SEL-547

Distributed Generator Interconnection Relay

User's Guide

20021206

Making Electric Power Safer,
More Reliable, and More Economical

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.

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

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

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.

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.

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

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.

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.

AVERTISSEMENT: Cet appareil est expédié avec des mots de passe par défaut. A l'installation, les mots de passe par défaut devront être changés pour des mots de passe confidentiels. Dans le cas contraire, un accés non-autorisé á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accés non-autorisé.

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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 Relay 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.

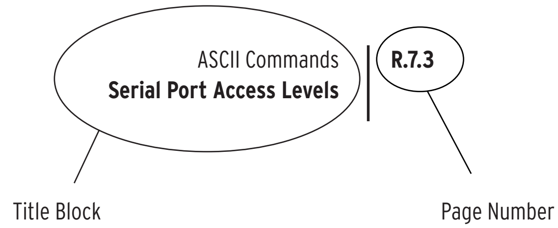
Section 8: Settings. Provides information about settings changes via the serial port, how EZ settings force global and Group 1 settings, and settings sheets.

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	ASCII and Compressed ASCII commands.
TAR 6 <Enter>	Commands/input that you type.
{CLOSE}	Relay front-panel pushbuttons.
<Enter>	Single keystroke command.
<Ctrl+D>	Multiple keystroke command to bring up a control window or activate a control function.
RELAY ELEMENTS	Front-panel LCD menu items.
Start	Dialog Boxes: Menu titles, options, drop-down or check box menu selections, highlighted options.

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

The SEL-547 Relay is a utility grade generation protection system relay designed to protect on-site 50–200 kW distributed generators with generated voltages up to 600 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.

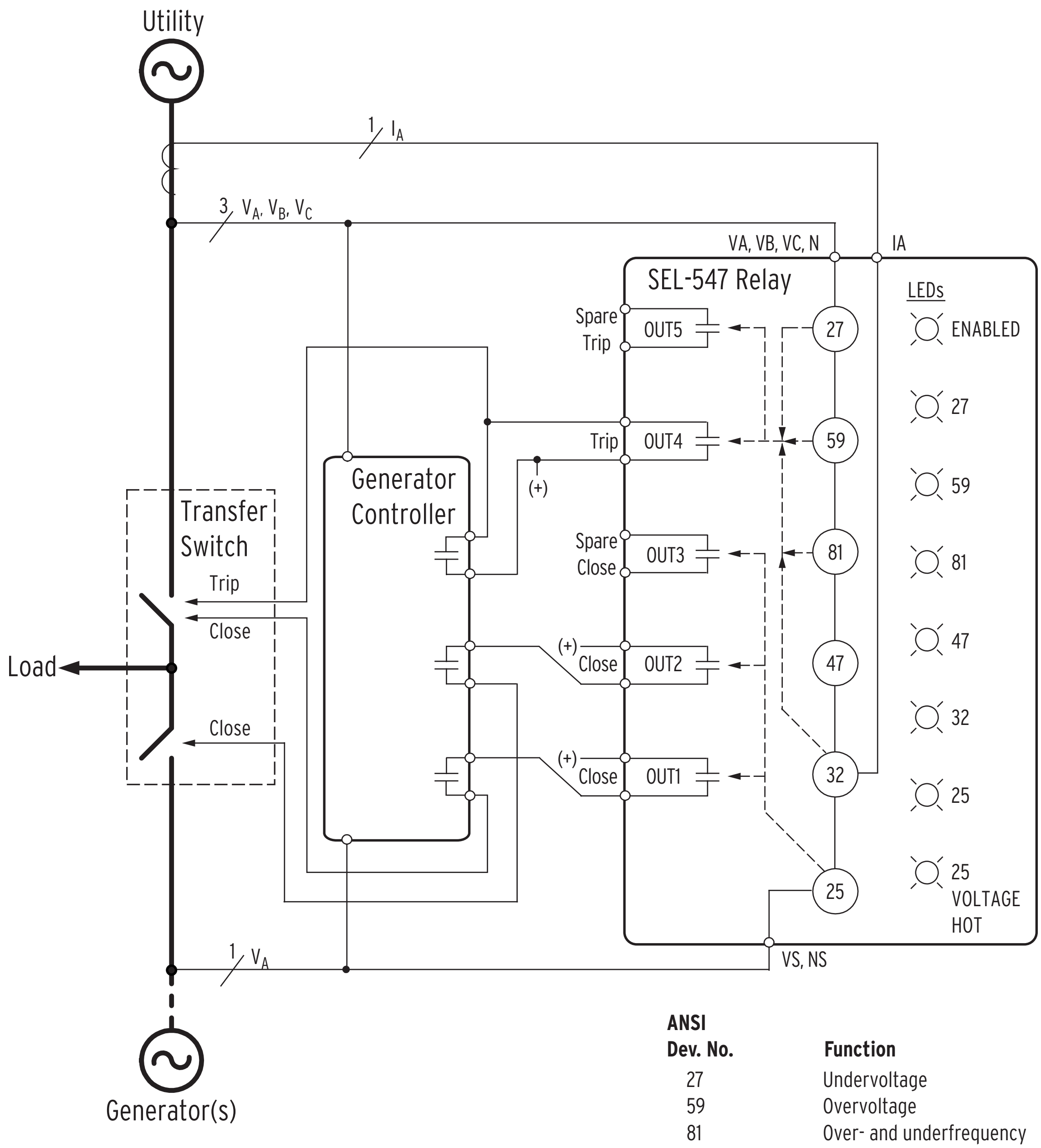
The SEL-547 is shipped with EZ settings—settings preset at the factory for basic applications. These settings are based on traditional relay applications and should be modified if you are using the SEL-547 for a custom application. Please refer to the SEL-547 *Reference Manual* for more details about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

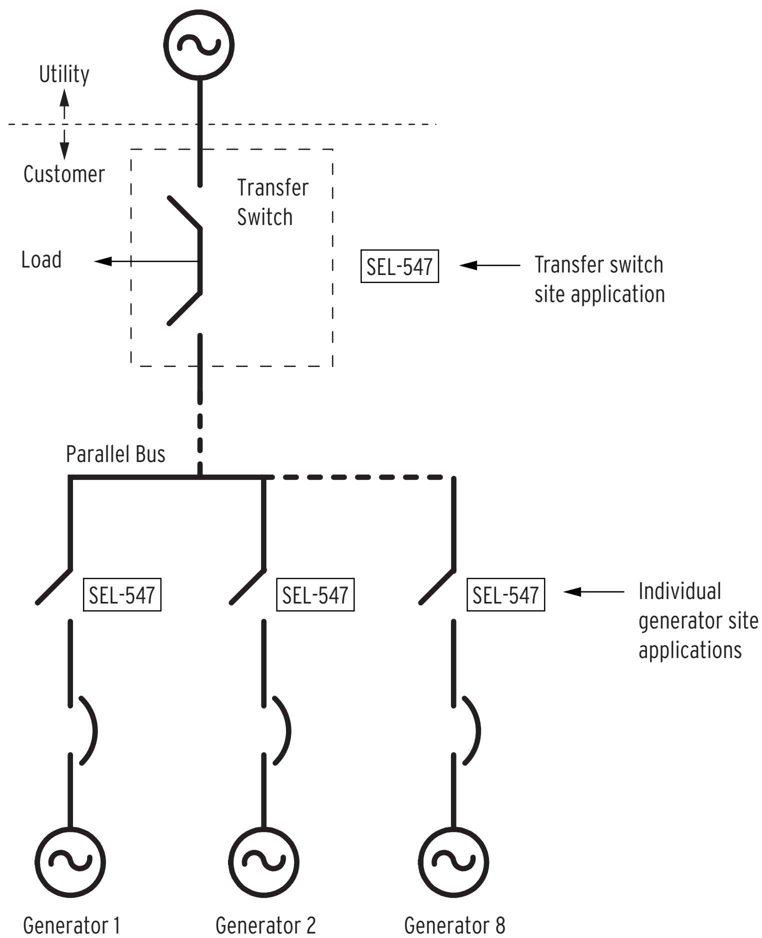


Figure 1.2 Applications for the SEL-547.

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.

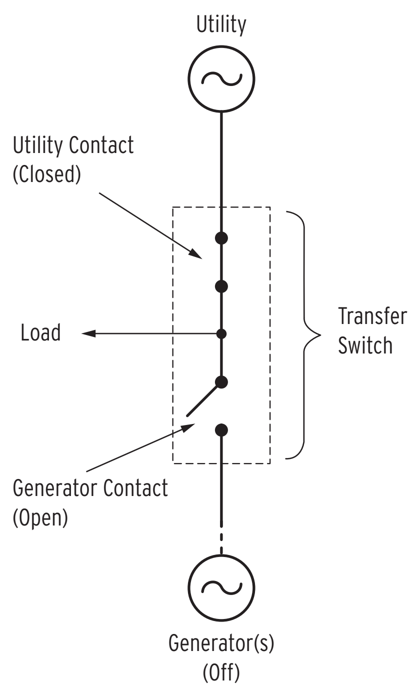


Figure 1.3 Utility Normally Serves the Load.

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.

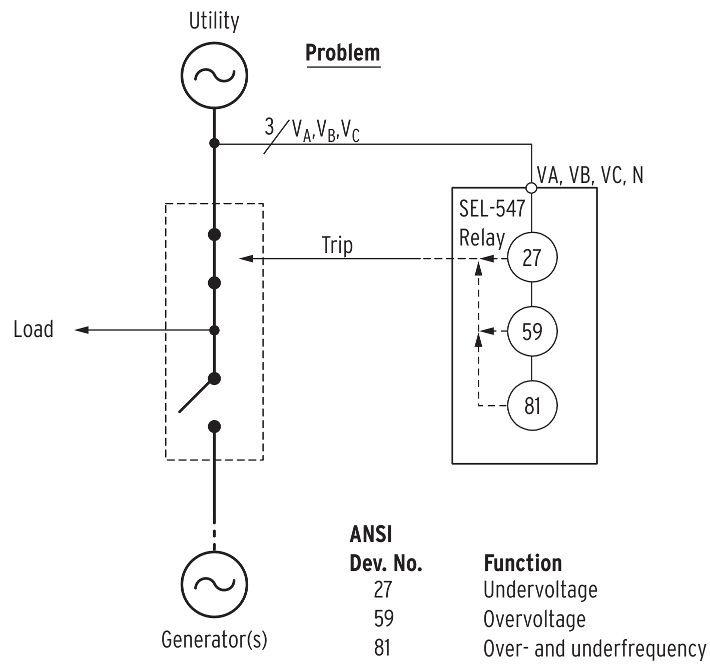


Figure 1.4 SEL-547 Detects a Utility Source Problem.

In *Figure 1.4* there is a problem in the utility system [over- and undervoltage or over- and underfrequency condition, due to 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.

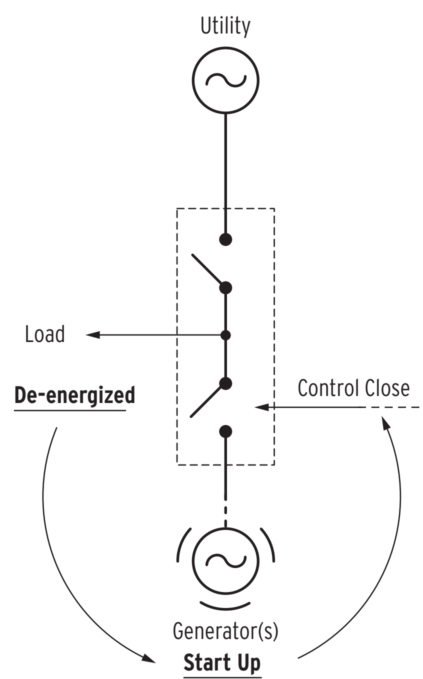


Figure 1.5 Load Is De-energized and Generator Starts Up.

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

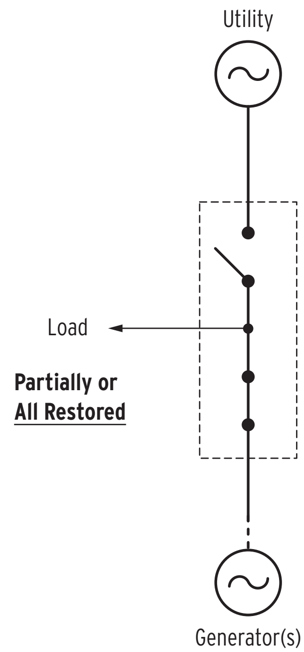


Figure 1.6 Generator Serves Load (or Partial Load) in Emergency Backup Role.

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 in its emergency backup role.

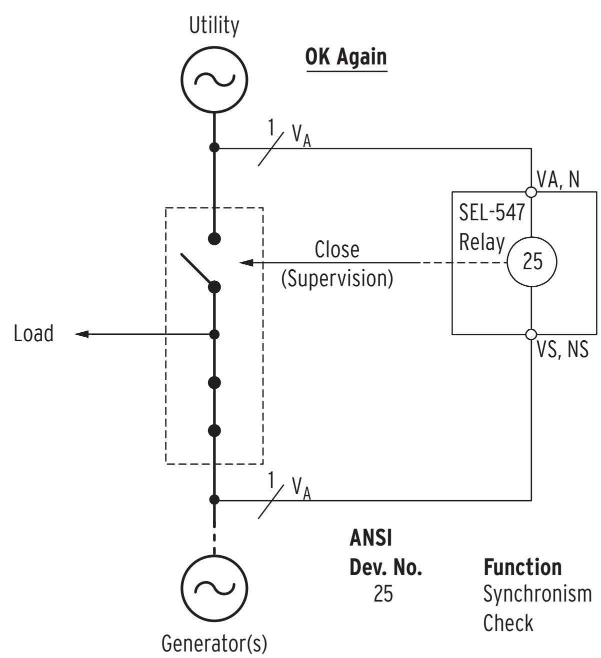


Figure 1.7 SEL-547 Detects Utility Source OK.

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.

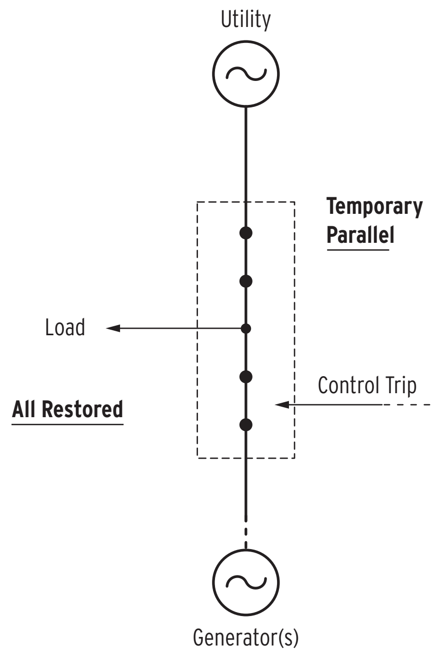


Figure 1.8 All Load Restored and Temporary Parallel Exists.

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

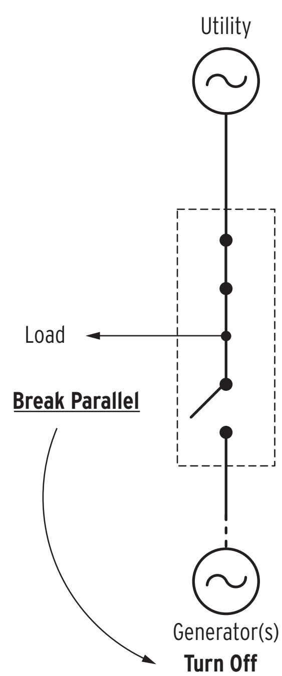


Figure 1.9 Parallel Broken and Generator Turned Off.

In *Figure 1.9*, the system is back to the state it was before the utility system problem. The customer load is entirely served 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.

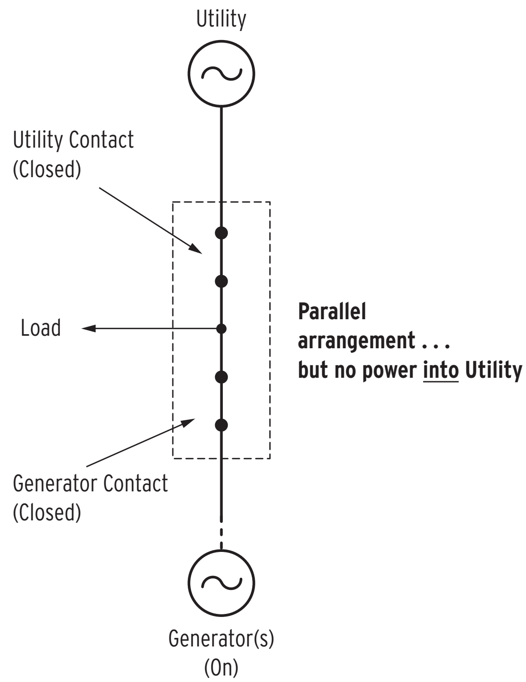


Figure 1.10 Utility and Customer Generator Normally Paralleled.

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).

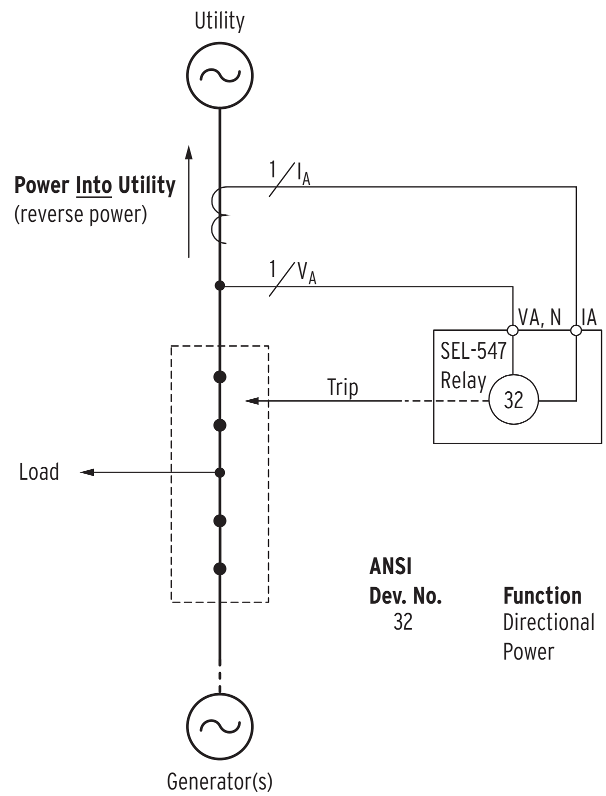


Figure 1.11 SEL-547 Detects Reverse Power Flow Into Utility.

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.

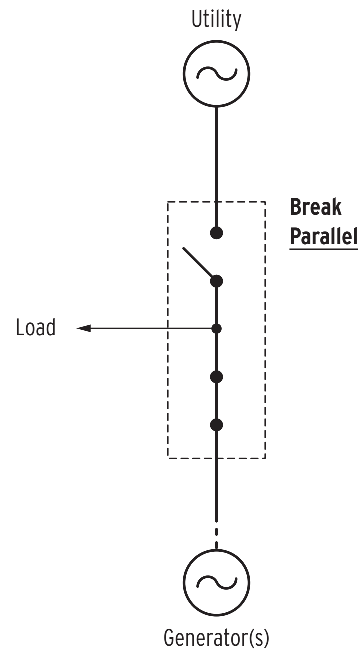


Figure 1.12 Parallel Broken and Customer Load and Generator Isolated Together.

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.

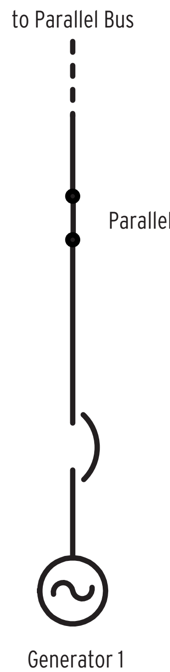


Figure 1.13 Individual Generator Paralleled With the Greater System.

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.

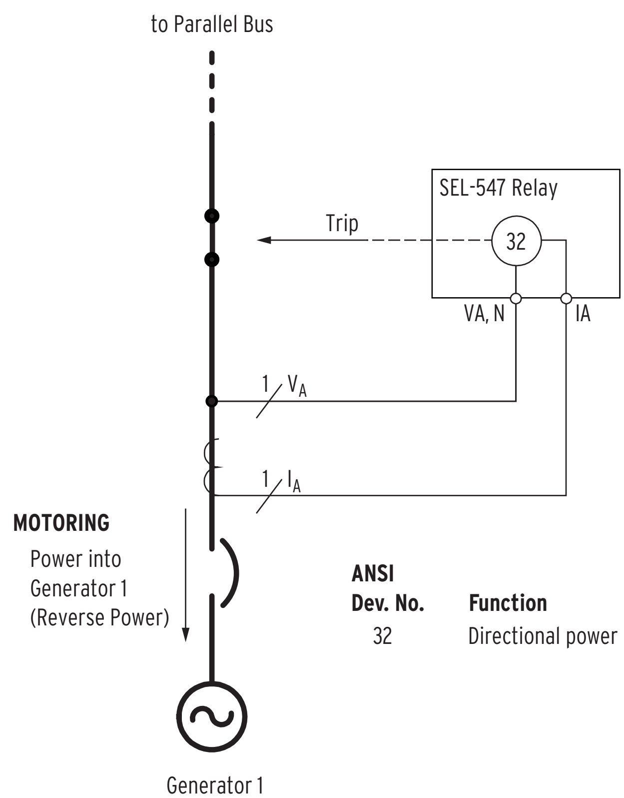


Figure 1.14 SEL-547 Detects Reverse Power Flow Into Generator.

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.

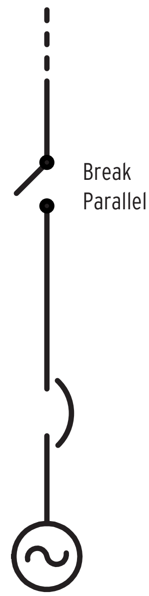


Figure 1.15 Parallel Broken and Motoring of Generator Stopped.

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

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 Adc, 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 2.7 on page R.2.12* for relay dimensions.

Humidity

5% to 95% noncondensing

Weight

2.55 pounds (1.16 kilograms)

Terminal Connections

See *Table 2.1 on page U.2.4*.

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 Cycle:	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 C37.90-1989
Impulse:	IEC 60255-5 (2000)

Certifications

ISO

Relay designed and manufactured using ISO-9001 certified quality program.

UL

UL 508 Industrial Control Equipment.

CSA

CSA C22.2 No. 14-95 Industrial Control Equipment.

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Section 2
Installation

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

Step 1: Mounting the Relay Enclosure

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.1.16*).
2. Mount the SEL-547 on a panel. See *Figure 2.1* for dimensions.

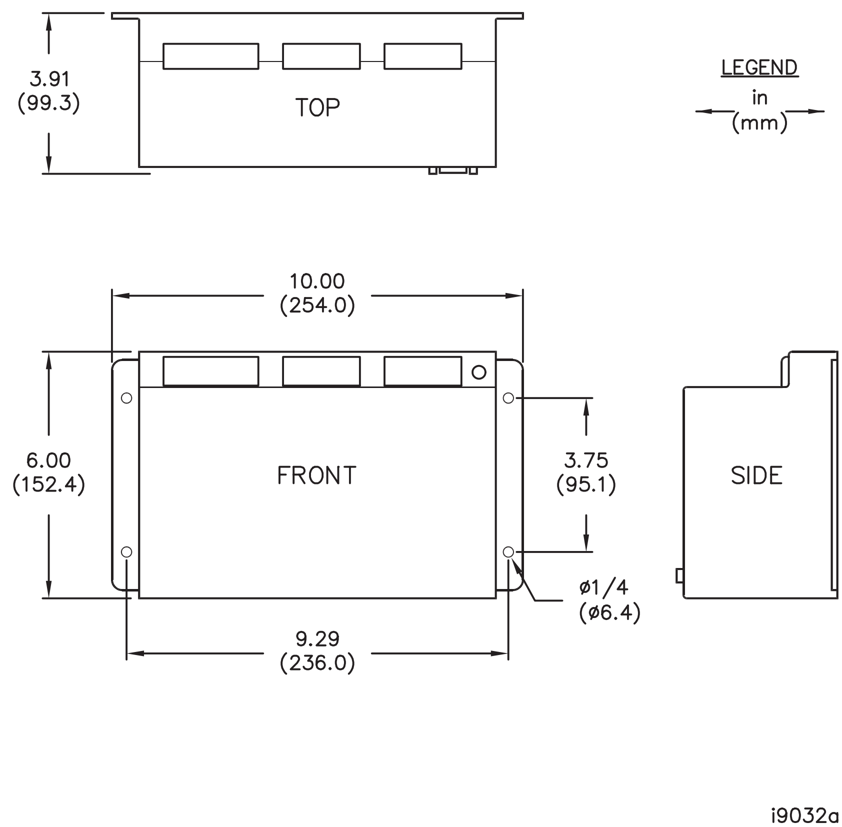

Figure 2.1 SEL-547 Chassis Dimensions (not to scale).

Step 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.

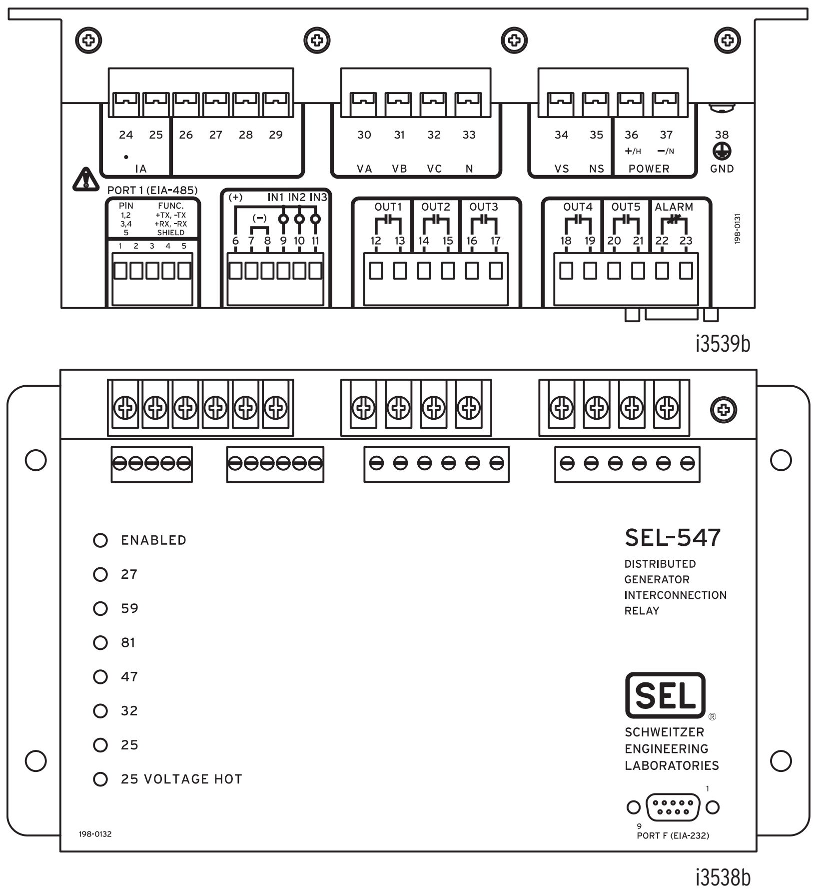

Figure 2.2 SEL-547 Top and Front Views.

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

Voltage and Current Connections

⚠WARNING
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 trippng (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.3.22* 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.3.20* for more details).

Voltage and current input ratings are in *Specifications on page U.1.16Section 1*.

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 through OUT5 provide tripping and close-supervision functions.

⚠CAUTION
SEL-547 output contacts are **not** meant to interrupt substantial currents. See the output contacts interrupt rating in *Specifications on page U.1.16*

- 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.

The dedicated ALARM output contact comes as a b-type 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 on page U.1.2*, 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.

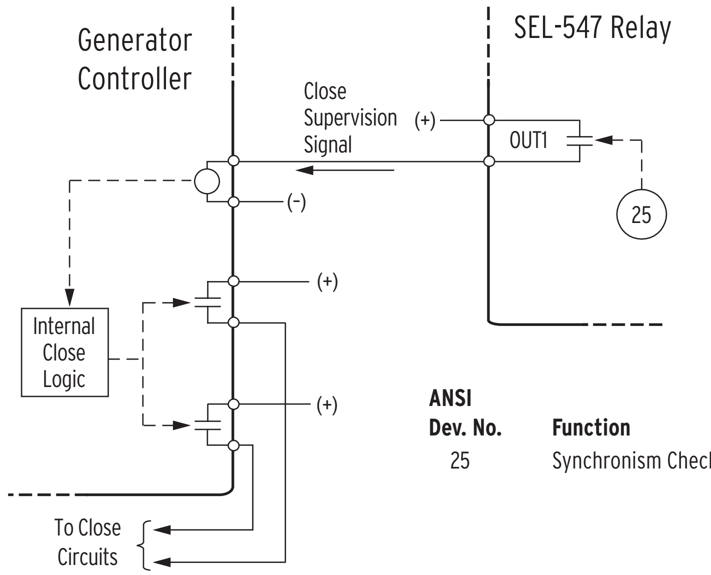

Figure 2.3 Alternative Close Supervision Wiring.

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 on page U.1.2*, 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.

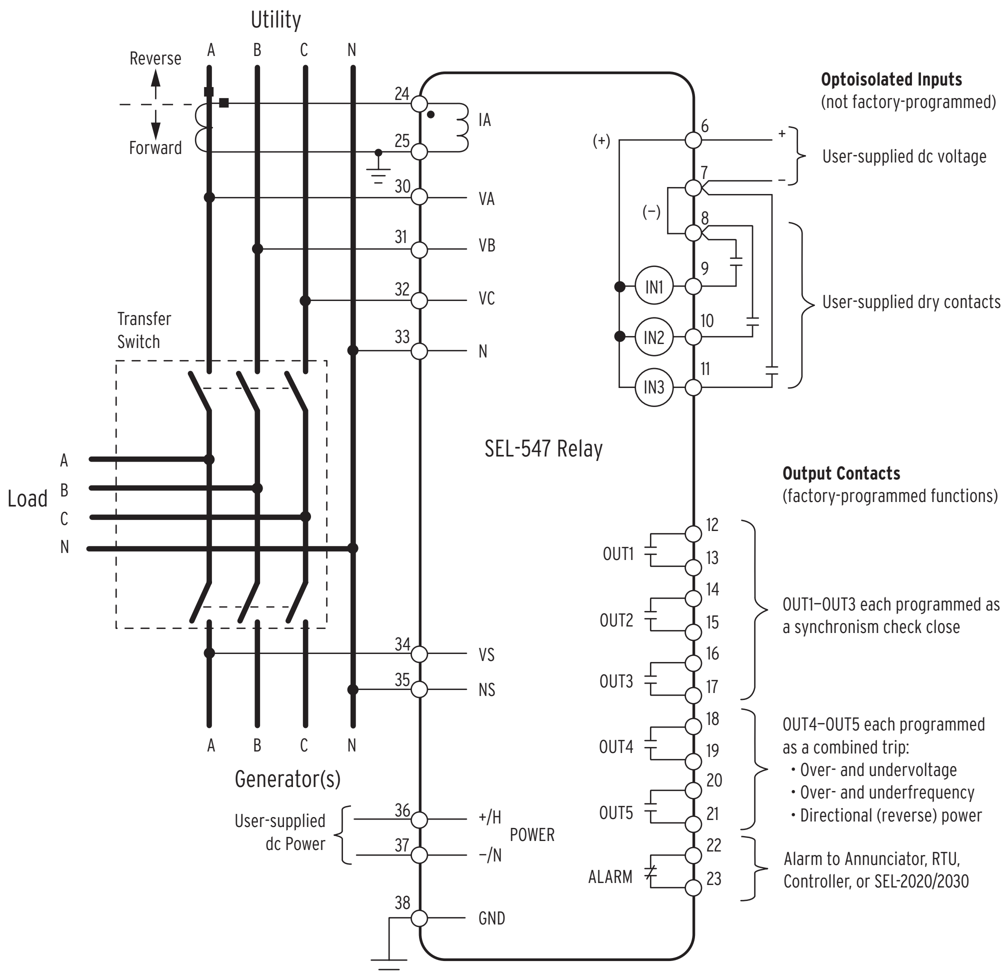

Figure 2.4 Connection Details (Transfer Switch Site Application).

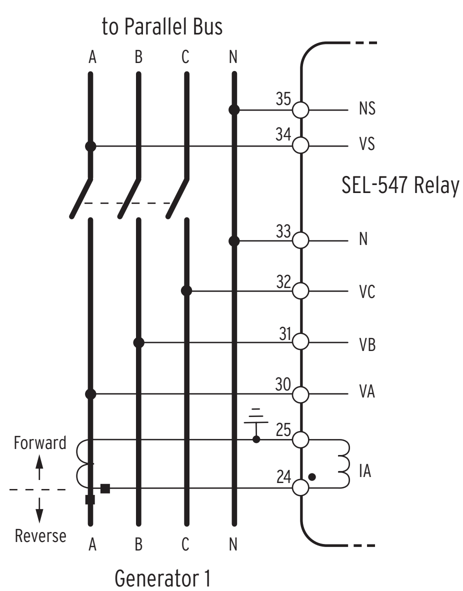

Figure 2.5 Voltage and Current Connection Details (Individual Generator Site Application).

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Section 3
Basic Relay Operations

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.

Step 3: Powering the Unit

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.

Step 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.

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.

2. Apply power to both the computer and to the relay.
3. Start the computer terminal emulation program.
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

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	
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 one 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.
Protocol setting selection LMD is not discussed in this manual.

[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).

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

6. View the relay report header. Type **QUIT <Enter>**. You will see a computer screen display similar to *Figure 3.1*. (Text that you type is emphasized in bold letters.) 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 **=** action 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.

Step 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 action 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 (can't 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.

