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Introduction to SEL Relays for New Users

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INTRODUCTION

The goal of this document is to serve as a starting point for customers new to SEL relays. The fundamentals in most relays are very similar, and this document is designed to aid anyone using an SEL relay for the first time. This document is not intended to cover every aspect of all SEL relays. For more information about each relay, refer to the individual relay instruction manual. The following sections are included in the document:

Section 1: Basics of an SEL Relay

Section 2: Front-Panel Navigation

Section 3: ACSELERATOR QuickSet SEL-5030 Software

Section 4: SELOGIC Control Equations

Section 5: Event Reporting

Section 6: Testing a Relay Element

Section 7: Communications

Section 8: Frequently Asked Questions

Section 9: More Help

Section 1: Basics of an SEL Relay

Functional Diagram of a Relay

You can find the functional diagram of a relay in the respective data sheet and instruction manual. This diagram depicts the available features in the relay. It helps users select a suitable relay for an application or find the appropriate digital relay to replace an electromechanical relay. In many cases, you can replace multiple electromechanical relays with a single digital relay because digital relays are multifunction devices. See *Figure 1* for an example functional diagram, including the various protection features as well as other features (such as metering, fault location, event reporting, etc.) that are available in the relay. The protection elements are represented by their ANSI codes (see *Appendix A* on page 45 for details). The elements that are marked with asterisks are ordering options. In some relays, three-phase voltage inputs are optional, so the protection elements that rely on voltage are optional as well.

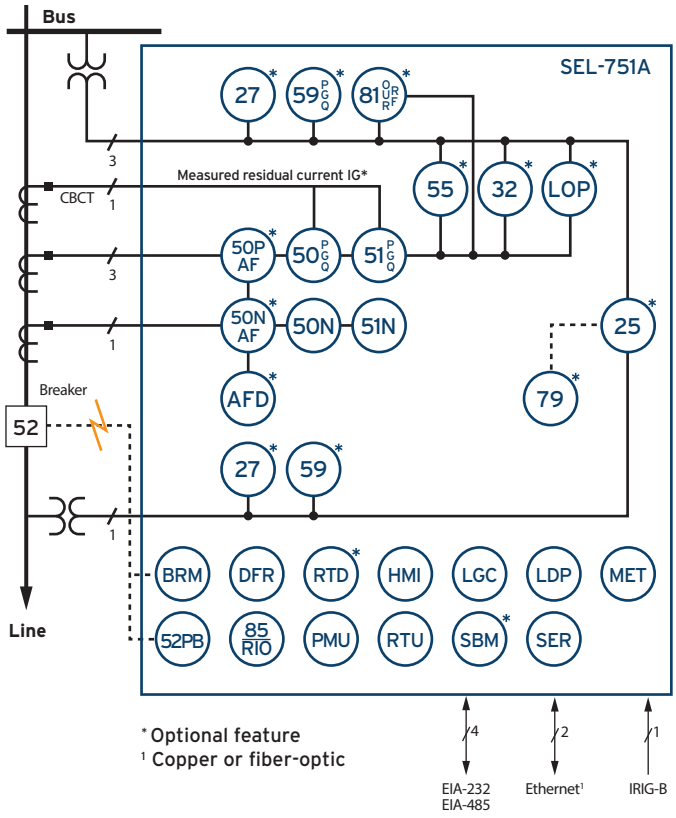


Figure 1 Functional Diagram for an SEL-751A

As shown in the diagram, the relay receives the phase currents through three single-phase CTs (one per phase), the neutral current through a core balance CT, and phase voltages through three PTs. These currents and voltages are used by different protection elements. As you can see in *Figure 1*, all protection elements that are tied to the CT inputs use the current quantities to make a protection decision; all the elements tied to the PT inputs use the voltage quantities to make a decision; elements tied to both the CT and PT inputs (55, 32, and 60) use both current and voltage quantities to make a decision.

Residual-Ground Versus Neutral-Ground Overcurrent

Most SEL relays have two types of ground overcurrent elements available:

- Residual-ground, which is a calculated value. It is a phasor sum of the three phase currents.
- Neutral-ground, which is the measured value from the IN input. This input could be from a zero-sequence CT or a residual connection from the individual phase CTs.

In all SEL relays except the SEL-501 Dual Universal Overcurrent Relay, the 50G/51G elements operate off the residual-ground current, and the 50N/51N elements operate off the neutral-ground current. In the SEL-501, the 50N/51N elements operate off residual-ground current.

Understanding Logic Diagrams and RWBs

Every protection function in an SEL relay is well-documented with logic diagrams and descriptions in the corresponding relay instruction manual. This logic is hard-coded into the relay and cannot be changed. *Figure 2* shows an example of a logic diagram for an overcurrent element. It consists of inputs, operators, and outputs. The inputs of a logic diagram are typically relay settings (e.g., pickup settings) and measured/calculated input quantities (e.g., phase currents). The operators perform the logical or relational operations on the logic inputs. The output is the result of the logic operations. In SEL relays, the outputs of relay logic are called Relay Word bits (RWBs), and they are labeled as such in *Figure 2*.

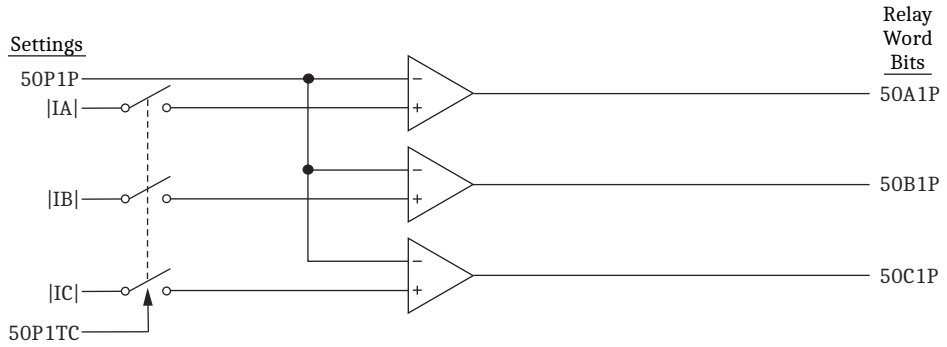


Figure 2 Instantaneous Overcurrent Element Logic Diagram for an SEL-751

An RWB is the output of a piece of relay logic. It is a logical bit that indicates the status of a single relay element, a portion of a complex relay element, or a logic equation. An RWB is always in one of two states: logical 1 (asserted) or logical 0 (deasserted). RWBs can be combined to form trip equations or custom SELOGIC® control equations. You can also use them to monitor relay operations during testing and analyze relay performance after a fault. The appendix of the relay instruction manual defines all the RWBs present in a relay.

In *Figure 2*, the triangle symbols represent comparators. If the value of the input coming into the **+** is greater than the value of the input coming into the **–**, the output of the comparator asserts. In this example, if the magnitude of the A-phase current (|IA|) becomes higher than the pickup setting (50P1P), the RWB 50A1P asserts (becomes a logical 1). For more information on how to read and understand these logic diagrams, see [1].

Trip Equation

You can combine the RWBs from different protection elements to form the trip equation by using SELOGIC operators. These are logical OR, AND, and NOT functions and are explained further in *Section 4: SELOGIC Control Equations*. In *Figure 3*, the trip RWB asserts if 50G1T, 50P1T, or 67P2T asserts. It also asserts if 27P1T asserts while LOP is deasserted.

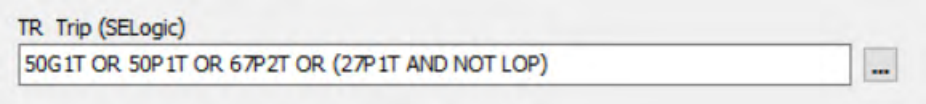


Figure 3 Example Trip Equation

Important Relay Identifiers

There are several important pieces of identifying information that you may need when working with your relay. These are as follows:

Part Number: The part number of the relay specifies what hardware and software options are present in the relay. The part number changes whenever the hardware in the relay is modified. Sometimes, firmware updates change the relay part number as well. You can find this number on the silver sticker (**P/N**) on the rear or side of the relay. You can also find it through the front panel or by using the **ID** or **STA** command in the terminal window, as explained in *Section 3: ACSELERATOR QuickSet SEL-5030 Software* on page 16. If you have a relay with a certain part number and want to know the hardware and software options present in the relay, you can use the reverse part number look up tool at selinc.com/products/ to find the necessary information (as explained in *Section 8: Frequently Asked Questions* on page 41).

Serial Number: Each relay SEL makes has a unique serial number that is issued at the time of manufacture. The serial number does not change with firmware upgrades or hardware changes. It remains constant throughout the life of the relay. You can find this number on the silver sticker (**S/N**) on the relay (along with the part number) or by using the **STA** command in the terminal window.

Firmware ID: The FID specifies what firmware is currently installed in the relay. You can find the FID either through the front-panel **STATUS** menu or by using the **STA** or **ID** command in the terminal window. Appendix A of the relay instruction manual lists all the firmware versions for the relay, a description of the modifications, and the instruction manual date code that corresponds to the firmware versions. The following is an example FID.

Table 1 Explanation for Example FID

SEL-751-R201-V1-Z007003-D20180921				
SEL-751	**R201-V1**	**Z007**	**003**	**D20180921**
This is the device model of the product. This relay is an SEL-751.	This is the firmware revision number. This relay has R201-V1 firmware currently installed.	This is the settings version number (SVN) or Z-number of the relay, and it is always the three digits following the Z. You need this number when creating new settings for the relay in QuickSet. The SVN of this relay is 007.	This is the protocol revision number.	This is the date code of the relay firmware. The format is year, month, day, which means that firmware R201-V1 was released on September 21, 2018. (D20180921).

SEL Relay Product Lines

SEL has developed different product lines to fit different markets and applications. *Table 2* outlines some widely used product lines.

Table 2 SEL Product Lines (Sheet 1 of 2)

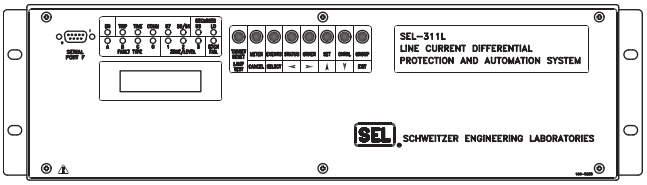
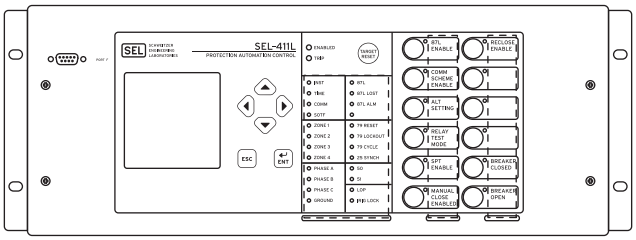
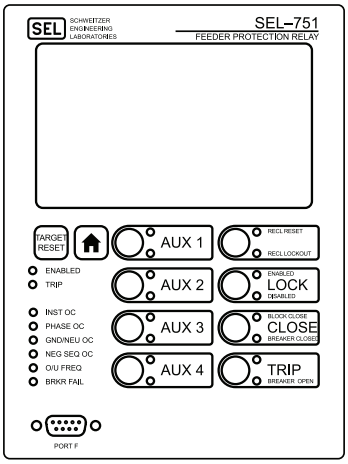
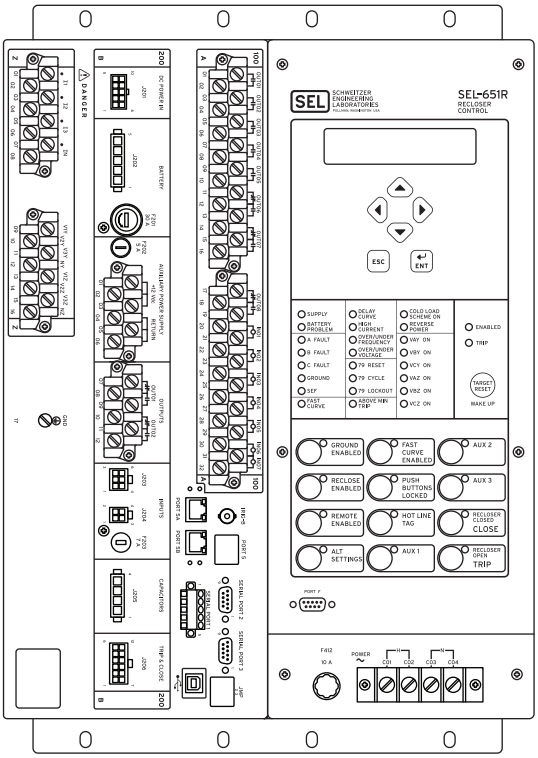
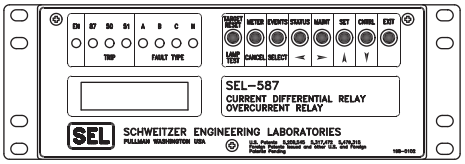
Product Line	Description	Image
SEL-300 series relays[a]	These relays are geared towards utility customers for feeder, transmission, transformer, and generator protection. They have a standard 19-inch width and can be ordered with either a rack- or panel-mounted chassis.	 **Figure 4 SEL-311L Relay**
SEL-400 series relays[a]	These relays are also geared towards utility customers but are designed for more complex installations and applications. They typically have more advanced features and I/O options, and they are often physically larger than the SEL-300 series relays. They have a standard 19-inch width and can be ordered with either a rack- or panel-mounted chassis.	 **Figure 5 SEL-411L Relay**
SEL-700 series relays[b]	These relays are geared towards the industrial market for feeder, transformer, motor, and generator protection. Their smaller form factor makes them ideal for retrofit applications.	 **Figure 6 SEL-751 Relay With Touchscreen Display**

Table 2 SEL Product Lines (Sheet 2 of 2)

Product Line	Description	Image
SEL Recloser Controls	This product line includes the SEL-351R/RS and SEL-651R/-1/-2/A, are mainly used as pole-top distribution recloser controls. These controls are compatible with a wide range of reclosers. You can find the entire list in the relevant instruction manual.	 **Figure 7 SEL-651R-2 Advanced Recloser Control**
SEL-500 series relays	These relays are geared towards utility customers for feeder, transformer, and generator protection. They are an older generation of products and have limited features compared to the other product lines. They can be suitable for applications where a small form factor is required and cost is of concern.	 **Figure 8 SEL-587 Relay**

[a] The SEL-300 and SEL-400 series relays are built on different hardware platforms, which you can consider in primary and backup configurations.

[b] The SEL-700 series relays are not a more advanced version of the SEL-300 and SEL-400 series relays. They represent a different product line designed to serve a different market.

Required Equipment for Interfacing With Relays

To work with SEL relays, you need the following equipment:

- A Microsoft Windows PC with a standard USB (USB-A) port
- An SEL-C662 cable and driver

  To connect to an SEL relay serially, you need an SEL-C662 (USB-to-serial) cable, which you can order at selinc.com/products. Note that most third-party USB-to-serial cables are not compatible with SEL relays.

