SEL-547

Distributed Generator Interconnection Relay

User's Guide

20200715

SCHWEITZER ENGINEERING LABORATORIES, INC.

PM547-02

⚠CAUTION

Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

⚠DANGER

Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

⚠DANGER

Contact with instrument terminals can cause electrical shock that can result in injury or death.

⚠WARNING

Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.

⚠WARNING

Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.

⚠ATTENTION

Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.

⚠DANGER

Débrancher tous les raccordements externes avant d'ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.

⚠DANGER

Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessuers ou la mort.

⚠AVERTISSEMENT

Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.

⚠AVERTISSEMENT

L'utilisation de cet appareil suivant des procédures différentes de celles indiquées dans ce manuel peut désarmer les dispositifs de protection d'opérateur normalement actifs sur cet équipement.

PM547-02

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Preface

This manual provides information and instructions for installing and operating the SEL-547 Relay. The two volumes that comprise this manual are for use by those experienced in protective relaying applications. Included are detailed technical descriptions of the relay and application examples.

Manual Overview

The SEL-547 Relay Manual consists of two volumes:

- User's Guide
- Reference Manual

In addition, the SEL-547 Relay Manual contains a comprehensive index that encompasses both volumes of the manual. The index appears at the end of each printed volume.

The SEL-547 Relay Manual describes common aspects of relay application and use. Read the user's guide to obtain the necessary information to install, set, test, and operate the relay; refer to the reference manual for more detailed information about settings and commands.

An overview of each manual section and topics follows.

User's Guide

Preface. Describes the manual organization and conventions used to present information.

Section 1: Introduction and Specifications. Introduces the SEL-547 features; summarizes relay functions and applications; lists relay specifications, type tests, and ratings.

Section 2: Installation. Provides instructions and information for mounting and connecting the relay, including top and front views of the SEL-547, wiring connection and detail diagrams, and hardware installation instructions.

Section 3: Basic Relay Operations. Describes how to perform fundamental operations such as applying power and communicating with the relay, setting and viewing passwords, checking relay status, understanding and using EZ settings, viewing metering data, reading event reports and SER (Sequential Events Recorder) data, operating relay control outputs, checking LEDs, and using relay features to make commissioning easier.

Section 4: Testing and Troubleshooting. Describes techniques for testing, troubleshooting, and maintaining the SEL-547; it includes the list of status notification messages and a troubleshooting chart.

Appendix A: Firmware and Manual Versions. Lists the current firmware versions and details differences between the current and previous versions.

Appendix B: Firmware Upgrade Instructions. Provides instructions for upgrading firmware in the SEL-547.

Appendix C: SEL-547 Relay EZ Settings Sheet.

Reference Manual

Preface. Describes the manual organization and conventions used to present information.

Section 1: Protection Functions. Describes the function of various relay protection elements, including voltage elements, synchronism check elements, frequency elements, and power elements. This section describes how the relay processes these elements and gives detailed specifics on protection scheme logic.

Section 2: SELOGIC Control Equation Programming. Describes the logic input/output of the relay, including SELOGIC® control equations, optoisolated inputs, remote control and latch control switches, setting groups, output contacts, and front-panel target LEDs.

Section 3: Analyzing Events. Explains how to obtain and interpret filtered event reports, event summaries, history reports, and SER reports.

Section 4: Communications. Explains the physical connection of the SEL-547 to various communications network topologies.

Section 5: SEL Communications Protocols. Describes the hardware and various SEL software protocols and how to apply these protocols; it includes details about SEL ASCII, SEL Compressed ASCII, SEL Distributed Port Switch, SEL Fast Meter, and SEL Fast Operate protocols.

Section 6: MODBUS RTU Communications. Describes the MODBUS® RTU Communications Protocol and how the SEL-547 supports this protocol.

Section 7: ASCII Commands. Provides information about serial port access levels, an ASCII command summary, and ASCII command explanations.

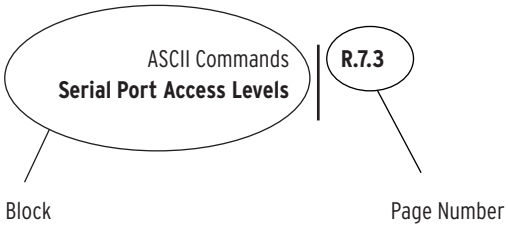
Section 8: Settings. Provides information about settings changes via the serial port, how EZ settings force global and Group 1 settings, and settings sheets.

Appendix A: Relay Word Bits. Contains a summary table of Relay Word bits.

SEL-547 Relay Command Summary. Contains a summary of relay commands.

Page Numbering

This manual shows page identifiers at the top of each page; see the figure below.



Page Number Format

The page number appears at the outside edge of each page; a vertical bar separates the page number from the page title block. The two volumes of the SEL-547 Relay Manual are represented by the following building blocks:

- page number character string
  - U is for User's Guide
  - R is for the Reference Manual.
- section number
- actual page number in the particular section

The section title is at the top of the page title block, with the main subsection reference in bold type underneath the section title.

Conventions

Typographic Conventions

This user's guide shows certain information with specific font and formatting attributes. The following table lists the typographic conventions in this documentation:

Typographic Conventions

Example	Description
STATUS	Commands typed at a command line interface on a PC.
TAR 6 <Enter>	Commands/input that you type.
<Enter>	Single keystroke command.
<Ctrl+D>	Multiple/combination keystroke on a PC keyboard.
Start > Settings	PC software dialog boxes and menu selections. The > character indicates submenus.
ENABLE	Relay front- or rear-panel labels.
Start	Dialog Boxes: Menu titles, options, drop-down or check box menu selections, highlighted options.
MAIN > METER	Relay front-panel LCD menus and relay responses visible on the PC screen. The > character indicates submenus.

Safety Information

This manual uses three kinds of hazard statements, formatted as follows:

⚠CAUTION
Indicates a potentially hazardous situation that, if not avoided, may result in minor or moderate injury or equipment damage.

⚠WARNING
Indicates a potentially hazardous situation that, if not avoided, **could** result in death or serious injury.

⚠DANGER
Indicates an imminently hazardous situation that, if not avoided, **will** result in death or serious injury.

Section 1
Introduction and Specifications

Overview

The SEL-547 Relay is a utility grade generation protection system relay designed typically to protect on-site 50–200 kW distributed generators with generated voltages up to 480 V.

The SEL-547 has the following inputs:

- Three phase-to-neutral voltage inputs
- One voltage input used for synchronization
- One phase current input

The SEL-547 has two communications ports:

- One EIA-485 port

  This port serves as a connection to a MODBUS® RTU communication protocol network.

- One EIA-232 port

  This port provides an ASCII user interface and a method for loading firmware upgrades.

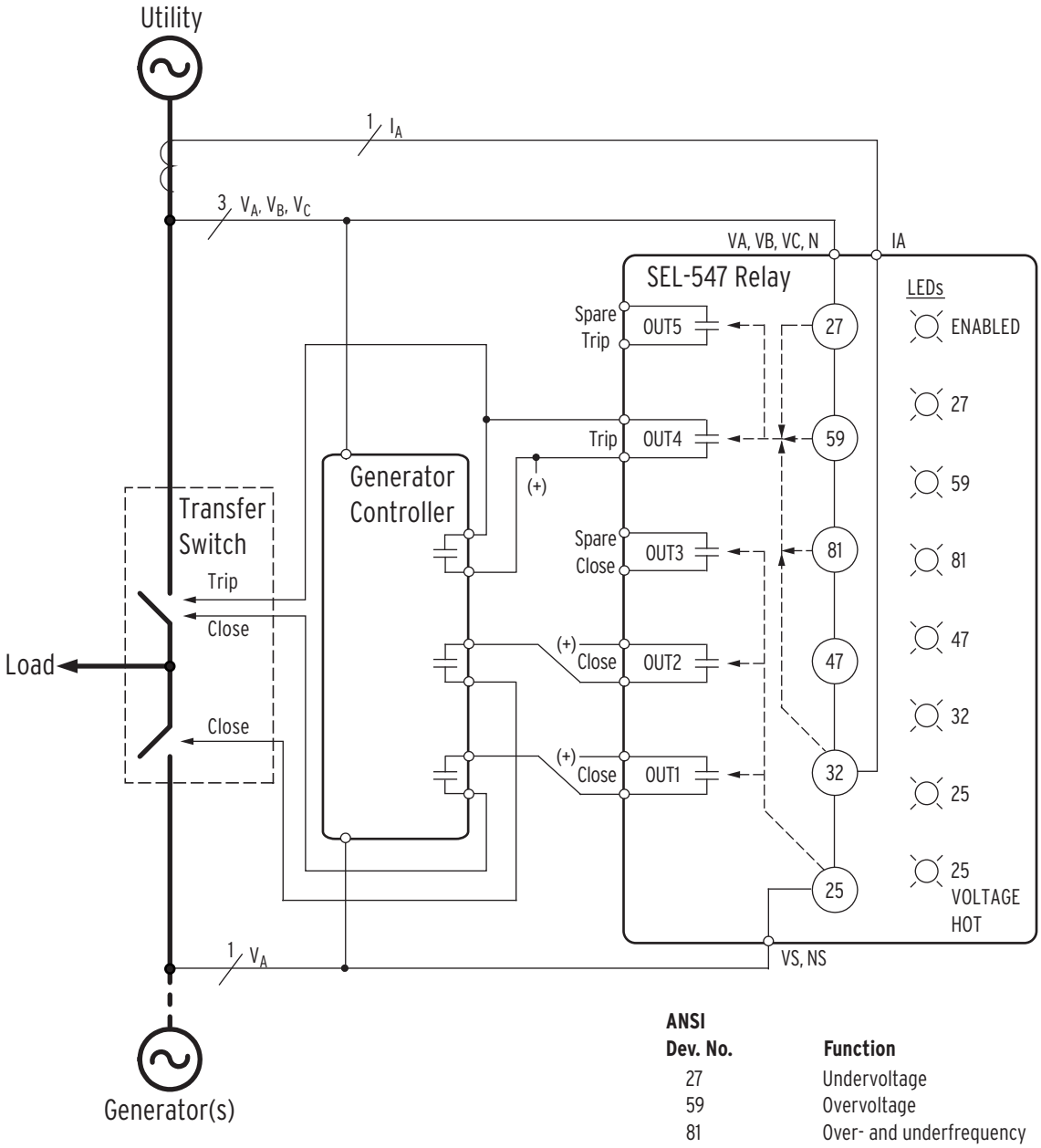
The SEL-547 is shipped with EZ settings—settings preset at the factory for basic applications. These settings are based on traditional relay applications and should be modified if you are using the SEL-547 for a custom application. Please refer to the SEL-547 *Reference Manual* for more details about settings and commands if you are developing a custom application.

This section introduces the SEL-547 and provides information on the following topics:

- Features
- Applications
- Specifications

Features

The SEL-547 has many protection, automation, and control features. *Figure 1.1* depicts a typical SEL-547 application.



ANSI Dev. No.	Function
27	Undervoltage
59	Overvoltage
81	Over- and underfrequency
47	Reverse-phase-sequence voltage
32	Directional power
25	Synchronism check

Figure 1.1 Typical SEL-547 Application (Transfer Switch Site Application)

The SEL-547 features include the following:

Over- and Undervoltage Protection. The SEL-547 has two (2) overvoltage elements (ANSI device 59) and two (2) undervoltage elements (ANSI device 27) for tripping for abnormal system voltage conditions. Each element has an independently set timer.

Over- and Underfrequency Protection. The SEL-547 has four (4) frequency elements (individually configurable as over- or underfrequency elements; ANSI device 81) for tripping for abnormal system frequency conditions. Each element has an independently set timer.

Reverse-Phase-Sequence Voltage Alarming. Front-panel indication of reverse-phase-sequence voltage (ANSI device 47) indicates that the three-phase voltage inputs are wired incorrectly (or there is a wiring error somewhere in the system).

Directional Power Protection. The SEL-547 has one (1) directional power element (ANSI device 32) for tripping for such abnormal system conditions as reverse power and generator motoring. The directional power element derives its power operating quantity from single-phase voltage and current quantities. The element has an independent timer and can be set to detect forward or reverse power flow.

Synchronism Check Close Supervision. The SEL-547 has one (1) synchronism check element (ANSI device 25) for system restoration supervision. Angle, voltage, and slip frequency settings provide for secure operation.

Front-Panel LEDs. Eight LEDs indicate relay and protection/control element status. The LEDs momentarily flash (if not already illuminated) at intervals from 5 to 60 seconds, indicating the working order of the LED.

Current and Voltage Inputs. The SEL-547 has three-phase (wye-connected) voltage inputs, one synchronism-check voltage input, and one single-phase current input

Inputs/Outputs. The SEL-547 has five (5) output contacts, one (1) alarm contact, and three (3) optoisolated inputs.

Access Levels. The SEL-547 has multiple access levels that are password protected.

Event Reporting and Sequential Events Recorder (SER). The SEL-547 has 15/30/60-cycle event reports, with per quarter cycle analog and digital information. A Sequential Events Recorder (SER) records up to 512 time-stamped and dated sequential events.

Communication. The SEL-547 has two communications ports: one EIA-232 and one EIA-485. It supports MODBUS® RTU Protocol. Electronic communication to the relay is not restricted by proprietary software. The SEL-547 can communicate using ASCII commands issued from nonproprietary terminal emulators.

Extended Features. At a higher access level, the following features are available for custom scheme design:

- sixteen (16) timers
- sixteen (16) latches
- sixteen (16) remote control (via serial port) logic points
- two (2) settings groups

Extra elements listed below also become available at the higher access level:

- two (2) overvoltage elements
- two (2) undervoltage element
- two (2) frequency elements
- one (1) synchronism check element
- three (3) directional power elements
- positive-, negative-, and zero-sequence voltage elements

The three (3) optoisolated inputs, five (5) output contacts, and seven (7) LEDs are programmable at this higher access level.

Operating Temperature and Specification Standards. The SEL-547 has an operating temperature range of –40° to +85°C and is qualified to UL and CSA standards.

Applications

There are two general applications of the SEL-547 (see *Figure 1.2*):

- **Transfer switch site application:** The SEL-547 protects the generator at the interconnection point (transfer switch) between the utility and the customer.
- **Individual generator site application:** The SEL-547 protects an individual generator at the individual generator site.

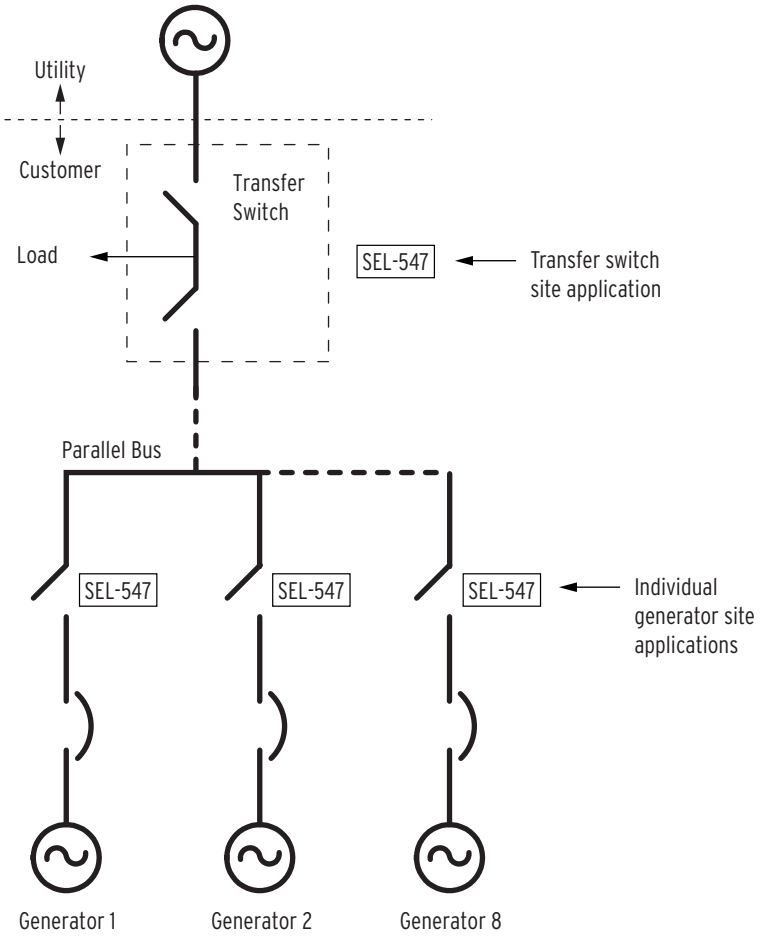


Figure 1.2 Applications for the SEL-547

The top half of *Figure 1.2* shows an SEL-547 applied at a transfer switch site—the boundary between the utility and the customer. This is where customer system separation occurs when utility supply problems are detected.

The bottom half of *Figure 1.2* shows an SEL-547 applied at an individual generator site—farther away from the boundary between the utility and the customer. This is where individual generator separation occurs when a system problem is detected.

Transfer Switch Site Application

The SEL-547 can be used in a transfer switch site application to protect generators performing an emergency backup role or operating in parallel with a utility supply. Please refer to *Section 2: Installation* for specific connections for this application.

Protecting Emergency Backup

In a transfer switch site application, the SEL-547 may protect a generator (or generators in aggregate) operating in an emergency backup role (the generator is normally off-line, but provides electrical power for part or all of the customer's load when the utility supply is lost).

Figure 1.3 through *Figure 1.9* depict the sequence of events that occur when the SEL-547 protects a generator in this mode.

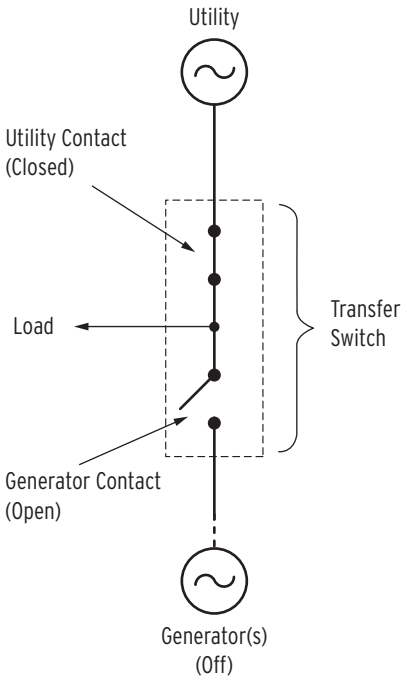


Figure 1.3 Utility Normally Serves the Load

Figure 1.3 depicts the normal operating mode, with the generator contact of the transfer switch open and the utility serving the customer load. The generator is off.

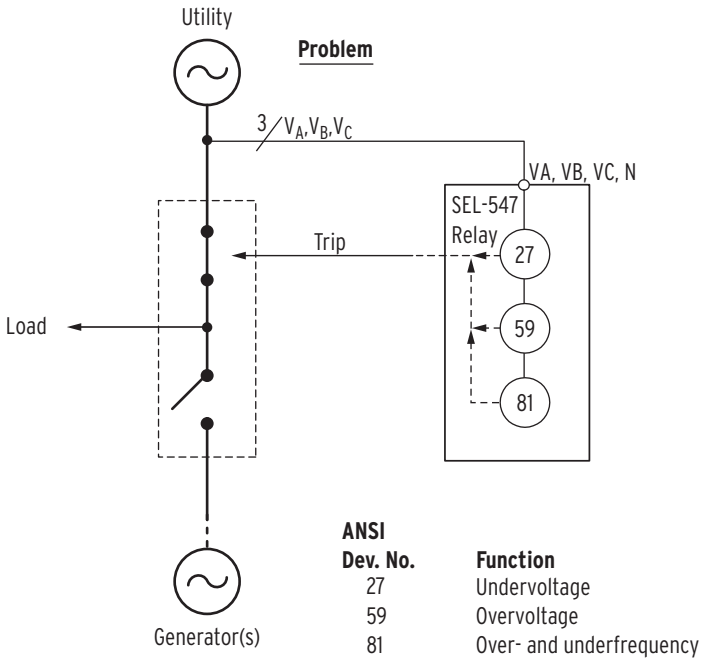


Figure 1.4 SEL-547 Detects a Utility Source Problem

In *Figure 1.4* there is a problem in the utility system [over- and undervoltage or over- and underfrequency condition, resulting from either a system-wide problem or a more local condition (e.g., islanding)]. The SEL-547 over- and undervoltage or over- and underfrequency elements detect the problem, and the relay issues a trip to the utility contact of the transfer switch.

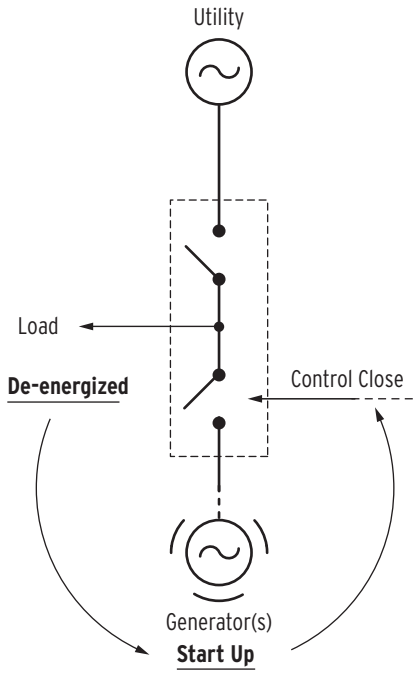


Figure 1.5 Load Is De-energized, and Generator Starts Up

Subsequently, the customer's system is isolated, with the load de-energized (see *Figure 1.5*). Upon detecting this condition, another control starts the generator and, in time, issues a close signal to the generator contact.

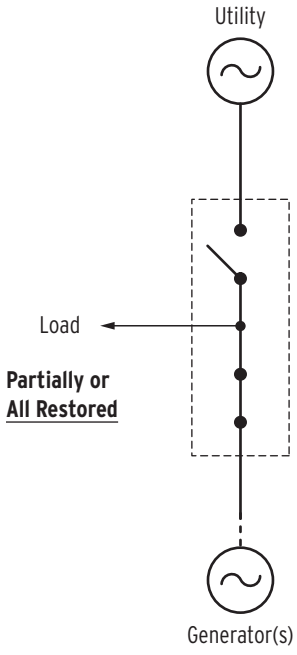


Figure 1.6 Generator Serves Load (or Partial Load) in Emergency Backup Role

In *Figure 1.6*, the generator contact of the transfer switch closes and restores part of or all of the load. The generator is operating as emergency backup.

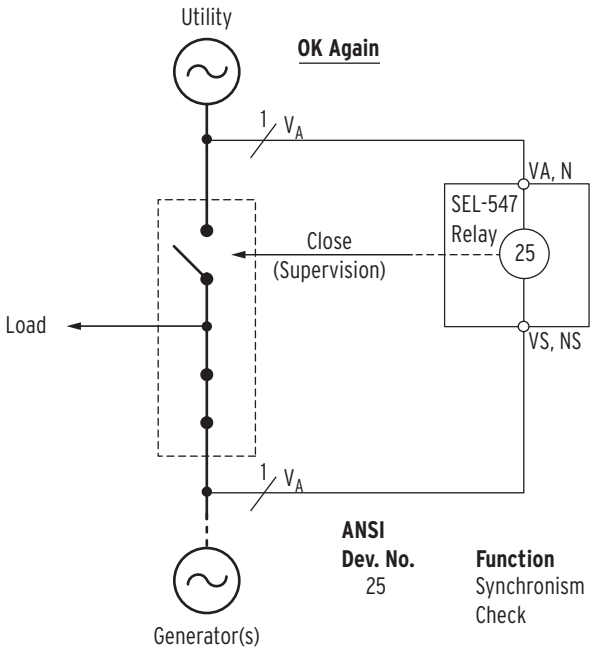


Figure 1.7 SEL-547 Detects Utility Source OK

Eventually, the utility supply voltage and frequency return within normal bounds (see *Figure 1.7*). The synchronism check element in the SEL-547 detects this (and that the voltage slip and angle across the open utility contact are within respective settings bounds) and supervises the closing of the utility contact of the transfer switch.

