

SEL-587Z


High-Impedance Differential Relay


Instruction Manual


20020903





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Section 1

Introduction and Specifications

Introduction

The SEL-587Z Relay is a high-impedance differential relay operating on the high-impedance principle. The unit provides three independent high-impedance elements, three independent overcurrent elements, two optoisolated inputs, four programmable output contacts, one alarm output contact, and two serial communication ports. Differential elements are set in volts for easy calculation of relay settings.

Apply the three independent high-impedance elements to single-zone bus protection, reactors, generators, large motors, or use single elements on grounded transformer windings as restricted earth fault protection. Use the instantaneous overcurrent elements for transformer bushing faults and the time-overcurrent elements to discriminate with other protection relays.

Overview

Instruction Manual

This instruction manual applies to the SEL-587Z. If you are unfamiliar with the relay, read the following sections in the outlined order.

Section 1: Introduction and Specifications. Provides a brief overview of the capabilities and general specifications of the relay.

Section 3: Relay Elements. Describes protection features and applications of the SEL-587Z.

Section 4: Control Logic. Explains the relay logic and logic inputs, SELOGIC® control equations, Relay Word bits, and relay outputs.

Section 5: Setting the Relay. Outlines making setting changes and includes the Settings Sheets.

Section 6: Serial Port Communications. Describes configuring the relay for serial communication and gives specific data on relay communications protocols.

Section 7: ASCII Command Reference. Presents an alphabetic list of relay ASCII commands used for control, viewing target information, and obtaining metering information.

Section 8: Front-Panel Interface. Explains monitoring and controlling the relay using the front panel.

Section 9: Event Reports and SER. Details event report generation, summary event report information, event report details, and interpreting event report data. This section also presents formats and applications of the Sequential Events Recorder (SER).

Section 2: Installation. Describes configuring, installing, and wiring the relay.

Section 10: Testing and Troubleshooting. Lists test procedures and a troubleshooting guide. You can use this section as a tutorial to check your understanding of relay operation.

Hardware

Figure 1.1 shows the front panel of the SEL-587Z.

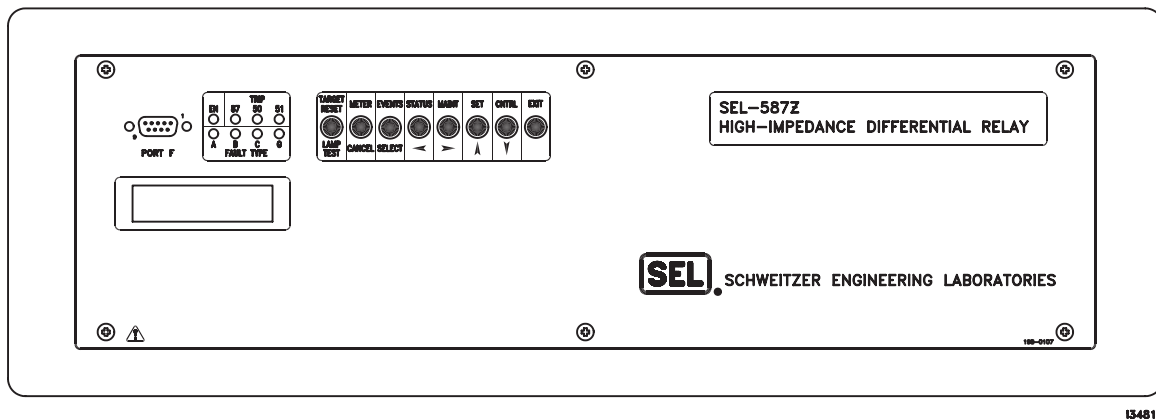


Figure 1.1 SEL-587Z Front Panel.

The block diagram in [Figure 1.2](#) shows the relay hardware arrangement. A single microprocessor, data acquisition system, and power supply perform the functions required to provide high-impedance differential and overcurrent protection.

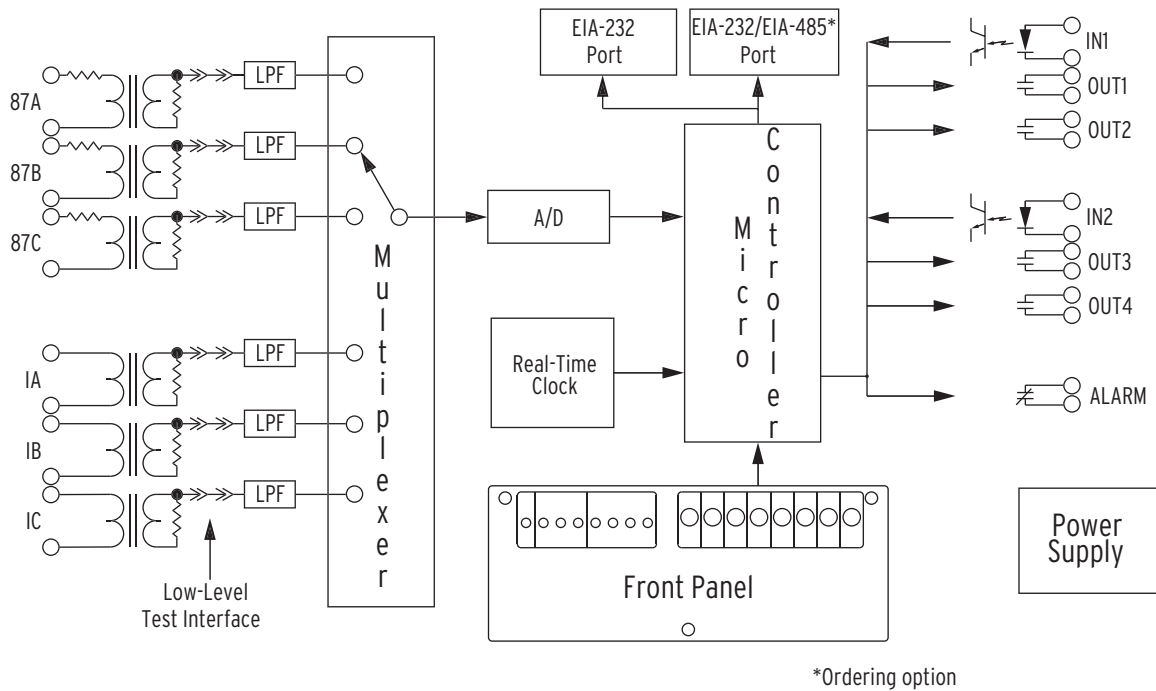


Figure 1.2 SEL-587Z Hardware Block Diagram.

SEL-587Z Functions

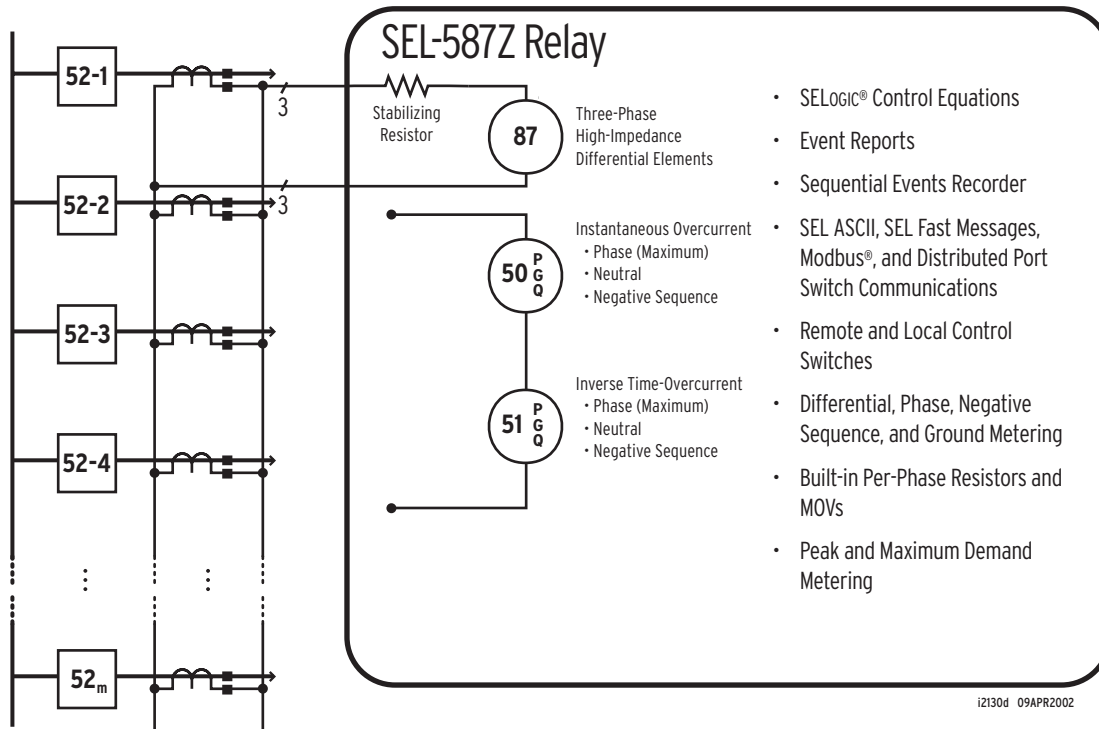


Figure 1.3 Protection Functions.

Differential Protection

Three independent high-impedance elements provide security for through faults, even during deep CT saturation conditions, yet provide fast clearance for in-zone faults. Built-in, per-phase metal oxide varistors (MOV) protect the CT wiring and relay against high-voltage surges during in-zone faults. Because the elements are independent, use single elements for sensitive restricted earth fault protection on grounded wye-connected transformer windings.

Overcurrent Protection

Three independent sets of overcurrent elements provide the following:

- Instantaneous phase and residual overcurrent elements
- Definite-time phase, residual, and negative-sequence overcurrent elements
- Inverse-time phase, residual, and negative-sequence overcurrent elements

Overcurrent element pickup settings and operating characteristics are independent from the differential element settings. When you use the SEL-587Z for transformer protection, the instantaneous overcurrent elements provide phase and ground overcurrent protection for bushing faults, while the time-overcurrent elements provide phase and ground protection for coordinating with other system protection.

Programmable Output Contacts

The SEL-587Z is equipped with SELOGIC® control equations that allow you to design a custom tripping scheme. SELOGIC control equation functions include timers, local and remote bits, tripping, event report triggering, and relay output contact control. An example of this flexibility is shown in [Figure 1.4](#), where OUT1 is set to operate the 86 lockout relay, OUT2 is set to report a CT open circuit, and OUT3 reports a bus zone alarm.

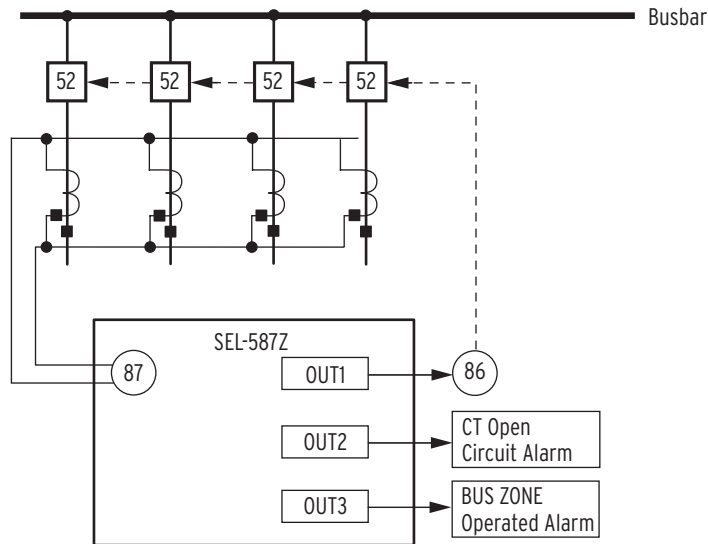


Figure 1.4 Bus Protection (simplified).

Applying the relay as transformer protection, [Figure 1.5](#) shows the same contacts configured for different functions. Now output contacts OUT1 and OUT2 are set to trip the high- and low-voltage breakers, and OUT3 and OUT4 are set to close the high- and low-voltage breakers. Set input IN1 to trip both high- and low-voltage breakers simultaneously in response to an external trip command.

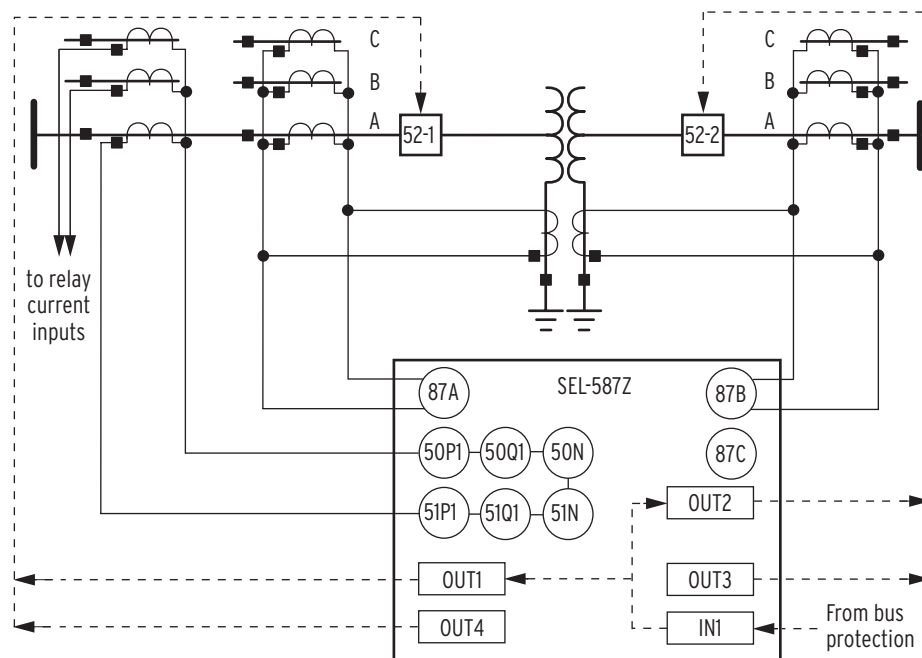


Figure 1.5 Transformer Protection (simplified).

Model Options

This relay is available with a number of options:

- 5.22" (132.6 mm) 3U rack-mount package
- 6.65" (168.9 mm) panel-mount package
- 6.65" (168.9 mm) projection panel-mount package
- 1 A or 5 A nominal current inputs
- One (2500 J) or two MOVs (5000 J)

Specifications

General

Terminal Connections

Rear Screw-Terminal Tightening Torque
Minimum: 8 in-lb (0.9 Nm)
Maximum: 12 in-lb (1.4 Nm)

Terminals or stranded copper wire. Ring terminals are recommended. Minimum temperature rating of 105°C.

High-Impedance Inputs (87A, 87B, 87C)

200 V nominal: 150 V continuous, linear to 3000 V symmetrical
Burden: 2000 Ω stabilizing resistance
Range: 20–800 V
Metal oxide varistor clamping voltage: 2000 V (8 x 20 μ s)
Metal oxide varistor maximum transient energy rating: 2500 J single or 5000 J double
Metal oxide varistor maximum continuous AC voltage rating: 750 V

AC Current Inputs (IA, IB, IC)

5 A nominal: 15 A continuous, 250 A for 1 s, 625 A for 1 cycle (sinusoidal waveform), linear to 100 A symmetrical
Burden: <0.16 VA @ 5 A, <1.15 VA @ 15 A
Range: 0.5–80 A
1 A nominal: 3 A continuous, 100 A for 1 s, 250 A for 1 cycle (sinusoidal waveform), linear to 20 A symmetrical
Burden: <0.06 VA @ 1 A, <0.18 VA @ 3 A
Range: 0.1–16 A

Frequency and Phase Rotation

System Frequency: 50 or 60 Hz
Phase Rotation: ABC or ACB rotation

Power Supply

125/250 V
Range: 85–350 Vdc or 85–264 Vac
Interruption: 100 ms @ 250 Vdc
Ripple: 5%
Burden: <5.5 W
48/125 V
Range: 36–200 Vdc or 85–140 Vac
Interruption: 100 ms @ 125 Vdc
Ripple: 5%
Burden: <5.5 W
24 Vdc
Range: 16–36 Vdc polarity dependent
Interruption: 25 ms @ 36 Vdc
Ripple: 5%
Burden: <5.5 W

Note: Interruption and Ripple per IEC 60255-11: 1979.

Output Contacts

Standard Outputs (5 contacts, including the alarm contact):

Make: 30 A
Carry: 6 A
1 s Rating: 100 A
MOV: 270 Vac, 360 Vdc, 40 J

Pickup/
Dropout Time: <5 ms

Breaking Capacity (10000 operations):
24 V 0.75 A L/R = 40 ms
48 V 0.50 A L/R = 40 ms
125 V 0.30 A L/R = 40 ms
250 V 0.20 A L/R = 40 ms

Cyclic Capacity (2.5 cycles/second):
24 V 0.75 A L/R = 40 ms
48 V 0.50 A L/R = 40 ms
125 V 0.30 A L/R = 40 ms
250 V 0.20 A L/R = 40 ms

Note: Make per IEEE C37.90: 1989; Breaking and Cyclic Capacity per IEC 60255-0-20: 1974.

Optoisolated Inputs

Standard Inputs (2 inputs, Control Voltage Jumpers):

24 Vdc: 15–30 Vdc
48 Vdc: 30–60 Vdc
125 Vdc: 80–150 Vdc
250 Vdc: 150–300 Vdc

Note: Optoisolated inputs draw approximately 4 mA of current. All current ratings are at nominal input voltages.

Communications Ports

Front Port: EIA-232
Rear Port
(Ground Isolated): EIA-232* or EIA-485*
(*order option)
Baud rate: 300–38400 bps

Time-Code Input

Relay accepts demodulated IRIG-B time-code input at rear-panel port.

Humidity

5% to 95% without condensation

Altitude

6560 feet (2000 m) AMSL

Operating Temperature

–40° to +185°F (–40° to +85°C)

Weight

9.01 lb (4.1 kg)

Routine Dielectric Strength Tests

performed on each manufactured relay)

AC current inputs,
optoisolated inputs,
and output contacts: 2500 Vac for 10 s
Power supply: 3100 Vdc for 10 s

Type Tests

Electromagnetic Compatibility (EMC)

Emissions: EN 50263: 1999
IEC 60255-25: 2000

Electromagnetic Compatibility Immunity

Conducted
Radio Frequency: ENV 50141: 1993
IEC 61000-4-6: 1996
IEC 60255-22-6: 2001
10 Vrms

Digital Radio
Telephone
Radio Frequency: ENV 50204: 1995
10 V/m at 900 MHz and 1.89 GHz

Electrostatic
Discharge: IEC 60255-22-2: 1996
IEC 61000-4-2: 1995

Levels 1, 2, 3, 4
IEEE C37.90.3: 2001
2, 4, and 8 kV contact;
4, 8, and 15 kV air

Fast Transient/
Burst: IEC 61000-4-4: 1995
IEC 60255-22-4: 1992
4 kV at 2.5 kHz and 5 kHz

Radiated Radio
Frequency: ENV 50140: 1993
IEC 60255-2-3: 2000
EN61000-4-3: 1996
IEC 61000-4-3: 1998

10 V/m
IEEE C37.90.2: 1995,
35 V/m

Surge Immunity: IEC 61000-4-5: 1995
2 kV line to line, 4 kV line to earth

Surge Withstand Capability:	IEC 60255-22-1: 1998 2.5 kV peak common mode, 2.5 kV peak differential mode IEEE C37.90.1: 1989 3.0 kV oscillatory, 5.0 kV fast transient IEEE C37.90.1: 1989 2.5 kV peak common mode, 2.5 kV peak differential mode oscillatory waveform, 4 kV at 2.5 kHz and 5 kHz fast transient waveform
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Environmental

Cold:	IEC 60068-2-1: 1990 EN 60068-2-1: 1993, Test Ad: Cold, 16 hours at -40°C
Dry Heat:	IEC 60068-2-2: 1974 EN 60068-2-2: 1993, Test Bd: Dry Heat, 16 hours at +85°C
Damp Heat, Cyclic:	IEC 60068-2-30: 1980, Test Db: 25°C to 55°C, 6 cycles, 95% humidity
Vibration:	IEC 60255-21-1: 1988 EN 60255-21-1: 1995 Class 1 Endurance, Class 2 Response IEC 60255-21-2: 1988 EN 60255-21-2: 1995 Class 1 Shock Withstand, Bump, Class 2 Shock Response IEC 60255-21-3: 1993 EN 60255-21-3: 1995 Class 2

Safety

Dielectric Strength:	IEC 60255-5: 2000 IEEE C37.90: 1989 2500 Vac on analogs, contact inputs, and contact outputs; 3100 Vdc on power supply
Impulse:	IEC 60255-5: 2000 0.5 J, 5 kV

Certifications

ISO:	Relay is designed and manufactured using ISO-9001 certified quality program.
Product Safety:	C22.2 No. 14-95 IEC 60255-6: 1988 EN 60255-6: 1994 UL 508
Installation/ Overvoltage:	IEC 61010: 1993 Category II, Pollution Degree 2
CSA certified	

Sampling

16 samples per power system cycle

Processing

Differential elements, optoisolated inputs, and contact outputs are processed at 1/8-cycle.
 Overcurrent elements are processed at 1/8-cycle.

Metering Accuracy

Instantaneous Currents:	
5 A Model:	±2% ±0.10 A
1 A Model:	±2% ±0.02 A
Demand Currents:	
5 A Model:	±2% ±0.10 A
1 A Model:	±2% ±0.02 A
High-Impedance Voltage:	±5% ±2 V

Differential Element

Pickup Range:	20–800 V
Pickup Accuracy (V secondary):	
5 A Model:	±5% ±4 V
1 A Model:	±5% ±4 V
Pickup Time (Max):	1.25 cycles

Instantaneous/Definite-Time Overcurrent Elements

Pickup Range (A secondary):	
5 A Model:	0.5–80.0 A
1 A Model:	0.1–16.0 A
Pickup Accuracy (A secondary):	
5 A Model:	±5% ±0.10 A
1 A Model:	±5% ±0.02 A
Pickup Time (Typ/Max):	0.75/1.25 cycles
Time Delay Range:	0–16000 cycles
Time Delay Accuracy:	±0.1% ±0.25 cycle

Time Overcurrent Elements

Pickup Range (A secondary):	
5 A Model:	0.5–16.0 A
1 A Model:	0.1–3.2 A
Pickup Accuracy (A secondary):	
5 A Model:	±5% ±0.10 A
1 A Model:	±5% ±0.02 A
Curves:	
U1 =	U.S. Moderately Inverse
U2 =	U.S. Inverse
U3 =	U.S. Very Inverse
U4 =	U.S. Extremely Inverse
U5 =	U.S. Short-Time Inverse
C1 =	IEC Class A (Standard Inverse)
C2 =	IEC Class B (Very Inverse)
C3 =	IEC Class C (Extremely Inverse)
C4 =	IEC Long-Time Inverse
C5 =	IEC Short-Time Inverse
Time-Dial Range	
U.S. Curves:	0.50–15.00, 0.01 step
IEC Curves:	0.05–1.00, 0.01 step
Timing Accuracy:	±4% ±1.5 cycles for current between 2 and 30 multiples of pickup. Curves operate on definite-time for current greater than 30 multiples of pickup or 16 times nominal.
Reset	
Characteristic:	Induction-disk reset emulation or 1-cycle linear reset

Section 2

Installation

Introduction

Design your installation using the mounting and connection information in this section. Options include rack, panel, or projection panel mounting. This section also includes information on configuring the relay for your application.

Relay Mounting and Maintenance

Ventilation

Allow at least one-rack unit (1.75" [44.5 mm]) free space below the SEL-587Z Relay for ventilation. Air flows from the bottom of the relay over the resistors and out the right side (as you face the relay).

Rack Mount

We offer the SEL-587Z in a rack-mount version that bolts easily into a standard 19-inch rack. See [Figure 2.1 on page 2.3](#). From the front of the relay, insert four rack screws (two on each side) through the holes on the relay mounting flanges.

Reverse the relay mounting flanges to cause the relay to project 2.75 inches (69.9 mm) from the front of your mounting rack and provide additional space at the rear of the relay for applications where the relay might otherwise be too deep to fit.

Panel Mount

We also offer the SEL-587Z in a panel-mount version for a clean look. Panel-mount relays have sculpted front-panel molding that covers all installation holes. See [Figure 2.1 on page 2.3](#). Cut your panel and drill mounting holes according to the dimensions in [Figure 2.1 on page 2.3](#). Insert the relay into the cutout, aligning four relay mounting studs on the rear of the relay front panel with the drilled holes in your panel, and use nuts to secure the relay to the panel.

The projection panel-mount option covers all installation holes and maintains the sculpted look of the panel-mount option; the relay projects 2.75 inches (69.9 mm) from the front of your panel. This ordering option increases space at the rear of the relay for applications where the relay would ordinarily be too deep to fit your cabinet.

Cleaning

Use care when cleaning the SEL-587Z. Use a mild soap or detergent solution and a damp cloth to clean the relay chassis. Allow the relay to air dry, or wipe dry with a soft dry cloth. Do not use abrasive materials or polishing compounds on any relay surface. Be careful cleaning the front and rear panels because a permanent plastic sheet covers each panel; do not use harsh chemical solvents such as xylene or acetone on these surfaces.

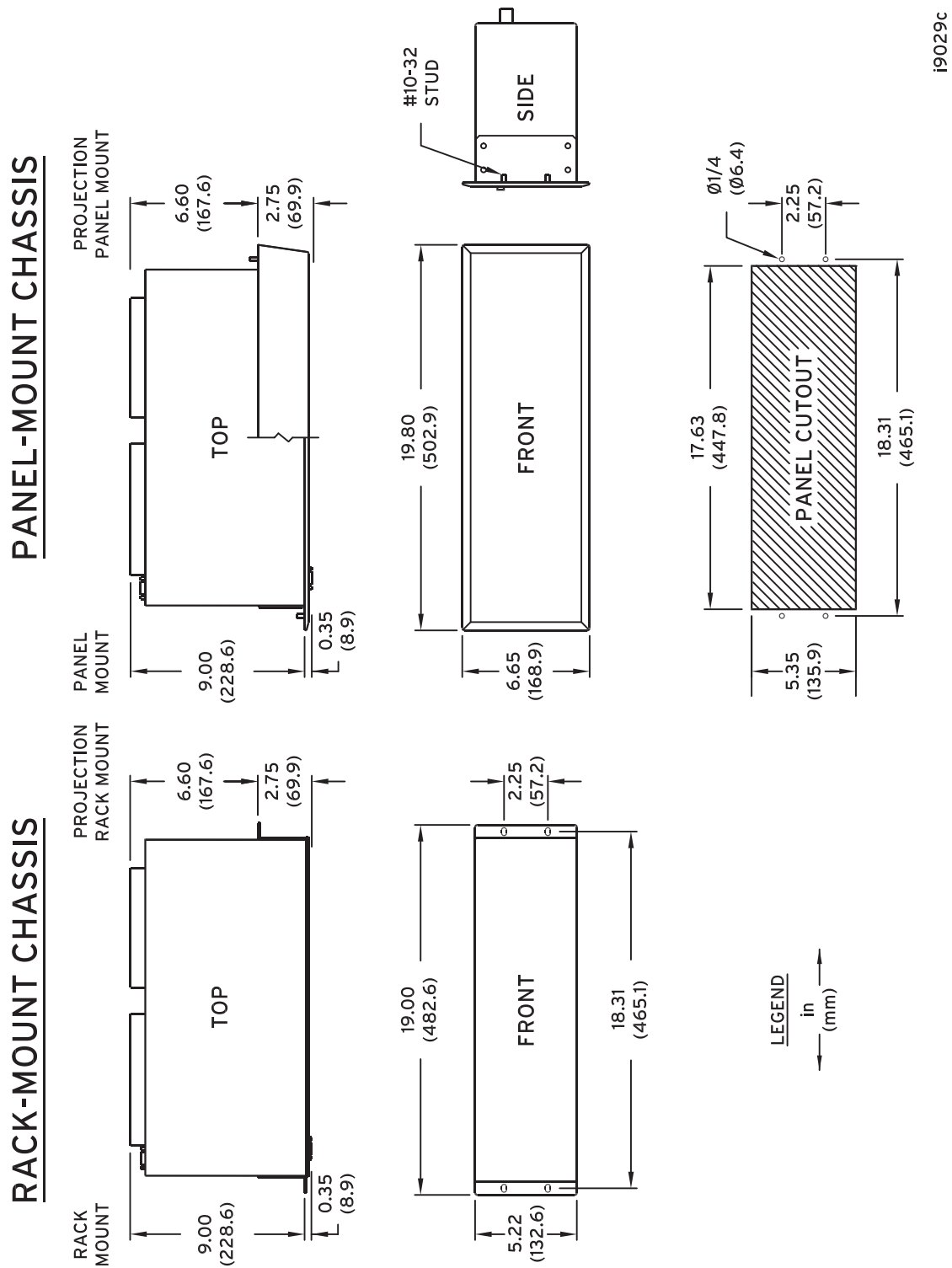


Figure 2.1 Relay Dimensions, Panel Cutout, and Drill Plan.

Rear-Panel Connections

Connect wiring to the conventional terminal blocks on the relay rear panel. Make terminal block connections with size #6-32 screws using a Phillips or slotted screwdriver (see [Section 1: Introduction and Specifications](#) for tightening torque information). You may request locking screws from the factory. Refer to [Figure 2.2](#) to make all terminal block connections. Be sure to use wire that is appropriate for your installation with an insulation rating of at least 105°C.

Output contacts OUT1–OUT4 and ALARM are not polarity dependent.

Optoisolator inputs IN1 and IN2 are not polarity dependent.

Connector terminals 101–112 and 201–216 accept wire size AWG 24 to 12.

Ground connection (terminal 217): tab size 0.250" x 0.032", screw size #6-32. Use 12 AWG (4 mm²) or heavier wire less than 6.6 feet (2 m) in length for this connection.

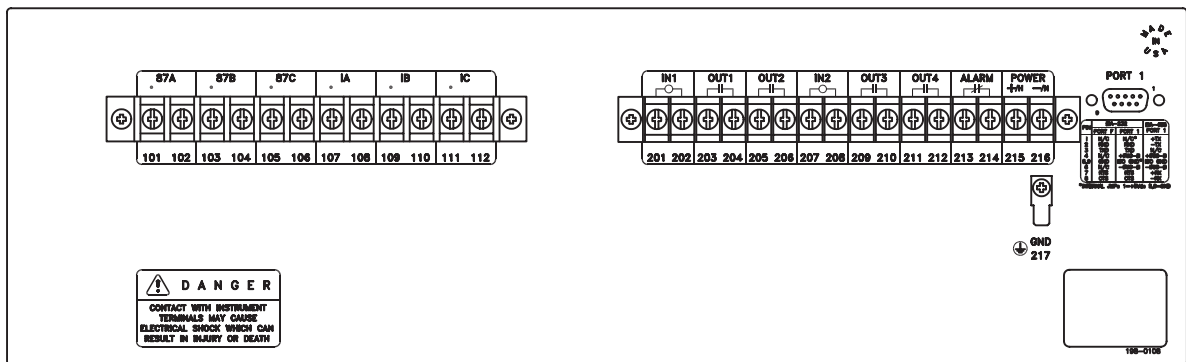


Figure 2.2 Relay Rear Panel.

Power

The SEL-587Z accepts dc power input for all three power supply models. The 48/125 Vdc supply also accepts 120 Vac; the 125/250 Vdc supply also accepts 120/240 Vac. When connecting a dc power source, you must connect the source with the proper polarity, as indicated by the + (terminal 215) and – (terminal 216) symbols on the power terminals. When connecting an ac power source, the + terminal #215 is hot (H), and the – terminal #216 is neutral (N).

The terminals labeled POWER on the rear panel (215 and 216) must connect to a power source that matches the power supply characteristics that your SEL-587Z specifies on the rear-panel serial number label. (See [Section 1: Introduction and Specifications](#) for complete power input specifications.)

The POWER terminals are isolated from chassis ground. Use 16 AWG (1.5 mm²) size or heavier wire to connect to the POWER terminals. Connection to external power must comply with IEC 947-1 and IEC 947-3.

Place an external switch, circuit breaker, or overcurrent device in the POWER leads for the SEL-587Z; this device must interrupt both the hot (H) and neutral (N) power leads. The maximum current rating for the power disconnect circuit breaker or overcurrent device (fuse) must be 20 A. Be sure to locate this device within 9.8 feet (3.0 m) of the relay.

SEL-587Z Relay AC/DC Connection Diagrams

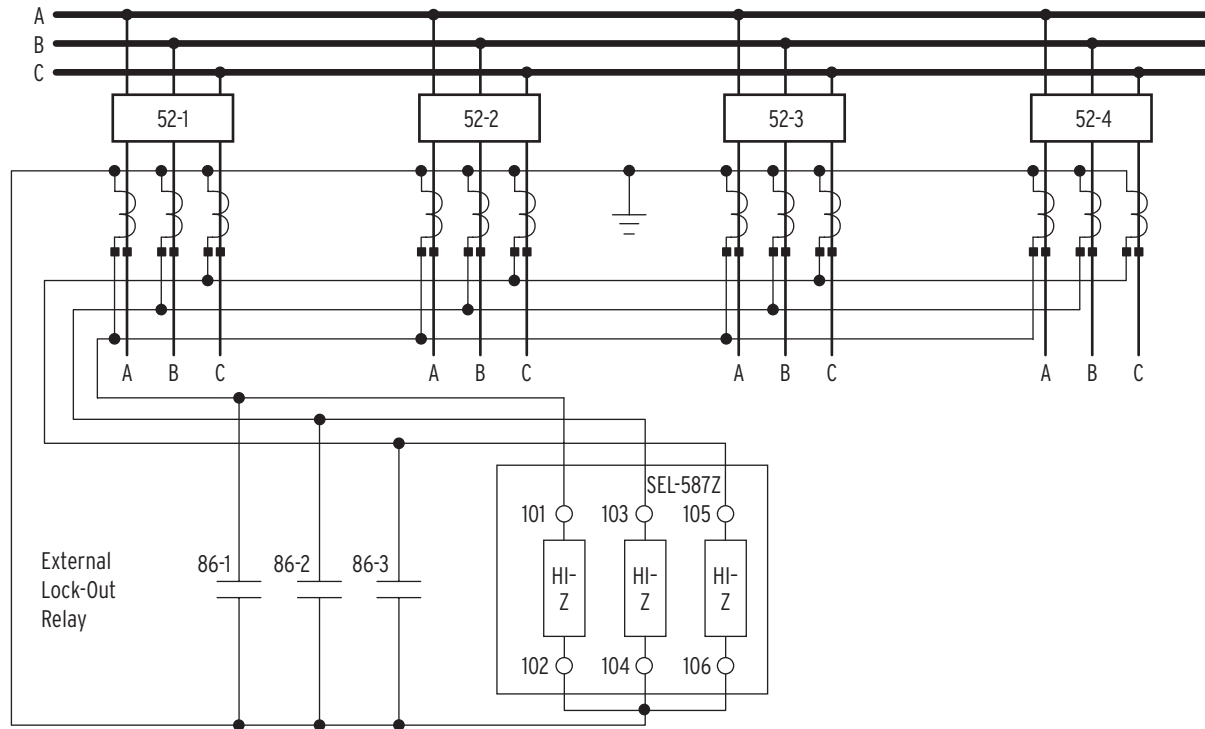


Figure 2.3 Example AC Connection for High-Impedance Bus Protection.

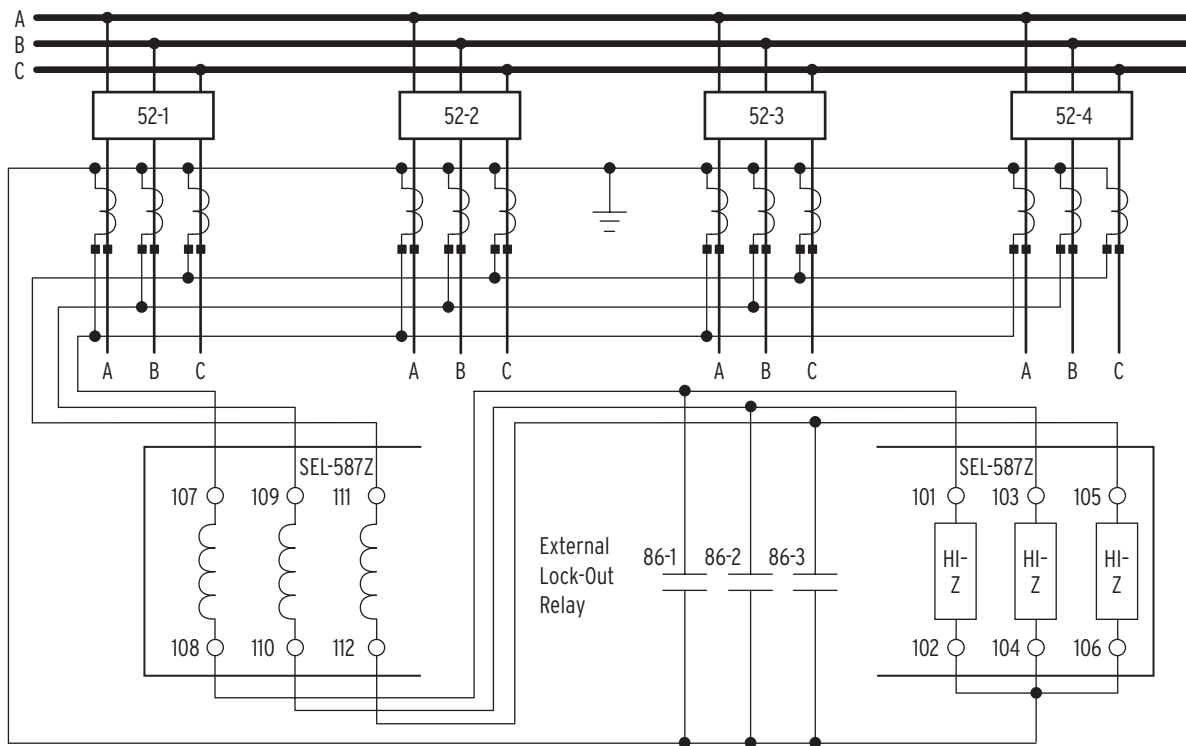


Figure 2.4 Example AC Connection With 50/51 Overcurrent Element.

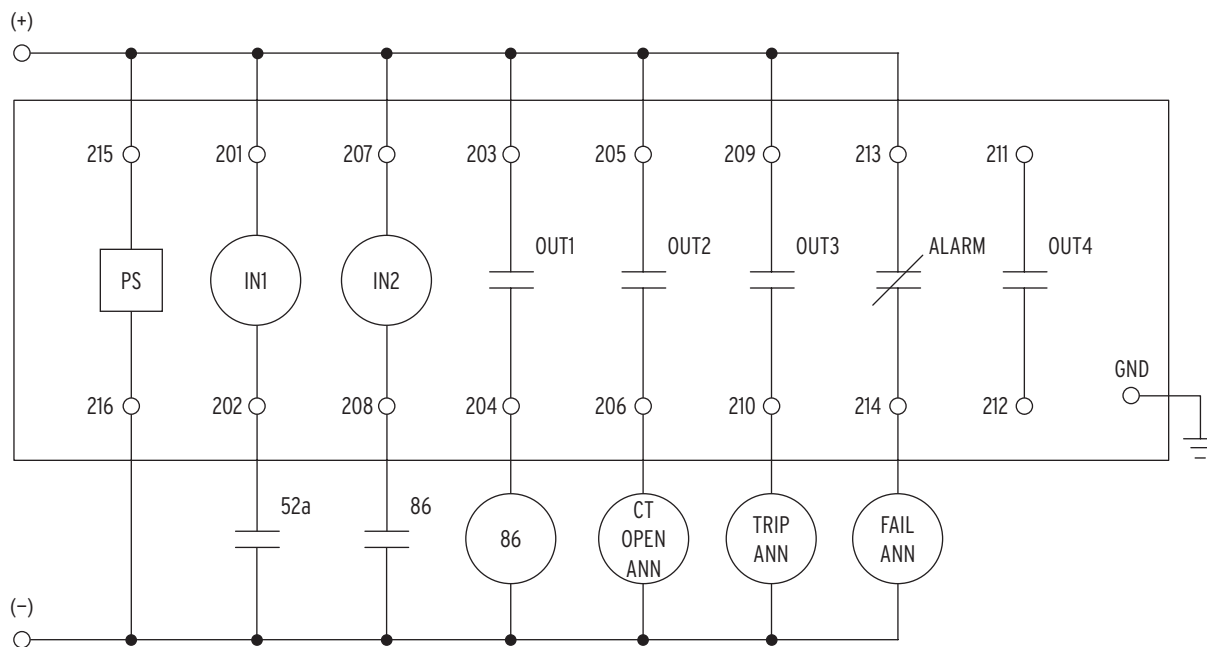


Figure 2.5 Example DC Connection.

Circuit Board Jumpers and Battery

Control Voltage Jumpers

CAUTION: Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Properly 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.

The SEL-587Z has field-changeable jumpers that select the control voltage for two digital inputs. Refer to [Section 1: Introduction and Specifications](#) for details on operating voltage and current levels.

The jumpers are factory configured to the control voltage specified at time of ordering. The jumpers may be changed as outlined below.

To change the control input voltage range using internal jumpers, take the following steps:

- Step 1. De-energize the relay.
- Step 2. Remove the six front-panel screws and the relay front panel.
- Step 3. Disconnect the analog signal ribbon cable and the power supply cable from the underside of the relay main board.
- Step 4. Grasp the black knob on the front of the draw-out assembly and pull the assembly from the relay chassis.
- Step 5. Locate the control voltage jumpers near the rear edge of the relay main board.

The jumpers are numbered JMP6 through JMP11. Refer to [Figure 2.6 on page 2.9](#).

- Step 6. Install or remove jumpers according to [Table 2.1](#) to select the desired control voltage level.
- Step 7. Slide the draw-out assembly into the relay chassis.
- Step 8. Reconnect the analog signal ribbon cable and the power supply cable.
- Step 9. Replace the relay front panel and reenergize the relay.

Table 2.1 Control Input Voltage Selection Jumper Positions

Control Voltage	IN1			IN2		
	JMP6	JMP7	JMP8	JMP9	JMP10	JMP11
250 Vdc	• •	• •	• •	• •	• •	• •
125 Vdc	—•	• •	• •	—•	• •	• •
48 Vdc	—•	—•	• •	—•	—•	• •
24 Vdc	—•	—•	—•	—•	—•	—•

Output Contact Jumpers

Jumpers JMP1 through JMP5 select the contact type for the output contacts. Refer to [Figure 2.6 on page 2.9](#). With a jumper in the A position, the corresponding output contact is an “a” type output contact. An “a” type output contact is open when the output contact coil is de-energized and closed when the output contact coil is energized. With a jumper in the B position, the corresponding output contact is a “b” type output contact. A “b” type output contact is closed when the output contact coil is de-energized and open when the output contact coil is energized. These jumpers are soldered in place.

In [Figure 2.6 on page 2.9](#), note that the ALARM output contact is a “b” contact and the other output contacts are all “a” contacts. This is how these jumpers are configured in a standard relay shipment.

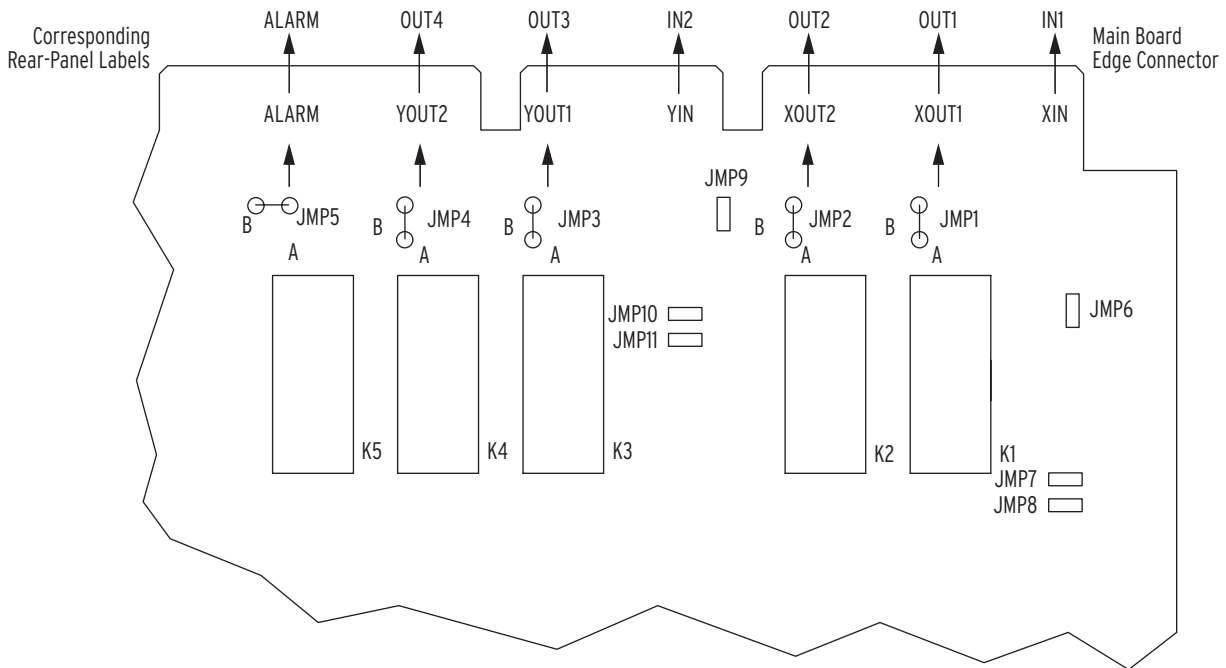


Figure 2.6 Input and Output Jumper Locations.

Password and Breaker Control Command Jumpers

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.

EIA-232 Serial Communications Port Voltage Jumper

Second Alarm Contact

[Section 7: ASCII Command Reference](#) contains operation information regarding the password and breaker control commands. Password and Breaker Control Command jumpers are on the front edge of the relay main board between the front-panel LEDs and the control pushbuttons. Remove the relay front panel to change them.

Put jumper JMP22 (left-most jumper) in place to disable serial port and front-panel password protection. With the jumper removed, password security is enabled. Set the password with the **PASSWORD** command as described in [Section 7: ASCII Command Reference](#).

Put jumper JMP24 (right-most jumper) in place to enable the output contact control commands (**OPEN**, **CLOSE**, and **PULSE**). Breaker output contact control commands are ignored while JMP24 is removed.

Jumper JMP12 and jumper JMP14 apply to the EIA-232 option only for Port 1 (rear port) and are at the rear of the main board, near the rear-panel EIA-232 serial communications port. Jumper JMP 12 connects or disconnects +5 Vdc to pin 1 on the EIA-232 serial communications port. For successful port voltage output, you must also apply jumper JMP14 (located near the rear communications port) to short pin 5 and pin 9 for the +5 Vdc ground return path. When jumper JMP12 and jumper JMP14 are in place, the rear communications port is no longer isolated.

In a standard relay shipment, jumpers JMP12 and JMP14 are removed (out of place) so that the +5 Vdc is not connected on the EIA-232 serial communications port and the port is isolated from ground. See [Section 6: Serial Port Communications](#).

Refer to [Figure 2.7 on page 2.10](#). Main board jumper JMP13 controls the operation of output contact OUT4. It provides the option of a second alarm output contact by changing the signal that drives output contact OUT4.

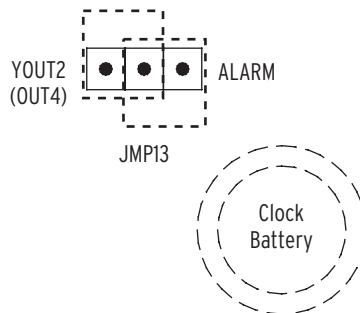


Figure 2.7 Output Contact OUT4 Control Jumper Location.

Table 2.2 Required Position of Jumper JMP13 for Desired Output Contact OUT4 Operation

Position	Output Contact OUT4 Operation
Jumper Left	Regular output contact OUT4 (operated by Relay Word bit OUT4). Jumper JMP13 comes in this position in a standard relay shipment.
Jumper Right	Extra Alarm output contact (operated by alarm logic/circuitry). Relay Word bit OUT4 does not have any effect on output contact OUT4 when jumper JMP13 is in this position.

If jumper JMP13 is in position ALARM and both output contacts OUT4 and ALARM are the same output contact type (“a” or “b”), these outputs will be in the same state (closed or open). If jumper JMP13 is in position ALARM and output contacts OUT4 and ALARM are different output contact types (one is an “a” and one is a “b”), these outputs will be in opposite states (one is closed and one is open).

Clock Battery

A lithium battery powers the relay clock (date and time) if the external dc source is lost or removed. The battery is a 3 V lithium coin cell. At room temperature (25°C) the battery will operate nominally for 10 years at rated load.

CAUTION: Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Properly 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.

CAUTION: There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac® no. BR2335 or equivalent recommended by manufacturer. Dispose of used batteries according to the manufacturer’s instructions.

If the dc source is lost or disconnected, the battery discharges to power the clock. When the relay is powered from an external source, the battery only experiences a low self-discharge rate. Thus, battery life can extend well beyond the nominal 10 years because the battery rarely has to discharge after the relay is installed. The battery cannot be recharged.

If the battery voltage is out of tolerance, an automatic status message is sent to the serial port and the front-panel display.

To change the battery, take the following steps:

- Step 1. De-energize the relay.
- Step 2. Remove the six front-panel screws and remove the relay front panel.
- Step 3. Disconnect the analog signal ribbon cable and power supply cable from the underside of the relay main board.
- Step 4. Grasp the black knob on the front of the draw-out assembly and pull the assembly from the relay chassis.
- Step 5. Locate the battery on the right-hand side of the relay main board.

- Step 6. Remove the battery from beneath the clip and install a new one.
The positive side (+) of the battery faces up.
- Step 7. Slide the draw-out assembly into the relay chassis.
- Step 8. Reconnect the analog signal ribbon cable and power supply cable.
- Step 9. Replace the relay front panel and reenergize the relay.
- Step 10. Set the relay date and time (see *DAT (Date) on page 7.8 in Section 7: ASCII Command Reference* and *TIM (Time) on page 7.21 in Section 7: ASCII Command Reference*).

Port Connector and Communications Cables

For information on making communications port connections to the relay, see [*Section 6: Serial Port Communications*](#).

Section 3

Relay Elements

Introduction

This section discusses the operation of the differential elements, blocking logic, and overcurrent elements. The section also presents recommendations for calculating protection element settings. Differential protection elements are discussed first, followed by overcurrent elements.

High-Impedance Protection

The SEL-587Z Relay combines high-impedance protection principles with advanced numerical technologies. The relay offers fast response during internal faults and high security for through faults. Other features are metering, sequential events reporting, digital fault recording, remote setting capabilities, SELOGIC® control equations, and a high flexibility in adapting the relay to required needs.

The SEL-587Z provides three independent high-impedance elements, one for each phase. The relay also provides single- and three-phase overcurrent elements with negative- and zero-sequence calculated elements. The low-impedance overcurrent elements have instantaneous, definite time (SELOGIC control equations timer), and time-overcurrent characteristics. All six elements are independent, resulting in a completely flexible relay.

Two separate digital filters optimize the input quantities to the elements. The half-cosine filter in the high-impedance elements primarily removes the dc component, but also the odd harmonics as a result of the filter characteristic, while the full-cosine filter in the overcurrent elements filters all but the fundamental frequency.

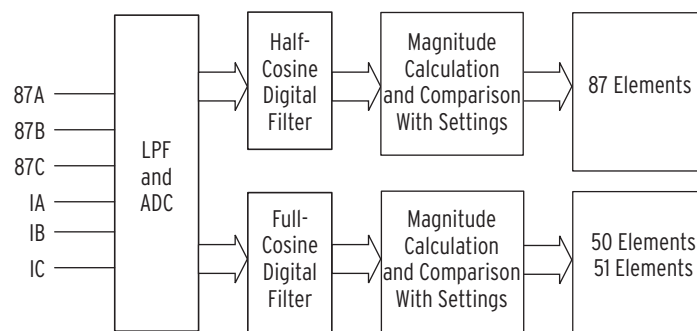


Figure 3.1 Differential Relay Currents.

High-Impedance Differential

The differential element compares the measured voltage with the differential element setting. Because the calculation compares two values, the element acts as a comparator, as shown in [Figure 3.2](#) (A-phase) to [Figure 3.4 on page 3.3](#). Each phase has a separate differential element to provide phase-segregated measurements. Each differential element has two levels, providing six settings in total. When the measured voltage exceeds the setting, the relay asserts the appropriate Relay Word bit. If the Relay Word bit was entered in the trip equation and assigned to an output contact, the output contact closing results in circuit breaker operation.

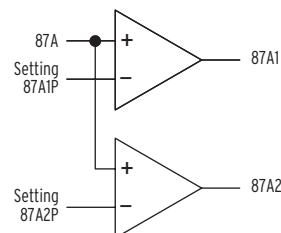


Figure 3.2 A-Phase High-Impedance Element.

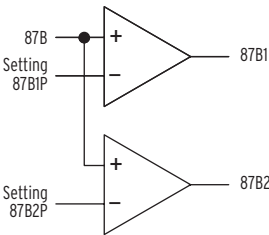


Figure 3.3 B-Phase High-Impedance Element.

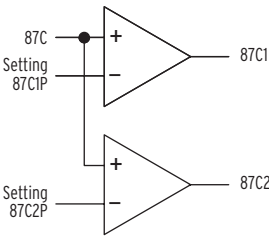


Figure 3.4 C-Phase High-Impedance Element.

Setting Description

Differential Element Pickups (87A1P through 87C2P) Range: OFF, 20–800 V

The SEL-587Z has three independent, high-impedance differential elements, each with two levels. Use differential elements 87A1, 87B1, and 87C1 for bus protection and elements 87A2, 87B2, and 87C2 for alarms. All six settings have the same range and are set in volts.

Table 3.1 summarizes the input, setting, and output relationship of the differential elements. All Relay Word bits are listed in *Appendix C: Relay Word Bits*.

Table 3.1 Differential Elements

Element Label	Input	Settings	Output (Relay Word Bit)
High Impedance	87A, 87B, 87C	87A1P, 87B1P, 87C1P	87A1, 87B1, 87C1
High Impedance	87A, 87B, 87C	87A2P, 87B2P, 87C2P	87A2, 87B2, 87C2

Setting Calculation

Circuit parameters:

- CT = ratio: 2000/5, type: C800, knee-point voltage: 432 V
- I_F = 50 kA (three-phase symmetrical)
- R_{CT} = 0.82 Ω
- R_{LEAD} = 0.6 Ω
- n = total number of circuits = 5

Balance two considerations when calculating the differential setting, for example, a low-value setting for maximum sensitivity for in-zone faults against a high-value setting to ensure stability for a saturated CT for through faults. First, calculate the minimum setting for the latter condition. *Figure 3.5* shows the equivalent circuit for a through fault with one CT saturating.