  The driver for the SEL-C662 cable is automatically installed by Microsoft Windows 10 operating systems and later. If you need to install the driver manually, you can find it on the SEL website by navigating to **Products > All Software** then selecting **Device Drivers and System Software**. Scroll down to SEL USB Driver, find the appropriate version for your computer, and select **DOWNLOAD**.

  Note that some relays have a front-panel USB port that you can use to communicate with the relay. In that case, you would need an SEL-C664 (or equivalent) cable and the USB driver. The process to download the driver for this cable is different from the one mentioned previously. Follow the process outlined in the relay instruction manual to download the driver.

- SEL software

  a. SEL Compass®: SEL Compass is a software program that serves as a hub for many resources available on the SEL website including software products and updates, instruction manuals, application guides, etc. You can download Compass from the SEL website by navigating to **Products > All Software** then selecting **Configuration**. Scroll down to SEL Compass and select **DOWNLOAD**. You need a valid mySEL account in order to use Compass and synchronize the most recent information and software updates.

  Once you have installed SEL Compass, go to **Tools > Options > mySEL Account** as shown in *Figure 9* and enter the username and password that you used to create your mySEL account. Select **OK** and exit the window. If at any point SEL Compass is not working as expected, first verify that the login credentials entered in Compass are correct.

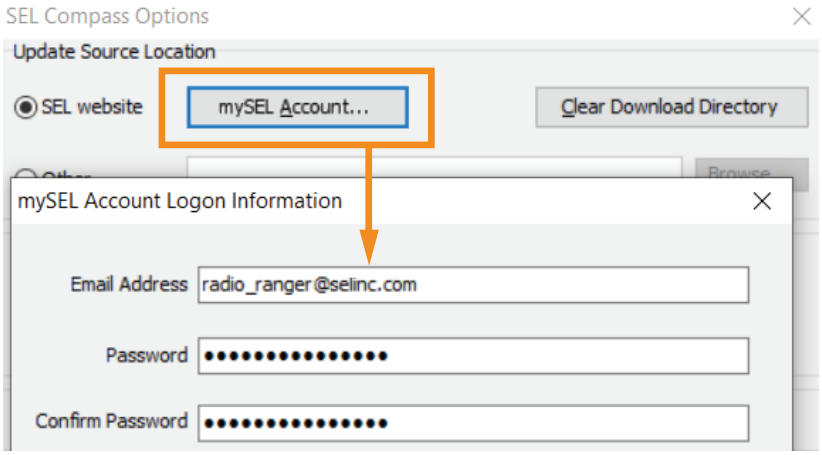


Figure 9 MySEL Account Login Information Verification in SEL Compass

To update software or literature in Compass, select **Check for Updates**, as shown in *Figure 10*. This displays all the drivers and documents that need an update. Right-click within the list and select **Select All**, then select **Apply Selected Changes**.

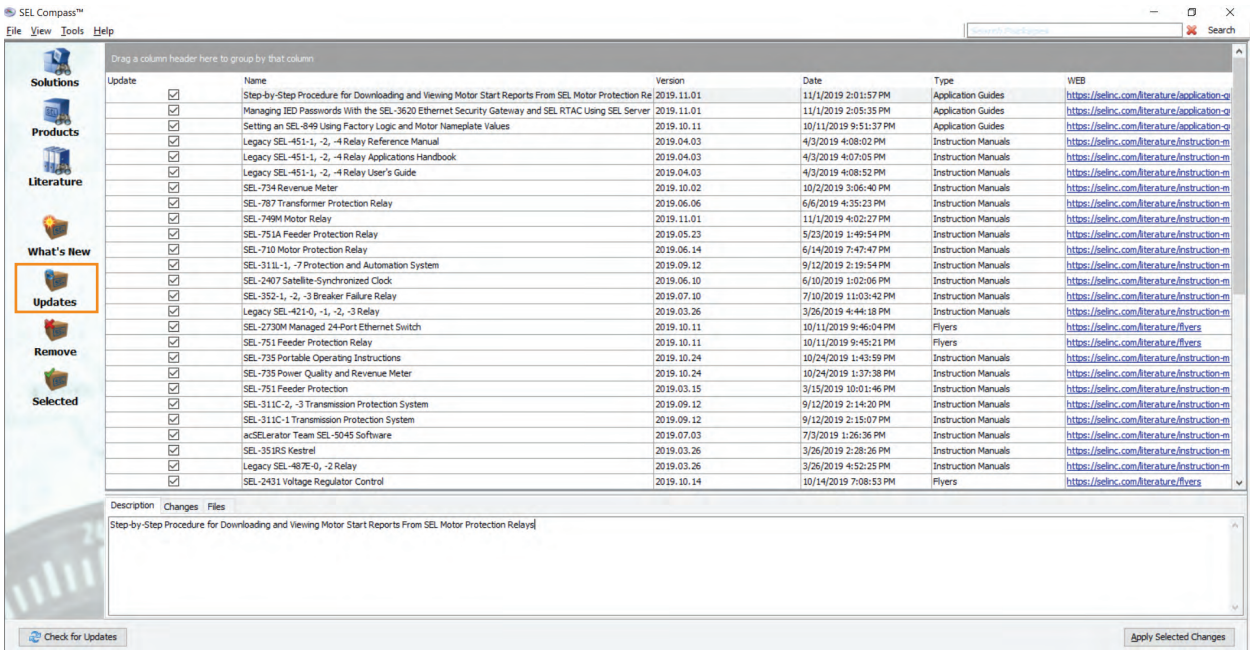


Figure 10 Check for Updates by Using SEL Compass

b. ACSELERATOR QuickSet® SEL-5030 Software: Use QuickSet to communicate with the relay, set the relay, send and read settings from the relay, and download reports from the relay. It is the most important software for working with SEL relays. You can download it either from the SEL website (by navigating to **Products > All Software Downloads**, and selecting **Configuration**; then scrolling down to ACSELERATOR QuickSet SEL-5030 Software and selecting **DOWNLOAD**) or through SEL Compass, and it is free of cost.

To download the software through SEL Compass, open SEL Compass and select **Products**. Under the Products tab, find and select the QuickSet box (which includes AcSELerator QuickSet in the Type column), as shown in *Figure 11*, and select **Apply Selected Changes**. This downloads and installs the software on your PC.

NOTE: You need a valid mySEL account to download any information from the SEL website.

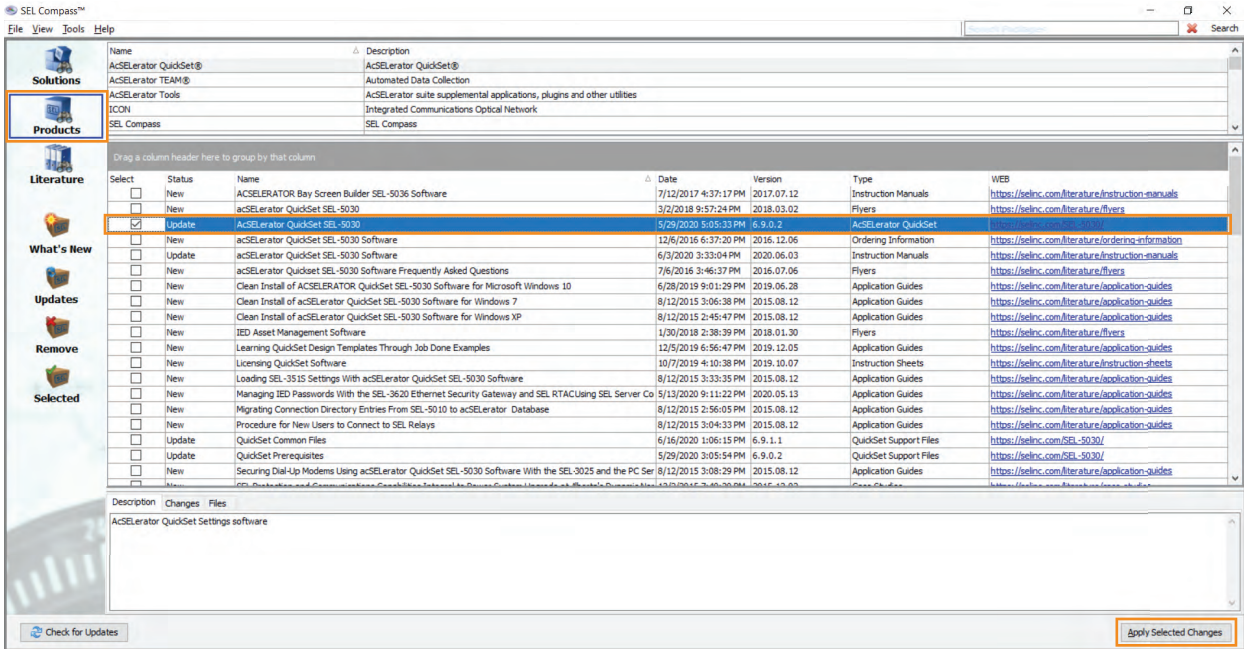


Figure 11 Installation of QuickSet Through SEL Compass

c. SEL-5601-2 SYNCHROWAVE® Event Software: use SYNCHROWAVE Event to view and analyze event reports downloaded from SEL relays. To learn more about this software, refer to *Section 5: Event Reporting* on page 29. You can download SYNCHROWAVE Event from either the SEL website or through SEL Compass.

Access Levels

To help users manage security and access, SEL relays have various access levels. Each access level has its own password and permissions. For better security, SEL strongly recommends that you change the passwords before putting the relay in service. The default passwords are printed in the instruction manuals and are accessible to the public. The four common access levels are as follows:

- Access Level 0: This is the default access level when you connect to the relay with a computer. From here, you can enter Access Level 1 by using the appropriate default password from *Table 3*.
- Access Level 1: This is the default access level when you are physically in front of the relay, accessing information via the front panel. At this access level, you can view metering data and download event reports. You can also view settings, but you cannot change them. From here, you can access Access Level 2 by using the appropriate default password from *Table 3*.
- Access Level 2: This access level grants you all the capabilities of Access Level 1, but you can also modify the relay settings and perform control actions such as pulsing output contacts, clearing or resetting data, etc.
- Access Level C: The calibration level is a restricted access level that you should only use under the direction of SEL.

Table 3 Default Passwords in SEL Relays

Relay	Level 1 Password	Level 2 Password
SEL-501	501	501
SEL-587	587	587
SEL-701	*Device already in Access Level 1	701
All others	OTTER	TAIL

Section 2: Front-Panel Navigation

You can use the front panel of an SEL relay to interface with the relay without a computer. Depending on the relay, this interaction is done using a touchscreen, single-function pushbuttons with an LCD display, or multifunction pushbuttons with an LCD display. Other features of the front panel of SEL relays include operator control pushbuttons, pushbutton LEDs, and target LEDs. Most of the information on the front panel (display screens, operator control pushbuttons, and target LEDs) is customizable.

Navigation Options

Navigating a Relay With a Touchscreen

You can order some relays with a touchscreen display, as shown in *Figure 12*, which provides an intuitive way to interface with the relay.

Use the Home pushbutton to wake up the touchscreen. You can navigate the touchscreen by tapping the folders and applications. Tap a folder to open it, or tap an application to run it. Tap the back arrow in the top left of the screen to go back or press the Home pushbutton to return to the homepage.

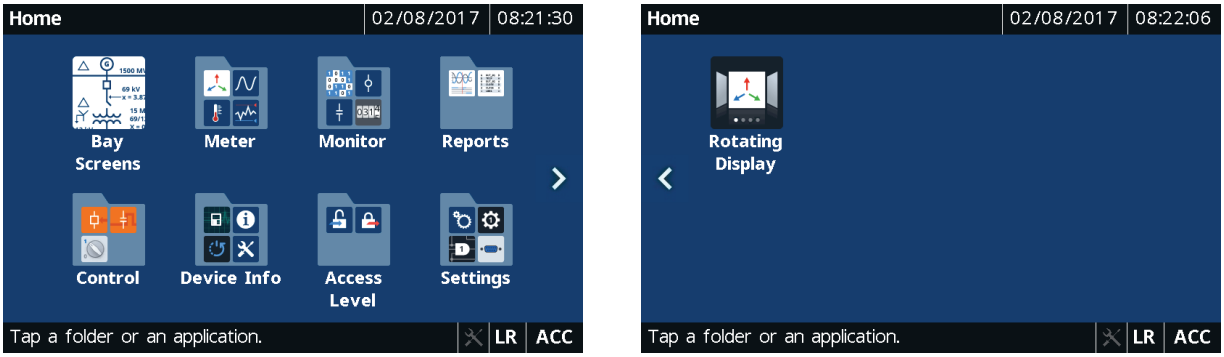


Figure 12 Touchscreen Display in an SEL-700 Series Relay

Navigating a Relay With Single-Function Pushbuttons

The SEL-400 series relays, SEL-651R, and the SEL-700 series relays all have single-function pushbuttons, shown in *Figure 13*. These pushbuttons consist of an up, down, left, and right as well as an escape and an enter button.

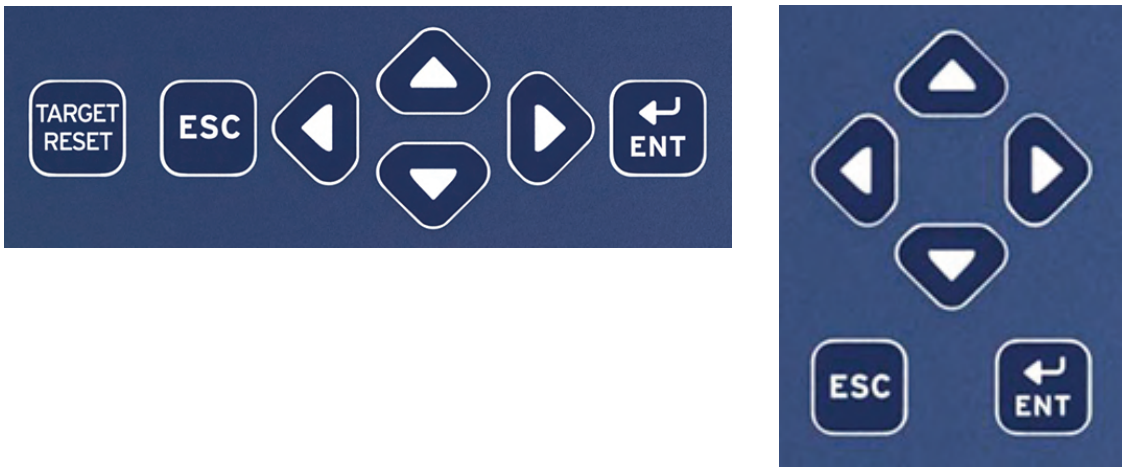


Figure 13 Single-Function Pushbuttons on the SEL-700 Series (Left) and SEL-651R/SEL-400 Series (Right)

In standby mode, the relay cycles through the rotating display. To move through these displays manually, use the arrow buttons and cycle through them.

