SEL-311C-1 Transmission Protection System

Instruction Manual

20120111

SCHWEITZER ENGINEERING LABORATORIES, INC.

⚠CAUTION

The relay contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with the front panel removed, work surfaces and personnel must be properly grounded or equipment damage may result.

⚠ATTENTION

Le relais contient des pièces sensibles aux décharges électrostatiques. Quand on travaille sur le relais avec les panneaux avant ou du dessus enlevés, toutes les surfaces et le personnel doivent être mis à la terre convenablement pour éviter les dommages à l'équipement.

⚠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.

⚠ATTENTION

Il y a un danger d'explosion si la pile électrique n'est pas correctement remplacée. Utiliser exclusivement Ray-O-Vac® No. BR2335 ou un équivalent recommandé par le fabricant. Se débarrasser des piles usagées suivant les instructions du fabricant.

⚠CAUTION

Never apply voltage signals greater than 9 V peak-peak to the low-level test interface (J10) or equipment damage may result.

⚠ATTENTION

Au risque de causer des dommages à l'équipement, ne jamais appliquer un signal de tension supérieur à 9 V crête à crête à l'interface de test de bas niveau (J10).

⚠WARNING

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

⚠AVERTISSEMENT

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

⚠WARNING

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

⚠AVERTISSEMENT

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

⚠WARNING

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

⚠AVERTISSEMENT

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

⚠DANGER

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

⚠DANGER

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

PM311C-02

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Preface

Manual Overview

The SEL-311C Instruction Manual describes common aspects of protection relay application and use. It includes the necessary information to install, set, test, and operate the relay and more detailed information about settings and commands.

An overview of each manual section and topics follows:

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

Section 1: Introduction and Specifications. Describes the basic features and functions of the SEL-311C, lists the relay specifications.

Section 2: Installation. Describes how to mount and wire the SEL-311C, illustrates wiring connections for various applications, describes operation of current board jumpers, and depicts relay front and rear panels.

Section 3: Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements. Describes the operation of the instantaneous/definite-time overcurrent elements (phase, residual ground, and negative sequence), time-overcurrent elements (phase, residual ground, and negative sequence), voltage elements (single phase, phase to phase, etc.), synchronism check elements, and frequency elements.

Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic. Describes the operation of loss-of-potential logic and its effect on directional elements; disturbance detector logic, load-encroachment logic and its application to phase overcurrent elements; voltage-polarized and current-polarized directional elements, Best Choice Ground Directional Element® logic and automatic settings.

Section 5: Trip and Target Logic. Describes the operation of general trip logic, qualified trip logic, switch-onto-fault trip logic, communications-assisted trip logic, and front-panel target LEDs.

Section 6: Close and Reclose Logic. Describes the close logic operation for automatic reclosures and other close conditions (e.g., manual close initiation via serial port or optoisolated inputs).

Section 7: Inputs, Outputs, Timers, and Other Control Logic. Describes the operation of optoisolated inputs IN101–IN106 and IN201–IN208, local control switches (local bit outputs LB1–LB16), remote control switches (remote bit outputs RB1–RB16), latch control switches (latch bit outputs LT1–LT16), multiple setting groups (six available), programmable timers (timer outputs SV1T–SV16T), logic variables (LV1–LV32), output contacts OUT101–OUT107 and ALARM and OUT201–OUT212, and rotating default displays.

Section 8: Metering and Monitoring. Describes the operation of the breaker monitor, station battery monitor, instantaneous metering, demand, energy, maximum/minimum, and synchrophasor metering.

Section 9: Setting the Relay. Explains how to enter settings and also contains the following setting reference information:

- Time-overcurrent curves (5 US and 5 IEC curves)
- Settings Sheets for general relay, SELOGIC® control equation, Global, SER, text label, and port settings

The *SEL-311C Settings Sheets* can be photocopied and filled out to set the SEL-311C.

Section 10: Communications. Describes serial, Ethernet, and USB communications, port connector pinout/terminal functions, communications cables, communications protocols, and ASCII commands.
See *SHO Command (Show/View Settings) on page 10.49* for a list of the *factory default settings* for the SEL-311C.

SEL-311C Command Summary. Briefly describes the serial port commands that are described in detail in *Section 10: Communications*.

Section 11: Front-Panel Interface. Describes the front-panel operation of pushbuttons and their correspondence to ASCII commands, local control switches (local bit outputs LB1–LB16), and rotating displays.

Section 12: Standard Event Reports and SER. Describes standard 15-, 30-, 60-, and 180-cycle event reports and sequential events recorder (SER) report.

Section 13: Testing and Troubleshooting. Describes general testing philosophy, methods, and tools and relay self-tests and troubleshooting.

Section 14: Appendices.

- *Appendix A: Firmware and Manual Versions*
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SEL-311C Command Summary. Summarizes the serial port commands that are fully described in *Section 10: Communications*.

Conventions

Typographic Conventions

There are three ways to communicate with the SEL-311C:

- ➤ Using a command line interface on a PC terminal emulation window
- ➤ Using the front-panel menus and pushbuttons
- ➤ Using ACSELERATOR QuickSet® SEL-5030 Software

The instructions in this manual indicate these options with specific font and formatting attributes. The following table lists these conventions.

Example	Description
STATUS	Commands typed at a command line interface on a PC.
<Enter>	Single keystroke on a PC keyboard.
<Ctrl+D>	Multiple/combination keystroke on a PC keyboard.
Start > Settings	PC software dialog boxes and menu selections. The > character indicates submenus.
CLOSE	Relay front-panel pushbuttons.
ENABLE	Relay front- or rear-panel labels.
MAIN > METER	Relay front-panel LCD menus and relay responses visible on the PC screen. The > character indicates submenus.
SELOGIC Control Equations	SEL trademarks and registered trademarks contain the appropriate symbol on first reference in a section. In the SEL-311C *Instruction Manual*, certain SEL trademarks appear in small caps. These include SELOGIC control equations.
Modbus®	Registered trademarks of other companies include the registered trademark symbol with the first occurrence of the term in a section.

Examples

This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-311C. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in the current version of your SEL-311C.

Safety Information

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

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

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

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

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Section 1

Introduction and Specifications

Overview

This section includes the following overviews of the SEL-311C Relay:

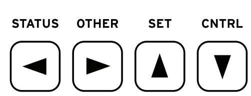
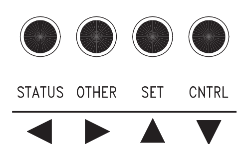
➤ *SEL-311C Models on page 1.1*

➤ *Specifications on page 1.2*

SEL-311C Models

This instruction manual covers the SEL-311C models with screw terminal blocks and Ethernet communications. *Table 1.1* describes distinguishing features of products covered and not covered by this manual. Use any row of the table to distinguish between relays covered and not covered by this manual.

Table 1.1 SEL-311C Models

Distinguishing Feature	SEL-311C Relays Covered by This Instruction Manual	SEL-311C Relays Not Covered by This Instruction Manual
Product Name	SEL-311C Transmission Protection System	SEL-311C Protection and Automation System
Model Number[a]	0311C1	0311C0
Menu Navigation Pushbuttons	Square with arrows inside buttons 	Round with arrows outside buttons 
Operator Control Pushbutton	Optional 	Not available on SEL-311C0
Ethernet Port(s) on Rear Panel	Yes	No
BNC Connector on Rear Panel	Yes	No
OUT101, OUT102, and OUT103 Polarity Indicators on Rear Panel	Yes	No

[a] The model numbers used in this table are derived from the SEL-311C ordering information sheets. These numbers should not be used to order an SEL-311C. To order an SEL-311C, refer to the actual ordering information sheets.

The SEL-311C Transmission Protection System is also available with single-pole trip as model number 0311C2. This model is covered by a separate instruction manual.

The SEL-311C can be ordered as a horizontal or vertical rack mount, horizontal or vertical panel mount, or horizontal or vertical projection panel mount (see *Figure 2.2*–*Figure 2.6*). Standard models come with six optoisolated inputs and eight output contacts. Extra I/O boards can be ordered on any SEL-311C model with 3U chassis.

Specifications

Important: Do not use the following specification information to order an SEL-311C. Refer to the actual ordering information sheets.

General

Terminal Connections

Note: Terminals or stranded copper wire. Ring terminals are recommended. Minimum temperature rating of 105ºC.

Tightening Torque

Terminals A01–A28 Terminals B01–B40 (if present):	7 in-lb (0.8 Nm)
Terminals Z01–Z27	7 in-lb (0.8 Nm)
Serial Port 1 (EIA-485, if present)	5 in-lb (0.6 Nm)

AC Voltage Inputs

Nominal Range	
Line to Neutral:	67–120 Vrms
Line to Line (open delta):	115–260 Vrms
Continuous:	300 Vrms 250 Vrms (UL)
Short-Term Overvoltage:	600 Vac for 10 seconds
Burden:	0.03 VA @ 67 V; 0.06 VA @ 120 V; 0.8 VA @ 300 V

AC Current Inputs

IA, IB, IC, and Neutral Channel IN

5 A Nominal:	15 A continuous, 500 A for 1 s, linear to 100 A symmetrical, 1250 A for 1 cycle
Burden:	0.27 VA @ 5 A, 2.51 VA @ 15 A
1 A Nominal:	3 A continuous, 100 A for 1 s, linear to 20 A symmetrical, 250 A for 1 cycle
Burden:	0.13 VA @ 1 A, 1.31 VA @ 3 A

Power Supply

Rated:	125/250 Vdc nominal or 120/230 Vac nominal
Range:	85–350 Vdc or 85–264 Vac
Burden:	<25 W
Rated:	48/125 Vdc nominal or 120 Vac nominal
Range:	38–200 Vdc or 85–140 Vac
Burden:	<25 W
Rated:	24/48 Vdc nominal
Range:	18–60 Vdc polarity dependent
Burden:	<25 W

Frequency and Rotation

Note: 60/50 Hz system frequency and ABC/ACB phase rotation are user-settable.

Frequency Tracking Range:	40.1–65 Hz (V_A or I_1 [positive-sequence current] required for frequency tracking; tracking switches to I_1 if V_A <10 V).

Output Contacts

Standard

Make:	30 A
Carry	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1s Rating:	50 A
MOV Protected:	270 Vac / 360 Vdc / 75 J
Pickup Time:	Less than 5 ms
Dropout Time:	Less than 5 ms, typical

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 cycle/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.
Note: Breaking and Cyclic Capacity per IEC 60255-0-20:1974.
Note: EA certified relays do not have MOV protected standard output contacts.

High-Current Interruption for OUT101, OUT102,OUT103, and Extra I/O Board

Make:	30 A
Carry	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1s Rating:	50 A
MOV Protection:	330 Vdc/145 J
Pickup Time:	Less than 5 ms
Dropout Time:	Less than 8 ms, typical

Breaking Capacity (10000 operations):

24 V	10 A	L/R = 40 ms
48 V	10 A	L/R = 40 ms
125 V	10 A	L/R = 40 ms
250 V	10 A	L/R = 20 ms

Cyclic Capacity (4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation):

24 V	10 A	L/R = 40 ms
48 V	10 A	L/R = 40 ms
125 V	10 A	L/R = 40 ms
250 V	10 A	L/R = 20 ms

Note: Make per IEEE C37.90-1989.
Note: Do not use high-current interrupting output contacts to switch ac control signals. These outputs are polarity dependent.
Note: Breaking and Cyclic Capacity per IEC 60255-0-20:1974.

Fast Hybrid (High-Speed High-Current Interrupting) Option

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
MOV Protection:	250 Vac / 330 Vdc / 145 J
Pickup Time:	Less than 200 µs
Dropout Time:	Less than 8 ms, typical

Breaking Capacity (10000 operations):

24 V	10 A	L/R = 40 ms
48 V	10 A	L/R = 40 ms
125 V	10 A	L/R = 40 ms
250 V	10 A	L/R = 20 ms

Cyclic Capacity (4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation):

24 V	10 A	L/R = 40 ms
48 V	10 A	L/R = 40 ms
125 V	10 A	L/R = 40 ms
250 V	10 A	L/R = 20 ms

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

SafeLock Trip/Close Pushbuttons

Resistive DC or AC Load With Arc Suppression Disabled

Make:	30 A
Carry:	6 A continuous carry
1s Rating:	50 A
MOV Protection:	250 Vac/330 Vdc/130 J

Breaking Capacity (2000 operations):

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.

High Interrupt DC Outputs With Arc Suppression Enabled

Make:	30 A
Carry:	6 A continuous carry
1s Rating:	50 A
MOV Protection:	330 Vdc / 130 J

Breaking Capacity (2000 operations):

48 V	10 A	L/R = 40 ms
125 V	10 A	L/R = 40 ms
250 V	10 A	L/R = 20 ms

Note: Make per IEEE C37.90-1989.

Breaker Open/Closed LEDs

250 Vdc:	on for 150–300 Vdc;	192–288 Vac
125 Vdc:	on for 80–150 Vdc;	96–144 Vac
48 Vdc:	on for 30–60 Vdc;	
24 Vdc:	on for 15–30 Vdc	

Note: With nominal control voltage applied, each LED draws 8 mA max. Jumpers may be set to 125 Vdc for 110 Vdc input and set to 250 Vdc for 220 Vdc input.

Optoisolated Input Ratings

When Used With DC Control Signals

250 Vdc:	on for 200–300 Vdc;	off below 150 Vdc
220 Vdc:	on for 176–264 Vdc;	off below 132 Vdc
125 Vdc:	on for 105–150 Vdc;	off below 75 Vdc
110 Vdc:	on for 88–132 Vdc;	off below 66 Vdc
48 Vdc:	on for 38.4–60 Vdc;	off below 28.8 Vdc
24 Vdc:	on for 15–30 Vdc	

When Used With AC Control Signals

250 Vdc:	on for 170.6–300 Vac;	off below 106.0 Vac
220 Vdc:	on for 150.3–264.0 Vac;	off below 93.2 Vac
125 Vdc:	on for 89.6–150.0 Vac;	off below 53.0 Vac
110 Vdc:	on for 75.1–132.0 Vac;	off below 46.6 Vac
48 Vdc:	on for 32.8–60.0 Vac;	off below 20.3 Vac
24 Vdc:	on for 12.8–30.0 Vac	

Note: AC mode is selectable for each input via Global settings IN101D–IN106D; IN201D–IN208D. AC input recognition delay from time of switching: 0.75 cycles maximum pickup, 1.25 cycles maximum dropout.
Note: All optoisolated inputs draw less than 10 mA of current at nominal voltage or AC RMS equivalent.

Time-Code Inputs

Relay accepts demodulated IRIG-B time-code input at Port 2 or the rear-panel BNC output.

Port 2, Pin 4 input current:	1.8 mA typical at 4.5 V (2.5 kΩ resistive)
BNC input current:	4 mA typical at 4.5 V (750 Ω resistive when input voltage is greater than 2 V)

Synchronization Accuracy

Internal Clock:	±1 µs
Synchrophasor reports (e.g., **MET PM**, **EVE P**, **CEV P**):	±10 µs
All Other Reports:	±5 ms

Simple Network Time Protocol (SNTP) Accuracy

Internal Clock:	±5 ms

Unsychronized Clock Drift

Relay Powered:	2 minutes per year typical

Communications Ports

EIA-232:	1 front, 2 rear
EIA-485:	1 rear with 2100 Vdc of isolation, optional
Per Port Baud Rate Selections:	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600
USB:	1 front, optional (Type B connector, CDC class device)
Ethernet:	1 standard 10/100BASE-T rear port (RJ45 connector) Second 10/100BASE-T rear port optional (RJ45 connector) 1 or 2 100BASE-FX rear ports optional (LC connectors) Internal Ethernet switch included with second Ethernet port.

Dimensions

Refer to *Figure 2.1*.

Weight

11 lbs (5.0 kg)—2U rack unit height relay
15 lbs (6.8 kg)—3U rack unit height relay

Operating Temperature

–40° to +185°F (–40° to +85°C)
(LCD contrast impaired for temperatures below –20°C.)
Temperature range is not applicable to UL compliant installations.

Type Tests

Environmental Tests

Cold:	IEC 60068-2-1:2007 Environmental testing procedures, Part 2-1: Tests – Test Ad: Cold
Damp Heat Cyclic:	IEC 60068-2-30:2005 Basic environmental testing procedures, Part 2-30: Tests, Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle), (six-day type test)
Dry Heat:	IEC 60068-2-2:2007 Environmental testing procedures, Part 2-2: Tests—Test Bd: Dry Heat
Environment:	IEC 60529:2001 + CRDG:2003 Degrees of Protection Provided by Enclosures (IP code): Object penetration and dust ingress, IP30 for category 2 equipment. For use in a Pollution Degree 2 environment

Routine Dielectric and Impulse Tests

Current inputs, optoisolated inputs, and output contacts:	2500 Vac for 10 s
Power Supply:	3100 Vdc for 10 s IEC 60255-5 Dielectric Tests: 2000 2500 Vac for 1 minute on analog inputs, optoisolated inputs, and output contacts 3100 Vdc for 1 minute on power supply
Impulse:	IEC 60255-5:2000 Electrical relays, Part 5: Insulation tests for electrical relays. Section 6.1.3: Impulse Voltage Tests, 0.5 Joule 5 kV

Electromagnetic Compatibility (EMC)

Conducted Emissions: IEC 60255-25:2000 Class A

Radiated Emissions: IEC 60255-25:2000 Class A

RFI and Interference Tests

Fast Transient Disturbance: IEC 60255-22-4:2008 Electrical disturbance tests for measuring relays and protection equipment, Section 4: Fast transient disturbance test, Severity Level: Class A
- 4 kV, 5 kHz on analog and power supply inputs
- 2 kV, 5 kHz on communications ports, digital inputs, and digital outputs

Radiated EMI: IEC 60255-22-3:2007 Electrical relays, Section 3: Radiated electromagnetic field disturbance tests, Severity Level 3 (10 V/m)
IEEE C37.90.2-2004, Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers, 35 V/m.

Surge Withstand: IEC 60255-22-1:2007 Electrical disturbance tests for measuring relays and protection equipment, Part 22-1: 1 MHz burst disturbance tests. Severity Level 3 (2.5 kV common mode, 2.5 kV differential)
IEEE C37.90.1-2002
- 2.5 kV oscillatory; 4.0 kV fast transient

ESD: IEC 60255-22-2:2008 Electrical disturbance tests for measuring relays and protective equipment, Electrostatic discharge tests, Severity Level 4 (8 kV contact discharge all points except serial ports, 15 kV air discharge to all other points)

Vibration and Shock Tests

Shock and Bump: IEC 60255-21-2:1988 Electrical relays, Part 21: Vibration, shock, bump, and seismic tests on measuring relays and protection equipment, Section Two: Shock and bump tests, Class 1
IEC 60255-21-3:1993 Electrical relays, Part 21: Vibration, shock, bump, and seismic tests on measuring relays and protection equipment, Section Three: Seismic tests, Class 2

Sinusoidal Vibration: IEC 60255-21-1:1988 Electrical relays, Part 21: Vibration, shock, bump, and seismic tests on measuring relays and protection equipment, Section One: Vibration tests (sinusoidal), Class 1

Certifications

ISO: Relay is designed and manufactured to an ISO-9001 certified quality program.
UL: Product Category NRGU, *UL-508*
UL: Product Category NRGU7, *C22.2, No.14*
CSA: C22.2 No. 14
CE: CE Mark

Processing Specifications and Oscillography

AC Voltage and Current Inputs

128 samples per power system cycle, 3 dB low-pass filter cut-off frequency of 3 kHz

Digital Filtering

Digital low-pass filter then decimate to 32 samples per cycle followed by one-cycle cosine filter.
Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.

Protection and Control Processing

4 times per power system cycle

Oscillography

Length: 15, 30, 60, or 180 cycles

Total Storage: 12 seconds of analog and binary

Sampling Rate: 128 samples per cycle unfiltered
32 and 16 samples per cycle unfiltered and filtered
4 samples per cycle filtered

Trigger: Programmable with Boolean expression

Format: ASCII and Compressed ASCII

Time-Stamp Resolution: 1 µs when high-accuracy time source is connected (**EVE P** or **CEV P** commands).
1 ms otherwise.

Time-Stamp Accuracy: See *Time-Code Inputs on page 1.3*.

Sequential Events Recorder

Time-Stamp Resolution: 1 ms

Time-Stamp Accuracy (with respect to time source): ± 5 ms

Relay Element Pickup Ranges and Accuracies

Mho Phase Distance Elements

Zones 1–4 Impedance Reach

Setting Range: OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal)
OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal)
Minimum sensitivity is controlled by the pickup of the supervising phase-to-phase overcurrent elements for each zone.

Accuracy: ±5% of setting at line angle for 30 ≤ SIR ≤ 60
±3% of setting at line angle for SIR < 30

Transient Overreach: < 5% of setting plus steady-state accuracy

Zones 1–4 Phase-to-Phase Current Fault Detectors (FD)

Setting Range: 0.5–170.00 A_{P-P} secondary, 0.01 A steps (5 A nominal)
0.1–34.00 A_{P-P} secondary, 0.01 A steps (1 A nominal)

Accuracy: ±0.05 A and ±3% of setting (5 A nominal)
±0.01 A and ±3% of setting (1 A nominal)

Transient Overreach: < 5% of pickup

Maximum Operating Time: See *Figure 3.13* and *Figure 3.14*.

Mho and Quadrilateral Ground Distance Element

Zones 1–4 Impedance Reach

Mho Element Reach: OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal)
OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal)

Quadrilateral Reactance Reach: OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal)
OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal)

Quadrilateral Resistance Reach:	OFF, 0.05 to 50 Ω sec, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 250 Ω sec, 0.01 Ω steps (1 A nominal) Minimum sensitivity is controlled by the pickup of the supervising phase and residual overcurrent elements for each zone.
Accuracy:	±5% of setting at line angle for 30 ≤ SIR ≤ 60 ±3% of setting at line angle for SIR < 30
Line Angle:	≥45° (Quadrilateral)
Transient Overreach:	<5% of setting plus steady-state accuracy

Zones 1–4 Phase and Residual Current Fault Detectors (FD)

Setting Range:	0.5–100.00 A secondary, 0.01 A steps (5 A nominal) 0.1–20.00 A secondary, 0.01 A steps (1 A nominal)
Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:	<5% of pickup
Max. Operating Time:	See *Figure 3.15* through *Figure 3.18*.

Instantaneous/Definite-Time Overcurrent Elements

Pickup Range:	0.25–100.00 A, 0.01 A steps (5 A nominal) 0.050–100.000 A, 0.010 A steps (5 A nominal—for residual ground elements) 0.05–20.00 A, 0.01 A steps (1 A nominal) 0.010–20.000 A, 0.002 A steps (1 A nominal—for residual ground elements)
Steady-State Pickup Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:	±5% of pickup
Time Delay:	0.00–16,000.00 cycles, 0.25 cycle steps
Timer Accuracy:	±0.25 cycle and ±0.1% of setting

Note: See pickup and reset time curves in *Figure 3.27* and *Figure 3.28*.

Time-Overcurrent Elements

Pickup Range:	0.25–16.00 A, 0.01 A steps (5 A nominal) 0.10–16.00 A, 0.01 A steps (5 A nominal—for residual ground elements) 0.05–3.20 A, 0.01 A steps (1 A nominal) 0.02–3.20 A, 0.01 A steps (1 A nominal—for residual ground elements)
Steady-State Pickup Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Time Dial Range:	0.50–15.00, 0.01 steps (US) 0.05–1.00, 0.01 steps (IEC)
Curve Timing Accuracy:	±1.50 cycles and ±4% of curve time for current between 2 and 30 multiples of pickup

Out-of-Step Elements

Blinders (R1) Parallel to the Line Angle:	0.05 to 70 Ω secondary –0.05 to –70 Ω secondary (5 A nominal) 0.25 to 350 Ω secondary –0.25 to –350 Ω secondary (1 A nominal)
Blinders (X1) Perpendicular to the Line Angle:	0.05 to 96 Ω secondary –0.05 to –96 Ω secondary (5 A nominal) 0.25 to 480 Ω secondary –0.25 to –480 Ω secondary (1 A nominal)
Accuracy (Steady State):	±5% of setting plus ±0.01 A for SIR (source to line impedance ratio) < 30 ±10% of setting plus ±0.01 A for 30 ≤ SIR ≤ 60 (5 A nominal) ±5% of setting plus ±0.05 A for SIR (source to line impedance ratio) < 30 10% of setting plus ±0.05 A for 30 ≤ SIR ≤ 60 (1 A Nominal)
Transient Overreach:	<5% of setting *plus* steady-state accuracy

Positive-Sequence Overcurrent Supervision

Setting Range	1.0–100.0 A, 0.01 A steps (5 A nominal) 0.2–20.0 A, 0.01 A steps (1 A nominal)
Accuracy	±3% of setting plus ±0.05 A (5 A nominal) ±3% of setting plus ±0.01 A (1 A nominal)
Transient Overreach:	< 5% of setting

Under- and Overvoltage Elements

Pickup Ranges:

Wye-Connected (Global setting PTCONN = WYE):	0.00–200.00 V, 0.01 V steps (negative-sequence element) 0.00–300.00 V, 0.01 V or 0.02 V steps (various elements) 0.00–520.00 V, 0.02 V steps (phase-to-phase elements)
Open-Delta Connected (when available, by Global setting PTCONN = DELTA):	0.00–120.00 V, 0.01 V steps (negative-sequence elements) 0.00–170.00 V, 0.01 V steps (positive-sequence element) 0.00–300.00 V, 0.01 V steps (various elements)
Steady-State Pickup Accuracy:	±0.5 V plus ±1% for 12.5–300.00 V (phase and synchronizing elements) ±0.5 V plus ±2% for 12.5–300.00 V (negative-, positive-, and zero-sequence elements, phase-to-phase elements)
Transient Overreach:	±5% of pickup

Synchronism-Check Elements

Slip Frequency Pickup Range:	0.005–0.500 Hz, 0.001 Hz steps
Slip Frequency Pickup Accuracy:	±0.003 Hz
Phase Angle Range:	0–80°, 1° steps
Phase Angle Accuracy:	±4°

Under- and Overfrequency Elements

Pickup Range:	40.10–65.00 Hz, 0.01 Hz steps
Steady-State *plus* Transient Overshoot:	±0.01 Hz for 1 Hz step change

Time Delay: 2.00–16,000.00 cycles, 0.25-cycle steps

Timer Accuracy: ±0.25 cycle and ±0.1% of setting

Undervoltage Frequency Element Block Range: 20.00–300.00 V_{LN} (wye) or V_{LL} (open-delta)

Timers

Pickup Ranges: 0.00–999,999.00 cycles, 0.25-cycle steps (reclosing relay and some programmable timers)
0.00–16,000.00 cycles, 0.25-cycle steps (some programmable and other various timers)

Pickup and Dropout Accuracy for all Timers: ±0.25 cycle and ±0.1% of setting

Substation Battery Voltage Monitor

Pickup Range: 20–300 Vdc, 0.02 Vdc steps

Pickup accuracy: ±2% of setting ±2 Vdc

Fundamental Metering Accuracy

Accuracies are specified at 20°C, at nominal system frequency, and voltage 67–250 V unless noted otherwise.

Voltages V_A, V_B, V_C: ±0.2% (67.0–300 V; wye-connected)

Voltages V_{AB}, V_{BC}, V_{CA}: ±0.4% (67.0–300 V; delta-connected)

Voltage V_S: ±0.2% (67.0–300 V)

Voltages $3V_0$, V_1, V_2: ($3V_0$ not available with delta-connected inputs) ± 0.6% (67.0–300 V)

Currents I_A, I_B, I_C: ±4 mA and ±0.1% (1.0–100 A) (5 A nominal)
±1 mA and ±0.1% (0.2–20 A) (1 A nominal)
Temperature coefficient: $[(0.0002\%)/(°C)^2] \cdot (\_\_°C - 20°C)^2$

Currents I_N: ±4 mA and ±0.1% (1.0–100 A) (5 A nominal)
±1 mA and ±0.1% (0.2–20 A) (1 A nominal)

Currents I_1, $3I_0$, $3I_2$: ±0.05 A and ±3% (0.5–100 A) (5 A nominal)
±0.01 A and ±3% (0.1–20 A) (1 A nominal)

Phase Angle Accuracy:

I_A, I_B, I_C
V_A, V_B, V_C, V_S (wye-connected voltages): ±0.5°

V_{AB}, V_{BC}, V_{CA}, V_S (delta-connected voltages): ±1.0°

MW/MVAR
(A, B, C, and 3-phase; wye-connected voltages)
MW/MVAR
(3-phase; open-delta connected voltages; balanced conditions)

Accuracy (MW/MVAR)	at load angle
for phase current ≥ 0.2 • I_{NOM}:	
0.35% / –	0° or 180° (unity power factor)
0.75% / 1.50%	±30° or ±150°
1.50% / 0.75%	±60° or ±120°
– / 0.35%	±90° (power factor = 0)

Energy Meter

Accumulators: Separate IN and OUT accumulators updated twice per second, transferred to non-volatile storage once per day.

ASCII Report Resolution: 0.1 MWh

Accuracy: The accuracy of the energy meter depends on applied current and power factor as shown in the power metering accuracy table above. The additional error introduced by accumulating power to yield energy is negligible when power changes slowly compared to the processing rate of twice per second.

Synchrophasor Accuracy

Maximum Data Rate in Messages per Second

IEEE C37.118 Protocol: 60 (nominal 60 Hz system)
50 (nominal 50 Hz system)

SEL Fast Message Protocol: 1

IEEE C37.118 Accuracy: Level 1 at maximum message rate when phasor has the same frequency as phase A voltage and frequency-based phasor compensation is enabled (PHCOMP=Y)

Current Range: (0.1–1.2) • I_{nom} (I_{nom} = 1 A or 5 A)

Frequency Range: ±5 Hz of nominal (50 or 60 Hz)

Voltage Range: 30 V–300 V

Phase Angle Range: –179.99° to 180°

Section 2
Installation

Overview

Design your rack or panel installation using the mounting and connection information in this section. This section also includes information for configuring the relay to your application.

This section covers the following topics:

Relay Mounting

Rack Mount

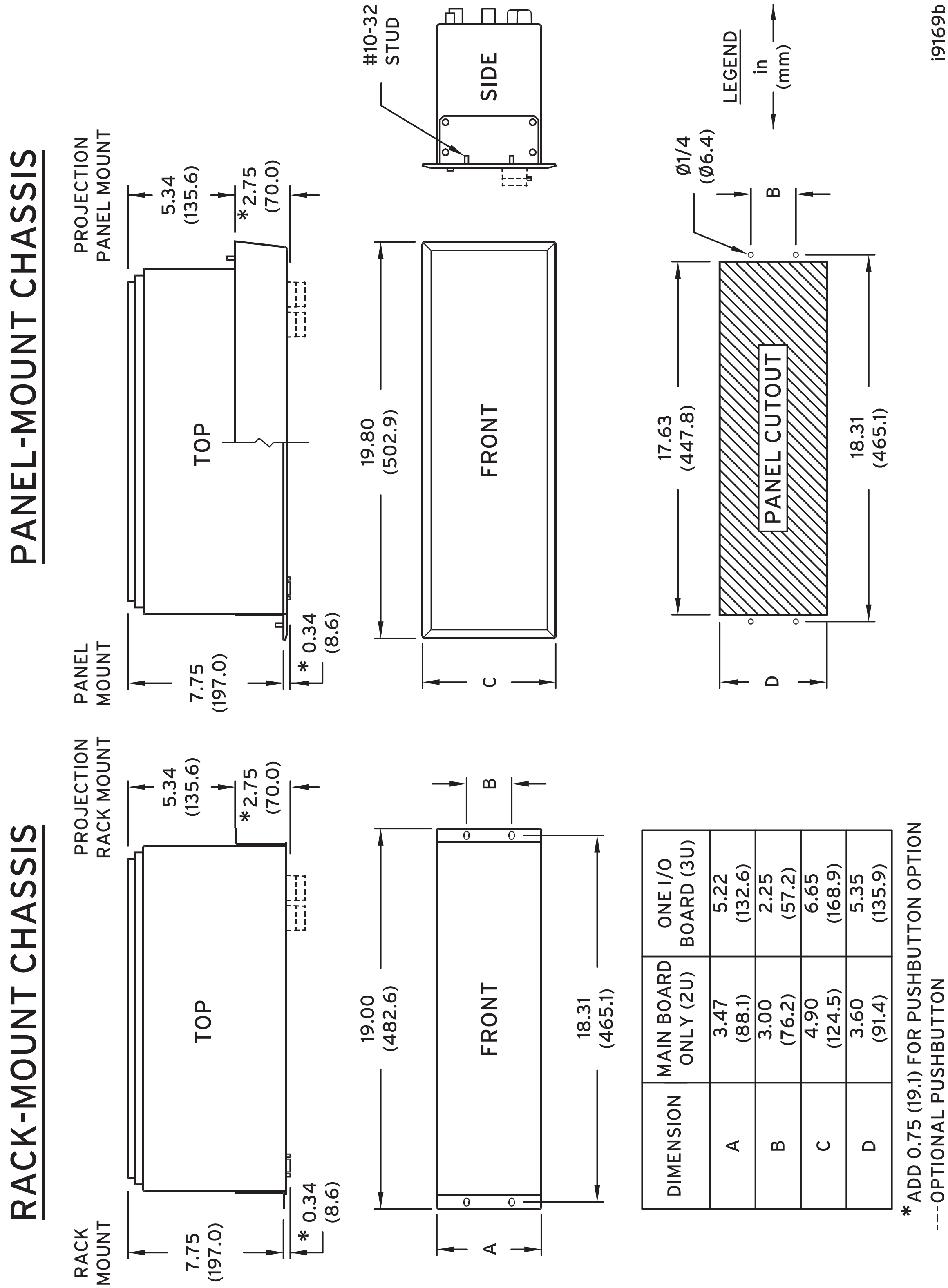
The SEL-311C rack-mount relay bolts easily into a standard 19-inch rack. See *Figure 2.1*. From the front of the relay, insert four rack screws (two on each side) through the holes on the relay mounting flanges.

Reverse the relay mounting flanges to cause the relay to project an additional 2.75 inches (70 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

The SEL-311C panel-mount option provides a clean look. Panel-mount relays have sculpted front-panel molding that covers all installation holes. Cut your panel and drill mounting holes according to the dimensions in *Figure 2.1*. 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 an additional 2.75 inches (70 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.



DIMENSION	MAIN BOARD ONLY (2U)	ONE I/O BOARD (3U)
A	3.47 (88.1)	5.22 (132.6)
B	3.00 (76.2)	2.25 (57.2)
C	4.90 (124.5)	6.65 (168.9)
D	3.60 (91.4)	5.35 (135.9)

Figure 2.1 SEL-311C Dimensions for Rack-Mount and Panel-Mount Models

Front-Panel and Rear-Panel Connection Diagrams

Figure 2.2–*Figure 2.6* represent examples of different relay configurations. View the SEL-311C Model Option Tables on our website for model options and additional front- and rear-panel drawings or contact your local SEL sales representative.