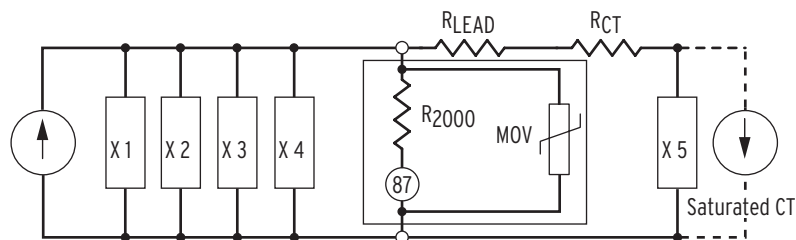


Figure 3.5 Equivalent Circuit for Through Fault.

Because the CT has saturated, the inductance (X5) falls to zero, effectively reducing the CT impedance to R_{CT} , the CT internal resistance. The following equation expresses the voltage developed across the high-impedance element:

$$V_r = (R_{CT} + P \cdot R_{LEAD}) \cdot \frac{I_F}{N} \quad \text{Equation 3.1}$$

where

- V_r = voltage across the high-impedance element
- I_F = maximum external fault current
- N = CT ratio
- R_{CT} = the CT secondary winding and lead resistance up to the CT terminals
- R_{LEAD} = the one-way resistance of lead from junction points to the most distant CT
- P = 1 for three-phase faults and 2 for single-phase-to-ground faults

Multiplier P is 2 for single-phase-to-ground faults because the fault current flows through both of the faulted-phase CT cables. During a balanced three-phase fault, the fault current in the return cable is 0; only the one-way cable resistance is involved so the P multiplier is 1.

The voltage is directly proportional to the CT secondary resistance and the CT secondary leads. Keep this voltage as low as possible by parallelling all the CT secondaries in the switchyard as closely as possible to the current transformers. Use the highest possible CT ratio, particularly for very high fault currents.

Calculate the voltage developed across the high-impedance element:

$$\begin{aligned} V_r &= \frac{I_F}{N} \cdot (R_{CT} + (R_{LEAD} \cdot P)) \\ &= \frac{50000}{400} \cdot (0.82 + (0.6 \cdot 1)) \\ &= 178 \text{ V (nearest volt)} \end{aligned} \quad \text{Equation 3.2}$$

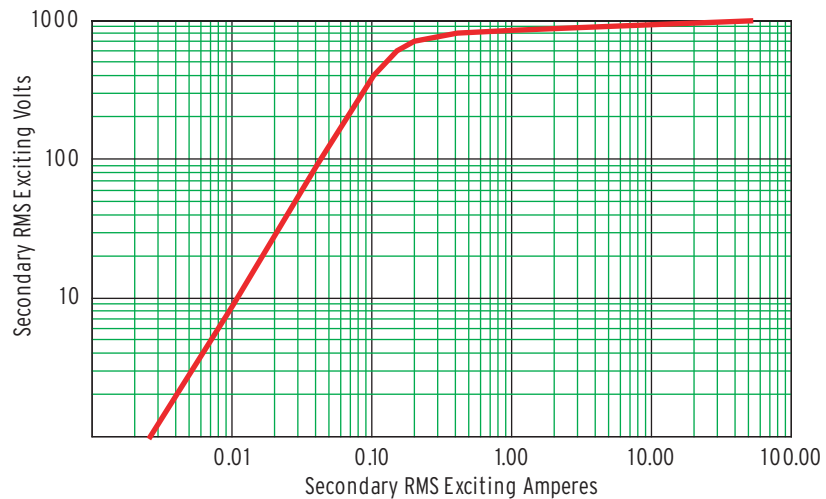


Figure 3.6 CT Characteristic.

This is a very pessimistic value, because the current transformer completely saturates only under extreme conditions. Comparing the calculated value with the CT knee-point voltage, [Figure 3.6](#) shows that 178 V is well below the knee-point voltage of 432 V.

Set the voltage elements of the high-impedance relay for the maximum possible voltage developed across the elements for an external fault as follows:

$$V_s = K \cdot V_r \quad \text{Equation 3.3}$$

where

- V_s = voltage setting
- K = a safety factor, representing the necessary security level and CT performance

For this example, choose K as 150 percent. Follow your company practices for setting this safety factor in your particular application.

$$\begin{aligned} V_s &= 1.5 \cdot V_r \\ &= 1.5 \cdot 178 \\ &= 267 \text{ V} \end{aligned} \quad \text{Equation 3.4}$$

Set the high-impedance elements $87A1P = 87B1P = 87C1P = 267 \text{ V}$.

Minimum Internal Fault Operating Current

Use the following equation to calculate the minimum primary current required to operate the relay for an internal fault:

$$I_{\min} = (n \cdot I_e + I_r + I_m) \cdot N \quad \text{Equation 3.5}$$

where

I_{\min}	=	minimum current
n	=	number of current transformers in parallel with the relay, per single phase
I_e	=	current transformer exciting current at relay setting voltage = V_r
I_r	=	current through the relay at relay setting voltage = V_r
I_m	=	current through the MOV at relay setting voltage = V_r

To achieve better sensitivity for the minimum internal fault current, use CTs with the highest possible knee voltage to assure small CT exciting current (I_e).

The SEL-587Z has a built-in high-value resistor (2000 ohm) that provides good sensitivity with a small relay current (I_r).

To assure a small leakage current (I_m) through the MOV at the relay setting voltage, the relay uses a high-quality device, selected to the highest possible clamping voltage within the rated insulation parameters.

Exciting Current (I_e)

The exciting (I_e) current is ± 110 mA as read from [Figure 3.6 on page 3.5](#) and for a voltage value of 267 V (V_s).

Current Through the Relay (I_r)

Use [Equation 3.6](#) to calculate the current through the relay.

$$\begin{aligned} I_r &= \frac{V_s}{R_{2000}} \\ &= \frac{267}{2000} \\ &= 134 \text{ mA} \end{aligned}$$

Equation 3.6

Current Through MOV (I_m)

The current through the MOV (I_m) is 0 A as read from [Figure 3.7 on page 3.7](#) and for a voltage value of 267 V (V_s).

Thus, we can ignore the current through the MOV.

Minimum Operating Current Calculation

[Equation 3.7](#) provides the total minimum primary current required to operate the relay.

$$\begin{aligned} I_{\min} &= (n \cdot I_e + I_r + 0) \cdot N \\ &= (5 \cdot 0.11 + 0.134) \cdot 400 \\ &= 274 \text{ A} \end{aligned}$$

Equation 3.7

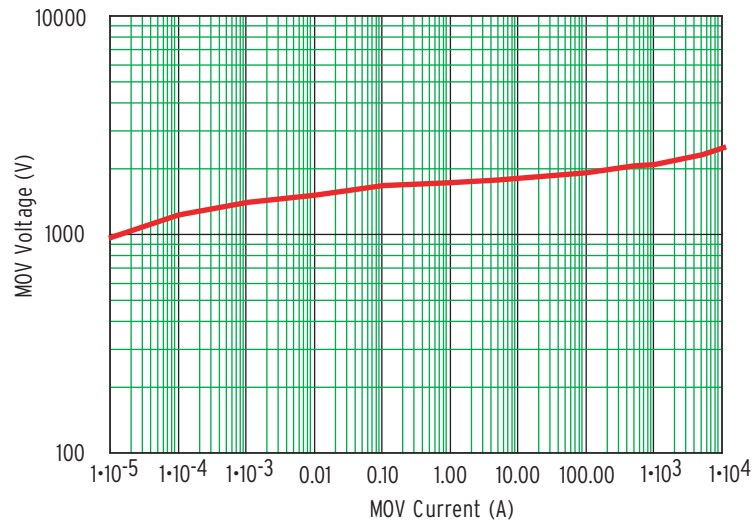


Figure 3.7 MOV Characteristic.

Determine MOV Size

CAUTION: Do not expose the MOVs to fault voltages for a period exceeding 4.0 cycles.

The metal oxide varistor plays an important role in clamping the voltage to an acceptable level. It is important to note that two ordering options are available: either a single 2500 J MOV or two MOVs to give a total of 5000 J. [Figure 3.8](#) shows the safe energy dissipation limits of the MOVs as a function of the knee-point voltage and the secondary fault current.

Always connect external shorting contacts from the lock-out relay to limit fault voltages applied at the relay input terminals to 4.0 cycles or fewer. For example, wire an output contact from the SEL-587Z to operate an 86 lock-out relay, which in turn shorts the inputs to the high-impedance elements. Do not rely on the circuit breaker to clear the fault current, because the circuit breaker operating time may exceed 4.0 cycles or may fail to open altogether.

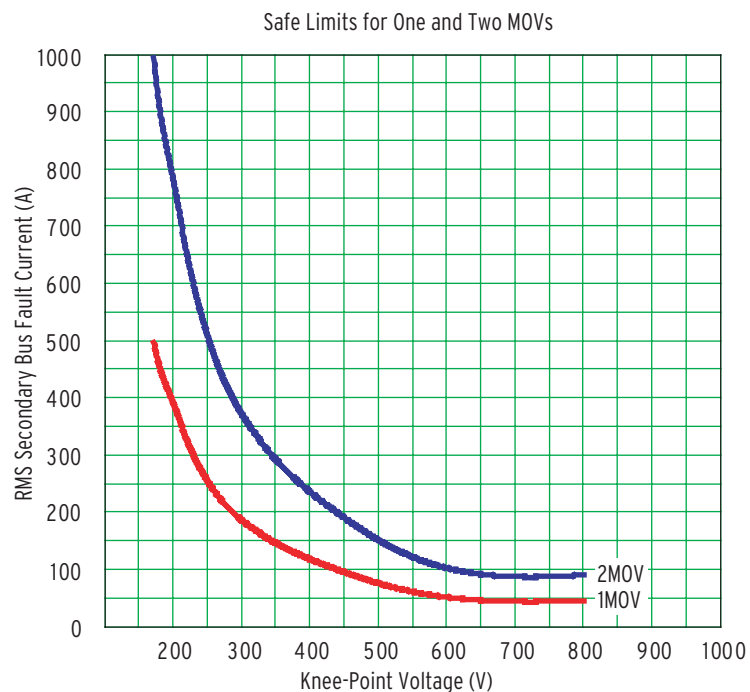


Figure 3.8 Energy Dissipation Limits of the MOVs (maximum four-cycle duration).

CT Selection Reference

Figure 3.8 on page 3.7 shows two curves. Consider the areas under the curves when selecting the number of MOVs to install: for an intersection point below the bottom curve, select a single MOV; for an intersection point below the top curve (between the two curves), select two MOVs. If the intersection point falls above the top line, select a different CT ratio, CT class, or both.

In our example, the fault secondary current of 125 A and 432 V intersects at a point between the two curves, i.e., a higher requirement than only one MOV, but not exceeding the top requirement. For this case, order two MOVs. Most applications should use the two MOV option.

It is vital that you select adequate current transformers for a high-impedance differential application. Use the procedures outlined in ANSI/IEEE Standard C37.110: 1996, *IEEE Guide for the Application of Current Transformers Used for Protective Relaying Purposes*. Connect the CT secondary windings in parallel on the basis that all CTs are matched in ratio. Whereas CT saturation is a possibility for through faults, CT saturation always occurs for in-zone faults. Select, therefore, a CT core of sufficiently large area to provide enough energy to the relay for fast operation.

Use bushing or toroidal CTs with fully distributed windings and low leakage flux. For multiratio CTs, use the highest ratio in order to minimize the secondary current and hence the voltage developed for the worst external fault. Also, higher CT tap values generate progressively higher voltages (autotransformer action); the voltage generated on the higher tap may exceed the CT secondary insulation value during bus faults.

CT Arrangements

Connect the CT secondary windings in parallel on the basis that all CTs are matched in ratio. Leads must be connected with the same polarity. Figure 3.9 depicts a single-phase representation of an application for a single-zone, five circuit breaker substation showing the CT polarity.

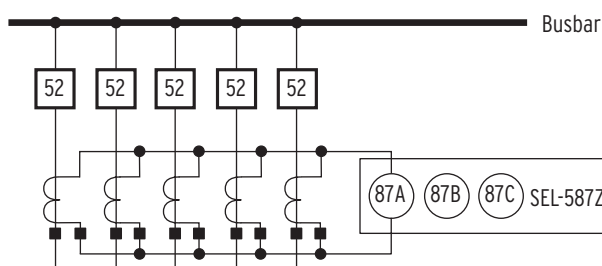


Figure 3.9 Single-Zone, Five Circuit Breaker Application (simplified).

CT Open Circuit Detection

Open circuiting a CT (faulty connector, removed test block, etc.) results in a voltage appearing across the relay elements, the value of which is proportional to the load current flowing through the missing CT input. For external faults or heavy loads, this voltage may rise to a value higher than the relay setting, resulting in relay misoperation. Set one level of the differential elements (87n2, n = A, B, C) to a low value to detect this condition. You can activate an alarm after a short time delay (minutes), block the trip elements after a longer time delay (minutes or hours), or both.

Use the high-impedance elements, 87A1, 87B1, and 87C1, for instantaneous high-impedance bus protection. Set the voltage elements according to the V_r calculation (see [Equation 3.2 on page 3.4](#)). Use the second set of elements, 87A2, 87B2, and 87C2, to detect CT open-circuit conditions.

Performance Detection

The application circuit of [Figure 3.10](#) provides high-impedance differential protection and continuously checks protection scheme operation. This application uses an external breaker failure lock-out (86) relay.

Breaker Failure/Bus Fault Cleared Detection

With reference to [Figure 3.10](#), connect the 50/51 elements and 86 contacts as shown. Following a bus fault, the 86 contacts short out the high-impedance elements, and the entire fault current flows through the 50/51 elements. Delay operation of the 50/51 elements for a suitable period to give all circuit breakers time to open. An element still picked up after the time delay indicates one or more circuit breakers have failed to open. Use the 50/51 elements to send a direct trip command to all adjacent substations to clear the fault, or assign them to supervise SCADA attempts to reenergize the bus.

MOV Degradation Detection and Back-Up Protection

Metal oxide varistors are in parallel with the resistors to clamp the voltage to less than 2 kV during bus faults. With degradation, the MOV may conduct larger current at lower applied voltages. At various degrees of MOV failure (short circuit), more current flows through the MOV, shunting current away from the high-impedance elements. [Figure 3.10](#) shows the application of the 50/51 overcurrent elements to detect this condition.

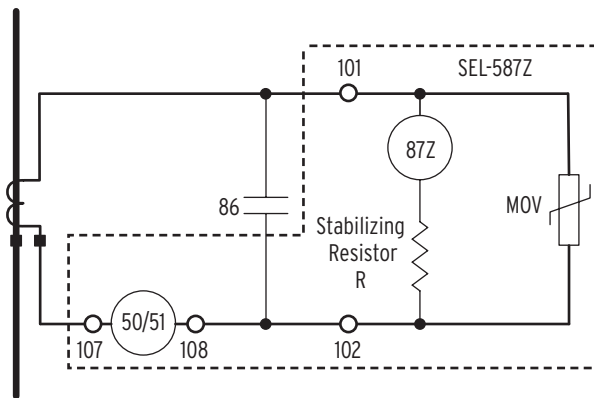


Figure 3.10 Overcurrent Elements in Differential Circuit (one phase shown).

In [Figure 3.10](#):

- R = 2000 Ω stabilizing resistor
- 86 = contact from the lock-out relay
- 50/51 = low-impedance overcurrent element

During normal balanced system conditions, the voltage measured across the high-impedance element is very low (theoretically zero), and very little current flows through the MOV. Therefore, the 50/51 elements are only effective to detect MOV failure during external faults (with one of the CTs saturating) or bus faults. However, the 50/51 elements provide back-up bus protection should the MOV fail during a heavy bus fault.

Overcurrent Protection

The SEL-587Z includes a set of nondirectional overcurrent elements to complement the differential protection. All overcurrent elements have independent pickup and time-delay settings. If necessary, you can externally torque control the inverse-time overcurrent elements using a setting or a control input.

The overcurrent elements measure the fundamental frequency value only, all harmonics are removed. If the CTs are wye connected, the relay can provide phase, negative-sequence, and residual overcurrent elements for that channel. If the CTs are delta connected, the relay provides only phase and negative-sequence overcurrent elements. In new installations, use wye-connected CTs whenever possible to maximize available protection and simplify overcurrent relay settings.

Overcurrent Elements

[Table 3.2](#) and [Table 3.3](#) summarize the overcurrent elements provided by the SEL-587Z. “Max” elements respond to the maximum value in any of the three phases. “Phase” elements measure each phase separately (a measuring element per phase).

Table 3.2 Instantaneous Overcurrent Elements

Element Description	Instantaneous Elements	Settings
Phase (IA, IB, and IC)	50P1, 50P2, 50P3 (max) 50A1, 50B1, 50C1 (phase) 50A2, 50B2, 50C2 (phase)	50P1P, 50P2P, 50P3P 50A1P, 50B1P, 50C1P 50A2P, 50B2P, 50C2P
Negative Sequence (3I2)	50Q1, 50Q2	50Q1P, 50Q2P
Residual (IG = IA + IB + IC)	50G1, 50G2	50G1P, 50G2P

Table 3.3 Inverse-Time Overcurrent Elements

Label	Inverse-Time Elements	Settings	Torque Control
Phase (IA, IB, and IC)	51P (max) 51A (phase) 51B (phase) 51C (phase)	51PP, 51PC, 51PTD, 51PRS 51AP, 51AC, 51ATD, 51ARS 51BP, 51BC, 51BTD, 51BRS 51CP, 51CC, 51CTD, 51CRS	51PTC 51ATC 51BTC 51CTC
Negative Sequence (3I2)	51Q	51QP, 51QC, 51QTD, 51QRS	51QTC
Residual (IG = IA + IB + IC)	51G	51GP, 51GC, 51GTD, 51GRS	51GTC

Instantaneous Overcurrent Element Maximum

[Figure 3.11 on page 3.11](#) shows the logic for the three-phase maximum overcurrent elements. The output is the assertion of the phase with the highest current value. The elements are not torque controlled.

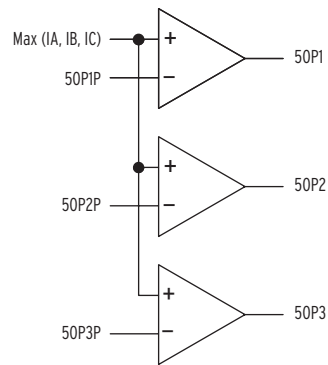


Figure 3.11 Instantaneous Overcurrent Maximum Elements.

Instantaneous Overcurrent Phase

Figure 3.12 shows the logic for the phase overcurrent elements. Each phase has two elements, comparing the individual phase current values against the phase settings. The elements are not torque controlled.

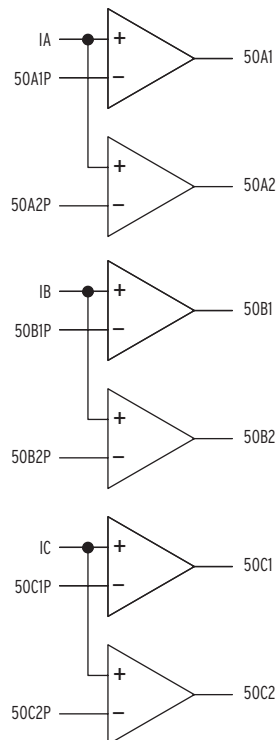


Figure 3.12 Phase Overcurrent Elements.

Instantaneous Negative-Sequence and Residual

Figure 3.13 on page 3.12 shows the logic for the negative-sequence and residual overcurrent elements. Each element has two levels. The elements are not torque controlled.

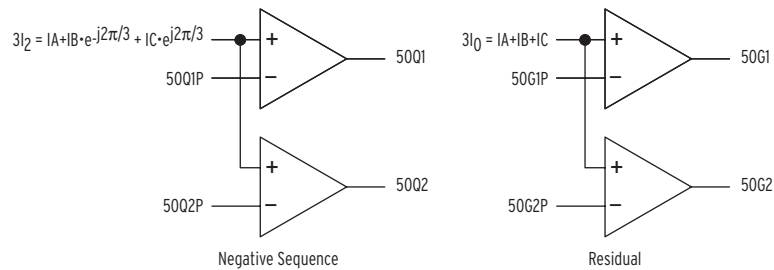


Figure 3.13 Negative-Sequence and Residual Overcurrent Elements.

Inverse-Time Overcurrent Element

Logic for the inverse-time overcurrent (TOC) phase element 51n is shown in Figure 3.14. Output Relay Word bits from the logic include inverse-time (51nT), instantaneous (51n), and reset (51nR) (where n = P, A, B, C, G, or Q) outputs. The instantaneous and reset outputs are provided for testing purposes. Pickup, torque-control, curve shape, time-dial, and reset characteristics are programmed with settings. Definite-time negative-sequence overcurrent element 51Q and definite-time residual overcurrent element 51G logic are similar. The elements are torque controlled by setting the Relay Word bit 51nTC to either one (permanently energized) or zero (disabled) or by entering a SELOGIC control equation. The latter provides conditional assertion of the element as a function of the SELOGIC control equation.

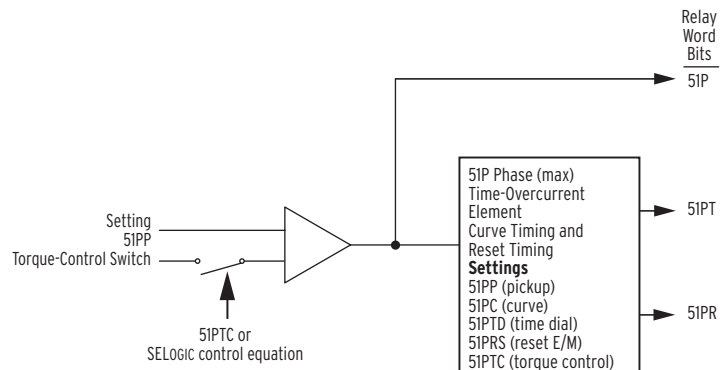


Figure 3.14 Inverse-Time Overcurrent (Max) Element.
(Identical for Negative- [51Q] and Zero-Sequence [51G] Elements)

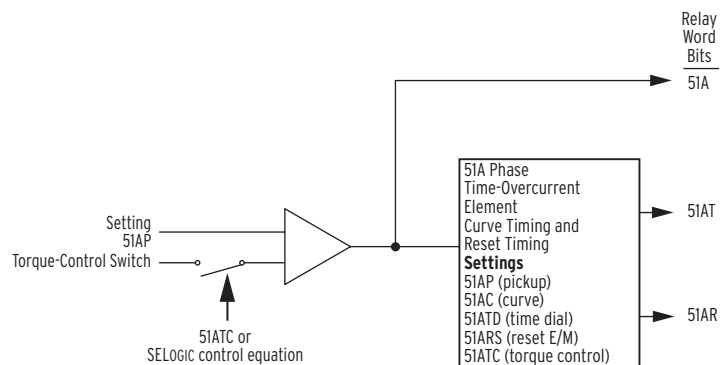


Figure 3.15 Inverse-Time Overcurrent
(A-Phase) Element (B- and C-Phase are similar).

Setting Descriptions

Pickup Settings

Refer to [Table 3.2 on page 3.10](#) and [Table 3.3 on page 3.10](#) for the setting labels. Use these settings to determine the level where the instantaneous overcurrent elements assert and at what level the time-overcurrent elements begin timing. The time-overcurrent element curves are scaled in multiples of this pickup setting. Disable an element by setting the pickup to OFF and disregard the other settings of the element.

Set the phase time-overcurrent element to provide sensitive detection and coordinated time-overcurrent protection for balanced and unbalanced fault conditions. Use the negative-sequence time-overcurrent element to provide sensitive detection and coordinated time-overcurrent protection for unbalanced fault conditions including phase-to-phase, phase-to-ground, and phase-to-phase ground faults. Set the residual time-overcurrent element to provide sensitive detection and coordinated time-overcurrent protection for phase-to-ground faults.

Torque-Control Settings

Refer to [Table 3.3 on page 3.10](#) for the setting labels. Torque control refers to a conditional enable of the element. Elements are torque controlled by setting the Relay Word bit 51nTC to either one (permanently energized) or zero (disabled) or by entering a SELOGIC control equation. The latter provides conditional assertion of the element as a function of the SELOGIC control equation.

Time-Dial Settings

Refer to [Table 3.3 on page 3.10](#) for the setting labels. Coordinate with downstream devices by delaying the instantaneous pickup of an element using this setting.

Curve Shape

Refer to [Table 3.3 on page 3.10](#) for the setting labels. Select curve shape and time-dial settings to coordinate with downstream phase, negative-sequence, and residual time-overcurrent elements. Refer to the time-overcurrent equations and curves (see [Time–Overcurrent Curve Equations on page 3.16](#)) for the specific time-overcurrent characteristic equations.

U.S. Curve Shapes

- U1–Moderately Inverse
- U2–Inverse
- U3–Very Inverse
- U4–Extremely Inverse
- U5–Short-Time Inverse

IEC Curve Shapes

- C1–Class A (Standard Inverse)
- C2–Class B (Very Inverse)

- C3–Class C (Extremely Inverse)
- C4–Long-Time Inverse
- C5–Short-Time Inverse

Reset Characteristic Settings

Refer to [Table 3.3 on page 3.10](#) for the setting labels. Set the time-overcurrent reset characteristic to emulate an induction disk relay reset characteristic or linear one-cycle reset.

The induction disk selection emulates the spring-torque governed disk reset action of an induction time-overcurrent unit. Set 51nRS = Y when the time-overcurrent element must coordinate with upstream electromechanical time-overcurrent relays during trip-reclose cycles.

The one-cycle reset selection fully resets the element one cycle after current drops below the element pickup setting. Set 51nRS = N when the time-overcurrent element must coordinate with upstream static or microprocessor-based time-overcurrent elements, which have fast reset characteristics.

Overcurrent Application Guidelines

Transformer Overcurrent and REF Protection

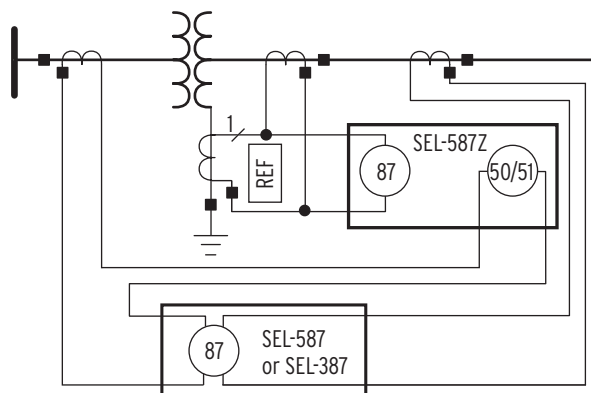


Figure 3.16 Transformer With Grounded-Wye-Connected Winding.

Set the SEL-587Z instantaneous overcurrent elements to detect high current faults, such as transformer bushing faults. Use time-overcurrent elements to detect transformer faults of lower current magnitude, faults not involving ground that the REF cannot detect, and excessive through currents caused by slow clearing external faults. Use appropriate delays to coordinate with upstream and downstream protection.

Thermal and mechanical damage curves should be available from the transformer manufacturer for specific transformer designs. You can consult several references, including the IEEE Standard C37.91: 2000, *IEEE Guide for Protective Relay Applications to Power Transformers*, that provide generic through-current limitations for various classes of transformers.

Conventional instantaneous overcurrent elements must be set sufficiently high to avoid tripping on transformer magnetizing inrush current, where peak currents may be many times the transformer full-load current. Transformer magnetizing inrush current contains substantial second-harmonic current and often contains a significant dc component. Unlike conventional electromechanical overcurrent elements, the SEL-587Z overcurrent elements ignore all but the fundamental frequency current, making the relay insensitive to the off-fundamental-frequency content of the magnetizing inrush current. The SEL-587Z instantaneous and inverse-time overcurrent elements need only be set for expected load and fault conditions.

Distribution Transformer Applications

When the SEL-587Z is applied to a distribution substation transformer serving load centers, expected load conditions include steady-state load as well as transient conditions caused by hot and cold load pickup.

Hot load pickup inrush occurs when a distribution circuit is energized shortly after being de-energized, such as in a feeder trip-reclose cycle. Hot load pickup inrush current that the SEL-587Z may see consists primarily of motor starting current from motor loads, incandescent and fluorescent lighting load inrush, and resistive heating element inrush. The overall effect is an inrush current several times the normal load current that may last for several seconds.

Cold load pickup inrush occurs when a distribution circuit is energized after being de-energized for a relatively long period of time. Cold load pickup includes many of the same inrush characteristics as hot load pickup, but is usually more severe and longer lasting because more thermostatically controlled systems need to satisfy heating or cooling requirements after the prolonged outage.

For these reasons, overcurrent protection must be tailored to meet the protection requirements for the specific transformer, avoid tripping for various types of nonfault transient conditions, and coordinate with upstream and downstream protection devices. These factors constrain the selection of settings and characteristics for the applied overcurrent protection.

Phase Overcurrent Protection

Set phase overcurrent element pickup settings above the highest expected load current to avoid tripping on normal load current.

Because you can use the negative-sequence overcurrent elements to detect phase-to-phase faults, you can set the phase overcurrent elements for three-phase fault detection only. This setting selection improves the ratio of the minimum phase fault current to maximum load current required for secure phase overcurrent relay application.

Negative-Sequence Overcurrent Protection

The negative-sequence elements respond to $|3I_2|$ current, where $3I_2 = I_a + I_b \cdot (1\angle 240) + I_c \cdot (1\angle 120)$. The negative-sequence overcurrent elements are uniquely suited to detect phase-to-phase faults and are not sensitive to balanced load.

The negative-sequence element is 1.73 times more sensitive to phase-to-phase faults than a phase overcurrent element with the same pickup setting.

While negative-sequence overcurrent elements do not respond to balanced load, these elements do detect the negative-sequence current present in unbalanced load. For this reason, select an element pickup setting above the maximum $3I_2$ current expected due to load unbalance.

When applied on the delta side of a delta-wye transformer, negative-sequence relay elements also provide sensitive fault protection for ground faults on the wye side of the transformer. This is not possible using only phase and residual overcurrent elements.

Residual Overcurrent Protection

The residual element responds to $3I_0$ current, where $3I_0 = I_a + I_b + I_c$. Residual overcurrent elements detect ground faults and do not respond to balanced load. The residual element is sensitive to unbalanced load, however, and should be set above the maximum $3I_0$ current expected due to load unbalance.

When applied on the delta side of a delta-wye transformer, residual overcurrent elements are insensitive to any type of fault on the wye side of the transformer and can only detect ground faults on the delta side. This eliminates any coordination constraints with protection devices on the wye side of the transformer, permitting very sensitive residual overcurrent element pickup settings.

Time-Overcurrent Curve Equations

Use [Equation 3.8](#) through [Equation 3.27 on page 3.18](#) to calculate the TOC operating and reset times for the 10 most common curves.

- tp = operating time in seconds
- tr = electromechanical induction-disk emulation reset time in seconds
(if electromechanical reset setting is made)
- TD = time-dial setting
- M = applied multiples of pickup current [for operating time (tp), $M > 1$; for reset time (tr), $M \leq 1$]

U.S. Moderately Inverse Curve: U1 Operating Time

$$tp = TD \cdot \left[0.0226 + \frac{0.0104}{M^{0.02} - 1} \right] \quad \text{Equation 3.8}$$

Reset Time

$$tr = TD \cdot \left[\frac{1.08}{1 - M^2} \right] \quad \text{Equation 3.9}$$

U.S. Inverse Curve: U2 Operating Time

$$tp = TD \cdot \left[0.180 + \frac{5.95}{M^2 - 1} \right] \quad \text{Equation 3.10}$$

Reset Time

$$t_r = TD \cdot \left[\frac{5.95}{1 - M^2} \right] \quad \text{Equation 3.11}$$

U.S. Very Inverse Curve: U3 Operating Time

$$t_p = TD \cdot \left[0.0963 + \frac{3.88}{M^2 - 1} \right] \quad \text{Equation 3.12}$$

Reset Time

$$t_r = TD \cdot \left[\frac{3.88}{1 - M^2} \right] \quad \text{Equation 3.13}$$

U.S. Extremely Inverse Curve: U4 Operating Time

$$t_p = TD \cdot \left[0.0352 + \frac{5.67}{M^2 - 1} \right] \quad \text{Equation 3.14}$$

Reset Time

$$t_r = TD \cdot \left[\frac{5.67}{1 - M^2} \right] \quad \text{Equation 3.15}$$

U.S. Short-Time Inverse Curve: U5 Operating Time

$$t_p = TD \cdot \left[0.00262 + \frac{0.00342}{M^{0.02} - 1} \right] \quad \text{Equation 3.16}$$

Reset Time

$$t_r = TD \cdot \left[\frac{0.323}{1 - M^2} \right] \quad \text{Equation 3.17}$$

I.E.C. Class A Curve (Standard Inverse): C1 Operating Time

$$t_p = TD \cdot \left[\frac{0.14}{M^{0.02} - 1} \right] \quad \text{Equation 3.18}$$

Reset Time

$$t_r = TD \cdot \left[\frac{13.5}{1 - M^2} \right] \quad \text{Equation 3.19}$$

I.E.C. Class B Curve (Very Inverse): C2 Operating Time

$$t_p = TD \cdot \left[\frac{13.5}{M - 1} \right] \quad \text{Equation 3.20}$$

Reset Time

$$t_r = TD \cdot \left[\frac{47.3}{1 - M^2} \right] \quad \text{Equation 3.21}$$

I.E.C. Class C Curve (Extremely Inverse): C3 Operating Time

$$t_p = TD \cdot \left[\frac{80.0}{M^2 - 1} \right] \quad \text{Equation 3.22}$$

Reset Time

$$t_r = TD \cdot \left[\frac{80.0}{1 - M^2} \right] \quad \text{Equation 3.23}$$

I.E.C. Long-Time Inverse Curve: C4 Operate Time

$$t_p = TD \cdot \left[\frac{120.0}{M - 1} \right] \quad \text{Equation 3.24}$$

Reset Time

$$t_r = TD \cdot \left[\frac{120.0}{1 - M} \right] \quad \text{Equation 3.25}$$

I.E.C. Short-Time Inverse Curve: C5 Operate Time

$$t_p = TD \cdot \left[\frac{0.05}{M^{0.04} - 1} \right] \quad \text{Equation 3.26}$$

Reset Time

$$t_r = TD \cdot \left[\frac{4.85}{1 - M^2} \right] \quad \text{Equation 3.27}$$

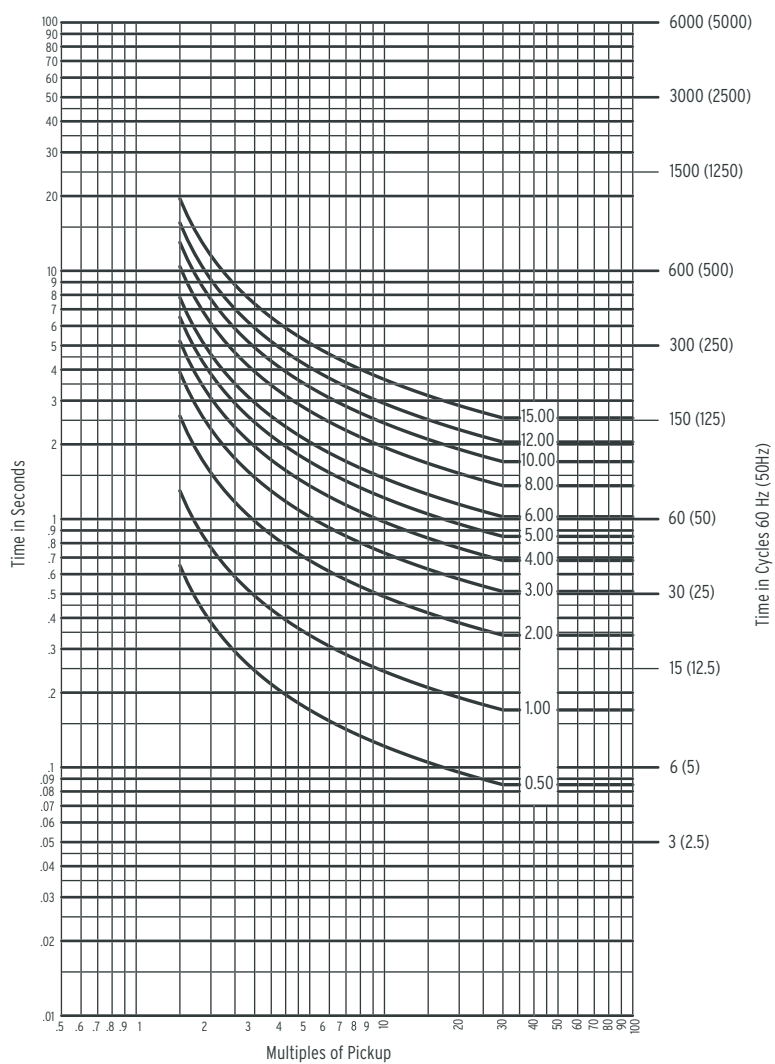
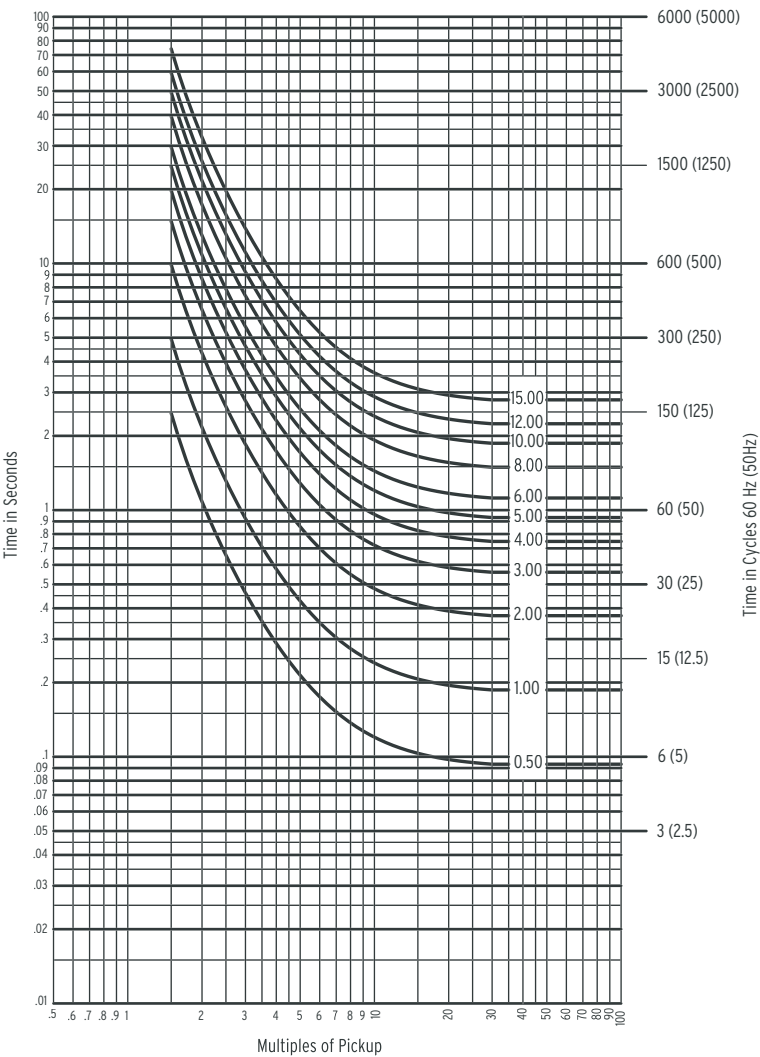


Figure 3.17 U.S. Moderately Inverse Curve: U1.



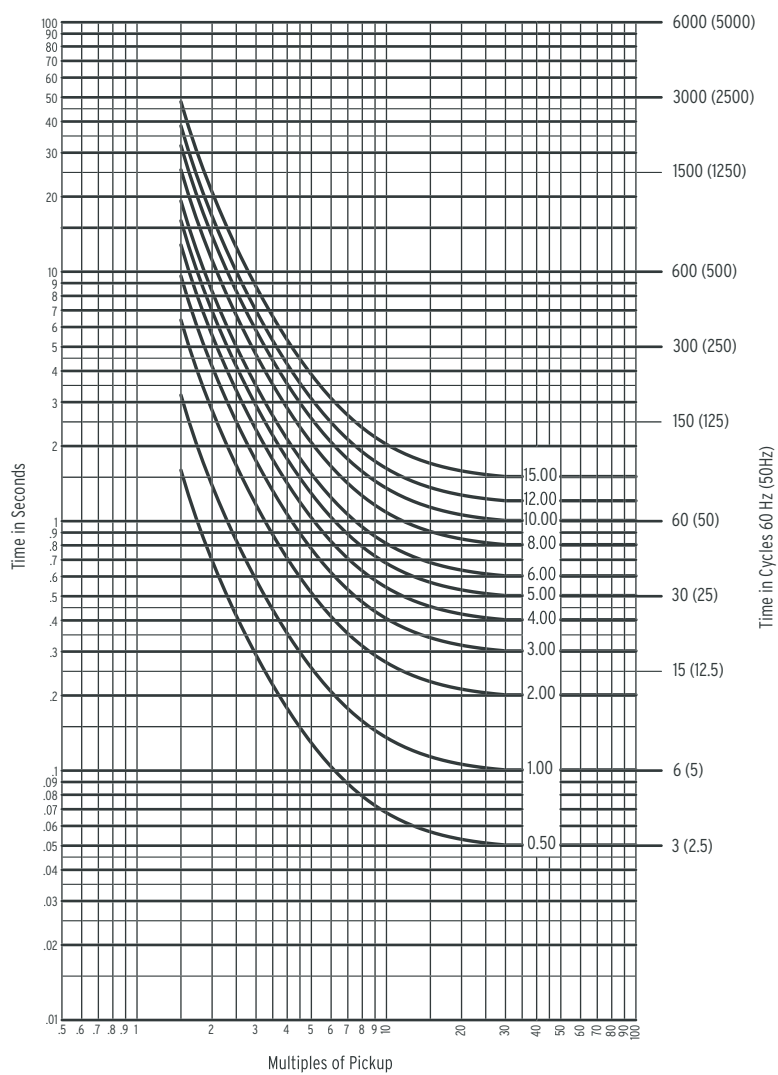


Figure 3.19 U.S. Very Inverse Curve: U3.

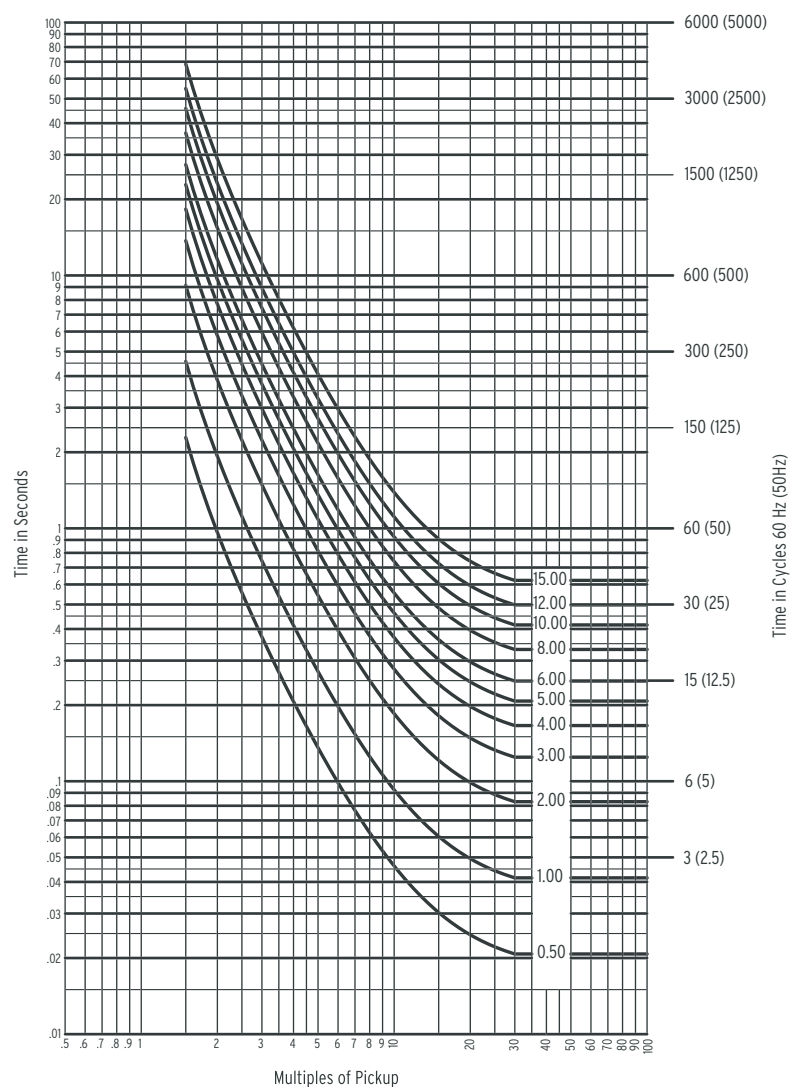


Figure 3.20 U.S. Extremely Inverse Curve: U4.

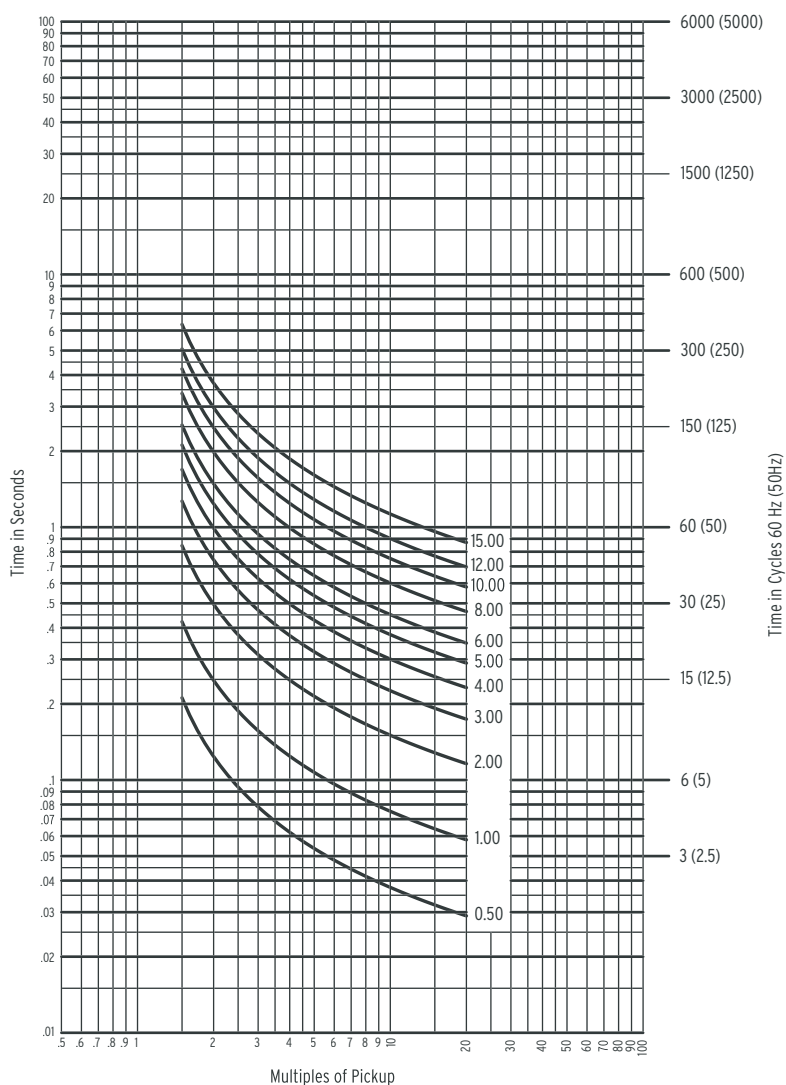


Figure 3.21 U.S. Short-Time Inverse Curve: U5.

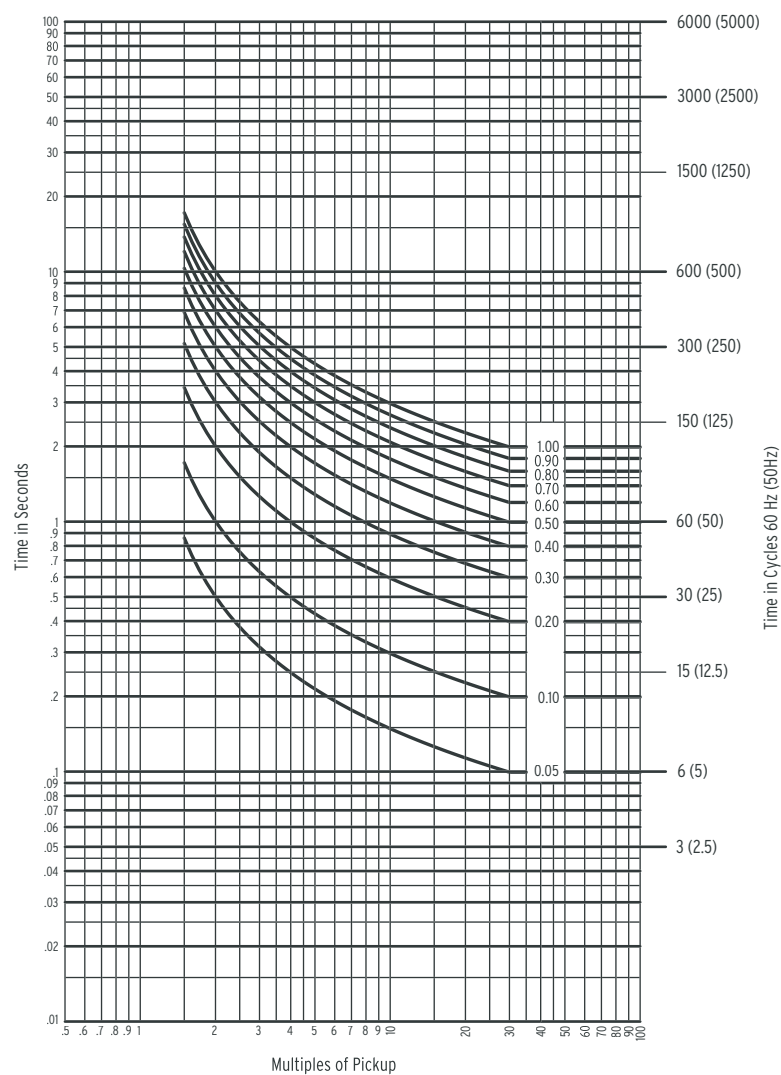


Figure 3.22 I.E.C. Class A Curve (Standard Inverse): C1.

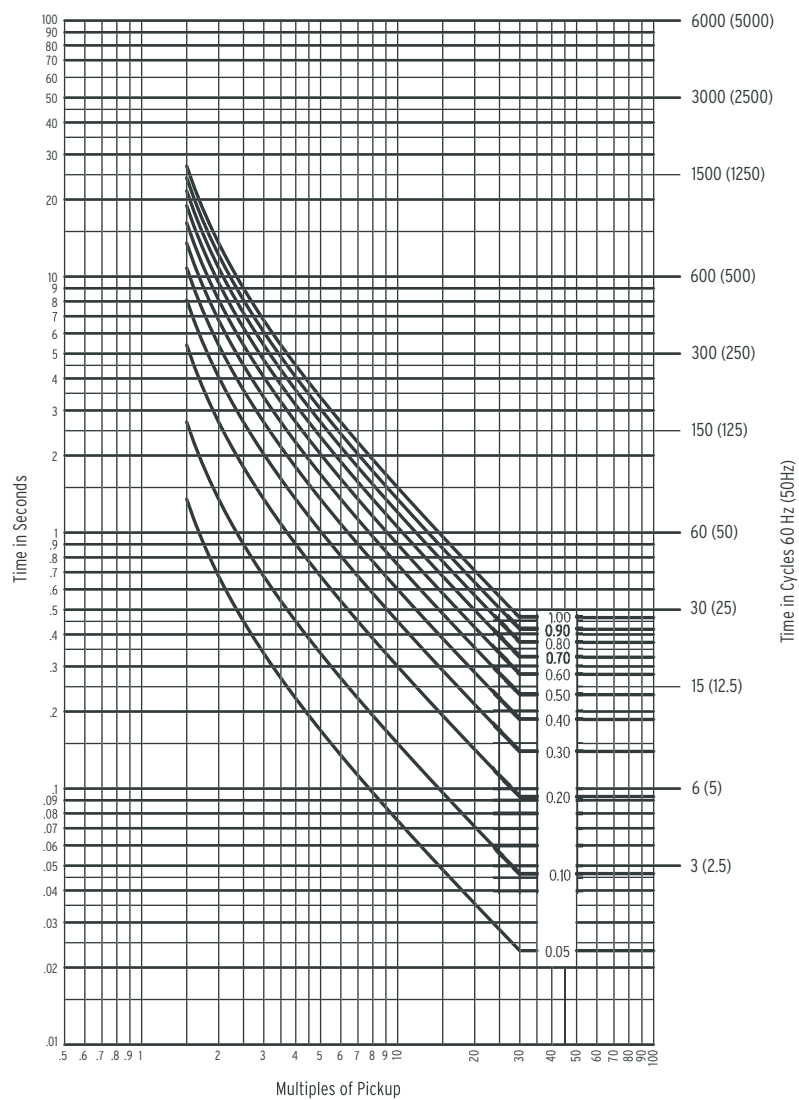


Figure 3.23 I.E.C. Class B Curve (Very Inverse): C2.

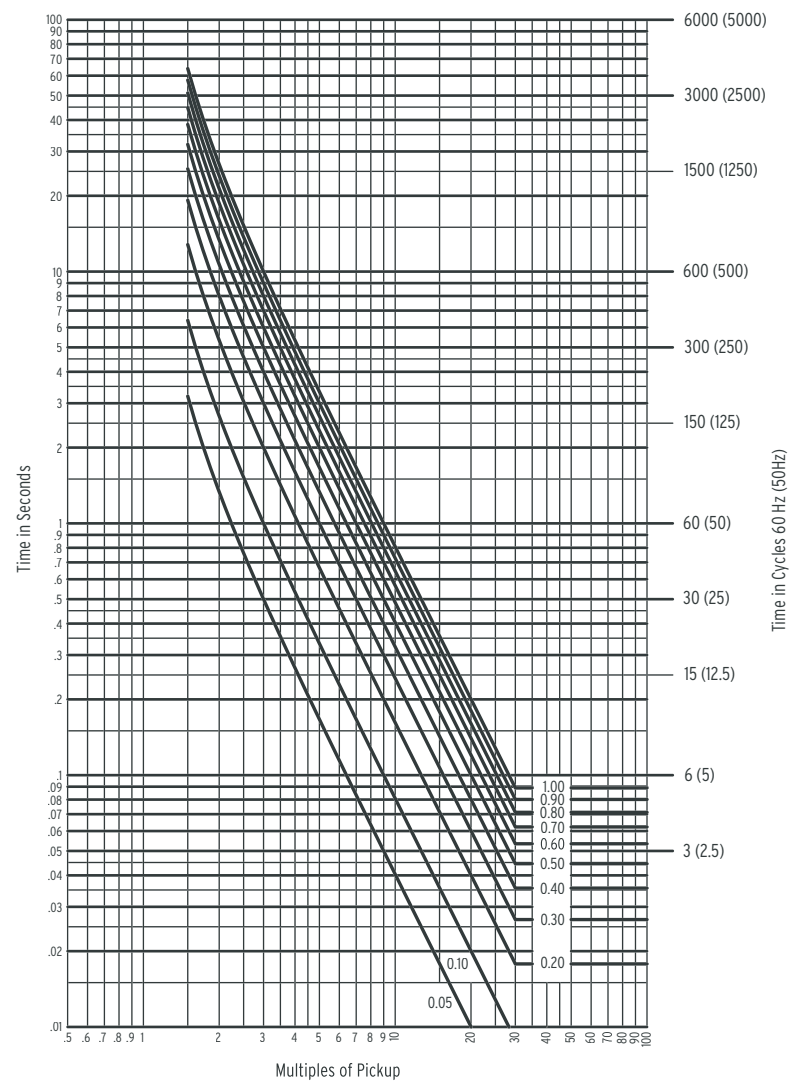


Figure 3.24 I.E.C. Class C Curve (Extremely Inverse): C3.