To access the main menu, press either the enter (**ENT**) or escape (**ESC**) button. To scroll through the menus, use the up and down arrows, and select a menu by using the **ENT** button. Use the arrow buttons to navigate the submenu and press **ENT** to select the feature you would like to access. To exit to the main menu, press the **ESC** button.

Navigating a Relay with Multifunction Pushbuttons

The SEL-300 and SEL-500 series relays have multifunction pushbuttons. These pushbuttons have a primary and secondary function, as shown in *Figure 14*. The primary function is listed above the secondary function.

In standby, the relay cycles through the programmable rotating display. Pressing a pushbutton performs the primary function of the pushbutton (for example, entering the METER menu). Once you press a button, you can use the secondary function (arrow keys) to navigate through the menu, select items, etc. Press the exit pushbutton to return to the rotating displays.

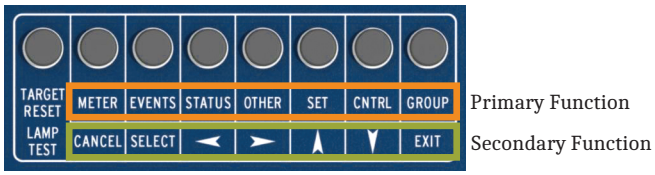


Figure 14 Multifunction Pushbuttons

Menu Options

Every SEL relay has slightly different information available via the front panel, which you can access by using the procedures previously described. The following are some of the most common menu options:

- METER: This contains menu items for viewing different types of metering data (e.g., fundamental current and voltage, peak, demand, light intensity, and so on). This is where you would go if you want to know what currents and voltages the relay is measuring in real time.
- EVENTS: This contains menu items for viewing and deleting event records captured by the relay. This is where you would go to quickly view event information such as fault currents, event type, etc. before downloading the reports from the relay. The information from the EVENTS menu is limited, and you need a computer to download the full event report and analyze the relay operation, as explained in *Section 5: Event Reporting* on page 29.
- SET/SHOW: This contains menu items for viewing or changing relay settings. Relay settings are organized into groups (Global, Group 1, Port, and so on) based on their function. You can use this option to quickly view or change a setting, but you need a computer for substantial settings changes or changes to relay logic. If you try to change a setting from the front panel, you are prompted to enter the Access Level 2 password before you can make a change.
- STATUS: This contains menu items for viewing the FID, serial number, part number, and self-test status of the relay.
- CONTROL: This contains menu items for pulsing output contacts (e.g., OUT301), or opening or closing the circuit breaker. The Access Level 2 password is required to perform such control functions.
- TARGETS: This contains menu items for viewing the binary state of RWBs inside the relay. The status of the RWBs is updated in real time. This can be used to monitor the status of elements during testing.

Target LEDs

SEL relays have target LEDs on the front panel to quickly show the user important information such as whether the relay is enabled or the relay tripped and what type of fault the relay tripped on. *Figure 15* depicts these target LEDs. One of the most vital target LEDs is the **ENABLED** LED (labeled either **EN** or **ENABLED**). This LED is non-programmable and illuminates when the relay is on, is functional, and has no self-test failures. If the **ENABLED** LED is not illuminated, the protection functions of the relay are disabled. You can find the list of self-tests that the relay performs in the instruction manual of the relay. The next most significant LED is the **TRIP** LED. This LED is non-programmable as well and illuminates every time the relay trips. The functions of the remaining LEDs are described in the relay instruction manual and may be programmable. If the relay allows for customization of these LEDs via programming, you can print new labels on an SEL Configurable Label sheet and install them by using the SEL Label Removal Tool, shown in *Figure 16*. You can find the configurable label templates on the SEL website by navigating to **Support > Documentation > View All Documents** and selecting the Configurable Labels check box. By looking at the first set of target LEDs in *Figure 15*, we can tell that the relay is enabled and has tripped on an instantaneous overcurrent element (50 element).

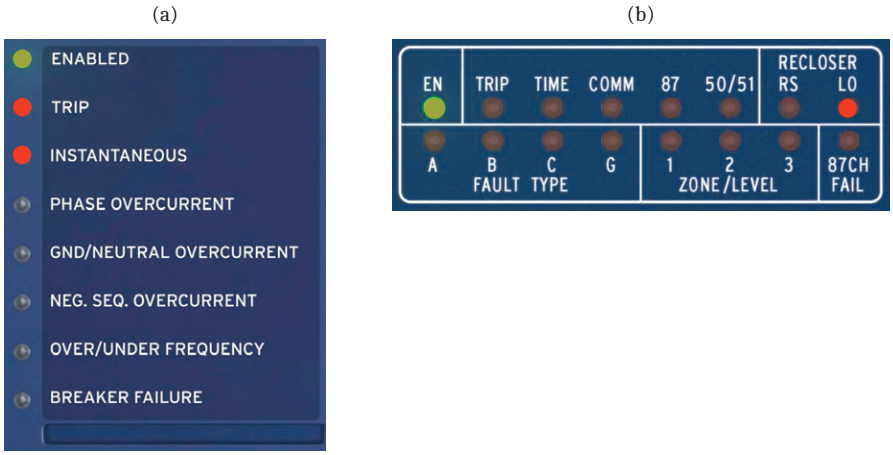


Figure 15 (a) Configurable and (b) Non-Configurable Target LEDs

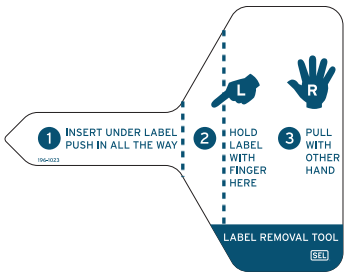


Figure 16 Label Removal Tool

When a trip occurs, the relay latches the trip-involved target LEDs. Pressing the **TARGET RESET** pushbutton resets the latch, and turns off the LEDs if the trip conditions have cleared. The LEDs turn off if the trip conditions have cleared. If the trip conditions remain, the relay re-illuminates the corresponding target LEDs. The **TARGET RESET** pushbutton also removes the message displayed on the LCD if the trip conditions have cleared.

Operator Control Pushbuttons

Many SEL relays come with operator control pushbuttons, as shown in *Figure 17*. These pushbuttons are programmable and can be used in SELOGIC to perform operator controls such as enabling/disabling reclosing or performing a manual trip or close operation. Pressing the pushbutton asserts the RWB associated with that pushbutton, which you can use in custom logic. *Section 4: SELOGIC Control Equations* on page 26 describes how to create custom logic when using SELOGIC control equations. Because the operator control pushbuttons are customizable, you can modify the pushbutton labels by using the SEL Label Removal Tool and SEL Configurable Labels.

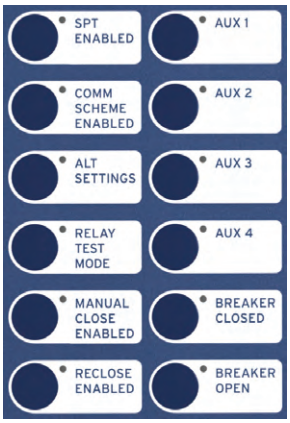


Figure 17 Operator Control Pushbuttons

SECTION 3: ACSELERATOR QUICKSET SEL-5030 SOFTWARE

Connecting to the Relay Via a Serial Connection

To connect to a relay through QuickSet, first plug in the USB end of the SEL-C662 cable to a USB port on your computer and the serial-port end to an open serial port (usually the front port) on the SEL relay. Next, open QuickSet and navigate to **Communications > Parameters**. You then see a screen similar to *Figure 18*.

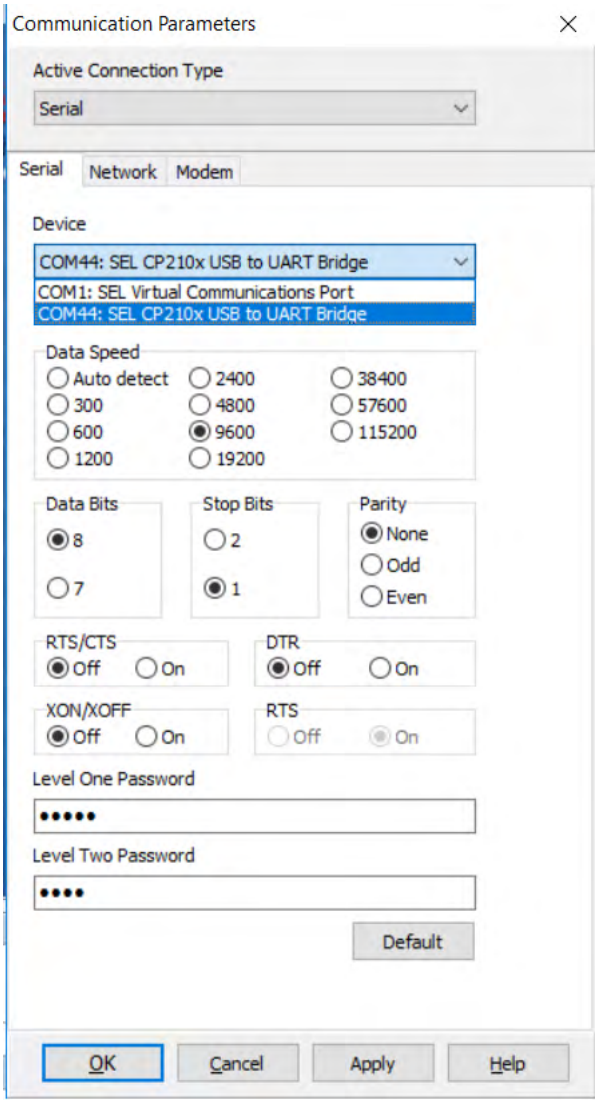


Figure 18 Communications Parameters While Connecting to an SEL Relay

Set the Active Connection Type to **Serial** and the Device Type to **SEL CP210x USB to UART Bridge**. Note that your COM port number may be different from what is shown in *Figure 18*. Select the data speed of the relay serial port. You can find the data speed of the serial port through the front panel by looking under `Port Settings`. Return to the main menu after viewing the port settings to avoid errors while trying to send or change settings in the relay. You can select the Auto Detect option, but it would take longer for the relay to find the correct speed and connect.

Once you are connected to the relay, the message at the bottom left corner of QuickSet changes from **Disconnected** to **Open: Connected**.

NOTE: If you are using the front-panel USB port, set the device type to SEL fast CDC USB Device. If you want to connect to the relay by using an Ethernet network connection, refer to the *ACSELERATOR QuickSet SEL-5030 Software Instruction Manual* for information regarding this type of connection.

Reading Settings From the Relay

Once connected to the relay, you can read the settings from the relay by going to **File > Read**. This reads all the settings from the relay and opens them as a settings file on your computer.

Note that even though you are connected to the relay, any changes made to this settings file are not automatically reflected on the relay. The settings file exists solely as a file on your computer until you send the settings to the relay (see *Sending your Settings File* on page 19 for more information).

Understanding Your Settings File

Settings Editor

The relay settings shown in the settings file are organized by groups in a settings tree, as shown in *Figure 19*. You can expand or contract different areas of the settings tree to view different groups and settings in the relay.

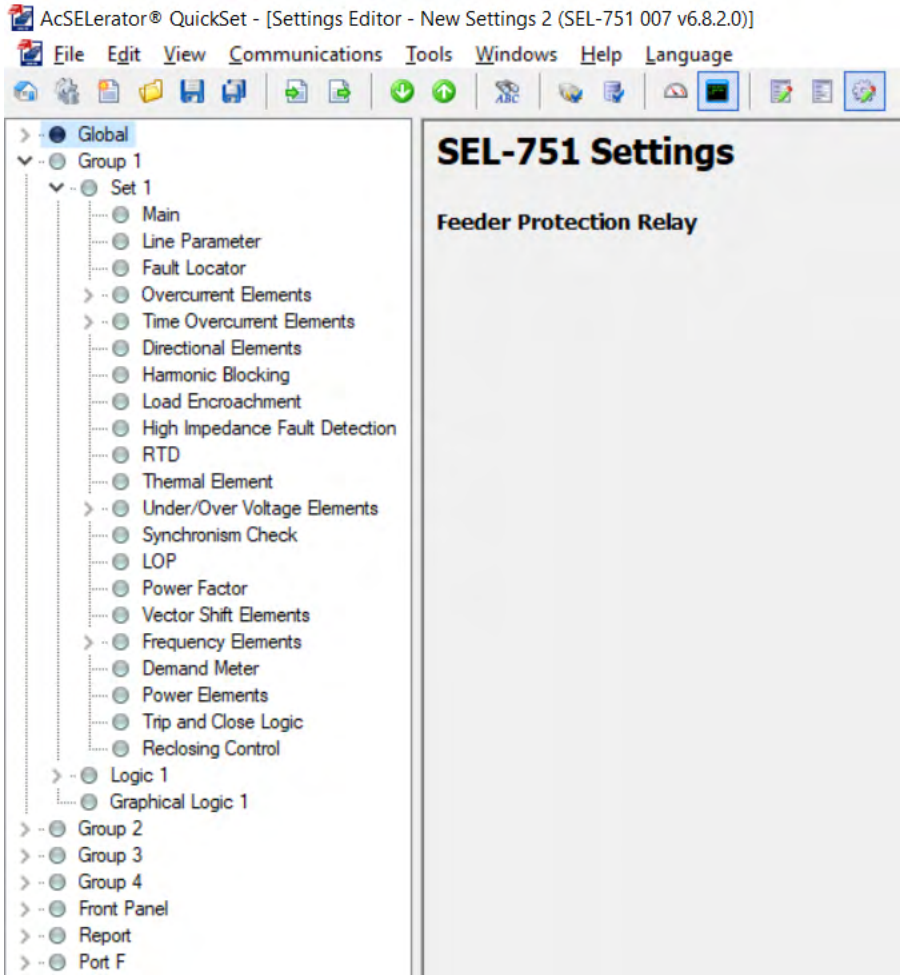


Figure 19 Settings Tree in an SEL-751 Relay

Setting Groups

In *Figure 19*, the relay has multiple groups (four groups in this case). Each group typically contains the protection settings (e.g., pickup settings) and logic settings (e.g., trip logic). The number of available groups varies from relay to relay. All groups have the same settings options, and you can enter different settings values for each group. This is equivalent to having multiple relays in a single box. However, only one group of settings can be active at a given time. You can use logic to switch between groups, but most users only use a single group (Group 1). One example of using an alternate settings group is to have pickup settings that change seasonally.

Global settings are common to all groups and never change, such as system frequency, phase rotation, etc.

Front-panel settings are related to the front panel of the relay. These include display points, target LEDs, operator control LEDs, etc. Note that for relays with a touchscreen display, the touchscreen display settings are not included in this group and fall under a separate group called Touchscreen settings.

Report settings are associated with the different types of reports available in the relay, such as the Sequential Events Recorder (SER) trigger lists (bits that are recorded in the SER), event report length, etc. For more information on the available reports and associated settings, refer to the instruction manual of the relay.

Port settings (such as protocol, data speed, etc.) are associated with the respective port (Port F, Port 1, etc.). Depending on the type of the port, the settings in this group are slightly different.