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 **=** action prompt.
2. Enter Access Level 1 with the command and password from Table 3.2.
3. Enter Access Level B with the command and password from Table 3.2.
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
```

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

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

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

7. Record the passwords.

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

Disable Passwords

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.

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

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

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.

Step 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.

Step 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 action prompt to view the date stored in the SEL-547.

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 action 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 action 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 action 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 action 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 action 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 action prompt:

TIM 17:14:00

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

Step 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*.

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) ?” action prompt.
<Ctrl+x> <Enter>	Abort settings session without saving changes and get back to the action 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
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

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

Description	Setting Label	Default Value
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.

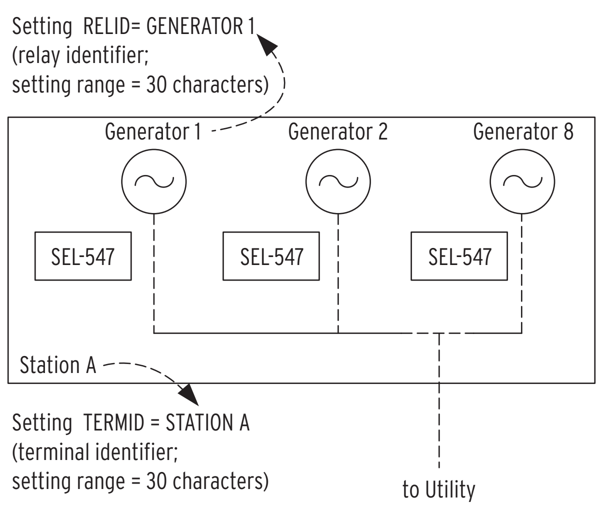


Figure 3.3 Settings RELID and TERMID.

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 on page U.3.21* 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 considerable larger (because the transfer switch has to handle all the incoming load current).

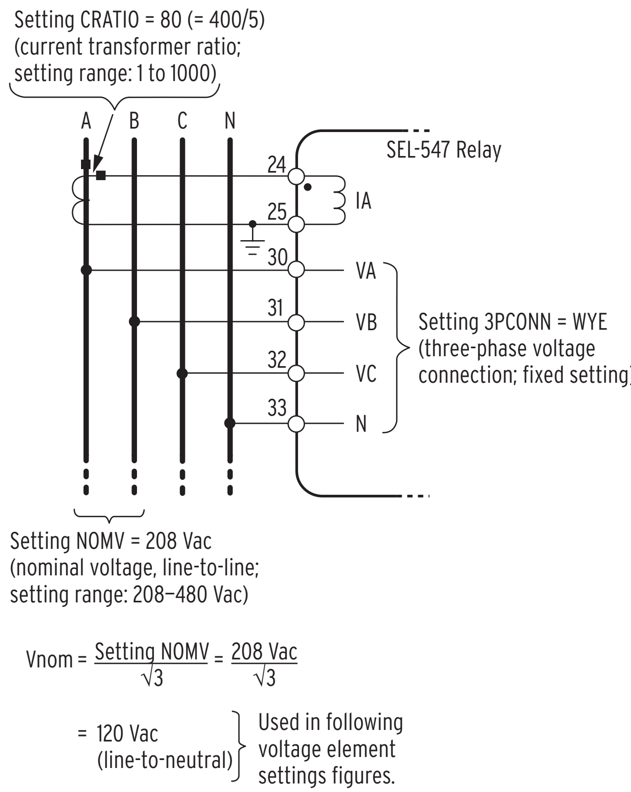


Figure 3.4 Settings CRATIO, 3PCONN, and NOMV.

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 on page U.2.7*) 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 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.

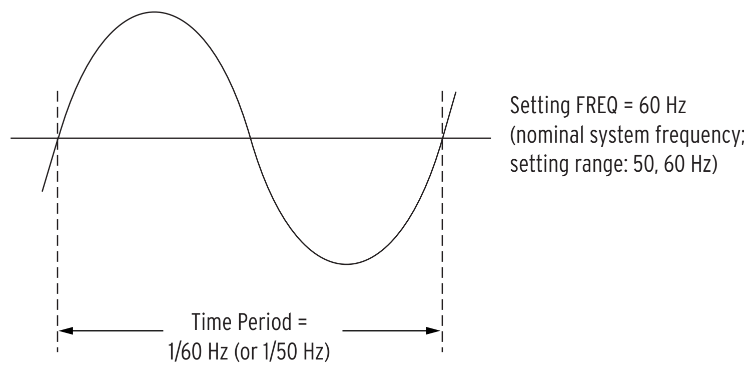


Figure 3.5 Setting FREQ.

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.

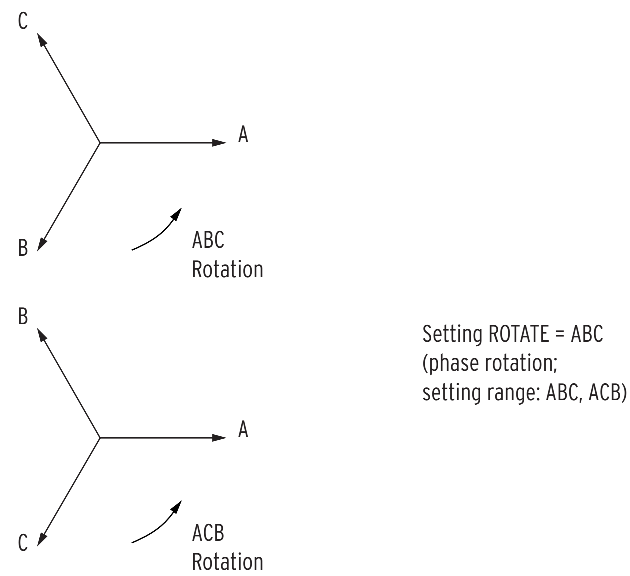


Figure 3.6 Setting ROTATE.

Setting DATE

The DATE setting determines whether the date will be entered (via the **DAT** command—see *Step 7: Setting the Date and Time on page U.3.9*) and displayed (in relay report headers—see **STA** command and others in *Step 6: Checking Relay Status on page U.3.8*) in

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

Setting LEDFL

In *Figure 3.7*, setting LEDFL is the time interval between the simultaneous flashing of the front-panel LEDs. The SEL-547 does not have a **{LAMP TEST}** pushbutton, so this automatic flashing of the LEDs indicates that they are in good working order. This flashing function can also be turned off (setting LEDFL = OFF).

If an LED is already illuminated, this flashing is of no effect. Also, the ENABLED LED is not affected by this flashing—it should be illuminated all the time anyway, indicating a functional unit.

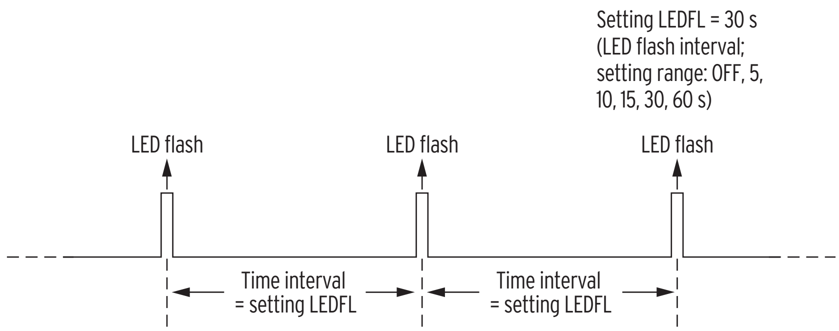


Figure 3.7 Setting LEDFL.

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.

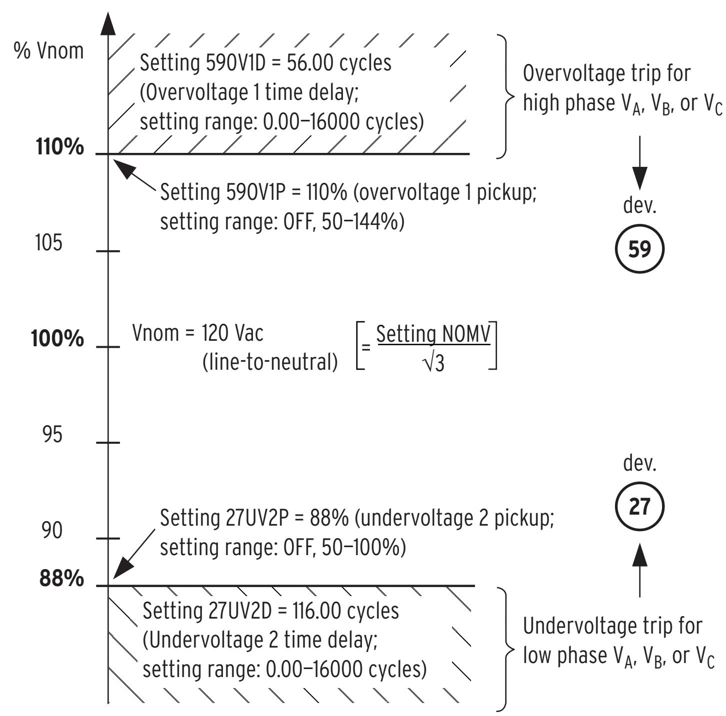


Figure 3.8 Voltage Element Settings—Example 1.

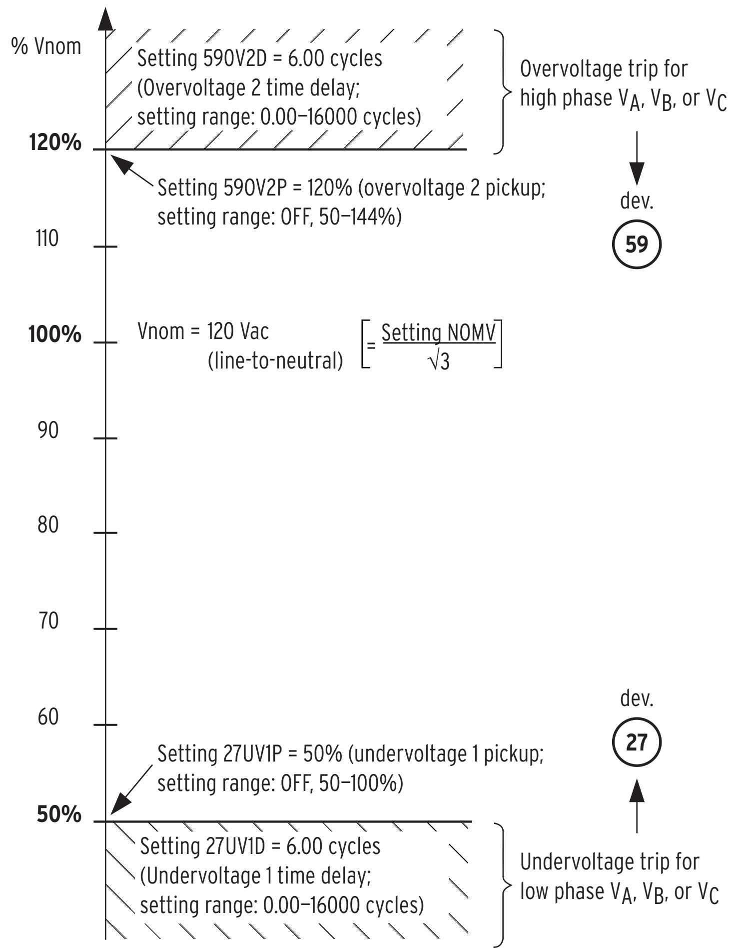


Figure 3.9 Voltage Element Settings—Example 2.

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 assure 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.

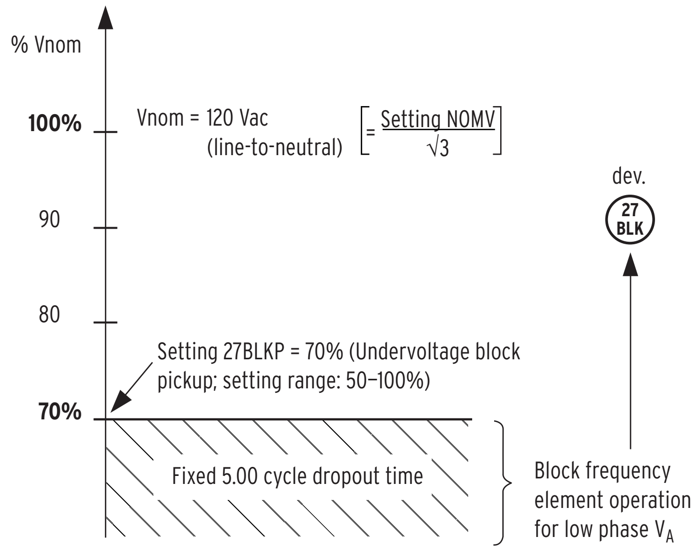


Figure 3.10 Setting 27BLKP (Undervoltage Block).

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.

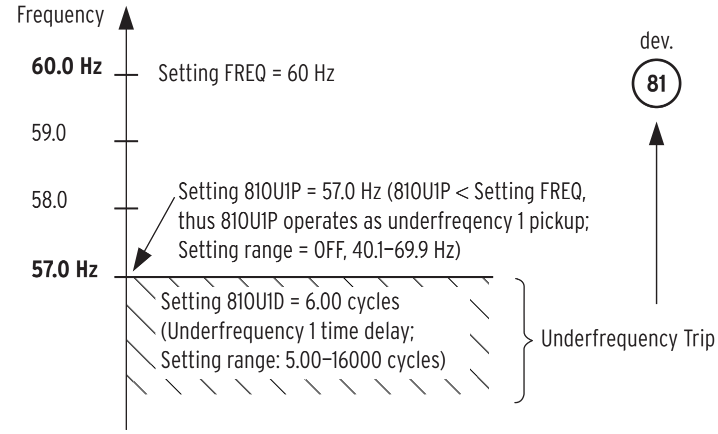


Figure 3.11 Frequency Element Settings—Example 1.

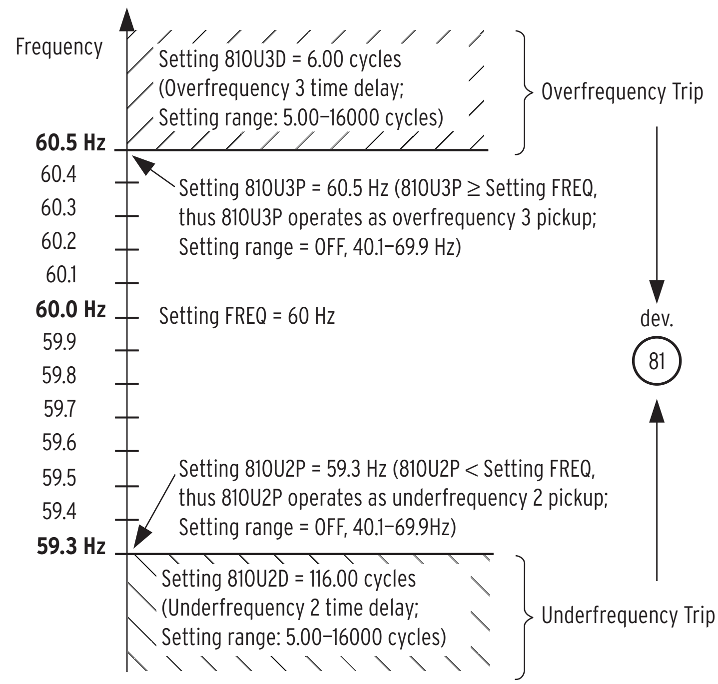


Figure 3.12 Frequency Element Settings—Example 2.

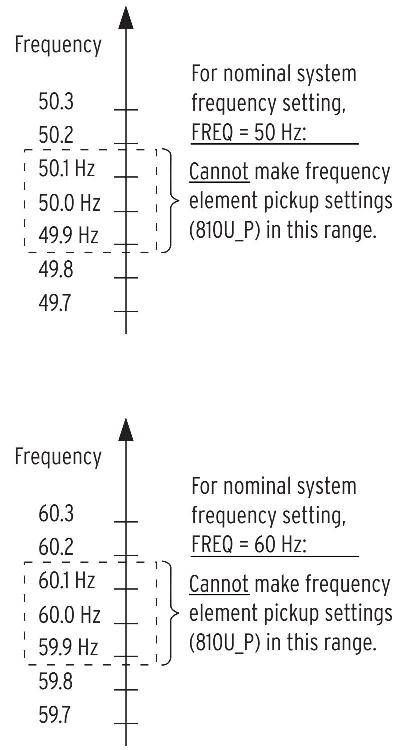


Figure 3.13 Frequency Element Setting Range Exclusions.

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):

$$\frac{50000\ \text{Watts}}{80} = 60\ \text{W sec. (three-phase)}$$

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).

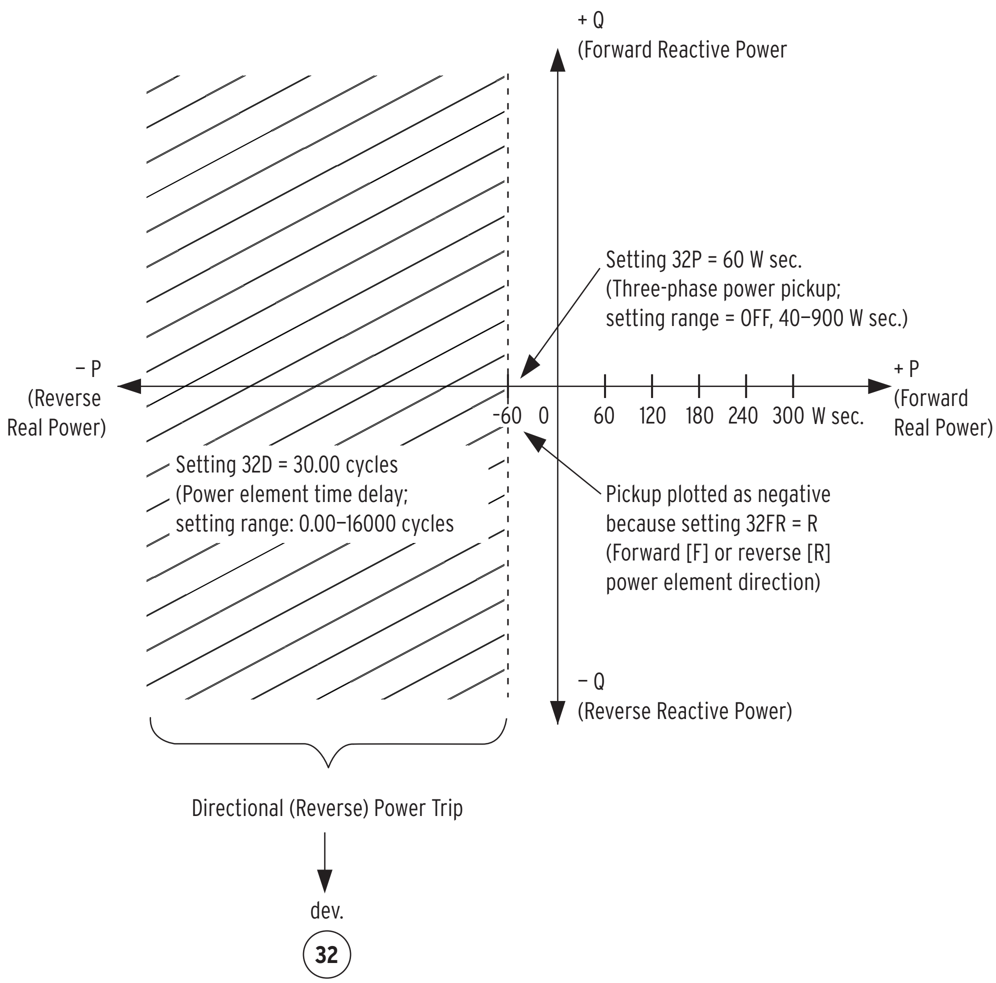


Figure 3.14 Directional Power Element Settings.

Synchronism Check Element Settings (device 25)

NOTE: Consult the IEEE P1547 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 on page U.1.8*). 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 through 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).

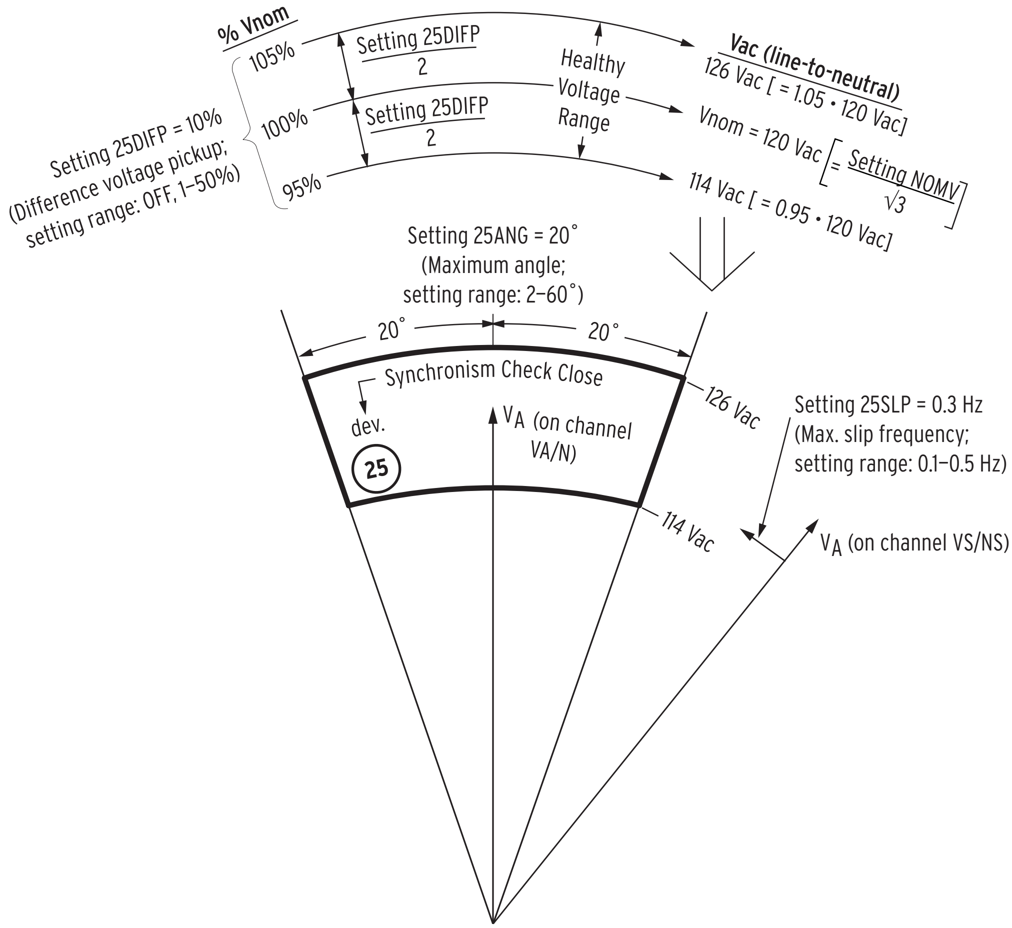


Figure 3.15 Synchronism Check Element Settings.

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:

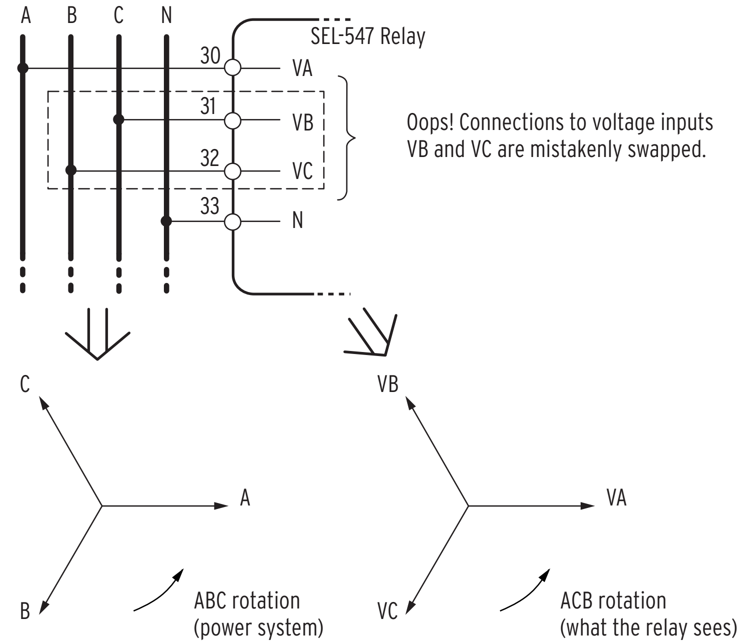
$$V_2(100\%) = \text{Vnom} = 120 \text{ Vac}$$

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 on page U.2.3*). *Figure 3.17* shows this implementation with the fixed pickup of 50 percent of nominal voltage Vnom:

$$0.5 \bullet \text{Vnom} = 0.5 \bullet 120 \text{ Vac} = 60 \text{ Vac}$$

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.

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

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

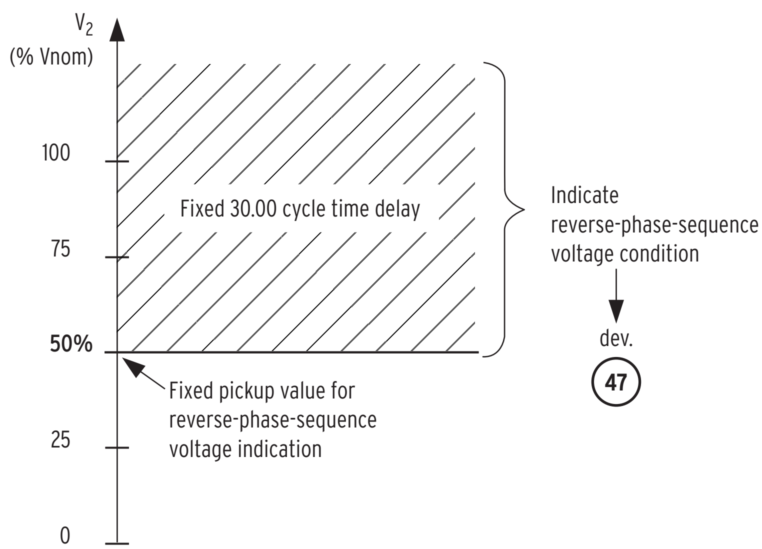


Figure 3.17 Reverse-Phase-Sequence Voltage Element.

Step 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 on page U.3.11*) 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 Van (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 on page U.2.7*). 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 on page U.3.15*).
- 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.

Step 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 nonvolatile 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*.

Step 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 through 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.1.16* 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 1 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.

Step 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 on page U.2.7*) 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 on page U.1.8*. 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).

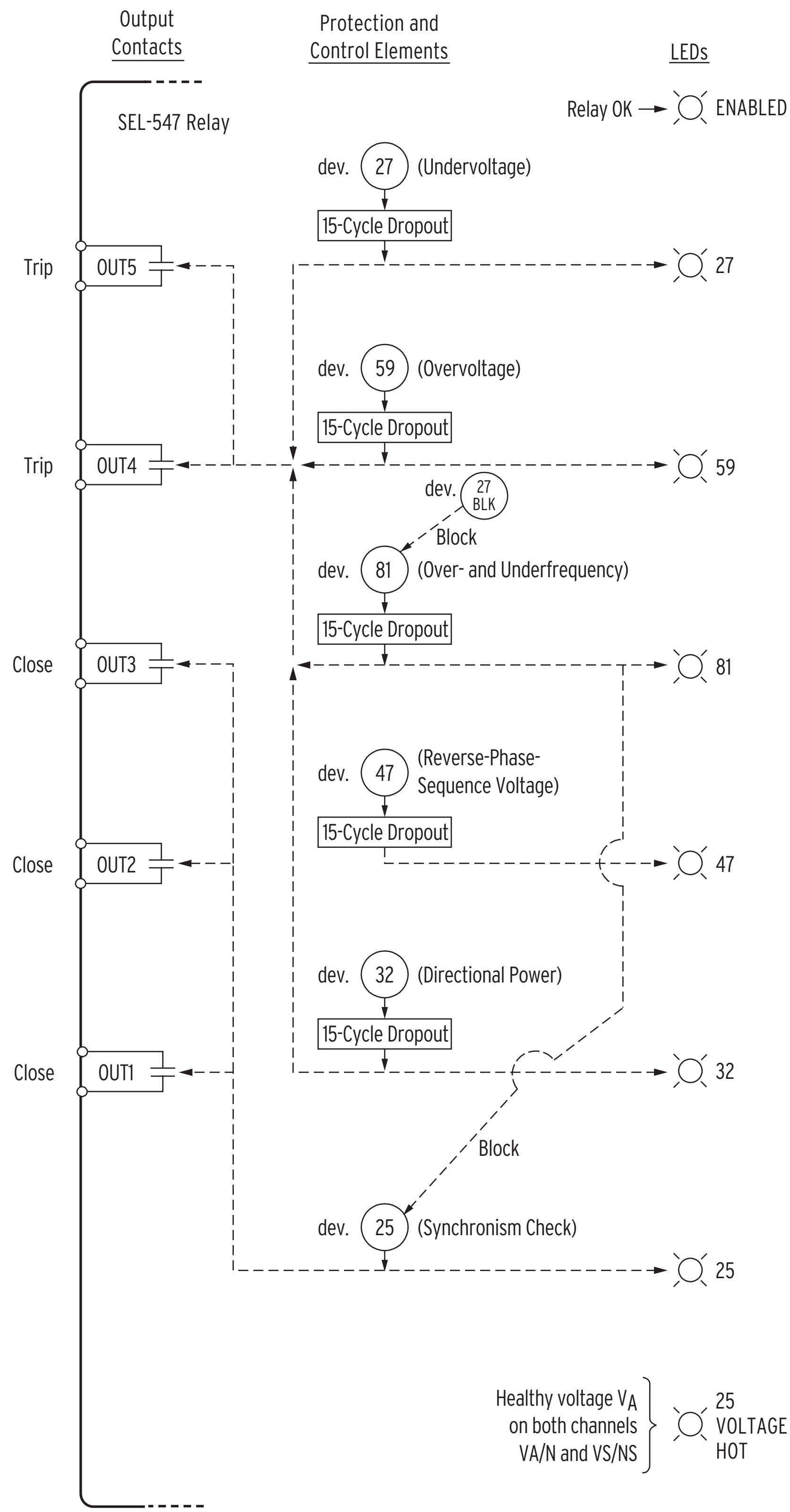


Figure 3.19 Output Contact and Front-Panel LED Logic.

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Section 4
Testing and Troubleshooting

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.4.7* 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 in the 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 correctly set and connected, 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, their operating characteristics do not change over time.

At SEL, we recommend that maintenance tests on SEL relays be limited under the guidelines provided above. The time saved may be spent analyzing event data and thoroughly testing 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

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.3.12 in the Reference Manual*).
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. This option is designated by a part number character, 05470A, where the A represents compatibility with the SEL-AMS. The relay is tested by applying low magnitude ac voltage signals to the relay voltage and current terminals shown in *Figure 2.2 on page U.2.3*. 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.

⚠CAUTION
Never apply voltage signals greater then 9 volts peak-to-peak to a SEL-5470A Relay.

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

Test Methods

NOTE: These test methods are for non-EZ settings. For more information on non-EZ settings, please refer to Section 8: Settings in the SEL-547 Reference Manual.

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)

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 through 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 through 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 EN 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

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.
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 on page U.2.7*.
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 = action 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 on page U.3.4*.
Incorrect communications cables.	Use SEL communications cables or cables you build according to SEL specifications. See *Figure 4.2* and *Figure 4.3 on page R.4.3 in the Reference Manual*.
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 on page U.3.4*.
Terminal emulation is not optimal.	Try other terminal types, such as VT-100 and VT-52 terminal emulations.

Table 4.4 Troubleshooting Procedures (Sheet 2 of 2)

Symptoms/Possible Cause	Diagnosis/Solution
System Does Not Respond to System Disturbances	
Relay is set improperly.	Review the relay settings. See *Step 8: Understanding and Using EZ Settings on page U.3.10*.
Improper test settings.	Restore operating settings.
Connection wiring error.	Confirm wiring (see *Figure 2.4* and *Figure 2.5 on page U.2.7*).
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.3.29.*
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.3.8*.
Output Remains Closed Following a System Disturbance	
Relay output contacts are burned closed.	Remove relay power. Remove the output contact connection. Check continuity; a-type contacts are normally open. Contact the SEL factory or your Technical Service Center if continuity checks fail.

Factory Assistance

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

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA USA 99163-5603
Telephone: (509) 332-1890
Fax: (509) 332-7990
Internet: www.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.3.8* 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
This firmware applies to the manual date code listed:		
SEL-547-R100-V0-Z001001-D20020430	➤ Manual update only. See *Table A.2* for a summary of manual updates.	20021206
SEL-547-R100-V0-Z001001-D20020430	➤ Original 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

Revision Date	Summary of Revisions
This manual differs from the previous versions as follows:	
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-2020 or SEL-2030 Communications Processor.

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

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 the XMODEM/CRC protocol (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 (included)

Optional Equipment

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

- SEL-5010 Relay Assistant Software program
- SEL-547 Relay User's Guide and Reference Manual

Upgrade Procedure

A Prepare the Relay

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.

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 the 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*).

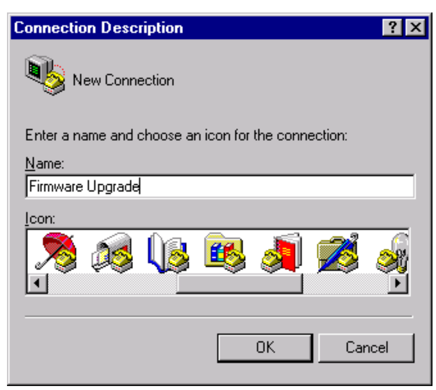

Figure B.1 Establishing a Connection.

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>**.

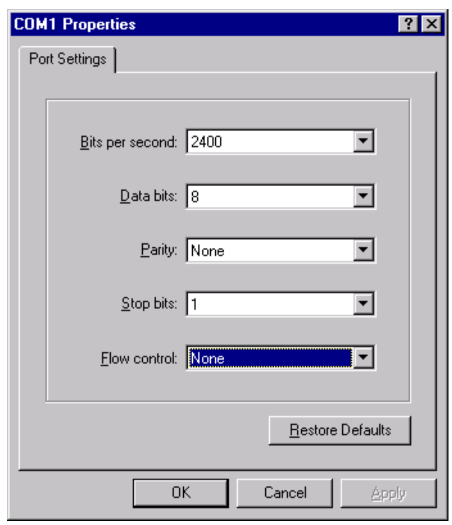

Figure B.3 Determining Communications Parameters for the Computer.

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**.

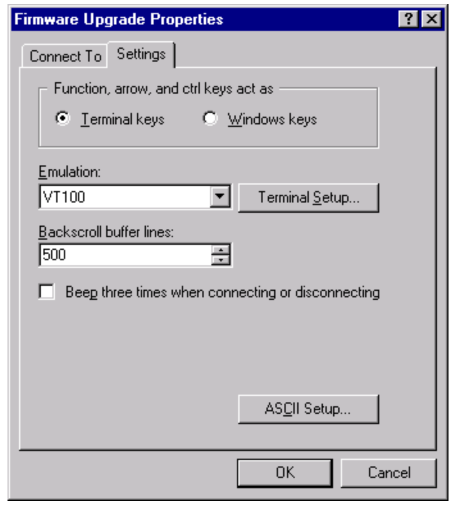

Figure B.4 Setting Terminal Emulation.

Step 8. Confirm serial communication.

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

If this is successful, proceed to *Save Settings and Other Data on page U.B.5*.

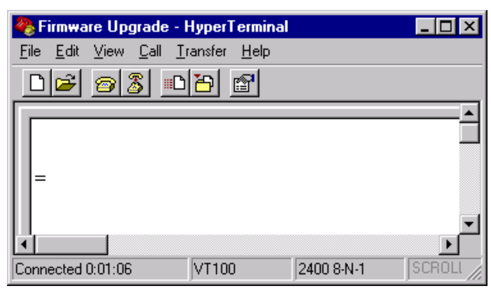

Figure B.5 Terminal Emulation Startup Prompt.

Failure to Connect

If you do not see the = action prompt, press **<Enter>** again. If you still do not see the = action 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.

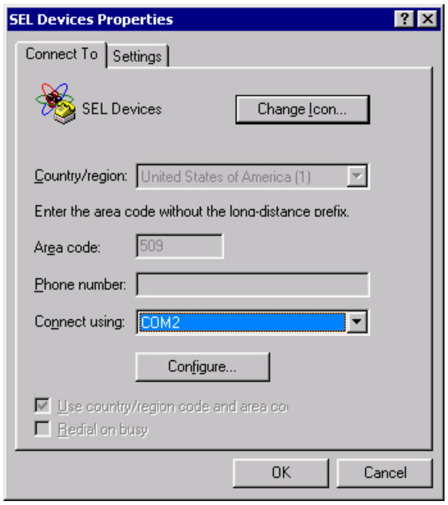

Figure B.6 Correcting Port Setting.

Step 3. Correct communications parameters.

a. From the **SEL Devices Properties** 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**.

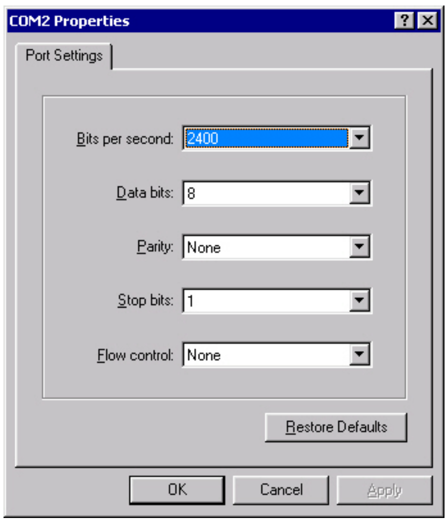

Figure B.7 Correcting Communications Parameters.

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

Step 6. Press **<Enter>** to obtain the = action 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 => action prompt.

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

Step 4. Type the correct Access Level 2 password.

You will see the =>> action 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.8*.

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 !> action prompt.

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

You will see another !> action 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 !> action 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*).

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 !> action prompt indicating that serial communication is successful.

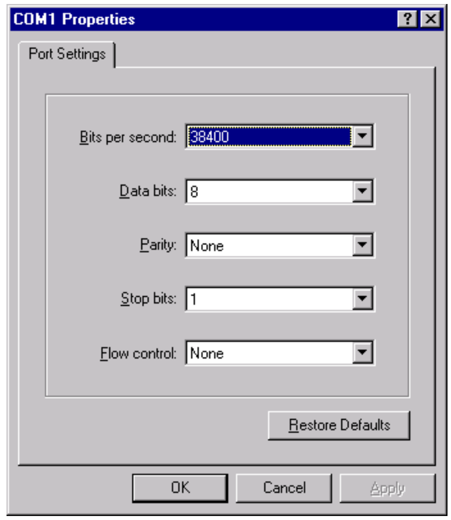

Figure B.9 Matching Computer to Relay Parameters.

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 !> action 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**.

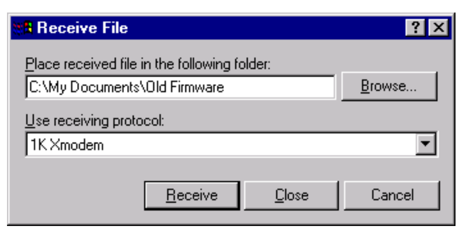

Figure B.10 Example Receive File Dialog Box.

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).

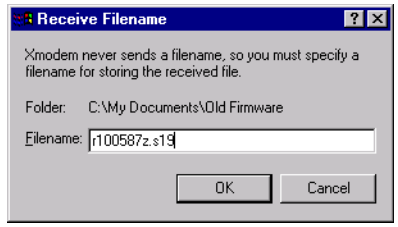

Figure B.11 Example Filename Identifying Old Firmware Version.

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

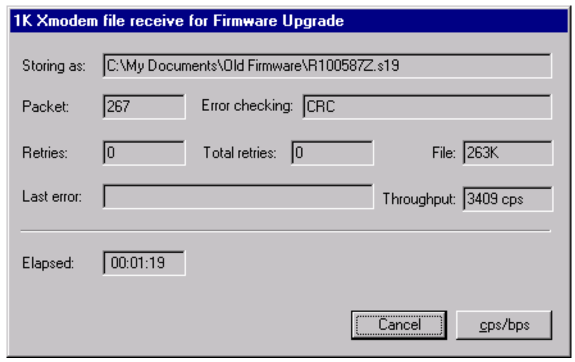

Figure B.12 Downloading of Old Firmware.

F Upload New Firmware

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

NOTE: This example shows uploading new firmware directly from the floppy 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.

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.

Step 2. Type **REC <Enter>** at the !> action 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.9 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.”

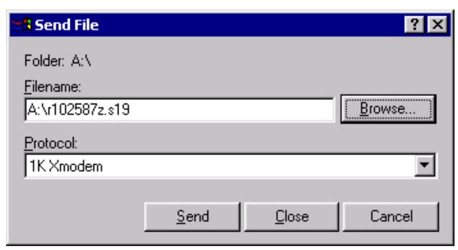

Figure B.13 Selecting the New Firmware to Send to the Relay.

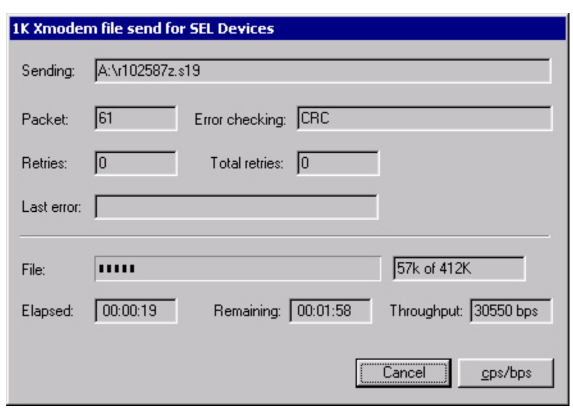

Figure B.14 Transferring New Firmware to the Relay.

G Check Relay Self-Tests

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

Unless there is a serious problem, the EN 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 = action prompt appears on your terminal screen.

If the EN LED is illuminated and the = action prompt is visible, proceed to *Verify Calibration, Status, and Metering on page U.B.12*. If this is not the case, perform the following steps.

EN LED Illuminated But No Access Level 0 = Action Prompt

If the EN LED is illuminated but the = action 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 = action prompt, indicating that serial communication is successful.

Step 3. Proceed to *Verify Calibration, Status, and Metering on page U.B.12*.

EN LED Not Illuminated

If the EN 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.7*.)

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 = action 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.3.6*.

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

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 EN LED illuminates.

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

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.3.6*.

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 lower-case and upper-case 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.5*, 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-20x0 port if you have an SEL-2020 or SEL-2030 Communications Processor connected to the relay.

This step reestablishes automatic data collection between the SEL-20x0 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.

Factory Assistance

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

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603
Tel: (509) 332-1890
Fax: (509) 332-7990
Internet: www.selinc.com

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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 Swich 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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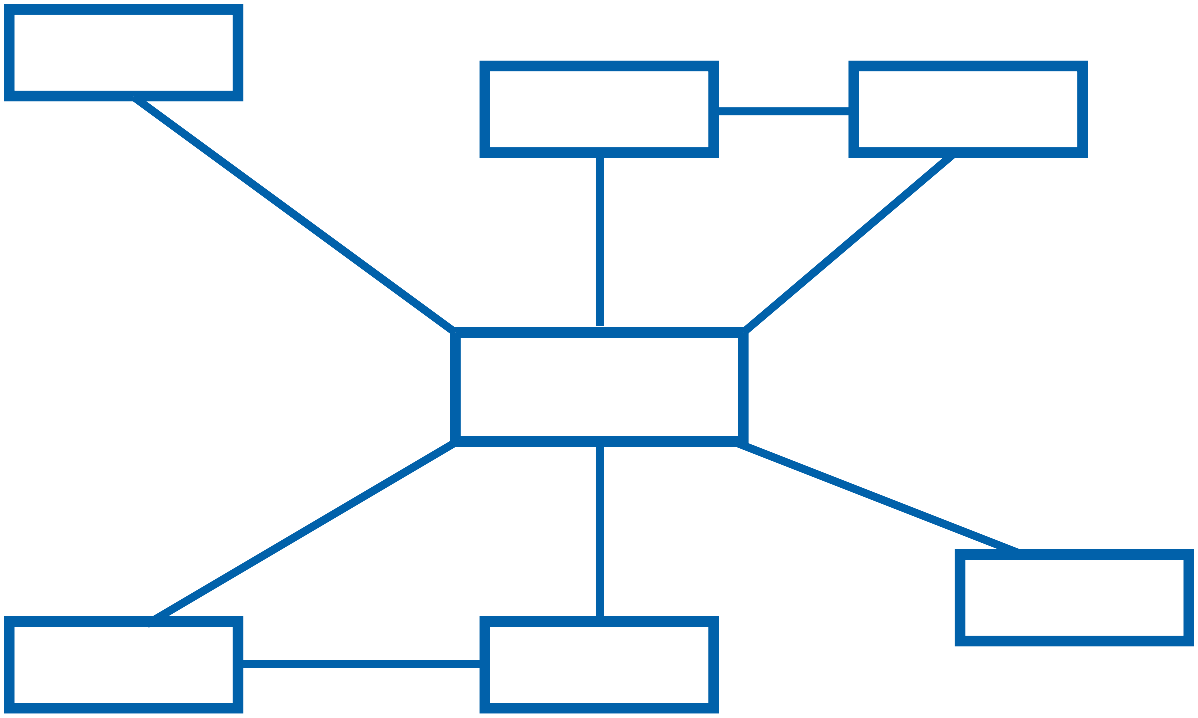

Protection, Integration, Automation, and Control by SEL™

SCHWEITZER ENGINEERING LABORATORIES

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Internet: www.selinc.com • E-mail: info@selinc.com

SEL-547

Distributed Generator Interconnection Relay

Reference Manual

20021206

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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.

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.

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.

AVERTISSEMENT: Cet appareil est expédié avec des mots de passe par défaut. A l'installation, les mots de passe par défaut devront être changés pour des mots de passe confidentiels. Dans le cas contraire, un accés non-autorisé á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accés non-autorisé.

PM547-03

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Section 3: Analyzing Events

Section 4: Communications

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Section 6: Modbus RTU Communications

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Section 8: Settings

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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 Relay 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.

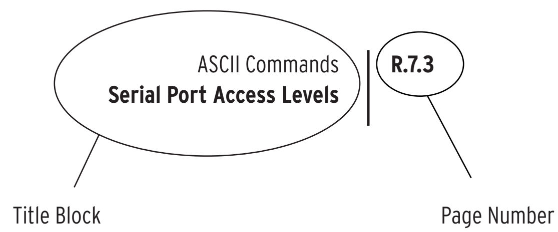
Appendix B: Firmware Upgrade Instructions. Provides instructions for upgrading firmware in the SEL-547.

Appendix C: SEL-547 Relay EZ Settings Sheet.

Reference Manual

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	ASCII and Compressed ASCII commands.
TAR 6 <Enter>	Commands/input that you type.
{CLOSE}	Relay front-panel pushbuttons.
<Enter>	Single keystroke command.
<Ctrl+D>	Multiple keystroke command to bring up a control window or activate a control function.
RELAY ELEMENTS	Front-panel LCD menu items.
Start	Dialog Boxes: Menu titles, options, drop-down or check box menu selections, highlighted options.

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

Protection Functions

This section provides a detailed explanation for each of the SEL-547 Relay protection functions. Each subsection provides an explanation of the function, along with a list of the corresponding settings and Relay Word bits. Logic diagrams and other figures are included.

Functions described in this section are listed below:

- Voltage elements
- Synchronism check elements
- Frequency elements
- Power elements

Voltage Elements

Enable numerous voltage elements by making the enable setting

EVOLT = Y

Voltage Values

The voltage elements operate off of various voltage values, as shown in *Table 1.1*.

Table 1.1 Voltage Values Used by Voltage Elements

Voltage	Description
V_A	A-phase voltage, from SEL-547 voltage input VA
V_B	B-phase voltage, from SEL-547 voltage input VB
V_C	C-phase voltage, from SEL-547 voltage input VC
$3V_0$	Zero-sequence voltage
V_2	Negative-sequence voltage
V_1	Positive-sequence voltage
V_S	Synchronism check voltage, from SEL-547 voltage input VS

Voltage Element Settings

Table 1.2 lists available voltage elements and the corresponding voltage inputs and settings ranges for the SEL-547.

Table 1.2 Voltage Elements Settings and Settings Ranges

Voltage Element (Relay Word Bits)	Operating Voltage	Pickup Setting/Range	See Figure
27A1 27B1 27C1	V_A V_B V_C	27P1P OFF, 55–400 V	*Figure 1.1*
27A2 27B2 27C2	V_A V_B V_C	27P2P OFF, 55–400 V	
27A3 27B3 27C3	V_A V_B V_C	27P3P OFF, 55–400 V	
27A4 27B4 27C4	V_A V_B V_C	27P4P OFF, 55–400 V	
59A1 59B1 59C1	V_A V_B V_C	59P1P OFF, 55–400 V	
59A2 59B2 59C2	V_A V_B V_C	59P2P OFF, 55–400 V	
59A3 59B3 59C3	V_A V_B V_C	59P3P OFF, 55–400 V	
59A4 59B4 59C4	V_A V_B V_C	59P4P OFF, 55–400 V	
59N1	$3V_0$	59N1P OFF, 55–400 V	*Figure 1.2*
59N2	$3V_0$	59N2P OFF, 55–400 V	
59Q1	V_2	59QP OFF, 55–267 V	
59Q2	V_2	59Q2P OFF, 55–267 V	
59V1	V_1	59V1P OFF, 55–400 V	
27S	V_S	27SP OFF, 55–400 V	*Figure 1.3*
59S1	V_S	59S1P OFF, 55–400 V	
59S2	V_S	59S2P OFF, 55–400 V	

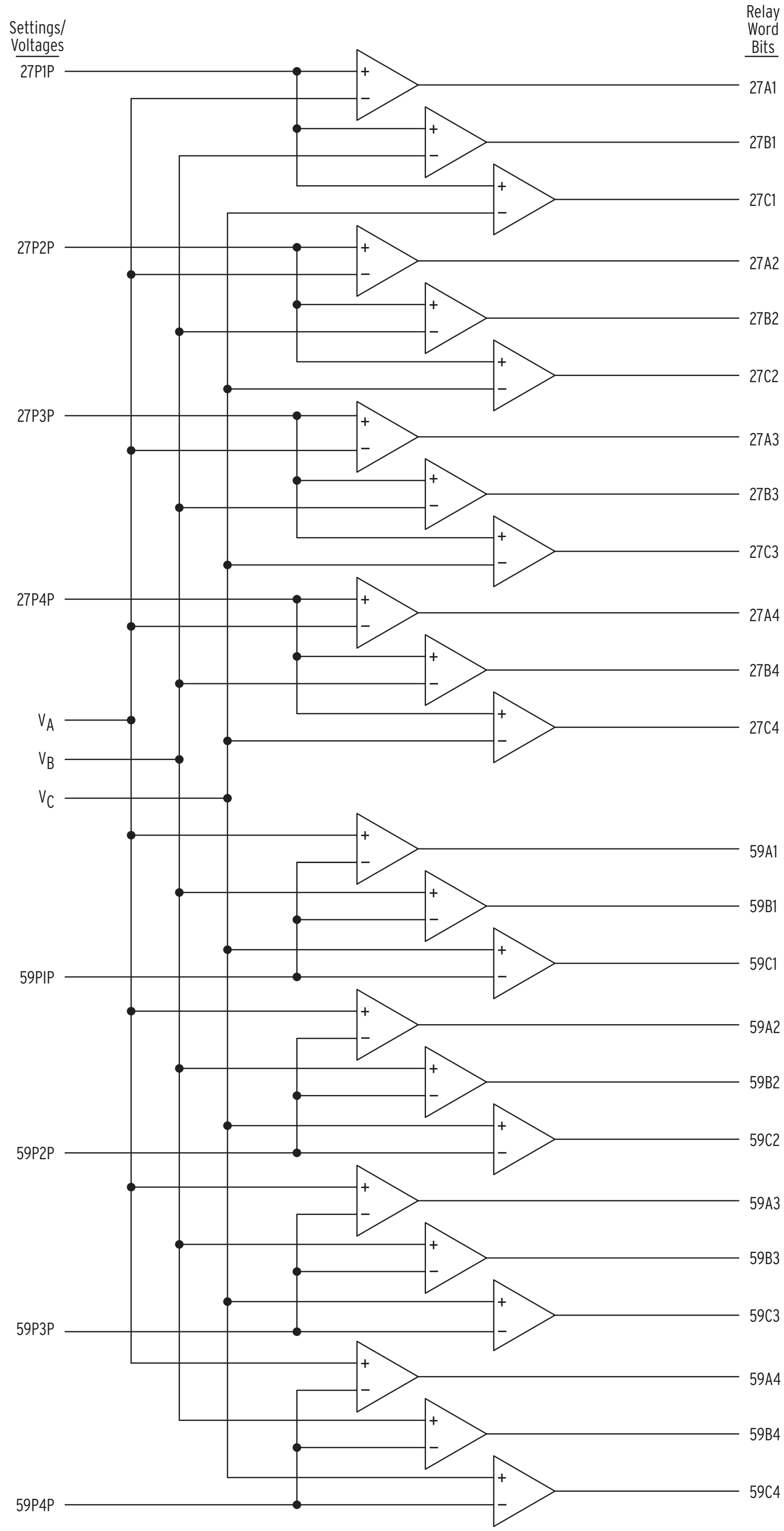


Figure 1.1 Single-Phase Voltage Elements.

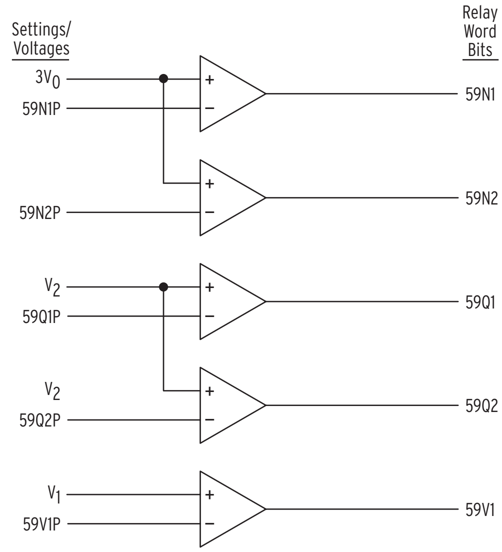


Figure 1.2 Sequence Voltage Elements.

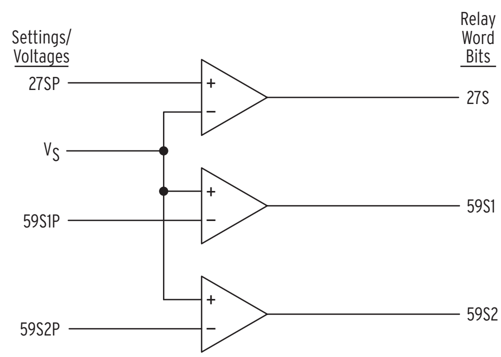


Figure 1.3 Channel VS Voltage Elements.

Accuracy

Pickup: ±2 V and ±3% of setting

Voltage Element Operation

Note that the voltage elements in *Table 1.2* and *Figure 1.1* through *Figure 1.3* are a combination of undervoltage (device 27) and overvoltage (device 59) type elements. Undervoltage elements (device 27) assert when the operating voltage goes below the corresponding pickup setting. Overvoltage elements (device 59) assert when the operating voltage goes above the corresponding pickup setting.

Undervoltage Element Operation Example

Refer to *Figure 1.1* (top of the figure).

Pickup setting 27P1P is compared to the magnitudes of the individual phase voltages V_A, V_B, and V_C. The logic outputs in *Figure 1.1* are the following Relay Word bits:

Table 1.3 Relay Word Bits for Undervoltage Element Operation Example

Relay Word Bit	Description
27A1	= 1 (logical 1), if $V_A <$ pickup setting 27P1P = 0 (logical 0), if $V_A \geq$ pickup setting 27P1P
27B1	= 1 (logical 1), if $V_B <$ pickup setting 27P1P = 0 (logical 0), if $V_B \geq$ pickup setting 27P1P
27C1	= 1 (logical 1), if $V_C <$ pickup setting 27P1P = 0 (logical 0), if $V_C \geq$ pickup setting 27P1P

Overvoltage Element Operation Example

Refer to *Figure 1.1* (bottom of the figure).

Pickup setting 59P1P is compared to the magnitudes of the individual phase voltages V_A, V_B, and V_C. The logic outputs in *Figure 1.1* are the following Relay Word bits:

Table 1.4 Relay Word Bits for Overvoltage Element Operation Example

Relay Word Bits	Description
59A1	= 1 (logical 1), if $V_A >$ pickup setting 59P1P = 0 (logical 0), if $V_A \leq$ pickup setting 59P1P
59B1	= 1 (logical 1), if $V_B >$ pickup setting 59P1P = 0 (logical 0), if $V_B \leq$ pickup setting 59P1P
59C1	= 1 (logical 1), if $V_C >$ pickup setting 59P1P = 0 (logical 0), if $V_C \leq$ pickup setting 59P1P

Synchronism Check Elements

Enable the two single-phase synchronism check elements by making the enable setting

E25 = Y

Figure 2.4 and *Figure 2.5 on page U.2.7 in the User's Guide* show where synchronism check can be applied. Synchronism check voltage input VS is connected to one side of the circuit breaker, on any desired phase. The other synchronizing phase (VA, VB, or VC voltage inputs) on the other side of the circuit breaker is setting-selected.

The two synchronism check elements use the same voltage window (to assure healthy voltage) and slip frequency settings (see *Figure 1.4*). They have separate angle settings (see *Figure 1.5*).

If the voltages are static (voltages not slipping with respect to one another) or setting TCLOSD = 0.00, the two synchronism check elements operate as shown in the top of *Figure 1.5*. The angle settings are checked for synchronism check closing.

If the voltages are not static (voltages slipping with respect to one another), the two synchronism check elements operate as shown in the bottom of *Figure 1.5*. The angle difference is compensated by breaker close time, and the breaker is ideally closed at a zero degree phase angle difference to minimize system shock.

These synchronism check elements are explained in detail in the following sections.

Synchronism Check Elements Settings

Table 1.5 Synchronism Check Elements Settings and Settings Ranges

Setting	Definition	Range
25VLO	Low voltage threshold for healthy voltage window	OFF, 55–400 V
25VHI	High voltage threshold for healthy voltage window	OFF, 55–400 V
25SF	Maximum slip frequency	0.1–1.0 Hz
25ANG1	Synchronism check element 25A1 maximum angle	2°–60°
25ANG2	Synchronism check element 25A2 maximum angle	2°–60°
SYNCP	Synchronizing phase or The number of degrees that synchronism check voltage V_S constantly lags voltage V_A	VA, VB, or VC 0°–330°, in 30° steps
TCLOSD	Breaker close time for angle compensation	0.00–60.00 cycles
BSYNCH	SELOGIC® control equation block synchronism check setting	Relay Word bits referenced in *Appendix A: Relay Word Bits.*

Setting SYNCP

The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCP are referenced to V_A, and they indicate how many degrees V_S constantly lags V_A. In any synchronism check application, voltage input VA-N always has to be connected to determine system frequency on one side of the circuit breaker (to determine the slip between V_S and V_A). V_A always has to meet the healthy voltage criteria (settings 25VHI and 25VLO—see *Figure 1.4*). Thus, for

NOTE: Settings SYNCP = 0 and SYNCP = VA are effectively the same (voltage V_S is directly synchronism checked with voltage V_A; V_S does not lag V_A). The relay will display the setting entered (SYNCP = VA or SYNCP = 0).

situations where V_S cannot be in phase with V_A, V_B, or V_C, it is most straightforward to have the angle setting choices (0, 30, …, 300, or 330 degrees) referenced to V_A.

See the Application Guide AG2002-02 entitled *Compensate for Constant Phase Angle Difference in Synchronism Check with the SEL-351 Relay Family* for more information on setting SYNCP with an angle setting.

Accuracy

Voltage Pickup: ±2 V and ±3% of setting

Slip Pickup: ±0.1 Hz

Angle Pickup: Greater of ±1° or ±(system slip [Hz] • 12°/Hz)

Voltage Input VS Connected Phase-to-Phase or Beyond Delta-Wye Transformer

Sometimes synchronism check voltage V_S cannot be in phase with voltage V_A, V_B, or V_C. This happens in applications where voltage input VS is connected:

- ➤ Phase-to-phase
- ➤ Beyond a delta-wye transformer

For such applications requiring V_S to be at a constant phase angle difference from any of the possible synchronizing voltages (V_A, V_B, or V_C), an angle setting is made with the SYNCP setting.

Synchronism Check Elements Voltage Inputs

The two synchronism check elements are single-phase elements, with single-phase voltage inputs V_P and V_S used for both elements:

Table 1.6 Synchronism Check Elements Voltage Inputs

Voltage Inputs	Description
V_P	Phase input voltage (V_A, V_B, or V_C), designated by setting SYNCP (e.g., if SYNCP = VA, then $V_P = V_A$)
V_S	Synchronism check voltage, from SEL-547 voltage input VS

For example, if V_P is designated as phase input voltage V_A (setting SYNCP = VA), then voltage input VS-NS is connected to A-phase on the other side of the circuit breaker. The voltage across terminals VA-N is synchronism checked with the voltage across terminals VS-NS (see *Figure 2.4* and *Figure 2.5 on page U.2.7 in the User's Guide*).

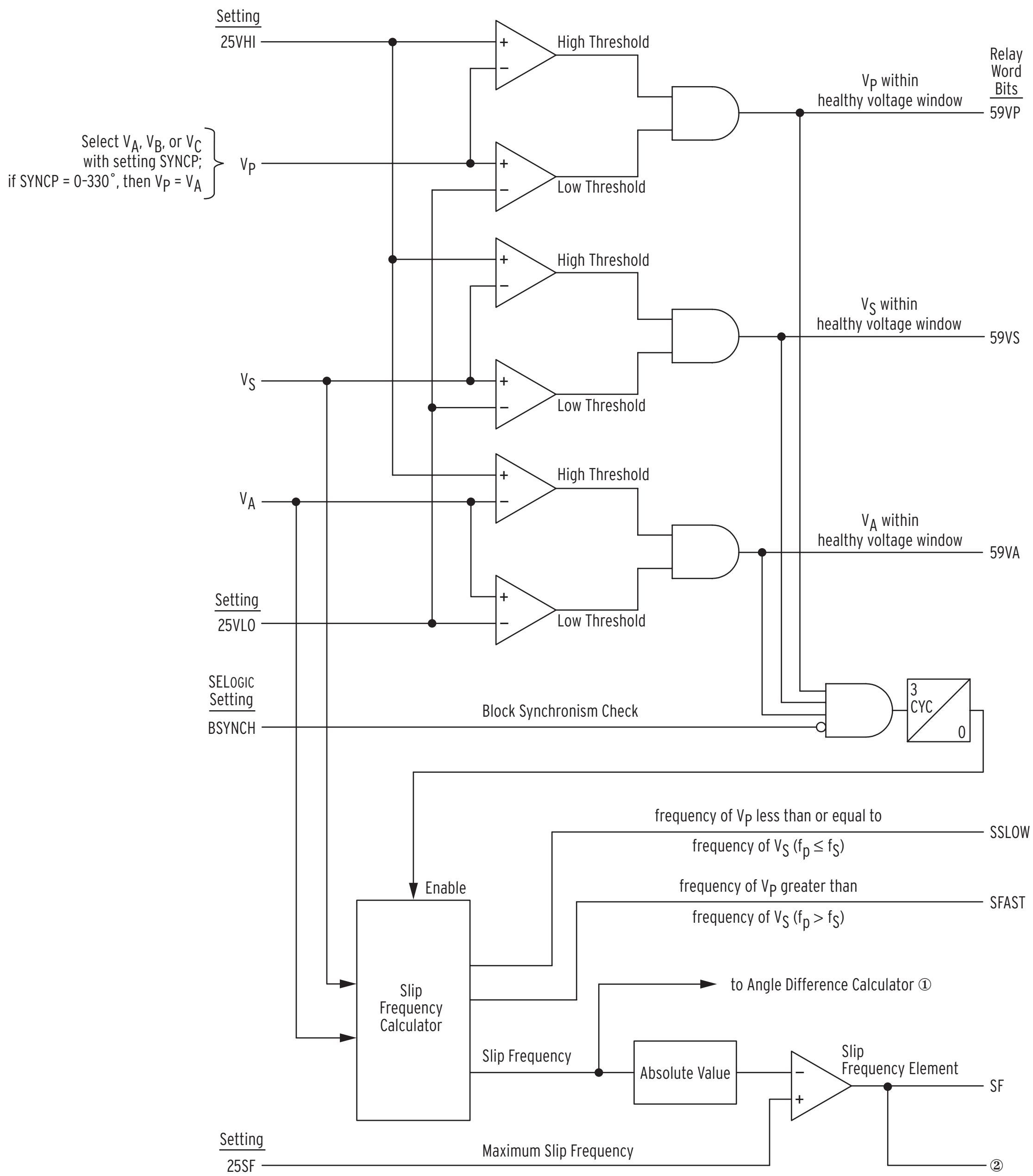


Figure 1.4 Synchronism Check Voltage Window and Slip Frequency Elements.

① See bottom of Figure 1.5

② to Figure 1.5.

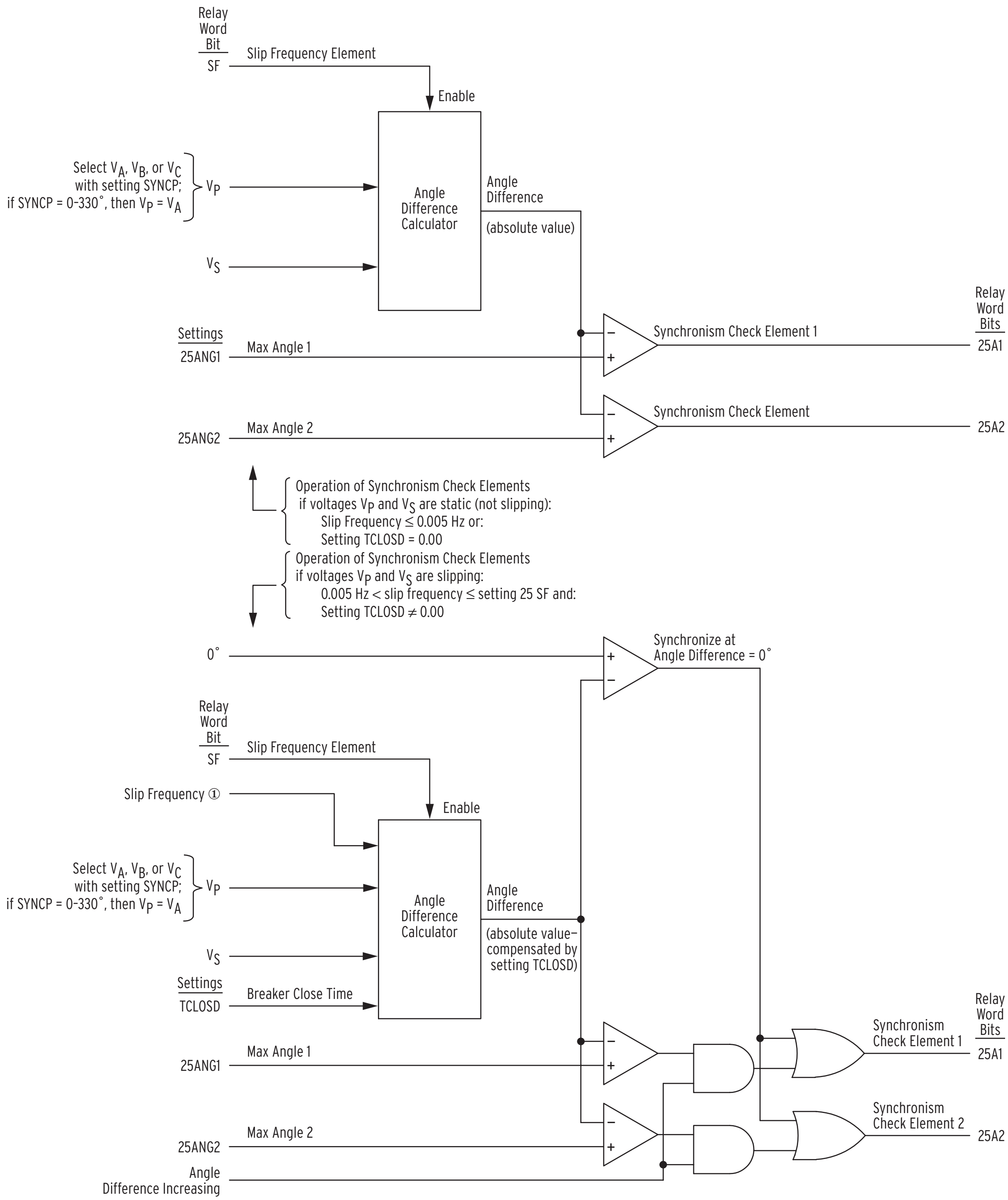


Figure 1.5 Synchronism Check Elements.

① from Figure 1.4

System Frequencies Determined From Voltages V_A and V_S

To determine slip frequency, first determine the system frequencies on both sides of the circuit breaker. Voltage V_S determines the frequency on one side. Voltage V_A determines the frequency on the other side. Thus, voltage terminals VA-N have to be connected, even if another voltage (e.g., voltage V_B) is to be synchronized with voltage V_S.

In most applications, all three voltage inputs (VA, VB, and VC) are connected to the three-phase power system and no additional connection concerns are needed for voltage connection VA-N. The presumption is that the frequency determined for A-phase is also valid for B- and C-phase in a three-phase power system.

However, for example, if voltage V_B is to be synchronized with voltage V_S and plans were to connect only voltage terminals VB-N and VS-NS, then voltage terminals VA-N will also have to be connected for frequency determination. If desired, voltage terminals VA-N can be connected in parallel with voltage terminals VB-N. In such a nonstandard parallel connection, remember that voltage terminals VA-N are monitoring B-phase. This understanding helps prevent confusion when observing metering and event report information or voltage element operation.

Another possible solution to this example (synchronism check voltage input VS-NS connected to V_B) is to make setting SYNCP = 120 (the number of degrees that synchronism check voltage V_S constantly lags voltage V_A) and connect voltage input VA-N to V_A. Voltage inputs VB and VC do not have to be connected.

System Rotation Can Affect Setting SYNCP

The solution in the preceding paragraph (described as follows) presumes the following about ABC system rotation:

- Voltage input VA is connected to A-phase
- Voltage input VS is connected to B-phase
- Setting SYNCP = 120 degrees (V_S constantly lags V_A by 120°)

If voltage input connections are the same, but system rotation is ACB, then setting SYNCP = 240 degrees (V_S constantly lags V_A by 240°). For more information on setting SYNCP with an angle setting, see Application Guide AG2002-02 entitled *Compensate for Constant Phase Angle Difference in Synchronism Check with the SEL-351 Relay Family.*

Synchronism Check Elements Operation

Voltage Window

Refer to *Figure 1.4*.

Single-phase voltage inputs V_P and V_S are compared to a voltage window, to verify that the voltages are healthy and lie within settable voltage limits 25VLO and 25VHI. If both voltages are within the voltage window, the following Relay Word bits assert:

- 59VP indicates that voltage V_P is within voltage window setting limits 25VLO and 25VHI
- 59VS indicates that voltage V_S is within voltage window setting limits 25VLO and 25VHI

As discussed previously, voltage V_A determines the frequency on the voltage V_P side of the circuit breaker. Voltage V_A is also run through voltage limits 25VLO and 25VHI to assure healthy voltage for frequency determination, with corresponding Relay Word bit output 59VA.

Other Uses for Voltage Window Elements

If voltage limits 25VLO and 25VHI are applicable to other control schemes, Relay Word bits 59VP, 59VS, and 59VA can be used in other logic at the same time they are used in the synchronism check logic.

If synchronism check is not being used, Relay Word bits 59VP, 59VS, and 59VA can still be used in other logic, with voltage limit settings 25VLO and 25VHI set as desired. Enable the synchronism check logic (setting E25 = Y) and make settings 25VLO and 25VHI. Apply Relay Word bits 59VP, 59VS, and 59VA in the desired logic scheme, using SELOGIC control equations. Even though synchronism check logic is enabled, the synchronism check logic outputs (Relay Word bits SF, 25A1, and 25A2) do not need to be used.

Block Synchronism Check Conditions

Refer to *Figure 1.4*.

The synchronism check element slip frequency calculator runs if both voltages V_P and V_S are healthy (59VP and 59VS asserted to logical 1) and the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). Setting BSYNCH is most commonly set to block synchronism check operation when the circuit breaker is closed (synchronism check is only needed when the circuit breaker is open):

BSYNCH = IN2 (see *Figure 2.8 on page R.2.12*)

Slip Frequency Calculator

Refer to *Figure 1.4*.

The synchronism check element Slip Frequency Calculator in *Figure 1.4* runs if voltages V_P, V_S, and V_A are healthy (59VP, 59VS, and 59VA asserted to logical 1) and the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). The Slip Frequency Calculator output is shown in *Equation* . All values are shown in units of Hz = slip cycles/second:

$$\text{Slip Freqency} = f_P - f_S \qquad \textbf{Equation 1.1}$$

Where

$f_P =$ frequency of voltage V_P (determined from V_A)
$f_S =$ frequency of voltage V_S

A complete slip cycle is one single 360-degree revolution of one voltage (e.g., V_S) by another voltage (e.g., V_P). Both voltages are thought of as revolving phasor-wise, so the slipping of V_S past V_P is the relative revolving of V_S past V_P. In a time period of one second, the angular distance between voltage V_P and V_S is shown below:

$$\text{Angular Distance} = \text{slip cycles/second} \bullet \frac{360°}{\text{slip cycle}} \bullet 1 \text{ second}$$

Equation 1.2

EXAMPLE 1.1 Calculating Slip Frequency and Angular Distance

In Figure 1.4, if voltage V_P has a frequency of 59.95 Hz and voltage V_S has a frequency of 60.05 Hz, the difference between them is the slip frequency (see Equation):

$$\begin{aligned}\text{Slip Frequency} &= 59.95 \text{ Hz} - 60.05 \text{ Hz}\\ &= -0.10 \text{ Hz}\\ &= -0.10 \text{ slip cycles/second}\end{aligned}$$

The slip frequency in this example is negative, indicating that voltage V_S is not slipping behind voltage V_P, but in fact slipping ahead of voltage V_P. In a time period of one second, the angular distance between voltage V_P and voltage V_S changes by 0.10 slip cycles, which translates into Equation 1.2:

$$\begin{aligned}\text{Angular Distance} &= 0.10 \text{ slip cyc per s} \cdot \frac{360°}{\text{slip cycle}} \cdot 1 \text{ s}\\ &= 36°\end{aligned}$$

Thus, in a time period of one second, the angular distance between voltage V_P and voltage V_S changes by 36 degrees.

The absolute value of the Slip Frequency output is run through a comparator and if the slip frequency is less than the maximum slip frequency setting, 25SF, Relay Word bit SF asserts to logical 1.

Generator Application for SSLOW and SFAST

Relay Word bits SSLOW and SFAST in *Figure 1.4* indicate the relative slip of voltages V_P and V_S:

$f_P < f_S$: SSLOW = logical 1, SFAST = logical 0

$f_P > f_S$: SSLOW = logical 0, SFAST = logical 1

An application idea for SSLOW and SFAST is a small generator installation: V_P is from the generator side and V_S is from the system side (other side of the open circuit breaker). With some logic (perhaps to create pulsing signals), SSLOW and SFAST are used as signals (via output contacts) to the generator governor. SSLOW indicates that the generator (V_P) is slower than (or equal in frequency to) the system (V_S), while SFAST indicates that the generator (V_P) is faster than the system (V_S). If the enable into the slip frequency calculator in *Figure 1.4* is disabled (e.g., SELOGIC setting BSYNCH asserts because the breaker closes; BSYNCH = 52A + …), then both SSLOW = logical 0 and SFAST = logical 0, regardless of slip frequency.

Angle Difference Calculator

The synchronism check element Angle Difference Calculator in *Figure 1.4* runs if the slip frequency is less than the maximum slip frequency setting 25SF (Relay Word bit SF is asserted).

Voltages V_P and V_S are Static

Refer to the top of *Figure 1.5*.

If the slip frequency is less than or equal to 0.005 Hz, the Angle Difference Calculator does **not** take into account breaker close time—it presumes voltages V_P and V_S are static (not slipping with respect to one another). This would usually be the case for an open breaker with voltages V_P and V_S that are paralleled via some other electric path in the power system. The Angle Difference Calculator calculates the angle difference between voltages V_P and V_S (see *Equation 1.3*):

$$\text{Angle Difference} = |(\angle V_P - \angle V_S)| \qquad \textbf{Equation 1.3}$$

EXAMPLE 1.2 Calculating Angle Difference

If SYNCP = 90 (indicating V_S constantly lags $V_P = V_A$ by 90 degrees), but V_S actually lags V_A by 100 angular degrees on the power system at a given instant, the Angle Difference Calculator automatically accounts for the 90 degrees:

$$\begin{aligned}\text{Angle Difference} &= |(\angle V_P - \angle V_S)| \\ &= 10^\circ\end{aligned}$$

Also, if breaker close time setting TCLOSD = 0.00, the Angle Difference Calculator does not take into account breaker close time, even if the voltages V_P and V_S are slipping with respect to one another. Thus, synchronism check elements 25A1 or 25A2 assert to logical 1 if the Angle Difference is less than corresponding maximum angle setting 25ANG1 or 25ANG2.

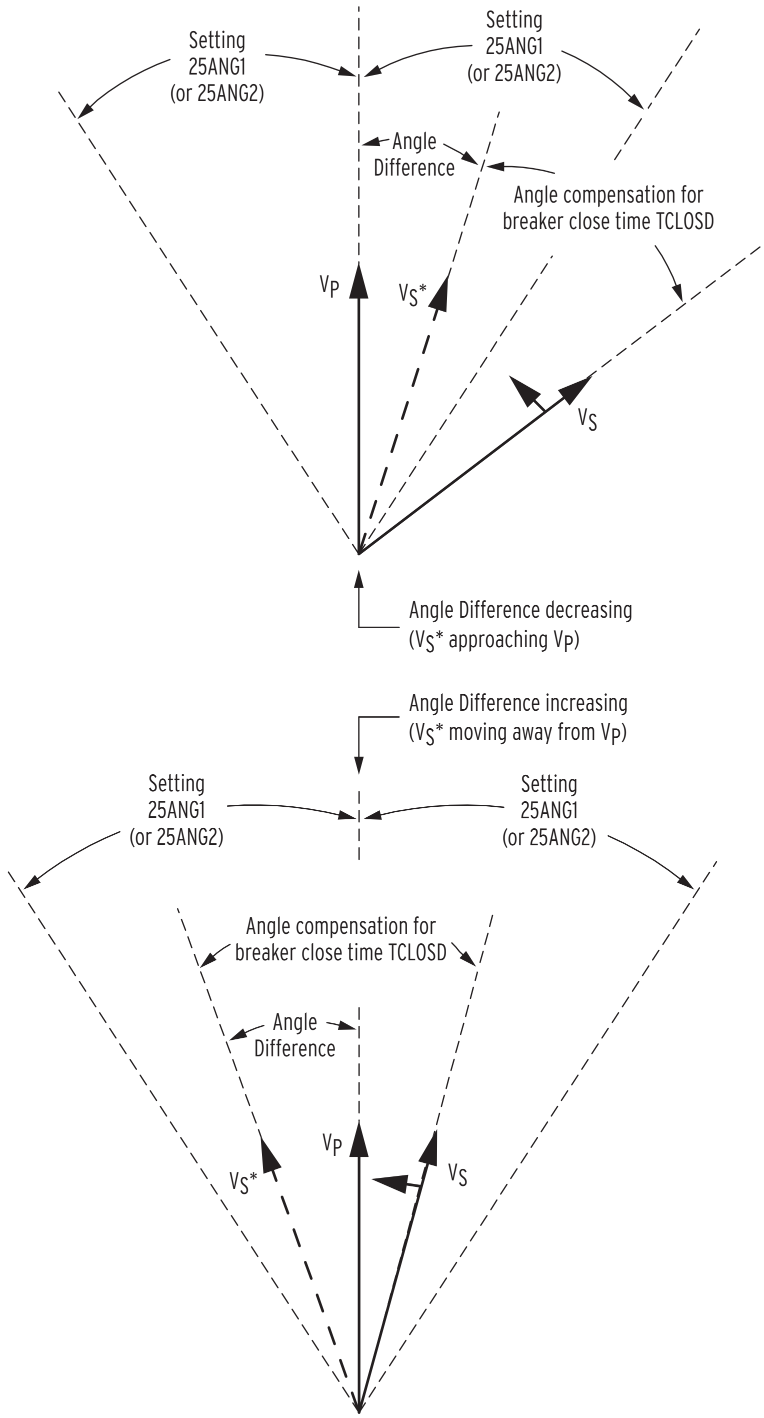


Figure 1.6 Angle Difference Between V_P and V_S Compensated by Breaker Close Time.
($f_P < f_S$ and V_P shown as referenced in this example)

Voltages V_P and V_S are Slipping

Refer to the bottom of *Figure 1.5*.

If the slip frequency is greater than 0.005 Hz and breaker close time setting TCLOSD ≠ 0.00, the Angle Difference Calculator takes the breaker close time into account with breaker close time setting TCLOSD (set in cycles; see *Figure 1.6*). The Angle Difference Calculator calculates the Angle Difference between voltages V_P and V_S, compensated with the breaker close time:

$$\text{Angle Difference} = \left|(\angle V_P - \angle V_S) + \left((f_P - f_S) \bullet \text{ TCLOSD} \bullet \frac{1\text{ s}}{60\text{ cyc}} \bullet \frac{360°}{\text{slip cyc}}\right)\right|$$

Equation 1.4

EXAMPLE 1.3 Angle Difference Example (Voltages V_P and V_S are Slipping)

Refer to the bottom of Figure 1.5.

If the breaker close time is 10 cycles, set TCLOSD = 10. Presume the slip frequency is the example slip frequency calculated previously. The Angle Difference Calculator calculates the angle difference between voltages V_P and V_S, compensated with the breaker close time:

$$\text{Angle Difference} = \left|(\angle V_P - \angle V_S) + \left((f_P - f_S) \cdot \text{ TCLOSD} \cdot \frac{1\text{ s}}{60\text{ cyc}} \cdot \frac{360°}{\text{slip cyc}}\right)\right|$$