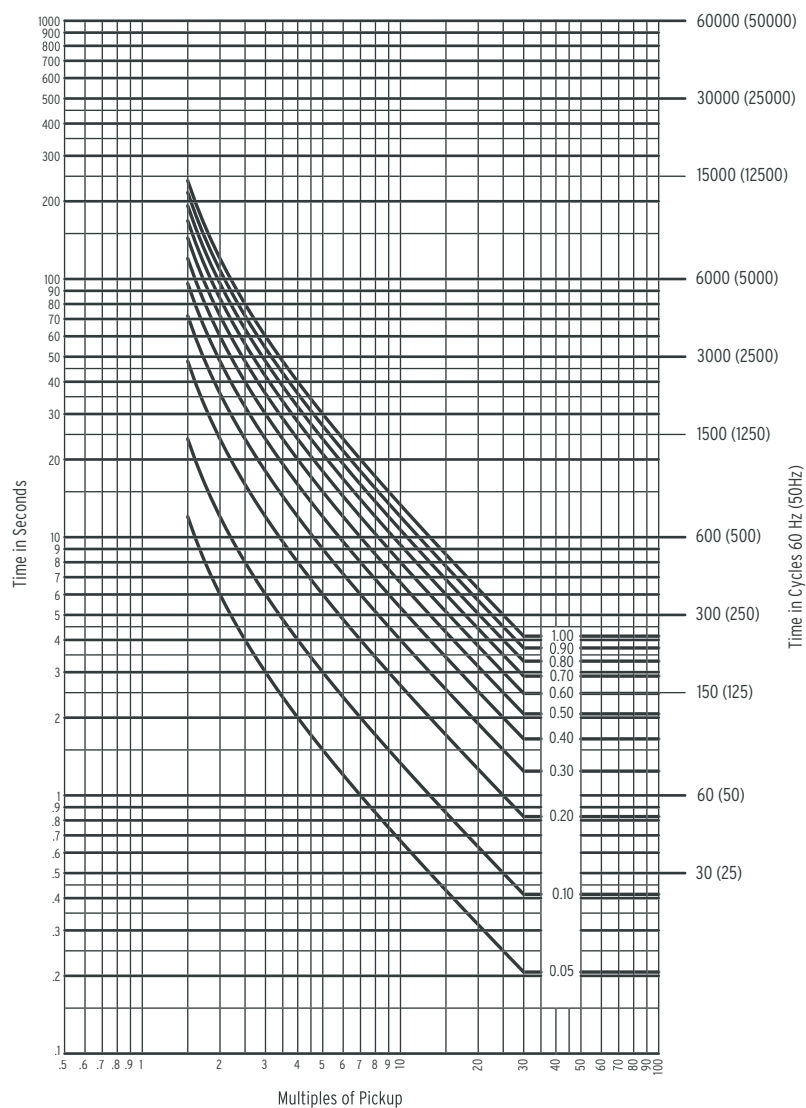


Figure 3.25 I.E.C. Long-Time Inverse Curve: C4.

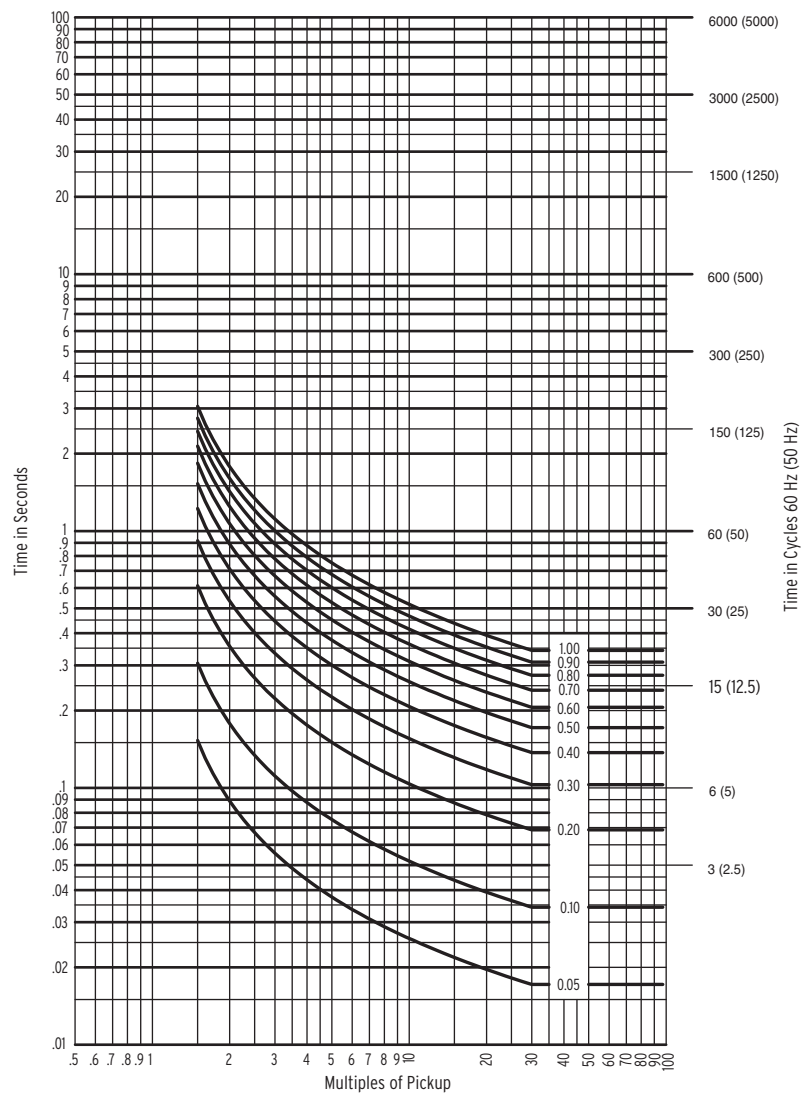


Figure 3.26 I.E.C. Short-Time Inverse Curve: C5.

Demand Ammetering

The SEL-587Z provides demand and peak demand ammetering for the following values:

Currents $I_{A,B,C}$	Input currents (A primary)
I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
$3I_2$	Negative-sequence current (A primary)

The SEL-587Z provides demand ammeters for I_A , I_B , I_C , negative-sequence, and residual currents. The relay saves time- and date-stamped peak demand readings for each of the quantities. View this information using the relay front-panel or serial port **METER D** commands.

Demand Ammeter Settings (DMTC, PDEMP, QDEMP, GDEMP)

The demand ammeters behave much like low-pass filters, responding to gradual trends in the current magnitude. The relay uses the demand ammeter time constant setting, DMTC, for all demand ammeter calculations. The time constant can be set from 5 to 255 minutes. The demand ammeters operate such that if demand current is reset and a constant input current is applied, the demand current output will be 90 percent of the constant input current value DMTC minutes later.

Settable demand ammeter thresholds are available for all three demand ammeters in units of amps secondary. The thresholds are PDEMP, QDEMP, and GDEMP for the phase (A, B, and C), negative-sequence, and residual demand ammeters. If demand currents exceed the set threshold, the respective Relay Word bit PDEM, QDEM, or GDEM asserts. You can use these Relay Word bits to alarm for phase overload and negative-sequence or residual current unbalance for Winding “n.”

Demand Ammeter Response

The example in [Figure 3.27 on page 3.30](#) shows the response of a thermal demand ammeter to a step current input. The current input is at a magnitude of zero and then suddenly goes to an instantaneous level of 1.0 per unit (a “step”).

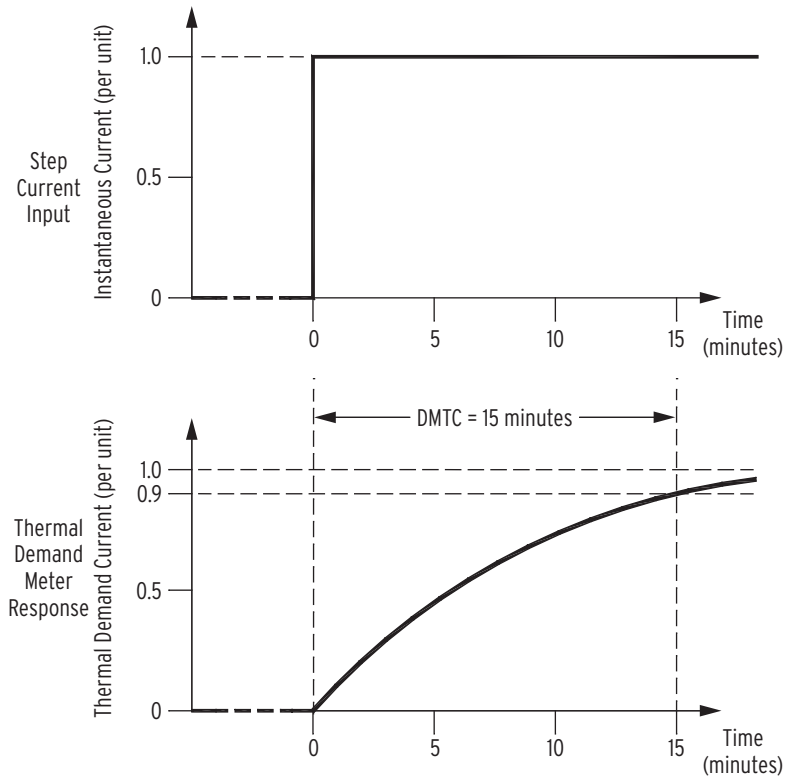


Figure 3.27 Response of Thermal Demand Ammeter to a Step Input (setting DMTC = 15 minutes).

The response of the thermal demand ammeter in [Figure 3.27](#) (bottom) to the step current input (top) is analogous to the series RC circuit in [Figure 3.28](#).

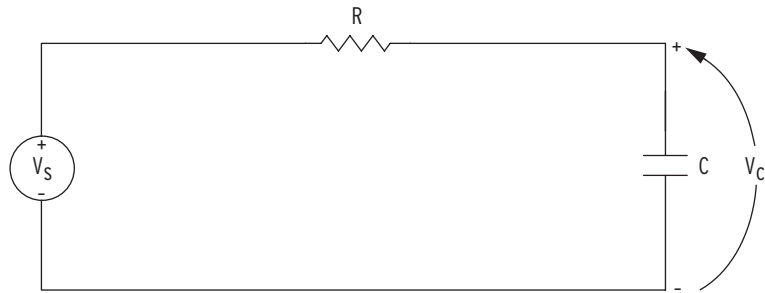


Figure 3.28 Voltage V_S Applied to Series RC Circuit.

In the analogy:

Voltage V_S in [Figure 3.28](#) corresponds to the step current input [Figure 3.27](#) (top).

Voltage V_C across the capacitor in [Figure 3.28](#) corresponds to the response of the thermal demand ammeter in [Figure 3.27](#) (bottom).

If voltage V_S in [Figure 3.28](#) has been at zero ($V_S = 0.0$ per unit) for some time, voltage V_C across the capacitor in [Figure 3.28](#) is also at zero ($V_C = 0.0$ per unit). If voltage V_S is suddenly stepped up to some constant value ($V_S = 1.0$ per unit), voltage V_C across the capacitor starts to rise toward the 1.0 per-unit value. This voltage rise across the capacitor is analogous to the response of the thermal demand ammeter in [Figure 3.27 on page 3.30](#) (bottom) to the step current input (top).

In general, as voltage V_C across the capacitor in [Figure 3.28 on page 3.30](#) cannot change instantaneously, the thermal demand ammeter response is not immediate either for the increasing or decreasing applied instantaneous current. The thermal demand ammeter response time is based on the demand ammeter time constant setting DMTC. Note in [Figure 3.27 on page 3.30](#) the thermal demand ammeter response (bottom) is at 90 percent (0.9 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step current input is first applied.

The SEL-587Z updates thermal demand values approximately every two seconds.

Setting Description

Demand Time Constant (DMTC)

Range: 5, 10, 15, 30, 60 minutes

The time constant setting defines the temperature rise of a device when a current is flowing through the device.

Demand Threshold Settings (PDEMP, QDEMP, GDEMP)

Range: OFF, 0.50-16.00 A

The threshold settings determine the pick-up values for the phase, negative, and residual demand threshold elements.

Setting Calculation

EXAMPLE 3.1 Setting the Relay (transformer)

Table 3.4 Transformer Detail

Operating Parameter	Value
MVA	50 MVA
Voltage ratio	132/69 kV
CTR _{HV}	1000/5 (wye connected)
Cooling system	2 stage
Winding temperature rise	55°C
Permissible continuous overload	<10%

The first step is to identify the thermal curve applicable to the device in order to find the time constant. For this example, we use the IEEE C57.91: 1995 standard for oil-immersed transformers. This standard specifies the temperature parameters for a transformer operating at full load at an ambient temperature of 30°C. An extract from the standard is presented in [Table 3.5 on page 3.32](#). The matching time constant is two hours.

The DMTC setting is thus $2.0 \cdot 60 = 120$ minutes.

Table 3.5 Temperature Parameters (IEEE C57.91: 1995)

Setting	THwr = 55°C			THwr = 65°C		
	CS = 1	CS = 2	CS = 3	CS = 1	CS = 2	CS = 3
OTR (hours)	3.0	2.0	1.25	3.0	2.0	1.25

Calculate the transformer HV full-load secondary current.

$$\begin{aligned}
 I_{FL} &= \frac{MVA \cdot 10^3}{\sqrt{3} \cdot V_{HV} \cdot CTR_{HV}} \\
 &= \frac{50 \cdot 10^3}{\sqrt{3} \cdot 132 \cdot 200} \\
 &= 1.09 \text{ A}
 \end{aligned}
 \tag{Equation 3.28}$$

where:

- I_{FL} = Full-load current
- V_{HV} = High-voltage side line-to-line voltage
- CTR_{HV} = High-voltage side current transformer ratio
- MVA = Transformer rating

Calculate the PDEMP setting.

Assume continuous overload conditions may not exceed 10 percent, and thus set the threshold to 10 percent higher than full load:

$$\begin{aligned}
 PDEMP &= 1.1 \cdot I_{FL} \\
 PDEMP &= 1.1 \cdot 1.09 \\
 PDEMP &= 1.2 \text{ A}
 \end{aligned}
 \tag{Equation 3.29}$$

Consider the following numerical example.

From the IEEE temperature curve

$$\theta_{CHAR} = I_{FIN} \cdot \left(1 - e^{-\frac{t}{\tau}} \right)
 \tag{Equation 3.30}$$

where:

- θ_{CHAR} = current at time t
- I_{FIN} = final current value (full load)
- θ = time constant (120 minutes)
- t = time of measurement

Calculating the current value after 120 minutes (1 time constant), with full-load current applied, yields the value in [Equation 3.31](#).

$$\begin{aligned}
 \theta_{CHAR} &= 1.09 \cdot \left(1 - e^{-\frac{120}{120}} \right) \\
 &= 0.69 \text{ A}
 \end{aligned}
 \tag{Equation 3.31}$$

The thermal demand element is calculated as shown in [Equation 3.32 on page 3.33](#).

$$\begin{aligned}
 \text{PDEMP} &= I_{\text{FL}} \cdot \left(1 - e^{\frac{-\ln(10) \cdot t}{\text{DMTC}}} \right) \\
 &= 1.09 \cdot \left(1 - e^{\frac{-\ln 10 \cdot 120}{120}} \right) \\
 &= 0.98 \text{ A (90 percent of 1.09 A)}
 \end{aligned}
 \tag{Equation 3.32}$$

where:

DMTC = time constant

ln = natural logarithm

After five time constants, the results from both equations are equal:

$$\begin{aligned}
 \text{PDEMP} = \theta_{\text{CHAR}} &= 1.2 \cdot \left(1 - e^{\frac{-600}{120}} \right) \\
 &= 1.2 \cdot \left(1 - e^{\frac{-\ln 10 \cdot 600}{120}} \right) \\
 &= 1.2 \text{ A}
 \end{aligned}
 \tag{Equation 3.33}$$

Calculate the time when PDEMP will assert for a 15 percent (1.25 A) overload, starting with zero element register values and a full-load step-function current flowing:

$$\begin{aligned}
 t &= \frac{-\text{DMTC}}{\ln(10)} \cdot \left(1 - \frac{\text{PDEMP}}{I_{\text{FL}}} \right) \\
 &= \frac{-120}{\ln(10)} \cdot \ln \left(1 - \frac{1.2}{1.25} \right) \\
 &= 168 \text{ min (or 1.4 time constants)}
 \end{aligned}
 \tag{Equation 3.34}$$

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Section 4

Control Logic

Introduction

This section describes the various components of control logic available in the SEL-587Z Relay, both fixed and configurable. For ease of applying the relay, certain commonly used logic functions, known as fixed logic, are already programmed in the relay. Although fixed logic cannot be changed, most of the fixed logic includes options that provide flexibility for different applications.

Inputs provided by the relay include optoisolated inputs, local control switches (local bits), and remote control switches (remote bits). The relay has two optoisolated inputs for use as the inputs in a SELOGIC® control equation.

Local (LB) and remote (RB) bits provide the equivalent of traditional control operations. Local bits use the front-panel LCD and pushbuttons to replace, for instance, the panel control switches used for opening and closing circuit breakers and motorized disconnects (isolators). Remote bits use the serial port to provide the equivalent control as from the local HMI.

Examples of fixed logic are Trip, Close, and Target logic. The relay also provides variables and timers to build custom logic. You can use this very powerful feature in many different and varying applications. Assign Relay Word bits to activate any of the four programmable output contacts.

Optoisolated Inputs

Relay Word bits IN1 and IN2 follow debounced optoisolated inputs IN1 and IN2, respectively,

IN1 is debounced input IN1

IN2 is debounced input IN2

EXAMPLE 4.1 Optoisolated Inputs

See Figure 4.1 for an example of an energized and de-energized optoisolated input and corresponding Relay Word bit states. Note the built-in pickup and dropout times of 0.25 cycle for energization or de-energization debounce.

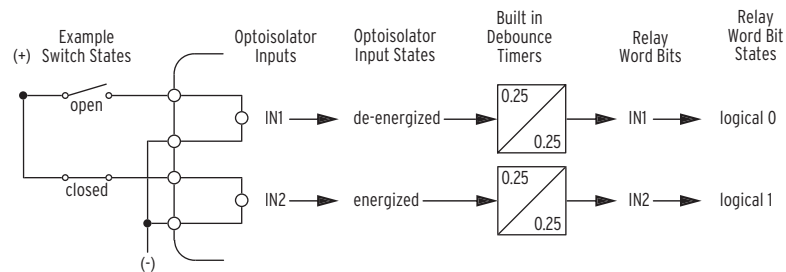


Figure 4.1 Example Operation of Optoisolated Inputs IN1 and IN2.

Configuration of the optoisolated inputs has the following format:

Relay variable (i.e., Relay Word bit, SELogic control equation) = IN1

You can initiate an event report in the SEL-587Z when any of the feeders trip.

Step 1. After wiring the feeder initiating contacts in parallel, connect the circuit to IN1.

Step 2. To start an event report, assert either Relay Word bit ER1 or ER2.

The correct Input 1 assignment to assert ER1 is as follows:

ER1 = **IN1** Event Report Trigger Condition 1

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

The relay polls the digital optoisolated inputs each processing interval (1/8 of a power system cycle). A digital input change of state occurs if the input remains in the changed state for two consecutive processing intervals; otherwise, the software retains the previous state.

The total time before the relay declares a change of optoisolated input state is expressed as follows:

$$\begin{aligned} \text{Time} &= \text{debounce time} + 2 \text{ processing intervals} \\ &= \left(\frac{1}{0.25 \cdot 60 \text{ Hz}} \right) + (2 \cdot 2.083) \\ &= 4.17 \text{ ms} + 4.17 \text{ ms} \\ &= 8.34 \text{ ms} \end{aligned}$$

Equation 4.1

After 8.34 ms, the software updates the IN1 and IN2 Relay Word bits to reflect the change of state.

More Settings Examples

EXAMPLE 4.2 Input Settings

Use Relay Word bit IN1 as the breaker input for the SELogic control equation close circuit breaker status setting:

52A = IN1 Circuit Breaker Status

Connect input IN1 to a 52a circuit breaker auxiliary contact. Just because Relay Word bit IN1 is assigned to the circuit breaker status setting 52A does not mean that Relay Word bit IN1 cannot be used in other SELogic control equation settings.

EXAMPLE 4.3 External Breaker Fail Input

Consider a breaker-and-a-half bus, as shown in Figure 4.2, with an SEL-587Z installed on each bus. Optoisolated input IN2 triggers the SEL-587Z to protect against bus faults, with a trip output contact from the relay operating an external 86 lockout relay.

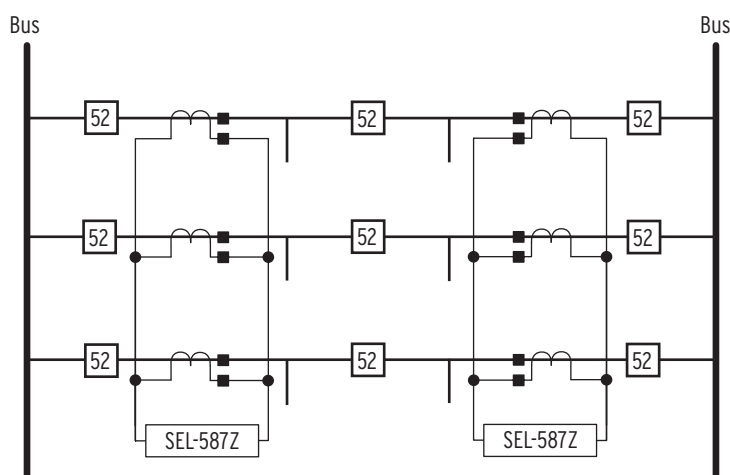


Figure 4.2 Breaker-and-a-Half Bus.

Make the following assignments to close the relay output contact for a differential element operation.

Assign the differential element Relay Word bits to internal trip logic TR1. Thus, when any differential Relay Word bits assert (= logical 1), the TR1 Relay Word bit also asserts.

TR1 = 87A1 + 87B1 + 87C1 Trip Conditions

Assign TRIP1 (output from the internal trip logic TR1) to Output Contact 1. When TR1 asserts, TRIP1 also asserts, which in turn asserts OUT1 (see [Trip Logic \(TRn, ULTRn, TDURD\)](#) on page 4.16).

OUT1 = TRIP1 Output Contact OUT1

To further protect the power system, use the same wiring for bus strip protection. For an external breaker fail input, wire the individual breaker fail relay outputs from all protection relays associated with that particular zone to input IN2 and reconfigure the relay as follows:

Assign Input 2 to SELogic control equation variable 7.

SV7 = IN2 SELogic Variable SV7

Assign additional debounce time delay.

SV7T = 0.5 cycle

Add SV7T to the TR1 logic.

TR1 = SV7T + 87A1 + 87B1 + 87C1 Trip Conditions

As before, assign the output to operate the 86 lockout relay.

OUT1 = TRIP1 Output Contact OUT1

EXAMPLE 4.4 Time Qualify Optoisolated Inputs

If an input needs to be debounced or time qualified more than the built-in 0.25 cycle, assign the input to a SELogiC control equation variables timer.

SV8 = **IN2** SELogiC Variable SV8

The output of the timer (Relay Word bit SV8T) can then be used in place of Relay Word bit IN1; see [Example 4.2 on page 4.3](#).

Local Control Switches (NLBn, SLBn, CLBn, PLBn)

Local control switches (local bits) emulate traditional panel switches and are operated via the front-panel pushbuttons and display. By pushing the CNTRL pushbutton, the front-panel pushbuttons are reassigned new functions to behave as panel switches (see [Local Control on page 8.8 in Section 8: Front-Panel Interface](#)). Local control switches differ from remote control switches in that you can only operate the local control switch via the front-panel pushbuttons and display; you can only operate the remote control switches via serial communications.

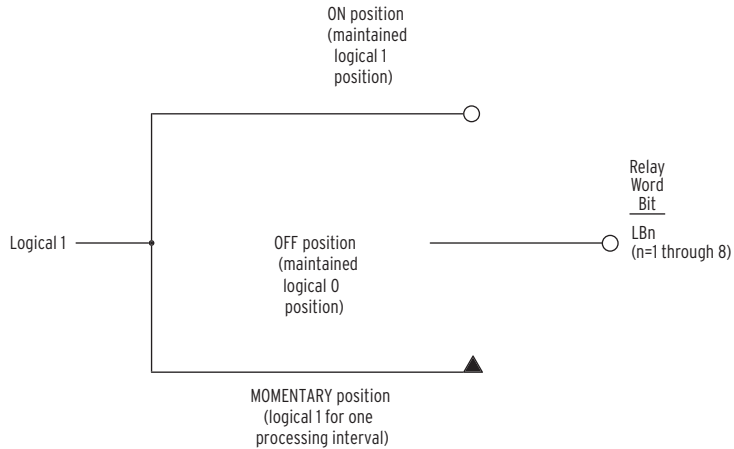


Figure 4.3 Local Control Switches Drive Local Bits LB1 Through LB8.

There are eight local control switches; the output of each switch (one switch is shown in [Figure 4.3](#)) is a Relay Word bit (local bit LBn, n = 1 through 8). Use these local bits in SELOGIC control equations.

To enable the local bits, enter a text string, called “labels,” using the **SET T** command. Making corresponding label settings enables other positions of the same local control panel switch. Each label is displayed on the front panel according to the step in the procedure. For example, assume the NLB1 label is “HV BRKR.” During the circular display, the message “HV BRKR” is shown on the display. Choose meaningful, unambiguous labels, as these identify the switch and communicate the switch “instructions” to the operator.

Table 4.1 Control Switch Position, Label Settings, and Local Control Switch State

Switch Position	Label Setting	Setting Definition	Logic State
N/A	NLBn	“Name” LBn–Enable Switch	N/A
CLOSED	SLBn	“Set” Local Bit LBn	logical 1
OPEN	CLBn	“Clear” Local Bit LBn	logical 0
MOMENTARY	PLBn	“Pulse” Local Bit LBn	logical 1 for one processing interval

EXAMPLE 4.5 Configure LB2 to Replace the Supervisory Control Switch

Entering specific settings configures LB2 to replace the Supervisory Control Switch.

Enable the switch, identify the function, and declare the message that the relay displays on the front panel during the rotating display. This message is always displayed together with the ensuing control action.

NLB2 = **Supervisory CS** Local Bit LB2 Name (14 characters)

Indicate the action to the operator. Selecting Yes turns the switch on.

SLB2 = **Turn ON** Set Local Bit LB2 Label (7 characters)

Ask to turn the switch off. Selecting Yes turns the switch off.

CLB2 = **Turn OFF** Clear Local Bit LB2 Label (7 characters)

Do not set PLB2 for this example.

PLB2 = Pulse Local Bit LB3 Label (7 characters)

Table 4.2 Local Bit Functions

Label	Function	Setting	Display
NLB2	Enable LB2	Supervisory CS	Supervisory CS
SLB2	Set LB2 to 1	Turn ON	Supervisory CS Turn ON? Yes No
CLB2	Set LB2 to 0	Turn OFF	Supervisory CS Turn ON? Yes No
PLB2	Pulse LB2	(not set)	(no display)

Label settings are made with serial port command **SET T** and viewed with serial port command **SHO T** (see [Section 5: Setting the Relay](#), **SET** and **SHO (Showset)** on page 7.15 in [Section 7: ASCII Command Reference](#)).

Any given local control switch can be configured to be one of the following three switch types:

ON/OFF

OFF/MOMENTARY

ON/OFF/MOMENTARY

Table 4.3 Local Control Switch Types and Required Label Settings

Local Switch Type	Label NLBn	Label CLBn	Label SLBn	Label PLBn
ON/OFF	X	X	X	
OFF/MOMENTARY	X	X		X
ON/OFF/MOMENTARY	X	X	X	X

Delete a Local Bit

If a local control switch is not used, “null out” all its corresponding label settings to make it inoperable by entering “NA” for the setting (see [Section 5: Setting the Relay](#)). The local bit that is “driven” by this inoperable local control switch is fixed at logical 0.

EXAMPLE 4.6 Local Bit Controls Bus Protection

Use Local Bit 3 to enable/disable the bus protection. Assume the scheme trip equations are as follows:

$$\begin{aligned} \text{TR1} &= 87\text{A1} + 87\text{B1} + 87\text{C1} \\ \text{OUT1} &= \text{TRIP1} \end{aligned} \quad \text{Equation 4.2}$$

Table 4.4 Local Bit LB3 Used as Bus Zone ON/OFF Switch

Local Bit	Label Settings	Function
LB3	NLB1 = Bus Zone Switch	Enable the switch and identify functions
	SLB1 = Turn ON	ON position, i.e., close switch
	CLB1 = Turn OFF	OFF position, i.e., open switch
	PLB1 =	MOMENTARY position—not used

Consider two possible trip equation modifications to AND the differential elements and the switch position.

$$\begin{aligned} \text{TR1} &= (87\text{A1} + 87\text{B1} + 87\text{C1}) * \text{LB3} \\ \text{OUT1} &= \text{TRIP1} \end{aligned} \quad \text{Equation 4.3}$$

or

$$\begin{aligned} \text{TR1} &= 87\text{A1} + 87\text{B1} + 87\text{C1} \\ \text{OUT1} &= \text{TRIP} * \text{LB3} \end{aligned} \quad \text{Equation 4.4}$$

In [Equation 4.3](#), the trip logic cannot assert when the bus zone switch is OFF, preventing incorrect protection operation. However, because TRIP1 cannot assert with the switch OFF, the associated LED cannot assert either. This means if a bus fault occurred during the period when the bus zone was switched OFF, no indication would be available. In the second option, [Equation 4.4](#), provides the same security but also makes the indication available.

Local Bit States Retained

Power Loss

The states of the local bits (Relay Word bits LB1 through LB8) are retained if power to the relay is lost and then restored. If a local control switch is in the ON position (corresponding local bit is asserted to logical 1) when power is lost, it will come back in the ON position (corresponding local bit is still asserted to logical 1) when power is restored. If a local control switch is in the OFF position (corresponding local bit is deasserted to logical 0) when power is lost, it will come back in the OFF position (corresponding local bit is still deasserted to logical 0) when power is restored. This is like a traditional installation with front-panel control switches. If power is lost to the panel, the front-panel control switches remain in position.

Settings Change

If relay settings are changed, the states of the local bits (Relay Word bits LB1 through LB8) are retained, much like in the preceding “Power Loss” explanation. The exception is if a new local control switch is configured as an OFF/MOMENTARY switch. Then, the corresponding local bit is forced to start at logical 0 after the settings change, regardless of the local bit state before the settings change.

If the local control switch is made inoperable because of a settings change, the corresponding local bit is fixed at logical 0, regardless of the local bit state before the settings change.

Remote Control Switches

Remote control switches are operated via the serial communications port only (see [CON \(Control\) on page 7.7 in Section 7: ASCII Command Reference](#)). These switches differ from local control switches in that remote control switches are operated via serial communications only, and local control switches are operated via the front-panel keyboard/display only.

The output of the remote control switch in [Figure 4.4](#) is a Relay Word bit (remote bit RB_n , $n = 1$ through 8). These remote bits are used in SELOGIC control equations.

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

ON—(logical 1)

OFF—(logical 0)

MOMENTARY—(logical 1 for one processing interval)

With SELOGIC control equations, the remote bits can be used in applications similar to those for which local bits are used (see [Local Control Switches \(NLB_n, SLB_n, CLB_n, PLB_n\) on page 4.5](#)).

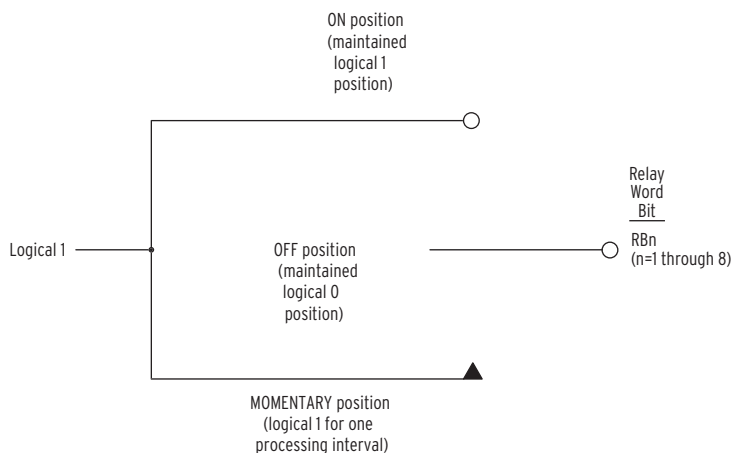


Figure 4.4 Remote Control Switches Drive Remote Bits RB1 Through RB8.

Remote Bit States Not Retained

Power Loss

The states of the remote bits (Relay Word bits RB1 through RB8) are not retained if power to the relay is lost and then restored. The remote control switches come back in the OFF position (corresponding remote bit is deasserted to logical 0) when power is restored to the relay.

Settings Change

If relay settings are changed, the states of the remote bits (Relay Word bits RB1 through RB8) are retained. If a remote control switch is in the ON position (corresponding remote bit is asserted to logical 1) before a settings change, it will come back in the ON position (corresponding remote bit is still asserted to logical 1) after the settings change. If a remote control switch is in the OFF position (corresponding remote bit is deasserted to logical 0) before a settings change, it will come back in the OFF position (corresponding remote bit is still deasserted to logical 0) after the settings change.

SELogic Control Equations

The outputs of the logic in most of the figures in this section are Relay Word bits. Relay Word bits have label names (e.g., 87A1, TRIP, CLOSE, etc.). These are logic points that can have a state of logical 1 or logical 0 depending on the operation of the associated logic. Logical 1 represents an element being picked up, timed out, or otherwise asserted. Logical 0 represents an element being dropped out or otherwise deasserted. All Relay Word bits and descriptions are shown in the tables that appear in [Appendix C: Relay Word Bits](#).

In addition to Relay Word bits, numerals 1 (logical 1) or 0 (logical 0) can be entered in a SELOGIC control equation setting. If a SELOGIC control equation setting is set equal 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.” Under [SHO \(Showset\) on page 7.15 in Section 7: ASCII Command Reference](#), note that a number of the factory SELOGIC control equation settings are set equal to 1 or 0.

SELOGIC control equation settings are the inputs for the logic in many of the figures in this section. See the [SEL-587Z Settings Sheets in Section 5: Setting the Relay](#) for a listing and short description of each of the SELOGIC control equation settings. See [SHO \(Showset\) on page 7.15 in Section 7: ASCII Command Reference](#) for a listing of the factory SELOGIC control equation settings shipped with the relay.

Logical Operators

SELOGIC control equation settings are written in Boolean algebraic logic, combining Relay Word bits together with different operators. Parentheses can also be used in SELOGIC control equation settings. More than one set of parentheses can be used in a given SELOGIC control equation setting, but they cannot be “nested” (parentheses within parentheses). Operators in a SELOGIC control equation setting are processed in the order indicated in [Table 4.5](#).

Table 4.5 Processing Order of SELogic Control Equation Operators

Operator	Logic Function
()	parentheses
!	NOT
*	AND
+	OR

The *, +, and ! functions may be used in any combination for any output contact.

The relay will not accept the following order of SELOGIC control equation operators: *+, **, +*, ++, !*, !+, !!, ().

Programming SELOGIC control equations consists of combining relay element bits with logic AND (*), OR (+), inversion (!), and single parentheses () in a single string for each SELOGIC control equation variable. [Table 4.6 on page 4.12](#) defines the use of these operators and important logic elements.

Table 4.6 SELogic Control Equation Logic

Logic	Definition
*	Logical AND. This symbol requires that the elements on either side of the * symbol be asserted before the logic condition is true, for example $51P * 50P1 = OUT1$.
+	Logical OR. This symbol requires that only one element on either side of the + symbol be asserted before the logical condition is true.
!	Invert. This symbol inverts the element immediately following the ! symbol.
\	At the end of the first line of a SELOGIC control equation, just before the [RETURN], the \ continues the same equation to the second line.
()	Parentheses group variables together and tell the relay to process the variables within the parentheses first.
0	Set equation to logical zero.
NA	Set equation to logical zero. Null (blank or do not run) an equation or label.
1	Set equation to logical one.

Application Rules

Number of Elements

Any single SELOGIC control equation setting is limited to nine Relay Word bits that can be combined with the SELOGIC control equation operators listed in [Table 4.5 on page 4.11](#). To get around this limitation, a SELOGIC control equation variable (SELOGIC control equation settings SV1 through SV14) can be used as an intermediate setting step (see [SELOGIC Control Equation Variables/Timers on page 4.14](#)).

For example, presume that the trip equation (SELOGIC control equation setting TR1) needs more than nine Relay Word bits in its equation setting. Part of the desired equation is put into the SELOGIC control equation setting SV1. The resultant SELOGIC control equation variable output (Relay Word bit SV1) is then set in SELOGIC control equation setting TR1.

Note in [Table 4.7 on page 4.13](#) that the SELOGIC control equation variables (SELOGIC control equation settings SV1 through SV14) are processed after the trip equation (SELOGIC control equations setting TR). Thus, any tripping via Relay Word bit SV1 is delayed one processing interval (1/8-cycle). For most applications, this is probably of no consequence.

As many as 250 Relay Word bits can be used to create SELOGIC control equation settings. You can build the equations using Relay Word bits in combination with the SELOGIC control equation operators listed in [Table 4.5 on page 4.11](#).

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 4.7](#) (top to bottom). The relay processing interval is every 1/8-cycle, and the Relay Word bit states (logical 1 or logical 0) are updated with each 1/8-cycle pass. Once a Relay Word bit is updated during a 1/8-cycle pass, it retains the state (logical 1 or logical 0) until updated again on the next 1/8-cycle pass.

Table 4.7 Processing Order of Relay Elements and Logic (top to bottom)

Relay Elements and Logic (corresponding SELogic control equations listed in parentheses)	Relay Word Bits
Local Control Switches	LB1–LB8
Remote Control Switches	RB1–RB8
Optoisolated Inputs	IN1, IN2
Demand Ammetering	PDEM, GDEM, QDEM
Differential Elements	87A1, 87A2, 87B1, 87B2, 87C1, 87C2
Instantaneous Overcurrent Elements	50P1–50P3, 50A1, 50B1, 50C1, 50A2, 50B2, 50C2, 50G1, 50G2, 50Q1, 50Q2
Time-Overcurrent Elements 51PTC, 51ATC, 51BTC, 51CTC, 51GTC, 51QTC	51P, 51PT, 51PR, 51A, 51AT, 51AR, 51B, 51BT, 51BR, 51C, 51CT, 51CR, 51G, 51GT, 51GR, 51Q, 51QT, 51QR
Trip Logic (TR1, 2, 3; ULTR1, 2, 3)	TRIP1, TRIP2, TRIP3
Close Logic (52A, CL, ULCL)	CLOSE, CF
SELOGIC Control Equation Variables/Timers (SV1–SV14)	SV1–SV14, SV5T–SV14T
Output Contacts (OUT1–OUT4)	OUT1–OUT4
Display Points (DP1–DP8)	
Event Report Triggers (ER1, ER2)	

SELogic Control Equation Variables/Timers

SELOGIC control equations allow the user to create customized logic in the relay. The variables are labeled SVn (SELOGIC control equation variable). Fourteen SELOGIC control equation variables (SV1 through SV14) are available, 10 of which have timer outputs (SV5T through SV14T) (see [Figure 4.5](#)). Combine the Relay Word bits to form the required logic for the specific application.

EXAMPLE 4.7 Close Feed Pumps for Long Busbar Fault

For example, in an installation, feed pumps must be closed if a bus fault lasts longer than 15 cycles. Select SELOGIC control equation variable SV8 to monitor the differential elements and to start the SV8T timer when any differential element asserts. Set timer pickup SV8PU to 15 cycles; and timer dropout SV8DO to 0. When SV8T asserts, close output OUT4, which is connected to the pumps. Enter the following:

SV8 = **87A1 + 87B1 + 87C1** SELogic Variable SV8

OUT4 = **SV8T** Output Contact OUT4

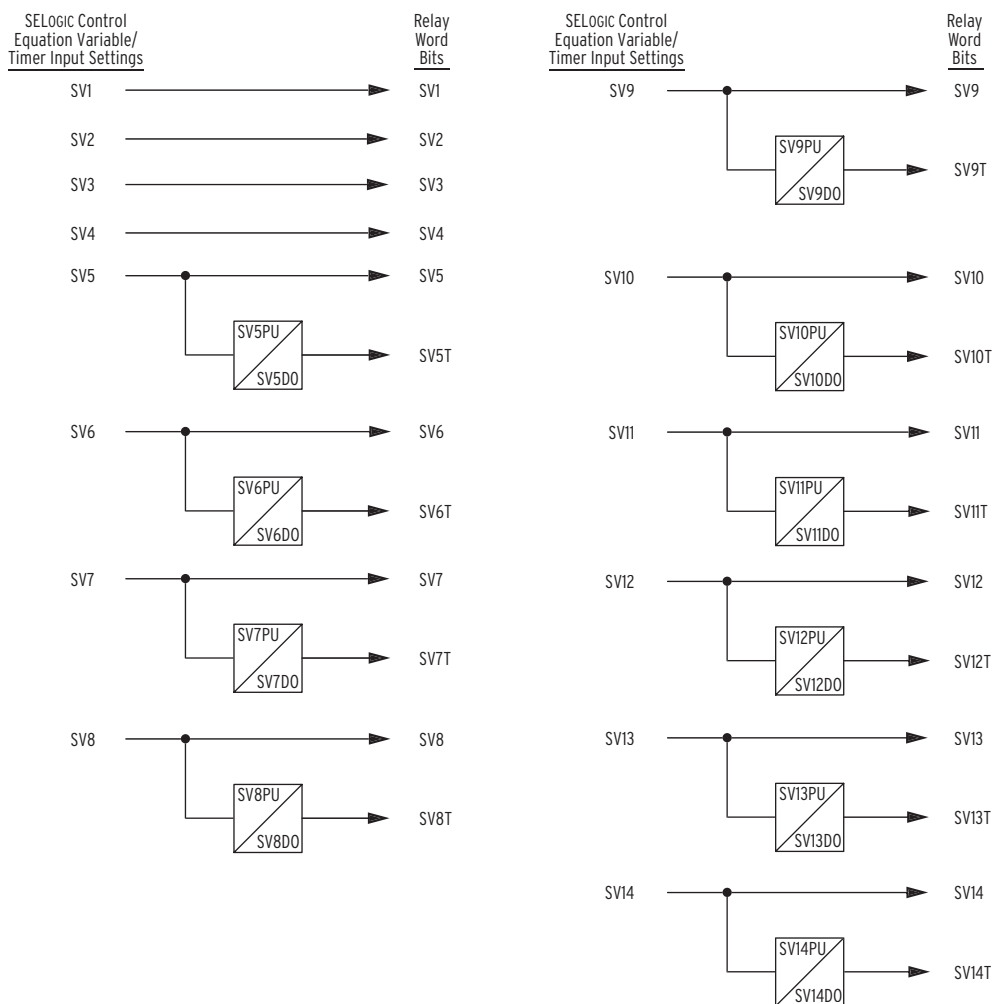


Figure 4.5 SELogic Control Equation Variables/Timers.

EXAMPLE 4.8 Transformer Settings Example

When the SEL-587Z is used as transformer protection, configure a dedicated breaker failure protection element as follows (see Figure 4.6):

SV6 = **TR1*50P1** SELogic Variable SV6

SV7 = **TR1*50P1** SELogic Variable SV7

Retrip:

OUT1 = **SV6T** Output Contact OUT1

Breaker failure trip:

OUT2 = **SV7T** Output Contact OUT2

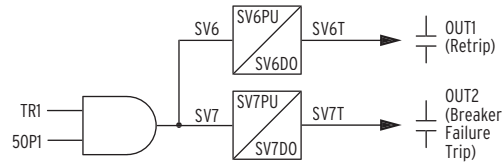


Figure 4.6 Breaker Failure Function Created With SELogic Control Equation Variables/Timers.

TR1 functions as a breaker failure initiate input. Phase instantaneous overcurrent element 50P1 functions as the fault detector.

Timer pickup setting SV6PU provides retrip delay, if desired (can be set to zero).

Timer pickup setting SV7PU provides breaker failure timing. Timer dropout setting SV7DO holds the breaker failure trip output (output contact OUT2) closed for extra time if needed after the breaker failure logic unlatches (fault detector 50P1 or TR1 drops out).

Trip Logic (TRn, ULTRn, TDURD)

The trip logic in [Figure 4.7](#) provides flexible tripping with the following three SELOGIC control equation settings:

- TRn–Trip Conditions
- ULTRn–Unlatch Trip Conditions
- TDURD–Minimum Trip Duration Time

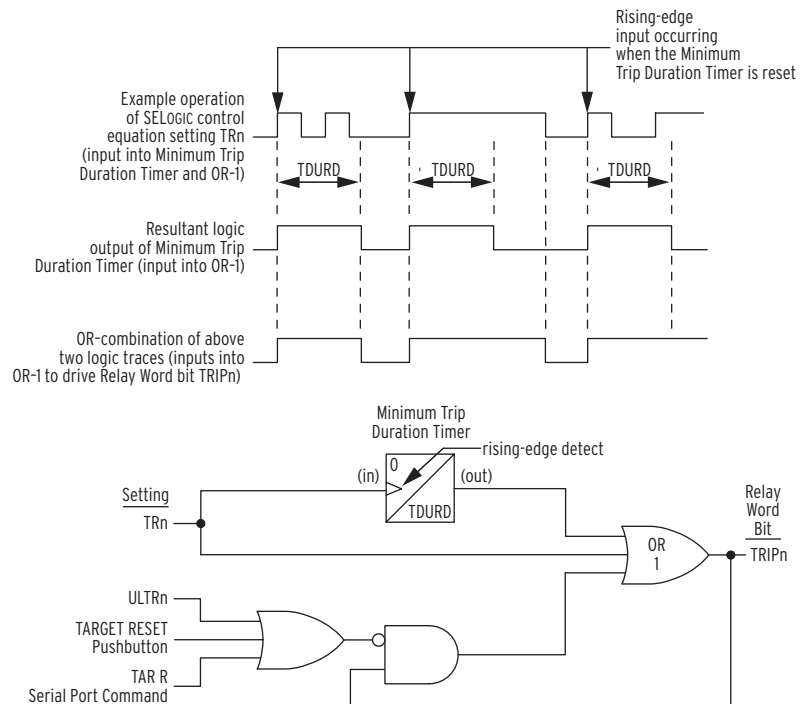


Figure 4.7 Trip Logic.

Set Trip

Any time setting $TR_n = \text{logical } 1$, Relay Word bit $TRIP_n$ asserts to logical 1, regardless of other trip logic conditions.

As shown in the time line example in [Figure 4.7](#), the Minimum Trip Duration Timer (setting TDURD) outputs a logical 1 for a time duration of “TDURD” cycles any time it sees a rising edge on its input (logical 0 to logical 1 transition), if it is not already timing. The TDURD timer assures that the TRIP Relay Word bit remains asserted at logical 1 for a minimum of “TDURD” cycles. If SELOGIC control equation setting $TR_n = \text{logical } 1$ beyond the TDURD time, Relay Word bit $TRIP_n$ remains asserted at logical 1 for as long as $TR_n = \text{logical } 1$. In this case, when TR_n finally deasserts ($TR_n = \text{logical } 0$), the $TRIP_n$ Relay Word bit deasserts immediately, i.e., the TDURD time is not considered again.

Unlatch Trip

Once Relay Word bit $TRIP_n$ is asserted to logical 1, it remains asserted at logical 1 until both of these conditions are true:

- Trip Duration Timer stops timing (output of the TDURD timer goes to logical 0).
- SELOGIC control equation setting TR_n deasserts to logical 0.

In addition one of the following must occur:

- SELOGIC control equation setting ULTRn asserts to logical 1.
- The front-panel {TARGET RESET} pushbutton is pressed.
- The **TAR R** (Target Reset) command is issued via the serial port.

The front-panel {TARGET RESET} pushbutton and **TAR R** (Target Reset) serial-port command are used primarily during testing. Use these functions to deassert the TRIP Relay Word bit to logical 0 if test conditions are such that setting ULTRn does not assert to logical 1 to automatically deassert the TRIP Relay Word bit instead.

EXAMPLE 4.9 Trip Logic SELogic Control Equation Settings

See the [SEL-587Z Settings Sheets](#) in [Section 5: Setting the Relay](#) for setting ranges.

The following is an example of using SELogic control equations in setting the trip, output, and unlatch functions.

High-impedance elements 87A2, 87B2, and 87C2 and time-overcurrent elements 51PT and 51GT trip directly.

TRI = 87A2 + 87B2 + 87C2 + 51P1T + 51G1T + 50P1 Trip Conditions

Both time-overcurrent element pickups 51PP and 51GP must be deasserted before the trip logic unlatches and the TRIPn Relay Word bit deasserts to logical 0.

ULTR1 = !(51P1 + 51G1) Unlatch Trip Conditions

Route the result of the trip logic in [Figure 4.7 on page 4.16](#) to output contact OUT1 with this SELogic control equation:

OUT1 = TRIPn Output Contact OUT1

See [Output Contacts on page 4.20](#) for more information on programming output contacts.

Close Logic (CL, ULCL, 52A, CFD)

The close logic in [Figure 4.8](#) provides flexible circuit breaker closing with SELLOGIC control equation settings:

- CL—(close conditions, other than **CLOSE** command)
- ULCL—(unlatch close conditions, other than breaker status, or close failure)
- 52A—(breaker status)
- CFD—(Close Failure Time)

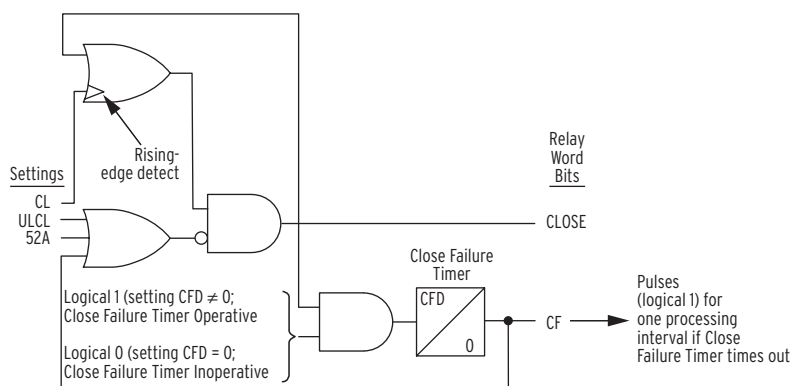


Figure 4.8 Close Logic.

Set Close

The CLOSE Relay Word bit can be asserted to logical 1 if all the following are true:

- The unlatch close condition is not asserted (ULCL = logical 0).
- The circuit breaker is open (52A = logical 0).
- A close failure condition does not exist (Relay Word bit CF = 0).

In addition, one of the following must occur:

- The serial communications port **CLOSE** command is issued (with Relay Word bit CC in the CL equation).
- SELLOGIC control equation setting CL goes from logical 0 to logical 1 (rising-edge transition).

Unlatch Close

If the CLOSE Relay Word bit is asserted at logical 1, it stays asserted at logical 1 until one of the following occurs:

- The unlatch close condition asserts (ULCL = logical 1).
- The circuit breaker closes (52A = logical 1).
- The Close Failure Timer times out (Relay Word bit CF = 1).

The Close Failure Timer is inoperative if setting CFD = 0. Then, the CLOSE Relay Word bit can be deasserted to logical 0 only if either of the following occurs:

- The unlatch close condition asserts (ULCL = logical 1).
- The circuit breaker closes (52A = logical 1).

EXAMPLE 4.10 Close Logic SELogic Control Equation Settings

See the [SEL-587Z Settings Sheets](#) in [Section 5: Setting the Relay](#) for setting ranges.

SELogic control equation setting CL is set with local bit LB4. Local bit LB4 closes directly (operates as a manual close switch via the front panel). See [Local Control Switches \(NLBn, SLBn, CLBn, PLBn\)](#) on [page 4.5](#) and [Section 8: Front-Panel Interface](#) for more information on local control.

CL = **LB4** Close Conditions

SELogic control equation setting ULCL is set with the TRIP1 Relay Word bit. This prevents the CLOSE Relay Word bit from being asserted any time the TRIP Relay Word bit is asserted (TRIP takes priority). See [Trip Logic \(TRn, ULTRn, TDURD\)](#) on [page 4.16](#).

ULCL = **TRIP1** Unlatch Close Conditions

SELogic control equation setting 52A is set with optoisolated input IN1. Input IN1 is connected to a 52a circuit breaker auxiliary contact. Setting 52A operates on 52a circuit breaker auxiliary contact logic. When a closed circuit breaker condition is detected, the CLOSE Relay Word bit is deasserted to logical 0. Setting 52A can handle a 52a or 52b circuit breaker auxiliary contact connected to an optoisolated input (see [Optoisolated Inputs](#) on [page 4.2](#) for more 52A setting examples).

52A = **IN1** Circuit Breaker Status

With setting CFD = 60.000 cycles, once the CLOSE Relay Word bit is asserted, it can remain asserted at logical 1 for a maximum of 60 cycles.

If SELogic control equation setting 52A is set with numeral 0 (52A = 0), then the close logic is inoperable.

Route the result of the close logic in [Figure 4.8 on page 4.18](#) to output contact OUT2 with the following SELogic control equation:

OUT2 = **CLOSE** Output Contact OUT2

Output Contacts

SELOGIC control equation settings OUT1 through OUT4 control Relay Word bits OUT1 through OUT4, respectively. Relay Word bits OUT1 through OUT4 in turn control output contacts OUT1 through OUT4, respectively. Alarm logic/circuitry controls the ALARM output contact. See [Figure 4.9 on page 4.21](#).

EXAMPLE 4.11 Default Settings

The default setting for high-impedance tripping follows:

OUT1 = **87A1 + 87B1 + 87C1** Output Contact OUT1

The default setting for a bus zone operated alarm follows:

OUT2 = **SV5T** Output Contact OUT2

The default setting for a CT open-circuit alarm follows:

OUT3 = **87A2 + 87B2 + 87C2** Output Contact OUT3

The default setting for a breaker fail follows:

OUT4 = **SV6T** Output Contact OUT4

Issuing the serial port command **PULSE *n*** (*n* = OUT1 through OUT4) asserts the corresponding Relay Word bit (OUT1 through OUT4) to logical 1. The assertion of SELOGIC control equation setting OUT_{*m*} (*m* = 1 through 4) to logical 1 also asserts the corresponding Relay Word bit OUT_{*m*} (*m* = 1 through 4) to logical 1.