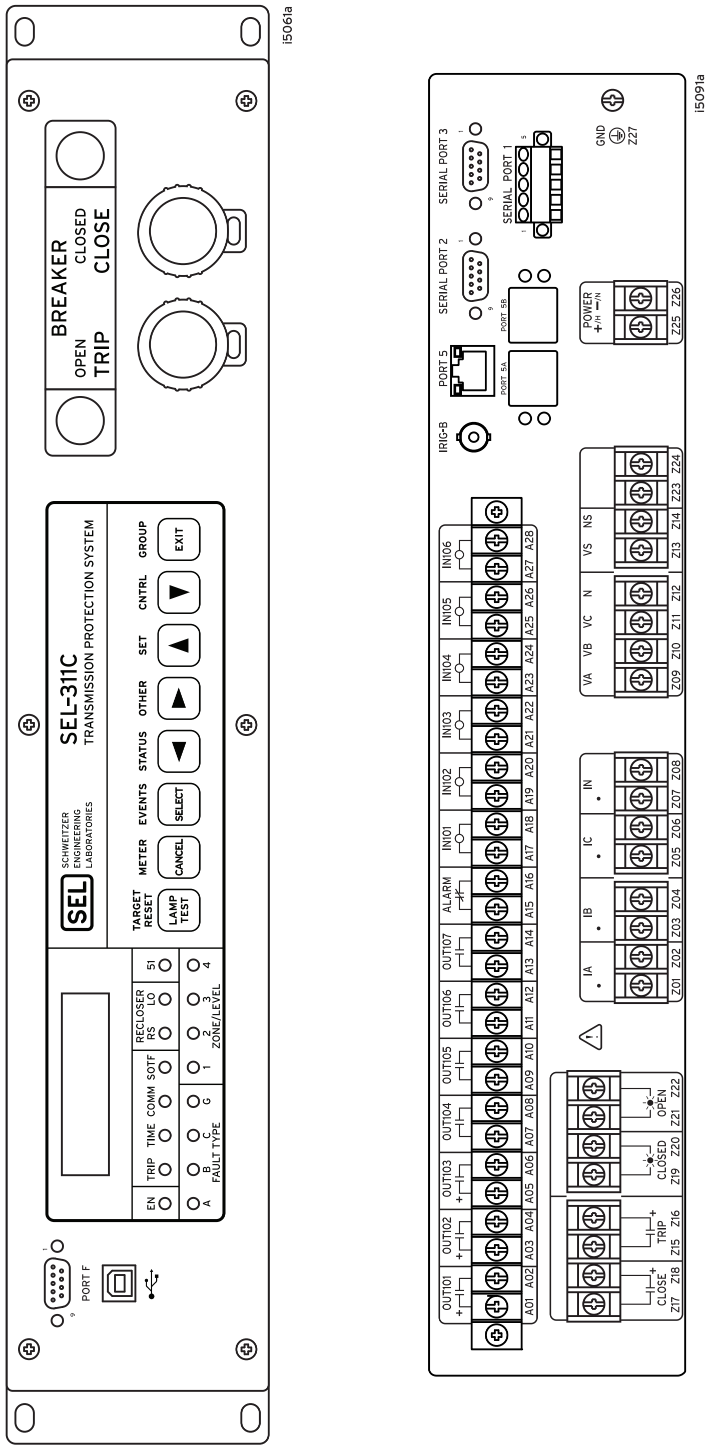


Figure 2.2 SEL-311C Front- and Rear-Panel Drawings; 2U Horizontal Rack-Mount With Optional EIA-485 and USB Ports and Optional Safelock Trip and Close Pushbuttons

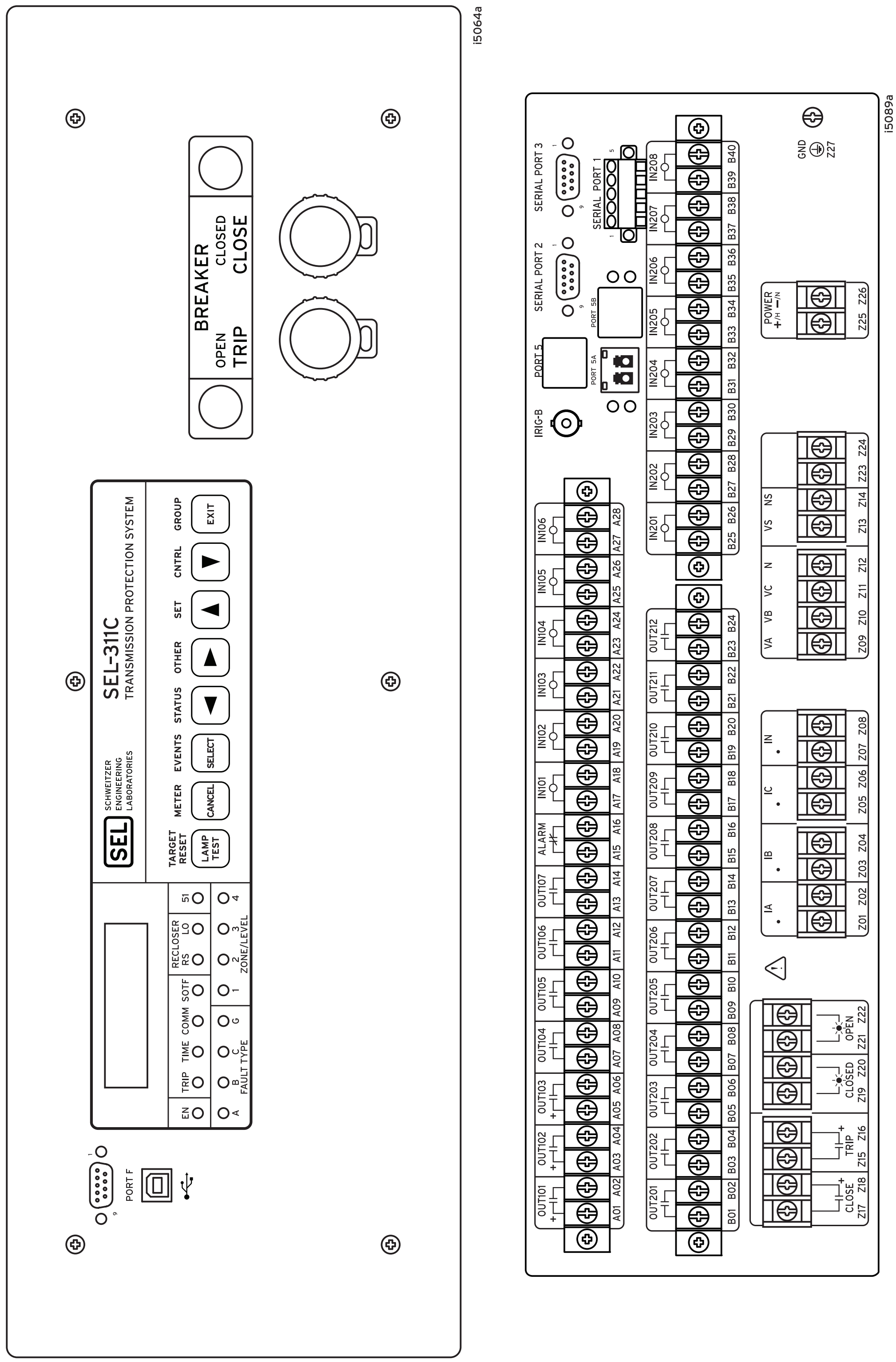


Figure 2.3 SEL-311C Front- and Rear-Panel Drawings; 3U Horizontal Panel Mount With Optional EIA-485 and USB Ports, Optional Safelock Trip/Close Pushbuttons, Optional Extra I/O Board With Standard Outputs, and Optional Single Fiber-Optic Ethernet Port.

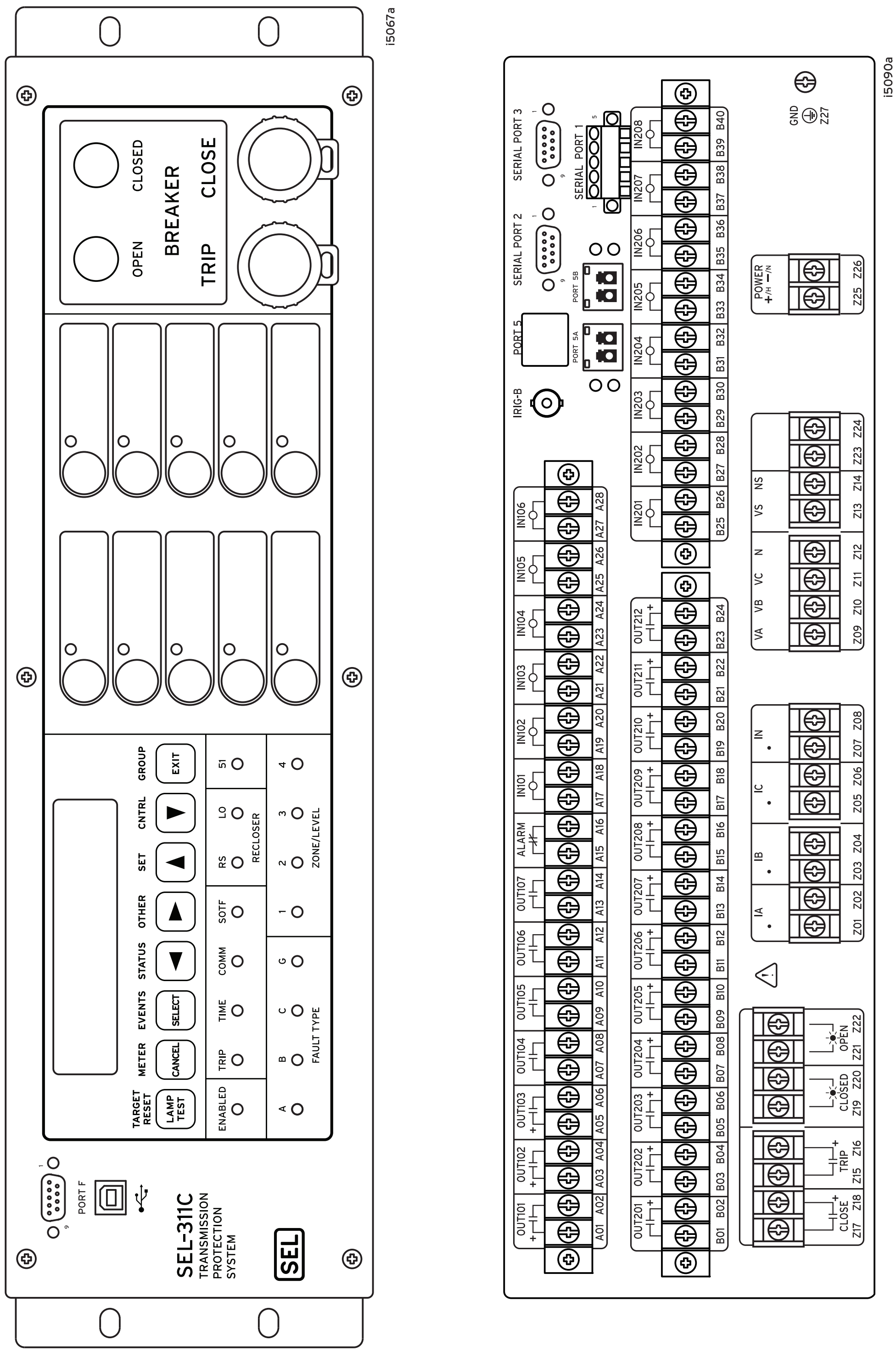


Figure 2.4 SEL-311C Front- and Rear-Panel Drawings; 3U Horizontal Rack-Mount With Optional Programmable Operator Controls and Target LEDS, Optional USB Port and SafeLock Trip/Close Pushbuttons, Optional Extra I/O Board With High-Current Interrupting Outputs, Optional EIA-485 Port, and Optional Dual Fiber Ethernet Port

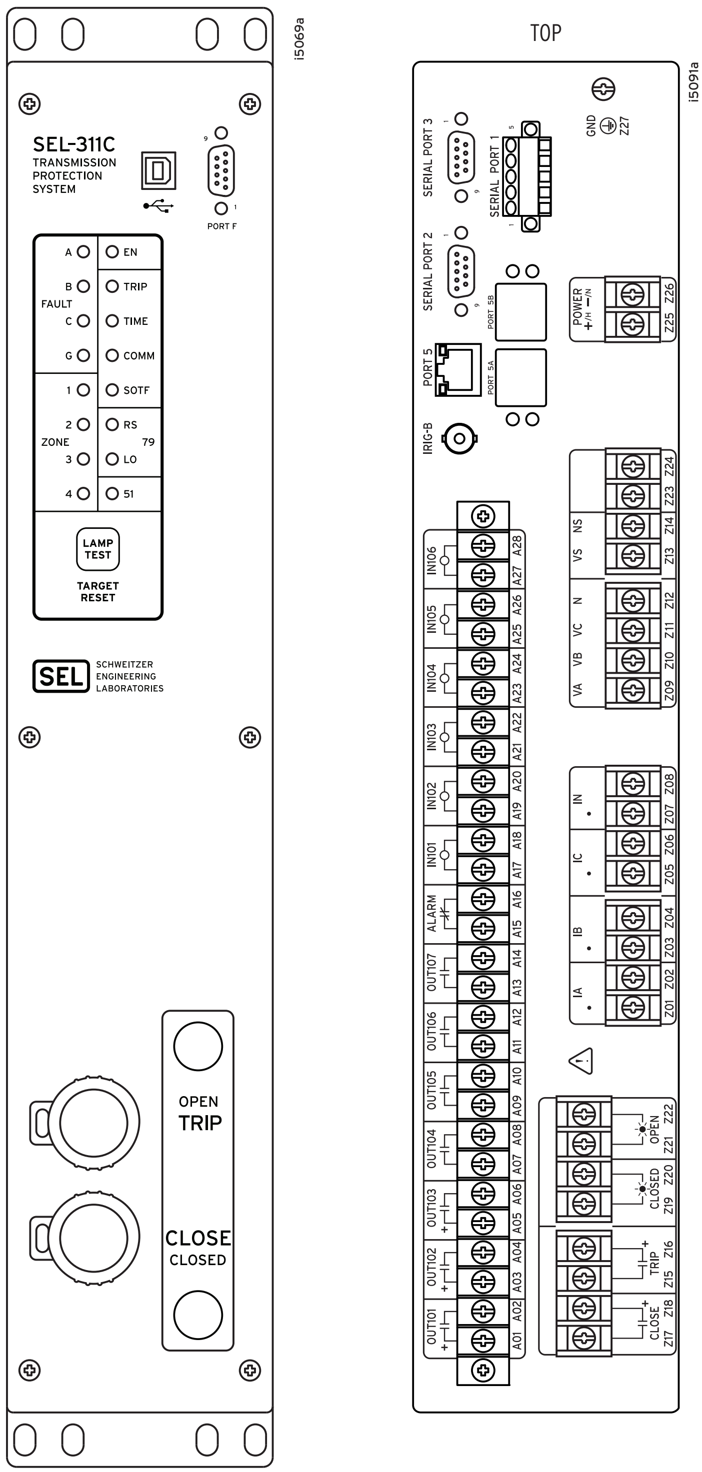


Figure 2.5 SEL-311C Front- and Rear-Panel Drawings; 2U Vertical Rack Mount With Optional USB Port, Optional SafeLock Trip/Close Pushbuttons, and Optional EIA-485 Port

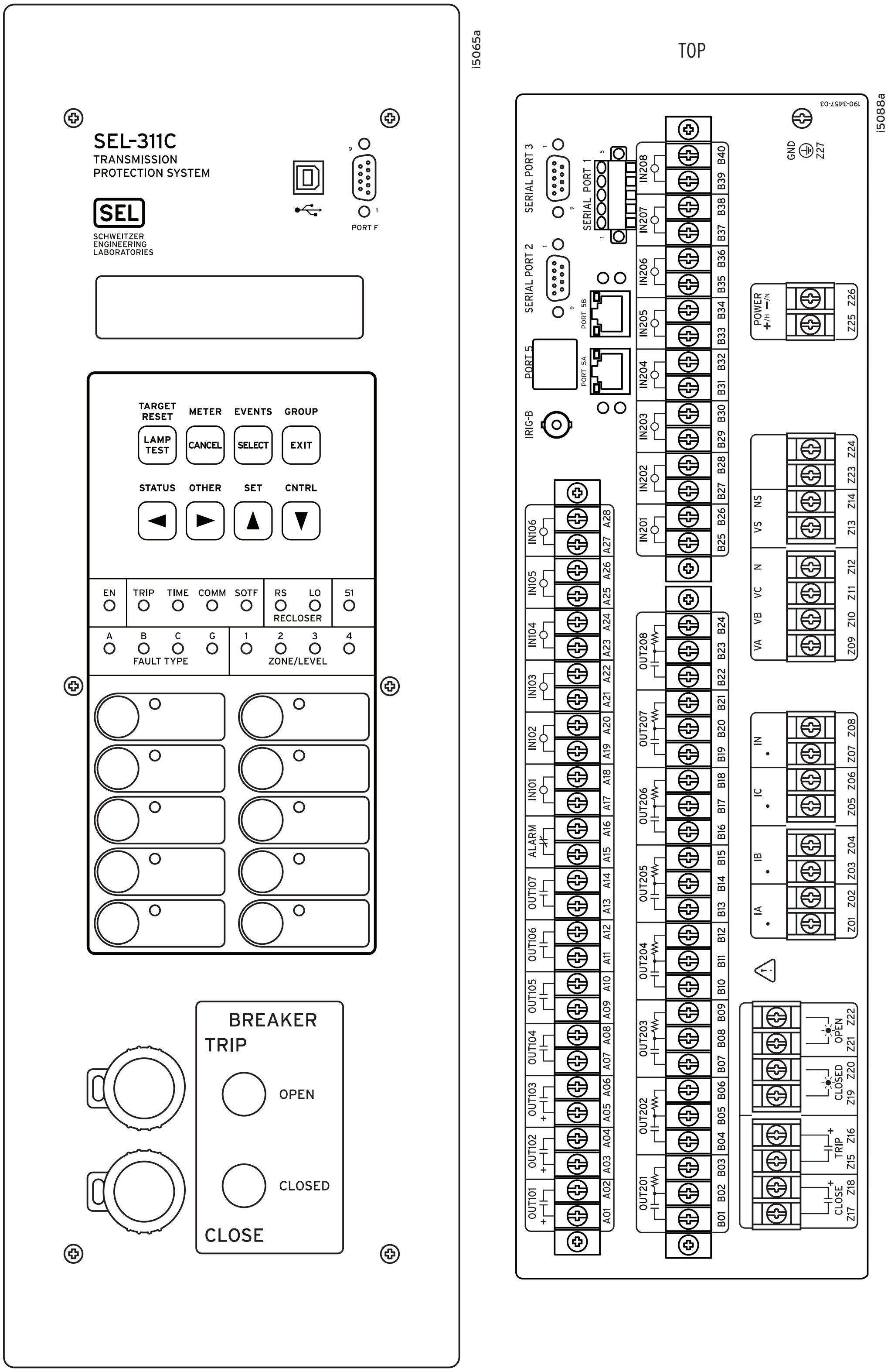


Figure 2.6 SEL-311C Front- and Rear-Panel Drawings; 3U Vertical Panel-Mount With Optional Programmable Operator Controls and Target LEDS, Optional Front-Panel USB Port and SafeLock Trip/Close Pushbuttons, Optional Extra I/O Board With High-Speed, High-Current Interrupting Outputs, Optional Dual Copper Ethernet, and Optional EIA-485 Port

Making Rear-Panel Connections

Refer to *Figure 2.13–Figure 2.17* for wiring examples of typical applications.

Required Equipment and General Connection Information

Tools: Phillips® or slotted-tip screwdriver

Parts: All screws in a standard relay shipment are size #6-32 Phil-slot. Contact SEL for optional screw types.

Ring terminals are recommended. Maximum tongue width is 7.9 mm (0.31 inches).

Chassis Ground

Ground the relay chassis at terminal **Z27** using a minimum #14 AWG copper conductor.

Power Supply

Connect control voltage to **POWER** terminals. Note the polarity indicators on terminals **Z25(+)** and **Z26(–)**. Control power passes through these terminals to a fuse and to the switching power supply. The control power circuitry is isolated from the relay chassis ground.

For UL/CSA compliant installations, a 15 A circuit breaker with disconnecting means must be installed in the power supply line to facilitate servicing the unit.

Refer to *Section 1: Introduction and Specifications* for power supply ratings. The relay power supply rating is listed on the serial number sticker on the relay rear panel.

Output Contacts

⚠WARNING
OUT101, OUT102, and **OUT103** are not polarity-dependent in legacy SEL-311C relays. See Table 1.1 for features that distinguish a legacy SEL-311C from a new SEL-311C. If you replace an older SEL-311C with a newer style SEL-311C, ensure that the connection polarity for **OUT101, OUT102,** and **OUT103** is correct, and ensure that **OUT101, OUT102,** and **OUT103** are not connected to ac loads.

All relays come with polarity-dependent high-current interrupting output contacts for **OUT101**, **OUT102**, and **OUT103** and with standard contacts for **OUT104–ALARM**.

See *High-Current Interrupting Output Contacts on page 2.9*.

Extra I/O

OUT201–OUT212 can be ordered with standard or high-current interrupting output contacts. An optional extra I/O board with eight high-speed, high-current interrupting contacts is also available.

Refer to *Specifications on page 1.2* for output contact ratings. Refer to the part number on the serial number sticker on the relay rear panel to determine the type of output contacts on the extra I/O board of your relay.

Standard Output Contacts

Model 0311 part numbers with a numeral “2” in the field in bold below (sample part number) indicate standard output contacts on the extra I/O board (**OUT201–OUT212**):

0311C11HA3A54**2**1

Standard output contacts are not polarity dependent.

High-Current Interrupting Output Contacts

All relay models have high-current interrupting output contacts for **OUT101**, **OUT102**, and **OUT103**. Model 0311 part numbers with a numeral "6" in the field in bold below (sample part number) indicate high-current interrupting output contacts on the extra I/O board (**OUT201–OUT212**):

0311C11HA3A54**6**1

NOTE: Do not use the high-current interrupting output contacts to switch ac control signals.

High-current interrupting output contacts are polarity dependent. Note the **+** polarity markings above terminals **A01**, **A03**, **A05**, **B02**, **B04**, **B06**, ..., **B24** in *Figure 2.2*. The extra I/O board of the relay in *Figure 2.3* does not show these **+** polarity markings (because it is the rear panel for an extra I/O board with standard output contacts).

As an example, consider the connection of terminals **B01** and **B02** (high-current interrupting output contact **OUT201**) in a circuit. Terminal **B02 (+)** must have a higher voltage potential than terminal **B01** in the circuit. The same holds true for output contacts **OUT202–OUT212**. For **OUT101, OUT102**, and **OUT103**, terminals **A01**, **A03,** and **A05** must have the higher potential.

Fast Hybrid High-Current Interrupting Output Contacts

Model 0311 part numbers with a numeral "5" in the field in bold below indicate fast hybrid high-current interrupting output contacts on the extra I/O board (OUT201 through OUT208):

0311C11HA3A54**5**1

Fast hybrid high-current interrupting output contacts are not polarity dependent and may be used to switch either ac or dc loads. Short transient inrush current may flow when a switch that is in series with the contact is closed while the contact is open. This transient will not energize the circuit used in typical applications. Trip and close coils and standard auxiliary relays will not pick up; however, an extremely sensitive digital input or light duty, high-speed auxiliary relay may pick up for this condition. The transient occurs when the capacitance of the output contact circuitry charges. A third terminal (B03 in *Figure 2.6*) provides a path for charging the capacitance when the circuit is open.

Figure 2.7 shows some possible connections for this third terminal that will eliminate the possibility of transients when closing a switch. Circuit load is not shown. In general, the third terminal must be connected to the dc rail that is on the same side as the open switch condition. If an open switch may exist on either side of the output contact, only one condition may be considered. Two open switches (one on each side of the contact) defeat the charge circuit.

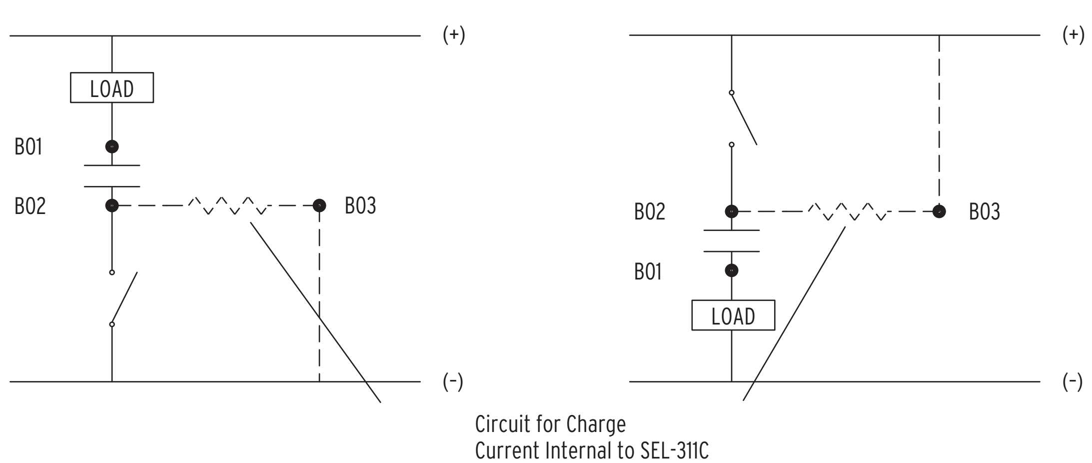


Figure 2.7 Possible Connections for Fast High-Current Interrupting Output Contacts (Third Terminal Connection Is Optional)

Optoisolated Inputs

The optoisolated inputs in the SEL-311C models (e.g., IN102, IN207) are not polarity dependent. Refer to *General Specifications on page 1.2* for optoisolated input ratings.

Inputs can be configured to respond to ac or dc control signals via Global settings IN101D–IN106D and IN201D–IN208D.

Refer to the serial number sticker on the relay rear panel for the optoisolated input voltage rating (listed under the LOGIC INPUT label).

SafeLock Trip and Close Pushbuttons

NOTE: The SafeLock Trip and Close pushbuttons are electrically isolated from the rest of the relay. To monitor the SafeLock trip and close button activity in the relay, wire an optoisolated input to each controlled circuit, and then monitor the input state using other relay functions. For example, inputs can be monitored using the Sequential Events Recorder (SER) Report. For SER details see Sequential Events Recorder (SER) Report on page 12.26.

Trip and close your circuit breaker or control other devices using the optional SafeLock Trip and Close pushbuttons even when the relay is without power. Provide bright, easily visible breaker status or the status of other devices using the integral breaker status LEDs. These features are electrically isolated and function independently of the rest of the relay. *Figure 2.18* shows example trip and close circuit connections in a dc system. The SafeLock pushbuttons come configured from the factory for dc operation, with the internal arc suppressor enabled. SafeLock pushbuttons with the internal arc suppressor enabled will not be damaged even if they are released while trip or close current is still flowing. See *Specifications on page 1.2* for current interrupting capability. When the arc suppressor is enabled, terminal Z16(+) must have a higher voltage potential than terminal Z15, and terminal Z18(+) must have a higher voltage potential than terminal Z17.

To use an ac trip or close potential, the arc suppression must be disabled for one or both pushbuttons. The arc suppressor should also be disabled when connecting the pushbuttons to loads that do not require arc suppression, such as certain magnetic actuator circuit breakers.

Jumpers on the pushbutton board in *Figure 2.22* determine if the arc suppressor on the SafeLock pushbuttons is enabled or disabled. See *Specifications on page 1.2* for load current ratings that the pushbuttons can switch without the assistance of the internal arc suppressors.

The breaker indicator LEDs are suitable for use in ac and dc systems. The operating voltage ranges of the LEDs are configured by jumpers as shown in *Figure 2.22*.

See *Circuit Board Connections and Jumpers on page 2.22* for instructions regarding access to circuit board jumpers.

SafeLock Pushbutton Lock and Tagout

The SafeLock pushbuttons have an extra deep protective sleeve to prevent inadvertent actuation. See *Figure 2.8*. Only an intentional button press will activate the buttons. Rotate the protective sleeve 90 degrees clockwise to lock the pushbuttons. In this locked position the button cannot be pressed, and the tab on the protective sleeve aligns with the tab on the button base. Use the aligned tabs to hang a lockout tag and prevent the button from being unlocked.

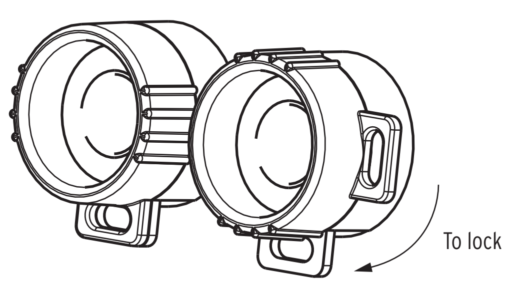


Figure 2.8 SafeLock Trip and Close Pushbuttons

Disabling the SafeLock Pushbutton Lock

Some applications do not permit a breaker control to be locked. Set-screws on the back of the button body behind the relay front panel allow you to freeze the rotating protective sleeve in the unlocked position, effectively disabling the locking mechanism. Follow these steps while referring to *Figure 2.9* to disable the locking mechanism.

⚠CAUTION
Ensure the button is unlocked before proceeding. Trying to freeze a button in the locked position may result in damage to the button mechanism.

1. Remove the relay front panel.
2. Locate the back of the button to be frozen in the unlocked position. Remove either mounting screw from the back of the button. Remove the spacer from the mounting screw. Retain the spacer in case you wish to enable the locking mechanism in the future.
3. Reseat the mounting screw removed in Step 2 without the spacer sleeve, being careful not to torque it past 4 in-lb. (0.5 Nm).
4. Test the button to ensure the protective sleeve will no longer rotate (the button cannot be locked), and that the button still moves when pressed.
5. Reinstall the relay front panel.

⚠CAUTION
Ensure button is in unlocked position before reseating screw. Inserting the screw without the spacer with the button in the locked position will result in damage to the button.

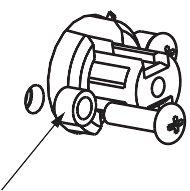


Figure 2.9 Remove Spacer and Reseat Screw to Disable Locking Mechanism

Current Transformer Inputs

Note the polarity dots above terminals **Z01**, **Z03**, **Z05**, and **Z07**. Refer to *Figure 2.13–Figure 2.17* for typical CT wiring examples.

Refer to the serial number sticker on the relay rear panel for the nominal current ratings (5 A or 1 A) for the phase (**IA**, **IB**, **IC**) and neutral (**IN**) current inputs (listed under label **AMPS AC**).

Potential Transformer Inputs

Note the signal labels (**VA**, **VB**, **VC**, **N**, **VS**, **NS**) on terminals **Z09–Z14**. *Figure 2.10* shows the internal connection for terminals **VA**, **VB**, **VC**, and **N**. Note also that **VS-NS** is a separate single-phase voltage input.

Voltage Input Rating

The continuous voltage input rating for the SEL-311C is 300 Vac.

This voltage rating applies to the three-phase voltage inputs (**VA-N**, **VB-N**, **VC-N**) as well as to the **VS-NS** voltage input. The voltage rating is for V_{LN} when the relay is wye-connected (three-phase, four-wire), or V_{LL} when the relay is delta connected (three-phase, three-wire). The following three subsections explain the wye and delta voltage input connections.

Wye-Connected Voltages (Global Setting PTCONN = WYE)

Any voltage input (i.e., **VA-N**, **VB-N**, **VC-N**, or **VS-NS**) can be connected to voltages up to 300 V continuous. *Figure 2.10* shows an example of wye-connected voltages. System frequency is determined from voltage connected to voltage input VA-N. Additionally, voltage input VS-NS measures frequency on the other side of an open breaker for synchronism check applications. See *Synchronism Check Elements on page 3.53* and *Frequency Elements on page 3.71*.

Delta-Connected Voltages (Global Setting PTCONN = DELTA)

Make Global setting PTCONN = DELTA to accept an open-delta PT connection. Phase-to-phase voltages up to 300 V continuous can be connected to voltage inputs VA-N or VC-N, when the relay is connected as shown in *Figure 2.11* or *Figure 2.17*. This connection requires an external jumper between the VB terminal (Z10) and the N terminal (Z12).

In this configuration, the relay cannot measure zero-sequence (3V0) voltage from the input terminals VA-N or VC-N, because the open-delta connection blocks zero-sequence voltage information. Relay functions that require zero-sequence voltage (also called 3V0) may be disabled, unless another 3V0 voltage source is supplied to the relay via terminal VS-NS (see *Broken-Delta VS Connection (Global Setting VSCONN = 3V0) on page 2.12*). Ground distance elements are disabled when PTCONN = DELTA.

Referring to *Figure 2.11* and *Figure 2.17*, when Global setting PTCONN = DELTA, the relay interprets the voltage signal detected across the VA-N terminals as V_{AB}, and the voltage signal detected across the VC-N terminals as V_{CB} (or $-V_{BC}$). Phase-to-phase voltage V_{CA} is derived internally with the equation $V_{CA} = V_{CB} - V_{AB}$. The relay does not use the voltage signal detected across the VB-N terminals, which should effectively be zero due to the jumper between VB and N. Unfiltered (raw) event reports are the only means by which signals applied to relay voltage terminals VA-N, VB-N, and VC-N can be directly observed. See *Unfiltered Event Reports With PTCONN = DELTA on page 12.15*.

System frequency is determined from voltage connected to voltage input VA-N. Additionally, voltage input VS-NS measures frequency on the other side of an open breaker for synchronism check applications (see *Synchronism Check Elements on page 3.53* and *Frequency Elements on page 3.71*).

Synchronism Check VS Connection (Global Setting VSCONN = VS)

When setting VSCONN = VS, voltage input VS is in its traditional role of voltage input for the synchronism check elements. *Figure 2.13*–*Figure 2.17* show examples of synchronism check voltage inputs applied to relay terminals VS-NS. See *Synchronism Check Elements on page 3.53*.

Broken-Delta VS Connection (Global Setting VSCONN = 3V0)

When Global setting PTCONN = DELTA, Global Setting VSCONN is available. Setting VSCONN = 3V0 adjusts the relay to accept a $3V_0$ zero-sequence voltage signal connected to voltage input VS-NS. This signal is usually derived from PTs connected wye (primary)/broken-delta (secondary):

$$V_S = V_A + V_B + V_C = 3V_0.$$

This signal is passed to certain relay functions that require zero-sequence voltage, such as zero-sequence voltage-polarized ground directional elements. Because setting VSCONN = 3V0, these elements use the $3V_0$ zero-sequence voltage measured by the VS-NS voltage input.

To prevent a broken-delta voltage source from exceeding the rated voltage of the relay voltage inputs, some applications require an external step-down transformer. *Figure 2.11* shows the PT wiring, including an instrumentation step-down transformer, for using relay terminals VS-NS as a zero-sequence voltage source. Group setting PTRS accommodates the ratio of the step-down transformer. See *Settings Explanations on page 9.16* for an example setting of PTRS when VSCONN = 3V0. For a complete listing of the changes caused by setting VSCONN = 3V0, see *Table 9.6* and related discussions.

Selecting Global setting VSCONN = 3V0 disables the synchronism check element. Therefore, input terminals **VS-NS** cannot be used for 3V0 measurement and as a synchronism check voltage input at the same time.

Polarity Check for VSCONN = 3V0

Refer to *Figure 2.11*. With setting VSCONN = 3V0, voltage input **VS** (terminals **VS-NS**) expects $3V_0$ voltage ($V_S = 3V_0 = V_A + V_B + V_C$) with the polarity shown. However, in a nonfault, balanced system condition, voltage $V_S = 3V_0 \approx 0$. The result is that a polarity problem with voltage input **VS**, such as when secondary wires on terminals **VS-NS** are on the wrong terminals, will not necessarily be apparent until a ground fault occurs or testing is performed.

