SEL-547

Distributed Generator Interconnection Relay

Reference Manual

20200715

SCHWEITZER ENGINEERING LABORATORIES

⚠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.

⚠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.

⚠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.

PM547-03

Table of Contents

Section 8: Settings

SEL-547 Relay Settings Sheets

Appendix A: Relay Word Bits

Index

SEL-547 Relay Command Summary

List of Tables

List of Figures

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.

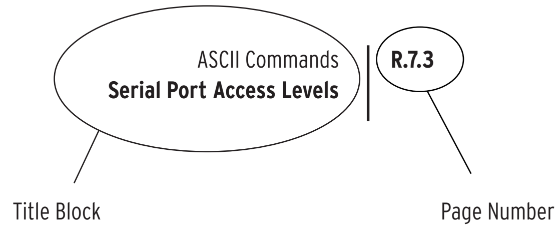
Section 8: Settings. Provides information about settings changes via the serial port, how EZ settings force global and Group 1 settings, and settings sheets.

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

Safety Information

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

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

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

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

Section 1
Protection Functions

Overview

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	

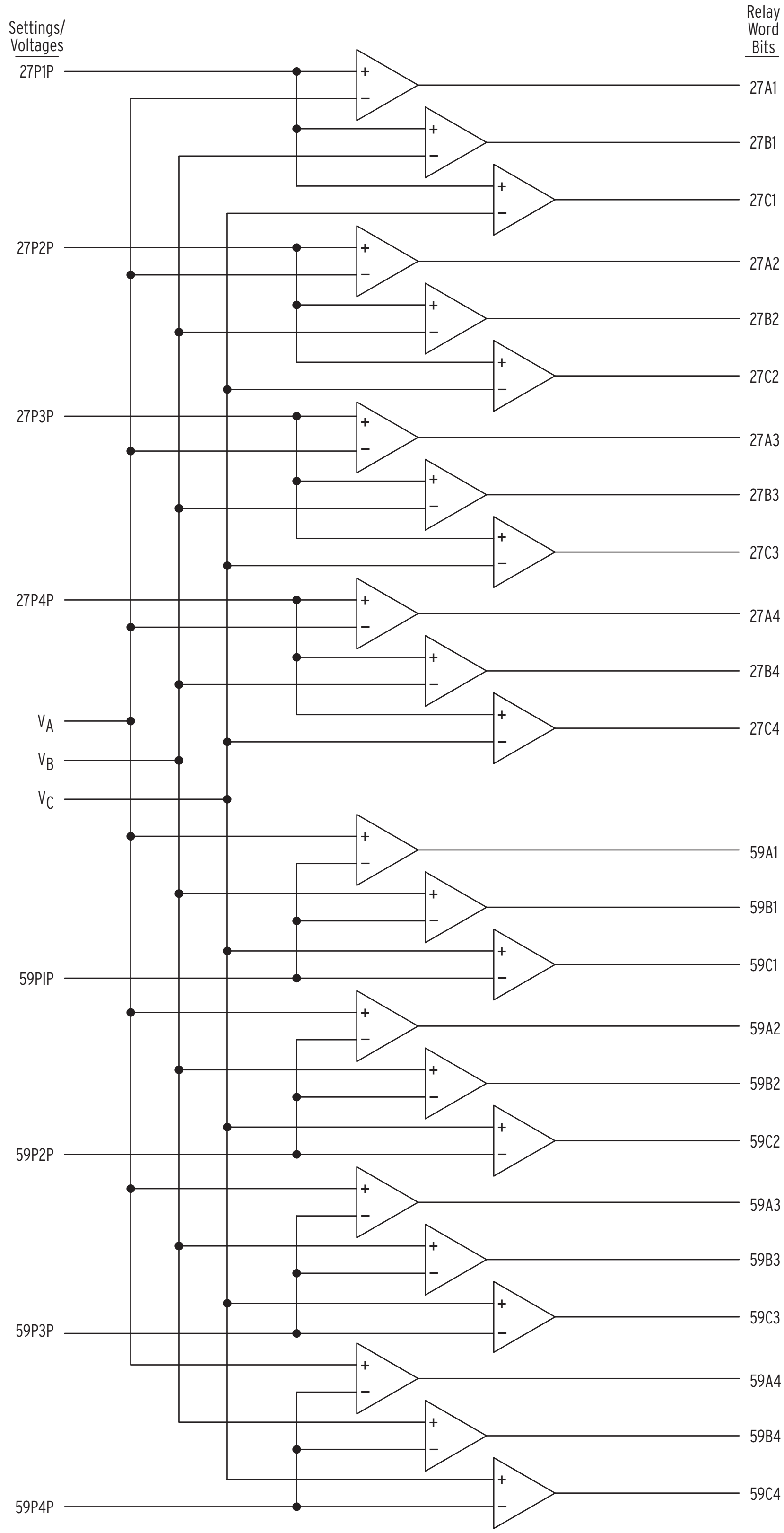


Figure 1.1 Single-Phase Voltage Elements

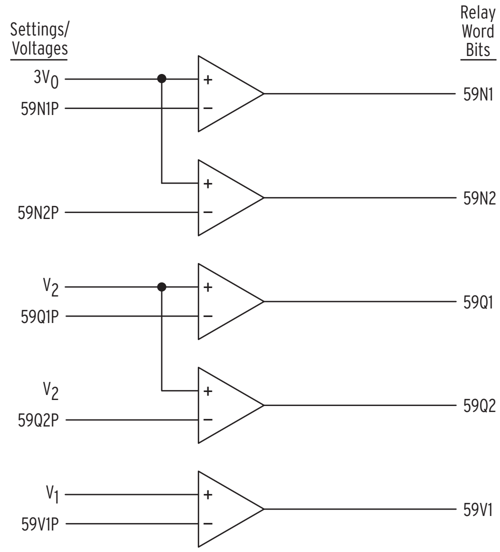


Figure 1.2 Sequence Voltage Elements

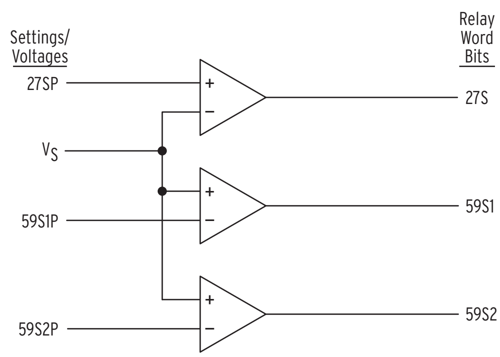


Figure 1.3 Channel VS Voltage Elements

Accuracy

Pickup: ±2 V and ±3% of setting

Voltage Element Operation

Note that the voltage elements in *Table 1.2* and *Figure 1.1*–*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

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).

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 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 SEL Application Guide *AG2002-02, 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).*

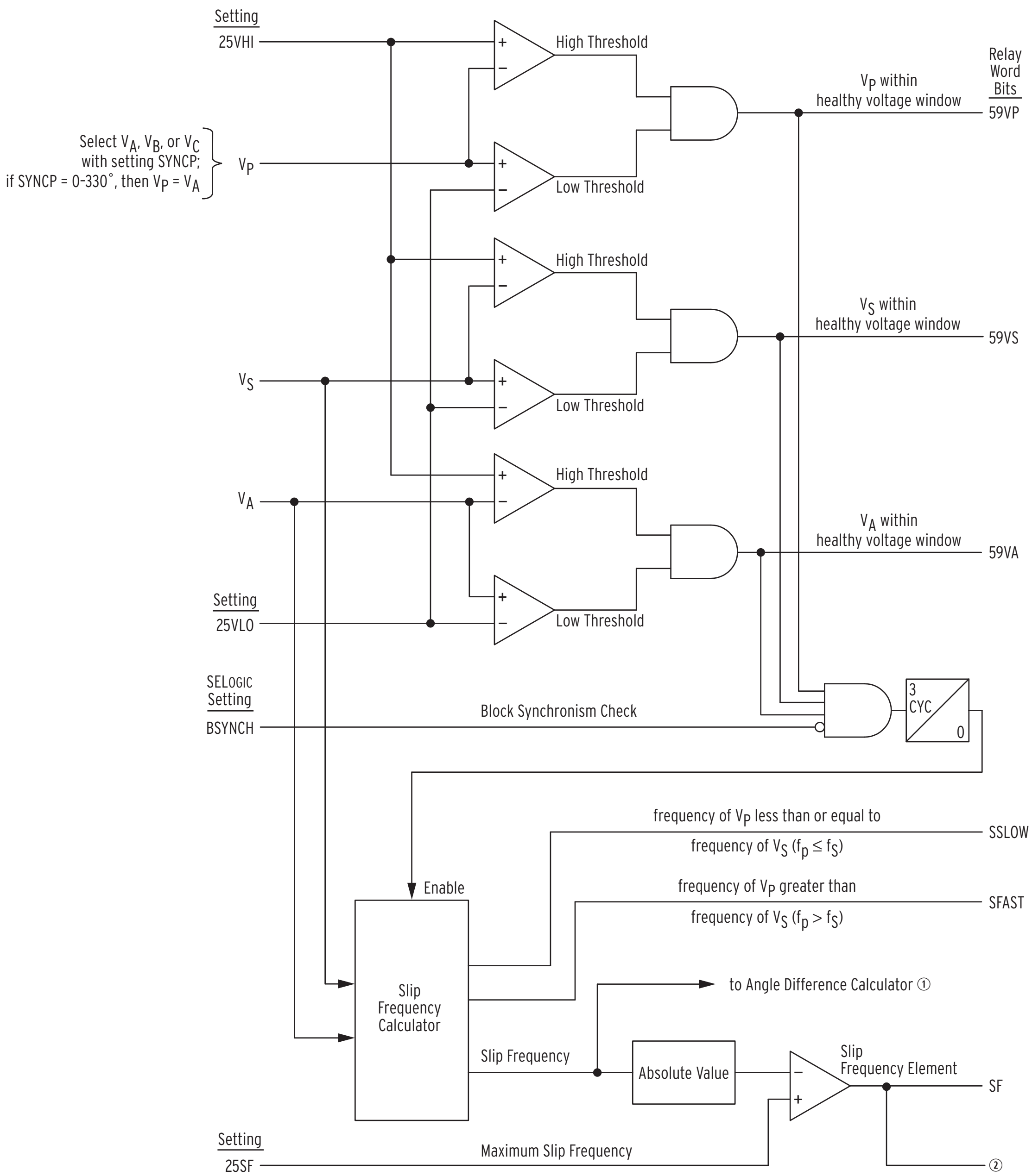


Figure 1.4 Synchronism Check Voltage Window and Slip Frequency Elements

① See bottom of Figure 1.5

② To Figure 1.5

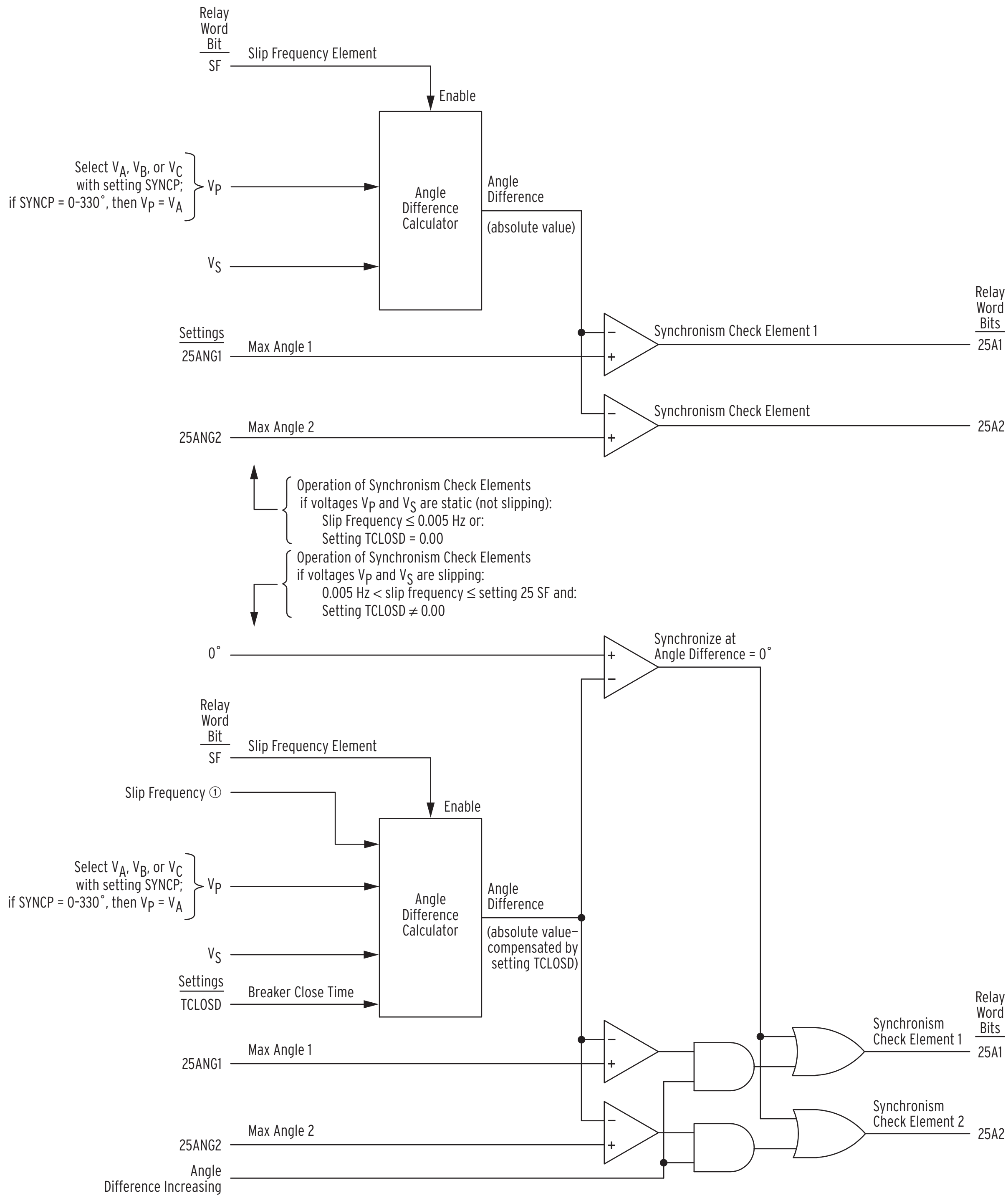


Figure 1.5 Synchronism Check Elements

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 SEL *Application Guide AG2002-02, 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 ensure 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*)

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 1.1*. 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:

$$\text{Angular Distance} = \text{slip cycles/second} \bullet \frac{360°}{\text{slip cycle}} \bullet 1 \text{ second} \qquad \textbf{Equation 1.2}$$

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 1.1):

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

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:

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

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.