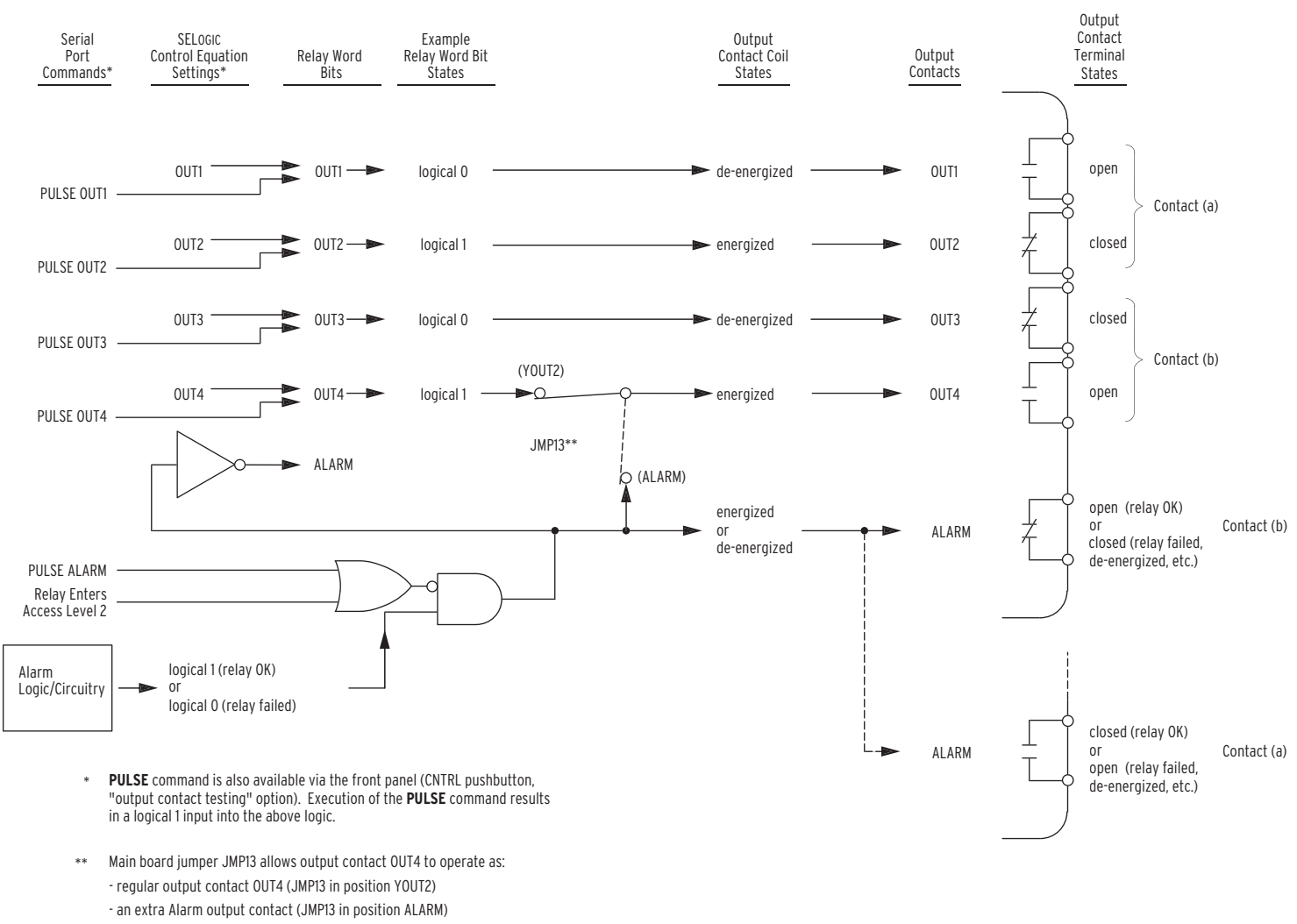


Figure 4.9 Logic Flow for Example Output Contact Operation.

See Figure 2.7 on page 2.10 in Section 2: Installation and Table 2.2 on page 2.10 in Section 2: Installation for more information on jumper JMP13.

The assertion of Relay Word bit OUT_m ($m = 1$ through 4) to logical 1 causes the energization of the corresponding output contact OUT_m coil. Depending on the contact type (a or b), the output contact closes or opens as demonstrated in [Figure 4.9 on page 4.21](#). An “a” type output contact is open when the output contact coil is de-energized and closed when the output contact coil is energized. A “b” type output contact is closed when the output contact coil is de-energized and open when the output contact coil is energized.

Notice in [Figure 4.9 on page 4.21](#) that all four possible combinations of output contact coil states (energized or de-energized) and output contact types (a or b) are demonstrated. See [Output Contact Jumpers on page 2.8 in Section 2: Installation](#) for output contact type options.

ALARM Output Contact

Output contacts assigned for alarm duty operate as “b” contacts. For more information on configuring alarm outputs, see [Output Contact Jumpers on page 2.8 in Section 2: Installation](#).

Also, refer to [Figure 4.9 on page 4.21](#) and [Relay Self-Tests on page 10.17 in Section 10: Testing and Troubleshooting](#).

When the relay is operating normally, the ALARM output contact coil is energized. The alarm logic/circuitry keeps the ALARM output contact coil energized. A “b” type output contact is closed when the output contact coil is de-energized and open when the output contact coil is energized. With the ALARM output contact factory setting of type “b,” the ALARM output contact closes when the coil is de-energized.

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

The Relay Word bit ALARM is deasserted to logical 0 when the relay is operating normally. When the serial port command **PULSE ALARM** is issued, the ALARM Relay Word bit momentarily asserts to logical 1. Also, when the relay enters Access Level 2, the ALARM Relay Word bit momentarily asserts to logical 1 (and the ALARM output contact coil is de-energized momentarily).

Rotating Display

Rotating displays on the front panel replace indicating lights. Traditional indicating panel lights are turned on and off by circuit breaker auxiliary contacts, front-panel switches, SCADA contacts, etc., to indicate such conditions as circuit breaker open/closed. See [Section 8: Front-Panel Interface](#) for more information on the rotating display.

Front-Panel Target LEDs

Refer to *Figure 1.1 on page 1.2 in Section 1: Introduction and Specifications* for the arrangement of the target LEDs on the front panel of the SEL-587Z.

Table 4.8 lists the front-panel targets. The relay updates these targets during a relay trip event.

Table 4.8 SEL-587Z Front-Panel Target LED Definitions

LED	Definition
EN	Relay Enabled—see subsection <i>Relay Self-Tests on page 10.17 in Section 10: Testing and Troubleshooting</i>
87	Any one of the 87 elements (87A1, 87A2, 87B1, 87B2, 87C1, 87C2) asserts
50	Any one of the 50 elements (50P1, 50P2, 50P3, 50A1, 50A2, 50B1, 50B2, 50C1, 50C2, 50Q1, 50Q2, 50G1, 50G2) asserts
51	Any one of the 51T elements (51PT, 51AT, 51BT, 51CT, 51QT, 51GT) asserts
A	51PT, 50P1, 50P2, or 50P3 element asserts and the A current exceeds the setting or an A-phase element (87A1, 87A2, 50A1, 50A2, 51AT) asserts
B	51PT, 50P1, 50P2, or 50P3 element asserts and the B current exceeds the setting or a B-phase element (87B1, 87B2, 50B1, 50B2, 51BT) asserts
C	51PT, 50P1, 50P2, or 50P3 element asserts and the C current exceeds the setting or a C-phase element (87C1, 87C2, 50C1, 50C2, 51CT) asserts
G	Any one of the ground elements (50G1, 50G2, 51GT) asserts

Nonvolatile Targets

The relay stores target information in nonvolatile memory. If the relay is powered off, the relay restores previous targets at cold start (initiation) time when powered on again.

Target Reset/Lamp Test

When the Target Reset/Lamp Test front-panel pushbutton is pressed, all front-panel LEDs are illuminated for one (1) second, and then the Fault Type target LEDs (87, 50, 51, A, B, C, and G) are extinguished.

Section 5

Setting the Relay

Introduction

This section contains tables of relay settings for the SEL-587Z Relay. 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. This section does not explain rules for hiding settings; these rules are discussed in the applications sections of the instruction manual where appropriate.

The settings prompts in this section are similar to the ASCII terminal prompts. The relay front panel **{SET}** pushbutton provides access to the relay (**SET**) and port (**SET P**) settings only. Use the corresponding relay and port settings sheets that follow in this section when making these settings via the front panel. Refer to *Figure 8.1 on page 8.2 in Section 8: Front-Panel Interface* for information about the front panel.

View settings with the respective serial port **SHOWSET** commands (**SHO**, **SHO L**, **SHO P**, **SHO T**, **SHO R**). See *SHO (Showset) on page 7.15 in Section 7: ASCII Command Reference*.

The relay supports Relay, Logic, Port, Text, and Sequential Events Recorder settings. A copy of all the settings is stored in nonvolatile EEPROM.

Voltage settings are in 1-V steps; current settings are in 0.1-A steps.

Settings Changes Via the Serial Port

NOTE: In this manual, commands you type appear in bold/uppercase: **SHOWSET**. You need to type only the first three letters of a command, for example, **SHO**. Computer keys you press appear in bold/uppercase/brackets: **<Enter>**. Relay front-panel pushbuttons you press appear in bold/uppercase/curly brackets: **{EVENTS}**.

See [Section 6: Serial Port Communications](#) for information on serial port communications and relay access levels. To change a specific setting, enter the command:

SET *n s*

where *n* = L, P, T, or R (parameter *n* is not entered for the Relay settings) and *s* is the name of the specific setting you want to access and begin setting. If *s* is not entered, the relay starts at the first setting. For example, to set Event Report 1, type the following:

SET L ER1 <Enter>

The relay responds with:

```
ER1 = 87A1+87B1+87C1
?
```

If you omit the *s* parameter, the relay starts at the top of the logic settings and responds with the following:

```
TR1 = 87A1+87B1+87C1
?
```

When you issue the **SET *n*** command, the relay starts at the top of the particular setting group and presents a setting. Enter a new setting and press **<Enter>**; if you want to retain the existing setting, then press **<Enter>** only. After the **<Enter>** keystroke, the relay presents the next setting, and so on. [Table 5.1](#) shows the editing keystrokes.

Table 5.1 SET Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains setting and moves to the next
^ <Enter>	Returns to previous setting
< <Enter>	Returns to previous setting
> <Enter>	Moves to next setting
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. When out of range, the relay generates an “Out of Range” message and prompts for the setting again.

When settings are complete, the relay displays the new settings and prompts for approval to enable them. Answer **Y <Enter>** to enable the new settings. While the active settings are updated (about one second), the relay is disabled, and the ALARM contact closes.

Settings Changes Via the Front Panel

The relay front-panel **{SET}** pushbutton provides access to the relay and port settings only. Use the corresponding relay and port settings sheets that follow in this section when making these settings via the front panel. Refer to [Figure 8.1 on page 8.2 in Section 8: Front-Panel Interface](#) for information about front-panel communications.

Identifier and System Parameter Settings

The following explanations are for relay settings (accessed under the **SET** command) that control general relay configuration.

Relay ID (RID) and Terminal ID (TID)

The SEL-587Z has two identifier labels: the Relay Identifier (RID) and the Terminal Identifier (TID). The Relay Identifier typically is used to identify the relay or the type of protection scheme. Typical Terminal Identifiers include an abbreviation of the substation name and line terminal.

The relay tags each report (event report, meter report, etc.) with the Relay Identifier and Terminal Identifier. This tagging helps you distinguish the report as one generated for a specific breaker and substation.

RID and TID settings may include the following characters: 0–9, A–Z, -, /, ., space.

CT Ratio (CTR)

Determine the CT ratio by dividing the nominal primary CT current by the nominal secondary CT current. If, for example, the nominal primary CT current is 2000 A and the nominal CT current is 5 A, the ratio is 2000/5 or 400. For this example, enter a value of 400.

System Frequency (NFREQ) and Phase Rotation (PHROT)

Use the relay settings NFREQ and PHROT to configure the SEL-587Z to your specific system.

Set NFREQ equal to your nominal power system frequency, either 50 Hz or 60 Hz.

Set PHROT equal to your power system phase rotation, either ABC or ACB.

DATE_F

Set the date format with this command. The format can be either mm/dd/yy or yy/mm/dd. Set DATE_F equal to MDY for the former and equal to YMD for the latter.

SEL-587Z Settings Sheets

Relay Settings (SET Command)

Identifier Labels

Relay Identifier (12 characters) (0–9, A–Z, -, /, ., space)

RID = _____

Terminal Identifier (12 characters) (0–9, A–Z, -, /, ., space)

TID = _____

Current Transformer Ratios

Phase (IA, IB, IC) CT Ratio (1–6000)

CTR = _____

Minimum Trip Duration Timer

Min. Trip Duration Time (0–8000 cycles in 0.125-cycle steps)

TDURD = _____

Differential Elements 87A1P–87C2P

High Imp. Pickup (OFF, 20–800 V)

87A1P = _____

High Imp. Pickup (OFF, 20–800 V)

87A2P = _____

High Imp. Pickup (OFF, 20–800 V)

87B1P = _____

High Imp. Pickup (OFF, 20–800 V)

87B2P = _____

High Imp. Pickup (OFF, 20–800 V)

87C1P = _____

High Imp. Pickup (OFF, 20–800 V)

87C2P = _____

Phase Instantaneous Overcurrent Elements 50P1–50P3

Phase Inst. Pickup

(OFF, 0.5–80.0 A) (5 A nominal)

(OFF, 0.1–16.0 A) (1 A nominal)

50P1P = _____

Phase Inst. Pickup

(OFF, 0.5–80.0 A) (5 A nominal)

(OFF, 0.1–16.0 A) (1 A nominal)

50P2P = _____

Phase Inst. Pickup

(OFF, 0.5–80.0 A) (5 A nominal)

(OFF, 0.1–16.0 A) (1 A nominal)

50P3P = _____

Single-Phase Instantaneous Overcurrent Elements 50A1-50C2

A Phase Inst. Pickup (OFF, 0.5–80.0 A) (5 A nominal) (OFF, 0.1–16.0 A) (1 A nominal)	50A1P	= _____
A Phase Inst. Pickup (OFF, 0.5–80.0 A) (5 A nominal) (OFF, 0.1–16.0 A) (1 A nominal)	50A2P	= _____
B Phase Inst. Pickup (OFF, 0.5–80.0 A) (5 A nominal) (OFF, 0.1–16.0 A) (1 A nominal)	50B1P	= _____
B Phase Inst. Pickup (OFF, 0.5–80.0 A) (5 A nominal) (OFF, 0.1–16.0 A) (1 A nominal)	50B2P	= _____
C Phase Inst. Pickup (OFF, 0.5–80.0 A) (5 A nominal) (OFF, 0.1–16.0 A) (1 A nominal)	50C1P	= _____
C Phase Inst. Pickup (OFF, 0.5–80.0 A) (5 A nominal) (OFF, 0.1–16.0 A) (1 A nominal)	50C2P	= _____

Phase Time-Overcurrent Element 51P

Phase Time-Overcurrent Pickup (OFF, 0.5–16.0 A) (5 A nominal) (OFF, 0.1–3.2 A) (1 A nominal)	51PP	= _____
Phase Time-Overcurrent Curve (U1–U5, C1–C5)	51PC	= _____
Phase Time-Overcurrent Time Dial 0.50–15.00 for curves U1–U5 0.05–1.00 for curves C1–C5	51PTD	= _____
Phase Time-Overcurrent Electromechanical Reset (Y, N)	51PRS	= _____

Phase Time-Overcurrent Element 51A-51C

A Phase Time-Overcurrent Pickup (OFF, 0.5–16.0 A) (5 A nominal) (OFF, 0.1–3.2 A) (1 A nominal)	51AP	= _____
A Phase Time-Overcurrent Curve (U1–U5, C1–C5)	51AC	= _____
A Phase Time-Overcurrent Time Dial 0.50–15.00 for curves U1–U5 0.05–1.00 for curves C1–C5	51ATD	= _____
A Phase Time-Overcurrent Electromechanical Reset (Y, N)	51ARS	= _____

B Phase Time-Overcurrent Pickup (OFF, 0.5–16.0 A) (5 A nominal) (OFF, 0.1–3.2 A) (1 A nominal)	51BP	= _____
B Phase Time-Overcurrent Curve (U1–U5, C1–C5)	51BC	= _____
B Phase Time-Overcurrent Time Dial 0.50–15.00 for curves U1–U5 0.05–1.00 for curves C1–C5	51BTD	= _____
B Phase Time-Overcurrent Electromechanical Reset (Y, N)	51BRS	= _____
C Phase Time-Overcurrent Pickup (OFF, 0.5–16.0 A) (5 A nominal) (OFF, 0.1–3.2 A) (1 A nominal)	51CP	= _____
C Phase Time-Overcurrent Curve (U1–U5, C1–C5)	51CC	= _____
C Phase Time-Overcurrent Time Dial 0.50–15.00 for curves U1–U5 0.05–1.00 for curves C1–C5	51CTD	= _____
C Phase Time-Overcurrent Electromechanical Reset (Y, N)	51CRS	= _____

Residual Ground Instantaneous Overcurrent Elements 50G1, 50G2

Residual Gnd. Inst. Pickup (OFF, 0.5–80.0 A) (5 A nominal) (OFF, 0.1–16.0 A) (1 A nominal)	50G1P	= _____
Residual Gnd. Inst. Pickup (OFF, 0.5–80.0 A) (5 A nominal) (OFF, 0.1–16.0 A) (1 A nominal)	50G2P	= _____

Residual Ground Instantaneous Overcurrent Elements 51G

Residual Gnd. Time-Overcurrent Pickup (OFF, 0.5–16.0 A) (5 A nominal) (OFF, 0.1–3.2 A) (1 A nominal)	51GP	= _____
Residual Gnd. Time-Overcurrent Curve (U1–U5, C1–C5)	51GC	= _____
Residual Gnd. Time-Overcurrent Time Dial 0.50–15.00 for curves U1–U5 0.05–1.00 for curves C1–C5	51GTD	= _____
Residual Gnd. Time-Overcurrent Electromechanical Reset (Y, N)	51GRS	= _____

Negative-Sequence Instantaneous Overcurrent Elements 50Q1, 50Q2

Neg.-Seq. Inst. Pickup (OFF, 0.5–80.0 A) (5 A nominal) (OFF, 0.1–16.0 A) (1 A nominal)	50Q1P	= _____
--	--------------	---------

Neg.-Seq. Inst. Pickup
(OFF, 0.5–80.0 A) (5 A nominal)
(OFF, 0.1–16.0 A) (1 A nominal)

50Q2P = _____

Negative-Sequence Time Overcurrent Element 51Q

Neg.-Seq. Time Overcurrent Pickup
(OFF, 0.5–16.0 A) (5 A nominal)
(OFF, 0.1–3.2 A) (1 A nominal)

51QP = _____

Neg.-Seq. Time Overcurrent Curve (U1–U5, C1–C5)

51QC = _____

Neg.-Seq. Time Overcurrent Time Dial
0.50–15.00 for curves U1–U5
0.05–1.00 for curves C1–C5

51QTD = _____

Neg.-Seq. Time Overcurrent Electromechanical Reset (Y, N)

51QRS = _____

Close Failure Timer

Close Failure Timer Pickup
(0–54000 cycles in 0.125-cycle steps)

CFD = _____

Demand Ammetering Settings

Time Constant (5, 10, 15, 30, 60 minutes)

DMTC = _____

Demand Phase Pickup
(OFF, 0.5–16.0 A) (5 A nominal)
(OFF, 0.1–3.2 A) (1 A nominal)

PDEMP = _____

Demand Residual Ground Pickup
(OFF, 0.5–16.0 A) (5 A nominal)
(OFF, 0.1–3.2 A) (1 A nominal)

GDEMP = _____

Demand Negative-Sequence Pickup
(OFF, 0.5–16.0 A) (5 A nominal)
(OFF, 0.1–3.2 A) (1 A nominal)

QDEMP = _____

SELogic® Variable Timers

SV5 Timer Pickup (0–54000.000 cycles in 0.125-cycle steps)

SV5PU = _____

SV5 Timer Dropout (0–54000.000 cycles in 0.125-cycle steps)

SV5DO = _____

SV6 Timer Pickup (0–54000.000 cycles in 0.125-cycle steps)

SV6PU = _____

SV6 Timer Dropout (0–54000.000 cycles in 0.125-cycle steps)

SV6DO = _____

SV7 Timer Pickup (0–54000.000 cycles in 0.125-cycle steps)

SV7PU = _____

SV7 Timer Dropout (0–54000.000 cycles in 0.125-cycle steps)

SV7DO = _____

SV8 Timer Pickup (0–54000.000 cycles in 0.125-cycle steps)

SV8PU = _____

SV8 Timer Dropout (0–54000.000 cycles in 0.125-cycle steps)	SV8DO	= _____
SV9 Timer Pickup (0–54000.000 cycles in 0.125-cycle steps)	SV9PU	= _____
SV9 Timer Dropout (0–54000.000 cycles in 0.125-cycle steps)	SV9DO	= _____
SV10 Timer Pickup (0–54000.000 cycles in 0.125-cycle steps)	SV10PU	= _____
SV10 Timer Dropout (0–54000.000 cycles in 0.125-cycle steps)	SV10DO	= _____
SV11 Timer Pickup (0–54000.000 cycles in 0.125-cycle steps)	SV11PU	= _____
SV11 Timer Dropout (0–54000.000 cycles in 0.125-cycle steps)	SV11DO	= _____
SV12 Timer Pickup (0–54000.000 cycles in 0.125-cycle steps)	SV12PU	= _____
SV12 Timer Dropout (0–54000.000 cycles in 0.125-cycle steps)	SV12DO	= _____
SV13 Timer Pickup (0–54000.000 cycles in 0.125-cycle steps)	SV13PU	= _____
SV13 Timer Dropout (0–54000.000 cycles in 0.125-cycle steps)	SV13DO	= _____
SV14 Timer Pickup (0–54000.000 cycles in 0.125-cycle steps)	SV14PU	= _____
SV14 Timer Dropout (0–54000.000 cycles in 0.125-cycle steps)	SV14DO	= _____

Other System Parameters

Nominal Frequency (50, 60 Hz)	NFREQ	= _____
Phase Rotation (ABC, ACB)	PHROT	= _____
Date Format (MDY, YMD)	DATE_F	= _____

SELogic Control Equation Settings (SET L Command)

Trip Logic

Trip Conditions	TR1	=	_____
Trip Conditions	TR2	=	_____
Trip Conditions	TR3	=	_____
Unlatch Trip Conditions	ULTR1	=	_____
Unlatch Trip Conditions	ULTR2	=	_____
Unlatch Trip Conditions	ULTR3	=	_____

Torque Control for Time-Overcurrent Elements

NOTE: Setting equation to zero (= 0) defeats corresponding element.

Phase Element 51PTC	51PTC	=	_____
Phase Element 51ATC	51ATC	=	_____
Phase Element 51BTC	51BTC	=	_____
Phase Element 51CTC	51CTC	=	_____
Residual Ground Element 51GTC	51GTC	=	_____
Negative-Sequence Element 51QTC	51QTC	=	_____

Close Logic

Circuit Breaker Status	52A	=	_____
Close Conditions	CL	=	_____
ULCL Unlatch Close Conditions	ULCL	=	_____

Event Report Trigger Conditions

Event Report Trigger Condition 1	ER1	=	_____
Event Report Trigger Condition 2	ER2	=	_____

SELogic Variables

SELOGIC Variable SV1	SV1	=	_____
SELOGIC Variable SV2	SV2	=	_____
SELOGIC Variable SV3	SV3	=	_____
SELOGIC Variable SV4	SV4	=	_____
SELOGIC Variable SV5	SV5	=	_____

SELOGIC Variable SV6	SV6	= _____
SELOGIC Variable SV7	SV7	= _____
SELOGIC Variable SV8	SV8	= _____
SELOGIC Variable SV9	SV9	= _____
SELOGIC Variable SV10	SV10	= _____
SELOGIC Variable SV11	SV11	= _____
SELOGIC Variable SV12	SV12	= _____
SELOGIC Variable SV13	SV13	= _____
SELOGIC Variable SV14	SV14	= _____

Output Contacts

Output Contact OUT1	OUT1	= _____
Output Contact OUT2	OUT2	= _____
Output Contact OUT3	OUT3	= _____
Output Contact OUT4	OUT4	= _____

Display Points

Display Point DP1	DP1	= _____
Display Point DP2	DP2	= _____
Display Point DP3	DP3	= _____
Display Point DP4	DP4	= _____
Display Point DP5	DP5	= _____
Display Point DP6	DP6	= _____
Display Point DP7	DP7	= _____
Display Point DP8	DP8	= _____

Port Settings (SET P Command)

NOTE: The RTSCTS setting does not appear if PROTO=LMD or MOD; PREFIX, ADDR, and SETTLE do not appear if PROTO=SEL or MOD; the SLAVE setting does not appear if PROTO=SEL or LMD. See [SEL Distributed Port Switch Protocol \(LMD\)](#) on page 6.10 in Section 6: [Serial Port Communications](#) for details on LMD protocol and see [Appendix D: Modbus RTU Communications Protocol](#) for details on Modbus protocol.

Port 1 (SET P 1) Rear Panel

Port Protocol (SEL, LMD, MOD)	PROTO	= _____
LMD Prefix (@, #, \$, %, &)	PREFIX	= _____
LMD Address (1–99)	ADDR	= _____
LMD Settling Time (0–30 seconds)	SETTLE	= _____
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED	= _____
Number Data Bits (7, 8)	BITS	= _____
Parity (Odd [O], Even [E], or None [N])	PARITY	= _____
Stop Bits (1, 2)	STOP	= _____
Timeout (for inactivity) (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)	SLAVE	= _____

Port F (SET P F) Front Panel

Port Protocol (SEL, LMD)	PROTO	= _____
LMD Prefix (@, #, \$, %, &)	PREFIX	= _____
LMD Address (1–99)	ADDR	= _____
LMD Settling Time (0–30 seconds)	SETTLE	= _____
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED	= _____
Number Data Bits (7, 8)	BITS	= _____
Parity (Odd [O], Even [E], or None [N])	PARITY	= _____
Stop Bits (1, 2)	STOP	= _____
Timeout (for inactivity) (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	= _____

Text Settings (SET T Command)

NOTE: Enter the following characters: 0-9, A-Z, -, /, ., space for each text label setting, subject to the specified character limit.
Enter NA to null a label.

Local Bit Labels

Local Bit LB1 Name (14 characters)	NLB1	= _____
Clear Local Bit LB1 Label (7 characters)	CLB1	= _____
Set Local Bit LB1 Label (7 characters)	SLB1	= _____
Pulse Local Bit LB1 Label (7 characters)	PLB1	= _____
Local Bit LB2 Name (14 characters)	NLB2	= _____
Clear Local Bit LB2 Label (7 characters)	CLB2	= _____
Set Local Bit LB2 Label (7 characters)	SLB2	= _____
Pulse Local Bit LB2 Label (7 characters)	PLB2	= _____
Local Bit LB3 Name (14 characters)	NLB3	= _____
Clear Local Bit LB3 Label (7 characters)	CLB3	= _____
Set Local Bit LB3 Label (7 characters)	SLB3	= _____
Pulse Local Bit LB3 Label (7 characters)	PLB3	= _____
Local Bit LB4 Name (14 characters)	NLB4	= _____
Clear Local Bit LB4 Label (7 characters)	CLB4	= _____
Set Local Bit LB4 Label (7 characters)	SLB4	= _____
Pulse Local Bit LB4 Label (7 characters)	PLB4	= _____
Local Bit LB5 Name (14 characters)	NLB5	= _____
Clear Local Bit LB5 Label (7 characters)	CLB5	= _____
Set Local Bit LB5 Label (7 characters)	SLB5	= _____
Pulse Local Bit LB5 Label (7 characters)	PLB5	= _____
Local Bit LB6 Name (14 characters)	NLB6	= _____
Clear Local Bit LB6 Label (7 characters)	CLB6	= _____
Set Local Bit LB6 Label (7 characters)	SLB6	= _____
Pulse Local Bit LB6 Label (7 characters)	PLB6	= _____
Local Bit LB7 Name (14 characters)	NLB7	= _____
Clear Local Bit LB7 Label (7 characters)	CLB7	= _____
Set Local Bit LB7 Label (7 characters)	SLB7	= _____
Pulse Local Bit LB7 Label (7 characters)	PLB7	= _____

Local Bit LB8 Name (14 characters)	NLB8	=	_____
Clear Local Bit LB8 Label (7 characters)	CLB8	=	_____
Set Local Bit LB8 Label (7 characters)	SLB8	=	_____
Pulse Local Bit LB8 Label (7 characters)	PLB8	=	_____

Display Point Labels

Display if DP1 = logical 1 (16 characters)	DP1_1	=	_____
Display if DP1 = logical 0 (16 characters)	DP1_0	=	_____
Display if DP2 = logical 1 (16 characters)	DP2_1	=	_____
Display if DP2 = logical 0 (16 characters)	DP2_0	=	_____
Display if DP3 = logical 1 (16 characters)	DP3_1	=	_____
Display if DP3 = logical 0 (16 characters)	DP3_0	=	_____
Display if DP4 = logical 1 (16 characters)	DP4_1	=	_____
Display if DP4 = logical 0 (16 characters)	DP4_0	=	_____
Display if DP5 = logical 1 (16 characters)	DP5_1	=	_____
Display if DP5 = logical 0 (16 characters)	DP5_0	=	_____
Display if DP6 = logical 1 (16 characters)	DP6_1	=	_____
Display if DP6 = logical 0 (16 characters)	DP6_0	=	_____
Display if DP7 = logical 1 (16 characters)	DP7_1	=	_____
Display if DP7 = logical 0 (16 characters)	DP7_0	=	_____
Display if DP8 = logical 1 (16 characters)	DP8_1	=	_____
Display if DP8 = logical 0 (16 characters)	DP8_0	=	_____

Sequential Events Recorder Settings (SET R Command)

NOTE: Sequential Events Recorder settings are comprised of three trigger lists. Each trigger list can include up to 24 Relay Word bits delimited by spaces or commas. See [Sequential Events Recorder \(SER\) Report on page 9.17 in Section 9: Event Reports and SER](#).

SER Trigger List 1	SER1	=	_____
SER Trigger List 2	SER2	=	_____
SER Trigger List 3	SER3	=	_____

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Section 6

Serial Port Communications

Introduction

The SEL-587Z Relay is equipped with two serial communications ports, one on the rear panel and one on the front panel. One example of using these ports is to connect the front serial port to a computer for local communications and the rear port to a modem for remote communications. Other devices useful for communication include the SEL-2020 or SEL-2030 Communications Processor. The SEL-587Z includes Modbus[®] RTU Communications Protocol as an option. You can use a variety of terminal emulation programs on your personal computer to communicate with the relay. Examples of PC-based terminal emulation programs include: Procomm Plus[®], Relay/Gold, Microsoft[®] Windows[®] Terminal, SmartCOM, and CROSSTALK[®].

For more information about connecting and using the SEL-587Z ports, see [*Rear-Panel Connections on page 2.4 in Section 2: Installation.*](#)

Port Connector and Communications Cables

The rear port can be ordered with either an EIA-232 or EIA-485 (4-wire) serial port; the front port will always be an EIA-232 port. The default settings for the serial port are:

Parameters	Default Values
Baud Rate	2400 bps
Data Bits	8
Parity	N
Stop Bits	1

To change the port settings, use the serial port **SET P** command (see [SEL-587Z Settings Sheets](#) in [Section 5: Setting the Relay](#)) or the front-panel **{SET}** pushbutton.

Port Connections

The 9-pin port connector is shown in [Figure 6.1](#).

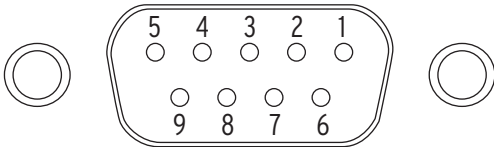


Figure 6.1 9-Pin Serial Port Connector.

[Table 6.1](#) lists the pinouts for the EIA-232 and EIA-485 ports.

Table 6.1 EIA-232 and EIA-485 Pinouts

Pin	Port F EIA-232	Port 1 EIA-232 Option	Port 1 EIA-485 (4-Wire Option)
1	N/C	N/C or +5 Vdc (main board jumper JMP12, see Section 2: Installation)	+TX
2	RXD	RXD	–TX
3	TXD	TXD	N/C
4	N/C	+IRIG-B	+IRIG-B
5	GND	Isolated GND	Isolated GND
6	N/C	IRIG-B	–IRIG-B
7	RTS	RTS	+RX
8	CTS	CTS	–RX
9	GND	Isolated GND (main board jumper JMP14, see Section 2: Installation)	Isolated GND

Communications Cables

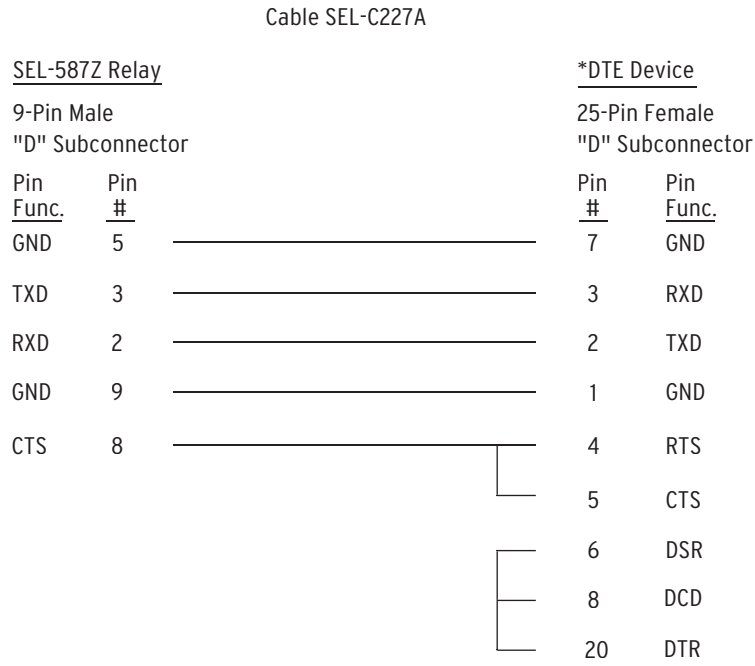
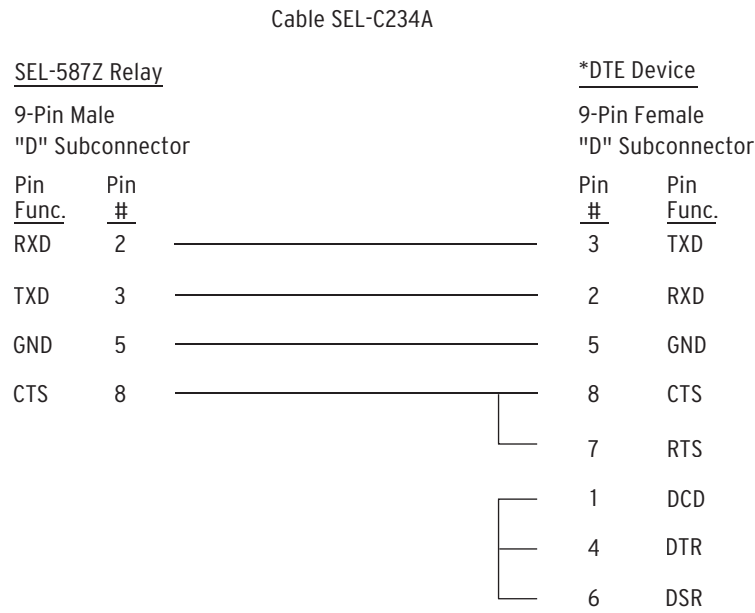
The communications ports pin functions are detailed in [Table 6.2 on page 6.3](#).

Table 6.2 Serial Communications Port Pin Function Definitions

Pin Function	Definition
N/C	No connection
+5 Vdc	5 Vdc power connection
RXD, RX	Receive data
TXD, TX	Transmit data
IRIG-B	IRIG-B time-code input
GND	Ground
Isolated GND	A ground plane not connected to the relay chassis
RTS	Request to send
CTS	Clear to send
DCD	Data carrier detect
DTR	Data terminal ready
DSR	Data set ready

The following cable diagrams show several types of EIA-232 serial communications cables. These and other cables are available from SEL. Contact the factory for more information.

For long-distance communications up to 500 meters and for electrical isolation of communications ports, use the SEL-2800 or SEL-2810 Fiber-Optic Transceivers. Contact SEL for details about these devices.



*DTE = Data Terminal Equipment (Computer, Terminal, etc.)

Figure 6.2 SEL-587Z to Computer.

Cable SEL-C222

<u>SEL-587Z Relay</u>			<u>*DCE Device</u>		
9-Pin Male			25-Pin Male		
"D" Subconnector			"D" Subconnector		
<u>Pin</u>	<u>Func.</u>	<u>Pin #</u>	<u>Pin</u>	<u>Func.</u>	<u>Pin #</u>
GND		5	7	GND	
TXD		3	2	TXD (IN)	
RTS		7	20	DTR (IN)	
RXD		2	3	RXD (OUT)	
CTS		8	8	CD (OUT)	
GND		9	1	GND	

*DCE = Data Communications Equipment (Modem, etc.)

Figure 6.3 SEL-587Z to Modem.

Cable SEL-C272A

<u>SEL-2020 or SEL-2030</u>			<u>SEL-587Z Relay</u>		
9-Pin Male			9-Pin Male		
"D" Subconnector			"D" Subconnector		
<u>Pin</u>	<u>Func.</u>	<u>Pin #</u>	<u>Pin</u>	<u>Func.</u>	<u>Pin #</u>
RXD		2	3	TXD	
TXD		3	2	RXD	
GND		5	5	GND	
RTS		7	7	RTS	
CTS		8	8	CTS	

Cable SEL-C273A

<u>SEL-2020 or SEL-2030</u>			<u>SEL-587Z Relay</u>		
25-Pin Male			9-Pin Male		
"D" Subconnector			"D" Subconnector		
<u>Pin</u>	<u>Func.</u>	<u>Pin #</u>	<u>Pin</u>	<u>Func.</u>	<u>Pin #</u>
TXD		2	3	TXD	
RXD		3	2	RXD	
IRIG+		4	4	IRIG+	
GND		5	5	GND	
IRIG-		6	6	IRIG-	
RTS		7	8	CTS	
CTS		8	7	RTS	

Figure 6.4 SEL-587Z to SEL-2020 or SEL-2030 Communications Processor.

Communications Protocols

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 6.3](#).

Table 6.3 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 Event Report Triggering on page 9.2 in Section 9: Event Reports and SER
Self-Test Warning or Failure	The relay sends a status report each time a self-test warning or failure condition is detected. See STA (Status) on page 7.18 in Section 7: ASCII Command Reference .

Access Levels

NOTE: In this manual, commands you type appear in bold/uppercase: **SHOWSET**. You need to type only the first three letters of a command, for example, **SHO**. Computer keys you press appear in bold/brackets: **<Enter>**. Relay front-panel pushbuttons you press appear in bold/uppercase/curly brackets: **{EVENTS}**.

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 the [Section 7: ASCII Command Reference](#). The commands can be accessed only from the corresponding access level. The access levels are:

Access Level 0 (the lowest access level)

Access Level 1

Access Level 2 (the highest access level)

Access Level 0

The relay issues the following prompt when you establish serial port communications:

=

This is referred to as Access Level 0. The relay recognizes only the **ACC** and **QUI** commands at Access Level 0. Enter the **ACC** command at the access level prompt:

=**ACC** **<Enter>**

The SEL-587Z goes to Access Level 1 [see [ACC and 2AC \(Access and 2Access\) on page 7.2 in Section 7: ASCII Command Reference](#) for more detail] when you enter the **ACC** command.

Access Level 1

The relay issues the following prompt in Access Level 1:

=>

The relay recognizes commands **2AC** through **TRI** from Access Level 1. For example, enter the **MET** command at the Access Level 1 computer screen prompt to view metering data:

=>**MET** **<Enter>**

The SEL-587Z goes to Access Level 2 [see *ACC and 2AC (Access and 2Access) on page 7.2 in Section 7: ASCII Command Reference*] when you enter the **2AC** command at the Access Level 1 prompt:

=>**2AC** <Enter>

Access Level 2

The relay issues the following prompt in Access Level 2:

=>>

The relay recognizes commands **CLO** through **SET** from Access Level 2. For example, enter the **SET** command at the Access Level 2 computer screen prompt to set the relay:

=>>**SET** <Enter>

While you are in Access Level 2, the relay recognizes any of the commands available in the lower access levels.

Hardware Protocol

SEL-587Z relays equipped with the EIA-232 port support RTS/CTS hardware handshaking.

To enable hardware handshaking, use the **SET P** command (or front-panel {**SET**} pushbutton) 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

Software protocols consist of standard SEL ASCII, SEL Distributed Port Switch Protocol (LMD), SEL Fast Meter, SEL Compressed ASCII, and Modbus® RTU. The Modbus protocol is available on the rear port only. Based upon the port PROTO setting, the relay activates SEL ASCII, SEL LMD, or Modbus RTU (rear port) protocol. SEL Fast Meter and SEL Compressed ASCII commands are always active if the protocol is SEL ASCII or SEL LMD. SEL Fast Meter and SEL Compressed ASCII are not available if the protocol is Modbus RTU.

SEL ASCII Protocol

SEL ASCII protocol is for manual and automatic communications.

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 can truncate commands to the first three characters. For example, **EVENT 1** <Enter> would become **EVE 1** <Enter>. You can use upper- and lowercase characters 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 sends the proper ASCII code to the relay.

The relay transmits all messages in the following format:

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

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.

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.

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:

Control Characters	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 Distributed Port Switch Protocol (LMD)

SEL LMD Protocol permits multiple SEL relays to share a common communications channel. The protocol is selected by setting the port setting PROTO = LMD. See [SEL Distributed Port Switch Protocol \(LMD\) on page 6.10](#) for more information on the SEL LMD protocol.

SEL Fast Meter Protocol

SEL Fast Meter protocol supports binary messages to transfer metering and control messages. The protocol is described in [Fast Meter on page 6.12](#).

SEL Fast Operate

SEL Fast Operate protocol supports binary messages to open/close circuit breakers, and to control Remote Bits. The protocol is described in *Fast Operate on page 6.15*.

SEL Compressed ASCII Protocol

SEL Compressed ASCII protocol provides compressed versions of some of the relay ASCII commands. Explanations of those commands are included in *Section 7: ASCII Command Reference*.

The SEL-587Z provides Compressed ASCII versions of some of the relay's 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.

Modbus RTU Protocol (available on the rear port only)

Modbus RTU protocol provides binary multidrop communication with the SEL-587Z. The protocol is described in *Appendix D: Modbus RTU Communications Protocol*.

SEL Distributed Port Switch Protocol (LMD)

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.

Settings

Use the front-panel **{SET}** pushbutton or the serial port **SET P 1** or **SET P F** command to activate the LMD protocol. Change the port PROTO setting from the default SEL to LMD to reveal the following settings:

Setting	Description
PREFIX	One character to precede the address. This should be a character which 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

The following explains the operation of the LMD protocol:

1. The relay ignores all input from the port selected to the LMD protocol until it detects the prefix character and the two-byte address.
2. Upon receipt of the prefix and address, the relay enables echo and message transmission.
3. Wait until you receive a prompt before entering commands to avoid losing echoed characters while the external transmitter is warming up.
4. Until the relay connection terminates, you can use the standard commands that are available when PROTO = SEL.
5. The **QUIT** command terminates the connection. If no data are sent to the relay before the port time-up period, it automatically terminates the connection.
6. Enter the sequence **CTRL-X QUIT <CR>** before entering the prefix character if all relays in the multidrop network do not have the same prefix setting.

NOTE: You can use the front-panel **{SET}** pushbutton to change the port settings to return to SEL protocol.

SEL Binary Protocols, Fast Meter, and Fast Operate

Introduction

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. The messages provided in the SEL-587Z are described in the following tables.

Message Lists

Table 6.4 Binary Message List

Request to Relay (hex)	Response From Relay
A5C0	Relay Definition Block
A5C1	Fast Meter Configuration Block
A5D1	Fast Meter Data Block
A5C2	Demand Fast Meter Configuration Block
A5D2	Demand Fast Meter Data Message
A5C3	Peak Demand Fast Meter Configuration Block
A5D3	Peak Demand Fast Meter Data Message
A5B9	Fast Meter Status Acknowledge
A5CE	Fast Operate Configuration Block
A5E0	Fast Operate Remote Bit Control
A5E3	Fast Operate Breaker Control

Table 6.5 ASCII Configuration Message List

Request to Relay (ASCII)	Response From Relay
ID	Firmware ID string (FID), checksum of the ROM code, Terminal ID Setting (TID), Modbus code, part number
DNA	ASCII Names of Relay Word Bits
BNA	ASCII Names of Bits in the A5B9 Status Byte

Message Definitions

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

Table 6.6 A5C0 Relay Definition Block

Data	Description
A5C0	Command
32	Length
03	Supports three protocols, SEL, LMD, and Modbus
03	Support three Fast Meter messages
03	Three status flag commands
A5C1	Fast Meter configuration command
A5D1	Fast Meter command
A5C2	Demand Fast Meter configuration command
A5D2	Demand Fast Meter command
A5C3	Peak Demand Fast Meter configuration command
A5D3	Peak Demand Fast Meter command
0004	Settings change bit
A5C100000000	Fast Meter configuration message
0004	Settings change bit
A5C200000000	Demand Fast Meter configuration message
0004	Settings change bit
A5C300000000	Peak Demand Fast Meter configuration message
0100	SEL protocol, Fast Operate
0101	LMD protocol, Fast Operate
0002	Modbus protocol
00	Reserved
xx	1-byte checksum of all preceding bytes

Fast Meter

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

Table 6.7 A5C1 Fast Meter Configuration Block (Sheet 1 of 2)

Data	Description
A5C1	Fast Meter command
5C	Length
01	One status flag byte
00	Scale factors in Fast Meter message
02	Two scale factors
06	Six analog input channels
04	Four samples per channel
0E	Fourteen digital banks
01	One calculation block
000C	Analog channel offset
003C	Time stamp offset
0044	Digital offset

Table 6.7 A5C1 Fast Meter Configuration Block (Sheet 2 of 2)

Data	Description
494100000000	Analog channel name (IA)
00	Analog channel type (integer)
01	Scale factor type (float)
0004	Scale factor offset in A5D1 message
494200000000	Analog channel name (IB)
00	Analog channel type (integer)
01	Scale factor type (float)
0004	Scale factor offset in A5D1 message
494300000000	Analog channel name (IC)
00	Analog channel type (integer)
01	Scale factor type (float)
0004	Scale factor offset in A5D1 message
383741000000	Analog channel name (87A)
00	Analog channel type (integer)
01	Scale factor type (float)
0008	Scale factor offset in A5D1 message
383742000000	Analog channel name (87B)
00	Analog channel type (integer)
01	Scale factor type (float)
0008	Scale factor offset in A5D1 message
383743000000	Analog channel name (87C)
00	Analog channel type (integer)
01	Scale factor type (float)
0008	Scale factor offset in A5D1 message
1-byte	Line configuration: 00–ABC, 01–ACB; based on PHROT relay setting
03	Calculation type (currents only)
FFFF	Skew correction offset (none)
FFFF	Rs scale factor offset (none)
FFFF	Xs scale factor offset (none)
00	IA channel index
01	IB channel index
02	IC channel index
FF	VA channel index (none)
FF	VB channel index (none)
FF	VC channel index (none)
00	Reserved
xx	1-byte checksum of all preceding bytes

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

Table 6.8 A5D1 Fast Meter Data Block

Data	Description
A5D1	Command
54	Message length
1 byte	Status Byte
4 bytes	Phase current scale factor (4-byte IEEE FPS)
4 bytes	Neutral current scale factor (4-byte IEEE FPS)
48 bytes	The first and third half-cycles of two cycles of data saved by the relay. The data are presented in quarter-cycle sets of integer data in the following order: IA, IB, IC, 87A, 87B, 87C.
8 bytes	Time stamp
15 bytes	Relay Word bits (TAR0–TAR13)
xx	1-byte checksum of all preceding bytes

In response to the A5C2 or A5C3 request, the relay sends the following Fast Meter configuration block:

Table 6.9 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 1 of 2)

Data	Description
A5C2 or A5C3	Demand (A5C2) or Peak Demand (A5C3) command
44	Length
01	# of status flag bytes
00	Scale factors in meter message
00	# of scale factors
05	# of analog input channels
01	# of samples per channel
00	# of digital banks
00	# of calculation blocks
0004	Analog channel offset
002C	Time stamp offset
FFFF	Digital offset
494100000000	Analog channel name (IA)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494200000000	Analog channel name (IB)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494300000000	Analog channel name (IC)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message

Table 6.9 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 2 of 2)

Data	Description
494700000000	Analog channel name (IG)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
334932000000	Analog channel name (3I2)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
00	Reserved
xx	1-byte checksum of all preceding bytes

In response to the A5D2 or A5D3 request, the relay sends the following block:

Table 6.10 A5D2/A5D3 Demand/Peak Demand Fast Meter Message

Data	Description
A5D2 or A5D3	Command
1 byte	Length
1 byte	1 Status Byte
40 -bytes	Demand IA, IB, IC, IG, 3I2 in 8-byte IEEE FPS
8 bytes	Time stamp
1 byte	Reserved
1 byte	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-587Z 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.

Fast Operate

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

Table 6.11 A5CE Fast Operate Configuration Block (Sheet 1 of 2)

Data	Description
A5CE	Command
24	Message length
01	Support one circuit breaker
0008	Support 8 remote bit set/clear commands
01	Allow remote bit pulse commands
00	Reserved
31	Operate code, open breaker 1
11	Operate code, close breaker 1

Table 6.11 A5CE Fast Operate Configuration Block (Sheet 2 of 2)

Data	Description
00	Operate code, clear remote bit RB1
20	Operate code, set remote bit RB1
40	Operate code, pulse remote bit RB1
01	Operate code, clear remote bit RB2
21	Operate code, set remote bit RB2
41	Operate code, pulse remote bit RB2
02	Operate code, clear remote bit RB3
22	Operate code, set remote bit RB3
42	Operate code, pulse remote bit RB3
03	Operate code, clear remote bit RB4
23	Operate code, set remote bit RB4
43	Operate code, pulse remote bit RB4
04	Operate code, clear remote bit RB5
24	Operate code, set remote bit RB5
44	Operate code, pulse remote bit RB5
05	Operate code, clear remote bit RB6
25	Operate code, set remote bit RB6
45	Operate code, pulse remote bit RB6
06	Operate code, clear remote bit RB7
26	Operate code, set remote bit RB7
46	Operate code, pulse remote bit RB7
07	Operate code, clear remote bit RB8
27	Operate code, set remote bit RB8
47	Operate code, pulse remote bit RB8
00	Reserved
xx	1-byte checksum of all preceding bytes

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

Table 6.12 A5E0 Fast Operate Remote Bit Control

Data	Description
A5E0	Command
06	Message length
1 byte	Operate code: 00–07 clear remote bit RB1–RB8 20–27 set remote bit RB1–RB8 40–47 pulse remote bit for RB1–RB8
1 byte	Operate validation: $4 \cdot \text{Operate code} + 1$
xx	1-byte checksum of preceding bytes

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

- The Operate code is valid
- The Operate validation = $4 \cdot \text{Operate code} + 1$
- The message checksum is valid
- The FAST_OP port setting is set to Y
- 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 (1/8 cycle).

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

Table 6.13 A5E3 Fast Operate Breaker Control

Data	Description
A5E3	Command
06	Message length
1 byte	Operate code: 31–OPEN breaker 11–CLOSE breaker
1 byte	Operate Validation: $4 \cdot \text{Operate code} + 1$
xx	1-byte checksum of all preceding bytes

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

- Conditions 1–5 defined in the A5E0 message are true
- The BREAKER jumper is in place on the SEL-587Z main board
- The TDURD setting is nonzero

ID Message

In response to the **ID** command, the relay sends the following information:

```
<STX>
"FID","yyy"<CR><LF>
"CID","yyy"<CR><LF>
"DEVID","yyy"<CR><LF>
"DEVCODE","yyy"<CR><LF>
"PARTNO","yyy"<CR><LF>
"CONFIG","yyy"<CR><LF>
<ETX>
```

where:

FID reports the FID string.

CID reports the checksum of the ROM code.

DEVID reports the terminal ID as set by the TID setting.

DEVCODE reports the Modbus code (53). The code is used for identification purposes by the SEL-2020/2030 and is not part of the Modbus subsystem.

PARTNO reports the part number.

CONFIG is the phase input current and neutral input current scaling are both set to the same value since the SEL-587Z does not differentiate. Both the voltage and current input connection (wye vs. delta) are reported as N/A.

yyyy is the four-byte ASCII hex representation of the checksum of each line.

<STX> is the ASCII start of transmission character.

<ETX> is the ASCII end of transmission character.

<CR> is the ASCII carriage return character.

<LF> is the ASCII line feed character.

An example output from the **ID** command is:

```
=>>ID
"FID=SEL-587Z-R100-V0-Z001001-D20020513","08F9"
"CID=80D6","025F"
"DEVID=STATION A","049C"
"DEVCODE=53","030F"
"PARTNO=0587ZXXX5XX2XX","06D6"
"CONFIG=111000","0386"

=>>
```

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. The DNA message is:

```
<STX> "EN","87","50","51","A","B","C","G","065A"
"51P","51PT","51PR","51A","51AT","51AR","51B","51BT","0A87"
"51BR","51C","51CT","51CR","51G","51GT","51GR","51Q","0A7F"
"51QT","51QR","*", "50P1","50P2","50P3","50A1","50A2","0A22"
"50B1","50B2","50C1","50C2","50G1","50G2","50Q1","50Q2","0A6E"
"87A1","87A2","87B1","87B2","87C1","87C2","*", "0923"
"","", "IN1","IN2","OC","CC","CF","0730"
"LB1","LB2","LB3","LB4","LB5","LB6","LB7","LB8","0994"
"RB1","RB2","RB3","RB4","RB5","RB6","RB7","RB8","09C4"
"SV1","SV2","SV3","SV4","SV5","SV6","SV7","SV8","0A6C"
"SV9","SV10","SV11","SV12","SV13","SV14","*", "09F2"
"TRIP1","TRIP2","TRIP3","CLOSE","*", "PDEM","GDEM","QDEM","0CDD"
"SV5T","SV6T","SV7T","SV8T","SV9T","SV10T","SV11T","SV12T","0DA1"
"SV13T","SV14T","*", "ALARM","OUT1","OUT2","OUT3","OUT4","0C84" <ETX>
```

where:

<STX> is the STX character (02)

<ETX> is the ETX character (03)

the last field in each line is the 4-byte ASCII hex representation of the checksum for the line

"*" indicates an unused bit location

The **DNA** command is available from Access Level 1 and higher.

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", "0639"<ETX>.

where:

"0639" is the 4-byte ASCII representation of the checksum

"*" indicates an unused bit location

Serial Port Settings

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

Serial port settings for the protocols are listed in [Table 6.14](#).