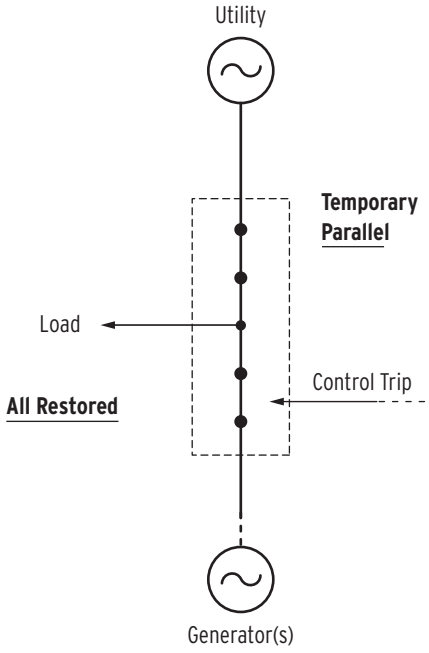


Figure 1.8 All Load Restored and Temporary Parallel Exists

In *Figure 1.8*, all the load is restored and the temporary parallel between the generator and the utility system is then broken.

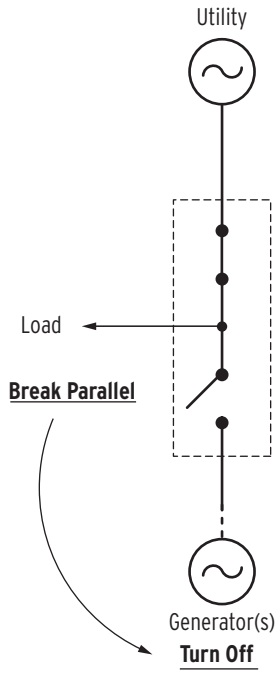


Figure 1.9 Parallel Broken and Generator Turned Off

In *Figure 1.9*, the system is back to the state it was before the utility system problem. The customer load is served entirely by the utility. The generator can be turned off and await the next time it will be needed for emergency backup power.

Preventing Power Export

In a transfer switch site application, the SEL-547 may also be used to prevent the export of power to the utility when a generator (or generators in aggregate) is operating in a parallel mode (the generator is online and operating in parallel with the utility supply). In this application, the generator cannot export power to the utility.

Figure 1.10 through *Figure 1.12* depict the sequence of events for a transfer switch site application protecting a generator operating in parallel with the utility supply.

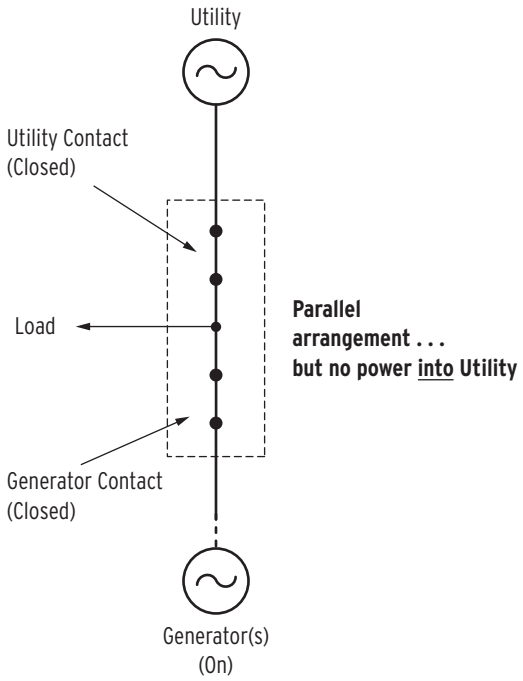


Figure 1.10 Utility and Customer Generator Normally Paralleled

In *Figure 1.10*, both the generator contact and utility contact of the transfer switch are closed, with a net flow of power from the utility to the customer (no power from the generator should flow into the utility).

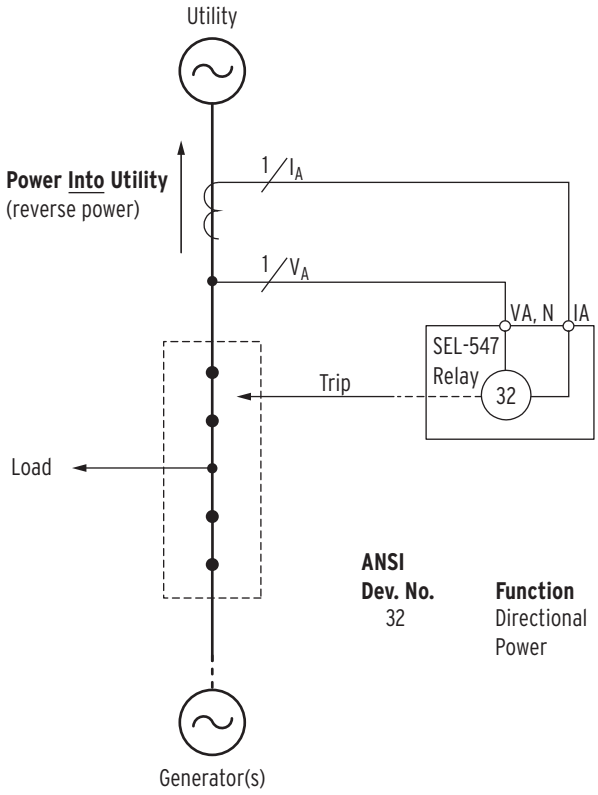


Figure 1.11 SEL-547 Detects Reverse Power Flow Into Utility

Because of reduced on-site customer load, increased generator output, or some other phenomenon, there is a net flow of power into the utility (*Figure 1.11*). The SEL-547 detects the reverse power flow and issues a trip signal to the utility contact of the transfer switch.

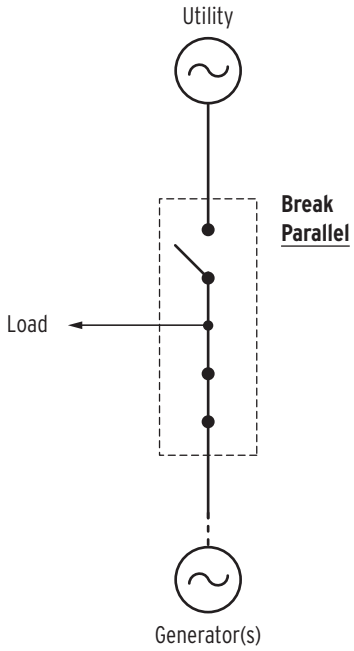


Figure 1.12 Parallel Broken and Customer Load and Generator Isolated Together

Parallel is broken and the customer load (or part of the load) is isolated with the customer-site generation. Eventually, the customer will again be paralleled (via synchronism-check operation, like in *Figure 1.7*) with the utility supply for normal operation.

Individual Generator Site Application

The SEL-547 may also be used to protect an individual generator at the generator site. Please refer to *Section 2: Installation* for specific connections for this application.

Preventing Generator Motoring

The SEL-547 may be used to prevent the motoring (utility power flowing into the generator) of an individual generator operating in parallel mode.

Figure 1.13 through *Figure 1.15* depict the sequence of events that occur when the SEL-547 prevents a generator operating in parallel mode from being motored.

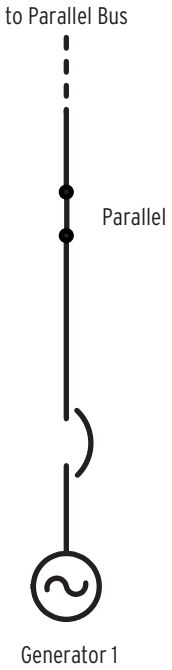


Figure 1.13 Individual Generator Paralleled With the Greater System

In *Figure 1.13*, the generator is operating in parallel with the rest of the greater system and power is flowing out of the generator to the parallel bus and to the customer on-site load.

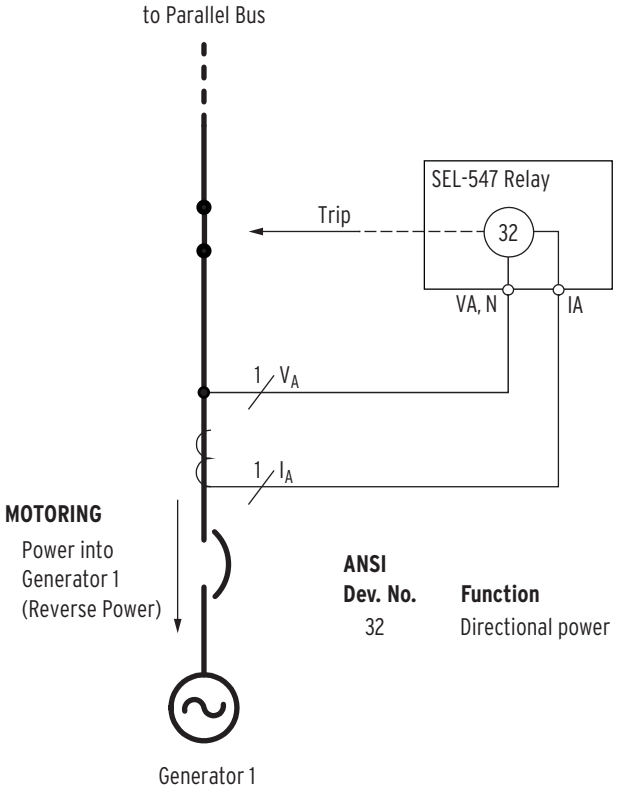


Figure 1.14 SEL-547 Detects Reverse Power Flow Into Generator

For some reason (e.g., the generator loses its prime mover), power from the power system flows into the generator, motoring the generator (see *Figure 1.14*). Motoring can be damaging to the generator, and the SEL-547 detects the reverse power flow into the generator and issues a trip.

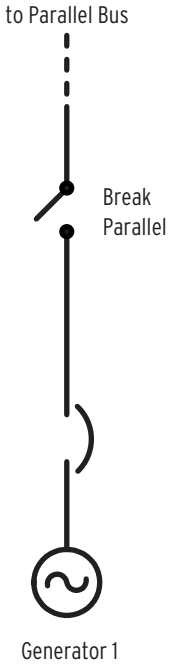


Figure 1.15 Parallel Broken and Motoring of Generator Stopped

In *Figure 1.15*, the breaker/switch is tripped, breaking parallel operation of the generator with the rest of the power system.

Using Other Elements for Individual Generator Site Applications

When the SEL-547 is applied at an individual generator site, other protection and control elements are available besides just directional power. Much like *Figure 1.3* through *Figure 1.9* show the operation of the transfer switch site SEL-547 over- and undervoltage or over- and underfrequency elements, the individual generator site SEL-547 over- and undervoltage or over- and underfrequency elements can likewise operate when the generator is paralleled with the rest of the system.

Synchronism check operation (similar to *Figure 1.7* for the transfer switch site application) can also occur with the individual generator site SEL-547—in scenarios where the parallel bus is already hot and a generator is brought online and needs to be paralleled.

Parallel Mode Application Considerations

When a generator is operating in parallel mode (the generator is online and operating in parallel with the utility supply), there are two common approaches to power system protection:

- Get the generators offline as quickly as possible to avoid potential islanding problems.
- Keep the generators online, in hopes that such generation will support system frequency and voltage, helping the system ride through the disturbance.

In get offline scenarios, over- and undervoltage and over- and underfrequency element settings in the SEL-547 are set closer to nominal values (e.g., underfrequency element pickup set to 59.5 Hz, as opposed to 58.0 Hz [for a 60 Hz system]) and/or with shorter time delays (e.g.,10 cycles as opposed to 60 cycles). This allows for quicker tripping for system voltage/frequency deviations away from nominal.

Conversely, keep online scenarios lean toward element settings in the SEL-547 being farther away from nominal values and/or with longer time delays. This makes for slower tripping for system voltage/frequency deviations away from nominal.

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system
UL Recognized to U.S. and Canadian safety standards (File E220228, NRAQ2/8)

General

AC Voltage Inputs

Nominal:	208–480 V_{L-L}
Continuous:	600 V_{L-L}
Measurement Range:	50–600 V_{L-L}
Burden:	< 0.05 VA at 277 V_{L-N}

AC Current Input

Nominal:	5 A
Continuous:	15 A
1 Second Thermal:	100 A
Measurement Range:	0.1 A–5 A
Burden:	< 0.5 VA at 5 A

Frequency and Rotation

System Frequency:	50 or 60 Hz
Phase Rotation:	ABC or ACB
Frequency Tracking:	40–70 Hz

Note: VA required for frequency tracking

Power Supply

Input Voltage:	6–32 Vdc
Power Consumption:	< 10 W

Output Contacts

Make:	30 A per IEEE C37.90
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
Voltage Rating:	250 Vac/330 Vdc continuous
Pickup Time:	8 ms, resistive load
Dropout Time:	16 ms, resistive load
Interrupt Rating:	< 0.1 A dc, resistive

Optoisolated Inputs

Whetting:	6–32 Vdc
Debounce Time:	1 power system cycle

Operating Temperature

–40° to +85°C (–40° to +185°F)

Dimensions

Refer to *Figure 2.1* for relay dimensions.

Humidity

5% to 95% noncondensing

Weight

1.16 kilograms (2.55 pounds)

Terminal Connections

See *Table 2.1*.

Processing Specifications

AC Voltage and Current Inputs

16 samples per power system cycle

Digital Filtering

One-cycle full cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.

Protection and Control Processing

4 times per power system cycle

Relay Element Settings Ranges and Accuracy

Directional Power (device 32)

Setting Range:	OFF, 40–900 W (secondary) in 1–W steps
Accuracy:	±3% of setting and ±5 W, power factor >±0.5 at nominal frequency
Time Delay Range:	0–16000 cycles in 0.25-cycle steps
Timer Accuracy:	±2% of setting and ±1 cycle

Note: Up to an 8-cycle delay is noticeable on the directional power element—especially if the power level is just above pickup. This additional delay is due to data averaging for accuracy at low power levels.

Frequency (device 81)

Setting Range:	OFF, 40.1–69.9 Hz, 0.1-Hz steps (not settable within 0.2 Hz of nominal frequency)
Accuracy:	±0.1 Hz
Time Delay Range:	5–16000 cycles in 0.25-cycle steps
Timer Accuracy:	±2% of setting and ±1 cycle

Reverse-Phase-Sequence Voltage (device 47)

Threshold:	Fixed at 50% of $Vnom_{L-N}$
Accuracy:	±3% of setting and ±2 V at nominal frequency
Time Delay:	Fixed at 30 cycles
Timer Accuracy:	±1 cycle

Undervoltage (device 27) and Overvoltage (device 59)

Specifications are at 20°C and at nominal system frequency.

Setting Range:

device 27:	OFF, 50–100% of $Vnom_{L-N}$, 1% steps
device 59:	OFF, 50–144% of $Vnom_{L-N}$, 1% steps
Accuracy:	±3% of setting and ±2 V at nominal frequency
Time Delay Range:	0–16000 cycles in 0.25-cycle steps
Timer Accuracy:	±2% of setting and ±1 cycle

Voltage Synchronization (device 25)

Slip Frequency:

Slip Frequency Pickup Range:	0.1–0.5 Hz in 0.1-Hz steps
Slip Frequency Pickup Accuracy:	±0.1 Hz

Close Angle:

Range: 2–60 degrees in 1-degree steps

Accuracy: Greater of:
±1 degree or
± (system slip [Hz] • 12 degrees/Hz)

Voltage Difference:

Setting Range: OFF, 1–50% of $Vnom_{L-N}$, 1% steps

Accuracy: ±3% of setting and ±2 V

Metering

Accuracies specified at 20°C and at nominal system frequency unless otherwise noted.

Voltages (45 V_{L-N} to 440 V_{L-N})

VA, VB, VC, VS: ±1%

Phase Angle Accuracy: ±1 degree

Current (0.05 A to 6.25 A)

IA: ±1% and ±1 mA

Phase Angle Accuracy: ±1 degree

Frequency Accuracy: ±0.1 Hz (40–70 Hz)

Integration and Automation

Communications Ports

EIA-232: 1 Front, DB 9-pin female receptacle

EIA-485: 1 Side, 5-position terminal block

Data Speed: 300–19200 bps

Type Tests

Electromagnetic Compatibility

Electromagnetic Compatibility Emissions: IEC 60255-25:2000
Radiated and conducted emissions

Electromagnetic Compatibility Immunity

Fast Transient Disturbance: IEC 60255-22-4:1992
4 kV at 2.5 kHz

Radiated EMI: IEC 60255-22-3:2000, 10 V/m
IEEE C37.90.2-1995, 35 V/m

Electrostatic Discharge: IEC 60255-22-2:1996
IEEE C37.90.3-2001, 8 kV contact

Magnetic Field Immunity: IEC 61000-4-8:1993
1000 A/m for 3 seconds,
100 A/m for 1 minute
IEC 61000-4-9:1993
1000 A/m pulse

Surge Withstand Capability Immunity: IEC 60255-22-1:1988
All Except Contact Inputs:
2.5 kV peak common mode
2.5 kV peak differential mode
Contact Inputs:
1 kV peak common mode
500 V peak differential mode
IEEE C37.90.1-1989
3.0 kV oscillatory
5.0 kV fast transient

Environmental Tests

Cold: IEC 60068-2-1:1990
Normal operating status at –40°C for 16 hours

Dry Heat: IEC 60068-2-2:1974
Normal operating status at +85°C for 16 hours

Damp Heat Cyclic: IEC 60068-2-30:1980
Normal operating status at 55°C, 6 cycles, 95% humidity

Sinusoidal Vibration: IEC 60255-21-1:1988
Vibration endurance, Class 1
Vibration response, Class 1

Shock and Bump: IEC 60255-21-2:1988
Shock withstand and bump, Class 1
Shock response, Class 2
IEC 60255-21-3:1993
Quake response, Class 2

Safety

Dielectric Strength and Impulse

Dielectric (HIPOT): IEEE C37.90-2005

Impulse: IEC 60255-5:2000

Section 2
Installation

Overview

The first steps in applying the SEL-547 Relay are installing and connecting the relay. This section describes common installation features and particular installation requirements for two common applications of the SEL-547.

This section provides basic wiring specifications and details for connecting the SEL-547 to your system. Please review these specifications and choose the wiring and connection diagrams (transfer switch site or individual generator site) appropriate to your application. If you are developing a custom application, please consult the SEL-547 *Reference Manual* for more detailed information about the settings and commands available with the SEL-547.

This section provides the following information:

- Top and front views of the SEL-547
- Wiring connection detail diagrams
- Hardware installation instructions

Task 1: Mounting the Relay Enclosure

Step 1. Mount the SEL-547 in a protected environment where the relay will not be exposed to direct sunlight, precipitation, or full wind pressure.

The mounting location should not exceed the temperature and humidity ratings for the relay (see *Specifications on page U.1.15*).

Step 2. Mount the SEL-547 on a panel. See *Figure 2.1* for dimensions.

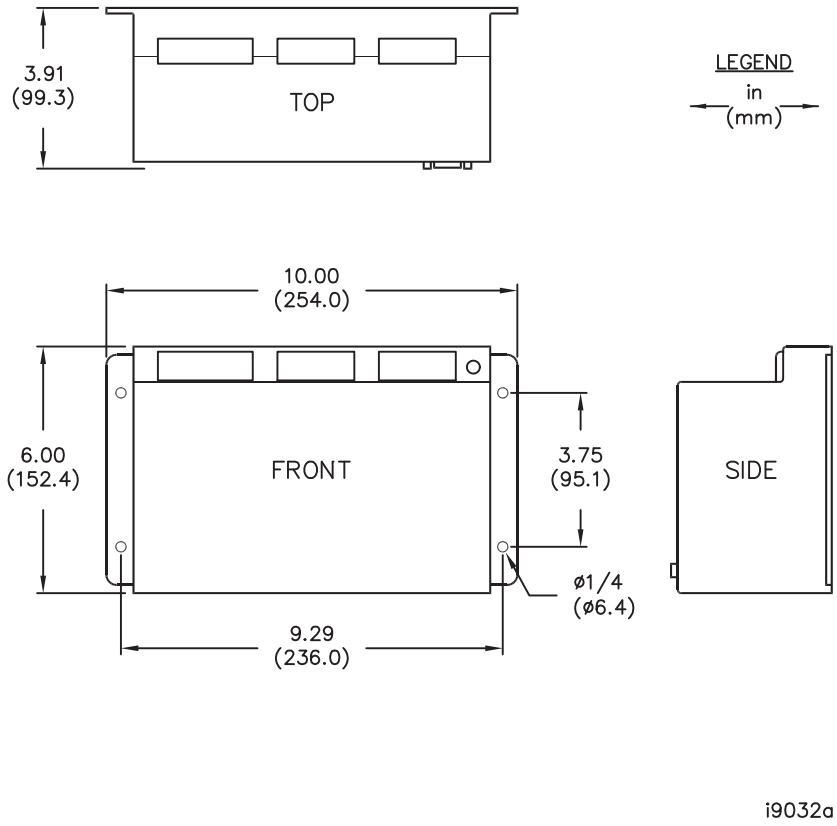


Figure 2.1 SEL-547 Chassis Dimensions (not to scale)

Task 2: Connecting the Relay

Grounding

Always attach a safety ground as the first connection you make to the SEL-547. Connect the grounding terminal labeled **GND** (terminal 38) to a rack frame ground or earth ground for proper safety and performance.

Wiring Specifications

The SEL-547 top view in *Figure 2.2* shows all the available connections and terminal position numbers.

The SEL-547 front view in *Figure 2.2* shows the front-panel LEDs and serial communications Port F (EIA-232).

⚠DANGER
Contact with instrument terminals can cause electrical shock that can result in injury or death.

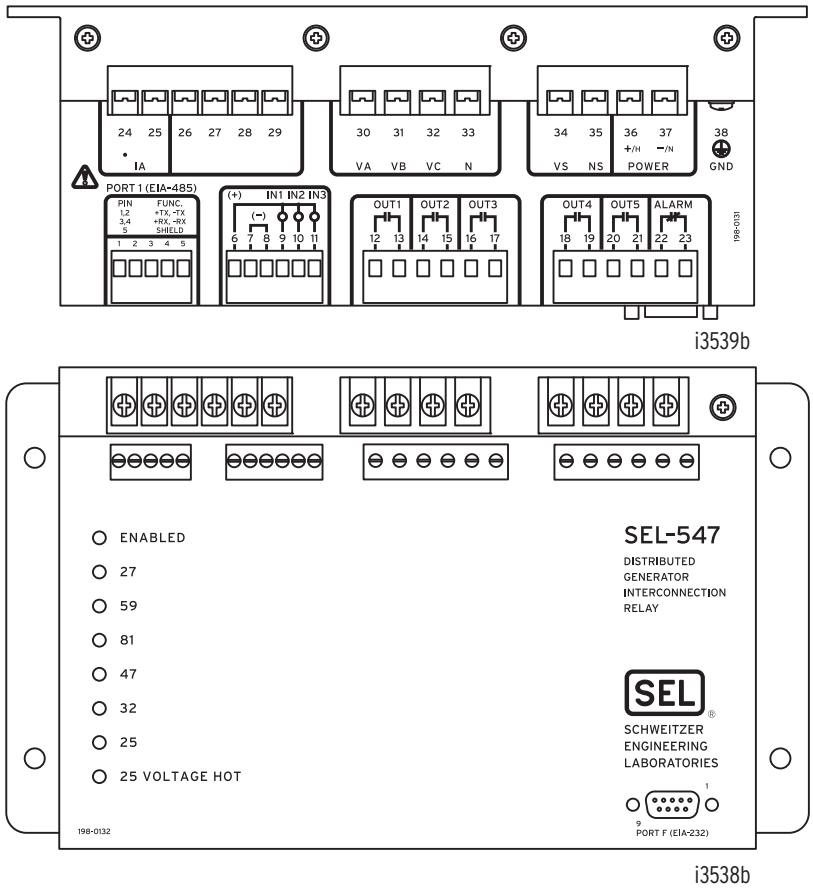


Figure 2.2 SEL-547 Top and Front Views

Terminal positions **1**–**23** are compression terminals, where a stripped wire is inserted into the terminal and held in place by tightening a small screw on top of each respective terminal position.