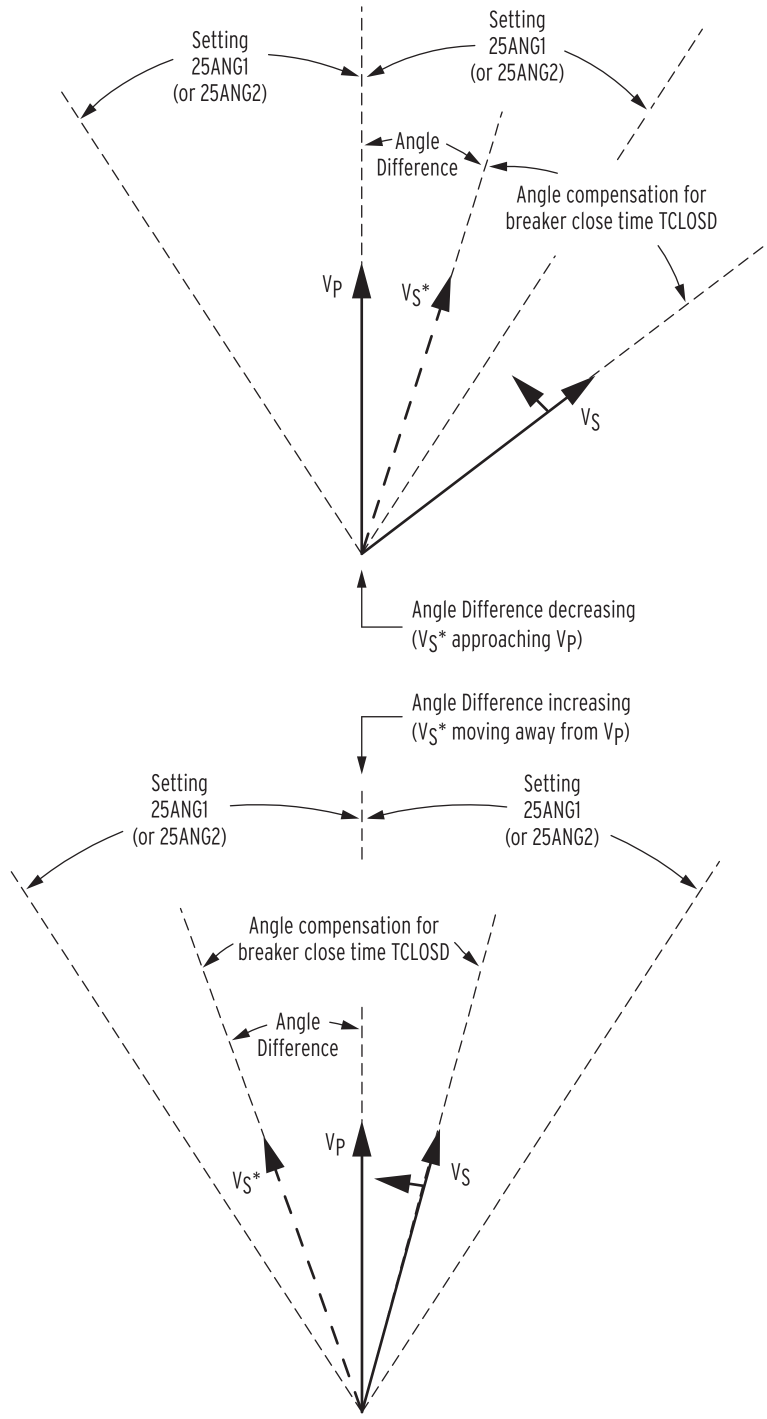


Figure 1.6 Angle Difference Between V_P and V_S Compensated by Breaker Close Time

($f_P < f_S$ 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:

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

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:

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

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

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

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.

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

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 the 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), **1–6**

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

Frequency Element Settings

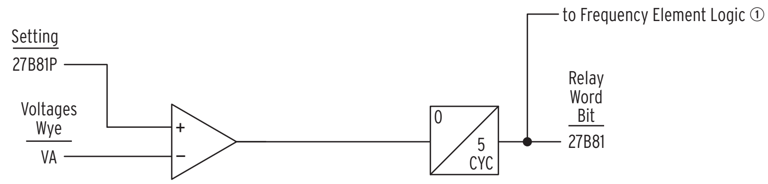


Figure 1.7 Undervoltage Block for Frequency Elements

① See Figure 1.8

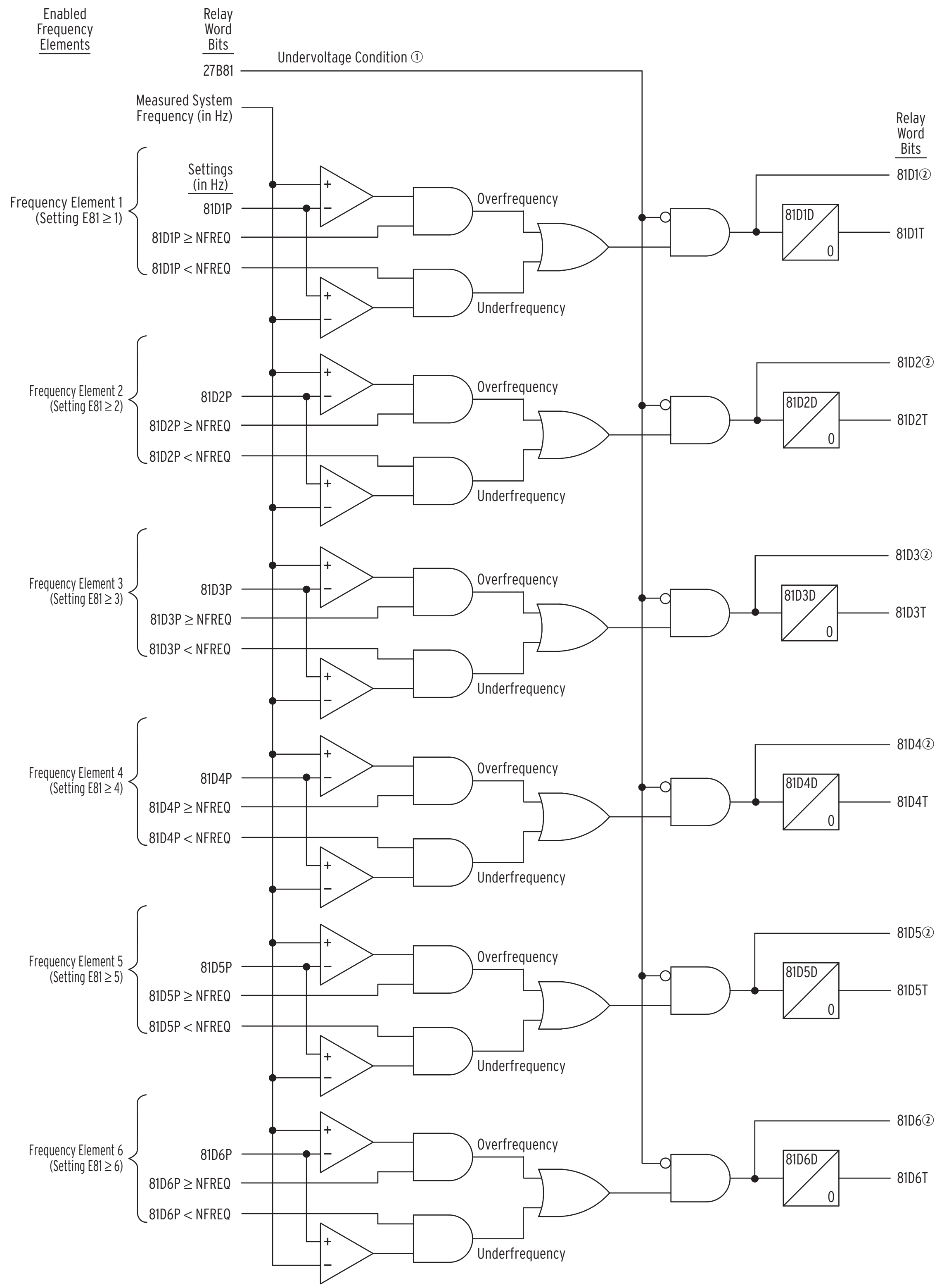


Figure 1.8 Levels 1–6 Frequency Elements

① From Figure 1.7

② 81D1–81D6 are for testing purposes only

Table 1.7 Frequency Elements Settings and Settings Ranges

Setting	Definition	Range
27B81P	undervoltage frequency element block	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–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–81D6T) do not have to be used.

Frequency Element Uses

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

The time-delayed frequency elements (81D1T–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* = 1–4), 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 –3 so that element PWRA*n* asserts for negative real or reactive power.

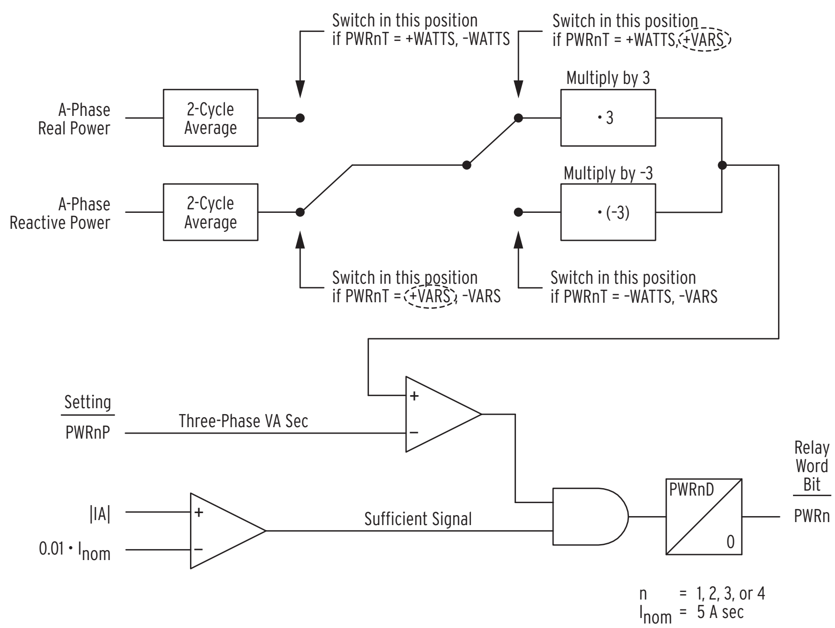


Figure 1.9 Power Elements Logic (+VARS Example Shown)

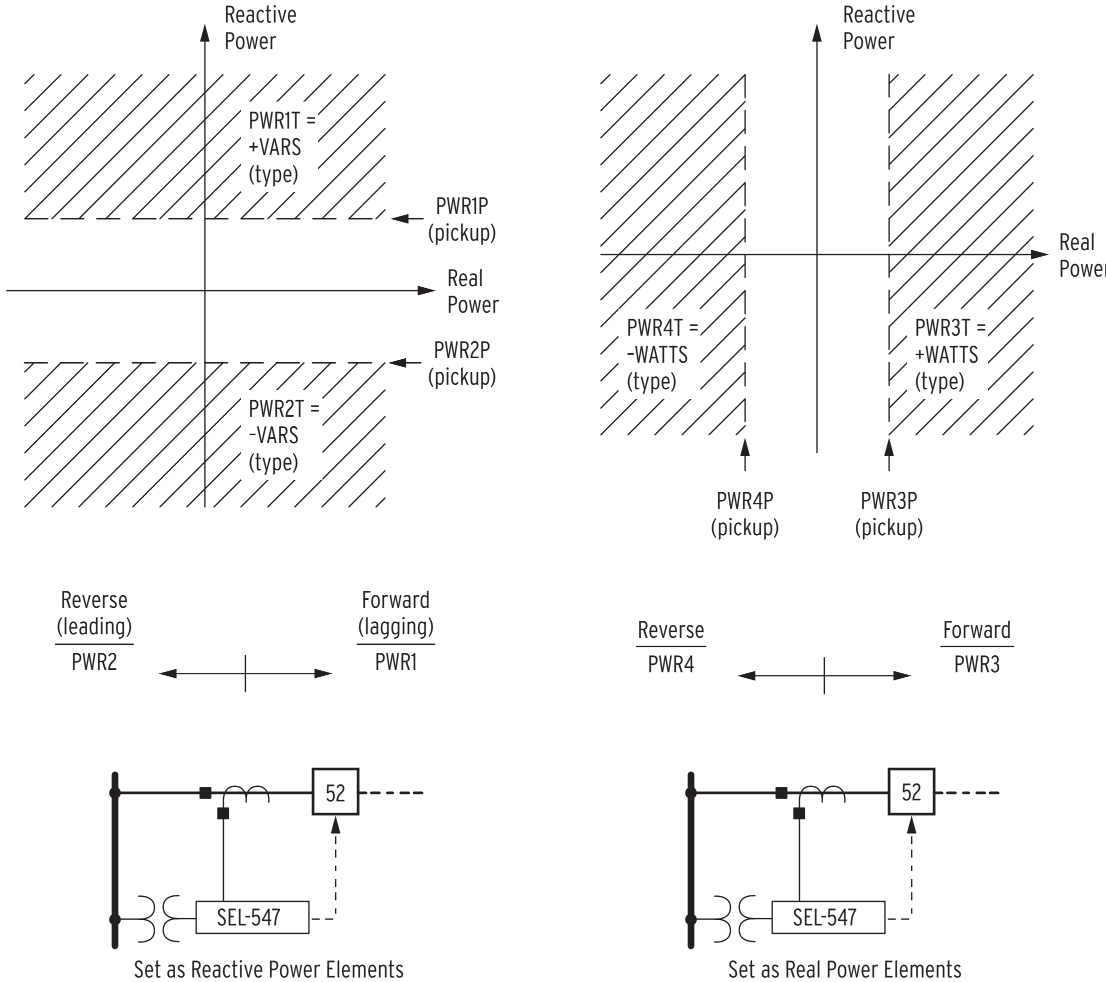


Figure 1.10 Power Elements Operation in the Real/Reactive Power Plane

This page intentionally left blank

Section 2

SELOGIC Control Equation Programming

Overview

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 *Appendix A: Relay Word Bits* for more information on Relay Word bits. 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 default SEL-547 Relay factory settings.