Table 6.14 Communications Settings

Field Description	Screen Name	Range	Default
PROTO = SEL			
Port Protocol	PROTO	SEL, LMD, MOD ^a	SEL
Baud Rate	SPEED	300, 1200, 2400, 4800, 9600, 19200, 38400	2400
Number Data Bits	BITS	7, 8	8
Parity	PARITY	O, E, N (O = Odd, E = Even, N = None)	N
Stop Bits	STOP	1, 2	1
Timeout	T_OUT	0–30 minutes	15
Automatic Message Output	AUTO	Y or N	N
Enable Hardware Handshaking	RTSCTS	Y or N	N
Fast Operate Enable	FASTOP	Y or N	N
PROTO = LMD			
Port Protocol	PROTO	SEL, LMD, MOD ^a	LMD
LMD Prefix	PREFIX	@, #, \$, %, &	@
LMD Address	ADDR	1–99	1
LMD Settling Time	SETTLE	0–30 seconds	0
Baud Rate	SPEED	300, 1200, 2400, 4800, 9600, 19200, 38400	2400
Number Data Bits	BITS	7, 8	8
Parity	PARITY	O, E, N (O = Odd, E = Even, N = None)	N
Stop Bits	STOP	1, 2	1
Timeout	T_OUT	0–30 minutes	15
Automatic Message Output	AUTO	Y or N	N
Fast Operate Enable	FASTOP	Y or N	N
PROTO = MOD			
Port Protocol	PROTO	SEL, LMD, MOD ^a	MOD
Baud Rate	SPEED	300, 1200, 2400, 4800, 9600, 19200	2400
Parity	PARITY	O, E, N (O = Odd, E = Even, N = None)	N
Stop Bits	STOP	1, 2	1
Modbus Slave ID	SLAVE	1–247	1

^a Modbus protocol is available on the rear port only.

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Section 7

ASCII Command Reference

Introduction

This section and the [SEL-587Z Relay Command Summary on page 7.22](#) and at the end of this manual list the serial port commands alphabetically. Much of the information available using the serial port commands is also available via the front-panel pushbuttons. See [Pushbuttons on page 8.4 in Section 8: Front-Panel Interface](#) for more information about the front-panel pushbuttons.

The primary differences between the serial port commands available at Access Level 1 and those available at Access Level 2 are:

- The Access Level 1 commands are primarily for viewing information (e.g., settings, metering, etc.), not for changing settings.
- The Access Level 2 commands change settings or operate relay parameters and output contacts.

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 “Invalid Command” to commands not listed in the [SEL-587Z Relay Command Summary on page 7.22](#) or entered incorrectly.

Command Definitions

The serial port command explanations that follow are in alphabetical order. This subsection shows the access levels where these commands are active. You need to type only the first three letters of the command to successfully issue the command.

ACC and 2AC (Access and 2Access)


ACC (Access Levels 0, 1) and 2AC (Access Levels 1, 2)

The access commands give entry to the next higher access levels. Different commands are available at the different access levels. [Table 7.1](#) shows how to navigate from a lower access level to a higher level.

Table 7.1 ACC and 2AC Commands

Minimum Access Level	Prompt	Serial Port Command	Password Level ^a	Description
0	=	ACC	1	ACCESS—allows entry to Access Level 1
1	=>	2AC	2	2ACCESS—allows entry to Access Level 2

^a If the main board password jumper JMP22 is not in place (JMP22 = OFF), passwords have to be entered when access level attempts are made. If the main board password jumper is in place (JMP22 = ON), passwords do not have to be entered when access level attempts are made. See [PAS \(Password\) on page 7.12](#) for more information.

 **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.

EXAMPLE 7.1 Access Level Attempt (password required)

Assume the following conditions exist:

- Main board password jumper JMP22 = OFF (passwords required to enter higher access levels)
- Access level = 0 (prompt "=")

At the prompt, enter the **ACC** command:

=ACC <Enter>

Because the main board jumper is not in place, the relay asks you to enter the Access Level 1 password and blocks out a space for you to enter it:

Password: ? @@@@

The relay is shipped with the default Access Level 1 password shown in the table under [PAS \(Password\) on page 7.12](#). Enter the default password:

Password: ? @@@@<Enter>

The relay replies:

```
BUS 1                      Date: 03/05/01    Time: 08:31:10.361
STATION A

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 goes back to the “=” prompt.

EXAMPLE 7.2 Access Level Attempt (password not required)

Assume the following conditions exist:

- Main board password jumper JMP22 = ON (passwords not required to enter higher access levels)
- Access level = 0 (prompt “=”)

At the computer screen prompt, enter the **ACC** command:

=ACC <Enter>

Because the main board jumper is in place, the relay does not ask for a password; it goes directly to Access Level 1. The relay responds:

```
BUS 1                      Date: 03/05/01    Time: 08:31:10.361
STATION A

Level 1
=>
```

The “=>” prompt indicates the relay is now in Access Level 1.

Example 7.1 on page 7.2 and *Example 7.2* demonstrate how to navigate from Access Level 0 to Access Level 1. The procedure to go from Access Level 1 to Access Level 2 is much the same, with command **2AC** entered at computer screen prompt “=>.” The relay closes the ALARM contact for one second after a successful Level 2 access. If access is denied, the ALARM contact also pulses.

CASCI 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:

CAS <CR>

The relay sends:

```

<STX> "CAS",n,"yyyy" <CR>
"COMMAND 1",l1,"yyyy" <CR>
"#H","xxxxx","xxxxx",.....,"xxxxx","yyyy" <CR>
"#D","ddd","ddd","ddd","ddd",.....,"ddd","yyyy" <CR>
"COMMAND 2",l1,"yyyy" <CR>
"#h","ddd","ddd",.....,"ddd","yyyy" <CR>
"#D","ddd","ddd","ddd","ddd",.....,"ddd","yyyy" <CR>
.
.
.
.
.
"COMMAND n",l1,"yyyy" <CR>
"#H","xxxxx","xxxxx",.....,"xxxxx","yyyy" <CR>
"#D","ddd","ddd","ddd","ddd",.....,"ddd","yyyy" <CR><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.

l1 is the minimum access level at which the command is available.

#H identifies 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 identifies 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 identifies a data format line; '#' is the maximum number of subsequent data lines.

ddd identifies a format field containing one of the following type designators:

I	Integer data
F	Floating point data
mS	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: "<STX>"No Data Available", "0668"<CR><ETX>.

CASII Command

Access Levels 0, 1, 2

Display the SEL-587Z Compressed ASCII configuration message by typing:

CAS <CR>

The relay sends:

```
<STX>"CAS",5,"YYYY"<CR>
"CST",1,"YYYY" <CR>
"25H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","87A","87B",
"87C","IA","IB","IC","MOF","+5V_PS","+5V_REG","-5V_REG","+10V_PS",
"-10V_PS","VBAT","TEMP","RAM","ROM","CR_RAM","EEPROM","YYYY" <CR>
"1D","I","I","I","I","I","I","I","9S","9S","9S","9S","9S","9S","9S",
"9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S",
"CHI",1,"YYYY" <CR>
"10H","REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC",
"EVENT","TARGETS","YYYY" <CR>
"20D","I","I","I","I","I","I","I","I","6S","22S","YYYY" <CR>
"CEV",1,"YYYY" <CR>
"1H","FID","YYYY"<CR>
"1D","40S","YYYY"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","YYYY" <CR>
"1D","I","I","I","I","I","I","I","I","YYYY" <CR>
"6H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","TARGETS","YYYY"<CR>
"1D","F","I","I","I","I","7S","22S","YYYY"<CR>
"8H","87A","87B","87C","IA","IB","IC","TRIG"," Names of Elements in Relay Word Rows 1-13","YYYY"
<CR>
"60D","F","F","F","F","F","F","F","1S","26S","YYYY" <CR>
"CEV L",1,"YYYY" <CR>
"1H","FID","YYYY"<CR>
"1D","40S","YYYY"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","YYYY" <CR>
"1D","I","I","I","I","I","I","I","I","YYYY" <CR>
"6H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","TARGETS","YYYY"<CR>
"1D","F","I","I","I","I","7S","22S","YYYY"<CR>
"8H","87A","87B","87C","IA","IB","IC","TRIG"," Names of Elements in Relay Word Rows 1-13","YYYY"
<CR>
"120D","F","F","F","F","F","F","F","1S","26S","YYYY" <CR>
"CEV R",1,"YYYY" <CR>
"1H","FID","YYYY"<CR>
"1D","40S","YYYY"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","YYYY" <CR>
"1D","I","I","I","I","I","I","I","I","YYYY" <CR>
"6H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","TARGETS","YYYY"<CR>
"1D","F","I","I","I","I","7S","22S","YYYY"<CR>
"8H","87A","87B","87C","IA","IB","IC","TRIG"," Names of Elements in Relay Word Rows 1-13","YYYY"
<CR>
"256D","F","F","F","F","F","F","F","1S","26S","YYYY" <CR>
<ETX>
```

CEVENT Command

Access Levels 1, 2

Display event report in Compressed ASCII format by typing:

CEV [*n x*] <CR>

The parameters in brackets, [], are optional.

n is the number of the event report, as used in the **EVE** command.

x = L specifies long event report, as used in the **EVE** command.

x = R specifies raw (unfiltered) analog data, as used in the **EVE** command.

The relay responds to the **CEV** command with the *n*th event report as shown below. Emphasized items are replaced with the actual relay data.

```

<STX>"FID","yyyy"<CR>
"FID=SEL-587Z-R100-V0-Z001001-D20020513","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","TARGETS","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx","xxxx","yyyy"<CR>
"87A","87B","87C","IA","IB","IC","TRIG","Names of Elements in Relay Word Rows 1 - 13","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,z,"HEX-ASCII Relay Word","yyyy"<CR>
"Analog and digital data repeated for each row of the event report"
"SETTINGS","yyyy"<CR>
"Relay and logic settings as displayed with the SHOWSET command (surrounded by quotes)","yyyy"<CR>
<ETX>

```

where:

xxxx are the data values corresponding to the first and third line labels

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

FREQ is the power system frequency as set by the NFREQ setting

SAM/CYC_A is the number of analog data samples per cycle (4, 8, or 16)

SAM/CYC_D is the number of digital data samples per cycle (4 or 8)

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

TRIG refers to the trigger record

z is ">" for trigger record and empty for all others, applied for CVE L and CVE R.

HEX-ASCII Relay Word is hex ASCII format of the Relay Word. The first element in the Relay Word is the most significant bit in the first character.

CHISTORY Command

Access Levels 1, 2

Display history data in Compressed ASCII format by typing:

CHI <CR>

The relay sends:

```

<STX>"REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC",
"EVENT","TARGETS","yyyy" <CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,"yyyy" <CR>
<ETX>

```

(the data (xxxx) line is then repeated for each record)

where:

xxxx are the data values corresponding to the first line labels and

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

CLO (Close)

Access Level 2

The **CLO** command asserts the CC Relay Word bit that can be programmed to an output contact to close circuit breakers. See *Section 4: Control Logic*.

To issue the **CLO** command, enter the following:

```
=>>>CLO <Enter>
Close Breaker (Y/N) ? Y <Enter>
Are you sure (Y/N) ? Y <Enter>
=>>>
```

Responding y/y to both prompts asserts Relay Word Bit CC for one processing interval. Typing **N** <Enter> after either of the above prompts will abort the command.

The **CLO** command is supervised by main board jumper JMP24. If the jumper is not in place (jumper JMP24 = OFF), the relay will not recognize the **CLO** command and responds “Aborted: No Breaker Jumper.”

CON (Control)

Access Level 2

The **CON** command is a two-step command you can use to control Relay Word bits RB1 through RB8, see *Section 4: Control Logic*. [At the Access Level 2 prompt, type **CON**, a space, and the number of the bit you wish to control (1–8).] The relay responds by repeating your command followed by a colon. At the colon, type the Control subcommand you wish to perform (See [Table 7.2](#)).

The following shows the steps necessary to pulse Remote Bit 5 (RB5):

```
=>>>CON 5 <Enter>
CONTROL RB5: PRB 5 <Enter>
=>>>
```

You must enter the same remote bit number in both steps in the command. If the bit numbers do not match, the relay responds “Invalid Command.”

Table 7.2 SEL-587Z Control Subcommands

Subcommand	Description
SRB <i>n</i>	Set Remote Bit <i>n</i> (“ON” position)
CRB <i>n</i>	Clear Remote Bit <i>n</i> (“OFF” position)
PRB <i>n</i>	Pulse Remote Bit <i>n</i> for one processing interval (1/8 cycle; “MOMENTARY” position)

See [Remote Control Switches on page 4.9 in Section 4: Control Logic](#).

CSTATUS Command

Access Levels 1, 2

Display status data in Compressed ASCII format by typing:

CST <CR>

The relay sends:

```
<STX>"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","87A","87B",
"87C","IA","IB","IC","MOF","+5V_PS","+5V_REG","-5V_REG","+10V_PS",
",-10V_PS","VBAT","TEMP","RAM","ROM","CR_RAM","EEPROM","yyyy" <CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"yyyy" <CR><ETX>
```

where:

xxxx are the data values corresponding to the first line labels and

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

DAT (Date)

Access Levels 1, 2

DAT displays the date stored by the internal calendar/clock. If you set the date format setting DATE_F to MDY, the date displays as month/day/year. If you set the date format setting DATE_F to YMD, the date displays as year/month/day.

To set the date, type **DATE mm/dd/yyyy <Enter>** if the DATE_F setting is MDY. If you set DATE_F to YMD, enter **DATE yyyy/mm/dd <Enter>**. The valid entry for the year is a number between 2000 and 2199. If you enter two digits for the year, the relay will automatically enter 20 preceding those numbers. To set the date to June 1, 2002, enter the following:

```
=>DATE 6/1/02 <Enter>
6/1/02
=>
```

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

EVE (Event)

Access Levels 1, 2

Use the **EVE** command to view 15-cycle event reports. See [Event Reports on page 9.2 in Section 9: Event Reports and SER](#) for further details on retrieving event reports.

HIS (History)

Access Levels 1, 2

The **HIS** [*x*] command displays the summary of the latest 10 events or allows you to clear the history buffer that contains the latest 10 events in nonvolatile memory.

If no parameters are specified in the **HIS** command, the relay displays the 10 most recent events in reverse chronological order.

If *x* is a number (0–10), the relay displays the *x* most recent events.

If *x* is “C” or “c,” the relay clears the history buffer and all corresponding event reports in nonvolatile memory.

The history report includes: the date and time the event was triggered, the type of event, and the front-panel targets if the event was a TRIP type of event. For more information on events and event reports, see [Event Reports on page 9.2 in Section 9: Event Reports and SER](#).

To display the relay event history, enter the following command:

=>HIS <Enter>

The relay responds with the event history:

BUS 1		Date: 02/04/2002		Time: 15:21:43.643	
STATION A					
#	DATE	TIME	EVENT	TARGETS	
1	01/31/2002	17:53:07.192	TRIG		
2	01/31/2002	17:55:25.276	ER1		
3	01/31/2002	17:59:13.369	TRIP1	A G	
=>					

ID

Access Levels 1, 2

In response to the **ID** command, the relay sends the following information:

```
<STX>
"FID", "yyy" <CR> <LF>
"CID", "yyy" <CR> <LF>
"DEVID", "yyy" <CR> <LF>
"DEVCODE", "yyy" <CR> <LF>
"PARTNO", "yyy" <CR> <LF>
"CONFIG", "yyy" <CR> <LF>
<ETX>
```

where:

FID reports the FID string.

CID reports the checksum of the ROM code.

DEVID reports the terminal ID as set by the TID setting.

DEVCODE reports the Modbus® code (53). The code is used for identification purposes by the SEL-2020/2030 and is not part of the Modbus subsystem.

PARTNO reports the part number.

CONFIG is the phase input current and neutral input current scaling are both set to the same value since the SEL-587Z does not differentiate. Both the voltage and current input connection (wye vs. delta) are reported as N/A.

yyyy is the four-byte ASCII hex representation of the checksum of each line.

<STX> is the ASCII start of transmission character.

<ETX> is the ASCII end of transmission character.

<CR> is the ASCII carriage return character.

<LF> is the ASCII line feed character.

An example output from the **ID** command is:

```
=>>ID
"FID=SEL-587Z-R100-V0-Z001001-D20020513","08F9"
"CID=80D6","025F"
"DEVID=STATION A","049C"
"DEVCODE=53","030F"
"PARTNO=0587ZXXX5XX2XX","06D6"
"CONFIG=111000","0386"

=>>
```

IRI (IRIG)

Access Levels 1, 2

The **IRI** command directs the relay to read the demodulated IRIG-B time code at the rear serial port input.

To force the relay to synchronize to IRIG-B, enter the following command:

=>IRI <Enter>

If the relay successfully synchronizes to IRIG, it sends the following header:

```
BUS 1                               Date: 03/05/01   Time: 10:15:09.609
STATION A

=>
```

If no IRIG-B code is present at the serial port input or if the code cannot be read successfully, the relay responds:

```
IRIG-B DATA ERROR

=>
```

If an IRIG-B signal is present, the relay continuously synchronizes its internal clock with IRIG-B and responds "<STX> IRIG SYNH IN PROGRESS <ETX>."

It is not necessary to issue the **IRI** command to synchronize the relay clock with IRIG-B. Use the **IRI** command to determine if the relay is properly reading the IRIG-B signal.

MET (Meter)

Access Levels 1, 2

The **MET** command displays instantaneous magnitudes and phase angles of the following:

Element	Description
87A	A-phase high-impedance element measured voltage (magnitude only)
87B	B-phase high-impedance element measured voltage (magnitude only)
87C	C-phase high-impedance element measured voltage (magnitude only)
IA	A-phase current in primary amps
IB	B-phase current in primary amps
IC	C-phase current in primary amps
IG	Calculated residual current in primary amps
3I2	Calculated negative-sequence current in primary amps

Current magnitudes are displayed in primary amperes. The SEL-587Z reports the phase angles referenced to IA (IA phase angle = 0, positive phase angles leading).

To view sequential instantaneous metering values, enter the command:

=>MET *n* <Enter>

where *n* is an optional parameter to specify the number of times to repeat the meter display. *n* may range from 1 to 32767. If *n* is not specified, the relay displays the meter report once:

BUS 1		Date: 02/04/2002		Time: 15:29:43.170	
STATION A					
	87A	87B	87C		
V MAG (V)	0	0	0		
	IA	IB	IC	IG	3I2
I MAG (A)	0	0	0	0	0
I ANG (DEG)	0.00	00.00	00.00	00.00	00.00
=>					

MET D (Demand Ammeter)

Access Levels 1, 2

The **MET D** command displays the demand and peak demand values of the following quantities:

Quantities	Description
Currents	I _{A,B,C} input currents (A primary)
I _G	Residual ground current (A primary; IG = 3I ₀ = IA + IB + IC)
3I ₂	Negative-sequence current (A primary)
Reset Time	Demand, peak—last time the demands and peak demands were reset

To view demand ammetering values, enter the command:

=>MET D <Enter>

BUS 1		Date: 02/04/2002		Time: 15:31:49.811	
STATION A					
	IA	IB	IC	IG	3I2
DEMAND	0	0	0	0	0
PEAK	0	0	0	0	0
LAST DEMAND RESET		01/31/2002 17:33:09.233			
LAST PEAK RESET		01/31/2002 17:16:39.333			
=>>					

Reset the accumulated demand values using the **MET RD** command. Reset the peak demand values using the **MET RP** command. For more information about demand ammetering, see [Demand Ammetering on page 3.29 in Section 3: Relay Elements](#).

OPE (Open)

Access Level 2

The **OPE** command asserts the OC Relay Word bit, which can be programmed to an output contact to trip circuit breakers.

To issue the **OPE** command, enter the following:

=>>OPE <Enter>	
Open Breaker (Y/N) ? Y	<Enter>
Are you sure (Y/N) ? Y	<Enter>
=>>	

Typing **N** <Enter> after either of the above prompts will abort the command.

The **OPE** command is supervised by main board jumper JMP24. If the jumper is not in place (jumper JMP24 = OFF), the relay will not recognize the **OPE** command and responds “Aborted: No Breaker Jumper.”

PAS (Password)

Access Level 2

Your SEL-587Z is shipped with factory default passwords.

Table 7.3 Password Requirements and Default Passwords

Access Level	Factory-Default Password
1	OTTER
2	TAIL

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.

You can use the **PAS** command to inspect or change existing access level passwords. To do so, type **PAS** <Enter> as in the following example:

=>>>PAS <Enter>	
1:	OTTER
2:	TAIL
=>>>	

To change the password for Access Level 1 to 5a8b7c, enter the following from Access Level 2:

```
=>>PAS 1 5a8b7c <Enter>
Set
=>>
```

Similarly, PAS 2 can be used to change the Level 2 password. After entering new passwords, type **PAS <Enter>** to inspect them. Make sure they are what you intended and record the new passwords.

Passwords may include up to six characters. Valid characters consist of “A–Z,” “a–z,” “0–9,” “-,” and “.” Passwords are case sensitive, i.e., 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.

Valid, Distinct, Strong Password Examples

Ot3579	A24.68	lh2dcs	4u-Iwg	.351r.
--------	--------	--------	--------	--------

If the passwords are lost or you wish to operate the relay without password protection, install JMP22 on the main board (jumper JMP22 = ON). With no password protection, you may gain access without knowing the passwords and view or change current passwords and settings.

PUL (Pulse)

Access Level 2

Use the **PUL** command to pulse any of the output contacts for a specified length of time. The command format is as follows:

PUL x y

where:

x is OUT1, OUT2, OUT3, OUT4, or ALARM

y is 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 type the following:

```
=>>PUL OUT1 5 <Enter>
Are you sure (Y/N) ? Y <Enter>
=>>
```

If the response to the “Are you sure (Y/N) ?” prompt is “N” or “n,” the command is aborted.

The **PUL** command is supervised by the main board breaker jumper, JMP24. If JMP24 is not in place (jumper JMP24 = OFF), the relay does not accept the **PUL** command and responds “Aborted: No Breaker Jumper.”

The relay generates an event report if you pulse the OUT1, OUT2, OUT3, or OUT4 contact.

QUI (Quit)

Access Levels 1, 2

The relay returns to Access Level 0 when you enter the **QUI** command:

=>**QUI** <Enter>

The relay sets the port access level to 0 and displays the following heading prompt:

BUS 1		Date: 03/05/01	Time: 08:55:33.986
STATION A			
=			

The “=” prompt indicates the relay is in Access Level 0.

The **QUI** command remaps the front-panel targets to the Relay Targets (TAR 0) and terminates the SEL LMD connection if it is established (see [SEL Distributed Port Switch Protocol \(LMD\) on page 6.10 in Section 6: Serial Port Communications](#)).

SER (Sequential Events Recorder)

Access Levels 1, 2

Use the **SER** command to view Sequential Events Records. For more information on SER reports, see [Sequential Events Recorder \(SER\) Report on page 9.17 in Section 9: Event Reports and SER](#).

SET

Access Level 2

Use the **SET** command to view or change the relay settings. This is an Access Level 2 command.

Table 7.4 SET Command Parameters

Class	Settings
SET	Relay settings
SET L	Logic settings
SET P I	Rear port settings
SET P F	Front port settings
SET T	Text settings
SET R	SER settings

The relay prompts for each setting in the order specified in the [SEL-587Z Settings Sheets](#) in [Section 5: Setting the Relay](#).

Keyed Entry After the Prompt	SEL-587Z Action
<CR>	Retains previous setting value
“^” or “<”	Backs up to previous setting value
“>”	Advances to next setting value
“END” or “end”	Skips to the end of the class

The relay performs limit checks as each value is entered. The limits for each setting are specified in the *Settings Sheets*. If a setting is out of limits, the relay responds “Out of range” and prompts for the value again.

After you enter a setting successfully, the relay will prompt you for the next setting in the class. After you have entered all settings in the class, the relay performs secondary settings checks to verify that the settings are in order. If a settings check fails, the relay displays a warning message and prompts for the settings value that caused the warning condition. If more than one setting value fails, the relay prompts for the first settings value that failed.

After you have entered the last setting in the class and settings have been modified, the relay displays a listing of the settings and then responds “Save changes (Y/N) ?” If you type “n” or “N,” the relay does not save the changes and responds “Settings aborted.” If you type “y” or “Y,” the relay saves the changes and responds “Settings saved.” The relay response is the same when no settings are changed.

Use the **TER** option to inhibit the relay from sending the setting class or instance readback when you end a setting session. SEL recommends that you use the **TERSE** option sparingly; you should review the readback information to confirm that you have entered the settings that you intended. You can use the **TERSE** option in any command at any position after typing **SET**. When you end the setting edit session, the relay responds, “Save settings (Y,N)?” If you answer **Y<Enter>**, the relay pulses the alarm contact, saves the new settings, then responds “Settings Saved.” If you answer **N<Enter>** to the save settings prompt, the relay responds “Settings aborted.”

For example, to set the differential element 87A2 pick-up value, enter the following:

```
Set 87A2P <Enter>
=>>
```

SHO (Showset)

Access Levels 1, 2

Use the **SHO** command to view relay settings.

The **SHO** command format is the following:

SHO x y

where:

x is the settings class to display

y is the name of the first setting to display

Table 7.5 Valid SHO Commands

Command	Settings Class
SHO	Relay settings
SHO L	SELOGIC® control equation settings
SHO P I	Rear port settings
SHO P F	Front port settings
SHO R	Sequential Events Recorder (SER) settings
SHO T	Text label settings

Parameter y is the name of the first setting to display. If y is not specified, all settings are shown in the selected settings class.

Sample **SHOWSET** commands showing all the factory settings are shown in [Figure 7.1](#).

=>SHO <Enter>			
Relay Settings:			
RID =BUS 1			
TID =STATION A			
CTR = 120 TDURD = 9.000			
87A1P = 125	87A2P = 40	87B1P = 125	87B2P = 40
87C1P = 125	87C2P = 40		
50P1P = OFF	50P2P = OFF	50P3P = OFF	
50A1P = 2.5	50A2P = 1.0	50B1P = 2.5	50B2P = 1.0
50C1P = 2.5	50C2P = 1.0		
51PP = OFF	51PC = U3	51PTD = 15.00	51PRS = N
51AP = OFF	51AC = U3	51ATD = 15.00	51ARS = N
51BP = OFF	51BC = U3	51BTD = 15.00	51BRS = N
51CP = OFF	51CC = U3	51CTD = 15.00	51CRS = N
50G1P = OFF	50G2P = OFF		
51GP = OFF	51GC = U3	51GTD = 15.00	51GRS = N
50Q1P = OFF	50Q2P = OFF		
51QP = OFF	51QC = U3	51QTD = 15.00	51QRS = N
CFD = 60.000			
Press RETURN to continue			
DMTC = 5	PDEMP = 5.00	GDEMP = 1.50	QDEMP = 1.50
SV5PU = 120.000	SV5DO = 0.000	SV6PU = 15.000	SV6DO = 0.000
SV7PU = 0.000	SV7DO = 0.000	SV8PU = 0.000	SV8DO = 0.000
SV9PU = 0.000	SV9DO = 0.000	SV10PU = 0.000	SV10DO = 0.000
SV11PU = 0.000	SV11DO = 0.000	SV12PU = 0.000	SV12DO = 0.000
SV13PU = 0.000	SV13DO = 0.000	SV14PU = 0.000	SV14DO = 0.000
NFREQ = 60	PHROT = ABC	DATE_F = MDY	

Figure 7.1 SHO Command Sample Display.

```
=>SHO L <Enter>

SELogic Control Equations:
TR1  =87A1 + 87B1 + 87C1 + 50A1 + 50B1 + 50C1
TR2  =0
TR3  =0
ULTR1 =!87A2 * !87B2 * !87C2 * !50A2 * !50B2 * !50C2
ULTR2 =1
ULTR3 =1
51PTC =1
51ATC =1
51BTC =1
51CTC =1
51GTC =1
51QTC =1
52A   =0
CL    =0
ULCL  =TRIP1
ER1   =87A1 + 87B1 + 87C1
ER2   =87A2 + 87B2 + 87C2

Press RETURN to continue
SV1   =0
SV2   =0
SV3   =0
SV4   =0
SV5   =0
SV6   =0
SV7   =0
SV8   =0
SV9   =0
SV10  =0
SV11  =0
SV12  =0
SV13  =0
SV14  =0
OUT1  =TRIP1
OUT2  =TRIP1
OUT3  =SV5T + SV6T
OUT4  =0
DP1   =0
DP2   =0

Press RETURN to continue
DP3   =0
DP4   =0
DP5   =0
DP6   =0
DP7   =0
DP8   =0
```

Figure 7.2 SHO L Command Sample Display.

```
=>>SHO P F <Enter>

PROTO    = SEL
SPEED    = 2400    BITS    = 8      PARITY    = N
STOP     = 1       T_OUT   = 15     AUTO      = N
RTSCTS   = N       FASTOP  = N

=>>
```

Figure 7.3 SHO P F Command Sample Display.

```
=>SHO R <Enter>

Sequential Events Recorder trigger lists:
SER1  =87A1 87A2 87B1 87B2 87C1 87C2
SER2  =50P1 50A1 50A2 50B1 50B2 50C1 50C2
SER3  =51PT 51AT 51BT 51CT 51GT 51QT
```

Figure 7.4 SHO R Command Sample Display.

=>SHO T <Enter>							
Text Labels:							
NLB1	=	CLB1	=	SLB1	=	PLB1	=
NLB2	=	CLB2	=	SLB2	=	PLB2	=
NLB3	=	CLB3	=	SLB3	=	PLB3	=
NLB4	=	CLB4	=	SLB4	=	PLB4	=
NLB5	=	CLB5	=	SLB5	=	PLB5	=
NLB6	=	CLB6	=	SLB6	=	PLB6	=
NLB7	=	CLB7	=	SLB7	=	PLB7	=
NLB8	=	CLB8	=	SLB8	=	PLB8	=
DP1_1	=	DP1_0	=				
DP2_1	=	DP2_0	=				
DP3_1	=	DP3_0	=				
DP4_1	=	DP4_0	=				
DP5_1	=	DP5_0	=				
DP6_1	=	DP6_0	=				
DP7_1	=	DP7_0	=				
DP8_1	=	DP8_0	=				

Figure 7.5 SHO T Command Sample Display.

STA (Status)

Access Levels 1, 2

Use the **STA** command to display the status report, showing the relay self-test information.

To view a status report, enter the command:

=>STA *n* <Enter>

where:

n is a number (*n* = 1, 2, 3, ...) that specifies the number of times to repetitively display the status report

If no number is entered after the **STA** command, the relay displays the status report only once.

After the **STA** command is entered, the relay replies with the following status report:

BUS 1		Date: 05/13/2002 Time: 14:17:01.359					
STATION A							
FID=SEL-587Z-R100-V0-Z001001-D20020513				CID=00FF			
SELF TESTS							
W=Warn		F=Fail					
OS	87A 3	87B 5	87C 3	IA 3	IB 3	IC 3	MOF 0
PS	+5V_PS 5.03	+5V_REG 5.03	-5V_REG -5.03	+10V_PS 10.35	-10V_PS -10.20	VBAT 2.82	
	TEMP 27.6	RAM OK	ROM OK	CR_RAM OK	EEPROM OK		
Relay Enabled							
=>							

Table 7.6 STA Command

Command Row	Column Definitions
FID	Firmware identifier string. It identifies the firmware revision.
CID	CID is the firmware checksum identifier.
OS	Offset displays measured dc offset voltages in millivolts for the current channels. The MOF (master) status is the dc offset in the A/D circuit when a grounded input is selected.
PS	Power Supply displays power supply voltages in Vdc for the power supply outputs. The +5V_REG and -5V_REG are regulated voltages for the A/D circuit. VBAT displays the Real Time Clock battery voltage.
TEMP	Displays the temperature in degrees Celsius. The temperature sensor is an output of the voltage reference in the A/D circuitry.
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.
W (Warning) or F (Failure)	These are appended to the displayed value 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:

```
Reboot the relay and clear status
Are you sure (Y/N) ?
```

If you select “N” or “n,” the relay displays “Canceled” and aborts the command.

If you select “Y,” the relay displays “Rebooting the relay.”

The relay then restarts (just like powering down, then powering up relay), and all diagnostics are run again before the relay is enabled.

Refer to *Relay Self-Tests on page 10.17 in Section 10: Testing and Troubleshooting* for self-test thresholds and corrective actions.

TAR (Target)

Access Levels 1, 2

The **TAR** command remaps the front-panel targets to display Relay Word bit information. *Table 7.7 on page 7.20* shows the Relay Word bits, and *Target LEDs on page 8.3 in Section 8: Front-Panel Interface* shows the targets. The four top row targets correspond to the four left-most Relay Word bits, and the bottom four targets correspond to the four right-most Relay Word bits.

The **TAR** command format is:

TAR m n

NOTE: The reset function also occurs when you type the CAN character **<Ctrl>X** on a serial communications terminal (see [SEL ASCII Protocol on page 6.7 in Section 6: Serial Port Communications](#)).

where m is:

the Relay Word bits row (1–13) to be displayed or

“0” (zero) to take the targets back to their normal front-panel target operation or

“R” to take the targets back to their normal front-panel target operation (like **TAR 0**), reset the FAULT TYPE targets (87, 50, 51, A, B, C, and G), and unlatch the trip logic for testing purposes (See [Appendix C: Relay Word Bits](#)).

where n is:

the number of times to repeat the displaying of the selected Relay Word bit row on the computer screen connected to the serial port.

If parameter n is not entered, the information displays once on the screen.

Parameter n does not affect the remapping of the front-panel targets. They are remapped according to parameter M and will stay in that new state until a new **TAR** command is executed or the port times out due to port inactivity (see serial port setting T_OUT in the **SHO P F** command display sample in [Figure 7.3 on page 7.17](#)). Port timeout takes the targets back to their normal front-panel target operation (like **TAR 0**).

If the **TAR** command is executed from the front panel (See [Figure 8.1 on page 8.2 in Section 8: Front-Panel Interface](#)), front-panel timeout is 15 minutes of front-panel pushbutton inactivity. Front-panel timeout takes the targets back to the normal front-panel target operation, also (like **TAR 0**).

Table 7.7 SEL-587Z Relay Word and Its Correspondence to TAR Command and Front-Panel LEDs

TAR 0 (Front-Panel LEDs)	EN	87	50	51	A	B	C	G
TAR1	51P	51PT	51PR	51A	51AT	51AR	51B	51BT
TAR2	51BR	51C	51CT	51CR	51G	51GT	51GR	51Q
TAR3	51QT	51QR	*	50P1	50P2	50P3	50A1	50A2
TAR4	50B1	50B2	50C1	50C2	50G1	50G2	50Q1	50Q2
TAR5	87A1	87A2	87B1	87B2	87C1	87C2	*	*
TAR6	*	*	*	IN1	IN2	OC	CC	CF
TAR7	LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8
TAR8	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8
TAR9	SV1	SV2	SV3	SV4	SV5	SV6	SV7	SV8
TAR10	SV9	SV10	SV11	SV12	SV13	SV14	*	*
TAR11	TRIP1	TRIP2	TRIP3	CLOSE	*	PDEM	GDEM	QDEM
TAR12	SV5T	SV6T	SV7T	SV8T	SV9T	SV10T	SV11T	SV12T
TAR13	SVT13T	SVT14T	*	ALARM	OUT1	OUT2	OUT3	OUT4

Command **TAR 5 10** is executed in the following example:

=>TAR 5 10 <Enter>							
87A1	87A2	87B1	87B2	87C1	87C2	*	*
1	0	0	0	0	1	0	0
1	0	0	0	0	1	0	0
1	0	0	0	0	1	0	0
1	0	0	0	0	1	0	0
1	0	0	0	0	1	0	0
1	0	0	0	0	1	0	0
1	0	0	0	0	1	0	0
1	0	0	0	0	1	0	0
1	0	0	0	0	1	0	0
87A1	87A2	87B1	87B2	87C1	87C2	*	*
1	0	0	0	0	1	0	0
1	0	0	0	0	1	0	0

Note that Relay Word Row 5 is repeated 10 times on the computer display. In this example, the differential elements 87A1 and 87C2 are asserted. Correspondingly, the “EN” LED is illuminated (corresponding to Relay Word bit 87A1 in Row 5) and the “B” LED is illuminated (corresponding to Relay Word bit 87C2 in Row 5) in the remapped front-panel targets.

TIM (Time)

Access Levels 1, 2

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:

```
=>TIM 23:30:00 <Enter>
23:30:00
=>
```

TRI (Trigger)

Access Levels 1, 2

Issue the **TRI** command to generate an event report:

```
=>TRI <Enter>
Triggered

=>
```

If the port AUTO setting is Y (yes), the relay generates a short event report at the serial port. If the event does not trigger within approximately one second, the relay responds:

```
<STX>
Did Not Trigger
<ETX>
```

The most common reason for the relay not triggering an event is because the relay is not enabled. Use the **STATUS** command to verify relay status.

See [Event Reports on page 9.2 in Section 9: Event Reports and SER](#) for more information on event reports.

SEL-587Z Relay Command Summary

Table 7.8 SEL-587Z Relay Commands^a

Command	Description
2ACCESS	Go to Access Level 2 (complete relay monitoring and control)
ACCESS	Go to Access Level 1 (monitor relay)
BNAME	ASCII Names of all relay status bits (Fast Meter)
CASCII	Generate the Compressed ASCII response configuration message
CEVENT	EVENT command for the Compressed ASCII response
CHISTORY	HISTORY command for the Compressed ASCII response
CLOSE	Access the CC Relay Word bit to close a circuit breaker
CONTROL	Set, clear, or pulse an internal remote bit
CSTATUS	STATUS command for the Compressed ASCII response
DATE	Display and set the date
DNAME	ASCII names of all relay digital I/O (Fast Meter)
EVENT	Display and acknowledge event reports
HISTORY	View event summaries/histories; clear event data
ID	Display the firmware identification, part number, and other configuration data
IRIG	Update the internal clock/calendar from the IRIG-B input
METER	Display metering data and internal relay operating variables
OPEN	Access the OC Relay Word bit to open a circuit breaker
PASSWORD	Display or change relay passwords
PULSE	Pulse a relay output contact
QUIT	Reduce access level to Access Level 0 (exit relay control)
SER	View Sequential Events Recorder reports
SET^a	Enter relay settings
SHOWSET^a	Display relay settings
STATUS	Report or clear relay status
TARGET	Display relay elements for a row in the Relay Word table
TIME	Display and set the internal clock
TRIGGER	Initiate a data capture and record an event report

^a See the table below for SET/SHOW options.

Table 7.9 SET/SHOW Command Options

Option	Setting Type
SET/SHOW	Relay settings
SET/SHOW L	Logic settings
SET/SHOW P 1	Rear port settings
SET/SHOW P F	Front port settings
SET/SHOW T	Text settings
SET/SHOW R	SER settings

Section 8

Front-Panel Interface

Introduction

This section describes how to get information, make settings, and execute control operations from the relay front panel. Also described in this section are the rotating display and display points.

Front-Panel Operation

Front-Panel Operation

A close-up view of the SEL-587Z Relay front panel is shown in [Figure 8.1](#). It includes a 2-line, 16-character LCD; 8 LED target indicators; and 8 pushbuttons for local control.

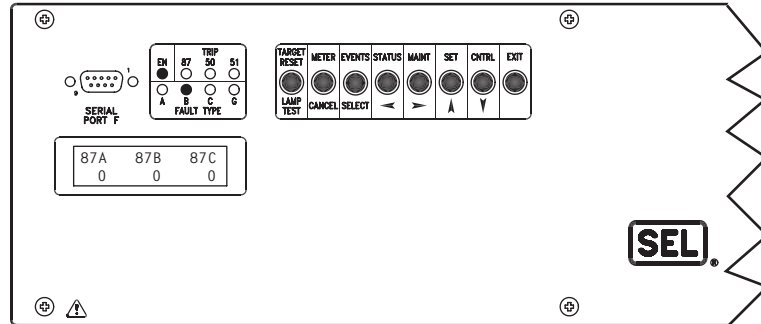


Figure 8.1 Front-Panel User Interface.

The LCD shows event, metering, setting, and relay self-test status information. The display is controlled with the eight multifunction pushbuttons. The target LEDs display relay target information as described by the legend.

Display Time-Out

If no pushbuttons are pressed on the front panel, the relay waits 15 minutes and then takes the following actions:

- The front-panel LCD resets to the default display.
- The front-panel access level reverts to Access Level 1.
- The LCD backlighting is turned off.
- Any routine being executed via a front-panel command is interrupted.
- The target LEDs revert to the default targets.

Liquid Crystal Display (LCD)

The LCD is controlled by the pushbuttons, automatic messages the relay generates, and programmable Display Points. The relay scrolls through any active, nonblank Display Points. If none are active, the relay scrolls through up to four two-line displays of the A-, B-, and C-phase currents in primary amperes.

Any message generated by the relay due to an alarm condition takes precedence over the normal default display. The **{EXIT}** pushbutton returns the display to the default display, if some other front-panel function is being performed.

Error messages such as self-test failures are displayed on the LCD in place of the rotating display when these occur. Do not remove power from the relay if this occurs; refer to [Troubleshooting Procedure on page 10.19 in Section 10: Testing and Troubleshooting](#) for further instructions.

At power up and before illuminating the EN LED, the relay scrolls through the metering displays while completing the initialization process. When the EN LED indicates that the relay is enabled, the LCD scrolls the metering displays and the active Display Points.

Menu choices on the LCD are listed horizontally on the second line. The first character of the menu choice is underlined. The left and right arrow buttons move the underline to the adjacent menu selection. Once the underline indicates your selection, use the **{SELECT}** pushbutton to proceed.

Target LEDs

The target LEDs are an indication of what the relay has detected on the power system and how the relay has reacted during a trip event. The front-panel legend gives a brief description of each target; also see [Appendix C: Relay Word Bits](#).

The only times the target LEDs do not illuminate according to the labels is when the **TAR** command is issued through one of the serial ports. The **TAR** command remaps the LEDs to follow a particular row in the Relay Word bits, such that a Relay Word bit that is asserted will light the corresponding LED position (see [TAR \(Target\) on page 7.19 in Section 7: ASCII Command Reference](#)).

The states of the LEDs are stored in nonvolatile memory. If power to the relay is lost, the LEDs will return to their last state when power is restored. EN responds only to internal self-test routines.

Password Access

Commands that are at Access Level 2 (**2AC**) are password protected from the front panel. Access Level 1 commands are not password protected when operating the front panel (Access Level 1 commands are password protected on the communications ports). The front panel is normally active at Access Level 1. If you issue a command from the front panel that requires a Level 2 password, the relay prompts you for a password. After you enter the password for the higher access level, you remain at that access level only until the front panel times out from inactivity or you EXIT from the specific command. When you EXIT the command, the front panel returns to Access Level 1.

If the password jumper, JMP22, is installed, there is no password protection, and you will not be prompted for a password.

When prompted for a password, enter the **2AC** password. All commands are available using the **2AC** password. The front-panel request for password shows a display of six characters, shown initially as ABCDEF, with the A underscored. Use the up/down arrow keys to scroll and set the first character of the password. Passwords are case sensitive; be sure you use upper- or lowercase letters as needed. Use the right arrow key to move to the second character, and adjust it using the up/down arrows as before. Continue this process until all six characters are filled. If the password has less than six characters, fill the remaining slots with a “blank,” found between the numeral 9 and the lowercase “a” in the character scroll. When the password is complete, push **{SELECT}** to enter it. If the password is correct, the relay will change to the higher level and permit you to perform that level’s commands. If it is incorrect, the relay will declare an “Invalid Password,” and allow another attempt. After three incorrect attempts, the relay will pulse the ALARM

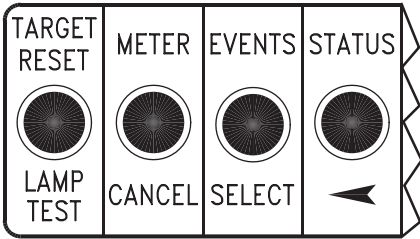
contact for one second and the front panel will exit the command you are trying to access. See *PAS (Password) on page 7.12 in Section 7: ASCII Command Reference* for more information on passwords.

Pushbuttons

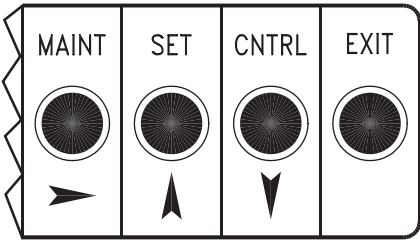
Eight multifunction pushbuttons control the front-panel display. The pushbutton legend defines the primary function in the top row and the secondary function in the bottom row. The primary functions are for command selection, and the secondary functions are for cursor movements and specific commands within dialogues. The eight pushbutton primary functions are discussed in the order of appearance from left to right on the front panel.

Primary Functions

Note in *Figure 8.2 on page 8.5* that the front-panel pushbutton primary functions correspond to serial port commands—both retrieve the same information or perform the same function. For more detail on the information provided by the front-panel pushbutton primary functions, refer to the corresponding serial port commands in *Section 7: ASCII Command Reference*. For example, for more information on the metering values available via the front-panel {METER} pushbutton, refer to the *MET (Meter) on page 7.11 in Section 7: ASCII Command Reference*.



Pushbutton	Function Description	Corresponding Serial Port Commands at Access Level 1 ^a
METER	View Instantaneous Metering Values both Magnitude and Angle. View Demand Metering Values. Reset Demand Metering Values.	METER METER D METER RD METER RP
EVENTS	View Event Summaries	HISTORY
STATUS	View Self-Test Status	STATUS



Pushbutton	Function Description	Corresponding Serial Port Commands:
		Access Level 1 ^a Access Level 2 ^b
MAINT	View or Change Date or Time; View Asserted Relay Word Bits	DATE TIME TARGET
SET	View or Change Settings for Relay or Serial Port	SHOWSET SHOWSET P (1, F) SET SET P (1, F)
CNTRL	Pulse Output Contacts ^c ; View or Operate Local Control	PULSE
EXIT	Exit Entirely and Return to Default Display	QUIT

^a Front-panel pushbutton functions that correspond to Access Level 1 serial port commands do not require entering the Access Level 1 password through the front panel.

^b Front-panel pushbutton functions that correspond to Access Level 2 serial port commands require entering the Access Level 2 password through the front panel if main board jumper JMP22 is not in place.

^c Output contacts are pulsed for only one second from the front panel.

Figure 8.2 Front-Panel Pushbuttons-Primary Functions.

Secondary Functions

After a primary function is selected (see *Figure 8.2 on page 8.5*), the pushbuttons revert to operating on their secondary functions (see *Figure 8.3*).

Use the left/right arrows to underscore a desired function. Then press the **{SELECT}** pushbutton to select the function.

Use left/right arrows to underscore a desired setting digit. Then use the up/down arrows to change the digit. After the setting changes are complete, press the **{SELECT}** pushbutton to select/enable the setting.

Press the **{CANCEL}** pushbutton to abort a setting change procedure and return to the previous display.

Press the **{EXIT}** pushbutton to return to the default display and activate the primary pushbutton functions again (see *Figure 8.2 on page 8.5* and *Figure 8.3*).

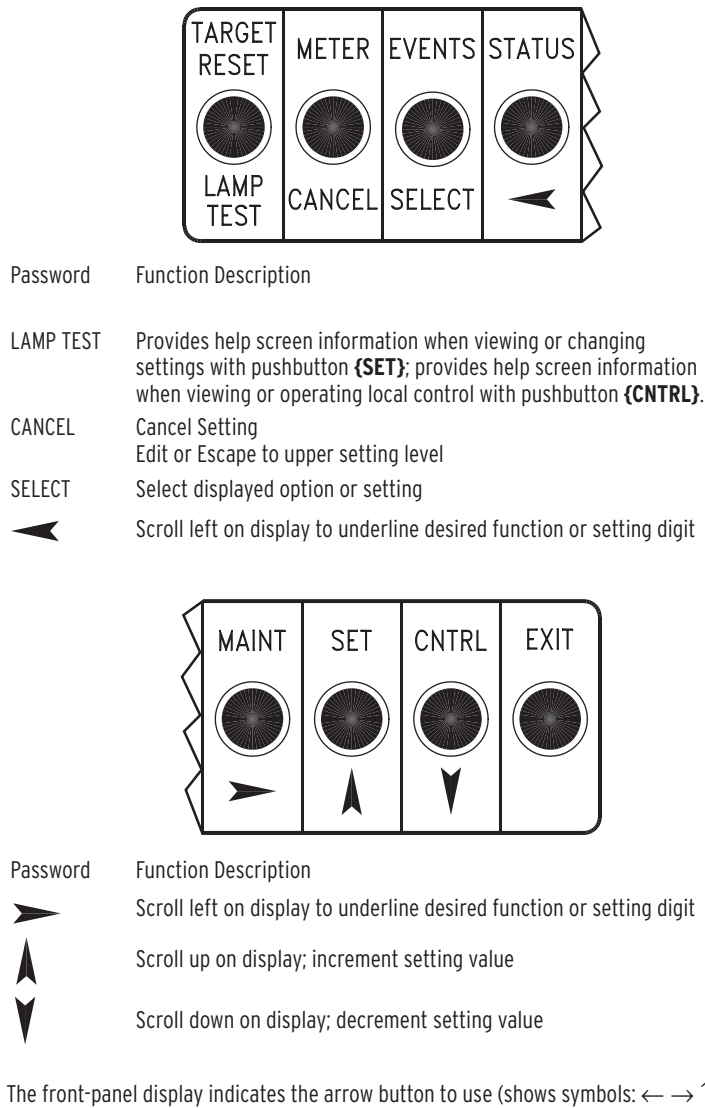


Figure 8.3 Front-Panel Pushbuttons-Secondary Functions.

Target Reset/ Lamp Test

The left-most pushbutton is dedicated to the **{TARGET RESET}** function. Except while viewing or editing settings, pressing **{TARGET RESET}** causes the front-panel LEDs to illuminate for a two-second lamp test and then clears all target LEDs except for the EN LED, which is illuminated if the relay is enabled. While viewing or editing settings, the **{TARGET RESET}** pushbutton acts as a Help function, showing specific information about the displayed setting.

Local Control

Local control asserts (sets to logical 1) or deasserts (sets to logical 0) local bits LB1 through LB8. These local bits are available as Relay Word bits and are used in SELOGIC control equations (see [Appendix C: Relay Word Bits](#)).

The front-panel primary function Local Control (accessed via the {CNTRL} pushbutton) does not have a serial port command equivalent. Use local control to enable/disable schemes, trip/close breakers, etc., via the front panel.

Local control can emulate the switch types shown in [Figure 8.4](#) through [Figure 8.6](#).

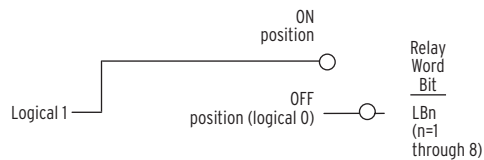


Figure 8.4 Local Control Switch Configured as an ON/OFF Switch.

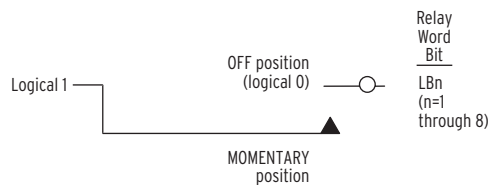


Figure 8.5 Local Control Switch Configured as an OFF/MOMENTARY Switch.

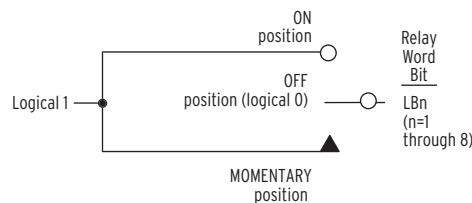


Figure 8.6 Local Control Switch Configured as an ON/OFF/MOMENTARY Switch.

Local control switches are created by making corresponding switch position label settings. These text label settings are set with the **SET T** command or viewed with the **SHOWSET T** command via the serial port [see [SET](#) and [SHO \(Showset\)](#) on page 7.15 in [Section 7: ASCII Command Reference](#)]. For more information on local control, see [Local Control Switches \(NLBn, SLBn, CLBn, PLBn\)](#) on page 4.5 in [Section 4: Control Logic](#).

EXAMPLE 8.1 Display Points and Local Bit Configuration

Set the first three local bits to emulate the following three switches:

1. Configure the first Local Bit as a bus zone ON/OFF switch.
2. Configure the second Local Bit as a breaker fail isolate ON/OFF switch, with the switch status visible on rotating display, using Display Points.
3. Configure the third Local Bit as a breaker TRIP switch.

=>>SET T TE

Text Labels:
Local Bit LB_ Name(14 char; enter NA to null)
NLB1 =
? **BUSZONE SW**
Clear Local Bit LB_ Label(7 char; enter NA to null)
CLB1 =
? **OFF**
Set Local Bit LB_ Label(7 char; enter NA to null)
SLB1 =
? **ON**
Pulse Local Bit LB_ Label(7 char; enter NA to null)
PLB1 =
? **NA**

This concludes configuring the first switch.

Local Bit LB_ Name(14 char; enter NA to null)
NLB2 =
? **BFI SW**
Clear Local Bit LB_ Label(7 char; enter NA to null)
CLB2 =
? **OFF**
Set Local Bit LB_ Label(7 char; enter NA to null)
SLB2 =
? **ON**
Pulse Local Bit LB_ Label(7 char; enter NA to null)
PLB2 =
? **NA**

This concludes configuring the second switch.

Local Bit LB_ Name(14 char; enter NA to null)
NLB3 =
? **MANUAL TRIP**
Clear Local Bit LB_ Label(7 char; enter NA to null)
CLB3 =
? **RETURN**
Set Local Bit LB_ Label(7 char; enter NA to null)
SLB3 =
? **NA**
Pulse Local Bit LB_ Label(7 char; enter NA to null)
PLB3 =
? **TRIP**
Local Bit LB_ Name(14 char; enter NA to null)
NLB4 =

This concludes configuring the third switch. To save the settings,
enter the following:

? **END**
Save Changes(Y/N)? Y
Settings saved
=>>

Next, configure the display point DP1:

=>>SET L DPI TE
SELogic Control Equations:
DP1 =0 [Enter the Relay Word bit whose status will be reported in the rotating
display, i.e., LB2]
? **LB2**
DP2 =0
? **END**
Save Changes(Y/N)? Y
Settings saved

Return to the text settings group:

```

=>>SET T DP1_1 TE
Text Labels:
Display Point DP_ Label(displays if DP_ = logical 1; 16 char; enter NA to null)
DP1_1 = [Enter the message to be displayed when the switch is closed.]
? BFI SW ON
Display Point DP_ Label(displays if DP_ = logical 0; 16 char; enter NA to null)
DP1_0 = [Enter the message to be displayed when the switch is open.]
? BFI SW OFF
Display Point DP_ Label(displays if DP_ = logical 1; 16 char; enter NA to null)
DP2_1 =
? END
Save Changes(Y/N)? Y
Settings saved

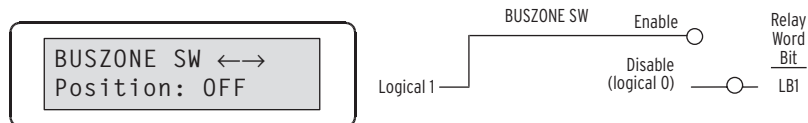
```

View Local Control

Access local control via the **{CNTRL}** pushbutton. If local control switches exist (i.e., corresponding switch position label settings were made), the following message displays with the rotating default display messages.