Intermediate calculations

$$\begin{aligned} f_P - f_S &= 59.95\text{ Hz} - 60.05\text{ Hz} \\ &= -0.10\text{ Hz} \\ &= -0.10\text{ slip cycles per second} \end{aligned}$$

$$\begin{aligned} \text{TCLOSD} \cdot \frac{1\text{ s}}{60\text{ cyc}} &= 10\text{ cyc} \cdot \frac{1\text{ s}}{60\text{ cyc}} \\ &= 0.167\text{ s} \end{aligned}$$

Results in

$$\begin{aligned} \text{Angle Difference} &= \left|(\text{-}V_P - \text{-}V_S) + \left((f_P - f_S) \cdot \text{ TCLOSD} \cdot \frac{1\text{ s}}{60\text{ cyc}} \cdot \frac{360°}{\text{slip cyc}}\right)\right| \\ &= \left|(\text{-}V_P - \text{-}V_S) + (-0.10 \cdot 0.167 \cdot 360°)\right| \\ &= \left|(\text{-}V_P - \text{-}V_S) + 6°\right| \end{aligned}$$

NOTE: The angle compensation in Figure 1.6 appears much greater than 6 degrees. Figure 1.6 is for general illustrative purposes only.

During the breaker close time (TCLOSD), the voltage angle difference between voltages V_P and V_S changes by 6 degrees. This 6-degree angle compensation is applied to voltage V_S, resulting in derived voltage V_S*, as shown in Figure 1.6.

The top of *Figure 1.6* shows the Angle Difference decreasing—V_S* is approaching V_P. Ideally, circuit breaker closing is initiated when V_S* is in phase with V_P (Angle Difference = 0 degrees). Then when the circuit breaker main contacts finally close, V_S is in phase with V_P, minimizing system shock.

The bottom of *Figure 1.6* shows the Angle Difference increasing—V_S* is moving away from V_P. Ideally, circuit breaker closing is initiated when V_S* is in phase with V_P (Angle Difference = 0 degrees). Then when the circuit breaker main contacts finally close, V_S is in phase with V_P. But in this case,

V_S* has already moved past V_P. In order to initiate circuit breaker closing when V_S* is in phase with V_P (Angle Difference = 0 degrees), V_S* has to slip around another revolution, relative to V_P.

Synchronism Check Element Outputs

Synchronism check element outputs (Relay Word bits 25A1 and 25A2 in *Figure 1.5*) assert to logical 1 for the conditions explained in the following text.

Voltages V_P and V_S are Static or Setting TCLOSD = 0.00

Refer to the top of *Figure 1.5*.

If V_P and V_S are static (not slipping with respect to one another), the Angle Difference between them remains constant—it is not possible to close the circuit breaker at an ideal zero degree phase angle difference. Thus, synchronism check elements 25A1 or 25A2 assert to logical 1 if the Angle Difference is less than corresponding maximum angle setting 25ANG1 or 25ANG2.

Also, if breaker close time setting TCLOSD = 0.00, the Angle Difference Calculator does not take into account breaker close time, even if the voltages V_P and V_S are slipping with respect to one another. Thus, synchronism check elements 25A1 or 25A2 assert to logical 1 if the Angle Difference is less than corresponding maximum angle setting 25ANG1 or 25ANG2.

Voltages V_P and V_S are Slipping and Setting TCLOSD ≠ 0.00

Refer to bottom of *Figure 1.5*. If V_P and V_S are slipping with respect to one another and breaker close time setting TCLOSD ≠ 0.00, the Angle Difference (compensated by breaker close time TCLOSD) changes through time. Synchronism check element 25A1 or 25A2 asserts to logical 1 for any one of the following two scenarios.

1. The top of *Figure 1.6* shows the Angle Difference decreasing—V_S* is approaching V_P. When V_S* is in phase with V_P (Angle Difference = 0 degrees), synchronism check elements 25A1 and 25A2 assert to logical 1.
2. The bottom of *Figure 1.6* shows the Angle Difference increasing—V_S* is moving away from V_P. V_S* was in phase with V_P (Angle Difference = 0 degrees), but has now moved past V_P. If the Angle Difference is increasing, but the Angle Difference is still less than maximum angle settings 25ANG1 or 25ANG2, then corresponding synchronism check elements 25A1 or 25A2 assert to logical 1.

   In this scenario of the Angle Difference increasing, but still being less than maximum angle settings 25ANG1 or 25ANG2, the operation of corresponding synchronism check elements 25A1 and 25A2 becomes less restrictive. Synchronism check breaker closing does not have to wait for voltage V_S* to slip around again in phase with V_P (Angle Difference = 0 degrees). There might not be enough time to wait for this to happen. Thus, the Angle Difference = 0 degrees restriction is eased for this scenario.

Frequency Elements

Six frequency elements are available. The desired number of frequency elements are enabled with the E81 enable setting as shown in *Figure 1.8*.

E81 = N (none), 1 through 6

Frequency is determined from the voltage connected to voltage terminals VA-N.

Frequency Element Settings

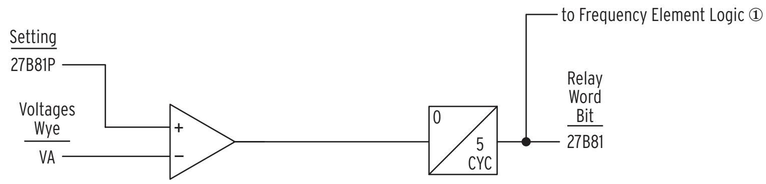


Figure 1.7 Undervoltage Block for Frequency Elements.

① see Figure 1.8.

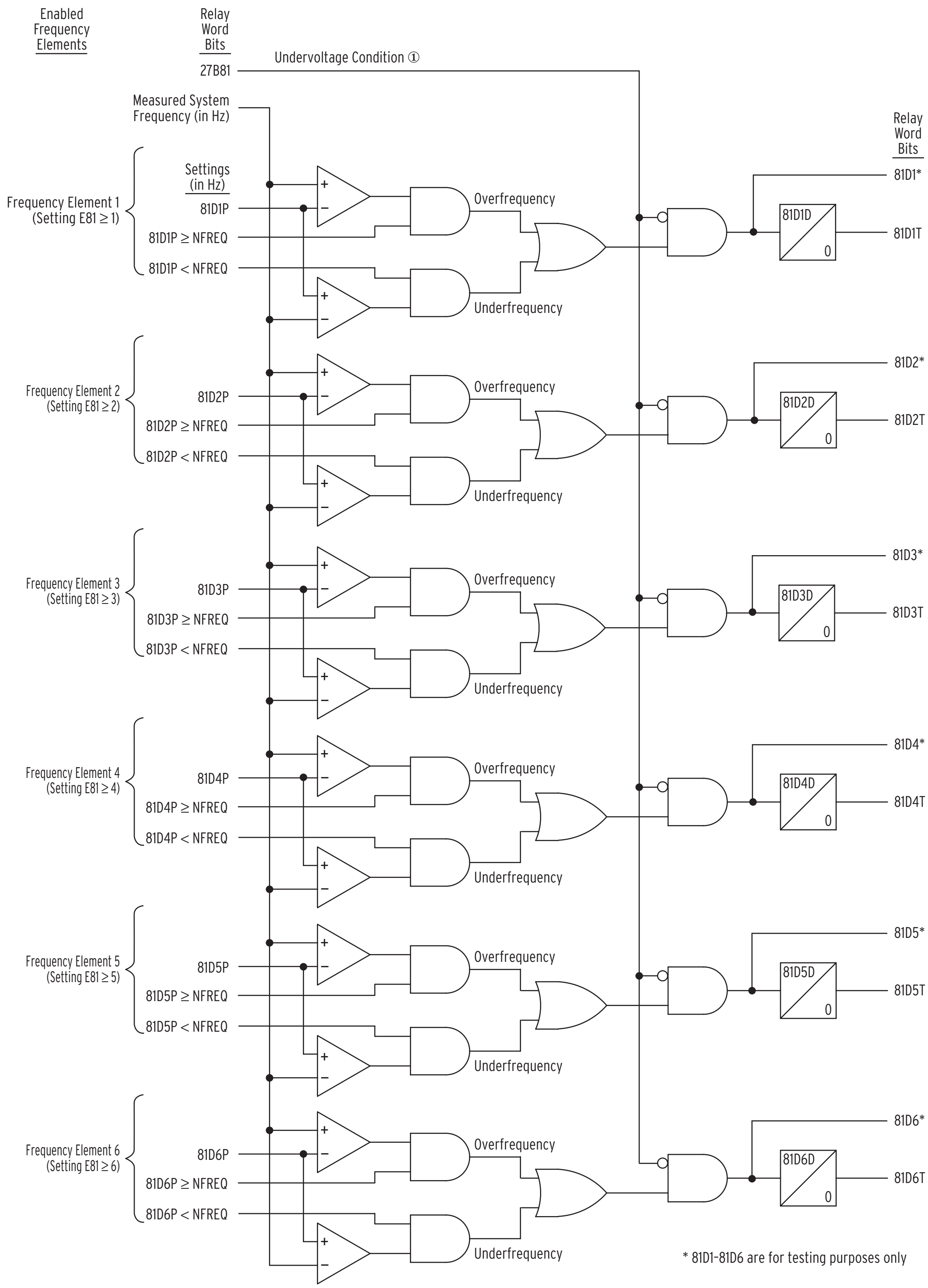


Figure 1.8 Levels 1 Through 6 Frequency Elements.

① from Figure 1.7.

Table 1.7 Frequency Elements Settings and Settings Ranges

Setting	Definition	Range
27B81P	undervoltage frequency element block	OFF, 55–400 V
81D1P	frequency element 1 pickup	OFF, 40.1–69.9 Hz
81D1D	frequency element 1 time delay	5.00–16000.00 cycles, in 0.25-cycle steps
81D2P	frequency element 2 pickup	OFF, 40.1–69.9 Hz
81D2D	frequency element 2 time delay	5.00–16000.00 cycles, in 0.25-cycle steps
81D3P	frequency element 3 pickup	OFF, 40.1–69.9 Hz
81D3D	frequency element 3 time delay	5.00–16000.00 cycles, in 0.25-cycle steps
81D4P	frequency element 4 pickup	OFF, 40.1–69.9 Hz
81D4D	frequency element 4 time delay	5.00–16000.00 cycles, in 0.25-cycle steps
81D5P	frequency element 5 pickup	OFF, 40.1–69.9 Hz
81D5D	frequency element 5 time delay	5.00–16000.00 cycles, in 0.25-cycle steps
81D6P	frequency element 6 pickup	OFF, 40.1–69.9 Hz
81D6D	frequency element 6 time delay	5.00–16000.00 cycles, in 0.25-cycle steps

Accuracy

Pickup: ±0.1 Hz

Timer: ±1 cycles and ±2% of setting

Create Over- and Underfrequency Elements

Refer to *Figure 1.8*.

Note that pickup settings 81D1P through 81D6P are compared to setting NFREQ. NFREQ is the nominal frequency setting (a global setting), set to 50 or 60 Hz.

Overfrequency Element

For example, make the following settings:

NFREQ = 60 Hz (nominal system frequency is 60 Hz)

E81 ≥ 1 (enable frequency element 1)

81D1P = 61.25 Hz (frequency element 1 pickup)

With 81D1P ≥ NFREQ, the overfrequency part of frequency element 1 logic is enabled. 81D1 and 81D1T operate as overfrequency elements. 81D1 is used in testing only.

Underfrequency Element

For example, make the following settings:

NFREQ = 60 Hz (nominal system frequency is 60 Hz)

E81 ≥ 2 (enable frequency element 2)

81D2P = 59.65 Hz (frequency element 2 pickup)

With 81D2P < NFREQ the underfrequency part of frequency element 2 logic is enabled. 81D2 and 81D2T operate as underfrequency elements. 81D2 is used in testing only.

Frequency Element Operation

Refer to *Figure 1.8*.

Overfrequency Element Operation

With the previous overfrequency element example settings, if system frequency is less than or equal to 61.25 Hz (81D1P = 61.25 Hz), frequency element 1 outputs

81D1 = logical 0 (instantaneous element)

81D1T = logical 0 (time delayed element)

If system frequency is greater than 61.25 Hz (81D1P = 61.25 Hz), frequency element 1 outputs

81D1 = logical 1 (instantaneous element)

81D1T = logical 1 (time delayed element)

Relay Word bit 81D1T asserts to logical 1 only after time delay 81D1D.

Underfrequency Element Operation

With the previous underfrequency element example settings, if system frequency is less than or equal to 59.65 Hz (81D2P = 59.65 Hz), frequency element 2 outputs

81D2 = logical 1 (instantaneous element)

81D2T = logical 1 (time delayed element)

Relay Word bit 81D2T asserts to logical 1 only after time delay 81D2D.

If system frequency is greater than 59.65 Hz (81D2P = 59.65 Hz), frequency element 2 outputs

81D2 = logical 0 (instantaneous element)

81D2T = logical 0 (time delayed element)

Other Uses for Undervoltage Element 27B81

If voltage pickup setting 27B81P is applicable to other control schemes, Relay Word bit 27B81 can be used in other logic at the same time it is used in the frequency element logic.

If frequency elements are not being used, Relay Word bit 27B81 can still be used in other logic with voltage setting 27B81P set as desired. Enable the frequency elements (setting E81 ≥ 1) and make setting 27B81P. Apply Relay Word bit 27B81 in desired logic scheme using SELOGIC control equations. Even though frequency elements are enabled, the frequency element outputs (Relay Word bits 81D1T through 81D6T) do not have to be used.

Frequency Element Uses

The instantaneous frequency elements (81D1 through 81D6) are used in testing only.

The time-delayed frequency elements (81D1T through 81D6T) are used for underfrequency load shedding, frequency restoration, and other schemes.

Power Elements

Four independent three-phase power elements are available. The group setting EPWR setting determines how many power elements are enabled:

EPWR = N (none), 1, 2, 3, 4 (single-phase)

Each enabled power element can be set to detect real power or reactive power. With SELOGIC control equations, the power elements provide a wide variety of protection and control applications. The following are examples of typical applications:

- ➤ Overpower and/or underpower protection/control
- ➤ Reverse power protection/control

Power Elements Settings

Table 1.8 Power Element Settings and Setting Ranges
(EPWR = 1, 2, 3, or 4)

Settings	Definition	Range
PWR1P, PWR2P, PWR3P, PWR4P	Power element pickup	OFF, 40–900 VA
PWR1T, PWR2T, PWR3T, PWR4T	Power element type	+WATTS, –WATTS, +VARS, –VARS
PWR1D, PWR2D, PWR3D, PWR4D	Power element time delay	0.00–16000 cycles, in 0.25-cycle steps

The power element type settings are made in reference to the load convention:

+WATTS: positive or forward real power

–WATTS: negative or reverse real power

+VARS: positive or forward reactive power (lagging)

–VARS: negative or reverse reactive power (leading)

Power Element Time Delay Setting Considerations

The four power element time delay settings (PWR1D–PWR4D) can be set to have no intentional delay for testing purposes. For protection applications involving the power element Relay Word bits, SEL recommends a minimum time delay setting of 5.00 cycles for general applications. The classical power calculation is a product of voltage and current, to determine the real and reactive power quantities. During a system disturbance, because of the high sensitivity of the power elements, the changing system phase angles and/or frequency shifts may cause transient errors in the power calculation.

Accuracy

Pickup: ±0.5 W and ±3% of setting, power factor > ±0.5 at nominal frequency

Timer: ±1 cycles and ±2% of setting

Three-Phase Power Element Calculations

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 to create an effective three-phase power value, with the resulting power quantity subject to the minimum voltage and current tests shown in the lower half of *Figure 1.9*.

Power Elements Logic Operation

In *Figure 1.9*, an example is shown with setting PWR*n*T = +VARS. This corresponds to the settings PWR1P (pickup) and PWR1T (type) in *Figure 1.10*.

In *Figure 1.10*, if the A-phase reactive power level is above pickup setting PWR*n*P, Relay Word bit PWRA*n* asserts (PWRA*n* = logical 1) after time delay setting PWR*n*D (*n* = 1 through 4), subject to the sufficient signal conditions.

The sufficient signal conditions in *Figure 1.10* require at least 1 percent nominal current.

Pickup setting PWR*n*P is always a positive number value (see *Table 1.8*). Thus, if –WATTS or –VARS are chosen with setting PWR*n*T, the corresponding real or reactive power values have to be multiplied by –1 so that element PWRA*n* asserts for negative real or reactive power.

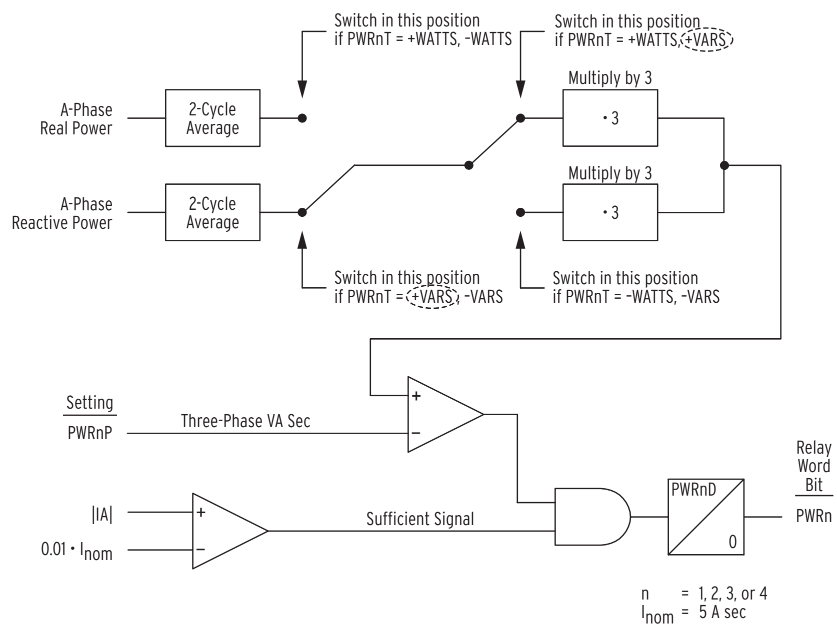


Figure 1.9 Single-Phase Power Elements Logic (+VARS Example Shown).

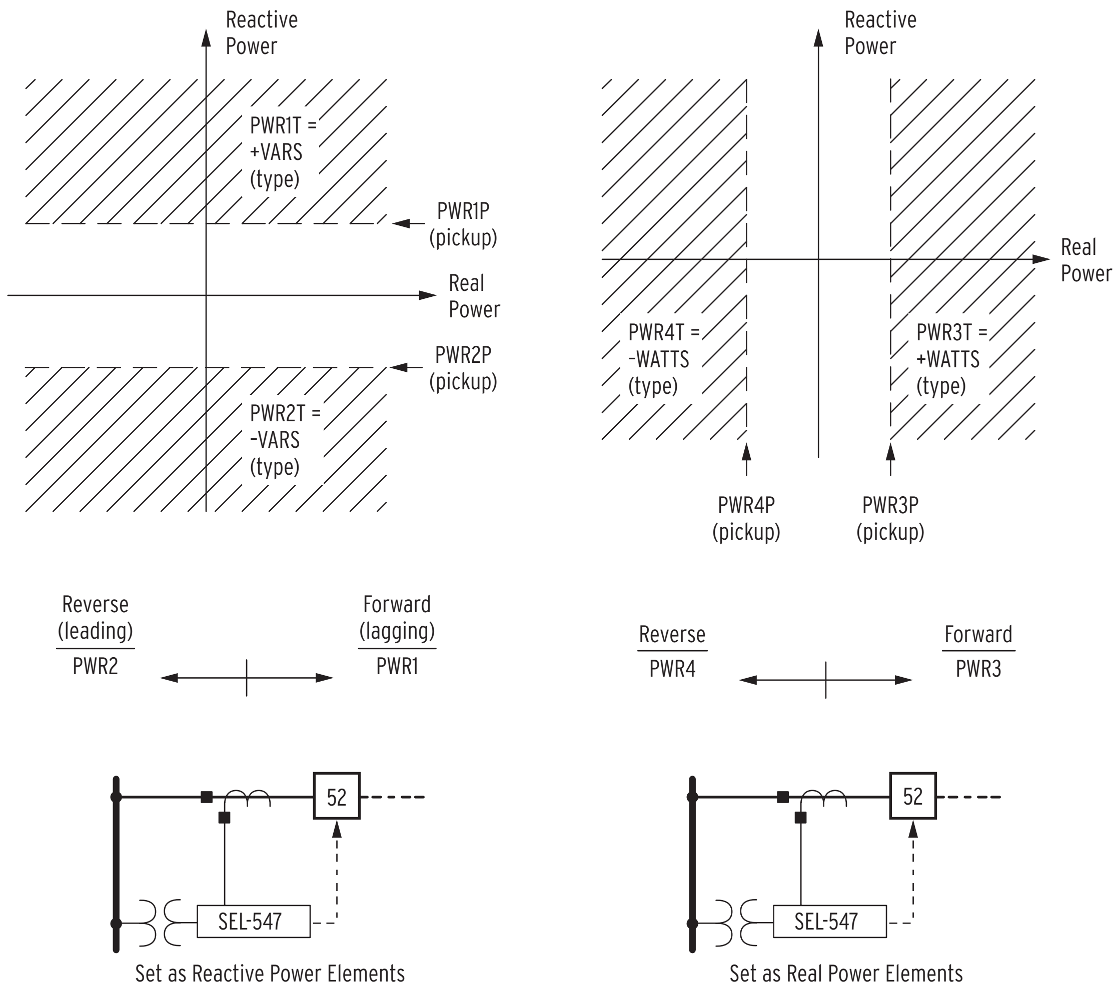


Figure 1.10 Power Elements Operation in the Real/Reactive Power Plane.

Section 2

SELOGIC Control Equation Programming

This section describes the use of SELOGIC® control equation programming to customize relay operation.

This section explains the settings and operation of the following relay logic inputs/outputs:

- SELOGIC control equations
- Optoisolated inputs (IN1–IN3)
- Remote control switches (remote bits RB1–RB16)
- Latch control switches (latch bits LT1–LT16)
- Multiple setting groups (group switching settings SS1 and SS2)
- Output contacts (OUT1–OUT5 and ALARM)
- Front-panel target LEDs

The above items are combined with the voltage, synchronism check, frequency, and power elements in SELOGIC control equation settings to realize numerous protection and control schemes.

Relay Word bits and SELOGIC control equation setting examples are used throughout this section. See *Section 8: Settings* for more information on Relay Word bits and SELOGIC control equation settings. See *Section 7: ASCII Commands* for more information on viewing and making SELOGIC control equation settings (**SHO L** and **SET L** commands).

SELOGIC Control Equations

Relay Word Bits

SELOGIC control equations combine relay protection and control elements with logic operators to create custom protection and control schemes. This section shows how to set the protection and control elements (Relay Word bits) in the SELOGIC control equations.

Additional SELOGIC control equation setting details are available in *SEL-547 Relay Settings Sheets* at the end of *Section 8: Settings*). See the **SHO** command (Show/View Settings) in *Section 7: ASCII Commands* for a list of the factory settings the SEL-547 Relay ships with in a standard relay shipment.

Most of the protection and control element logic outputs shown in the various figures in *Section 1: Protection Functions* and *Section 2* are Relay Word bits (labeled as such in the figures). Each Relay Word bit has a label name and can be in either of the following states:

1 (logical 1) or 0 (logical 0)

Logical 1 represents an element being picked up, timed out, or otherwise asserted.

Logical 0 represents an element being dropped out or otherwise deasserted.

A complete listing of Relay Word bits and their descriptions are referenced in *Appendix A: Relay Word Bits*.

Relay Word Bit Operation Example-Phase Undervoltage Element 27A1

As an example of protection element operation via the logic output of Relay Word bits, a phase undervoltage element is examined. Refer to phase undervoltage element 27A1 in *Figure 1.1 on page R.1.4*. Read the text that accompanies *Figure 1.1* (*Table 1.2* and following text). The Relay Word bit 27A1 is the logic output of the phase undervoltage element. It indicates that the A-phase voltage magnitude is below the level of the phase undervoltage pickup setting 27P1P.

Phase Undervoltage Element 27A1 Pickup Indication

If the A-phase current is at or above the level of the phase undervoltage pickup setting 27P1P, Relay Word bit 27A1 is in the following state:

27A1 = 0 (logical 0)

If the A-phase current is below the level of the phase undervoltage pickup setting 27P1P, Relay Word bit 27A1 is in the following state:

27A1 = 1 (logical 1)

Other Relay Word Bits

The preceding example was for a phase undervoltage element, demonstrating Relay Word bit operation for pickup conditions. Other Relay Word bits (e.g., those for overvoltage elements, frequency elements, and power elements) behave similarly in their assertion or deassertion to logical 1 or logical 0, respectively.

Relay Word bits are used in SELOGIC control equations, which are explained in the following subsection.

SELOGIC Control Equations

Many of the protection and control element logic inputs shown in the various figures in *Section 1* and *Section 2* are SELOGIC control equations (labeled SELOGIC Settings in figures). SELOGIC control equations are set with combinations of Relay Word bits to accomplish such functions as the following:

- ➤ Assigning functions to optoisolated inputs
- ➤ Operating output contacts
- ➤ Switching active setting groups

Traditional or advanced custom schemes can be created with SELOGIC control equations.

SELOGIC Control Equation Operators

SELOGIC control equation settings use logic similar to Boolean algebra logic, combining Relay Word bits together using one or more of the six SELOGIC control equation operators listed in *Table 2.1*.

Table 2.1 SELOGIC Control Equation Operators

Operator[a]	Logic Function
/	rising edge detect
\	falling edge detect
()	parentheses
!	NOT
*	AND
+	OR

[a] Operators in a SELOGIC control equation setting are processed in the order shown above.

SELOGIC Control Equation Parentheses Operator ( )

More than one set of parentheses ( ) can be used in a SELOGIC control equation setting. For example, the following SELOGIC control equation setting has two sets of parentheses:

SV7 = (SV7+IN101)*(27A1+27B1+27C1)

In the above example, the logic within the parentheses is processed first and then the two parentheses resultants are ANDed together. Parentheses cannot be nested (parentheses within parentheses) in a SELOGIC control equation setting.

SELOGIC Control Equation NOT Operator !

The NOT operator ! is applied to a single Relay Word bit and also to multiple elements (within parentheses). Following are examples of both.

Example of NOT Operator ! Applied to Single Element

The internal circuit breaker status logic in the SEL-547 operates on 52a circuit breaker auxiliary contact logic. The SELOGIC control equation circuit breaker status setting is labeled 52A. See *Optoisolated Inputs on page R.2.12* for more information on SELOGIC control equation circuit breaker status setting 52A.

When a circuit breaker is closed, the 52a circuit breaker auxiliary contact is closed. When a circuit breaker is open, the 52a contact is open.

If a 52a contact is connected to optoisolated input IN101, the SELOGIC control equation circuit breaker status setting 52A is set:

52A = IN101

Conversely, if a 52b contact is connected to optoisolated input IN101, the SELOGIC control equation circuit breaker status setting 52A is set:

52A = !IN101 [=NOT(IN101)]

With a 52b contact connected, if the circuit breaker is closed, the 52b contact is open and input IN101 is de-energized [IN101 = 0 (logical 0)]:

52A = !IN101 = NOT(IN101) = NOT(0) = 1

Thus, the SELOGIC control equation circuit breaker status setting 52A sees a closed circuit breaker.

With a 52b contact connected, if the circuit breaker is open, the 52b contact is closed and input IN101 is energized [IN101 = 1 (logical 1)]:

52A = !IN101 = NOT(IN101) = NOT(1) = 0

Thus, the SELOGIC control equation circuit breaker status setting 52A sees an open circuit breaker.

Example of NOT Operator ! Applied to Multiple Elements (Within Parentheses)

The SELOGIC variable timer input setting SV1 may be set as follows:

SV1 = !(27B1 + 59B1)

Refer also to *Output Contacts on page R.2.30*.

In this setting example, the variable timer input condition becomes true only when both the 27B1 (B-phase undervoltage element pickup indication) and 59B1 (B-phase overvoltage element pickup indication) Relay Word bits deassert:

SV1 = !(27B1 + 59B1) = NOT(27B1 + 59B1)

As stated previously, the logic within the parentheses is performed first. In this example, the states of Relay Word bits 27B1 and 59B1 are ORed together. Then the NOT operator is applied to the logic resultant from the parentheses.

If either one of 27B1 or 59B1 is still asserted [e.g., 59B1 = 1 (logical 1)], the variable timer input condition is not true:

SV1 = NOT(27B1 + 59B1) = NOT(0 + 1) = NOT(1) = 0

If both 27B1 and 59B1 are deasserted [i.e., 27B1 = 0 and 59B1 = 0 (logical 0)], the variable timer input condition is true:

SV1 = NOT(27B1 + 59B1) = NOT(0 + 0) = NOT(0) = 1

and the variable timer (SV1T) can begin timing, subject to settings SV1PU and SV1DO (see *Figure 2.3*).

SELOGIC Control Equation Rising Edge Operator /

The rising edge operator / is applied to individual Relay Word bits only—not to groups of elements within parentheses. For example, the SELOGIC control equation event report generation setting can be set to use rising edge operators:

ER = /SV7T + /SV8T

The Relay Word bits in this setting example are listed below:

SV7T. SELOGIC Variable Timer with default value set to level one undervoltage elements with 6-cycle timer (see *Figure 1.1 on page R.1.4*, *Figure 2.3*, and *Figure 2.4*)

SV8T. SELOGIC Variable Timer with default value set to level two undervoltage elements with 116-cycle timer (see *Figure 1.1 on page R.1.4*, *Figure 2.3*, and *Figure 2.4*)

When setting ER sees a logical 0 to logical 1 transition, it generates an event report (if the relay is not already generating a report that encompasses the new transition). The rising edge operators in the above setting example allow setting ER to see each transition individually.

Suppose a prolonged undervoltage event occurs. *Figure 2.1* demonstrates the action of the rising edge operator / on the individual elements in setting ER.

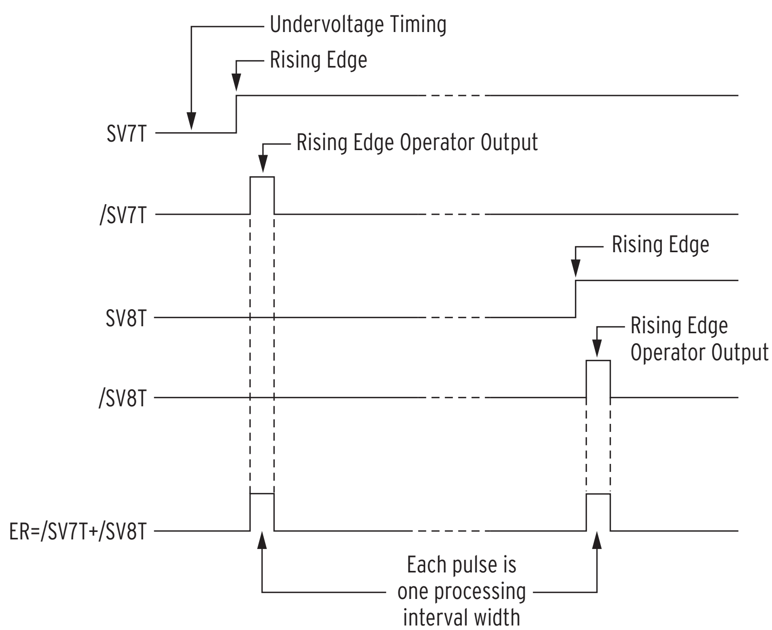


Figure 2.1 Result of Rising Edge Operators on Individual Elements in Setting ER.

In *Figure 2.1* setting ER sees two separate rising edges because the rising edge operators / are applied. The rising edge operator / in front of a Relay Word bit sees this logical 0 to logical 1 transition as a rising edge and the resultant asserts to logical 1 for one processing interval. The assertion of SV8T is some appreciable time later than the assertion of SV7T and will generate another event report.

If the rising edge operators / were not applied and setting ER was ER = SV7T + SV8T, the ER setting would not see the assertion of SV8T, because SV7T would continue to be asserted at logical 1, as shown in *Figure 2.1*.

SELOGIC Control Equation Falling Edge Operator \

The falling edge operator \ is applied to individual Relay Word bits only—not to groups of elements within parentheses. The falling edge operator \ operates similar to the rising edge operator, but looks for Relay Word bit deassertion (element going from logical 1 to logical 0). The falling edge operator \ in front of a Relay Word bit sees this logical 1 to logical 0 transition as a falling edge and asserts to logical 1 for one processing interval.

EXAMPLE 2.1 SELOGIC Control Equation Falling Edge Operator

Suppose the SELOGIC control equation event report generation setting is set with the detection of the falling edge of an underfrequency element:

ER = ... + \81D1T

When frequency goes above the corresponding pickup level 81D1P, Relay Word bit 81D1T deasserts and generates an event report (if the relay is not already generating a report that encompasses the new transition). This allows a recovery from an underfrequency condition to be observed.

See *Figure 1.8 on page R.1.19* and *Table 1.7 on page R.1.20*. *Figure 2.2* demonstrates the action of the falling edge operator \ on the underfrequency element in setting ER.

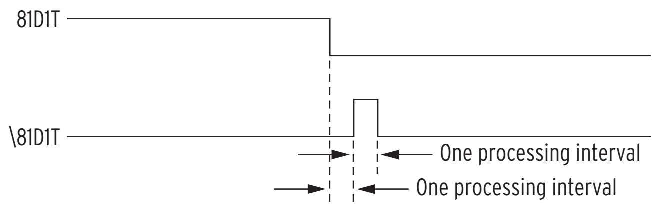


Figure 2.2 Result of Falling Edge Operator on a Deasserting Underfrequency Element.

SELOGIC Control Equation Variables/Timers

Sixteen (16) SELOGIC control equation variables/timers are available. Each SELOGIC control equation variable/timer has a SELOGIC control equation setting input and variable/timer outputs as shown in *Figure 2.3* and *Figure 2.4*.

Timers SV1T through SV6T in *Figure 2.3* have a setting range of a little over 4.5 hours:

0.00–999999.00 cycles in 0.25-cycle increments

Timers SV7T through SV16T in *Figure 2.4* have a setting range of almost 4.5 minutes:

0.00–16000.00 cycles in 0.25-cycle increments

These timer setting ranges apply to both pickup and dropout times (SV*n*PU and SV*n*DO, *n* = 1 through 16).

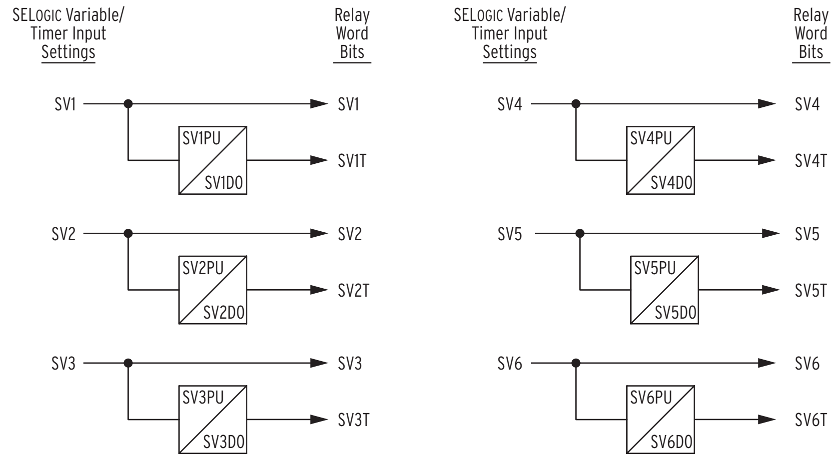


Figure 2.3 SELOGIC Control Equation Variables/Timers SV1/SV1T Through SV6/SV6T.

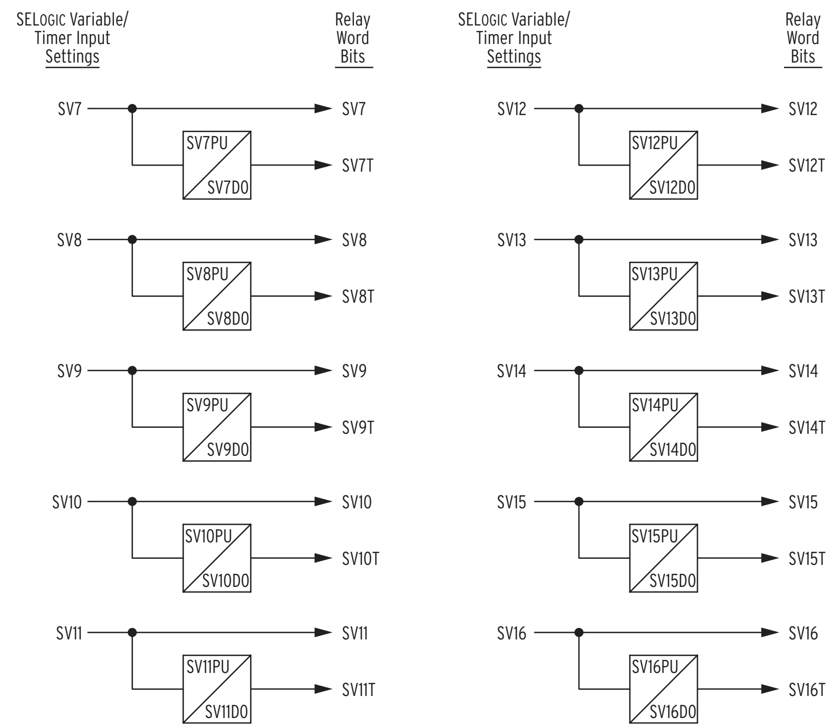


Figure 2.4 SELOGIC Control Equation Variables/Timers SV7/SV7T Through SV16/SV16T.

Breaker Control Example

A variable timer enables proper utilization of the **OPEN** and **CLOSE** commands (see command explanation in *Section 7: ASCII Commands*). Issuing these commands from the proper access level asserts the corresponding Relay Word bit (OC or CC) for one processing interval. This assertion would not be long enough to operate a Trip or Close Coil connected to output contacts controlled by these Relay Word bits. Instead, set SELogic control equation variable timers equal to the OPEN and CLOSE Relay Word bits. This allows for a sustained assertion tied to a user-settable cycle duration (SV_DO), ensuring proper Trip or Close Coil operation (see *Figure 2.5*).

SV14 = OC

OUT1 = SV14T

SV15 = CC

OUT2 = SV15T

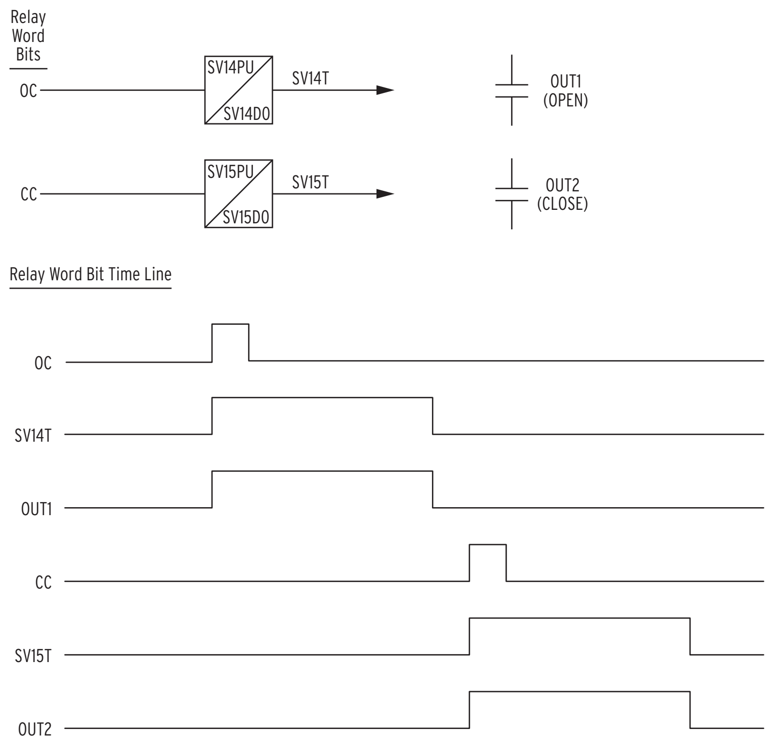


Figure 2.5 Breaker Control With Timer Created With SELogic Control Equation Variables/Timers.

Additional Settings Example

Another application idea is a seal-in circuit with a timer (see *Figure 2.6*):

SV14 = (SV14 + IN1)*IN2

OUT1 = SV14T

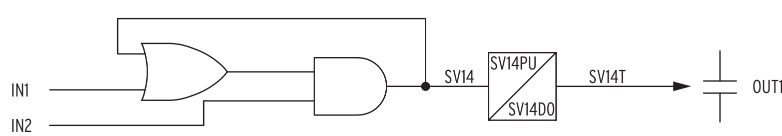


Figure 2.6 Seal-in Circuit With Timer Created With SELogic Control Equation Variables/Timers.

Note that the above SELOGIC control equation setting SV14 creates a seal-in circuit (as shown in Figure 2.6) by virtue of SELOGIC control equation setting SV14 being set equal to Relay Word bit SV14 (SELOGIC control equation variable SV14):

SV14 = (SV14 + IN1)*IN2

Optoisolated input IN1 functions as an initiate seal-in input, while input IN2 functions as a maintain seal-in input. Input IN1 need only be pulsed (Relay Word bit IN1 = logical 1, momentarily) to initiate the seal-in creation. The seal-in is made and maintained (SV14 = logical 1) if input IN2 continues to be asserted (Relay Word bit IN2 = logical 1).

If the seal-in is maintained for pickup time setting SV14PU, Relay Word bit SV14T asserts to logical 1. Output contact OUT1 then asserts (SELOGIC control equation setting OUT1 = SV14T).

The seal-in circuit in Figure 2.6 is reminiscent of breaker failure circuits, where input IN1 provides the trip initiate input, input IN2 provides the fault detector input, pickup time setting SV14PU provides the breaker failure time, and output contact OUT1 provides the breaker failure trip. Dropout time setting SV14DO could be set for a minimum sustained time for breaker failure tripping.

Timers Reset When Power Lost, Settings Changed, or Active Setting Group Changed

If power is lost to the relay, settings are changed (for the active setting group), or the active setting group is changed, the SELOGIC control equation variables/timers are reset. Relay Word bits SV*n* and SV*n*T (*n* = 1 through 16) are reset to logical 0 and corresponding timer settings SV*n*PU and SV*n*DO load up again after power restoration, settings change, or active setting group switch.

Preceding Figure 2.6 is an effective seal-in logic circuit, created by use of Relay Word bit SV14 (SELOGIC control equation variable SV7) in SELOGIC control equation SV7:

SV14 = (SV14 + IN1)*IN2

If power is lost to the relay, settings are changed (for the active setting group), or the active setting group is changed, the seal-in logic circuit is broken by virtue of Relay Word bit SV14 being reset to logical 0 (assuming input IN1 is not asserted). Relay Word bit SV7T is also reset to logical 0, and timer settings SV7PU and SV7DO load up again.

Set All SELOGIC Control Equations

SELOGIC control equations cannot be left blank. Set all SELOGIC control equations in one of the following ways:

- Single Relay Word bit (e.g., SV1 = IN101)
- Combination of Relay Word bits (e.g., SV7 = 27A1+27B1+27C1)
- Directly to logical 1 (e.g., SS1 = 1)
- Directly to logical 0 (e.g., SS2 = 0)

Set SELOGIC Control Equations Directly to 1 or 0

SELOGIC control equations can be set directly to 1 (logical 1) or 0 (logical 0) instead of with Relay Word bits. If a SELOGIC control equation setting is set directly to 1, it is always asserted/on/enabled. If a SELOGIC control equation setting is set equal to 0, it is always deasserted/off/disabled.

SELOGIC Control Equation Limitations

Any single SELOGIC control equation setting is limited to 15 Relay Word bits that can be combined together with the SELOGIC control equation operators listed in *Table 2.2*. If this limit must be exceeded, use a SELOGIC control equation variable (SELOGIC control equation settings SV1–SV12) as an intermediate setting step.

For example, assume that the output contact equation OUT5 needs more than 15 Relay Word bits in its equation setting. Instead of placing all Relay Word bits into OUT5, program some of them into the SELOGIC control equation setting SV1. Next, use the resultant SELOGIC control equation variable output (Relay Word bit SV1) in the SELOGIC control equation trip setting OUT5.

Table 2.2 SELOGIC Control Equation Settings Limitations the SEL-547

Model Number	SELOGIC Control Equation Settings Limitations per Setting Group
547	Total number of elements ≤ 128 Total number of rising edge or falling edge operators ≤ 22

SELOGIC control equation settings that are set directly to 1 (logical 1) or 0 (logical 0) also have to be included in these limitations—each such setting counted as one Relay Word bit.

After SELOGIC control equation settings changes have been made and the settings are saved, the SEL-547 responds with the following message:

xxx Elements and yy Edges remain available

Where
xxx = Relay Word bits can still be used.
yy = rising or falling edge operators can still be applied in the SELOGIC control equations for the particular settings group.

Processing Order and Processing Interval

The relay elements and logic (and corresponding SELOGIC control equation settings and resultant Relay Word bits) are processed in the order shown in *Table 2.3* (top to bottom). They are processed every quarter-cycle (1/4-cycle), and the Relay Word bit states (logical 1 or logical 0) are updated with each quarter-cycle pass. Thus, the relay processing interval is 1/4-cycle. Once a Relay Word bit is asserted, it retains the state (logical 1 or logical 0) until it is updated again in the next processing interval.

Table 2.3 Processing Order of Relay Elements and Logic (Top to Bottom)

Relay Elements and Logic (related SELogic Control Equations listed in parentheses)	Order of processing of the SELogic Control Equations (listed in parentheses) and Relay Word Bits	Reference Location
Analog and Digital Data Acquisition	IN1–IN3, IAMET	*Section 2*
Remote Control Switches	RB8–RB1, RB16–RB9	*Section 2*
Power Elements	PWR1, PWR2, PWR3, PWR4	*Section 1*
Latch Control Switches (SET*n*, RST*n*, where *n* = 1 to 16)	[(SET*n*), (RST*n*), where *n*= 1 to 16], LT1–LT16	*Section 2*
Frequency Elements	27B81, 81D1, 81D1T, 81D2, 81D2T, 81D3, 81D3T, 81D4, 81D4T, 81D5, 81D5T, 81D6, 81D6T	*Section 1*
Voltage Elements	59A1, 27A1, 59A2, 27A2, 59B1, 27B1, 59B2, 27B2, 59C1, 27C1, 59C2, 27C2, 59S1, 27S, 59S2, 59V1, 59Q1, 59Q2, 59N1, 59N2	*Section 1*
Synchronism Check Elements and Vs (BSYNCH)	(BSYNCH), 59VS, 59VP, 59VA, SSLOW, SFAST, SF, 25A1, 25A2,	*Section 1*
SELogic Control Equation Variables/Timers (SV1–SV16)	[(SV*n*), SV*n*, SV*n*T, where *n* = 1 to 16]	*Section 2*
OUT101–OUT107	OUT1–OUT5	*Section 2*
Setting Group Control (SS1–SS2)	(SS1–SS2)	*Section 2*
Event Report Trigger (ER)	(ER)	*Section 3*
Alarm	ALARM	*Section 2*

Asynchronous Processing. The Relay Word bits in *Table 2.4* are processed separately from the above list. They can be thought of as being processed just before (or just after) *Table 2.3*.

Table 2.4 Processing Order of Relay Elements and Logic (Top to Bottom)

Relay Elements and Logic (related SELogic Control Equations listed in parentheses)	Order of processing of the SELogic Control Equations (listed in parentheses) and Relay Word Bits	Reference Location
Setting group indication (SS1–SS2)	SG2–SG1	*Section 2*
Breaker remote control bits	CC, OC	*Section 7*

Optoisolated Inputs

Figure 2.7 shows the resultant Relay Word bits IN1 through IN3 that follow corresponding optoisolated inputs IN1 through IN3 in the SEL-547. The figure shows examples of energized and de-energized optoisolated inputs and corresponding Relay Word bit states. To assert an input, apply rated control voltage to the appropriate terminal pair (see Figure 2.2 on page U.2.3 in the User's Guide).

Figure 2.7 is used for the following discussion and examples.

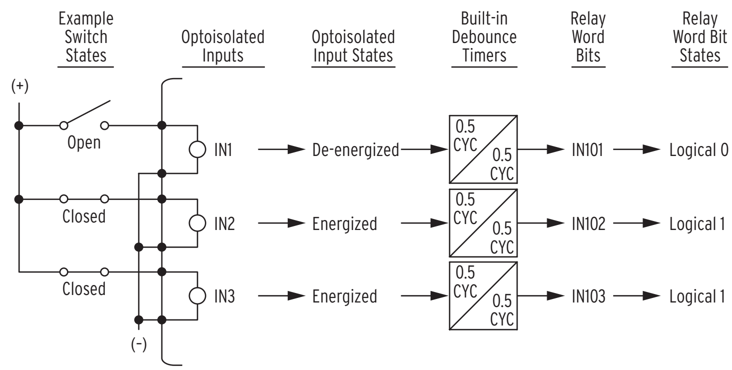


Figure 2.7 Example Operation of SEL-547 Optoisolated Inputs IN1, IN2, and IN3.

Input Debounce Timers

Each input has fixed pickup/dropout timers (0.5 cycles pickup and dropout) for input energization/de-energization debounce, as shown in Figure 2.7.

If more than 0.5 cycle of debounce is needed, run Relay Word bit IN1, IN2, or IN3 through a SELOGIC control equation variable timer and use the output of the timer for input functions (see Figure 2.3 and Figure 2.4).

Input Functions

There are no optoisolated input settings such as IN1 =, IN2 =, IN3 =.

Optoisolated inputs IN1, IN2, and IN3 receive their function by how their corresponding Relay Word bits IN1, IN2, and IN3 are used in SELOGIC control equations.

Inputs IN1, IN2, and IN3 have no function from the factory—their corresponding Relay Word bits IN1, IN2, and IN3 are not used in any SELOGIC control equations from the factory.

Settings Examples

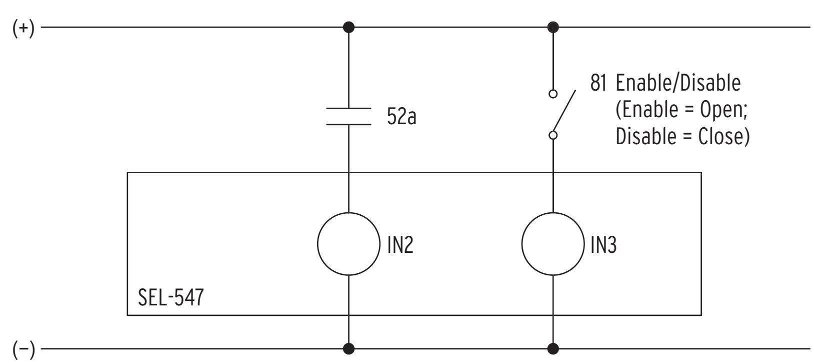


Figure 2.8 Circuit Breaker Auxiliary Contact and Underfrequency Element Control Switch Connected to Optoisolated Inputs IN2 and IN3.

Example functions given to inputs IN2 and IN3, as shown in *Figure 2.8*, are described in the following discussions.

Input IN2

Input IN2 is connected to a 52a circuit breaker auxiliary contact in *Figure 2.8*. This breaker status information is used to perform the following functions:

- Block the synchronism check function when the breaker is closed (input IN2 is energized and corresponding Relay Word bit IN2 = logical 1)
- Further supervise the operation of the 25 VOLTAGE HOT front-panel LED (require that not only the voltages on both sides of the circuit breaker are hot, but that the circuit breaker is open [input IN2 is de-energized and corresponding Relay Word bit IN2 = logical 0])

The corresponding SELOGIC control equations settings that realize these functions are listed below, respectively:

- BSYNCH—block synchronism check
- LED8—bottom LED [25 VOLTAGE HOT LED]

The settings are preset at the factory as shown below:

- BSYNCH = SV11T
- LED8 = CLKPUL + 59VS * 59VP

Input IN2 (connected to a 52a circuit breaker auxiliary contact) is then added to these settings to realize the above described, desired control:

- BSYNCH = SV11T + IN2
- LED8 = CLKPUL + 59VS * 59VP * !IN2

In the above settings, notice that the addition of Relay Word bit IN2 to setting BSYNCH is an OR operation, while the addition of IN2 to setting LED8 is an AND operation. In the BSYNCH setting, the closed breaker (IN2 = logical 1) is an additional, independent condition that blocks synchronism check. Thus, IN2 is ORed into the BSYNCH setting.

In the LED8 setting, the open breaker [!IN2= NOT(IN2) = logical 1] is an additional supervising condition (along with the voltages on either side of the open breaker) that determines if the 25 VOLTAGE HOT LED illuminates. Thus, !IN2 is ANDed into the LED8 setting, with the two voltage elements—see *Figure 2.9*:

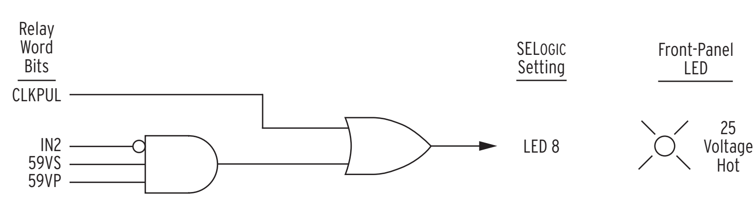


Figure 2.9 Breaker Status (52a connected to Input IN2) Supervises Operation of 25 VOLTAGE HOT LED.

If a 52b circuit breaker auxiliary contact (normally closed when the circuit breaker is open) is connected to input IN2 instead of a 52a, the settings are changed as shown below:

➤ BSYNCH = SV11T + !IN2

➤ LED8 = CLKPUL + 59VS * 59VP * IN2

Relay Word bit IN2 can be used in other SELOGIC control equations settings as well.

Input IN3

Input IN3 is connected to a switch to enable/disable a level of underfrequency loadshedding in *Figure 2.8*. The switch function is described below:

➤ Enable a particular level of underfrequency loadshedding when the switch is open.

(Input IN3 is de-energized and corresponding Relay Word bit IN3 = logical 0)

➤ Disable a particular level of underfrequency loadshedding when the switch is closed.

(Input IN3 is energized and corresponding Relay Word bit IN3 = logical 1)

From the factory, the frequency elements are set in the following logic:

➤ SV11 = 81DIT + 81D2T + 81D3T + 81D4T

Frequency element 81D2T is factory set as an underfrequency element. To have frequency element 81D2T supervised by input IN3, with the above described, desired control, add Relay Word bit IN3, as follows:

➤ SV11 = 81DIT + !IN3 * 81D2T + 81D3T + 81D4T

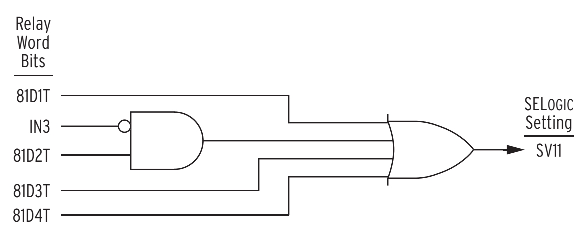


Figure 2.10 Input IN3 Supervises the Operation of Underfrequency Element 81D2T.

Relay Word bit IN3 can be used in other SELOGIC control equations settings as well.

Remote Control Switches (Remote Bits)

Remote Bit Operation

Remote control switches are operated via a serial communications port only (see *CON Command (Control Remote Bit) on page R.7.16*).

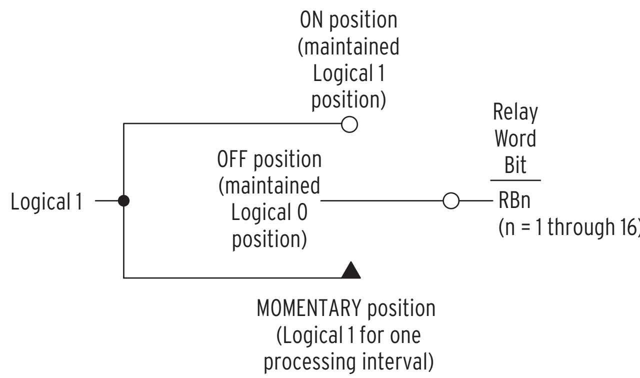


Figure 2.11 Remote Control Switches Drive Remote Bits RB1 Through RB16.

The output of the remote control switch in *Figure 2.11* is a Relay Word bit RB*n* (*n* = 1 through 16), called a remote bit. The remote control switch logic in *Figure 2.11* repeats for each remote bit RB1 through RB16. Use these remote bits in SELOGIC control equations.