Terminal positions **24**–**38** are screw terminals, where a wire with a ring terminal is held in place by tightening down the larger screw for each respective terminal position. Note that terminal positions **26**–**29** are not used—do **not** make any connections to them.

Table 2.1 lists dimensional and tightening torque information for these terminals.

Table 2.1 Terminal Wiring Specifications

Terminals	Wire Size or Screw Size / Lug Width	Tightening Torque
1–**23**	24 to 12 AWG (strip 8 mm [0.3 in] and install with a small slotted-tip screwdriver; maximum of two wires per terminal)	Min: 0.4 Nm (3.5 in-lb) Max: 0.6 Nm (5.3 in-lb)
24–**38**	Screw size: #6-32 Lug width: 8.4 mm (0.33 in) (lug width not a restriction for terminal **38**)	Min: 0.9 Nm (8 in-lb) Max: 1.4 Nm (12 in-lb)

Voltage and Current Connections

IMPORTANT NOTE: For personnel safety and equipment protection, ensure that appropriate fuses are installed on the voltage connections to terminal positions 30 (VA), 31 (VB), 32 (VC), and 34 (VS).

Figure 2.4 shows wye-connected voltages [208 Vac to 480 Vac line-to-line (corresponding 120 Vac to 277 Vac line-to-neutral)] connect directly to voltage inputs **VA**, **VB**, **VC**, and neutral-point **N**.

The connection is made directly—there are no interposing voltage transformers. These voltages are used in the following protection and control elements:

- Undervoltage tripping (device 27)
- Overvoltage tripping (device 59)
- Over- and underfrequency tripping (device 81)
- Reverse-phase-sequence (i.e., negative-sequence) alarming (device 47)
- Directional power tripping (device 32)
- Synchronism check close supervision (device 25)

Single-phase voltage (120 Vac to 277 Vac line-to-neutral) connects directly to voltage input **VS/NS**. The connection is made directly—there are no interposing voltage transformers—and the connection is made to A-phase. This A-phase connection facilitates synchronism check element operation (A-phase voltage on terminals **VS/NS** is synchronism checked with A-phase voltage on terminals **VA/N** on the other side of the open breaker/switch—see *Synchronism Check Element Settings (device 25) on page U.3.19* for more details).

Single-phase current (A-phase, 5 A secondary nominal) is brought into current input **IA**. The connection is made to a current transformer on A-phase. This A-phase connection facilitates directional power element operation (A-phase current into the **IA** terminals is combined with A-phase voltage on terminals **VA/N** to derive a directional power element—see *Directional Power Element Settings (device 32) on page U.3.18* for more details).

Voltage and current input ratings are in *Specifications on page U.1.15*.

Control Inputs

Figure 2.4 shows optoisolated input connections, but they are not needed to operate the SEL-547 directly from the factory. Thus, you do not need to make connections to terminal positions **6** through **11**, unless you are using SELOGIC® control equation programming that makes use of the optoisolated inputs. (See *Section 2: SELOGIC Control Equation Programming in the Reference Manual*.)

If you use the optoisolated inputs, observe the polarity indicated in the connections in *Figure 2.4* (voltage range 6–32 Vdc).

- Note that terminal position **6** makes an internal positive voltage connection to each optoisolated input (**IN1**–**IN3**).
- Also, note that terminal positions **7** and **8** are bused together internally, providing an effective negative voltage bus.

Control Outputs

The output contacts in *Figure 2.4* (**OUT1**–**OUT5** and **ALARM**) are dry contacts and are not polarity dependent.

Output contacts **OUT1**–**OUT5** provide tripping and close-supervision functions.

- The trip contacts (e.g., **OUT4**) trip directly, in parallel with tripping from the generator controller (the generator controller is separate from the SEL-547).
- The close contacts (e.g., **OUT1**) provide synchronism check close supervision for close signals coming from the generator controller.

IMPORTANT NOTE: SEL-547 output contacts are **not** meant to interrupt substantial currents. See the output contacts interrupt rating in Specifications on page U.1.15.

The dedicated **ALARM** output contact comes as a b contact (normally closed). Under normal operating conditions (relay powered up and OK), the **ALARM** output contact is open. If you approve settings changes or change a password, the **ALARM** output contact closes for one second (see the **PAS** and **SET** commands in *Section 3: Basic Relay Operations*). If a status warning occurs, the **ALARM** output contact closes for five seconds. For a status failure or loss of power to the SEL-547, the **ALARM** output contact closes and remains closed.

Alternative Close Supervision Wiring

In *Figure 1.1*, the close supervision output contacts of the SEL-547 (**OUT1** and **OUT2**) are shown wired in series with close output contacts from the separate generator controller. Alternatively (as shown in *Figure 2.3*), a close supervision output contact of the SEL-547 could be wired to an input on the generator controller—signaling to the generator controller when the SEL-547 sees appropriate synchronism check close conditions. Then the direct close action would be taken just by the close output contacts of the generator controller.

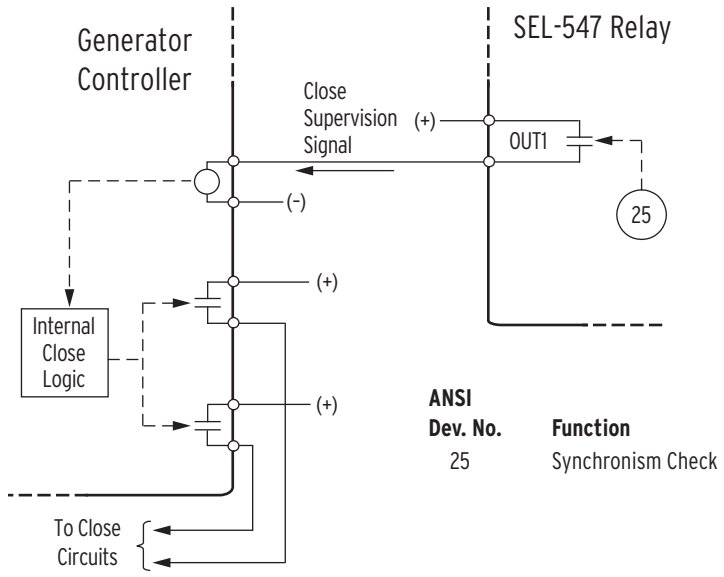


Figure 2.3 Alternative Close Supervision Wiring

The achieved results in *Figure 2.3* (i.e., supervision of closing by the SEL-547 synchronism check element) are effectively the same as the portrayed close circuits in *Figure 1.1*, but without two close output contacts (one from the

SEL-547 and one from the generator controller) wired in series for an effective close. The realization of the scheme shown in *Figure 2.3* is dependent on the following:

- The nature of the generator controller input (to which the SEL-547 close supervision output contact wires to, if such an input is available)
- The internal close logic in the generator controller (if it is configurable to take in the SEL-547 close supervision signal).

The close circuit wiring in *Figure 2.3* would nearly eliminate the possibility of damaging an SEL-547 close supervision output contact (the SEL-547 close supervision output contact asserts a relatively high-impedance input on the generator controller—no high-magnitude current to be interrupted). Any possible close circuit current interruption would be handled by the generator controller close output contacts or by other means.

Connection Diagrams

You can apply the SEL-547 in many power system protection schemes. *Figure 2.4* and *Figure 2.5* show the connection details for two common SEL-547 applications.

Note that only the power system voltage and current connection **differences** are shown in *Figure 2.5*, in contrast to *Figure 2.4*—other connections (e.g., **POWER**) remain the same.

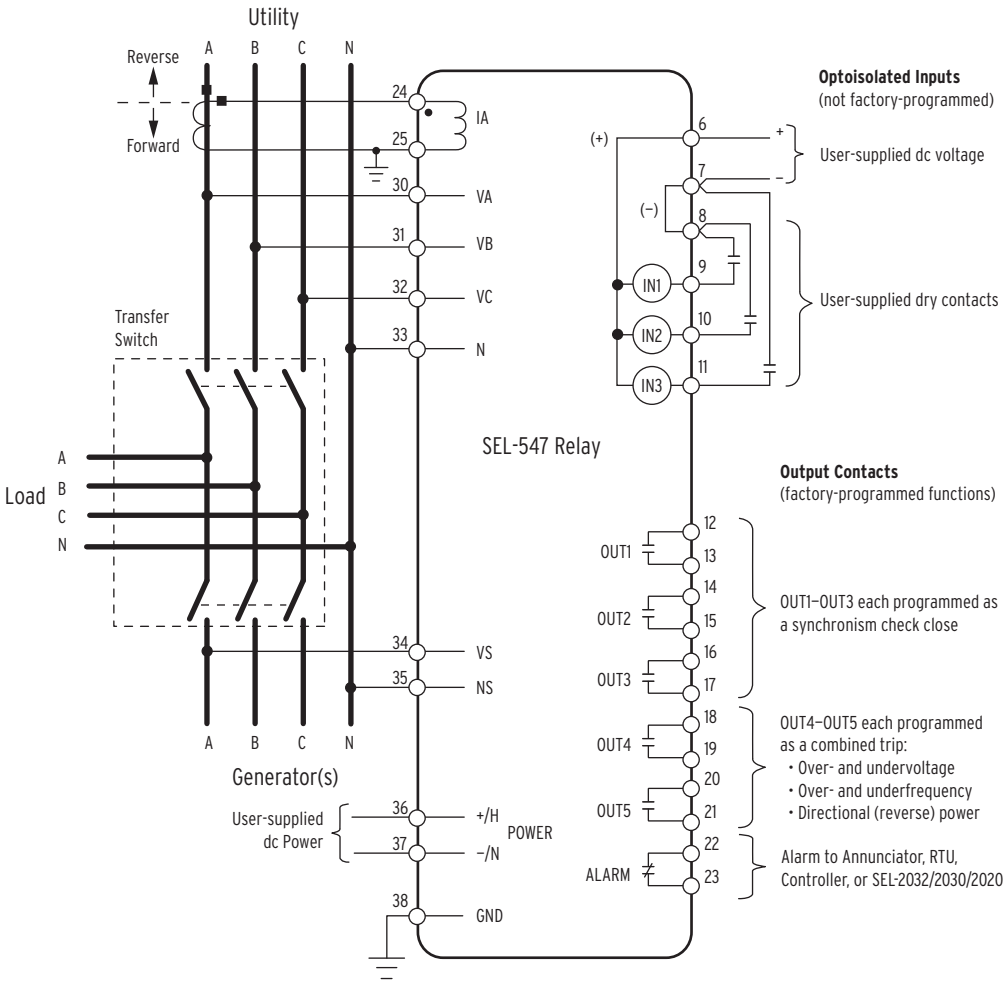


Figure 2.4 Connection Details (Transfer Switch Site Application)

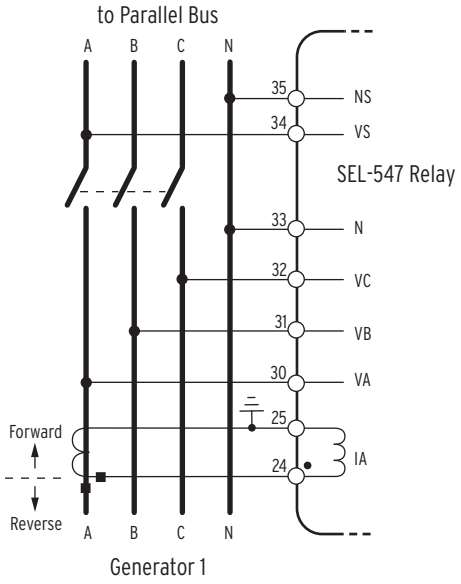


Figure 2.5 Voltage and Current Connection Details (Individual Generator Site Application)

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Section 3
Basic Relay Operations

Overview

The SEL-547 Relay is a powerful tool for generator protection. Understanding basic relay operation principles and methods will help you use the SEL-547 effectively. This section presents the fundamental knowledge you need to operate the SEL-547, organized by task. These tasks help you become familiar with the relay and include the following:

- Powering the unit
- Establishing communication
- Changing the default passwords
- Checking relay status
- Setting the date and time
- Understanding and using EZ settings
- Viewing metering quantities
- Reading SER and event reports
- Operating relay outputs
- Checking LEDs

Perform these tasks to gain a good understanding of relay operation and to confirm that the relay is properly connected.

Task 3: Powering the Unit

Step 1. Power the SEL-547 with 6 to 32 Vdc (consumption < 10 watts).

Observe proper polarity, as indicated by the **+/H** (terminal position **36**) and the **–/N** (terminal position **37**) on the **POWER** connections.

Upon connecting power, the **ENABLED** LED should illuminate, after the relay does an internal self-check.

Task 4: Establishing Communications

Making a Serial Port Connection

The SEL-547 has two serial communications ports:

- Front-panel Port F (EIA-232)
- Top-side panel Port 1 (EIA-485)

The following steps use any popular computer terminal emulation software and SEL serial cables to connect to the SEL-547. Use an SEL Cable C234A to connect a 9-pin computer serial port to the SEL-547. Use an SEL Cable C227A to connect a 25-pin computer serial port to the relay. See *Section 4: Communications in the Reference Manual* for further information on serial communications connections. These and other cables are available from SEL. Contact the factory or your local distributor for more information.

Step 1. Connect the computer and the SEL-547 using the serial communications cable.

Use the 9-pin serial port labeled **PORT F** on the relay front panel.

Step 2. Apply power to both the computer and to the relay.

Step 3. Start the computer terminal emulation program.

Step 4. Set your computer terminal emulation program to the communications port settings listed in the Default Value column of *Table 3.1*.

Also set the terminal program to emulate either VT100 or VT52 terminals. These terminal emulations work best with SEL relays.

Table 3.1 SEL-547 Serial Port Settings (Sheet 1 of 2)

Description	Setting Label	Default Value	
		Port F (EIA-232)	Port 1 (EIA-485)
Protocol (SEL, LMD, MOD)[a] SEL=SEL ASCII Protocol LMD=SEL Distributed Port Switch Protocol MOD=MODBUS Protocol	PROTO	SEL	MOD
Baud Rate (300, 1200, 2400, 4800, 9600, 19200)	SPEED	9600	9600
Data Bits (7, 8)[b]	BITS	8	
Parity (O, E, N) O=odd, E=even, N=None	PARITY	N	N
Stop Bits (1, 2)	STOP	1	2
Minutes to Port Time-Out (0–30)[b]	T_OUT	15	

Table 3.1 SEL-547 Serial Port Settings (Sheet 2 of 2)

Description	Setting Label	Default Value	
		Port F (EIA-232)	Port 1 (EIA-485)
Send Auto Messages to Port (Y, N)[b]	AUTO	N	
Enable Hardware Handshaking (Y, N)[c]	RTSCTS	N	
Fast Operate Enable (Y, N)[b]	FASTOP	N	
MODBUS Slave ID (1–247)[d]	MODID		1

[a] SEL ASCII protocol (setting PROTO = SEL) allows you to communicate with the SEL-547 by entering the commands listed in Table 3.3.
Only one port at a time can be designated as a MODBUS® port (setting PROTO = MOD). See Section 6: MODBUS RTU Communications in the Reference Manual for more information on MODBUS protocol.
[b] The indicated settings are not available on a designated MODBUS port (setting PROTO = MOD).
[c] The Enable hardware handshaking setting RTSCTS is only available on Port F (EIA-232), when setting PROTO = SEL.
[d] The MODBUS slave ID setting MODID is only available on the designated MODBUS port (setting PROTO = MOD).

Step 5. Check the communications link by pressing the **<Enter>** key on the computer keyboard to confirm that you can communicate with the relay.

You will see the = prompt at the left side of your computer screen (column 1). If you do not see the prompt, check the cable connections and confirm the settings for the default communications parameters of *Table 3.1* in your terminal emulation program.

Step 6. View the relay report header.

a. Type **QUIT <Enter>**.

You will see a computer screen display similar to *Figure 3.1*. If you see jumbled characters, change the terminal emulation type in the computer terminal program.

```
=QUIT <Enter>

GENERATOR                                Date: 03/15/2002 Time: 00:01:05.209
STATION A
=
```

Figure 3.1 Response Header

When you communicate with the relay at the = prompt, you are in security Access Level 0. You cannot control relay functions at this level. Higher access levels are password protected and allow increased control over relay operation.

Task 5: Changing the Default Passwords

Access Levels, Passwords, and ASCII Commands

Table 3.2 and *Table 3.3* combined show

- Basic access levels
- Commands and default passwords required to enter those access levels
- Commands available at these basic access levels

At a given access level, you can issue any of the commands that you can issue at a lower access level. For example, the **MET** command is an Access Level 1 command that also works when the serial port is at higher Access Level B.

Commands are case insensitive; you can enter the command with any combination of upper- and lowercase letters (for example: **MET**, **Met**, or **met**).

Use **<Ctrl+X>** (hold down the **Ctrl** key and press the **X** key on your PC keyboard) to abort any command and get back to the prompt of the current access level.

Table 3.2 Access Levels and Passwords

Desired Access Level	Access Level Command	Factory Default Password	Resulting Prompt	What can I do at this Access Level?
0 (lowest)	If at higher access level, enter **QUIT** command to return to Access Level 0.	No password required; this is the access level at initial connection.	=	Can only go to Access Level 1.
1	**ACC** (enter at Access Level 0)	OTTER	=>	View information (e.g., metering values) and settings (cannot change settings); go to Access Level B.
B	**BAC** (enter at Access Level 1)	EDITH	==>	Operate output contacts and change settings.

NOTE: More commands are available for each access level than are listed in Table 3.3. There are also more commands available at an additional access level (Access Level 2). See Section 7: ASCII Commands in the Reference Manual for more information on these commands.

Table 3.3 Available ASCII Commands, by Access Level

Access Level	Prompt	Serial Port Command	Command Description
0	=	**ACC**	Go to Access Level 1 (see *Table 3.2*)
1	=>	**BAC**	Go to Access Level B (see *Table 3.2*)
1	=>	**DAT**	View/change date
1	=>	**MET**	View metering data
1	=>	**QUIT**	Quit and go to Access Level 0 (see *Table 3.2*)
1	=>	**SER**	Display Sequential Events Recorder data
1	=>	**SHO E**	Show/view EZ settings
1	=>	**SHO P *n***	Show/view serial port *n* settings (*n* = 1 or F)
1	=>	**STA**	View relay status/identification information
1	=>	**TIM**	View/change time
B	==>	**PUL**	Pulse output contact
B	==>	**SET E**	Change EZ settings
B	==>	**SET P *n***	Change serial port *n* settings (*n* = 1 or F)
B	==>	**PAS**	View/change passwords

PAS (Password Command)

⚠WARNING
This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

Use the **PAS** command to view or change existing passwords.

Step 1. After establishing communication with the SEL-547, you should be at Access Level 0.

Verify this by pressing the **<Enter>** key and receiving a relay response of an = prompt.

Step 2. Enter Access Level 1 with the command and password from *Table 3.2*.

Step 3. Enter Access Level B with the command and password from *Table 3.2*.

Step 4. Issue the **PAS** command at Access Level B.

The SEL-547 responds with a list of the passwords (factory default passwords shown below—compare to *Table 3.2*):

```
1: OTTER
B: EDITH
```

Step 5. Change the Access Level B password from EDITH to a unique password.

For example, to change it to tY76r3, enter

PAS B tY76r3

The other access level passwords are similarly changed.

Passwords may contain up to six (6) characters. Valid characters include

A–Z (uppercase letters)

a–z (lowercase letters)

0–9 (numerals)

- (hyphen)

. (period)

Note above that uppercase and lowercase letters are treated as different characters. Strong passwords (i.e., passwords not easily cracked/broken) consist of

The maximum six (6) characters

Contain at least one special character or numeral and mixed-case letters

Do not form a name, date, acronym, word, or anything intuitive

Step 6. Review and verify your new passwords, by entering the **PAS** command again.

```
1: OTTER
B: tY76r3
```

Step 7. Record the passwords.

After any password change, the **ALARM** output contact closes for one second.

Disable Passwords

Step 1. To disable Access Level 1 password protection, enter

PAS 1 DISABLE

(this must be entered in uppercase letters)

The other access level passwords are similarly disabled.

Step 2. Verify that the Access Level 1 password is disabled by entering the **PAS** command.

```
1: DISABLE
B: tY76r3
```

Step 3. Record the passwords.

Once a password is disabled, you will no longer need a password to enter that Access Level.

After any password change, the **ALARM** output contact closes for one second.

Passwords Forgotten or Lost?

For the first 60 seconds after power up, the passwords are defeated and you can gain access to whatever desired level (issuing the access commands given in *Table 3.2*) without having to enter the corresponding password. This is helpful in instances when the password has been forgotten or lost. After gaining such access, you can view or change the passwords by issuing the **PAS** command at Access Level B.

Task 6: Checking Relay Status

STA (Status Command)

Use the **STA** command to view SEL-547 internal self-test status. Numerous channels and components are monitored, and the results (offset [**OS**] voltage values or **OK/Fail** messages) are listed in *Figure 3.2*:

```
=>STA <Enter>

GENERATOR 1                        Date: 04/30/02    Time: 00:57:08.742
STATION A

FID=SEL-547-R100-V0-Z001001-D20020430 CID=xxxx

SELF TESTS

W=Warn    F=Fail

       IA      VA      VB      VC      VS      IA8
OS    -0       7       7       8       5       4

       MOF     FREQ    RAM     ROM     A/D     CR_RAM  EEPROM
       OK      OK      OK      OK      OK      OK      OK

Relay Enabled

=>
```

Figure 3.2 STA Command Response

The following are appended to the offset voltage values in the **STA** command output, if there is a problem with the components corresponding to these offset voltages:

W—for Warning

F—for Fail

For a W (Warning)

- the **ALARM** output contact pulses for five seconds
- an automatic message is sent to the port when port setting AUTO = Y
- the relay is **not** disabled

For a F (Failure)

- the **ALARM** output contact closes and stays closed
- an automatic message is sent to the port when port setting AUTO = Y
- the relay is disabled

STA Command Helps Uniquely Identify the Relay

The beginning of the status report printout (see *Figure 3.2*) contains SEL-547 settings RELID (Relay Identifier) and TERMID (Terminal Identifier), the relay firmware identification string (FID), and checksum string (CID). These strings contain information to uniquely identify the relay and the version of firmware that is operating.

Task 7: Setting the Date and Time

DAT (Date Command)

Use the **DAT** command to view or change the date stored in the SEL-547.

Viewing the Date

Enter **DAT** at the prompt to view the date stored in the SEL-547.

NOTE: The SEL-547 does not have battery backup to maintain the clock (time and date) when control power is removed from the relay.