Search Function

If you do not know the location (group or subgroup) of a certain setting or RWB, you can use the search function (**<Ctrl+F>**) to find it. *Figure 20* shows the search function window. A window at the bottom of the screen displays all the occurrences of the particular search string in the settings file.

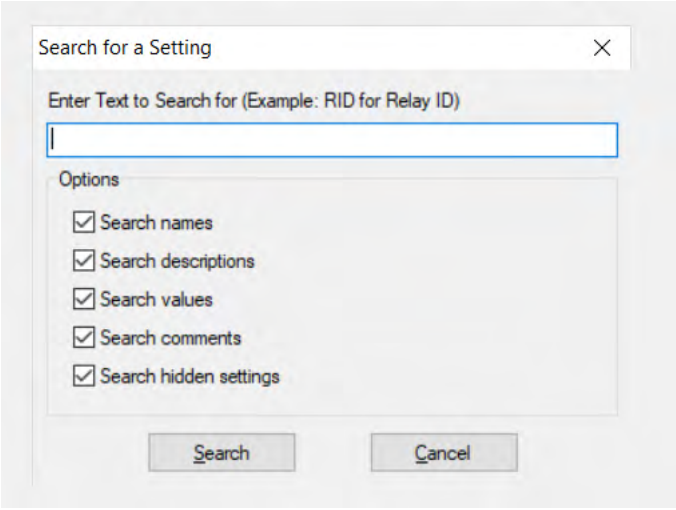


Figure 20 Search Function Window

Saving Your Settings File

Saving your settings file is very similar to saving any file on your computer except that it includes one additional step. Settings files cannot exist on their own and need to be saved inside a database (*.RDB files). Multiple settings files can be stored in a single database. A common example is to have the settings files of all the relays in a substation stored in one database file.

NOTE: To share a settings file via email, etc., you must send the *.RDB file. Keep in mind that it includes all the individual relay settings files. If you do not want to share all the files, copy the settings files that you want to share and create a separate *.RDB file to send instead.

To save a settings file, follow these steps:

- Navigate to **File > Save As**.
- To save settings to an existing *.RDB database, use the **…** button to navigate to the existing database. To create a new settings database, select **New** and create a database file in the location of your choice.
- Enter a name for the settings file under Settings Name and then select **OK**. In *Figure 21*, the settings file named Example Settings is being saved in the database titled SEL RELAY DATABASE.

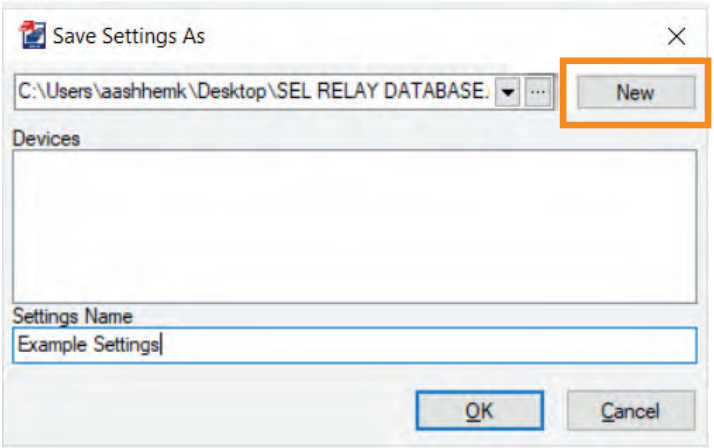


Figure 21 Saving a Settings File in a Database

Sending your Settings File

To send settings to the connected relay, navigate to **File > Send**. A screen similar to *Figure 22* appears. This screen allows you to select the groups that you want to send to the relay. SEL recommends that you always select all the groups and send them to the relay to make sure that all changes made in QuickSet are reflected in the relay.

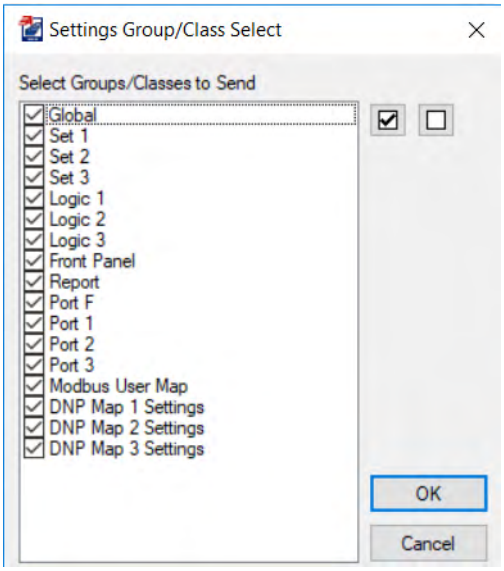


Figure 22 Select Groups/Classes to Send

HMI

In addition to using the front panel of the relay for metering and control purposes, users with a PC can use the HMI tool option in QuickSet. Navigate to **Tools > HMI > HMI** to display a screen similar to the one shown in *Figure 23*. The HMI tree view shows all the functions available in the HMI.

NOTE: Some older SEL relays may not include the HMI tool option in QuickSet.

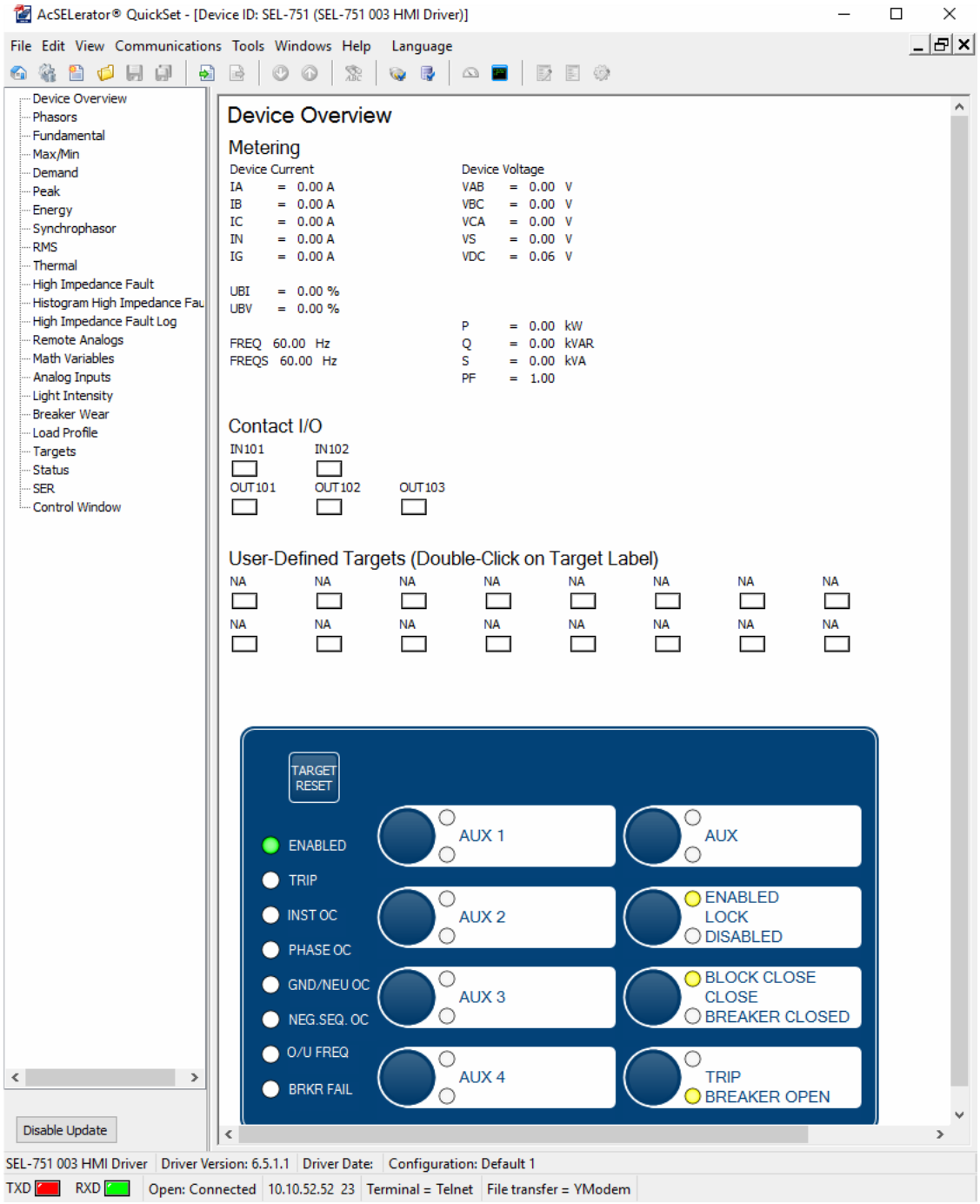


Figure 23 HMI Default View for an SEL-751 Relay

Some commonly used functions include:

- The Device Overview tab provides an overview of the device. It shows the instantaneous metering values, I/O status, and a list of user-defined targets. You can use user-defined targets during testing to monitor the status of selected RWBs. Double-click the target name (NA when you first open the HMI window) to select the RWB that you want to monitor from a drop-down list.
- The Phasors tab displays the instantaneous current and voltage phasors along with their values. This is useful during commissioning to ensure proper wiring, phase rotation, etc.

- The Targets tab displays the status of RWBs present in the relay. When an RWB has a value of 1 (or has a yellow background), it is asserted, and when the RWB has a value of 0 (or has a white background), it is deasserted.
- The SER tab displays the SER data. This window is blank by default and gets populated with the SER data once you select **Update SER** at the bottom of the screen. You can choose to filter the information displayed by entering the dates or row numbers. See *Section 6: Testing a Relay Element* on page 34 for more information on SER data.
- The Status tab displays the relay self-test status. You can also view the FID and part number from this window. If the relay failed any self-test or there is a warning condition, you can see that in this window.
- The Control tab allows you to reset metering data, clear event history, clear the SER, or trigger events. You can also use it to reset targets or set the time and date. You can pulse output contacts from this tab as well.

Terminal Window

The terminal window allows you to issue commands to retrieve the same type of information that you could get by using the HMI tool in QuickSet or the front panel of the relay. You can find the entire list of commands available in the relay under the Command Summary section of the instruction manual.

Common commands from Access Level 1:

STA: displays the serial number, part number, FID, and relay self-test status.

SHO: displays the relay settings.

MET: displays the relay metering data.

HIS: shows a summary of all the event reports present in the relay at the time.

SER: displays the date and time stamp of assertion and deassertion of RWBs programmed in the SER list. For more information on SER data, refer to *Section 6: Testing a Relay Element* on page 34.

TAR *n*: displays the current state (0 or 1) of the RWB *n*.

DAT: display or change the date.

TIM: display or change the time.

Common commands from Access Level 2:

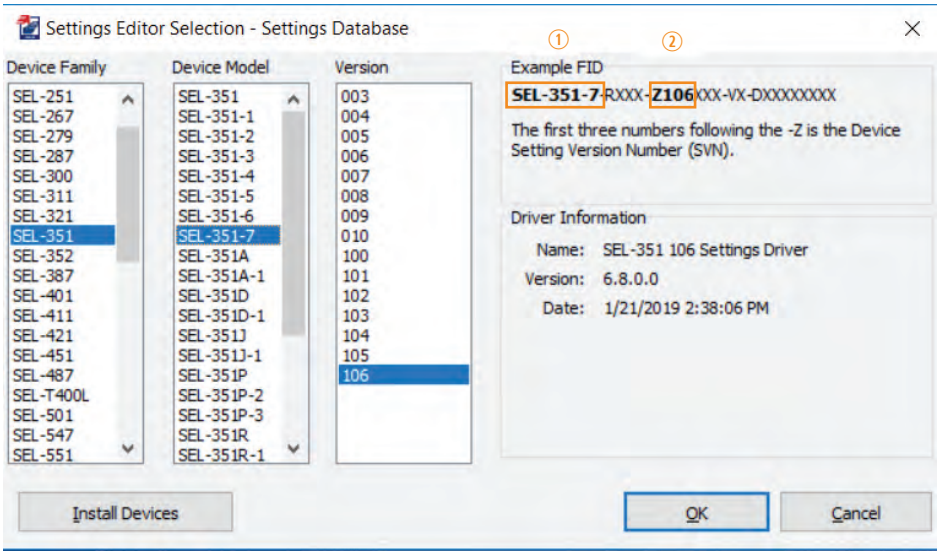
SET: sets the relay or changes settings in a relay.

PAS *n*: changes the password of Access Level 1 (PAS 1) or Access Level 2 (PAS 2).

Note that only the HMI window or the terminal window can be used at a given time. Using the HMI takes over the terminal window and does not allow you to type commands. To switch to the terminal window, select the Disable Update icon in the HMI window.

Creating a New Settings File

One way to create a settings file for a given relay is to read the default settings from the relay and enter your settings in that file; however, if you do not have access to the relay when you need to create the settings, you must create a new settings file from scratch. To do that, navigate to **File > New** and select the appropriate Device Family, Device Model, and Version of your relay, as shown in *Figure 24*.



The device model (①) and settings version number (②) (SVN) of the relay are part of the FID and can be found as described in *Important Relay Identifiers* on page 4.

Figure 24 Selecting the Relay Type for a New Settings File

Next, enter the correct part number of the relay, as shown in *Figure 25*. Refer to *Section 1: Basics of an SEL Relay* on page 2 for details on finding the part number. Select **Edit** to type the full part number of the relay, or use the drop-down menus to select each required digit. Once the part number is entered, select **OK,** and a settings file with the default settings generates.

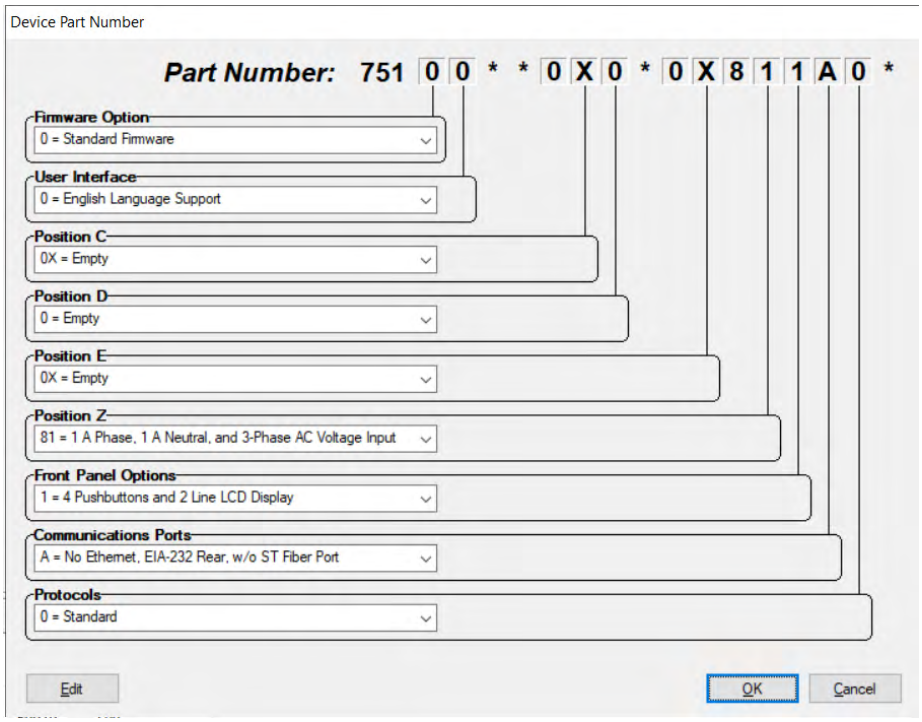


Figure 25 Part Number Selection

Settings Conversion

If the settings version number (SVN) was incorrectly selected at the time the settings file was created or the SVN changed because of a firmware upgrade, you must convert the file before you can send it to the relay. To do a settings conversion, navigate to **Tools > Settings > Convert**, pick the settings file that you want to convert, select the new device type that you want to convert to, and select **Convert**, as shown in *Figure 26*. The software generates a report with settings that have been added, removed, or changed between settings versions and need to be addressed. Review the information in the report and accept or address the changes.