Wye-Connected PT Example

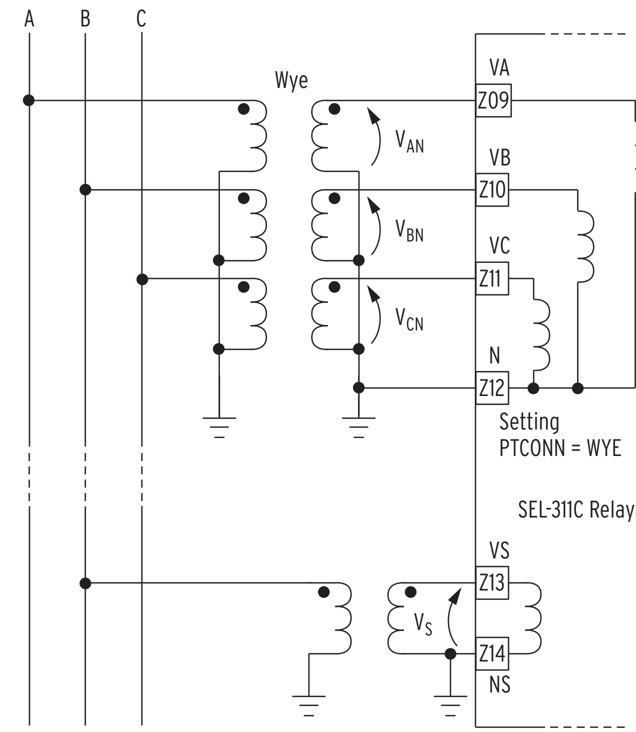


Figure 2.10 Wye-Connected PTs With Phase-Ground Connected Synchronism Check Input

Open-Delta-Connected PT Example

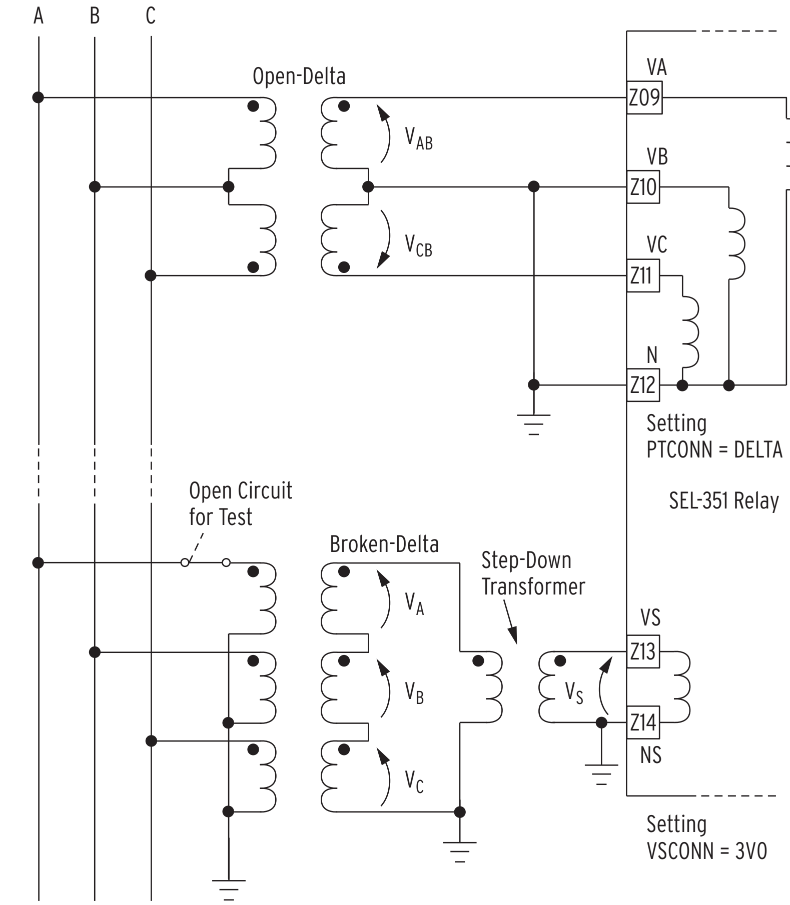


Figure 2.11 Broken-Delta Secondary Connection to Voltage Input VS, Delta-Connected PTs

To verify the correct polarity on voltage input **VS**, perform the following test on the primary side of one of the PTs connected in broken-delta secondary (refer to *Figure 2.11*) and observe the resultant voltage phase angle differences.

Open circuit the primary side of the PT connected to power system phase A. With the resultant collapse of secondary voltage V_A ($V_A = 0$) in the broken-delta secondary circuit, the voltage at voltage input **VS** is:

$$V_S = 3V_0 = V_A + V_B + V_C = V_B + V_C$$

Figure 2.12 shows the resultant voltage V_S, with respect to the delta-connected power system voltages connected to the voltage inputs **VA**, **VB**, **VC** (ABC rotation used in this example). For this scenario of the collapse of secondary voltage V_A ($V_A = 0$) in the broken-delta secondary, note that voltage V_S is 150 degrees out-of-phase with voltage V_{AB} (from voltage input **VA**).

Use the **METER** command (via serial port or front panel) to compare these voltage phase angles. If the phase angle difference between V_S and V_{AB} is 150 degrees (within a few degrees), then the polarity of voltage input **VS** is deemed correct. If the phase angle difference between V_S and V_{AB} is 30 degrees (again, within a few degrees), then the secondary wires from the broken-delta secondary in *Figure 2.11* need to be swapped in connection to terminals **VS-NS**.

NOTE: When the relay is connected to open-delta PTs and Global setting PTCONN = DELTA, there is no “3V0” value in the **METER** command (via serial port or front panel).

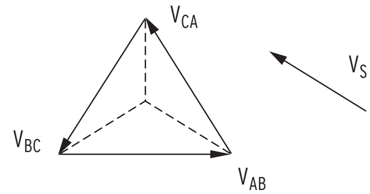


Figure 2.12 Resultant Voltage V_S from the Collapse of Voltage V_A in the Broken-Delta Secondary (Compared to the Delta-Connected Power System Voltages)

Making Communications Connections

USB Port

The optional front-panel USB port is intended for fast local access to the relay. Use SEL cable C664 to connect a personal computer to the relay USB port. See *Establishing Communications Using the USB Port on page 10.2*.

Ethernet Ports

The SEL-311C is equipped with either one or two fiber-optic or twisted-pair rear-panel Ethernet ports. Connect the relay to an Ethernet switch using SEL fiber-optic cable C807 with LC connectors, or SEL CAT5 cable C627 with RJ-45 connectors. Many computers support autocrossover, so cable C627 can also be used to connect the relay directly to these computers. For computers that do not support autocrossover, use crossover cable C628. See *Establishing Communications Using an Ethernet Port and Telnet or the Read-Only Web Server on page 10.7*.

The 1300 nm fiber-optic Ethernet ports are designed for 62.5µm fiber with LC connectors. The total link budget is 11 dB. See the *Fiber-Optic Products and Applications* data sheet on the SEL website for instructions on how to calculate fiber system losses.

Serial Ports

Optional serial **PORT 1** on all the SEL-311C models is an EIA-485 port (4-wire). The serial **PORT 1** plug-in connector accepts wire size AWG 24 to 12. Strip the wires 0.31 inches (8 mm) and install with a small slotted-tip screwdriver.

All EIA-232 ports accept 9-pin D-subminiature male connectors. **PORT 2** on all SEL-311C models includes the IRIG-B time-code signal input (see *Table 10.3*; see following discussion on IRIG-B time code input).

The pin definitions for all the ports are detailed in *Table 10.3*–*Table 10.5*.

Refer to *Table 2.1* for a list of cables available from SEL for various communication applications. Refer to *Communications Cables on page 10.11* for detailed cable diagrams for selected cables.

NOTE: Listing of devices not manufactured by SEL in Table 2.1 is for the convenience of our customers. SEL does not specifically endorse or recommend such products, nor does SEL guarantee proper operation of those products, or the correctness of connections, over which SEL has no control.

For example, to connect any EIA-232 port to the 9-pin male connector on a laptop computer, order cable number C234A and specify the length needed (standard length is eight feet). To connect the SEL-311C **PORT 2** to an SEL Communications Processor or Automation Controller that supplies the communication link and the IRIG-B time synchronization signal, order cable number C273A. For connecting devices at distances over 50 feet, SEL offers fiber-optic transceivers. The SEL-2800 family of transceivers provides fiber-optic links between devices for electrical isolation and long distance signal transmission. Contact SEL for further information on these products.

Table 2.1 Communication Cables to Connect the SEL-311C to Other Devices

SEL-311C EIA-232 Serial Ports	Connect to Device (gender refers to the device)	SEL Cable No.
All EIA-232 ports	PC, 25-Pin Male (DTE)	C227A
All EIA-232 ports	Laptop PC, 9-Pin Male (DTE)	C234A
All EIA-232 ports	PC, USB	C662
Front-panel USB port	PC, USB	C664
All EIA-232 ports	SEL Communications Processor, Automation Controller, or SEL-2100 without IRIG-B	C272A
2	SEL Communications Processor, Automation Controller, or SEL-2100 with IRIG-B	C273A
All EIA-232 ports	SEL-PRTU	C231
All EIA-232 ports	SEL-DTA2	C272A
2[a] 3[a]	Port-powered modem, 5 Vdc Powered	C220[a]
All EIA-232 ports	Standard modem, 25-Pin Female (DCE)	C222

[a] A corresponding main board jumper must be installed to power the modem with +5 Vdc (0.5 A limit) from the SEL-311C. See Figure 2.19.

See *Establishing Communications Using a Serial Port on page 10.1* for more information.

IRIG-B Time-Code Input

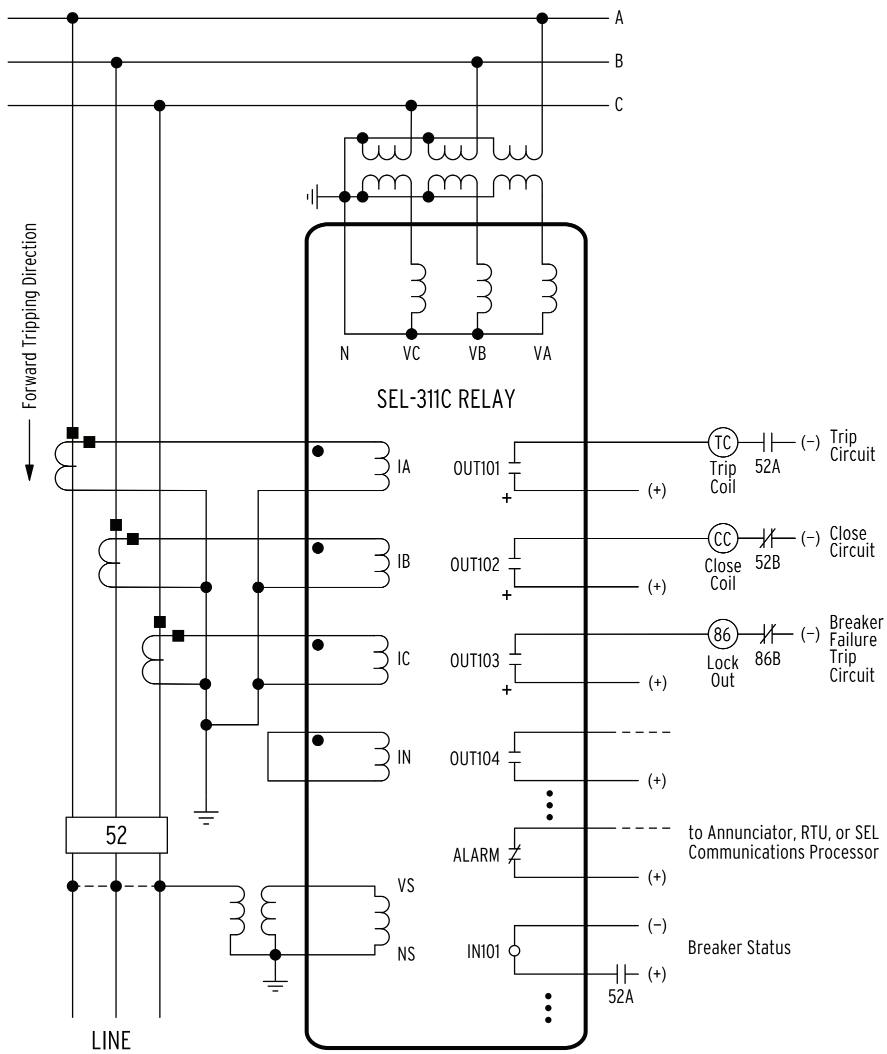
The SEL-311C accepts a demodulated IRIG-B time signal to synchronize the relay internal clock with an external source. The demodulated IRIG-B time signal can come via an SEL Communications Processor, Automation Controller, or the SEL-2100 Logic Processor listed in *Table 2.1*, or from a satellite-synchronized clock, such as the SEL-2407®, SEL-2404, or SEL-2401. The IRIG-B time signal can be connected to the rear-panel BNC connector labeled IRIG or to PORT 2.

A demodulated IRIG-B time code can be input into serial PORT 2 by connecting the port to an SEL Communications Processor or Automation Controller using Cable C273A.

Connect the rear-panel BNC connector directly to a high-accuracy satellite-synchronized clock such as the SEL-2407 or SEL-2401 to synchronize the relay internal clock within one microsecond and enable high-accuracy synchrophasors. See *Appendix N: Synchrophasors* for more information on enabling and using synchrophasors in the SEL-311C.

If a time code is input to serial PORT 2 and the BNC IRIG connector, the relay synchronizes to the time code received on the BNC connector.

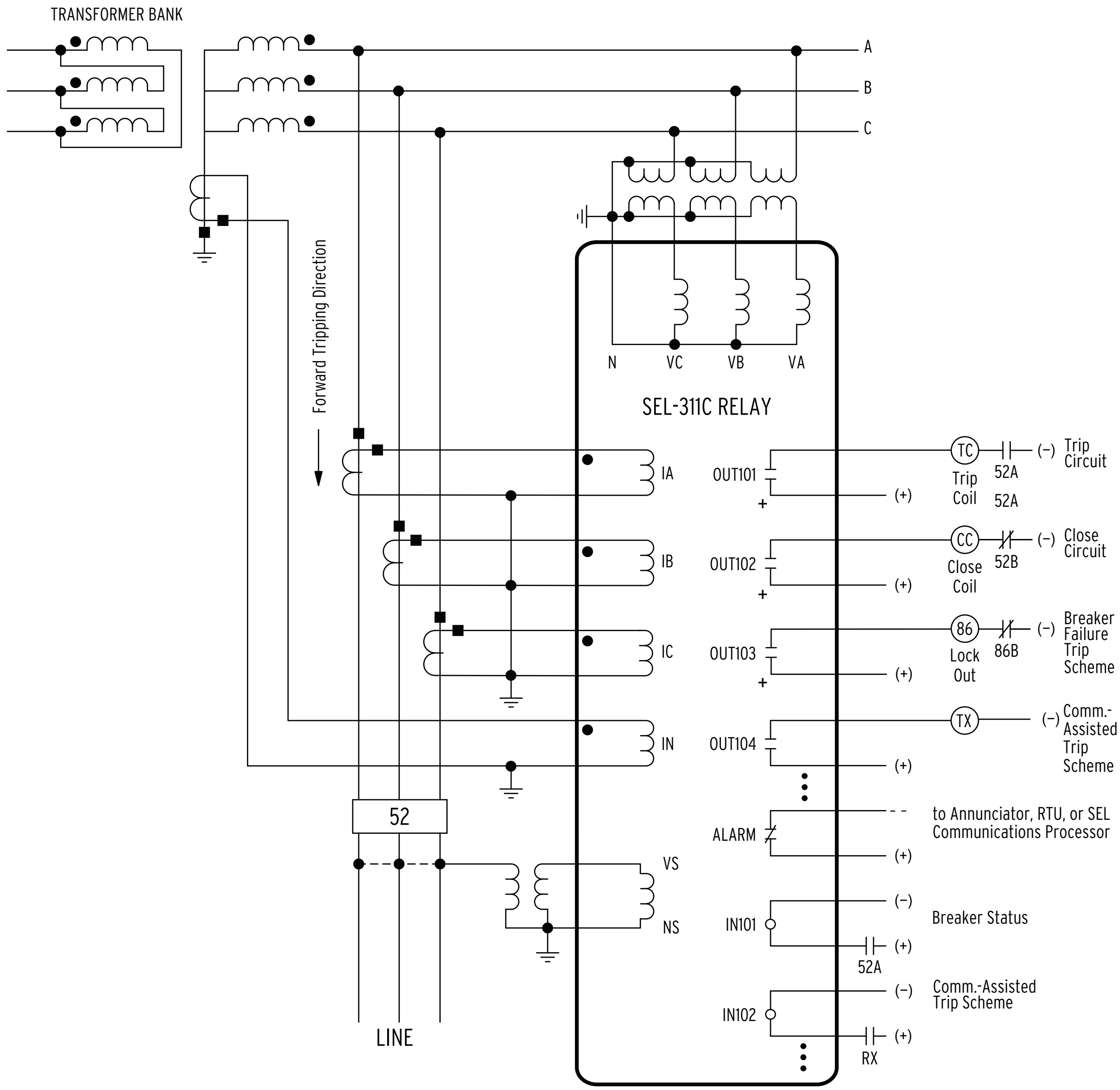
SEL-311C AC/DC Connection Diagrams for Various Applications



Voltage Channel VS is used in voltage and synchronism check elements and voltage metering.

Current Channel IN does not need to be connected. Channel IN provides current for current polarized directional elements.

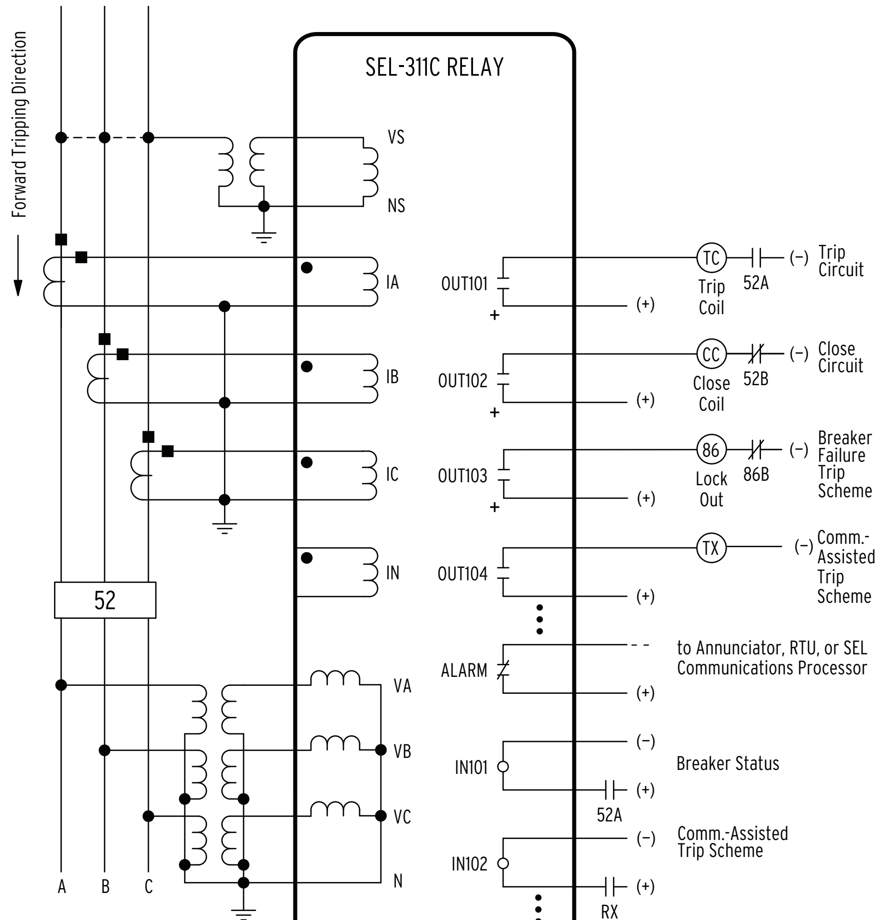
Figure 2.13 SEL-311C Provides Distance and Overcurrent Protection, Reclosing, and Synchronism Check for a Transmission Line



Voltage Channel VS does not need to be connected. It is used only in voltage and synchronism check elements and voltage metering.

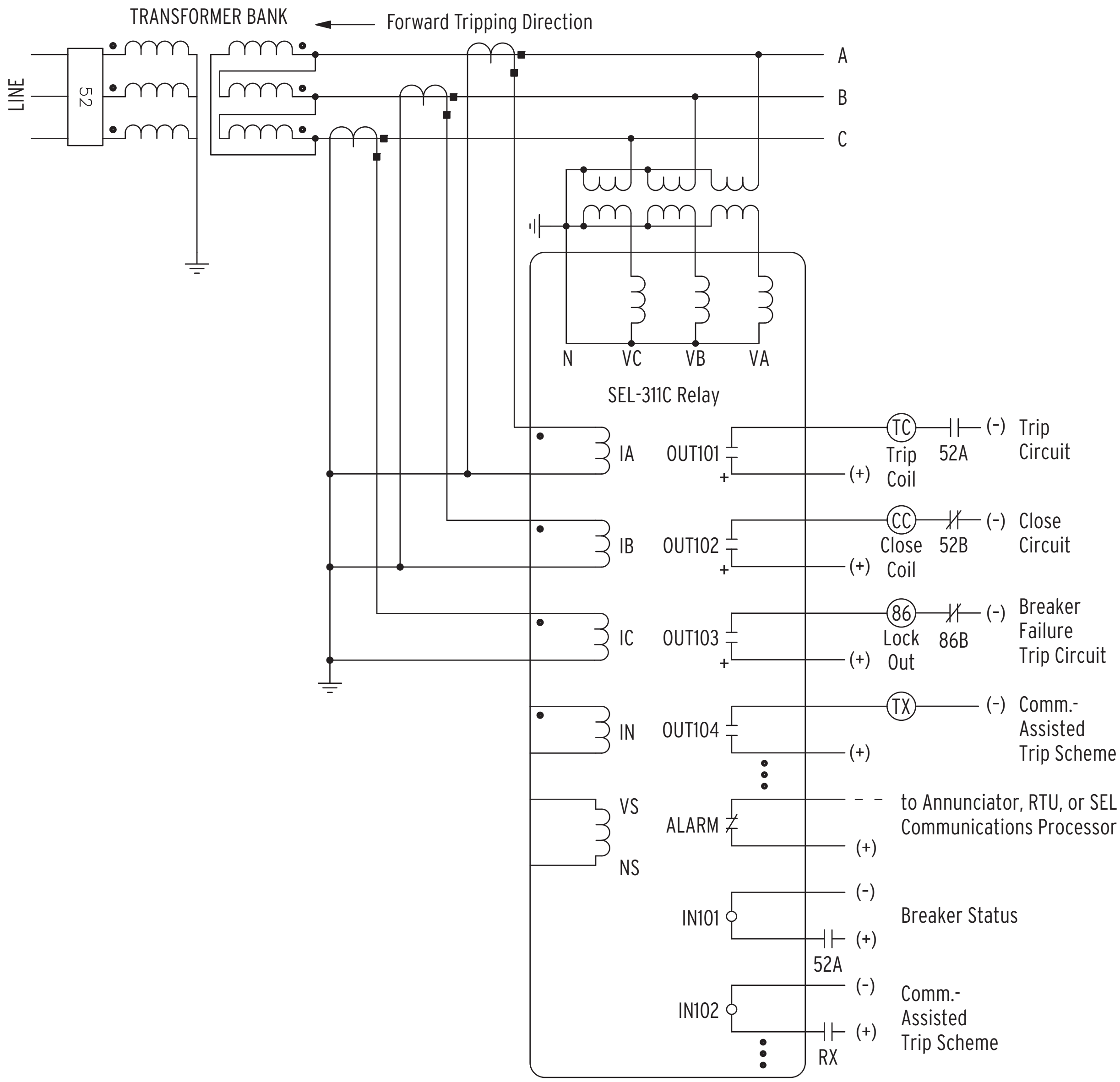
In this example, current Channel IN provides current polarization for a directional element used to control ground elements.

Figure 2.14 SEL-311C Provides Distance and Overcurrent Protection and Reclosing for a Transmission Line (Current-Polarization Source Connected to Channel IN)



Voltage Channel VS does not need to be connected. It is used only in voltage and synchronism check elements and voltage metering.

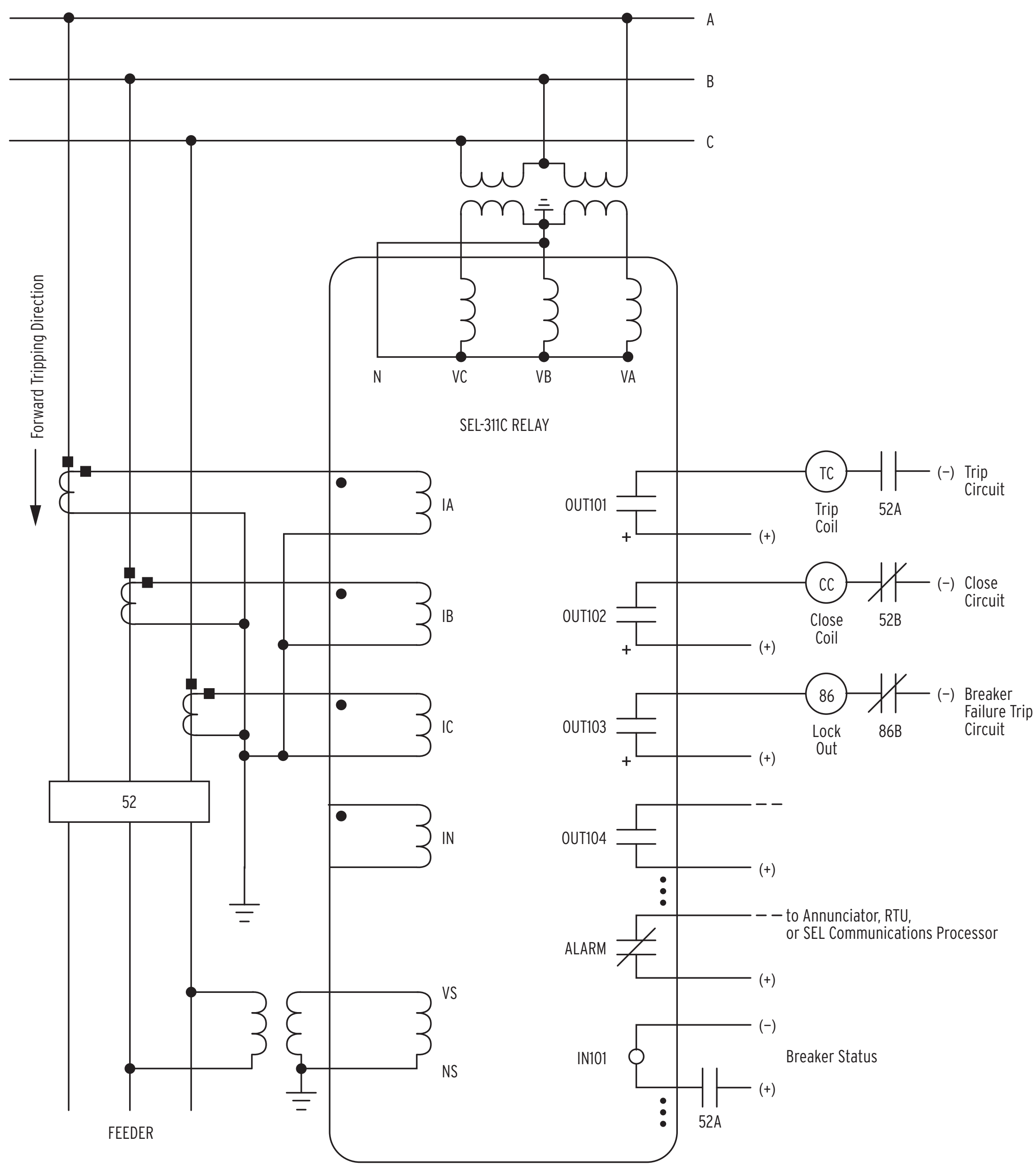
Figure 2.15 SEL-311C Provides Distance and Overcurrent Protection and Reclosing for a Transmission Line With Line-Connected Potential Transformers



Use compensator distance elements for line protection through a delta-wye transformer.

Voltage VS does not need to be connected.

Figure 2.16 SEL-311C Line Protection Through a Delta-Wye Transformer Using Compensator Distance Elements



The voltage inputs can accept open-delta PT (three-wire) connection (as shown) when Global setting PTCONN = DELTA.

Voltage terminal **VB (Z10)** must be tied to voltage terminal **N (Z12)**, as shown.

Voltage Channel VS is shown connected for use in voltage and synchronism check elements and voltage metering. See Synchronism Check VS Connection (Global Setting VSCONN = VS) on page 2.12. The synchronism check voltage is connected between phases B and C. To account for the phase difference between VA and VBC, use group setting SYNCP. See Synchronism Check Elements on page 3.53.

Figure 2.17 SEL-311C Provides Distance and Overcurrent Protection and Reclosing for a Transmission Line Using Compensator Distance Elements (Delta Connected PTs and Line-to-Line Synchronism Check Connection)

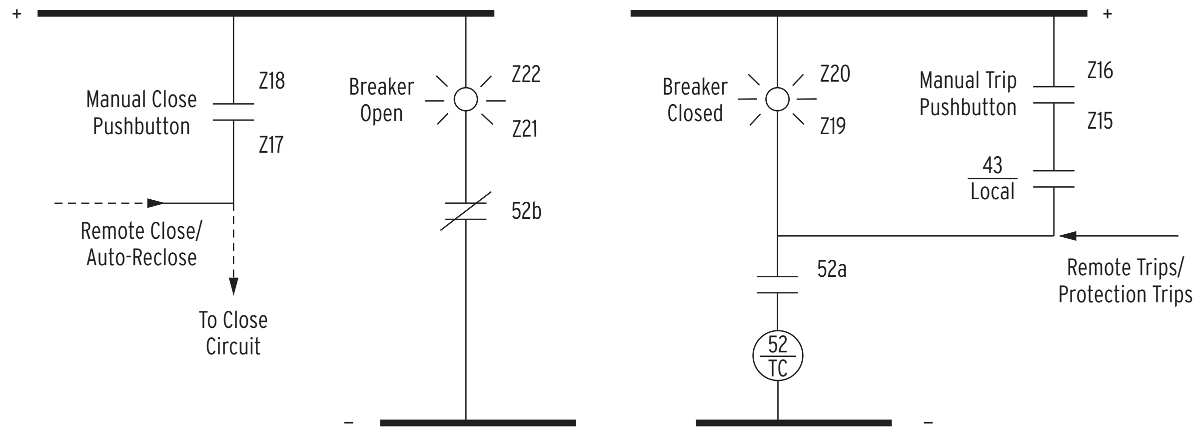


Figure 2.18 SEL-311C Example Wiring Diagram Using the SafeLock Trip/Close Pushbuttons

Circuit Board Connections and Jumpers

Accessing the Relay Circuit Boards

⚠**CAUTION**
Remove all sources of voltage from the relay before removing equipment covers or disassembling the relay.

⚠**CAUTION**
The relay contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with the front panel removed, work surfaces and personnel must be properly grounded or equipment damage may result.

NOTE: Optional USB and Ethernet connections reside on daughter cards that attach to the bottom of the mainboard. Be careful not to damage these daughter cards when handling the mainboard.

To change circuit board jumpers or replace the clock battery, refer to *Figure 2.19–Figure 2.22* and perform the following steps:

Step 1. De-energize the relay.

Step 2. Remove any cables connected to communications ports on the front and rear panels or the BNC connector on the rear panel.

Step 3. Loosen the six front-panel screws (they remain attached to the front panel), and remove the relay front panel.

Step 4. Remove the ribbon cable from the front panel.

Step 5. Remove the LED connectors from the front panel, if equipped.

Step 6. Identify which boards must be removed to accomplish the desired tasks.

a. For the Access jumper, Breaker Control jumper, serial port **+5 V** jumpers, extra alarm output jumper, the battery for the battery-backed clock, or the A/B output jumpers for **OUT101** through **ALARM**, remove the mainboard only. The mainboard is the top most board in the relay chassis. If the relay has not yet been installed in a panel, the top cover can be removed by removing the seven cover screws.

b. To access the A/B output jumpers for OUT201 through OUT212 if equipped, remove the mainboard, then remove the extra I/O board below the mainboard.

c. To access the arc suppression jumpers and the breaker status LED voltage input jumpers on the SafeLock pushbutton board, remove the relay top cover and mainboard, then remove the extra I/O board below the mainboard, if equipped. It is not necessary to remove the SafeLock pushbutton board.

Step 7. Disconnect circuit board cables as necessary to allow the desired board and drawout tray to be removed. Removal of the extra I/O board requires removal of the main board first. Ribbon cables can be removed by grasping the connector of the gray cable and pulling forward.

Step 8. Grasp the drawout assembly of the board and pull the assembly from the relay chassis.

Step 9. Locate the jumper(s) or battery to be changed (refer to *Figure 2.19*–*Figure 2.22*).

Make the desired changes. Note that the output contact jumpers are soldered in place.

Step 10. When finished, slide the drawout assembly into the relay chassis.

Step 11. Reconnect the cables and replace the relay front-panel cover.

Step 12. Replace any cables previously connected to the relay rear panel.

Step 13. Re-energize the relay.