The relay will reply with the stored date. For example, it replies with

```
4/13/02
```

If the corresponding DATE setting (see *Table 3.5*) is set as MDY, then this date is April 13, 2002. If the DATE setting was set as YMD, the SEL-547 would have replied (for April 13, 2002) with

```
02/4/13
```

Changing the Date

Enter **DAT and** the correct date at the prompt to change the date stored in the SEL-547.

For example, to change the date stored in the SEL-547 to May 2, 2002 (when the DATE setting is set MDY), enter the following at the prompt:

DAT 5/2/02

To change the date stored in the SEL-547 to November 22, 2002 (when the DATE setting is set YMD), enter the following at the prompt:

DAT 02/11/22

You can separate the month, day, and year parameters with spaces, commas, slashes (used above), colons, and semicolons.

TIM (Time Command)

Use the **TIM** command to view or change the time stored in the SEL-547.

Viewing the Time

Enter **TIM** at the prompt to view the time stored in the SEL-547.

The relay will reply with the stored date. For example, it replies with

```
2:36:47
```

This time is 2:36 a.m. (and 47 seconds).

Changing the Time

Enter **TIM** *and* the correct time at the prompt to change the time stored in the SEL-547.

For example, to change the time stored in the SEL-547 to 5:14 p.m., enter the following at the prompt:

TIM 17:14:00

You can separate the hours, minutes, and seconds parameters with spaces, commas, slashes, colons (used above), and semicolons.

Task 8: Understanding and Using EZ Settings

This section describes the SEL-547 EZ settings. These settings are preset for protection and control elements used in either of the common applications (transfer switch or individual generator) and are listed in *Table 3.5*.

If you are developing a custom application that is beyond the scope of the EZ settings, please refer to *Section 8: Settings in the Reference Manual*, which discusses additional settings not available in the EZ settings.

Most of the EZ settings are explained in the figures that follow in this section. Some of the settings differences between the applications are explained in the following settings examples text. Variations of settings are possible, depending on local utility practice and interpretation of applicable standards.

An EZ settings sheet is in *Appendix C: SEL-547 Relay EZ Settings Sheet*.

Making EZ Settings Changes

EZ settings can be

- Displayed via the **SHO E** (show EZ settings) command, or
- Set via the **SET E** (set EZ settings) command.

Table 3.5 lists the EZ settings (protection and control settings) made with the **SET E** command. To jump directly to a particular setting (e.g., setting 27BLKP), enter the command: **SET E 27BLKP**. To jump directly to a particular setting (e.g., setting 27BLKP) and not have all the settings scroll by for approval at the end, enter the command: **SET E 27BLKP TERSE**.

Use the navigation keystrokes listed in *Table 3.4* while making settings.

Table 3.4 Actions at Settings Prompts

Keystrokes	SEL-547 Response
<Enter>	Accept setting and move to the next setting; if at the last setting, exit settings.
[value] <Enter>	Enter the given value, validate it, and move to the next setting if valid; if at the last setting, exit settings.
^ <Enter>	Move to the previous setting; if at the top of settings, stay at the present setting.
< <Enter>	Move to the top of the previous settings category; if at the top of settings, stay at the present setting.
> <Enter>	Move to the top of the next settings category; if in the last category, exit settings.
END <Enter>	End the present settings session, so you do not have to scroll through all the remaining settings. Prepare to exit settings via the `Save changes (Y,N)?` prompt.
<Ctrl+x> <Enter>	Abort settings session without saving changes and get back to the prompt of the access level you are in.

While you are editing settings, the relay remains active with the previous settings (the new, desired settings have not been approved/saved yet). When new EZ settings are approved, the relay will be disabled for a few seconds, while the new EZ settings are being saved. The **ALARM** output contact also closes for one second.

Set Elements OFF if Not Used

If you are not using an element (e.g., the directional power element), make sure to set the corresponding pickup setting equal to OFF (e.g., 32P = OFF). If the pickup setting for a particular element is set equal to OFF, then the other corresponding settings for the element (e.g., time delay setting 32D) are hidden. Pickup setting 27BLKP (undervoltage block pickup—blocks the operation of the frequency elements) is the only pickup setting that cannot be set equal to OFF.

Table 3.5 EZ Settings for Protection and Control Elements in the SEL-547 (Sheet 1 of 2)

Description	Setting Label	Default Value
General Settings		
Relay Identifier (30 characters)	RELID	GENERATOR 1
Terminal Identifier (30 characters)	TERMID	STATION A
Current Transformer Ratio (1–1000)	CRATIO	80
Nominal Voltage, line-to-line (208–480 Vac)	NOMV	208
Three-Phase Voltage Connection (WYE) [fixed setting]	3PCONN	WYE
Nominal System Frequency (50, 60 Hz)	FREQ	60
Phase Rotation (ABC, ACB)	ROTATE	ABC
Date Format (MDY, YMD)	DATE	MDY
LED Flash Interval (OFF, 5, 10, 15, 30, 60 s)	LEDFL	30
Voltage Element Settings (device 27/59; 4 elements)		
Undervoltage 1 Pickup (OFF, 50–100%)[a]	27UV1P	50
Undervoltage 1 Time Delay (0.00–16000 cyc)[b]	27UV1D	6.00

Table 3.5 EZ Settings for Protection and Control Elements in the SEL-547 (Sheet 2 of 2)

Description	Setting Label	Default Value
Undervoltage 2 Pickup (OFF, 50–100%)[a]	27UV2P	88
Undervoltage 2 Time Delay (0.00–16000 cyc)[b]	27UV2D	116.00
Overvoltage 1 Pickup (OFF, 50–144%)[a]	59OV1P	110
Overvoltage 1 Time Delay (0.00–16000 cyc)[b]	59OV1D	56.00
Overvoltage 2 Pickup (OFF, 50–144%)[a]	59OV2P	120
Overvoltage 2 Time Delay (0.00–16000 cyc)[b]	59OV2D	6.00
Frequency Element Settings (device 81; 4 elements)		
Undervoltage Block Pickup (50–100%)[a]	27BLKP	70
Over- and Underfrequency 1 Pickup (OFF, 40.1–69.9 Hz)	81OU1P	57.0
Over- and Underfrequency 1 Time Delay (5.00–16000 cyc)[b]	81OU1D	6.00
Over- and Underfrequency 2 Pickup (OFF, 40.1–69.9 Hz)	81OU2P	59.3
Over- and Underfrequency 2 Time Delay (5.00–16000 cyc)[b]	81OU2D	116.00
Over- and Underfrequency 3 Pickup (OFF, 40.1–69.9 Hz)	81OU3P	60.5
Over- and Underfrequency 3 Time Delay (5.00–16000 cyc)[b]	81OU3D	6.00
Over- and Underfrequency 4 Pickup (OFF, 40.1–69.9 Hz)	81OU4P	OFF
Over- and Underfrequency 4 Time Delay (5.00–16000 cyc)[b]	81OU4D	6.00
Directional Power Element Settings (device 32; 1 element)		
Three-Phase Power Pickup (OFF, 40–900 watts, secondary)	32P	60
Power Element, Forward or Reverse (F, R)	32FR	R
Power Element Time Delay (0.00–16000 cyc)[b]	32D	30.00
Synchronism Check Element Settings (device 25; 1 element)		
Difference Voltage Pickup (OFF, 1–50%)[a]	25DIFP	10
Maximum Slip Frequency (0.1–0.5 Hz)	25SLP	0.3
Maximum Angle (2–60 degrees)	25ANG	20

[a] Voltage pickup settings are in percent of Vnom (see Figure 3.4).
[b] All time delay settings are set in 0.25-cycle steps.

Settings Examples and Element Realization

Settings RELID and TERMID

Settings RELID and TERMID are listed as a header in the output response of a number of the serial port commands (see *Section 7: ASCII Commands in the Reference Manual*). They more readily allow the relay output to be identified, helping answer the question, “Which relay did this information come from?”

In *Figure 3.3*, the SEL-547 of interest is the one on Generator 1 (setting RELID = GENERATOR 1) and the greater facility within which the eight generators reside is called Station A (setting TERMID = STATION A).

For an application at a transfer switch site, as opposed to an individual generator site, setting RELID might be set something like RELID = TRANSFER SWITCH, instead.

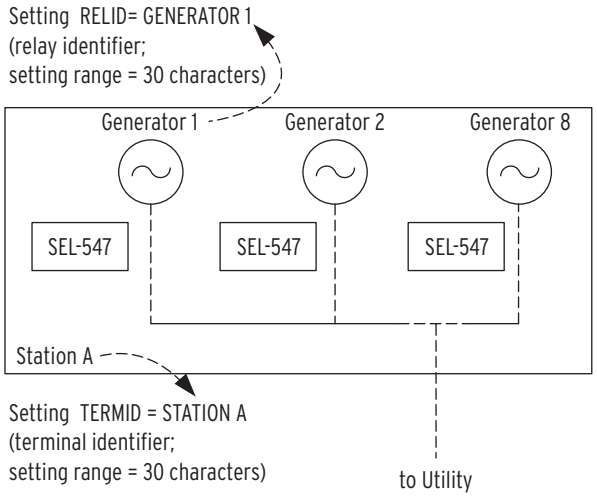


Figure 3.3 Settings RELID and TERMID

Setting CRATIO

In *Figure 3.4*, setting CRATIO = 80 (= 400 / 5) is the current transformer ratio setting, corresponding to the current transformer on A-phase, connected to current input IA. Note the polarity indication on terminal position 24 on the relay and the standard polarity indications represented on the current transformer.

Current input **IA** is used later in *Figure 3.14* in calculating effective three-phase real power for the directional power element. Current input **IA** is rated 5 A secondary nominal.

A primary rating of 400 A on the current transformer indicates that the current transformer is most likely on a single generator (e.g., 100 kW generator at 208 V, line-to-line):

$$\frac{100000\ \text{W}}{208\ \text{V} \bullet \sqrt{3}} = 278\ \text{A} \qquad (278\ \text{A} < 400\ \text{A})$$

For a transfer switch site application, the primary rating of the current transformer would likely be considerably larger (because the transfer switch has to handle all the incoming load current).

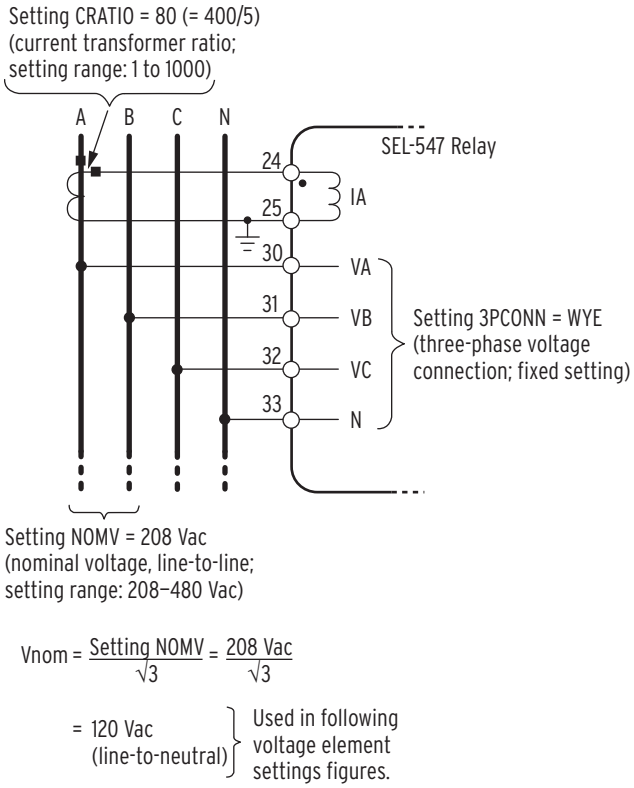


Figure 3.4 Settings CRATIO, 3PCONN, and NOMV

Setting NOMV

In *Figure 3.4*, setting NOMV = 208 Vac is the nominal line-to-line voltage rating of the three-phase voltage connected to voltage inputs **VA**, **VB**, **VC**, and neutral-point **N**. Note that the derived Vnom (= 120 Vac, line-to-neutral) value is used in voltage element figures that follow in this section (*Figure 3.8* through *Figure 3.10* and *Figure 3.15*).

It is assumed that the voltage connected to voltage inputs **VS/NS** (see *Figure 2.4* and *Figure 2.5*) is also at the Vnom rating (= 120 Vac, line-to-neutral).

Setting 3PCONN

In *Figure 3.4*, setting 3PCONN = WYE indicates that the three-phase voltage connected to voltage inputs **VA**, **VB**, **VC**, and neutral-point **N** is wye-connected (i.e., the three-phase voltage has a neutral reference). Note that the voltage is connected directly from the customer's system—no interposing voltage transformers are required, as long as the voltage is 480 Vac line-to-line or less (corresponding 277 Vac line-to-neutral or less).

Setting 3PCONN = WYE is a fixed setting at this time.

Setting FREQ

In *Figure 3.5*, setting FREQ = 60 Hz is the nominal system frequency, used as a reference in frequency element figures that follow in this section.

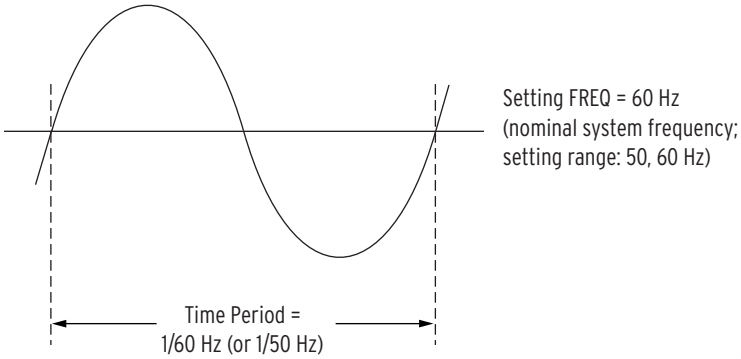


Figure 3.5 Setting FREQ

Setting ROTATE

In *Figure 3.6*, setting ROTATE = ABC is the system phase rotation, used as a reference in following *Figure 3.16*, dealing with reverse-phase rotation.

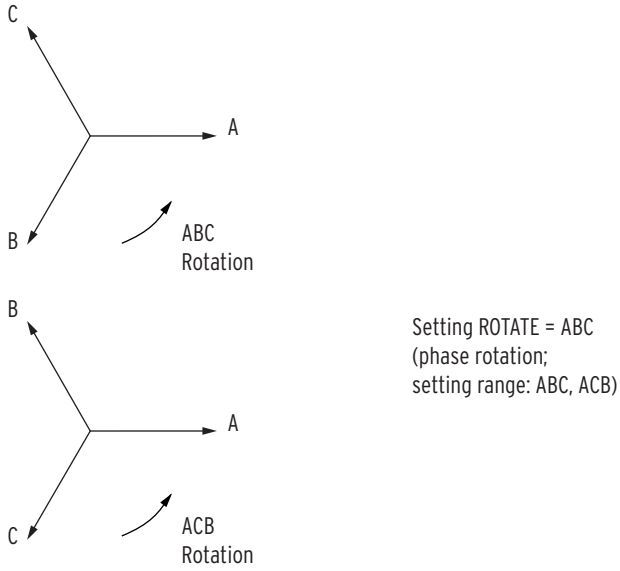


Figure 3.6 Setting ROTATE

Setting DATE

The DATE setting determines whether the date will be entered (via the **DAT** command—see *Task 7: Setting the Date and Time on page U.3.7*) and displayed (in relay report headers—see **STA** command and others in *Task 6: Checking Relay Status on page U.3.6*) in

- Month/Day/Year format (setting DATE = MDY)
- Year/Month/Day format (setting DATE = YMD)

Setting LEDFL

As illustrated in *Figure 3.7*, setting LEDFL determines the time between flashes for simultaneously flashing front-panel LEDs. The SEL-547 has no **{LAMP TEST}** pushbutton, so the LEDs instead flash automatically to indicate that they are operating properly. Flashing can be turned off by setting LEDFL = OFF.

An already illuminated LED does not flash. The **ENABLED** LED, for example, does not flash–this LED always should be illuminated to indicate a functional unit.

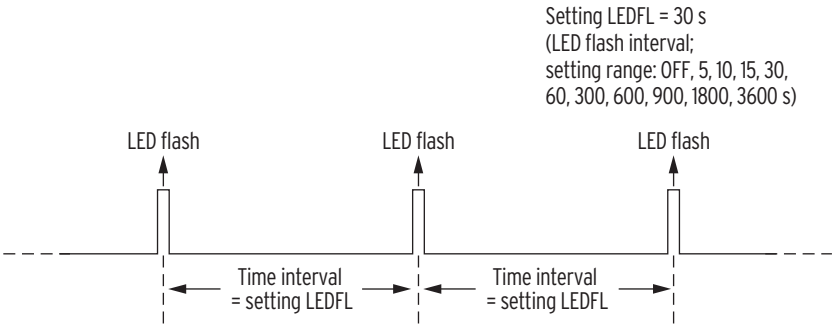


Figure 3.7 Setting LEDFL

Voltage Element Settings (device 27/59)

In *Figure 3.8* and *Figure 3.9*, voltage element pickup settings are set in terms of percentage of Vnom (= 120 Vac, line-to-neutral, derived default value). See *Figure 3.4* for Vnom derivation.

Note that the elements in *Figure 3.8* are closer to Vnom than are the elements in *Figure 3.9*. Correspondingly, the elements in *Figure 3.8* are set with more time delay than those in *Figure 3.9*. In general for any voltage element, if any phase voltage crosses a pickup threshold for the corresponding time delay, a trip is issued (device 27 or device 59 asserts).

NOTE: Consult the IEEE P1547 Standard to make these voltage element settings.

There are two (2) undervoltage and two (2) overvoltage elements available.

Undervoltage conditions are the most common abnormal voltage conditions. But, overvoltage conditions can occur for certain scenarios (e.g., a generator islanding with a small load). Thus, overvoltage elements (device 59) need to be set as well.

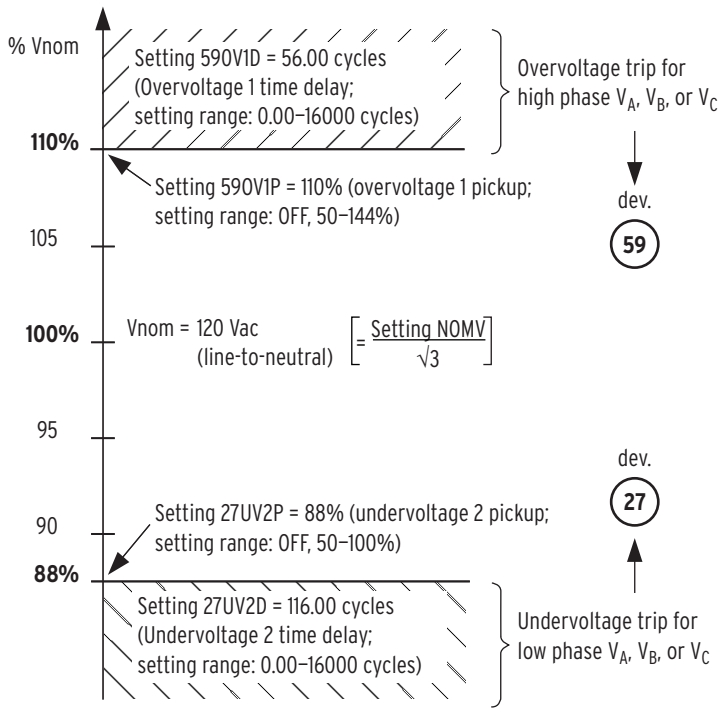


Figure 3.8 Voltage Element Settings–Example 1

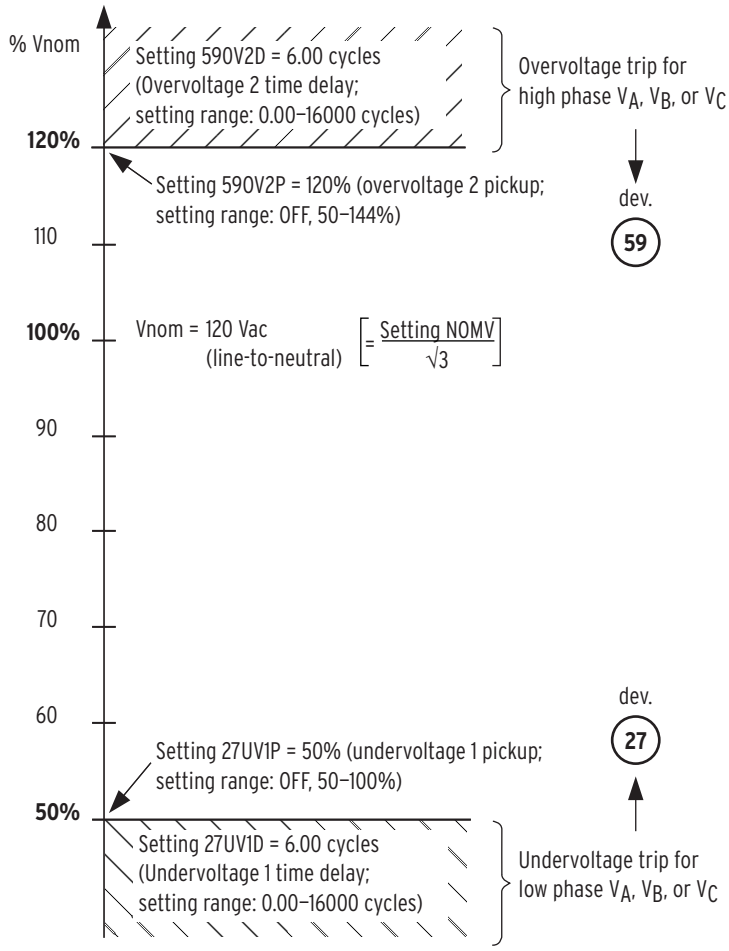


Figure 3.9 Voltage Element Settings—Example 2

Frequency Element Settings (device 81)

Frequency Element Setting 27BLKP

NOTE: Consult the IEEE P1547 Standard to make these frequency element settings.

There are four (4) frequency elements available.

In *Figure 3.10* setting 27BLKP is set in terms of percentage of Vnom (= 120 Vac, line-to-neutral, derived default value). See *Figure 3.4* for Vnom derivation.

Setting 27BLKP = 70% is the voltage pickup threshold for voltage V_A, under which frequency element operation is blocked.

$$0.7 \bullet \text{Vnom} = 0.7 \bullet 120 \text{ Vac} = 84 \text{ Vac, line-to-neutral}$$

NOTE: This undervoltage element blocks frequency element operation.

System frequency is derived from voltage V_A, and there needs to be sufficient voltage signal from which to derive the system frequency. Setting 27BLKP helps ensure this. In this example, if voltage V_A goes below 84 Vac, the operation of all frequency elements is blocked. When voltage V_A goes above 84 Vac, there is a 5-cycle fixed dropout time until the frequency elements are enabled again.

Pickup setting 27BLKP is the only pickup setting that cannot be set equal to OFF. It operates only on voltage V_A—voltages V_B, V_C, and V_S have no effect.