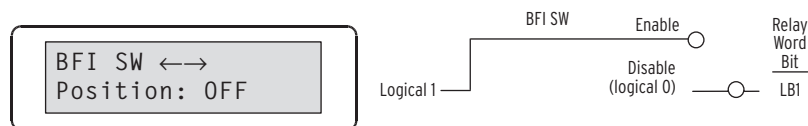
Press CNTRL for
Local Control

Press the **{CNTRL}** pushbutton, and the first set local control switch displays (shown here with example settings):

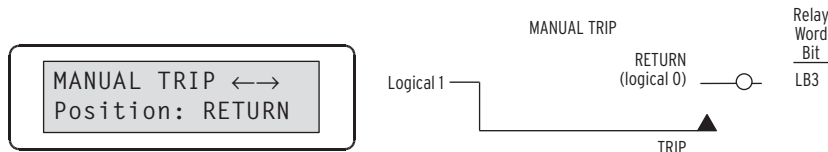


LB1 is configured as an ON/OFF switch, labeled BUSZONE SW. The switch is in the OPEN position.

Press the right arrow pushbutton and scroll to the next set local control switch:



and to the next local control switch:



The MANUAL TRIP: RETURN/TRIP switch is an OFF/MOMENTARY switch.

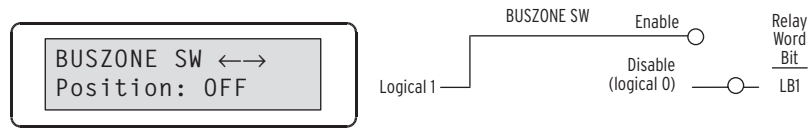
There are no more local control switches configured. Press the right arrow pushbutton and scroll to the “output contact testing” function:

Output Contact<-->
Testing

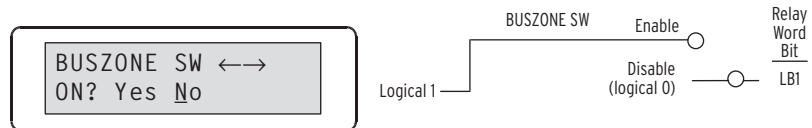
This front-panel function provides the same function as the serial port **PULSE** command (See [Figure 8.2 on page 8.5](#)).

Operate Local Control

Press the right arrow pushbutton, and scroll back to the first set local control switch in the factory default settings:

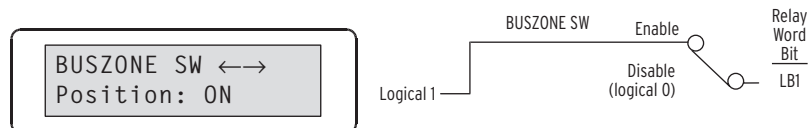


Press the **{SELECT}** pushbutton and the operate option for the displayed local control switch displays:

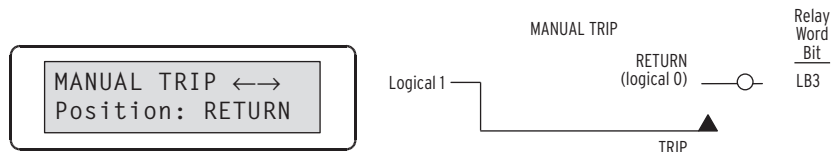


With this first local control switch (BUSZONE ON/OFF) in the OPEN position, the CLOSE position is the only operate option.

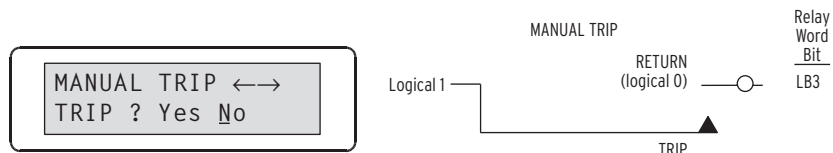
Scroll left with the left arrow pushbutton and then **{SELECT}** “Yes” (press **{SELECT}** pushbutton). The display then shows the new local control switch position:



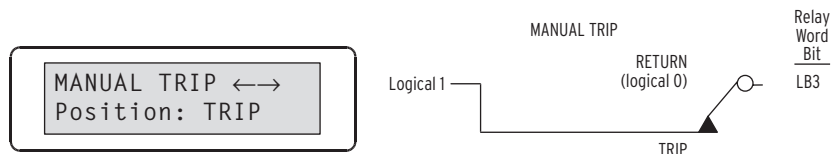
Use the right arrow pushbutton, and scroll to the manual trip switch:



Press the **{SELECT}** pushbutton, and the operate option for the displayed local control switch displays:



Scroll left with the left arrow pushbutton and then **{SELECT}** “Yes.” The display then shows the new local control switch position:



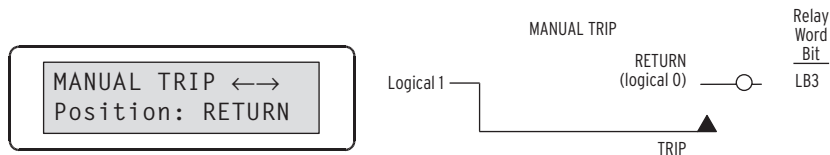
Because this is an OFF/MOMENTARY type switch, the MANUAL TRIP switch returns to the RETURN position after momentarily being in the TRIP position. Technically, the MANUAL TRIP switch (being an OFF/MOMENTARY type switch) is in the:

TRIP position for one processing interval (1/8 cycle; long enough to assert the corresponding local bit LB3 to logical 1).

and then returns to the:

RETURN position (local bit LB3 deasserts to logical 0 again).

On the display, the MANUAL TRIP switch is shown to be in the TRIP position for two seconds (long enough to be seen by human eyes), and then it returns to the RETURN position:

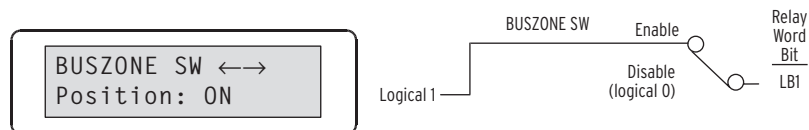


The MANUAL CLOSE switch is an OFF/MOMENTARY type switch, like the MANUAL TRIP switch and operates similarly. Press {EXIT} to return to the rotating display.

Local Control State Retained

Local bit states are stored in nonvolatile memory, so when power to the relay is turned off, the local bit states are retained.

For example, local bit LB1 controls the CLOSE/OPEN of the BUSZONE switch. If local bit LB1 is at logical 1, the BUSZONE switch is ON:



If power to the relay is turned off and then turned on again, local bit LB1 remains at logical 1, and the BUSZONE switch is still ON. This is like a traditional panel, where enabling/disabling of reclosing and other functions is accomplished by panel-mounted switches. If dc control voltage to the panel is lost and then restored, the switch positions are still in place. If the BUSZONE switch is in the CLOSE position (switch closed) before the power outage, it will be in the same position after the outage when power is restored.

Rotating Display

The six relay elements, 87A, 87B, 87C, followed by IA, IB and IC display if no local control is operational (i.e., no corresponding switch position label settings were made) and no display point labels are enabled for display.

In addition to the six elements, a message labeled “Press CNTRL for Local Control” displays if at least one local control switch is operational. It is a reminder of how to access the local control function. See the preceding discussion in this section and *Local Control Switches (NLBn, SLBn, CLBn, PLBn) on page 4.5 in Section 4: Control Logic* for more information on local control.

If display point labels are also enabled, the “Press CNTRL for Local Control” displays for two seconds and then is followed by enabled display point labels in subsequent two-second rotations. The display is on a two-second rotation for each screen.

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Section 9

Event Reports and SER

Introduction

Analyze events with event report summaries and event reports. For example, selecting an event report with the **EVE L** command provides a report with 15 cycles of input voltages, input currents, high-impedance elements, overcurrent elements, inputs and outputs with 1/8-cycle data resolution, summary report, and settings.

Full-length event reports are stored in nonvolatile memory for later retrieval. Software programs such as the SEL-5601 Analytic Assistant convert the event report data to oscillography. Use the **HISTORY** command to obtain an index of these stored reports.

Enable automatic messaging to configure the SEL-587Z Relay to send event report summaries of the serial port and to a printer, for example, to obtain a hard copy at the instant the report is triggered.

Event Reports

See [Figure 9.2 on page 9.15](#) for an example event report.

Event Report Triggering

The relay triggers (generates) an event report when any of the following occurs:

- Trip element assertion (TRIP1, TRIP2, TRIP3)
- Assertion of any element set in the ER1 (variable 1 for event report trigger) logic setting
- Assertion of any element set in the ER2 (variable 2 for event report trigger) logic setting
- Issuance of the **TRIGGER** command
- Issuance of the **PULSE OUT1–OUT4** command

If automessaging is enabled, the relay sends an event report summary to the communications port upon any of these occurrences.

Relay elements set in the ER1 and ER2 SELOGIC® control equation variables trigger the event reports in a level-sensitive manner, while TRIP1, TRIP2, TRIP3 variables trigger the event report on rising edges. For elements set in the ER1 and ER2 equations, the relay does not generate multiple event reports when additional relay elements pick up. Only the first relay element of any continuous sequence triggers an event report.

The relay triggers a second report for the same event if the trip occurs after the first report ends. Thus, the relay records the beginning and end of each event for which it trips. A second event is not provided if any of the trip outputs assert at or less than 11 cycles after the first report is triggered. This is why ER2 is available, i.e., select elements in ER1 and ER2 carefully, so that event reports are created when more elements are picked up. For example, enter 50 elements in ER1 and 51 elements in ER2.

For events triggered via the TRIP1, TRIP2, TRIP3 equations, additional event reports are generated even while any or all relay elements remain picked up.

The relay records trigger date and time to the nearest eighth-cycle and references these to the TRIGGER row of data in the report. The TRIGGER row is indicated by a > symbol after the IC analog channel in the event report. The relay stores 10 event reports in nonvolatile flash memory.

Relay Word Bit TRIP

Relay Word bit TRIP_n (n= 1, 2, 3) is typically assigned to an output contact for tripping a circuit breaker (e.g., SELOGIC control equation setting OUT1 = TRIP1). SELOGIC control equation setting TR_n controls the assertion of Relay Word bit TRIP (see [Trip Logic \(TR_n, ULTR_n, TDURD\) on page 4.16 in Section 4: Control Logic](#)). Any condition that is set to trip in setting TR_n (e.g., TR1 = 51PT + 51GT + 50P1 + LB3) does not have to be entered in SELOGIC control equation settings ER1 or ER2. The assertion of Relay Word bit TRIP1 automatically triggers an event report.

Programmable SELogic Control Equation Settings ER1 and ER2

The programmable SELOGIC control equation settings ER1 and ER2 are set to trigger event reports for conditions other than tripping conditions already listed in SELOGIC control equation setting TRn. The factory settings are:

$$\text{ER1} = 87\text{A1} + 87\text{B1} + 87\text{C1}$$

$$\text{ER2} = 87\text{A2} + 87\text{B2} + 87\text{C2}$$

Equation 9.1

ER1 is factory set with the three differential elements 87A1, 87B1, and 87C1. Thus, at the inception of a fault, whichever element asserts first triggers an event report.

ER2 is factory set with the second-level differential elements 87A2, 87B2, and 87C2. For CT open-circuit detection, an event report is triggered when an open-circuit condition occurs.

ER1 and ER2 trigger event reports independently and are rising-edge sensitive (logical 0 to logical 1 transition). For example, if a line-to-ground fault occurs and 87A1 asserts first in setting ER1 (logical 0 to logical 1 transition), an event report will be triggered. If 87A1 remains asserted and then a short time later 87A2 asserts, a second report will not be generated for the assertion of 87A2. ER1 is already at logical 1 because of the initial assertion of 87A1.

See [SELOGIC Control Equations on page 4.11 in Section 4: Control Logic](#) for more information about SELOGIC control equations.

TRIGGER and PULSE Serial Port Commands

The **TRIGGER** serial port command generates event reports, primarily for testing purposes.

The **PULSE** serial port command is used to assert the output contacts for testing purposes or for remote control. If output contact OUT1, OUT2, OUT3, or OUT4 is asserted with the **PULSE** command, an event report is also generated.

See [Section 7: ASCII Command Reference](#) for more information about serial port commands.

Event Report Summary

Each time the relay generates an event report, it also generates a corresponding event summary (see [Figure 9.1 on page 9.4](#)). Event summaries present:

- Relay and terminal identifiers (settings RID and TID)
- Date and time when the event was triggered
- Event type
- Front-panel fault type targets at the time of trip
- 87 voltages, phase, negative-sequence and 3I₀ current magnitudes taken from the event report row with maximum voltages 87A, 87B, 87C and with maximum current A, B, C for all fault types

This event summary information is also contained in the corresponding event report. The identifiers, date, and time information is at the top of the event report, and the other information follows at the end. See [Figure 9.2 on page 9.15](#).

The example event summary in [Figure 9.1](#) corresponds to the event report in [Figure 9.2 on page 9.15](#):

BUS 1		Date:	05/13/2002	Time:	12:00:53.528
STATION A					
Event:	TRIP1	Targets:	87 50 A B C		
Voltages (V),	ABC:	469	858	643	
Currents (A Pri),	ABCGQ:	4715	6140	5136	9 1754

Figure 9.1 Example Event Summary.

If serial port setting AUTO = Y, the event summary is sent from the serial port a few seconds after the event.

The latest 10 event summaries are stored in nonvolatile memory and are accessed by the **HISTORY** command. These event summaries correspond to the latest 10 event reports also stored in nonvolatile memory.

Event Type

The “Event:” field shows the event type. The possible event types and their descriptions are shown in [Table 9.1](#). Note the correspondence to the preceding event report triggering conditions (see [Event Report Triggering on page 9.2](#)).

Table 9.1 Event Types

Event	Event Triggered by:
TRIP	Assertion of Relay Word bit TRIP
ER1	SELOGIC control equation setting ER1
ER2	SELOGIC control equation setting ER2
TRIG	Issuance of TRIGGER serial port command
PULSE	Issuance of PULSE serial port command

Voltages and Currents

The “Voltage (V), ABC” field shows the voltages present in the event report row containing the maximum phase voltage. The listed voltages are:

Phase (A = channel IA, B = channel IB, C = channel IC)

The “Currents (A pri), ABCGQ:” field shows the currents present in the event report row containing the maximum phase current. The listed currents are:

Phase (A = channel IA, B = channel IB, C = channel IC)

Calculated residual (G = $3I_0$; calculated from channels IA, IB, and IC)

Negative-sequence (Q = $3I_2$; calculated from channels IA, IB, and IC)

Event Report History

Review a brief summary of as many as 10 of the latest events by using the front-panel display and the **{EVENTS}** pushbutton or the serial port **HISTORY** command (see [HIS \(History\) on page 7.9 in Section 7: ASCII Command Reference](#)). The event history contains the event report number, the date and time the event occurred, the event type, and relay targets. Use the event report history as an event report index, from which you can identify an event report for further examination.

The **HISTORY** command displays the summary of the latest 10 events or allows the user to clear the HISTORY archive. The command format is as follows:

HISTORY [x]

If no arguments are specified in the **HISTORY** command, the relay displays the 10 most recent events in reverse chronological order.

If x is a number (0–10), the relay displays the x most recent events. If x is “C” or “c”, the relay clears the history archive and event reports.

The format for a typical HISTORY report is shown below:

```
=>>HIS<Enter>
```

BUS 1			Date: 05/13/2002		Time: 04:10:50.905	
STATION A						
#	DATE	TIME	EVENT	TARGETS		
1	11/07/2001	19:01:38.302	ER2			
2	10/28/2001	11:10:00.982	TRIP1	87 A		
3	08/14/2001	04:31:12.905	TRIP2	51 B G		
4	12/31/2000	23:31:50.732	TRIG			
5	06/03/2000	01:07:24.992	TRIP1	50 A B C G		

If no events are contained in the history archive, the relay responds “History Buffer Empty.”

Retrieving Event Reports

The latest 10 event reports are stored in nonvolatile memory. Any given event report has four different ways it can be displayed, depending on the particular serial port command issued to the relay. The command choices are shown below. The n parameter refers to the event report number ($n = 1$ through 10), with $n = 1$ being the most recent event report and $n = 10$ being the oldest event report.

Table 9.2 Event Report

Serial Port Command	Format
EVENT n	Event report with 15 cycles of the input voltages, input currents, high-impedance elements, overcurrent elements, inputs and outputs with 1/4-cycle data resolution, summary report, and settings.
EVENT L n	Long event report with 15 cycles of the input voltages, input currents, high-impedance elements, overcurrent elements, inputs and outputs with 1/8-cycle data resolution, summary report, and settings.
EVENT L C n	Same as long event with SEL-5601 digital data in 1/8-cycle resolution appended after settings are shown.
EVENT R	Displays raw (unfiltered) analog data in 1/16 cycle resolution.
EVENT R C n	Same as raw event with SEL-5601 digital data in 1/8-cycle resolution appended after settings are shown.

If no numeric n parameter is entered with the serial port command, the most recent event report ($n = 1$) is displayed.

If an event report is requested that does not exist, the relay responds “Invalid Event.”

If any of the relay settings or logic changes after an event was triggered, only the logic settings are displayed. Instead of the group settings, the relay shows the message “RELAY SETTINGS CHANGED SINCE EVENT.”

Event Report Column Definitions

The **EVENT** serial port commands can be entered with only the first three letters of the word **EVENT**. For example, the next-most recent 1/8-cycle resolution event report can be retrieved by entering the command:

EVE L 2

Refer to the example event report in [Figure 9.2 on page 9.15](#) to view event report columns. This example event report displays rows of information each 1/8-cycle and is retrieved with the **EVENT L n** command.

The columns contain current, element, input, and output information. The current columns show currents in primary amperes. The other columns show a number, letter, or symbol to indicate the condition of the elements, inputs, and outputs.

Analog Columns

The current columns show sampled current (after filtering) in primary amperes.

Table 9.3 Event Report Current Columns

Column Heading	Definition
87A	Voltage measured by high-impedance element 87A
87B	Voltage measured by high-impedance element 87B
87C	Voltage measured by high-impedance element 87C
IA	Current measured by channel IA
IB	Current measured by channel IB
IC	Current measured by channel IC

Note that the analog values change from plus to minus (–) values in [Figure 9.2 on page 9.15](#), indicating the sinusoidal nature of the waveforms.

Digital Element Columns

Various SEL-587Z Relay Word bits appear in the columns to the right of the analog columns. [Table 9.4 on page 9.7](#) lists the elements that can appear in these columns.

[Obtaining RMS Phasors From 4-Samples/Cycle Event Reports on page 9.15](#) explains how event report current column data can be converted to phasor rms current values.

Table 9.4 Digital Element Columns (Sheet 1 of 7)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
All columns		.	Element/input/output not picked up or not asserted, unless otherwise stated
87ABC1	87A1, 87B1, 87C1	3	Phases A, B, and C level 1 high-impedance differential elements asserted
	87A1, 87B1	a	Phases A and B level 1 high-impedance differential elements asserted
	87B1, 87C1	b	Phases B and C level 1 high-impedance differential element asserted
	87C1, 87A1	c	Phases C and A level 1 high-impedance differential elements asserted
	87A1	A	Phase A level 1 high-impedance differential elements asserted
	87B1	B	Phase B level 1 high-impedance differential elements asserted
	87C1	C	Phase C level 1 high-impedance differential elements asserted
87ABC2	87A2, 87B2, 87C2	3	Phases A, B, and C level 2 high-impedance differential elements asserted
	87A2, 87B2	a	Phases A and B level 2 high-impedance differential elements asserted
	87B2, 87C2	b	Phases B and C level 2 high-impedance differential element asserted
	87C2, 87A2	c	Phases C and A level 2 high-impedance differential elements asserted
	87A2	A	Phase A level 2 high-impedance differential elements asserted
	87B2	B	Phase B level 2 high-impedance differential elements asserted
	87C2	C	Phase C level 2 high-impedance differential elements asserted
51P	51P, 51PT, 51PR	r	Phase time-overcurrent element deasserted but not reset
		.	Phase time-overcurrent element deasserted and fully reset
		p	Phase time-overcurrent element picked up and timing
		T	Phase time-overcurrent element picked up and timed out
		l	Phase time-overcurrent element is not picked up but timing element is asserted

Table 9.4 Digital Element Columns (Sheet 2 of 7)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
51A	51A, 51AT, 51AR	r . p T l	A-phase time-overcurrent element deasserted but not reset A-phase time-overcurrent element deasserted and fully reset A-phase time-overcurrent element picked up and timing A-phase time-overcurrent element picked up and timed out A-phase time-overcurrent element is not picked up but timing element is asserted
51B	51B, 51BT, 51BR	r . p T l	B-phase time-overcurrent element deasserted but not reset B-phase time-overcurrent element deasserted and fully reset B-phase time-overcurrent element picked up and timing B-phase time-overcurrent element picked up and timed out B-phase time-overcurrent element is not picked up but timing element is asserted
51C	51C, 51CT, 51CR	r . p T l	C-phase time-overcurrent element deasserted but not reset C-phase time-overcurrent element deasserted and fully reset C-phase time-overcurrent element picked up and timing C-phase time-overcurrent element picked up and timed out C-phase time-overcurrent element is not picked up but timing element is asserted
51G	51G, 51GT, 51GR	r . p T l	Residual ground time-overcurrent element deasserted but not reset Residual ground time-overcurrent element deasserted and fully reset Residual ground time-overcurrent element picked up and timing Residual ground time-overcurrent element picked up and timed out Residual ground time-overcurrent element is not picked up but timing element is asserted

Table 9.4 Digital Element Columns (Sheet 3 of 7)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
51Q	51Q1, 51Q1T, 51Q1R	r	Negative-sequence time-overcurrent element deasserted but not reset
		.	Negative-sequence time-overcurrent element deasserted and fully reset
		p	Negative-sequence time-overcurrent element picked up and timing
		T	Negative-sequence time-overcurrent element picked up and timed out
		l	Negative-sequence time-overcurrent element is not picked up but timing element is asserted
50P123	50P1, 50P2, 50P3	d	All three phase instantaneous overcurrent elements picked up
		a	Phase instantaneous overcurrent elements 50P1 and 50P2 picked up
		b	Phase instantaneous overcurrent elements 50P2 and 50P3 picked up
		c	Phase instantaneous overcurrent elements 50P3 and 50P1 picked up
		1	Phase instantaneous overcurrent element 50P1 picked up
		2	Phase instantaneous overcurrent element 50P2 picked up
		3	Phase instantaneous overcurrent element 50P3 picked up
50ABC1	50A1, 50B1, 50C1	3	All three level 1 single-phase instantaneous overcurrent elements picked up
		a	Level 1 single-phase instantaneous overcurrent elements 50A1 and 50B1 picked up
		b	Level 1 single-phase instantaneous overcurrent elements 50B1 and 50C1 picked up
		c	Level 1 single-phase instantaneous overcurrent elements 50C1 and 50A1 picked up
		A	Level 1 single-phase instantaneous overcurrent element 50A1 picked up
		B	Level 1 single-phase instantaneous overcurrent element 50B1 picked up
		C	Level 1 single-phase instantaneous overcurrent element 50C1 picked up

Table 9.4 Digital Element Columns (Sheet 4 of 7)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
50ABC2	50A2, 50B2, 50C2	3	All three level 2 single-phase instantaneous overcurrent elements picked up
		a	Level 2 single-phase instantaneous overcurrent elements 50A2 and 50B2 picked up
		b	Level 2 single-phase instantaneous overcurrent elements 50B2 and 50C2 picked up
		c	Level 2 single-phase instantaneous overcurrent elements 50C2 and 50A2 picked up
		A	Level 2 single-phase instantaneous overcurrent element 50A2 picked up
		B	Level 2 single-phase instantaneous overcurrent element 50B2 picked up
		C	Level 2 single-phase instantaneous overcurrent element 50C2 picked up
50G12	50G1, 50G2	1	Residual ground instantaneous overcurrent element 50G1 picked up
		2	Residual ground instantaneous overcurrent element 50G2 picked up
		b	Both residual ground instantaneous overcurrent elements 50G1 and 50G2 picked up
50Q12	50Q1, 50Q2	1	Negative-sequence instantaneous overcurrent element 50Q1 picked up
		2	Negative-sequence instantaneous overcurrent element 50Q2 picked up
		b	Both negative-sequence instantaneous overcurrent elements 50Q1 and 50Q2 picked up
Lcl 12	LB1, LB1	1	Local bit LB1 asserted
		2	Local bit LB2 asserted
		b	Both LB1 and LB2 asserted
Lcl 34	LB3, LB4	3	Local bit LB3 asserted
		4	Local bit LB4 asserted
		b	Both LB3 and LB4 asserted
Lcl 56	LB5, LB6	5	Local bit LB5 asserted
		6	Local bit LB6 asserted
		b	Both LB5 and LB6 asserted
Lcl 78	LB7, LB8	7	Local bit LB7 asserted
		8	Local bit LB8 asserted
		b	Both LB7 and LB8 asserted

Table 9.4 Digital Element Columns (Sheet 5 of 7)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
Rem 12	RB1, RB2	1	Remote bit RB1 asserted
		2	Remote bit RB2 asserted
		b	Both RB1 and RB2 asserted
Rem 34	RB3, RB4	3	Remote bit RB3 asserted
		4	Remote bit RB4 asserted
		b	Both RB3 and RB4 asserted
Rem 78	RB7, RB8	7	Remote bit RB7 asserted
		8	Remote bit RB8 asserted
		b	Both RB7 and RB8 asserted
Rem OC	OC, CC	o	OPEN command issued
		c	CLOSE command issued
SV 12	SV1, SV2	1	SELOGIC control equation variable SV1 asserted
		2	SELOGIC control equation variable SV2 asserted
		b	Both SV1 and SV2 asserted
SV 34	SV3, SV4	3	SELOGIC control equation variable SV3 asserted
		4	SELOGIC control equation variable SV4 asserted
		b	Both SV3 and SV4 asserted
SV 5T	SV5, SV5T	p	SELOGIC control equation variable SV5 asserted; timer not timed out
		T	SELOGIC control equation variable SV5 asserted and timer SV5T asserted
		d	SELOGIC control equation variable SV5 deasserted; timer SV5T asserted
SV 6T	SV6, SV6T	p	SELOGIC control equation variable SV6 asserted; timer not timed out
		T	SELOGIC control equation variable SV6 asserted and timer SV6T asserted
		d	SELOGIC control equation variable SV6 deasserted; timer SV6T asserted
SV 7T	SV7, SV7T	p	SELOGIC control equation variable SV7 asserted; timer not timed out
		T	SELOGIC control equation variable SV7 asserted and timer SV7T asserted
		d	SELOGIC control equation variable SV7 deasserted; timer SV75T asserted

Table 9.4 Digital Element Columns (Sheet 6 of 7)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
SV 8T	SV8, SV8T	p	SELOGIC control equation variable SV8 asserted; timer not timed out
		T	SELOGIC control equation variable SV8 asserted and timer SV8T asserted
		d	SELOGIC control equation variable SV8 deasserted; timer SV8T asserted
SV 9T	SV9, SV9T	p	SELOGIC control equation variable SV9 asserted; timer not timed out
		T	SELOGIC control equation variable SV9 asserted and timer SV9T asserted
		d	SELOGIC control equation variable SV9 deasserted; timer SV9T asserted
SV 10T	SV10, SV10T	p	SELOGIC control equation variable SV10 asserted; timer not timed out
		T	SELOGIC control equation variable SV10 asserted and timer SV10T asserted
		d	SELOGIC control equation variable SV10 deasserted; timer SV10T asserted
SV 11T	SV11, SV11T	p	SELOGIC control equation variable SV11 asserted; timer not timed out
		T	SELOGIC control equation variable SV11 asserted and timer SV11T asserted
		d	SELOGIC control equation variable SV11 deasserted; timer SV11T asserted
SV 12T	SV12, SV12T	p	SELOGIC control equation variable SV12 asserted; timer not timed out
		T	SELOGIC control equation variable SV12 asserted and timer SV12T asserted
		d	SELOGIC control equation variable SV12 deasserted; timer SV12T asserted
SV 13T	SV13, SV13T	p	SELOGIC control equation variable SV13 asserted; timer not timed out
		T	SELOGIC control equation variable SV13 asserted and timer SV13T asserted
		d	SELOGIC control equation variable SV13 deasserted; timer SV13T asserted

Table 9.4 Digital Element Columns (Sheet 7 of 7)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
SV 14T	SV14, SV14T	p	SELOGIC control equation variable SV14 asserted; timer not timed out
		T	SELOGIC control equation variable SV14 asserted and timer SV14T asserted
		d	SELOGIC control equation variable SV14 deasserted; timer SV14T asserted
Out 1&2 ^a	OUT1, OUT2	1	Output contact OUT1 asserted
		2	Output contact OUT2 asserted
		b	Both OUT1 and OUT2 asserted
Out 3&4 ^a	OUT3, OUT4	3	Output contact OUT3 asserted
		4	Output contact OUT4 asserted
		b	Both OUT3 and OUT4 asserted
Out ALM	ALARM	A	Relay failed or PULSE A command issued
In1&2	IN1, IN2	1	Optoisolated input IN1 asserted
		2	Optoisolated input IN2 asserted
		b	Both IN1 and IN2 asserted

^a Output contacts can be A or B type contacts (see [Output Contact Jumpers on page 2.8 in Section 2: Installation](#)).

Example Event Report

The example event report shown in [Figure 9.2 on page 9.15](#) is from a report generated with the **EVE** command.

In [Figure 9.2 on page 9.15](#), the arrow (>) in the column following the IC current column identifies the “trigger” row. This is the row that corresponds to the Date and Time values at the top of the event report.

The asterisk (*) in the column following the IC current column identifies the row with the maximum phase current. The maximum phase current is calculated from the row identified with the asterisk and the row one-quarter cycle previous. These currents are listed at the end of the example event report. If the “trigger” row (>) and the maximum phase current row (*) are the same row, the * symbol takes precedence and is displayed. Because the relay samples at 1/8-cycles, the 1/4-cycle report contains only half of the processed information. To ensure the asterisk (*) and arrow (>) appear in the event report, use the 1/8-cycle report.

```

BUS 1                               Date: 05/13/2002   Time: 12:00:53.528
STATION A

FID=SEL-587Z-R100-V0-Z001001-D20020513      CID=9D2D

      87 51 50 Lcl Rem SELogic Var OutI
      AA PAA
      BB 1BBGQ 11111 13A1
      CC 2CC11 135713570 135678901234 &&L&
      IC 12PABCGQ31222 24682468C 24TTTTTTTTTT 24M2

      Volts      Amps Pri
      87A 87B 87C IA IB IC
      0 -1 0 0 -1 0 .....
      0 0 0 0 2 0 .....
      1 0 0 0 1 0 .....
      -1 0 0 0 -2 -1 .....

      0 0 0 0 -4 0 .....
      0 0 0 0 2 0 .....
      0 0 0 0 2 0 .....
      8 -120 108 19 -382 344>.b.....bb.. ..... b...

      448 -367 -81 1641 -1366 -278 33.....33.. ..... b...
      -138 776 -637 -518 3210 -2669 33.....33.. ..... b...
      -813 287 527 -4608 2410 2200 33.....33.. ..... b...
      139 -773 633 997 -5648 4642 33.....33.. ..... b...

      812 -288 -525 5932 -2095 -3841*33.....33.. ..... b...
      -138 773 -635 -993 5638 -4634 33.....33.. ..... b...
      -813 288 525 -5933 2099 3836 33.....33.. ..... b...
      137 -773 635 988 -5640 4634 33.....33.. ..... b...

      813 -288 -525 5935 -2105 -3830 33.....33.. ..... b...
      -135 772 -636 -987 5638 -4638 33.....33.. ..... b...
      -815 289 525 -5934 2107 3828 33.....33.. ..... b...
      136 -772 637 982 -5638 4640 33.....33.. ..... b...

      9 cycles of the event report not shown

      814 -297 -518 5943 -2168 -3780 33.....33.. ..... b...
      -127 769 -642 -918 5612 -4682 33.....33.. ..... b...
      -814 297 517 -5946 2174 3777 33.....33.. ..... b...
      125 -768 641 913 -5612 4684 33.....33.. ..... b...

Event: TRIP1 Targets: 87 50 A B C
Voltages (V), ABC: 469 858 643
Currents (A Pri), ABCGQ: 4715 6140 5136 9 1759

Relay Settings:
RID =BUS 1
TID =STATION A
CTR = 120 TDURD = 9.000
87A1P = 125 87A2P = 40 87B1P = 125 87B2P = 40
87C1P = 125 87C2P = 40
50P1P = OFF 50P2P = OFF 50P3P = OFF
50A1P = 2.5 50A2P = 1.0 50B1P = 2.5 50B2P = 1.0
50C1P = 2.5 50C2P = 1.0
51PP = OFF 51PC = U3 51PTD = 15.00 51PRS = N
51AP = OFF 51AC = U3 51ATD = 15.00 51ARS = N
51BP = OFF 51BC = U3 51BTD = 15.00 51BRS = N
51CP = OFF 51CC = U3 51CTD = 15.00 51CRS = N
50G1P = OFF 50G2P = OFF
51GP = OFF 51GC = U3 51GTD = 15.00 51GRS = N
50Q1P = OFF 50Q2P = OFF
51QP = OFF 51QC = U3 51QTD = 15.00 51QRS = N
CFD = 60.000
DMTC = 5 PDEMP = 5.00 GDEMP = 1.50 QDEMP = 1.50
SV5PU = 120.000 SV5DO = 0.000 SV6PU = 15.000 SV6DO = 0.000
SV7PU = 0.000 SV7DO = 0.000 SV8PU = 0.000 SV8DO = 0.000
SV9PU = 0.000 SV9DO = 0.000 SV10PU = 0.000 SV10DO = 0.000
SV11PU = 0.000 SV11DO = 0.000 SV12PU = 0.000 SV12DO = 0.000
SV13PU = 0.000 SV13DO = 0.000 SV14PU = 0.000 SV14DO = 0.000
NFREQ = 60 PHROT = ABC DATE_F = MDY

Text Labels:
NLB1 = CLB1 = SLB1 = PLB1 =
NLB2 = CLB2 = SLB2 = PLB2 =
NLB3 = CLB3 = SLB3 = PLB3 =
NLB4 = CLB4 = SLB4 = PLB4 =
NLB5 = CLB5 = SLB5 = PLB5 =
NLB6 = CLB6 = SLB6 = PLB6 =
NLB7 = CLB7 = SLB7 = PLB7 =
NLB8 = CLB8 = SLB8 = PLB8 =
DP1_1 = DP1_0 =
DP2_1 = DP2_0 =
DP3_1 = DP3_0 =
DP4_1 = DP4_0 =
DP5_1 = DP5_0 =
DP6_1 = DP6_0 =

```

(Continued on next page)

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```

DP7_1 =          DP7_0 =
DP8_1 =          DP8_0 =
SELogic Control Equations:
TR1  =87A1 + 87B1 + 87C1 + 50A1 + 50B1 + 50C1
TR2  =0
TR3  =0
ULTR1 =!87A2 * !87B2 * !87C2 * !50A2 * !50B2 * !50C2
ULTR2 =1
ULTR3 =1
51PTC =1
51ATC =1
51BTC =1
51CTC =1
51GTC =1
51QTC =1
52A   =0
CL    =0
ULCL  =TRIP1
ER1   =87A1 + 87B1 + 87C1
ER2   =87A2 + 87B2 + 87C2
SV1   =0
SV2   =0
SV3   =0
SV4   =0
SV5   =0
SV6   =0
SV7   =0
SV8   =0
SV9   =0
SV10  =0
SV11  =0
SV12  =0
SV13  =0
SV14  =0
OUT1  =TRIP1
OUT2  =TRIP1
OUT3  =SV5T + SV6T
OUT4  =0
DP1   =0
DP2   =0
DP3   =0
DP4   =0
DP5   =0
DP6   =0
DP7   =0
DP8   =0

```

Figure 9.2 Example Event Report (1/4-cycle sample).

Obtaining RMS Phasors From 4-Samples/Cycle Event Reports

Sampling at 1/4-cycle generates data at 90-degree electrical intervals, thus presenting the recorded values in the correct format for phasor calculations. Similar calculations are possible with data generated using the **EVE L** command (1/8-cycle reports) by using every other row of analog values.

Use the column data in an event report to calculate phasor values. You can use a calculator to convert rectangular data to phasor data.

Polar Calculator Method

A method for finding the phasor magnitude and angle from event report quarter-cycle data pairs is to use a polar-capable calculator or computer program. Many calculators and computer programs convert Cartesian (X and Y) coordinate data to polar data. Key or enter the X value (present value or lower value of a column pair) and the Y value (later value or upper value in a column pair) as Cartesian (rectangular) coordinates. Perform the keystrokes necessary for your calculator or computing program to convert to polar coordinates. This is the phasor value for the data pair.

For example, use two rows of voltage data from the event report to calculate an rms phasor voltage. At the first sample pair of Cycle [4], the rms phasor for the 87A column is $823.6 \angle 99.6^\circ$ V. The present sample of the sample pair ($X = -138$) is a scaled instantaneous voltage value (divided by $\sqrt{2}$) that relates to the rms phasor voltage value by the following expression:

$$X = -138 = 823.6 \cdot \cos(99.6^\circ) \quad \text{Equation 9.2}$$

Sequential Events Recorder (SER) Report

See [Figure 9.3 on page 9.20](#) for an example SER report.

SER Row Triggering

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

SER1 = 87A1, 87B1, 87C1, 87A2, 87B2, 87C2

SER2 = 50P1, 50A1, 50B1, 50C1, 50A2, 50B2, 50C2

SER3 = 51PT, 51AT, 51BT, 51CT, 51GT, 51QT

The elements are Relay Word bits from the first 13 rows of [Appendix C: Relay Word Bits](#). Any assertion or deassertion of a listed element triggers a row in the SER report. For example, setting SER1 contains:

Differential element pickups (87A1, 87B1, 87C1)

CT open-circuit detection (87A2, 87B2, 87C2)

Thus, any time one of these elements picks up, times out, or drops out, a row is triggered in the SER report.

Also, if the relay is newly powered up or a settings change is made, a row is triggered in the SER report with the message “Relay newly powered up or settings changed.”

Each row in the SER report contains date, time, current, relay element, optoisolated input, and output contact information.

Making SER Trigger Settings

Each SER trigger setting (SER1, SER2, or SER3) can be set with up to 24 elements (see [Appendix C: Relay Word Bits](#)). Thus, up to 72 elements can be monitored altogether for SER report row triggering.

The SER settings can be made using spaces or commas as delimiters between elements. For example, if setting SER1 is made as follows:

SER1 = 51P1,51G1 51P1T,,51G1T , 50P1, , 50P2

The setting displays as:

SER1 = 51P1 51G1 51P1T 51G1T 50P1 50P2

Retrieving SER Rows

The latest 512 rows of the SER report are stored in nonvolatile memory. Row 1 is the most recently triggered row, and row 512 is the oldest. These lines are accessed with the **SER** command in the following different ways:

Table 9.5 Accessing SER Report

Example SER Serial Port Commands	Format
SER	If SER is entered with no numbers following it, all available rows are displayed (up to Row 256). 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 512 257	Use this format to view any SER row between Row 512 and Row 257 (if these exist). The rows display with the newest row (Row 257) at the beginning (top) of the report and the oldest row (Row 512) at the end (bottom) of the report. Reverse chronological progression through the report is down the page in ascending row number.
SER 3/30/96	If SER is entered with one date following it (date 3/30/96 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 2/17/96 3/23/96	If SER is entered with two dates following it (date 2/17/96 chronologically precedes date 3/23/96 in this example), all the rows between (and including) dates 2/17/96 and 3/23/96 are displayed, if they exist. They display with the oldest row (date 2/17/96) at the beginning (top) of the report and the latest row (date 3/23/96) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 3/16/96 1/5/96	If SER is entered with two dates following it (date 3/16/96 chronologically follows date 1/5/96 in this example), all the rows between (and including) dates 1/5/96 and 3/16/96 are displayed, if they exist. They display with the latest row (date 3/16/96) at the beginning (top) of the report and the oldest row (date 1/5/96) 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.

For any **SER** report request, no more than 256 rows can be displayed at a time. To view **SER** rows between Row 257 and Row 512, you must specify the range after the **SER** command (see [Table 9.5 on page 9.18](#)).

If the requested **SER** report rows do not exist, the relay responds “Invalid Record.”

If there are no rows in the **SER** report buffer, the relay responds “No **SER** data.”

Clearing SER Buffer

NOTE: Clear the **SER** Buffer with care. Automated clearing of the **SER** buffer should be limited to reduce the possibility of wearing out the nonvolatile memory. Limit automated **SER C** commands to once per week or less.

If the **SER C** command is entered, the relay prompts the operator for confirmation:

```
Clear SER Buffer
Are you sure (Y/N)?
```

If “Y” is entered, the relay clears the **SER** reports from nonvolatile memory. If “N” is entered, no reports are cleared, and the relay responds “Canceled.”

SER Column Definitions

Refer to the example **SER** report in [Figure 9.3 on page 9.20](#) to view **SER** report columns. Note in [Figure 9.3 on page 9.20](#) that a row in the **SER** report is actually two lines long; the first line contains row, date, time, and any written message, and the second line contains the current and the other relay information.

The column definitions in [Table 9.3 on page 9.6](#) and [Table 9.4 on page 9.7](#) also apply to the columns of the **SER** Report. The **SER** Report has a few additional columns:

Table 9.6 SER Report Additional Columns

Column Heading	Definition
Row	SER report row number (1 through 512)
Date	Date that the SER report row was triggered
Time	Time (24-hour time) that the SER report row was triggered

The **SER** report analog columns (87A, 87B, 87C, IA, IB, IC) display magnitude values (currents in primary), rather than sampled current values, as the event report current columns do.

Example Sequential Events Recorder (SER) Report

The example sequential events recorder (SER) report in [Figure 9.3](#) corresponds to the example event report in [Figure 9.2 on page 9.15](#).

Row	Date	Time	Amps	Pri	IC	Relay	newly powered up or settings changed
87A	87B	87C	IA	IB	IC	12PABCGQ31222	24682468C 24TTTTTTTTT 24M2
12	10/05/2001	13:13:36.107			0	.....	.....
11	10/05/2001	15:24:12.243			0	.....	.....
10	10/05/2001	15:38:22.256			0	.....	.....
9	10/05/2001	17:12:22.256			0	.....	.....
8	10/05/2001	18:42:12.465			0	.....	.....
7	10/05/2001	18:42:37.324			0	.....	.....
6	10/05/2001	18:42:37.324			0	.....	.....
5	10/05/2001	18:42:37.324			0	.....	.....

Figure 9.3 Example Sequential Events Recorder (SER) Report.

Section 10

Testing and Troubleshooting

Introduction

Use this section for determining and establishing test routines for the SEL-587Z Relay. Included are discussions on testing philosophies, methods, and tools. Example test procedures are shown for the overcurrent elements, differential elements, and metering. Relay troubleshooting procedures are listed at the end of the section.

Protective relay testing is generally divided into three categories: acceptance, commissioning, and maintenance testing. The categories differ by when testing takes place in the life cycle of the relay, as well as by differences in the test complexity.

This section describes when each test is performed, the goals of testing at that time, and the relay functions that you need to test at each point. This information is intended as a guideline for testing SEL relays.

Testing Methods and Tools

Test Features

The following features assist you during relay testing.

Command/Feature	Description
METER	The METER command shows the currents and voltages presented to the relay in primary values, referenced to IA. Compare these quantities against other devices of known accuracy.
EVENT	The relay generates an event report in response to faults or disturbances. Each report contains current and voltage information, relay element states, and input/output contact information. If you question the relay response or your test method, use the EVENT command to display detailed information.
TARGET	Use the TARGET n command to view the state of relay control inputs, relay outputs, and relay elements individually during a test.
SER	Use the Sequential Events Recorder (SER) for timing tests by setting the SER trigger settings (SER1, SER2, or SER3) to trigger for specific elements asserting or deasserting. View the SER with the SER command.
Programmable Outputs	Use programmable outputs to isolate individual relay elements. Refer to the SET command.

For more information on these features and commands, see [Section 7: ASCII Command Reference](#).

Low-Level Test Interface

The SEL-587Z has a low-level test interface between the calibrated input module and the separately calibrated processing module. You test the relay in either of two ways:

- By applying ac signals to the relay inputs (conventional method)
- By applying low-magnitude ac voltage signals to the low-level test interface

Access the test interface by removing the relay front panel.

[Figure 10.1 on page 10.3](#) shows the low-level interface connections. Remove the ribbon cable between the two modules to access the outputs of the input module and the inputs to the processing module (relay main board).

You can test the relay processing module using signals from the SEL-4000 Relay Test System. Never apply voltage signals greater than 6.2 V peak-to-peak to the low-level test interface. [Figure 10.1 on page 10.3](#) shows the signal scaling factors.

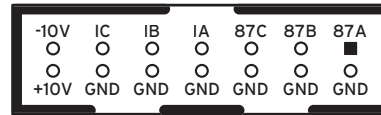
CAUTION: Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work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

You can test the input module two different ways:

Measure the outputs from the input module with an accurate voltmeter, and compare the readings to accurate instruments in the relay input circuits,

or

Replace the ribbon cable, press the front-panel **{METER}** pushbutton, and compare the relay readings to other accurate instruments in the relay input circuits.



Input Module Output : 71.43 mV at Nominal Current (1 A or 5 A)

Processing Module Input : 6.2 V p-p Maximum

U.S. Patent 5,479,315

Figure 10.1 Low-Level Test Interface.

Test Methods

Test the pickup and dropout of relay elements using one of three methods: front-panel target LCD/LED indication, output contact operation, or the Sequential Events Recorder (SER).

Target LED Illumination

During testing use target LED illumination to determine relay element status. Using the **TAR** command, set the front-panel targets to display the element under test. Monitor element pickup and dropout by observing the target LEDs.

For example, the phase instantaneous overcurrent element 50P1 appears in Relay Word Row 3. When you type the command **TAR 3<Enter>**, the terminal displays the labels and status for each bit in the Relay Word Row (3), and the LEDs display their status. Thus, with these new targets displayed, if the Level 1 phase instantaneous overcurrent element (50P1) asserts, the top row, right-side LED illuminates. See [Appendix C: Relay Word Bits](#) for a list of all Relay Word elements.

Be sure to reset the front-panel targets to the default targets after testing before returning the relay to service. This can be done by pressing the front-panel **{TARGET RESET}** pushbutton, or by issuing the **TAR R** command from the serial port.

Output Contact Operation

To test using this method, set one programmable output contact to assert when the element under test picks up. With the **SET L n** command, enter the Relay Word bit name of the element under test. For example, setting **OUT4 = 50P1** results in output contact OUT4 closing when 50P1 asserts.

For an “a” contact, when the condition asserts, the output contact closes. When the condition deasserts, the output contact opens.

For a “b” contact, when the condition asserts, the output contact opens. When the condition deasserts, the output contact closes.

Programmable contacts can be changed to “a” or “b” contacts with a solder jumper. Refer to *Output Contact Jumpers on page 2.8 in Section 2: Installation* for jumper locations. Using contact operation as an indicator, you can measure element operating characteristics, stop timers, etc.

Tests in this section assume an “a” output contact.

Sequential Events Recorder (SER)

To test using this method, set the SERn to trigger for the element under test. With the **SET R** command, put the element name in the SER1, SER2, or SER3 setting.

Whenever an element asserts or deasserts, a time stamp is recorded. View the SER report with the **SER** command. Clear the SER report with the **SER C** command.

Acceptance Testing

SEL performs detailed acceptance testing on all new relay models and versions. We are certain that your SEL-587Z meets published specifications. Even so, you can perform acceptance testing on a new relay model to become familiar with the relay operating theory and settings; this familiarity helps you apply the relay accurately and correctly. A summary of acceptance testing guidelines is presented in [Table 10.1](#).

Table 10.1 Acceptance Testing

Details	Description
Time	Test when qualifying a relay model for use on the utility system.
Goals	Confirm that the relay meets published critical performance specifications such as operating speed and element accuracy. Confirm that the relay meets the requirements of the intended application. Gain familiarity with relay settings and capabilities.
Test	Test all protection elements and logic functions critical to your intended application.

Required Equipment

The following equipment is necessary to perform all of the acceptance tests:

- A terminal or computer with terminal emulation with EIA-232 serial interface
- Interconnecting data cable between terminal and relay
- Source of relay control power
- Source of one current at nominal frequency
- Source of one voltage at nominal frequency
- Ohmmeter or contact opening/closing sensing device

Initial Checkout

- Step 1. Purpose: Be sure you received the relay in satisfactory condition.

Method: Inspect the instrument for physical damage such as dents or rattles.

- Step 2. Purpose: Verify requirements for relay logic inputs, control power voltage level, and voltage and current inputs.

Method: Refer to the information sticker on the rear panel of the relay. Actual information stickers vary, but [Figure 10.2 on page 10.6](#) provides an example. Check the information on this sticker before applying power to the relay or starting tests. Be sure your dc supply is correctly adjusted for the control and logic input requirements. The logic input voltage rating is jumper selectable. The sticker gives the factory default voltage rating.

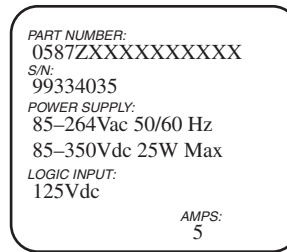


Figure 10.2 Relay Part Number and Hardware Identification Sticker.

Power Supply

- Step 1. Purpose: Establish control power connections.

Method: Connect a frame ground to terminal marked GND on the rear panel and connect rated control power to terminals marked + and –. Relays supplied with 125 or 250 V power supplies may be powered from a 115 Vac wall receptacle for testing. Other power supplies require dc voltage and are polarity sensitive.

Serial Communication

- Step 1. Purpose: Verify the communications interface setup.

Method: Connect a computer terminal to the serial port of the relay.

Communications Parameters: 2400 Baud, 8 Data Bits, 1 Stop Bit, N Parity

Cables: SEL-C234A for 9-pin subminiature male computer connection;

SEL-C227A for 25-pin male computer connection

- Step 2. Purpose: Apply control voltage to the relay, and start Access Level 0 communication.

Method: Apply control voltage to the relay. The enable target (EN) LED should illuminate. If not, be sure that power is present. Press the **<Enter>** key from your terminal to get the Access Level 0 response from the relay. The = prompt should appear, indicating that you have established communications at Access Level 0 (presuming correct terminal configuration).

The ALARM relay should hold its “b” contact open.

If these do not occur, turn off the power, and refer to the [Relay Troubleshooting on page 10.19](#).

- Step 3. Purpose: Establish Access Level 1 communication.

Method: Type **ACC <Enter>**. At the prompt, enter the Access Level 1 password and press **<Enter>**. The => prompt should appear, indicating that you have established communications at Access Level 1.

- Step 4. Purpose: Verify relay self-test status.

Method: Type **STA <Enter>**. The following display should appear on the terminal:

NOTE: If you are using a battery simulator, be sure the simulator voltage level is stabilized before turning the relay on.