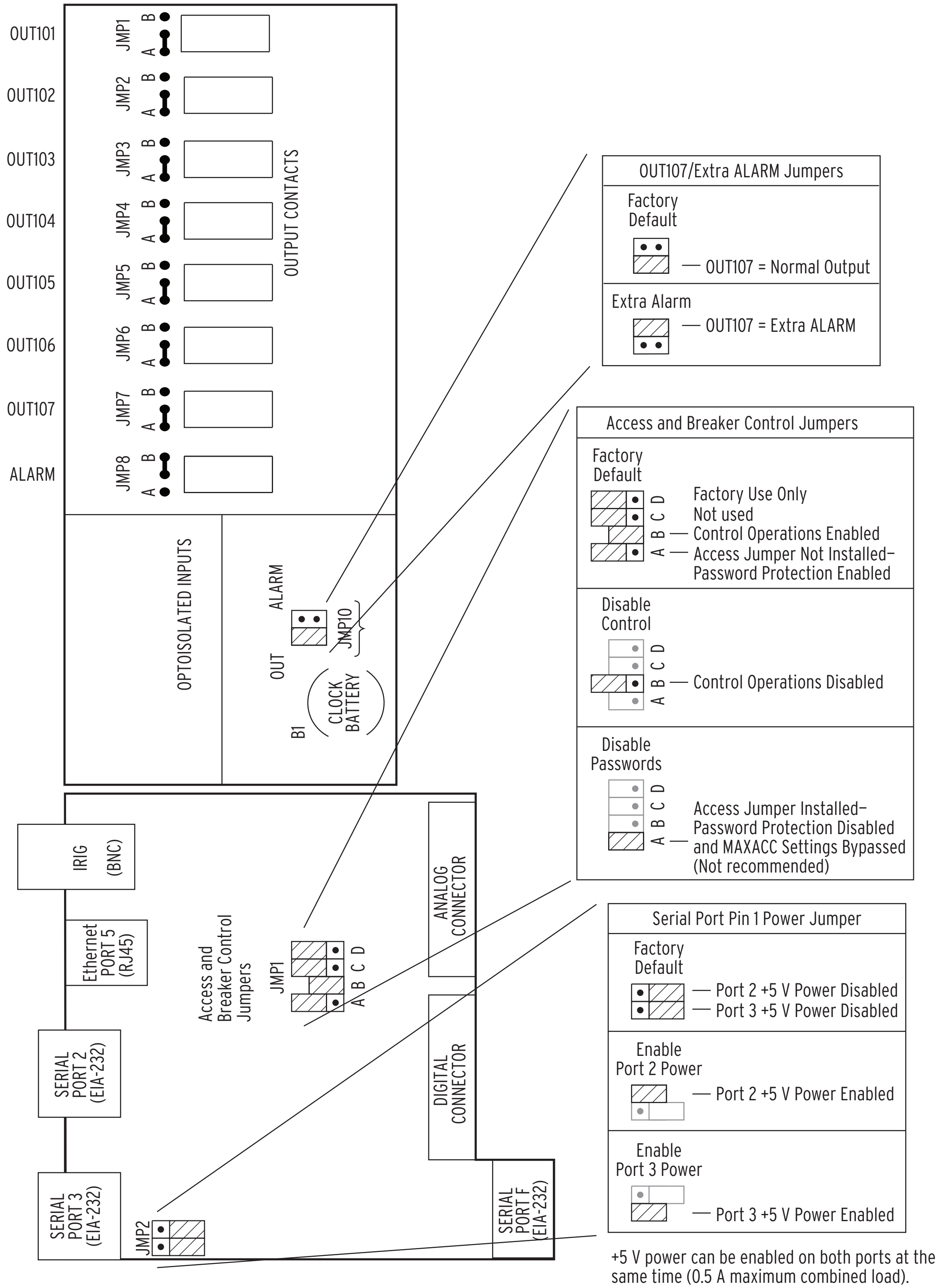


Figure 2.19 Jumper, Connector, and Major Component Locations on the SEL-311C Main Board

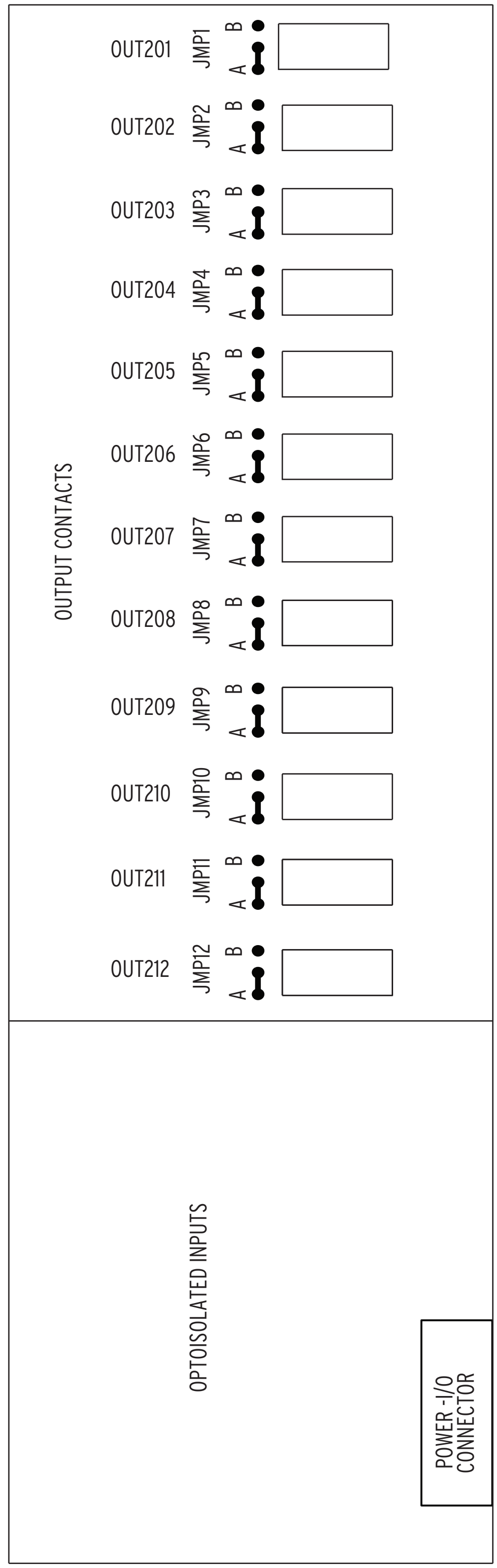


Figure 2.20 Jumper, Connector, and Major Component Locations on the SEL-311C Extra I/O Board With Standard and High-Current Interrupting Outputs

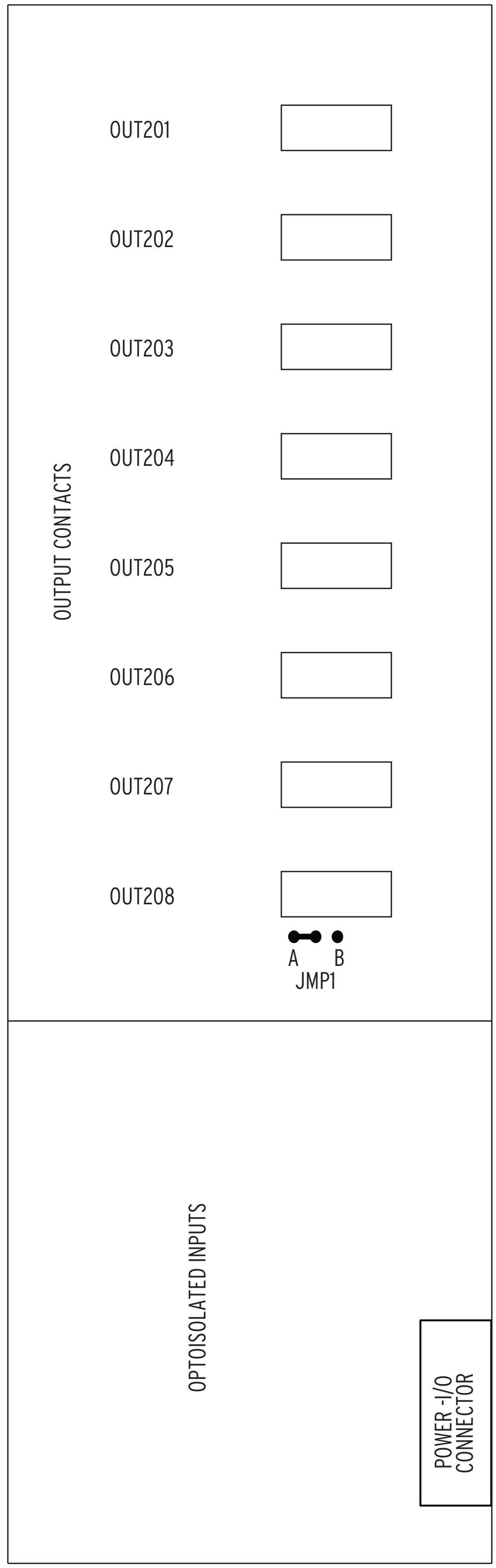


Figure 2.21 Jumper, Connector, and Major Component Locations on the SEL-311C Extra I/O Board With Fast, High-Current Interrupting Outputs

Output Contact Jumpers

⚠WARNING
The jumpers that determine if an output is form a or form b are soldered into the circuit board. Follow proper desoldering and soldering procedures when changing those jumpers, or return the relay to the factory to have the jumpers changed.

Figure 2.19, *Figure 2.20*, and *Figure 2.21* show the exact location of jumpers that determine output contact type (form a or form b). With a jumper in the A position, the corresponding output contact is a form a output contact. A form a 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 form b output contact. A form b 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.

Note that the ALARM output contact is a form b output contact and the other output contacts are all form a output contacts. This is how these jumpers are configured in a standard relay shipment. Refer to *Figure 7.28*–*Figure 7.30* for examples of output contact operation for different output contact types. All outputs on the Main Board and the standard output and high-current interrupting extra I/O boards are jumper configurable. Only output OUT208 of the Fast, High-Current Interrupting Extra I/O Board is jumper configurable. This output is shipped as a form a contact. Outputs OUT201–OUT207 are fixed form a contacts.

"Extra Alarm" Output Contact Control Jumper

The SEL-311C has one dedicated alarm output contact. Often more than one alarm output contact is needed for such applications as local or remote annunciation, backup schemes, etc. An extra alarm output contact is available without the addition of any external hardware.

Output contact OUT107 can be converted to operate as an "extra alarm" output contact by moving a jumper on the main board.

Figure 2.19 shows the location, function, and default factory configuration of JMP10, the jumper that controls OUT107. With the jumper in the OUT position, the output contact operates regularly. With the jumper in the ALARM position, the output contact is driven by the same signal that operates the dedicated ALARM output contact.

If an output contact is operating as an "extra alarm" (driven by the same signal that operates the dedicated ALARM output contact), it will be in the *opposite state* of the dedicated ALARM output contact in a *standard relay shipment*. In a standard relay shipment, the dedicated ALARM output contact comes as a form b output contact and all the other output contacts (including OUT107) come as form a output contacts.

The output contact type for any output contact on the mainboard can be changed (see *Output Contact Jumpers*). Thus, the dedicated ALARM output contact and the "extra alarm" output contact can be configured as the same output contact type if desired (e.g., both can be configured as form b type output contacts).

Access and Breaker Jumpers

Figure 2.19 shows the location, function, and factory default configuration for the Access and Breaker Control jumpers.

Use the Access jumper to enable access to any front-panel communications port, any enabled rear-panel communications ports, and the front panel user interface. When the Access jumper is installed, passwords are disabled, and connection to any enabled communications port is allowed full access to inspect/change/reset all reports, settings, etc., to upgrade firmware, and to control the circuit breaker (if the Breaker jumper is installed as described below) without password authentication.

NOTE: The Access jumper was formerly called the Password jumper.

The Access jumper also affects the relay behavior for settings EPORT and MAXACC at power-up as follows:

- For the front-panel serial port (Port F), and the optional USB port, the Access jumper overrides the port enable setting EPORT = N, and enables the port(s) with EIA-232 Port F default settings for PROTO, SPEED, BITS, PARITY, STOP, and RTSCTS. If the Port F setting EPORT was already set to Y, the front port(s) remain enabled, and the EIA-232 Port F uses its previous settings.
- For the front-panel serial port (Port F), and the optional USB port, the Access jumper overrides the Port F MAXACC setting and allows access to security levels 1, B, 2, or C without a password.
- For rear-panel serial ports (Port 1, 2, or 3), and Ethernet Port 5 Telnet sessions, if that port has setting EPORT = Y, the Access jumper overrides that port's MAXACC setting, and allows access to security levels 1, B, 2, or C without a password.
- For rear-panel serial ports (Port 1, 2, or 3), and Ethernet Port 5, if that port has setting EPORT = N, the Access jumper has no effect, and the port remains disabled.

Use the Breaker jumper to enable or disable breaker control **OPEN**, **CLOSE** and **PULSE** commands through the SEL ASCII protocol and breaker operations through the SEL Fast Operate protocol, DNP, Modbus, and the front-panel menu-driven user interface. Note that the Breaker jumper does *not* supervise operation of Local Bits, Remote Bits, or the SafeLock Trip/Close pushbuttons.

EIA-232 Serial Port Voltage Jumpers

Figure 2.19 shows the location, function, and default factory configuration of the serial port Pin 1 power jumpers. These two jumpers connect or disconnect +5 Vdc to Pin 1 on the corresponding EIA-232 serial ports. The +5 Vdc is rated at 0.5 A maximum combined for both ports. See *Table 10.5* for EIA-232 serial port pin functions.

In a standard relay shipment, the jumpers are “OFF” (not in place) so that the +5 Vdc is not connected to Pin 1 on the corresponding EIA-232 serial ports. Put the jumpers “ON” (in place) so that +5 Vdc is connected to Pin 1 on the corresponding EIA-232 serial ports.

Condition of Acceptability for North American Product Safety Compliance

To meet product safety compliance for end-use applications in North America, use an external fused rated 3 A or less in-line with the +5 Vdc source on Pin 1. SEL fiber-optic transceivers include a fuse that meets this requirement.

SafeLock Trip/Close Pushbutton and Breaker Status LED Jumpers

Jumpers on the pushbutton board are used to select the proper control voltage for breaker open/closed indicating LEDs on the front panel of the relay. *Figure 2.22* shows the jumper locations and their functions. The jumpers come preset from the factory with the voltage range set the same as the control input voltage, as determined by the part number at order time.

The voltage setting can be different for each LED. To access these jumpers, the relay front cover, top cover, main board, and any Extra I/O board (if present) must first be removed. See instructions and precautions in *Accessing the Relay Circuit Boards on page 2.22*.

NOTE: With arc suppression enabled, the corresponding output polarity marks must be followed when wiring the control.

Jumpers on the pushbutton board in *Figure 2.22* determine if the arc suppressor on the SafeLock pushbuttons is enabled or disabled. Disable the arc suppressor when connecting the pushbuttons to loads that do not require arc suppression, such as certain magnetic actuator circuit breakers, or when controlling ac loads. See *Specifications on page 1.2* for load current ratings that the pushbuttons can switch without the assistance of the internal arc suppressors. Arc suppression comes enabled from the factory.

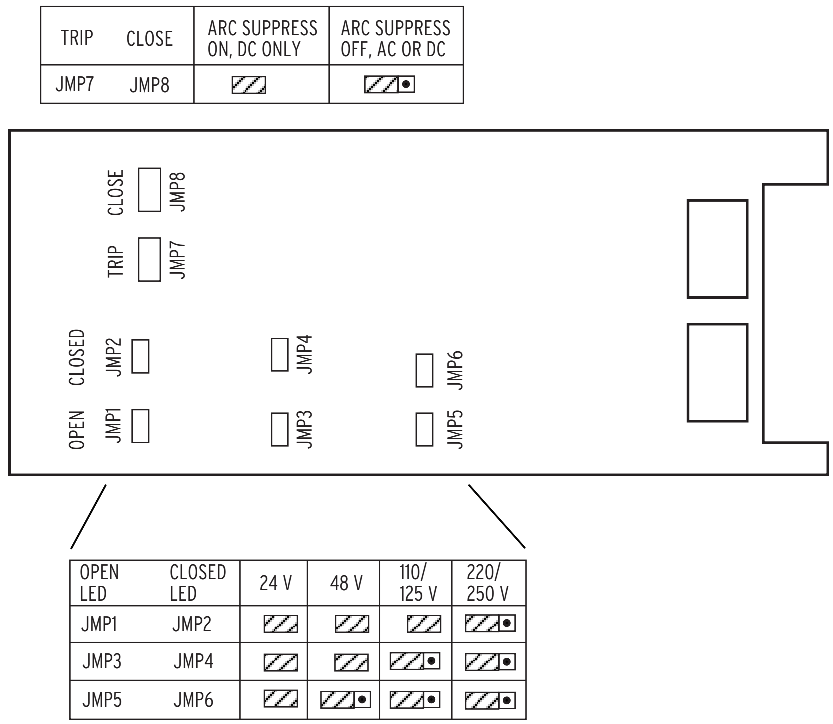


Figure 2.22 Jumper Locations for the SEL-311C SafeLock Pushbutton Board

Clock Battery

⚠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.

Refer to *Figure 2.19* for clock battery location (front of main board). 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 nominally operate for 10 years at rated load.

If the dc source is lost or disconnected, the battery powers 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 relay does not maintain the date and time after power loss, replace the battery. Follow the instructions in *Accessing the Relay Circuit Boards on page 2.22* to remove the relay main board.

Step 1. Remove the battery from beneath the clip and install a new one. The positive side (+) of the battery faces up.

Step 2. Reassemble the relay as described in *Accessing the Relay Circuit Boards on page 2.22*.

Step 3. Set the relay date and time via serial communications port or front panel (see *Section 10: Communications* or *Section 11: Front-Panel Interface*, respectively).

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Section 3

Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements

Overview

This section provides a detailed explanation for each of the SEL-311C protection functions. Each subsection provides an explanation of the function, along with a list of the corresponding settings and Relay Word bits. Logic diagrams are included for many functions.

The protection functions in this section are as follows:

- *Distance Elements on page 3.1*
- *Out-of-Step Characteristics on page 3.30*
- *Instantaneous/Definite-Time Overcurrent Elements on page 3.35*
- *Time-Overcurrent Elements on page 3.43*
- *Voltage Elements on page 3.49*
- *Synchronism Check Elements on page 3.53*
- *Frequency Elements on page 3.71*

Protection element accuracy information is listed in *Specifications on page 1.2*.

Distance Elements

Phase Distance Elements

The SEL-311C Relay has four independent zones of phase distance protection. All zones are independently set. Zones 1 and 2 are fixed to operate in the forward direction only. Zones 3 and 4 can be set to operate in either the forward or reverse direction.

Choose from one of the two types of available phase distance elements best suited for your system by enabling up to four zones using the Group setting E21P:

- Select Positive-Sequence Memory Polarized Elements (Phase Pairs) with E21P = 1, 2, 3, or 4.
- Select Compensator Distance Elements with E21P = 1C, 2C, 3C, or 4C.
- Disable all phase distance elements with E21P = N.

The phase distance element outputs are M1P, M2P, M3P, and M4P for Zone 1 through Zone 4.

Only one type of phase distance element may be enabled at a time. See *Phase Distance Element Settings and Logic Diagrams on page 3.6* for detailed information.

See *Directional Control Settings on page 4.29* for details on specifying the Zone 3 and zone 4 direction using Group settings DIR3 and DIR4.

Positive-Sequence Memory Polarized Elements (Phase Pairs)

The SEL-311C positive-sequence memory polarized elements are arranged in phase pairs, MAB*n*, MBC*n*, and MCA*n*, where *n* = Zone 1 through Zone 4. The positive-sequence voltage polarization provides security and creates an expanded mho characteristic. The phase pair distance elements operate on phase-to-phase, phase-to-phase-to-ground, and three-phase faults.

For faults involving ground, the SEL-311C fault identification logic determines the fault type and disables the mho element phase-pairs that include the grounded phase. This functionality is only available when using wye-connected potential transformers (i.e., when Global setting PTCONN = WYE).

Not Recommended for Use With Open-Delta Potential Transformers

Mho phase pair elements are not recommended in systems with open-delta connected potential transformers. When PTCONN = DELTA, fault identification logic cannot be used to supervise the mho phase pair elements, and as a result, these elements may overreach for some phase-to-phase-to-ground faults. The SEL-311C automatically removes the E21P = 1, 2, 3, 4 settings choices when initially making Global setting PTCONN = DELTA (only the compensator setting choices E21P = 1C, 2C, 3C, and 4C remain).

For special applications it is possible to select the mho phase elements when PTCONN = DELTA by making Group setting EADVS = Y. This selection will then allow E21P = 1, 2, 3, 4. For more information see *Phase Distance Element Settings and Logic Diagrams on page 3.6*.

For information on voltage connections see *Potential Transformer Inputs on page 2.11*. For information on the PTCONN setting see *Settings for Voltage Input Configuration on page 9.16*.

See Page 5 of the technical paper: "*Evaluation of Distance and Directional Relay Elements on Lines With Power Transformers or Open-Delta VTs*" by Karl Zimmerman and Dan Roth, 2005, available from www.selinc.com.

Compensator Distance Phase Elements

Compensator distance elements are included for distance relaying through wye-delta transformer banks, for open-delta potential transformer applications, and for applications that require a different operating principle for backup relaying. The compensator distance phase-elements implemented in the SEL-311C detect phase-to-phase, phase-to-phase-to-ground, and three-phase faults.

The SEL-311C compensator distance phase elements are arranged in phase-to-phase (MPP*n*) and three-phase (MABC*n*) elements, where *n* = Zone 1 through Zone 4.

Compensator distance elements are available for both wye-connected (Global setting PTCONN = WYE) and open-delta connected (PTCONN = DELTA) potential transformer applications.

Operating Principles of Phase Distance Elements

A digital relay mho element tests the angle between a line drop-compensated voltage and a polarizing (reference) voltage using the following concepts.

Sampled currents and voltages are represented in the relay as vectors by using the most recent sample as the real vector component and the sample taken one quarter cycle earlier as the imaginary vector component. See *Figure 12.7* and *Figure 12.8* for a description of this process.

➤ If vector $V_1 = |V_1| \angle \theta_1$ and vector $V_2 = |V_2| \angle \theta_2$, then $V_1 \bullet (V_2 \text{ conjugate}) = V_1 \bullet V_2^* = [\,|V_1| \bullet |V_2|\,] \angle (\theta_1 - \theta_2)$

The angle of the vector quantity $V_1 \bullet V_2^*$ is the test angle of the mho element.

➤ Test for $V_1 \bullet V_2^*$ balance point at $\theta_1 - \theta_2 = 0$ degrees by calculating $\sin(\theta_1 - \theta_2)$. In a digital relay, this is done by examining the sign (+ or –) of the imaginary component of $V_1 \bullet V_2^*$, written $Im(V_1 \bullet V_2^*)$.

➤ Test for $V_1 \bullet V_2^*$ balance point at $\theta_1 - \theta_2 = 90$ degrees by calculating $\cos(\theta_1 - \theta_2)$. In a digital relay, this is done by examining the sign (+ or –) of the real component of $V_1 \bullet V_2^*$, written $Re(V_1 \bullet V_2^*)$.

Table 3.1 shows the different calculations used for the positive-sequence polarized mho elements and compensator-distance mho elements. Notice that the positive-sequence polarized mho element equation is the solution of *Equation 3.1* for the quantity "|Z|," which represents the relay reach at the balance point. This equation is in the form of a line drop-compensated voltage and a polarizing (reference) voltage.

$$0 = Re[(Z \bullet I - V) \bullet Vmem^*]$$ **Equation 3.1**

Table 3.1 Phase Distance Calculations (Sheet 1 of 2)

Positive-Sequence Polarized Mho Element	Compensator-Distance Mho Element
Phase A-B $|Z| = \dfrac{Re(V_{AB} \bullet V_{AB}mem^*)}{Re(1\angle Z \bullet I_{AB} \bullet V_{AB}mem^*)}$	Phase-to-Phase Element (Forward direction, ABC phase rotation calculations shown) $mPP = Im[(V_{AB} - Z \bullet I_{AB}) \bullet (V_{BC} - Z \bullet I_{BC})^*]$
Phase B-C $|Z| = \dfrac{Re(V_{BC} \bullet V_{BC}mem^*)}{Re(1\angle Z \bullet I_{BC} \bullet V_{BC}mem^*)}$	Three-Phase Element (Forward direction, ABC phase rotation calculations shown) $mABC = Im[(V_{AB} - Z \bullet I_{AB}) \bullet (-jV_{AB} - 0.25 \bullet V_{C}mem)^*]$
Phase C-A $|Z| = \dfrac{Re(V_{CA} \bullet V_{CA}mem^*)}{Re(1\angle Z \bullet I_{CA} \bullet V_{CA}mem^*)}$	mPP = Phase-to-phase torque calculation. Positive torque restrains, negative torque operates.

Table 3.1 Phase Distance Calculations (Sheet 2 of 2)

Positive-Sequence Polarized Mho Element	Compensator-Distance Mho Element
Z = Impedance measurement at the line angle.	mABC = Three-phase torque calculation. Positive torque restrains, negative torque operates. Z = Replica line impedance at operating or balance point.

As mentioned previously, a digital relay mho element tests the angle between a line drop-compensated voltage and a polarizing (reference) voltage. *Figure 3.1* through *Figure 3.3* show the operating voltages "inside" positive-sequence polarized mho elements and compensator-distance mho elements. Note that V1mem is the polarizing voltage for the positive-sequence polarized mho element and (Z • I – V) is the line drop-compensated voltage.

In the compensator distance phase-to-phase element, the polarizing voltage is the unfaulted phase-to-phase voltage, and the line drop-compensated voltage is the faulted phase-to-phase voltage. In the compensator distance three-phase element, the polarizing voltage is $(-jV_{AB} - 0.25 \cdot V_{C}\text{mem})$ and the line drop compensated voltage is $(V_{AB} - Z \cdot I_{AB})$.

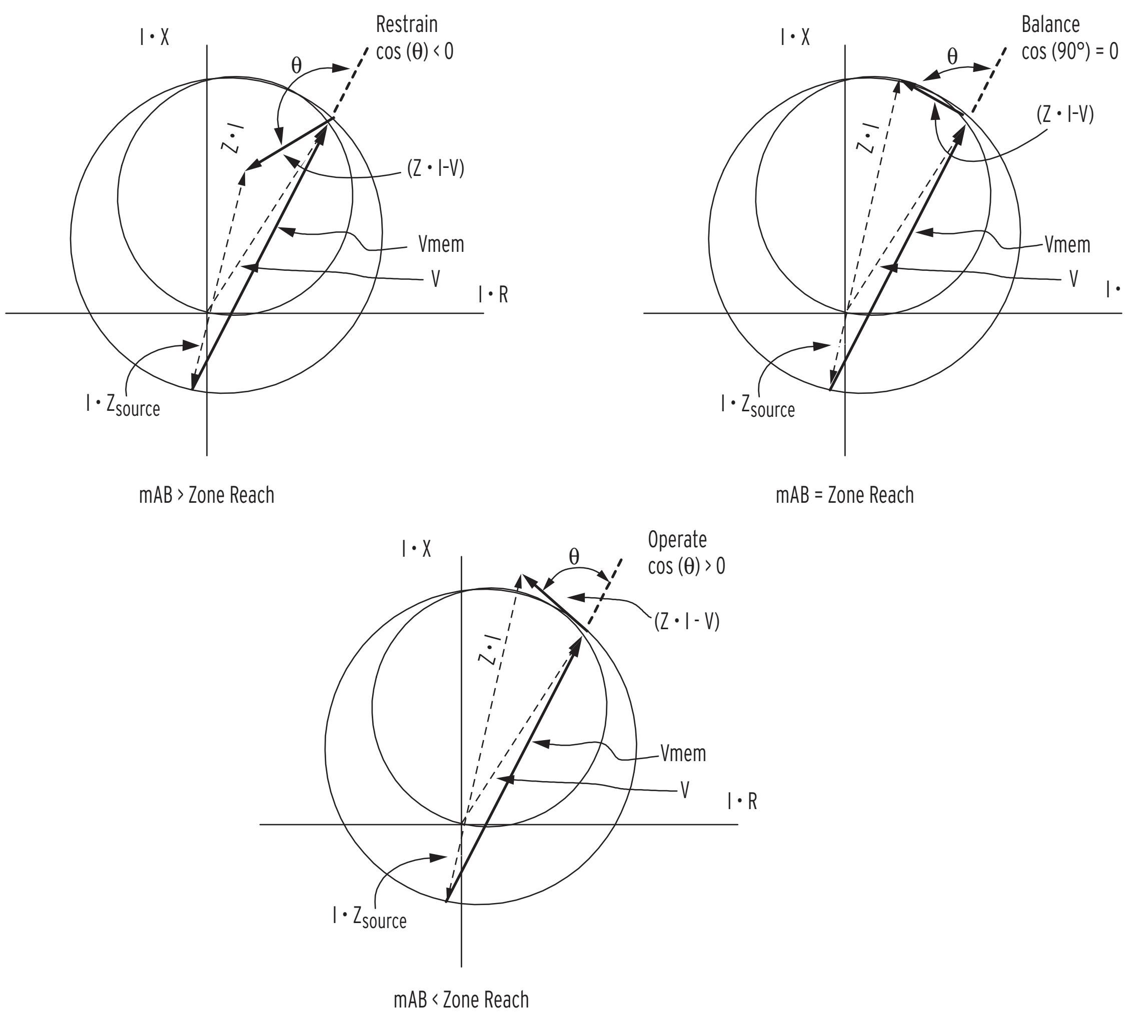
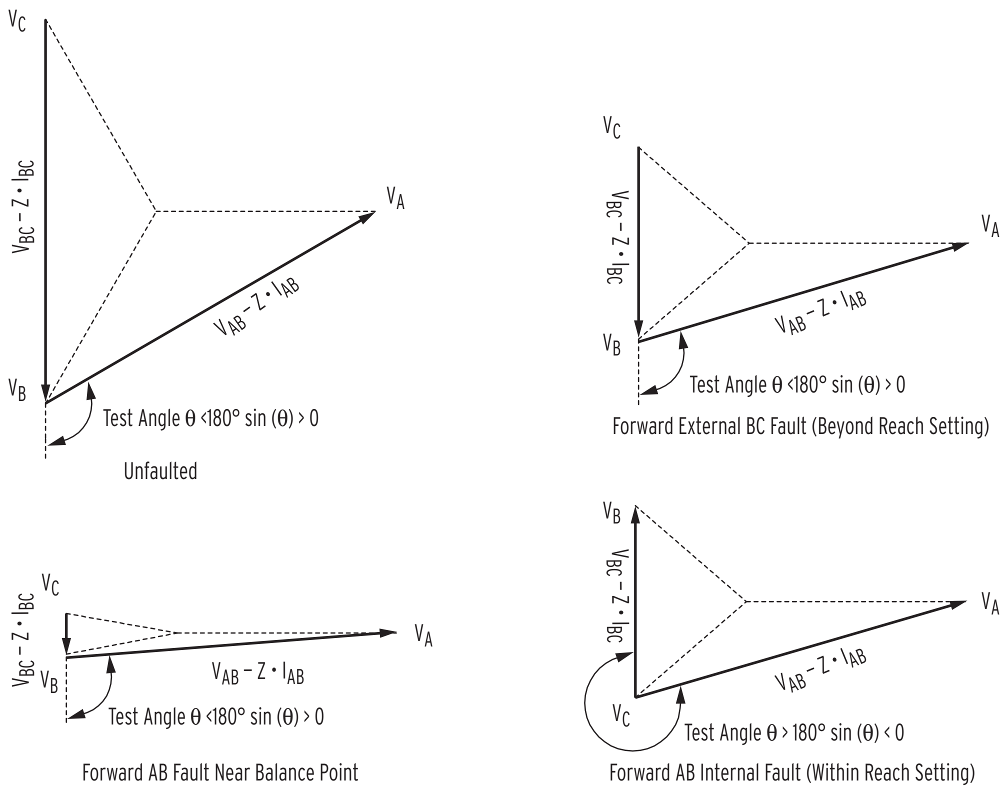
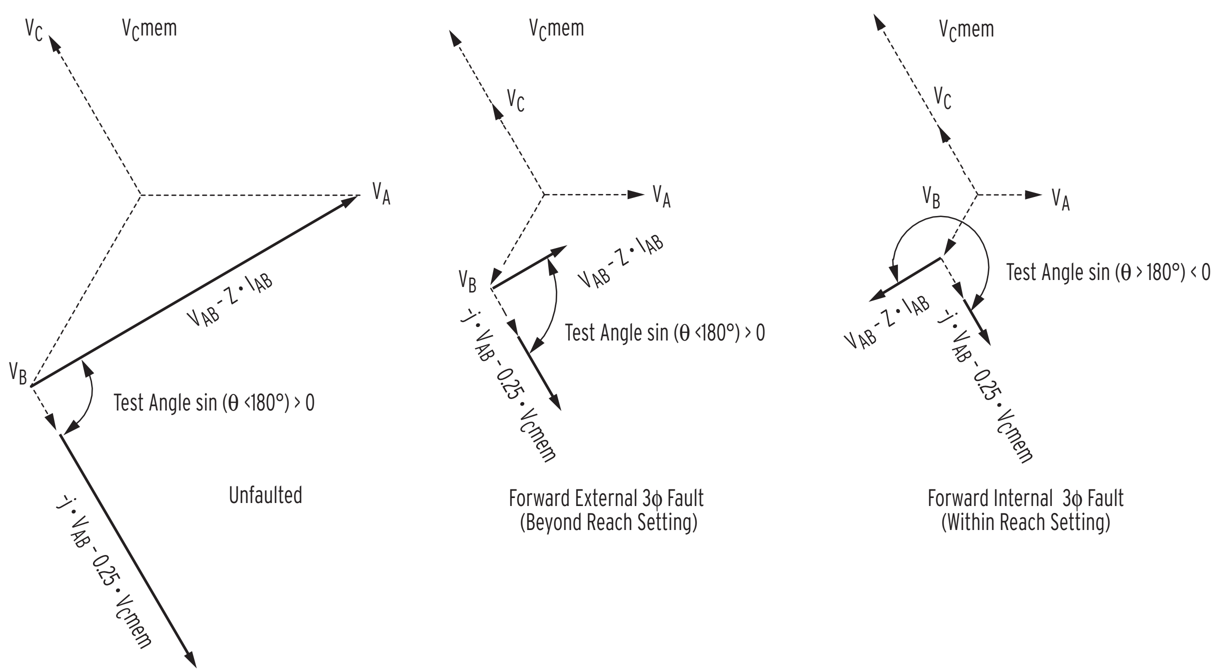


Figure 3.1 Positive-Sequence Polarized Mho Element With Reach Equal to Line Impedance



Note: V_A, V_B, and V_C are internal element voltages, not system voltages.

Figure 3.2 Compensator-Distance Phase-to-Phase Element Operation



Note: V_A, V_B, and V_C are internal element voltages, not system voltages.

Figure 3.3 Compensator-Distance Three-Phase Element Operation

Phase Distance Element Applications

Positive-sequence polarized and compensator distance mho elements each have different operating advantages in different protection environments, but work equally well in the majority of transmission line applications. Consider using compensator distance elements when:

- A different phase-distance operating principle is desired for backup relaying.
- Protecting a transmission line through a delta-wye transformer. The compensator distance element reaches through a delta-wye transformer bank for phase-to-phase, phase-to-phase-to-ground, and three-phase faults. Calculate the total primary impedance as the sum of the per-unit transformer and line impedances, then convert from per-unit to actual primary impedance at the protected bus voltage. The compensator distance element measures impedance through the transformer for all phase faults and will not overreach on ground faults. See SEL *Application Guide AG96-16: Applying* SEL *Distance Relays on Lines with Power Transformers or Open Delta VTs* for more information.
- Blocking reclose on three-phase faults. Relay Word bits MPP*n* (Zone/Level *n* phase-to-phase compensator distance element) and MABC*n* (Zone/Level *n* three-phase compensator distance element) may be used to discriminate between phase-to-phase and three-phase faults in the SELOGIC® control equation 79DTL (drive-to-lockout).

  79DTL = MABC2 * !MPP2 …

  Note that both three-phase and single-phase compensator distance elements will operate for Phase A-B faults within the protected zone since the three-phase element uses $V_C$mem (V_C memorized voltage) for polarizing.
- Protecting a transmission line equipped with open-delta connected potential transformers. Compensator distance elements are available for both wye-connected (Global setting PTCONN = WYE) and open-delta connected (PTCONN = DELTA) potential transformer applications and perform well in both configurations.

Phase Distance Element Settings and Logic Diagrams

Table 3.2 lists the Phase Distance Element settings. Group setting E21P selects how many zones of mho phase distance elements to enable and which type. If E21P is set to N, the phase distance elements are defeated. If E21P is set to a value of *n* = 1, 2, 3, or 4, that many positive-sequence memory polarized elements (phase pairs) are enabled. If E21P is set to a value of 1C, 2C, 3C, or 4C, that many compensator distance elements are enabled.

Only one type of phase distance element may be enabled at a time. For example, with E21P = 2C, in *Figure 3.4* and *Figure 3.5* the logic signal called "C in E21P" disables the upper logic (MAB1 and MAB2) and enables the lower logic (MPP1, MABC1, MPP2, MABC2). In this example, the logic in *Figure 3.6* is not executed because the number in the E21P setting is less than 3.