Most of the protection and control element logic outputs shown in the various figures in *Section 1: Protection Functions* and in this section 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*. 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: Protection Functions* and in this section 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+IN1)*(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

Circuit breaker status logic can be programmed in the SEL-547. This example uses SELogic control equation setting SV1 and optoisolated input **IN1**. See *Optoisolated Inputs on page R.2.11* for more information on optoisolated inputs.

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 **IN1**, the SELOGIC control equation setting SV1 is set:

SV1 = **IN1**

Conversely, if a 52b contact is connected to optoisolated input **IN1**, the SELOGIC control equation setting SV1 is set:

SV1 = **!IN1** [=NOT(IN1)]

With a 52b contact connected, if the circuit breaker is closed, the 52b contact is open and input **IN1** is de-energized [IN1 = 0 (logical 0)]:

SV1 = **!IN1 = NOT(IN1) = NOT(0) = 1**

Thus, the SELOGIC control equation setting SV1 sees a closed circuit breaker.

With a 52b contact connected, if the circuit breaker is open, the 52b contact is closed and input **IN1** is energized [IN1 = 1 (logical 1)]:

SV1 = **!IN1 = NOT(IN1) = NOT(1) = 0**

Thus, the SELOGIC control equation setting SV1 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.2.28*.

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*, *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*, *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.

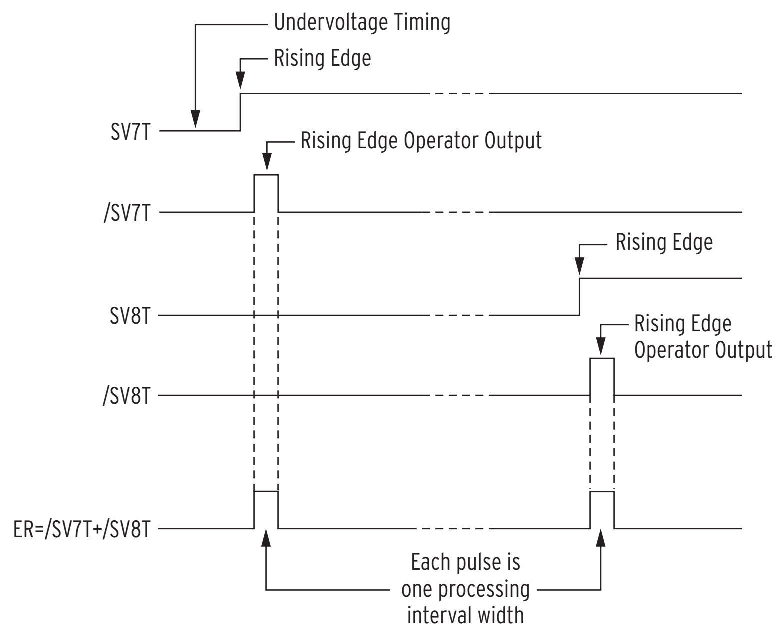


Figure 2.1 Result of Rising Edge Operators on Individual Elements in Setting ER

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* and *Table 1.7*. *Figure 2.2* demonstrates the action of the falling edge operator \ on the underfrequency element in setting ER.

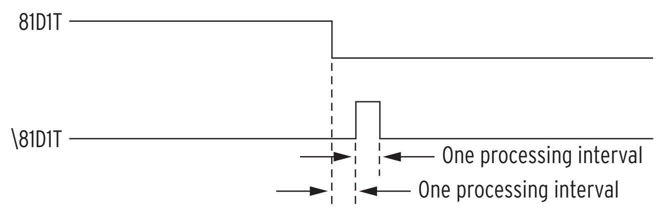


Figure 2.2 Result of Falling Edge Operator on a Deasserting Underfrequency Element

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–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 –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* = 1–16).

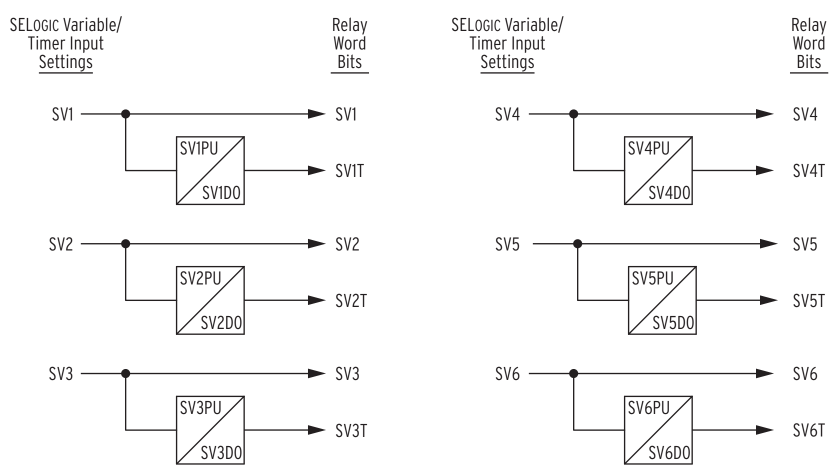


Figure 2.3 SELOGIC Control Equation Variables/Timers SV1/SV1T-SV6/SV6T

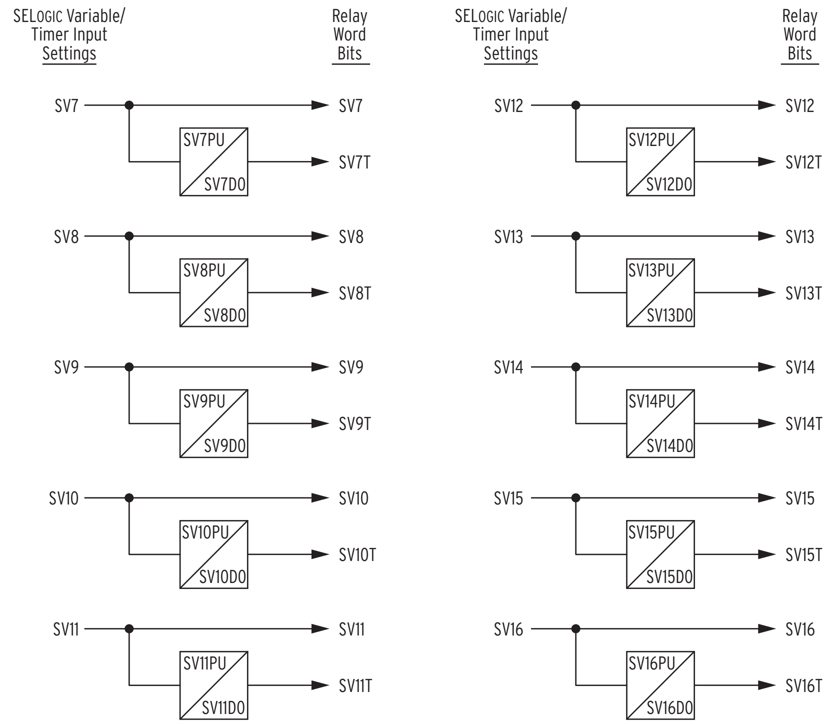


Figure 2.4 SELogic Control Equation Variables/Timers SV7/SV7T-SV16/SV16T

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**

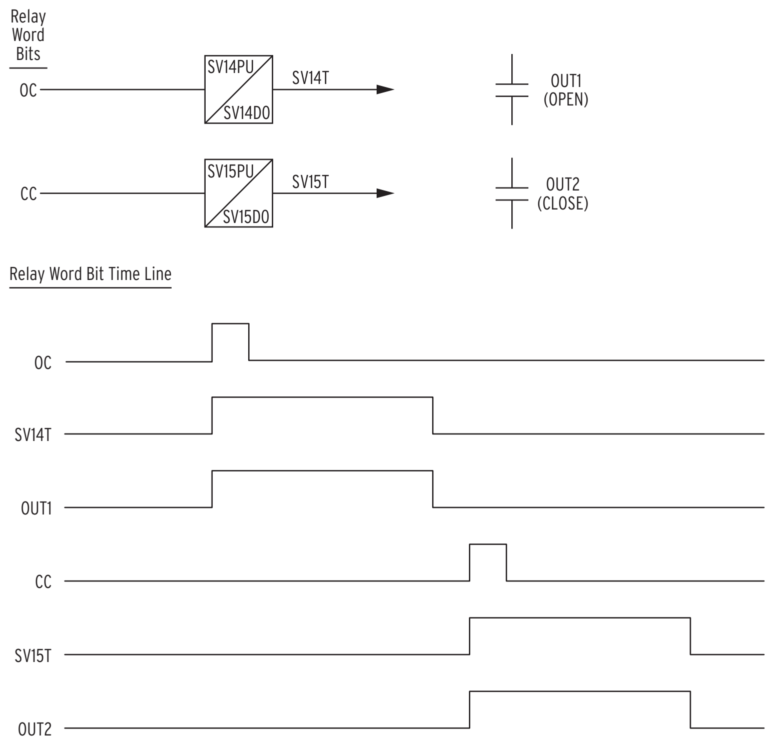


Figure 2.5 Breaker Control With Timer Created With SELOGIC Control Equation Variables/Timers

Additional Settings Example

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

SV14 = **(SV14 + IN1)*IN2**

OUT1 = **SV14T**

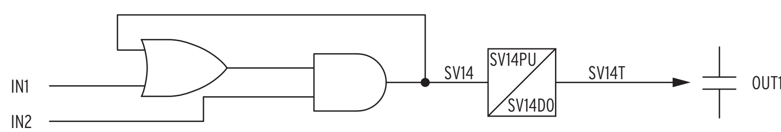


Figure 2.6 Seal-in Circuit With Timer Created With SELOGIC Control Equation Variables/Timers

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* = 1–16) 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 SV14) in SELOGIC control equation SV14:

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 SV14T is also reset to logical 0, and timer settings SV14PU and SV14DO 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 = IN1)
- 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 2.1*. If this limit must be exceeded, use a SELOGIC control equation variable (SELOGIC control equation settings SV1–SV16) 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) (Sheet 1 of 2)

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*= 1–16], 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 V_S (BSYNCH)	(BSYNCH), 59VS, 59VP, 59VA, SSLOW, SFAST, SF, 25A1, 25A2,	*Section 1*

Table 2.3 Processing Order of Relay Elements and Logic (Top to Bottom) (Sheet 2 of 2)

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**
SELOGIC Control Equation Variables/Timers (SV1–SV16)	[(SV*n*), SV*n*, SV*n*T, where *n* = 1–16]	*Section 2*
OUT1–OUT5	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–IN3 that follow corresponding optoisolated inputs IN1–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*).

Figure 2.7 is used for the following discussion and examples.

