commands (except commands to change the mode). All protection logic is disabled and all data quality is marked as invalid.

Simulation: In this mode, the relay continues to process normal GOOSE messages until a simulated GOOSE message is received for a subscription. Once a simulated GOOSE message is received, only simulated GOOSE messages are processed for that subscription. The simulated mode only terminates when LPHDSIM is returned to FALSE. When the relay is not in simulation mode, only normal GOOSE messages are processed for all subscriptions.

Touchscreen Display

The SEL-700BT Motor Bus Transfer Relay comes with a touchscreen display (5-inch, color, 800 x 480 pixels). The touchscreen display makes relay data metering, monitoring, and control quick and efficient. The touchscreen features a straightforward application-driven control structure and includes intuitive and graphical screen designs.

The touchscreen display allows you to:

- View and control bay screens
- Access metering and monitoring data
- Inspect targets
- View event history, summary data, and SER information
- View relay status and configuration
- Control relay operations
- View and edit settings
- Enable the rotating display
- Program control pushbuttons to jump to a specific screen
- Visualize and synchronize your bus to the system with the built-in Synchroscope application

You can navigate the touchscreen by selecting the folders and applications. The folders and applications of the Home screen are shown in *Figure 8* and *Figure 9*. Folders and applications are labeled according to functionality. Additional folder and application screens for the SEL-700BT touchscreen display can be seen in *Figure 10* through *Figure 18*.

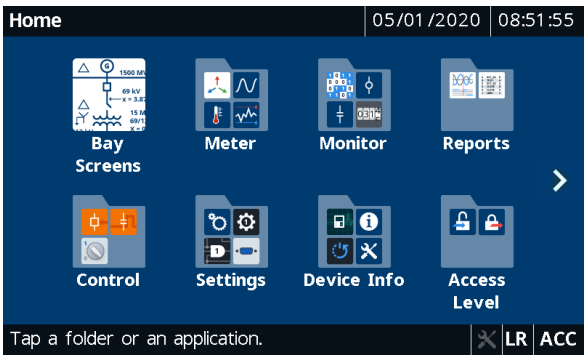


Figure 8 First Home Screen (Default FPHOME Screen)

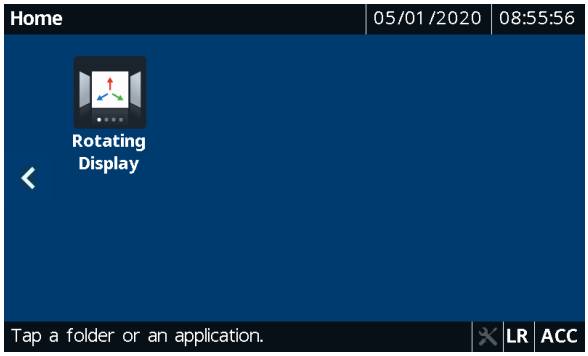


Figure 9 Second Home Screen

Bay Screens Application

The SEL-700BT provides you the ability to design bay configuration screens to meet your system needs. The bay configuration can be displayed as an SLD on the touchscreen. You can create as many as five bay screens with up to two controllable breakers, eight controllable two-position disconnects, and two controllable three-position disconnects. ANSI and IEC symbols, along with analog and digital labels, are available for you to create detailed SLDs of the bay to indicate the status and control of the breaker and disconnects, bus voltages, and power flow through the breaker. *Figure 10* shows the default SLD for the touchscreen display.

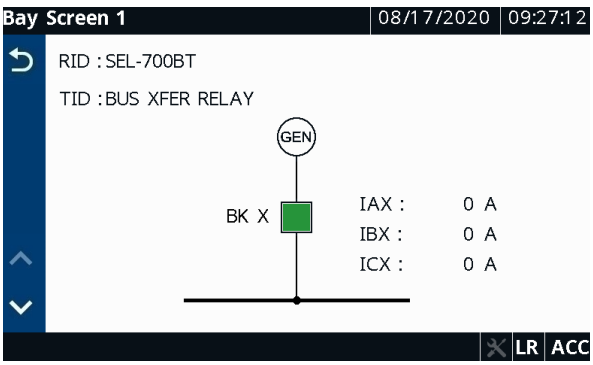


Figure 10 Default Bay Screen

Meter Folder Applications

The applications in the Meter folder are part-number dependent. Only those metering applications specific to your part number appear in the Meter folder. Select an application in the **Meter** folder to display the report for that particular application. Select the **Phasor** application to view the current and voltage phasors (see *Figure 11*).

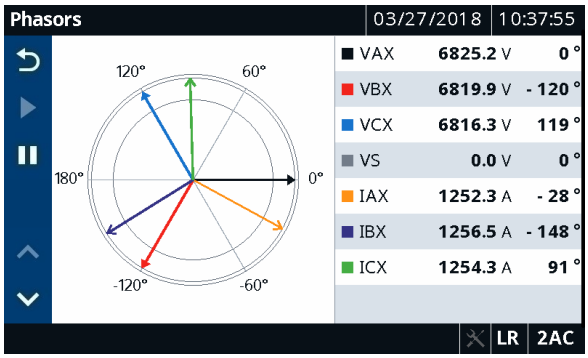


Figure 11 Meter Phasors

Select the **Energy** application to view the energy metering quantities (see *Figure 12*). A reset feature is provided for the Energy, Max/Min, Thermal, Demand, and Peak Demand applications. Press the **Reset** button 0.00 (see *Figure 12*) to navigate to the reset confirmation screen. Once you confirm the reset, the data are reset to zero.

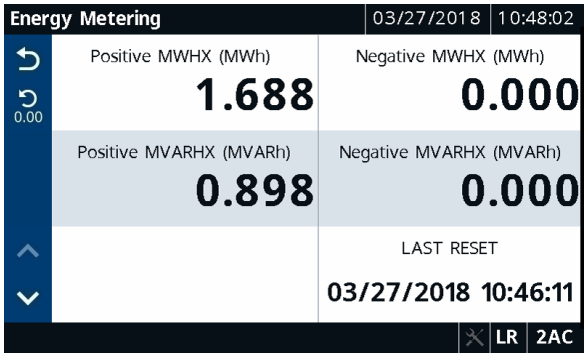


Figure 12 Meter Energy

Reports Folder Applications

Select the **Reports** folder to navigate to the screen where you can access the Events and SER applications. Use these applications to view events and SERs. To view the event summary (see *Figure 13*) of a particular event record, you can select the event record on the Event History screen. You can also trigger an event report from the Event History screen.

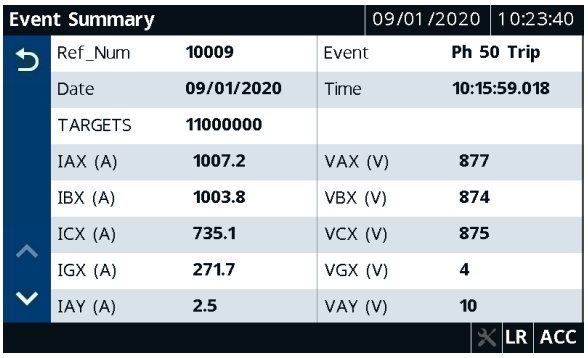


Figure 13 Event Summary

Select the **Sequential Events Recorder** application to view a history of the SER reports (see *Figure 14*).

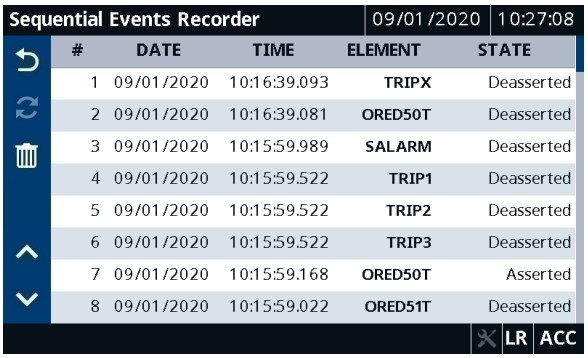


Figure 14 Sequential Events Recorder

Select the **Trash** button, shown in *Figure 14*, on the Event History and Sequential Events Recorder screens and confirm the delete action to remove the records from the relay.