Some of the settings in *Table 3.2* are hidden under the control of the Enable Advanced Settings (EADVS = N) group setting.

The mho phase distance element logic is shown in *Figure 3.4* through *Figure 3.6*. In each figure, the upper part of the logic diagram contains the positive-sequence memory polarized elements (phase pairs) and the lower part contains the compensator distance elements.

For the mho phase pair elements, only the logic for AB pair is shown in detail (upper portions of *Figure 3.4* through *Figure 3.6*). The logic for phase pairs BC and CA is similar, and the outputs are shown entering the OR gate that generates the phase distance element outputs M1P, M2P, M3P, and M4P, along with the compensator distance element outputs MPP*n* and MABC*n*, *n* = 1 through 4.

Table 3.2 Distance Elements Settings

Mho Phase Distance Elements (Zones 1–4)	
Enable Setting for Mho Phase (E21P)[a]:	N, 1–4, 1C–4C N = Disabled 1–4 Selects number of Positive-Sequence Memory Polarized Elements (Phase Pairs) 1C–4C Selects number of Compensator Distance Elements
Setting range for Mho Phase Distance Elements (Z1P–Z4P):	OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal) Minimum sensitivity is controlled by the pickup of the supervising phase-to-phase overcurrent elements for each zone.
Phase-to-Phase Current Fault Detectors (Zones 1–4)	
Setting Range for Phase-to-Phase Current Fault Detectors (50PP1–50PP4)[b]:	0.50–170.00 A_{P-P} secondary, 0.01 A steps (5 A nominal) 0.10–34.00 A_{P-P} secondary, 0.01 A steps (1 A nominal)
Max. Operating Time:	See pickup and reset time curves in *Figure 3.27* and *Figure 3.28*.

[a] Selections 1–4 are unavailable if Global Setting PTCONN = DELTA and Group Setting EADVS = N.
[b] If setting EADVS = N, settings 50PP2–50PP4 are at minimum values and are hidden.

Considerations for Using Mho Phase Pair Elements With Open-Delta Connected PTs

Mho phase pair elements are not recommended in systems with open-delta connected potential transformers. The SEL-311C does not allow selection E21P = 1, 2, 3, or 4 when EADVS = N and PTCONN = DELTA.

The phase-pair mho elements properly handle phase-to-phase and three-phase faults on open-delta connected systems, but certain faults involving ground with fault resistance may be mischaracterized by the fault identification logic. For this reason, the SEL-311C does not use fault identification logic to disable the phase pair mho distance elements when PTCONN = DELTA. See *Not Recommended for Use With Open-Delta Potential Transformers on page 3.2*.

As shown in the upper-middle portion of *Figure 3.4* through *Figure 3.6*, when Global setting PTCONN = DELTA, the SEL-311C fault identification logic is not used for mho phase pair selection. The PTCONN = DELTA signal prevents the fault identification logic outputs FSA and FSB from blocking the AB phase pair mho element.

This means that the AB phase pair element will be allowed to operate, subject to the other enabling conditions, even during A-G or B-G ground faults, or B-C-G and C-A-G line-line-ground faults when PTCONN =DELTA. Similarly, the BC and CA phase pair mho elements may operate for unsuitable fault types.

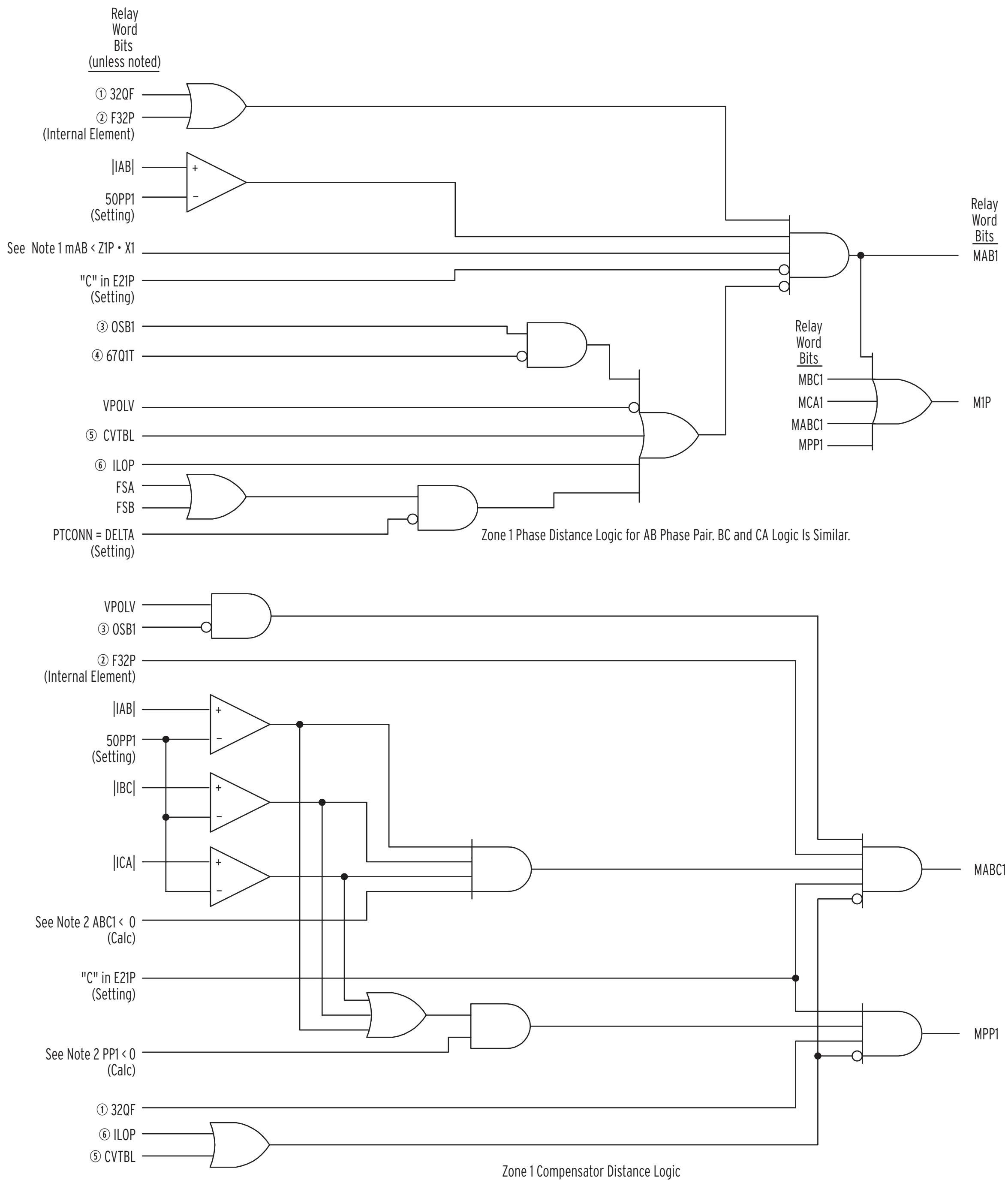
Normally the phase-to-phase current detector pickup settings 50PP1, 50PP2, 50PP3, and 50PP4 are set at minimum values for maximum distance element sensitivity, which works well with wye-connected PTs. For open-delta applications, consider setting 50PP1, 50PP2, 50PP3, and 50PP4 to higher values. Use the results from a fault study to select the pickup for each zone to be comfortably below the expected minimum fault current. This practice may mitigate the risk of incorrect element selection. Settings 50PP2 through 50PP4 are accessible when EADVS = Y.

By contrast, the compensator distance phase elements do not rely on fault identification logic and are recommended for use in open-delta PT applications with no other adjustments.

For information on the PTCONN setting see *Settings for Voltage Input Configuration on page 9.16*.

Out-of-Step Block Differences in Mho Phase Pair Elements

The out-of-step blocking input to the mho phase pair elements in the SEL-311C differs between the Zone 1 and the remaining zones. The main difference is that the Zone 1 logic in *Figure 3.4* does not rely on the UBD (Unblock Delay) setting, but instead uses the directional negative-sequence definite-time overcurrent element 67Q1T to unblock. The UBD timer is used for Zones 2, 3, and 4, along with the appropriate negative-sequence directional element 32QF or 32QR. See *Out-of-Step Blocking of Distance Elements on page 3.31* for application details.

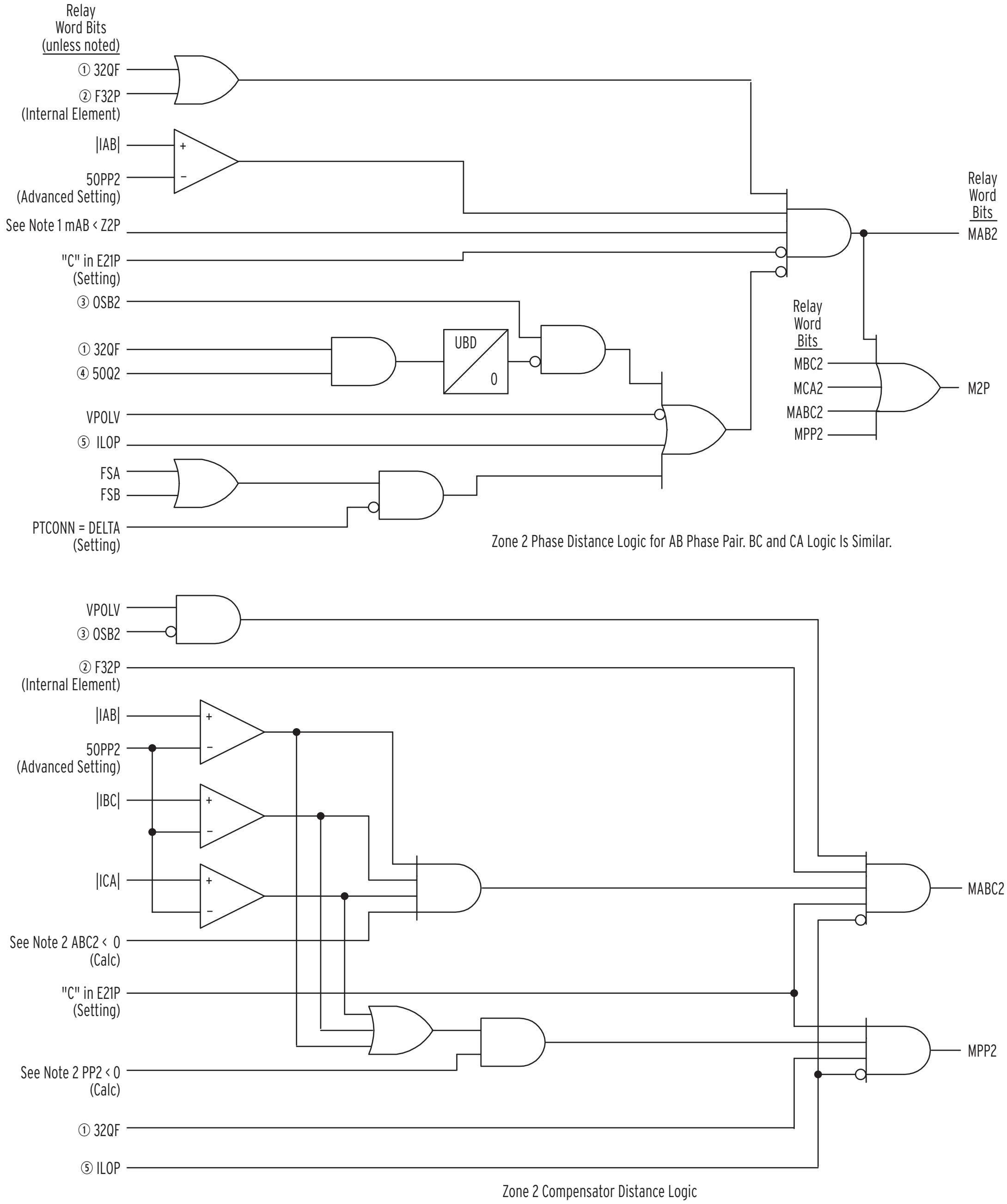


Note 1: mAB = A-Phase to B-Phase Distance Calculation, Z1P = Zone 1 Distance Setting, X1 = Zone 1 Extension from Table 3.4 and Table 3.6.

Note 2: ABC1 and PP1 are compensator distance element calculations. Zone 1 extension, if active, is included in this calculation.

① From Figure 4.20; ② from Figure 4.21; ③ from Figure 3.23; ④ from Figure 3.30; ⑤ from Figure 4.9; ⑥ from Figure 4.1.

Figure 3.4 Zone 1 Phase Distance Logic

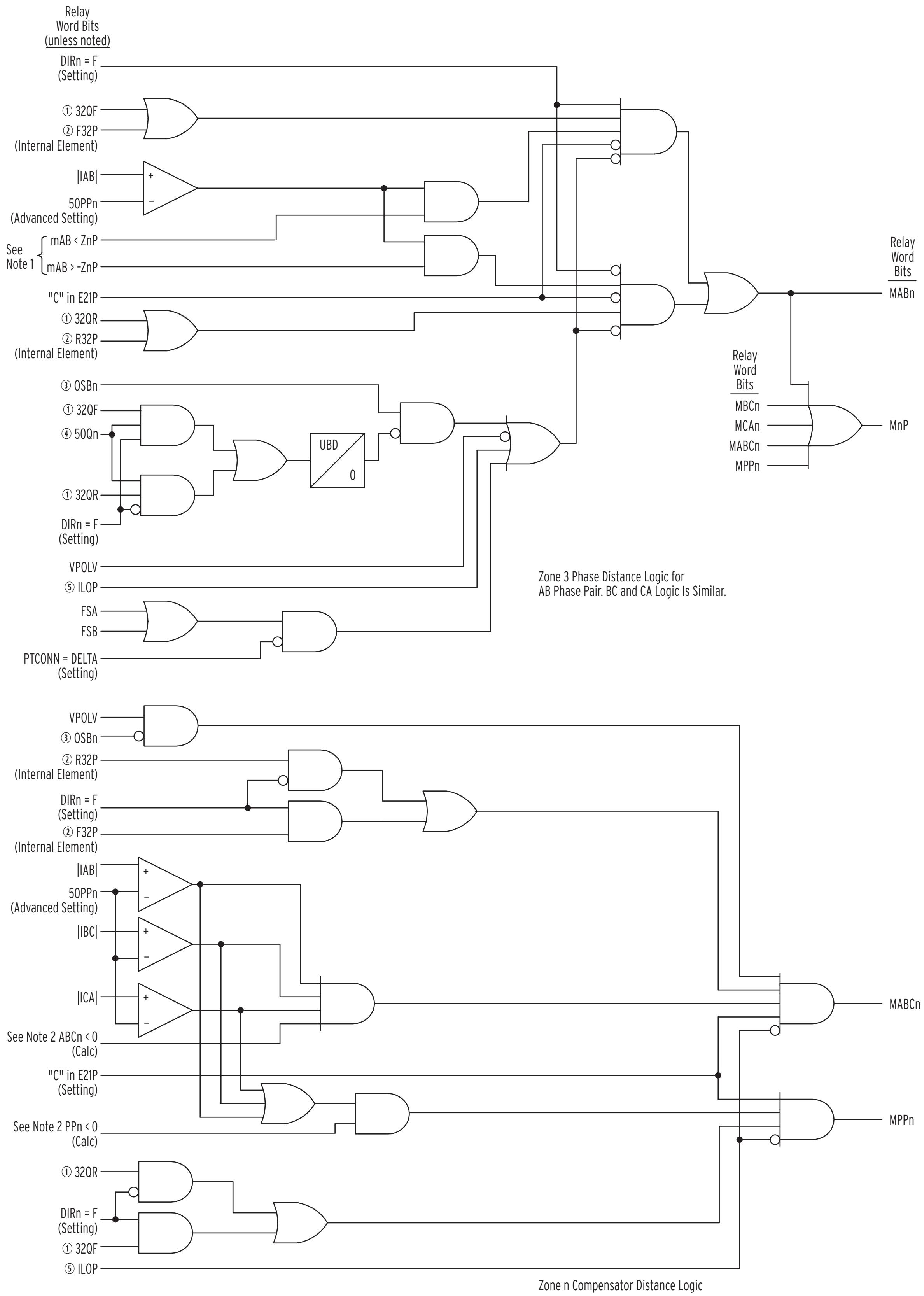


Note 1: mAB = A-Phase to B-Phase Distance Calculation, Z2P = Zone 2 Distance Setting.

Note 2: ABC2 and PP2 are compensator distance element calculations.

① From Figure 4.20; ② from Figure 4.21; ③ from Figure 3.23; ④ from Figure 3.30; ⑤ from Figure 4.1.

Figure 3.5 Zone 2 Phase Distance Logic



Note 1: mAB = A-Phase to B-Phase Distance Calculation, ZnP = Zone n Distance Setting, n = 3 for Zone 3, n = 4 for Zone 4.
Note 2: ABCn and PPn are compensator distance element calculations, n = 3 for Zone 3, n = 4 for Zone 4.
① From Figure 4.20; ② from Figure 4.21; ③ from Figure 3.23; ④ from Figure 3.30; ⑤ from Figure 4.1.

Figure 3.6 Zones 3 and 4 Phase Distance Logic

Ground Distance Elements

For wye-connected potential transformer applications, (when Global setting PTCONN = WYE), the SEL-311C has four independent zones of mho and quadrilateral ground distance protection. All zones are independently set. Zones 1 and 2 are forward direction only, and Zones 3 and 4 can be set in either the forward or reverse direction.

Not Available for Delta-Connected PTs

For open-delta connected PT applications (when Global setting PTCONN = DELTA), the ground distance elements are unavailable, and the relay internally disables all settings in *Table 3.3*. For information on voltage connections see *Potential Transformer Inputs on page 2.11*. For information on the PTCONN setting see *Settings for Voltage Input Configuration on page 9.16*.

Ground Distance Element Settings and Logic Diagrams

Table 3.3 lists the settings for the ground distance elements. *Figure 3.7* through *Figure 3.9* contain the logic for the mho ground distance elements, and *Figure 3.10* through *Figure 3.12* contain the logic for the quadrilateral ground elements.

The mho ground distance elements are enabled by the Group Setting E21MG = 1–4. These elements use positive-sequence voltage polarization for security and to create an expanded mho characteristic. Disable the mho ground distance elements by making Group Setting E21MG = N.

The quadrilateral ground elements are enabled by the Group Setting E21XG = 1–4. The directional polarizing quantity for the reactance portion of the quadrilateral ground distance element may be selected from negative sequence current or zero-sequence current if Advanced Settings are enabled (Setting EADVS = Y). Disable the mho ground distance elements by making Group Setting E21XG = N.

As shown in *Figure 3.7* through *Figure 3.9*, the mho and quadrilateral ground distance element outputs are combined as Z1G, Z2G, Z3G, and Z4G for Zones 1 through 4.

Both types of ground distance elements may be enabled at once.

See *Directional Control Settings on page 4.29* for details on specifying the Zone 3 and Zone 4 direction using Group settings DIR3 and DIR4.

Out-of-Step Block Applies to Zone 1 Ground Elements

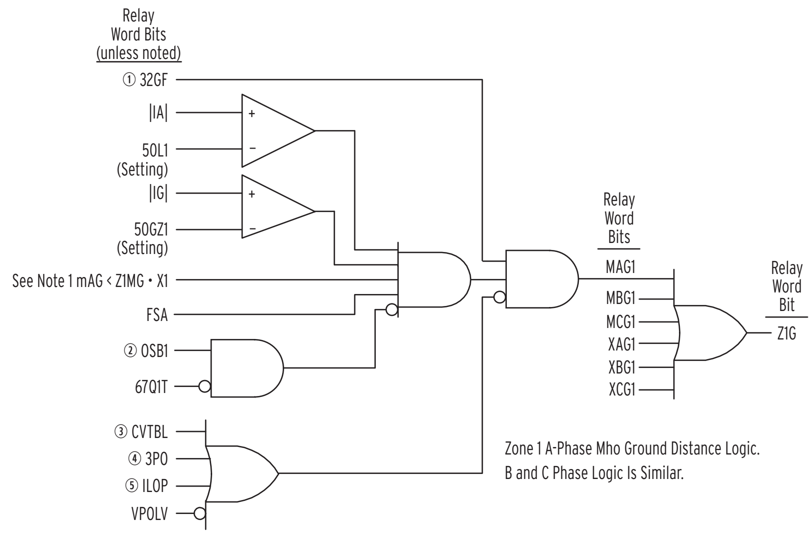
The SEL-311C Zone 1 ground distance elements feature an out-of step block function. The Zone 1 logic in *Figure 3.7* and *Figure 3.10* uses the directional negative-sequence definite-time overcurrent element 67Q1T to defeat the OSB1 input. This allows the ground elements to operate for a close-in fault during a out-of-step condition. See *Out-of-Step Blocking of Distance Elements on page 3.31* for application details.

Table 3.3 Ground Distance Elements Settings

Impedance Reach (Zones 1–4)	
Enable Setting for Mho Ground (E21MG): Quadrilateral Ground (E21XG):	N, 1–4 N, 1–4
Settings range for Mho elements (Z1MG–Z4MG):	OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal)
Settings range for Quadrilateral Reactance elements (XG1–XG4):	OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal)
Settings range for Quadrilateral Resistance elements (RG1–RG4):	OFF, 0.05 to 50 Ω sec, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 250 Ω sec, 0.01 Ω steps (1 A nominal) Minimum sensitivity is controlled by the pickup of the supervising phase and residual overcurrent elements for each zone.
Phase and Residual Current Fault Detectors (Zones 1–4)	
Setting Range for Phase and Residual Current Fault Detectors 50L1–50L4[a] and 50GZ1–50GZ4[a]:	0.50–100.00 A secondary, 0.01 A steps (5 A nominal) 0.10–20.00 A secondary, 0.01 A steps (1 A nominal)
Other Settings	
Settings range for zero-sequence compensation (ZSC) factor magnitude k0M1[b]: k0M[b]:	0.000–6.000 unitless (Zone 1) 0.000–6.000 unitless (Zone 2, 3, 4 advanced setting hidden and set to k0M1 when EADVS = N)
Settings range for zero-sequence compensation (ZSC) factor angle k0A1[b]: k0A[b]:	–180.0 to +180.0 degrees (Zone 1) –180.0 to +180.0 degrees (Zones 2, 3, and 4 advanced setting hidden and set to k0A1 when EADVS = N)
Settings range for quadrilateral ground polarizing quantity (hidden and set to I2 when EADVS = N) XGPOL:	I2 (negative-sequence current) or IG (zero-sequence current) (advanced setting)
Settings range for nonhomogeneous correction angle (hidden and set to –3 when EADVS = N) TANG:	–45.0 to +45.0 degrees (advanced setting)

[a] If EADVS = N, levels 2–4 fault detectors are set at their minimum values and are hidden.
[b] For most applications, set k0M1 and k0A1 according to Equation 3.2. When EADVS = Y, set k0M = k0M1 and k0A = k0A1.

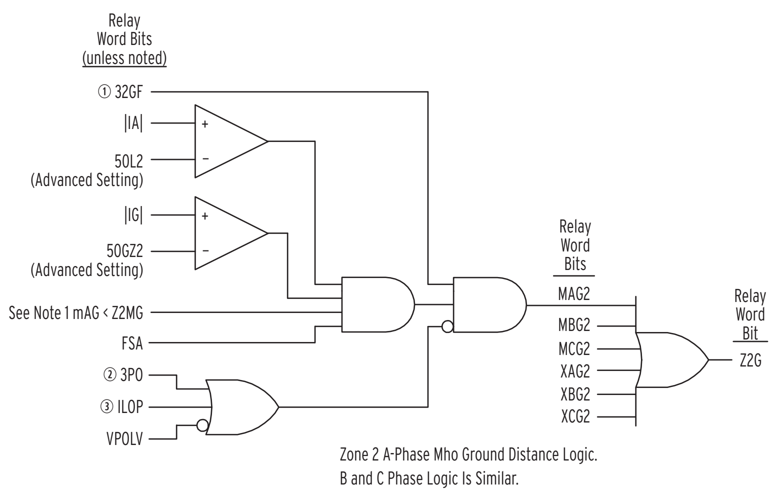
$$k0M1\angle k0A1 = \frac{(Z0MAG\ \angle Z0ANG) - (Z1MAG\ \angle Z1ANG)}{3 \cdot (Z1MAG\ \angle Z1ANG)} \qquad \textbf{Equation 3.2}$$



Note 1: mAG = A-Phase-to-Ground Distance Calculation, Z1MG = Zone 1 Distance Setting, X1 = Zone 1 Extension from Table 3.4 or Table 3.7.

① From Figure 4.18; ② from Figure 3.23; ③ from Figure 4.9; ④ from Figure 5.3; ⑤ from Figure 4.1.

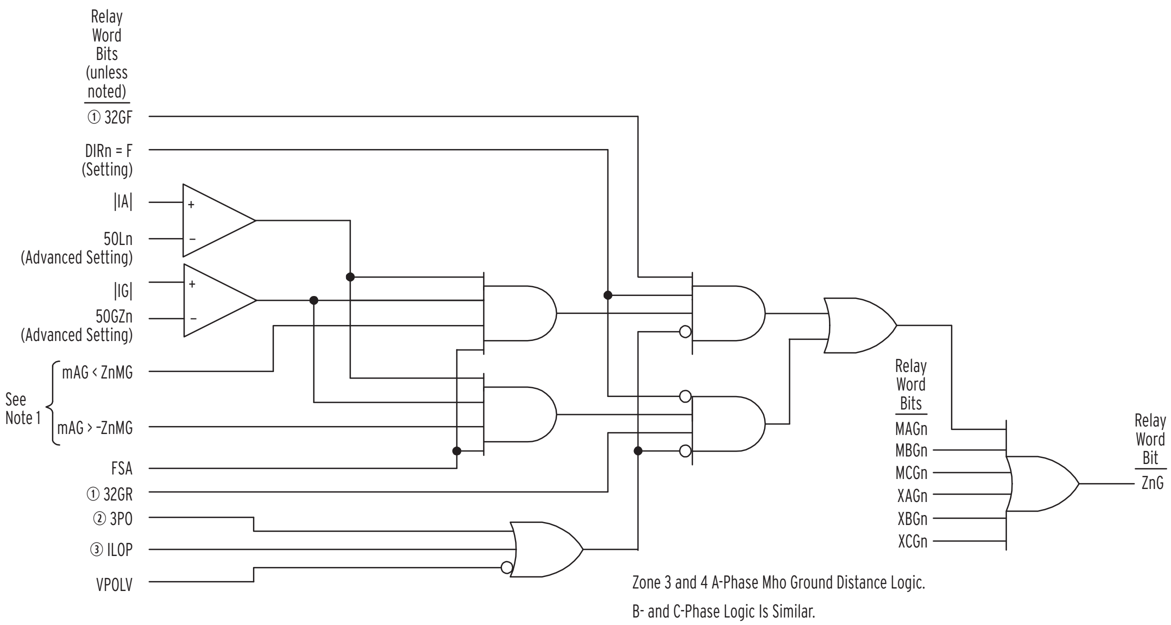
Figure 3.7 Zone 1 Mho Ground Distance Logic



Note 1: mAG = A-Phase to Ground Distance Calculation, Z2MG = Zone 2 Distance Setting.

① From Figure 4.18; ② from Figure 5.3; ③ from Figure 4.1.

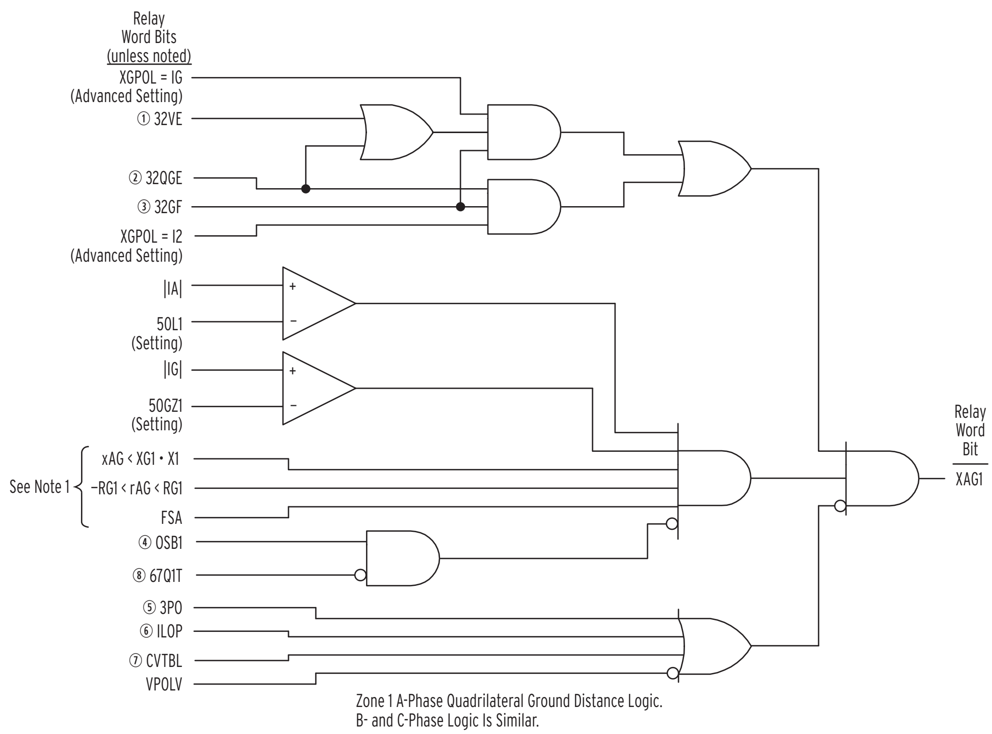
Figure 3.8 Zone 2 Mho Ground Distance Logic



Note 1: mAG = A-Phase to Ground Distance Calculation, ZnMG = Zone n Distance Setting, n = 3 for Zone 3, n = 4 for Zone 4.

① From Figure 4.18; ② from Figure 5.3; ③ from Figure 4.1.

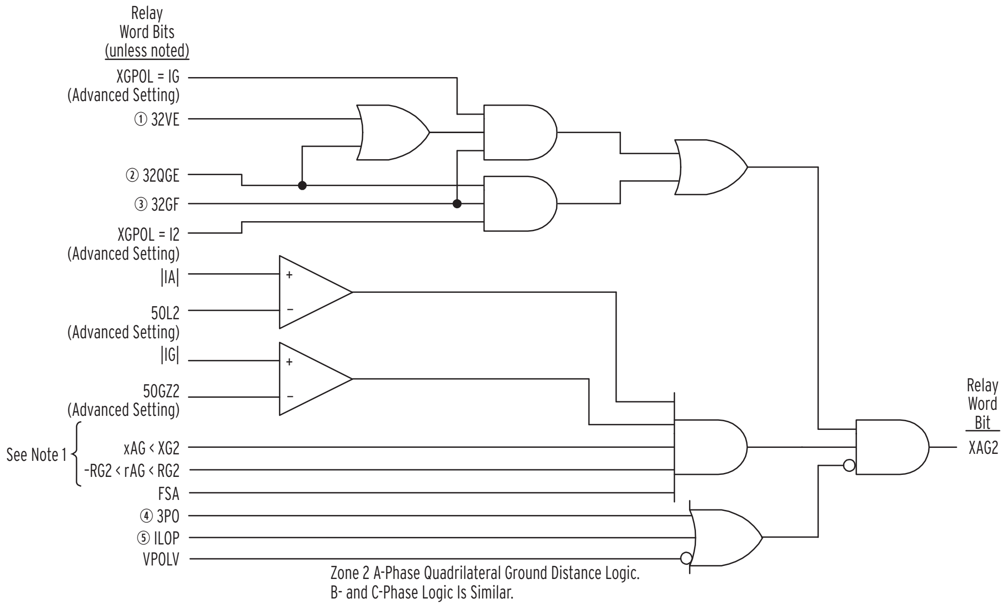
Figure 3.9 Zones 3 and 4 Mho Ground Distance Logic



Note 1: xAG = A-Phase to Ground Reactance Calculation, XG1 = Zone 1 Reactance Setting, X1 = Zone 1 Extension from Table 3.4 or Table 3.7, rAG = A-Phase to Ground Resistance Calculation, RG1 = Zone 1 Resistance Setting.

① From Figure 4.14; ② from Figure 4.13; ③ from Figure 4.18; ④ from Figure 3.23; ⑤ from Figure 5.3; ⑥ from Figure 4.1; ⑦ from Figure 4.9; ⑧ from Figure 3.30.

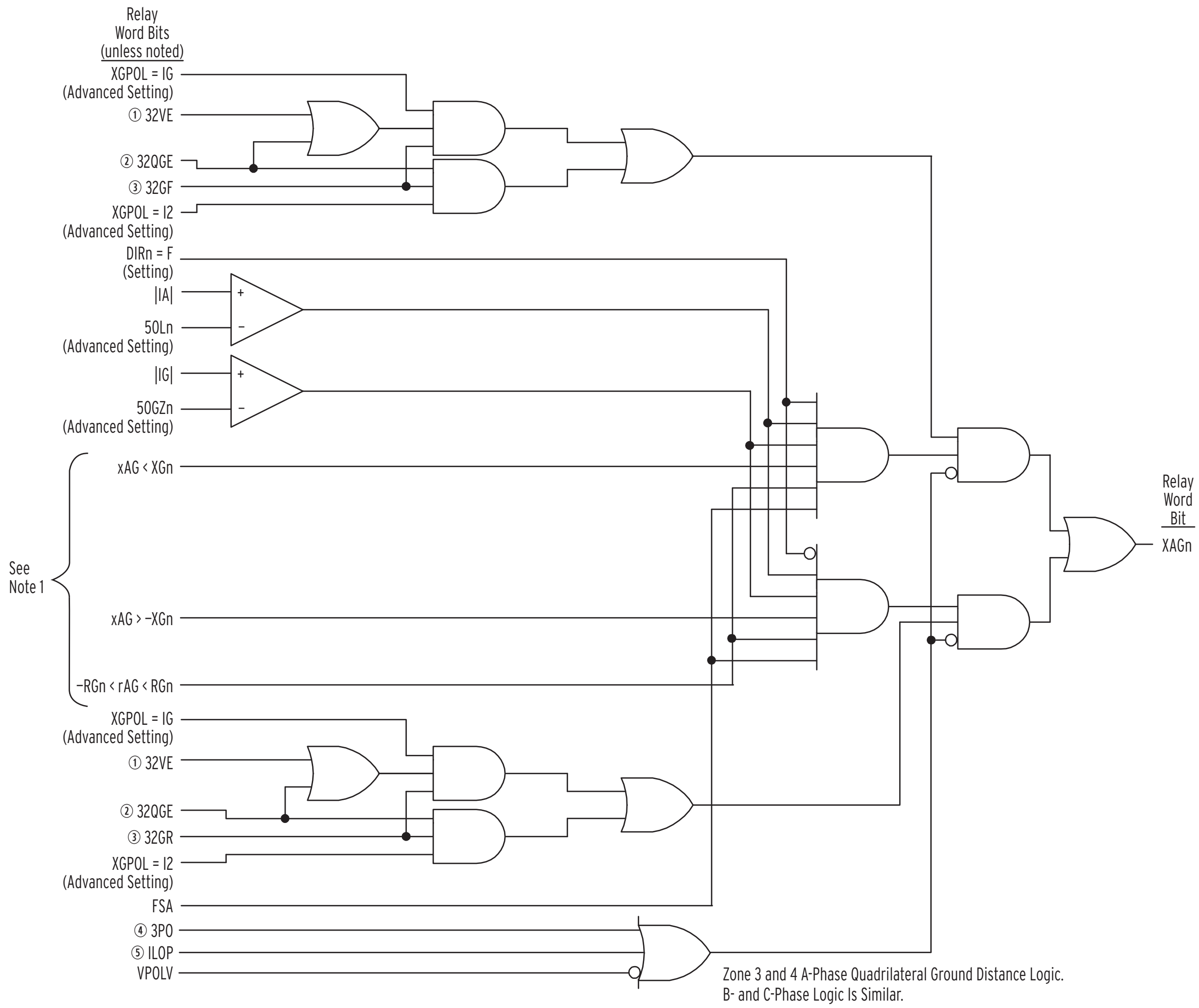
Figure 3.10 Zone 1 Quadrilateral Ground Distance Logic



Note 1: xAG = A-Phase to Ground Reactance Calculation, XG2 = Zone 2 Reactance Setting, rAG = A-Phase to Ground Resistance Calculation, RG2 = Zone 2 Resistance Setting.