Any given remote control switch can be put in one of the following three positions:

- ON (remote bit RB*n* = logical 1)
- OFF (remote bit RB*n* = logical 0)
- MOMENTARY (remote bit RB*n* = logical 1 for one processing interval [1/4 cycle])

Figure 2.11 shows the remote control switch as a three-position switch, but most remote bit applications are one of the following:

- ON/OFF Switch
- OFF/MOMENTARY Switch

ON/OFF Switch

Remote control switch is in either the ON (remote bit RB*n* = logical 1) or OFF (remote bit RB*n* = logical 0) position.

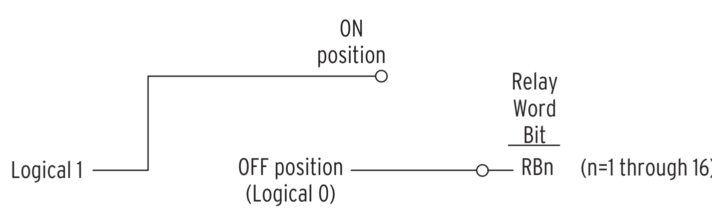


Figure 2.12 Remote Control Switch Used as an ON/OFF Switch.

OFF/MOMENTARY Switch

Remote control switch is maintained in the OFF position (remote bit RB*n* = logical 0) and pulses to the MOMENTARY position (remote bit RB*n* = logical 1) for one processing interval (1/4 cycle).

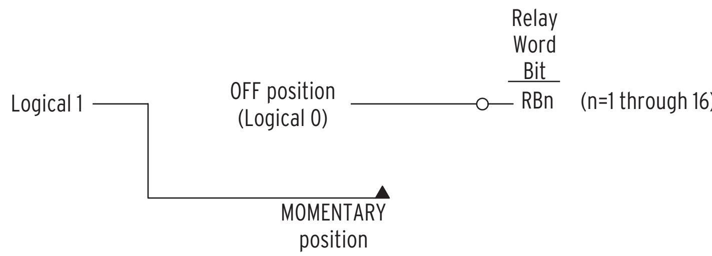


Figure 2.13 Remote Control Switch Used as an OFF/MOMENTARY Switch.

Remote Bit States Not Retained When Power Lost

The states of the remote bits (Relay Word bits RB1 through RB16) are not retained if power to the relay is lost and then restored. The remote control switches always come back in the OFF position (corresponding remote bits RB*n* are deasserted to logical 0) when power is restored to the relay.

Remote Bit States Retained When Settings Changed or Active Setting Group Changed

The states of the remote bits (Relay Word bits RB1 through RB16) are retained if settings are changed for the active setting group or the active setting group is changed (the relay is momentarily disabled during the actual change process). If a remote control switch is in the ON position (corresponding remote bit RB*n* is asserted to logical 1) before a setting change or an active setting group change, it comes back in the ON position (corresponding remote bit RB*n* is still asserted to logical 1) after the change. If a remote control switch is in the OFF position (corresponding remote bit RB*n* is deasserted to logical 0) before a settings change or an active setting group change, it comes back in the OFF position (corresponding remote bit is still deasserted to logical 0) after the change.

If settings are changed for the nonactive setting group, there is no interruption of the remote bit states (the relay is not disabled, even momentarily).

Remote Bit Applications

See *Figure 2.21* and accompanying text for an application that includes remote bits.

Effectively, remote bits are logic inputs into the SEL-547 (like an optoisolated input is a logic input into the SEL-547), but remote bits can only be operated via a serial communications port (see *CON Command (Control Remote Bit) on page R.7.16*).

Remote bits can also be operated via fast operate commands (see *Section 5: SEL Communications Protocols*) and Modbus® protocol (see *Section 6: Modbus RTU Communications*).

Latch Control Switches (Latch Bits)

Latch Control Switch Operation

The latch control switch feature of this relay replaces latching relays. Traditional latching relays maintain their output contact state when set. An SEL-547 latch control switch retains its state even when control power is lost. If the latch control switch is set to a programmable output contact and control power is lost, the state of the latch control switch is stored in nonvolatile memory, but the output contact will go to its de-energized state. When the control power is applied back to the relay, the programmed output contact will go back to the state of the latch control switch after relay initialization.

The state of a traditional latching relay output contact is changed by pulsing the latching relay inputs (see *Figure 2.14*). Pulse the set input to close (set) the latching relay output contact. Pulse the reset input to open (reset) the latching relay output contact. Often the external contacts wired to the latching relay inputs are from remote control equipment (e.g., SCADA, RTU).

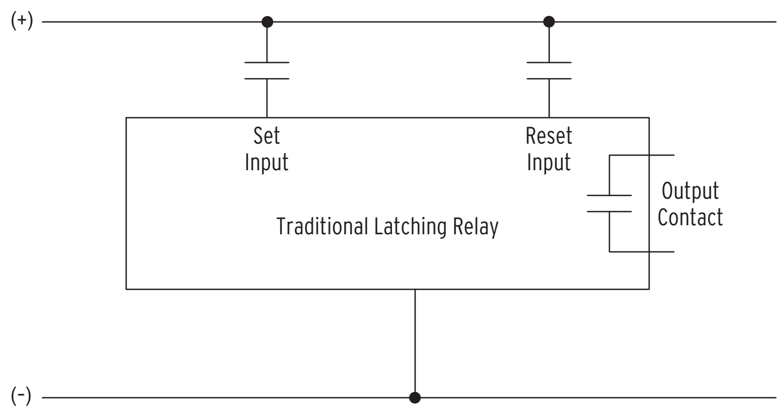


Figure 2.14 Traditional Latching Relay.

The sixteen (16) latch control switches in the SEL-547 provide latching relay type functions.

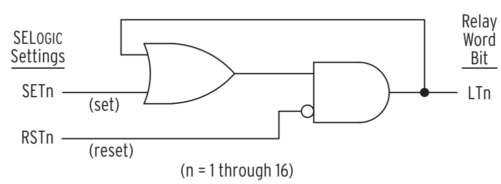


Figure 2.15 Latch Control Switches Drive Latch Bits LT1 Through LT16.

The output of the latch control switch in *Figure 2.15* is a Relay Word bit LT*n* (*n* = 1 through 16), called a latch bit. The latch control switch logic in *Figure 2.15* repeats for each latch bit LT1 through LT16. Use these latch bits in SELOGIC control equations.

These latch control switches each have the following SELOGIC control equation settings:

SET*n* (set latch bit LT*n* to logical 1; *n* = 1 through 16)
RST*n* (reset latch bit LT*n* to logical 0; *n* = 1 through 16)

If setting asserts to logical 1, latch bit LT*n* asserts to logical 1. If setting RST*n* asserts to logical 1, latch bit LT*n* deasserts to logical 0. If both settings SET*n* and RST*n* assert to logical 1 at the same time, setting RST*n* has priority and latch bit LT*n* deasserts to logical 0.

Operate Latch Control Switch With Two Inputs

Figure 2.14 shows individual contacts asserting separate set and reset inputs of a traditional latching relay. The same can be done with the internal latch control switches in the SEL-547, as shown in *Figure 2.16*:

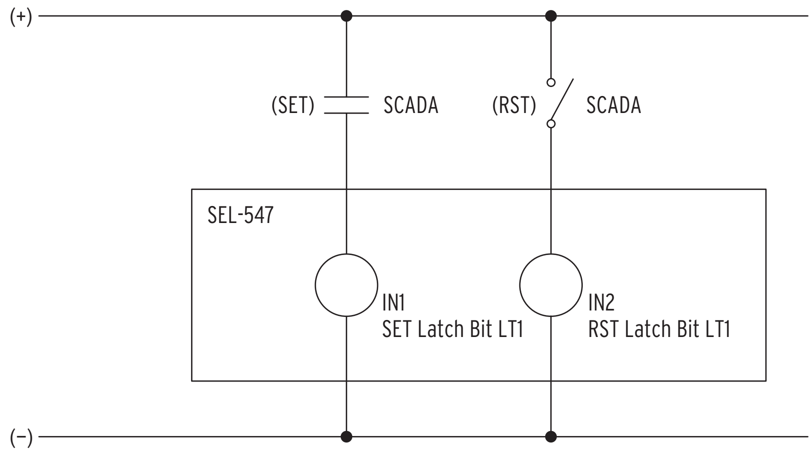


Figure 2.16 Separate SCADA Contacts Pulse Inputs IN1 and IN2 to Set/Reset Latch Bit LT1.

In the *Figure 2.16* example, separate SCADA contacts are connected to optoisolated inputs IN1 and IN2, respectively. Pulse the appropriate SCADA contact to change the state of latch bit LT1. The SCADA contacts are not maintained, just pulsed to set/reset latch bit LT1 to logical 1 / logical 0.

The following SELOGIC control equations realize the logic in *Figure 2.16*:

- SET1 = IN1 (input IN1 sets latch bit LT1 to logical 1)
- RST1 = IN2 (input IN2 resets latch bit LT1 to logical 0)

The above SELOGIC control equations are portrayed in the logic in *Figure 2.17*.

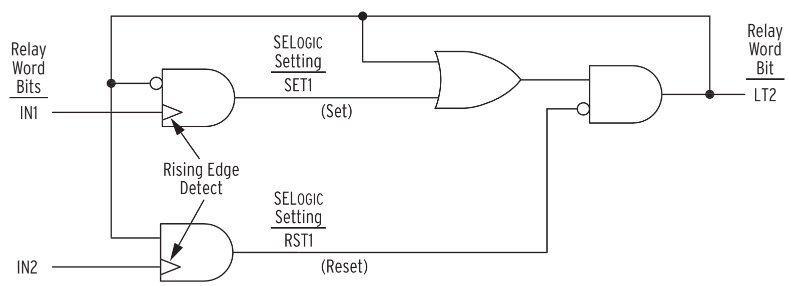


Figure 2.17 Latch Bit LT1 is Set/Reset by Separate Inputs.

Operate Latch Control Switch With One Input

Alternatively, a single input can set/reset an internal latch control switch in the SEL-547:

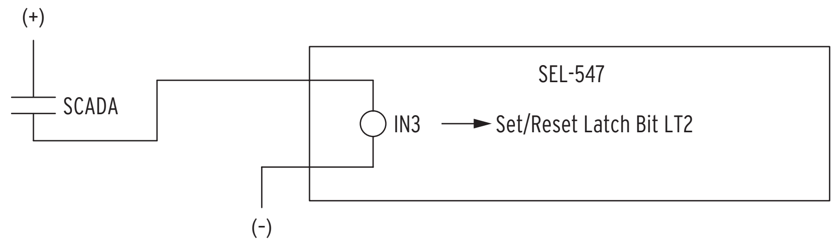


Figure 2.18 Single SCADA Contact Pulses Input IN3 to Set/Reset Latch Bit LT2.

In the *Figure 2.18* example, a single SCADA contact is connected to optoisolated input IN3. Each pulse of the SCADA contact changes the state of latch bit LT2. The SCADA contact is not maintained, just pulsed to set/rest latch bit LT2 to logical 1 / logical 0.

If latch bit LT2 starts out set to logical 1, and the SCADA contact is pulsed, then latch bit LT2 resets to logical 0. If the SCADA contact is pulsed again, then latch bit LT2 sets back to logical 1. The latch control switch operates in a cyclic manner, with each pulsing of the SCADA contact (and subsequent momentary assertion of input IN3):

> pulse to set (LT2 = logical 1) ... pulse to reset (LT2 = logical 0) ... pulse to set (LT2 = logical 1) ... pulse to reset (LT2 = logical 0) ...

The following SELOGIC control equations realize the logic in *Figure 2.19*:

- SET2 = /IN3 * !LT2

  [= (rising edge of input IN3) AND NOT(LT2)]
- RST2 = /IN3 * LT2

  [= (rising edge of input IN3) AND LT2]

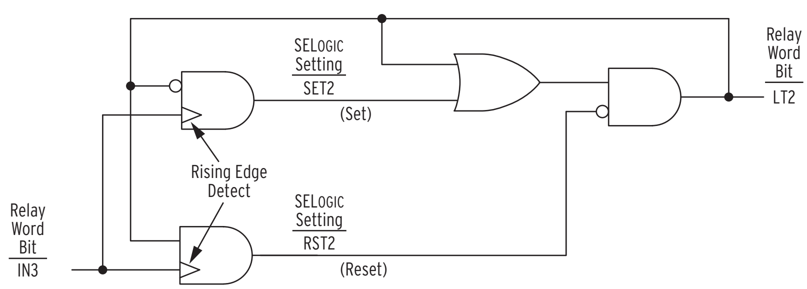


Figure 2.19 Latch Bit LT2 is Set/Reset by a Single Input.

Feedback Control

Note in *Figure 2.19* that the latch control switch output (latch bit LT2) is effectively used as feedback for SELOGIC control equation settings SET2 and RST2. The feedback of latch bit LT2 guides input IN3 to the correct latch control switch input.

If latch bit LT2 = logical 0, input IN3 is routed to setting SET2 (set latch bit LT2):

SET2 = IN3 * !LT2 = /IN3 * NOT(LT2) = /IN3 * NOT(logical 0)
= /IN3 * (logical 1) = /IN3 = rising edge of input IN3

RST2 = /IN3 * LT2 = /IN3 * (logical 0)
= logical 0

If latch bit LT2 = logical 1, input IN3 is routed to setting RST2 (reset latch bit LT2):

SET2 = /IN3 * !LT2 = /IN3 * NOT(LT2) = /IN3 * NOT(logical 1) =
= /IN3 * (logical 0)
= logical 0

RST2 = /IN3 * LT2 = /IN3 * (logical 1)
= /IN3 = rising edge of input IN3

Rising Edge Operators

Refer to *Figure 2.19* and *Figure 2.20*.

The rising edge operator in front of Relay Word bit IN3 (/IN3) sees a logical 0 to logical 1 transition as a rising edge, and /IN3 asserts to logical 1 for one processing interval.

The rising edge operator on input IN3 is necessary because any single assertion of optoisolated input IN3 by the SCADA contact will last for at least a few cycles, and each individual assertion of input IN3 should only change the state of the latch control switch once (e.g., latch bit LT2 changes state from logical 0 to logical 1).

For example in *Figure 2.19*, if latch bit LT2 = logical 0, input IN3 is routed to setting SET2 (as discussed previously):

SET2 = IN3 * !LT2 = /IN3 * NOT(LT2) = /IN3 * NOT(logical 0)
= /IN3 * (logical 1) = /IN3 = rising edge of input IN3

If input IN3 is then asserted for a few cycles by the SCADA contact (see Pulse 1 in *Figure 2.20*), SET2 is asserted to logical 1 for one processing interval. This causes latch bit LT2 to change state to latch bit LT2 = logical 1, the next processing interval.

With latch bit LT2 now at logical 1 for the next processing interval, input IN3 is routed to setting RST2 (as discussed previously):

RST2 = /IN3 * LT2 = /IN3 * (logical 1)
= /IN3 = rising edge of input IN3

This would then appear to enable the reset input (setting RST2) the next processing interval. But the rising edge condition occurred the preceding processing interval. /IN3 is now at logical 0, so setting RST2 does not assert, even though input IN3 remains asserted for at least a few cycles by the SCADA contact.

If the SCADA contact deasserts and then asserts again (new rising edge—see Pulse 2 in *Figure 2.20*), the reset input (setting RST2) asserts and latch bit LT2 deasserts back to logical 0 again. Thus, each individual assertion of input IN3 (Pulse 1, Pulse 2, Pulse 3, and Pulse 4 in *Figure 2.20*) changes the state of latch control switch just once.

Refer to the preceding subsection *Optoisolated Inputs on page R.2.12* and *Figure 2.7 on page R.2.12*. Relay Word bit IN3 shows the state of optoisolated input IN3 after the input pickup/dropout debounce time of 0.5 cycles. Thus, when using Relay Word bit IN3 in *Figure 2.19* and *Figure 2.20* and associated SELOGIC control equations, keep in mind any time delay produced by the input pickup/dropout debounce time of 0.5 cycles.

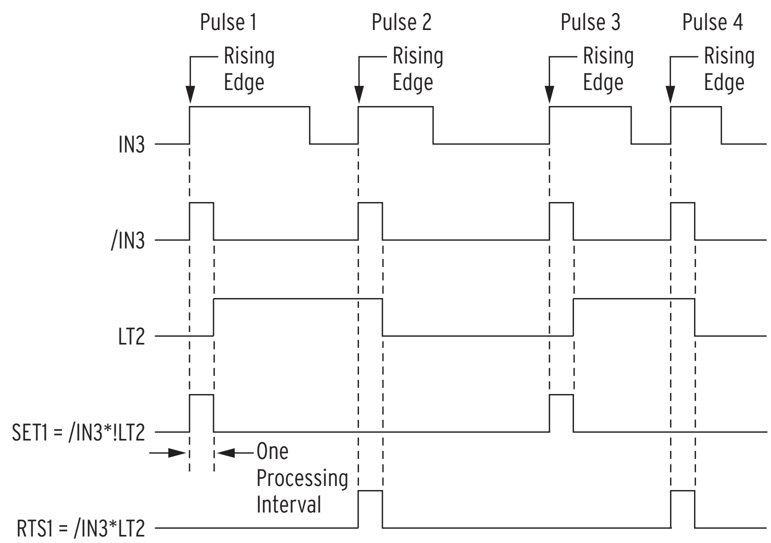


Figure 2.20 Latch Control Switch Operation Time Line.

Operate Latch Control Switches With Remote Bits

Use a remote bit to set/reset a latch control switch, instead of an optoisolated input. For example, substitute remote bit RB1 for optoisolated input IN3 in the settings accompanying *Figure 2.19* (see resultant *Figure 2.21*):

- ➤ SET2 = /RB1*!LT2

  [= (rising edge of remote bit RB1) AND NOT(LT2)]

- ➤ RST2 = /RB1*LT2

  [= (rising edge of remote bit) AND LT2]

If latch bit LT2 starts out set to logical 1, and remote bit RB1 is pulsed, then latch bit LT2 resets to logical 0. If remote bit RB1 is pulsed again, then latch bit LT2 sets back to logical 1. The latch control switch operates in a cyclic manner, with each pulsing of remote bit RB1:

> pulse to set (LT2 = logical 1) ... pulse to reset (LT2 = logical 0) ... pulse to set (LT2 = logical 1) ... pulse to reset (LT2 = logical 0) ...

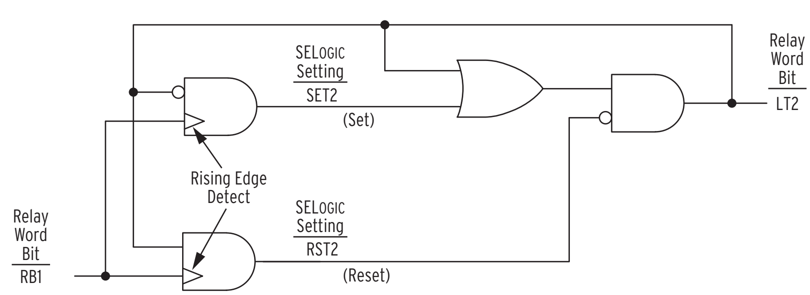


Figure 2.21 Latch Bit LT2 is Set/Reset by Remote Bit RB1.

Remote bits (Relay Word bits RB1 through RB16) are operated through a serial port. See *CON Command (Control Remote Bit) on page R.7.16* for more information on remote bits.

Latch Control Switch Applications

Applications for the latch control switches in the SEL-547 are numerous. One application is to supervise an element, without having to maintain a signal on an optoisolated input—just pulse the input, as demonstrated in *Figure 2.19* and *Figure 2.20*. The latch bit output (e.g., LT2) maintains the logic signal (LT2 = logical 1 or logical 0) after the pulse goes away.

For example, substitute latch bit LT2 output from *Figure 2.19* in place of input IN3 in *Figure 2.10*:

SV11 = 81DIT + !LT2 * 81D2T + 81D3T + 81D4T

Then, input IN3 just has to be pulsed (not maintained) to effect a desired logical outcome (i.e., a maintained !LT2 = logical 1 or !LT2 = logical 0 for supervision of frequency element 81D2T).

The above latch bit LT2 substitution could just as well have been

SV11 = 81DIT + LT2 * 81D2T + 81D3T + 81D4T

In the previous example, the NOT (!) in front of input IN3 (see *Figure 2.10*) was needed because of logic requirements (input IN3 de-energized enables frequency element 81D2T—so, if a wire fell loose on input IN3, frequency element 81D2T would still be enabled). By using latch bit LT2 (instead of input IN3 directly) to supervise frequency element 81D2T, maintaining input IN3 in either an energized or de-energized state is not a concern—input IN3 is just pulsed (not maintained) to affect a change of the state of latch bit LT2.

Latch Control Switch Considerations

Power Loss

The states of the latch bits (LT1 through LT16) are retained if power to the relay is lost and then restored. If a latch bit is asserted (e.g., LT2 = logical 1) when power is lost, it comes back asserted (LT2 = logical 1) when power is restored. If a latch bit is deasserted (e.g., LT3 = logical 0) when power is lost, it comes back deasserted (LT3 = logical 0) when power is restored. This feature makes the latch bit feature behave the same as traditional latching relays. In a traditional installation, if power is lost to the panel, the latching relay output contact position remains unchanged.

If a latch bit is set to a programmable output contact (e.g., OUT3 = LT2) and power to the relay is lost; the state of the latch bit is stored in nonvolatile memory but the output contact will go to its de-energized state. When power to the relay is restored, the programmable output contact will go back to the state of the latch bit after relay initialization.

Settings Change or Active Setting Group Change

If individual settings are changed (for the active setting group or the other setting group) or the active setting group is changed, the states of the latch bits (Relay Word bits LT1 through LT16) are retained, much like in the preceding *Power Loss* explanation.

If individual settings are changed for a setting group (other than the active setting group), there is no interruption of the latch bits (the relay is not momentarily disabled).

If individual settings changes (for the active setting group) or an active setting group change causes a direct or effective change in SELOGIC control equation settings SET*n* or RST*n* (*n* = 1 through 16), the retained states of the latch bits can be changed, subject to the newly enabled settings.

Nonvolatile Memory Limitation

The latch bit states are stored in nonvolatile memory so they can be retained during power loss, settings change, or active setting group change. The nonvolatile memory is rated for a finite number of writes for all cumulative latch bit state changes. Exceeding the limit can result in an EEPROM self-test failure. An average of 70 cumulative latch bit state changes per day can be made for a 25-year relay service life.

This requires that SELOGIC control equation settings SET*n* and RST*n* for any given latch bit LT*n* (*n* = 1 through 16; see *Figure 2.15*) be set with care. Settings SET*n* and RST*n* cannot result in continuous cyclical operation of latch bit LT*n*. Use timers to qualify conditions set in settings SET*n* and RST*n*. If any optoisolated inputs IN1 through IN3 are used in settings SET*n* and RST*n*, the inputs have their own debounce timer that can help in providing the necessary time qualification (see *Figure 2.7*).

In the preceding example (*Figure 2.18*, *Figure 2.19*, and *Figure 2.20*), the SCADA contact cannot be asserting/deasserting continuously, thus causing latch bit LT2 to change state continuously. Note that the rising edge operators in the SET2 and RST2 settings keep latch bit LT2 from cyclically operating for any single assertion of the SCADA contact.

Another variation to the example application in *Figure 2.18*, *Figure 2.19*, and *Figure 2.20* that adds more security is a timer with pickup/dropout times set the same (see *Figure 2.22* and *Figure 2.23*). Suppose that SV6PU and SV6DO are both set to 300 cycles. Then the SV6T timer keeps the state of latch bit LT2 from being able to be changed at a rate faster than once every 300 cycles (5 seconds).

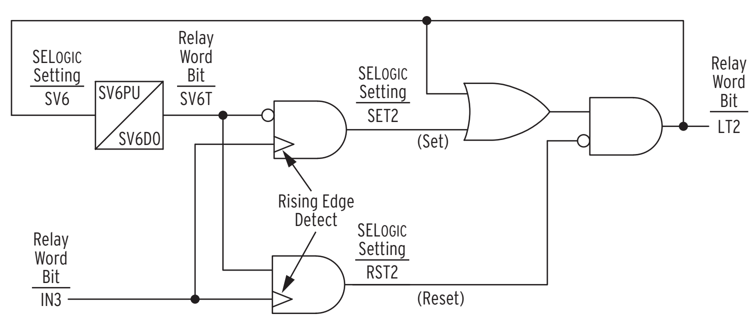


Figure 2.22 Latch Control Switch (With Time Delay Feedback) Controlled by a Single Input to Set/Reset Latch Bit LT2.

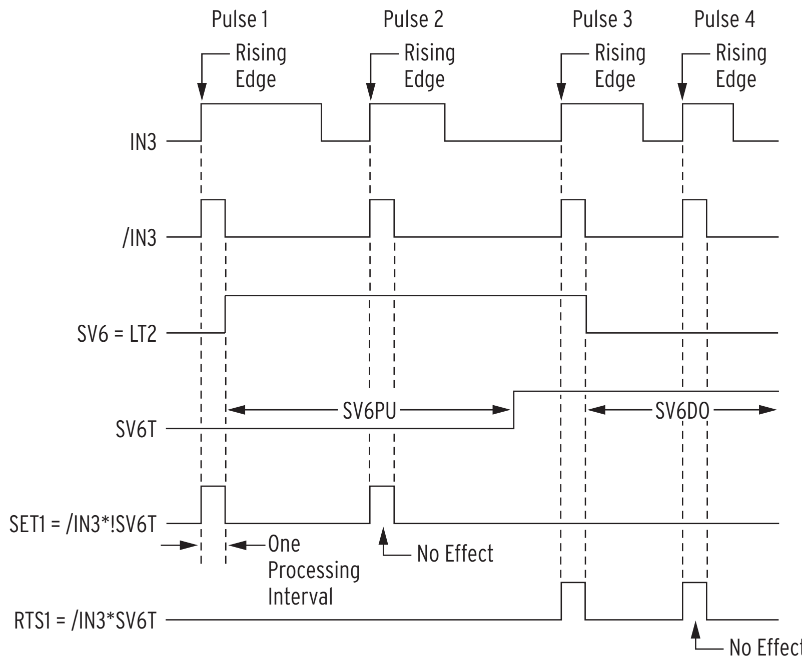


Figure 2.23 Latch Control Switch (With Time Delay Feedback) Operation Time Line.

Multiple Setting Groups

The relay has two (2) independent setting groups. Each setting group has complete relay element (voltage, frequency, synchronism check, etc.) and SELOGIC control equation settings.

Active Setting Group Indication

⚠CAUTION
If EZ settings are enabled, some Group 1 settings are overwritten by the EZ settings.

Only one setting group can be active at a time. Relay Word bits SG1 and SG2 indicate the active setting group.

Table 2.5 Definitions for Active Setting Group Indication Relay Word Bits SG1 Through SG2

Relay Word Bit	Definition
SG1	Indication that setting Group 1 is the active setting group
SG2	Indication that setting Group 2 is the active setting group

For example, if setting Group 2 is the active setting group, Relay Word bit SG2 asserts to logical 1, and Relay Word bit SG1 deasserts to logical 0.

Selecting the Active Setting Group

Select the active setting group using one of the following methods:

- SELOGIC control equation settings SS1 and SS2
- Serial port **GROUP** command (see *Section 7: ASCII Commands*)

SELOGIC control equation settings SS1 and SS2 have priority over the serial port **GROUP** command in selecting the active setting group.

Operation of SELOGIC Control Equation Settings SS1 and SS2

Each setting group has its own set of SELOGIC control equation settings SS1 and SS2.

Table 2.6 Definitions for Active Setting Group Switching SELOGIC Control Equation Settings SS1 and SS6

Setting	Definition
SS1	Go to (or remain in) setting Group 1
SS2	Go to (or remain in) setting Group 2

The operation of these settings is explained with the following example:

Assume the active setting group starts out as setting Group 1. Corresponding Relay Word bit SG1 asserts to logical 1 as an indication that setting Group 1 is the active setting group (see *Table 2.5*).

With setting Group 1 as the active setting group, setting SS1 has priority. If setting SS1 is asserted to logical 1, setting Group 1 remains the active setting group, regardless of the activity of setting SS2. With settings SS1 and SS2 both deasserted to logical 0, setting Group 1 still remains the active setting group.

With setting Group 1 as the active setting group, if setting SS1 deasserts to logical 0 and setting SS2 asserts to logical 1, the relay switches from setting Group 1 as the active setting group to setting Group 2 as the active setting group, after qualifying time setting TGR:

Operation of Serial Port GROUP Command

SELOGIC control equation settings SS1 and SS2 have priority over the serial port **GROUP** command in selecting the active setting group. If either SS1 or SS2 asserts to logical 1, the serial port **GROUP** command cannot be used to switch the active setting group. But if SS1 and SS2 both deassert to logical 0, the serial port **GROUP** command can be used to switch the active setting group.

See *Section 7: ASCII Commands* for more information on the serial port **GROUP** command.

Relay Disabled Momentarily During Active Setting Group Change

The relay is disabled for a few seconds while the relay is in the process of changing active setting groups. Relay elements, timers, and logic are reset, unless indicated otherwise in specific logic description [e.g., remote bit (RB1 through RB16), and latch bit (LT1 through LT16) states are retained during an active setting group change]. The output contacts do not change state until the relay enables in the new settings group and the SELOGIC control equations are processed to determine the output contact status for the new group. For instance, if setting OUT1 = logical 1 (effectively) in Group 1, and setting OUT1 = logical 1 (effectively) in Group 2, and the relay is switched from Group 1 to Group 2, output contact OUT1 stays energized before, during, and after the group change. However, if the Group 2 setting was OUT1 = logical 0 (effectively) instead, then OUT1 remains energized until the relay enables in Group 2, solves the SELOGIC control equations, and causes OUT1 to deenergize. See *Figure 2.27* for examples of output contacts in the de-energized state (i.e., corresponding output contact coils de-energized).

Selecting the Active Setting Group Example

Use a single optoisolated input to switch between the two setting groups in the SEL-547. In this example, optoisolated input IN1 on the relay is connected to a SCADA contact in *Figure 2.24*. Each pulse of the SCADA contact changes the active setting group from one setting group (e.g., setting Group 1) to another (e.g., setting Group 2). The SCADA contact is not maintained, just pulsed to switch from one active setting group to another.

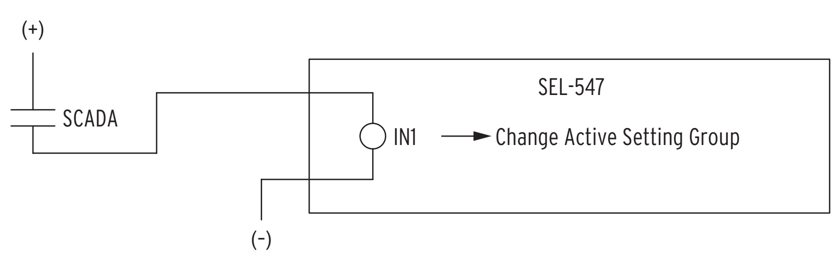


Figure 2.24 SCADA Contact Pulses Input IN1 to Switch Active Setting Group Between Setting Groups 1 and 2.

If setting Group 1 is the active setting group and the SCADA contact is pulsed, setting Group 2 becomes the active setting group. If the SCADA contact is pulsed again, then setting Group 1 becomes the active setting group again. The setting group control operates in a cyclical manner, with each pulsing of the SCADA contact (and subsequent momentary assertion of input IN1):

> pulse to activate setting Group 2 ... pulse to activate setting Group 1 ...
> pulse to activate setting Group 2 ... pulse to activate setting Group 1 ...

This logic is implemented in the SELOGIC control equation settings in *Table 2.7*.

Table 2.7 SELOGIC Control Equation Settings for Switching Active Setting Group Between Setting Groups 1 and 2

Setting Group 1	Setting Group 2
SV8 = SG1	SV8 = SG2
SS1 = 0	SS1 = IN1*SV8T
SS2 = IN1*SV8T	SS2 = 0

SELOGIC control equation timer input setting SV8 in *Table 2.7* has logic output SV8T, shown in operation in *Figure 2.25* for both setting Groups 1 and 2.

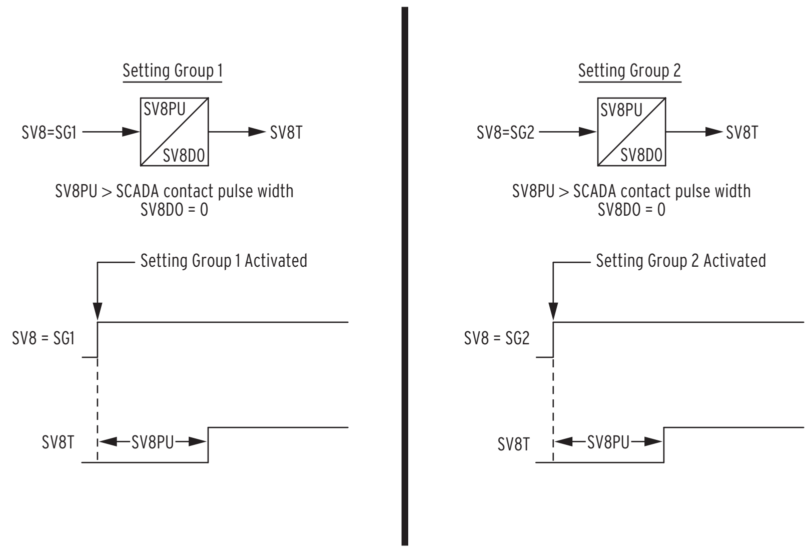


Figure 2.25 SELOGIC Control Equation Variable Timer SV8T Used in Setting Group Switching.

In this example, timer SV8T is used in both setting groups—different timers could have been used with the same operational result. The timers reset during the setting group change, allowing the same timer to be used in both setting groups.

Timer pickup setting SV8PU is set greater than the pulse width of the SCADA contact and less than the Group Change Delay Setting, TGR. (*Figure 2.24*). This allows only one active setting group change (e.g., from setting Group 1 to 2) for each pulse of the SCADA contact (and subsequent assertion of input IN1). The function of the SELOGIC control equations in *Table 2.7* becomes more apparent in the following example scenario.

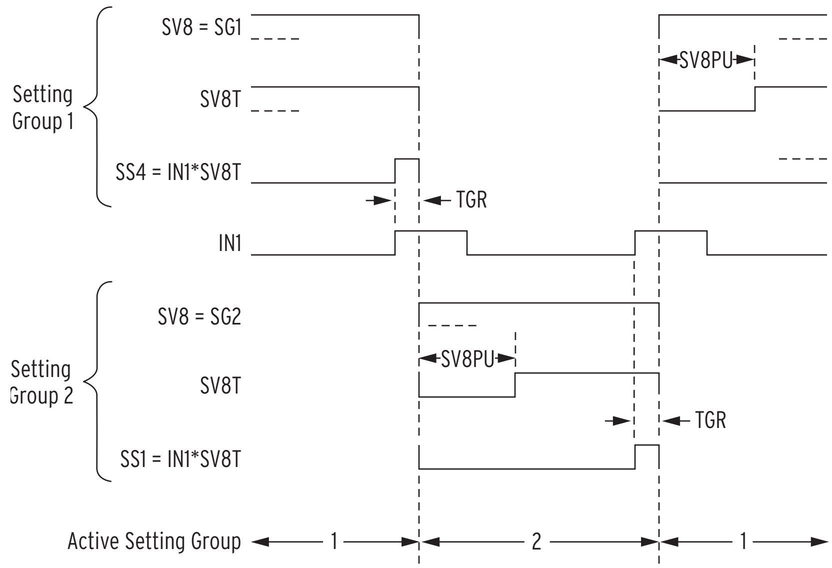


Figure 2.26 Active Setting Group Switching (With Single Input) Time Line.

Step 1. Start Out in Setting Group 1

The relay has been in setting Group 1 for some time, with timer logic output SV8T asserted to logical 1, thus enabling SELOGIC control equation setting SS2 for the assertion of input IN1.

Step 2. Switch to Setting Group 2

The SCADA contact pulses input IN1, and the active setting group changes to setting Group 2 after qualifying time setting TGR (perhaps set at a few cycles to qualify the assertion of setting SS2). Optoisolated input IN1 also has its own built-in debounce time of 0.5 cycles (see *Figure 2.7*).

Note that *Figure 2.26* shows both setting Group 1 and setting Group 2 settings. The setting Group 1 settings (top of *Figure 2.26*) are enabled only when setting Group 1 is the active setting group and likewise for the setting Group 2 settings at the bottom of the figure.

Setting Group 2 is now the active setting group, and Relay Word bit SG2 asserts to logical 1. After the relay has been in setting Group 2 for a time period equal to SV8PU, the timer logic output SV8T asserts to logical 1, thus enabling SELOGIC control equation setting SS1 for a new assertion of input IN1.

Note that input IN1 is still asserted as setting Group 2 is activated. Pickup time SV8PU keeps the continued assertion of input IN1 from causing the active setting group to revert back again to setting Group 1 for a single assertion of input IN1. This keeps the active setting group from being changed at a time interval less than time SV8PU.

Step 3. Switch Back to Setting Group 1

The SCADA contact pulses input IN1 a second time, and the active setting group changes back to setting Group 1 after qualifying time setting TGR (perhaps set at a few cycles to qualify the assertion of setting SS1). Optoisolated input IN1 also has its own built-in debounce time of 0.5 cycles (see *Figure 2.7*).

Active Setting Group Considerations

Power Loss

The active setting group is retained if power to the relay is lost and then restored. If a particular setting group is active (e.g., setting Group 1) when power is lost, it comes back with the same setting group active when power is restored.

Settings Change

If individual settings are changed (for the active setting group or the other setting group), the active setting group is retained, much like in the preceding *Power Loss* explanation.

If individual settings are changed for a setting group (other than the active setting group), there is no interruption of the active setting group (the relay is not momentarily disabled).

If individual settings changes (for the active setting group) cause a direct or effective change in SELOGIC control equation settings SS1 or SS2, the active setting group can be changed, subject to the newly enabled settings.

Nonvolatile Memory Limitation

The active setting group is stored in nonvolatile memory so it can be retained during power loss or settings change. The nonvolatile memory is rated for a finite number of writes for all setting group changes. Exceeding the limit can result in an EEPROM self-test failure. An average of one (1) setting group change per day can be made for a 25-year relay service life.

This requires that SELOGIC control equation settings SS1 and SS2 (see *Table 2.7*) be set with care. Settings SS1 and SS2 cannot result in continuous cyclical changing of the active setting group. Time setting TGR qualifies settings SS1 and SS26 before changing the active setting group. If optoisolated inputs IN1 through IN3 are used in settings SS1 and SS2, the inputs have their own built-in debounce times that can help in providing the necessary time qualification (see *Figure 2.7*).

Output Contacts

Output Contact Operation

Figure 2.27 shows the example operation of output contact Relay Word bits OUT1 through OUT5 due to the following:

- ➤ SELOGIC control equation operation (SELOGIC control equation settings OUT1 through OUT5)

  or

- ➤ **PULSE** command execution

The output contact Relay Word bits in turn control the actual output contacts OUT1 through OUT5.

Alarm logic/circuitry controls the dedicated ALARM output contact.

OUT1–OUT5

The execution of the serial port command **PUL *n*** (*n* = OUT1 through OUT5) asserts the corresponding Relay Word bit (OUT1 through OUT5) to logical 1. See *Section 7: ASCII Commands* for more information on the **PUL** (Pulse) command.

The assertion of SELOGIC control equation setting OUT*m* (*m* = 1 through 5) to logical 1 also asserts the corresponding Relay Word bit OUT*m* (*m* = 1 through 5) to logical 1.

The assertion of Relay Word bit OUT*m* (*m* = 1 through 5) to logical 1 causes the energization of the corresponding output contact OUT*m* coil. Output contacts OUT1 through OUT5 are a-type output contacts, so they are open when their respective output contact coil is de-energized and closed when their respective output contact coil is energized.

Other output contact specifications are given in *Specifications on page U.1.16 in the User's Guide*.

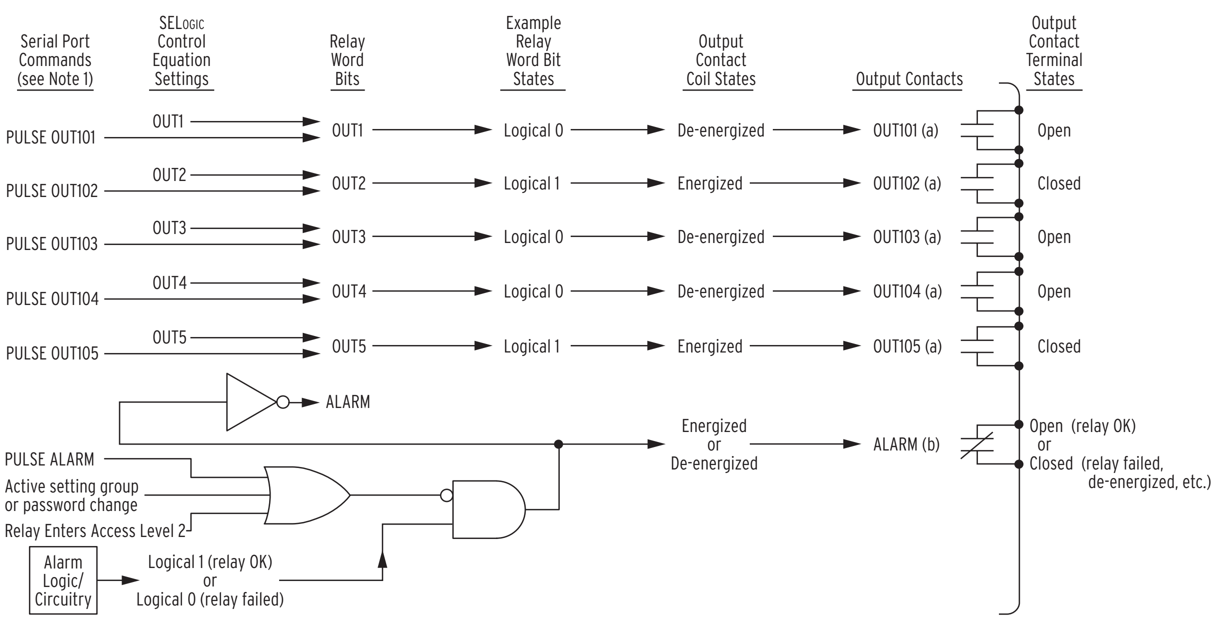


Figure 2.27 Logic Flow for Example Output Contact Operation.

ALARM Output Contact

When the relay is operational, the ALARM output contact coil is energized. The alarm logic/circuitry keeps the ALARM output contact coil energized. The ALARM output contact opens as demonstrated in *Figure 2.27*. The b-type output contact is closed when the output contact coil is de-energized and open when the output contact coil is energized.

To verify ALARM output contact mechanical integrity, execute the serial port **PULSE ALARM** command. Execution of this command momentarily de-energizes the ALARM output contact coil.

The Relay Word bit ALARM is deasserted to logical 0 when the relay is operational. When the serial port **PULSE ALARM** command is executed, the ALARM Relay Word bit momentarily asserts to logical 1. Also, when the relay enters Access Level 2, a password is changed, or an active setting group is changed, the ALARM Relay Word bit momentarily asserts to logical 1 (and the ALARM output contact coil is de-energized momentarily).

Factory Settings Example

In *Figure 2.28*, three of the output contacts (OUT1, OUT2, and OUT3) are used for close supervision and the other two (OUT4 and OUT5) are used for tripping.

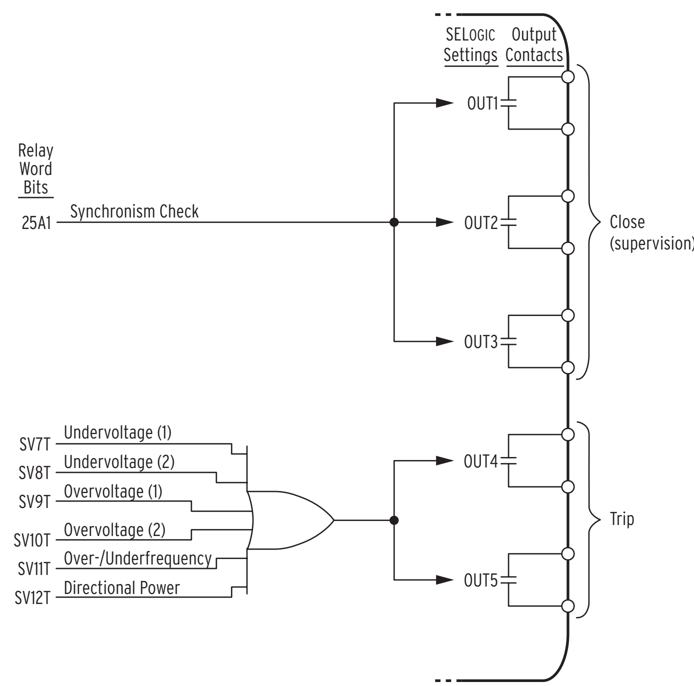


Figure 2.28 Output Contact Logic.

Front-Panel Target LEDs

Eight (8) programmable front-panel target LEDs are available. Each front-panel target LED has a SELOGIC control equation setting input as shown in Table 2.8:

Table 2.8 SEL-547 Front-Panel Target LED Definitions

Front-Panel Target LED Label	Relay Word Bit	Default Value SELOGIC Control Equation Setting
ENABLED	LED1	Controlled by hardware enable logic
27	LED2	LED2 = CLKPUL + SV7T + SV8T
59	LED3	LED3 = CLKPUL + SV9T + SV10T
81	LED4	LED4 = CLKPUL + SV11T
47	LED5	LED5 = CLKPUL + SV13T
32	LED6	LED6 = CLKPUL + SV12T
25	LED7	LED7 = CLKPUL + 25A1
25 VOLTAGE HOT	LED8	LED8 = CLKPUL + (59VS * 59VP)

The front-panel LED illuminates if its corresponding control equation is asserted. The Relay Word bit CLKPUL (see Figure 2.29) asserts at intervals defined by the Clock Pulse Interval Global Setting INTRVL. This allows for regular illumination of the LEDs in lieu of a front-panel lamp test pushbutton.

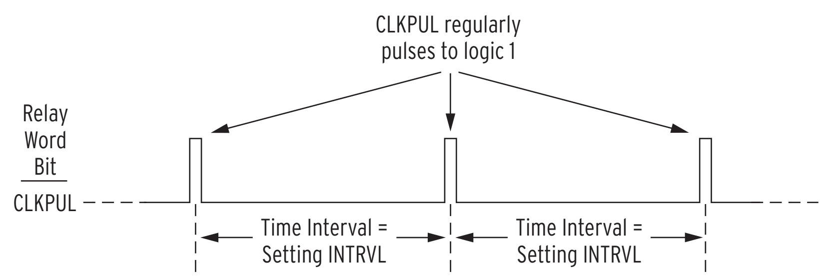


Figure 2.29 LED Flashing Logic.

Factory Settings Example

In *Figure 2.30*, LED7 will illuminate upon the assertion of any one of two Relay Word bits: CLKPUL and 25A1. CLKPUL is factory set to assert every 30 seconds (INTRVL = 30), causing LED7 to momentarily illuminate every 30 seconds.

25A1 is the Relay Word bit output of the first Synchronism Check Element. Assertion of this output bit will also cause LED7 to illuminate. Deassertion of the corresponding control equation will extinguish the front-panel LED (See *Figure 2.31*).

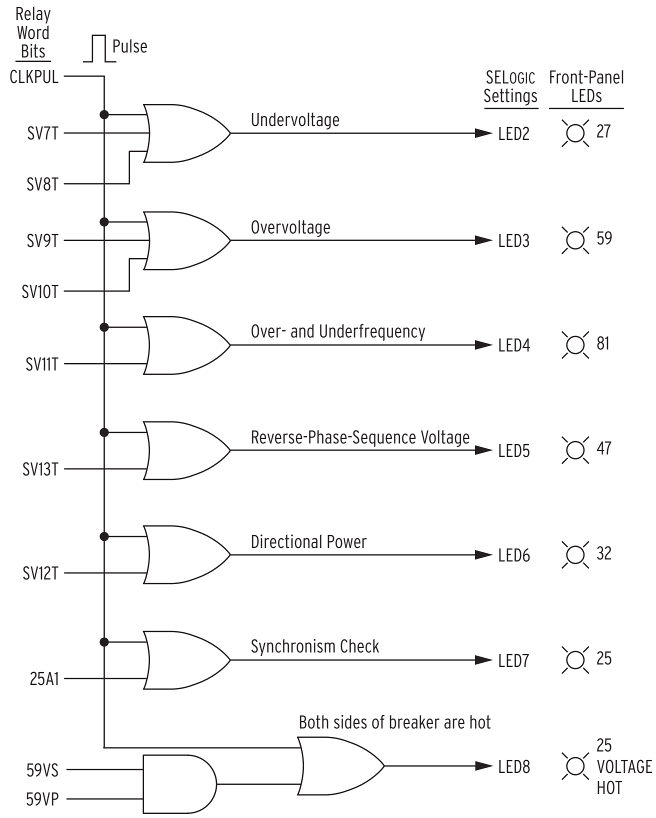


Figure 2.30 Front-Panel LED Logic.

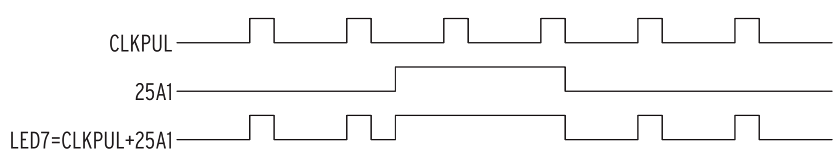


Figure 2.31 LED2 Illumination Time Line.

There is no other logic involved in the control of the front-panel LEDs. There is no sealing in of LED illumination (e.g., seal-in on trip), unless a programmable latch is used in custom logic (e.g., LED7 = LT7; see *Figure 2.15*).

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Section 3
Analyzing Events

The SEL-547 Relay features power system data analysis capabilities. It provides the following useful analysis tools:

- Event reporting
  - Event reports
  - Event summaries
  - Event histories
- SER (Sequential Events Recorder)

An event is a representation of the operating conditions of the power system at a specific time. Events include instances such as a relay trip, an abnormal situation in the power system that triggers a relay element, or an event capture command.

Information from relay event reports and SER data is valuable for outage analysis, outage management, or relay settings coordination.

Introduction

The SEL-547 offers two styles of event reports:

- Standard 15-, 30- or 60-cycle event reports.
- Sequential events recorder (SER) report.

Resolution: 1 ms

Accuracy: +1/4 cycle

The event reports contain date, time, current, voltage, frequency, relay element, optoisolated input, and output contact information.

The relay generates (triggers) standard 15-, 30- or 60-cycle event reports by fixed and programmable conditions. These reports show information for 15, 30, or 60 continuous cycles, which depends on the LER setting (see the following subsection). The relay stores the most recent event report data in nonvolatile memory. Eight 15-cycle, four 30-cycle, or two 60-cycle reports are maintained; if more reports are triggered, the latest event report overwrites the oldest event report. See *Figure 3.5* for an example standard 15-cycle event report.

The relay adds lines in the sequential events recorder (SER) report for a change of state of a programmable condition. The SER lists date and time-stamped lines of information each time a programmed condition changes state. The relay stores the latest 512 lines of the SER report in nonvolatile memory. If the report fills up, newer rows overwrite the oldest rows in the report. See *Figure 3.8* for an example SER report.

Standard 15-, 30-, or 60-Cycle Event Reports

Event Report Length (Settings LER and PRE)

The SEL-547 provides user-programmable event report length and prefault length. Event report length is 15, 30, or 60 cycles. Prefault length ranges from 1 to 59 cycles. Prefault length is the first part of the event report that precedes the event report triggering point.

Set the event report length with the LER setting. Set the prefault length with the PRE setting. See the **SET G** command in *Section 8: Settings* for instructions on setting the LER and PRE settings.

Changing the LER setting will erase all events stored in nonvolatile memory. Changing the PRE setting has no effect on the nonvolatile reports.

Standard Event Report Triggering

The relay triggers (generates) a standard event report when any of the following occur:

- Programmable SELOGIC® control equation setting ER asserts to logical 1
- **TRI** (Trigger Event Reports) serial port command executed
- Output contacts OUT1–OUT5 pulsed via the serial port **PUL** (Pulse Output Contact) command

Programmable SELOGIC Control Equation Setting ER

The programmable SELOGIC control equation event report trigger setting ER is set to trigger standard event reports. When setting ER sees a logical 0 to logical 1 transition, it generates an event report (if the SEL-547 is not already generating a report that encompasses the new transition). For example, the SEL-547 may be set as follows:

ER = /27A1 + /59A1 + /OUT4

Note the rising edge operator / in front of each of these elements. See *Section 2: SELOGIC Control Equation Programming* for more information on rising edge operators and SELOGIC control equations in general.

The Relay Word bits in this factory-setting example are shown in *Table 3.1*:

Table 3.1 Factory-Setting Example Relay Word Bits

Relay Word Bits	Description
27A1	A-phase voltage below phase undervoltage pickup setting 27P1P (see *Figure 1.1 on page R.1.4*)
59A1	A-phase voltage above phase overvoltage pickup setting 59P1P (see *Figure 1.1 on page R.1.4*)
OUT4	Output contact OUT4 is set as a trip output (see *Output Contacts on page R.2.30*)

TRI (Trigger Event Report) and PUL (Pulse Output Contact) Commands

The sole function of the serial port **TRI** command is to generate standard event reports, primarily for testing purposes.

The **PUL** command asserts the output contacts for testing purposes or for remote control. If output contact OUT1–OUT5 asserts via the **PUL** command, the relay triggers a standard event report. The **PUL** command is available at the serial port.

See *Section 7: ASCII Commands* for more information on the **TRI** and **PUL** commands.

Standard Event Report Summary

Each time the relay generates a standard event report, it also generates a corresponding event summary (see *Figure 3.1*). Event summaries contain the following information:

- Event type
- System frequency at the front of the event report
- Front-panel fault type targets at the time of trip
- Phase (VA, VB, VC), Sychronism (VS), calculated zero-sequence ($3V_0$), and negative-sequence (V_2) voltages
- A-phase current

The relay includes the event summary in the standard event report. The identifiers, date, and time information is at the top of the standard event report, and the other information follows at the end. See *Figure 3.5*.

The example event summary in *Figure 3.1* corresponds to the full-length standard 15-cycle event report in *Figure 3.5*.