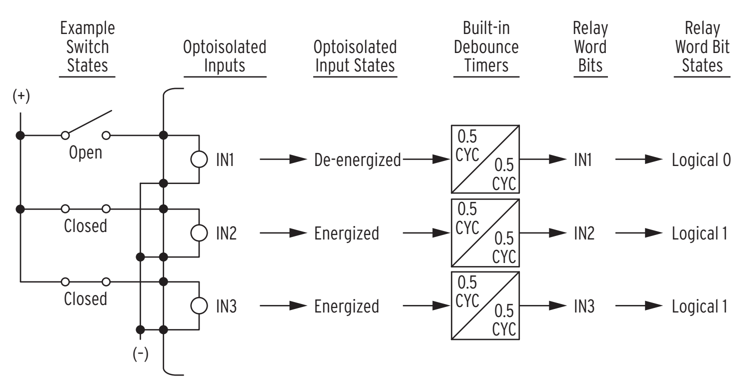


Figure 2.7 Example Operation of SEL-547 Optoisolated Inputs IN1, IN2, and IN3

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

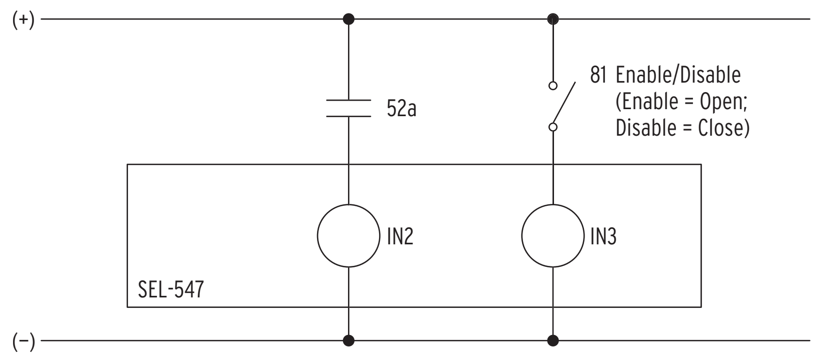


Figure 2.8 Circuit Breaker Auxiliary Contact and Underfrequency Element Control Switch Connected to Optoisolated Inputs IN2 and IN3

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*:

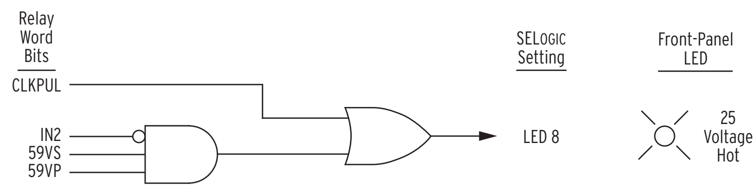


Figure 2.9 Breaker Status (52a connected to Input IN2) Supervises Operation of 25 VOLTAGE HOT LED

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 load shedding in *Figure 2.8*. The switch function is described below:

- Enable a particular level of underfrequency load shedding when the switch is open.

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

- Disable a particular level of underfrequency load shedding 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 = **81D1T + 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 = **81D1T + !IN3 * 81D2T + 81D3T + 81D4T**

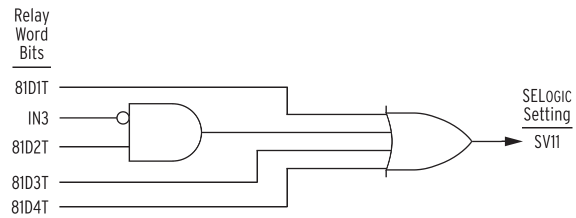


Figure 2.10 Input IN3 Supervises the Operation of Underfrequency Element 81D2T

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.7.15*).

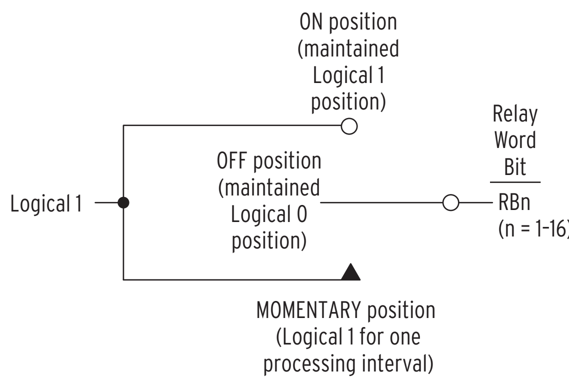


Figure 2.11 Remote Control Switches Drive Remote Bits RB1–RB16

The output of the remote control switch in *Figure 2.11* is a Relay Word bit RB*n* (*n* = 1–16), called a remote bit. The remote control switch logic in *Figure 2.11* repeats for each remote bit RB1–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.

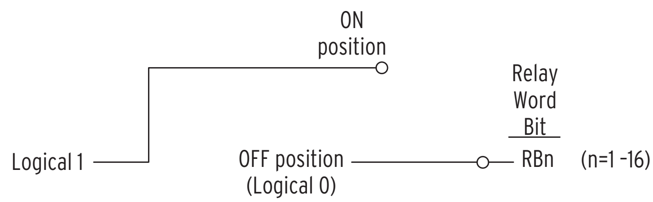


Figure 2.12 Remote Control Switch Used as an ON/OFF Switch

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).

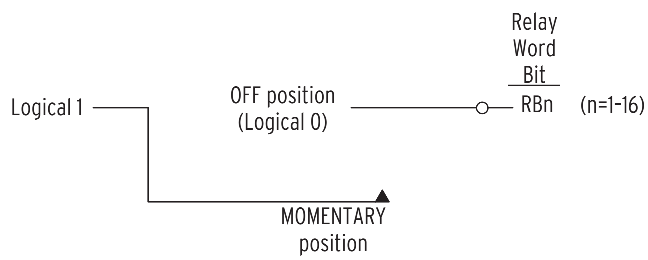


Figure 2.13 Remote Control Switch Used as an OFF/MOMENTARY Switch

Remote Bit States Not Retained When Power Lost

The states of the remote bits (Relay Word bits RB1–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–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.7.15*).

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).

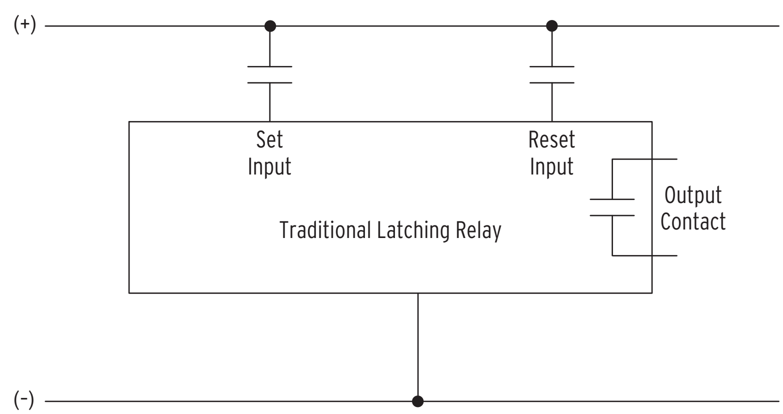


Figure 2.14 Traditional Latching Relay

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

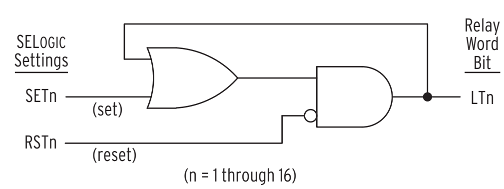


Figure 2.15 Latch Control Switches Drive Latch Bits LT1–LT16

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

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

SETn (set latch bit LTn to logical 1; n = 1-16)

RSTn (reset latch bit LTn to logical 0; n = 1-16)

If setting SET*n* 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*:

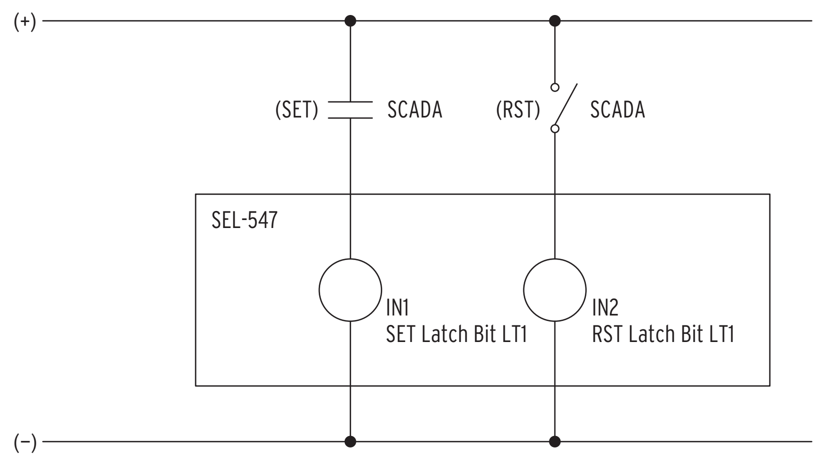


Figure 2.16 Separate SCADA Contacts Pulse Inputs IN1 and IN2 to Set/Reset Latch Bit LT1

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*.

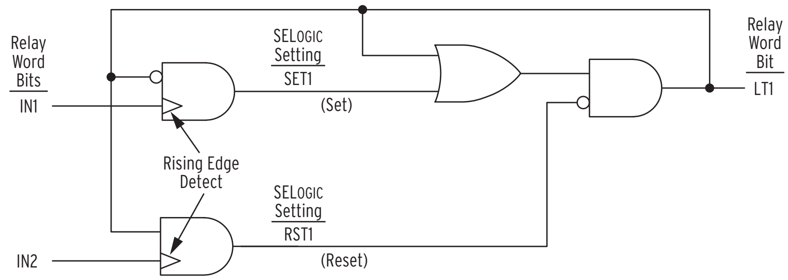


Figure 2.17 Latch Bit LT1 is Set/Reset by Separate Inputs

Operate Latch Control Switch With One Input

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

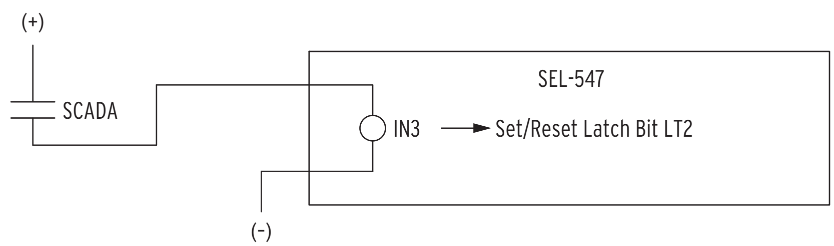


Figure 2.18 Single SCADA Contact Pulses Input IN3 to Set/Reset Latch Bit LT2

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]

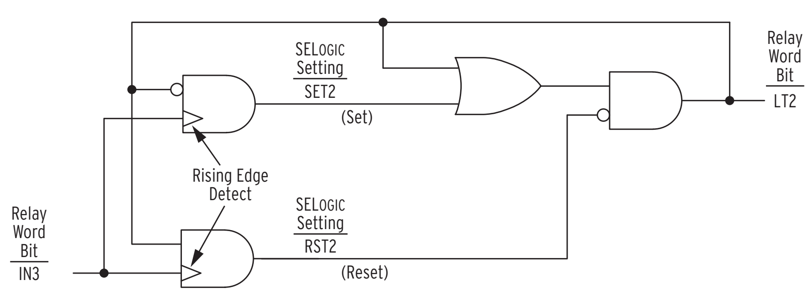


Figure 2.19 Latch Bit LT2 is Set/Reset by a Single Input

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. The rising edge of input 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 the latch control switch just once.

Refer to the preceding subsection *Optoisolated Inputs on page R.2.11* and *Figure 2.7*. 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.

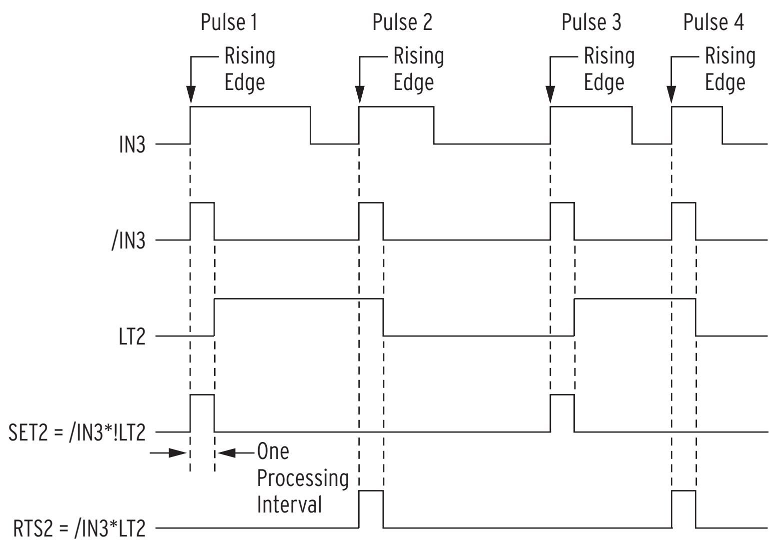


Figure 2.20 Latch Control Switch Operation Time Line

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) ...

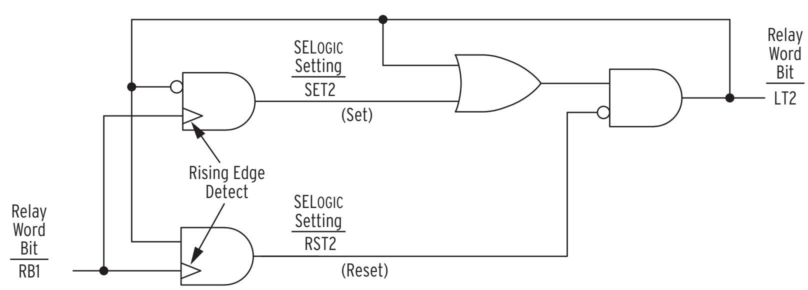


Figure 2.21 Latch Bit LT2 is Set/Reset by Remote Bit RB1

Remote bits (Relay Word bits RB1–RB16) are operated through a serial port. See *CON Command (Control Remote Bit) on page R.7.15* 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 = **81D1T + !LT2 * 81D2T + 81D3T + 81D4T**

Then, input **LT2** 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 = **81D1T + 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 effect a change of the state of latch bit LT2.

Latch Control Switch Considerations

Power Loss

The states of the latch bits (LT1–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–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* = 1–16), 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* = 1–16; 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–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).