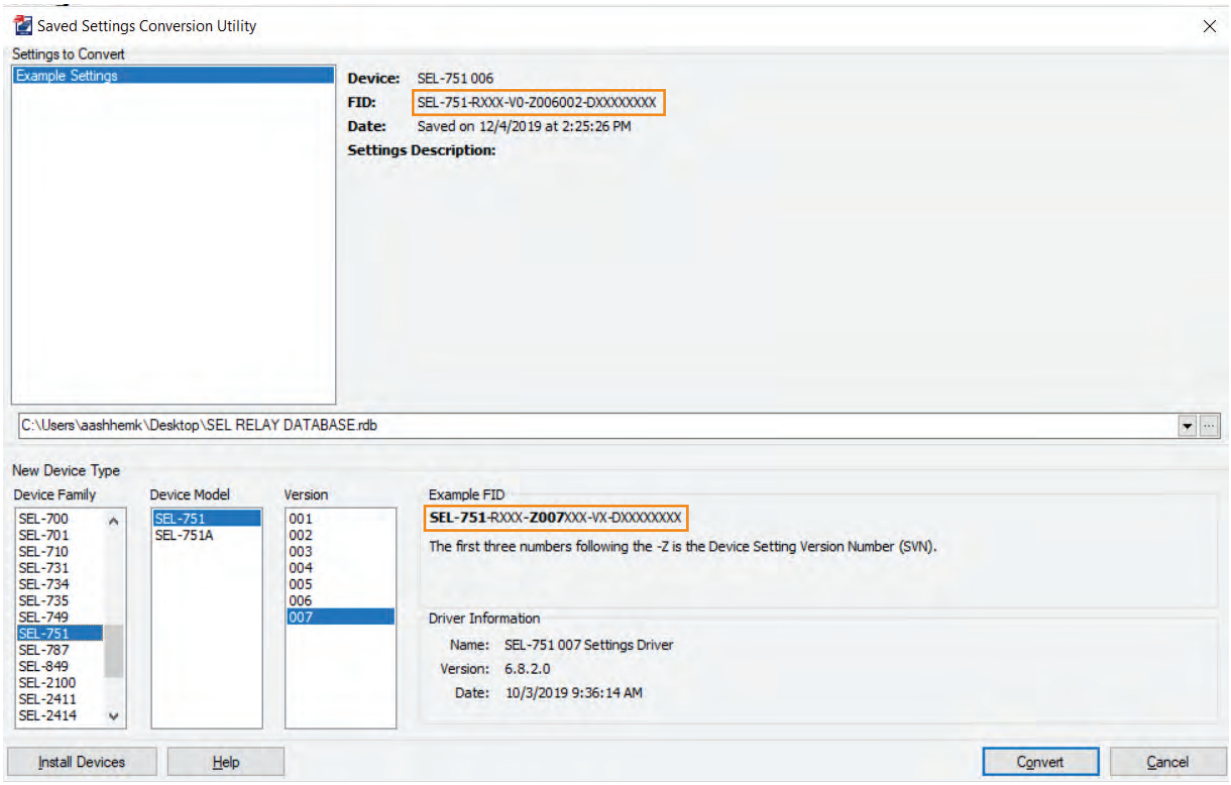


Figure 26 Settings Conversion From One Version to Another

QuickSet Help

If you are new to QuickSet and need help navigating through the software, navigate to **Help > Contents** or press **<F1>** on your keyboard. This directs you to the QuickSet instruction manual.

If you need information regarding the settings you need to enter, navigate to **Help > Settings Help**. This directs you to the instruction manual of the relay for which you have the Settings Editor open.

Note that the manuals must be installed on your PC through SEL Compass for you to access them with the HELP function. You may also download the manuals from the website and refer to them independently of the HELP function.

SECTION 4: SELOGIC CONTROL EQUATIONS

SELOGIC control equations allow you to combine elements and build entire control schemes inside the relay. The most important SELOGIC control equation in the relay is the TRIP equation.

SELOGIC Control Equation Operators

Table 4 outlines the Boolean operators available in the different generations of SEL relays. The function of each operator is explained within *Table 4*.

Table 4 SELOGIC Operators in Decreasing Order of Precedence

Boolean Operators in SEL-400, SEL-600 and SEL-700 Series Relays	Boolean Operators in SEL-300 and SEL-500 Series Relays	Description
()	()	Parenthesis—Used for grouping elements and controlling the execution order of operations in a SELOGIC control equation.
NOT	!	Boolean complement—Used to invert a Boolean value (change a 0 to a 1, or a 1 to a 0).
R_TRIG	/	Rising-edge detector—Used to detect when a value changes its state from 0 to 1.
F_TRIG	\	Falling-edge detector—Used to detect when a value changes its state from 1 to 0.
<, >, <=, >=		Comparison—Used to compare the logical value of Boolean variables or analog value of math variables.
=, <>		Equality, Inequality—Used to compare numerical or Boolean values with the result of a logical 0 (if the comparison is not true) or logical 1 (if the comparison is true).
AND	*	AND operator—Used to perform a logical AND operation where the output is true if all the inputs are true. This is equivalent to putting the input elements in series.
OR	+	OR operator—Used to perform a logical OR operation where the output is true if any one of the inputs are true. This is equivalent to putting the input elements in parallel.

Additional SELOGIC Control Elements

Latch Bits

Latch bits provide a way to seal in a relay element operation. When a latch is set, the output of the latch is asserted and stays asserted until the latch is reset. In *Figure 27*, LT01 asserts when SET01 asserts and stays asserted until RST01 asserts.

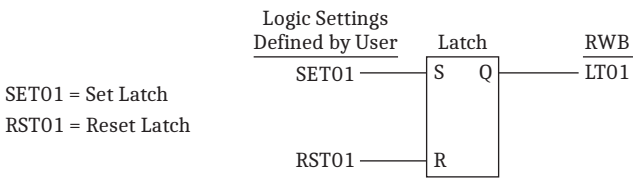


Figure 27 Example of a Latch Bit in an SEL-700 Series Relay

Note that the logic settings and RWBs may have different names in the different product lines. *Table 5* outlines the variable names in the SEL-300, SEL-400, SEL-600, and SEL-700 series relays.

Table 5 Latch Bit Variables

Item	SEL-300	SEL-400	SEL-500	SEL-600, SEL-700
Set equation	SET1–SET16	PLT01S–PLT32S	SET1–SET8	SET01–SET32
Reset equation	RST1–RST16	PLT01S–PLT32R	RST1–RST8	RST01–RST32
Output (RWB)	LT1–LT16	PLT01–PLT32	LT1–LT8	LT01–LT32

SELOGIC Variable/Timer Control Logic

SELOGIC variables and timers are used in place of auxiliary timers. You can use them to delay the operation of an element or function. Timers have a pickup time (PU) and a dropout time (DO) available to achieve this. You can use the SELOGIC variables without the timer to perform intermediary logic functions. In the SEL-400 series relays, these timers are called conditioning timers. In *Figure 28* and *Figure 29*, SV05T asserts after SV05 stays asserted for SV05PU time. Then, SV05T stays asserted for SV05DO time after SV05 drops out.

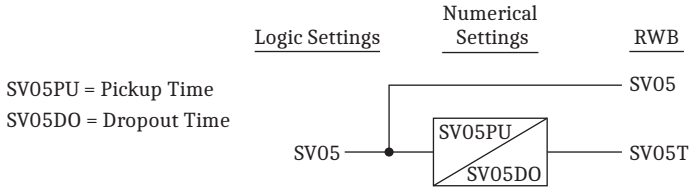


Figure 28 Example of an SV Timer in an SEL-700 Series Relay

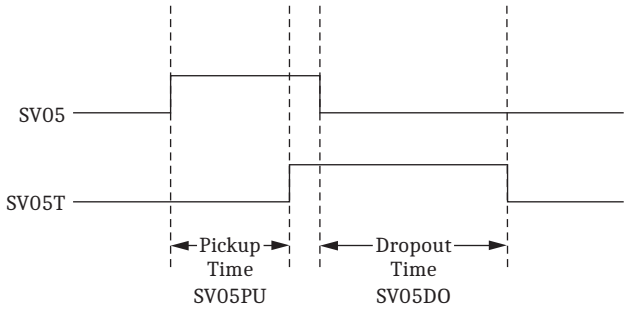


Figure 29 Timing Diagram of SV Timers

Note that the logic settings and RWBs can be named differently in the different product lines. *Table 6* outlines the variable names in the SEL-300, SEL-400, SEL-600, and SEL-700 series relays.

Table 6 SELOGIC Control Variables/Timers (Sheet 1 of 2)

Item	SEL-300	SEL-400	SEL-500	SEL-600	SEL-700
Input	SV1–SV16	PCT01IN–PCT32IN	SV1–SV14	SV01–SV64	SV01–SV32
Pickup time	SV1PU–SV16PU	PCT01PU–PCT32PU	SV1PU–SV14PU	SV01PU–SV64PU	SV01PU–SV32PU

Table 6 SELOGIC Control Variables/Timers (Sheet 2 of 2)

Item	SEL-300	SEL-400	SEL-500	SEL-600	SEL-700
Dropout time	SV1DO–SV16DO	PCT01DO–PCT32DO	SV1DO–SV14DO	SV01DO–SV64DO	SV01DO–SV32DO
Output	SV1T–SV16T	PCT01Q–PCT32Q	SV1T–SV14T	SV01T–SV64T	SV01T–SV32T

TRIP Logic

Figure 30 shows the logic diagram of the built-in TRIP logic in an SEL-751. The relay logic allows you to define the conditions that cause a trip and the conditions that unlatch the trip. Note that the TRIP logic slightly varies from relay to relay; however, the features outlined here are common to all relays.

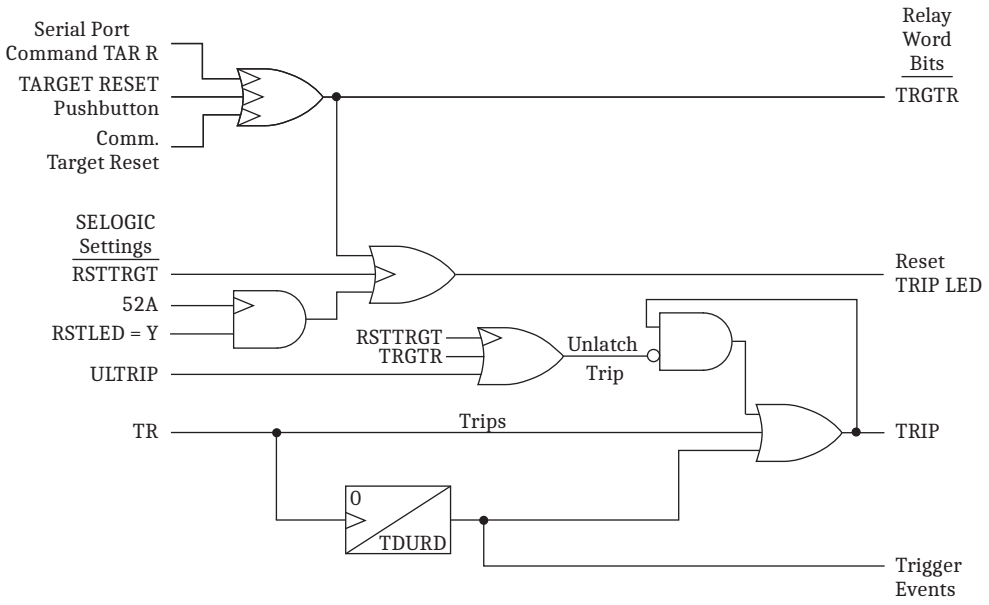


Figure 30 TRIP Logic in the SEL-751

The TR SELOGIC control equation provides the conditions to trip the breaker. It can include multiple protective RWBs, the front-panel or serial-port initiated **OPEN** command, or remote trips. All of these RWBs are combined with SELOGIC operators. The RWB TRIP is the output of the trip logic. Once the TR equation becomes true, the TRIP RWB asserts and latches itself in.

The TRIP RWB stays asserted until one of the unlatch trip conditions becomes true.

The output of this relay logic, the TRIP RWB, is usually assigned to an output contact, e.g., OUT101, OUT102, etc. The output contact is wired to the trip coil of the circuit breaker. When the TRIP RWB asserts, it closes the output contact, thereby completing the circuit and energizing the trip coil. The breaker then opens and interrupts the fault current.

SECTION 5: EVENT REPORTING

Event reports provide a short (typically 15 to 180 cycles) capture of the power system (as an oscillographic representation) and protective relay elements when an event is triggered. It includes the primary value of currents, voltages, and other analog quantities; an event summary, the states of protection elements, digital inputs, and digital outputs; and the settings in service at the time of the event trigger.

NOTE: In some relays, the settings in the event report might be the settings at the time of the download, and, in that case, the report displays a message to convey that the relay settings have been changed.

Generated event reports are stored in the nonvolatile memory of the relay. This means that the data are saved and protected even if power is lost to the relay. However, the relay can store only a finite number of event reports in its nonvolatile memory, and old event reports get overwritten by new event reports. The number of event reports that can be stored in the nonvolatile memory depends on the length of the event report and sample rate, and you can find that number in the applicable relay instruction manual.

Event reports are usually available in a CEV (compressed event) file format. This format is SEL-specific, and you can view the files through SYNCHROWAVE Event software. You can also export them as COMTRADE files by using the software. In some relays, raw event reports (explained in *Types of Event Reports* on page 29) are directly available in COMTRADE format.

Types of Event Reports

All SEL relays store at least two types of event reports: raw (unfiltered) and filtered. Some relays store a third type of report, known as the differential report. All these event report types are important and have different purposes.

As illustrated in *Figure 31*, current measured by a CT is brought to the relay inputs and stepped down by an internal transformer to a milliampere-level signal. This signal is then converted into a millivolt-level signal that the relay circuit boards can handle. Next, the voltage is read by an analog-to-digital converter that converts the analog signal to digital samples. These samples are then passed through a digital cosine filter that calculates an equivalent 60 Hz phasor. The process is similar for voltages. Most relay algorithms use these phasors to perform their protection functions.