Control Folder Applications

Select the **Control** folder to navigate to the screen where you can access the Breaker Control, Output Pulsing, and Local Bits applications. Use the applications to perform breaker control operations, pulse output contacts (*Figure 15*), and control the local bits (*Figure 16*).

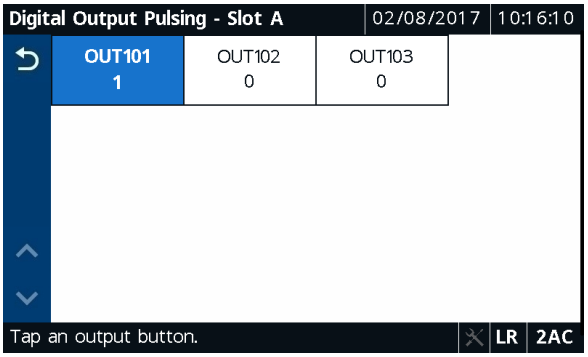


Figure 15 Digital Output Pulsing-Slot A

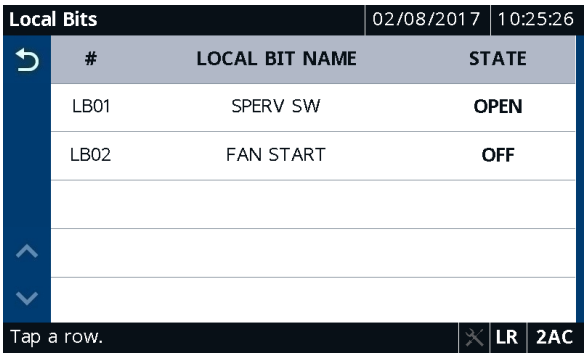


Figure 16 Local Bits

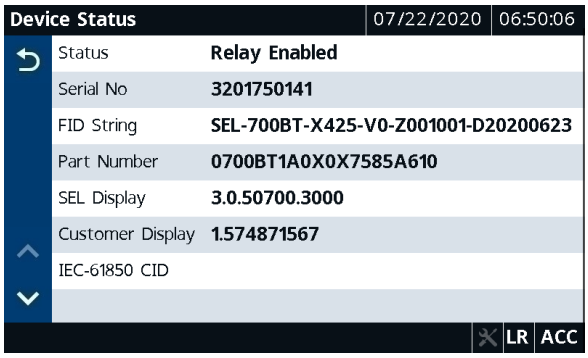


Figure 17 Status

Device Info Folder Applications

Select the **Device Info** folder to navigate to the screen where you can access specific device information applications (Status, Configuration, and Trip & Diag. Messages) and the Reboot application.

Select the **Status** application to view the relay status, firmware version, part number, etc. (see *Figure 17*).

To view the trip and diagnostic messages, select the **Trip & Diag. Messages** application (see *Figure 18*). When a diagnostic failure, trip, or warning occurs, the relay displays the diagnostic message on the screen until it is either overriden by the restart of the rotating display, or the inactivity timer expires.

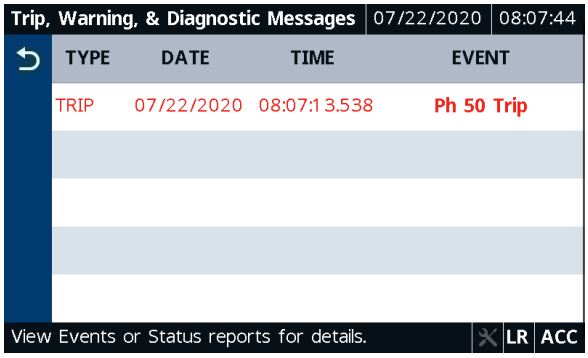


Figure 18 Trip and Diagnostics

Automation

Flexible Control Logic and Integration

The SEL-700BT can be ordered with as many as four independently operated serial ports:

- EIA-232 port on the front panel
- EIA-232 or EIA-485 port on the Slot B in the rear
- EIA-232 fiber-optic port on Slot B card in the rear
- EIA-232 or EIA-485 port on the optional communications card in Slot C in the rear

Optionally, the relay supports single or dual, copper or fiber-optic Ethernet ports.

The relay does not require special communications software. You can use any system that emulates a standard terminal system. Establish communication by connecting: computers, modems, protocol converters, printers, an SEL Real-Time Automation Controller (RTAC), SEL communications processor, SEL computing platform, SCADA serial port, and RTUs for local or remote communication. Refer to *Table 4* for a list of communications protocols available in the SEL-700BT.

Table 4 Communications Protocols

Type	Description
Simple ASCII	Plain language commands for human and simple machine communications. Use for metering, setting, self-test status, event reporting, and other functions.
Compressed ASCII	Comma-delimited ASCII data reports. Allows external devices to obtain relay data in an appropriate format for direct import into spreadsheets and database programs. Data are checksum protected.
Extended Fast Meter and Fast Operate	Binary protocol for machine-to-machine communications. Quickly updates SEL communications processors, RTUs, and other substation devices with metering information, relay element, I/O status, time-tags, open and close commands, and summary event reports. Data are checksum protected. Binary and ASCII protocols operate simultaneously over the same communications lines so control operator metering information is not lost while a technician is transferring an event report. Direct communications with the SEL-2600 RTD Module are possible using the unsolicited Fast Meter protocol to read incoming temperature data from the SEL-2600.
Fast SER Protocol	Provides SER events to an automated data collection system.
Fast Message Protocol	Use this protocol to write remote analog data from other SEL relays or communications processors via unsolicited writes.
DNP3	Serial or Ethernet-based DNP3 protocols. Provides default and mappable DNP3 objects that include access to metering data, protection elements, Relay Word bits, contact I/O, targets, SER, relay summary event reports, and setting group selection.
Modbus	Serial- or Ethernet-based Modbus with point remapping. Includes access to metering data, protection elements, contact I/O, targets, SER, relay summary event reports, and setting groups.
IEC 61850 Edition 2	Ethernet-based international standard for interoperability between intelligent devices in a substation. Operates remote bits and I/O. Monitors Relay Word bits and analog quantities.
Event Messenger	The use of SEL-3010 Event Messenger allows you to receive alerts directly on your cell phone. Alerts can be triggered through relay events and can include quantities measured by the relay.
SNTP	Ethernet-based protocol that provides time synchronization of the relay.
IEEE 1588-2008 firmware-based PTP	Ethernet-based protocol that provides time synchronization of the relay.
PRP	Provides seamless recovery from any single Ethernet network failure in a dual redundant Ethernet network, in accordance with IEC 62439-3.
IEC 60870-5-103	Serial communications protocol–international standard for interoperability between intelligent devices in a substation.
EtherNet/IP	Ethernet-based protocol that includes access to metering data, protection elements, targets, and contact I/O.
RSTP	Provides faster recovery in response to changes and failures in switched mode dual redundant Ethernet networks in accordance with IEEE 802.1Q-2014.

Apply an SEL communications processor as the hub of a star network, with point-to-point fiber or copper connection between the hub and the SEL-700BT (*Figure 19*).

The communications processor supports external communications links including the public switched telephone network for engineering access to dial-out alerts and private line connections of the SCADA system.