① From Figure 4.14; ② from Figure 4.13; ③ from Figure 4.18; ④ from Figure 5.3; ⑤ from Figure 4.1.

Figure 3.11 Zone 2 Quadrilateral Ground Distance Logic



Note 1: xAG = A-Phase to Ground Reactance Calculation, XGn = Zone n Reactance Setting, rAG = A-Phase to Ground Resistance Calculation; RGn = Zone n Resistance Setting, n = 3 for Zone 3, n = 4 for Zone 4.

① From Figure 4.14; ② from Figure 4.13; ③ from Figure 4.18; ④ from Figure 5.3; ⑤ from Figure 4.1.

Figure 3.12 Zones 3 and 4 Quadrilateral Ground Distance Logic

Distance Element Operating Time Curves at Nominal Frequency

Figure 3.13 through *Figure 3.18* show operating times for the SEL-311C distance elements. The diagrams show operating times at each test point. Operating times include output contact closure time.

For the distance element test, a fault was applied at a location representing a percentage of the Zone 1 relay reach setting. Tests were performed for source impedance ratios (SIR) of 0.1, 1.0, 10.0, 30.0, and 60.0. No prefault load current or fault resistance was included. Operating times are the same for 50 Hz and 60 Hz.

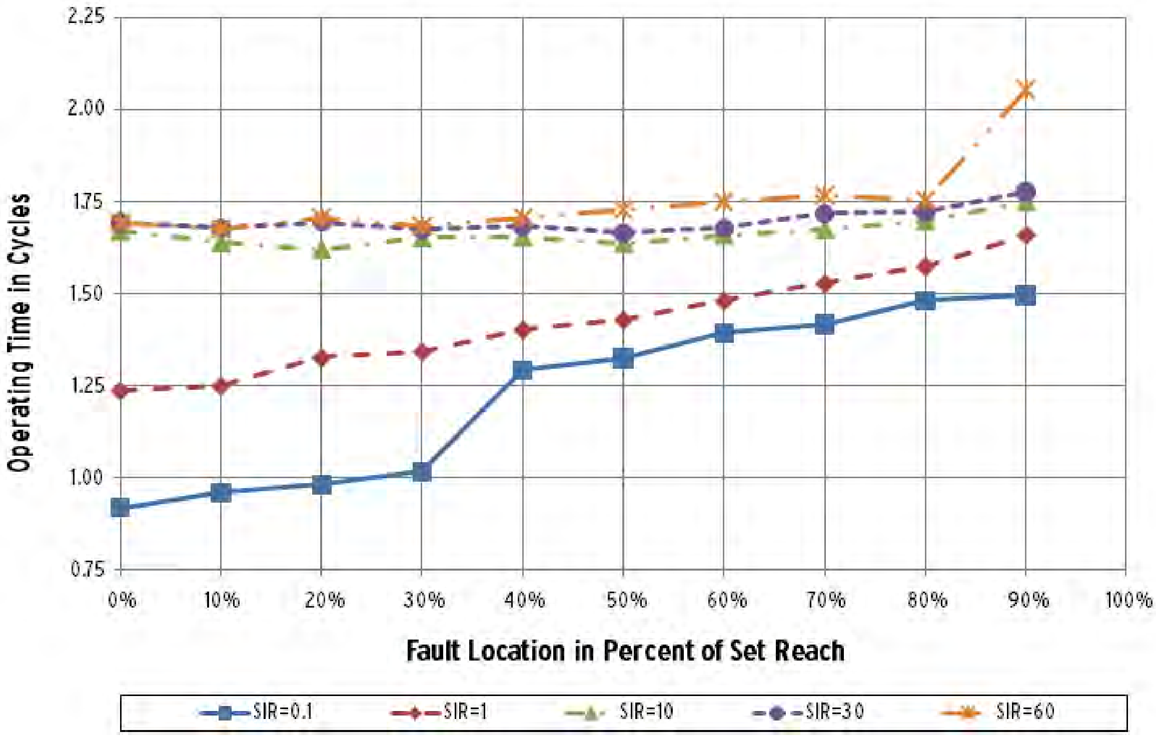


Figure 3.13 SEL-311C Mho Element Operating Times, Standard Outputs (Phase-to-Phase Faults)

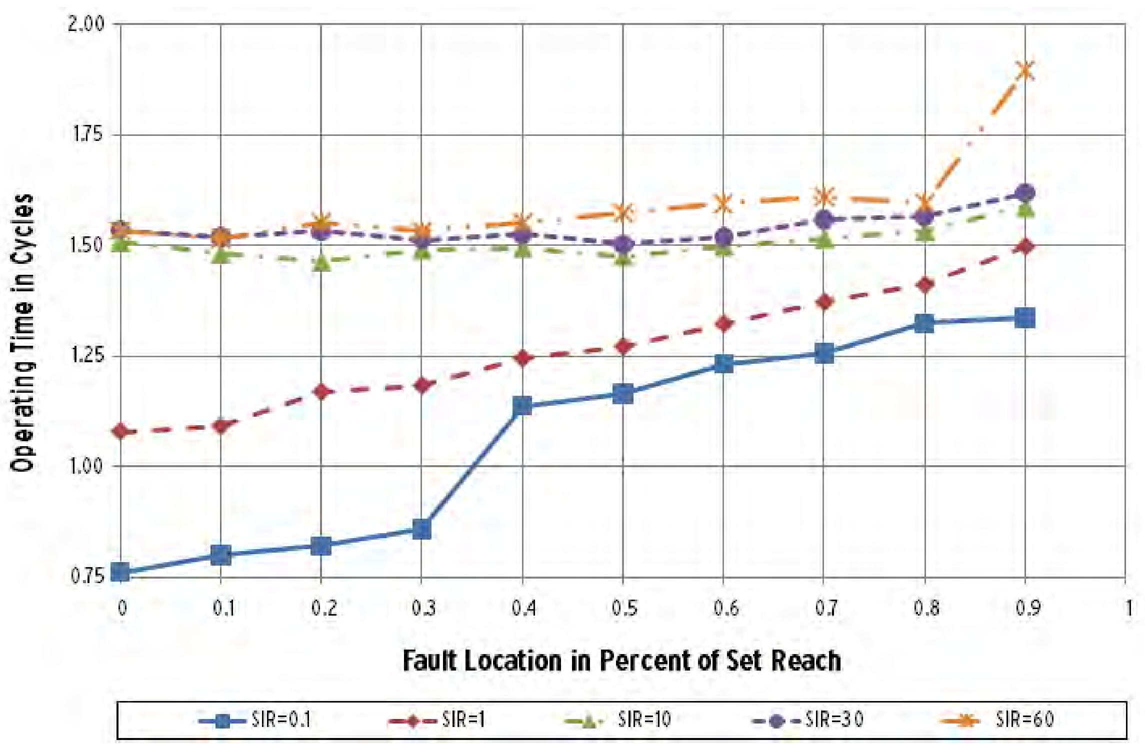


Figure 3.14 SEL-311C Phase Mho Element Operating Times, Hybrid Outputs (Phase-to-Phase Faults)

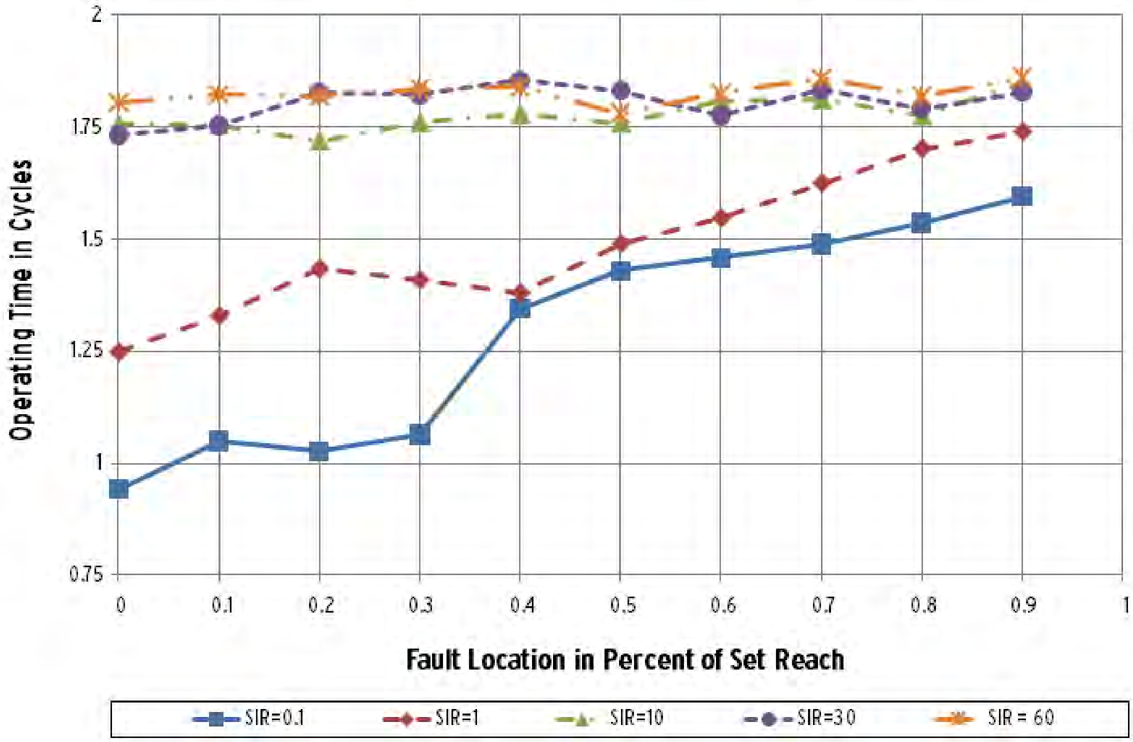


Figure 3.15 SEL-311C Mho Ground Element Operating Times, Standard Outputs (Single-Line-to-Ground Faults)

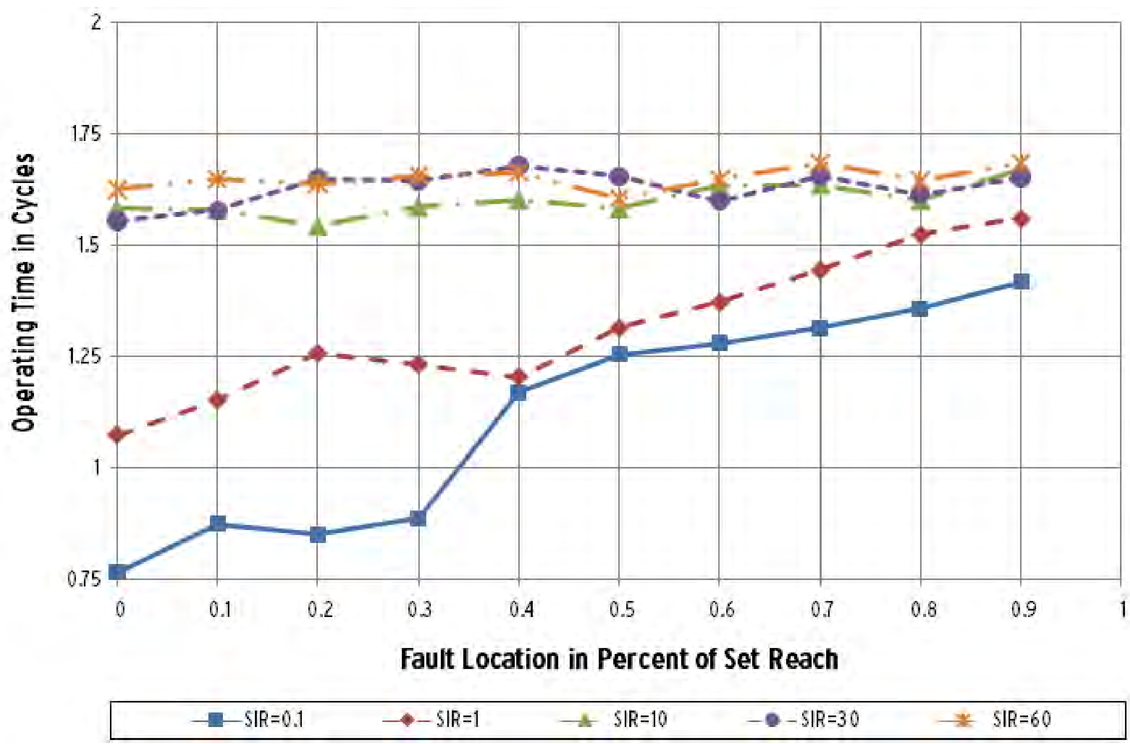


Figure 3.16 SEL-311C Mho Ground Element Operating Times, Hybrid Outputs (Single-Line-to-Ground Faults)

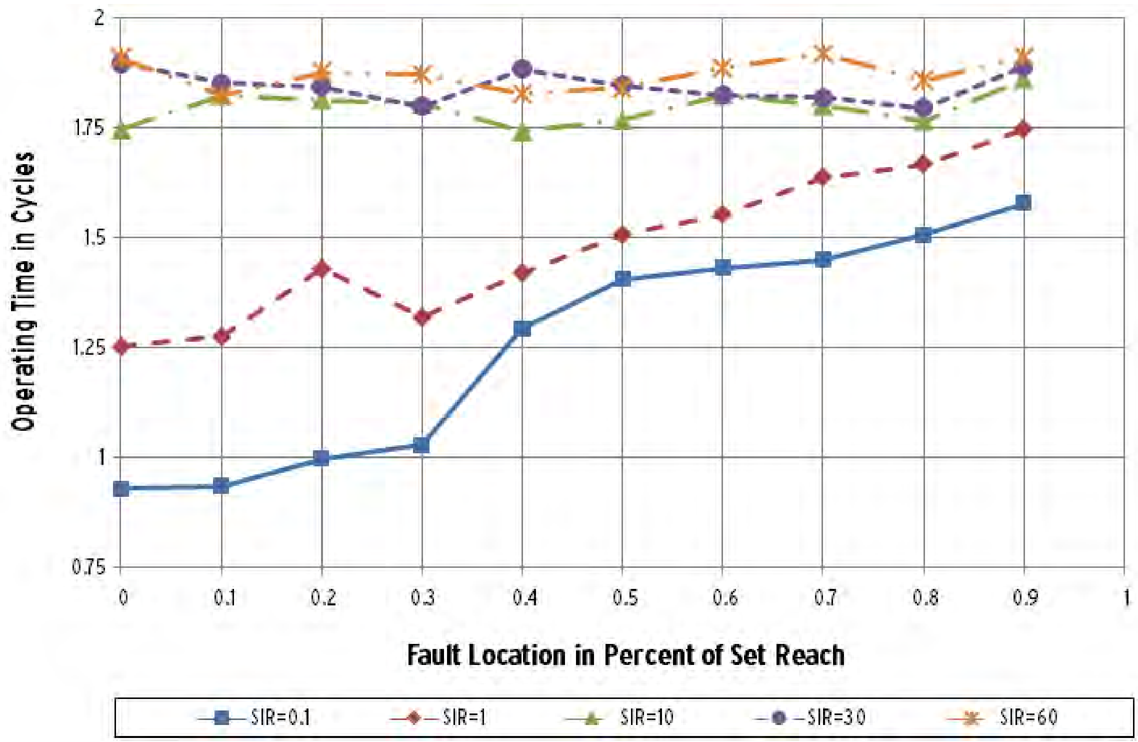


Figure 3.17 SEL-311C Quadrilateral Ground Element Operating Times, Standard Outputs (Single-Line-to-Ground Faults)

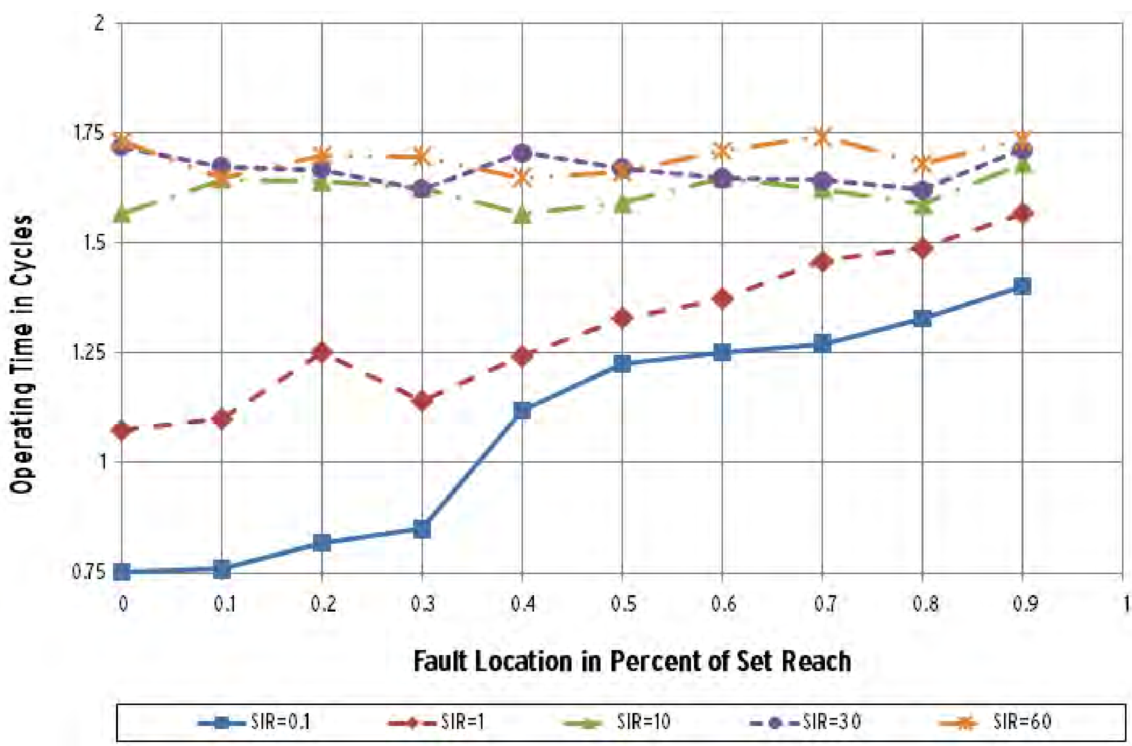


Figure 3.18 SEL-311C Quadrilateral Ground Element Operating Times, Hybrid Outputs (Single-Line-to-Ground Faults)

Additional Distance Element Supervision

The SEL-311C uses Relay Word bit VPOLV for positive-sequence memory supervision of mho and quadrilateral characteristics. VPOLV asserts when the memorized positive-sequence polarizing voltage is greater than 1 Volt.

When using the SEL-311C with wye-connected potential transformers (when Global setting PTCONN = WYE), the following elements are supervised with Fault Identification Selection (FIDS) logic.

- Mho phase pair (enabled by E21P = 1–4)
- Mho ground (enabled by E21MG = 1–4)
- Quadrilateral Ground (enabled by E21XG = 1–4)

The FIDS logic identifies the faulted phase(s) for all faults involving ground by comparing the angle between I0 and I2. For example, when FIDS selects A-phase, FSA asserts and enables A-phase ground distance elements and BC-phase distance elements. Distance elements BG, CG, AB, and CA are blocked.

When the SEL-311C is connected to delta-connected potential transformers (when Global setting PTCONN = DELTA), the ground distance elements are unavailable and the mho phase pair distance elements (enabled by E21P = 1–4 when EADVS = Y) are not supervised with FIDS logic. Use these mho phase pair distance elements only in limited applications—see *Considerations for Using Mho Phase Pair Elements With Open-Delta Connected PTs on page 3.7*.

The compensator distance elements (E21P = 1C–4C) are not supervised by the FIDS logic and work equally well in either PT configuration. The compensator distance elements are recommended for delta-connected PT applications.

Zone 1 Extension

The SEL-311C features two Zone 1 extension schemes, selected by Group setting EZ1EXT:

- EZ1EXT = N disables Zone 1 extension, and hides the remaining settings.
- EZ1EXT = Y enables the combined phase and ground Zone 1 extension scheme shown in *Figure 3.19* and uses the settings shown in *Table 3.5*.
- EZ1EXT = I enables the independent phase and ground Zone 1 extension scheme, and allows external SELOGIC® control, as shown in *Figure 3.20*, and uses the settings shown in *Table 3.8*.

Zone 1 Extension Settings Validation

For either type of Zone 1 Extension, the relay performs the following settings validation to ensure the extended reach values are valid:

- Zone 1 and Zone 2 reach must be defined for each enabled distance element type
- Zone 2 reach > 110% • [Zone 1 reach] • [extension multiplier]

If either of these checks fails, the relay or PC Software will display an error message and not accept the settings.

Combined Phase and Ground Zone 1 Extension

NOTE: Because the Z1EXTD timer is cleared during a settings change or group change, Zone 1 extension may begin immediately after the relay initializes if the breaker is closed.

When enabled by setting EZ1EXT = Y, this function modifies the reach of all Zone 1 distance elements by multiplier setting Z1EXTM once the circuit breaker has been closed for Z1EXTD time and 3PO deasserts. All Zone 1 reaches retreat to their set reach when the breaker opens and 3PO asserts.

The required settings are shown in *Table 3.5* and the logic diagram is shown in *Figure 3.19*.

The Zone 1 reach cannot be extended if any of the following elements are asserted: M1P, M2P, Z1G, Z2G, 51G, or 51Q.

NOTE: When EZ1EXT = Y, Relay Word bits Z1XP and Z1XG exactly follow the state of Z1X.

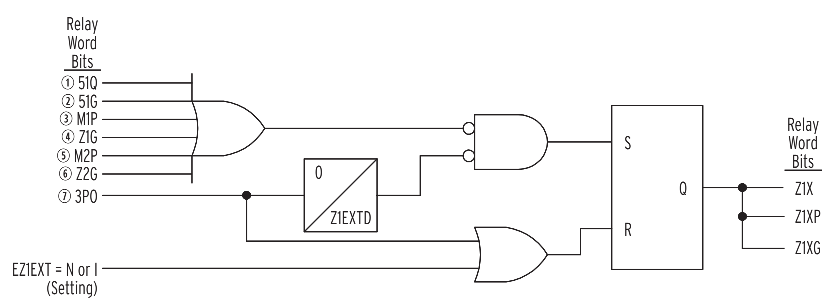
As shown in *Table 3.4*, when the Relay Word bit Z1X is asserted, the relay internally multiplies the Zone 1 phase and ground reach settings by the Z1EXTM value, and uses the resulting extended reach settings in the enabled Zone 1 distance elements (see *Figure 3.4*, *Figure 3.7*, and *Figure 3.10*). When the Relay Word bit Z1X is deasserted, the relay uses the normal Zone 1 reach settings in the enabled Zone 1 phase and ground distance elements.

Table 3.4 Effect of Zone 1 Extension Multiplier when EZ1EXT = Y

Relay Word Bit Z1X State:	Effective Zone 1 Phase Distance Element reach (Figure 3.4):	Effective Zone 1 Mho Ground Distance Element reach (Figure 3.7):	Effective Zone 1 Quadrilateral Ground Distance Element Reach (Figure 3.10):
Asserted	Z1P • Z1EXTM	Z1MG • Z1EXTM	XG1 • Z1EXTM
Deasserted	Z1P	Z1MG	XG1

Table 3.5 Combined Phase and Ground Zone 1 Extension Settings

Description	Setting	Setting Details
Zone 1 Extension (Y, I, N)	EZ1EXT = Y {Yes}	Setting choice "Y" enables the internal extension logic and exposes the following settings.
Zone 1 Extension Delay	Z1EXTD (0.00 to 16000.00 cycles)	Sets the minimum time the breaker must be closed before extending the Zone 1 reach.
Zone 1 Extension Distance Multiplier	Z1EXTM (1.00 to 4.00, unitless)	Sets the scalar by which all Zone 1 reach settings are multiplied.



① From Figure 3.33; ② from Figure 3.32; ③ from Figure 3.4; ④ from Figure 3.7; ⑤ from Figure 3.5; ⑥ from Figure 3.8; ⑦ from Figure 5.3

Figure 3.19 Combined Phase and Ground Zone 1 Extension Logic

Independent Phase and Ground Zone 1 Extension

NOTE: When EZ1EXT = I, Relay Word bits Z1XP, Z1XG, and Z1X have separate behavior. Z1X does not exactly follow the state of Z1XP, and should be used for testing only.

NOTE: The Independent Phase and Ground Zone 1 Extension logic was not available in legacy SEL-311C relays. Legacy relays only featured the combined extension logic.

When enabled by setting EZ1EXT = I, the SEL-311C provides two more settings to separately enable phase (EZ1EXTP = Y, N) and ground (EZ1EXTG = Y, N) Zone 1 extension logic, and permits two SELOGIC Control Equations to provide a direct means of controlling Zone 1 extension.

The required settings are shown in *Table 3.8* and the logic diagram is shown in *Figure 3.20*.

As shown in *Table 3.6*, when the Relay Word bit Z1XP is asserted, the relay internally multiplies the Zone 1 phase reach settings by the Z1EXTMP value, and uses the resulting extended reach settings in the enabled Zone 1 phase distance element (see *Figure 3.4*). When the Relay Word bit Z1XP is deasserted, the relay uses the normal Zone 1 reach settings in the enabled Zone 1 phase distance element.

Table 3.6 Effect of Zone 1 Phase Extension Multiplier When EZ1EXT = I

Relay Word Bit Z1XP State	Effective Zone 1 Phase Distance Element Reach (Figure 3.4)
Asserted	Z1P • Z1EXTMP
Deasserted	Z1P

As shown in *Table 3.7*, when the Relay Word bit Z1XG is asserted, the relay internally multiplies the Zone 1 ground reach settings by the Z1EXTMG value, and uses the resulting extended reach settings in the enabled Zone 1 ground distance elements (see *Figure 3.7* and *Figure 3.10*). When the Relay Word bit Z1XG is deasserted, the relay uses the normal Zone 1 reach settings in the enabled Zone 1 ground distance element.

Table 3.7 Effect of Zone 1 Ground Extension Multiplier When EZ1EXT = I

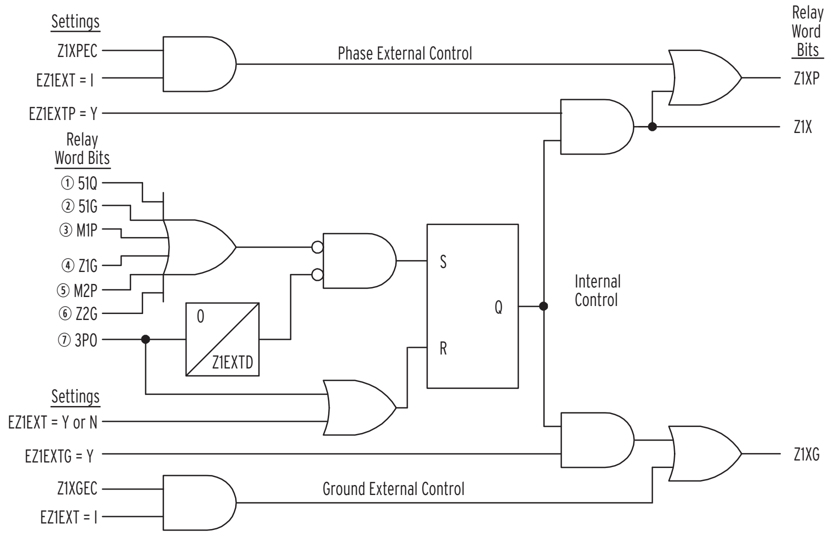
Relay Word Bit Z1XG State	Effective Zone 1 Mho Ground Distance Element Reach (Figure 3.7)	Effective Zone 1 Quadrilateral Ground Distance Element Reach (Figure 3.10)
Asserted	Z1MG • Z1EXTMG	XG1 • Z1EXTMG
Deasserted	Z1MG	XG1

Table 3.8 Independent Phase and Ground Zone 1 Extension Settings (Sheet 1 of 2)

Description	Setting	Setting Detail
Group Settings (**SET n** command, n = Setting Group 1 to 6)		
Zone 1 Extension (Y, I, N)	EZ1EXT = I {Independent}	Setting choice "I" enables external SELOGIC control and exposes the following two settings.
Zone 1 Phase Element Extension (Y, N)	EZ1EXTP = Y {Yes}	Setting choice "Y" enables internal phase extension logic
Zone 1 Ground Element Extension (Y, N)	EZ1EXTG = Y {Yes}	Setting choice "Y" enables internal ground extension logic
Zone 1 Extension Delay	Z1EXTD (0.00–16000.00 cycles)	Sets the minimum time the breaker must be closed before extending the Zone 1 reach. Setting exposed when either EZ1EXTP = Y or EZ1EXTG = Y.
Zone 1 Extension Phase Distance Multiplier	Z1EXTMP (1.00–4.00, unitless)	Sets the scalar by which all Zone 1 phase reach settings are multiplied.
Zone 1 Extension Ground Distance Multiplier	Z1EXTMG (1.00–4.00, unitless)	Sets the scalar by which all Zone 1 ground reach settings are multiplied.

Table 3.8 Independent Phase and Ground Zone 1 Extension Settings (Sheet 2 of 2)

Description	Setting	Setting Detail
Logic Settings (always visible) (**SET L n** command, n = setting group 1 to 6)		
Zone 1 extension–phase, external control	Z1XPEC {SELOGIC equation}	Control or override Zone 1 phase extension
Zone 1 extension–ground, external control	Z1XGEC {SELOGIC equation}	Control or override Zone 1 ground extension



① From Figure 3.33; ② from Figure 3.32; ③ from Figure 3.4; ④ from Figure 3.7; ⑤ from Figure 3.5; ⑥ from Figure 3.8; ⑦ from Figure 5.3

Figure 3.20 Independent Phase and Ground Zone 1 Extension Logic

Internal Zone 1 Phase Reach Extension

NOTE: Because the Z1EXTD timer is cleared during a settings change or group change, Zone 1 extension may begin immediately after the relay initializes if the breaker is closed.

When EZ1EXTP = Y, this function modifies the reach of the enabled Zone 1 phase distance element by the multiplier setting Z1EXTMP once the circuit breaker has been closed for Z1EXTD time and 3PO deasserts. The Zone 1 reach retreats to its original value when the breaker opens and 3PO asserts.

The Zone 1 phase reach cannot be extended if any of the following elements are asserted: M1P, M2P, Z1G, Z2G, 51G, or 51Q.

Internal Zone 1 Ground Reach Extension

When EZ1EXTG = Y, this function modifies the reach of the enabled Zone 1 ground distance elements by the multiplier setting Z1EXTMG once the circuit breaker has been closed for Z1EXTD time and 3PO deasserts. The Zone 1 reach retreats to its original value when the breaker opens and 3PO asserts.

The Zone 1 ground reach cannot be extended if any of the following elements are asserted: M1P, M2P, Z1G, Z2G, 51G, or 51Q.

External SELOGIC Control Option

The independent phase and ground Zone 1 extension setting (EZ1EXT = I) allows control of phase and ground Zone 1 extension using SELOGIC control equations.

- ➤ Z1XPEC: Zone 1 extension—phase, external control
- ➤ Z1XGEC: Zone 1 extension—ground, external control

At the top of *Figure 3.20*, the Z1XPEC SELOGIC control equation is supervised by EZ1EXT.

When EZ1EXT = I

➤ Z1XPEC acts as direct control when the corresponding Zone 1 Phase Extension logic setting EZ1EXTP = N.

  In this scenario, the Z1XP Relay Word bit exactly follows the SELOGIC equation Z1XPEC.

➤ Z1XPEC acts as an override when the corresponding Zone 1 Phase Extension logic setting EZ1EXTP = Y.

  In this scenario, the Z1XP Relay Word bit is the logical OR of the SELOGIC equation Z1XPEC, and the Phase Internal Control logic in *Figure 3.20*.

When EZ1EXT = N or Y, Z1XPEC has no effect on the Zone 1 Phase Extension function.

At the bottom of *Figure 3.20*, the Z1XGEC SELOGIC control equation is supervised by EZ1EXT.

When EZ1EXT = I

➤ Z1XGEC acts as direct control when the corresponding Zone 1 Ground Extension logic setting EZ1EXTG = N.

  In this scenario, the Z1XG Relay Word bit exactly follows the SELOGIC equation Z1XGEC.

➤ Z1XGEC acts as an override when the corresponding Zone 1 Ground Extension logic setting EZ1EXTG = Y.

  In this scenario, the Z1XG Relay Word bit is the logical OR of the SELOGIC equation Z1XGEC and the Ground Internal Control logic in *Figure 3.20*.

When EZ1EXT = N or Y, Z1XGEC has no effect on the Zone 1 Ground Extension function.

The SEL-311C factory default for the Zone 1 extension SELOGIC settings are shown below.

Z1XPEC = **0** (= logical 0)

Z1XGEC = **0** (= logical 0)

The external control method for Zone 1 reach is **not** supervised by the three-pole open status (3PO), or the elements M1P, M2P, Z1G, Z2G, 51G, and 51Q.

Settings Example. A system uses two control signals to separately enable phase and ground Zone 1 phase extension. The phase control is to be connected to optoisolated input **IN201**, and the ground control to **IN202**. Internal control is not required on the phase element, but is required 10 s after breaker closure on the ground elements.

The design requires front-panel indication when each extension is active. The system frequency is 50 Hz in this example.

Settings:

Global:

NFREQ = **50 Hz** {nominal frequency}

IN201D = **1.00 cycles** {input debounce timer}

IN202D = **1.00 cycles** {input debounce timer}

Group 1:

EZ1EXT = **I** {independent phase and ground}

EZ1EXTP = **N** {no internal phase extension control}

EZ1EXTG = **Y** {enable internal ground extension control}

Z1EXTD = **500.00 cycles** {10 s at 50 Hz}

Z1EXTMP = **1.10** {110% phase reach}

Z1EXTMG = **1.20** {120% ground reach}

Logic 1:

DP5 = **Z1XP** {Use display point 5 for phase}

DP6 = **Z1XG** {Use display point 6 for ground}

Z1XPEC = **IN201** {Phase external control}

Z1XGEC = **IN202** {Ground external control}

Text:

DP5_1 = **"PHASE Z1 EXT ON"** {Phase active display point}

DP5_0 = **"PHASE Z1 EXT OFF"** {Phase inactive display point}

DP6_1 = **"GND Z1 EXT ON"** {Ground active display point}

DP6_0 = **"GND Z1 EXT OFF"** {Phase inactive display point}

Zone Time Delay Elements

The SEL-311C supports two philosophies of zone timing: independent or common timing (see *Figure 3.21*). For the independent timing mode, the phase and ground distance elements drive separate timers for each zone. For the common mode, the phase and ground distance elements both drive a common timer.