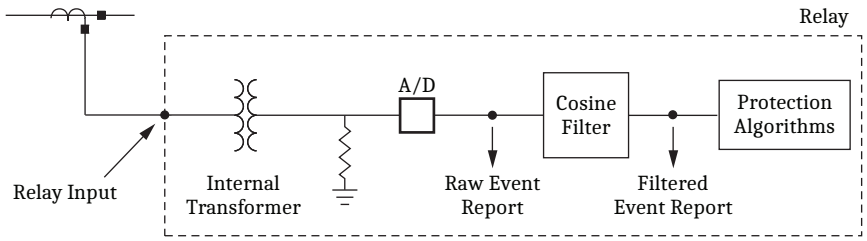


Figure 31 Simplified Signal Processing in an SEL Relay

- Filtered event reports: Filtered event reports are captured after the cosine filter in *Figure 31*. The filtered data contains only the fundamental (60 Hz) quantities and is clean of any harmonics or DC offset. The filtered event data suffices for most event reporting needs because these are the signals that most relay protection algorithms use.

- Raw event reports: Raw event reports are captured before the cosine filter in *Figure 31* and contain data that closely match the actual signals that occur on the power system. The waveforms contain some higher harmonics and DC offset. Raw event reports show conditions such as CT saturation, inrush, decaying DC offset, power system harmonics, and input contact bounce.
- Differential event reports: Differential event reports (present in some differential relays) contain information necessary for analyzing differential relay operations such as operate, restraint, and harmonic currents.

Triggering an Event Report

Event reports are generated in the relay when one of the following occurs:

- The TRIP RWB asserts.
- SELOGIC control equation ER (event report trigger equation) asserts—You can program it to any condition for which you would like to trigger an event but not trip the relay. One example is to include the pickup of a 51 element in the ER equation. You might not want to trip when the 51 element first picks up, but generating an event report for when it does can provide useful information.
- Serial-port command **TRIGGER** (or TRI) is executed from the HMI or the terminal window.

Downloading an Event Report

To download an event report, open QuickSet and select **Tools > Events > Get Event Files**. All the event reports currently stored in the relay display on the screen along with their date and time stamps, as shown in *Figure 32*. Select the boxes of all event reports that you want to download (①) and select the appropriate event type (raw/comtrade, filtered, or differential) and sampling rate (②). Then choose the event length (③), if required, select **Get Selected Events** (④), and enter the name and location where you want to save the report(s).

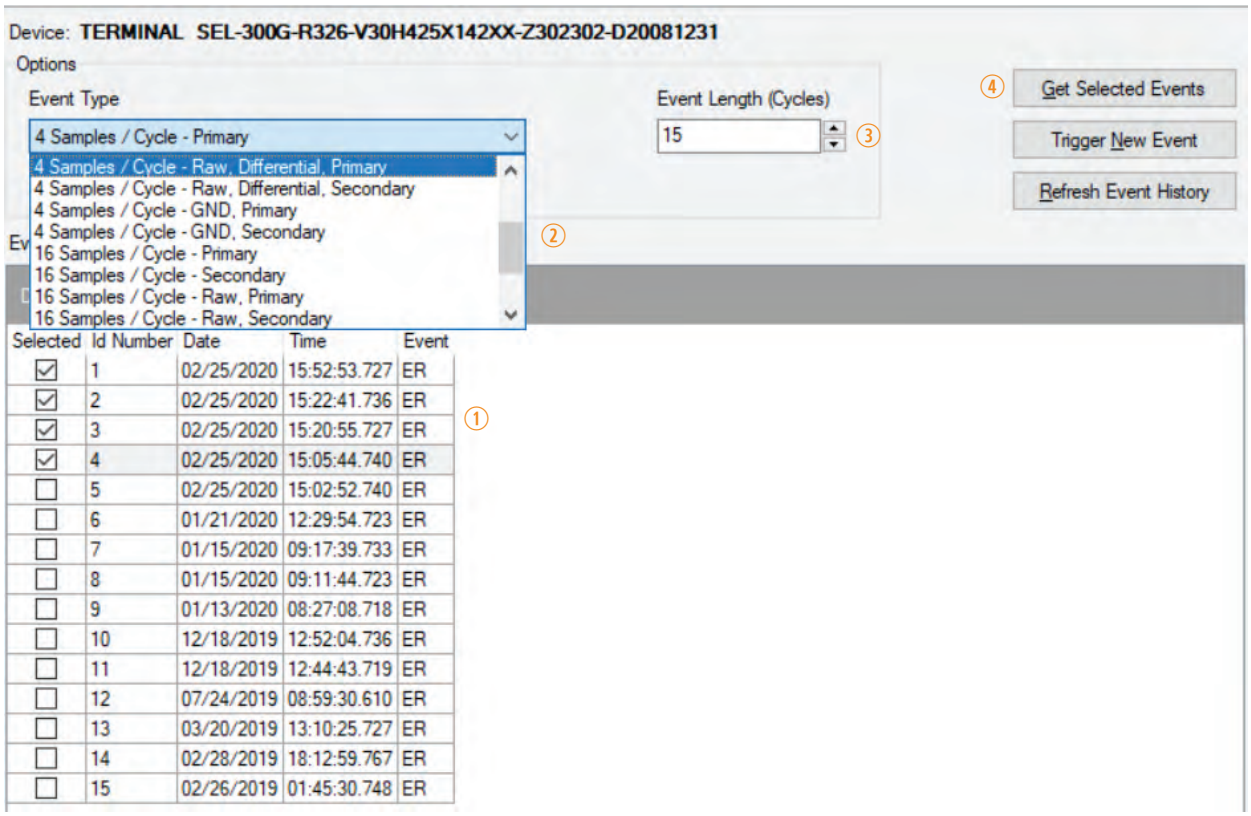


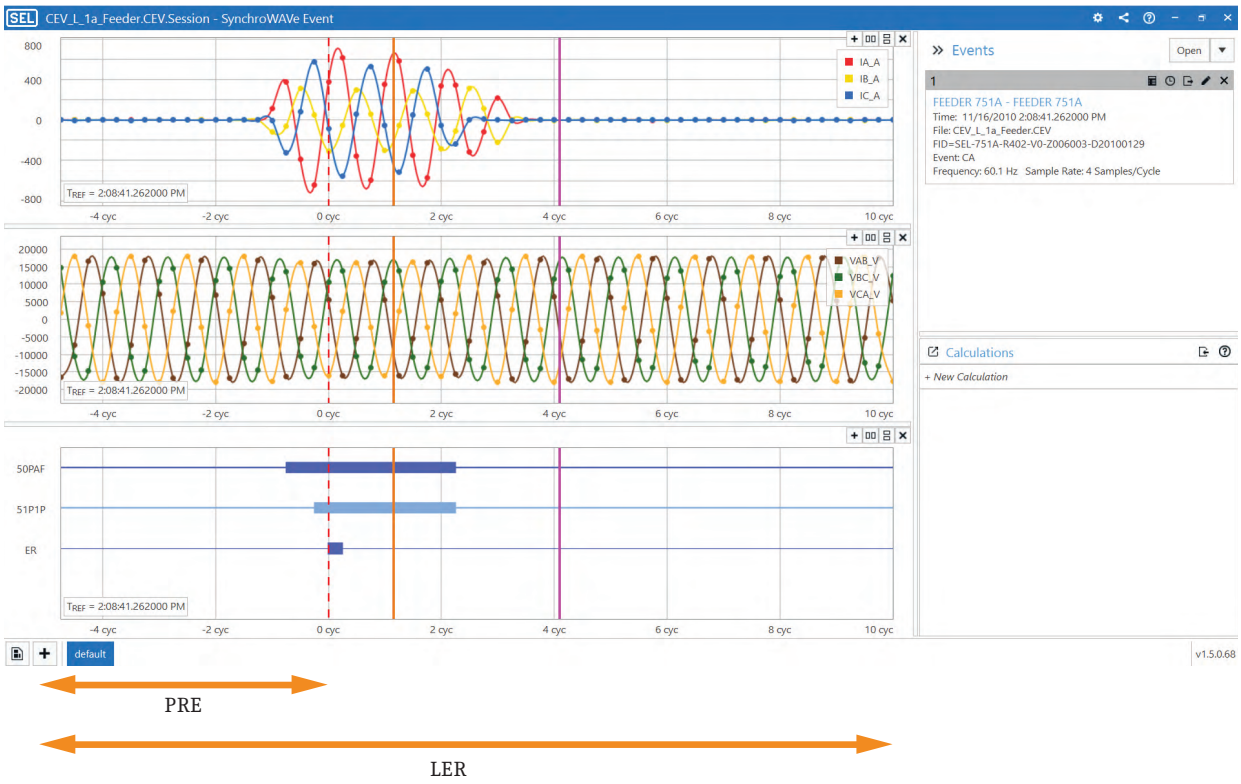
Figure 32 Event Report Download Screen

Keep in mind the following points when downloading the reports:

- SEL recommends always downloading the report with the highest sampling rate. This takes more time to download but gives you the most information possible.
- Some relays require you to specify the event length while downloading the event reports. In such cases, ensure that the event length matches the LER setting in your relay settings so that the entire event report is downloaded without any missing data.
- SEL recommends always downloading both filtered and raw event reports (and differential, if available). Both filtered and raw event reports provide useful information. For example, raw events help in analyzing CT saturation or CVT transients, and filtered event reports show the quantities based on which relay made a protection decision.
- SEL recommends downloading the event reports as soon as possible because they might get overwritten by newer events. The relay can store a finite number of event reports in its nonvolatile memory. When all the space is used, the relay overwrites the oldest event reports.

Viewing an Event Report

Figure 33 shows the default view when you open an event report by using SYNCHROWAVE Event. The top right corner has a basic summary of the event report and includes the date, time, FID, event type, and sampling rate. Below that is a space to perform custom calculations.



Note: The LER setting determines the length of the event report, and the PRE setting determines how much of that total event length will be pre-fault data (data before the event trigger point).

Figure 33 Sample Event Report Viewed With SYNCHROWAVE Event

The main three default charts consist of two analog charts (showing current and voltage) and one digital chart (showing the status of the RWBs). Press **+** on a chart to add or remove signals from the chart. You can move the dividers between charts to expand/contract each chart. To learn more about navigating through SYNCHROWAVE Event, visit selinc.com/products/5601-2/?vidId=122926.

The digital chart showing RWB status is incredibly useful when analyzing relay performance after a fault. When the event report generates because of a trip, the TRIP RWB appears in the default view along with the RWB that caused the trip equation to assert. This allows you to identify what element caused the trip just by looking at the default view. Similarly, if the event report generated because of the assertion of the ER equation, the ER RWB and the RWB that caused the ER equation to assert appear in the default view. Observing and identifying the RWB that caused the event report to generate is the key to event analysis.

To learn more about event analysis and the procedures for analyzing event reports, refer to the following white papers on the SEL website at Support > Documentation > White Papers:

- "Event Analysis Tutorial Part 1: Problem Statements" [2]
- "Event Analysis Tutorial Part 2: Answer Key" [3]
- "Advanced Event Analysis Tutorial Part 1: Questions" [4]
- "Advanced Event Analysis Tutorial Part 2: Answer Key" [5]

SYNCHROWAVE Event Product Comparison (Licensed vs Unlicensed)

You can download SYNCHROWAVE Event from the SEL website or through SEL Compass, as outlined in *Section 1: Basics of an SEL Relay* on page 2. There is a free and a licensed version available. To purchase the license, contact your local sales representative or customer service representative (CSR) (see *Customer Service Representative (CSR)* and *Sales Representative* on page 44 for information on contacting your CSR or sales representative, respectively). *Table 7* highlights the differences between the free and licensed versions of the software. When you download the free version for the first time, you are able to use all of the features available in the licensed version for a 60-day trial period, after which you are limited to the features available in the free version.

Table 7 Free vs Licensed Versions of SYNCHROWAVE Event

Feature	Full License	Free Version
Enhanced GUI	•	•
Analog Oscillography	•	•
Digital Display	•	•
Phasor Diagram	•	•
Harmonic Analysis	•	•
Spectral Analysis	•	•
Custom Calculation Engine	•	
Multiple Event Report Analysis	•	
Traveling-Wave Lattice Diagram	•	
Mho Circle Diagram (Specific Relays)	•	
Saved Configurations	•	
Alpha Plane Analysis (Specific Relays)	•	

SECTION 6: TESTING A RELAY ELEMENT

Testing is an important part of the commissioning process and helps identify any errors in the scheme or settings before the relay is put into service. Relay testing is typically divided into two parts:

- Tests performed at the time the relay is installed or commissioned. A good example would be testing different protection functions to understand whether they are operating as intended.
- Tests performed periodically once the relay is in service. SEL relays are equipped with extensive self-tests, so traditional periodic test procedures can be eliminated or greatly reduced.

NOTE: You can find application guides that give detailed instructions on testing certain elements on the SEL website under **Support > Documentation > Application Guides**.

Testing Tools

You can use the following monitoring and reporting tools during relay testing:

- Metering: You can view metering information such as the fundamental voltages and currents, frequency, etc., either from the front panel, terminal window (**MET** command), or the QuickSet HMI window. This helps you confirm that the relay is measuring the correct voltages and currents from the power system.
- Event Report: The relay records a 15-, 64-, or 180-cycle event report (depending on the relay) in response to faults or disturbances. Each report contains the current and voltage information, relay element states, and input/output contact information. If you question the relay response to a certain event, look at the event report. To know more about event reporting and how to download event files, refer to *Section 5: Event Reporting* on page 29.
- Sequential Event Recorder (SER): The SER records the date and time stamp when an RWB asserts or deasserts. You must assign the RWBs that you want to monitor through the SER to the SER variables in the relay settings file. The SER report is different from a normal event report in that it is only a log of RWB assertions and deassertions and contains no analog values. It provides a convenient means to verify the sequence of operations (e.g., reclosing operation) and timing tests. You can view SER data either by using the SER tab in QuickSet HMI or by using the **SER** command in the terminal window.
- Targets: You can use targets to view the state of relay elements, inputs, or outputs individually during a test. It shows the status of the RWB in real time. It is helpful during pickup tests because you can see the status of the RWB change as you go above or below the pickup value. You can view the targets either through the front panel, terminal window in QuickSet, or the HMI window in QuickSet.

Example A: Testing an Instantaneous Overcurrent Element

In this section, we use the testing tools available to us to test an instantaneous overcurrent element. Note that this section is not intended to serve as a testing document that can be used while testing a specific relay element. Refer to the relay instruction manual or follow your company's testing guidelines and procedures. The purpose of this section is only to provide an example of how to identify and use the testing tools available in SEL relays.

Figure 34 illustrates the logic diagram for a typical instantaneous overcurrent protection element in an SEL relay.