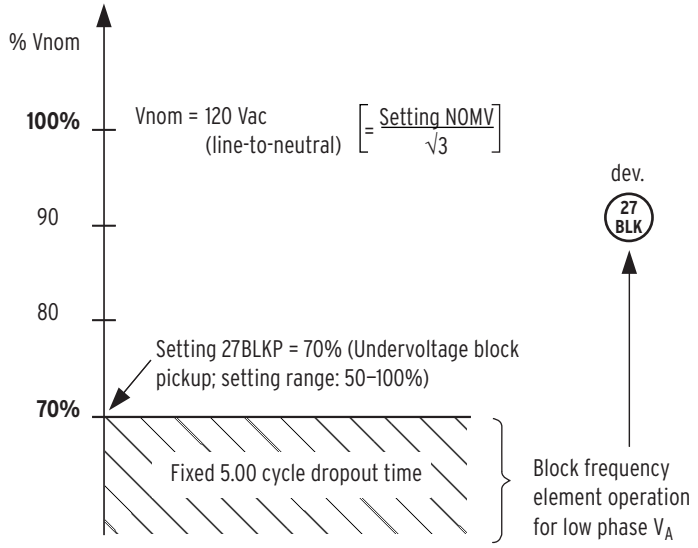


Figure 3.10 Setting 27BLKP (Undervoltage Block)

Settings 81OUXX

Note that the underfrequency element in *Figure 3.12* is closer to the nominal system frequency (setting FREQ = 60 Hz) than is the underfrequency element in *Figure 3.11*. Correspondingly, the underfrequency element in *Figure 3.12* is set with more time delay than the underfrequency element in *Figure 3.11*. In general for any frequency element, if the system frequency crosses a pickup threshold for the corresponding time delay, a trip is issued (device 81 asserts).

Underfrequency conditions are the most common abnormal frequency conditions. But, overfrequency conditions can occur for certain scenarios (e.g., a generator islanding with a small load). Thus, an overfrequency element also needs to be set.

Again, the undervoltage frequency block element in *Figure 3.10* (resultant device 27BLK) blocks the operation of any of the frequency elements in *Figure 3.11* and *Figure 3.12*. Note that the fourth frequency element is not used in these default settings (pickup 81OU4P = OFF).

Because of element accuracy and practicality, the frequency element pickups cannot be set at or next to the nominal system frequency value, as shown in *Figure 3.13*.

System frequency for the frequency elements is derived from voltage V_A. Voltages V_B, V_C, and V_S have no effect on determining system frequency for the frequency elements.

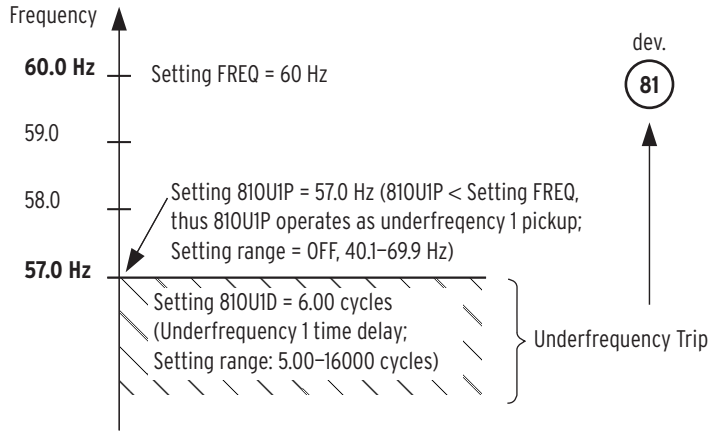


Figure 3.11 Frequency Element Settings—Example 1

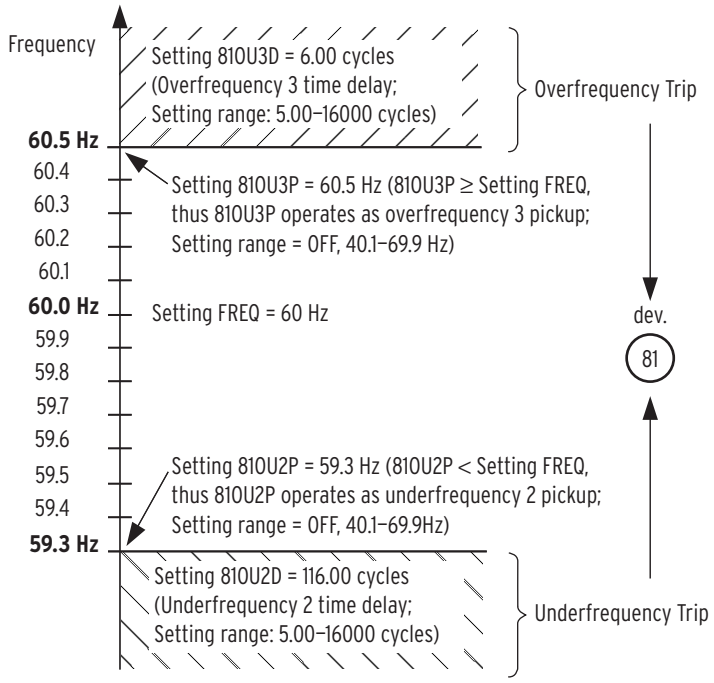


Figure 3.12 Frequency Element Settings—Example 2

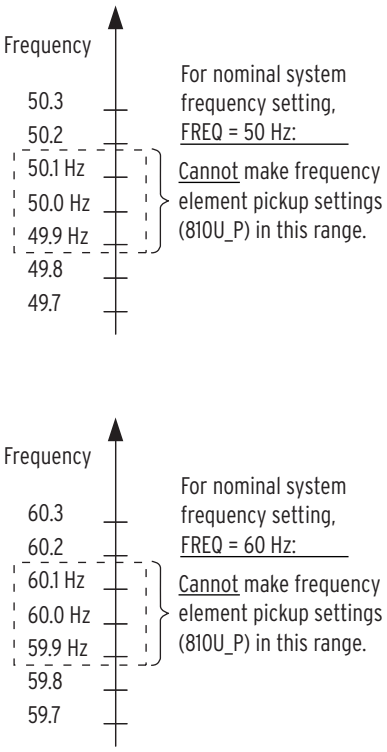


Figure 3.13 Frequency Element Setting Range Exclusions

Directional Power Element Settings (device 32)

NOTE: There is one (1) directional power element available.

Figure 3.14 is a plot, in the power plane, of the directional power element default settings. Pickup setting 32P = 60 W, secondary (real power) corresponds to about 10 percent of the rating of a 50 kW generator (interconnected with a 400:5 ratio current transformer; 400/5 = 80):

$$\frac{50000 \text{ Watts}}{80} = 625 \text{ W sec. (three-phase)}$$

Take 10 percent of this secondary value:

$$625 \text{ W sec.} \bullet 0.1 = 62.5 \text{ W sec.} \approx 60 \text{ W sec. (three-phase)}$$

Pickup setting 32P = 60 W, sec. is an effective three-phase power value, even though only A-phase current is brought into the SEL-547. The relay makes a single-phase power calculation with current **IA** and line-to-neutral voltage **VA** (brought into terminals **VA/N**). This single-phase power value is multiplied by three (• 3) to create an effective three-phase power value. This value is then compared to three-phase power pickup setting 32P.

The above 10 percent of generator nameplate derivation of three-phase power pickup setting 32P would work well for an SEL-547 applied at an individual generator (to prevent motoring), but would not necessarily be applicable at a transfer switch site. At the transfer switch site, the concern is inadvertent power flow into the utility, not individual generator motoring. Thus, the settings for pickup setting 32P and time delay setting 32D would be more of a function of what the utility permits (power level and time duration-wise) for reverse power into the utility.

The actual reverse or forward direction is determined by power element direction setting 32FR, in concert with correct current transformer connection to the relay on A-phase, taking into account proper polarity.

If the derived three-phase power level crosses the pickup threshold 32P (in the designated forward or reverse direction, per setting 32FR) for the set time delay 32D, a trip is issued (device 32 asserts).

To achieve directional power element accuracy (especially for low power levels), 8 cycles of data averaging is performed. This effective 8-cycle delay is in addition to time delay setting 32D—it is especially noticeable for power levels just above pickup (setting 32P).

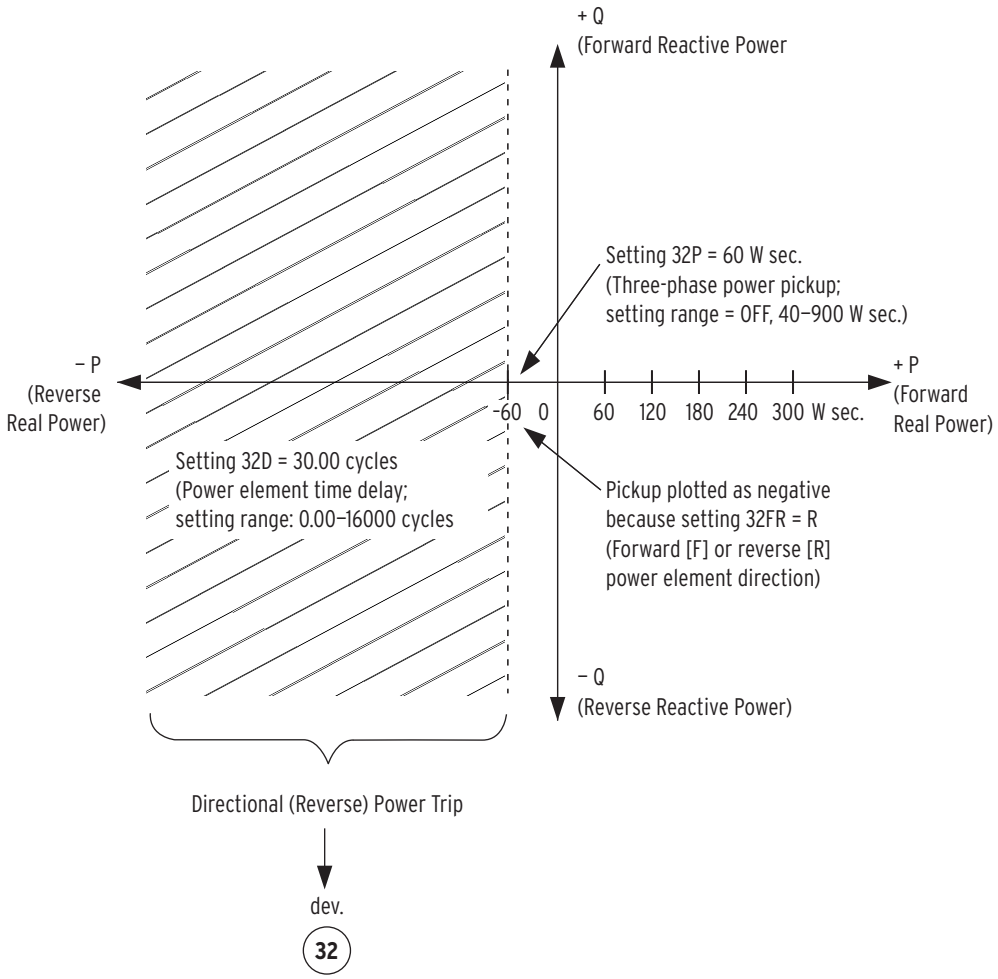


Figure 3.14 Directional Power Element Settings

Synchronism Check Element Settings (device 25)

NOTE: Consult the IEEE 1547 Standard to make these synchronism check element settings.

There is one (1) synchronism check element available.

Figure 3.15 (bottom half) is a plot, in the voltage-phasor plane, of the synchronism check element with factory settings.

In the top half of *Figure 3.15*, note that the healthy voltage range is derived by applying a percentage difference setting (specifically the difference voltage pickup setting 25DIFP = 10%, default setting) to Vnom = 120 Vac.

The percentage difference is split (10%/2 = 5%) above and below Vnom:

120 Vac • (1.00 + 0.05) = 126 Vac (upper healthy voltage limit)

120 Vac • (1.00 – 0.05) = 114 Vac (lower healthy voltage limit)

In the bottom half of *Figure 3.15*, note that the voltages compared for synchronism check are both the same phase (voltage V_A) on opposite sides of the breaker/switch (see synchronism check scenario in *Figure 1.7*). The bottom half of *Figure 3.15* portrays all parameters referenced to V_A (on channel **VA/N**), with V_A (on channel **VS/NS**) slipping by. If all the following are true about both voltages, then the synchronism check element (device 25) asserts, allowing close supervision via programmed output contacts **OUT1**–**OUT3**:

- The voltages are within the healthy voltage range [range derived from the difference voltage pickup setting 25DIFP (= 10%, default setting)].
- The angle difference between the voltages is less than the maximum angle setting 25ANG (= 20°, default setting).
- The slip frequency between the voltages is less than the maximum slip frequency setting 25SLP (= 0.3 Hz, default setting).

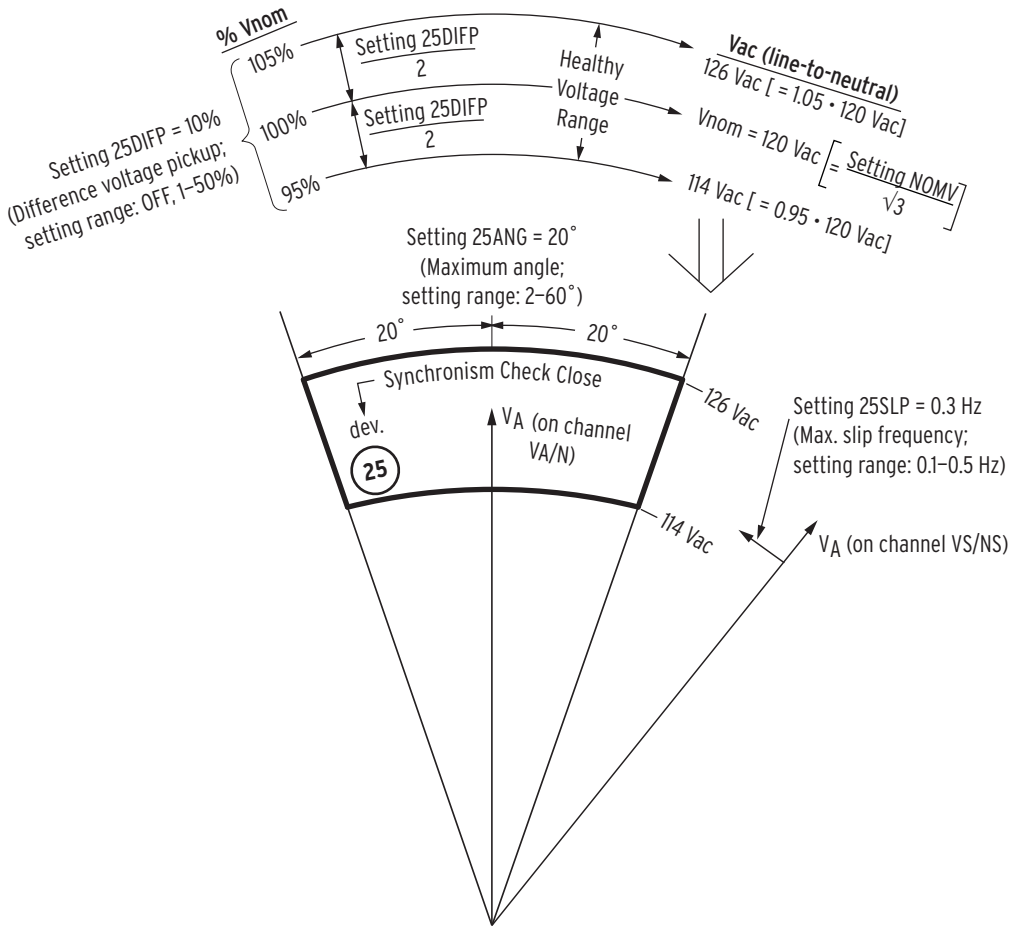


Figure 3.15 Synchronism Check Element Settings

Reverse-Phase-Sequence Voltage Element (device 47)

NOTE: This element requires no settings. It illuminates LED **47** as a warning to indicate reverse-phase rotation.

As shown in *Figure 3.16*, if two of the three-phase voltage inputs are mistakenly swapped (e.g., **VB** and **VC** are swapped), the relay ends up seeing reverse-phase rotation, with resultant full-value (100 percent) reverse-phase-sequence (i.e., negative-sequence) voltage V_2:

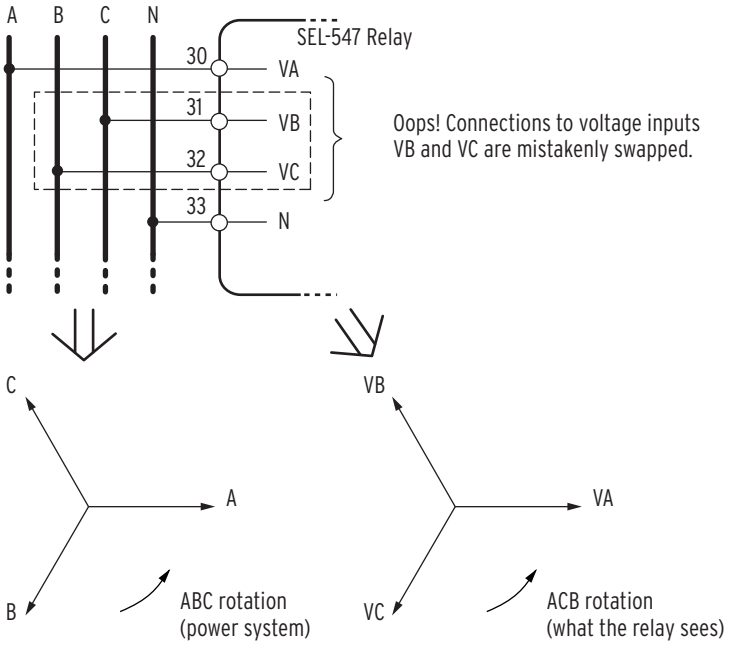
$$V_2(100\%) = Vnom = 120\ Vac$$

See *Figure 3.4* for Vnom derivation.

To indicate such a condition, a reverse-phase-sequence voltage element (ANSI device number 47) is set to illuminate a front-panel LED (labeled **47**, see *Figure 2.2*). *Figure 3.17* shows this implementation with the fixed pickup of 50 percent of nominal voltage Vnom:

$$0.5 \bullet Vnom = 0.5 \bullet 120\ Vac = 60\ Vac$$

If reverse-phase-sequence (negative-sequence) voltage V_2 exceeds this fixed 50 percent pickup threshold for the fixed 30-cycle time delay, as shown in *Figure 3.17*, the front-panel **47** LED illuminates, indicating a wiring/phasing problem. No settings are made (pickup threshold and time delay are fixed) and no trip is issued—again, only LED **47** is illuminated as a warning.



Setting ROTATE = ABC. Thus, the SEL-547 Relay sees full-value (100%) reverse-phase-sequence (i.e., negative-sequence) voltage.

$$V_2\ (100\%) = Vnom = \frac{\text{Setting NOMV}}{\sqrt{3}} = \frac{208\ Vac}{\sqrt{3}} = 120\ Vac \text{ (line-to-neutral)}$$

Figure 3.16 Full-Value (100%) Reverse-Phase-Sequence Voltage

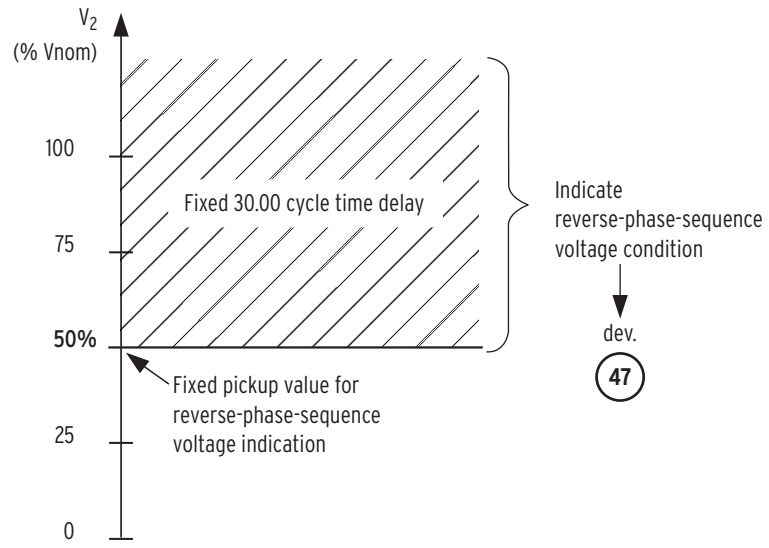


Figure 3.17 Reverse-Phase-Sequence Voltage Element

Task 9: Viewing Metering Quantities

MET (Meter Command)

Use the **MET** command to view instantaneous metering values for the following:

- **Current channel** IA (primary): measured secondary current into the SEL-547 is adjusted by the current transformer ratio setting CRATIO (see *Table 3.5*) and the resulting primary value is displayed.
- **Voltage channels VA, VB, VC, and VS**: there is no voltage transformer ratio setting, so these voltage values are not adjusted—most commonly, the voltage channels are connected (line-to-neutral) directly to the system (connected **VA/N**, **VB/N**, **VC/N**, and **VS/NS**, respectively).
- **Voltages VAB, VBC, and VCA**: line-to-line voltages derived from voltage channels VA, VB, and VC.
- **Three-phase power values** (primary): kW (real), kVAR (reactive), power factor (PF), and indication of leading or lagging PF. The relay makes a single-phase power calculation with current IA (primary) and voltage VA. This single-phase power value is multiplied by three (• 3) to create an effective three-phase power value.
- **Sequence voltages**: all derived from voltage channels VA, VB, and VC.
  - V1 = positive-sequence voltage
  - V2 = negative-sequence voltage
  - 3V0 = zero-sequence voltage
- **System frequency**: measured on voltage channel VA.

Voltage channel VA is the zero (0) degree reference for all the other voltage and current metering values, as long as VA > 25 V to neutral (otherwise, current channel IA is the zero degree reference).

Metering Values Help in Commissioning

Use the metering values to check that all voltage and current wiring is properly connected (see *Figure 2.4* and *Figure 2.5*). If the system is relatively balanced, the following should be apparent in the metering values:

- VA, VB, and VC voltage values are nearly the same in magnitude and 120 degrees apart in angle (see *Figure 3.6*).
- For ABC phase rotation (setting ROTATE = ABC), the angles are (approximately):
  - VA: 0 degrees
  - VB: –120 degrees
  - VC: 120 degrees
- For ACB phase rotation (setting ROTATE = ACB), the angles are (approximately):
  - VA: 0 degrees
  - VB: 120 degrees
  - VC: –120 degrees
- VS (synchronism check voltage) and VA are close in magnitude and angle (if breaker/switch is closed).
- V1 (positive-sequence voltage) magnitude is close to the level of the VA, VB, and VC voltage magnitudes.
- V2 (negative-sequence voltage) and 3V0 (zero-sequence voltage) are quite small in magnitude, compared to the VA, VB, and VC voltage magnitudes.
- Presuming load is not too lagging or leading (power factor [PF] close to 1.00), current **IA** should be close to voltage VA in angle (if power flow is in the forward direction) or close to 180 degrees away from voltage **VA** in angle (if power flow is in the reverse direction).

Scrolling Metering

If you want to scroll metering values repeatedly (e.g., for testing), enter the **MET** command with a number following (for the number of times to scroll the metering values by—set number up to 32767). For example, if you issue the **MET 1000** command, the metering report will scroll by 1000 times.

Task 10: Reading SER and Event Reports

SER (Sequential Events Recorder Command)

The **SER** command displays the Sequential Events Recorder data. The SER lists date and time stamped lines of information each time a programmed condition changes state, as shown in *Figure 3.18*:

```
#     Date      Time          Element          State

126   03/30/02  07:15:35.120  OUT4             Asserted
125   03/30/02  07:15:35.453  OUT4             Deasserted
```

Figure 3.18 SER Command Display

The above example shows two entries, with output contact **OUT4** asserting (closing) and then deasserting (opening). From the time difference between the entries (0.333 seconds), we see that **OUT4** was closed for 20 cycles (trip operation, containing 15-cycle dropout). Note that the row numbering (left-hand column) decreases for increasing time (the smaller the SER row number, the more recent the entry).