Table 3.9 Zone Timing Settings

Settings	Common Timer: Independent Phase Timer: Independent Ground Timer:	Z1D–Z4D Z1PD–Z4PD Z1GD–Z4GD
Ranges	Pickup:	OFF, 0.00–16,000.00 cycles, 0.25-cycle steps

Select independent zone timing by using Relay Word bits M*n*PT and Z*n*GT (where *n* is the protection zone number) in the appropriate SELOGIC trip equation.

TR = **M2PT + Z2GT + 51GT + 51QT**

Select common zone timing by using Relay Words bits Z*n*T (where *n* is the protection zone number) in the appropriate SELOGIC trip equation.

TR = **Z2T + 51GT + 51QT**

Zone 2 Sequential Time Delay Logic

A sequential timing mode is available for the Zone 2 elements, with timing that starts with the forward-set Zone 4 elements. This logic is shown at the bottom of *Figure 3.21*.

This mode requires Zone 4 to be set in the forward direction to match Zone 2. Make setting DIR4 = F as discussed in *Directional Control Settings on page 4.29*.

This timing mode allows a weak terminal that detects a forward fault with an overreaching Zone 4 element to start timing for Zone 2, using the Zone 2 delay settings. If the remote line terminal trips first and causes the fault current to redistribute, the local relay may pick up a Zone 2 element. Because the

Zone 2 sequential timer has already been partially or completely satisfied, the sequential timing output can be used to trip the local terminal much faster than a regular Zone 2 timer, which would just be starting to time. This helps especially in applications that do not use communications-assisted tripping.

If the Zone 2 element does not pickup, the sequential timer output cannot assert.

If a fault starts out in Zone 2, the sequential timing logic output will assert at the same time as the corresponding Zone 2 timers, because we expect the forward set Zone 4 elements to assert for any Zone 2 fault.

No additional time delay settings are required for the sequential timing logic, because the Zone 2 delay settings Z2G, Z2PD, and Z2GD are used in the sequential timers. The regular Zone 2 and Zone 4 timing functions use separate timers, and are still operable when the sequential timing is underway.

To use the sequential timing feature, include the appropriate Relay Word bits Z2SEQT, M2PSEQT, or Z2GSEQT in the TR SELOGIC equation as required for your application.

Example settings using a sequential common timer.

Group 1:

E21P = **4** (or 4C)

E21MG = **4**

and/or

E21ZG = **4**

•
•
•

Z2D = **10.00 cycles**

Z4D = **30.00 cycles**

•
•
•

DIR4 = **F**

Logic 1:

TR = **Z2SEQT + Z2T + Z4T + 51GT + 51QT**

TRQUAL = **M1P + Z1G**

TRCOMM = **M2P + Z2G**

The example TR expression includes Z2T, which covers the situation where the Zone 4 element or time delay settings are somehow set incorrectly. In most expected cases, we know that the Z2SEQT element will assert before the Z2T element, and the fault would be cleared before the Z2T element timer could operate. Including the Z2T element is precautionary.

The TRCOMM setting in this example is included for discussion. If communications are available, the sequential zone timing logic would not be any faster, but would be a good backup if the communications were out of service.

Suspend Timing Logic

The timing of each common zone timer is frozen or suspended if the timer is timing and the timer input drops out. The duration of the suspension is one cycle. This feature prevents the timer resetting when a fault evolves (e.g., phase-phase to three-phase, phase-ground to phase-phase-ground). If the timer expires, the suspension logic is blocked.

Availability Determined by Number of Distance Elements Enabled

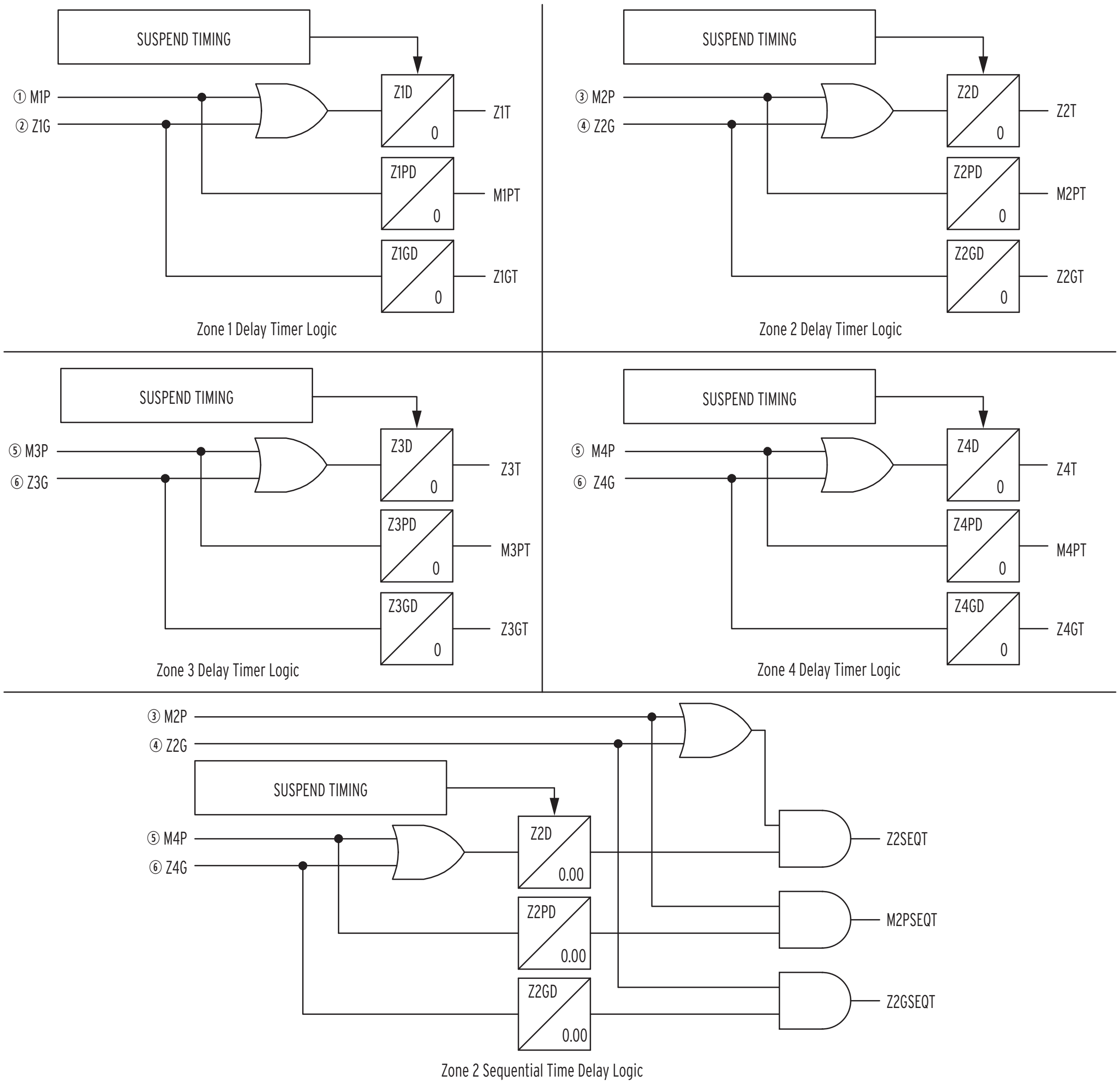
If E21P, E21MG, and/or E21XG are set to anything but N, the common timers are enabled according to the lower of the two enables. For example, if E21P = 3C and E21MG = 2, enable Z1D and Z2D (two Zones as defined by the E21MG setting).

When any zone time delay is set to OFF, the timer output is disabled, and the corresponding delay element remains at logical 0 regardless of the distance element status.

The sequential time delay element M2PSEQT requires E21P = 4 or 4C.

The sequential time delay element Z2GSEQT requires E21MG = 4 and/or E21XG = 4.

The sequential time delay element Z2SEQT requires E21P = 4 or 4C and [E21MG = 4 and/or E21XG = 4.]



① From Figure 3.4; ② from Figure 3.7; ③ from Figure 3.5; ④ from Figure 3.8; ⑤ from Figure 3.6; ⑥ from Figure 3.9.

Figure 3.21 Zone Timing Elements

Out-of-Step Characteristics

NOTE: The out-of-step logic cannot be used when setting Z1ANG is less than 45 degrees. In that case, setting EOOS must equal N.

The out-of-step (OOS) detection logic detects stable or unstable power swings. When the positive-sequence impedance remains between Zones 5 and 6 longer than the OOS blocking delay (setting OSBD), or the OOS tripping delay (setting OSTD), the relay makes a decision to either block tripping or to allow tripping.

The OOS Relay Word outputs are used for alarming or controlling other equipment.

Normally, the Zone 5 and Zone 6 bottom reactance and left resistance element settings are mirror images of the top reactance and right resistance element settings (e.g., X1B5 = –X1T5). The SEL-311C makes these settings automatically. Enable the advanced user settings to set these elements individually (EADVS = Y).

Other Out-of-Step References

The out-of-step block (OSB) functions in the SEL-311C are a simplified version of those found in the SEL-421 Protection, Automation, and Control System. Refer to the *SEL-421 Application Handbook* and *SEL-421 Reference Manual* for application ideas and guidelines.

Another general reference is the *SEL Application Guide 97-13: SEL-321-5 Relay Out-of-Step Logic*, although the terminology differs somewhat from the SEL-311C.

OSB Settings Descriptions and Logic Diagrams

The OSB settings are summarized in *Table 3.10*, and the logic diagrams are shown in *Figure 3.22* and *Figure 3.23*. The Relay Word bit outputs are listed in *Table 3.12*.

The timer setting UBOSBD, shown in *Figure 3.22*, is an adaptive setting calculated by the relay. This adaptive setting, which is the expected duration of the swing within the inner blinders, is based on the actual time it takes for the swing to travel between the Zone 6 and Zone 5 blinders prior to moving into inner blinders. If the swing stays between the inner blinders for a period longer than UBOSBD cycles, an unblock signal is asserted.

In the SEL-311C, the user can increase the adaptive setting UBOSBD in multiples of setting UBOSBF. If UBOSBF is set at a multiplier of one, the relay will calculate the expected time to traverse the inner blinders based on the rate at which the swing transitions from Zone 6 to Zone 5. Similarly, if UBOSBF is set at a multiplier of 4, the relay will multiply the adaptive time setting by four.

The SEL-311C includes OSB latching logic. This includes the one second dropout timer, the latch, and the UBOSB override shown in *Figure 3.23*. This feature mimics the function performed by the SEL-421 relay OSBLTCH = Y setting.

Table 3.10 Out-of-Step Settings

Enable Setting:	EOOS = Y
Block Zone Settings (Zone 1–Zone 4):	OOSB*n* = Y, N (*n* = 1–4)
Out-of-Step Block Time Delay[a]: Pickup Ranges:	OSBD 0.50–8,000.00 cycles, 0.25-cycle steps
Enable Out-of-Step Tripping[b]:	EOOST = N, I, O
Out-of-Step Trip Time Delay[a]: Pickup Ranges:	OSTD 0.50–8,000.00 cycles, 0.25-cycle steps
Zones 5 and 6 Reactance and Resistance Elements	
Settings range for Zone 5 and Zone 6 Reactance Reach:	X1T5 and X1T6 0.05 to 96 Ω sec, 0.01 Ω steps (5 A nominal) 0.25 to 480 Ω sec, 0.01 Ω steps (1 A nominal)
Settings range for Zone 5 and Zone 6 Resistance Reach:	R1R5 and R1R6 0.05 to 70 Ω sec, 0.01 Ω steps (5 A nominal) 0.25 to 350 Ω sec, 0.01 Ω steps (1 A nominal)
Advanced Settings (EADVS = Y) range for Zone 5 and Zone 6 Reactance Reach:	X1B5 and X1B6 –96 to –0.05 Ω sec, 0.01 Ω steps (5 A nominal) –480 to –0.25 Ω sec, 0.01 Ω steps (1 A nominal)
Advanced Settings (EADVS = Y) range for Zone 5 and Zone 6 Resistance Reach:	R1L5 and R1L6) –70 to –0.05 Ω sec, 0.01 Ω steps (5 A nominal) –350 to –0.25 Ω sec, 0.01 Ω steps (1 A nominal)
Inner Blinders:	Set by the relay internally at 0.1 • Z1MAG or $0.25/I_{NOM}$, whichever is greater.
Positive Sequence Current Supervision Element 50ABC	
Setting Range for Positive-Sequence Current Supervision:	50ABCP 1.00–100.00 A secondary, 0.01 A steps (5 A nominal) 0.20–20.00 A secondary, 0.01 A steps (1 A nominal)
Negative-Sequence Current Unblock Time Delay[c]: Setting Range:	UBD (see *Figure 3.5* and *Figure 3.6*) 0.5–120.0 cycles, 0.25-cycle steps
Out-of-Step Angle Change Unblock Rate (Advanced Setting: EADVS = Y): Setting Range:	UBOSBF 1–10 unitless

[a] OSBD must be set greater than OSTD (if enabled by EOOST = I or O) by at least 0.50 cycles.
[b] Option I enables tripping on the way into Zone 5; Option O enables tripping on the way out of Zone 5; Option N disables OST (Out-of-Step Trip).
[c] UBD time only affects unblocking of Zone 2–Zone 4 phase pair elements.

Out-of-Step Blocking of Distance Elements

The SEL-311C OSB functions are similar to the SEL-421 relay. The four OSB control levels are individually enabled by settings EOOSB1 = Y, N through EOOSB4 = Y, N.

The Relay Word bits OSB1–OSB4 from *Figure 3.23* can be traced to the distance element logic diagrams:

- *Figure 3.4–Figure 3.6* (Phase distance elements Zone 1 through Zone 4)
- *Figure 3.7* (Mho ground element Zone 1)
- *Figure 3.10* (Quadrilateral ground element Zone 1)

Table 3.11 summarizes how the OSB signals are supervised by different means depending on the distance element.

Table 3.11 OSB Blocking and Unblocking of Distance Elements

Element Setting	Phase-Pairs (E21P = 1, 2, etc.)	Compensator (E21P = 1C, 2C, etc.)	Ground Mho (E21MG = 1, 2, etc.)	Ground Quad. (E21XG = 1, 2, etc.)
EOOSB1 = Y	OSB1, unblocked by 67Q1T[a]	OSB1, no unblocking	OSB1, unblocked by 67Q1T[a]	OSB1, unblocked by 67Q1T[a]
EOOSB2 = Y	OSB2, unblocked by [50Q2 AND 32QF][b] asserted longer than UBD timer setting	OSB2, no unblocking	Note[c]	Note[c]
EOOSB3 = Y (DIR3 = F/R)	OSB3, unblocked by [50Q3 AND (32QF/32QR)][b] asserted longer than UBD timer setting	OSB3, no unblocking	Note[c]	Note[c]
EOOSB4 = Y (DIR4 = F/R)	OSB4, unblocked by [50Q4 AND (32QF/32QR)][b] asserted longer than UBD timer setting	OSB4, no unblocking	Note[c]	Note[c]

[a] Differs from legacy SEL-311C models. 67Q1T comes from Figure 3.30.
[b] Differs from legacy SEL-311C models. 32QF/32QR come from Figure 4.20.
[c] Element unaffected by OSB logic.

Table 3.12 OOS Relay Word Bits

Relay Word Bits	Description	Relay Word Bits	Description
50ABC	Positive-sequence current above threshold	OSTO	Outgoing out-of-step trip
X6ABC	Impedance inside Zone 6	OST	Out-of-step trip
X5ABC	Impedance inside Zone 5	OSB1	Block Zone 1 during an out-of-step condition
UBOSB	Unblock out-of-step blocking	OSB2	Block Zone 2 during an out-of-step condition
OSB	Out-of-step block	OSB3	Block Zone 3 during an out-of-step condition
OSTI	Incoming out-of-step trip	OSB4	Block Zone 4 during an out-of-step condition

Out-of-Step Trip

The SEL-311C out-of-step trip function is enabled by setting EOOST = O for outgoing (trip on the way out of Zone 5) or I for incoming (trip on the way in to Zone 5) swings. The time delay setting OSTD must be set less than the OSBD setting by at least 0.50 cycles.

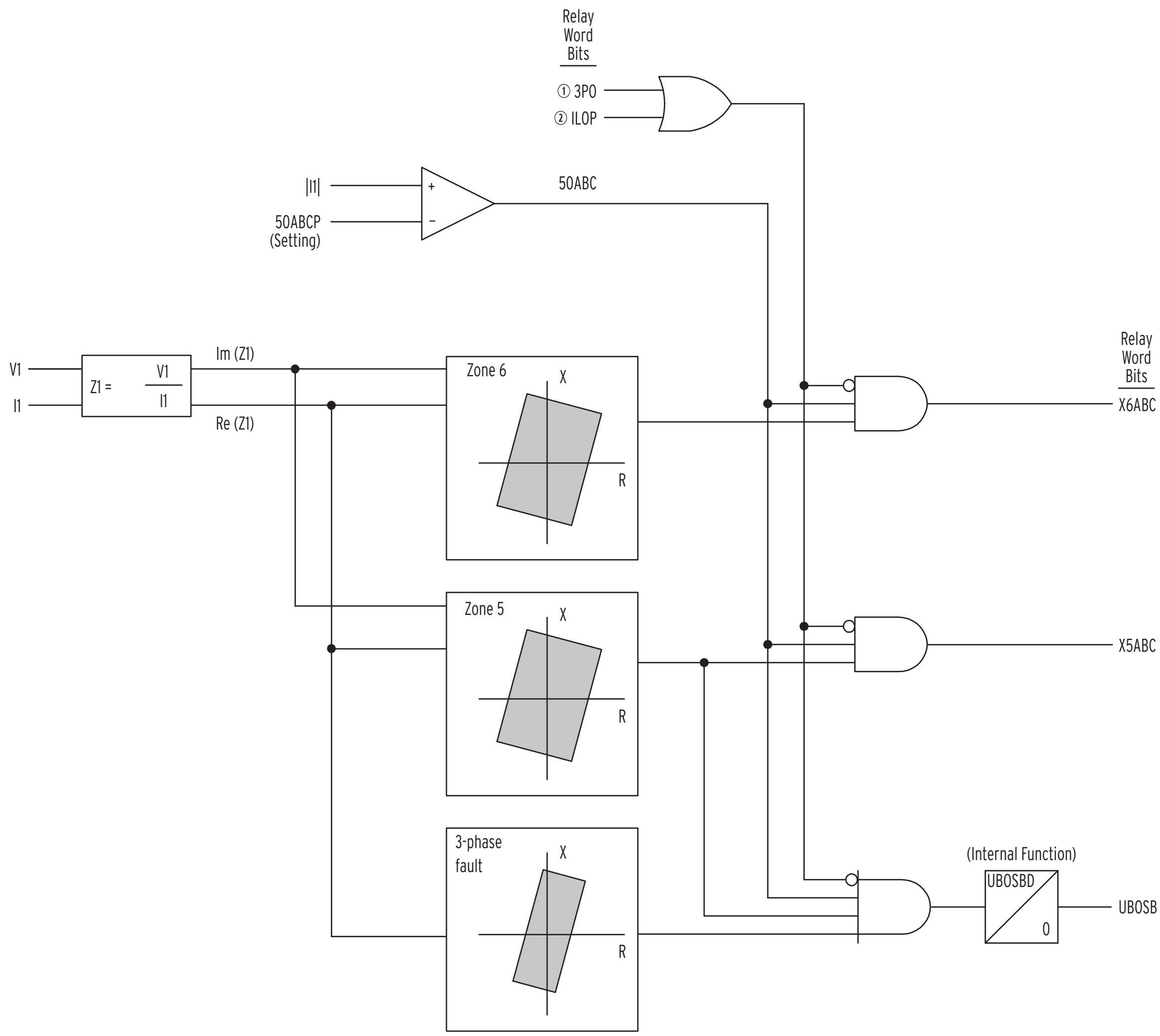
NOTE: The OST, OSTI, and OSTO Relay Word bits may only assert for one processing interval, and may not successfully activate the trip logic if used in the TRQUAL SELOGIC equation. Use them in the TR equation, instead. See TRQUAL Qualified Trip Conditions on page 5.2 for more information.

The out-of-step trip application is similar to the SEL-421 relay, and there is no built-in connection to the trip logic of the SEL-311C. For out-of-step tripping applications, the OST Relay Word bit must be included in the relay TR equation. For example, to force a trip on out-of-step, with no reclose, you would include OST in these settings:

TR = **... + OST** (add OST to the trip conditions SELOGIC Equation)

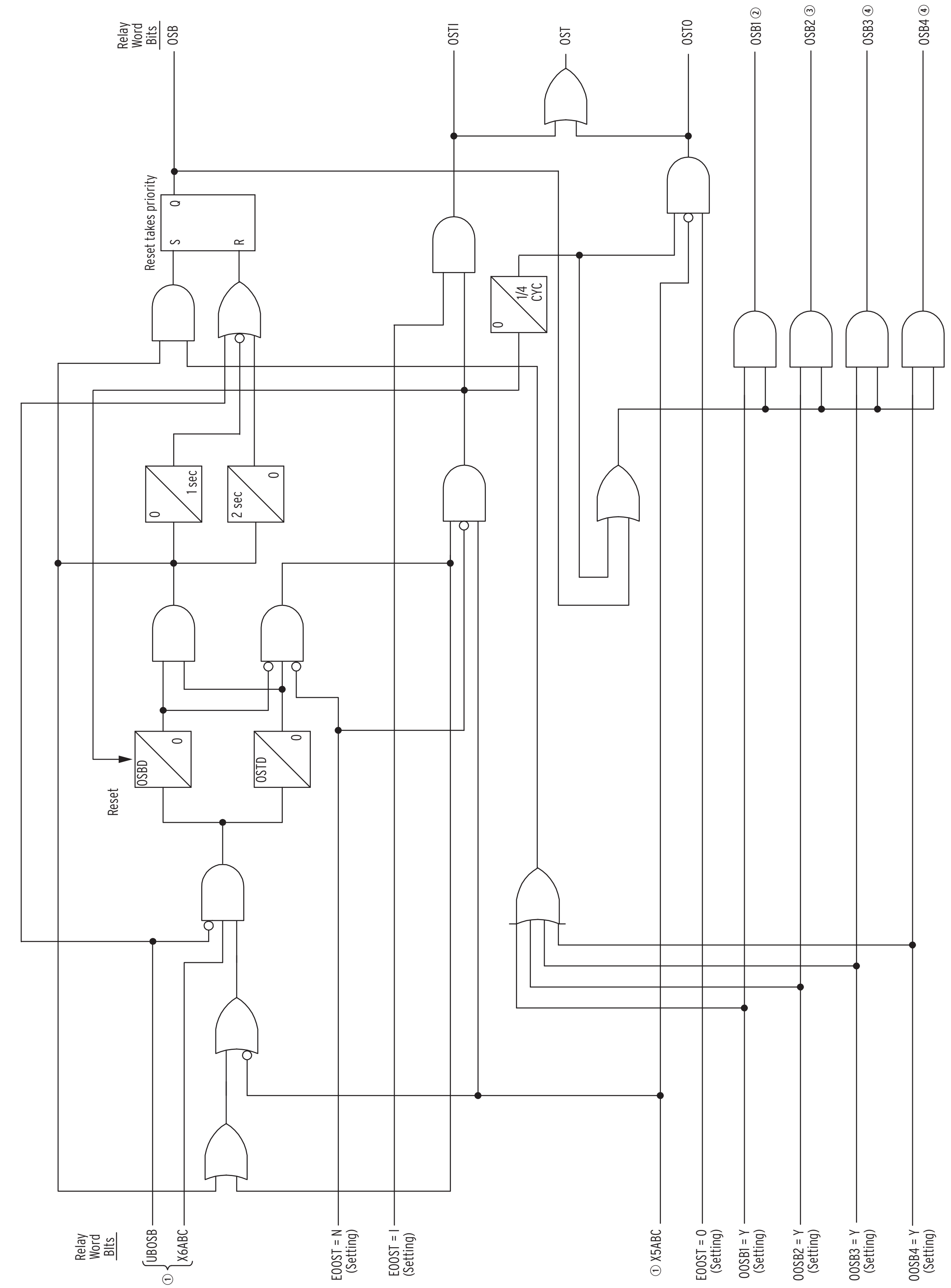
79DTL = **... + OST** (add OST to the drive-to-lockout conditions)

Refer to the *SEL-421 Application Handbook* for detailed out-of-step examples.



① From Figure 5.3; ② from Figure 4.1.

Figure 3.22 Out-of-Step Zone Detection Logic



① From Figure 3.22; ② to Figure 3.4, Figure 3.7, and Figure 3.10; ③ to Figure 3.5; ④ to Figure 3.6.

Figure 3.23 Out-of-Step Logic

Instantaneous/Definite-Time Overcurrent Elements

Phase Instantaneous/ Definite-Time Overcurrent Elements

Four levels of phase instantaneous/definite-time overcurrent elements are available. The different levels are enabled with the E50P enable setting, as shown in *Figure 3.24* and *Figure 3.25*.

All phase instantaneous/definite-time overcurrent elements are available for use in any tripping or control scheme.

Settings Ranges

Settings Range	Description
Pickup Settings 50P1P–50P4P	
OFF, 0.25–100.00 A secondary	5 A nominal phase current inputs, IA, IB, IC
OFF, 0.05–20.00 A secondary	1 A nominal phase current inputs, IA, IB, IC
Definite-Time Settings 67P1D–67P4D	
0.00–16000.00 cycles, in 0.25-cycle steps	

Pickup Operation

The phase instantaneous/definite-time overcurrent element logic begins with *Figure 3.24*. The pickup settings for each level (50P1P–50P4P) are compared to the magnitudes of the individual phase currents I_A, I_B, and I_C. The logic outputs are Relay Word bits and operate as follows (Level 1 example shown):

50A1 = 1 (logical 1), if $I_A >$ pickup setting 50P1P
= 0 (logical 0), if $I_A \leq$ pickup setting 50P1P
50B1 = 1 (logical 1), if $I_B >$ pickup setting 50P1P
= 0 (logical 0), if $I_B \leq$ pickup setting 50P1P
50C1 = 1 (logical 1), if $I_C >$ pickup setting 50P1P
= 0 (logical 0), if $I_C \leq$ pickup setting 50P1P
50P1 = 1 (logical 1), if at least one of the Relay Word bits 50A1, 50B1, or 50C1 is asserted (e.g., 50B1 = 1)
= 0 (logical 0), if all three Relay Word bits 50A1, 50B1, and 50C1 are deasserted (50A1 = 0, 50B1 = 0, and 50C1 = 0)

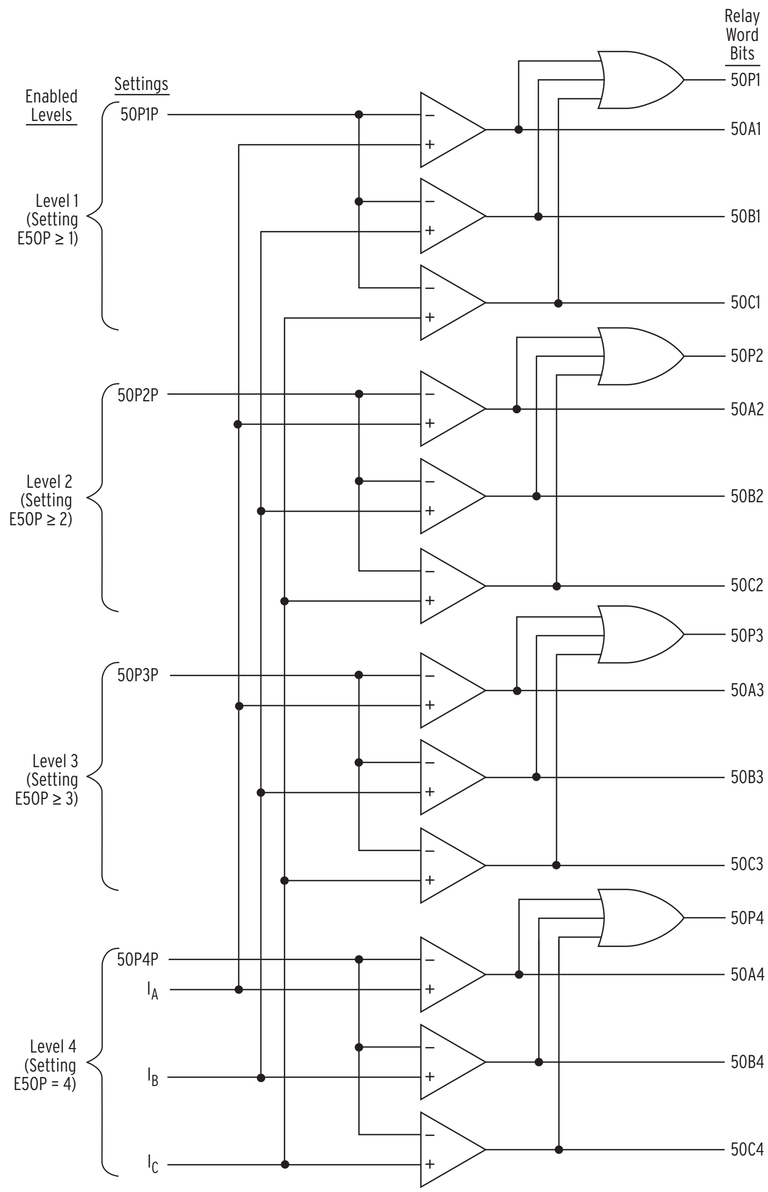
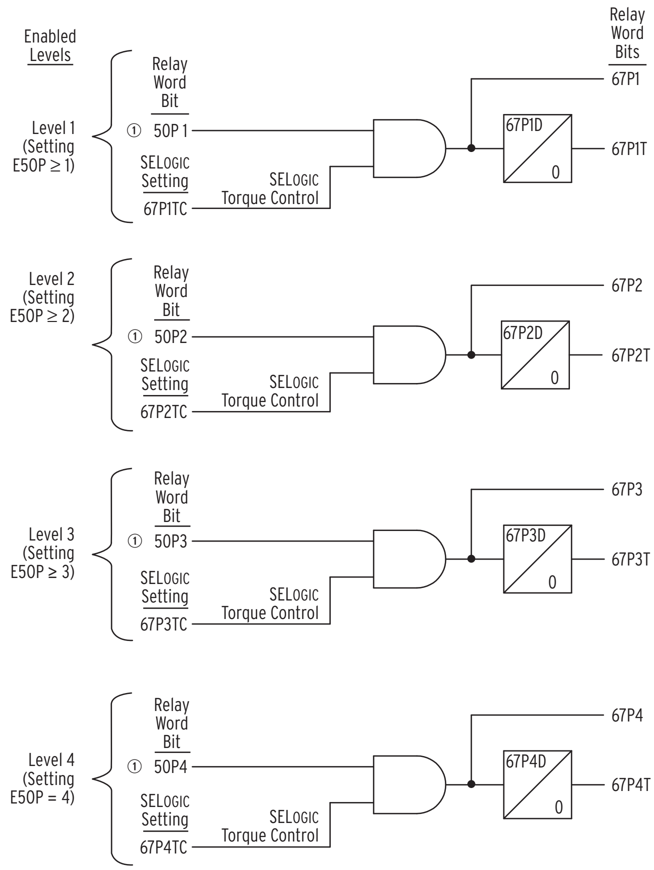


Figure 3.24 Levels 1 Through 4 Phase Instantaneous Overcurrent Elements

These Relay Word bit outputs then become inputs to *Figure 3.25*. Ideally, set 50P1P > 50P2P > 50P3P > 50P4P so that instantaneous/definite-time overcurrent elements 50P1–50P4 and 67P1–67P4 will display in an organized fashion in event reports (see *Figure 12.5* and *Table 12.4*).



① From Figure 3.24

Figure 3.25 Levels 1 Through 4 Phase Instantaneous/Definite-Time Overcurrent Elements (With Torque Control)

Phase Instantaneous/Definite-Time Overcurrent Elements are Nondirectional

Unlike the ground and negative-sequence overcurrent elements, the SEL-311C phase instantaneous/definite-time overcurrent elements do not contain any built-in directional control.

If directional control is desired, refer to *Overcurrent Directional Control Provided by Torque Control Settings on page 4.38*.

Torque Control

NOTE: All overcurrent element SELOGIC control equation torque control settings are set directly to logical 1 (e.g., 67P1TC = 1) for the **factory default settings**. See SHO Command (Show/View Settings) on page 10.49 for a list of the factory default settings.

Levels 1 through 4 in *Figure 3.25* have corresponding SELOGIC control equation torque control settings 67P1TC–67P4TC. SELOGIC control equation torque control settings cannot be set directly to logical 0. The following are torque control setting examples for Level 1 phase instantaneous/definite-time overcurrent elements 67P1/67P1T.

67P1TC = **1** Setting 67P1TC set directly to logical 1:

Then phase instantaneous/definite-time overcurrent element 67P1 directly follows the state of 50P1 from *Figure 3.24*, and definite-time element 67P1T has an intentional time-delayed pickup defined by setting 67P1D.

67P1TC = **IN105** Input **IN105** deasserted (67P1TC = IN105 = logical 0):

Then phase instantaneous/definite-time overcurrent elements 67P1/67P1T are defeated and nonoperational, regardless of any other setting.

Input **IN105** asserted (67P1TC = IN105 = logical 1):

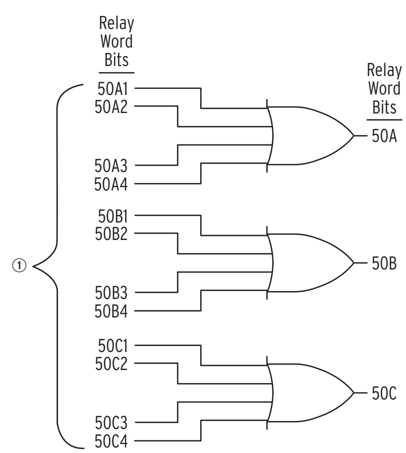
Then phase instantaneous/definite-time overcurrent element 67P1 directly follows the state of 50P1 from *Figure 3.24*, and definite-time element 67P1T has an intentional time-delayed pickup defined by setting 67P1D.

Sometimes SELOGIC control equation torque control settings are set to provide directional control. See *Overcurrent Directional Control Provided by Torque Control Settings on page 4.38*.

Combined Single-Phase Instantaneous Overcurrent Elements

The single-phase instantaneous overcurrent element Relay Word bit outputs in *Figure 3.24* are combined together in *Figure 3.26*, producing Relay Word bit outputs 50A, 50B, and 50C.

Relay Word bits 50A, 50B, and 50C can be used to indicate the presence or absence of fault current in a particular phase.



① From Figure 3.24.

Figure 3.26 Combined Single-Phase Instantaneous Overcurrent Elements

Pickup and Reset Time Curves

NOTE: The pickup time curve in Figure 3.27 is not valid for conditions with a saturated CT, where the resultant current to the relay is nonsinusoidal.

Figure 3.27 and *Figure 3.28* show pickup and reset time curves applicable to all nondirectional instantaneous overcurrent elements with sinosoidal waveforms applied (60 Hz or 50 Hz relays). These times do not include output contact operating time and, thus, are accurate for determining element operation time for use in internal SELOGIC control equations.