```

=>>STA

BUS 1                               Date: 05/13/2002 Time: 12:23:53.231
STATION A

FID=SEL-587Z-R100-V0-Z001001-D20020513      CID=E3D0

SELF TESTS

W=Warn    F=Fail

      87A      87B      87C      IA      IB      IC      MOF
OS      3        3        3        3        3        3        0

      +5V_PS   +5V_REG  -5V_REG  +10V_PS  -10V_PS  VBAT
PS      4.99    5.04    -5.06    10.23   -10.17   3.35

      TEMP     RAM      ROM      CR_RAM   EEPROM
      33.8     OK       OK       OK       OK

Relay Enabled

->>

```

Figure 10.3 STA Command.

The *STA (Status)* on page 7.18 in *Section 7: ASCII Command Reference* explains the values listed in the above status printout.

Step 5. Purpose: View factory settings entered before shipment.

Method: The relay is shipped with factory settings; type **SHO** <Enter> to view the settings. The *SEL-587Z Settings Sheets* in *Section 5: Setting the Relay* include a complete description of the settings. The terminal display should look similar to the following:

```

=>>SHO

Relay Settings:
RID  =BUS 1
TID  =STATION A
CTR  = 120      TDURD = 9.000
87A1P = 125     87A2P = 40      87B1P = 125      87B2P = 40
87C1P = 125     87C2P = 40
50P1P = OFF     50P2P = OFF     50P3P = OFF
50A1P = 2.5     50A2P = 1.0     50B1P = 2.5     50B2P = 1.0
50C1P = 2.5     50C2P = 1.0
51PP = OFF     51PC = U3      51PTD = 15.00   51PRS = N
51AP = OFF     51AC = U3      51ATD = 15.00   51ARS = N
51BP = OFF     51BC = U3      51BTD = 15.00   51BRS = N
51CP = OFF     51CC = U3      51CTD = 15.00   51CRS = N
50G1P = OFF     50G2P = OFF
51GP = OFF     51GC = U3      51GTD = 15.00   51GRS = N
50Q1P = OFF     50Q2P = OFF
51QP = OFF     51QC = U3      51QTD = 15.00   51QRS = N
CFD  = 60.000

Press RETURN to continue
DMTC = 5        PDEMP = 5.00    GDEMP = 1.50    QDEMP = 1.50
SV5PU = 120.000 SV5D0 = 0.000   SV6PU = 15.000  SV6D0 = 0.000
SV7PU = 0.000   SV7D0 = 0.000   SV8PU = 0.000   SV8D0 = 0.000
SV9PU = 0.000   SV9D0 = 0.000   SV10PU= 0.000   SV10D0= 0.000
SV11PU= 0.000   SV11D0= 0.000   SV12PU= 0.000   SV12D0= 0.000
SV13PU= 0.000   SV13D0= 0.000   SV14PU= 0.000   SV14D0= 0.000
NFREQ = 60      PHROT = ABC     DATE_F= MDY
->>

```

Figure 10.4 SHO Command.

The *SHO (Showset)* on page 7.15 in *Section 7: ASCII Command Reference* explains the other settings available with variations of the **SHO** command.

Outputs

- Step 1. Purpose: Verify that contact outputs operate when you execute the **PULSE** command.

Method:

- a. Isolate all circuitry connected to the output contacts.
- b. Set the target LEDs to display the contact outputs by typing **TAR 13 <Enter>**. The front-panel LEDs should now follow Row 13 of the Relay Word where the outputs are listed.
- c. Execute the **PULSE OUT n** ($n = 1$ to 4) command for each output contact. Verify that the corresponding target LED illuminates and output contact closes for approximately one second. For example, type **PUL OUT1 <Enter>** to test output contact OUT1.

Inputs

- Step 1. Purpose: Verify that logic inputs assert when control voltage is applied across the respective terminal pair.

Method:

- a. Set the target LEDs to display the contact inputs by typing **TAR 6 <Enter>**. The fourth and fifth front-panel LEDs should now follow logic inputs IN1 and IN2, which are in Relay Word Row 6.
- b. Apply the appropriate control voltage to each input and make sure the corresponding target LED illuminates. Note that the control voltage required to assert an input is jumper selectable.
- c. If you suspect the jumpers to be different from the factory default, refer to [Circuit Board Jumpers and Battery on page 2.8 in Section 2: Installation](#) for the jumper locations.

Metering

- Step 1. Purpose: Connect simulated power system secondary current sources to the relay.

Method: Turn power off to the relay and connect current sources. If three current sources are available, connect them to the relay as shown in [Figure 10.5 on page 10.9](#). If only two current sources are available, connect the sources as shown in [Figure 10.6 on page 10.9](#) to generate balanced positive-sequence currents.

Set the current sources to deliver 1A secondary. Set the current angles (e.g., B-phase lags A-phase by 120°) according to the phase rotation setting PHROT (i.e., PHROT = ABC or ACB).

- Step 2. Purpose: Verify correct current levels.

Method: Turn relay power on, and use the **METER** command to display the currents applied in Step 1. With applied currents of 1A secondary per phase and a current transformer ratio of 120:1 (assuming setting CTR = 120), the displayed line currents should be close to 120 amperes primary.

Step 3. Purpose: Verify phase rotation.

Method: Verify that residual (IG) and negative-sequence (3I2) quantities are approximately zero (or much less than the approximately 120 A primary displayed for the phases). If IG equals approximately three times the applied current, then all three phases have the same angle. If 3I2 equals approximately three times the applied current then the phase rotation is reversed. Turn the current sources off.

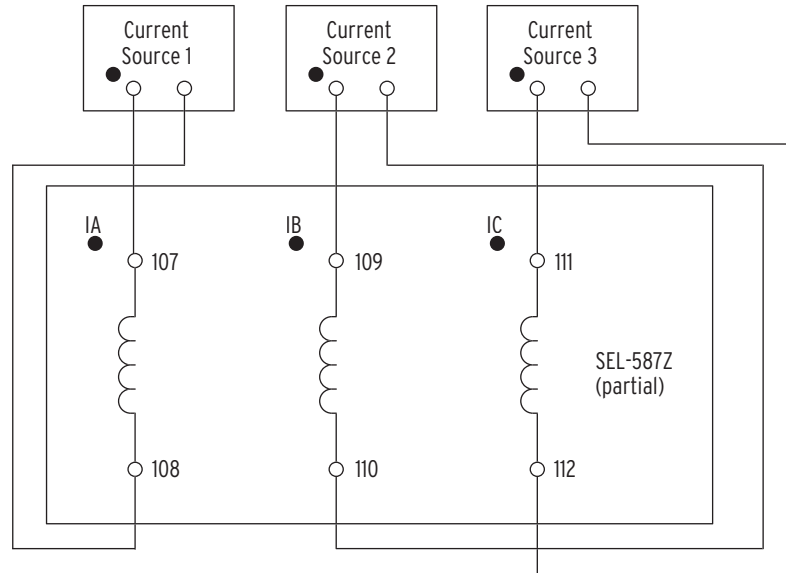


Figure 10.5 Test Connections for Balanced Load With Three-Phase Current Sources.

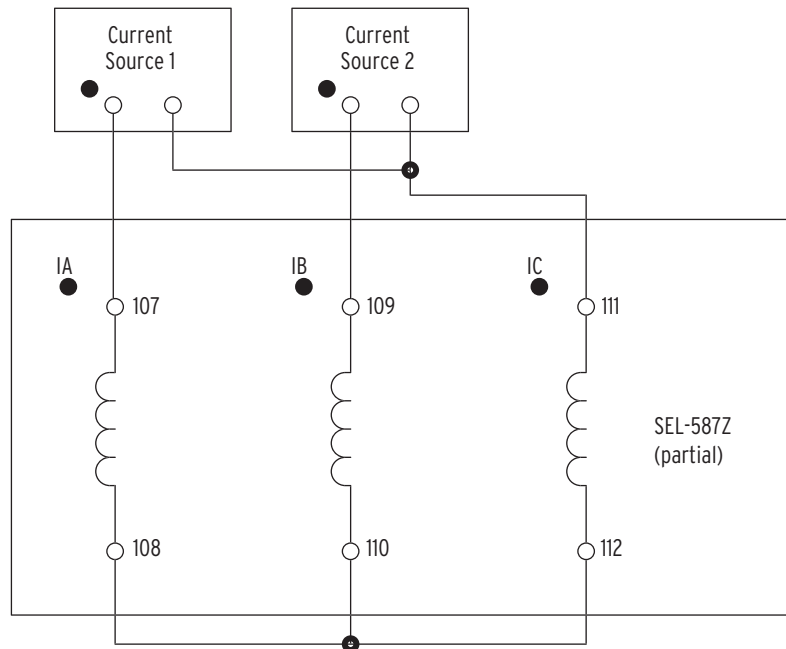


Figure 10.6 Test Connections With Two-Phase Current Sources.

Instantaneous Overcurrent Elements

NOTE: This example tests the 50A1 phase overcurrent element. Use the same procedure to test all instantaneous overcurrent elements for each phase.

- Step 1. Purpose: Determine the expected instantaneous overcurrent element pickup value.
- Method: Execute the **SHO** command via the relay front panel or serial port and verify the setting (i.e., **SHO 50A1P<Enter>**).
- Step 2. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.
- Method: Execute the **TARGET** command (i.e., **TAR 3<Enter>**). The SEL-587Z now displays the state of several overcurrent elements on the front-panel LED and LCD display. More overcurrent elements are on the next row; to view their status, type in **TAR 4<Enter>**.
- Step 3. Purpose: Connect and apply a single current test source until the appropriate LED illuminates.
- Method: Connect a single current test source (i.e., source 1 to current input IA) as shown in [Figure 10.5 on page 10.9](#). Turn on the current test source for the phase under test, and slowly increase the magnitude of current applied until the appropriate element asserts (i.e., 50A1), causing the LED to illuminate (i.e., top row, right hand side; see [Table 10.2](#). Note the magnitude of the current applied. It should equal the 50A1P setting $\pm 5\%$ of the setting and ± 0.1 A secondary.
- Step 4. Purpose: Repeat test for each instantaneous overcurrent element.
- Method: Repeat steps 1 through 3 for each instantaneous overcurrent element listed in [Table 10.2](#). Remember to view the element with the **TAR** command (see [Table 10.2](#)). The computer terminal will display the LED labels from left to right when the **TAR** command is issued.

Table 10.2 Instantaneous Overcurrent Elements and Corresponding Settings/Relay Word Bits/TAR Commands

Element	Pickup Setting	Relay Word Bit	TAR
A-phase Level 1	50A1P	50A1	3
A-phase Level 2	50A2P	50A2	3
B-phase Level 1	50B1P	50B1	4
B-phase Level 2	50B2P	50B2	4
C-phase Level 1	50C1P	50C1	4
C-phase Level 2	50C2P	50C2	4
Maximum Phase Level 1	50P1P	50P1	3
Maximum Phase Level 2	50P2P	50P2	3
Maximum Phase Level 3	50P3P	50P3	3
Residual Ground Level 1	50G1P	50G1	4
Residual Ground Level 2	50G2P	50G2	4
Negative-Sequence Level 1	50Q1P	50Q1	4
Negative-Sequence Level 2	50Q2P	50Q2	4

Inverse-Time Overcurrent Elements

NOTE: This example tests the 51A phase inverse-time overcurrent element. Use the same procedure to test all inverse-time overcurrent elements for each phase.

Step 1. Purpose: Determine the expected time delay for the overcurrent element.

Method:

- Execute the **SHO** command via the relay front panel or serial port and verify the time delay settings (i.e., **SHO 51AP<Enter>**). The delay settings will follow the pickup settings when they are displayed.
- Calculate the time delay to pickup (t_p). Inverse-time elements are calculated using three element settings and the operating time equations shown in [SEL-587Z Settings Sheets](#) in [Section 5: Setting the Relay](#). TD is the time-dial setting (i.e., 51ATD), and M is the applied multiple of pickup current.

For example, if 51AP = 2.2 A, 51AC = U3, and 51ATD = 4.0, we can use the equation below to calculate the expected operating time for M = 3 (applied current equals M • 51AP = 6.6 A):

$$\begin{aligned} t_p &= TD \cdot \left(0.0963 + \frac{3.88}{M^2 - 1} \right) \\ &= 4 \cdot \left(0.0963 + \frac{3.88}{3^2 - 1} \right) \\ &= 2.33 \text{ seconds} \end{aligned} \quad \text{Equation 10.1}$$

Step 2. Purpose: Set the Sequential Event Recorder to record the element timing.

Method: Use **SET R SER1<Enter>** to set SER1 equal to the element pickup and time-out Relay Word bits (i.e., 51A, 51AT). When prompted, set SER2, and SER3 to NA. Save settings.

Step 3. Purpose: Connect and apply a single current test source at a level that is M times greater than the pickup (i.e., 2.2 • M = 6.6 A; M = 3 for this example).

Method: Connect a single current test source (i.e., source 1 to current input 1A) as shown in [Figure 10.5 on page 10.9](#). Turn on the single current test source for the phase under test at the desired level.

Step 4. Purpose: Verify the operation times.

Method: Type **SER<Enter>** to view the sequential event records. The assertion and deassertion of each element listed in the SER1, 2, and 3 settings is recorded. Subtract the time from the assertion of the pickup (i.e., 51A) to the assertion of the time-delayed element (i.e., 51AT). SER C clears the Sequential Events Records.

Step 5. Purpose: Repeat the test for each inverse-time overcurrent element.

Method: Repeat steps 1 through 4 for each time element listed in [Table 10.3 on page 10.12](#) for each phase. Remember to set the SER for the appropriate elements and apply current to the appropriate phase.

NOTE: If the electromechanical induction-disk reset emulation is enabled (i.e., 51ARS = Y), the element under test may take some time to reset fully. If the element is not fully reset when you run a second test, the time to trip will be lower than expected. Usually this setting is set 51ARS = N.

Table 10.3 Inverse-Time Overcurrent Elements and Corresponding Settings/Relay Word Bits/TAR Commands

Element/Settings	Setting Names	Relay Word Bit	TAR
Maximum Phase			
Pickup	51PP	51P (picked up)	1
Curve	51PC		
Time Dial	51PTD	51PT (timed out)	1
Electromechanical Reset	51PRS		
Phase A			
Pickup	51AP	51A (picked up)	1
Curve	51AC		
Time Dial	51ATD	51AT (timed out)	1
Electromechanical Reset	51ARS		
Phase B			
Pickup	51BP	51B (picked up)	1
Curve	51BC		
Time Dial	51BTD	51BT (timed out)	1
Electromechanical Reset	51BRS		
Phase C			
Pickup	51CP	51C (picked up)	2
Curve	51CC		
Time Dial	51CTD	51CT (timed out)	2
Electromechanical Reset	51CRS		
Residual Ground			
Pickup	51GP	51G (picked up)	2
Curve	51GC		
Time Dial	51GTD	51GT (timed out)	2
Electromechanical Reset	51GRS		
Negative-Sequence			
Pickup	51QP	51Q (picked up)	2
Curve	51QC		
Time Dial	51QTD	51QT (timed out)	3
Electromechanical Reset	51QRS		

Phase Overcurrent Elements

The SEL-587Z has many phase overcurrent elements as shown in [Table 10.2 on page 10.10](#) and [Table 10.3](#). Two kinds of elements are available: elements that operate based on a comparison between the maximum phase current directly applied to the phase inputs and the phase overcurrent setting (50/51P) and those operating on the specific phase current setting (50/51A, 50/51B, and 50/51C).

Test the instantaneous and inverse-time phase overcurrent elements by applying current to the inputs and comparing relay operation to the phase overcurrent settings. These tests were outlined previously in this section.

Negative-Sequence Overcurrent Elements

The SEL-587Z has three negative-sequence overcurrent elements as shown in [Table 10.2 on page 10.10](#) and [Table 10.3](#). They all operate based on a comparison between a negative-sequence calculation of the three-phase inputs and the negative-sequence overcurrent setting. The negative-sequence calculation that is performed on the three-phase inputs is as follows (assuming ABC rotation):

$$3I_2 = \text{A-phase} + \text{B-phase (shifted by } -120^\circ) + \text{C-phase (shifted by } 120^\circ)$$
Equation 10.2

This means that if balanced positive-sequence currents are applied to the relay, the relay reads $3I_2 = 0$ (load conditions).

For testing purposes, apply a single-phase current to the relay and the negative-sequence overcurrent elements will operate. For example, assume one ampere on A-phase and zero on B- and C-phases:

$$3I_2 = 1 + 0 \text{ (shifted } -120^\circ) + 0 \text{ (shifted } 120^\circ) = 1 \text{ (simulated ground fault condition)}$$
Equation 10.3

Test the instantaneous and inverse-time negative-sequence overcurrent elements by applying current to the inputs and comparing relay operation to the negative-sequence overcurrent settings. These tests were outlined previously in this section.

Residual Ground Overcurrent Elements

The SEL-587Z has three residual ground overcurrent elements. They all operate based on a comparison between a residual calculation of the three-phase inputs and the residual ground overcurrent setting. The residual calculation that is performed on the three-phase inputs is as follows:

$$IG = \text{A-phase} + \text{B-phase} + \text{C-phase}$$
Equation 10.4

This means that if balanced positive-sequence currents are applied to the relay, the relay reads $IG = 0$ (load conditions) because the currents cancel one another.

For testing purposes, apply a single-phase current to the relay and the residual overcurrent elements will operate. For example, assume one ampere on A-phase and zero on B- and C-phases:

$$IG = 1 + 0 + 0 = 1 \text{ (simulated ground fault condition)}$$
Equation 10.5

Test the instantaneous and time-delayed residual overcurrent elements by applying current to the inputs and comparing relay operation to the residual overcurrent settings. These tests were outlined previously in this section.

High-Impedance Differential Elements

NOTE: This example tests the 87A1 differential element. Use the same procedure to test all differential elements for each phase.

- Step 1. Purpose: Determine the expected differential element pickup value.
Method: Execute the **SHO** command via the relay front panel or serial port and verify the setting (i.e., **SHO 87A1P<Enter>**).
- Step 2. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.
Method: Execute the **TARGET** command (i.e., **TAR 5<Enter>**). The SEL-587Z now displays the state of all six differential elements on the front-panel LED and LCD display.
- Step 3. Purpose: Connect and apply a voltage test source until the appropriate LED illuminates.
Method: Connect a single voltage test source (i.e., source 1 to voltage input 87A) as shown in [Figure 10.7 on page 10.14](#). Turn on the voltage test source for the phase under test, and slowly increase the magnitude of voltage applied until the

appropriate element asserts (i.e., 87A1), causing the LED to illuminate (i.e., top row, first from the left; See [Table 10.4](#)). Note the magnitude of the voltage applied. It should equal the 87A1 element setting $\pm 5\%$ of the setting and ± 4 V.

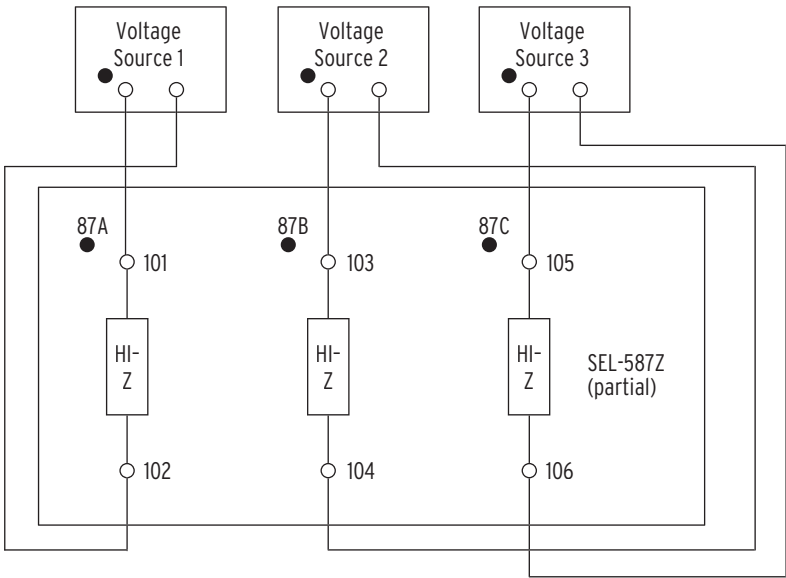


Figure 10.7 Test Connections for Three-Phase Voltage Sources.

Repeat Steps 1 through 3 for each voltage element listed in [Table 10.4](#). Remember to view the element with the **TAR** command (See [Table 10.4](#)). The computer terminal will display the LED labels from left to right when the **TAR** command is issued.

Table 10.4 Instantaneous Overcurrent Elements and Corresponding Settings/Relay Word Bits/TAR Commands

Element	Pickup Setting	Relay Word Bit	TAR
Differential Element A-Phase Level 1	87A1P	87A1	5
Differential Element A-Phase Level 2	87A2P	87A2	5
Differential Element B-Phase Level 1	87B1P	87B1	5
Differential Element B-Phase Level 2	87B2P	87B2	5
Differential Element C-Phase Level 1	87C1P	87C1	5
Differential Element C-Phase Level 2	87C2P	87C2	5

Commissioning Testing

SEL performs a complete functional check and calibration of each SEL-587Z before shipment so that your relay operates correctly and accurately. You should perform commissioning tests to verify proper connection of the relay to the power system and all auxiliary equipment:

- Check control signal inputs and outputs.
- Check breaker auxiliary inputs, SCADA control inputs, and monitoring outputs.
- Verify that the relay current and voltage inputs are the proper magnitude and phase rotation.

Brief fault tests confirm that the relay settings and protection scheme logic are correct. You do not need to test every relay element, timer, and function in these tests.

At commissioning time, use the relay **METER** command to record load currents.

Maintenance Testing

The SEL-587Z uses extensive self-testing routines and features detailed metering and event reporting functions. These features reduce your dependence on routine maintenance testing. When you want to perform maintenance testing, follow the recommendations in [Table 10.5](#).

Table 10.5 Maintenance Testing

Details	Description
Time	Test at scheduled intervals or when there is an indication of a problem with the relay or power system.
Goals	Confirm that the relay is measuring ac quantities accurately. Check that scheme logic and protection elements function correctly. Verify that auxiliary equipment functions correctly.
Tests	Test all relay features/power system components that did not operate during an actual fault within the past maintenance interval.

You can use the SEL-587Z reporting features as maintenance tools. Periodically compare the relay **METER** command output to other meter readings on a line to verify that the relay measures currents and voltages correctly and accurately.

Each occurrence of a fault tests the protection system and relay application. Review relay event reports in detail after each fault to determine the areas needing your attention. Use the event report current, voltage, and relay element data to determine that the relay protection elements and communications channels operate properly. Inspect event report input and output data to determine whether the relay asserts outputs at the correct times and whether auxiliary equipment operates properly.

At each maintenance interval, the only items to test are those that have not operated (via fault conditions and otherwise) during the maintenance interval. The basis for this testing philosophy is simple: you do not need to perform further maintenance testing for a correctly set and connected relay that measures the power system properly and for which no relay self-test has failed.

The SEL-587Z is based on microprocessor technology; the relay internal processing characteristics do not change over time. For example, if time-overcurrent element operating times change, these changes occur because of alterations to relay settings and/or differences in the signals applied to the relay. You do not need to verify relay element operating characteristics as a part of maintenance checks.

SEL recommends that you limit maintenance tests on SEL relays according to the guidelines listed in [Table 10.5 on page 10.16](#). You will spend less time checking relay operations that function correctly. You can use the time you save to analyze event data and thoroughly test systems needing more attention.

Relay Self-Tests

The SEL-587Z runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see [Table 10.6](#)):

- The relay disables protection elements and trip/close logic. All output contacts are de-energized. The EN front-panel LED is extinguished.
- The ALARM output contact signals an alarm condition by going to the de-energized state. If the ALARM output contact is a “b” contact (normally closed), it closes for an alarm condition or if the relay is de-energized. If the ALARM output contact is an “a” contact (normally open), it opens for an alarm condition or if the relay is de-energized. Alarm condition signaling can be five-second pulses (Pulsed) or permanent (Latched).
- The relay generates automatic STATUS reports at the serial port for warnings and failures.
- The relay displays failure messages on the relay LCD display for failures.

Use the serial port **STATUS** command or front-panel **{STATUS}** pushbutton to view relay self-test status.

Table 10.6 Relay Self-Tests (Sheet 1 of 2)

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
87A, 87B, 87C, IA, IB, IC offset	Warning	30 mV	No	Pulsed	Measures the dc offset at each of the current input channels every 0.2 seconds.
Master offset	Warning	20 mV	No	Pulsed	Measures the dc offset at the A/D every 0.2 seconds.
	Failure	30 mV	Yes	Latched	
+5 V PS	Warning	+4.75 V +5.25 V	No	Pulsed	Measures the +5 V power supply every 0.2 seconds.
	Failure	+4.70 V +5.50 V	Yes	Latched	
±5 V REG	Warning	±4.65 V ±5.35 V	No	Pulsed	Measures the regulated 5 V power supply every 0.2 seconds.
	Failure	±4.50 V ±5.50 V	Yes	Latched	
±10 V PS	Warning	±9.00 V ±11.00 V	No	Pulsed	Measures the 10 V power supply every 0.2 seconds
	Failure	±8.00 V ±12.00 V	Yes	Latched	
VBAT	Warning	+2.25 V +5.00 V	No	Pulsed	Measures the Real Time clock battery every 0.2 seconds.
	Failure	+2.10 V +6.00 V	No	Pulsed	
TEMP	Warning	−40° +85°C	No		Measures the temperature at the A/D voltage reference every 0.2 seconds.
	Failure	−50° +100°C	Yes	Latched	
RAM	Failure		Yes	Latched	Performs a read/write test on system RAM every 60 seconds.

Table 10.6 Relay Self-Tests (Sheet 2 of 2)

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
ROM	Failure	checksum	Yes	Latched	Performs a checksum test on the relay program memory every 0.2 seconds.
CR_RAM	Failure	checksum	Yes	Latched	Performs a checksum test on the active copy of the relay settings every 0.2 seconds.
EEPROM	Failure	checksum	Yes	Latched	Performs a checksum test on the nonvolatile copy of the relay settings every 0.2 seconds.
Microprocessor Crystal ^a	Failure		Yes	Latched	The relay monitors the microprocessor crystal. If the crystal fails, the relay displays “CLOCK STOPPED” on the LCD display. The test runs continuously.
Microprocessor ^a	Failure		Yes	Latched	The microprocessor examines each program instruction, memory access, and interrupt. The relay displays “VECTOR nn” on the LCD upon detection of an invalid instruction, memory access, or spurious interrupt. The test runs continuously.
+5 V PS Under/Overvoltage ^a	Failure	+4.65 V +5.95 V	Yes	Latched	A circuit on the SEL-587Z main board monitors the +5 V power supply. Upon detection of a failure, the circuit forces the microprocessor to reset.

^a The following self-tests are performed by dedicated circuitry in the microprocessor and the SEL-587Z main board. Failures in these tests shut down the microprocessor and are not shown in the STATUS report.

Relay Troubleshooting

Inspection Procedure

Complete the following procedure before disturbing the relay. After you finish the inspection, proceed to [Troubleshooting Procedure](#).

- Step 1. Measure and record the power supply voltage at the power input terminals.
- Step 2. Check to see that the power is on. Do not turn the relay off.
- Step 3. Measure and record the voltage at all control inputs.
- Step 4. Measure and record the state of all output relays.

Troubleshooting Procedure

All Front-Panel LEDs Dark

- Step 1. Input power not present or fuse is blown.
- Step 2. Self-test failure.

Cannot See Characters on Relay LCD Screen

- Step 1. Relay is de-energized. Check to see if the ALARM contact is closed.
- Step 2. LCD contrast is out of adjustment. Use the steps below to adjust the contrast.
 - a. Remove the relay front panel by removing the six front-panel screws.
 - b. Press any front-panel pushbutton. The relay should turn on the LCD back lighting.
 - c. Locate the contrast adjust potentiometer directly adjacent to the EN LED.
 - d. Use a small screwdriver to adjust the potentiometer.
 - e. Replace the relay front panel.

Relay Does Not Respond to Commands From Device Connected to Serial Port

- Step 1. Communications device not connected to relay.
- Step 2. Relay or communications device at incorrect baud rate or other communication parameter incompatibility, including cabling error.
- Step 3. Relay serial port has received an XOFF, halting communications. Type <Ctrl>Q to send relay an XON and restart communications.

Relay Does Not Respond to Faults

- Step 1. Relay improperly set.
- Step 2. Improper test source settings.
- Step 3. CT input wiring error.
- Step 4. Analog input cable between transformer secondary and main board loose or defective.
- Step 5. Failed relay self-test.

Relay Calibration

The SEL-587Z is factory calibrated. If you suspect that the relay is out of calibration, please contact the factory.

Factory Assistance

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

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

Appendix A

Firmware and Manual Versions

Firmware

Determining the Firmware Version in Your Relay

To find the firmware revision number in your relay, view the status report using the serial port **STATUS** command or the front-panel {**STATUS**} pushbutton.

For firmware versions with the date code of April 18, 2002, or later, the FID label will appear as follows with the Part/Revision number in bold:

FID=SEL-587Z-**Rxxx-V0-Z001001-Dxxxxxxx**

The firmware revision number is after the “R” and the release date follows the “D.”

For example:

FID=SEL-587Z-**R100-V0-Z001001-D20020418**

is firmware revision number 100, release date April 18, 2002.

[Table A.1](#) lists the firmware versions, a description of modifications, and the instruction manual date code that corresponds to firmware versions for the SEL-587Z. The most recent firmware version is listed first.

Table A.1 Firmware Revision History

Firmware Identification (FID) Number	Description of Changes	Manual Date Code
This firmware differs from the previous versions as follows: SEL-587Z-R102-V0-Z001001-D20020903	► Update ACCESS and 2ACCESS commands to accept six (6) character passwords.	20020903
This firmware applies to the manual date code listed: SEL-587Z-R100-V0-Z001001-D20020418	► Manual update only--See Table A.2 on page A.2 for summary of manual updates.	20020628
SEL-587Z-R100-V0-Z001001-D20020418	► Original Release	20020418

Instruction Manual

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

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

Table A.2 Instruction Manual Revision History

Revision Date	Summary of Revisions
This manual differs from the previous versions as follows:	
20020903	Appendix A ➤ Updated for R102 firmware revision.
This manual differs from the previous versions as follows:	
20020628	Title Page ➤ Added date code. Section 1 ➤ Included mention of projection panel-mount package in Model Options on page 1.6 . Section 2 ➤ Included information about projection panel-mount package in Panel Mount on page 2.2 . ➤ Updated Figure 2.1 on page 2.3 to include projection panel-mount view. Manual Change Information ➤ Removed Manual Change Information page from front of manual and incorporated information in this table.
This manual differs from the previous versions as follows:	
20020418	Initial Release.

Appendix B

Firmware Upgrade Instructions

SEL occasionally offers firmware upgrades to improve the performance of your relay. Changing physical components to upgrade the relay firmware is unnecessary because the SEL-587Z Relay stores firmware in Flash memory.

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

NOTE: SEL strongly recommends that you perform the firmware upgrade at the location of the relay and with a direct connection from the personal computer to one of the serial ports of the relay. Do not attempt to load firmware from a remote location because problems can arise that you will not be able to address from a distance. When upgrading at the substation, do not attempt to load the firmware into the relay through an SEL-2020 or SEL-2030 Communications Processor.

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

- A. Prepare the Relay
- B. Establish a Terminal Connection
- C. Save Settings and Other Data
- D. Start SELBOOT
- E. Download Existing Firmware
- F. Upload New Firmware
- G. Check Relay Self-Tests
- H. Verify Calibration, Status, Breaker Wear, and Metering
- I. Return Relay to Service

Required Equipment

Gather the following equipment before starting this firmware upgrade.

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

Optional Equipment

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

- SEL-5010 Relay Assistant Software program
- SEL-587Z Relay Instruction Manual

Upgrade Procedure

A Prepare the Relay

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

Typically, these include changing settings or disconnecting external voltage sources or output contact wiring to disable relay control functions.
- Step 2. Apply power to your relay.
- Step 3. From the relay front panel, press the **{SET}** pushbutton.
- Step 4. Use the arrow pushbuttons to navigate to **PORT**.
- Step 5. Press the **{SELECT}** pushbutton.
- Step 6. Use the arrow pushbuttons to navigate to the relay serial port you plan to use.
- Step 7. Press the **{SELECT}** pushbutton.
- Step 8. With **SHOW** selected, press the **{SELECT}** pushbutton.
- Step 9. Press the down arrow pushbutton to scroll through the port settings and keep a written record of the value for each setting.

You will use many of these settings later in the upgrade procedure.
- Step 10. At the **EXIT SETTINGS?** prompt, highlight “Yes” and press the **{SELECT}** pushbutton.
- Step 11. Connect an SEL-C234A (or equivalent) serial communications cable to the relay serial port you identified in [Step A.6](#) above.

B Establish Terminal Connection

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

- Step 1. Connect a serial communications cable to the computer serial port.
 - a. Check the back of your computer for a label identifying the serial communications ports.
 - b. Choose a port and connect an SEL-C234A (or equivalent) serial communications cable to the personal computer serial port.

If there is no identification label, connect the cable to any computer serial port. Note that you might later change this computer serial port selection to establish communication between your relay and your computer if this connection is unsuccessful.
- Step 2. Disconnect any other serial port connection.

Step 3. Open HyperTerminal.

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

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

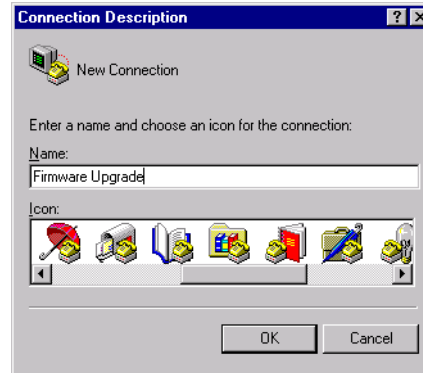


Figure B.1 Establishing a Connection.

Step 5. Select the computer serial port you are using to communicate with the relay (*Figure B.2*) and click **OK**. This port matches the port connection that you made in *Step B.1 on page B.2*.



Figure B.2 Selecting the Computer Serial Port.

NOTE: The settings for your computer (*Figure B.3 on page B.4*) must match the settings you recorded earlier for the relay (e.g., hardware and software flow control settings should match what you recorded in *Step A.9 on page B.2*).

Step 6. Establish serial port communications parameters.

- a. Enter the serial port communications parameters (*Figure B.3*) that correspond to the relay settings you recorded in *Step A.9 on page B.2*.

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

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

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

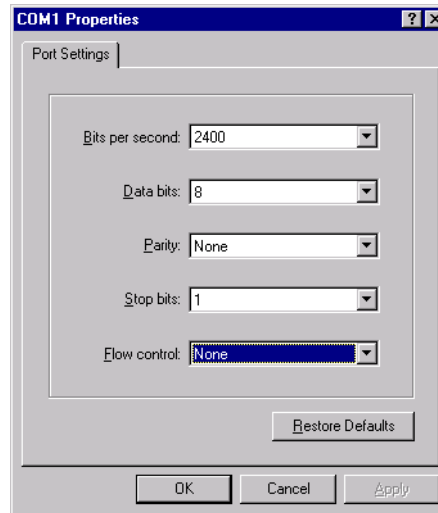


Figure B.3 Determining Communications Parameters for the Computer.

Step 7. Set terminal emulation to VT100.

- a. From the File menu, choose Properties.
- b. Select the Settings tab in the Firmware Upgrade Properties dialog box ([Figure B.4](#)).
- c. Select VT100 from the “Emulation:” list box and click **OK**.

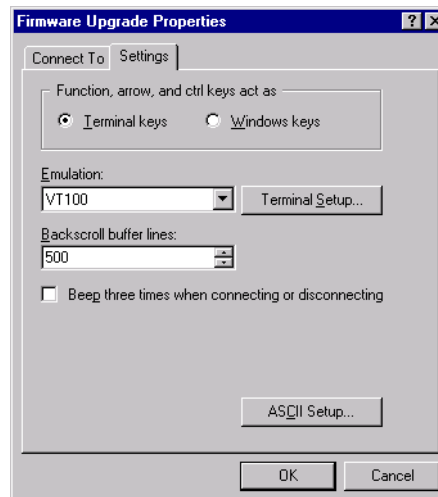


Figure B.4 Setting Terminal Emulation.

Step 8. Confirm serial communication.

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

If this is successful, proceed to [Save Settings and Other Data on page B.6](#).

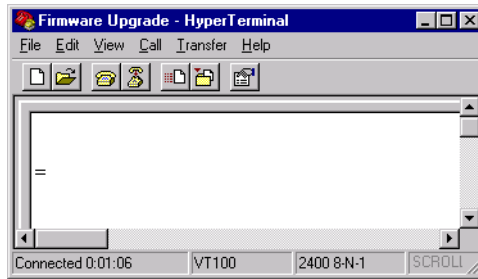


Figure B.5 Terminal Emulation Startup Prompt.

Failure to Connect

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

- Step 1. From the Call menu, choose Disconnect to terminate communication.
- Step 2. Correct your port setting.
 - a. From the File menu, choose Properties.
You should see a dialog box similar to [Figure B.6](#).
 - b. Select a different port in the “Connect using:” list box.

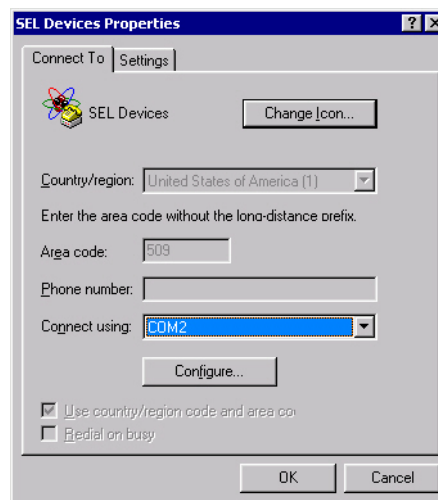


Figure B.6 Correcting Port Setting.

- Step 3. Correct communications parameters.
 - a. From the *filename* Properties dialog box shown in [Figure B.6](#), click Configure.
 - b. You will see a dialog box similar to [Figure B.7](#).
- Step 4. Change settings in the appropriate list boxes to match the settings you recorded in [Step A.9 on page B.2](#) and click **OK**.

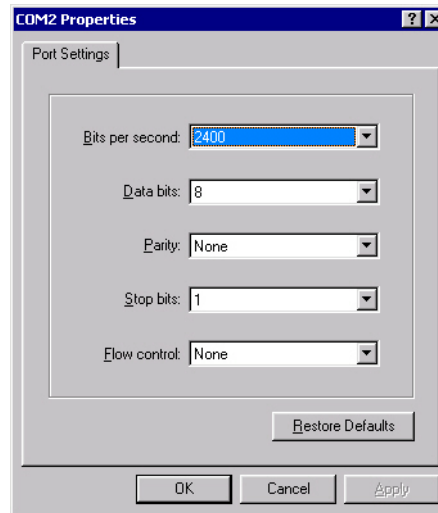


Figure B.7 Correcting Communications Parameters.

- Step 5. From the Call menu, choose Connect to reestablish communication with the relay.
- Step 6. Press **<Enter>** to obtain the “=” prompt in the terminal emulation window.

C Save Settings and Other Data

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

Enter Access Level 2

- Step 1. Using the communications terminal, at Access Level 0 type **ACC<Enter>**.
- Step 2. Type the Access Level 1 password and press **<Enter>**.
You will see the => action prompt.
- Step 3. Type **2AC<Enter>**.
- Step 4. Type the correct Access Level 2 password.
You will see the ==>> action prompt.

View Passwords and FID

- Step 1. Type **PAS<Enter>** at Access Level 2 to view relay passwords.
Make a written record of the original password settings in case you need these passwords later.
- Step 2. Type **ID<Enter>** to view the relay firmware identifier (FID).
Make a written record of the FID identifier number for use in [Download Existing Firmware on page B.9](#) of this document.

Backup Relay Settings

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

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

- Step 1. From the Transfer menu in HyperTerminal, select Capture Text.
- Step 2. Enter a directory and file name for a text file where you will record existing relay settings.
- Step 3. Click **Start**.

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

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

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

- Step 5. From the Transfer menu in HyperTerminal, select Capture Text and click **Stop**.
- Step 6. Print the text file you created in [Step 3](#) through [Step 5](#).
Save this file for later reference.

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

This setting is SPEED in the **SHO P** relay settings output. The SPEED value should be the same as the value you recorded earlier in [Prepare the Relay on page B.2](#).

D Start SELBOOT

- Step 1. Start the relay SELBOOT program.

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

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

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

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

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

The relay responds, "Relay Disabled."

- Step 2. Wait for the SELBOOT program to load.

The front-panel LCD screen displays the SELBOOT-500-Rxxx firmware number (e.g., "SELboot-500- R100").

xxx is the SELBOOT revision number and is a different revision number from the relay firmware revision number.

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

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

You will see another !> SELBOOT action prompt.

Commands Available in SELBOOT

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

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

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

FLASH Type : 040          Checksum = 370E 0K
!>
```

Establish a High-Speed Connection

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

Match Computer Communications Speed to the Relay

- Step 1. From the Call menu, choose Disconnect to terminate communication.
- Step 2. From the File menu, choose Properties.
- Step 3. Choose Configure.
- Step 4. Change your computer communications speed to match the new data transmission rate in the relay (*Figure B.8 on page B.8*).
- Step 5. Click **OK** twice.
You should not have to reestablish communication; HyperTerminal reestablishes communication automatically the second time you click **OK**.
- Step 6. Press **<Enter>** to check for the SELBOOT action prompt **!>** indicating that serial communication is successful.

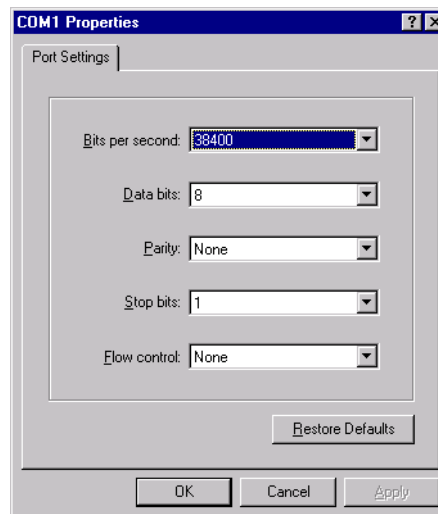


Figure B.8 Matching Computer to Relay Parameters.

E Download Existing Firmware

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

- Step 1. Type **SEN<Enter>** at the SELBOOT prompt to initiate the firmware transfer from the relay to your computer.
- Step 2. From the Transfer menu in HyperTerminal, select Receive File.
You should see a dialog box similar to [Figure B.9](#).
- Step 3. Enter the pathname of a folder on your computer hard drive where you want to record the existing relay firmware
- Step 4. Select “1K Xmodem” if you have this protocol available on your PC.
- Step 5. If you do not have 1K Xmodem, choose “Xmodem.”
- Step 6. Click **Receive**.

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

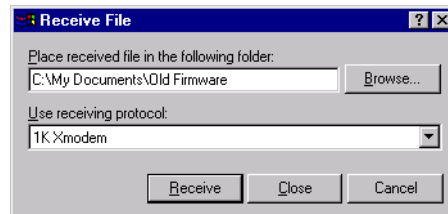


Figure B.9 Example Receive File Dialog Box.

- Step 7. Enter a filename that clearly identifies your existing firmware version ([Figure B.10](#)).

SEL lists the firmware revision number first, then the product number. These files have an .s19 extension (e.g., r100587Z.s19).

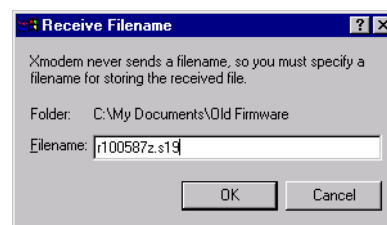


Figure B.10 Example Filename Identifying Old Firmware Version.

For a successful download, you should see a dialog box similar to [Figure B.11](#). After the transfer, the relay responds, “Download completed successfully!”

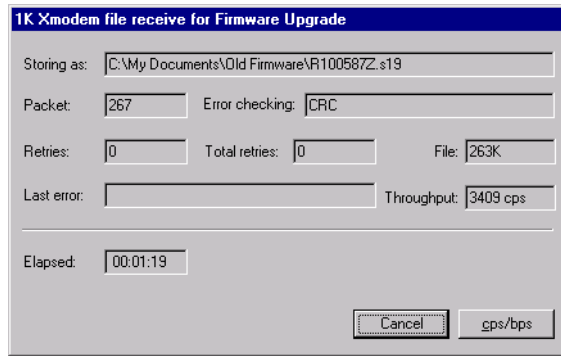


Figure B.11 Downloading of Old Firmware.

F Upload New Firmware

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

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

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

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

The relay prompts whether you want to erase the existing firmware.

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

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

The relay responds, “Erasing,” and erases the existing firmware.

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

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

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

- Step 5. Send new firmware to the relay.

- a. From the Transfer menu in HyperTerminal, choose Send File (*Figure B.12*).
- b. In the Filename text box, type the location and filename of your new firmware or use the Browse button to select the firmware file.

- c. In the Protocol text box, select “1K Xmodem” if you have this protocol available.
If you do not have 1K Xmodem, select “Xmodem.”
- d. Click **Send** to send the file containing the new firmware (e.g., r101587Z.s19).

You should see a dialog box similar to [Figure B.13 on page B.11](#). Incrementing numbers in the Packet box and a bar advancing from left to right in the File box indicate a transfer in progress.

NOTE: The relay restarts in SELBOOT if relay power fails while receiving new firmware after the firmware is erased. At power up, the relay defaults to a data speed of 2400 bps. Perform the steps beginning at [Establish Terminal Connection on page B.2](#) to increase the serial connection data speed. Then resume the firmware upgrade process again at [Upload New Firmware on page B.10](#) of this document.

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

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

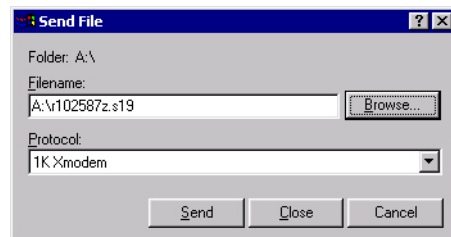


Figure B.12 Selecting the New Firmware to Send to the Relay.

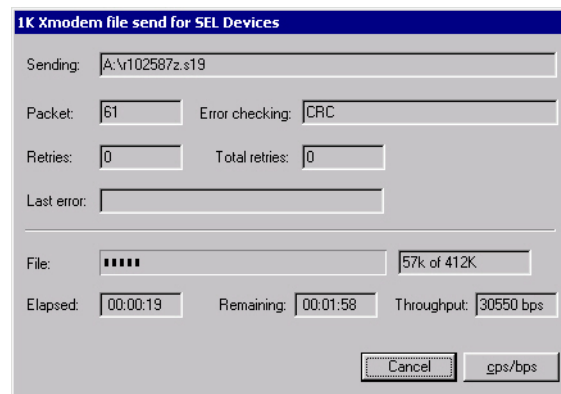


Figure B.13 Transferring New Firmware to the Relay

G Check Relay Self-Tests

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

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

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

If the EN LED is illuminated and the Access Level 0 prompt is visible, proceed to [Verify Calibration, Status, and Metering on page B.13](#). If this is not the case, perform the following steps.

EN LED Illuminated But No Access Level 0 Prompt

If the EN LED is illuminated but the Access Level 0 prompt does not appear, the relay data transmission rate is at the value that you recorded in [Prepare the Relay on page B.2](#).

- Step 1. Change the computer terminal speed to match the relay data transmission rate. Perform [Step A.3](#) through [Step A.10 on page B.2](#). Next, follow the procedure in [Match Computer Communications Speed to the Relay on page B.8](#).
- Step 2. Press **<Enter>** to check for the Access Level 0 action prompt = indicating that serial communication is successful.
- Step 3. Proceed to [Verify Calibration, Status, and Metering on page B.13](#).

EN LED Not Illuminated

If the EN LED does not illuminate, the relay can display various self-test status messages.

- Step 1. Press the **{STATUS}** pushbutton on the relay front panel to view front-panel status messages. Use the up and down pushbuttons to scroll through the various status messages.

If no fail status message appears, contact your Technical Service Center (see [Section 10: Testing and Troubleshooting](#)).

If fail status messages display CR_RAM and EEPROM messages, the relay data transmission rate has reverted to the factory default of 2400 bps, settings are at the default values, and the relay default passwords are active.
- Step 2. Change the computer terminal speed to match the default relay data transmission rate (2400 bps). (See [Match Computer Communications Speed to the Relay on page B.8](#).)
 - a. Terminate relay communication.
 - b. Change communications software settings to 2400 bps, 8 data bits, 1 stop bit.
 - c. Reestablish communication.
 - d. Press **<Enter>** to check for the Access Level 0 action prompt = indicating that serial communication is successful
- Step 3. Issue the **ACC** and **2AC** commands to enter Access Level 2.

The factory default passwords are in effect; use the default relay passwords listed in the **PAS** command in [Section 7: ASCII Command Reference](#).
- Step 4. Type **R_S<Enter>** to restore factory default settings in the relay.

The relay prompts whether to restore default settings. If your relay does not accept the **R_S** command, contact the factory or your Technical Service Center for assistance.
- Step 5. Type **Y<Enter>**.

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

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

- Step 6. Press **<Enter>** to check for the Access Level 0 action prompt = indicating that serial communication is successful.
- Step 7. Use the **ACC** and **2AC** commands to reenter Access Level 2.
The factory default passwords are in effect; use the default relay passwords listed in the **PAS** command in [Section 7: ASCII Command Reference](#).
- Step 8. Restore original settings.
- If you have SEL-5010 software, restore original settings as necessary.
 - If you do not have the SEL-5010 software, restore original settings by issuing the necessary **SET** commands: **SET**, **SET L**, **SET P 1**, **SET P F**, **SET T**, and **SET R**.
- Step 9. Use the **PAS** command to set the original relay passwords.
- Type **PAS 1: Ot3579<Enter>** to set the Access Level 1 password to Ot3579.
Use a similar format for other password levels. The **PAS** command is case sensitive, so the relay treats lower-case and upper-case letters differently.
- Step 10. If any failure status messages still appear on the relay display, see the [Section 10: Testing and Troubleshooting](#). You can also contact the factory or your Technical Service Center for assistance.

H Verify Calibration, Status, and Metering

- Step 1. Use the **ACC** and **2AC** commands to reenter Access Level 2.
- Step 2. Type **SHO C<Enter>** to verify the relay calibration settings.
If the settings do not match the settings contained in the text file you recorded in [Save Settings and Other Data on page B.6](#), contact the factory or your Technical Service Center for assistance.
- Step 3. Type **ID<Enter>** to display relay firmware information including the relay part number. Confirm that the new firmware revision number appears in the FID string.
- Step 4. Reenter Access Level 2 (if necessary).
- Step 5. Type **STA<Enter>** to verify that all relay self-test parameters are within tolerance.
- Step 6. Apply current and voltage signals to the relay.
- Step 7. Type **MET<Enter>** to verify that the current and voltage signals are correct.
- Step 8. Use the **TRIGGER (TRI)** and **EVENT (EVE)** commands to verify that the magnitudes of the current and voltage signals you applied to the relay match those displayed in the event report.
- Step 9. If these values do not match, check the relay settings and wiring.

I Return Relay to Service

- Step 1. Follow your company procedures for returning a relay to service.
- Step 2. Autoconfigure the SEL-20x0 port if you have an SEL-2020 or SEL-2030 Communications Processor connected to the relay.

This step reestablishes automatic data collection between the SEL-20x0 Communications Processor and the SEL-587Z Relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

The relay is now ready for your commissioning procedure.

Appendix C

Relay Word Bits

Software programs use variables as building blocks in realizing the relay algorithms. Digital words are eight bits in length, each bit having a value of either logical 1 or logical 0, depending on the status of the variable. The Relay Word is a collection of selected program variables. Some of the Relay Word bits are used in fixed logic that cannot be altered, but many are available to create custom logic to satisfy a particular application. The Relay Word thus contains placeholders, the Relay Word bits, for each of the protection elements and logic conditions in the SEL-587Z Relay. Each Relay Word bit is updated every eighth-cycle. For more information on using Relay Word bits to program the relay, see [SELOGIC Control Equations on page 4.11 in Section 4: Control Logic](#).

Note that the relay saves rows 1–13 of the Relay Word for the event reports. [Table C.1](#) lists the SEL-587Z Relay Word. [Table C.2](#) through [Table C.10](#) define the Relay Word bits.

Table C.1 SEL-587Z Relay Word Bit Summary

Row	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
0	EN	87	50	51	A	B	C	G
1	51P1	51PT	51PR	51A	51AT	51AR	51B	51BT
2	51BR	51C	51CT	51CR	51G	51GT	51GR	51Q
3	51QT	51QR	*	50P1	50P2	50P3	50A1	50A2
4	50B1	50B2	50C1	50C2	50G1	50G2	50Q1	50Q2
5	87A1	87A2	87B1	87B2	87C1	87C2	*	*
6	*	*	*	IN1	IN2	OC	CC	CF
7	LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8
8	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8
9	SV1	SV2	SV3	SV4	SV5	SV6	SV7	SV8
10	SV9	SV10	SV11	SV12	SV13	SV14	*	*
11	TRIP1	TRIP2	TRIP3	CLOSE	*	PDEM	GDEM	QDEM
12	SV5T	SV6T	SV7T	SV8T	SV9T	SV10T	SV11T	SV12T
13	SV13T	SV14T	*	ALARM	OUT1	OUT2	OUT3	OUT4

Table C.2 Relay Word Bits: Overcurrent Elements

Row	Name	Description
1	51P1	Phase time-overcurrent element pickup
1	51PT	Phase time-overcurrent element
1	51PR	Phase time-overcurrent element reset
1	51A	A-phase time-overcurrent element pickup
1	51AT	A-phase time-overcurrent element
1	51AR	A-phase time-overcurrent element reset
1	51B	B-phase time-overcurrent element pickup
1	51BT	B-phase time-overcurrent element
2	51BR	B-phase time-overcurrent element reset
2	51C	C-phase time-overcurrent element pickup
2	51CT	C-phase time-overcurrent element
2	51CR	C-phase time-overcurrent element reset
2	51G	Residual ground time-overcurrent element pickup
2	51GT	Residual ground time-overcurrent element
2	51GR	Residual ground time-overcurrent element reset
2	51Q	Negative-sequence time-overcurrent element pickup
3	51QT	Negative-sequence time-overcurrent element
3	51QR	Negative-sequence time-overcurrent element reset
3	*	Reserved for future use
3	50P1	First phase overcurrent element pickup
3	50P2	Second phase overcurrent element pickup
3	50P3	Third phase overcurrent element pickup
3	50A1	First single-phase instantaneous overcurrent element
3	50A2	Second single-phase instantaneous overcurrent element
4	50B1	First single-phase instantaneous overcurrent element
4	50B2	Second single-phase instantaneous overcurrent element
4	50C1	First single-phase instantaneous overcurrent element
4	50C2	Second single-phase instantaneous overcurrent element
4	50G1	First residual ground overcurrent element pickup
4	50G2	Second residual ground overcurrent element pickup
4	50Q1	First negative-sequence definite-time overcurrent element pickup
4	50Q2	Second negative-sequence definite-time overcurrent element pickup

Table C.3 Relay Word Bits: High-Impedance Elements

Row	Name	Description
5	87A1	A-phase first high-impedance element pickup
5	87A2	A-phase second high-impedance element pickup
5	87B1	B-phase first high-impedance element pickup
5	87B2	B-phase second high-impedance element pickup
5	87C1	C-phase first high-impedance element pickup
5	87C2	C-phase second high-impedance element pickup
5	*	Reserved for future use
5	*	Reserved for future use
6	*	Reserved for future use
6	*	Reserved for future use
6	*	Reserved for future use

Table C.4 Relay Word Bits: Local Bits

Row	Name	Description
7	LB1	Local Bit 1
7	LB2	Local Bit 2
7	LB3	Local Bit 3
7	LB4	Local Bit 4
7	LB5	Local Bit 5
7	LB6	Local Bit 6
7	LB7	Local Bit 7
7	LB8	Local Bit 8

Table C.5 Relay Word Bits: Remote Bits

Row	Name	Description
8	RB1	Remote Bit 1
8	RB2	Remote Bit 2
8	RB3	Remote Bit 3
8	RB4	Remote Bit 4
8	RB5	Remote Bit 5
8	RB6	Remote Bit 6
8	RB7	Remote Bit 7
8	RB8	Remote Bit 8

Table C.6 Relay Word Bits: SELogic Control Equation Variables

Row	Name	Description
9	SV1	SELOGIC control equation variable
9	SV2	SELOGIC control equation variable
9	SV3	SELOGIC control equation variable
9	SV4	SELOGIC control equation variable
9	SV5	SELOGIC control equation variable timer input
9	SV6	SELOGIC control equation variable timer input
9	SV7	SELOGIC control equation variable timer input
9	SV8	SELOGIC control equation variable timer input
10	SV9	SELOGIC control equation variable timer input
10	SV10	SELOGIC control equation variable timer input
10	SV11	SELOGIC control equation variable timer input
10	SV12	SELOGIC control equation variable timer input
10	SV13	SELOGIC control equation variable timer input
10	SV14	SELOGIC control equation variable timer input
10	*	Reserved for future use
10	*	Reserved for future use
12	SV5T	SELOGIC control equation variable timer output
12	SV6T	SELOGIC control equation variable timer output
12	SV7T	SELOGIC control equation variable timer output
12	SV8T	SELOGIC control equation variable timer output
12	SV9T	SELOGIC control equation variable timer output
12	SV10T	SELOGIC control equation variable timer output
12	SV11T	SELOGIC control equation variable timer output
12	SV12T	SELOGIC control equation variable timer output
13	SV13T	SELOGIC control equation variable timer output
13	SV14T	SELOGIC control equation variable timer output
13	*	Reserved for future use

Table C.7 Relay Word Bits: Trip/Close Logic

Row	Name	Description
11	TRIP1	Trip 1 logic output
11	TRIP2	Trip 2 logic output
11	TRIP3	Trip 3 logic output
11	CLOSE	Close logic output
11	*	Reserved for future use

Table C.8 Relay Word Bits: Demand Elements

Row	Name	Description
11	PDEM	Phase demand current above pickup setting
11	GDEM	Zero-sequence demand current above pickup setting
11	QDEM	Negative-sequence demand current above pickup setting

Table C.9 Relay Word Bits: Input and Output Contacts

Row	Name	Description
6	IN1	Input IN1
6	IN2	Input IN2
13	ALARM	Output contact ALARM
13	OUT1	Output contact OUT1
13	OUT2	Output contact OUT2
13	OUT3	Output contact OUT3
13	OUT4	Output contact OUT4

Table C.10 Relay Word Bits: Miscellaneous

Row	Name	Description
6	OC	Open Command
6	CC	Close Command
6	CF	Close failure logic output

Table C.11 Alphabetic List of Relay Word Bits (Sheet 1 of 3)

Name	Definition	Row
50A1	First single-phase instantaneous overcurrent element	3
50A2	Second single-phase instantaneous overcurrent element	3
50B1	First single-phase instantaneous overcurrent element	4
50B2	Second single-phase instantaneous overcurrent element	4
50C1	First single-phase instantaneous overcurrent element	4
50C2	Second single-phase instantaneous overcurrent element	4
50G1	First residual ground overcurrent element pickup	4
50G2	Second residual ground overcurrent element pickup	4
50P1	First phase overcurrent element pickup	3
50P2	Second phase overcurrent element pickup	3
50P3	Third phase overcurrent element pickup	3
50Q1	First neg.-seq. definite-time overcurrent element pickup	4
50Q2	Second neg.-seq. definite-time overcurrent element pickup	4
51A	A-phase time-overcurrent element pickup	1
51AR	A-phase time-overcurrent element reset	1
51AT	A-phase time-overcurrent element	1
51B	B-phase time-overcurrent element pickup	1
51BR	B-phase time-overcurrent element reset	2
51BT	B-phase time-overcurrent element	1

Table C.11 Alphabetic List of Relay Word Bits (Sheet 2 of 3)

Name	Definition	Row
51C	C-phase time-overcurrent element pickup	2
51CR	C-phase time-overcurrent element reset	2
51CT	C-phase time-overcurrent element	2
51G	Residual ground time-overcurrent element pickup	2
51GR	Residual ground time-overcurrent element reset	2
51GT	Residual ground time-overcurrent element	2
51P1	Phase time-overcurrent element pickup	1
51PR	Phase time-overcurrent element reset	1
51PT	Phase time-overcurrent element	1
51Q	Negative-sequence time-overcurrent element pickup	2
51QR	Negative-sequence time-overcurrent element reset	3
51QT	Negative-sequence time-overcurrent element	3
87A1	A-phase first high-impedance element pickup	5
87A2	A-phase second high-impedance element pickup	5
87B1	B-phase first high-impedance element pickup	5
87B2	B-phase second high-impedance element pickup	5
87C1	C-phase first high-impedance element pickup	5
87C2	C-phase second high-impedance element pickup	5
ALARM	Output contact ALARM	13
CC	Close command	6
CF	Close failure logic output	6
CLOSE	Close logic output	11
GDEM	Zero-sequence demand current above pickup setting	11
IN1	Input IN1	6
IN2	Input IN2	6
LB1	Local Bit 1	7
LB2	Local Bit 2	7
LB3	Local Bit 3	7
LB4	Local Bit 4	7
LB5	Local Bit 5	7
LB6	Local Bit 6	7
LB7	Local Bit 7	7
LB8	Local Bit 8	7
OC	Open command	6
OUT1	Output contact OUT1	13
OUT2	Output contact OUT2	13
OUT3	Output contact OUT3	13
OUT4	Output contact OUT4	13
PDEM	Phase demand current above pickup setting	11
QDEM	Negative-sequence demand current above pickup setting	11
RB1	Remote Bit 1	8

Table C.11 Alphabetic List of Relay Word Bits (Sheet 3 of 3)

Name	Definition	Row
RB2	Remote Bit 2	8
RB3	Remote Bit 3	8
RB4	Remote Bit 4	8
RB5	Remote Bit 5	8
RB6	Remote Bit 6	8
RB7	Remote Bit 7	8
RB8	Remote Bit 8	8
SV1	SELOGIC control equation variable	9
SV10	SELOGIC control equation variable timer input	10
SV10T	SELOGIC control equation variable timer output	12
SV11	SELOGIC control equation variable timer input	10
SV11T	SELOGIC control equation variable timer output	12
SV12	SELOGIC control equation variable timer input	10
SV12T	SELOGIC control equation variable timer output	12
SV13	SELOGIC control equation variable timer input	10
SV13T	SELOGIC control equation variable timer output	13
SV14	SELOGIC control equation variable timer input	10
SV14T	SELOGIC control equation variable timer output	13
SV2	SELOGIC control equation variable	9
SV3	SELOGIC control equation variable	9
SV4	SELOGIC control equation variable	9
SV5	SELOGIC control equation variable timer input	9
SV5T	SELOGIC control equation variable timer output	12
SV6	SELOGIC control equation variable timer input	9
SV6T	SELOGIC control equation variable timer output	12
SV7	SELOGIC control equation variable timer input	9
SV7T	SELOGIC control equation variable timer output	12
SV8	SELOGIC control equation variable timer input	9
SV8T	SELOGIC control equation variable timer output	12
SV9	SELOGIC control equation variable timer input	10
SV9T	SELOGIC control equation variable timer output	12
TRIP1	Trip 1 logic output	11
TRIP2	Trip 2 logic output	11
TRIP3	Trip 3 logic output	11

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Appendix D

Modbus RTU Communications Protocol

Modbus Overview

This appendix describes Modbus® RTU communications features supported by the SEL-587Z Relay. Complete specifications for the Modbus protocol are available from the Modicon Web site at www.modicon.com.