SER Data Helps in Commissioning

Use the SER command to display a log of the operation of inputs (**IN1**–**IN3**), output contacts (**OUT1**–**OUT5**), and any other elements in a commissioning routine.

For a more detailed explanation of SER data, see *Section 3: Analyzing Events in the Reference Manual*.

Event Reports

The event reports contain date, time, current, voltage, frequency, relay element, optoisolated input, and output contact information. The relay generates event reports by fixed and programmable conditions. The relay stores event report data in volatile memory.

Event Report Data Helps in Commissioning

Use the **TRI** command to automatically generate a standard event report during your commissioning routine. The resultant event report data will help confirm proper installation and application of the SEL-547.

For a more detailed explanation of Event Reports, please see *Section 3: Analyzing Events in the Reference Manual*.

Task 11: Operating Relay Outputs

Output Logic Timing

Most of the elements in *Figure 3.19* run through independent 15-cycle dropout timers that extend a signal for 15 cycles after the resultant element drops out. These dropout times reduce the likelihood of output contact chatter for elements operating near pickup points.

In addition, the 15-cycle dropout time guarantees a minimum 15-cycle trip time. Presumably, the trip output contacts (**OUT4** and **OUT5**) are **not** operating any breaker failure schemes and there is no instantaneous reclosing, so this 15-cycle dropout time should not be a problem.

Independent of timers, a given output contact (**OUT1**–**OUT5**) takes

- 8 ms to pick up/assert
- 16 ms to drop out/deassert

for any logic that is set to operate it. See *Specifications on page U.1.15* for other output contact details.

PUL (Pulse Command)

Use the **PUL** command to pulse/energize any of the outputs contacts (**OUT1**, **OUT2**, **OUT3**, **OUT4**, **OUT5**, or **ALARM**) for one second. For example, issuing the **PUL OUT1** command causes the **OUT1** output contact to close for one second.

To lengthen the output contact pulsing (up to 30 seconds maximum), enter a number (in seconds) at the end of the command. For example, issuing the **PUL OUT3 22** command causes the **OUT3** output contact to close for 22 seconds.

Pulsing Output Contacts Helps in Commissioning

Use the **PUL** command to check that all output contact wiring is properly connected—effectively closing the identified output contact to make a continuity check.

Task 12: Checking LEDs

Front-Panel LED Operation

The front-panel LEDs do not latch in/seal in; they illuminate solely by the logic that drives them, as shown in *Figure 3.19*.

Check Front-Panel LED 47

Front-panel LED **47** (reverse-phase-sequence voltage) is especially useful in commissioning—it indicates if three-phase voltage (connections **VA**, **VB**, **VC**, and **N**–see *Figure 2.4* and *Figure 2.5*) is

- Connected correctly (LED **47** extinguished)
- Not connected correctly (LED **47** illuminated)

The correct operation of LED **47** presumes correct settings are made—especially those dealing with nominal voltage (setting NOMV) and phase rotation (setting ROTATE). See *Figure 3.16* and *Figure 3.17* and accompanying text for more information on LED **47** and its operation.

You may want to swap two voltage leads momentarily (e.g., **VB** and **VC**, as shown in *Figure 3.16*; make sure the output contacts are isolated from their trip/control circuits) and see LED **47** illuminate.

Check Other Front-Panel LEDs

LED 27 and LED 59

If three-phase voltage is connected (connections **VA**, **VB**, **VC**, and **N**) and voltage element settings are made correctly, then both front-panel LED **27** and LED **59** remain extinguished.

You may want to momentarily remove a voltage lead (e.g., remove voltage lead for **VA**; make sure the output contacts are isolated from their trip/control circuits) and see LED **27** illuminate. Remove any combination of voltage leads for connections **VA**, **VB**, and **VC**, and see LED **27** illuminate. This LED **27** illumination may take a little waiting, depending on the undervoltage element time delay settings (see *Figure 3.8* and *Figure 3.9*).

LED 81

If A-phase voltage is connected (connections **VA/N**), frequency element settings are made correctly, and no frequency disturbance exists on the system, then front-panel LED **81** remains extinguished.

LED 32

If A-phase voltage and current are connected (connections **VA/N** and **IA**), directional power element settings are made correctly, and power flow is opposite of the intended direction of operation for the directional power element (or there is no power flow at all), then front-panel LED **32** remains extinguished.

LED 25 and LED 25 VOLTAGE HOT

If A-phase voltages on opposite sides of a breaker/switch are connected (connections **VA/N** and **VS/NS**), the breaker/switch is closed, and synchronism check element settings are made correctly, then both front-panel LED **25** and LED **25 VOLTAGE HOT** illuminate. If the breaker/switch is open, but the system is paralleled through another path, these LEDs still illuminate.

You may want to momentarily remove one or the other connected A-phase voltages (make sure the output contacts are isolated from their trip/control circuits) and see both front-panel LED **25** and LED **25 VOLTAGE HOT** extinguish.

The **25 VOLTAGE HOT** LED is only an indication that voltage V_A (on channel VA/N) and voltage V_A (on channel VS/NS) are both within the healthy voltage range shown in *Figure 3.15*. These voltages are used for synchronism check, as also shown in the scenario in *Figure 1.7*. The **25 VOLTAGE HOT** LED is **not** a further indication of anything else (it is not an indication that these voltages also fall within the angle setting 25ANG and maximum slip frequency setting 25SLP parameters).

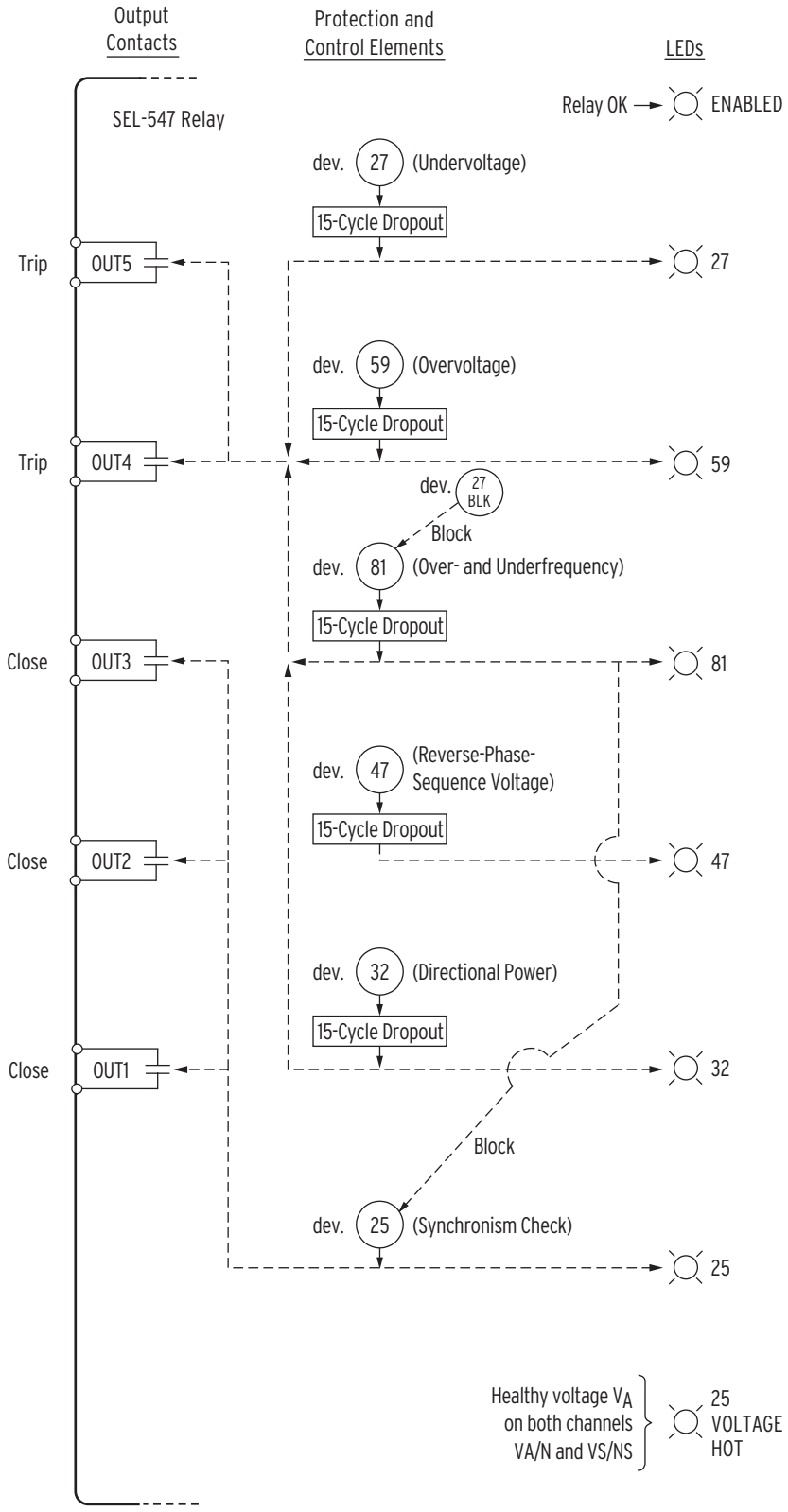


Figure 3.19 Output Contact and Front-Panel LED Logic

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Section 4

Testing and Troubleshooting

Overview

This section contains guidelines for determining and establishing test routines for the SEL-547 Relay. The relay incorporates self-tests to help you diagnose potential difficulties should these occur. The subsection *Troubleshooting on page U.4.6* contains a quick-reference table for common relay operation problems.

This section includes the following information:

- Testing philosophy
- Test methods and tools
- Relay self-tests
- Troubleshooting procedures

The SEL-547 is factory calibrated; this section contains no calibration information. If you suspect that the relay is out of calibration, contact your Technical Service Center or the SEL factory. Factory assistance information is located at the end of this section.

Testing

Testing Philosophy

Protective relay testing may be divided into three categories:

- Acceptance
- Commissioning
- Maintenance testing

The categories are differentiated according to when they take place in the life cycle of the relay as well as by test complexity.

The paragraphs below describe when to perform each type of test, the goals of testing at that time, and the relay functions that you need to test at each point. This information is intended as a guideline for testing SEL relays.

Acceptance Testing

When: When qualifying a relay model to be used on the utility system.

Goals:
1. Ensure the relay meets published critical performance specifications, such as operating speed and element accuracy.
2. Ensure that the relay meets the requirements of the intended application.
3. Gain familiarity with the relay settings and capabilities.

What to Test: All protection elements and logic functions critical to the intended application.

SEL performs detailed acceptance testing on all new relay models and versions. We are certain that the relays we ship meet their published specifications. It is important for you to perform acceptance testing on a relay if you are unfamiliar with its operating theory, protection scheme logic, or settings. This helps ensure the accuracy and correctness of the relay settings when you issue them.

Commissioning Testing

When: When installing a new protection system.

Goals:
1. Ensure that all system ac and dc connections are correct.
2. Ensure that the relay functions as intended using your settings.
3. Ensure that all auxiliary equipment operates as intended.

What to Test: All connected or monitored inputs and outputs, polarity and phase rotation of ac connections, simple check of protection elements.

SEL performs a complete functional check and calibration of each relay before it is shipped. This helps ensure that you receive a relay that operates correctly and accurately. Commissioning tests should verify that the relay is properly connected to the power system and all auxiliary equipment. Verify control signal inputs and outputs. Use an ac connection check to verify that the relay current and voltage inputs are of the proper magnitude and phase rotation.

Brief fault tests ensure that the relay settings are correct. It is not necessary to test every relay element, timer, and function in these tests.

At commissioning time, use the relay **METER** command to verify the ac current and voltage magnitude and phase rotation. Use the **PULSE** command to verify relay output contact operation.

Maintenance Testing

When: At regularly scheduled intervals or when there is an indication of a problem with the relay or system.

Goals:
1. Ensure that the relay is measuring ac quantities accurately.
2. Ensure that scheme logic and protection elements are functioning correctly.
3. Ensure that auxiliary equipment is functioning correctly.

What to Test: Anything not shown to have operated during an actual fault within the past maintenance interval.

SEL relays use extensive self-testing capabilities and feature detailed metering and event reporting functions that lower the utility dependence on routine maintenance testing.

Use the SEL relay reporting functions as maintenance tools. Periodically verify that the relay is making correct and accurate current and voltage measurements by comparing the relay METER output to other meter readings on that line. Review relay event reports in detail after each fault. Using the event report current, voltage, and relay element data, you can determine that the relay protection elements are operating properly. Using the event report input and output data, you can determine that the relay is asserting outputs at the correct instants and that auxiliary equipment is operating properly. At the end of your maintenance interval, the only items that need testing are those that have not operated during the maintenance interval.

The basis of this testing philosophy is simple: If the relay is set and connected correctly, is measuring properly, and no self-test has failed, there is no reason to test it further.

Each time a fault occurs the protection system is tested. Use event report data to determine areas requiring attention.

Because SEL relays are microprocessor-based, the relay operating characteristics do not change over time.

At SEL, we recommend that maintenance tests on SEL relays be limited under the guidelines provided above. Use the time you save to analyze event data and thoroughly test those systems that require more attention.

Testing Methods and Tools

Test Features Provided by the Relay

The following features assist you during relay testing.

Table 4.1 Testing Commands (Sheet 1 of 2)

Command	Description
METER Command	The **METER** command shows the ac currents and voltages (magnitude and phase angle) presented to the relay in primary values. In addition, the command shows power system frequency (FREQ) and the voltage input to the relay power supply terminals (VDC). Compare these quantities against other devices of known accuracy. (See *Section 7: ASCII Commands in the Reference Manual*).
EVENT Command	The relay generates a 15-, 30-, or 60-cycle event report in response to faults or disturbances. Each report contains current and voltage information, relay element states, and input/output contact information. If you question the relay response or your test method, use the event report for more information. (See *Section 3: Analyzing Events in the Reference Manual*).
SER Command	The relay provides a Sequential Events Recorder (SER) event report that time-tags changes in relay element and input/output contact states. The SER provides a convenient means to verify the pickup/dropout of any element in the relay. (See *Sequential Events Recorder (SER) Report on page R.3.10*).

Table 4.1 Testing Commands (Sheet 2 of 2)

Command	Description
TARGET Command	Use the **TARGET** command to view the state of relay control inputs, relay outputs, and relay elements individually during a test. (See *Section 7: ASCII Commands in the Reference Manual*).
PULSE Command	Use the **PULSE** command to test the contact output circuits. (See *Section 7: ASCII Commands in the Reference Manual*).

Low-Level Test Interface

The SEL-547 has an ordering option for low-level test interface. The relay is tested by applying low magnitude ac voltage signals to the relay voltage and current terminals shown in *Figure 2.2*. The processing module of the relay can be tested using signals from the SEL-RTS Low-Level Relay Test System.

Table 4.2 shows the signal scaling factors.

Table 4.2 Low-Level Test Interface Scale Factors

Input Channels	Input Channel Nominal Rating	Input Value	Corresponding Low-Level Input Value	Scale Factor (Input/Low Level Input) (V/V or A/V)
VA, VB, VC, VS	300 V	120 V	240 mV	500.00
IA	5 A	5 A	706 mV	7.08

IMPORTANT NOTE: Never apply voltage signals greater than 9 volts peak-to-peak to an SEL-5470A Relay.

Test Methods

Test the pickup and dropout of relay elements, using one of the following three methods:

- Target command indication
- Output contact closure
- Sequential events recorder (SER)

NOTE: These test methods are for non-EZ settings. For more information on non-EZ settings, please refer to Section 8: Settings in the Reference Manual.

The examples below show the settings necessary to route the phase undervoltage element 27A1 to the output contacts and the SER. The 27A1 element, like many in the SEL-547, is controlled by enable settings (see *Section 8: Settings in the Reference Manual*). To enable the 27A1 element, set the EVOLT enable setting to the following:

EVOLT = **Y** (via the **SET 1** command)

To view the 27A1 element status from the serial port, issue the **TAR 27A1** command. The relay will display the state of all elements in the Relay Word row containing the 27A1 element.

Review the **TAR** command descriptions in *Section 7: ASCII Commands in the Reference Manual* for further details on displaying element status via the **TAR** commands.

Testing Via Output Contacts

You can set the relay to operate an output contact for testing a single element. Use the **SET L** command (SELOGIC® control equations) to set an output contact (e.g., **OUT1**–**OUT5**) to the element under test. The available elements are the Relay Word bits referenced in *Appendix A: Relay Word Bits in the Reference Manual*.

For example, to test the phase undervoltage element 27A1 via output contact OUT4, make the following setting:

OUT4 = **27A1**

Do not forget to reenter the correct relay settings when you are finished testing and ready to place the relay in service.

Testing Via Sequential Events Recorder

You can set the relay to generate an entry in the Sequential Events Recorder (SER) for testing relay elements. Use the **SET R** command to include the element(s) under test in any of the SER trigger lists (SER1–SER3). See *Section 3: Analyzing Events in the Reference Manual*.

To test the phase undervoltage element 27A1 with the SER, make the following setting:

SER1 = **27A1**

Element 27A1 asserts when A-phase voltage is below the pickup of the phase undervoltage pickup setting. The assertion and deassertion of this element is time-stamped in the SER report. Use this method to verify timing. Do not forget to reenter the correct relay settings when you are ready to place the relay in service.

Relay Self-Tests

The relay runs a variety of self-tests. It takes the following corrective actions for out-of-tolerance conditions (see *Table 4.3*):

- **Relay Disabled:** The relay disables protection elements and logic. All output contacts are de-energized. The **ENABLED** front-panel LED is extinguished.
- **ALARM Output:** The **ALARM** output contact signals an alarm condition by going to its de-energized state. The **ALARM** output contact is a b contact (normally closed); therefore, it closes for an alarm condition or if the relay is de-energized. Alarm condition signaling can be a single 5-second pulse (Pulsed) or permanent (Latched).
- The relay generates automatic STATUS reports at the serial port for warnings and failures.

Use the serial port **STATUS** command to view relay self-test status.

Table 4.3 Relay Self-Tests (Sheet 1 of 2)

Self-Test	Condition	Limits	Relay Disabled	ALARM Output	Description
IA, VA, VB, VC, VS Offset	Warning	50 mV	No	Pulsed	Measures the dc offset at each of the input channels every 10 seconds.
RAM	Failure		Yes	Latched	Performs a read/write test on system RAM every 60 seconds.

Table 4.3 Relay Self-Tests (Sheet 2 of 2)

Self-Test	Condition	Limits	Relay Disabled	ALARM Output	Description
ROM	Failure	checksum	Yes	Latched	Performs a checksum test on the relay program memory every 10 seconds.
A/D	Failure		Yes	Latched	Validates proper number of conversions each 1/4 cycle.
FREQ	Failure		Yes	Latched	Validates proper zero crossings for frequency tracking.
CR_RAM	Failure	checksum	Yes	Latched	Performs a checksum test on the active copy of the relay settings every 10 seconds.
EEPROM	Failure	checksum	Yes	Latched	Performs a checksum test on the nonvolatile copy of the relay settings every 10 seconds.
The following self-tests are performed by dedicated circuitry in the microprocessor and the SEL-547 main board. Failures in these tests shut down the microprocessor and are not shown in the STATUS report.					
Microprocessor Crystal	Failure		Yes	Latched	The relay monitors the microprocessor crystal. The test runs continuously.
Microprocessor	Failure		Yes	Latched	The microprocessor examines each program instruction, memory access, and interrupt. The test runs continuously.

Troubleshooting

Troubleshooting procedures for common problems are listed in *Table 4.4*. The table lists symptoms, possible causes, and corresponding diagnoses/solutions. Related SEL-547 commands are listed in bold capitals.

Table 4.4 Troubleshooting Procedures (Sheet 1 of 2)

Symptoms/Possible Cause	Diagnosis/Solution
Front-Panel Dark	
Power is off.	Verify that battery power is operational.
Input power is not present.	Verify that power is present at the SEL-547 terminals **36** and **37**.
Blown power supply fuse.	Contact the SEL factory or your Technical Service Center.
Status Failure Notice	
Self-test failure.	Contact the SEL factory or your Technical Service Center. The **ALARM** relay output contacts close for a status failure. See *Figure 2.4*.

Table 4.4 Troubleshooting Procedures (Sheet 2 of 2)

Symptoms/Possible Cause	Diagnosis/Solution
Alarm Output Asserts	
Power is off.	Restore power.
Blown power supply fuse.	Contact the SEL factory or your Technical Service Center.
Internal component failure.	Contact the SEL factory or your Technical Service Center.
Self-test failure (**ENABLED** LED is not illuminated).	Contact the SEL factory or your Technical Service Center.
System Does Not Respond to Commands	
No communication; no = prompt.	Confirm cable connections and types (see *Section 4: Communications in the Reference Manual*). If OK, type **<Ctrl+X>**. This resets the terminal program.
Communications device is not connected to the system.	Connect a communications device.
Incorrect data speed (baud rate) or other communications parameters.	Configure your terminal port parameters to the particular relay port settings. See *Table 3.1*.
Incorrect communications cables.	Use SEL communications cables or cables you build according to SEL specifications. See *Figure 4.2 on page R.4.2* and *Figure 4.3 on page R.4.3*.
Communications cabling error.	Check cable connections.
Terminal Displays Meaningless Characters	
Data speed (baud rate) is set incorrectly.	Check the terminal parameters configuration. See *Table 3.1*.
Terminal emulation is not optimal.	Try other terminal types, such as VT-100 and VT-52 terminal emulations.
System Does Not Respond to System Disturbances	
Relay is set improperly.	Review the relay settings. See *Task 8: Understanding and Using EZ Settings on page U.3.8*.
Improper test settings.	Restore operating settings.
Connection wiring error.	Confirm wiring (see *Figure 2.4* and *Figure 2.5*).
Input voltages and current phasing rotation errors.	Use relay metering and note status of front-panel LED 47. See *Check Front-Panel LED 47 on page U.3.25*.
Check the relay self-test status.	Contact the SEL factory or your Technical Service Center with relay status warning and status failure information. See *STA Command Helps Uniquely Identify the Relay on page U.3.7*.
Output Remains Closed Following a System Disturbance	
Relay output contacts are burned closed.	Remove relay power. Remove the output contact connection. Check continuity; a contacts are normally open. Contact the SEL factory or your Technical Service Center if continuity checks fail.

Technical Support

We appreciate your interest in SEL products and services. If you have any questions or comments, please contact us at:

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E-mail: info@selinc.com

Appendix A

Firmware and Manual Versions

Firmware

Determining the Firmware Version in Your Relay

To find the firmware version number in your SEL-547 Relay, use the **STA** command (see *STA (Status Command) on page U.3.6* for more information on the **STA** command). The firmware revision number is after the R, and the release date is after the D. For example, the following is firmware revision number 100, release date April 30, 2002.

FID=SEL-547-R100-V0-Z001001-D20020430

Table A.1 lists the firmware versions, a description of modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

Table A.1 Firmware Revision History

Firmware Identification (FID) Number	Description of Changes	Manual Date Code
SEL-547-R101-V0-Z001001-D20080922	Manual update only (see *Table A.2*).	20200715
SEL-547-R101-V0-Z001001-D20080922	Manual update only (see *Table A.2*).	20180612
SEL-547-R101-V0-Z001001-D20080922	Manual update only (see *Table A.2*).	20120719
SEL-547-R101-V0-Z001001-D20080922	Manual update only (see *Table A.2*).	20120127
SEL-547-R101-V0-Z001001-D20080922	Minor firmware change to improve factory calibration procedure.	20080922
SEL-547-R100-V0-Z001001-D20020430	Manual update only (see *Table A.2*).	20050117
SEL-547-R100-V0-Z001001-D20020430	Manual update only (see *Table A.2*).	20021206
SEL-547-R100-V0-Z001001-D20020430	Initial firmware release.	20020523

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date.