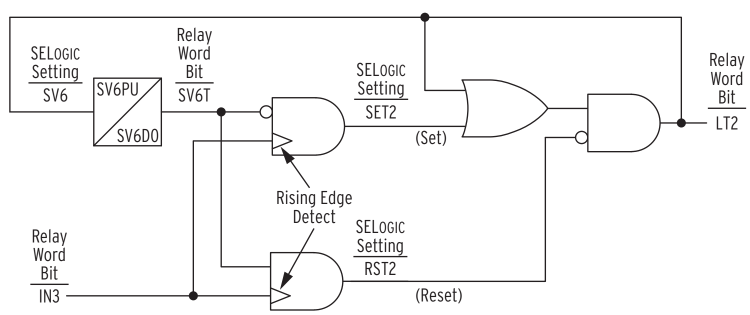


Figure 2.22 Latch Control Switch (With Time Delay Feedback) Controlled by a Single Input to Set/Reset Latch Bit LT2

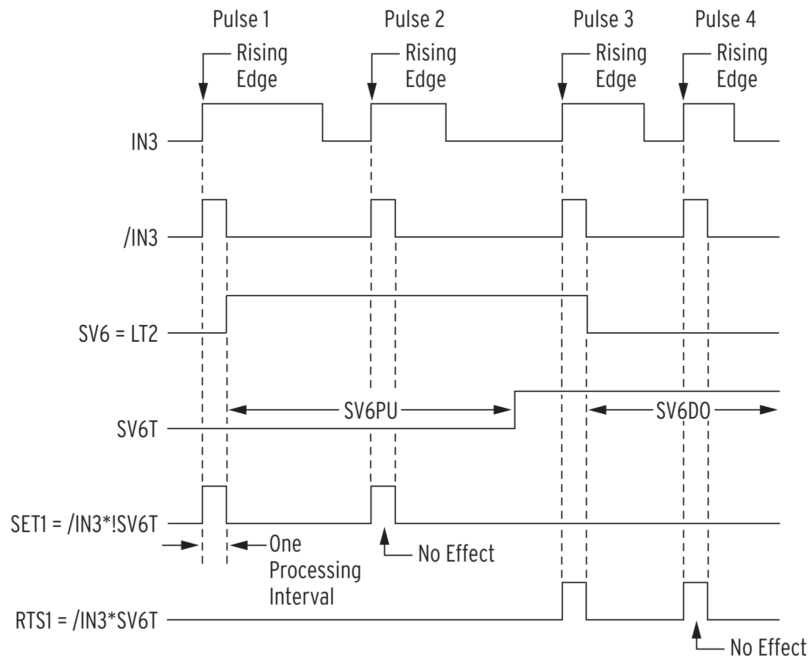


Figure 2.23 Latch Control Switch (With Time Delay Feedback) Operation Time Line

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

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

IMPORTANT NOTE: If EZ settings are enabled, some Group 1 settings are overwritten by the EZ settings.

Table 2.5 Definitions for Active Setting Group Indication Relay Word Bits SG1 and 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 SS2

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–RB16), and latch bit (LT1–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 were 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 de-energize. 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.

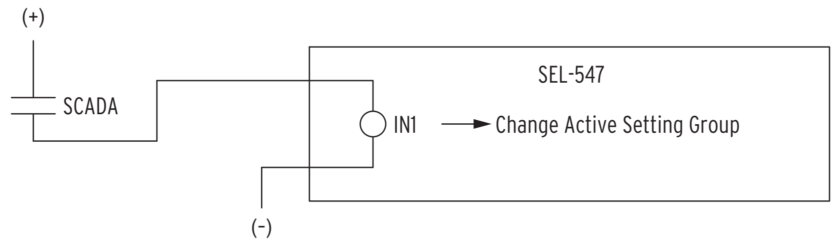


Figure 2.24 SCADA Contact Pulses Input IN1 to Switch Active Setting Group Between Setting Groups 1 and 2

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.

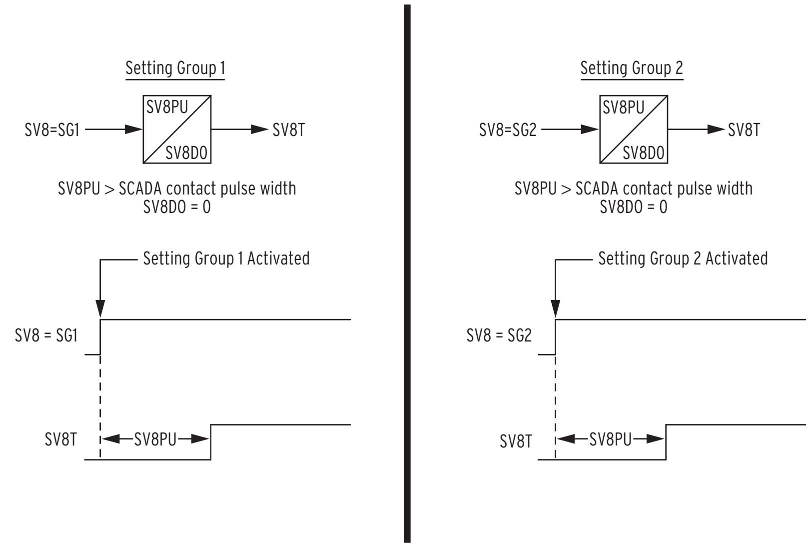


Figure 2.25 SELOGIC Control Equation Variable Timer SV8T Used in Setting Group Switching

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.

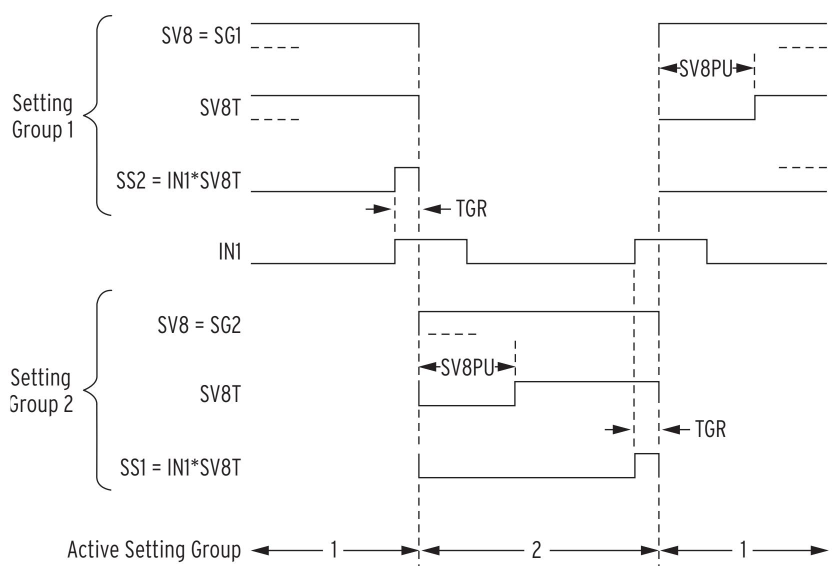


Figure 2.26 Active Setting Group Switching (With Single Input) Time Line

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 SS2 before changing the active setting group. If optoisolated inputs **IN1–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–OUT5 resulting from the following:

- SELOGIC control equation operation (SELOGIC control equation settings OUT1–OUT5)

  or

- **PULSE** command execution

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

Alarm logic/circuitry controls the dedicated **ALARM** output contact.

OUT1–OUT5

The execution of the serial port command **PUL *n*** (*n* = OUT1–OUT5) asserts the corresponding Relay Word bit (OUT1–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* = 1–5) to logical 1 also asserts the corresponding Relay Word bit OUT*m* (*m* = 1–5) to logical 1.

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

Other output contact specifications are given in *Specifications on page U.1.15 in the User's Guide*.

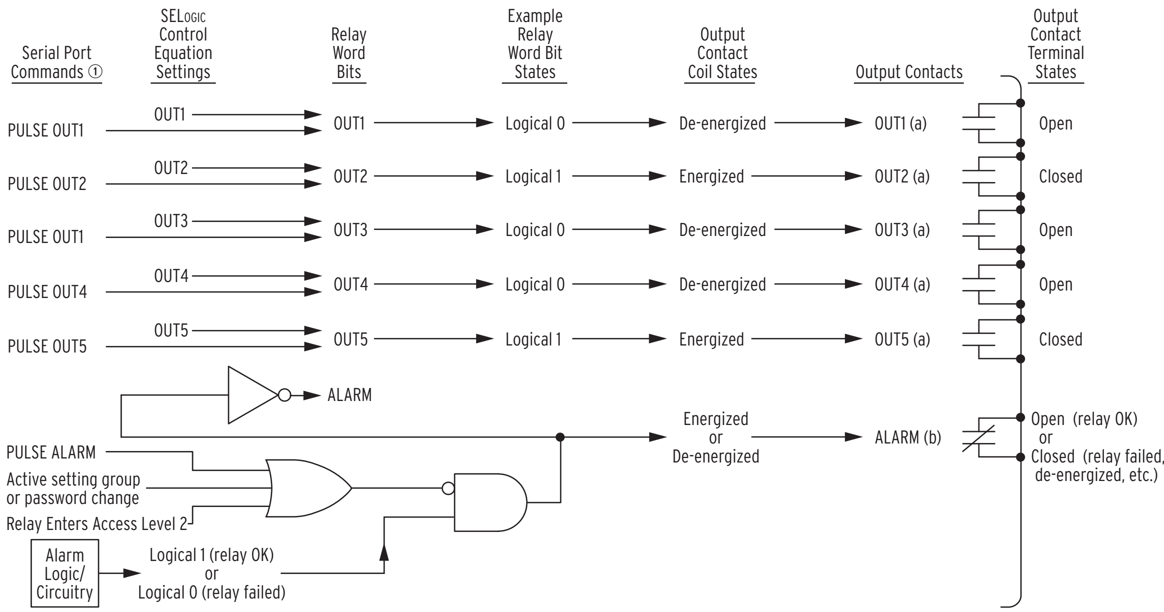


Figure 2.27 Logic Flow for Example Output Contact Operation
① Execution of the **PULSE** command results in a logical 1 input into the above logic (one-second default pulse width).

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.

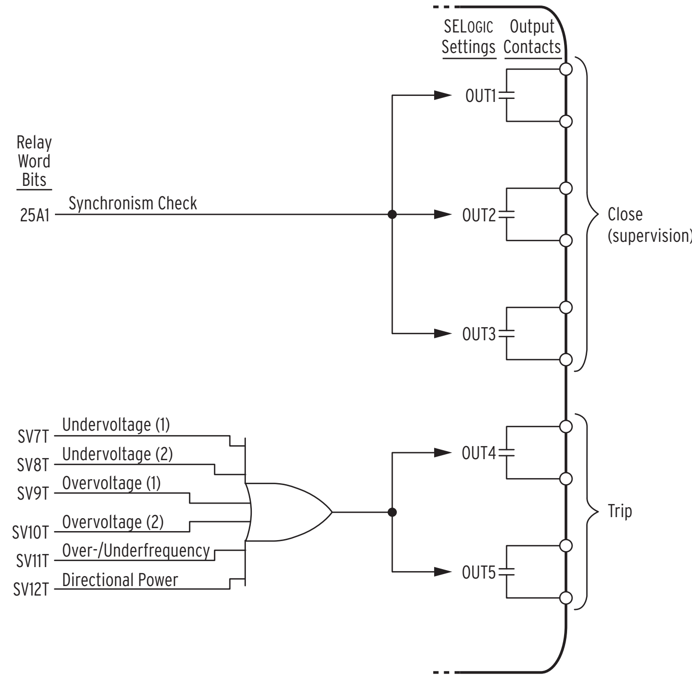


Figure 2.28 Output Contact Logic

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.

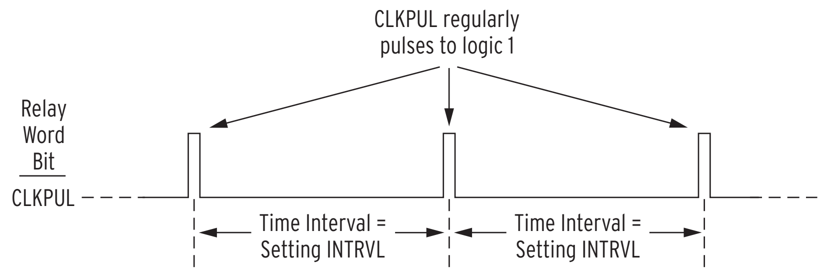


Figure 2.29 LED Flashing Logic

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*).

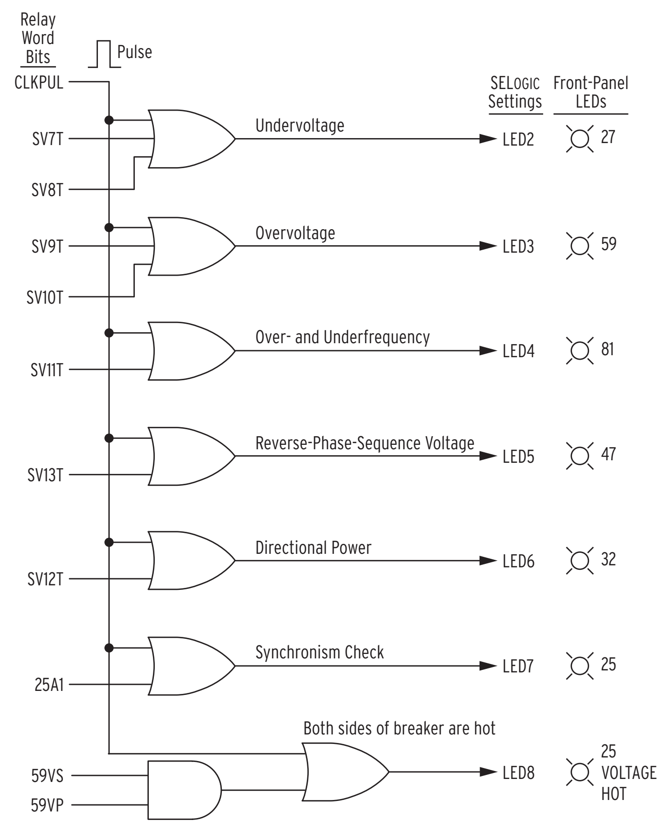


Figure 2.30 Front-Panel LED Logic

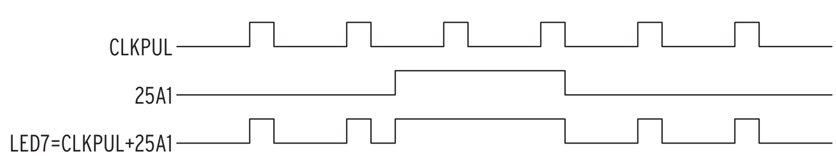


Figure 2.31 LED2 Illumination Time Line

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*).