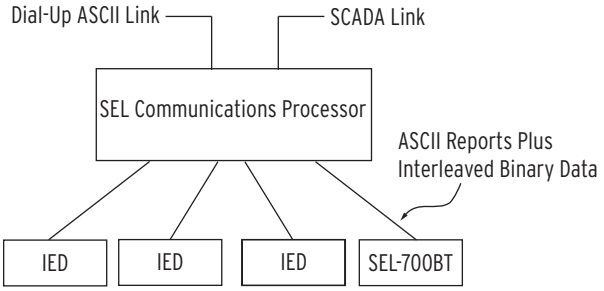


Figure 19 Example Communications System

SEL manufactures a variety of standard cables for connecting this and other relays to a variety of external

devices. Consult your SEL representative for more information on cable availability. SEL-700BT control logic improves integration in the following ways:

- **Replaces traditional panel control switches**. Eliminate traditional panel control switches with 32 local bits. Set, clear, or pulse local bits with the front-panel pushbuttons and display. Program the local bits into your control scheme with SELOGIC control equations. Use the local bits to perform functions such as a trip test or a breaker trip/close.
- **Eliminates RTU-to-relay wiring**. Eliminate RTU-to-relay wiring with 32 remote bits. Set, clear, or pulse remote bits using serial port commands. Program the remote bits into your control scheme with SELOGIC control equations. Use remote bits for SCADA-type control operations such as trip, close, and settings group selection.
- **Replaces traditional latching relays**. Replace up to 32 traditional latching relays for such functions as "remote control enable" with latch bits. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the nonvolatile latch bits using optoisolated inputs, remote bits, local bits, or any programmable logic condition. The latch bits retain their state when the relay loses power.
- **Replaces traditional indicating panel lights**. Replace traditional indicating panel lights with 32 programmable displays. Define custom messages (e.g., `Breaker Open`, `Breaker Closed`) to report power system or relay conditions on the front-panel display. Use Advanced SELOGIC control equations to control which messages the relay displays.
- **Eliminates external timers**. Eliminate external timers for custom protection or control schemes with 32 general purpose SELOGIC control equation timers. Each timer has independent time-delay pickup and dropout settings. Program each timer input with any desired element (e.g., time qualify a current element). Assign the timer output to trip logic, transfer trip communications, or other control scheme logic.
- **Eliminates settings changes.** Selectable setting groups make the SEL-700BT ideal for applications requiring frequent setting changes and for adapting the protection to changing system conditions.

The relay stores three setting groups. Select the active setting group by optoisolated input, command, or other programmable conditions. Use these setting groups to cover a wide range of protection and control contingencies.

Switching setting groups switches logic and relay element settings. Program groups for different operating conditions, such as station maintenance, seasonal operations, emergency contingencies, loading, source changes, and downstream relay setting changes.

Fast SER Protocol

SEL Fast SER Protocol provides SER events to an automated data collection system. SEL Fast SER Protocol is available on any rear serial port. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from SEL-700BT relays.

SEL relays and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible to people using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information, and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data.

Fast Message Protocol

SEL Fast Message Protocol is a method to input or modify remote analogs in the SEL-700BT. These remote analogs can then be used in SEL Math or SELOGIC control equations. Remote analogs can also be modified via Modbus, DNP3, and IEC 61850.

Ethernet Network Architectures

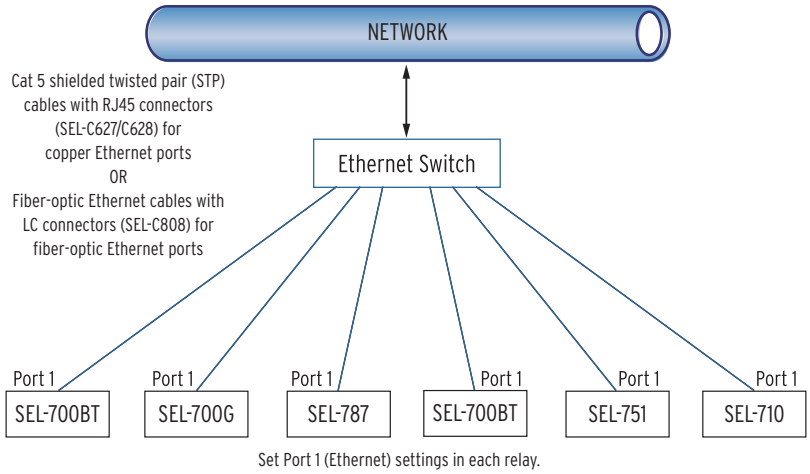


Figure 20 Simple Ethernet Network Configuration

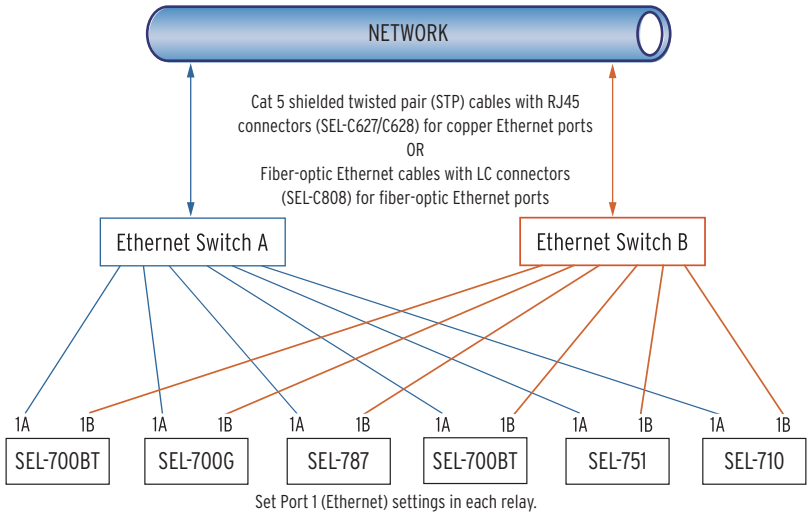


Figure 21 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

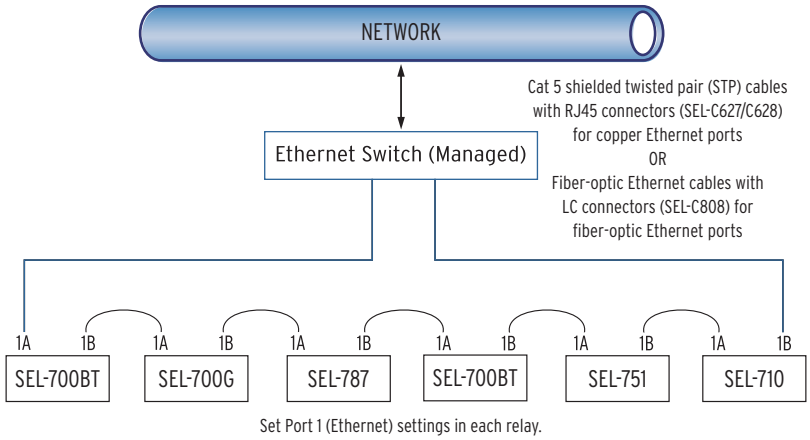


Figure 22 Ethernet Network Configuration With Ring Structure (Switched Mode)

Additional Features

MIRRORED BITS Relay-to-Relay Communications

The SEL-patented MIRRORED BITS communications technology provides bidirectional relay-to-relay digital communications. MIRRORED BITS can operate independently on as many as two EIA-232 rear serial ports and one fiber-optic rear serial port on a single SEL-700BT.

This bidirectional digital communication creates eight additional virtual outputs (transmitted MIRRORED BITS) and eight additional virtual inputs (received MIRRORED BITS) for each serial port operating in the MIRRORED BITS mode (see *Figure 23*). Use these MIRRORED BITS to transmit/receive information between upstream relays and a downstream relay to enhance coordination and achieve faster tripping for downstream faults. MIRRORED BITS technology also helps reduce total scheme operating time by eliminating the need to assert output contacts to transmit information.

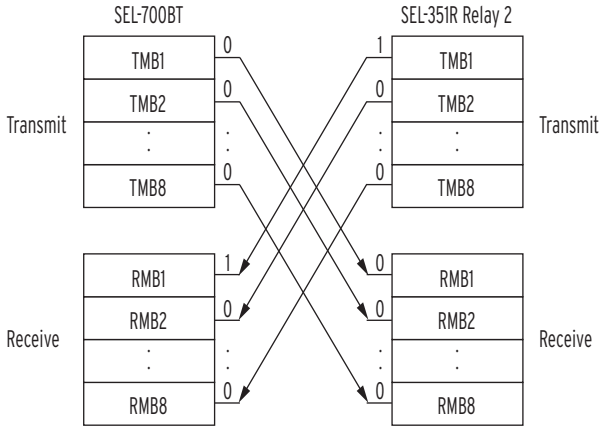


Figure 23 MIRRORED BITS Transmit and Receive Bits

Status and Trip Target LEDs

The SEL-700BT includes 24 tricolor status and trip target LEDs on the front panel. When shipped from the factory, all LEDs are predefined and fixed in settings. You can reprogram these LEDs for specific applications. This combination of targets is explained and shown in *Figure 26*. Some front-panel relabeling of LEDs may be needed if you reprogram them for unique or specific applications—see *Configurable Labels*.