Table A.2 lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.2 Instruction Manual Revision History (Sheet 1 of 3)

Revision Date	Summary of Revisions
20200715	**User's Guide, Section 1** ➤ Updated CE and UL information and reorganized certifications in *Specifications*.
20180612	**User's Guide, Section 1** ➤ Removed CE certification and updated Power Consumption in *Specifications*. **User's Guide, Appendix B** ➤ Updated firmware upgrade instructions. **Reference Manual, Section 1** ➤ Updated *Table 1.7: Frequency Element Settings and Settings Ranges*. **Reference Manual, Section 3** ➤ Updated *Event Report Length (Settings LER and PRE)*.
20120719	**User's Guide, Section 1** ➤ Added CE certification to *Specifications*. **User's Guide, Appendix B** ➤ Updated firmware upgrade instructions.
20120127	**Reference Manual, Section 7** ➤ Added Access Level C information to *Serial Port Access Levels*. ➤ Added the CAL and PAS C command information to *Command Explanations*.
20080922	**User's Guide, Appendix A** ➤ Updated for firmware version R101.
20050117	**User's Guide, Section 1** ➤ Corrected typographical, stylistic, and grammatical errors. **User's Guide, Section 2** ➤ Corrected grammatical and stylistic errors. ➤ Modified *Figure 2.27*. **User's Guide, Section 3** ➤ Corrected grammatical and stylistic errors. ➤ Modified *Figure 3.7*. ➤ Corrected sentence to read that the relay stores event report data in volatile memory in *Event Reports, Task 10: Reading SER and Event Reports*. **User's Guide, Section 4** ➤ Corrected grammatical and stylistic errors. **User's Guide, Appendix A** ➤ Added list of corrections made in this version of the instruction manual to *Table A.2*. **User's Guide, Appendix B** ➤ Corrected stylistic errors. **Reference Manual, Section 1** ➤ Corrected stylistic errors. ➤ Modified *Figure 1.4*, *Figure 1.5*, *Figure 1.7*, *Figure 1.8*, and *Figure 1.9*.

Table A.2 Instruction Manual Revision History (Sheet 2 of 3)

Revision Date	Summary of Revisions
	Reference Manual, Section 2 ➤ Made stylistic changes. ➤ Modified example of NOT Operator ! applied to single element. ➤ Modified *Figure 2.17*, *Figure 2.20*, *Table 2.6*, *Figure 2.26*, and *Figure 2.27*. **Reference Manual, Section 3** ➤ Corrected stylistic errors. ➤ Corrected sentence to read that the relay stores the most recent event report data in volatile memory in *Introduction.* ➤ Corrected sentences to read that changing the LER setting will erase all events stored in volatile memory and changing the PRE setting has no effect on the volatile reports in *Event Report Length (Settings LER and PRE, Standard 15-, 30-, or 60-Cycle Event Reports.* ➤ Corrected sentence to read that the latest event summaries are stored in volatile memory and are accessed by the **HIS** (Event Summaries/History) command in *Standard Event Report Summary.* ➤ Corrected sentence to read the latest event reports are stored in volatile memory in *Retrieving Full-Length Standard Event Reports*. ➤ Corrected sentence to read the **HIS C** command clears the event summaries and corresponding standard event reports from volatile memory in *Clearing Standard Event Report Buffer.* ➤ Modified *Table 3.5* and *Figure 3.5*. **Reference Manual, Section 4** ➤ Removed *Fiber-Optic Serial Communications and Communications Card* from list of topics in *Overview.* ➤ Corrected typographical and stylistic errors. **Reference Manual, Section 5** ➤ Corrected typographical and stylistic errors. **Reference Manual, Section 7** ➤ Corrected typographical and stylistic errors. ➤ Corrected sentences to read **HIS *x*** displays event summaries or allows you to clear event summaries (and corresponding event reports) from volatile memory and if *x* is C or c, the relay clears the event summaries and all corresponding event reports from volatile memory in *HIS Command (Event Summaries/History*). ➤ Corrected listed default range for **SHO *n*** setting. ➤ Corrected listed range of group settings for **COP *m n*** command. ➤ Changed occurrence of IN101 to IN1. **Reference Manual, Section 8** ➤ Corrected stylistic and cross-reference errors. ➤ Modified *Table 8.1*. **Reference Manual, Command Summary** ➤ Corrected stylistic errors. ➤ Corrected definition of **HIS C** command to read clear all event reports from volatile memory. **Reference Manual, Settings Sheets** ➤ Corrected cross-reference errors. ➤ Corrected range for the Clock Pulse Signal Setting. ➤ Corrected typographical and stylistic errors. ➤ Corrected listing of *SELOGIC Control Equation Variable Timer Input Equation* settings. ➤ Corrected listing of *Front-Panel LED Equation* settings. ➤ Corrected listing of *Output Contact Equation* settings. **Reference Manual, Appendix A** ➤ Corrected stylistic errors ➤ Modified *Table A.2*.

Table A.2 Instruction Manual Revision History (Sheet 3 of 3)

Revision Date	Summary of Revisions
20021206	➤ Reorganized the previous instruction manual into a user's guide and combined it with a reference manual, in order to provide more information and make the product documentation easier to use. ➤ Extensively reorganized many sections and rewrote some sections. ➤ Added section overviews and a comprehensive index.
20020523	Initial Release.

Appendix B
Firmware Upgrade Instructions

Firmware (Flash) Upgrade

SEL occasionally offers firmware upgrades to improve the performance of your relay. Changing physical components to upgrade the relay firmware is unnecessary because the SEL-547 stores firmware in Flash memory.

A firmware loader program called SELBOOT resides in the relay. To upgrade firmware use the SELBOOT program to download an SEL-supplied file from a personal computer to the relay via any communications port. This procedure is described in the following steps.

NOTE: SEL recommends that you perform the firmware upgrade at the location of the relay and with a direct connection from the personal computer to one of the serial ports of the relay. Do not attempt to load firmware from a remote location because problems can arise that you will not be able to address from a distance. When upgrading at the substation, do not attempt to load the firmware into the relay through an SEL Communications Processor.

Perform the firmware upgrade process in the following sequence (these steps are described in detail later):

A. Prepare the Relay

B. Establish a Terminal Connection

C. Save Settings and Other Data

D. Start SELBOOT

E. Download Existing Firmware

F. Upload New Firmware

G. Check Relay Self-Tests

H. Verify Calibration, Status, Breaker Wear, and Metering

I. Return Relay to Service

Required Equipment

Gather the following equipment before starting this firmware upgrade.

- Personal computer
- Terminal emulation software that supports 1K Xmodem or Xmodem (these instructions use HyperTerminal from a Microsoft® Windows® operating system)
- Serial communications cable (SEL-C234A or equivalent)
- Disk containing firmware upgrade file
- Firmware Upgrade Instructions

Optional Equipment

These items help you manage relay settings and understand procedures in the firmware upgrade process:

- SEL-5010 Relay Assistant Software

  The SEL-5010 Relay Assistant software has a feature that guides you through the conversion process. This upgrade guide will assist you with steps C, D, E, F, and G of these upgrade

instructions. If you do not have the latest SEL-5010 software, please contact your customer service representative or the factory for details on getting the SEL-5010 Relay Assistant software.

➤ SEL-547 Relay User's Guide and Reference Manual

Upgrade Procedure

A Prepare the Relay

Step 1. If the relay is in service, follow your company practices for removing a relay from service.

Typically, these include changing settings or disconnecting external voltage sources or output contact wiring to disable relay control functions.

Step 2. Apply power to your relay.

Step 3. Connect an SEL Cable C234A (or equivalent) serial communications cable to the Port F (EIA-232) serial port on the front of the relay.

B Establish Terminal Connection

To establish communication between your relay and a personal computer, you must be able to modify your serial communications parameters (i.e., data transmission rate, data bits, parity), disable any hardware or software flow control in your computer terminal emulation software, and transfer files with 1K Xmodem or Xmodem protocol.

Step 1. Connect a serial communications cable to the computer serial port.

a. Check the back of your computer for a label identifying the serial communications ports.

b. Choose a port and connect an SEL-C234A (or equivalent) serial communications cable to the personal computer serial port.

If there is no identification label, connect the cable to any computer serial port. Note that you might later change this computer serial port selection to establish communication between your relay and your computer if this connection is unsuccessful.

Step 2. Disconnect any other serial port connection.

Step 3. Open **HyperTerminal**.

On a personal computer running Windows, you would typically click the **Start** button, point to **Programs**, and point to **Accessories**.

Step 4. Enter a name, select any icon, and click **OK** (*Figure B.1*).

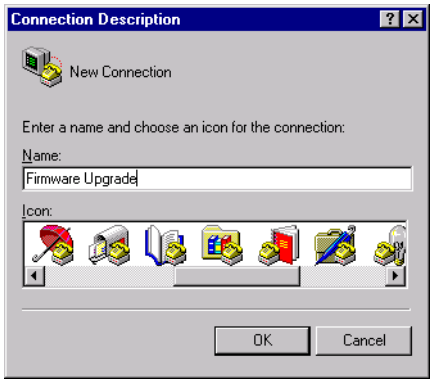

Figure B.1 Establishing a Connection

Step 5. Select the computer serial port you are using to communicate with the relay (*Figure B.2*) and click **OK**.

This port matches the port connection that you made in *Step 1*.

Figure B.2 Selecting the Computer Serial Port

NOTE: The settings for your computer (Figure B.3) must match the settings for the relay (e.g., hardware and software flow control settings should match).

Step 6. Establish serial port communications parameters.

a. Enter the serial port communications parameters (*Figure B.3*) that correspond to the relay settings.

These settings are SPEED (Bits per second), BITS, PARITY, STOP (Stop bits), and RTSCTS (Flow control).

If computer settings do not match relay settings, change the computer settings to match relay settings.

b. Click **OK** and press **<Enter>**.

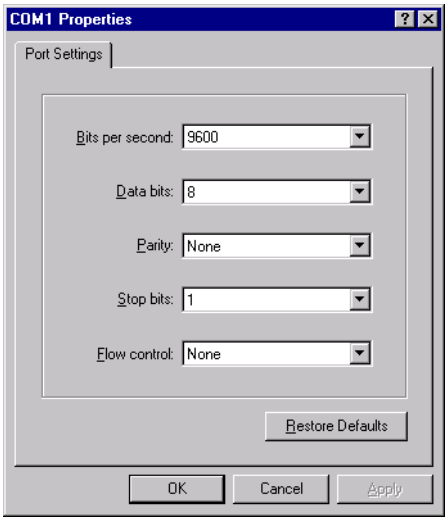

Figure B.3 Determining Communications Parameters for the Computer

Step 7. Set terminal emulation to VT100.

a. From the **File** menu, choose **Properties**.

b. Select the **Settings** tab in the **Firmware Upgrade Properties** dialog box (*Figure B.4*).

c. Select **VT100** from the **Emulation** list box and click **OK**.

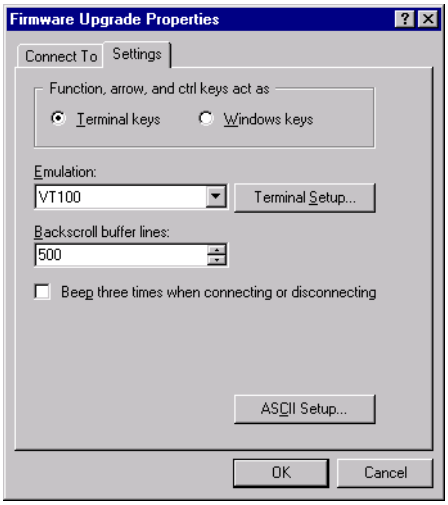

Figure B.4 Setting Terminal Emulation

Step 8. Confirm serial communication.

You should see a screen and the Access Level 0 prompt similar to that in *Figure B.5*. The prompt appears when you press **<Enter>**.

If this is successful, proceed to *Save Settings and Other Data on page U.B.6*.

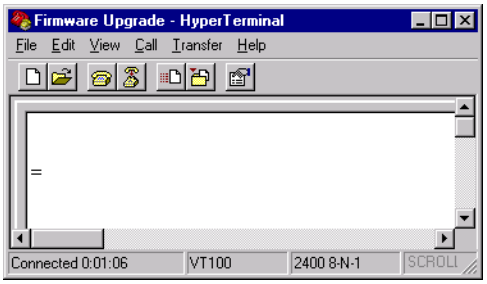

Figure B.5 Terminal Emulation Startup Prompt

Failure to Connect

If you do not see the = prompt, press **<Enter>** again. If you still do not see the = prompt, you have either selected the incorrect serial communications port on your computer or the computer speed setting does not match the data transmission rate of your relay. Perform the following steps to reattempt a connection.

Step 1. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 2. Correct your port setting.

a. From the **File** menu, choose **Properties**.

You should see a dialog box similar to *Figure B.6*.

b. Select a different port in the **Connect using** list box.

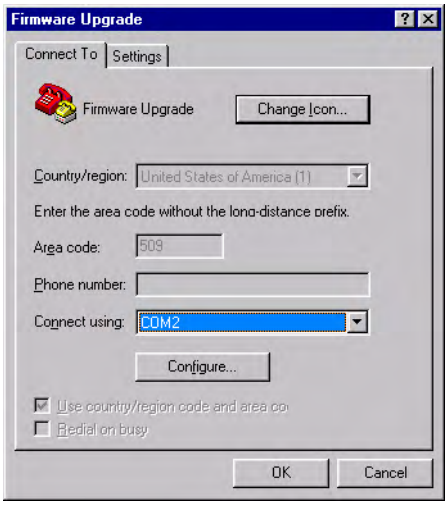

Figure B.6 Correcting Port Setting

Step 3. Correct communications parameters.

a. From the dialog box shown in *Figure B.6*, click **Configure**.

b. You will see a dialog box similar to *Figure B.7*.

Step 4. Change settings in the appropriate list boxes to match the relay settings and click **OK**.

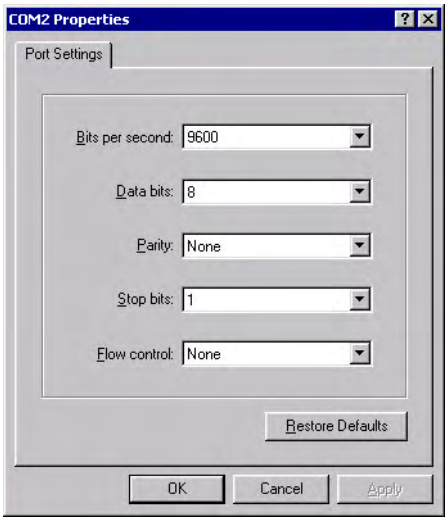

Figure B.7 Correcting Communications Parameters

Step 5. From the **Call** menu, choose **Connect** to reestablish communication with the relay.

Step 6. Press **<Enter>** to obtain the = prompt in the terminal emulation window.

C Save Settings and Other Data

If the relay contains History (HIS), Event (EVE), Metering (MET), or Sequential Events Recorder (SER) data that you want to retain, retrieve, and record this information prior to performing the firmware upgrade.

Enter Access Level 2

Step 1. Using the communications terminal, at Access Level 0 type **ACC <Enter>**.

Step 2. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

Step 3. Type **2AC <Enter>.**

Step 4. Type the correct Access Level 2 password.

You will see the =>> prompt.

View Passwords and FID

Step 1. Type **PAS <Enter>** at Access Level 2 to view relay passwords.

Make a written record of the original password settings in case you need these passwords later.

Step 2. Type **ID <Enter>** to view the relay firmware identifier (FID).

Make a written record of the FID identifier number for use in *Download Existing Firmware on page U.B.9*.

Backup Relay Settings

The relay preserves the settings and passwords during the firmware upgrade process. However, if relay power is interrupted during the firmware upgrade process, the relay can lose the settings. Make a copy of the original relay

settings in case you need to reenter settings. If you have SEL-5010 Relay Assistant Software available for your relay, use this software to record existing relay settings and proceed to *Start SELBOOT on page U.B.7*. Otherwise, perform the following steps.

Step 1. From the **Transfer** menu in **HyperTerminal**, select **Capture Text**.

Step 2. Enter a directory and file name for a text file where you will record existing relay settings.

Step 3. Click **Start**.

The **Capture Text** command copies all the information you retrieve and all the key strokes you type until you send the command to stop capturing text. The terminal emulation program stores these data in the text file.

Step 4. Type **SHO C <Enter>** to retrieve the relay calibration settings.

If you do not already have copies of the Relay, Logic, Port, Text, and SER settings, use the following **SHOW** commands to retrieve the necessary settings: **SHO**, **SHO L**, **SHO P 1**, **SHO P F**, and **SHO R**.

Step 5. From the **Transfer** menu in **HyperTerminal**, select **Capture Text** and click **Stop**.

Step 6. Print the text file you created in *Step 3* through *Step 5*.

Save this file for later reference.

Step 7. Make a written record of the present relay data transmission setting for later use in the upgrade procedure.

This setting is SPEED in the **SHO P** relay settings output.

D Start SELBOOT

Step 1. Start the relay SELBOOT program.

a. Type **L_D <Enter>**.

The relay responds, `Disable relay to send or receive firmware (Y/N)?`

b. Type **Y <Enter>**.

The relay responds, `Are you sure (Y/N)?`

c. Type **Y <Enter>**.

The relay responds, `Relay Disabled`.

Step 2. Wait for the SELBOOT program to load.

When finished loading the SELBOOT program, the relay responds to the terminal with the SELBOOT !> prompt.

Step 3. Press **<Enter>** to confirm that the relay is in SELBOOT.

You will see another !> prompt.

Commands Available in SELBOOT

To list the commands available in SELBOOT, type **HELP <Enter>**. The relay displays a list similar to the following:

```
!>HELP <Enter>
SELboot-5xx-R100

bau "rate"  ; Set baud rate to 300, 1200, 2400, 4800, 9600, 19200, or 38400 baud
era         ; Erase the existing relay firmware
exi         ; Exit this program and restart the device
fid         ; Print the relays firmware id
led         ; Test the LEDs
rec         ; Receive new firmware for the relay using xmodem
sen         ; Send the relays firmware to a pc using xmodem
hel         ; Print this list

FLASH Type : 040         Checksum = 370E  OK
!>
```

Figure B.8 Commands Available in SELBOOT

Establish a High-Speed Connection

At the !> prompt, type **BAU 38400 <Enter>**.

Match Computer Communications Speed to the Relay

Step 1. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 2. From the **File** menu, choose **Properties**.

Step 3. Choose **Configure**.

Step 4. Change your computer communications speed to match the new data transmission rate in the relay (*Figure B.9*).

This example assumes successful connection at Port 1, as described in *Establish Terminal Connection on page U.B.2*.

Step 5. Click **OK** twice.

You should not have to reestablish communication; HyperTerminal reestablishes communication automatically the second time you click **OK**.

Step 6. Press **<Enter>** to check for the !> prompt indicating that serial communication is successful.

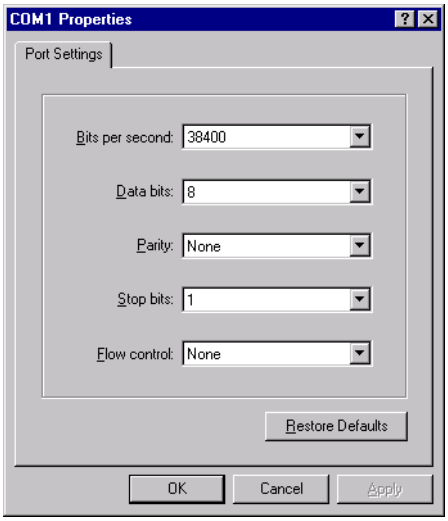

Figure B.9 Matching Computer to Relay Parameters

E Download Existing Firmware

Copy the firmware presently in the relay in case the new firmware upload is unsuccessful. To make a backup of the existing firmware you will need as much as 3 MB of free disk space. This backup procedure takes between 5 and 10 minutes at 38400 bps.

Step 1. Type **SEN <Enter>** at the !> prompt to initiate the firmware transfer from the relay to your computer.

Step 2. From the **Transfer** menu in **HyperTerminal**, select **Receive File**.

You should see a dialog box similar to *Figure B.10*.

NOTE: After beginning the following procedure, you must enter this information quickly before the relay times out.

Step 3. Enter the pathname of a folder on your computer hard drive where you want to record the existing relay firmware

Step 4. Select **1K Xmodem** if you have this protocol available on your PC.

If you do not have 1K Xmodem, choose **Xmodem**.

Step 5. Click **Receive**.

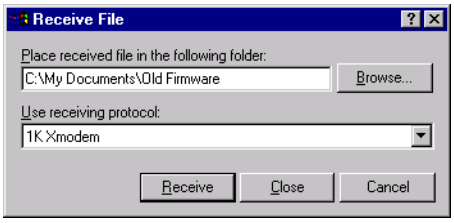

Figure B.10 Example Receive File Dialog Box

Step 6. Enter a filename that clearly identifies your existing firmware version (*Figure B.11*).

SEL lists the firmware revision number first, then the product number. These files have an .s19 extension (e.g., r100547.s19).

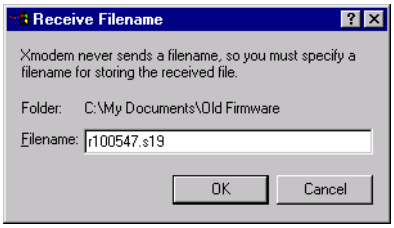

Figure B.11 Example Filename Identifying Old Firmware Version

For a successful download, you should see a dialog box similar to *Figure B.12*. After the transfer, the relay responds, `Download completed successfully!`

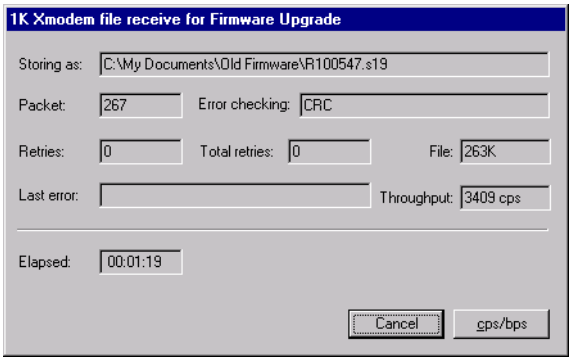

Figure B.12 Downloading of Old Firmware

F Upload New Firmware

Step 1. Insert the disk containing the new firmware into the appropriate disk drive on your computer.

Some firmware is in self-extracting compressed files (files with .exe extensions). If you have firmware in such files, from Windows Explorer double-click on the file you want and select a directory on your local hard drive where you want to access the uncompressed files. Be sure that these uncompressed files have an .s19 extension.

NOTE: This example shows uploading new firmware directly from the disk. For a faster upload (and less potential for file corruption), copy the new firmware to your local hard drive and upload the new firmware from your hard drive.

Step 2. Type **REC <Enter>** at the !> prompt to command the relay to receive new firmware.

The relay responds with the following message to make sure you want to erase the existing firmware.

```
!>REC <Enter>
Caution! -  This command erases the relays firmware.
If you erase the firmware, new firmware must be loaded into the relay
before it can be put back into service.
```

Step 3. Type **Y** to erase the existing firmware and load new firmware. (To abort, press **<Enter>**.)