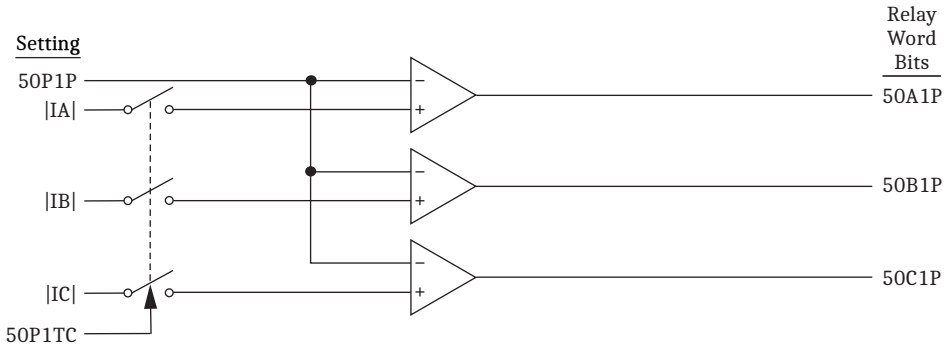


Figure 34 Instantaneous Overcurrent Element Logic in an SEL-751

In *Figure 34*, if the magnitude of the A-phase current (|IA|) becomes higher than the pickup setting (50P1P), the RWB 50A1P asserts (becomes a logical 1). Similarly, if the magnitude of the B-phase (|IB|) or C-phase (|IC|) currents become higher than the pickup setting, the corresponding RWB asserts.

The goal is to observe the magnitude of current at which the RWB asserts and verify that this value is very close to the pickup setting. By reviewing the various testing tools introduced in *Testing Tools* on page 34, we can determine that using targets is the best tool in this case to monitor the RWBs in real time.

Example Test Procedure

Step 1. Note the pickup setting (50P1P) from the settings file or the **SHO** command on the terminal window.

Step 2. Using a test set, inject current to the current inputs at the back of the relay. Start by injecting a quantity less than the pickup and increase the value of the injected quantity in steps, until the corresponding RWB asserts. For example, if 50P1P = 5 A secondary, start from 4.5 A secondary and increase in steps of 0.1 A.

Step 3. Monitor the RWBs through the TARGETS menu.

Using the Front Panel

Touchscreen Relay: From the front panel, navigate to **Monitor > Relay Word bits**, and navigate to the RWB that you would like to monitor.

Two-line LCD Display: Navigate to **Menu > Targets** and then to the appropriate row number to get the status of the RWB. To know the RWBs present in a certain row, refer to the Relay Word Bits section in the appropriate instruction manual.

Using the HMI Window in QuickSet

Go to **Tools > HMI > HMI** and select the **Targets** tab to view the RWBs.

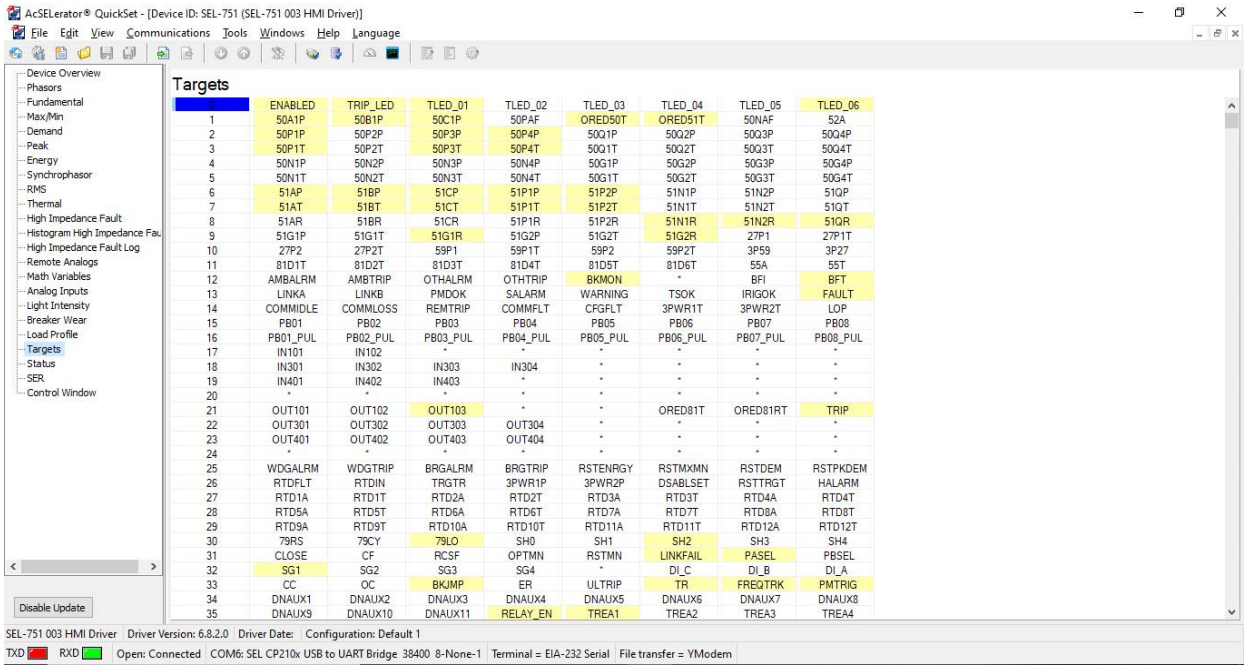
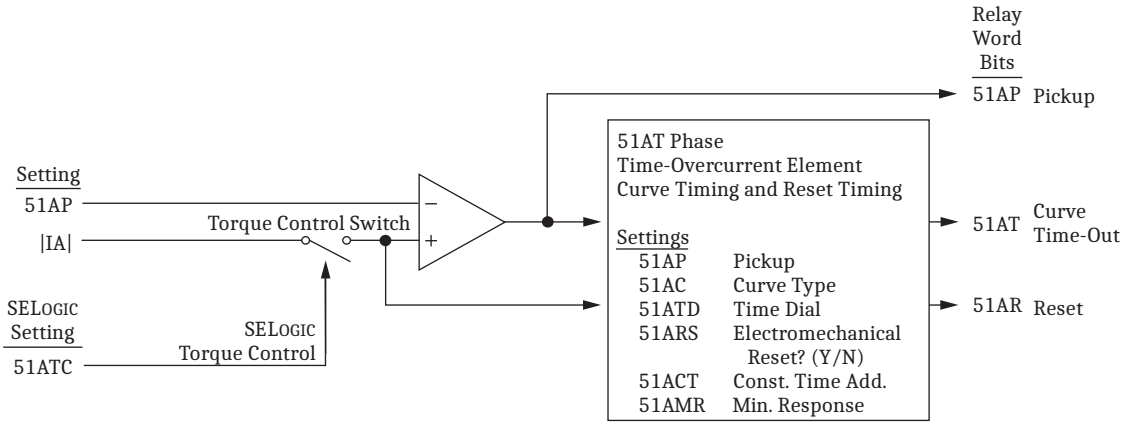


Figure 35 Targets Window in the QuickSet HMI Tool of an SEL-751

Example B: Testing an Inverse Time-Overcurrent Element

In this section, we explore another testing tool for testing a time-overcurrent element. *Figure 36* illustrates the logic diagram for a typical time-overcurrent protection element in an SEL-751.



Logic State of 51ATC Controls the Torque Control Switch

51ATC State	Torque Control Switch Position	Setting 51ARS =	Reset Timing
Logical 1	Closed	Y	Electromechanical
Logical 0	Open	N	1 Cycle

Note: 51AT element shown above; 51BT and 51CT are similar.

Figure 36 Time-Overcurrent Element Logic in an SEL-751

In *Figure 36*, when the magnitude of the A-phase current (|IA|) becomes higher than the pickup setting (51AP), the RWB 51AP asserts (becomes a logical 1) and the relay starts timing based on the curve type (51AC), time dial (51ATD) setting, and magnitude of current injected (multiples of pickup). Once the curve times out, 51AT asserts. The operation is similar for B- and C-phases.

The goal here is to calculate the expected operating time and verify that the relay asserts the timed output in the expected time. By reviewing the various testing tools introduced in *Testing Tools* on page 34, we can determine that the SER is a suitable tool to verify that the time taken for the relay curve to time out and assert the appropriate timed output matches the calculated time.

Example Test Procedure

Step 1. Note the pickup setting, time dial setting, and curve type from the settings file or the **SHO** command on the terminal window.

Step 2. Confirm that the RWBs to be monitored (e.g., 51AP, 51AT, 51BP, 51BT, 51CP, and 51CT) are added in the SER variables in the settings file.

Step 3. Use the IEEE standard inverse-time characteristics equations for overcurrent relays and calculate the operating time based on the curve type, time dial setting, and magnitude of current (in terms of multiples of pickup) you want to apply to the relay. For example, if you want to inject 12 A secondary and the pickup setting is 3 A secondary, the multiples of pickup, M, is 12 A / 3 A = 4. Refer to [6] and the accompanying spreadsheet to calculate the expected operating time. These equations can also be found in the instruction manual.

Step 4. Inject the current (determined in *Step 3*) for slightly longer than the operating time calculated in *Step 3*.

Step 5. View the SER data either through the SER tab in QuickSet HMI or by using the SER command in the terminal window, as shown in *Figure 37*. Note the time of assertion of the pickup element and the timed-out element.

Step 6. Verify that the time difference between the assertion of the two elements is equal to the calculated operating time.

QuickSet Communications

Send Ctrl Characters

```
Clearing Complete

=>>SER

SEL-751                                  Date: 10/24/2019   Time: 22:22:44.329
FEEDER RELAY                             Time Source: Internal

Serial No = 3171360199      FID = SEL-751-R201-V1-Z007003-D20180921
CID = 56AB
```

#	DATE	TIME	ELEMENT	STATE
14	10/24/2019	22:22:32.057	51AP	Asserted
13	10/24/2019	22:22:32.061	51CP	Asserted
12	10/24/2019	22:22:32.061	51BP	Asserted
11	10/24/2019	22:22:33.099	51BT	Asserted
10	10/24/2019	22:22:33.099	51AT	Asserted
9	10/24/2019	22:22:33.112	51CT	Asserted
8	10/24/2019	22:22:36.104	51P1T	Asserted
7	10/24/2019	22:22:38.563	51BP	Deasserted
6	10/24/2019	22:22:38.568	51CP	Deasserted
5	10/24/2019	22:22:38.572	51AP	Deasserted
4	10/24/2019	22:22:38.580	51P1T	Deasserted
3	10/24/2019	22:22:38.580	51BT	Deasserted
2	10/24/2019	22:22:38.584	51CT	Deasserted
1	10/24/2019	22:22:38.588	51AT	Deasserted

```
=>>
```

Figure 37 SER Data Through the Terminal Window

Thus, by using the SER, we can effectively test the time-overcurrent element.

SECTION 7: COMMUNICATIONS

A communications interface and protocol are required for communicating with any SEL relay. A communications interface is the physical connection on a device. Once a physical connection is established, you need a communications protocol to interact with the relay.

Communications Interfaces

You can order devices with different physical communications interfaces, including an EIA-485 port, EIA-232 port, fiber-optic serial port, and copper or fiber Ethernet port. *Table 8* explains some common interfaces. Note that not all of the following interfaces are available in all relays, and you should refer the relay instruction manual to know the available options for that particular relay.

Table 8 SEL Relay Communications Port Interfaces (Sheet 1 of 2)

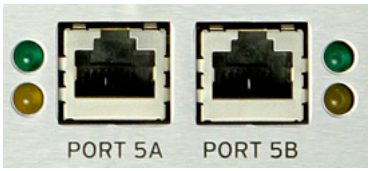
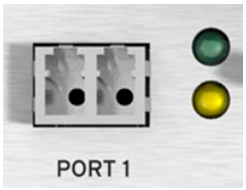
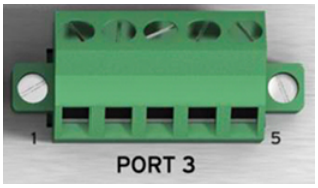
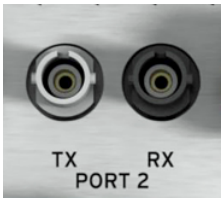
Port	Figure	Description
Copper Ethernet port	 **Figure 38 Copper Ethernet Ports**	Ordering a relay with an on-board Ethernet port allows you to connect the device to an Ethernet switch (with a spare RJ45 10/100 port) and subsequently allows for communication on an Ethernet network. This port is typically assigned as Port 1 on an SEL-700/SEL-2400 series device or Port 5 on an SEL-300/SEL-400/SEL-600 series device. You can enable many different protocols on this port, thus allowing co-mingling of different services. Examples of protocols that can be enabled are as follows: Telnet: remote terminal access to the relay for QuickSet programming, event retrieval, SEL protocol, etc. FTP: read/send settings files as well as event records DNP/Modbus/MMS: enable a server (aka. slave) instance of these protocols to allow the relay to be polled by a communications processor, RTU, or SCADA system SNTP: enable medium-accuracy time synchronization of the relay over an Ethernet network IEC 61850: enable high-speed peer-to-peer GOOSE messaging over an Ethernet network You can also order Ethernet ports in a dual configuration that allows for connection to redundant networks. The maximum recommended length for a copper Ethernet connection is 100 meters.
Fiber-optic Ethernet port	 **Figure 39 Fiber-Optic Ethernet Port**	Functionality for fiber-optic Ethernet ports is identical to those of copper Ethernet ports, only the communications medium is different. It is important to note that these interfaces are ordered with a specific standard (e.g., 100BASE-FX), and the matching device on the other end of the connection (such as a switch) must match this standard exactly. There is no autonegotiation such as is present with copper-based Ethernet. SEL recommends using a fiber-optic connection for longer runs because there is not the problem of electrical interference that exists with a copper-based Ethernet connection.

Table 8 SEL Relay Communications Port Interfaces (Sheet 2 of 2)

Port	Figure	Description
EIA-232 serial port	 **Figure 40 EIA-232 Port 2**	Most SEL relays have one or more DB-9 connectors, usually an EIA-232 serial port with a DTE pinout (a null modem cable would be used to communicate with a PC). Relays support a variable number of these ports, usually one dedicated front port for programming and one to three rear ports, depending on configuration. EIA-232 ports have a distance specification of approximately 50 ft. This port defaults to a protocol of SEL, which allows for terminal access and programming of the relay. Other possible protocols (depending on the relay model) include DNP3, Modbus, MIRRORED BITS® Communications, and IEC C37.118 (synchrophasors). Although the EIA-232 standard assigns Pins 4 and 6 of the DB-9 connector to DTR (Data Terminal Ready) and DSR (Data Set Ready), these pins are permanently re-assigned in hardware in most SEL relays and are instead used for an IRIG-B time synchronization input on one of the rear ports.
EIA-485 serial port	 **Figure 41 EIA-485 Port 3**	EIA-485 ports connect the relay to an EIA-485 point-to-point or multidrop communications network. EIA-485 has greater distance specifications (approximately 4000 ft) than EIA-232 (approximately 50 ft) because of the signaling type used on the wire. It is traditionally used with Modbus or DNP3 protocol that support unique server addressing. SEL recommends four-wire communications, but two-wire communications are possible. SEL and MIRRORED BITS protocols are only supported in a four-wire point-to-point configuration.
Fiber-optic serial port	 **Figure 42 Fiber-Optic Port 2**	Protocol support for fiber-optic serial ports is identical to that of the EIA-232 and EIA-485 ports, although the communications medium is a 50062.5 µm multimode fiber-optic cable rather than copper cabling. This port is equivalent to the relay having a built-in SEL-2812MR transceiver and usually communicates either directly to another relay with a matching port or a communications processor with an SEL-2812MT or SEL-2812MR transceiver on its own EIA-232 port.