Event Messenger Points

The SEL-700BT, when used with the SEL-3010 Event Messenger, can allow for ASCII-to-voice translation of as many as 32 user-defined messages, along with analog data that have been measured or calculated by the relay. With this combination, you can receive voice messages on any phone for alerts to transition of any Relay Word bits in the relay.

Verbal notification of breaker openings, fuse failures, RTD alarms, etc. can now be sent directly to your cell phone through the use of your SEL-700BT and SEL-3010 (must be connected to an analog telephone line). In addition, messages can include an analog value such as current, voltage, or power measurements made by the SEL-700BT.

Configurable Labels

Use the configurable labels to relabel the operator controls and LEDs (shown in *Figure 26*) to suit the installation requirements. This feature includes preprinted labels (with factory-default text), blank label media, and a Microsoft® Word template on CD-ROM. This allows quick, professional-looking labels for the SEL-700BT. Labels may also be customized without the use of a PC by writing the new label on the blank stock provided. The ability to customize the control and indication features allows specific utility or industry procedures to be implemented without the need for adhesive labels. All of the figures in this data sheet show the factory-default labels of the SEL-700BT.

Web Server

Web Server allows you to communicate with the relay via the Ethernet Port without the need for additional communication software (web browser required). Web Server allows you to access metering and monitoring data, and also supports firmware upgrades.

Firmware Download Via Ethernet Ports

Relay firmware can be securely downloaded to your relay via the Ethernet port. The firmware is digitally signed to prevent malicious modification. Additionally, the Ethernet firmware download allows you to access and update all your network relays simultaneously.

Relay Dimensions

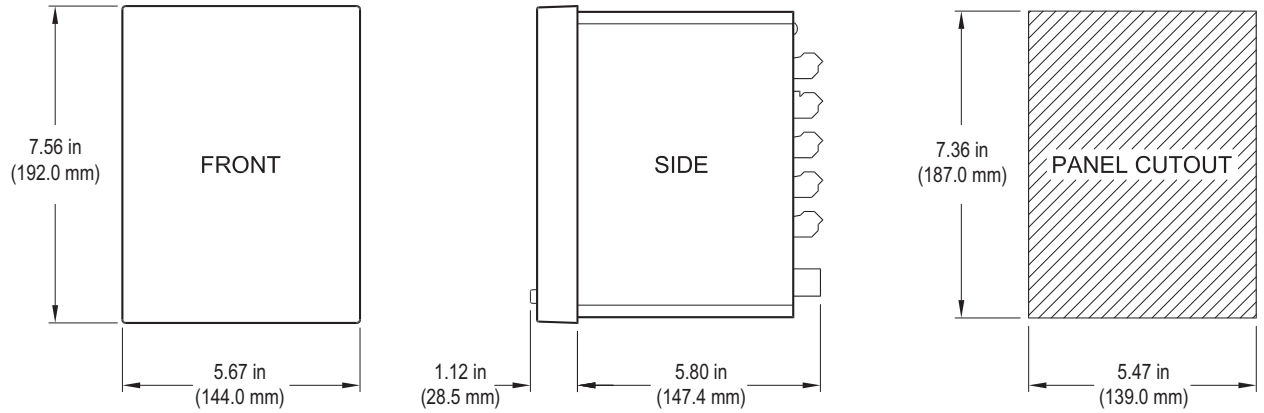


Figure 24 SEL-700BT Dimensions for Rack- and Panel-Mount Models

Hardware Overview

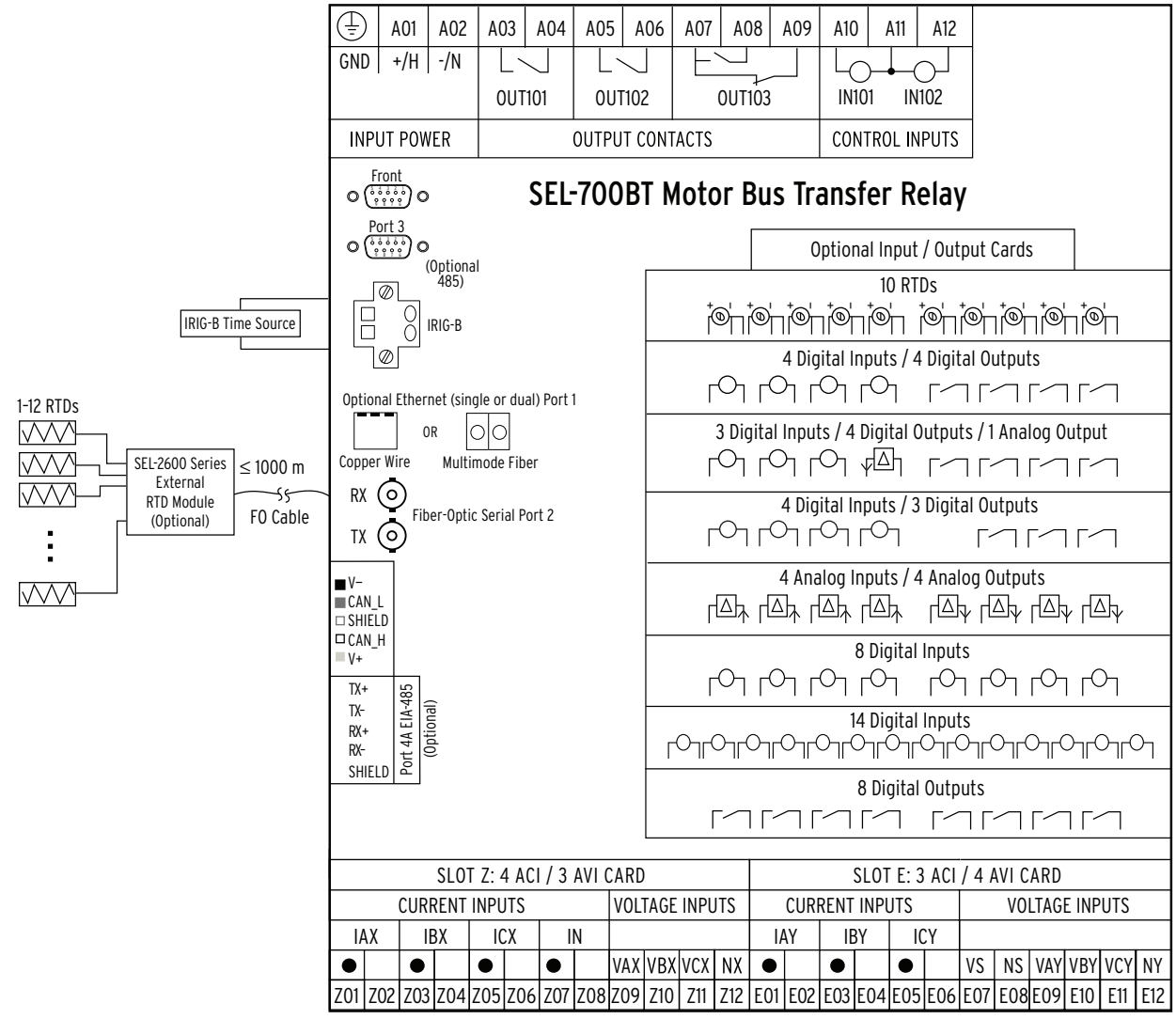
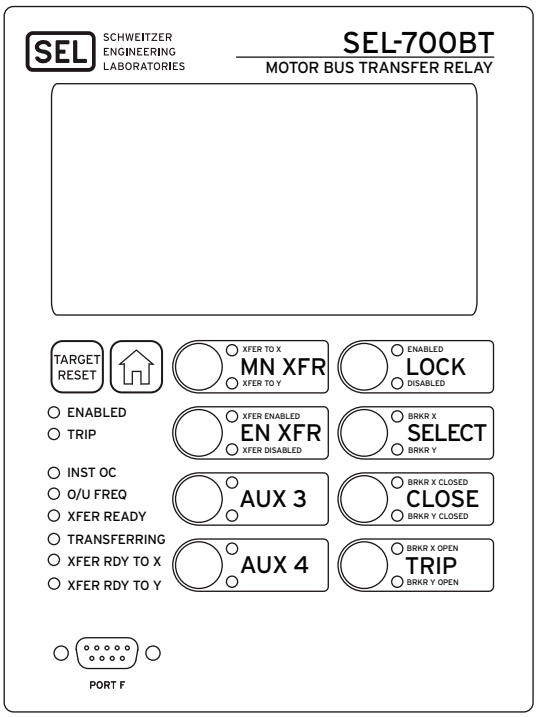