The relay responds `Erasing` and erases the existing firmware.

When finished erasing, the relay responds `Erase successful` and prompts you to press any key to begin transferring the new firmware.

```
Are you sure you wish to erase the existing firmware? (Y/N) Y <Enter>
Erasing
Erase successful
Press any key to begin transfer, then start transfer at the PC <Enter>
```

Step 4. Press any key (**<Enter>** is sufficient) to start the file transfer routine.

Step 5. Send new firmware to the relay.

a. From the **Transfer** menu in **HyperTerminal**, choose **Send File** (*Figure B.13*).

b. In the **Filename** text box, type the location and filename of your new firmware or click the **Browse** button to select the firmware file.

c. In the **Protocol** text box, select **1K Xmodem** if you have this protocol available.

If you do not have 1K Xmodem, select **Xmodem**.

d. Click **Send** to send the file containing the new firmware (e.g., r101547.s19).

You should see a dialog box similar to *Figure B.14*. Incrementing numbers in the **Packet** box and a bar advancing from left to right in the **File** box indicate a transfer in progress.

NOTE: The relay restarts in SELBOOT if relay power fails while receiving new firmware after the firmware is erased. At power up, the relay defaults to a data speed of 9600 bps. Perform the steps beginning at Establish Terminal Connection on page U.B.2 to increase the serial connection data speed. Then resume the firmware upgrade process again at Upload New Firmware on page U.B.10 of this document.

Receiving software takes approximately 10 minutes at 38400 bps. If you click **Send** and see no indication of a transfer in progress within a few minutes, use the **REC** command again and reattempt the transfer.

After the transfer completes, the relay displays `Upload completed successfully. Attempting a restart.`

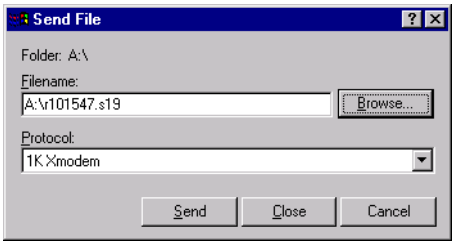

Figure B.13 Selecting the New Firmware to Send to the Relay

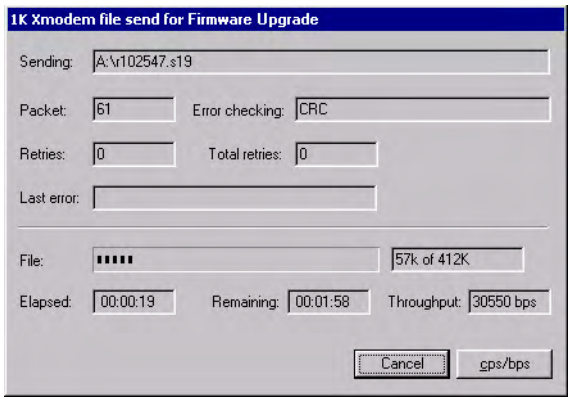

Figure B.14 Transferring New Firmware to the Relay

No Access Level 0 = Prompt

If no Access Level 0 = prompt appears in the terminal emulation window, one of three things could have occurred. Refer to *Table B.1* to determine the best solution.

Table B.1 Troubleshooting New Firmware Upload

Problem	Solution
The restart was successful, but the relay data transmission rate reverted to the rate at which the relay was operating prior to entering SELBOOT (the rate you recorded in *Prepare the Relay on page U.B.1*).	Change the computer terminal speed to match the relay data transmission rate you recorded in *Prepare the Relay* (see *Match Computer Communications Speed to the Relay on page U.B.8*). Step 1. From the **Call** menu, choose **Disconnect** to terminate relay communication. Step 2. Change the communications software settings to the values you recorded in *Prepare the Relay*. Step 3. From the **Call** menu, choose **Connect** to reestablish communication. Step 4. Press **<Enter>** to check for the Access Level 0 = prompt indicating that serial communication is successful. Step 5. If you get no response, proceed to *Match Computer Communications Speed to the Relay*.
The restart was successful, but the relay data transmission rate reverted to 9600 bps (the settings have been reset to default).	Match the computer terminal speed to a relay data transmission rate of 9600 bps. Step 1. From the **Call** menu, choose **Disconnect** to terminate relay communication. Step 2. Change the communications software settings to 9600 bps, 8 data bits, no parity, and 1 stop bit (see *Match Computer Communications Speed to the Relay*). Step 3. From the **Call** menu, choose **Connect** to reestablish communication. Step 4. Press **<Enter>** to check for the Access Level 0 = prompt indicating successful serial communication. If you see a SELBOOT !> prompt, type **EXI <Enter>** to exit SELBOOT. Check for the Access Level 0 = prompt. If you see the Access Level 0 = prompt, proceed to *Check Relay Self-Tests*.
The restart was unsuccessful, in which case the relay is in SELBOOT.	Reattempt to upload the new firmware (beginning at *Establish a High-Speed Connection on page U.B.8*) or contact the factory for assistance.

G Check Relay Self-Tests

Step 1. View the front-panel **ENABLED** LED and confirm that the LED is illuminated.

Unless there is a serious problem, the **ENABLED** LED illuminates without any intervention, and the relay retains all settings. (LED illumination can be delayed for as long as two minutes).

Step 2. Press **<Enter>** and confirm that the Access Level 0 = prompt appears on your terminal screen.

If the **ENABLED** LED is illuminated and the = prompt is visible, proceed to *Verify Calibration, Status, and Metering on page U.B.14*. If this is not the case, perform the following steps.

ENABLED LED Illuminated But No Access Level 0 = Prompt

If the **ENABLED** LED is illuminated but the = prompt does not appear, the relay data transmission rate has reverted to the value used in *Step 6 on page U.B.3*.

Step 1. Change the computer terminal speed to match the relay data transmission rate.

Step 2. Press **<Enter>** to check for the = prompt, indicating that serial communication is successful.

Step 3. Proceed to *Verify Calibration, Status, and Metering on page U.B.14*.

ENABLED LED Not Illuminated

If the **ENABLED** LED does not illuminate, the relay data transmission rate has possibly reverted to the factory default of 9600 bps, settings are at the default values, and the relay default passwords are active.

Step 1. Change the computer terminal speed to match the default relay data transmission rate (9600 bps). (See *Match Computer Communications Speed to the Relay on page U.B.8*.)

a. Terminate relay communication.

b. Change communications software settings to 9600 bps, 8 data bits, 1 stop bit.

c. Reestablish communication.

d. Press **<Enter>** to check for the = prompt, indicating that serial communication is successful

Step 2. Issue the **ACC** and **2AC** commands to enter Access Level 2.

The factory default passwords are in effect; use the default relay passwords listed in the **PAS** command in *PAS (Password Command) on page U.3.5*.

Step 3. Type **R_S <Enter>** to restore factory default settings in the relay.

NOTE: **R_S** command is allowed at Access Level 2 only if the ENABLED LED does not illuminate because of a diagnostic failure.

The relay prompts whether to restore default settings. If the relay does not accept the **R_S** command, contact the factory or your Technical Service Center for assistance.

Step 4. Type **Y <Enter>**.

The relay can take as long as two minutes to restore default settings. The relay then reinitializes, and the **ENABLED** LED illuminates.

Step 5. Press **<Enter>** to check for the = prompt, indicating that serial communication is successful.

NOTE: If the relay prompts you to enter a part number, use either the number from the label on the disk containing your firmware or the number from the new part number sticker (if supplied).

Step 6. Use the **ACC** and **2AC** commands to reenter Access Level 2.

The factory default passwords are in effect; use the default relay passwords listed in the **PAS** command in *PAS (Password Command) on page U.3.5*.

Step 7. Restore original settings.

- ➢ If you have SEL-5010 software, restore original settings as necessary.
- ➢ If you do not have the SEL-5010 software, restore original settings by issuing the necessary **SET** commands: **SET**, **SET L**, **SET P 1**, **SET P F**, and **SET R**.

Step 8. Use the **PAS** command to set the original relay passwords.

Type **PAS 1: Ot3579 <Enter>** to set the Access Level 1 password to Ot3579.

Use a similar format for other password levels. The **PAS** command is case sensitive, so the relay treats lowercase and uppercase letters differently.

Step 9. If any failure status messages still appear on the relay display, see *Section 4: Testing and Troubleshooting*. You can also contact the factory or your Technical Service Center for assistance.

H Verify Calibration, Status, and Metering

Step 1. Use the **ACC** and **2AC** commands to reenter Access Level 2.

Step 2. Type **SHO C <Enter>** to verify the relay calibration settings.

If the settings do not match the settings contained in the text file you recorded in *Save Settings and Other Data on page U.B.6*, contact the factory or your Technical Service Center for assistance.

Step 3. Type **ID <Enter>** to display relay firmware information including the relay part number. Confirm that the new firmware revision number appears in the FID string.

Step 4. Reenter Access Level 2 (if necessary).

Step 5. Type **STA <Enter>** to verify that all relay self-test parameters are within tolerance.

Step 6. Apply current and voltage signals to the relay.

Step 7. Type **MET <Enter>** to verify that the current and voltage signals are correct.

Step 8. Use the **TRI** and **EVE** commands to verify that the magnitudes of the current and voltage signals you applied to the relay match those displayed in the event report.

If these values do not match, check the relay settings and wiring.

I Return the Relay to Service

Step 1. Follow your company procedures for returning a relay to service.

Step 2. Autoconfigure the SEL communications processor port if you have an SEL communications processor connected to the relay.

This step reestablishes automatic data collection between the SEL communications processor and the SEL-547 Relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

The relay is now ready for your commissioning procedure.

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Appendix C

SEL-547 Relay EZ Settings Sheet

EZ Settings (use SHO E and SET E commands)

General Settings

Relay Identifier (30 characters)	**RELID**	= _____
Terminal Identifier (30 characters)	**TERMID**	= _____
Current Transformer Ratio (1–1000)	**CRATIO**	= _____
Nominal Input Voltage, line-to-line (208–480 Vac)	**NOMV**	= _____
Three-Phase Voltage Connection (WYE); fixed setting	**3PCONN**	= _____
Nominal System Frequency (50, 60 Hz)	**FREQ**	= _____
Phase Rotation (ABC, ACB)	**ROTATE**	= _____
Date Format (MDY, YMD)	**DATE**	= _____
LED Flash Interval (OFF, 5, 10, 15, 30, 60 sec.)	**LEDFL**	= _____

Voltage Element Settings (device 27/59; 4 elements)

Undervoltage 1 Pickup (OFF, 50–100%); see *Note 1*	**27UV1P**	= _____
Undervoltage 1 Time Delay (0.00–16000 cyc)	**27UV1D**	= _____
Undervoltage 2 Pickup (OFF, 50–100%); see *Note 1*	**27UV2P**	= _____
Undervoltage 2 Time Delay (0.00–16000 cyc)	**27UV2D**	= _____
Overvoltage 1 Pickup (OFF, 50–144%); see *Note 1*	**59OV1P**	= _____
Overvoltage 1 Time Delay (0.00–16000 cyc)	**59OV1D**	= _____
Overvoltage 2 Pickup (OFF, 50–144%); see *Note 1*	**59OV2P**	= _____
Overvoltage 2 Time Delay (0.00–16000 cyc)	**59OV2D**	= _____

Frequency Element Settings (device 81; 4 elements)

Undervoltage Block Pickup (50–100%); see *Note 1*	**27BLKP**	= _____
Over- and Underfrequency 1 Pickup (OFF, 40.1–69.9 Hz)	**81OU1P**	= _____
Over- and Underfrequency 1 Time Delay (5.00–16000 cyc)	**81OU1D**	= _____
Over- and Underfrequency 2 Pickup (OFF, 40.1–69.9 Hz)	**81OU2P**	= _____

Over- and Underfrequency 2 Time Delay (5.00–16000 cyc)	**81OU2D**	=
Over- and Underfrequency 3 Pickup (OFF, 40.1–69.9 Hz)	**81OU3P**	=
Over- and Underfrequency 3 Time Delay (5.00–16000 cyc)	**81OU3D**	=
Over- and Underfrequency 4 Pickup (OFF, 40.1–69.9 Hz)	**81OU4P**	=
Over- and Underfrequency 4 Time Delay (5.00–16000 cyc)	**81OU4D**	=

Directional Power Element Settings (device 32; 1 element)

Three-Phase Power Pickup (OFF, 40–900 Watts, secondary)	**32P**	=
Power Element, Forward or Reverse (F, R)	**32FR**	=
Power Element Time Delay (0.00–16000 cyc)	**32D**	=

Synchronism Check Element Settings (device 25; 1 element)

Difference Voltage Pickup (OFF, 1–50%); see *Note 1*	**25DIFP**	=
Maximum Slip Frequency (0.1–0.5 Hz)	**25SLP**	=
Maximum Angle (2–60 degrees)	**25ANG**	=

Port Settings (use SHO P n and SET P n commands)

(*n* = F, for Port F; *n* = 1, for Port 1)			Port F (EIA-232)	Port 1 (EIA-485)
Protocol (SEL, LMD, MOD) SEL=SEL ASCII Protocol LMD=SEL Distributed Port Switch Protocol (not discussed in manual) MOD=MODBUS® Protocol (only one port can be a MODBUS port)	**PROTO**	=		
Baud Rate (300, 1200, 2400, 4800, 9600, 19200)	**SPEED**	=		
Data Bits (7, 8); see *Note 2*	**BITS**	=		
Parity (O, E, N); O=odd, E=even, N=none	**PARITY**	=		
Stop Bits (1, 2)	**STOP**	=		
Minutes to Port Time-Out (0–30); see *Note 2*	**T_OUT**	=		
Send Auto Messages to Port (Y, N); see *Note 2*	**AUTO**	=		
Enable Hardware Handshaking (Y, N); SEL ASCII port only	**RTSCTS**	=		N/A
Fast Operate Enable (Y, N); see *Note 2*	**FASTOP**	=		
MODBUS Slave ID (1–247); MODBUS port only	**MODID**	=		

Note 1

All voltage pickup settings are in percent of Vnom (Vnom = setting NOMV/$\sqrt{3}$ = nominal input voltage, line-to-neutral).

Note 2

These settings are **not** available on a MODBUS port.

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Index

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V

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SEL-547 Relay Command Summary

Command	Description
Access Level 0 Command	Access Level 0 is the initial relay access level. The relay automatically returns to Access Level 0 when a serial port time-out setting expires or after a QUIT command. The screen prompt is: =
ACC	Enter Access Level 1. The relay prompts the user for the Access Level 1 password in order to enter Access Level 1.
Access Level 1 Commands	The Access Level 1 commands allow the user to look at settings information and not change it, and to retrieve and reset event, recorder, and metering data. The screen prompt is: =>
2AC	Enter Access Level 2. The relay prompts for the entry of the Access Level 2 password in order to enter Access Level 2.
BAC	Enter Breaker Access Level (Access Level B). The relay prompts the user for the Access Level B password.
DAT	Show date.
DAT *mm/dd/yy*	Enter date in this manner if global Date Format setting, DATE_F, is set to MDY.
DAT *yy/mm/dd*	Enter date in this manner if global Date Format setting, DATE_F, is set to YMD.
EVE *n*	Show event report *n* with 4 samples per cycle (*n* = 1 to highest numbered event report, where 1 is the most recent report; see **HIS** command). If *n* is omitted, (**EVE** command) most recent report is displayed.
EVE *n* R	Show event report *n* in raw (unfiltered) format with 16 samples per cycle resolution.
EVE *n* C	Show event report *n* in Compressed ASCII format.
EVE *n* A	Show event report *n* with analog section only.
EVE *n* S*x*	Show event report *n* with *x* samples per cycle (*x* = 4 or 16).
EVE *n* L	Show event report *n* with 16 samples per cycle (similar to **EVE *n* S16**).
EVE *n* L*y*	Show first *y* cycles of event report *n* (*y* = 1 to global setting LER).
EVE *n* V	Show event report *n* with variable scaling for analog values.
GRO	Display active group number.
HIS *n*	Show brief summary of *n* latest event reports, where 1 is the most recent entry. If *n* is not specified, (**HIS** command) all event summaries are displayed.
HIS C	Clear all event reports from volatile memory.
MET *k*	Display instantaneous metering data. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
QUI	Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) connection.
SER	Show entire Sequential Events Recorder (SER) report.
SER *n*	Show latest *n* rows in the SER report (*n* = 1–512, where 1 is the most recent entry).
SER *m n*	Show rows *m* through *n* in the SER report (*m* = 1–512).
SER *d1*	Show all rows in the SER report recorded on the specified date (see **DAT** command for date format).
SER *d1 d2*	Show all rows in the SER report recorded between dates *d1* and *d2*, inclusive.
SER C	Clears SER report from nonvolatile memory.
SHO *n*	Show relay settings (voltage, frequency, timers, etc.) for Group *n* (*n* = 1–2, if not specified, default is active setting group).
SHO *n* L	Show SELOGIC® control equation settings for Group *n* (*n* = 1–2, if not specified, default is the SELOGIC control equations for the active setting group).
SHO E	Show/view EZ settings.
SHO G	Show global settings.
SHO R	Show SER and settings.
SHO P *n*	Show serial port *n* settings, (*n* = 1 or F, if not specified, default is active port).

Command	Description
SHO ... *name*	For all **SHO** commands, jump ahead to specific setting by entering setting name.
STA	Show relay self-test status.
TAR *n k*	Display Relay Word row. If *n* = 0–62, display row *n*. If n is an element name (e.g., 50A1) display row containing element *n*. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
TAR LIST	Shows all the Relay Words in all of the rows.
TAR ROW . . .	Shows the Relay Word row number at the start of each line, with other selected Target commands as described above, such as *n*, name, *k*, and LIST.
TIM	Show or set time (24 hour time). Show current relay time by entering **TIM**. Set the current time by entering TIM followed by the time of day (e.g., set time 22:47:36 by entering **TIM 22:47:36**).
TRI	Trigger an event report.
Access Level B Commands	Access Level B commands primarily allow the user to operate the output contacts and change port and EZ settings. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
CLO	Close circuit breaker (assert Relay Word bit CC).
OPE	Open circuit breaker (assert Relay Word bit OC).
PUL *n k*	OUT201–OUT212) for *k* seconds. Specify parameter *n*; *k* = 1–30 seconds; if not specified, default is 1.
SET E	Change relay EZ settings.
SET P *n*	Change serial port *n* settings, (*n* = 1 or F, if not specified, default is active port).
Access Level 2 Commands	The Access Level 2 commands allow unlimited access to relay settings, parameters, and output contacts. All Access Level 1 and Access Level B commands are available from Access Level 2. The screen prompt is: =>>
CAL	Enter Access Level C. If the main board password jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CON *n*	Control Relay Word bit RB*n* (Remote Bit *n*; *n* = 1–16). Execute **CON *n*** and the relay responds: `CONTROL RBn`. Then reply with one of the following:
SRB *n*	Set Remote Bit *n* (assert RB*n*).
CRB *n*	Clear Remote Bit *n* (deassert RB*n*).
PRB *n*	Pulse Remote Bit *n* [assert RB*n* for 1/4 cycle].
COP *m n*	Copy relay and logic settings from group *m* to group *n* (*m* and *n* are numbers 1–6).
GRO *n*	Change active group to group *n* (*n* = 1–2).
PAS	Show existing Access Level 1, Level B, and Level 2 passwords.
PAS 1 *xxxxxx*	Change Access Level 1 password to *xxxxxx*.
PAS B *xxxxxx*	Change Access Level B password to *xxxxxx*.
PAS 2 *xxxxxx*	Change Access Level 2 password to *xxxxxx*.
PAS C *xxxxxx*	Change Access Level C password to *xxxxxx*. Entering DISABLE as the password disables the password requirement for the specified access level.
SET *n*	Change relay settings (voltage, frequency, timers, etc.) for group *n* (*n* = 1–2, if not specified, default is active setting group).
SET *n* L	Change SELOGIC control equation settings for group *n* (*n* = 1–2, if not specified, default is the SELOGIC control equations for the active setting group).
SET G	Change global settings.
SET R	Change SER settings.
SET ... *name*	For all **SET** commands, jump ahead to specific setting by entering setting name.
SET ... TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after settings entry.

Command	Description
STA C	Resets self-test warnings/failures and reboots the relay.
VER	Show relay configuration and firmware version.
Key Stroke Commands	
Ctrl+Q	Send **XON** command to restart communications port output previously halted by XOFF.
Ctrl_S	Send **XOFF** command to pause communications port output.
Ctrl+X	Send **CANCEL** command to abort current command and return to current access level prompt.
Key Stroke Commands When Using SET Command	
<ENTER>	Retains setting and moves on to next setting.
^ <ENTER>	Returns to previous setting.
< <ENTER>	Returns to previous setting section.
> <ENTER>	Skips to next setting section.
END <ENTER>	Exits setting editing session, then prompts user to save settings.
Ctrl+X	Aborts setting editing session without saving changes.

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SEL-547 Relay Command Summary

Command	Description
Access Level 0 Command	Access Level 0 is the initial relay access level. The relay automatically returns to Access Level 0 when a serial port time-out setting expires or after a QUIT command. The screen prompt is: =
ACC	Enter Access Level 1. The relay prompts the user for the Access Level 1 password in order to enter Access Level 1.
Access Level 1 Commands	The Access Level 1 commands allow the user to look at settings information and not change it, and to retrieve and reset event, recorder, and metering data. The screen prompt is: =>
2AC	Enter Access Level 2. The relay prompts for the entry of the Access Level 2 password in order to enter Access Level 2.
BAC	Enter Breaker Access Level (Access Level B). The relay prompts the user for the Access Level B password.
DAT	Show date.
DAT *mm/dd/yy*	Enter date in this manner if global Date Format setting, DATE_F, is set to MDY.
DAT *yy/mm/dd*	Enter date in this manner if global Date Format setting, DATE_F, is set to YMD.
EVE *n*	Show event report *n* with 4 samples per cycle (*n* = 1 to highest numbered event report, where 1 is the most recent report; see **HIS** command). If *n* is omitted, (**EVE** command) most recent report is displayed.
EVE *n* R	Show event report *n* in raw (unfiltered) format with 16 samples per cycle resolution.
EVE *n* C	Show event report *n* in Compressed ASCII format.
EVE *n* A	Show event report *n* with analog section only.
EVE *n* S*x*	Show event report *n* with *x* samples per cycle (*x* = 4 or 16).
EVE *n* L	Show event report *n* with 16 samples per cycle (similar to **EVE *n* S16**).
EVE *n* L*y*	Show first *y* cycles of event report *n* (*y* = 1 to global setting LER).
EVE *n* V	Show event report *n* with variable scaling for analog values.
GRO	Display active group number.
HIS *n*	Show brief summary of *n* latest event reports, where 1 is the most recent entry. If *n* is not specified, (**HIS** command) all event summaries are displayed.
HIS C	Clear all event reports from volatile memory.
MET *k*	Display instantaneous metering data. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
QUI	Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) connection.
SER	Show entire Sequential Events Recorder (SER) report.
SER *n*	Show latest *n* rows in the SER report (*n* = 1–512, where 1 is the most recent entry).
SER *m n*	Show rows *m* through *n* in the SER report (*m* = 1–512).
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SER C	Clears SER report from nonvolatile memory.
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SHO *n* L	Show SELOGIC® control equation settings for Group *n* (*n* = 1–2, if not specified, default is the SELOGIC control equations for the active setting group).
SHO E	Show/view EZ settings.
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> <ENTER>	Skips to next setting section.
END <ENTER>	Exits setting editing session, then prompts user to save settings.
Ctrl+X	Aborts setting editing session without saving changes.

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