NOTE: A variety of transceivers are available to convert port types, and you can find them on the SEL website under **Products > Communications > Transceivers**.

Communications Protocols

All SEL relays with support for the following protocols only support server (AKA, slave) instances of said protocols. For example, an SEL relay can never issue a scan by using one of these protocols to request data from another device.

SEL Communications Protocol

SEL protocol is a suite of protocols that provides the ability to send commands and receive a response from SEL relays (using terminal software), to read and send settings files (by using QuickSet) and to retrieve metering and RWB information (by using a communications processor).

Modbus Communications

Modbus RTU is a binary protocol that permits communications between a single master device and multiple slave devices. The master transmits a message that includes the address of the slave device that you want the message to reach. All the slave devices receive the message, but only the slave device with the matching address responds. Modbus is the most common protocol in the industry. It is typically used by PLC devices to retrieve information from relays and build automation logic or to send the data to HMIs or distributed control systems (DCS) for monitoring purposes.

DNP3 Communications

DNP (Distributed Network Protocol) is an open protocol used in electric power and water utilities. It was developed for communications between various types of data acquisition and control equipment such as SCADA stations, Control Centers, RTUs, and IEDs. DNP is very similar to Modbus but has some features specific to the electric power industry, such as data with time stamping, event information retrieval, and time synchronization.

Mirrored Bits Communications

Mirrored Bits is a bidirectional relay-to-relay communications protocol that uses a dedicated line and allows IEDs (relays) to exchange information in a fast, secure, and reliable manner at minimal cost. This protocol is only supported over serial ports and not Ethernet ports. It is SEL-specific and typically used for protection applications such as direct transfer trips, high-speed pilot line protection, etc.

Telnet Communications

A Telnet connection provides access to the relay user interface. You can use all the ASCII commands accepted via the serial ports as well as the SEL Fast Meter Protocol while Telnet communications are enabled.

IEC 61850 GOOSE Communications

GOOSE is part of the IEC 61850 suite of protocols. This protocol is used for high-speed control messaging between IEDs (relays). It can quickly and conveniently transfer the status of RWBs, controls, and measured values between peer devices on a network. GOOSE, unlike Mirrored Bits communication, is not SEL-specific and can work with other vendors. It requires an Ethernet connection to exchange information. GOOSE can be used for applications similar to those for which Mirrored Bits communications is used, such as transfer tripping and sharing digital data between relays.

IEC 61850 MMS Communications

MMS is also a part of the IEC 61850 suite of protocols. You can use this protocol to report data from the relay to a client system such as a communications processor, HMI, or SCADA system.

Section 8: Frequently Asked Questions

Q1—I received a service bulletin from SEL on a product I own. What does this mean and what should I do?

In the rare event that SEL has identified an issue with a relay, SEL issues a service bulletin to affected customers. The service bulletin details the problem and the solution SEL has provided, which may include upgrading the firmware in the relay or sending the product back to the factory to be fixed. SEL provides the upgrades or fixes associated with service bulletins for free.

Q2—When do I need to upgrade the firmware in my relay?

Appendix A of most relay instruction manuals shows the complete firmware history of the product from initial release to the most current release. Most firmware updates released by SEL are for feature enhancements, improvements, and minor fixes. In these cases, the decision to update the relay firmware is left to the discretion of the user. Because these upgrades are optional and would be done to add additional features, there is usually a small cost associated with them. If you receive a service bulletin on a product you own that offers a firmware upgrade, SEL will provide that upgrade for free.

Q3—Can I downgrade the firmware in my relay?

SEL does not recommending downgrading firmware. Using older firmware can result in fewer features and make you vulnerable to security concerns. Performing firmware downgrades includes a risk that calibration settings inside the relay will be lost. If a downgrade is necessary, it is best to send the relay back to the factory for the conversion.

Q4—My relay is not working as expected. What should I do?

Contact your local technical support (*Section 9: More Help* on page 44) via email or phone, or call the SEL tech line at 1.509.338.3838. An SEL engineer will help troubleshoot the issue. Most issues are settings-related and can be resolved by working with an application engineer. If the problem is found to be hardware related, then the relay might need to be shipped back to the factory for diagnosis and repair. In such a case, a CSR will process a Return Materials Authorization (RMA) for you, and you will be given instructions on sending the relay back to SEL for free repairs.

Q5—Can I borrow a relay for evaluation or to practice with in my lab?

SEL loans out equipment for short periods of time under certain conditions. Contact your local sales representative to process a loan request. Note that loaners are intended only for evaluation purposes and should not be used in the field.

Q6—I would like to know what features are present in my relay. Where can I find this information?

The SEL website has a reverse lookup for relay part numbers. Using the menu at the top of the page, navigate to **Products > View All Products**. Type the part number in the reverse lookup tool, as shown in *Figure 43*, to see the features of the product with the corresponding part number. You can also directly type the part number in the search toolbar at the top of the main page.

Figure 43 Reverse Lookup on the SEL Website

Q7—How do I get drawings of my part number?

Perform a reverse part number lookup for the product (as explained in *Question 6* on page 41). Scroll to the bottom of the Configuration Summary page to view the drawings. The drawings are available in PDF format as well as in AutoCAD format. Open the PDF file in Adobe Reader or Adobe Acrobat and select the hardware and software options you chose to configure the part number (or open the .dwg file in AutoCAD or an AutoCAD viewer and select the options to configure the drawing). This configures a drawing corresponding to the part number. Further instructions are available in the Instructions document available with the drawing links. Note that the drawings for the SEL-500 series relays are available as-is and need not be configured based on the part number.

Drawings

Drawing Type	Drawing Formats	
	PDF	DWG
FAQ & Instructions: How to use the Master Configurable Drawings	PDF (1,004.61 kB)	
Dimension	PDF (34.86 kB)	DWG (27.97 kB)
Front, Right, Rear	PDF (4.98 MB)	DWG (5.13 MB)

Figure 44 Drawing Types Available on the SEL Website

Q8—I want to buy a new relay, what is the process?

To order a new relay, contact your local sales representative. You can find your representative on the SEL website under **Support > Sales Representatives**, as explained in *Section 9: More Help* on page 44.

Q9—I am new to SEL relays and need some assistance setting up the relay. Is there a way SEL can help me?

SEL Engineering Services, Inc. (SEL ES) can help you set and/or commission your relay. For more information, navigate to **Engineering Services** on the SEL website. SEL has also developed QuickSet Design Templates, which are simplified versions of the settings files, to assist with setting certain distribution protection and control products. Some examples include the main-tie-main scheme templates that use the SEL-751/SEL-751A or SEL-351S relays, templates to set SEL-651R Advanced Recloser Controls and interface them with different reclosers, etc. These templates are free and can be downloaded from the SEL website under **Support > Documentation > View All Documents** and selecting the **Design Template Guides** check box. To make modifications to the logic developed in the template, you need to purchase a QuickSet license. Note that Design Templates are provided and supported as-is, and any modification is solely the responsibility of the user.

Q10—I am not able to connect to the relay through the SEL-C662 cable. Am I doing something wrong?

It is likely that the SEL USB (SEL-C662) driver was not installed on your PC. Download the SEL USB drivers from the SEL website as described in *Required Equipment for Interfacing With Relays* on page 7. Once the driver is downloaded, you can see **SEL CP210x USB to UART Bridge** as an option for Device Type under Communications Parameters in QuickSet.

Q11—Why will QuickSet not communicate with my new relay?

Once you have confirmed that it is not a cable issue (as explained in *Question 10*), the next step is to check if the settings version number (SVN), or Z-number, of your relay is available in QuickSet. Navigate to **File > New** and verify that the SVN is available in the settings editor selection page. New relays have the latest SVN, and if this is not available in QuickSet, it is likely that the driver of the relay is not up to date in QuickSet. Update the driver through SEL Compass as outlined in *Section 3: ACSELERATOR QuickSet SEL-5030 Software* on page 16 to solve the issue.

Q12—How do I find the correct relay for my application?

The SEL website (selinc.com) has many tools to help you with this. The products are organized into different categories based on the equipment they are intended to protect, such as Generator Protection, Substation Protection, etc. Furthermore, there are feature comparison tables under each category that help you understand the different features available in each relay. Additionally, your local sales representative (see *Section 9: More Help* on page 44) can help you with configuring part numbers.

Q13—I need training. Who do I contact?

To view scheduled SEL training, go to the **Education and Events** tab on the SEL website. There are different types of training opportunities available. This can be either through SEL University or attending local classroom and interactive seminars or recorded webinars on the SEL website. SEL can also provide customized training at the customer site that is designed to cater to the needs of your company in particular. Contact your local sales representative or application engineer for assistance in planning such training.

Q14—Can I send settings to an in-service relay?

When sending settings, protection functions might be disabled for a short amount of time. It is best practice to remove the relay from service before sending settings. Refer to [7] to learn more about this.

Q15—What is the service life of an SEL relay?

SEL relays come with a 10-year warranty but are designed for a useful life of 20 years. Reference [8] discusses in depth the service life of a microprocessor relay.

Q16—Can I store SEL equipment for an extended period of time without energizing it?

Refer to [9] for storage recommendations and background information on extended storage for SEL equipment.

Q17—Can I use the same relay model for primary and backup protection?

Refer to [10] for information on the use and reliability of two SEL devices as primary and backup relays.

Section 9: More Help

Relay Instruction Manual

SEL instruction manuals are very comprehensive and have most of the information associated with the relay. Most questions can be answered by referring to the instruction manual. You can download these manuals from the SEL website under **Support > Product Literature > Instruction Manuals** or from SEL Compass under **Literature** (see *Section 1: Basics of an SEL Relay* on page 2).

Technical Support

You can find your local application engineer on the SEL website under **Support > Customer Support > Technical Support**. Enter the country and state/province, and the website lists all the protection, automation, and communication application engineers assigned who support the area. You can also contact the SEL Technical Support line at 1.509.338.3838 to get in touch with an application engineer (see *Technical Support* on page 47).

Customer Service Representative (CSR)

CSRs can help you with the Return Materials Authorization (RMA) process, information regarding your SEL account, or questions on the status of an order or invoice. If you are unsure about who to contact regarding an issue, you can contact your CSR. Even if the CSR is not able to personally help you, CSRs have the knowledge and capability to connect you to the right resource, be it internal SEL employees or sales representatives. You can find your local CSR on the SEL website under **Support > Customer Support > Customer Service**. Enter your country and state/province, and the website lists the CSR who supports the area.

Sales Representative

Sales representatives can help you find the right relays based on your application and can assist you with the ordering process. They can also assist you with basic technical questions that you may have before or after the purchase of the relay. They act as middlemen between customers and SEL by identifying the correct point of contact inside SEL based on the customer's needs. You can find their information on the SEL website under **Support > Customer Support > Sales Representatives**. Enter your country and state/province, and the website lists the names and the contact information of the sales representatives who support the area.

Publications

The SEL website has a number of publications in the form of technical papers, white papers, and application guides to help customers apply and maximize the use of SEL products. You can find these under **Support > Publications**. These papers and guides are great resources to learn more about SEL products and tools.

Conclusion

This application guide outlines all the basics needed to get started with SEL relays. It is meant to be a reference document for anyone new to SEL relays. To learn more about each relay, refer to the appropriate relay instruction manual.

APPENDIX A

ANSI standard device numbers help identify the features of a protective device such as a relay or circuit breaker. *Table 9* lists the ANSI device codes.

Table 9 ANSI Device Codes (Sheet 1 of 2)

Code	Device	Code	Device
1	Master element	49	Machine or transformer thermal relay
2	Time-delay starting or closing relay	50	Instantaneous overcurrent relay
3	Checking or interlocking relay	51	AC inverse-time overcurrent relay
4	Master contactor	52	AC circuit breaker
5	Stopping device	53	Field excitation relay
6	Starting circuit breaker	54	Turning gear engaging device
7	Rate-of-change relay	55	Power factor relay
8	Control power disconnecting device	56	Field application relay
9	Reversing device	57	Short-circuiting or grounding device
10	Unit sequence switch	58	Rectification failure relay
11	Multifunction device	59	Overvoltage relay
12	Over-speed device	60	Voltage or current balance relay
13	Synchronous-speed device	61	Density switch or sensor
14	Under-speed device	62	Time-delay stopping or opening relay
15	Speed or frequency matching device	63	Pressure switch
16	Data communications device	64	Ground detector relay
17	Shunting or discharge switch	65	Governor
18	Accelerating or decelerating	66	Notching or jogging device
19	Starting-to-running transition contactor	67	AC directional overcurrent relay
20	Electrically operated valve	68	Blocking or out-of-step relay
21	Distance relay	69	Permissive control device
22	Equalizer circuit breaker	70	Rheostat
23	Temperature control device	71	Liquid level switch
24	Volts per hertz relay	72	DC circuit breaker
25	Synchronizing or synchronism-check relay	73	Load-resistor contactor
26	Apparatus thermal device	74	Alarm relay
27	Undervoltage relay	75	Position changing mechanism
28	Flame detector	76	DC overcurrent relay
29	Isolating contactor or switch	77	Telemetering device
30	Annunciator relay	78	Phase-angle measuring relay
31	Separate excitation device	79	AC reclosing relay
32	Directional power relay	80	Flow switch
33	Position switch	81	Frequency relay
34	Master sequence device	82	DC load-measuring reclosing relay

Table 9 ANSI Device Codes (Sheet 2 of 2)

Code	Device	Code	Device
35	Brush-operating or slip-ring short-circuiting device	83	Automatic sensitive control or transfer relay
36	Polarity or polarizing voltage device	84	Operating mechanism
37	Undercurrent or underpower relay	85	Pilot communications, carrier or pilot-wire relay
38	Bearing protective device	86	Lockout relay
39	Mechanical condition monitor	87	Differential protective relay
40	Field (over- and underexcitation) relay	88	Auxiliary motor or motor generator
41	Field circuit breaker	89	Line switch
42	Running circuit breaker	90	Regulating device
43	Manual transfer or selector device	91	Voltage directional relay
44	Unit sequence starting relay	92	Voltage and power directional relay
45	Abnormal atmospheric condition monitor	93	Field-changing contactor
46	Reverse-phase or phase-balance current relay	94	Tripping or trip-free relay
47	Phase-sequence or phase-balance voltage relay	95–99	Used only for specific applications
48	Incomplete sequence relay		

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Technical Support

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