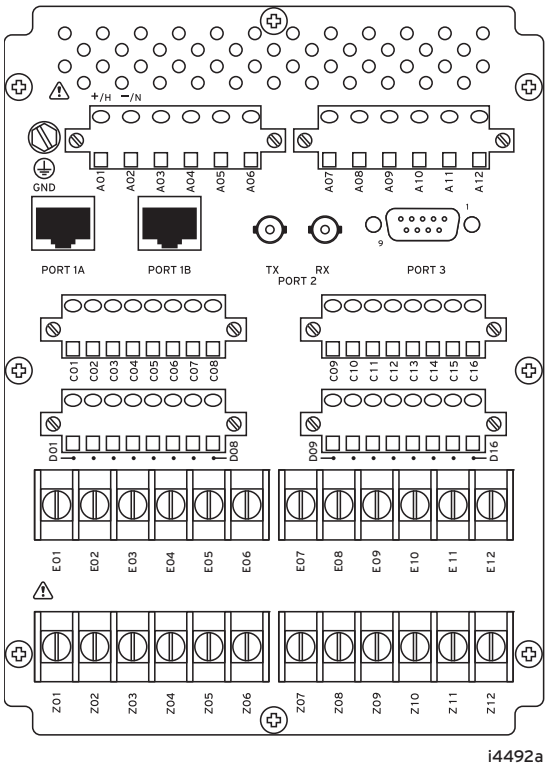
Figure 25 Typical Connection Diagram

Relay Panel Diagrams

(A) Front Panel With Default Configuration Labels

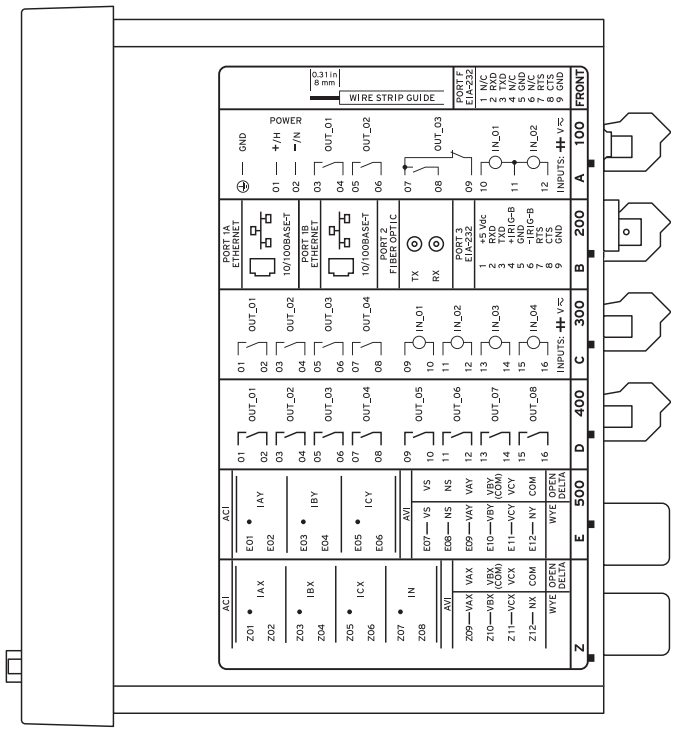


(B) Rear-Panel View



i4492a

(C) Side-Panel View



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

i4489a

Figure 26 Dual Copper Ethernet, 4 DI/4 DO, 8 DO, 3 ACI/4 AVI, 4 ACI/3 AVI (Relay MOT 0700BT1A1A2X7585A630)

Applications

Motor Bus Transfer (MBT)

The SEL-700BT relay has built-in logic for MBT. MBT allows users to quickly transfer load to an auxiliary feeder from the primary feeder during faults to the primary feeder. This instantaneous transfer of load allows users to keep processes running without requiring a cold start. *Figure 27* shows the MBT system.

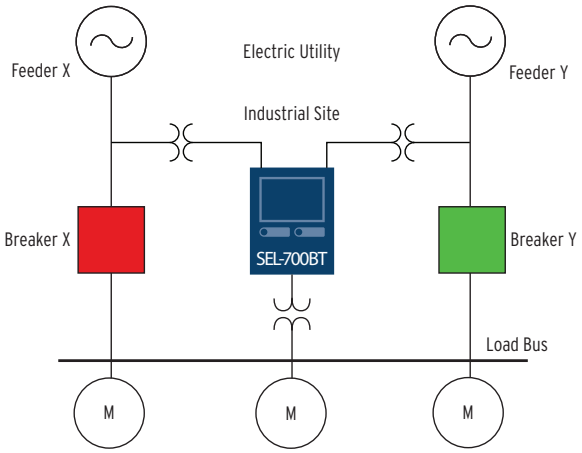


Figure 27 MBT System

The SEL-700BT provides four types of transfers: fast bus transfer (FBT), in which the transfer occurs shortly after the first breaker opens and before the phase of the residual voltage deviates from the system; in-phase transfer (IPT), which occurs when the phase of the system voltage and the residual voltage align; residual bus transfer (RBT), in which the relay waits for the residual voltage to fall below a certain threshold before transferring the bus; and fixed time transfer, which is configurable using SELOGIC control equations.

Depending on the system inertia at the time of the transfer and the conditions initiating the transfer, different methods will be appropriate. The SEL-700BT-based MBT system provides all the transfer methods built-in to one product.

Fast Bus Transfer

The FBT mode switches the motor bus to an alternate source with no intentional delay. It is initiated at very high speeds (less than 10 cycles) before the motors on the bus have a chance to slow down significantly.

In-Phase Transfer

In cases in which an FBT is not possible, the SEL-700BT will check for the alternate source voltage to be in phase with the residual voltage on the motor bus. The transfer will be initiated when the two voltages are in-phase, thereby minimizing transient torques on the motors.

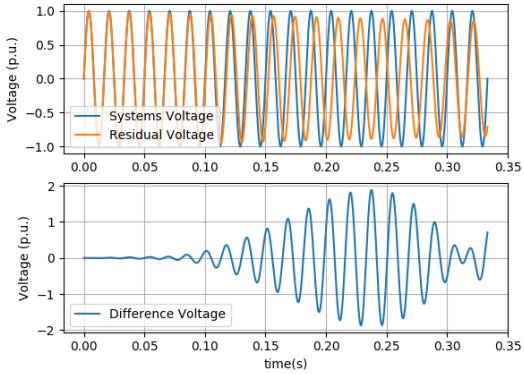


Figure 28 System, Residual, and Difference Voltages

In *Figure 28*, an FBT needs to be initiated before the system and residual voltage fall out of phase. If that occurs, the SEL-700BT will wait for the two voltages to align back in-phase (approximately 0.3 seconds) before initiating the transfer.

Residual Bus Transfer

The relay accurately measures the residual voltage in order to close when the closing current and torques are low. This is applicable for low-inertia motors and loads that may slow too fast for a high-speed transfer.

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B, Class A

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

CE Mark in accordance with the requirements of the European Union

RCM Mark in accordance with the requirements of Australia

UKCA Mark in accordance with the requirements of United Kingdom

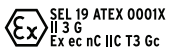
Normal Locations

UL Listed to U.S. and Canadian safety standards (File E212775, NRGU, NRGU7)

Hazardous Locations

UL Certified Hazardous Locations to U.S. and Canadian standards CL I, DIV 2; GP A, B, C, D; T3C, maximum surrounding temperature of 50°C (File E470448)

EU



EN 60079-0:2012 + A11:2013, EN 60079-7:2015, EN 60079-15:2010, EN 60079-11:2012

Ambient air temperature shall not exceed –20°C ≤ Ta ≤ 50°C

Note: Where so marked, ATEX and UL Hazardous Locations Certification tests are applicable to rated supply specifications only and do not apply to the absolute operating ranges, continuous thermal, or short circuit duration specifications.