Section 3
Analyzing Events

Overview

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

NOTE: The event report data are stored in volatile memory only, and this data will be lost if the relay loses power. The SER data are stored in nonvolatile memory, therefore these data are not affected by loss of power.

- 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 volatile 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.

Event report data is stored in volatile memory only. Changing the LER setting will erase all events stored in volatile memory. Changing the PRE setting has no effect on the volatile 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*)
59A1	A-phase voltage above phase overvoltage pickup setting 59P1P (see *Figure 1.1*)
OUT4	Output contact **OUT4** is set as a trip output (see *Output Contacts on page R.2.28*)

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), Synchronism (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 volatile 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.3.2*).

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)
- Synchronism 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 volatile 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.

where

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-2032, SEL-2030, or SEL-2020 Communications Processor takes 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.5.6* 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–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*).

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 volatile memory. See *Section 7: ASCII Commands* 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 relate 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 2 b	Optoisolated input IN1 asserted. Optoisolated input IN2 asserted. Both IN1 and IN2 asserted.
In 3	IN3	3	Optoisolated input IN3 asserted.
Out 12	OUT1, OUT2	1 2 b	Output contact OUT1 asserted. Output contact OUT2 asserted. Both OUT1 and OUT2 asserted.
Out 34	OUT3, OUT4	3 4 b	Output contact OUT3 asserted. Output contact OUT4 asserted. Both OUT3 and OUT4 asserted.
Out 5A	OUT5, ALARM	5 6 b	Output contact OUT5 asserted. Output contact ALARM asserted. Both OUT5 and ALARM asserted.
27 13	27A1, 27A3, 27B1, 27B3, 27C1, 27C3	A B C a b c 3	A-phase undervoltage element 27A1 or 27A3 picked up. B-phase undervoltage element 27B1 or 27B3 picked up. C-phase undervoltage element 27C1 or 27C3 picked up. 27A_ and 27B_ elements picked up. 27B_ and 27C_ elements picked up. 27C_ and 27A_ elements picked up. 27A_, 27B_, and 27C_ elements picked up.
27 24	27A2, 27A4, 27B2, 27B4, 27C2, 27C4	A B C a b c 3	A-phase undervoltage element 27A2 or 27A4 picked up. B-phase undervoltage element 27B2 or 27B4 picked up. C-phase undervoltage element 27C2 or 27C4 picked up. 27A_ and 27B_ elements picked up. 27B_ and 27C_ elements picked up. 27C_ and 27A_ elements picked up. 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 B C a b c 3	A-phase overvoltage element 59A1 or 59A3 picked up. B-phase overvoltage element 59B1 or 59B3 picked up. C-phase overvoltage element 59C1 or 59C3 picked up. 59A_ and 59B_ elements picked up. 59B_ and 59C_ elements picked up. 59C_ and 59A_ elements picked up. 59A_, 59B_, and 59C_ elements picked up.
59 24	59A2, 59A4, 59B2, 59B4, 59C2, 59C4	A B C a b c 3	A-phase overvoltage element 59A2 or 59A4 picked up. B-phase overvoltage element 59B2 or 59B4 picked up. C-phase overvoltage element 59C2 or 59C4 picked up. 59A_ and 59B_ elements picked up. 59B_ and 59C_ elements picked up. 59C_ and 59A_ elements picked up. 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,	1	Channel VS instantaneous overvoltage element 59S1 picked up.
	59S2	2	Channel VS instantaneous overvoltage element 59S2 picked up.
		b	Both 59S1 and 59S2 picked up.
59 Q	59Q1,	1	Negative-sequence overvoltage element 59Q1 picked up.
	59Q2	2	Negative-sequence overvoltage element 59Q2 picked up.
		b	Both 59Q1 and 59Q2 picked up.
59 N	59N1,	1	Zero-sequence overvoltage element 59N1 picked up.
	59N2	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,	1	Frequency element 81D1 picked up.
	81D2	2	Frequency element 81D2 picked up.
		b	Both 81D1 and 81D2 picked up.
81 34	81D3,	3	Frequency element 81D3 picked up.
	81D4	4	Frequency element 81D4 picked up.
		b	Both 81D3 and 81D4 picked up.
81 56	81D5,	5	Frequency element 81D5 picked up.
	81D6	6	Frequency element 81D6 picked up.
		b	Both 81D5 and 81D6 picked up.
32 12	PWR1,	1	Level 1 power element PWR1 picked up.
	PWR2	2	Level 2 power element PWR2 picked up.
		b	Both PWR1 and PWR2 picked up.
32 34	PWR3,	3	Level 3 power element PWR3 picked up.
	PWR4	4	Level 4 power element PWR4 picked up.
		b	Both PWR3 and PWR4 picked up.
25 59V	59VP,	P	Phase voltage window element 59VP picked up (used in synchronism check.)
	59VS	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,	1	Synchronism check element 25A1 picked up.
	25A2	2	Synchronism check element 25A2 picked up.
		b	Both 25A1 and 25A2 picked up.
25 SPE	SFAST,	F	Synchronism check frequency element SFAST picked up.
	SSLOW	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 Variable 1	SV1, SV1T	p	SELOGIC control equation variable timer input SV_ asserted; timer timing on pickup time; timer output SV_T not asserted.
SELOGIC Variable 2	SV2, SV2T		
SELOGIC Variable 3	SV3, SV3T		
SELOGIC Variable 4	SV4, SV4T		
SELOGIC Variable 5	SV5, SV5T	T	SELOGIC control equation variable timer input SV_ asserted; timer timed out on pickup time; timer output SV_T asserted.
SELOGIC Variable 6	SV6, SV6T		
SELOGIC Variable 7	SV7, SV7T		
SELOGIC Variable 8	SV8, SV8T		
SELOGIC Variable 9	SV9, SV9T		
SELOGIC Variable 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 Variable 11	SV11, SV11T		
SELOGIC Variable 12	SV12, SV12T		
SELOGIC Variable 13	SV13, SV13T		
SELOGIC Variable 14	SV14, SV14T		
SELOGIC Variable 15	SV15, SV15T		
SELOGIC Variable 16	SV16, SV16T		
Rem 12	RB1, RB2	1 2 b	Remote bit RB1 asserted. Remote bit RB2 asserted. Both RB1 and RB2 asserted.
Rem 34	RB3, RB4	3 4 b	Remote bit RB3 asserted. Remote bit RB4 asserted. Both RB3 and RB4 asserted.
Rem OC	OC, CC	o c	**OPE** (Open) command executed. **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–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.
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........ ...    2
 -527 -271    6   84 -271 60.0 ..bb5 BB...... .... .. b*bS ......Tp........ ...    3  4
 -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                       see Figure 3.1
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
```

(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.

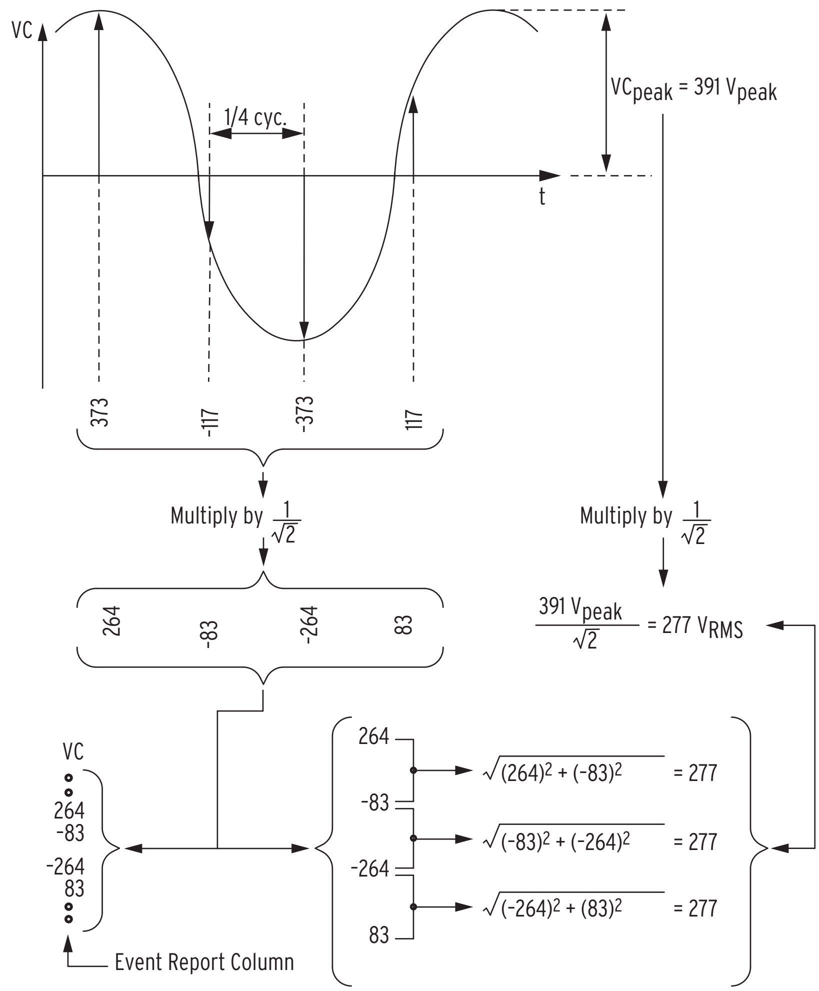


Figure 3.6 Derivation of Event Report Voltage Values and RMS Voltage Values From Sampled Voltage Waveform

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.

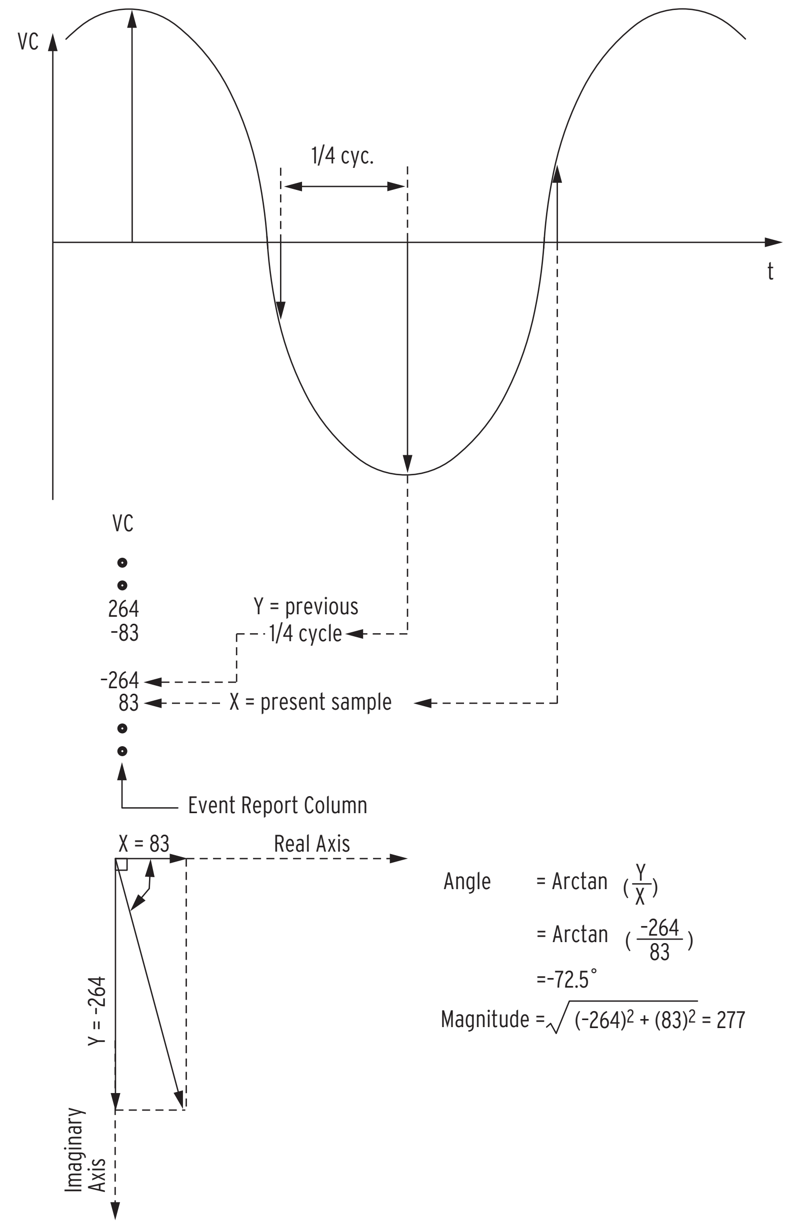


Figure 3.7 Derivation of Phasor RMS Voltage Values From Event Report Voltage Values

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:

$$VC = 277\ \text{V} \angle{-72.5°} \qquad \textbf{Equation 3.1}$$

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

$$277\ \text{V} * \cos(-72.5°) = 83\ \text{V} \qquad \textbf{Equation 3.2}$$

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

This page intentionally left blank

Section 4
Communications

Overview

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

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* and *Table 4.2* provide terminal information for Port 1 (EIA-485).

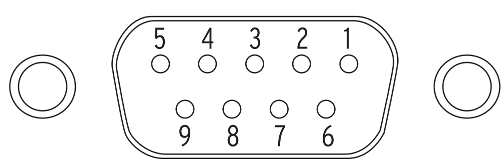


Figure 4.1 DB-9 Connector Pinout for Port F (EIA-232; female connector)

Table 4.1 Pinout Functions for Port F (EIA-232) (Sheet 1 of 2)

Pin	Function
1	N/C
2	RXD
3	TXD
4	N/C

Table 4.1 Pinout Functions for Port F (EIA-232) (Sheet 2 of 2)

Pin	Function
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 to which they connect (which would be the opposite gender).

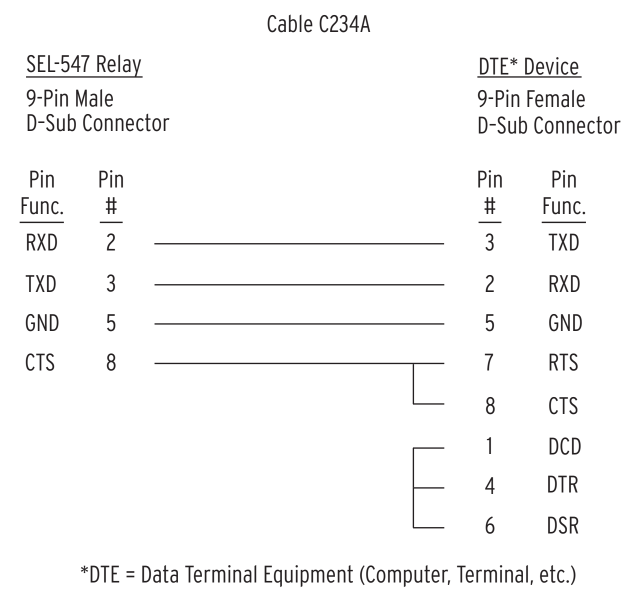


Figure 4.2 SEL Cable C234A
SEL-547 to Computer/9-pin connector

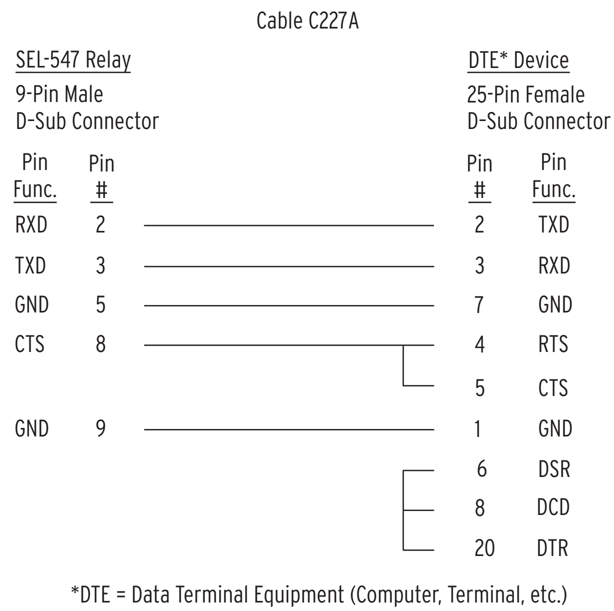


Figure 4.3 SEL Cable C227A
SEL-547 to Computer/25-pin connector

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
SHIELD	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.

This page intentionally left blank

Section 5

SEL Communications Protocols

Overview

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 lowercase 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 *CEVENT Command (SEL-547) on page R.5.6* for definition of the **Names of elements in the relay word Rows 0–19 separated by spaces** field.

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

C00018FC0000000002000000330000000000081

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).

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>
```