```
GENERATOR 1                         Date: 01/01/02    Time: 00:00:15.718

STATION A


Event: ER    Frequency: 60.0

Targets: 11000011          Current IA: 540
Voltages VA,VB,VC,VS,V2,3V0: 277  233  277  277   25   74
```

Figure 3.1 Example Event Summary.

The relay sends event summaries to all serial ports with setting AUTO = Y each time an event triggers.

The latest event summaries are stored in nonvolatile memory and are accessed by the **HIS** (Event Summaries/History) command.

Event Type

The Event: field shows the event type. The possible event types and their descriptions are shown in the table below. Note the correspondence to the preceding event report triggering conditions (see *Standard Event Report Triggering on page R.3.3*).

Table 3.2 Event Types

Event Type	Description
ER	SELOGIC control equation setting ER.
TRIG	Execution of **TRI** command.
PULSE	Execution of **PUL** command.

Targets

The Targets: field reports the targets at initiation of the event report. Each target is reported as on or off via a 1 or 0. The targets include: ENABLED, 27, 59, 81, 47, 32, 25, and 25 VOLTAGE HOT.

Current

The Current IA: field shows the A-phase current present in the event report trigger row.

Voltages

The Voltages VA, VB, VC, VS, V2, 3V0: field shows the phase voltages present in the event report trigger row. The listed voltages are:

- Phase (A = channel VA, B = channel VB, C = channel VC)
- Sychronism voltage (VS = channel VS)
- Negative-sequence (V2 = V_2; calculated from channels VA, VB, and VC)
- Zero-sequence (3V0 = $3V_0$; calculated from channels VA, VB, and VC)

Retrieving Full-Length Standard Event Reports

The latest event reports are stored in nonvolatile memory. Each event report includes three sections:

- Current, voltage, frequency, contact outputs, optoisolated inputs, and digital values
- Event summary
- Group, SELOGIC control equations, and global settings

Use the **EVE** command to retrieve the reports. There are several options to customize the report format. The general command format is shown below:

EVE [*n* S*x* L*y* L R A V C

Where

n = Event number (1—number of events stored). Defaults to 1 if not listed, where 1 is the most recent event.
S*x* = Display *x* samples per cycle (4 or 16); defaults to 4 if not listed.
L*y* = Display *y* cycles of data (1—LER). Defaults to LER value if not listed. Unfiltered reports (R parameter) display an extra cycle of data.
L = Display 16 samples per cycle; same as the S16 parameter.
R = Specifies the unfiltered (raw) event report. Defaults to 16 samples per cycle unless overridden with the S*x* parameter.
A = Specifies that only the analog section of the event is displayed (current, voltage, frequency, output contacts, optoisolated inputs).
V = Specifies variable scaling for analog values.
C = Display the report in Compressed ASCII format.

Table 3.3 lists example **EVE** commands.

Table 3.3 Example EVE Commands

Serial Port Command	Description
EVE	Display the most recent event report at 1/4-cycle resolution.
EVE 2	Display the second event report at 1/4-cycle resolution.
EVE S16 L10	Display 10 cycles of the most recent report at 1/16-cycle resolution.
EVE C 2	Display the second report in Compressed ASCII format at 1/16-cycle resolution.
EVE L	Display most recent report at 1/16-cycle resolution.
EVE R	Display most recent report at 1/16-cycle resolution; analog and digital data are unfiltered (raw).
EVE 2 A R S4 V	Display the unfiltered analog section of the second event report at 1/4-cycle resolution, with variable scaling of the analog values.

If an event report is requested that does not exist, the relay responds with the following message:

```
Invalid Event
```

Compressed ASCII Event Reports

The SEL-547 provides compressed ASCII event reports to facilitate event report storage and display. The SEL-2020 Communications Processor and the SEL-5601 Analytic Assistant software take advantage of the compressed ASCII format. Use the **EVE C** command or **CEVENT** command to display compressed ASCII event reports. See the **CEVENT** command discussion in *CEVENT Command (SEL-547) on page R.5.8* for further information.

Filtered and Unfiltered Event Reports

The SEL-547 samples the basic power system measurands (ac voltage, ac current, and optoisolated inputs) 16 times per power system cycle. The relay filters the measurands to remove transient signals. The relay operates on the filtered values and reports them in the event report.

To view the raw inputs to the relay, select the unfiltered event report (e.g., EVE R). Use the unfiltered event reports to observe:

- Power system harmonics on channels IA, VA, VB, VC, VS
- Decaying dc offset during fault conditions on IA
- Optoisolated input contact bounce on channels IN1 through IN3

The filters for ac current and voltage and station battery are fixed. You can adjust the optoisolated input debounce via debounce settings (see *Figure 2.7 on page R.2.12*).

Raw event reports display one extra cycle of data at the beginning of the report.

Clearing Standard Event Report Buffer

The **HIS C** command clears the event summaries and corresponding standard event reports from nonvolatile memory. See *Section 7: ASCII Commands in the Reference Manual* for more information on the **HIS** (Event Summaries/History) command.

Standard Event Report Column Definitions

Refer to the example event report in *Figure 3.5* to view event report columns.

This example event report displays rows of information each 1/4 cycle and was retrieved with the **EVE** command.

The columns contain ac current, ac voltage, frequency, output, input, and protection and control element information.

Current, Voltage, and Frequency Columns

Table 3.4 summarizes the event report current, voltage, and frequency columns.

NOTE: The ac values change from plus (+) to minus (–) values in Figure 3.5, indicating the sinusoidal nature of the waveforms.

Table 3.4 Standard Event Report Current, Voltage, and Frequency Columns

Column Heading	Definition
IA	Current measured by channel IA (primary A)
VA	Voltage measured by channel VA (primary V)
VB	Voltage measured by channel VB (primary V)
VC	Voltage measured by channel VC (primary V)
VS	Voltage measured by channel VS (primary V)
Freq	Frequency of channel VA (or V_1 if V_A is not present) (Hz)

Other figures help in understanding the information available in the event report current columns:

- *Figure 3.6* shows how event report voltage column data relates to the actual sampled voltage waveform and rms voltage values.
- *Figure 3.7* shows how event report voltage column data can be converted to phasor rms voltage values.

Variable Scaling for Analog Values

The following example shows the difference between two cycles of the analog values of an event report without variable scaling (**EVE** command) and with variable scaling (**EVE V** command). Variable scaling event reports display data for currents less than 10 A with two decimal places and data for voltages less than 10 V with one decimal place.

Example without variable scaling (**EVE**):

```
=>>EVE <Enter>
   .
   .
   .
                              InOut 27 59     81  32  25  SELOGIC         Rem
                                             2       5  S Variable
 Amps              Volts      13135 12 12    7135 13 9S1P         1111111 130
   IA    VA    VB    VC    VS Freq 2 24A 34S34SQN B246 24 VF2E 1234567890123456 24C
   .
   .
   .
[5]
  116    60   114 -264    60 60.0 ..b3. .B...... .... .. b*bF .......p........ ...
 -527  -271    21   84  -271 60.0 ..b3. BB...... .... .. b*bF ......pp........ ...
 -116   -60   -16  264   -60 60.0 ..b3. BB...... .... .. b*bF ......pp........ ...
  527   271    -6  -84   271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
[6]
  116    60     7 -264    59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -527  -271     6   84  -271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -116   -60    -7  264   -59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -116   -60    -7  264   -59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
   .
   .
   .
```

Figure 3.2 EVE Command Report (Without Variable Scaling).

Example with variable scaling (**EVE V**):

NOTE: The V option has no effect for compressed event reports (**EVE C**) because the analog values automatically have variable scaling.

```
=>>EVE V <Enter>
   .
   .
   .
                              InOut 27 59     81  32  25  SELOGIC         Rem
                                             2       5  S Variable
 Amps              Volts      13135 12 12    7135 13 9S1P         1111111 130
   IA    VA    VB    VC    VS Freq 2 24A 34S34SQN B246 24 VF2E 1234567890123456 24C
   .
   .
   .
[5]
  116    60   114 -264    60 60.0 ..b3. .B...... .... .. b*bF .......p........ ...
 -527  -271    21   84  -271 60.0 ..b3. BB...... .... .. b*bF ......pp........ ...
 -116   -60   -16  264   -60 60.0 ..b3. BB...... .... .. b*bF ......pp........ ...
  527   271  -6.2  -84   271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
[6]
  116    60   6.7 -264    59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -527  -271   6.1   84  -271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -116   -60  -6.7  264   -59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
  527   271  -6.1  -84   271 60.0 ..b3. BB...... .... .. b*bF ......pp........ ...
   .
   .
   .
```

Figure 3.3 EVE V Command Report (With Variable Scaling).

Output, Input, and Protection, and Control Columns

Table 3.5 summarizes the event report output, input, protection and control columns. See *Appendix A: Relay Word Bits* for more information on the Relay Word bits shown in *Table 3.5*.

Table 3.5 Output, Input, and Protection, and Control Element Event Report Columns (Sheet 1 of 3)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
All columns		.	Element/input/output not picked up or not asserted, unless otherwise stated.
In 12	IN1, IN2	1	Optoisolated input IN1 asserted.
		2	Optoisolated input IN2 asserted.
		b	Both IN1 and IN2 asserted.
In 3	IN3	3	Optoisolated input IN3 asserted.
Out 12	OUT1, OUT2	1	Output contact OUT1 asserted.
		2	Output contact OUT2 asserted.
		b	Both OUT1 and OUT2 asserted.
Out 34	OUT3, OUT4	3	Output contact OUT3 asserted.
		4	Output contact OUT4 asserted.
		b	Both OUT3 and OUT4 asserted.
Out 5A	OUT5, ALARM	5	Output contact OUT5 asserted.
		6	Output contact ALARM asserted.
		b	Both OUT5 and ALARM asserted.
27 13	27A1, 27A3, 27B1, 27B3, 27C1, 27C3	A	A-phase undervoltage element 27A1 or 27A3 picked up.
		B	B-phase undervoltage element 27B1 or 27B3 picked up.
		C	C-phase undervoltage element 27C1 or 27C3 picked up.
		a	27A_ and 27B_ elements picked up.
		b	27B_ and 27C_ elements picked up.
		c	27C_ and 27A_ elements picked up.
		3	27A_, 27B_ and 27C_ elements picked up.
27 24	27A2, 27A4, 27B2, 27B4, 27C2, 27C4	A	A-phase undervoltage element 27A2 or 27A4 picked up.
		B	B-phase undervoltage element 27B2 or 27B4 picked up.
		C	C-phase undervoltage element 27C2 or 27C4 picked up.
		a	27A_ and 27B_ elements picked up.
		b	27B_ and 27C_ elements picked up.
		c	27C_ and 27A_ elements picked up.
		3	27A_, 27B_ and 27C_ elements picked up.
27 S	27S	*	Channel VS instantaneous undervoltage element 27S picked up.
59 13	59A1, 59A3, 59B1, 59B3, 59C1, 59C3	A	A-phase overvoltage element 59A1 or 59A3 picked up.
		B	B-phase overvoltage element 59B1 or 59B3 picked up.
		C	C-phase overvoltage element 59C1 or 59C3 picked up.
		a	59A_ and 59B_ elements picked up.
		b	59B_ and 59C_ elements picked up.
		c	59C_ and 59A_ elements picked up.
		3	59A_, 59B_ and 59C_ elements picked up.
59 24	59A2, 59A4, 59B2, 59B4, 59C2, 59C4	A	A-phase overvoltage element 59A2 or 59A4 picked up.
		B	B-phase overvoltage element 59B2 or 59B4 picked up.
		C	C-phase overvoltage element 59C2 or 59C4 picked up.
		a	59A_ and 59B_ elements picked up.
		b	59B_ and 59C_ elements picked up.
		c	59C_ and 59A_ elements picked up.
		3	59A_, 59B_ and 59C_ elements picked up.

Table 3.5 Output, Input, and Protection, and Control Element Event Report Columns (Sheet 2 of 3)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
59 S	59S1, 59S2	1	Channel VS instantaneous overvoltage element 59S1 picked up.
		2	Channel VS instantaneous overvoltage element 59S2 picked up.
		b	Both 59S1 and 59S2 picked up.
59 Q	59Q1, 59Q2	1	Negative-sequence overvoltage element 59Q1 picked up.
		Q	Negative-sequence overvoltage element 59Q2 picked up.
		b	Both 59Q1 and 59Q2 picked up.
59 N	59N1, 59N2	1	Zero-sequence overvoltage element 59N1 picked up.
		2	Zero-sequence overvoltage element 59N2 picked up.
		b	Both 59N1 and 59N2 picked up.
81 27B	27B81	*	Frequency logic instantaneous undervoltage element 27B81 picked up.
81 12	81D1, 81D2	1	Frequency element 81D1 picked up.
		2	Frequency element 81D2 picked up.
		b	Both 81D1 and 81D2 picked up.
81 34	81D3, 81D4	3	Frequency element 81D3 picked up.
		4	Frequency element 81D4 picked up.
		b	Both 81D3 and 81D4 picked up.
81 56	81D5, 81D6	5	Frequency element 81D5 picked up.
		6	Frequency element 81D6 picked up.
		b	Both 81D5 and 81D6 picked up.
32 12	PWR1, PWR2	1	Level 1 power element PWR1 picked up.
		2	Level 2 power element PWR2 picked up.
		b	Both PWR1 and PWR2 picked up.
32 34	PWR3, PWR4	3	Level 3 power element PWR3 picked up.
		4	Level 4 power element PWR4 picked up.
		b	Both PWR3 and PWR4 picked up.
25 59V	59VP, 59VS	P	Phase voltage window element 59VP picked up (used in synchronism check.)
		S	Channel VS voltage window element 59VS picked up (used in synchronism check.)
		b	Both 59VP and 59VS picked up.
25 SF	SF	*	Slip frequency element SF picked up (used in synchronism check).
25 12	25A1, 25A2	1	Synchronism check element 25A1 picked up.
	2	2	Synchronism check element 25A2 picked up.
	b	b	Both 25A1 and 25A2 picked up.
25 SPE	SFAST, SSLOW	F	Synchronism check frequency element SFAST picked up.
		S	Synchronism check frequency element SSLOW picked up.

Table 3.5 Output, Input, and Protection, and Control Element Event Report Columns (Sheet 3 of 3)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
SELOGIC Var 1	SV1, SV1T	p	SELOGIC control equation variable timer input SV_ asserted; timer timing on pickup time; timer output SV_T not asserted.
SELOGIC Var 2	SV2, SV2T		
SELOGIC Var 3	SV3, SV3T		
SELOGIC Var 4	SV4, SV4T		
SELOGIC Var 5	SV5, SV5T	T	SELOGIC control equation variable timer input SV_ asserted; timer timed out on pickup time; timer output SV_T asserted.
SELOGIC Var 6	SV6, SV6T		
SELOGIC Var 7	SV7, SV7T		
SELOGIC Var 8	SV8, SV8T		
SELOGIC Var 9	SV9, SV9T		
SELOGIC Var 10	SV10, SV10T	d	SELOGIC control equation variable timer input SV_ not asserted; timer previously timed out on pickup time; timer output SV_T remains asserted while timer timing on dropout time.
SELOGIC Var 11	SV11, SV11T		
SELOGIC Var 12	SV12, SV12T		
SELOGIC Var 13	SV13, SV13T		
SELOGIC Var 14	SV14, SV14T		
SELOGIC Var 15	SV15, SV15T		
SELOGIC Var 16	SV16, SV16T		
Rem 12	RB1, RB2	1	Remote bit RB1 asserted.
		2	Remote bit RB2 asserted.
		b	Both RB1 and RB2 asserted.
Rem 34	RB3, RB4	3	Remote bit RB3 asserted.
		4	Remote bit RB4 asserted.
		b	Both RB3 and RB4 asserted.
Rem OC	OC, CC	o	**OPE** (Open) command executed.
		c	**CLO** (Close) command executed.

Sequential Events Recorder (SER) Report

See *Figure 3.8* for an example SER report.

SER Triggering

The relay triggers (generates) an entry in the SER report for a change of state of any one of the elements listed in the SER1, SER2, and SER3 trigger settings. The factory default settings are listed below:

SER1 = SV7T, SV8T, SV9T, SV10T, SV11T, SV12T, SV13T

SER2 = 81D1T, 81D2T, 81D3T, 81D4T, 25A1

SER3 = IN1, IN2, IN3, OUT1, OUT2, OUT3, OUT4, OUT5

The elements are Relay Word bits referenced in *Appendix A: Relay Word Bits*. The relay monitors each element in the SER lists every 1/4 cycle. If an element changes state, the relay time-tags the changes in the SER. For example, setting SER1 contains the following:

SELOGIC variable timers (SV7T through SV13T)

Thus, any time one of these variable timer elements picks up or drops out, the relay time-tags the change in the SER.

The other two SER factory settings (SER2 and SER3) trigger rows in the SER event report for such things as optoisolated input (IN1), output contact (OUT1), and frequency element timers (81D1T).

The relay adds a message to the SER to indicate power up:

```
Relay newly powered up
```

The relay adds a message to the SER to indicate a settings change has been made (to active setting group):

```
Relay settings changed
```

Each entry in the SER includes SER row number, date, time, element name, and element state.

Making SER Trigger Settings

Enter up to 24 element names in each of the SER settings via the **SET R** command. See *Appendix A: Relay Word Bits* for references to valid relay element (Relay Word bit) names. See the **SET R** command in *Section 7: ASCII Commands* and the corresponding settings sheets in *Section 8: Settings*. Use commas to delimit the elements. For example, if you enter setting SER1 as follows:

SER1 = SV7T,SV8T,SV9T,,SV10T , SV11T, , SV12T

The relay displays the setting as follows:

```
SER1 = SV7T,SV8T,SV9T,SV10T,SV11T,SV12T
```

The relay can monitor up to 72 elements in the SER (24 in each of SER1, SER2, and SER3).

Nonvolatile Memory Limitation

The relay triggers a row in the Sequential Events Recorder (SER) event report for any change of state in any one of the elements listed in the SER1, SER2, or SER3 trigger settings. Nonvolatile memory is used to store the latest 512 rows of the SER event report so they can be retained during power loss. The nonvolatile memory is rated for a finite number of writes. Exceeding the limit can result in an EEPROM self-test failure. An average of one state change every three minutes can be made for a 25-year relay service life.

Retrieving SER Reports

The relay saves the latest 512 rows of the SER in nonvolatile memory. Row 1 is the most recently triggered row, and row 512 is the oldest. View the SER report by date or SER row number as outlined in the examples below.

Table 3.6 SER Reports

Example SER Serial Port Commands	Format
SER	If **SER** is entered with no numbers following it, all available rows are displayed (up to row number 512). They display with the oldest row at the beginning (top) of the report and the latest row (Row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 17	If **SER** is entered with a single number following it (17 in this example), the first 17 rows are displayed, if they exist. They display with the oldest row (Row 17) at the beginning (top) of the report and the latest row (Row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 10 33	If **SER** is entered with two numbers following it (10 and 33 in this example; 10 < 33), all the rows between (and including) rows 10 and 33 are displayed, if they exist. They display with the oldest row (Row 33) at the beginning (top) of the report and the latest row (Row 10) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 47 22	If **SER** is entered with two numbers following it (47 and 22 in this example; 47 > 22), all the rows between (and including) rows 47 and 22 are displayed, if they exist. They display with the newest row (Row 22) at the beginning (top) of the report and the oldest row (Row 47) at the end (bottom) of the report. Reverse chronological progression through the report is down the page and in ascending row number.
SER 3/30/97	If **SER** is entered with one date following it (date 3/30/97 in this example), all the rows on that date are displayed, if they exist. They display with the oldest row at the beginning (top) of the report and the latest row at the end (bottom) of the report, for the given date. Chronological progression through the report is down the page and in descending row number.

Table 3.6 SER Reports

Example SER Serial Port Commands	Format
SER 2/17/97 3/23/97	If **SER** is entered with two dates following it (date 2/17/97 chronologically precedes date 3/23/97 in this example), all the rows between (and including) dates 2/17/97 and 3/23/97 are displayed, if they exist. They display with the oldest row (date 2/17/97) at the beginning (top) of the report and the latest row (date 3/23/97) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 3/16/97 1/5/97	If **SER** is entered with two dates following it (date 3/16/97 chronologically follows date 1/5/97 in this example), all the rows between (and including) dates 1/5/97 and 3/16/97 are displayed, if they exist. They display with the latest row (date 3/16/97) at the beginning (top) of the report and the oldest row (date 1/5/97) at the end (bottom) of the report. Reverse chronological progression through the report is down the page and in ascending row number.

The date entries in the above example **SER** commands are dependent on the Date Format setting DATE_F. If setting DATE_F = MDY, then the dates are entered as in the above examples (Month/Day/Year). If setting DATE_F = YMD, then the dates are entered Year/Month/Day.

If the requested SER event report rows do not exist, the relay responds as follows:

```
No SER Data
```

Clearing the SER Report

Clear the SER report from nonvolatile memory with the **SER C** command as shown in *Figure 3.4*:

```
=>SER C <Enter>
Clear the SER
Are you sure (Y/N) ? Y <Enter>
Clearing Complete
```

Figure 3.4 Clearing the SER Report.

Example Standard 15-Cycle Event Report

The following example standard 15-cycle event report in *Figure 3.5* also corresponds to the example sequential events recorder (SER) report in *Figure 3.8*. The callout numbers in *Figure 3.5* correspond to the SER row numbers in *Figure 3.8*. The row explanations follow *Figure 3.8*.

In *Figure 3.5*, the arrow (>) in the column following the Freq column identifies the trigger row. This row corresponds to the Date and Time values at the top of the event report.

```
GENERATOR 1                       Date: 01/01/02    Time: 00:00:15.718

STATION A


FID=SEL-547-R100-V0-Z001001-D20020430       CID=B920

                               InOut 27 59     81  32  25  SELogic          Rem
                                              2       5  S Variable
 Amps               Volts      13135 12 12    7135 13 9S1P          1111111 130

   IA   VA   VB   VC   VS Freq 2 24A 34S34SQN B246 24 VF2E 1234567890123456 24C
[1]
  117   60  204 -264   60 60.0 ..b3. ........ .... .. b*bF ................ ...
 -527 -270  187   83 -271 60.0 ..b3. ........ .... .. b*bF ................ ...
 -117  -60 -204  264  -60 60.0 ..b3. ........ .... .. b*bF ................ ...
  527  270 -187  -83  270 60.0 ..b3. ........ .... .. b*bF ................ ...
[2]
  117   60  204 -264   60 60.0 ..b3. ........ .... .. b*bF ................ ...
 -527 -271  187   83 -271 60.0 ..b3. ........ .... .. b*bF ................ ...
 -117  -60 -204  264  -60 60.0 ..b3. ........ .... .. b*bF ................ ...
  527  271 -187  -83  270 60.0 ..b3. ........ .... .. b*bS ................ ...
[3]
  117   60  204 -264   60 60.0 ..b3. ........ .... .. b*bS ................ ...
 -527 -271  187   83 -270 60.0 ..b3. ........ .... .. b*bS ................ ...
 -117  -60 -204  264  -60 60.0 ..b3. ........ .... .. b*bS ................ ...
  527  271 -187  -83  270 60.0 ..b3. ........ .... .. b*bF ................ ...
[4]
  117   60  204 -264   60 60.0 ..b3. ........ .... .. b*bF ................ ...
 -527 -271  187   83 -271 60.0 ..b3. ........ .... .. b*bF ................ ...
 -116  -60 -204  264  -60 60.0 ..b3. ........ .... .. b*bF ................ ...
  527  271 -111  -84  271 60.0>..b3. .B...... .... .. b*bF .......p........ ...
[5]
  116   60  114 -264   60 60.0 ..b3. .B...... .... .. b*bF .......p........ ...
 -527 -271   21   84 -271 60.0 ..b3. BB...... .... .. b*bF ......pp........ ...
 -116  -60  -16  264  -60 60.0 ..b3. BB...... .... .. b*bF ......pp........ ...
  527  271   -6  -84  271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
[6]
  116   60    7 -264   59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -527 -271    6   84 -271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -116  -60   -7  264  -59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
  527  271   -6  -84  271 60.0 ..b3. BB...... .... .. b*bF ......pp........ ...
[7]
  116   60    7 -264   59 60.0 ..b3. BB...... .... .. b*bF ......pp........ ...
 -527 -271    6   84 -271 60.0 ..b3. BB...... .... .. b*bF ......pp........ ...
 -116  -60   -7  264  -59 60.0 ..b3. BB...... .... .. b*bF ......pp........ ...
  527  271   -6  -84  271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
[8]
  116   59    7 -264   59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -527 -271    6   84 -271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -116  -59   -7  264  -59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
  528  271   -6  -84  271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
[9]
  116   59    7 -264   59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -528 -271    6   84 -271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -116  -59   -7  264  -59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
  527  271   -6  -84  271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
```

see Figure 3.1

firmware identifier

firmware checksum identifier

5

one-cycle of data

6, 7, 8

see Figure 3.6 and Figure 3.7 for details on this example one cycle C-phase (channel VC) voltage

(Continued on next page)

Figure 3.5 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution.

(Continued from previous page)

```
[10]
  116   59    7 -264   59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -527 -271    6   84 -271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -115  -59   -7  264  -59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
  527  271   -6  -84  271 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
[11]
  115   59    7 -264   59 60.0 ..b3. BB...... .... .. b*bS ......pp........ ...
 -527 -271    6   84 -271 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
 -115  -59   -7  264  -59 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
  527  271   -6  -84  271 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
[12]
  115   59    7 -264   59 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
 -528 -271    6   84 -271 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
 -115  -59   -7  264  -59 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
  528  271   -6  -84  271 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
[13]
  115   59    7 -264   59 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
 -528 -271    6   84 -271 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
 -115  -59   -7  264  -59 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
  528  271   -6  -85  271 60.0 ..bb5 BB...... .... .. b*bF ......Tp........ ...
[14]
  115   59    7 -264   59 60.0 ..bb5 BB...... .... .. b*bF ......Tp........ ...
 -528 -271    6   85 -271 60.0 ..bb5 BB...... .... .. b*bF ......Tp........ ...
 -115  -59   -7  264  -59 60.0 ..bb5 BB...... .... .. b*bF ......Tp........ ...
  528  271   -6  -85  271 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
[15]
  115   59    7 -264   59 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
 -528 -271    6   85 -271 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
 -114  -59   -7  264  -59 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...
  528  271   -6  -85  271 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...