General

AC Current Input

Phase and Neutral Currents

I_{NOM} = 1 A or 5 A secondary depending on the model

Measurement Category:	II

I_{NOM} = 5 A

Continuous Rating:	3 • I_{NOM} @ 85°C 4 • I_{NOM} @ 55°C
A/D Measurement Limit:	217 A peak (154 A rms) symmetrical
Saturation Current Rating:	Linear to 96 A symmetrical
1-Second Thermal:	500 A
Burden (per Phase):	<0.1 VA @ 5 A

I_{NOM} = 1 A

Continuous Rating:	3 • I_{NOM} @ 85°C 4 • I_{NOM} @ 55°C
A/D Measurement Limit:	43 A peak (31 A rms) symmetrical
Saturation Current Rating:	Linear to 19.2 A symmetrical
1-Second Thermal:	100 A
Burden (per Phase):	<0.01 VA @ 1 A

AC Voltage Inputs

V_{NOM} (L-L secondary) Range:	20–250 V (if DELTA_Y := DELTA) 20–440 V (if DELTA_Y := WYE)
Rated Continuous Voltage:	300 Vac
10-Second Thermal:	600 Vac
Burden:	<0.1 VA
Input Impedance:	2 MΩ single-ended (phase-to-neutral) 4 MΩ differential (phase-to-phase)

Power Supply

Relay Start-Up Time:	Approximately 5–10 seconds (after power is applied until the **ENABLED** LED turns on)

High-Voltage Supply

Rated Supply Voltage:	110–240 Vac, 50/60 Hz 110–250 Vdc
Input Voltage Range (Design Range):	85–264 Vac 85–275 Vdc
Power Consumption:	<50 VA (ac) <25 W (dc)
Interruptions:	50 ms @ 125 Vac/Vdc 100 ms @ 250 Vac/Vdc

Low-Voltage Supply

Rated Supply Voltage:	24–48 Vdc
Input Voltage Range (Design Range):	19.2–60 Vdc
Power Consumption:	<25 W (dc)
Interruptions:	10 ms @ 24 Vdc 50 ms @ 48 Vdc

Fuse Ratings

LV Power Supply Fuse

Rating:	3.15 A
Maximum Rated Voltage:	300 Vdc, 250 Vac
Breaking Capacity:	1500 A at 250 Vac
Type:	Time-lag T

HV Power Supply Fuse

Rating:	3.15 A
Maximum Rated Voltage:	300 Vdc, 250 Vac
Breaking Capacity:	1500 A at 250 Vac
Type:	Time-lag T

Output Contacts

The relay supports Form A, B, and C outputs.

Dielectric Test Voltage:	2500 Vac
Impulse Withstand Voltage (U_{IMP}):	5000 V
Mechanical Durability:	100,000 no-load operations

Standard Contacts

Pickup/Dropout Time:	≤8 ms (coil energization to contact closure)

DC Output Ratings

Rated Operational Voltage:	250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Continuous Carry:	6 A @ 70°C 4 A @ 85°C
1-Second Thermal:	50 A
Contact Protection:	360 Vdc, 115 J MOV protection across open contacts

Breaking Capacity (10,000 Operations) per IEC 60255-0-20:1974:

24 Vdc	0.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Cyclic (2.5 Cycles/Second) per IEC 60255-0-20:1974:

24 Vdc	0.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

AC Output Ratings

Maximum Operational Voltage (U_e) Rating:	240 Vac
Insulation Voltage (U_i) Rating (excluding EN 61010-1):	300 Vac
1-Second Thermal:	50 A
Contact Rating Designation:	B300

B300 (5 A Thermal Current, 300 Vac Max)			
	Maximum Current		Max VA
Voltage	120 Vac	240 Vac	—
Make	30 A	15 A	3600
Break	3 A	1.5 A	360
PF < 0.35, 50–60 Hz			

Utilization Category: AC-15

AC-15		
Operational Voltage (Ue)	120 Vac	240 Vac
Operational Current (Ie)	3 A	1.5 A
Make Current	30 A	15 A
Break Current	3 A	1.5 A
Electromagnetic loads > 72 VA, PF < 0.3, 50–60 Hz		

Voltage Protection Across Open Contacts: 270 Vac, 115 J

Fast Hybrid (High-Speed, High-Current Interrupting)

DC Output Ratings

Rated Operational Voltage:	250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Continuous Carry:	6 A @ 70°C 4 A @ 85°C
1-Second Thermal:	50 A
Open State Leakage Current:	<500 µA
MOV Protection (Maximum Voltage):	250 Vac/330 Vdc
Pickup Time:	<50 µs, resistive load
Dropout Time:	≤8 ms, resistive load

Break Capacity (10,000 Operations) per IEC 60255-0-20:1974:

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Cyclic Capacity (4 Cycles in 1 Second, Followed by 2 Minutes Idle for Thermal Dissipation) per IEC 60255-0-20:1974:

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

AC Output Ratings

See *AC Output Ratings* for *Standard Contacts*.

Optoisolated Control Inputs

When Used With DC Control Signals

Pickup/Dropout Time:	Depends on the input debounce settings
250 V:	ON for 200–312.5 Vdc OFF below 150 Vdc
220 V:	ON for 176–275 Vdc OFF below 132 Vdc
125 V:	ON for 100–156.2 Vdc OFF below 75 Vdc
110 V:	ON for 88–137.5 Vdc OFF below 66 Vdc
48 V:	ON for 38.4–60 Vdc OFF below 28.8 Vdc
24 V:	ON for 15–30 Vdc OFF for <5 Vdc

When Used With AC Control Signals

Pickup Time:	2 ms
Dropout Time:	16 ms
250 V:	ON for 170.6–312.5 Vac OFF below 106 Vac
220 V:	ON for 150.2–275 Vac OFF below 93.3 Vac
125 V:	ON for 85–156.2 Vac OFF below 53 Vac
110 V:	ON for 75.1–137.5 Vac OFF below 46.6 Vac
48 V:	ON for 32.8–60 Vac OFF below 20.3 Vac
24 V:	ON for 14–30 Vac OFF below 5 Vac
Current Draw at Nominal DC Voltage:	2 mA (at 220–250 V) 4 mA (at 48–125 V) 10 mA (at 24 V)
Rated Impulse Withstand Voltage (U_{imp}):	4000 V

Analog Output (Optional)

	1A0	4A0
Current:	4–20 mA	±20 mA
Voltage:	—	±10 V
Load at 1 mA:	—	0–15 kΩ
Load at 20 mA:	0–300 Ω	0–750 Ω
Load at 10 V:	—	>2000 Ω
Refresh Rate:	100 ms	100 ms
% Error, Full Scale, at 25°C:	<±1%	<±0.55%
Select From:	Analog quantities available in the relay	

Analog Input (Optional)

Maximum Input Range:	±20 mA ±10 V Operational range set by user
Input Impedance:	200 Ω (current mode) >10 kΩ (voltage mode)

Accuracy at 25°C

With user calibration:	0.050% of full scale (current mode) 0.025% of full scale (voltage mode)
Without user calibration:	Better than 0.5% of full scale at 25°C
Accuracy Variation With Temperature:	±0.015% per °C of full scale (±20 mA or ±10 V)

Frequency and Phase Rotation

System Frequency:	50, 60 Hz
Phase Rotation:	ABC, ACB
Frequency Tracking:	15–70 Hz

Time-Code Input

Format:	Demodulated IRIG-B
On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V
Input Impedance:	2 kΩ

Synchronization Accuracy

Internal Clock:	±1 µs
All Reports:	±5 ms
SNTP Accuracy:	±1 ms (in an ideal network)
PTP Accuracy:	±1 ms
Unsynchronized Clock Drift Relay Powered:	2 minutes per year, typically

Communications Ports

Standard EIA-232 (2 Ports)

Location:	Front Panel Rear Panel
Data Speed:	300–38400 bps

EIA-485 Port (Optional)

Location:	Rear Panel
Data Speed:	300–19200 bps

Ethernet Port (Optional)