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-587Z Modbus communication allows a Modbus master device to:

- Acquire metering, monitoring, and event data from the relay.
- Control SEL-587Z output contacts.
- Read the SEL-587Z 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 D.1](#).

Table D.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-587Z 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-587Z are described in [Table D.2 on page D.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-587Z supports the Modbus function codes shown in [Table D.2](#).

Table D.2 SEL-587Z 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
07h	Read Exception Status
08h	Loopback Diagnostic
10h	Preset Multiple Registers
64h	Scattered Register Read

Exception Responses

The SEL-587Z sends an exception code under the conditions described in [Table D.3](#).

Table D.3 SEL-587Z Modbus Exception Codes

Exception Code	Error Type	Description
01	Illegal Function Code	The received function code is either undefined or unsupported.
02	Illegal Data Address	The received command contains an unsupported address in the data field.
03	Illegal Data Value	The received command contains a value that is out of range.
04	Device Error	The SEL-587Z is in the wrong state for the requested function.
06	Busy	The SEL-587Z 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 D.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-587Z 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-587Z, 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 D.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:

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 D.9 on page D.8](#) 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 D.5 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 zeroes to make an even byte.

Input numbers are defined below:

Input Numbers	Description
1	Input 1
2	Input 2

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:

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 D.18 on page D.16](#). 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 D.6 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:

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 D.18 on page D.16](#). You may read a maximum of 125 registers at once with this function code.

Table D.7 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:

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 D.8 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-587Z are listed in [Table D.9 on page D.8](#). The physical coils (Coils 1–5) are self-resetting. If the relay is disabled or the breaker jumper is not installed, it will respond with error code 4 (Device Error). Remote Bit Coils 14–21 return zero when read. Remote Bit Coils 6–13 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.

Table D.9 SEL-587Z Command Coils

Coil	Field
1	OUT1
2	OUT2
3	OUT3
4	OUT4
5	ALARM
6	RB1
7	RB2
8	RB3
9	RB4
10	RB5
11	RB6
12	RB7
13	RB8
14	Pulse RB1
15	Pulse RB2
16	Pulse RB3
17	Pulse RB4
18	Pulse RB5
19	Pulse RB6
20	Pulse RB7
21	Pulse RB8

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

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-587Z 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 D.10 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:

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

07h Read Exception Status Command

The SEL-587Z uses this function to allow a Modbus master to read the present status (get a “snapshot” view) of the relay and protected circuit by reading eight predefined status bits.

Table D.11 07h Read Exception Status Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (07h)
0 bytes	No Data Fields Are Sent
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (07h)
1 byte	Status Byte
2 bytes	CRC-16
The status byte is sent most significant bit first, and consists of the following bits:	
Bit 0	OUT4 Status
Bit 1	OUT3 Status
Bit 2	OUT2 Status
Bit 3	OUT1 Status
Bit 4	Alarm Output status
Bit 5	Input 2 Status
Bit 6	Input 1 Status
Bit 7	Relay Status

If the bit is set to 1, the following are true:

- Output and Alarm contacts are asserted.
- Relay inputs are asserted.
- Relay is disabled.

If the bit is set to 0, the following are true:

- Output and Alarm contacts are deasserted.
- Relay inputs are deasserted.
- Relay is enabled.

The relay response to errors in the query is shown below:

Error	Error Code Returned	Communication Counter Increments
Format error	Illegal Data Value (03h)	Bad Packet Format

08h Loopback Diagnostic Command

The SEL-587Z 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 D.12 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:

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 D.13 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:

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

64h Scattered Register Read

The SEL-587Z uses this function to allow a Modbus master to read noncontiguous registers in a single request. A maximum of 100 registers can be read in a single query.

Table D.14 64h Scattered Register Read Command (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (64h)
1 byte	Query Data Length
1 byte	Subfunction Code (04h) ^a
1 byte	Transmission Number
2 bytes	Address of First Register

Table D.14 64h Scattered Register Read Command (Sheet 2 of 2)

Bytes	Field
2 bytes	Address of Second Register
•	•
•	•
•	•
2 bytes	Address of nth Register
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (64h)
1 byte	Response Data Length
1 byte	Subfunction Code (04h) ^a
1 byte	Transmission Number
2 bytes	Data from First Register
2 bytes	Data from Second Register
•	•
•	•
•	•
2 bytes	Data from nth Register
2 bytes	CRC-16

^a Only subfunction 04h is supported.

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

Error	Error Code Returned	Communication Counter Increments
Incorrect/Illegal query data length	Illegal Data Value (03h)	Bad Packet Format
Invalid subfunction code	Illegal Data Value (03h)	Illegal Function Code/Op Code
Illegal register address	Illegal Data Address (02h)	Invalid Address

Controlling Output Contacts

The SEL-587Z Modbus Register Map ([Table D.18 on page D.16](#)) includes three fields that allow a Modbus master to force the relay to perform a variety of operations. Use Modbus function codes 06h or 10h to write the appropriate command codes and parameters into the registers shown in [Table D.18 on page D.16](#). If function code 06h is used to write to a command code that has parameters, the parameters must be written before the command code.

Table D.15 SEL-587Z Modbus Command Region

Address	Field
0090h	Command Code
0091h	Parameter 1
0092h	Parameter 2

Table D.16 defines the command codes, their function and associated parameters, and the Modbus function code used to initiate the related command code.

NOTE: Following a reset of the History Buffer, the History Selection, Event Selection, and Event Channel Selection (see [Table D.18 on page D.16](#)) remain at the same values as previously set. Additionally, History and Event records that do not contain data, because they are cleared, will return “not applicable” (8000 hex) for all values.

Table D.16 Modbus Command Codes

Command Code	Function	Parameter Definition	Modbus Function Code
01	Open	No Parameter	06h, 10h
02	Close	No Parameter	06h, 10h
03	Reset Targets	No Parameter	06h, 10h
04	Trigger	No Parameter	06h, 10h
05	Pulse OUT1	1–30 seconds duration (defaults to 1 second)	06h, 10h
06	Pulse OUT2	1–30 seconds duration (defaults to 1 second)	06h, 10h
07	Pulse OUT3	1–30 seconds duration (defaults to 1 second)	06h, 10h
08	Pulse OUT4	1–30 seconds duration (defaults to 1 second)	06h, 10h
09	Pulse Alarm	1–30 seconds duration (defaults to 1 second)	06h, 10h
10	Switch Protocol ^a	0080h	06h, 10h
11 ^b	Reset Data Regions	0000 0000 0000 0001 Demand Metering 0000 0000 0000 0010 Peak Metering 0000 0000 0000 0100 History Buffer 0000 0000 0000 1000 Communication Counters	06h, 10h

^a Switches the serial port protocol to SEL-ASCII, the baud rate, parity, stop bits, and flow control remain the same.

^b Parameter of Command code 11 is bit masked to allow you to manipulate several data regions simultaneously.

Remote Bits- Command Code 12: 0Ch-Control Remote Bits

This code controls the remote bits. This command code has two parameters.

Parameter 1 determines the bit operation.

Value	Operation
1	Set
2	Clear
3	Pulse (1/8 cycle)

Parameter 2 determines which bit to control. It is bit masked for future expansion, but only one bit can be controlled at a time. The highest numbered bit will be controlled if more than one bit occurs in the parameter.

Bit Pattern	Remote Bit
0000 0000 0000 0001	RB1
0000 0000 0000 0010	RB2
0000 0000 0000 0100	RB3
0000 0000 0000 1000	RB4
0000 0000 0001 0000	RB5
0000 0000 0010 0000	RB6
0000 0000 0100 0000	RB7
0000 0000 1000 0000	RB8

Error Codes:

- If the relay is disabled while the commands are issued, the relay will return error code 04h (device error).
- If the **TRIGGER** command cannot be executed due to multiple events in progress, the relay will return error code 06h (device busy).
- If the breaker jumper is not installed when a pulse output command is issued, the relay will return error code 04h (device error).

Reading Event Data Using Modbus

The Modbus Register Map ([Table D.18 on page D.16](#)) provides a feature that allows you to download complete event data via Modbus. The SEL-587Z stores the 10 latest 15-cycle, full-length event reports. Refer to *Section 8: Event Reports* for more detailed description.

The event report will contain both analog and digital data. To download the event data using Modbus, proceed as follows:

- Step 1. Write the event number you wish to download at address 00B1h.
- Step 2. Write the channel number you wish to download at address 00B2h.
- Step 3. Read the four-sample per cycle event data from the Modbus Map.

Table D.17 Assign Event Report Channel Using Address 00B2

Set 00B2	To Read Data From Channel
1	87A
2	87B
3	87C
4	IA
5	IB
6	IC
7	IG
8	Relay Element Status Row 1 ^a
9	Relay Element Status Row 2 ^a
10	Relay Element Status Row 3 ^a
11	Relay Element Status Row 4 ^a
12	Relay Element Status Row 5 ^a
13	Relay Element Status Row 6 ^a
14	Relay Element Status Row 7 ^a
15	Relay Element Status Row 8 ^a
16	Relay Element Status Row 9 ^a
17	Relay Element Status Row 10 ^a
18	Relay Element Status Row 11 ^a
19	Relay Element Status Row 12 ^a
20	Relay Element Status Row 13 ^a

^a Refer to Appendix C: Relay Word Bits to obtain the contents of each relay element status row. Relay Element Status Row 0, which represents targets, is displayed at 00FB in [Table D.18 on page D.16](#).

If you select an event number that has no data available, 8000h will be returned.

Reading History Data Using Modbus

The Modbus Register Map ([Table D.18](#)) provides a feature that allows you to download complete history of the last 10 events via Modbus. The history contains the date and time stamp, type of event that triggered the report, and the targets. Refer to [NOTE 3](#) in the Modbus Map for a list of event types.

To download the history data using Modbus, write the event number (1–10) to address 00C1h. Then read the history of the specific event number you requested from the Modbus Map ([Table D.18](#)).

If you select a history number for which there is no data available, 8000h will be returned.

Modbus Map

All registers are 16 bits with bit locations ranging from 0 to 15.

Relay Word bits, targets, and contact status are mapped in bit positions 8 through 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 D.18 Modbus Map (Sheet 1 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Relay ID						
0000–0016	FID ^a	ASCII String	–	–	–	–
0017–0019	Revision ^a	ASCII String	–	–	–	–
001A–0022	Relay ID ^a	ASCII String	–	–	–	–
0023–002B	Terminal ID ^a	ASCII String	–	–	–	–
002C	Reserved (see <i>NOTE 1</i>)					
002D	Device Tag # ^b	15047	–	–	–	–
002E	Feature Set ID ^b	0	–	–	–	–
002F	Reserved					
Relay Status						
0030	Channel 87A offset value ^c	mV	–5000	5000	1	1
0031	Channel 87A status message ^b 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0032	Channel 87B offset value ^c	mV	–5000	5000	1	1
0033	Channel 87B status message ^b 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0034	Channel 87C offset value ^c	mV	–5000	5000	1	1
0035	Channel 87C status message ^b 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0036	Channel 1A offset value ^c	mV	–5000	5000	1	1

Table D.18 Modbus Map (Sheet 2 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0037	Channel IA status message ^b 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0038	Channel IB offset value ^c	mV	–5000	5000	1	1
0039	Channel IB status message ^b 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
003A	Channel IC offset value ^c	mV	–5000	5000	1	1
003B	Channel IC status message ^b 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
003C	(MOF) DC offset in A/D circuit when a grounded input is selected ^c	mV	–5000	5000	1	1
003D	MOF status message ^b 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
003E	+5 V power supply voltage value ^b	V	0	600	1	0.01
003F	+5 V power ^b supply status message 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0040	+5_REG power ^b supply value	V	0	600	1	0.01
0041	+5_REG power supply status message ^b 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0042	–5_REG power supply value ^c	V	–600	0	1	0.01
0043	–5_REG power supply status message ^b 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–

Table D.18 Modbus Map (Sheet 3 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0044	+10_ps power supply value ^b	V	0	1500	1	0.01
0045	+10_ps power supply status message ^b 0 = OK 1 = Warn 2 = Fail	—	—	—	—	—
0046	−10_ps power supply value ^c	V	−1500	0	1	0.01
0047	−10_ps power supply status message ^b 0 = OK 1 = Warn 2 = Fail	—	—	—	—	—
0048	VBAT power supply value ^b	V	0	500	1	0.01
0049	VBAT power supply status message ^b 0 = OK 1 = Warn 2 = Fail	—	—	—	—	—
004A	TEMP in degrees Celsius ^c	°C	−100	100	1	1
004B	Temperature status ^b 0 = OK 1 = Warn 2 = Fail	—	—	—	—	—
004C	RAM status ^b 0 = OK 2 = Fail	—	—	—	—	—
004D–004F	ROM status ^b 0 = OK 2 = Fail	—	—	—	—	—
004E	CR_RAM status ^b 0 = OK 2 = Fail	—	—	—	—	—
004F	EEPROM status ^b 0 = OK 2 = Fail	—	—	—	—	—
0050	Enable status ^b 0 = relay enabled 2 = relay disabled	—	—	—	—	—
0051–005F	Reserved					

Table D.18 Modbus Map (Sheet 4 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Instantaneous Metering						
0060	Inst. voltage A-phase ^b	Volts	0	65535	1	1
0061	Inst. voltage B-phase ^b	Volts	0	65535	1	1
0062	Inst. voltage C-phase ^b	Volts	0	65535	1	1
0063	Inst. current A-phase ^b	Amps	0	65535	1	1
0064	Inst. current A-phase angle ^b	Degrees	0	36000	1	0.01
0065	Inst. current B-phase ^b	Amps	0	65535	1	1
0066	Inst. current B-phase angle ^b	Degrees	0	36000	1	0.01
0067	Inst. current C-phase ^b	Amps	0	65535	1	1
0068	Inst. current C-phase angle ^b	Degrees	0	36000	1	0.01
0069	Inst. residual current ^b	Amps	0	65535	1	1
006A	Inst. residual current angle ^b	Degrees	0	36000	1	0.01
006B	Inst. neg.-seq. current ^b	Amps	0	65535	1	1
006C	Inst. neg.-seq. current angle ^b	Degrees	0	36000	1	0.01
0072	Inst. neg.-seq. current ^b	Amps	0	65535	1	1
006D–006F	Reserved					
Demand						
0070	Demand current A-phase ^b	Amps	0	65535	1	1
0071	Demand current B-phase ^b	Amps	0	65535	1	1
0072	Demand current C-phase ^b	Amps	0	65535	1	1
0073	Demand residual current I _G ^b	Amps	0	65535	1	1
0074	Demand neg.-seq. current 3I ₂ ^b	Amps	0	65535	1	1

Table D.18 Modbus Map (Sheet 5 of 15)

Address (Hex)	Field	Units	Range			Scale Factor	
			Low	High	Step		
Last Reset Time and Date-Demand Metering							
0075	Time	ss	0	59	1	1	
0076		mm	0	59	1	1	
0077		hh	0	23	1	1	
0078		Date	dd	1	31	1	1
0079		mm	1	12	1	1	1
007A		yyyy	1992	2999	1	1	1
Peak Demand Meter							
007B	Peak demand current A-phase ^b	Amps	0	65535	1	1	
007C	Peak demand current B-phase ^b	Amps	0	65535	1	1	
007D	Peak demand current C-Phase ^b	Amps	0	65535	1	1	
007E	Peak demand residual current I _G ^b	Amps	0	65535	1	1	
007F	Peak demand neg.-seq. current 3I ₂ ^b	Amps	0	65535	1	1	
Last Reset Time and Date-Peak Demand Metering							
0080	Time	ss	0	59	1	1	
0081		mm	0	59	1	1	
0082		hh	0	23	1	1	
0083		Date	dd	1	31	1	1
0084		mm	1	12	1	1	1
0085		yyyy	1992	2999	1	1	1
0086-008F	Reserved						
Relay Time and Date							
0090 (RW) (see <i>NOTE 2</i>)	Time ^b	ss	0	59	1	1	
0091 (RW)	^b	mm	0	59	1	1	
0092 (RW)	^b	hh	0	23	1	1	
0093 (RW)	Date ^b	dd	1	31	1	1	
0094 (RW)	^b	mm	1	12	1	1	
0095 (RW)	^b	yyyy	1992	2999	1	1	
0096-009F	Reserved						

Table D.18 Modbus Map (Sheet 6 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Relay Word						
00A0	Targets 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 = G Bit 9 = C Bit 10 = B Bit 11 = A Bit 12 = 51 Bit 13 = 50 Bit 14 = 87 Bit 15 = Enable					
00A1	Contacts 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 = OUT4 Bit 9 = OUT3 Bit 10 = OUT2 Bit 11 = OUT1 Bit 12 = ALARM Bit 13 = IN2 Bit 14 = IN1 Bit 15 = 0					
00A2	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 = 51BT Bit 9 = 51B Bit 10 = 51AR Bit 11 = 51AT					

Table D.18 Modbus Map (Sheet 7 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00A3	Bit 12 = 51A					
	Bit 13 = 51PR					
	Bit 14 = 51PT					
	Bit 15 = 51P					
	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 = 51Q					
	Bit 9 = 51GR					
	Bit 10 = 51GT					
	Bit 11 = 51G					
	Bit 12 = 51CR					
	Bit 13 = 51CT					
	Bit 14 = 51C					
00A4	Bit 15 = 51BR					
	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 = 50A2					
	Bit 9 = 50A1					
	Bit 10 = 50P3					
	Bit 11 = 50P2					
	Bit 12 = 50P1					
	Bit 13 = *					
	Bit 14 = 51QR					
	Bit 15 = 51QT					
	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.					
00A5	Bits 1–7 = 0					
	Bit 8 = 50Q2					

Table D.18 Modbus Map (Sheet 8 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00A6	Bit 9 = 50Q1					
	Bit 10 = 50G2					
	Bit 11 = 50G1					
	Bit 12 = 50C2					
	Bit 13 = 50C1					
	Bit 14 = 50B2					
	Bit 15 = 50B1					
	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 = *					
	Bit 9 = *					
	Bit 10 = 87C2					
	Bit 11 = 87C1					
00A7	Bit 12 = 87B2					
	Bit 13 = 87B1					
	Bit 14 = 87A2					
	Bit 15 = 87A1					
	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 = CF					
	Bit 9 = CC					
	Bit 10 = OC					
	Bit 11 = IN2					
	Bit 12 = IN1					
	Bit 13 = *					
	Bit 14 = *					
	Bit 15 = *					

Table D.18 Modbus Map (Sheet 9 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00A8	Row 7 Bit 0 = 1 if any of bits 8–15 are set to 1. Bit 0 = 0 if all of bits 8–15 are set to 0. Bits 1–7 = 0 Bit 8 = LB8 Bit 9 = LB7 Bit 10 = LB6 Bit 11 = LB5 Bit 12 = LB4 Bit 13 = LB3 Bit 14 = LB2 Bit 15 = LB1					
00A9	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 = RB8 Bit 9 = RB7 Bit 10 = RB6 Bit 11 = RB5 Bit 12 = RB4 Bit 13 = RB3 Bit 14 = RB2 Bit 15 = RB1					
00AA	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 = SV8 Bit 9 = SV7 Bit 10 = SV6 Bit 11 = SV5 Bit 12 = SV4					

Table D.18 Modbus Map (Sheet 10 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00AB	Bit 13 = SV3					
	Bit 14 = SV2					
	Bit 15 = SV1					
	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 = SV14					
	Bit 11 = SV13					
	Bit 12 = SV12					
	Bit 13 = SV11					
	Bit 14 = SV10					
	Bit 15 = SV9					
00AC	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 = QDEM					
	Bit 9 = GDEM					
	Bit 10 = PDEM					
	Bit 11 = *					
	Bit 12 = CLOSE					
	Bit 13 = TRIP3					
	Bit 14 = TRIP2					
	Bit 15 = TRIP1					
00AD	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 = SV12T					
	Bit 9 = SV11T					

Table D.18 Modbus Map (Sheet 11 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00AE	Bit 10 = SV10T					
	Bit 11 = SV9T					
	Bit 12 = SV8T					
	Bit 13 = SV7T					
	Bit 14 = SV6T					
	Bit 15 = SV5T					
	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 = OUT4					
	Bit 9 = OUT3					
	Bit 10 = OUT2					
	Bit 11 = OUT1					
00AF	Bit 12 = ALARM					
	Bit 13 = *					
	Bit 14 = SV14T					
	Bit 15 = SV13T					
Commands (See NOTE 2) (See Table D.16 on page D.13 for a command list)						
00B0 (W)	Command Code					
00B1 (W)	Parameter 1					
00B2 (W)	Parameter 2					
00B3-00BF	Reserved					
History Records						
00C0	Number of History Records ^b		1	10	1	1
00C1 (RW) (see NOTE 2)	History Selection ^b		1	10	1	1
00C2	Event Time ^b	millisec	0	999	1	1
00C3	^b	ss	0	59	1	1
00C4	^b	mm	0	59	1	1
00C5	^b	hh	0	23	1	1
00C6	Event Date ^b	dd	1	31	1	1
00C7	^b	mm	1	12	1	1
00C8	^b	yyyy	2000	2999	1	1
00C9	Event Type ^a	ASCII string				1

Table D.18 Modbus Map (Sheet 12 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00CA		see <i>NOTE 3</i>				
00CB						
00CC						
00CD	Event Type Code	see <i>NOTE 3</i>				1
00CE	Targets	EN 87 50 51 A B C G	0	65535	1	1
00CF	Reserved					
Event Reporting						
00D0	Number event records ^b		1	10	1	1
00D1 (RW) (see <i>NOTE 2</i>)	Event selection ^b		1	10	1	1
00D2 (RW)	Channel selection ^b		1	20	1	1
00D3	1/4 cycle ^c		–32767	32767	1	1
00D4	1/2 cycle ^c		–32767	32767	1	1
00D5	3/4 cycle ^c		–32767	32767	1	1
00D6	1 cycle ^c		–32767	32767	1	1
00D7	1 1/4 cycle ^c		–32767	32767	1	1
00D8	1 1/2 cycle ^c		–32767	32767	1	1
00D9	1 3/4 cycle ^c		–32767	32767	1	1
00DA	2 cycle ^c		–32767	32767	1	1
00DB	2 1/4 cycle ^c		–32767	32767	1	1
00DC	2 1/2 cycle ^c		–32767	32767	1	1
00DD	2 3/4 cycle ^c		–32767	32767	1	1
00DE	3 cycle ^c		–32767	32767	1	1
00DF	3 1/4 cycle ^c		–32767	32767	1	1
00E0	3 1/2 cycle ^c		–32767	32767	1	1
00E1	3 3/4 cycle ^c		–32767	32767	1	1
00E2	4 cycle ^c		–32767	32767	1	1
00E3	4 1/4 cycle ^c		–32767	32767	1	1
00E4	4 1/2 cycle ^c		–32767	32767	1	1
00E5	4 3/4 cycle ^c		–32767	32767	1	1
00E6	5 cycle ^c		–32767	32767	1	1
00E7	5 1/4 cycle ^c		–32767	32767	1	1
00E8	5 1/2 cycle ^c		–32767	32767	1	1
00E9	5 3/4 cycle ^c		–32767	32767	1	1
00EA	6 cycle ^c		–32767	32767	1	1
00EB	6 1/4 cycle ^c		–32767	32767	1	1
00EC	6 1/2 cycle ^c		–32767	32767	1	1

Table D.18 Modbus Map (Sheet 13 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00ED	6 3/4 cycle ^c		-32767	32767	1	1
00EE	7 cycle ^c		-32767	32767	1	1
00EF	7 1/4 cycle ^c		-32767	32767	1	1
00F0	7 1/2 cycle ^c		-32767	32767	1	1
00F1	7 3/4 cycle ^c		-32767	32767	1	1
00F2	8 cycle ^c		-32767	32767	1	1
00F3	8 1/4 cycle ^c		-32767	32767	1	1
00F4	8 1/2 cycle ^c		-32767	32767	1	1
00F5	8 3/4 cycle ^c		-32767	32767	1	1
00F6	9 cycle ^c		-32767	32767	1	1
00F7	9 1/4 cycle ^c		-32767	32767	1	1
00F8	9 1/2 cycle ^c		-32767	32767	1	1
00F9	9 3/4 cycle ^c		-32767	32767	1	1
00FA	10 cycle ^c		-32767	32767	1	1
00FB	10 1/4 cycle ^c		-32767	32767	1	1
00FC	10 1/2 cycle ^c		-32767	32767	1	1
00FD	10 3/4 cycle ^c		-32767	32767	1	1
00FE	11 cycle ^c		-32767	32767	1	1
00FF	11 1/4 cycle ^c		-32767	32767	1	1
0100	11 1/2 cycle ^c		-32767	32767	1	1
0101	11 3/4 cycle ^c		-32767	32767	1	1
0102	12 cycle ^c		-32767	32767	1	1
0103	12 1/4 cycle ^c		-32767	32767	1	1
0104	12 1/2 cycle ^c		-32767	32767	1	1
0105	12 3/4 cycle ^c		-32767	32767	1	1
0106	13 cycle ^c		-32767	32767	1	1
0107	13 1/4 cycle ^c		-32767	32767	1	1
0109	13 1/2 cycle ^c		-32767	32767	1	1
0109	13 3/4 cycle ^c		-32767	32767	1	1
010A	14 cycle ^c		-32767	32767	1	1
010B	14 1/4 cycle ^c		-32767	32767	1	1
010C	14 1/2 cycle ^c		-32767	32767	1	1
010D	14 3/4 cycle ^c		-32767	32767	1	1
010E	15 cycle ^c		-32767	32767	1	1
010F	Reserved					

Table D.18 Modbus Map (Sheet 14 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Event Summary Data						
0110	Event type	ASCII string				
0111		see <i>NOTE 3</i>				
0112						
0113						
0114	Event Type Code	see <i>NOTE 3</i>				
Date and Time						
0115	Event time	millisec	0	999	1	1
0116		ss	0	59	1	1
0117		mm	0	59	1	1
0118		hh	0	23	1	1
0119	Event date	dd	1	31	1	1
011A		mm	1	12	1	1
011B		yyyy	1992	2999	1	1
011C	Event targets	EN 87 50 51 A B C G	1992	2999	1	1
011D	Event Voltage A-phase	Volts	0	65535	1	1
011E	Event Voltage B-phase	Volts	0	65535	1	1
011F	Event Voltage C-phase	Volts	0	65535	1	1
0120	Event Current A-phase	Amps	0	65535	1	1
0121	Event Current B-phase	Amps	0	65535	1	1
0122	Event Current C-phase	Amps	0	65535	1	1
0123	Event Residual Current IG	Amps	0	65535	1	1
0124	Event Neg.-Seq. Current	Amps	0	65535	1	1
0125 – 012F	Reserved					
Maximum Current Limit						
0130	Multiplier (Phase Voltage)	Volts	–32767	32767	1	
0131	Scale	Exponent	–4	4	1	
0132	Multiplier (Phase Current)	Amps	–32767	32767	1	
0133	Scale	Exponent	–4	4	1	
0134–013F	Reserved					

Table D.18 Modbus Map (Sheet 15 of 15)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Communication Counter						
0140	Number of messages received		0	65535	1	1
0141	Number of messages sent to other devices		0	65535	1	1
0142	Invalid address		0	65535	1	1
0143	Bad CRC		0	65535	1	1
0144	UART error		0	65535	1	1
0145	Illegal function code/Op code		0	65535	1	1
0146	Illegal register		0	65535	1	1
0147	Illegal write		0	65535	1	1
0148	Bad packet format		0	65535	1	1
0149	Bad packet length		0	65535	1	1
014A	Reserved	15047	—	—	—	—
014B	Reserved					
014C	Reserved					
014D–1FFA	Reserved					
1FFB	Device tag #					
1FFC	Feature set ID	0				
1FFD–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.

Registers (R) are read-only registers.

All other registers are read only.

NOTE 3. Event Types

ASCII	CODE
TRIP1	93
TRIP2	94
TRIP3	95
ERI	71
ER2	72
PULSE	92
TRIG	15

NOTE 4. Event and History Reporting

The Modbus register map ([Table D.18 on page D.16](#)) provides a feature that allows you to download complete event data or History data via Modbus. The SEL-587Z stores the 10 latest event reports and 10 latest event summaries (History data) in nonvolatile memory.

The event report extraction will be through 20 channels. These channels must be assigned as follows:

Channel	Label
Ch 1	87A
Ch 2	87B
Ch 3	87C
Ch 4	IA
Ch 5	IB
Ch 6	IC
Ch 7	IG
Ch 8 to 20	Relay Words (TAR 1–13)

Extract event report data to obtain the following 1/4-cycle information:

- Input currents from both windings
- Resultant residual currents
- 13 rows of Relay Word bits associated with the applications

The first byte is the Relay Word row associated with the channel; the second byte is 1 if any bit in a particular row changed.

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Glossary

“a” Contact	A breaker auxiliary contact (ANSI Standard Device Number 52A) that closes when the breaker is closed and opens when the breaker is open.
“a” Output	A relay control output that closes when the output relay asserts.
“b” Contact	A breaker auxiliary contact (ANSI Standard Device Number 52B) that opens when the breaker is closed and closes when the breaker is open.
“b” Output	A relay control output that opens when the output relay asserts.
3U, 4U, 5U	The designation of the vertical height of a device in rack units. One rack unit, U, is approximately 1.75 inches or 44.45 mm.
A	Abbreviation for amps or amperes; unit of electrical current flow.
Acceptance Testing	Testing that confirms that the relay meets published critical performance specifications and requirements of the intended application. Such testing involves testing protection elements and logic functions when qualifying a relay model for use on the utility system.
Access Level	A relay command level with a specified set of relay information and commands. Except for Access Level 0, you must have the correct password to enter an access level.
Access Level 0	The least secure and most limited access level. No password protects this level. From this level, you must enter a password to go to a higher level.
Access Level 1	A relay command level you use to monitor (view) relay information. The default access level for the relay front panel.
Access Level 2	The most secure access level where you have total relay functionality and control of all settings types.
Admittance	The reciprocal of impedance; I/V .
AND Operator	Logical AND. An operator in Boolean SELOGIC control equations that requires fulfillment of conditions on both sides of the operator before the equation is true. Represented by * symbol.
ANSI Standard Device Numbers	A list of standard numbers used to represent electrical protection and control relays. Standard device numbers include the following: <ul style="list-style-type: none">25 Synchronism-check element27 Undervoltage Element32 Directional Elements50 Overcurrent Element51 Inverse-Time Overcurrent Element52 AC Circuit Breaker59 Overvoltage Element67 Definite-Time Overcurrent

79	Recloser
86	Breaker Failure Lockout
87	Differential
89	Disconnect

These numbers are frequently used within a suffix letter to further designate their application. The suffix letters used in this instruction manual include the following:

P	Phase Element
G	Residual/Ground Element
N	Neutral/Ground Element
Q	Negative-Sequence (3I2) Element

Apparent Power, S	Complex power expressed in units of volt-amps (VA), kilovolt-amps (kVA), or megavolt-amps (MVA). Accounts for both real (P) and reactive (Q) power dissipated in a circuit: $S = P + jQ$. This is power at the fundamental frequency only; no harmonics are included in this quantity.
Arcing Resistance	The resistance in the arc resulting from a power line fault.
ASCII	Abbreviation for American Standard Code for Information Interchange. Defines a standard set of text characters. The SEL-587Z Relay uses ASCII text characters to communicate using front-panel and rear-panel EIA-232 serial ports on the relay.
ASCII Terminal	A terminal without built-in logic or local processing capability that can only send and receive information.
Assert	To activate. To fulfill the logic or electrical requirements needed to operate a device. To set a logic condition to the true state (logical 1) of that condition. To apply a closed contact to an SEL-587Z Relay input. To close a normally open output contact. To open a normally closed output contact.
AT Modem Command Set Dialing String Standard	The command language standard that Hayes Microcomputer Products, Inc. developed to control auto-dial modems from an ASCII terminal (usually EIA-232 connected) or a PC (personal computer) containing software allowing emulation of such a terminal.
Autoconfiguration	The ability to determine relay type, model number, metering capability, port ID, baud rate, passwords, relay elements, and other information that an IED (an SEL-2020/2030 communications processor) needs to automatically communicate with relays.
Automatic Messages	Messages including status failure and status warning messages that the relay generates at the serial ports and displays automatically on the front-panel LCD.
Autotransformer	A transformer with at least two common windings.
Bandpass Filter	A filter that passes frequencies within a certain range and blocks all frequencies outside this range.
Bolted Fault	A fault with essentially zero impedance or resistance between the shorted conductors.
Boolean Logic Statements	Statements consisting of variables that behave according to Boolean logic operators such as AND, NOT, and OR.

Breaker Auxiliary Contact	An electrical contact associated with a circuit breaker that opens or closes to indicate the breaker position. A form-a breaker auxiliary contact (ANSI Standard Device Number 52A) closes when the breaker is closed and opens when the breaker is open. A form-b breaker auxiliary contact (ANSI Standard Device Number 52B) opens when the breaker is closed and closes when the breaker is open.
Breaker-and-a-half Configuration	A switching station arrangement of three circuit breakers per two circuits; the two circuits share one of the circuit breakers.
CCVT	Coupling-capacitor voltage transformer that uses a capacitive voltage divider to reduce transmission voltage to a level safe for metering and relaying devices. See CVT.
Checksum	A method for checking the accuracy of data transmission involving summation of a group of digits and comparison of this sum to a previously calculated value.
CID	Checksum identification of the firmware.
Cold Start	Beginning a system from power up without carryover of previous system activities.
Commissioning Testing	Testing that serves to validate all system ac and dc connections and confirm that the relay, auxiliary equipment, and SCADA interface all function as intended with your settings. Perform such testing when installing a new protection system.
Communications Protocol	A language for communication between devices.
Contact Input	See Optoisolated Input.
Contact Output	Relay outputs that affect the state of other equipment. Connect contact outputs to circuit breaker trip and close coils, breaker failure auxiliary relays, communications-assisted tripping circuits, and SCADA systems.
Control Input	See Optoisolated Input.
Control Output	See Contact output.
Coordination Timer	A timer that delays an overreaching element so that a downstream device has time to operate.
CT	Current transformer.
CT Subsidence Current	Subsidence current appears as a small exponentially decaying dc current with a long time constant. This current results from the energy trapped in the CT magnetizing branch after the circuit breaker opens to clear a fault or interrupt load.
CTR	Current transformer ratio.
Current Transformer Saturation	The point of maximum current input to a current transformer; any change of input beyond the saturation point fails to produce any appreciable change in output.

CVT	Capacitive voltage transformer that uses a capacitive voltage divider to reduce transmission voltage to a level safe for metering and relaying devices. See CCVT.
Data Bit	A single unit of information that can assume a value of either logical 0 or logical 1 and can convey control, address, information, or frame check sequence data.
DC Offset	A dc component of fault current that results from the physical phenomenon preventing an instantaneous change of current in an inductive circuit.
DCE Devices	Data communication equipment devices (modems).
Deassert	To deactivate. To remove the logic or electrical requirements needed to operate a device. To clear a logic condition to its false state (logical 0). To open the circuit or open the contacts across an SEL-587Z Relay input. To open a normally open output contact. To close a normally closed output contact.
Debounce Time	The time that masks the period when relay contacts continue to move after closing; debounce time covers this indeterminate state.
Delta	A phase-to-phase series connection of circuit elements, particularly voltage transformers or loads.
Demand Meter	A measuring function that calculates a thermal average of instantaneous measurements over time.
Differential Protection	A protection scheme that responds to the difference between incoming and outgoing electrical quantities, usually currents.
DMTC Period	The time of the demand meter time constant in demand metering.
Dropout Time	The time measured from the removal of an input signal until the output signal deasserts. You can set the time, in the case of a logic variable timer, or the dropout time can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element dropout time.
DTE Devices	Data terminal equipment (computers, terminals, printers, relays, etc.).
Dumb Terminal	See ASCII terminal.
EEPROM	Electrically Erasable Programmable Read-Only Memory. Nonvolatile memory where relay settings, event reports, SER records, and other nonvolatile data are stored.
EHV	Extra high voltage. Voltages greater than 230 kV.
EIA-232	Electrical definition for point-to-point serial data communications interfaces, based on the standard EIA/TIA-232. Formerly known as RS-232.
EIA-485	Electrical standard for multidrop serial data communications interfaces, based on the standard EIA/TIA-485. Formerly known as RS-485.
Electromechanical Reset	Setting of the relay to match the reset characteristics of an electromechanical overcurrent relay.
ESD (Electrostatic Discharge)	The sudden transfer of charge between objects at different potentials caused by direct contact or induced by an electrostatic field.

Event History	A quick look at recent relay activity that includes a standard report header; event number, date, time, and type; maximum fault phase current; and targets.
Event Report	A text-based collection of data stored by the relay in response to a triggering condition, such as a fault or ASCII TRI command. The data show relay measurements before and after the trigger, in addition to the states of protection elements, relay inputs, and relay outputs each processing interval. After an electrical system fault, use event reports to analyze relay and system performance.
Event Summary	<p>A shortened version of stored event reports. An event summary includes items such as event date and time, event type, prefault and fault voltages, currents, and sequence current.</p> <p>The relay sends an event report summary (if auto messaging is enabled) to the relay serial port a few seconds after an event.</p>
Fail-Safe	Refers to an output that is open during normal relay operation and closed when relay power is removed or if the relay fails. Configure alarm outputs for fail-safe operation.
Falling Edge	Transition from logical 1 to logical 0.
Falling-Edge Trigger	Boolean SELLOGIC control equation operator that triggers an operation upon logic detection of a falling edge. Represented by the \ symbol.
Fast Meter	SEL binary serial port command used to collect metering data with SEL relays.
Fast Operate	SEL binary serial port command used to perform control with SEL relays.
FID	Relay firmware identification string. Lists the relay model, firmware version and date code, and other information that uniquely identifies the firmware installed in a particular relay.
Firmware	The nonvolatile program stored in the relay that defines relay operation.
Flash Memory	A type of nonvolatile relay memory used for storing large blocks of nonvolatile data.
Fundamental Frequency	The component of the measured electrical signal with a frequency equal to the normal electrical system frequency, usually 50 Hz or 60 Hz. Generally used to differentiate between the normal system frequency and any harmonic frequencies present.
Global Settings	General settings including those for relay and station identifiers, date format, phase rotation, nominal system frequency.
Ground Overcurrent Elements	Elements that operate by comparing a residual ground calculation of the three-phase inputs with the residual overcurrent threshold setting. The relay asserts ground overcurrent elements when a relay residual current calculation exceeds ground current setting thresholds.
Hexadecimal Address	A register address consisting of a numeral with an “h” suffix or a “0x” prefix.
High-Impedance Differential Relay	A device connected in parallel with paralleled CTs that form a differential protection zone. During an external fault, the high-impedance forces circulating fault current to flow through the saturated CT instead of the relay.

HMI	Human machine interface.
HV	High voltage. System voltage greater than or equal to 100 kV and less than 230 kV.
IA, IB, IC	Measured A-phase, B-phase, and C-phase currents.
IED	Intelligent electronic device.
IG	Residual current, calculated from the sum of the phase currents. In normal, balanced operation, this current is very small or zero.
Infinite Bus	A constant-voltage bus.
Input Conditioning	The establishment of debounce time and assertion level.
Instantaneous Meter	Type of meter data presented by the SEL-587Z Relay that includes the present values measured at the relay ac inputs. The word “Instantaneous” is used to differentiate these values from the measurements presented by the demand and other meter types.
IRIG-B	A time code input that the relay can use to set the internal relay clock.
Jitter	Time, amplitude, frequency, or phase-related abrupt, spurious variations in duration, magnitude, or frequency.
L/R	Circuit inductive/resistive ratio.
LED	Light-emitting diode. Used as indicators on the relay front panel.
LMD	SEL distributed port switch protocol.
Local Bits	The Relay Word bit outputs of local control switches that you access through the SEL-587Z Relay front panel. Local control switches replace traditional panel-mounted control switches.
Lockout Relay	An auxiliary relay that prevents operation of associated devices until reset either electrically or by hand.
Logical 0	A “false” logic condition, dropped out element, or deasserted control input or control output.
Logical 1	A “true” logic condition, picked up element, or asserted control input or control output.
Low-Level Test Interface	An interface that provides a means for interrupting the connection between the relay input transformers and the input processing module and allows inserting reduced-scale test quantities for relay testing.
Maintenance Testing	Testing that confirms that the relay is measuring ac quantities accurately and verifies correct functioning of auxiliary equipment, scheme logic, and protection elements.
Maximum Dropout Time	The maximum time interval following a change of input conditions between the deassertion of the input and the deassertion of the output.
MOD	Motor-operated disconnect.
MOV	Metal-oxide varistor.

Negative-Sequence	A configuration of three-phase currents and voltages. The currents and voltages have equal magnitude and a phase displacement of 120°, and have clockwise phase rotation with current and voltage maxima that occur differently from that for positive-sequence configuration. If positive-sequence maxima occur as ABC, negative-sequence maxima occur as ACB.
Negative-Sequence Impedance	Impedance of a device or circuit that results in current flow with a balanced negative-sequence set of voltage sources.
Negative-Sequence Overcurrent Elements	Elements that operate by comparing a negative-sequence calculation of the three-phase secondary inputs with negative-sequence overcurrent setting thresholds. The relay asserts these elements when a relay negative-sequence calculation exceeds negative-sequence current setting thresholds.
NEMA	National Electrical Manufacturers' Association.
Neutral Impedance	An impedance from neutral to ground on a device such as a generator or transformer.
Nonvolatile Memory	Relay memory that persists over time to maintain the contained data even when the relay is deenergized.
NOT Operator	A logical operator that produces the inverse value. Represented by the ! symbol.
Optoisolated Input	Relay inputs for monitoring the state of external circuits. Connect auxiliary relay and circuit breaker contacts to the optoisolated inputs.
OR Operator	Logical OR. A Boolean SELOGIC control equation operator that compares two Boolean values and yields either a logical 1 if either compared Boolean value is logical 1 or a logical 0 if both compared Boolean values are logical 0. Represented by the + symbol.
Parentheses Operator	Use paired parentheses to control the execution of operations in a SELOGIC control equation.
PC	Personal computer.
Peak Demand Metering	Maximum demand and a time stamp for phase currents, negative-sequence and zero-sequence currents, and powers. The SEL-587Z Relay stores peak demand values and the date and time these occurred to nonvolatile storage once per day, overwriting the previously stored value if the new value is larger. Should the relay lose control power, the relay restores the peak demand information saved at 23:50 hours on the previous day.
Phase Overcurrent Element	Elements that operate by comparing the phase current applied to the secondary current inputs with the phase overcurrent setting. The relay asserts these elements when any combination of the phase currents exceeds phase current setting thresholds.
Phase Rotation	The sequence of voltage or current phasors in a multiphase electrical system. In an ABC phase rotation system, the B-phase voltage lags the A-phase voltage by 120°, and the C-phase voltage lags B-phase voltage by 120°. In an ACB phase rotation system, the C-phase voltage lags the A-phase voltage by 120°, and the B-phase voltage lags the C-phase voltage by 120°.
Pickup Time	The time measured from the application of an input signal until the output signal asserts. You can set the time, as in the case of a logic variable timer, or

	the pickup time can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element pickup time.
Pinout	The definition or assignment of each electrical connection at an interface. Typically refers to a cable, connector, or jumper.
Port Settings	Communications port settings such as Data Bits, Speed, and Stop Bits.
Positive-Sequence	A configuration of three-phase currents and voltages. The currents and voltages have equal magnitude and a phase displacement of 120°. With conventional rotation in the counter-clockwise direction, the positive-sequence current and voltage maxima occur in ABC order.
Positive-Sequence Impedance	Impedance of a device or circuit that results in current flow with a balanced positive-sequence set of voltage sources.
Power Factor	The cosine of the angle by which phase current lags or leads phase voltage in an ac electrical circuit. Power factor equals 1.0 for power flowing to a pure resistive load.
Protection-Disabled State	Suspension of relay protection element and trip/close logic processing and deenergization of all control outputs.
PT	Potential transformer. Also referred to as a voltage transformer or VT.
PTR	Potential transformer ratio.
RAM	Random Access Memory. Volatile memory where the relay stores intermediate calculation results, Relay Word bits, and other data.
Real Power	Power that produces actual work. The portion of apparent power that is real, not imaginary.
Relay Word Bit	A single relay element or logic result. A Relay Word bit can equal either logical 1 or logical 0. Logical 1 represents a “true” logic condition, picked up element, or asserted control input or control output. Logical 0 represents a “false” logic condition, dropped out element, or deasserted control input or control output. Use Relay Word bits in SELOGIC control equations.
Remote Bit	A Relay Word bit with a state that is controlled by serial port commands, including the CONTROL command or a binary Fast Operate command.
Report Settings	Event report and Sequential Events Recorder settings.
Residual Current	The sum of the measured phase currents. In normal, balanced operation, this current is very small or zero.
Residual Overcurrent Protection	Overcurrent protection that operates at conditions exceeding a threshold of system unbalance ($3I_0 = I_A + I_B + I_C$).
Rising Edge	Transition from logical 0 to logical 1, or the beginning of an operation.
Rising-Edge Trigger	Boolean SELOGIC control equation operator that triggers an operation upon logic detection of a rising edge. Represented by the / symbol.
RMS	Root-mean-square. This is the effective value of the current and voltage measured by the relay, accounting for the fundamental frequency and higher-order harmonics in the signal.

RTU	Remote Terminal Unit.
RXD	Received data.
SCADA	Supervisory control and data acquisition.
Self-Test	A function that verifies the correct operation of a critical device subsystem and indicates detection of an out-of-tolerance condition. The SEL-587Z Relay has self-tests that validate the relay power supply, microprocessor, memory, and other critical systems.
SELOGIC Control Equation	A relay setting that allows you to control a relay function (such as a control output) using a logical combination of relay element outputs and fixed logic outputs.
Sequential Events Recorder	A relay function that stores a record of the date and time of each assertion and deassertion of every Relay Word bit in a list that you set in the relay. SER provides a useful way to determine the order and timing of events of a relay operation.
SER	Sequential Events Recorder or the relay serial port command to request a report of the latest 512 sequential events.
Settle/Settling Time	Time required for an input signal to result in an unvarying output signal within a specified range.
Shunt Admittance	The admittance resulting from the presence of a device in parallel across other devices or apparatus that diverts some current away from these devices or apparatus.
Shunt Capacitance	The capacitance between a network connection and any existing ground.
Shunt Current	The current that a parallel-connected high-resistance or high-impedance device diverts away from devices or apparatus.
Source Impedance	The impedance of an energy source at the input terminals of a device or network.
Status Failure	A severe out-of-tolerance internal operating condition. The relay issues a status failure message and enters a protection-disabled state.
Status Warning	Out-of-tolerance internal operating conditions that do not compromise relay protection, yet are beyond expected limits. The relay issues a status warning message and continues to operate.
Strong Password	A mix of valid password characters in a six-character combination that does not spell common words in any portion of the password. Valid password characters are numbers, upper- and lower-case alphabetic characters, “.” (period), and “-” (hyphen).
Terminal Emulation Software	Software such as Microsoft [®] HyperTerminal or ProComm [®] Plus that can be used to send and receive ASCII text messages and files via a computer serial port.
Thermal Demand	Thermal demand is a continuous exponentially increasing or decreasing accumulation of metered quantities; used in demand metering.

Thermal Withstand Capability	The capability of equipment to withstand a predetermined temperature value for a specified time.
Three-Phase Fault	A fault involving all three phases of a three-phase power system.
Three-Pole Trip	A circuit breaker operation that occurs when the circuit breaker opens all three poles at the same time.
Time Delay on Pickup	The time interval between initiation of a signal at one point and detection of the same signal at another point.
Time Dial	A control that governs the time scale of the time-overcurrent characteristic of a relay. Use the time-dial setting to vary relay operating time.
Time-Delayed Tripping	Tripping that occurs after expiration of a pre-determined time.
Time-Overcurrent Element	An element that operates according to an inverse relationship between input current and time, with higher current causing faster relay operation.
Torque Control	A method of using one relay element to supervise the operation of another.
Transformer Impedance	The resistive and reactive parameters of a transformer looking in to the transformer primary or secondary windings. Use industry accepted open-circuit and short-circuit tests to determine these transformer equivalent circuit parameters.
TXD	Transmitted data.
Unbalanced Fault	All faults that do not include all three phases of a system.
Volatile Storage	A storage device that cannot retain data following removal of relay power.
VT	Voltage transformer. Also referred to as a potential transformer or PT.
Warm Start	The reset of a running system without removing and restoring power.
Wye	A phase-to-neutral connection of circuit elements, particularly voltage transformers or loads. To form a wye connection using transformers, connect the nonpolarity side of each of three voltage transformer secondaries in common (the neutral), and take phase to neutral voltages from each of the remaining three leads. When properly phased, these leads represent the A-phase-, B-phase-, and C-phase-to-neutral voltages. This connection is frequently called 'four-wire wye,' alluding to the three phase leads plus the neutral lead.
Zero-Sequence	A configuration of three-phase currents and voltages with currents and voltages that occur simultaneously, are always in phase, and have equal magnitude ($3I_0 = I_A + I_B + I_C$).
Zero-Sequence Impedance	Impedance of a device or circuit resulting in current flow when a single voltage source is applied to all phases.
Zero-Sequence Overcurrent Element	Overcurrent protection that operates at conditions exceeding a threshold of system unbalance.
Z-Number	That portion of the relay FID string that identifies the proper ACSELERATOR software relay driver version and HMI driver version when creating or editing relay settings files.

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SEL-587Z Relay Command Summary

SEL-587Z Relay Commands^a

Command	Description
2ACCESS	Go to Access Level 2 (complete relay monitoring and control)
ACCESS	Go to Access Level 1 (monitor relay)
BNAME	ASCII Names of all relay status bits (Fast Meter)
CASCII	Generate the Compressed ASCII response configuration message
CEVENT	EVENT command for the Compressed ASCII response
CHISTORY	HISTORY command for the Compressed ASCII response
CLOSE	Access the CC Relay Word bit to close a circuit breaker
CONTROL	Set, clear, or pulse an internal remote bit
CSTATUS	STATUS command for the Compressed ASCII response
DATE	Display and set the date
DNAME	ASCII names of all relay digital I/O (Fast Meter)
EVENT	Display and acknowledge event reports
HISTORY	View event summaries/histories; clear event data
ID	Display the firmware identification, part number, and other configuration data
IRIG	Update the internal clock/calendar from the IRIG-B input
METER	Display metering data and internal relay operating variables
OPEN	Access the OC Relay Word bit to open a circuit breaker
PASSWORD	Display or change relay passwords
PULSE	Pulse a relay output contact
QUIT	Reduce access level to Access Level 0 (exit relay control)
SER	View Sequential Events Recorder reports
SET^a	Enter relay settings
SHOWSET^a	Display relay settings
STATUS	Report or clear relay status
TARGET	Display relay elements for a row in the Relay Word table
TIME	Display and set the internal clock
TRIGGER	Initiate a data capture and record an event report

^a See the table below for SET/SHOW options.

SET/SHOW Command Options

Option	Setting Type
SET/SHOW	Relay settings
SET/SHOW L	Logic settings
SET/SHOW P 1	Rear port settings
SET/SHOW P F	Front port settings
SET/SHOW T	Text settings
SET/SHOW R	SER settings

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