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.

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

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

Data	Description
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)
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 (Sheet 1 of 2)

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

Table 5.6 A5D1 Fast Meter Data Block (Sheet 2 of 2)

Data	Description
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

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

Data	Description
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
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 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.7.6*.
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.7.10*.

Section 6
MODBUS RTU Communications

Overview

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 modicon.com.

This section covers the following topics:

- Using the MODBUS protocol
- MODBUS commands
- Modbus 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 (Sheet 1 of 2)

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.

Table 6.3 SEL-547 MODBUS Exception Codes (Sheet 2 of 2)

Exception Code	Error Type	Description
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
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

Table 6.14 SEL-547 Command Coils (Sheet 2 of 2)

Coil	Field
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	–	–	–	–	–

Table 6.22 MODBUS Map (Sheet 2 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
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	–	–	–	–	–
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

Table 6.22 MODBUS Map (Sheet 3 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
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
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

Table 6.22 MODBUS Map (Sheet 4 of 12)

Address (Hex)	Field	Units	Range Low	Range High	Range Step	Scale Factor
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					
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 = *					

Table 6.22 MODBUS Map (Sheet 5 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	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					
	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					

Table 6.22 MODBUS Map (Sheet 6 of 12)

Address (Hex)	Field	Units	Range Low	Range High	Range Step	Scale Factor
	Bit 9 = 59C1					
	Bit 10 = 59B1					
	Bit 11 = 59A1					
	Bit 12 = 27C4					
	Bit 13 = 27B4					
	Bit 14 = 27A4					
	Bit 15 = 27C3					
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					

Table 6.22 **MODBUS Map** (Sheet 7 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	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					
	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					

Table 6.22 MODBUS Map (Sheet 8 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	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					
	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					

Table 6.22 MODBUS Map (Sheet 9 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 11 = SV5T					
	Bit 12 = SV8					
	Bit 13 = SV7					
	Bit 14 = SV6					
	Bit 15 = SV5					
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					

Table 6.22 MODBUS Map (Sheet 10 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bits 1–7 = 0					
	Bit 8 = LT8					
	Bit 9 = LT7					
	Bit 10 = LT6					
	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					

Table 6.22 MODBUS Map (Sheet 11 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00A2	Row 18					
	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 = 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

Table 6.22 MODBUS Map (Sheet 12 of 12)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00C5	Illegal function code/Op code[b]	–	0	65535	1	1
00C6	Illegal register[b]	–	0	65535	1	1
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

Overview

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 C (restricted access level, should be used under direction of SEL only)

Access Level 0

Once serial port communications are established with the relay, the relay sends the following 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 = prompt:

```
=ACC <Enter>
```

The **ACC** command takes the relay to Access Level 1 [see *ACC, BAC, 2AC, and CAL Commands (Go To Access Level 1, B, 2, or C) on page R.7.5* for more detail].

Access Level 1

When the relay is in Access Level 1, the relay sends the following 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 prompt to view metering data:

```
=>MET <Enter>
```

The **BAC** command allows the relay to go to Access Level B [see *ACC, BAC, 2AC, and CAL Commands (Go To Access Level 1, B, 2, or C)* for more detail]. Enter the **BAC** command at the Access Level 1 prompt:

```
=>BAC <Enter>
```

Access Level B

When the relay is in Access Level B, the relay sends the prompt:

```
==>
```

Commands **CLO** through **PUL** in *Table 7.1* are available from Access Level B. For example, enter the **CLO** command at the Access Level B 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, 2AC, and CAL Commands (Go To Access Level 1, B, 2, or C) on page R.7.5* for more detail]. Enter the **2AC** command at the Access Level B prompt:

```
==>2AC <Enter>
```

Access Level 2

When the relay is in Access Level 2, the relay sends the 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 prompt to make relay settings:

```
=>>SET <Enter>
```

Any of the Access Level 1 and Access Level B commands are also available (commands **2AC** through **PUL** in *Table 7.1*) in Access Level 2.

Access Level C

The CAL access level is intended for use by the SEL factory, and for use by SEL field service personnel to help diagnose troublesome installations. A list of commands available at the CAL level is available from SEL upon request. Do not enter the CAL access level except as directed by SEL.

The **CAL** command allows the relay to go to Access Level C [see *ACC, BAC, 2AC, and CAL Commands (Go To Access Level 1, B, 2, or C) on page R.7.5* for more detail]. Enter the **CAL** command at the Access Level 2 prompt:

```
=>>CAL <Enter>
```

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 (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 (Sheet 1 of 2)

Access Level	Prompt	Serial Port Command	Command Description
0	=	**ACC**	Go to Access Level 1
1	=>	**2AC**	Go to Access Level 2
1	=>	**BAC**	Go to Access Level B
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

Table 7.1 Serial Port Command Summary (Sheet 2 of 2)

Access Level	Prompt	Serial Port Command	Command Description
1	=>	**TIM**	View/change time
1	=>	**TRI**	Trigger an event report
B	==>	**CLO**	Close breaker
B	==>	**OPE**	Open breaker
B	==>	**PUL**	Pulse output contact
2	=>>	**CAL**	Go to Access Level C
2	=>>	**CON**	Control remote bit
2	=>>	**COP**	Copy setting group
2	=>>	**GRO *n***	Change active setting group
2	=>>	**PAS**	View / change passwords
2	=>>	**SET**	Change settings
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, 2AC, and CAL Commands (Go To Access Level 1, B, 2, or C)

The **ACC**, **BAC**, **2AC**, and **CAL** 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**, **2AC**, and **CAL** 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
- **CAL** moves from Access Level 2 to Access Level C

Access Level Attempt

At the Access Level 0 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 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 => 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 (= 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 prompt. The relay closes the ALARM contact for one second after a successful Level B, Level 2, or Level C 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.2.23* 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 volatile 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 volatile 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  11000000

=>
```

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 *Task 9: Viewing Metering Quantities on page U.3.22*.

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 = 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 or 2); *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). The value *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*. The value *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.

NOTE: The Relay Word row containing the LED1 bit is repeated 10 times. Command **TAR 0** will report the same data because the LED1 bit is in Row 0 of the Relay Word.

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

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.2.7*).

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.2.7*).

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 one second.

To pulse **OUT1** for five 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) ?` prompt is **N** or **n**, the command is aborted.

The relay generates an event report if any of the **OUT1–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–RB16 (see Rows 17 and 18 in *Appendix A: Relay Word Bits*). At the Access Level 2 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.2.14* 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 2. 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 *Multiple Setting Groups on page R.2.23*).

For example, to copy settings from Group 1 to Group 2 issue the following command:

```
=>>COP 1 2 <Enter>
Copy 1 to 2
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:

```
=>>
GENERATOR 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–SS2 are asserted to logical 1, the active setting group may not be changed with the **GRO** command; SELOGIC control equations settings SS1–SS2 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 = IN1 and optoisolated input IN1 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.2.23*.

PAS Command (View/Change Passwords)

PAS allows you to inspect or change existing passwords at Access Level 2 and allows you inspect or change the Level C password from Level C (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, 2, and C

Access Level	Factory Default Password
1	OTTER
B	EDITH
2	TAIL
C	CLARKE

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 want to disable password protection for a specific access level, set the password to DISABLE. For example, **PAS 1 DISABLE** disables password protection for Level 1.

R_S Command (Restore Default Settings)

The **R_S** command restores the factory default settings and passwords and reboots the relay. This command is only available when the relay encounters a status failure during the firmware upgrade process.

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

Section 8
Settings

Overview

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)	*R.SET.1–R.SET.5*
SET L *n*	SELOGIC (Group *n*)	SELOGIC® control equations for settings Group *n* (*n* = 1, 2)	*R.SET.6–R.SET.8*
SET G	Global	Global settings	*R.SET.9*
SET R	SER	Sequential Events Recorder trigger conditions	*R.SET.10*
SET P *n*	Port	Serial port settings for Serial Port *n* (*n* = 1 or F)	*R.SET.11–R.SET.12*
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*) and the **ENABLED** LED extinguishes (see *Table 2.8*) 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*), but the **ENABLED** LED remains on (see *Table 2.8*) 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.7.8*.

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*.

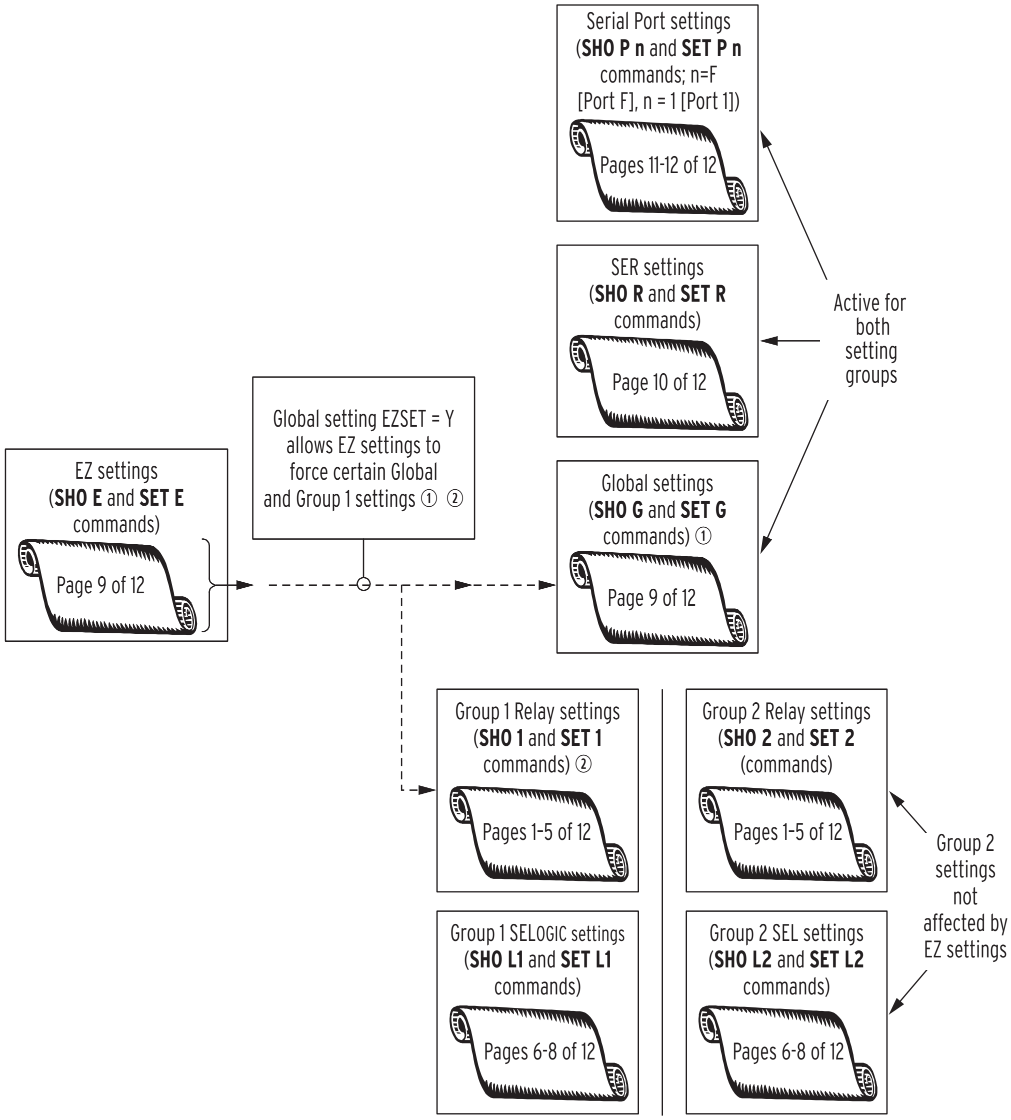


Figure 8.1 EZ Settings Relationship With Global and Group Settings
① See Table 8.3; ② See Table 8.4

Table 8.3 Global Settings and Corresponding EZ Settings (Sheet 1 of 2)

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 (0.00–16000 cyc)	TGR	0.00	
Nominal Frequency (50, 60 Hz)	NFREQ	60	FREQ
Phase Rotation (ABC, ACB)	PHROT	ABC	ROTATE
Date Format (MDY, YMD)	DATE_F	MDY	DATE
Length of Event Report (15, 30, 60 cyc)	LER	15	

Table 8.3 Global Settings and Corresponding EZ Settings (Sheet 2 of 2)

Description	Setting Label	Default Value	Corresponding EZ Setting (if any)
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, 5–3600 sec)	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 (30 characters)	RID	GENERATOR 1	RELID
Terminal Identifier (30 characters)	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, 55–400 V, sec)	27P1P	60	27UV1P—see *Table 8.5*
Phase Undervoltage Pickup (OFF, 55–400 V, sec)	27P2P	106	27UV2P—see *Table 8.5*
Phase Undervoltage Pickup (OFF, 55–400 V, sec)	27P3P	OFF	
Phase Undervoltage Pickup (OFF, 55–400 V, sec)	27P4P	OFF	
Phase Overvoltage Pickup (OFF, 55–400 V, sec)	59P1P	132	59OV1P—see *Table 8.5*
Phase Overvoltage Pickup (OFF, 55–400 V, sec)	59P2P	144	59OV2P—see *Table 8.5*
Phase Overvoltage Pickup (OFF, 55–400 V, sec)	59P3P	OFF	
Phase Overvoltage Pickup (OFF, 55–400 V, sec)	59P4P	OFF	
Zero-Seq (3V0) Overvoltage PU (OFF, 55–400 V, sec)	59N1P	OFF	
Zero-Seq (3V0) Overvoltage PU (OFF, 55–400 V, sec)	59N2P	OFF	
Neg-Seq (V2) Overvoltage PU (OFF, 55–267 V, sec)	59Q1P	60	see *Table 8.5*
Neg-Seq (V2) Overvoltage PU (OFF, 55–267 V, sec	59Q2P	OFF	
Pos-Seq (V1) Overvoltage PU (OFF, 55–400 V, sec)	59V1P	OFF	
Channel VS Undervoltage PU (OFF, 55–400 V, sec)	27SP	OFF	
Channel VS Overvoltage PU (OFF, 55–400 V, sec)	59S1P	OFF	
Channel VS Overvoltage PU (OFF, 55–400 V, sec)	59S2P	OFF	

Table 8.4 Group Settings and Corresponding EZ Settings (Sheet 2 of 3)

Description	Setting Label	Default Value	Corresponding EZ Setting (if any)
Frequency Element Settings			
Undervoltage Block (55–400 V, sec)	27B81P	84	27BLKP
Frequency Pickup (OFF, 40.1–69.9 Hz)	81D1P	57.0	81OU1P
Frequency Element Time Delay (5.00–16000 cyc)	81D1D	6.00	81OU1D
Frequency Pickup (OFF, 40.1–69.9 Hz)	81D2P	59.3	81OU2P
Frequency Element Time Delay (5.00–16000 cyc)	81D2D	116.00	81OU2D
Frequency Pickup (OFF, 40.1–69.9 Hz)	81D3P	60.5	81OU3P
Frequency Element Time Delay (5.00–16000 cyc)	81D3D	6.00	81OU3D
Frequency Pickup (OFF, 40.1–69.9 Hz)	81D4P	OFF	81OU4P
Frequency Element Time Delay (5.00–16000 cyc)	81D4D	6.00	81OU4D
Frequency Pickup (OFF, 40.1–69.9 Hz)	81D5P	OFF	
Frequency Element Time Delay (5.00–16000 cyc)	81D5D	6.00	
Frequency Pickup (OFF, 40.1–69.9 Hz)	81D6P	OFF	
Frequency Element Time Delay (5.00–16000 cyc)	81D6D	6.00	
Synchronism Check Element Settings			
Voltage Window—Low Threshold (55–400 V, sec)	25VLO	114	25DIFP—see *Table 8.5*
Voltage Window—High Threshold (55–400 V, sec)	25VHI	126	25DIFP—see *Table 8.5*
Maximum Slip Frequency (0.1–1 Hz)	25SF	0.3	25SLP
Maximum Angle 1 (2–60 deg)	25ANG1	20	25ANG
Maximum Angle 2 (2–60 deg)	25ANG2	20	
Synch. Phase for Channel VS			
(VA,VB,VC or 0–330 deg. lag VA)	SYNCP	VA	
Breaker Close Time for Angle Comp. (0.00–60 cyc)	TCLOSD	0.00	
Power Element Settings			
Three-Phase Power Pickup (OFF, 40–900 VA, sec)	PWR1P	60	32P
Power Element Type (+WATTS, –WATTS, +VARS, –VARS)	PWR1T	–WATTS	32FR—see *Table 8.5*
Power Element Time Delay (0.00–16000 cyc)	PWR1D	30.00	32D
Three-Phase Power Pickup (OFF, 40–900 VA, sec)	PWR2P	OFF	
Power Element Type (+WATTS, –WATTS, +VARS, –VARS)	PWR2T	–WATTS	
Power Element Time Delay (0.00–16000 cyc)	PWR2D	0.00	
Three-Phase Power Pickup (OFF, 40–900 VA, sec)	PWR3P	OFF	
Power Element Type (+WATTS, –WATTS, +VARS, –VARS)	PWR3T	–WATTS	
Power Element Time Delay (0.00–16000 cyc)	PWR3D	0.00	
Three-Phase Power Pickup (OFF, 40–900 VA, sec)	PWR4P	OFF	
Power Element Type (+WATTS, –WATTS, +VARS, –VARS)	PWR4T	–WATTS	
Power Element Time Delay (0.00–16000 cyc)	PWR4D	0.00	

Table 8.4 Group Settings and Corresponding EZ Settings (Sheet 3 of 3)

Description	Setting Label	Default Value	Corresponding EZ Setting (if any)
SELOGIC Variable Timer Settings			
SV_ Timer Pickup (0.00–999999 cyc)	SV1PU	0.00	
SV_ Timer Dropout (0.00–999999 cyc)	SV1DO	0.00	
SV_ Timer Pickup (0.00–999999 cyc)	SV2PU	0.00	
SV_ Timer Dropout (0.00–999999 cyc)	SV2DO	0.00	
SV_ Timer Pickup (0.00–999999 cyc)	SV3PU	0.00	
SV_ Timer Dropout (0.00–999999 cyc)	SV3DO	0.00	
SV_ Timer Pickup (0.00–999999 cyc)	SV4PU	0.00	
SV_ Timer Dropout (0.00–999999 cyc)	SV4DO	0.00	
SV_ Timer Pickup (0.00–999999 cyc)	SV5PU	0.00	
SV_ Timer Dropout (0.00–999999 cyc)	SV5DO	0.00	
SV_ Timer Pickup (0.00–999999 cyc)	SV6PU	0.00	
SV_ Timer Dropout (0.00–999999 cyc)	SV6DO	0.00	
SV_ Timer Pickup (0.00–16000 cyc)	SV7PU	6.00	27UV1D
SV_ Timer Dropout (0.00–16000 cyc)	SV7DO	15.00	
SV_ Timer Pickup (0.00–16000 cyc)	SV8PU	116.00	27UV2D
SV_ Timer Dropout (0.00–16000 cyc)	SV8DO	15.00	
SV_ Timer Pickup (0.00–16000 cyc)	SV9PU	56.00	59OV1D
SV_ Timer Dropout (0.00–16000 cyc)	SV9DO	15.00	
SV_ Timer Pickup (0.00–16000 cyc)	SV10PU	6.00	59OV2D
SV_ Timer Dropout (0.00–16000 cyc)	SV10DO	15.00	
SV_ Timer Pickup (0.00–16000 cyc)	SV11PU	0.00	
SV_ Timer Dropout (0.00–16000 cyc)	SV11DO	15.00	
SV_ Timer Pickup (0.00–16000 cyc)	SV12PU	0.00	
SV_ Timer Dropout (0.00–16000 cyc)	SV12DO	15.00	
SV_ Timer Pickup (0.00–16000 cyc)	SV13PU	30.00	
SV_ Timer Dropout (0.00–16000 cyc)	SV13DO	15.00	
SV_ Timer Pickup (0.00–16000 cyc)	SV14PU	0.00	
SV_ Timer Dropout (0.00–16000 cyc)	SV14DO	0.00	
SV_ Timer Pickup (0.00–16000 cyc)	SV15PU	0.00	
SV_ Timer Dropout (0.00–16000 cyc)	SV15DO	0.00	
SV_ Timer Pickup (0.00–16000 cyc)	SV16PU	0.00	
SV_ Timer Dropout (0.00–16000 cyc)	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/$\sqrt{3}$) Group 1 settings 27P2P, 59P1P, and 59P2P are derived similarly, from their corresponding EZ settings
59Q1P	59Q1P = 0.5 • (NOMV/$\sqrt{3}$)
25VLO	25VLO = (NOMV/$\sqrt{3}$) – (diff/2) [diff = (25DIFP/100) • (NOMV/$\sqrt{3}$)]
25VHI	25VHI = (NOMV/$\sqrt{3}$) + (diff/2) [diff = (25DIFP/100) • (NOMV/$\sqrt{3}$)]
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 8.4*) and global setting PHROT (Phase Rotation; see *Table 8.3*). 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.2.23* 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.2.23* 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 (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 2.3 and Figure 2.4)

SELOGIC Control Equation Variable SV1	**SV1**	= ____________
SELOGIC Control Equation Variable SV2	**SV2**	= ____________
SELOGIC Control Equation Variable SV3	**SV3**	= ____________
SELOGIC Control Equation Variable SV4	**SV4**	= ____________
SELOGIC Control Equation Variable SV5	**SV5**	= ____________
SELOGIC Control Equation Variable SV6	**SV6**	= ____________
SELOGIC Control Equation Variable SV7	**SV7**	= ____________
SELOGIC Control Equation Variable SV8	**SV8**	= ____________
SELOGIC Control Equation Variable SV9	**SV9**	= ____________
SELOGIC Control Equation Variable SV10	**SV10**	= ____________
SELOGIC Control Equation Variable SV11	**SV11**	= ____________
SELOGIC Control Equation Variable SV12	**SV12**	= ____________
SELOGIC Control Equation Variable SV13	**SV13**	= ____________
SELOGIC Control Equation Variable SV14	**SV14**	= ____________
SELOGIC Control Equation Variable SV15	**SV15**	= ____________
SELOGIC Control Equation Variable SV16	**SV16**	= ____________

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**	= ____________

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**	= ________________

Setting Group Selection Equations (see Table 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: 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.2.23)

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, 60 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.2.30)

Clock Pulse Interval (OFF, 5, 10, 15, 30, 60, 300, 600, 900, 1800, 3600 seconds)	**INTRVL**	= ________

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.3.10*.

SER Trigger List 1

SER1 = ____________________

SER Trigger List 2

SER2 = ____________________

SER Trigger List 3

SER3 = ____________________

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: SEL Communications Protocols* 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) [The BITS 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) [The MODID 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 FASTOP

- 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 *SEL Fast Operate Protocol on page R.5.12* 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: Protection Functions* and *Section 2: SELOGIC Control Equation Programming*. 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 2.27*)	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*)	
	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*)	
	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 (see *Figure 1.10*)	
	PWR3	Level 3 three-phase power element (see *Figure 1.10*)	
	PWR4	Level 4 three-phase power element (see *Figure 1.10*)	
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*)	

Table A.2 Relay Word Bit Definitions for SEL-547 (Sheet 5 of 5)

Row	Bit	Definition	Primary Application
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*)	
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

Index

T

V

SEL-547 Relay Command Summary

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

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

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

This page intentionally left blank

SEL-547 Relay Command Summary

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

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

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

This page intentionally left blank