Single/Dual 10/100BASE-T copper (RJ45 connector)
Single/Dual 100BASE-FX (LC connector)

Standard Multimode Fiber-Optic Port

Location:	Rear Panel
Data Speed:	300–38400 bps

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

Wavelength:	1300 nm
Optical Connector Type:	LC
Fiber Type:	Multimode
Link Budget:	16.1 dB
Typical TX Power:	–15.7 dBm
RX Min. Sensitivity:	–31.8 dBm
Fiber Size:	62.5/125 µm
Approximate Range:	~6.4 km
Data Rate:	100 Mbps
Typical Fiber Attenuation:	–2 dB/km

Port 2 Serial

Wavelength:	820 nm
Optical Connector Type:	ST
Fiber Type:	Multimode
Link Budget:	8 dB
Typical TX Power:	–16 dBm
RX Min. Sensitivity:	–24 dBm
Fiber Size:	62.5/200 µm
Approximate Range:	~1 km
Data Rate:	5 Mbps
Typical Fiber Attenuation:	–4 dB/km

Optional Communications Cards

Option 1:	EIA-232 or EIA-485 communications card

Communications Protocols

SEL, Modbus, DNP, FTP, TCP/IP, Telnet, SNTP, IEEE-1588-2008 firmware-based PTP, IEC 61850 Edition 2, IEC 60870-5-103, PRP, IEEE 802.1Q-2014 Rapid Spanning Tree Protocol (RSTP), MIRRORED BITS, EVMSG, and EtherNetIP

Operating Temperature

IEC Performance Rating:	–40° to +85°C (–40° to +185°F) (per IEC/EN 60068-2-1 and 60068-2-2)

NOTE: Not applicable to UL applications
NOTE: The front-panel display is impaired for temperatures below –20°C and above +70°C

Operating Environment

Insulation Class:	I
Pollution Degree:	2
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude Without Derating (Consult the Factory for Higher Altitude Derating):	2000 m

Dimensions

144.0 mm (5.67 in) x 192.0 mm (7.56 in) x 147.4 mm (5.80 in)

Weight

2.7 kg (6.0 lb)

Relay Mounting Screw (#8–32) Tightening Torque

Minimum:	1.4 Nm (12 in-lb)
Maximum:	1.7 Nm (15 in-lb)

Terminal Connections

Terminal Block

Screw Size:	#6
Ring Terminal Width:	0.310 inch maximum

Terminal Block Tightening Torque

Minimum:	0.9 Nm (8 in-lb)
Maximum:	1.4 Nm (12 in-lb)

Compression Plug Tightening Torque

Minimum:	0.5 Nm (4.4 in-lb)
Maximum:	1.0 Nm (8.8 in-lb)

Compression Plug Mounting Ear Screw Tightening Torque

Minimum:	0.18 Nm (1.6 in-lb)
Maximum:	0.25 Nm (2.2 in-lb)

Product Standards

Electromagnetic Compatibility:	IEC 60255-26:2013 IEC 60255-27:2013 UL 508 CSA C22.2 No. 14-05

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 + CRDG:2003 IP54 enclosed in panel (touchscreen display models) IP50 for terminals enclosed in the dust protection assembly (protection against solid foreign objects only) (SEL Part #915900170). The 10°C temperature derating applies to the temperature specifications of the relay. IP10 for terminals and the relay rear panel IP20 for terminals and the relay rear panel with optional terminal block cover

Vibration Resistance:	IEC 60255-21-1:1988 IEC 60255-27:2013, Section 10.6.2.1 Endurance: Class 2 Response: Class 2
Shock Resistance:	IEC 60255-21-2:1988 IEC 60255-27:2013, Section 10.6.2.2 IEC 60255-27:2013, Section 10.6.2.3 Withstand: Class 1 Response: Class 2 Bump: Class 1
Seismic (Quake Response):	IEC 60255-21-3:1993 IEC 60255-27:2013, Section 10.6.2.4 Response: Class 2
Cold:	IEC 60068-2-1:2007 IEC 60255-27:2013, Section 10.6.1.2 IEC 60255-27:2013, Section 10.6.1.4 –40°C, 16 hours
Dry Heat:	IEC 60068-2-2:2007 IEC 60255-27:2013, Section 10.6.1.1 IEC 60255-27:2013, Section 10.6.1.3 85°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 IEC 60255-27:2013, Section 10.6.1.5 40°C, 93% relative humidity, 10 days
Damp Heat, Cyclic:	IEC 60068-2-30:2001 IEC 60255-27:2013, Section 10.6.1.6 25°–55°C, 6 cycles, 95% relative humidity
Change of Temperature:	IEC 60068-2-14:2009 IEC 60255-1:2010, Section 6.12.3.5 –40° to 85°C, ramp rate 1°C/min, 5 cycles

Dielectric Strength and Impulse Tests

Dielectric (HiPot):	IEC 60255-27:2013, Section 10.6.4.3 IEEE C37.90-2005 1.0 kVac on analog outputs, Ethernet ports 2.0 kVac on analog inputs, IRIG 2.5 kVac on contact I/O 3.6 kVdc on power supply, current, and voltage inputs
Impulse:	IEC 60255-27:2013, Section 10.6.4.2 0.5 J, 5 kV on power supply, contact I/O, ac current, and voltage inputs 0.5 J, 530 V on analog outputs IEEE C37.90:2005 0.5 J, 5 kV 0.5 J, 530 V on analog outputs

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEC 60255-26:2013, Section 7.2.3 IEEE C37.90.3:2001 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2010 IEC 60255-26:2013, Section 7.2.4 10 V/m IEEE C37.90.2-2004 20 V/m
Fast Transient, Burst Immunity[a]:	IEC 61000-4-4:2012 IEC 60255-26:2013, Section 7.2.5 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity[a]:	IEC 61000-4-5:2005 IEC 60255-26:2013, Section 7.2.7 2 kV line-to-line 4 kV line-to-earth
Surge Withstand Capability Immunity[a]:	IEC 61000-4-18:2010 IEC 60255-26:2013, Section 7.2.6 2.5 kV common mode 1.0 kV differential mode 1.0 kV common mode on comm. ports IEEE C37.90.1-2012 2.5 kV oscillatory 4.0 kV fast transient
Conducted RF Immunity:	IEC 61000-4-6:2008 IEC 60255-26:2013, Section 7.2.8 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2009 IEC 60255-26:2013, Section 7.2.10 Severity Level: 1000 A/m for 3 seconds 100 A/m for 1 minute; 50/60 Hz IEC 61000-4-9:2001 Severity Level: 1000 A/m IEC 61000-4-10:2001 Severity Level: 100 A/m (100 kHz and 1 MHz)
Power Supply Immunity:	IEC 61000-4-11:2004 IEC 61000-4-17:1999 IEC 61000-4-29:2000 IEC 60255-26:2013, Section 7.2.11 IEC 60255-26:2013, Section 7.2.12 IEC 60255-26:2013, Section 7.2.13

EMC Emissions

Conducted Emissions:	IEC 60255-26:2013 Class A FCC 47 CFR Part 15.107 Class A Canada ICES-001 (A) / NMB-001 (A) EN 55011:2009 + A1:2010 Class A EN 55022:2010 + AC:2011 Class A EN 55032:2012 + AC:2013 Class A CISPR 11:2009 + A1:2010 Class A CISPR 22:2008 Class A CISPR 32:2015 Class A
Radiated Emissions:	IEC 60255-26:2013 Class A FCC 47 CFR Part 15.109 Class A Canada ICES-001 (A) / NMB-001 (A) EN 55011:2009 + A1:2010 Class A EN 55022:2010 + AC:2011 Class A EN 55032:2012 + AC:2013 Class A CISPR 11:2009 + A1:2010 Class A CISPR 22:2008 Class A CISPR 32:2015 Class A

Processing Specifications and Oscillography

AC Voltage and Current Inputs:	32 samples per power system cycle
Analog Inputs:	4 samples per power system cycle
Frequency Tracking Range:	15–70 Hz
Digital Filtering:	One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
Protection and Control Processing:	Processing interval is 4 times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms). The 51 protection element is processed twice per cycle. Analog quantities for rms data are determined through use of data averaged over the previous 8 cycles.