Event: ER    Frequency: 60.0
Targets: 11000011          Current IA: 540
Voltages VA,VB,VC,VS,V2,3V0: 277  233  277  277   25   74

EZ Settings:

RELID =GENERATOR 1                     TERMID=STATION A
CRATIO= 120       NOMV  = 480      3PCONN= WYE
FREQ  = 60        ROTATE= ABC      DATE  = MDY      LEDFL = 30
27UV1P= 50        27UV1D= 6.00
27UV2P= 88        27UV2D= 116.00
59OV1P= 110       59OV1D= 56.00
59OV2P= 120       59OV2D= 6.00
27BLKP= 70
81OU1P= 57.0      81OU1D= 6.00
81OU2P= 59.3      81OU2D= 116.00
81OU3P= 60.5      81OU3D= 6.00
81OU4P= OFF
32P   = 60        32FR  = R        32D   = 30.00
25DIFP= 10        25SLP = 0.3      25ANG = 20

Group 1
Group Settings:

RID   =GENERATOR 1                     TID   =STATION A
CTR   = 120
EVOLT = Y         E25   = Y        E81   = 6
ESV   = 16        EPWR  = 4

27P1P = 139       27P2P = 244      27P3P = OFF      27P4P = OFF
59P1P = 305       59P2P = 333      59P3P = OFF      59P4P = OFF
59N1P = OFF       59N2P = OFF      59Q1P = 139      59Q2P = OFF
59V1P = OFF       27SP  = OFF      59S1P = OFF      59S2P = OFF
27B81P= 194       81D1P = 57.0     81D1D = 6.00
81D2P = 59.3      81D2D = 116.00   81D3P = 60.5     81D3D = 6.00
81D4P = OFF       81D5P = OFF
81D6P = OFF
25VLO = 263       25VHI = 291      25SF  = 0.3
25ANG1= 20        25ANG2= 20       SYNCP = VA       TCLOSD= 0.00
PWR1P = 60        PWR1T = -WATTS   PWR1D = 30.00
PWR2P = OFF
PWR3P = OFF
PWR4P = OFF
SV1PU = 0.00      SV1DO = 0.00     SV2PU = 0.00     SV2DO = 0.00
SV3PU = 0.00      SV3DO = 0.00     SV4PU = 0.00     SV4DO = 0.00
SV5PU = 0.00      SV5DO = 0.00     SV6PU = 0.00     SV6DO = 0.00
SV7PU = 6.00      SV7DO = 15.00    SV8PU = 116.00   SV8DO = 15.00
SV9PU = 56.00     SV9DO = 15.00    SV10PU= 6.00     SV10DO= 15.00
SV11PU= 0.00      SV11DO= 15.00    SV12PU= 0.00     SV12DO= 15.00
```

2

see Figure 3.1

(Continued on next page)

Figure 3.5 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (continued).

(Continued from previous page)

```
SV13PU= 30.00    SV13DO= 15.00    SV14PU= 0.00     SV14DO= 0.00
SV15PU= 0.00     SV15DO= 0.00     SV16PU= 0.00     SV16DO= 0.00

SELogic group 1

SELogic Control Equations:
SV1   =0
SV2   =0
SV3   =0
SV4   =0
SV5   =0
SV6   =0
SV7   =27A1 + 27B1 + 27C1
SV8   =27A2 + 27B2 + 27C2
SV9   =59A1 + 59B1 + 59C1
SV10  =59A2 + 59B2 + 59C2
SV11  =81D1T + 81D2T + 81D3T + 81D4T
SV12  =PWR1
SV13  =59Q1
SV14  =0
SV15  =0
SV16  =0
OUT1  =25A1
OUT2  =25A1
OUT3  =25A1
OUT4  =SV7T + SV8T + SV9T + SV10T + SV11T + SV12T
OUT5  =SV7T + SV8T + SV9T + SV10T + SV11T + SV12T
LED2  =CLKPUL + SV7T + SV8T
LED3  =CLKPUL + SV9T + SV10T
LED4  =CLKPUL + SV11T
LED5  =CLKPUL + SV13T
LED6  =CLKPUL + SV12T
LED7  =CLKPUL + 25A1
LED8  =CLKPUL + 59VS + 59VP
SS1   =1
SS2   =0
ER    =27B1 + 27B2
BSYNCH=SV11T
SET1  =0
RST1  =0
SET2  =0
RST2  =0
SET3  =0
RST3  =0
SET4  =0
RST4  =0
SET5  =0
RST5  =0
SET6  =0
RST6  =0
SET7  =0
RST7  =0
SET8  =0
RST8  =0
SET9  =0
RST9  =0
SET10 =0
RST10 =0
SET11 =0
RST11 =0
SET12 =0
RST12 =0
SET13 =0
RST13 =0
SET14 =0
RST14 =0
SET15 =0
RST15 =0
SET16 =0
RST16 =0


Global Settings:
EZSET = Y
PCONN = WYE      TGR   = 0.00
NFREQ = 60       PHROT = ABC      DATE_F= MDY
LER   = 15       PRE   = 4        INTRVL= 30


PARTNO=0547OXXXXXXXXXX

=>>
```

Figure 3.5 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (continued).

Figure 3.6 and *Figure 3.7* look in detail at 1 cycle of C-phase voltage (channel VC) identified in *Figure 3.5*. *Figure 3.6* shows how the event report ac voltage column data relates to the actual sampled waveform and rms values. *Figure 3.7* shows how the event report voltage column data can be converted to phasor rms values. Current is processed similarly.

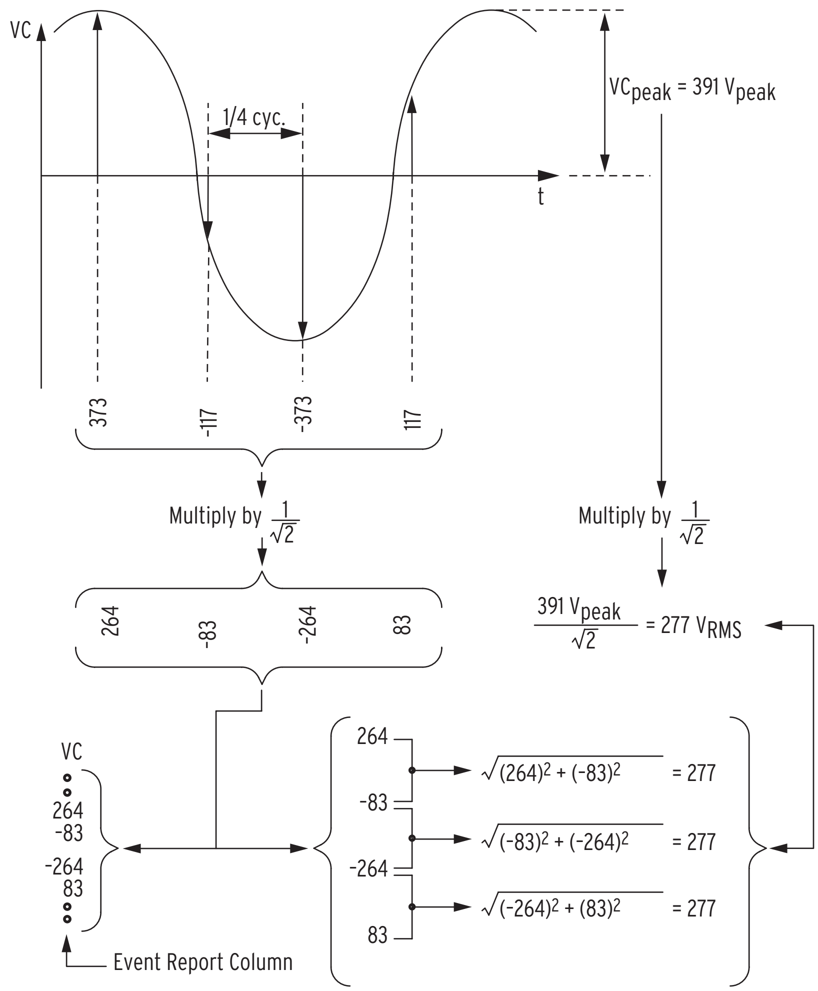

Figure 3.6 Derivation of Event Report Voltage Values and RMS Voltage Values From Sampled Voltage Waveform.

In *Figure 3.6*, note that any two rows of voltage data from the event report in *Figure 3.5*, 1/4 cycle apart, can be used to calculate rms voltage values.

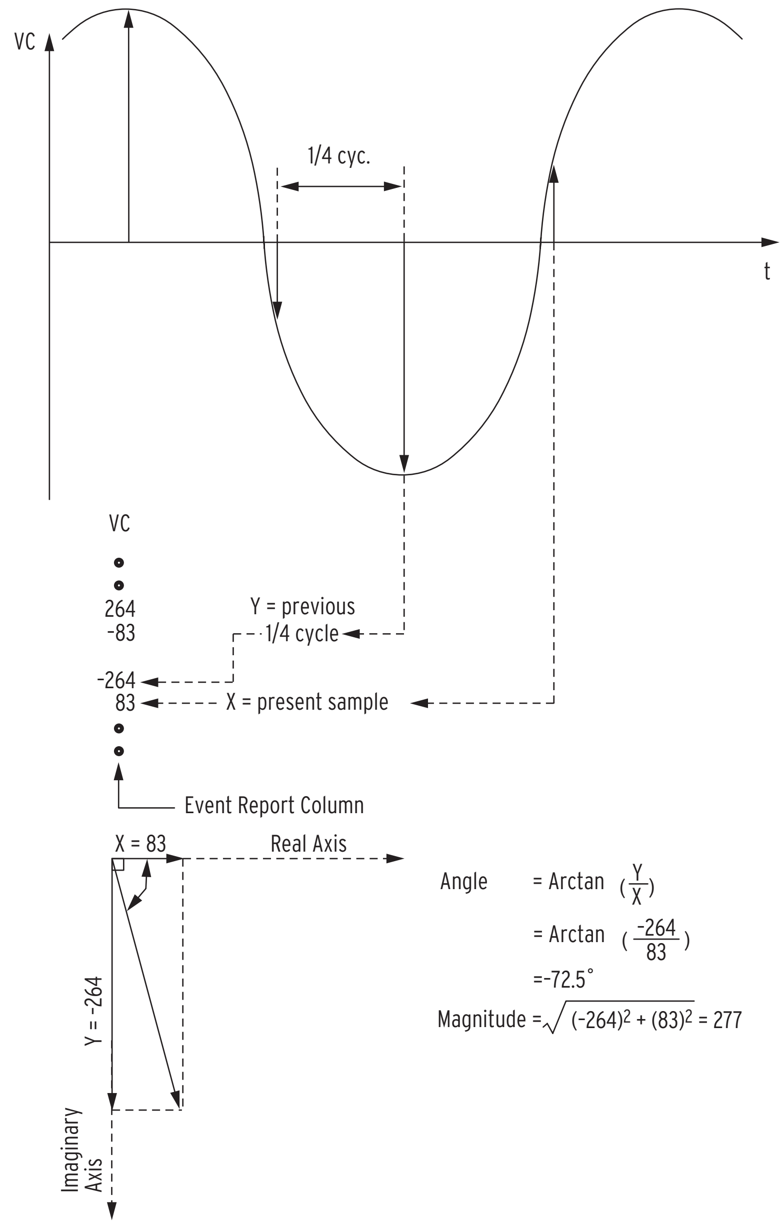

Figure 3.7 Derivation of Phasor RMS Voltage Values From Event Report Voltage Values.

In *Figure 3.7*, note that two rows of voltage data from the event report in *Figure 3.5*, 1/4 cycle apart, can be used to calculate phasor rms voltage values. In *Figure 3.7*, at the present sample, the phasor rms voltage value is:

$$VC = 277\ V\ \angle{-72.5°}$$

The present sample (VC = 83 V) is a real rms voltage value that relates to the phasor rms voltage value:

$$277\ V * \cos(-72.5°) = 83\ V$$

Example Sequential Events Recorder (SER) Report

The following example sequential events recorder (SER) report in *Figure 3.8* also corresponds to the example standard 15-cycle event report in *Figure 3.5*.

```
GENERATOR 1                        Date: 01/01/02    Time: 00:01:34.781
STATION A

FID=SEL-547-R100-V0-Z001001-D20020430       CID=B920

#     Date      Time           Element            State

9     01/01/02  00:00:01.270    Relay newly powered up
8     01/01/02  00:00:01.354   OUT1               Asserted
7     01/01/02  00:00:01.354   OUT2               Asserted
6     01/01/02  00:00:01.354   OUT3               Asserted
5     01/01/02  00:00:01.354   25A1               Asserted
4     01/01/02  00:00:15.826   OUT4               Asserted
3     01/01/02  00:00:15.826   OUT5               Asserted
2     01/01/02  00:00:15.826   SV7T               Asserted
1     01/01/02  00:00:17.651   SV8T               Asserted
```

Figure 3.8 Example Sequential Events Recorder (SER) Event Report.

The SER event report rows in *Figure 3.8* are explained in the following text, numbered in correspondence to the # column in *Figure 3.8*. The boxed, numbered comments in *Figure 3.5* also correspond to the # column numbers in *Figure 3.8*. The SER event report in *Figure 3.8* contains records of events that occurred before and after the standard event report in *Figure 3.5*.

Table 3.7 SER Report Explanations

SER Row No.	Explanation
9	Relay newly powered up.
8, 7, 6, 5	OUT1, OUT2, OUT3, and 25A1 assert, indicating valid synchronism check (e.g., VA and VS are both within healthy voltage range, maximum angle difference, and maximum slip frequency settings). Related settings: OUT1 = 25A1 OUT2 = 25A1 OUT3 = 25A1
4, 3, 2	OUT4, OUT5, AND SV7T assert, indicating undervoltage element pickup with 6-cycle delay. Related settings: OUT4 = SV7T OUT5 = SV7T SV7 = 27A1 + 27B1 + 27C1 SV7PU = 6.00
1	SV8T asserts 1.825 seconds later (e.g., 110 cycles), indicating undervoltage element pickup with 116-cycle delay. Related settings: SV8 = 27A1 + 27B1 + 27C1 SV8PU = 116.00

Section 4
Communications

This section provides information on communications interface options for the SEL-547 Relay. The following are topics are discussed:

- EIA-232 Serial Communications
- EIA-485 Serial Communications
- Fiber-Optic Serial Communications
- Communications Card

Serial Communications Ports

Two Ports

The SEL-547 has two serial communications ports:

- Port F (EIA-232)—located on the front panel
- Port 1 (EIA-485)—located on the top-side panel

From the factory, these ports are set up for:

- Port F (EIA-232)—SEL ASCII protocol
- Port 1 (EIA-485)—Modbus® protocol

SEL ASCII protocol allows you to communicate with the SEL-547 by entering the commands listed in *Section 7: ASCII Commands*. For more information on Modbus protocol, see *Section 6: Modbus RTU Communications.*

Serial Port Hardware and Serial Communications Cables

Figure 4.1 and *Table 4.1* provide pinout information for Port F (EIA-232). *Figure 2.2 on page U.2.3 in the User's Guide* and *Table 4.2* provide terminal information for Port 1 (EIA-485).

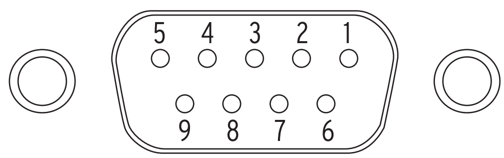

Figure 4.1 DB-9 Connector Pinout for Port F (EIA-232; female connector)

Table 4.1 Pinout Functions for Port F (EIA-232)

Pin	Function
1	N/C
2	RXD
3	TXD
4	N/C
5, 9	GND
6	N/C
7	RTS
8	CTS

Table 4.2 Terminal Functions for Port 1 (EIA-485)

Terminal	Function
1	+TX
2	–TX
3	+RX
4	–RX
5	SHIELD

Figure 4.2 and *Figure 4.3* are schematics of popular SEL-manufactured cables that connect from Port F (EIA-232) to a computer (or other DTE [Data Terminal Equipment]). The male/female references in the cable diagrams refer to the cable connector, not the device/port they are connecting to (which would be the opposite gender).

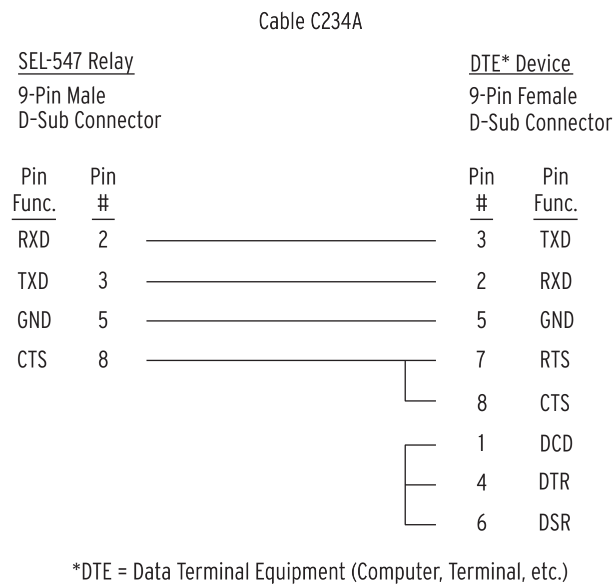

Figure 4.2 SEL Cable C234A
SEL-547 to Computer/9-pin connector

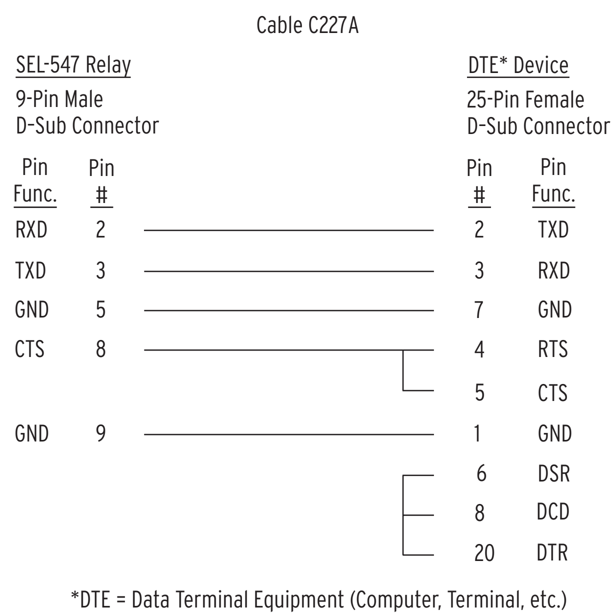

Figure 4.3 SEL Cable C227A
SEL-547 to Computer/25-pin connector

Table 4.3 provides definitions of all the pins/terminals listed in *Table 4.1* and *Table 4.2*. At the end of *Table 4.3*, definitions are also given for the additional pins on the DTE devices used in communications, as shown in the bottom parts of *Figure 4.2* and *Figure 4.3*.

Table 4.3 Serial Communications Port Pin/Terminal Function Definitions

Pin Function	Definition
N/C	No Connection
RXD, RX	Receive Data
TXD, TX	Transmit Data
GND	Ground
SHEILD	Shielded Ground
RTS	Request to Send
CTS	Clear to Send
DCD	Data Carrier Detect
DTR	Data Terminal Ready
DSR	Data Set Ready

For connecting devices at distances over 100 feet or for electrical isolation, SEL offers fiber-optic transceivers. The SEL-2800 family of transceivers provides fiber-optic links between devices for electrical isolation and long distance signal transmission. Contact SEL for further information on these products.

Section 5

SEL Communications Protocols

This section describes the SEL communications protocols available in the SEL-547 Relay. The following types of protocols are discussed:

- Hardware protocol
- Software protocols
  - SEL ASCII protocol
  - SEL Compressed ASCII protocol
  - SEL Distributed Port Switch protocol
  - SEL Fast Meter protocol
  - SEL Fast Operate protocol

Hardware Protocol

All EIA-232 serial ports support RTS/CTS hardware handshaking. RTS/CTS handshaking is not supported on the EIA-485 Serial Port 1.

To enable hardware handshaking, use the **SET P** command to set RTSCTS = Y. Disable hardware handshaking by setting RTSCTS = N.

If RTSCTS = N, the relay permanently asserts the RTS line.

If RTSCTS = Y, the relay deasserts RTS when it is unable to receive characters.

If RTSCTS = Y, the relay does not send characters until the CTS input is asserted.

Software Protocols

The SEL-547 provides standard SEL protocols: SEL ASCII, SEL Compressed ASCII, SEL Distributed Port Switch Protocol (LMD), SEL Fast Meter, and SEL Fast Operate. The relay activates protocols on a per-port basis.

To select SEL ASCII protocol, set the port PROTO setting to SEL.

To select SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD.

SEL Fast Meter, SEL Fast Operate, and SEL Compressed ASCII commands are active when PROTO is set to either SEL or LMD.

SEL ASCII Protocol

SEL ASCII protocol is designed for manual and automatic communications.

1. All commands received by the relay must be of the form:

   <command><CR> or **<command><CRLF>**

   A command transmitted to the relay should consist of the command followed by either a **<CR>** (carriage return) or a **<CRLF>** (carriage return and line feed). You may truncate commands to the first three characters. For example, **EVENT 1 <CR>** would become **EVE 1 <CR>**. Upper and lower case characters may be used without distinction, except in passwords.

NOTE: The **<Enter>** key on most keyboards is configured to send the ASCII character 13 (^M) for a carriage return. This manual instructs you to press the **<Enter>** key after commands, which should send the proper ASCII code to the relay.

2. The relay transmits all messages in the following format:

```
<STX><MESSAGE LINE 1><CRLF>
<MESSAGE LINE 2><CRLF>
.
.
.
<LAST MESSAGE LINE><CRLF>< ETX>
```

Figure 5.1 SEL ASCII Protocol Transmission Format.

   Each message begins with the start-of-transmission character (ASCII 02) and ends with the end-of-transmission character (ASCII 03). Each line of the message ends with a carriage return and line feed.

3. The relay implements XON/XOFF flow control.

   The relay transmits XON (ASCII hex 11) and asserts the RTS output (if hardware handshaking enabled) when the relay input buffer drops below 25 percent full.

   The relay transmits XOFF (ASCII hex 13) when the buffer is over 75 percent full. If hardware handshaking is enabled, the relay deasserts the RTS output when the buffer is approximately 95 percent full. Automatic transmission sources should monitor for the XOFF character so they do not overwrite the buffer. Transmission should terminate at the end of the message in progress when XOFF is received and may resume when the relay sends XON.

4. You can use the XON/XOFF protocol to control the relay during data transmission.

   When the relay receives XOFF during transmission, it pauses until it receives an XON character. If there is no message in progress when the relay receives XOFF, it blocks transmission of any message presented to its buffer. Messages will be accepted after the relay receives XON.

   The CAN character (ASCII hex 18) aborts a pending transmission. This is useful in terminating an unwanted transmission.

   Control characters can be sent from most keyboards with the following keystrokes:

   XON: **<Ctrl+Q>**
   (hold down the Control key and press Q)

   XOFF: **<Ctrl+S>**
   (hold down the Control key and press S)

   CAN: **<Ctrl+X>**
   (hold down the Control key and press X)

SEL Compressed ASCII Protocol

The SEL-547 provides compressed ASCII versions of some of the relay ASCII commands. The compressed ASCII commands allow an external device to obtain data from the relay, in a format which directly imports into spreadsheet or database programs, and which can be validated with a checksum.

The SEL-547 provides the following compressed ASCII commands (see *Table 5.1*):

Table 5.1 Compressed ASCII Commands

Command	Description
CASCII	Configuration message
CSTATUS	Status message
CHISTORY	History message
CEVENT	Event message

CASCII Command (General Format)

The compressed ASCII configuration message provides data for an external computer to extract data from other compressed ASCII commands. To obtain the configuration message for the compressed ASCII commands available in an SEL relay, type the following:

```
CAS <CR>
```

The relay sends the following:

```
<STX>"CAS",n,"yyyy"<CR><LF>
"COMMAND 1",ll,"yyyy"<CR><LF>
"#H","xxxxx","xxxxx",......,"xxxxx","yyyy"<CR><LF>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR><LF>
"COMMAND 2",ll,"yyyy"<CR><LF>
"#h","ddd","ddd",......,"ddd","yyyy"<CR><LF>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR><LF>
.
.
.
"COMMAND n",ll,"yyyy"<CR><LF>
"#H","xxxxx","xxxxx",......,"xxxxx","yyyy"<CR><LF>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR><LF><ETX>
```

Where

n	is the number of compressed ASCII command descriptions to follow.
COMMAND	is the ASCII name for the compressed ASCII command as sent by the requesting device. The naming convention for the compressed ASCII commands is a 'C' preceding the typical command. For example, **CSTATUS** (abbreviated to CST) is the compressed **STATUS** command.
ll	is the minimum access level at which the command is available.
#H	is a header line to precede one or more data lines; '#' is the number of subsequent ASCII names. For example, 21H identifies a header line with 21 ASCII labels.
#h	is a header line to precede one or more data lines; '#' is the number of subsequent format fields. For example, '8h' identifies a header line with 8 format fields.
xxxxx	is an ASCII name for corresponding data on following data lines. Maximum ASCII name width is 10 characters.
#D	is a data format line; '#' is the maximum number of subsequent data lines.
ddd	is a format field containing one of the following type designators: I = Integer data F = Floating point data *m*S = String of maximum *m* characters (e.g., 10S for a 10-character string)
yyyy	is the 4-byte hex ASCII representation of the checksum.

A compressed ASCII command may require multiple header and data configuration lines.

If a compressed ASCII request is made for data that are not available, (e.g. the history buffer is empty or invalid event request), the relay responds with the following message:

```
<STX>"No Data Available","yyyy"<CR><LF><ETX>
```

CASCII Command (SEL-547)

Display the SEL-547 compressed ASCII configuration message by sending the following:

```
CAS <CR>
```

The relay sends the following:

```
<STX>
"CAS",5,"yyyy"<CR><LF>
"CST",1,"yyyy"<CR><LF>
"1H","FID","yyyy"<CR><LF>
"1D","45S","yyyy"<CR><LF>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR><LF>
"1D","I","I","I","I","I","I","I","yyyy"<CR><LF>
"13H","IA","VA","VB","VC","VS","IA8","MOF","FREQ","RAM","ROM","A/D","CR_RAM",
"EEPROM","yyyy"<CR><LF>
"1D","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S",
"9S","9S","9S","9S","9S","9S","9S","9S","yyyy"<CR><LF>
"CHI",1,"yyyy"<CR><LF>
"1H","FID","yyyy"<CR><LF>
"1D","45S","yyyy"<CR><LF>
"17H","REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC",
"EVENT","LOCATION","CURR","VA","VB","VC","VS","FREQ","GROUP","TARGETS",
"yyyy"<CR><LF>
"8D","I","I","I","I","I","I","I","I","6S","F","F","F","F","F","F","I","8S","yyyy"<CR
    ><LF>
"CEV",1,"yyyy"<CR><LF>
"1H","FID","yyyy"<CR><LF>
"1D","45S","yyyy"<CR><LF>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR><LF>
"1D","I","I","I","I","I","I","I","yyyy"<CR><LF>
"13H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT",
"TARGETS","IA","VA","VB","VC","VS","V2","3V0","yyyy"<CR><LF>
"1D","F","I","I","I","6S","8S","I","I","I","I","I","I","I","yyyy"<CR><LF>
"8H","IA","VA","VB","VC","VS","FREQ","TRIG","Names of elements in the relay word Rows 0–19 separated by
    spaces","yyyy"<CR><LF>
"60D","F","F","F","F","F","F","2S","40S","yyyy"<CR><LF>
"CEV C",1,"yyyy"<CR><LF>
"1H","FID","yyyy"<CR><LF>
"1D","45S","yyyy"<CR><LF>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR><LF>
"1D","I","I","I","I","I","I","I","yyyy"<CR><LF>
"13H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT",
"TARGETS","IA","VA","VB","VC","VS","V2","3V0","yyyy"<CR><LF>
"1D","F","I","I","I","6S","8S","I","I","I","I","I","I","I","yyyy"<CR><LF>
"8H","IA","VA","VB","VC","VS","FREQ","TRIG","Names of elements in the relay word Rows 0–19 separated by
    spaces ","yyyy"<CR><LF>
"240D","F","F","F","F","F","F","2S","40S","yyyy"<CR><LF>
"CEV R",1,"yyyy"<CR><LF>
"1H","FID","yyyy"<CR><LF>
"1D","45S","yyyy"<CR><LF>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR><LF>
"1D","I","I","I","I","I","I","I","yyyy"<CR><LF>
"13H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT",
"TARGETS","IA","VA","VB","VC","VS","V2","3V0","yyyy"<CR><LF>
"1D","F","I","I","I","6S","8S","I","I","I","I","I","I","I","yyyy"<CR><LF>
"8H","IA","VA","VB","VC","VS","FREQ","TRIG","Names of elements in the relay word Rows 0–19 separated by
    spaces ","yyyy"<CR><LF>
"256D","F","F","F","F","F","F","2S","40S","yyyy"<CR><LF>
<ETX>
```

Where

yyyy is the 4-byte hex ASCII representation of the checksum.

See the CEVENT command for definition of the **Names of elements in the relay word Rows 0–19 separated by spaces** field.

CSTATUS Command (SEL-547)

Display status data in compressed ASCII format by sending the following:

```
CST <CR>
```

The relay sends the following:

```
<STX>"FID","yyyy"<CR><LF>
"Relay FID string","yyyy"<CR><LF>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR><LF>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR><LF>
"IA","VA","VB","VC","VS","IA8","MOF","FREQ","RAM","ROM","A/D","CR_RAM","EEPROM","yyy
    y"<CR><LF>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR><LF><ETX>
```

Where

xxxx are the data values corresponding to the first line labels.
yyyy is the 4-byte hex ASCII representation of the checksum.

CHISTORY Command (SEL-547)

Display history data in compressed ASCII format by sending the following:

```
CHI <CR>
```

The relay sends the following:

```
<STX>"FID","yyyy"<CR><LF>
"Relay FID string","yyyy"<CR><LF>
    "REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC",
"EVENT","CURR","VA","VB","VC","VS","FREQ","GROUP","TARGETS",
"yyyy"<CR><LF>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,
xxxx,xxxx,xxxx,xxxx, xxxx, xxxx,"xxxx","yyyy"<CR><LF><ETX>

(the last line is then repeated for each record)
```

Where

xxxx are the data values corresponding to the first line labels
yyyy is the 4-byte hex ASCII representation of the checksum.

If the history buffer is empty, the relay responds as follows:

```
<STX>"No Data Available","yyyy"<CR><LF><ETX>
```

CEVENT Command (SEL-547)

Display event report in compressed ASCII format by sending the following:

```
CEV [n Sx Ly L R C]   (parameters in [ ] are optional)
```

Where

n is the event number (1–8) if LER = 15, (1–4) if LER = 30, (1–2) if LER = 60, defaults to 1.

S*x* is *x* samples per cycle (4 or 16); defaults to 4. If S*x* parameter is present, it overrides the L parameter.

L*y* *y* cycles event report length (1–LER) for filtered event reports, (1–LER+1) for raw event reports, defaults to 15 if not specified.

L 16 samples per cycle; overridden by the S*x* parameter, if present.

R specifies raw (unfiltered) data; defaults to 16 samples per cycle unless overridden by the S*x* parameter. Defaults to 16 cycles in length unless overridden with the L*y* parameter.

C specifies 16 samples per cycle, 15-cycle length.

The relay responds to the **CEV** command with the *n*th event report as shown below. Items in **bold** will be replaced with the actual relay data.

```
<STX>"FID","yyyy"<CR><LF>
"Relay FID string","yyyy"<CR><LF>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR><LF>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR><LF>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT",
"TARGETS","IA","VA","VB","VC","VS","V2","3V0","yyyy"<CR><LF>
xxxx,xxxx,xxxx,xxxx,"xxxx","xxxx",xxxx,xxxx,xxxx,xxxx,xxxx,xxxx, xxxx,"yyyy"<CR><LF>
"IA","VA","VB","VC","VS","FREQ","TRIG","Names of elements in the Relay Word separated by
     spaces","yyyy"<CR><LF>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,z,"HEX-ASCII Relay Word","yyyy"<CR><LF>
Analog and digital data repeated for each row of the event report
"SETTINGS","yyyy"<CR><LF>
"Relay group, logic, and global settings as displayed with the showset command (surrounded by
     quotes)","yyyy"<CR><LF><ETX>
```

Where

xxxx	are the data values corresponding to the line labels.
yyyy	is the 4-byte hex ASCII representation of the checksum.
FREQ	is the power system frequency at the trigger instant.
SAM/CYC_A	is the number of analog data samples per cycle (4 or 16).
SAM/CYC_D	is the number of digital data samples per cycle (4 or 16).
NUM_OF_CYC	is the number of cycles of data in the event report.
EVENT	is the event type.
TARGETS	are the front-panel tripping targets.
IA, VA, VB, VC, VS, V2, and 3V0	are the current and voltages.
TRIG	refers to the trigger record.
z	is > for the trigger row and empty for all others. HEX-ASCII Relay Word is the hex ASCII format of the relay word. The first element in the relay word is the most significant bit in the first character.

If samples per cycle are specified as 16, the analog data are displayed at 1/16-cycle intervals and digital data at 1/4-cycle intervals. The digital data are displayed as a series of hex ASCII characters. The relay displays digital data only when they are available. When no data are available, the relay sends only the comma delimiter in the digital data field.

If the specified event does not exist, the relay responds as follows:

```
<STX>"No Data Available","yyyy"<CR><LF><ETX>
```

The **Names of elements in the Relay Word separated by spaces** field is shown below for the SEL-547.

```
"LED1 LED2 LED3 LED4 LED5 LED6 LED7 LED8 * * * * * IN3 IN2 IN1 ALARM * * OUT5 OUT4 OUT3
OUT2 OUT1 27A1 27B1 27C1 27A2 27B2 27C2 27A3 27B3 27C3 27A4 27B4 27C4 59A1 59B1 59C1
59A2 59B2 59C2 59A3 59B3 59C3 59A4 59B4 59C4 59N1 59N2 59Q1 59Q2 59V1 27S 59S1 59S2
59VA 59VP 59VS SF 25A1 25A2 SFAST SSLOW 81D1 81D2 81D3 81D4 81D5 81D6 27B81 * 81D1T
81D2T 81D3T 81D4T 81D5T 81D6T * * PWR1 PWR2 PWR3 PWR4 * * * * SV1 SV2 SV3 SV4 SV1T SV2T
SV3T SV4T SV5 SV6 SV7 SV8 SV5T SV6T SV7T SV8T SV9 SV10 SV11 SV12 SV9T SV10T SV11T
SV12T SV13 SV14 SV15 SV16 SV13T SV14T SV15T SV16T LT1 LT2 LT3 LT4 LT5 LT6 LT7 LT8 LT9
LT10 LT11 LT12 LT13 LT14 LT15 LT16 RB1 RB2 RB3 RB4 RB5 RB6 RB7 RB8 RB9 RB10 RB11 RB12
RB13 RB14 RB15 RB16 SG1 SG2 DELTA OC CC CLKPUL * IAMET"
```

These names are listed in the *Appendix A: Relay Word Bits*.

A typical **HEX-ASCII Relay Word** is shown below:

C00018FC000000000200000033000000000000081

Each bit in the **HEX-ASCII Relay Word** reflects the status of a Relay Word bit. The order of the labels in the **Names of elements in the relay word separated by spaces** field matches the order of the **HEX-ASCII Relay Word**. In the example above, the first two bytes in the **HEX-ASCII Relay Word** are C0. In binary, this evaluates to 11000000. Mapping the labels to the bits yields:

Labels	LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
Bits	1	1	0	0	0	0	0	0

In this example, the LED1 and LED2 elements are asserted (logical 1); all others are deasserted (logical 0).

SEL Distributed Port Switch Protocol (LMD)

The SEL Distributed Port Switch Protocol (LMD) permits multiple SEL relays to share a common communications channel. It is appropriate for low-cost, low-speed port switching applications where updating a real-time database is not a requirement. The protocol is selected by setting the port setting PROTO = LMD.

SEL Distributed Port Switch Protocol (LMD) permits multiple SEL relays to share a common communications channel.

Settings

Use the serial port **SET P** command to activate the LMD protocol. Change the port PROTO setting from the default SEL to LMD to reveal the following settings:

PREFIX. One character to precede the address. This should be a character that does not occur in the course of other communications with the relay. Valid choices are one of the following: @, #, $, %, &. The default is @.

ADDR. Two-character ASCII address. The range is 01 to 99. The default is 01.

SETTLE. Time in seconds that transmission is delayed after the request to send (RTS line) asserts. This delay accommodates transmitters with a slow rise time.

Operation

Step 1. The relay ignores all input from this port until it detects the prefix character and the two-byte address.

Step 2. Upon receipt of the prefix and address, the relay enables echo and message transmission.

Step 3. Wait until you receive a prompt before entering commands to avoid losing echoed characters while the external transmitter is warming up.

Step 4. Until the relay connection terminates, you can use the standard commands that are available when PROTO is set to SEL.

Step 5. The **QUIT** command terminates the connection. If no data are sent to the relay before the port timeup period, it automatically terminates the connection.

Enter the sequence **<Ctrl+X> QUIT <Enter>** before entering the prefix character if all relays in the multidrop network do not have the same prefix setting.

SEL Fast Meter Protocol

SEL Fast Meter protocol supports binary messages to transfer metering and control messages.

SEL relays have two separate data streams that share the same serial port. The human data communications with the relay consist of ASCII character commands and reports that are intelligible to humans using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to exploit this feature. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

SEL Application Guide AG95-10, *Configuration and Fast Meter Messages*, is a comprehensive description of the SEL binary messages. Below is a description of the messages provided in the SEL-547.

Message Lists

Table 5.2 Binary Message List

Request to Relay (hex)	Response From Relay
A5C0	Relay Definition Block
A5C1	Fast Meter Configuration Block
A5D1	Fast Meter Data Block
A5B9	Fast Meter Status Acknowledge

Table 5.3 ASCII Configuration Message List

Request to Relay (ASCII)	Response From Relay
DNA	ASCII Names of Relay Word bits
BNA	ASCII Names of bits in the A5B9 Status Byte

Message Definitions

A5C0 Relay Definition Block

In response to the A5C0 request, the relay sends the following block:

Table 5.4 A5C0 Relay Definition Block

Data	Description
A5C0	Command
18	Message length
02	Support two protocols: SEL and LMD
01	Support Fast Meter
01	Status flag for Settings change
A5C1	Fast Meter configuration
A5D1	Fast Meter message
0004	Settings change bit
A5C100000000	Reconfigure Fast Meter on settings change
0100	SEL protocol with Fast Operate
0101	LMD protocol with Fast Operate
00	Reserved
xx	Checksum

A5C1 Fast Meter Configuration Block

In response to the A5C1 request, the relay sends the following block:

Table 5.5 A5C1 Fast Meter Configuration Block (Sheet 1 of 2)

Data	Description
A5C1	Fast Meter command
6A	Length
01	One status flag byte
00	Scale factors in Fast Meter message
00	# of scale factors
06	# of analog input channels
02	# of samples per channel
14	# of digital banks
02	Two calculation blocks
0004	Analog channel offset
0034	Time stamp offset
003C	Digital offset
494100000000	Analog channel name (IA)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564100000000	Analog channel name (VA)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564200000000	Analog channel name (VB)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564300000000	Analog channel name (VC)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
565300000000	Analog channel name (VS)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
465245510000	Analog channel name (FREQ)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
0x	Line Configuration (00-ABC wye, 01-ACB wye)
0x	Calculation Block (02-Voltages only, 04-Single phase IA and VA)

Table 5.5 A5C1 Fast Meter Configuration Block (Sheet 2 of 2)

Data	Description
FFFF	No Deskew angle
FFFF	No Rs compensation (–1)
FFFF	No Xs compensation (–1)
xx	IA channel index (FF if Voltages only, 00 if Single phase IA and VA)
FF	IB channel index (not present)
FF	IC channel index (not present)
01	VA channel index
xx	VB channel index (02 if Voltages only, FF if Single phase IA and VA)
xx	VC channel index (03 if Voltages only, FF if Single phase IA and VA)
00	Reserved
checksum	1-byte checksum of all preceding bytes

A5D1 Fast Meter Data Block

In response to the A5D1 request, the relay sends the following block:

Table 5.6 A5D1 Fast Meter Data Block

Data	Description
A5D1	Command code
1 byte	Length
1 byte	1 Status Byte
48 bytes	X and Y components of: IA, VA, VB, VC, VS, and Freq in 4-byte IEEE FPS
8 bytes	Time stamp
20 bytes	20 Digital banks: TAR0–TAR19
1 byte	Reserved
checksum	1-byte checksum of all preceding bytes

A5B9 Fast Meter Status Acknowledge Message

In response to the A5B9 request, the relay clears the Fast Meter (message A5D1) Status Byte. The SEL-547 Status Byte contains one active bit, STSET (bit 4). The bit is set on power up and on settings changes. If the STSET bit is set, the external device should request the A5C1, A5C2, and A5C3 messages. The external device can then determine if the scale factors or line configuration parameters have been modified.

SEL Fast Operate Protocol

Message Definition

A5CE Fast Operate Configuration Block

In response to the A5CE request, the relay sends the following block:

Table 5.7 A5CE Fast Operate Configuration Block (Sheet 1 of 2)

Data	Description
A5CE	Command
3C	Length
01	Support 1 circuit breaker
0010	Support 16 remote bit set/clear commands
0100	Allow remote bit pulse commands
31	Operate code, open breaker 1
11	Operate code, close breaker 1
00	Operate code, clear remote bit RB1
20	Operate code, set remote bit RB1
40	Operate code, pulse remote bit RB1
01	Operate code, clear remote bit RB2
21	Operate code, set remote bit RB2
41	Operate code, pulse remote bit RB2
02	Operate code, clear remote bit RB3
22	Operate code, set remote bit RB3
42	Operate code, pulse remote bit RB3
03	Operate code, clear remote bit RB4
23	Operate code, set remote bit RB4
43	Operate code, pulse remote bit RB4
04	Operate code, clear remote bit RB5
24	Operate code, set remote bit RB5
44	Operate code, pulse remote bit RB5
05	Operate code, clear remote bit RB6
25	Operate code, set remote bit RB6
45	Operate code, pulse remote bit RB6
06	Operate code, clear remote bit RB7
26	Operate code, set remote bit RB7
46	Operate code, pulse remote bit RB7
07	Operate code, clear remote bit RB8
27	Operate code, set remote bit RB8
47	Operate code, pulse remote bit RB8
08	Operate code, clear remote bit RB9
28	Operate code, set remote bit RB9
48	Operate code, pulse remote bit RB9

Table 5.7 A5CE Fast Operate Configuration Block (Sheet 2 of 2)

Data	Description
09	Operate code, clear remote bit RB10
29	Operate code, set remote bit RB10
49	Operate code, pulse remote bit RB10
0A	Operate code, clear remote bit RB11
2A	Operate code, set remote bit RB11
4A	Operate code, pulse remote bit RB11
0B	Operate code, clear remote bit RB12
2B	Operate code, set remote bit RB12
4B	Operate code, pulse remote bit RB12
0C	Operate code, clear remote bit RB13
2C	Operate code, set remote bit RB13
4C	Operate code, pulse remote bit RB13
0D	Operate code, clear remote bit RB14
2D	Operate code, set remote bit RB14
4D	Operate code, pulse remote bit RB14
0E	Operate code, clear remote bit RB15
2E	Operate code, set remote bit RB15
4E	Operate code, pulse remote bit RB15
0F	Operate code, clear remote bit RB16
2F	Operate code, set remote bit RB16
4F	Operate code, pulse remote bit RB16
00	Reserved
checksum	1-byte checksum of all preceding bytes

A5E0 Fast Operate Remote Bit Control

The external device sends the following message to perform a remote bit operation:

Table 5.8 A5E0 Fast Operate Remote Bit Control

Data	Description
A5E0	Command
06	Length
1 byte	Operate code: 00–0F clear remote bit RB1–RB16 20–2F set remote bit RB1–RB16 40–4F pulse remote bit for RB1–RB16 for one processing interval
1 byte	Operate validation: 4 • Operate code + 1
checksum	1-byte checksum of preceding bytes

The relay performs the specified remote bit operation if the following conditions are true:

1. The Operate code is valid.
2. The Operate validation = 4 • Operate code + 1.
3. The message checksum is valid.
4. The FASTOP port setting is set to Y.
5. The relay is enabled.

Remote bit set and clear operations are latched by the relay. Remote bit pulse operations assert the remote bit for one processing interval (1/4 cycle).

It is common practice to route remote bits to output contacts to provide remote control of the relay outputs. If you wish to pulse an output contact closed for a specific duration, SEL recommends using the remote bit pulse command and SELOGIC® control equations to provide secure and accurate contact control. The remote device sends the remote bit pulse command; the relay controls the timing of the output contact assertion. You can use any remote bit (RB1–RB16), and any SELOGIC control equation timer (SV1–SV16) to control any of the output contacts (OUT101–OUT107). For example, to pulse output contact OUT104 for 30 cycles with Remote Bit RB4 and SELOGIC control equation timer SV4, issue the following relay settings:

via the **SET** command

SV4PU = 0

SV4 pickup time = 0

SV4DO = 30

SV4 dropout time is 30 cycles

via the **SET L** command

SV4 = RB4

SV4 input is RB4

OUT104 = SV4T

route SV4 timer output to OUT104

A5E3 Fast Operate Open / Close Message

To pulse the contact, send the A5E006430DDB command to the relay.

The external device sends the following message to perform a fast open/close:

Table 5.9 A5E3 Fast Operate Open/Close Message

Data	Description
A5E3	Command
06	Length
1 byte	Operate Code 31—OPEN breaker 11—CLOSE breaker
1 byte	Operate Validation: 4 • Operate code + 1
checksum	1-byte checksum of preceding bytes

The relay performs the specified breaker operation if the conditions 1–5 defined in the A5E0 messages are true.

DNA Message

In response to the DNA command, the relay sends names of the Relay Word bits transmitted in the A5D1 message. The first name is associated with the MSB, the last name with the LSB. These names are listed in the Relay Word Bits table in *Appendix A: Relay Word Bits*. The DNA command is available from Access Level 1 and higher.

```
<STX>"xxxxx","xxxxx","xxxxx","xxxxx","xxxxx","xxxxx","xxxxx","xxxxx","yyyy"<CR>
<ETX>
```

Where

<STX>	is the STX character (02).
<ETX>	is the ETX character (03).
xxxxx	is each name in ASCII, appearing in order from MSB to LSB.
yyyy	is the 4-byte ASCII representation of the checksum.
*	is an unused bit location.

BNA Message

In response to the BNA command, the relay sends names of the bits transmitted in the Status Byte in the A5D1 message. The first name is the MSB, the last name is the LSB. The BNA message is:

```
<STX>"*","*","*","STSET","*","*","*","*","yyyy"<CR><LF><ETX>
```

Where

yyyy	is the 4-byte ASCII representation of the checksum.
*	is an unused bit location.

The BNA command is available from Access Level 1 and higher.

Serial Port Automatic Messages

When the serial port AUTO setting is Y, the relay sends automatic messages to indicate specific conditions. The automatic messages are described in *Table 5.10*.

Table 5.10 Serial Port Automatic Messages

Condition	Description
Power Up	The relay sends a message containing the present date and time, Relay and Terminal Identifiers, and the Access Level 0 action prompt when the relay is turned on.
Event Trigger	The relay sends an event summary each time an event report is triggered. See *Section 3: Analyzing Events*.
Group Switch	The relay displays the active settings group after a group switch occurs. See *GRO Command (Display Active Setting Group Number) on page R.7.7*.
Self-Test Warning or Failure	The relay sends a status report each time a self-test warning or failure condition is detected. See *STA Command (Relay Self-Test Status) on page R.7.11*.

Section 6
Modbus RTU Communications

This section describes Modbus® RTU communications protocol features supported by the SEL-547 Relay. Complete specifications for the Modbus protocol are available from the Modicon Web site at www.modicon.com.

This section covers the following topics:

- ➤ Using the Modbus protocol
- ➤ Modbus commands
- ➤ Modus map

Using the Modbus Protocol

Enable Modbus protocol using the serial port settings. When Modbus protocol is enabled, the relay switches the port to Modbus protocol and deactivates the ASCII protocol.

Modbus RTU is a binary protocol that permits communication between a single master device and multiple slave devices. The communication is half duplex; only one device transmits at a time. The master transmits a binary command that includes the address of the desired slave device. All of the slave devices receive the message, but only the slave device with the matching address responds.

The SEL-547 Modbus communication allows a Modbus master device to:

➤ Acquire metering data from the relay.

➤ Control SEL-547 output contacts.

Read the SEL-547 self-test status and learn the present condition of all relay protection elements.

Queries

Modbus RTU master devices initiate all exchanges by sending a query. The query consists of the fields shown in *Table 6.1*.

Table 6.1 Modbus Query Fields

Field	Number of Bytes
Slave Device Address	1 byte
Function Code	1 byte
Data Region	0–251 bytes
Cyclical Redundancy Check (CRC)	2 bytes

The SEL-547 SLAVEID setting defines the device address. Set this value to a unique number for each device on the Modbus network. For Modbus communication to operate properly, no two slave devices may have the same address.

Function codes supported by the SEL-547 are described in *Table 6.2*.

The CRC detects errors in the received data. If an error is detected, the relay discards the packet.

Responses

The slave device sends a response message after it performs the action requested in the query. If the slave cannot execute the command for any reason, it sends an error response. Otherwise, the slave device response is formatted similarly to the query including the slave address, function code, data (if applicable), and a cyclical redundancy check value.

Supported Function Codes

The SEL-547 supports the Modbus function codes shown in *Table 6.2*.

Table 6.2 SEL-547 Modbus Function Codes

Codes	Description
01h	Read Coil Status
02h	Read Input Status
03h	Read Holding Registers
04h	Read Input Registers
05h	Force Single Coil
06h	Preset Single Register
08h	Loopback Diagnostic
10h	Preset Multiple Registers

Exception Responses

The SEL-547 sends an exception code under the conditions described in *Table 6.3*.

Table 6.3 SEL-547 Modbus Exception Codes

Exception Code	Error Type	Description
01	Illegal Function Code	The received function code is either undefined or unsupported.
02	Illegal Data Address	The received command contains an unsupported address in the data field.
03	Illegal Data Value	The received command contains a value that is out of range.
04	Device Error	The SEL-547 is in the wrong state for the requested function.
06	Busy	The SEL-547 is unable to process the command at this time due to a busy resource.

In the event that any of the errors listed in *Table 6.3* occur, the relay assembles a response message that includes the exception code in the data field. The relay sets the most significant bit in the function code field to indicate to the master that the data field contains an error code, instead of the requested data.

Cyclical Redundancy Check (CRC)

The SEL-547 calculates a two-byte CRC value using the device address, function code, and data fields. It appends this value to the end of every Modbus response. When the master device receives the response, it recalculates the CRC. If the calculated CRC matches the CRC sent by the SEL-547, the master device uses the data received. If there is not a match, the check fails and the message is ignored. The devices use a similar process when the master sends queries.

Modbus Commands

01h Read Coil Status Command

Use function code 01h to read the On/Off status of the selected bits (coils). You may read the status of up to 2000 bits per query. Note that the relay coil addresses start at 0 (e.g., Coil 1 is located at address zero). The relay returns 8 bits per byte, most significant bit first, with zeroes padded into incomplete bytes.

Table 6.4 01h Read Coil Status Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (01h)
2 bytes	Address of the First Bit
2 bytes	Number of Bits to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (01h)
1 byte	Bytes of data (n)
n bytes	Data
2 bytes	CRC-16

To build the response, the relay calculates the number of bytes required to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the relay adds one more byte to maintain the balance of bits, padded by zeroes to make an even byte.

The relay responses to errors in the query are shown below:

Table 6.5 01h Read Coil Status Errors

Error	Error Code Returned	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

Please refer to *Table 6.14* for coil number assignments.

02h Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (inputs). You may read the status of up to 2000 bits per query. Note that the input addresses start at 0 (e.g., Input 1 is located at address zero). The input status is packed one input per bit of the data field. The least significant byte (LSB) of the first data byte contains the starting input address in the query. The other inputs follow towards the high order end of this byte, and from low order to high order in subsequent bytes.

Table 6.6 02h Read Input Status Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
2 bytes	Address of the First Bit
2 bytes	Number of Bits to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
1 byte	Bytes of data (n)
n bytes	Data
2 bytes	CRC-16

To build the response, the relay calculates the number of bytes required to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the relay adds one more byte to maintain the balance of bits, padded by zeros to make an even byte.

Input numbers are defined below:

Table 6.7 02h Read Input Numbers

Input Numbers	Description
1	Input 1
2	Input 2
3	Input 3

Input addresses start at 0000 (i.e., Input 1 is located at Input Address 0000).

The relay responses to errors in the query are shown below:

Table 6.8 02h Read Input Errors

Error	Error Code Returned	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register map shown in *Table 6.22*. You may read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. If you are accustomed to 4X references with this function code, for five-digit addressing, add 40001 to the standard database address.

Table 6.9 03h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
1 byte	Bytes of data (n)
n bytes	Data
2 bytes	CRC-16

The relay responses to errors in the query are shown below:

Table 6.10 03h Read Holding Register Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

04h Read Input Registers Command

Use function code 04h to read from the Modbus Register map shown in *Table 6.22*. You may read a maximum of 125 registers at once with this function code.

Table 6.11 04h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
1 byte	Bytes of data (n)
n bytes	Data
2 bytes	CRC-16

The relay responses to errors in the query are shown below:

Table 6.12 04h Read Holding Register Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

05h Force Single Coil Command

Use function code 05h to set or clear a coil.

Table 6.13 05h Force Single Coil Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (05h)
2 bytes	Coil Reference
1 byte	Operation Code (FF for bit set, 00 for bit clear)
1 byte	Placeholder (00)
2 bytes	CRC-16

The command response is identical to the command request.

The coil numbers supported by the SEL-547 are listed in *Table 6.14*. The physical coils (Coils 1–6) are self-resetting. If the relay is disabled, it will respond with error code 4 (Device Error). Remote Bit Coils 23–38 return zero when read. Remote Bit Coils 7–22 can be set or cleared and return to the corresponding state when read. Pulsing a remote bit already in the set state clears that remote bit after a one-second delay. The Open/Close Contact Coils 39–40 return zero when read.

Table 6.14 SEL-547 Command Coils (Sheet 1 of 2)

Coil	Field
1	OUT1
2	OUT2
3	OUT3
4	OUT4
5	OUT5
6	ALARM
7	RB1
8	RB2
9	RB3
10	RB4
11	RB5
12	RB6
13	RB7
14	RB8

Table 6.14 SEL-547 Command Coils (Sheet 2 of 2)

Coil	Field
15	RB9
16	RB10
17	RB11
18	RB12
19	RB13
20	RB14
21	RB15
22	RB16
23	Pulse RB1
24	Pulse RB2
25	Pulse RB3
26	Pulse RB4
27	Pulse RB5
28	Pulse RB6
29	Pulse RB7
30	Pulse RB8
31	Pulse RB9
32	Pulse RB10
33	Pulse RB11
34	Pulse RB12
35	Pulse RB13
36	Pulse RB14
37	Pulse RB15
38	Pulse RB16
39	Pulse OC
40	Pulse CC

The relay responses to errors in the query are shown below:

Table 6.15 05h Force Single Coil Errors

Error	Error Code Returned	Communication Counter Increments
Invalid bit (coil) number	Illegal Data Address (02h)	Invalid Address
Illegal bit state requested	Illegal Data Value (03h)	Illegal Function Code/Op Code
Format error	Illegal Data Value (03h)	Bad Packet Format

06h Preset Single Register Command

The SEL-547 uses this function to allow a Modbus master to write directly to a database register. These registers are used to write the command code and parameters for the command region, selecting the event number or channel number for Event data region and setting the Relay Date and Time. If you are accustomed to 4X references with this function code, for six-digit addressing, add 400001 to the standard database addresses.

Table 6.16 06h Preset Single Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (06h)
2 bytes	Register Address
2 bytes	Data
2 bytes	CRC-16

The command response is identical to the command request.

The relay responses to errors in the query are shown below:

Table 6.17 06h Preset Singe Register Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register address	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal register value	Illegal Data Value (03h)	Illegal Write
Format error	Illegal Data Value (03h)	Bad Packet Format

08h Loopback Diagnostic Command

The SEL-547 uses this function to allow a Modbus master to perform a diagnostic test on the Modbus communications channel and relay. When the subfunction field is 0000h, the relay returns a replica of the received message.

Table 6.18 08h Loopback Diagnostic Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field (identical to data in Master request)
2 bytes	CRC-16

The relay responses to errors in the query are shown below:

Table 6.19 08h Loopback Diagnostic Errors

Error	Error Code Returned	Communication Counter Increments
Illegal subfunction code	Illegal Data Value (03h)	Illegal Function Code/Op Code
Format error	Illegal Data Value (03h)	Bad Packet Format

10h Preset Multiple Registers Command

This function code works much like code 06h, except that it allows you to write multiple registers at once, up to 100 per operation. If you are accustomed to 4X references with the function code, for six-digit addressing, simply add 400001 to the standard database addresses.

Table 6.20 10h Preset Multiple Registers Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers to Write
1 byte	Bytes of Data (n)
n bytes	Data
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers
2 bytes	CRC-16

The relay responses to errors in the query are shown below:

Table 6.21 10h Preset Multiple Registers Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register to set	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal number of registers to set	Illegal Data Value (03h)	Illegal Register Illegal Write
Incorrect number of bytes in query data region	Illegal Data Value (03h)	Bad Packet Format Illegal Write
Invalid register data value	Illegal Data Value (03h)	Illegal Write

Modbus Map

All registers are 16 bit with bit locations ranging from 0 to 15.

Relay Word bits, targets, and contact status are mapped in bit positions 8–15 in the Register. The 0 bit position of this Register is set equal to 1 if any of the 1–15 positions are set to 1.

Table 6.22 Modbus Map (Sheet 1 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Relay ID						
0000–0016	FID[a]	ASCII String	–	–	–	–
0017–002C	Relay ID[a]	ASCII String	–	–	–	–
002D–002F	Reserved (see *Note 1*)					
Relay Status						
0030	Channel IA status message[b] 0 = OK 1 = Warn	–	–	–	–	–
0031	Channel IA8 status message[b] 0 = OK 1 = Warn	–	–	–	–	–
0032–0033	Reserved	–	–	–	–	–
0034	Channel VA status message[b] 0 = OK 1 = Warn	–	–	–	–	–
0035	Channel VB status message[b] 0 = OK 1 = Warn	–	–	–	–	–
0036	Channel VC status message[b] 0 = OK 1 = Warn	–	–	–	–	–
0037	Channel VS status message[b] 0 = OK 1 = Warn	–	–	–	–	–
0038	MOF status message[b] 0 = OK 2 = Fail	–	–	–	–	–
0039	FREQ status[b] 0 = OK 2 = Fail	–	–	–	–	–
003A	RAM status[b] 0 = OK 2 = Fail	–	–	–	–	–

Table 6.22 Modbus Map (Sheet 2 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
003B	ROM status[b] 0 = OK 2 = Fail	–	–	–	–	–
003C	A/D status[b] 0 = OK 2 = Fail	–	–	–	–	–
003D	CR_RAM status[b] 0 = OK 2 = Fail	–	–	–	–	–
003E	EEPROM status[b] 0 = OK 2 = Fail	–	–	–	–	–
003F	Enable status[b] 0 = relay enabled, 2 = relay disabled	–	–	–	–	–
0040–004F	Reserved	–	–	–	–	–
Instantaneous Meter						
0050	Instantaneous current A-phase[b]	Amps	0	65535	1	0.1
0051	Instantaneous current A-phase angle[c]	Degrees	–1800	1800	1	0.1
0052–0055	Reserved					
0056	Instantaneous voltage V_{AB}[b]	Volts	0	12000	1	0.1
0057	Instantaneous voltage V_{AB} angle[c]	Degrees	–1800	1800	1	0.1
0058	Instantaneous voltage V_{BC}[b]	Volts	0	12000	1	0.1
0059	Instantaneous voltage V_{BC} angle[c]	Degrees	–1800	1800	1	0.1
005A	Instantaneous voltage V_{CA}[b]	Volts	0	12000	1	0.1
005B	Instantaneous voltage V_{CA} angle[c]	Degrees	–1800	1800	1	0.1
005C	Instantaneous voltage A-phase[b]	Volts	0	6000	1	0.1
005D	Instantaneous voltage A-phase angle[c]	Volts	–1800	1800	1	0.1
005E	Instantaneous voltage B-phase[b]	Volts	0	6000	1	0.1
005F	Instantaneous voltage B-phase angle[c]	Volts	–1800	1800	1	0.1
0060	Instantaneous voltage C-phase[b]	Volts	0	6000	1	0.1
0061	Instantaneous voltage C-phase angle[c]	Volts	–1800	1800	1	0.1

Table 6.22 Modbus Map (Sheet 3 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0062	Instantaneous synchronizing voltage VS[b]	Volts	0	6000	1	0.1
0063	Instantaneous synchronizing voltage VS angle[c]	Volts	–1800	1800	1	0.1
0064	Instantaneous zero-sequence voltage $3V_0$[b]	Volts	0	18000	1	0.1
0065	Instantaneous zero-sequence voltage $3V_0$ angle[c]	Volts	–1800	1800	1	0.1
0066	Instantaneous positive-sequence voltage V_1[b]	Volts	0	6000	1	0.1
0067	Instantaneous positive-sequence voltage V_1 angle[c]	Volts	–1800	1800	1	0.1
0068	Instantaneous negative-sequence voltage V_2[b]	Volts	0	6000	1	0.1
0069	Instantaneous negative-sequence voltage V_2 angle[c]	Volts	–1800	1800	1	0.1
006A	Instantaneous 3-phase real power[c]	kW	–32767	32767	1	0.1
006B	Instantaneous 3-phase reactive power[c]	kVar	–32767	32767	1	0.1
006C	Instantaneous 3-phase power factor[c]	–	–100	100	1	0.01
006D	Instantaneous 3-phase lead/lag[b] 0 = lag, 1 = lead	–	–	–	–	–
006E	System frequency[b]	Hz	40	70	1	0.1
006F–007F	Reserved					
Relay Time and Date						
0080 (RW) (see Note 2)	Time[b]	ss	0	59	1	1
0081 (RW)	[b]	mm	0	59	1	1
0082 (RW)	[b]	hh	0	23	1	1
0083 (RW)	Date[b]	dd	1	31	1	1
0084 (RW)	[b]	mm	1	12	1	1
0085 (RW)	[b]	yyyy	2000	2999	1	1
0086–008F	Reserved					

Table 6.22 Modbus Map (Sheet 4 of 12)

Address (Hex)	Field	Units	Range Low	Range High	Range Step	Scale Factor
Relay Word						
0090	Row 0					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = LED8					
	Bit 9 = LED7					
	Bit 10 = LED6					
	Bit 11 = LED5					
	Bit 12 = LED4					
	Bit 13 = LED3					
	Bit 14 = LED2					
	Bit 15 = LED1					
0091	Row 1					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = IN1					
	Bit 9 = IN2					
	Bit 10 = IN3					
	Bit 11 = *					
	Bit 12 = *					
	Bit 13 = *					
	Bit 14 = *					
	Bit 15 = *					
0092	Row 2					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = OUT1					
	Bit 9 = OUT2					

Table 6.22 Modbus Map (Sheet 5 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 10 = OUT3					
	Bit 11 = OUT4					
	Bit 12 = OUT5					
	Bit 13 = *					
	Bit 14 = *					
	Bit 15 = ALARM					
0093	Row 3					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 27B3					
	Bit 9 = 27A3					
	Bit 10 = 27C2					
	Bit 11 = 27B2					
	Bit 12 = 27A2					
	Bit 13 = 27C1					
	Bit 14 = 27B1					
	Bit 15 = 27A1					
0094	Row 4					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 59A2					
	Bit 9 = 59C1					
	Bit 10 = 59B1					
	Bit 11 = 59A1					
	Bit 12 = 27C4					
	Bit 13 = 27B4					
	Bit 14 = 27A4					
	Bit 15 = 27C3					

Table 6.22 Modbus Map (Sheet 6 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0095	Row 5					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 59C4					
	Bit 9 = 59B4					
	Bit 10 = 59A4					
	Bit 11 = 59C3					
	Bit 12 = 59B3					
	Bit 13 = 59A3					
	Bit 14 = 59C2					
	Bit 15 = 59B2					
0096	Row 6					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 59S2					
	Bit 9 = 59S1					
	Bit 10 = 27S					
	Bit 11 = 59V1					
	Bit 12 = 59Q2					
	Bit 13 = 59Q1					
	Bit 14 = 59N2					
	Bit 15 = 59N1					
0097	Row 7					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = SSLOW					
	Bit 9 = SFAST					
	Bit 10 = 25A2					
	Bit 11 = 25A1					

Table 6.22 Modbus Map (Sheet 7 of 12)

Address (Hex)	Field	Units	Range Low	Range High	Range Step	Scale Factor
	Bit 12 = SF					
	Bit 13 = 59VS					
	Bit 14 = 59VP					
	Bit 15 = 59VA					
0098	Row 8					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = *					
	Bit 9 = 27B81					
	Bit 10 = 81D6					
	Bit 11 = 81D5					
	Bit 12 = 81D4					
	Bit 13 = 81D3					
	Bit 14 = 81D2					
	Bit 15 = 81D1					
0099	Row 9					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = *					
	Bit 9 = *					
	Bit 10 = 81D6T					
	Bit 11 = 81D5T					
	Bit 12 = 81D4T					
	Bit 13 = 81D3T					
	Bit 14 = 81D2T					
	Bit 15 = 81D1T					
009A	Row 10					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					

Table 6.22 Modbus Map (Sheet 8 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 8 = *					
	Bit 9 = *					
	Bit 10 = *					
	Bit 11 = *					
	Bit 12 = PWR4					
	Bit 13 = PWR3					
	Bit 14 = PWR2					
	Bit 15 = PWR1					
009B	Row 11					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = SV4T					
	Bit 9 = SV3T					
	Bit 10 = SV2T					
	Bit 11 = SV1T					
	Bit 12 = SV4					
	Bit 13 = SV3					
	Bit 14 = SV2					
	Bit 15 = SV1					
009C	Row 12					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = SV8T					
	Bit 9 = SV7T					
	Bit 10 = SV6T					
	Bit 11 = SV5T					
	Bit 12 = SV8					
	Bit 13 = SV7					
	Bit 14 = SV6					
	Bit 15 = SV5					

Table 6.22 Modbus Map (Sheet 9 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
009D	Row 13					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = SV12T					
	Bit 9 = SV11T					
	Bit 10 = SV10T					
	Bit 11 = SV9T					
	Bit 12 = SV12					
	Bit 13 = SV11					
	Bit 14 = SV10					
	Bit 15 = SV9					
009E	Row 14					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = SV16T					
	Bit 9 = SV15T					
	Bit 10 = SV14T					
	Bit 11 = SV13T					
	Bit 12 = SV16					
	Bit 13 = SV15					
	Bit 14 = SV14					
	Bit 15 = SV13					
009F	Row 15					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = LT8					
	Bit 9 = LT7					
	Bit 10 = LT6					

Table 6.22 **Modbus Map** (Sheet 10 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 11 = LT5					
	Bit 12 = LT4					
	Bit 13 = LT3					
	Bit 14 = LT2					
	Bit 15 = LT1					
00A0	Row 16					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = LT16					
	Bit 9 = LT15					
	Bit 10 = LT14					
	Bit 11 = LT13					
	Bit 12 = LT12					
	Bit 13 = LT11					
	Bit 14 = LT10					
	Bit 15 = LT9					
00A1	Row 17					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = RB8					
	Bit 9 = RB7					
	Bit 10 = RB6					
	Bit 11 = RB5					
	Bit 12 = RB4					
	Bit 13 = RB3					
	Bit 14 = RB2					
	Bit 15 = RB1					
00A2	Row 18					
	Bit 0 = 1 if any of bits 8–15 are set to 1					

Table 6.22 Modbus Map (Sheet 11 of 12)

Address (Hex)	Field	Units	Range Low	Range High	Range Step	Scale Factor
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = RB16					
	Bit 9 = RB15					
	Bit 10 = RB14					
	Bit 11 = RB13					
	Bit 12 = RB12					
	Bit 13 = RB11					
	Bit 14 = RB10					
	Bit 15 = RB9					
00A3	Row 19					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = IAMET					
	Bit 9 = *					
	Bit 10 = CLK-PUL					
	Bit 11 = CC					
	Bit 12 = OC					
	Bit 13 = *					
	Bit 14 = SG2					
	Bit 15 = SG1					
00A4–00BF	Reserved					
Communication Counter						
00C0	Number of messages received[b]	–	0	65535	1	1
00C1	Number of messages sent to other devices[b]	–	0	65535	1	1
00C2	Invalid address[b]	–	0	65535	1	1
00C3	Bad CRC[b]	–	0	65535	1	1
00C4	UART error[b]	–	0	65535	1	1
00C5	Illegal function code/Op code[b]	–	0	65535	1	1
00C6	Illegal register[b]	–	0	65535	1	1

Table 6.22 Modbus Map (Sheet 12 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00C7	Illegal write[b]	–	0	65535	1	1
00C8	Bad packet format[b]	–	0	65535	1	1
00C9	Bad packet length[b]	–	0	65535	1	1
00CA–FFFF	Reserved					

[a] Two 8-bit ASCII characters per register.
[b] 16-bit unsigned value.
[c] 16-bit signed value.

Note 1. Reserved addresses return 8000h.

Note 2. Registers (RW) are read-write registers.
Registers (W) are write-only registers.
All other registers are read only.

Section 7
ASCII Commands

You can use a communications terminal or a terminal emulation program to set and operate the SEL-547 Relay.

This section provides the following information about ASCII commands:

- ➤ Serial port access levels
- ➤ Command summary
- ➤ Command explanations

Serial Port Access Levels

Commands can be issued to the relay via the serial port to view metering values, change relay settings, etc. The available serial port commands are listed in *Table 7.1*. The commands can be accessed only from the corresponding access level as shown in *Table 7.1*. The SEL-547 has the following access levels:

- Access Level 0 (the lowest access level)
- Access Level 1
- Access Level B
- Access Level 2 (the highest access level)

Access Level 0

Once serial port communications are established with the relay, the relay sends the following action prompt:

```
=
```

This is referred to as Access Level 0. The only command that is available at Access Level 0 is the **ACC** command (see *Table 7.1*). Enter the **ACC** command at the Access Level 0 = action prompt:

```
=ACC <Enter>
```

The **ACC** command takes the relay to Access Level 1 [see *ACC, BAC, and 2AC Commands (Go To Access Level 1, B, or 2) on page R.7.6* for more detail].

Access Level 1

When the relay is in Access Level 1, the relay sends the following action prompt:

```
=>
```

Commands **BAC** through **TRI** in *Table 7.1* are available from Access Level 1. For example, enter the **MET** command at the Access Level 1 action prompt to view metering data:

```
=>MET <Enter>
```

The **BAC** command allows the relay to go to Access Level B [see *ACC, BAC, and 2AC Commands (Go To Access Level 1, B, or 2)* in the *Command Explanations* subsection for more detail]. Enter the **BAC** command at the Access Level 1 action prompt:

```
=>BAC <Enter>
```

Access Level B

When the relay is in Access Level B, the relay sends the action prompt:

```
==>
```

Commands **BRE n** through **PUL** in *Table 7.1* are available from Access Level B. For example, enter the **CLO** command at the Access Level B action prompt to close the circuit breaker:

```
==>CLO <Enter>
```

While in Access Level B, any of the Access Level 1 commands are also available (commands **BAC** through **TRI** in *Table 7.1*).

The **2AC** command allows the relay to go to Access Level 2 [see *ACC, BAC, and 2AC Commands (Go To Access Level 1, B, or 2) on page R.7.6* in this section for more detail]. Enter the **2AC** command at the Access Level B action prompt:

```
==>2AC <Enter>
```

Access Level 2

When the relay is in Access Level 2, the relay sends the action prompt:

```
=>>
```

Commands **CON** through **VER** in *Table 7.1* are available from Access Level 2. For example, enter the **SET** command at the Access Level 2 action prompt to make relay settings:

```
=>>SET <Enter>
```

Any of the Access Level 1 and Access Level B commands are also available (commands **BAC** through **PUL** in *Table 7.1*) in Access Level 2.

Command Summary

Table 7.1 alphabetically lists the serial port commands within a given access level. The serial port commands at the different access levels offer varying levels of control:

- The Access Level 1 commands primarily allow you to look at information only (settings, metering, etc.), not change it.
- The Access Level B commands primarily allow you to operate output contacts or change the relay EZ settings and port settings.
- The Access Level 2 commands primarily allow you to change additional relay settings restricted in previous access levels (i.e., group, global, logic, report).

A higher access level can access the serial port commands in a lower access level. The commands are shown in uppercase letters, but they can also be entered with lowercase letters.

Table 7.1 Serial Port Command Summary

Access Level	Prompt	Serial Port Command	Command Description
0	=	ACC	Go to Access Level 1
1	=>	BAC	Go to Access Level B
1	=>	2AC	Go to Access Level 2
1	=>	DAT	View/change date
1	=>	EVE	Event reports
1	=>	GRO	Display active setting group number
1	=>	HIS	Event summaries/histories
1	=>	MET	Metering data
1	=>	QUI	Quit access level
1	=>	SER	Sequential Events Recorder
1	=>	SHO	Show/view settings
1	=>	STA	Relay self-test status
1	=>	TAR	Display relay element status
1	=>	TIM	View/change time
1	=>	TRI	Trigger an event report
B	==>	CLO	Close breaker
B	==>	OPE	Open breaker
B	==>	PUL	Pulse output contact
B	==>	SET	Change settings
2	=>>	CON	Control remote bit
2	=>>	COP	Copy setting group
2	==>	GRO *n*	Change active setting group
2	=>>	PAS	View / change passwords
2	=>>	VER	Show relay configuration and firmware version

The relay responds with "Invalid Access Level" if a command is entered from an access level lower than the specified access level for the command. The relay responds as shown below to commands entered incorrectly or not listed in *Table 7.1*:

```
Invalid Command
```

Many of the command responses display the following header at the beginning:

```
GENERATOR 1                          Date: 03/05/01    Time: 17:03:26.484
STATION A
```

The definitions are listed below:

FEEDER 1. This is the RID setting (the relay is shipped with the default setting RID = GENERATOR 1.

STATION A. This is the TID setting (the relay is shipped with the default setting TID = STATION A.

Date. This is the date the command response was given [except for relay response to the **EVE** command (Event), where it is the date the event occurred]. You can modify the date display format (Month/Day/Year or Year/Month/Day) by changing the DATE_F relay setting.

Time. This is the time the command response was given (except for relay response to the **EVE** command, where it is the time the event occurred).

The serial port command explanations that follow in the *Command Explanations* subsection are in the same order as the commands listed in *Table 7.1*.

Command Explanations

Access Level 0 Commands

ACC, BAC, and 2AC Commands (Go To Access Level 1, B, or 2)

The **ACC**, **BAC**, and **2AC** commands provide entry to the multiple access levels. Different commands are available at the different access levels as shown in *Table 7.1*. Commands **ACC**, **BAC**, and **2AC** are explained together because they operate similarly.

- **ACC** moves from Access Level 0 to Access Level 1.
- **BAC** moves from Access Level 1 to Access Level B.
- **2AC** moves from Access Level 1 or B to Access Level 2

Access Level Attempt

At the Access Level 0 action prompt, enter the **ACC** command:

```
=ACC <Enter>
```

The relay asks for the Access Level 1 password to be entered:

```
Password: ? @@@@@@
```

The relay is shipped with the default Access Level 1 password shown in *Table 7.3*. At the action prompt above, enter the default password and press the **<Enter>** key. The relay responds:

```
GENERATOR 1                          Date: 03/05/01    Time: 08:31:10.361
STATION A


Level 1
=>
```

Figure 7.1 Entering Access Level 1.

The => action prompt indicates the relay is now in Access Level 1.

If the entered password is incorrect, the relay asks for the password again (Password: ?). The relay will ask up to three times. If the requested password is incorrectly entered three times, the relay closes the ALARM contact for one second and remains at Access Level 0 (= action prompt).

The above example demonstrates how to go from Access Level 0 to Access Level 1. The procedure to go from Access Level 1 to Access Level B, Access Level 1 to Access Level 2, or Access Level B to Access Level 2 is much the same, with command **BAC** or **2AC** entered at the access level screen action prompt. The relay closes the ALARM contact for one second after a successful Level B or Level 2 access. If access is denied, the ALARM contact closes for one second.

Access Level 1 Commands

DAT Command (View/Change Date)

DAT displays the date stored by the internal calendar/clock. If the date format setting DATE_F is set to MDY, the date is displayed as month/day/year. If the date format setting DATE_F is set to YMD, the date is displayed as year/month/day.

To set the date, type **DATE mm/dd/yy <Enter>** if the DATE_F setting is MDY. If the DATE_F is set to YMD, enter **DATE yy/mm/dd <Enter>**. To set the date to June 1, 2001, enter:

```
=>DATE 6/1/01 <Enter>
6/1/01
=>
```

Figure 7.2 Setting the Date With the DAT Command.

NOTE: After setting the date, allow at least 60 seconds before powering down the relay or the new setting may be lost.

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

EVE Command (Event Reports)

Use the **EVE** command to view event reports. See *Section 3: Analyzing Events* for further details on retrieving event reports.

GRO Command (Display Active Setting Group Number)

Use the **GRO** command to display the active settings group number. See *Multiple Setting Groups on page R.2.25* for further details on settings groups.

HIS Command (Event Summaries/History)

HIS *x* displays event summaries or allows you to clear event summaries (and corresponding event reports) from nonvolatile memory.

If no parameters are specified with the **HIS** command, the relay displays the most recent event summaries in reverse chronological order.

```
=HIS <Enter>
```

If *x* is a number, the relay displays the *x* most recent event summaries. The maximum number of available event summaries is a function of the LER (length of event report) setting.

```
=HIS x <Enter>
```

If *x* is C or c, the relay clears the event summaries and all corresponding event reports from nonvolatile memory.

The event summaries include the date and time the event was triggered, the type of event, the fault location, the maximum phase current in the event, the power system frequency, the number of the active setting group, the reclose shot count, and the front-panel targets.

To display the relay event summaries, enter the following command:

```
=>HIS <Enter>
GENERATOR 1                          Date: 02/01/01    Time: 08:40:16.740
STATION A

#     DATE      TIME      EVENT  CURR VOLTAGE(VA,VB,VC,VS) FREQ GRP TARGETS

1  02/01/01 08:33:00.365 TRIG     0    0    0    0    0  60.0  1  11000000
2  01/31/01 20:32:58.361 PULSE    0    0    0    0    0  60.0  1  1100000

=>
```

Figure 7.3 Displaying Event Summaries With the HIS Command.

The event type listed in the EVENT column is one of the following:

- ER. Event report generated by assertion of SELOGIC® control equation event report trigger condition setting ER.
- PULSE. Event report generated by execution of the **PUL** (Pulse) command.
- TRIG. Event report generated by execution of the **TRI** (Trigger) command.

The TARGETS column will display any of the following illuminated front-panel target LEDs if the event report is generated by the assertion of the ER Relay Word bit:

ENABLED 27 59 81 47 32 25 25 VOLTAGE HOT

For more information on event reports, see *Section 3: Analyzing Events*.

MET Command (Metering Data)

The **MET** commands provide access to the relay metering data. Metered quantities include phase voltages and A-phase current, sequence component voltages, power, and frequency. For more information on the **MET** command, see *Step 9: Viewing Metering Quantities on page U.3.25 in the User's Guide*.

QUI Command (Quit Access Level)

The **QUI** command returns the relay to Access Level 0.

To return to Access Level 0, enter the following command:

```
=>QUI <Enter>
```

The relay sets the port access level to 0 and responds as shown below:

```
GENERATOR 1                          Date: 03/05/01    Time: 08:55:33.986
STATION A

=
```

The = action prompt indicates the relay is back in Access Level 0.

The **QUI** command terminates the SEL Distributed Port Switch Protocol (LMD) connection if it is established [see *Section 5: SEL Communications Protocols* for details on SEL Distributed Port Switch Protocol (LMD)].

SER Command (Sequential Events Recorder Report)

Use the **SER** command to view the Sequential Events Recorder report. For more information on SER reports, see *Section 3: Analyzing Events*.

SHO Command (Show/View Settings)

Use the **SHO** command to view relay settings, SELOGIC control equations, global settings, serial port settings, sequential events recorder (SER) settings, and text label settings. Below are the **SHO** command options.

SHO n. Show relay settings. *n* specifies the setting group (1, 2, 3, 4, 5, or 6); *n* defaults to the active setting group if not listed.

SHO L n. Show SELOGIC control equation settings. *n* specifies the setting group (1 or 2); *n* defaults to the active setting group if not listed.

SHO G. Show global settings.

SHO P n. Show serial port settings. *n* specifies the port (1 or F); *n* defaults to the active port if not listed.

SHO R. Show sequential events recorder (SER) settings.

You may append a setting name to each of the commands to specify the first setting to display (e.g., **SHO 1 EVOLT** displays the setting Group 1 relay settings starting with setting EVOLT). The default is the first setting.

The **SHO** commands display only the enabled settings. To display all settings, including disabled/hidden settings, append an **A** to the **SHO** command (e.g., **SHO 1 A**).

Below are sample **SHOWSET** commands for the SEL-547 showing the factory default settings.

```
=>SHO 1 <Enter>
Group 1
Group Settings:

RID   =GENERATOR 1                    TID   =STATION A
CTR   = 80
EVOLT = Y        E25   = Y        E81   = 6
ESV   = 16       EPWR  = 4

27P1P = 60       27P2P = 106      27P3P = OFF      27P4P = OFF
59P1P = 132      59P2P = 144      59P3P = OFF      59P4P = OFF
59N1P = OFF      59N2P = OFF      59Q1P = 60       59Q2P = OFF
59V1P = OFF      27SP  = OFF      59S1P = OFF      59S2P = OFF
27B81P= 84       81D1P = 57.0     81D1D = 6.00
81D2P = 59.3     81D2D = 116.00   81D3P = 60.5     81D3D = 6.00
81D4P = OFF      81D5P = OFF
81D6P = OFF
25VLO = 114      25VHI = 126      25SF  = 0.3
25ANG1= 20       25ANG2= 20       SYNCP = VA       TCLOSD= 0.00
PWR1P = 60       PWR1T = -WATTS   PWR1D = 30.00
PWR2P = OFF

Press RETURN to continue
PWR3P = OFF
PWR4P = OFF
SV1PU = 0.00     SV1DO = 0.00     SV2PU = 0.00     SV2DO = 0.00
SV3PU = 0.00     SV3DO = 0.00     SV4PU = 0.00     SV4DO = 0.00
SV5PU = 0.00     SV5DO = 0.00     SV6PU = 0.00     SV6DO = 0.00
SV7PU = 6.00     SV7DO = 15.00    SV8PU = 116.00   SV8DO = 15.00
SV9PU = 56.00    SV9DO = 15.00    SV10PU= 6.00     SV10DO= 15.00
SV11PU= 0.00     SV11DO= 15.00    SV12PU= 0.00     SV12DO= 15.00
SV13PU= 30.00    SV13DO= 15.00    SV14PU= 0.00     SV14DO= 0.00
SV15PU= 0.00     SV15DO= 0.00     SV16PU= 0.00     SV16DO= 0.00

=>>
```

Figure 7.4 SHO 1 Factory Default Settings.

```
=>SHO L <Enter>
SELogic group 1

SELogic Control Equations:
SV1   =0
SV2   =0
SV3   =0
SV4   =0
SV5   =0
SV6   =0
SV7   =27A1 + 27B1 + 27C1
SV8   =27A2 + 27B2 + 27C2
SV9   =59A1 + 59B1 + 59C1
SV10  =59A2 + 59B2 + 59C2
SV11  =81D1T + 81D2T + 81D3T + 81D4T
SV12  =PWR1
SV13  =59Q1
SV14  =0
SV15  =0
SV16  =0
OUT1  =25A1

Press RETURN to continue
OUT2  =25A1
OUT3  =25A1
OUT4  =SV7T + SV8T + SV9T + SV10T + SV11T + SV12T
OUT5  =SV7T + SV8T + SV9T + SV10T + SV11T + SV12T
LED2  =CLKPUL + SV7T + SV8T
LED3  =CLKPUL + SV9T + SV10T
LED4  =CLKPUL + SV11T
LED5  =CLKPUL + SV13T
LED6  =CLKPUL + SV12T
LED7  =CLKPUL + 25A1
LED8  =CLKPUL + 59VS + 59VP
SS1   =1
SS2   =0
ER    =0
BSYNCH=SV11T
SET1  =0
RST1  =0
SET2  =0
RST2  =0
SET3  =0

Press RETURN to continue
RST3  =0
SET4  =0
RST4  =0
SET5  =0
RST5  =0
SET6  =0
RST6  =0
SET7  =0
RST7  =0
SET8  =0
RST8  =0
SET9  =0
RST9  =0
SET10 =0
RST10 =0
SET11 =0
RST11 =0
SET12 =0
RST12 =0
SET13 =0

Press RETURN to continue
RST13 =0
SET14 =0
RST14 =0
SET15 =0
RST15 =0
SET16 =0
RST16 =0

=>>
```

Figure 7.5 SHO L Factory Default Settings.

```
=>>SHO G <Enter>

Global Settings:
EZSET = Y
PCONN = WYE       TGR   = 0.00
NFREQ = 60        PHROT = ABC       DATE_F= MDY
LER   = 15        PRE   = 4         INTRVL= 30

=>>
```

Figure 7.6 SHO G Factory Default Settings.

```
=>>SHO P <Enter>
Port F

PROTO = SEL
SPEED = 9600      BITS  = 8         PARITY= N         STOP  = 1
T_OUT = 15        AUTO  = N         RTSCTS= N         FASTOP= N

=>>
```

Figure 7.7 SHO P Factory Default Settings.

```
=>>SHO R <Enter>

Sequential Events Recorder trigger lists:
SER1  =SV7T,SV8T,SV9T,SV10T,SV11T,SV12T,SV13T
SER2  =81D1T,81D2T,81D3T,81D4T,25A1
SER3  =IN1,IN2,IN3,OUT1,OUT2,OUT3,OUT4,OUT5

=>>
```

Figure 7.8 SHO R Factory Default Settings.

STA Command (Relay Self-Test Status)

The **STA** command displays the status report, showing the relay self-test information.

To view a status report, enter the command where *n* is an optional parameter to specify the number of times (1–32767) to repeat the status display. If *n* is not specified, the status report is displayed once.

```
=>STA n <Enter>
```

The output of an SEL-547 is shown in *Figure 7.9*.

```
=>STA <Enter>

GENERATOR 1                       Date: 01/05/02    Time: 00:01:17.360
STATION A

FID=SEL-547-R100-V0-Z001001-D20020430       CID=B920

SELF TESTS

W=Warn    F=Fail

       IA      VA      VB      VC      VS      IA8
OS     18      17      19      18      16      26

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

 Relay Enabled

=>
```

Figure 7.9 STA Command Output.

STA Command Row and Column Definitions

FID. FID is the firmware identifier string. It identifies the firmware revision.

CID. CID is the firmware checksum identifier.

OS. OS = Offset; displays measured dc offset voltages in millivolts for the current and voltage channels. The MOF (master) status is the dc offset in the A/D circuit when a grounded input is selected.

RAM, ROM, CR_RAM (critical RAM), and EEPROM. These tests verify the relay memory components. The columns display OK if memory is functioning properly; the columns display FAIL if the memory area has failed.

A/D. Analog to Digital convert status.

W (Warning) or F (Failure). W or F is appended to the values to indicate an out-of-tolerance condition.

The relay latches all self-test warnings and failures in order to capture transient out-of-tolerance conditions. To reset the self-test statuses, use the **STA C** command from Access Level 2:

```
=>>STA C <Enter>
```

The relay responds as follows:

```
Reboot the relay and clear status
Are you sure (Y/N) ?
```

If you select N or n, the relay displays the following message and aborts the command:

```
Canceled
```

If you select Y, the relay displays the following message:

```
Rebooting the relay
```

The relay then restarts (just like powering down, then powering up the relay), and all diagnostics are rerun before the relay is enabled.

Refer to *Section 4: Testing and Troubleshooting in the User's Guide* for self-test thresholds and corrective actions.

TAR Command (Display Relay Element Status)

The **TAR** command displays the status of front-panel target LEDs or relay elements, whether they are asserted or deasserted. The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. The rows correspond to the Relay Word rows as described in *Section 8: Settings*.

A Relay Word bit is either at a logical 1 (asserted) or a logical 0 (deasserted). Relay Word bits are used in SELOGIC control equations. See *Section 8: Settings* and *Section 2: SELOGIC Control Equation Programming*.

The **TAR** command options are:

TAR n k or TAR ROW n k. Shows Relay Word row number *n* (0–19). *k* is an optional parameter to specify the number of times (1–32767) to repeat the Relay Word row display. If *k* is not specified, the Relay Word row is displayed once. Adding **ROW** to the command displays the Relay Word Row number at the start of each line.

TAR name k or TAR ROW name k. Shows Relay Word row containing Relay Word bit *name* (e.g., TAR 27A1 displays Relay Word Row 3). Valid names are shown in *Appendix A: Relay Word Bits*. *k* is an optional parameter to specify the number of times (1–32767) to repeat the Relay Word row display. If *k* is not specified, the Relay Word row is displayed once. Adding **ROW** to the command displays the Relay Word Row number at the start of each line.

TAR LIST or TAR ROW LIST. Shows all the Relay Word bits in all of the rows. Adding **ROW** to the command displays the Relay Word Row number at the start of each line.

Command **TAR LED1 10** is executed in the following example:

```
=>TAR LED1 10 <Enter>

LED1   LED2   LED3   LED4   LED5   LED6   LED7   LED8
1      1      0      0      0      0      0      0
1      1      0      0      0      0      0      0
1      1      0      0      0      0      0      0
1      1      0      0      0      0      0      0
1      1      0      0      0      0      0      0
1      1      0      0      0      0      0      0
1      1      0      0      0      0      0      0
1      1      0      0      0      0      0      0

LED1   LED2   LED3   LED4   LED5   LED6   LED7   LED8
1      1      0      0      0      0      0      0
1      1      0      0      0      0      0      0

=>
```

Figure 7.10 TAR LED1 10 Command Example.

NOTE: The Relay Word row containing the LED1 bit is repeated 10 times. Command **TAR 0** will report the same data since the LED1 bit is in Row 0 of the Relay Word.

Command **TAR ROW LIST** is executed in the following example:

```
=>TAR ROW LIST <Enter>

Row   LED1   LED2   LED3   LED4   LED5   LED6   LED7   LED8
0     1      1      0      0      0      0      0      0

Row   *      *      *      *      *      IN3    IN2    IN1
1     0      0      0      0      0      0      0      0

Row   ALARM  *      *      OUT5   OUT4   OUT3   OUT2   OUT1
2     0      0      0      1      1      0      0      0

Row   27A1   27B1   27C1   27A2   27B2   27C2   27A3   27B3
3     1      1      1      1      1      1      0      0

Row   27C3   27A4   27B4   27C4   59A1   59B1   59C1   59A2
4     0      0      0      0      0      0      0      0
.
.(10 rows not shown)
.
Row   LT1    LT2    LT3    LT4    LT5    LT6    LT7    LT8
15    0      0      0      0      0      0      0      0

Row   LT9    LT10   LT11   LT12   LT13   LT14   LT15   LT16
16    0      0      0      0      0      0      0      0

Row   RB1    RB2    RB3    RB4    RB5    RB6    RB7    RB8
17    0      0      0      0      0      0      0      0

Row   RB9    RB10   RB11   RB12   RB13   RB14   RB15   RB16
18    0      0      0      0      0      0      0      0

Row   SG1    SG2    *      OC     CC     CLKPUL *      IAMET
19    1      0      0      0      0      0      0      1

=>
```

Figure 7.11 TAR ROW LIST Command Example.

TIM Command (View/Change Time)

TIM displays the relay clock. To set the clock, type **TIM** and the desired setting, then press **<Enter>**. Separate the hours, minutes, and seconds with colons, semicolons, spaces, commas, or slashes. To set the clock to 23:30:00, enter the information shown in the first line below:

NOTE: After setting the time, allow at least 60 seconds before powering down the relay or the new setting may be lost.

```
=>TIM 23:30:00 <Enter>
23:30:00
=>
```

Figure 7.12 Setting the Clock With the TIM Command.

TRI Command (Trigger Event Report)

Issue the **TRI** command to generate an event report:

```
=>TRI <Enter>
Triggered
=>
```

Figure 7.13 Issuing the TRI Command.

If the serial port AUTO setting = Y, the relay sends the summary event report:

```
GENERATOR 1                       Date: 01/05/02    Time: 00:11:06.113
STATION A

Event: TRIG  Frequency: 60.0
Targets: 11000000          Current IA:   0
Voltages VA,VB,VC,VS,V2,3V0:   0    0    0    0    0    0
=>>
```

Figure 7.14 Generating an Event Report With the TRI Command.

See *Section 3: Analyzing Events* for more information on event reports.

Access Level B Commands

CLO Command (Close Breaker)

The **CLO** (CLOSE) command asserts Relay Word bit CC for 1/4 cycle when it is executed. Relay Word bit CC can then be programmed into SELOGIC control equations in order to assert output contacts (See *Breaker Control Example on page R.2.8*).

To issue the **CLO** command, enter the following:

```
==>CLO <Enter>
Close Breaker  (Y/N) ? Y <Enter>
Are you sure (Y/N) ? Y <Enter>
==>
```

Figure 7.15 Issuing the CLO Command.

Typing **N <Enter>** after either of the above prompts will abort the command.

OPE Command (Open Breaker)

The **OPE** (OPEN) command asserts Relay Word bit OC for 1/4 cycle when it is executed. Relay Word bit OC can then be programmed into SELOGIC control equations in order to assert output contacts (See *Breaker Control Example on page R.2.8*).

To issue the **OPE** command, enter the following:

```
==>OPE <Enter>
Open Breaker  (Y/N) ? Y <Enter>
Are you sure (Y/N) ? Y <Enter>
==>
```

Figure 7.16 Issuing the OPE Command.

Typing **N <Enter>** after either of the above prompts will abort the command.

PUL Command (Pulse Output Contact)

The **PUL** command allows you to pulse any of the output contacts for a specified length of time. The command format is:

PUL *x y*

Where

x = the output name (e.g. OUT1, OUT5, ALARM).

y = the pulse duration (1–30) in seconds. If y is not specified, the pulse duration defaults to 1 second.

To pulse OUT1 for 5 seconds, enter the following:

```
==>PUL OUT1 5 <Enter>
Are you sure (Y/N) ? Y <Enter>
==>
```

Figure 7.17 Issuing the PUL Command.

If the response to the “Are you sure (Y/N) ?” action prompt is N or n, the command is aborted.

The relay generates an event report if any of the OUT1 through OUT5 contacts are pulsed. The **PUL** command is primarily used for testing purposes.

Access Level 2 Commands

CON Command (Control Remote Bit)

The **CON** command is a two-step command that allows you to control Relay Word bits RB1 through RB16 (see Rows 17 and 18 in *Appendix A: Relay Word Bits*). At the Access Level 2 action prompt, type **CON**, a space, and the number of the remote bit you wish to control (1-16). The relay responds by repeating your command followed by a colon. At the colon, type the Control subcommand you wish to perform.

The following example shows the steps necessary to pulse Remote Bit 5 (RB5):

```
=>>CON 5 <Enter>
CONTROL RB5: PRB 5 <Enter>
=>>
```

Figure 7.18 Issuing the CON Command.

You must enter the same remote bit number in both steps in the command. If the bit numbers do not match, the relay responds as follows:

```
Invalid Command
```

Table 7.2 SEL-547 Control Subcommands

Subcommand	Description
SRB *n*	Set Remote Bit *n* (ON position)
CRB *n*	Clear Remote Bit *n* (OFF position)
PRB *n*	Pulse Remote Bit *n* for 1/4 cycle (MOMENTARY position)

See *Remote Control Switches (Remote Bits) on page R.2.15* for more information.

COP m n Command (Copy Setting Group)

Copy relay and SELOGIC control equation settings from setting Group *m* to setting Group *n* with the **COP *m n*** command. Setting group numbers range from 1 to 6. After entering settings into one setting group with the **SET** and **SET L** commands, copy them to the other groups with the **COP** command. Use the **SET** and **SET L** commands to modify the copied settings. The relay disables for a few seconds and the ALARM output pulses if you copy settings into the active group. This is similar to a Group Change (see *Section 2: SELOGIC Control Equation Programming*).

For example, to copy settings from Group 1 to Group 3 issue the following command:

```
=>>COP 1 3 <Enter>
Copy 1 to 3
Are you sure (Y/N) ? Y <Enter>

Please wait...
Settings copied
=>>
```

Figure 7.19 Copying Settings With the COP m n Command.

GRO n Command (Change Active Setting Group)

The **GRO *n*** command changes the active setting group to setting Group *n*. To change to settings Group 2, enter the following:

```
==>GRO 2 <Enter>
Change to Group 2
Are you sure (Y/N) ? Y <Enter>
Active Group = 2
==>
```

Figure 7.20 Changing the Active Setting Group With the GRO n Command.

The relay switches to Group 2 and pulses the ALARM contact. If the serial port AUTO setting = Y, the relay sends the group switch report:

```
==>
FEEDER 1                          Date: 02/02/01    Time: 09:40:34.611
STATION A

Active Group = 2
==>
```

Figure 7.21 Successful Group Switch Report.

If any of the SELOGIC control equations settings SS1 through SS2 are asserted to logical 1, the active setting group may not be changed with the **GRO** command; SELOGIC control equations settings SS1 through SS6 have priority over the **GRO** command in active setting group control.

For example, assume setting Group 1 is the active setting group and the SS1 setting is asserted to logical 1 (e.g., SS1 = IN101 and optoisolated input IN101 is asserted). An attempt to change to setting Group 2 with the **GRO 2** command will not be accepted:

```
==>GRO 2 <Enter>
Change to Group 2
Are you sure (Y/N) ? Y<Enter>
 Changing
No group change
Active Group = 1
==>
```

Figure 7.22 Unsuccessful Group Switch Report.

For more information on setting group selection, see *Multiple Setting Groups on page R.2.25*.

PAS Command (View/Change Passwords)

PAS allows you to inspect or change existing passwords (see *Table 7.3*).

⚠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.

Table 7.3 Factory Default Passwords—Access Levels 1, B, and 2

Access Level	Factory Default Password
1	OTTER
B	EDITH
2	TAIL

To inspect passwords, type the following:

```
=>>PAS <Enter>
1:OTTER
B:EDITH
2:TAIL
=>>
```

Figure 7.23 Inspecting Passwords With the PAS Command.

To change the password for Access Level 1 to Ot3579, enter the following:

```
=>>PAS 1 Ot3579 <Enter>
Set
=>>
```

Figure 7.24 Changing Passwords With the PAS Command.

Similarly, **PAS B** and **PAS 2** can be used to change the Level B and Level 2 passwords, respectively.

Passwords may include up to six characters. The following characters are valid:

- A–Z
- a–z
- 0–9
- - (hyphen)
- . (period)

Upper- and lowercase letters are treated as different characters. Strong passwords consist of six characters, with at least one special character or digit and mixed case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks.

Examples of valid, distinct strong passwords include the following:

Ot3579 A24.68 Ih2dcs 4u-Iwg .351s.

After entering new passwords, type **PAS <Enter>** to inspect them. Make sure they are what you intended, and record the new passwords.

If you wish to disable password protection for a specific access level, simply set the password to DISABLE. For example, **PAS 1 DISABLE** disables password protection for Level 1.

SET Command (Change Settings)

The **SET** command allows you to view or change the relay settings. For more information on relay settings, see *Section 8: Settings*.

VER Command (Show Relay Configuration and Firmware Version)

The **VER** command provides relay configuration and information such as nominal current input ratings.

An example printout of the **VER** command follows:

```
Level 2
=>>VER <Enter>
Partnumber: 0547OXXXXXXXXXX

Mainboard: 0547
Analog Input Voltage (PT): 300 Vac, Wye-connected
Analog Input Current (CT): 5 Amp
Extended Relay Features:
  Base Model