Oscillography

Length:	15, 64, 180 cycles
Sampling Rate:	32 samples per cycle unfiltered 4 samples per cycle filtered

Trigger:	Programmable with Boolean expression
Format:	ASCII and Compressed ASCII Binary COMTRADE (32 samples per cycle unfiltered)
Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy:	±5 ms

Sequential Events Recorder

Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy (With Respect to Time Source) for all RWBs except those corresponding to digital inputs (IN*xxx*):	±5 ms
Time-Stamp Accuracy (With Respect to Time Source) for RWBs corresponding to digital inputs (IN*xxx*):	1 ms

Relay Elements

Instantaneous/Definite Time-Overcurrent (50P, 50G, 50N, 50Q)

Pickup Setting Range, A secondary	
5 A models:	0.50–96.00 A, 0.01 A steps
1 A models:	0.10–19.20 A, 0.01 A steps
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (steady-state pickup)
Time Delay:	0.00–400.00 seconds, 0.01 seconds steps, ±0.5% plus ±0.25 cycle 0.10–400.00 seconds, 0.01 seconds steps, ±0.5% plus ±0.25 cycle for 50Q
Pickup/Dropout Time:	<1.5 cycle

Inverse-Time Overcurrent (51P, 51G, 51N, 51Q)

Pickup Setting Range, A secondary	
5 A models:	0.50–16.00 A, 0.01 A steps
1 A models:	0.10–3.20 A, 0.01 A steps
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (steady-state pickup)
Time Dial	
US:	0.50–15.00, 0.01 steps
IEC:	0.05–1.00, 0.01 steps
Accuracy:	±1.5 cycles plus ±4% between 2 and 30 multiples of pickup (within rated range of current)

Undervoltage (27P, 27PP, 27V1, 27S)

Pickup Range:	Off, 2.0–300.0 V (2.0–520.0 V for phase-to-phase wye connected; 2.0–170.0 V positive-sequence, delta connected)
Accuracy:	±5% of setting plus ±2 V
Pickup/Dropout Time:	<1.5 cycle
Time Delay:	0.00–120.00 seconds, 0.01 second steps
Accuracy:	±0.5% plus ±0.25 cycle

Overvoltage (59P, 59PP, 59V1, 59S, 59Q, 59G)

Pickup Range:	Off, 2.0–300.0 V (2.0–520.0 V for phase-to-phase wye connected; 2.0–170.0 V positive sequence, delta connected)
Pickup Range (59G, 59Q):	Off, 2.0–200.0 V
Accuracy:	±5% of setting plus ±2 V
Pickup/Dropout Time:	<1.5 cycle
Time Delay:	0.00–120.00 seconds, 0.01 second steps
Accuracy:	±0.5% plus ±0.25 cycle

Inverse-Time Undervoltage (27I)

Setting Range:	OFF, 2.00–300.00 V (Phase elements, positive-sequence elements, phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V (Phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Dial:	0.00–16.00 s
Accuracy:	±1.5 cyc plus ±4% between 0.95 and 0.1 multiples of pickup

Inverse-Time Overvoltage (59I)

Setting Range:	OFF, 2.00–300.00 V (Phase elements, sequence elements, or phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V (Phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Dial:	0.00–16.00 s
Accuracy:	±1.5 cyc plus ±4% between 1.05 and 5.5 multiples of pickup

Vector Shift (78VS)

Pickup Setting Range:	2.0°–30.0°, 0.1° increment
Accuracy:	±10% of the pickup setting, ±1 degree
Voltage Supervision Threshold:	20.0%–100.0% • VNOM
Pickup Time:	<3 cycles

Frequency (81)

Setting Range:	Off, 15.00–70.00 Hz
Accuracy:	±0.01 Hz (V1 > 60 V)
Pickup/Dropout Time:	<4 cycles
Time Delay:	0.00–400.00 seconds, 0.01 second steps
Accuracy:	±0.5% plus ±0.25 cycle

RTD Protection

Setting Range:	Off, 1°–250°C
Accuracy:	±2°C
RTD Open-Circuit Detection:	>250°C
RTD Short-Circuit Detection:	<–50°C
RTD Types:	PT100, NI100, NI120, CU10
RTD Lead Resistance:	25 ohm max. per lead
Update Rate:	<3 s
Noise Immunity on RTD Inputs:	To 1.4 Vac (peak) at 50 Hz or greater frequency
RTD Fault/Alarm/Trip Time Delay:	Approx. 12 s

Rate-of-Change of Frequency (81R)

Pickup Setting Range:	Off, 0.10–15.00 Hz/s
Accuracy:	±100 mHz/s plus ±3.33% of pickup
Trend Setting:	INC, DEC, ABS
Pickup/Dropout Time:	3–30 cycles, depending on pickup setting

Pickup/ Dropout Delay Range:	0.10–60.00/0.00–60.00 s, 01 s increments
Voltage Supervision (Positive Sequence) Pickup Range:	Off, 12.5–300.0 V, 0.1 V increments

Synchronism Check (25X) for X-Side Breaker

Synchronism-Check Voltage Source:	VAX, VBX, VCX, VABX, VBCX, VCAX or angle from VAX or VABX
Voltage Window High Setting Range:	0.00–300.00 V
Voltage Window Low Setting Range:	0.00–300.00 V
Steady-State Voltage Accuracy:	±5% plus ±2.0 V (over the range of 12.5–300 V)
Maximum Percentage Voltage Difference:	1.0–15.0%
Minimum Slip Frequency:	–1.00 Hz to 0.99 Hz
Maximum Slip Frequency:	–0.99 Hz to 1.00 Hz
Steady-State Slip Accuracy:	±0.02 Hz
Close Acceptance Angle 1, 2:	0°–80°
Target Close Angle:	–15° to 15°
Breaker Close Delay:	0.001–1.000 s
Close Failure Angle:	3°–120°
Steady-State Angle Accuracy:	±2°

Synchronism Check (25Y) for Y-Side Breaker

Synchronism-Check Voltage Source:	VAY, VBY, VCY, VABY, VBCY, VCAY or angle from VAY or VABY
Voltage Window High Setting Range:	0.00–300.00 V
Voltage Window Low Setting Range:	0.00–300.00 V
Steady-State Voltage Accuracy:	±5% plus ±2.0 V (over the range of 12.5–300 V)
Maximum Percentage Voltage Difference:	1.0–15.0%
Maximum Slip Frequency:	–0.05 Hz to 0.50 Hz
Steady-State Slip Accuracy:	±0.02 Hz
Close Acceptance Angle 1, 2:	0°–80°
Breaker Close Delay:	0.001–1.000 s
Steady-State Angle Accuracy:	±2°

Metering Accuracy

Accuracies are specified at 20°C, nominal frequency, ac currents within (0.2–20.0) • I_{NOM} A secondary, and ac voltages within 50–250 V secondary unless otherwise noted.

Phase Currents:	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
3-Phase Average Current:	±1% of reading
IG (Residual Current):	±2% of reading, ±2° (±5.0° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
IN (Neutral Current):	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
3I2 Negative-Sequence Current:	±2% of reading
System Frequency:	±0.01 Hz of reading for frequencies within 20–70 Hz (V1 > 60 V)
Line-to-Line Voltages:	±1% of reading, ±1° for voltages within 24–264 V
3-Phase Average Line-to-Line Voltage:	±1% of reading for voltages within 24–264 V
Line-to-Ground Voltages:	±1% of reading, ±1° for voltages within 24–264 V
3-Phase Average Line-to-Ground Voltages:	±1% of reading for voltages within 24–264 V
3V2 Negative-Sequence Voltage:	±2% of reading for voltages within 24–264 V
Real 3-Phase Power (kW):	±3% of reading for 0.10 < pf < 1.00
Reactive 3-Phase Power (kVAR):	±3% of reading for 0.00 < pf < 0.90
Apparent 3-Phase Power (kVA):	±3% of reading
Power Factor:	±2% of reading
RTD Temperatures:	±2°C

[a] Front-port serial cable (non-fiber) lengths assumed to be <3 m.

Notes

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