SELboot checksum 5B90 OK
FID=SEL-547-R100-V0-Z001001-D20020430

SELboot-547-R101

If above information is unexpected,
contact SEL for assistance
=>>
```

Figure 7.25 VER Command Output.

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Section 8
Settings

This section discusses settings in the following sequence:

- Settings changes via the serial port
- EZ settings force global and Group 1 settings
- Settings sheets

Settings Changes via the Serial Port

Change or view settings with the **SET** and **SHOWSET** serial port commands. *Table 8.1* lists the serial port **SET** commands.

The relay hides some settings based upon other settings. If you set an enable setting to OFF, for example, the relay hides all settings associated with that enable setting.

Table 8.1 Serial Port SET Commands

Command	Settings Type	Description	Settings Sheets[a]
SET *n*	Group *n*	Voltage elements, frequency element, power elements, timers, etc., for settings Group *n* (*n* = 1, 2)	1–4
SET L *n*	SELOGIC (Group *n*)	SELOGIC® control equations for settings Group *n* (*n* = 1, 2)	5–7
SET G	Global	Global settings	8
SET R	SER	Sequential Events Recorder trigger conditions	9
SET P *n*	Port	Serial port settings for Serial Port *n* (*n* = 1 or F)	10
SET E	EZ	Reduced set of settings for distributed generator interconnections	[b]

[a] Settings Sheets are located at the end of this section.
[b] See the SEL-547 Distributed Generator Interconnection Relay User's Guide.

When you issue the **SET** command, the relay presents a list of settings, one at a time. Enter a new setting, or press **<Enter>** to accept the existing setting. Editing keystrokes are shown in *Table 8.2*.

Table 8.2 Set Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains setting and moves to the next setting.
^ <Enter>	Returns to previous setting.
< <Enter>	Returns to previous setting section.
> <Enter>	Moves to next setting section.
END <Enter>	Exits editing session, then prompts you to save the settings.
<Ctrl+X>	Aborts editing session without saving changes.

The relay checks each entry to ensure that it is within the setting range. If an entry is not within the setting range, an "Out of Range" message is generated, and the relay prompts for the setting again.

When all the settings are entered, the relay displays the new settings and prompts for approval to enable them. Answer **Y <Enter>** to enable the new settings. If changes are made to the Global or SER settings (see *Table 8.1*)—or if changes are made to the Group or SELOGIC settings for the active setting group (see *Table 8.1*)—the relay is disabled while it saves the new settings. The ALARM contact closes momentarily (see *Figure 2.27 on page R.2.30*) and the ENABLED LED extinguishes (see *Table 2.8 on page R.2.32*) while the relay is disabled. The relay is disabled for about 1 second. If SELOGIC settings are changed for the active group, the relay can be disabled for up to 15 seconds.

If changes are made to the Relay or Logic settings for a setting group other than the active setting group (see *Table 8.1*), the relay is not disabled while it saves the new settings. The ALARM contact closes momentarily (see *Figure 2.27 on page R.2.30*), but the ENABLED LED remains on (see *Table 2.8 on page R.2.32*) while the new settings are saved.

View settings with the respective serial port **SHOWSET** commands (**SHO**, **SHO L**, **SHO G**, **SHO R**, **SHO P**). See *SHO Command (Show/View Settings) on page R.7.9*.

EZ Settings Force Global and Group 1 Settings

Figure 8.1 shows the overall relationship between EZ settings and the global and group settings. Refer to *SEL-547 Relay Settings Sheets on page R.SET.1*.

Global setting EZSET (= Y or N) enables the EZ settings when it is set as EZSET = Y. This enabling of the EZ settings causes these EZ settings values to be forced on to their corresponding global and Group 1 settings values (see correspondence in *Table 8.3* and *Table 8.4*, respectively). The Group 1 and global settings then take on the corresponding EZ setting value—they retain no memory of their old values. Not all global and Group 1 settings are forced to these new EZ settings values—just those that have corresponding EZ settings, as indicated in *Table 8.3* and *Table 8.4*.

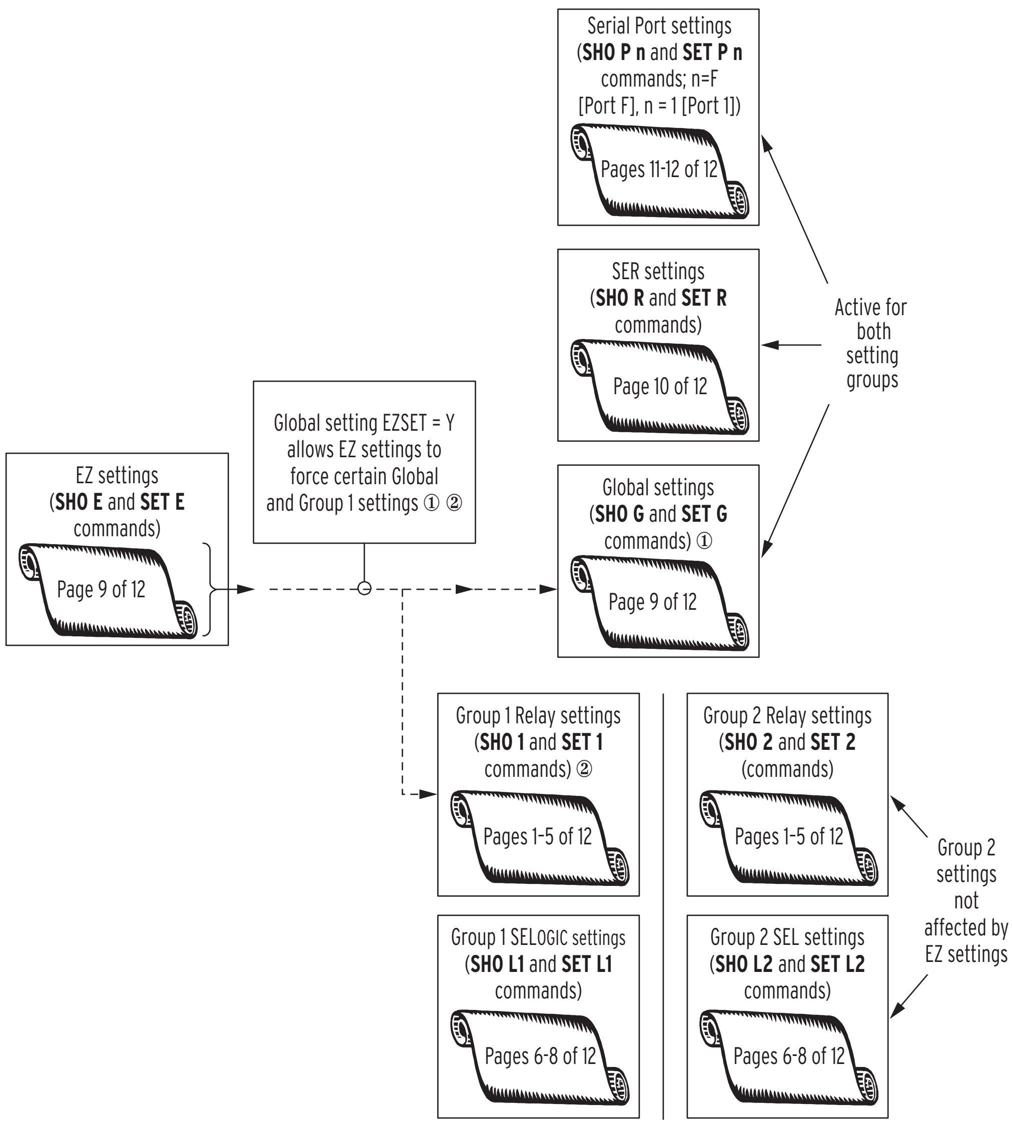

Figure 8.1 EZ Settings Relationship With Global and Group Settings.
① See *Table 8.3*; ② See *Table 8.4*

Table 8.3 Global Settings and Corresponding EZ Settings

Description	Setting Label	Default Value	Corresponding EZ Setting (if any)
Enable EZ Settings(Y,N)	EZSET	Y	
Phase Potential Connection(WYE)	PCONN	WYE	3PCONN
Group Change Delay(0.00–16000cyc)	TGR	0.00	
Nominal Frequency(50,60Hz)	NFREQ	60	FREQ
Phase Rotation(ABC,ACB)	PHROT	ABC	ROTATE
Date Format(MDY,YMD)	DATE_F	MDY	DATE
Length of Event Report(15,30,60cyc)	LER	15	
Cycle Length of Prefault in Event Report(1–14) OR Cycle Length of Prefault in Event Report(1–29) OR Cycle Length of Prefault in Event Report(1–59)	PRE	4	
Clock Pulse Interval(OFF,5–3600sec)	INTRVL	30	LEDFL

Table 8.4 Group Settings and Corresponding EZ Settings (Sheet 1 of 3)

Description	Setting Label	Default Value	Corresponding EZ Setting (if any)
Identifier and Instrument Transformer Settings			
Relay Identifier(30characters)	RID	GENERATOR 1	RELID
Terminal Identifier(30characters)	TID	STATION A	TERMID
Current Transformer Ratio(1–1000)	CTR	80	CRATIO
Enable Settings			
Voltage Elements(Y,N)	EVOLT	Y	see *Table 8.5*
Synchronism Check(Y,N)	E25	Y	25DIFP—see *Table 8.5*
Frequency Elements(N,1–6)	E81	6	see *Table 8.5*
SELOGIC Variable Timers(N,1–16)	ESV	16	see *Table 8.5*
Power Elements(N,1–4)	EPWR	4	see *Table 8.5*
Voltage Element Pickup Settings			
Phase Undervoltage Pickup(OFF,55–400V,sec)	27P1P	60	27UV1P—see *Table 8.5*
Phase Undervoltage Pickup(OFF,55–400V,sec)	27P2P	106	27UV2P—see *Table 8.5*
Phase Undervoltage Pickup(OFF,55–400V,sec)	27P3P	OFF	
Phase Undervoltage Pickup(OFF,55–400V,sec)	27P4P	OFF	
Phase Overvoltage Pickup(OFF,55–400V,sec)	59P1P	132	59OV1P—see *Table 8.5*
Phase Overvoltage Pickup(OFF,55–400V,sec)	59P2P	144	59OV2P—see *Table 8.5*
Phase Overvoltage Pickup(OFF,55–400V,sec)	59P3P	OFF	
Phase Overvoltage Pickup(OFF,55–400V,sec)	59P4P	OFF	
Zero-Seq(3V0) Overvoltage PU(OFF,55–400V,sec)	59N1P	OFF	
Zero-Seq(3V0) Overvoltage PU(OFF,55–400V,sec)	59N2P	OFF	

Table 8.4 Group Settings and Corresponding EZ Settings (Sheet 2 of 3)

Description	Setting Label	Default Value	Corresponding EZ Setting (if any)
Neg-Seq(V2) Overvoltage PU(OFF,55–267V,sec)	59Q1P	60	see *Table 8.5*
Neg-Seq(V2) Overvoltage PU(OFF,55–267V,sec	59Q2P	OFF	
Pos-Seq(V1) Overvoltage PU(OFF,55–400V,sec)	59V1P	OFF	
Channel VS Undervoltage PU(OFF,55–400V,sec)	27SP	OFF	
Channel VS Overvoltage PU(OFF,55–400V,sec)	59S1P	OFF	
Channel VS Overvoltage PU(OFF,55–400V,sec)	59S2P	OFF	
Frequency Element Settings			
Undervoltage Block(55–400V,sec)	27B81P	84	27BLKP
Frequency Pickup(OFF,40.1–69.9Hz)	81D1P	57.0	81OU1P
Frequency Element Time Delay(5.00–16000cyc)	81D1D	6.00	81OU1D
Frequency Pickup(OFF,40.1–69.9Hz)	81D2P	59.3	81OU2P
Frequency Element Time Delay(5.00–16000cyc)	81D2D	116.00	81OU2D
Frequency Pickup(OFF,40.1–69.9Hz)	81D3P	60.5	81OU3P
Frequency Element Time Delay(5.00–16000cyc)	81D3D	6.00	81OU3D
Frequency Pickup(OFF,40.1–69.9Hz)	81D4P	OFF	81OU4P
Frequency Element Time Delay(5.00–16000cyc)	81D4D	6.00	81OU4D
Frequency Pickup(OFF,40.1–69.9Hz)	81D5P	OFF	
Frequency Element Time Delay(5.00–16000cyc)	81D5D	6.00	
Frequency Pickup(OFF,40.1–69.9Hz)	81D6P	OFF	
Frequency Element Time Delay(5.00–16000cyc)	81D6D	6.00	
Synchronism Check Element Settings			
Voltage Window—Low Threshold(55–400V,sec)	25VLO	114	25DIFP—see *Table 8.5*
Voltage Window—High Threshold(55–400V,sec)	25VHI	126	25DIFP—see *Table 8.5*
Maximum Slip Frequency(0.1–1Hz)	25SF	0.3	25SLP
Maximum Angle 1 (2–60deg)	25ANG1	20	25ANG
Maximum Angle 2 (2–60deg)	25ANG2	20	
Synch. Phase for Channel VS			
(VA,VB,VC or 0–330 deg. lag VA)	SYNCP	VA	
Breaker Close Time for Angle Comp.(0.00–60cyc)	TCLOSD	0.00	
Power Element Settings			
Three-Phase Power Pickup(OFF,40–900VA,sec)	PWR1P	60	32P
Power Element Type(+WATTS, –WATTS, +VARS, –VARS)	PWR1T	–WATTS	32FR—see *Table 8.5*
Power Element Time Delay(0.00–16000cyc)	PWR1D	30.00	32D
Three-Phase Power Pickup(OFF,40–900VA,sec)	PWR2P	OFF	
Power Element Type(+WATTS, –WATTS, +VARS, –VARS)	PWR2T	–WATTS	
Power Element Time Delay(0.00–16000cyc)	PWR2D	0.00	
Three-Phase Power Pickup(OFF,40–900VA,sec)	PWR3P	OFF	
Power Element Type(+WATTS, –WATTS, +VARS, –VARS)	PWR3T	–WATTS	

Table 8.4 Group Settings and Corresponding EZ Settings (Sheet 3 of 3)

Description	Setting Label	Default Value	Corresponding EZ Setting (if any)
Power Element Time Delay(0.00–16000cyc)	PWR3D	0.00	
Three-Phase Power Pickup(OFF,40–900VA,sec)	PWR4P	OFF	
Power Element Type(+WATTS, –WATTS, +VARS, –VARS)	PWR4T	–WATTS	
Power Element Time Delay(0.00–16000cyc)	PWR4D	0.00	
SELogic Variable Timer Settings			
SV_ Timer Pickup (0.00–999999cyc)	SV1PU	0.00	
SV_ Timer Dropout(0.00–999999cyc)	SV1DO	0.00	
SV_ Timer Pickup (0.00–999999cyc)	SV2PU	0.00	
SV_ Timer Dropout(0.00–999999cyc)	SV2DO	0.00	
SV_ Timer Pickup (0.00–999999cyc)	SV3PU	0.00	
SV_ Timer Dropout(0.00–999999cyc)	SV3DO	0.00	
SV_ Timer Pickup (0.00–999999cyc)	SV4PU	0.00	
SV_ Timer Dropout(0.00–999999cyc)	SV4DO	0.00	
SV_ Timer Pickup (0.00–999999cyc)	SV5PU	0.00	
SV_ Timer Dropout(0.00–999999cyc)	SV5DO	0.00	
SV_ Timer Pickup (0.00–999999cyc)	SV6PU	0.00	
SV_ Timer Dropout(0.00–999999cyc)	SV6DO	0.00	
SV_ Timer Pickup (0.00–16000cyc)	SV7PU	6.00	27UV1D
SV_ Timer Dropout(0.00–16000cyc)	SV7DO	15.00	
SV_ Timer Pickup (0.00–16000cyc)	SV8PU	116.00	27UV2D
SV_ Timer Dropout(0.00–16000cyc)	SV8DO	15.00	
SV_ Timer Pickup (0.00–16000cyc)	SV9PU	56.00	59OV1D
SV_ Timer Dropout(0.00–16000cyc)	SV9DO	15.00	
SV_ Timer Pickup (0.00–16000cyc)	SV10PU	6.00	59OV2D
SV_ Timer Dropout(0.00–16000cyc)	SV10DO	15.00	
SV_ Timer Pickup (0.00–16000cyc)	SV11PU	0.00	
SV_ Timer Dropout(0.00–16000cyc)	SV11DO	15.00	
SV_ Timer Pickup (0.00–16000cyc)	SV12PU	0.00	
SV_ Timer Dropout(0.00–16000cyc)	SV12DO	15.00	
SV_ Timer Pickup (0.00–16000cyc)	SV13PU	30.00	
SV_ Timer Dropout(0.00–16000cyc)	SV13DO	15.00	
SV_ Timer Pickup (0.00–16000cyc)	SV14PU	0.00	
SV_ Timer Dropout(0.00–16000cyc)	SV14DO	0.00	
SV_ Timer Pickup (0.00–16000cyc)	SV15PU	0.00	
SV_ Timer Dropout(0.00–16000cyc)	SV15DO	0.00	
SV_ Timer Pickup (0.00–16000cyc)	SV16PU	0.00	
SV_ Timer Dropout(0.00–16000cyc)	SV16DO	0.00	

For most setting forcing, the EZ setting is directly substituted for the corresponding global or Group 1 setting, when global setting EZSET is changed to EZSET = Y. Some of the Group 1 settings are derived or otherwise forced to some value when global setting EZSET is changed to EZSET = Y, as shown in *Table 8.5*.

Table 8.5 Derivation of Particular Forced Group 1 Settings

Group 1 Setting	Setting Derivation (when Global Setting EZSET = Y)
EVOLT	EVOLT = Y
E25	E25 = Y (if EZ setting 25DIFP ≠ OFF) E25 = N (if EZ setting 25DIFP = OFF)
E81	E81 = 6 (upper limit of setting range)
ESV	ESV = 16 (upper limit of setting range)
EPWR	EPWR = 4 (upper limit of setting range)
27P1P	27P1P = (27PUV1P/100) • (NOMV/_3) Group 1 settings 27P2P, 59P1P, and 59P2P are derived similarly, from their corresponding EZ settings
59Q1P	59Q1P = 0.5 • (NOMV/_3)
25VLO	25VLO = (NOMV/_3) – (diff/2) [diff = (25DIFP/100) • (NOMV/_3)]
25VHI	25VHI = (NOMV/_3) + (diff/2) [diff = (25DIFP/100) • (NOMV/_3)]
PWR1T	PWR1T = +WATTS (if EZ setting 32FR = F) PWR1T = –WATTS (if EZ setting 32FR = R)

If global setting EZSET is then changed back to EZSET = N, the affected global and Group 1 settings retain the settings they were forced to previously, unless otherwise changed later, via the global setting command **SET G** and the Group 1 setting command **SET 1**, respectively.

Settings Forcing Analogy

An analogy for this setting forcing is found in the use of a die in a machine shop:

- The die is the EZ settings.
- The active use of the die is when global setting EZSET is set as EZSET = Y.
- The metal piece is the global and Group 1 settings (that have correspondence to the EZ settings; see *Table 8.3* and *Table 8.4*).

When the metal piece is struck with the die (global setting EZSET = Y), the metal piece (global and Group 1 settings) then takes on the shape of the die (EZ settings). If the metal piece is then set aside and the die is no longer used (global setting EZSET = N), the metal piece still retains the shape of the die (EZ settings). If other machinery is then used on the metal piece (command **SET G** or command **SET 1** make settings changes on the global or Group 1 settings, respectively; still global setting EZSET = N), the metal piece is changed. But, if the metal piece is then struck with the die again (global setting EZSET = Y again), the metal piece (global and group 1 settings) takes on the shape of the die (EZ settings) again.

Settings Forcing Example

Consider Group 1 setting CTR (Current Transformer Ratio; see *Table 8.3*) and global setting PHROT (Phase Rotation; see *Table 8.4*). Their corresponding EZ settings are CRATIO and ROTATE, respectively. If global setting EZSET = Y and EZ settings CRATIO = 80 and ROTATE = ABC, then the corresponding global/Group 1 settings are forced to PHROT = ABC and CTR = 80, respectively:

Table 8.6 Global Setting EZSET = Y

EZ Settings	Forced Settings
ROTATE = ABC	PHROT = ABC (global setting)
CRATIO = 80	CTR = 80 (Group 1 setting)

Now change global setting EZSET to EZSET = N. With global setting EZSET = N, global setting PHROT and Group 1 setting CTR are no longer forced by the EZ settings and can be changed with global setting command **SET G** (e.g., PHROT = ACB) and Group 1 setting command **SET 1** (e.g., CTR = 100), respectively:

Table 8.7 Set Global Setting EZSET to EZSET = N

EZ Settings	Settings Changed With SET G and SET 1 Commands
ROTATE = ABC	PHROT = ACB (global setting)
CRATIO = 80	CTR = 100 (Group 1 setting)

Change global setting EZSET back to EZSET = Y. Global setting PHROT and Group 1 setting CTR are then forced back to PHROT = ABC and CTR = 80, respectively.

Table 8.8 Global Setting EZSET = Y

EZ Settings	Forced Settings
ROTATE = ABC	PHROT = ABC (global setting)
CRATIO = 80	CTR = 80 (Group 1 setting)

Note that the EZ settings are never directly the active settings—they are effectively active by forcing certain corresponding global settings and Group 1 settings, when global setting EZSET = Y. The global settings are active all the time. The Group 1 settings are active only if settings Group 1 is the active settings group (see subsection *Multiple Setting Groups on page R.2.25* for more information).

Group 2 Settings Not Forced

In *Figure 8.1*, notice that the Group 2 settings are not affected at all by EZ settings—none of the Group 2 settings are forced by the EZ settings.

Global settings are always active. So, even if Group 2 is the active settings group, certain global settings (see *Table 8.3*) are still forced by the EZ settings, if global setting EZSET = Y. Certain Group 1 settings (see *Table 8.4*) are also forced by the EZ settings, but these forced Group 1 settings only have effect if settings Group 1 is the active settings group (see subsection *Multiple Setting Groups on page R.2.25* for more information).

EZ Setting NOMV

Notice that EZ setting NOMV (nominal voltage, line-to-line) does not have a corresponding Group 1 or global setting that it forces, but it is used in calculations shown in *Table 8.5*. It converts the EZ voltage pickup settings (set in terms of percentage of nominal voltage) to actual line-to-neutral voltage values for the corresponding Group 1 voltage element pickup settings.

SEL-547 Relay Settings Sheets

These settings sheets include the definition and input range for each setting in the relay.

Group n Settings (Serial Port Command SET n, n = 1, 2)

Identifier Labels

Relay Identifier (30 characters)

RID = ______________________________

Terminal Identifier (30 characters)

TID = ______________________________

Current Transformer Ratio for Current Channel IA

Current Transformer Ratio (1–1000)	**CTR**	= ________

Enable Settings

Voltage elements (Y, N) (see *Figure 1.1, Figure 1.2, and Figure 1.3*)	**EVOLT**	= ________
Synchronism check (Y, N) (see *Figure 1.4 and Figure 1.5*)	**E25**	= ________
Frequency elements (N, 1–6) (see *Figure 1.8*)	**E81**	= ________
SELOGIC® Control Equation Variable Timers (N, 1–16) (see *Figure 2.3 and Figure 2.4*)	**ESV**	= ________
Power element levels (N, 1–4) (see *Figure 1.9*)	**EPWR**	= ________

Voltage Elements (see Figure 1.1, Figure 1.2, and Figure 1.3)

(Make the following settings if preceding enable setting EVOLT =Y)

Phase undervoltage pickup (OFF, 55–400 V secondary)	**27P1P**	= ________
Phase undervoltage pickup (OFF, 55–400 V secondary)	**27P2P**	= ________
Phase undervoltage pickup (OFF, 55–400 V secondary)	**27P3P**	= ________
Phase undervoltage pickup (OFF, 55–400 V secondary)	**27P4P**	= ________
Phase overvoltage pickup (OFF, 55–400 V secondary)	**59P1P**	= ________
Phase overvoltage pickup (OFF, 55–400 V secondary)	**59P2P**	= ________
Phase overvoltage pickup (OFF, 55–400 V secondary)	**59P3P**	= ________
Phase overvoltage pickup (OFF, 55–400 V secondary)	**59P4P**	= ________
Zero-sequence (3V0) overvoltage pickup (OFF, 55–400 V secondary)	**59N1P**	= ________

Zero-sequence (3V0) overvoltage pickup (OFF, 55–400 V secondary)	**59N2P**	= ________
Negative-sequence (V2) overvoltage pickup (OFF, 55–267 V secondary)	**59Q1P**	= ________
Negative-sequence (V2) overvoltage pickup (OFF, 55–267 V secondary)	**59Q2P**	= ________
Positive-sequence (V1) overvoltage pickup (OFF, 55–400 V secondary)	**59V1P**	= ________
Channel VS undervoltage pickup (OFF, 55–400 V secondary)	**27SP**	= ________
Channel VS overvoltage pickup (OFF, 55–400 V secondary)	**59S1P**	= ________
Channel VS overvoltage pickup (OFF, 55–400 V secondary)	**59S2P**	= ________

Frequency Element (see Figure 1.8)

(Make the following settings if preceding enable setting E81 = 1–6)

Phase undervoltage block (OFF, 55–400 V secondary)	**27B81P**	= ________
Level 1 pickup (OFF, 40.1–69.9 Hz)	**81D1P**	= ________
Level 1 time delay (5.00–16000.00 cycles in 0.25-cycle steps)	**81D1D**	= ________
Level 2 pickup (OFF, 40.1–69.9 Hz)	**81D2P**	= ________
Level 2 time delay (5.00–16000.00 cycles in 0.25-cycle steps)	**81D2D**	= ________
Level 3 pickup (OFF, 40.1–69.9 Hz)	**81D3P**	= ________
Level 3 time delay (5.00–16000.00 cycles in 0.25-cycle steps)	**81D3D**	= ________
Level 4 pickup (OFF, 40.1–69.9 Hz)	**81D4P**	= ________
Level 4 time delay (5.00–16000.00 cycles in 0.25-cycle steps)	**81D4D**	= ________
Level 5 pickup (OFF, 40.1–69.9 Hz)	**81D5P**	= ________
Level 5 time delay (5.00–16000.00 cycles in 0.25-cycle steps)	**81D5D**	= ________
Level 6 pickup (OFF, 40.1–69.9 Hz)	**81D6P**	= ________
Level 6 time delay (5.00–16000.00 cycles in 0.25-cycle steps)	**81D6D**	= ________

Synchronism Check Elements (see Figure 1.4 and Figure 1.5)

(Make the following settings if preceding enable setting E25 = Y)

Voltage window—low threshold (OFF, 55–400 V secondary)	**25VLO**	= ________
Voltage window—high threshold (OFF, 55–400 V secondary)	**25VHI**	= ________
Maximum slip frequency (0.1–1.0 Hz)	**25SF**	= ________
Maximum angle 1 (2°–60°)	**25ANG1**	= ________
Maximum angle 2 (2°–60°)	**25ANG2**	= ________

Synchronizing phase (VA, VB, VC or 0° to 330° in 30° steps; degree option is for V_S not in phase with V_A, V_B, or V_C—set with respect to V_S constantly lagging V_A)	**SYNCP**	= ________
Breaker close time for angle compensation (0.00–60.00 cycles in 0.25-cycle steps)	**TCLOSD**	= ________

Power Elements (see Figure 1.9)

(Number of power element settings dependent on preceding enable setting EPWR = 1–4)

Three-Phase Power Element 1 Pickup (OFF, 40–900 VA secondary, three-phase)	**PWR1P**	= ________
Pwr Ele. 1 Type (+WATTS, -WATTS, +VARS, -VARS)	**PWR1T**	= ________
Pwr Ele. 1 Time Delay (0.00–16000.00 cyc. in 0.25-cycle steps)	**PWR1D**	= ________
Three-Phase Power Element 2 Pickup (OFF, 40–900 VA secondary, three-phase)	**PWR2P**	= ________
Pwr Ele. 2 Type (+WATTS, -WATTS, +VARS, -VARS)	**PWR2T**	= ________
Pwr Ele. 2 Time Delay (0.00–16000.00 cyc. in 0.25-cycle steps)	**PWR2D**	= ________
Three-Phase Power Element 3 Pickup (OFF, 40–900 VA secondary, three-phase)	**PWR3P**	= ________
Pwr Ele. 3 Type (+WATTS, -WATTS, +VARS, -VARS)	**PWR3T**	= ________
Pwr Ele. 3 Time Delay (0.00–16000.00 cyc. in 0.25-cycle steps)	**PWR3D**	= ________
Three-Phase Power Element 4 Pickup (OFF, 40–900 VA secondary, three-phase)	**PWR4P**	= ________
Pwr Ele. 4 Type (+WATTS, -WATTS, +VARS, -VARS)	**PWR4T**	= ________
Pwr Ele. 4 Time Delay (0.00–16000.00 cyc. in 0.25-cycle steps)	**PWR4D**	= ________

SELogic Control Equation Variable Timers (see Figure 2.3 and Figure 2.4)

(Number of timer pickup/dropout settings dependent on preceding enable setting ESV = 1–16)

SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1PU**	= ________
SV1 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1DO**	= ________
SV2 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2PU**	= ________
SV2 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2DO**	= ________

SV3 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3PU**	= ________
SV3 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3DO**	= ________
SV4 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4PU**	= ________
SV4 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4DO**	= ________
SV5 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5PU**	= ________
SV5 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5DO**	= ________
SV6 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6PU**	= ________
SV6 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6DO**	= ________
SV7 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7PU**	= ________
SV7 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7DO**	= ________
SV8 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8PU**	= ________
SV8 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8DO**	= ________
SV9 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9PU**	= ________
SV9 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9DO**	= ________
SV10 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10PU**	= ________
SV10 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10DO**	= ________
SV11 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11PU**	= ________
SV11 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11DO**	= ________
SV12 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12PU**	= ________
SV12 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12DO**	= ________
SV13 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13PU**	= ________
SV13 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13DO**	= ________

SV14 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14PU**	=________
SV14 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14DO**	=________
SV15 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15PU**	=________
SV15 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15DO**	=________
SV16 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16PU**	=________
SV16 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16DO**	=________

SELOGIC Control Equation (Group n) Settings

(Serial Port Command SET L n; n = 1, 2)

SELOGIC control equation settings consist of Relay Word bits (see *Table A.1*) and SELOGIC control equation operators * (AND), + (OR), ! (NOT), / (rising edge), \ (falling edge), and ( ) (parentheses). Numerous SELOGIC control equation settings examples are given in *Section 1* and *Section 2*. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). *Section 2: SELOGIC Control Equation Programming* gives SELOGIC control equation details, examples, and limitations.

SELOGIC Control Equation Variable Timer Input Equations (see Figure 2.21 and Figure 2.22)

SELOGIC Control Equation Variable SV1	**SV1**	= ____________
SELOGIC Control Equation Variable SV2	**SV16**	= ____________
SELOGIC Control Equation Variable SV3	**SV16**	= ____________
SELOGIC Control Equation Variable SV4	**SV16**	= ____________
SELOGIC Control Equation Variable SV5	**SV16**	= ____________
SELOGIC Control Equation Variable SV6	**SV16**	= ____________
SELOGIC Control Equation Variable SV7	**SV16**	= ____________
SELOGIC Control Equation Variable SV8	**SV16**	= ____________
SELOGIC Control Equation Variable SV9	**SV16**	= ____________
SELOGIC Control Equation Variable SV10	**SV16**	= ____________
SELOGIC Control Equation Variable SV11	**SV16**	= ____________
SELOGIC Control Equation Variable SV12	**SV16**	= ____________
SELOGIC Control Equation Variable SV13	**SV16**	= ____________
SELOGIC Control Equation Variable SV14	**SV16**	= ____________
SELOGIC Control Equation Variable SV15	**SV16**	= ____________
SELOGIC Control Equation Variable SV16	**SV16**	= ____________

Front-Panel LED Equations

LED2 (27)	**LED2**	= ____________
LED3 (59)	**LED3**	= ____________
LED4 (81)	**LED4**	= ____________
LED5 (47)	**LED5**	= ____________
LED6 (32)	**LED6**	= ____________
LED7 (25)	**LED7**	= ____________
LED8 (25 Voltage Hot)	**LED8**	= ____________

Output Contact Equations (see Figure 2.27)

Output Contact OUT1	**OUT1**	= ____________
Output Contact OUT2	**OUT2**	= ____________
Output Contact OUT3	**OUT3**	= ____________
Output Contact OUT4	**OUT4**	= ____________
Output Contact OUT5	**OUT5**	= ____________

Setting Group Selection Equations (see Figure 2.6)

Select Setting Group 1	**SS1**	= ____________
Select Setting Group 2	**SS2**	= ____________

Other Equations

Event report trigger conditions (see *Section 3*)	**ER**	= ____________
Block synchronism check elements (see *Figure 1.4*)	**BSYNCH**	= ____________

Latch Bits Set/Reset Equations (see Figure 2.15)

Set Latch Bit LT1	**SET1**	= ____________
Reset Latch Bit LT1	**RST1**	= ____________
Set Latch Bit LT2	**SET2**	= ____________
Reset Latch Bit LT2	**RST2**	= ____________
Set Latch Bit LT3	**SET3**	= ____________
Reset Latch Bit LT3	**RST3**	= ____________
Set Latch Bit LT4	**SET4**	= ____________
Reset Latch Bit LT4	**RST4**	= ____________
Set Latch Bit LT5	**SET5**	= ____________
Reset Latch Bit LT5	**RST5**	= ____________
Set Latch Bit LT6	**SET6**	= ____________
Reset latch Bit LT6	**RST6**	= ____________
Set Latch Bit LT7	**SET7**	= ____________
Reset Latch Bit LT7	**RST7**	= ____________
Set Latch Bit LT8	**SET8**	= ____________
Reset Latch Bit LT8	**RST8**	= ____________
Set Latch Bit LT9	**SET9**	= ____________
Reset Latch Bit LT9	**RST9**	= ____________

Set Latch Bit LT10	**SET10**	= ______________________
Reset Latch Bit LT10	**RST10**	= ______________________
Set Latch Bit LT11	**SET11**	= ______________________
Reset Latch Bit LT11	**RST11**	= ______________________
Set Latch Bit LT12	**SET12**	= ______________________
Reset Latch Bit LT12	**RST12**	= ______________________
Set Latch Bit LT13	**SET13**	= ______________________
Reset Latch Bit LT13	**RST13**	= ______________________
Set Latch Bit LT14	**SET14**	= ______________________
Reset latch Bit LT14	**RST14**	= ______________________
Set Latch Bit LT15	**SET15**	= ______________________
Reset Latch Bit LT15	**RST15**	= ______________________
Set Latch Bit LT16	**SET16**	= ______________________
Reset Latch Bit LT16	**RST16**	= ______________________

Global Settings (Serial Port Command SET G)

EZ Settings Enable (see Section 3: Basic Relay Operations in the User's Guide)

Enable EZ Settings (Y,N)	**EZSET**	= ____________

Fixed Setting

Phase Potential Connection (WYE [fixed setting])	**PCONN**	= WYE

Settings Group Change Delay (see Multiple Setting Groups on page R.2.25)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps)	**TGR**	= ____________

Power System Configuration

Nominal system frequency (50 Hz, 60 Hz)	**NFREQ**	= ____________
System phase rotation (ABC, ACB)	**PHROT**	= ____________

Date Format

Date format (MDY, YMD)	**DATE_F**	= ____________

Event Report Parameters (see Section 3)

Length of event report (15, 30 cycles)	**LER**	= ____________
Length of prefault in event report (1 to LER-1 cycles in 1-cycle steps)	**PRE**	= ____________

Clock Pulse Signal Setting (see Front-Panel Target LEDs on page R.2.32)

Clock Pulse Interval (OFF, 5, 10, 15, 30, 60, 300, 600, 900, 1800, 3600 minutes)	**INTRVL**	= ____________

Date ___________
Group___________

Sequential Events Recorder Settings (Serial Port Command SET R)

Sequential Events Recorder settings are comprised of three trigger lists. Each trigger list can include up to 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See *Sequential Events Recorder (SER) Report on page R.3.12*.

SER Trigger List 1

SER1 = ______________________________

SER Trigger List 2

SER2 = ______________________________

SER Trigger List 3

SER3 = ______________________________

Date ___________
Group___________

Serial Port n Settings (Serial Port Command SET P n; n = 1, F)

Protocol Settings

Protocol (SEL, LMD, MOD)	**PROTO**	= _________

- ➤ For standard SEL ASCII protocol, set PROTO = SEL.
- ➤ For SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD.
  Refer to *Section 5* for details on the LMD protocol.
- ➤ For Modbus® RTU Protocol, set PROTO = MOD.
  Refer to *Section 6* for details on the Modbus protocol. Only one port at a time can be designated as a Modbus port.

The following three extra settings are used if PROTO = LMD.

LMD Prefix (@, #, $, %, &)	**PREFIX**	= _________
LMD Address (01–99)	**ADDR**	= _________
LMD Settling Time (0–30 seconds)	**SETTLE**	= _________

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200)	**SPEED**	= _________
Data Bits (7, 8) [This setting is not available on a designated Modbus port (setting PROTO = MOD)]	**BITS**	= _________
Parity (O, E, N) {Odd, Even, None}	**PARITY**	= _________
Stop Bits (1, 2)	**STOP**	= _________

Other Port Settings

Time-out (0–30 minutes)	**T_OUT**	= _________
Send Auto Messages to Port (Y, N)	**AUTO**	= _________
Enable Hardware Handshaking (Y, N)	**RTSCTS**	= _________
Fast Operate Enable (Y, N)	**FASTOP**	= _________
Modbus Slave ID (1–247) [This setting is only available on a designated Modbus port (setting PROTO = MOD)]	**MODID**	= _________

Setting T_OUT

- ➤ Set T_OUT to the number of minutes of serial port inactivity for an automatic log out.
- ➤ Set T_OUT = 0 for no port time out.
- ➤ This setting is not available on a designated Modbus port (setting PROTO = MOD).

Setting AUTO

- Set AUTO = Y to allow automatic messages at the serial port.
- This setting is not available on a designated Modbus port (setting PROTO = MOD).

Setting RTSCTS

- Set RTSCTS = Y to enable hardware handshaking.
- With RTSCTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line.
- Setting RTSCTS is only available for serial Port F (EIA-232), when setting PROTO = SEL (SEL ASCII protocol).

Setting RTSCTS

- Set FASTOP = Y to enable binary Fast Operate messages at the serial port.
- Set FASTOP = N to block binary Fast Operate messages.
- This setting is not available on a designated Modbus port (setting PROTO = MOD).
- Refer to Appendix C for the description of the SEL-547 Fast Operate commands.

Appendix A
Relay Word Bits

This section contains a table of the Relay Word bits available in the SEL-547 Relay.

Relay Word Bits

Relay Word bits are used in SELOGIC® control equation settings. Numerous SELOGIC control equation settings examples are given in *Section 1* and *Section 2*. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). *Section 2: SELOGIC Control Equation Programming* gives SELOGIC control equation details, examples, and limitations.

The Relay Word bit row numbers correspond to the row numbers used in the **TAR** command [see *Section 7: ASCII Commands*].

Table A.1 SEL-547 Relay Word Bits

Row	Relay Word Bits[a]							
0	LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
1	*	*	*	*	*	IN3	IN2	IN1[1]
2	ALARM	*	*	OUT5	OUT4	OUT3	OUT2	OUT1[2]
3	27A1	27B1	27C1	27A2	27B2	27C2	27A3	27B3
4	27C3	27A4	27B4	27C4	59A1	59B1	59C1	59A2
5	59B2	59C2	59A3	59B3	59C3	59A4	59B4	59C4
6	59N1	59N2	59Q1	59Q2	59V1	27S	59S1	59S2
7	59VA	59VP	59VS	SF	25A1	25A2	SFAST	SSLOW
8	81D1	81D2	81D3	81D4	81D5	81D6	27B81	*
9	81D1T	81D2T	81D3T	81D4T	81D5T	81D6T	*	*
10	PWR1	PWR2	PWR3	PWR4	*	*	*	*
11	SV1	SV2	SV3	SV4	SV1T	SV2T	SV3T	SV4T
12	SV5	SV6	SV7	SV8	SV5T	SV6T	SV7T	SV8T
13	SV9	SV10	SV11	SV12	SV9T	SV10T	SV11T	SV12T
14	SV13	SV14	SV15	SV16	SV13T	SV14T	SV15T	SV16T
15	LT1	LT2	LT3	LT4	LT5	LT6	LT7	LT8
16	LT9	LT10	LT11	LT12	LT13	LT14	LT15	LT16
17	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8
18	RB9	RB10	RB11	RB12	RB13	RB14	RB15	RB16
19	SG1	SG2	*	OC	CC	CLKPUL	*	IAMET

[a] Asterisks indicate the Relay Word bit position is not used.

Table A.2 Relay Word Bit Definitions for SEL-547 (Sheet 1 of 5)

Row	Bit	Definition	Primary Application
0	LED1	Front-panel ENABLED LED illuminated	Front-panel LED status
	LED2	Front-panel 27 LED illuminated	
	LED3	Front-panel 59 LED illuminated	
	LED4	Front-panel 81 LED illuminated	
	LED5	Front-panel 47 LED illuminated	
	LED6	Front-panel 32 LED illuminated	
	LED7	Front-panel 25 LED illuminated	
	LED8	Front-panel 25 VOLTAGE HOT LED illuminated	
1	IN3	Optoisolated input IN3 asserted (see *Figure 2.7*)	Circuit breaker status, Control via optoisolated inputs
	IN2	Optoisolated input IN2 asserted (see *Figure 2.7*)	
	IN1	Optoisolated input IN1 asserted (see *Figure 2.7*)	
2	ALARM	ALARM output contact indicating that relay failed or **PULSE ALARM** command executed (see *Figure 2.24*)	Output contact status
	OUT5	Output contact OUT5 asserted (see *Figure 2.27*)	
	OUT4	Output contact OUT4 asserted (see *Figure 2.27*)	
	OUT3	Output contact OUT3 asserted (see *Figure 2.27*)	
	OUT2	Output contact OUT2 asserted (see *Figure 2.27*)	
	OUT1	Output contact OUT1 asserted (see *Figure 2.27*)	
3	27A1	A-phase instantaneous undervoltage element (A-phase voltage below pickup setting 27P1P; see *Figure 1.1*)	Control
	27B1	B-phase instantaneous undervoltage element (B-phase voltage below pickup setting 27P1P; see *Figure 1.1*)	
	27C1	C-phase instantaneous undervoltage element (C-phase voltage below pickup setting 27P1P; see *Figure 1.1*)	
	27A2	A-phase instantaneous undervoltage element (A-phase voltage below pickup setting 27P2P; see *Figure 1.1*)	
	27B2	B-phase instantaneous undervoltage element (B-phase voltage below pickup setting 27P2P; see *Figure 1.1*)	
	27C2	C-phase instantaneous undervoltage element (C-phase voltage below pickup setting 27P2P; see *Figure 1.1*)	
	27A3	A-phase instantaneous undervoltage element (A-phase voltage below pickup setting 27P3P; see *Figure 1.1*)	Control
	27B3	B-phase instantaneous undervoltage element (B-phase voltage below pickup setting 27P3P; see *Figure 1.1*)	
4	27C3	C-phase instantaneous undervoltage element (C-phase voltage below pickup setting 27P3P; see *Figure 1.1*)	
	27A4	A-phase instantaneous undervoltage element (A-phase voltage below pickup setting 27P4P; see *Figure 1.1*)	Control
	27B4	B-phase instantaneous undervoltage element (B-phase voltage below pickup setting 27P4P; see *Figure 1.1*)	
	27C4	C-phase instantaneous undervoltage element (C-phase voltage below pickup setting 27P4P; see *Figure 1.1*)	
	59A1	A-phase instantaneous overvoltage element (A-phase voltage above pickup setting 59P1P; see *Figure 1.1*)	

Table A.2 Relay Word Bit Definitions for SEL-547 (Sheet 2 of 5)

Row	Bit	Definition	Primary Application
	59B1	B-phase instantaneous overvoltage element (B-phase voltage above pickup setting 59P1P; see *Figure 1.1*)	
	59C1	C-phase instantaneous overvoltage element (C-phase voltage above pickup setting 59P1P; see *Figure 1.1*)	
	59A2	A-phase instantaneous overvoltage element (A-phase voltage above pickup setting 59P2P; see *Figure 1.1*)	
5	59B2	B-phase instantaneous overvoltage element (B-phase voltage above pickup setting 59P2P; see *Figure 1.1*)	
	59C2	C-phase instantaneous overvoltage element (C-phase voltage above pickup setting 59P2P; see *Figure 1.1*)	
	59A3	A-phase instantaneous overvoltage element (A-phase voltage above pickup setting 59P3P; see *Figure 1.1*)	
	59B3	B-phase instantaneous overvoltage element (B-phase voltage above pickup setting 59P3P; see *Figure 1.1*)	
	59C3	C-phase instantaneous overvoltage element (C-phase voltage above pickup setting 59P3P; see *Figure 1.1*)	
	59A4	A-phase instantaneous overvoltage element (A-phase voltage above pickup setting 59P4P; see *Figure 1.1*)	
	59B4	B-phase instantaneous overvoltage element (B-phase voltage above pickup setting 59P4P; see *Figure 1.1*)	
	59C4	C-phase instantaneous overvoltage element (C-phase voltage above pickup setting 59P4P; see *Figure 1.1*)	
6	59N1	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N1P; see *Figure 1.2*)	
	59N2	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N2P; see *Figure 1.2*)	
	59Q1	Negative-sequence instantaneous overvoltage element (negative-sequence voltage above pickup setting 59Q1P; see *Figure 1.2*)	
	59Q2	Negative-sequence instantaneous overvoltage element (negative-sequence voltage above pickup setting 59Q2P; see *Figure 1.2*)	
	59V1	Positive-sequence instantaneous overvoltage element (positive-sequence voltage above pickup setting 59V1P; see *Figure 1.2*)	
	27S	Channel VS instantaneous undervoltage element (channel VS voltage below pickup setting 27SP; see *Figure 1.3*)	
	59S1	Channel VS instantaneous overvoltage element (channel VS voltage above pickup setting 59S1P; see *Figure 1.3*)	
	59S2	Channel VS instantaneous overvoltage element (channel VS voltage above pickup setting 59S2P; see *Figure 1.3*)	
7	59VA	Channel VA voltage window element (channel VA voltage between threshold settings 25VLO and 25VHI; see *Figure 1.4*)	Testing
	59VP	Phase voltage window element [selected phase voltage (V_P) between threshold settings 25VLO and 25VHI; see *Figure 1.4*)	
	59VS	Channel VS voltage window element (channel VS voltage between threshold settings 25VLO and 25VHI; see *Figure 1.4*)	
	SF	Slip frequency between voltages V_P and V_S less than setting 25SF (see *Figure 1.4*)	

Table A.2 Relay Word Bit Definitions for SEL-547 (Sheet 3 of 5)

Row	Bit	Definition	Primary Application
	25A1	Synchronism check element (see *Figure 1.5*)	Close supervision
	25A2	Synchronism check element (see *Figure 1.5*)	
	SFAST	$f_P > f_S$ (frequency $V_P >$ frequency V_S; see *Figure 1.4*)	Special Control Schemes
	SSLOW	$f_P \le f_S$ (frequency $V_P \le$ frequency V_S; see *Figure 1.4*)	
8	81D1	Level 1 instantaneous frequency element (with corresponding pickup setting 81D1P; see *Figure 1.8*)	Testing
	81D2	Level 2 instantaneous frequency element (with corresponding pickup setting 81D2P; see *Figure 1.8*)	
	81D3	Level 3 instantaneous frequency element (with corresponding pickup setting 81D3P; see *Figure 1.8*)	
	81D4	Level 4 instantaneous frequency element (with corresponding pickup setting 81D4P; see *Figure 1.8*)	
	81D5	Level 5 instantaneous frequency element (with corresponding pickup setting 81D5P; see *Figure 1.8*)	
	81D6	Level 6 instantaneous frequency element (with corresponding pickup setting 81D6P; see *Figure 1.8*)	
	27B81	Undervoltage element for frequency element blocking (A-phase voltage below pickup setting 27B81P; see *Figure 1.7*)	
9	81D1T	Level 1 definite-time frequency element 81D1T timed out (derived from 81D1; see *Figure 1.8*)	Tripping, Control
	81D2T	Level 2 definite-time frequency element 81D2T timed out (derived from 81D2; see *Figure 1.8*)	
	81D3T	Level 3 definite-time frequency element 81D3T timed out (derived from 81D3; see *Figure 1.8*)	
	81D4T	Level 4 definite-time frequency element 81D4T timed out (derived from 81D4; see *Figure 1.8*)	
	81D5T	Level 5 definite-time frequency element 81D5T timed out (derived from 81D5; see *Figure 1.8*)	
	81D6T	Level 6 definite-time frequency element 81D6T timed out (derived from 81D6; see *Figure 1.8*)	
10	PWR1	Level 1 three-phase power element (see *Figure 1.10*)	Tripping, Control
	PWR2	Level 2 three-phase power element	
	PWR3	Level 3 three-phase power element	
	PWR4	Level 4 three-phase power element	
11	SV1	SELOGIC control equation variable timer input SV1 asserted (see *Figure 2.3*)	Testing, Seal-in functions, etc. (see *Figure 2.6*)
	SV2	SELOGIC control equation variable timer input SV2 asserted (see *Figure 2.3*)	
	SV3	SELOGIC control equation variable timer input SV3 asserted (see *Figure 2.3*)	
	SV4	SELOGIC control equation variable timer input SV4 asserted (see *Figure 2.3*)	
	SV1T	SELOGIC control equation variable timer output SV1T asserted (see *Figure 2.3*)	Tripping, Control; replacing traditional timers
	SV2T	SELOGIC control equation variable timer output SV2T asserted (see *Figure 2.3*)	
	SV3T	SELOGIC control equation variable timer output SV3T asserted (see *Figure 2.3*)	
	SV4T	SELOGIC control equation variable timer output SV4T asserted (see *Figure 2.3*)	

Table A.2 Relay Word Bit Definitions for SEL-547 (Sheet 4 of 5)

Row	Bit	Definition	Primary Application
12	SV5	SELOGIC control equation variable timer input SV5 asserted (see *Figure 2.3*)	Testing, Seal-in functions, etc. (see *Figure 2.6*)
	SV6	SELOGIC control equation variable timer input SV6 asserted (see *Figure 2.3*)	
	SV7	SELOGIC control equation variable timer input SV7 asserted (see *Figure 2.4*)	
	SV8	SELOGIC control equation variable timer input SV8 asserted (see *Figure 2.4*)	
	SV5T	SELOGIC control equation variable timer output SV5T asserted (see *Figure 2.3*)	Tripping, Control; replacing traditional timers
	SV6T	SELOGIC control equation variable timer output SV6T asserted (see *Figure 2.3*)	
	SV7T	SELOGIC control equation variable timer output SV7T asserted (see *Figure 2.4*)	
	SV8T	SELOGIC control equation variable timer output SV8T asserted (see *Figure 2.4*)	
13	SV9	SELOGIC control equation variable timer input SV9 asserted (see *Figure 2.4*)	Testing, Seal-in functions, etc. (see *Figure 2.6*)
	SV10	SELOGIC control equation variable timer input SV10 asserted (see *Figure 2.4*)	
	SV11	SELOGIC control equation variable timer input SV11 asserted (see *Figure 2.4*)	
	SV12	SELOGIC control equation variable timer input SV12 asserted (see *Figure 2.4*)	
	SV9T	SELOGIC control equation variable timer output SV9T asserted (see *Figure 2.4*)	Tripping, Control; replacing traditional timers
	SV10T	SELOGIC control equation variable timer output SV10T asserted (see *Figure 2.4*)	
	SV11T	SELOGIC control equation variable timer output SV11T asserted (see *Figure 2.4*)	
	SV12T	SELOGIC control equation variable timer output SV12T asserted (see *Figure 2.4*)	
14	SV13	SELOGIC control equation variable timer input SV13 asserted (see *Figure 2.4*)	Testing, Seal-in functions, etc. (see *Figure 2.6*)
	SV14	SELOGIC control equation variable timer input SV14 asserted (see *Figure 2.4*)	
	SV15	SELOGIC control equation variable timer input SV15 asserted (see *Figure 2.4*)	
	SV16	SELOGIC control equation variable timer input SV16 asserted (see *Figure 2.4*)	
	SV13T	SELOGIC control equation variable timer output SV13T asserted (see *Figure 2.4*)	Tripping, Control; replacing traditional timers
	SV14T	SELOGIC control equation variable timer output SV14T asserted (see *Figure 2.4*)	
	SV15T	SELOGIC control equation variable timer output SV15T asserted (see *Figure 2.4*)	
	SV16T	SELOGIC control equation variable timer output SV16T asserted (see *Figure 2.4*)	
15	LT1	Latch Bit 1 asserted (see *Figure 2.15*)	Control—replacing traditional latching relays
	LT2	Latch Bit 2 asserted (see *Figure 2.15*)	
	LT3	Latch Bit 3 asserted (see *Figure 2.15*)	
	LT4	Latch Bit 4 asserted (see *Figure 2.15*)	
	LT5	Latch Bit 5 asserted (see *Figure 2.15*)	
	LT6	Latch Bit 6 asserted (see *Figure 2.15*)	
	LT7	Latch Bit 7 asserted (see *Figure 2.15*)	
	LT8	Latch Bit 8 asserted (see *Figure 2.15*)	
16	LT9	Latch Bit 9 asserted (see *Figure 2.15*)	Control—replacing traditional latching relays
	LT10	Latch Bit 10 asserted (see *Figure 2.15*)	
	LT11	Latch Bit 11 asserted (see *Figure 2.15*)	
	LT12	Latch Bit 12 asserted (see *Figure 2.15*)	
	LT13	Latch Bit 13 asserted (see *Figure 2.15*)	
	LT14	Latch Bit 14 asserted (see *Figure 2.15*)	
	LT15	Latch Bit 15 asserted (see *Figure 2.15*)	
	LT16	Latch Bit 16 asserted (see *Figure 2.15*)	

Table A.2 Relay Word Bit Definitions for SEL-547 (Sheet 5 of 5)

Row	Bit	Definition	Primary Application
17	RB1	Remote Bit 1 asserted (see *Figure 2.11*)	Control via serial port
	RB2	Remote Bit 3 asserted (see *Figure 2.11*)	
	RB3	Remote Bit 4 asserted (see *Figure 2.11*)	
	RB4	Remote Bit 5 asserted (see *Figure 2.11*)	
	RB5	Remote Bit 6 asserted (see *Figure 2.11*)	
	RB6	Remote Bit 7 asserted (see *Figure 2.11*)	
	RB7	Remote Bit 8 asserted (see *Figure 2.11*)	
	RB8	Remote Bit 8 asserted (see *Figure 2.11*)	
18	RB9	Remote Bit 9 asserted (see *Figure 2.11*)	Control via serial port
	RB10	Remote Bit 10 asserted (see *Figure 2.11*)	
	RB11	Remote Bit 11 asserted (see *Figure 2.11*)	
	RB12	Remote Bit 12 asserted (see *Figure 2.11*)	
	RB13	Remote Bit 13 asserted (see *Figure 2.11*)	
	RB14	Remote Bit 14 asserted (see *Figure 2.11*)	
	RB15	Remote Bit 15 asserted (see *Figure 2.11*)	
	RB16	Remote Bit 16 asserted (see *Figure 2.11*)	
19	SG1	Setting Group 1 active (see *Table 2.5*)	Indication
	SG2	Setting Group 2 active (see *Table 2.5*)	
	OC	Asserts 1/4 cycle for Open Command execution	Testing, Control
	CC	Asserts 1/4 cycle for Close Command execution	
	CLKPUL	Asserts momentarily for 16 msec. at regular intervals, corresponding to setting INTRVL (Clock Pulse Interval)	Automatic LED lamp test
	IAMET	Channel IA high-gain mode active (asserts at threshold just below 0.6A)	Embedded in event report logic

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Page numbers appearing in bold mark the location of the topic's primary discussion.

U=User's Guide; R=Reference Manual

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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 action 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 action 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 for use with the SEL-5601 Analytic Assistant.
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* Ly	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 nonvolatile 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 G	Show global settings.
SHO R	Show SER and settings.
SHO P *p*	Show serial port *p* settings, (*p* = 1 or F, if not specified, default is active port).
SHO ... name	For all **SHO** commands, jump ahead to specific setting by entering setting name.

Command	Description
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 action 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	Change relay EZ settings.
SET P *p*	Change serial port p settings, (p = 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 action prompt is: =>>
CON *n*	Control Relay Word bit RB*n* (Remote Bit *n*; *n* = 1–16). Execute **CON *n*** and the relay responds: CONTROL RB*n*. 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. 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.
STA C	Resets self-test warnings/failures and reboots the relay.
VER	Show relay configuration and firmware version.

Command	Description
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 action 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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