Output contact pickup/dropout time for the various output types is defined in *Specifications on page 1.2*. Add the appropriate time to the values from *Figure 3.27* and *Figure 3.28* to obtain expected operate times for testing and commissioning.

If instantaneous overcurrent elements are made directional (with standard directional elements such as 32QF), the pickup time curve in *Figure 3.27* is adjusted as follows:

multiples of pickup setting $\leq$ 4: add 0.25 cycle

multiples of pickup setting $>$ 4: add 0.50 cycle

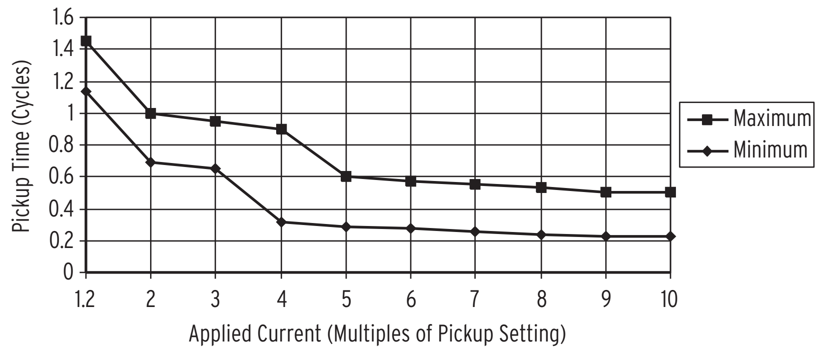


Figure 3.27 Nondirectional Instantaneous Overcurrent Element Pickup Time Curve

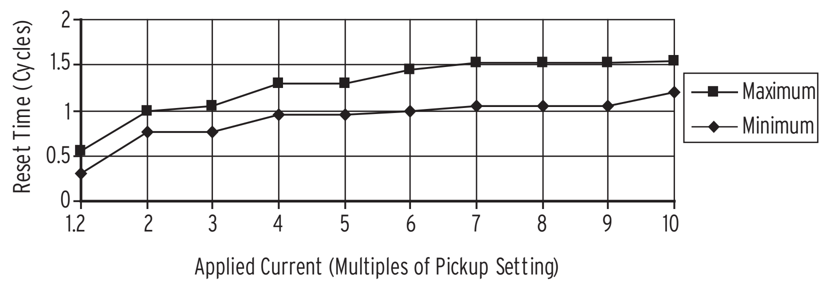


Figure 3.28 Nondirectional Instantaneous Overcurrent Element Reset Time Curve

Residual Ground Instantaneous/ Definite-Time Overcurrent Elements

Four levels of residual ground instantaneous/definite-time overcurrent elements are available. The different levels are enabled with the E50G enable setting, as shown in *Figure 3.29*.

In *Figure 3.29* the Level 1 (67G1) and Level 2 (67G2) elements have their directional control fixed forward. Levels 3 and 4 have selectable forward or reverse directional controls. See *Directional Control Settings on page 4.29* for details on specifying the Zone 3 and Zone 4 direction using Group settings DIR3 and DIR4.

The Level 2 and Level 3 residual ground overcurrent elements are used in some embedded functions in the SEL-311C. The connection is visible in the logic diagrams where Relay Word bits 50G3, 67G2 or 67G3 are shown as inputs. Some examples include Permissive Overreaching Transfer Trip logic, shown in *Figure 5.6*, and Directional Comparison Blocking logic, shown in *Figure 5.14*.

To understand the operation of *Figure 3.29*, follow the explanation given for *Figure 3.24* and *Figure 3.25*, substituting residual ground current I_G ($I_G = 3I_0 = I_A + I_B + I_C$) for phase currents and substituting like settings and Relay Word bits.

Ideally, set 50G1P > 50G2P > 50G3P > 50G4P so that instantaneous/definite-time overcurrent elements 50G1–50G4 and 67G1–67G4 will display in an organized fashion in event reports (see *Figure 12.5* and *Table 12.4*).

Settings Ranges

NOTE: For pickup settings less than:

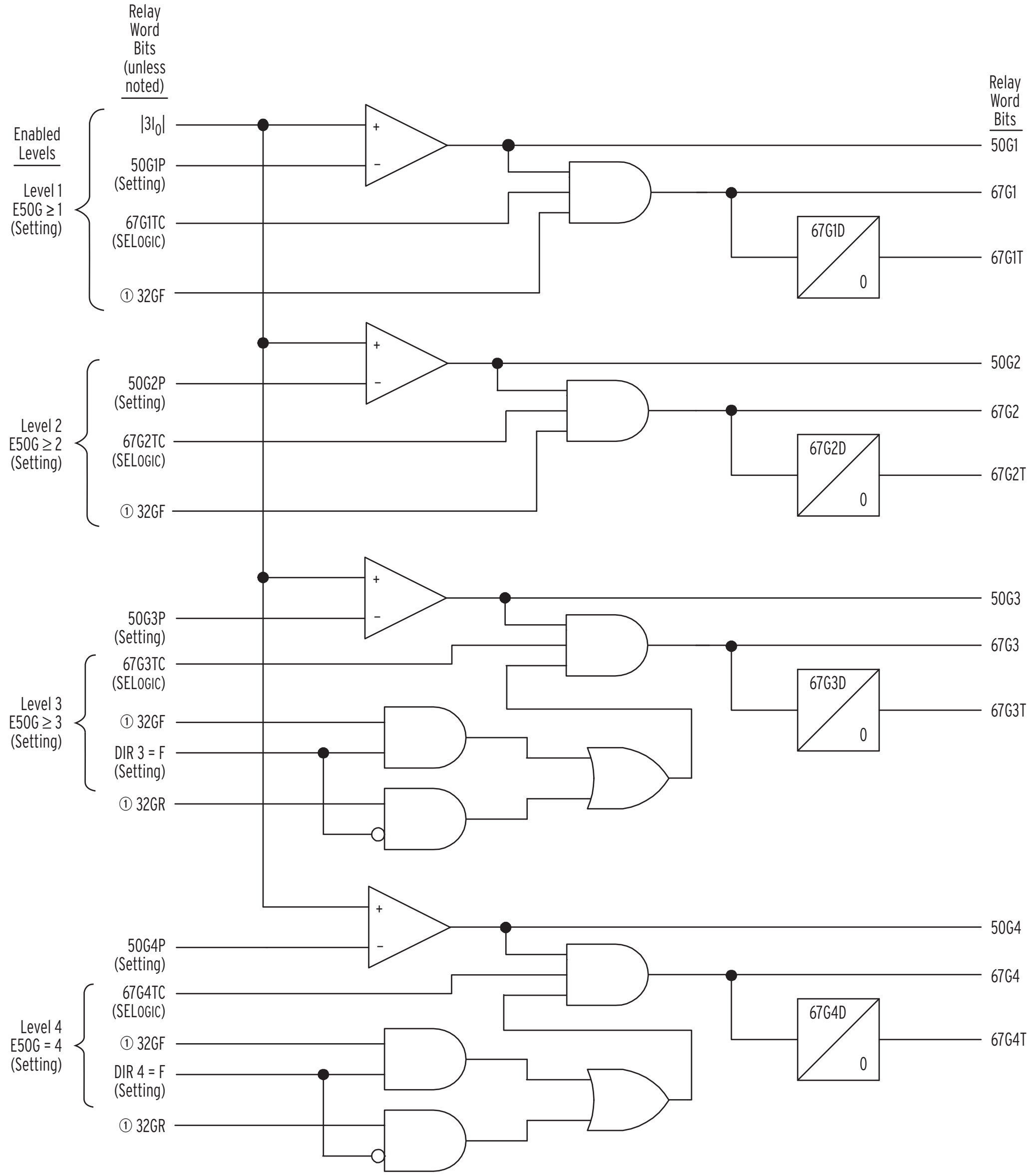
0.25 A secondary (5 A nominal)
0.05 A secondary (1 A nominal)

an additional 2-cycle time delay is added on all residual ground instantaneous (50G1–50G4, 67G1–67G4) and definite-time (67G1T–67G4T) overcurrent elements. Any time delay provided by the definite-time settings (67G1D–67G4D) is in **addition** to this 2-cycle time delay.

Settings Range	Description
Pickup Settings 50G1P–50G4P	
0.050–100.00 A secondary in 0.010 A steps	5 A nominal phase current inputs, IA, IB, IC
0.010–20.00 A secondary in 0.002 A steps	1 A nominal phase current inputs, IA, IB, IC
Definite-Time Settings 67G1D–67G4D	
0.00–16000.00 cycles, in 0.25-cycle steps	

Pickup and Reset Time Curves

See *Figure 3.27* and *Figure 3.28*.



① From Figure 4.18.

Figure 3.29 Levels 1 Through 4 Residual Ground Instantaneous/Definite-Time Overcurrent Elements With Directional and Torque Control

Negative-Sequence Instantaneous/ Definite-Time Overcurrent Elements

Four levels of negative-sequence instantaneous/definite-time overcurrent elements are available. The different levels are enabled with the E50Q enable setting, as shown in *Figure 3.30*.

In *Figure 3.30* the Level 1 (67Q1) and Level 2 (67Q2) elements have their directional control fixed forward. Level 3 and Level 4 have selectable forward and reverse directional controls. See *Directional Control Settings on page 4.29* for details on specifying the Zone 3 and Zone 4 direction using Group settings DIR3 and DIR4.

The Level 2 and Level 3 negative-sequence overcurrent elements are used in some embedded functions in the SEL-311C. The connection is visible in the logic diagrams where Relay Word bits 50Q3, 67Q2 or 67Q3 are shown as inputs. Some examples include Permissive Overreaching Transfer Trip logic, shown in *Figure 5.6*, and Directional Comparison Blocking logic, shown in *Figure 5.14*.

IMPORTANT: See Appendix G: Setting Negative-Sequence Overcurrent Elements for information on setting negative-sequence overcurrent elements.

To understand the operation of *Figure 3.30*, follow the explanation given for *Figure 3.24* and *Figure 3.25*, substituting negative-sequence current:

$3I_2 = I_A + a^2 \bullet I_B + a \bullet I_C$ (Global setting PHROT = ABC)

$3I_2 = I_A + a^2 \bullet I_C + a \bullet I_B$ (Global setting PHROT = ACB)

where:

$a = 1 \angle 120°$

$a^2 = 1 \angle -120°$

for phase currents and substituting like settings and Relay Word bits.

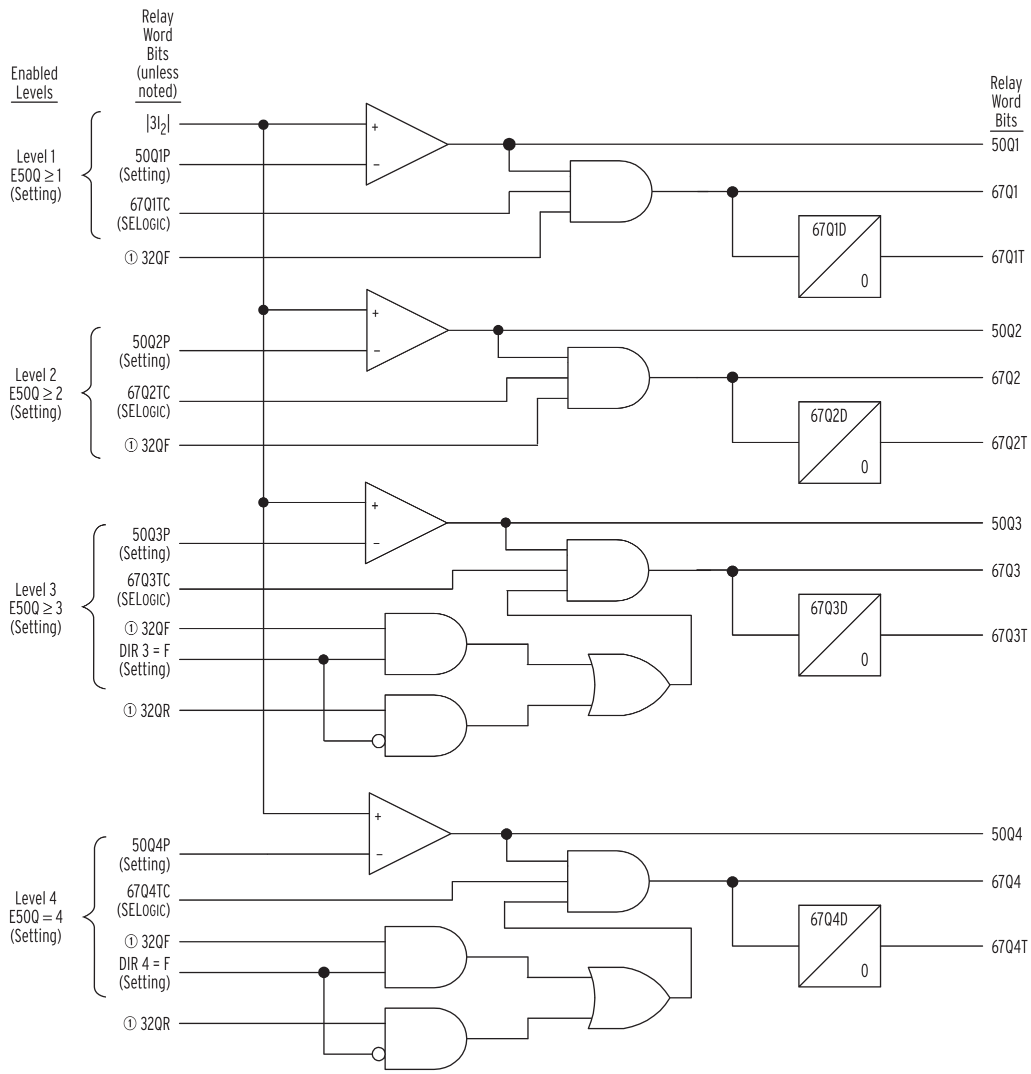
Ideally, set 50Q1P > 50Q2P > 50Q3P > 50Q4P so that instantaneous/definite-time overcurrent elements 50Q1–50Q4 and 67Q1–67Q4 will display in an organized fashion in event reports (see *Figure 12.5* and *Table 12.4*).

Settings Ranges

Settings Range	Description
Pickup Settings 50Q1P–50Q4P	
0.25–100.00 A secondary	5 A nominal phase current inputs, IA, IB, IC
0.05–20.00 A secondary	1 A nominal phase current inputs, IA, IB, IC
Definite-Time Settings 67Q1D–67Q4D	
0.00–16000.00 cycles, in 0.25-cycle steps	

Pickup and Reset Time Curves

See *Figure 3.27* and *Figure 3.28*.



① From Figure 4.20.

Figure 3.30 Levels 1 Through 4 Negative-Sequence Instantaneous/Definite-Time Overcurrent Elements With Directional and Torque Control

Time-Overcurrent Elements

Phase Time-Overcurrent Elements

One phase time-overcurrent element is available. This element is enabled with the E51P enable setting as follows:

Table 3.13 Available Phase Time-Overcurrent Elements

Time-Overcurrent Element	Enabled With Setting	Operating Current	See Figure
51PT	E51P = Y	I_{ABC}, maximum of A-, B-, and C-phase currents	*Figure 3.31*

Settings Ranges

Besides the settings involved with the Torque Control Switch operation in *Figure 3.31*, the 51PT phase time-overcurrent element has the following settings:

Table 3.14 Phase Time-Overcurrent Element (Maximum Phase) Settings

Setting	Definition	Range
51PP	pickup	0.25–16.00 A secondary (5 A nominal phase current inputs, IA, IB, IC) 0.05–3.20 A secondary (1 A nominal phase current inputs, IA, IB, IC)
51PC	curve type	U1–U5 (US curves) see *Figure 9.1–Figure 9.10* C1–C5 (IEC curves)
51PTD	time dial	0.50–15.00 (US curves) see *Figure 9.1–Figure 9.10* 0.05–1.00 (IEC curves)
51PRS	electromechanical reset timing	Y, N
51PTC	SELOGIC control equation torque control setting	Relay Word bits referenced in *Table D.2* or set directly to logical 1 (=1)[a]

[a] SELOGIC control equation torque control setting 51PTC cannot be set directly to logical 0.

See *Time-Overcurrent Curves on page 9.4* for additional time-overcurrent element setting information.

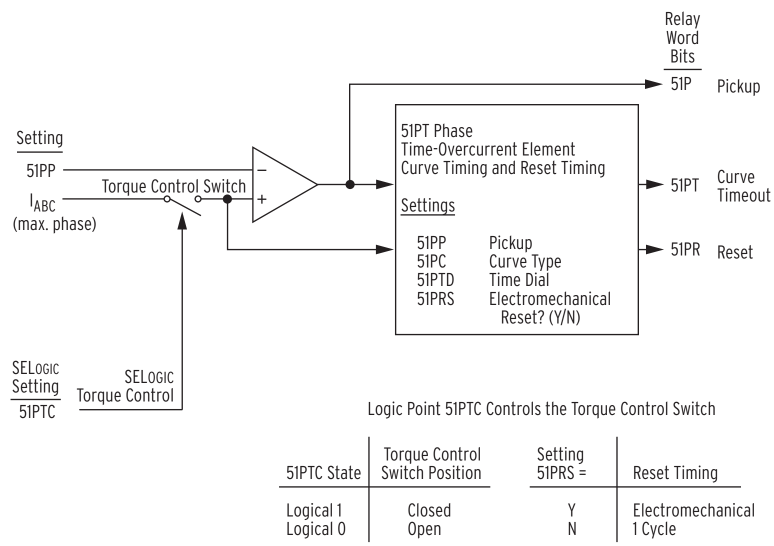


Figure 3.31 Phase Time-Overcurrent Element 51PT

51PT Element Logic Outputs

The logic outputs in *Figure 3.31* are the Relay Word bits shown in *Table 3.15*.

Table 3.15 Phase Time-Overcurrent Element (Maximum Phase) Logic Outputs

Relay Word Bit[a]	Definition/Indication	Application
51P	Maximum phase current, I_{ABC}, is greater than phase time-overcurrent element pickup setting 51PP.	Element pickup testing or other control applications.
51PT	Phase time-overcurrent element is timed out on its curve.	Tripping and other control applications. See *Trip Logic on page 5.1*.
51PR	Phase time-overcurrent element is fully reset.	Element reset testing or other control applications.

[a] When E51P = N or 51PP = OFF, the relay deasserts all three Relay Word bit outputs.

51PT Element Torque Control Switch Operation

Torque Control Switch Closed

The pickup comparator in *Figure 3.31* compares the pickup setting (51PP) to the maximum phase current, I_{ABC}, if the Torque Control Switch is closed. I_{ABC} is also routed to the curve timing/reset timing functions. The Relay Word bit logic outputs operate as follows with the Torque Control Switch closed:

51P = 1 (logical 1), if I_{ABC} > pickup setting 51PP and the phase time-overcurrent element is timing or is timed out on its curve

= 0 (logical 0), if $I_{ABC} \leq$ pickup setting 51PP

51PT = 1 (logical 1), if I_{ABC} > pickup setting 51PP and the phase time-overcurrent element is timed out on its curve

= 0 (logical 0), if I_{ABC} > pickup setting 51PP and the phase time-overcurrent element is timing, but not yet timed out on its curve

= 0 (logical 0), if $I_{ABC} \leq$ pickup setting 51PP

51PR = 1 (logical 1), if $I_{ABC} \leq$ pickup setting 51PP and the phase time-overcurrent element is fully reset

= 0 (logical 0), if $I_{ABC} \leq$ pickup setting 51PP and the phase time-overcurrent element is timing to reset (not yet fully reset)

= 0 (logical 0), if I_{ABC} > pickup setting 51PP and the phase time-overcurrent element is timing or is timed out on its curve

Torque Control Switch Open

If the Torque Control Switch in *Figure 3.31* is open, maximum phase current, I_{ABC}, **cannot** get through to the pickup comparator (setting 51PP) and the curve timing/reset timing functions. For example, suppose that the Torque Control Switch is closed, I_{ABC} is shown below:

I_{ABC} > pickup setting 51PP

and the phase time-overcurrent element is timing or is timed out on its curve. If the Torque Control Switch is then opened, I_{ABC} effectively appears as a magnitude of zero (0) to the pickup comparator:

I_{ABC} = 0 A (effective) < pickup setting 51PP

This results in Relay Word bit 51P deasserting to logical 0. I_{ABC} also effectively appears as a magnitude of zero (0) to the curve timing/reset timing functions, resulting in Relay Word bit 51PT also deasserting to logical 0. The phase time-overcurrent element then starts to time to reset. Relay Word bit 51PR asserts to logical 1 when the phase time-overcurrent element is fully reset.

Torque Control

Refer to *Figure 3.31*.

NOTE: All overcurrent element SELOGIC control equation torque control settings are set directly to logical 1 (e.g., 51PTC = 1) for the factory default settings. See SHO Command (Show/View Settings) on page 10.49 for a list of the factory default settings.

SELOGIC control equation torque control settings (e.g., 51PTC) cannot be set directly to logical 0. The following are settings examples of SELOGIC control equation torque control setting 51PTC for phase time-overcurrent element 51PT.

51PTC = **1** Setting 51PTC set directly to logical 1:

The Torque Control Switch closes and phase time-overcurrent element 51PT is enabled and nondirectional.

51PTC = **IN105**

Input **IN105** deasserted (51PTC = IN105 = logical 0):

The Torque Control Switch opens and phase time-overcurrent element 51PT is defeated and nonoperational, regardless of any other setting.

Input **IN105** asserted (51PTC = IN105 = logical 1):

The Torque Control Switch closes and phase time-overcurrent element 51PT is enabled and nondirectional.

51PTC = **M2P**

The 51P/51PT uses the Zone 2 mho phase distance element to provide forward directional control.

Other SELOGIC control equation torque control settings may be set to provide directional control. See *Overcurrent Directional Control Provided by Torque Control Settings on page 4.38*.

Reset Timing Details (51PT Element Example)

Refer to *Figure 3.31*.

Any time current I_{ABC} goes above pickup setting 51PP and the phase time-overcurrent element starts timing, Relay Word bit 51PR (reset indication) = logical 0. If the phase time-overcurrent element times out on its curve, Relay Word bit 51PT (curve time-out indication) = logical 1.

Setting 51PRS = Y

If electromechanical reset timing setting 51PRS = Y, the phase time-overcurrent element reset timing emulates electromechanical reset timing. If maximum phase current, I_{ABC}, goes above pickup setting 51PP (element is timing or already timed out) and then current I_{ABC} goes below 51PP, the element starts to time to reset, emulating electromechanical reset timing. Relay Word bit 51PR (resetting indication) = logical 1 when the element is fully reset. See *Time-Overcurrent Curves on page 9.4* for reset curve equations.

Setting 51PRS = N

If reset timing setting 51PRS = N, element 51PT reset timing is a 1-cycle dropout. If current I_{ABC} goes above pickup setting 51PP (element is timing or already timed out) and then current I_{ABC} goes below pickup setting 51PP, there is a 1-cycle delay before the element fully resets. Relay Word bit 51PR (reset indication) = logical 1 when the element is fully reset.

Residual Ground Time-Overcurrent Element

To understand the operation of *Figure 3.32*, follow the explanation given for *Figure 3.31* in *Phase Time-Overcurrent Elements on page 3.43*, substituting residual ground current I_G ($I_G = 3I_0 = I_A + I_B + I_C$) for maximum phase current I_{ABC} and substituting like settings and Relay Word bits.

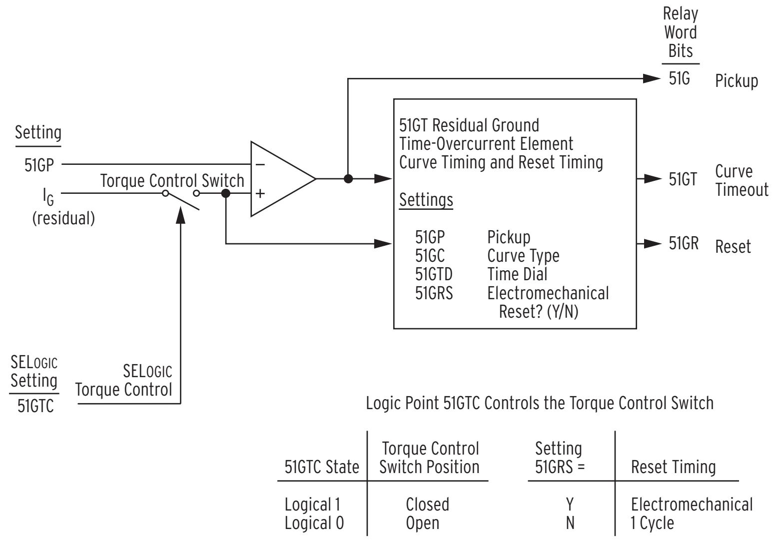


Figure 3.32 Residual Ground Time-Overcurrent Element 51GT

Settings Ranges

Table 3.16 Residual Ground Time-Overcurrent Element Settings

Setting	Definition	Range
51GP	pickup	0.10–16.00 A secondary (5 A nominal phase current inputs, IA, IB, IC) 0.02–3.20 A secondary (1 A nominal phase current inputs, IA, IB, IC)
51GC	curve type	U1–U5 (US curves) see *Figure 9.1–Figure 9.10* C1–C5 (IEC curves)
51GTD	time dial	0.50–15.00 (US curves) see *Figure 9.1–Figure 9.10* 0.05–1.00 (IEC curves)
51GRS	electromechanical reset timing	Y, N
51GTC	SELOGIC control equation torque control setting	Relay Word bits referenced in *Table D.2* or set directly to logical 1 (= 1)[a]

[a] SELOGIC control equation torque control setting 51GTC cannot be set directly to logical 0.

The residual ground time-overcurrent element 51GT is nondirectional. In applications where directionality is required, see *Overcurrent Directional Control Provided by Torque Control Settings on page 4.38*. See *Time-Overcurrent Curves on page 9.4* for additional time-overcurrent element setting information.

Negative-Sequence Time-Overcurrent Element

To understand the operation of *Figure 3.33*, follow the explanation given for *Figure 3.31* in *Phase Time-Overcurrent Elements on page 3.43*, substituting negative-sequence current $3I_2$

$$3I_2 = I_A + a^2 \cdot I_B + a \cdot I_C \text{ (ABC rotation)}$$

$$3I_2 = I_A + a^2 \cdot I_C + a \cdot I_B \text{ (ACB rotation)}$$

where:

$a = 1 \angle 120°$

$a^2 = 1 \angle –120°$

for maximum phase current I_{ABC} and like settings and Relay Word bits.

IMPORTANT: See Setting Negative-Sequence Overcurrent Elements on page G.1 for information on setting negative-sequence overcurrent elements.

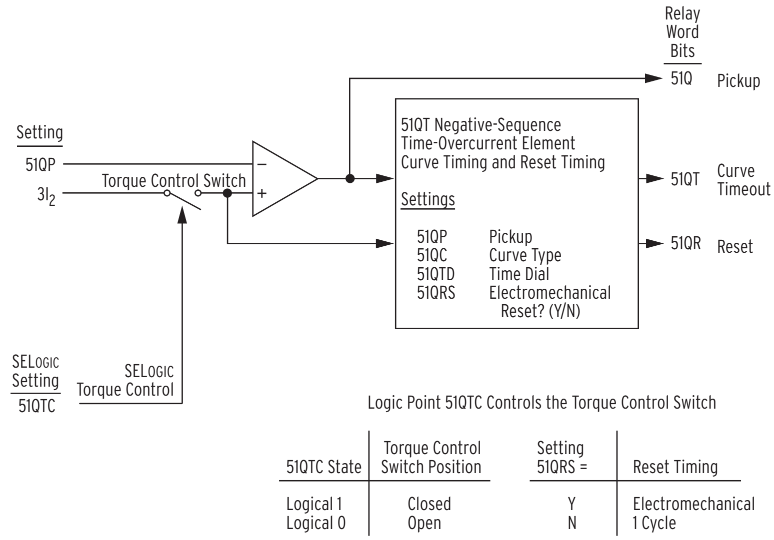


Figure 3.33 Negative-Sequence Time-Overcurrent Element 51QT

Settings Ranges

Table 3.17 Negative-Sequence Time-Overcurrent Element Settings

Setting	Definition	Range
51QP	pickup	0.25–16.00 A secondary (5 A nominal phase current inputs, IA, IB, IC) 0.05–3.20 A secondary (1 A nominal phase current inputs, IA, IB, IC)
51QC	curve type	U1–U5 (US curves) see *Figure 9.1–Figure 9.10* C1–C5 (IEC curves)
51QTD	time dial	0.50–15.00 (US curves) see *Figure 9.1–Figure 9.10* 0.05–1.00 (IEC curves)
51QRS	electromechanical reset timing	Y, N
51QTC	SELOGIC control equation torque control setting	Relay Word bits referenced in *Table D.2* or set directly to logical 1 (= 1)[a]

[a] SELOGIC control equation torque control setting 51QTC cannot be set directly to logical 0.

The negative-sequence time-overcurrent element 51QT is nondirectional. In applications where directionality is required, see *Overcurrent Directional Control Provided by Torque Control Settings on page 4.38*. See *Time-Overcurrent Curves on page 9.4* for additional time-overcurrent element setting information.

Voltage Elements

Enable the general-purpose voltage elements by making the enable setting:

EVOLT = **Y**

Voltage Values

The voltage elements operate off of various voltage values shown in *Table 3.18*.

Table 3.18 Voltage Values Used by Voltage Elements

Voltage	Description
V_A	A-phase voltage, from SEL-311C rear-panel voltage input **VA**[a]
V_B	B-phase voltage, from SEL-311C rear-panel voltage input **VB**[a]
V_C	C-phase voltage, from SEL-311C rear-panel voltage input **VC**[a]
V_{AB}	Phase-to-phase voltage[b]
V_{BC}	Phase-to-phase voltage[b]
V_{CA}	Phase-to-phase voltage
$3V_0$	Zero-sequence (residual) voltage[a, c]
V_2	Negative-sequence voltage
V_1	Positive-sequence voltage
V_S	Synchronism check voltage, from SEL-311C rear-panel voltage input **VS**[d]

[a] Not available when delta connected (PTCONN = DELTA).
[b] Measured directly when delta connected.
[c] When PTCONN = WYE, the relay calculates zero-sequence voltage 3V0 from the phase voltage signals VA, VB, and VC, and uses the value to operate the zero-sequence voltage elements 59N1 and 59N2. When PTCONN = DELTA, calculated zero-sequence voltage 3V0 is not available and the voltage elements 59N1 and 59N2 are disabled.
[d] Voltage VS can be used in the synchronism check elements when Global setting VSCONN = VS (see Synchronism Check Elements on page 3.53). Voltage VS can be connected to a zero-sequence voltage source (typically a broken-delta connection) when Global setting VSCONN = 3V0 (see Broken-Delta VS Connection (Global Setting VSCONN = 3V0) on page 2.12). Voltage VS is also used in the two voltage elements listed in Table 3.20 and in Figure 3.38, independent of the VSCONN setting.

NOTE: Voltage VS cannot be used for 3V0 measurement and as a synchronism check input at the same time.

Voltage Element Settings

Table 3.19 through *Table 3.21* list available voltage elements and the corresponding voltage inputs and settings ranges for SEL-311C relays. The Global setting PTCONN determines the relay voltage configuration as one of the following:

- ➤ Wye connected (PTCONN = WYE), use *Table 3.19* and *Table 3.20*
- ➤ Delta connected (PTCONN = DELTA), use *Table 3.20* and *Table 3.21*

For more information on wye- and delta-connected voltage inputs, see *Settings for Voltage Input Configuration on page 9.16*.

Table 3.19 Voltage Elements Settings and Settings Ranges (Wye-Connected PTs) (Sheet 1 of 2)

Voltage Element (Relay Word Bits)	Operating Voltage	Pickup Setting/Range	See Figure
27A	V_A	27P 0.00–300.00 V secondary	*Figure 3.34*
27B	V_B		
27C	V_C		
3P27 = 27A * 27B * 27C			

NOTE: Voltage element pickup settings should not be set near zero, because they can assert or deassert due to noise when no signal is applied. SEL recommends a minimum setting of 2.00 V.

Table 3.19 Voltage Elements Settings and Settings Ranges (Wye-Connected PTs) (Sheet 2 of 2)

Voltage Element (Relay Word Bits)	Operating Voltage	Pickup Setting/Range	See Figure
59A 59B 59C 3P59 = 59A * 59B * 59C	V_A V_B V_C	59P 0.00–300.00 V secondary	
27AB 27BC 27CA	V_{AB} V_{BC} V_{CA}	27PP 0.00–520.00 V secondary	*Figure 3.35*
59AB 59BC 59CA	V_{AB} V_{BC} V_{CA}	59PP 0.00–520.00 V secondary	
59N1	$3V_0$	59N1P 0.00–300.00 V secondary	
59N2	$3V_0$	59N2P 0.00–300.00 V secondary	
59Q	V_2	59QP 0.00–200.00 V secondary	
59V1	V_1	59V1P 0.00–300.00 V secondary	

Table 3.20 Voltage Elements Settings and Settings Ranges (VS Channel)

Voltage Element (Relay Word Bits)	Operating Voltage	Pickup Setting/Range	See Figure
27S	V_S	27SP 0.00–300.00 V secondary	*Figure 3.38*
59S	V_S	59SP 0.00–300.00 V secondary	

Table 3.21 Voltage Elements Settings and Settings Ranges (Delta-Connected PTs)

Voltage Element (Relay Word Bits)	Operating Voltage	Pickup Setting/Range	See Figure
27AB 27BC 27CA 3P27 = 27AB * 27BC * 27CA	V_{AB} V_{BC} V_{CA}	27PP 0.00–300.00 V secondary	*Figure 3.36*
59AB 59BC 59CA 3P59 = 59AB * 59BC * 59CA	V_{AB} V_{BC} V_{CA}	59PP 0.00–300.00 V secondary	
59Q	V_2	59QP 0.00–120.00 V secondary	*Figure 3.37*
59V1	V_1	59V1P 0.00–170.00 V secondary	

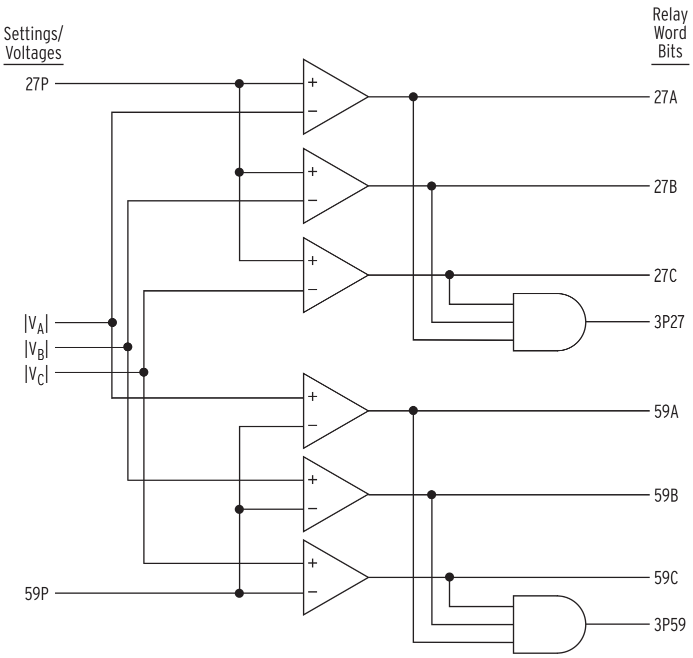


Figure 3.34 Single-Phase and Three-Phase Voltage Elements (Wye-Connected)

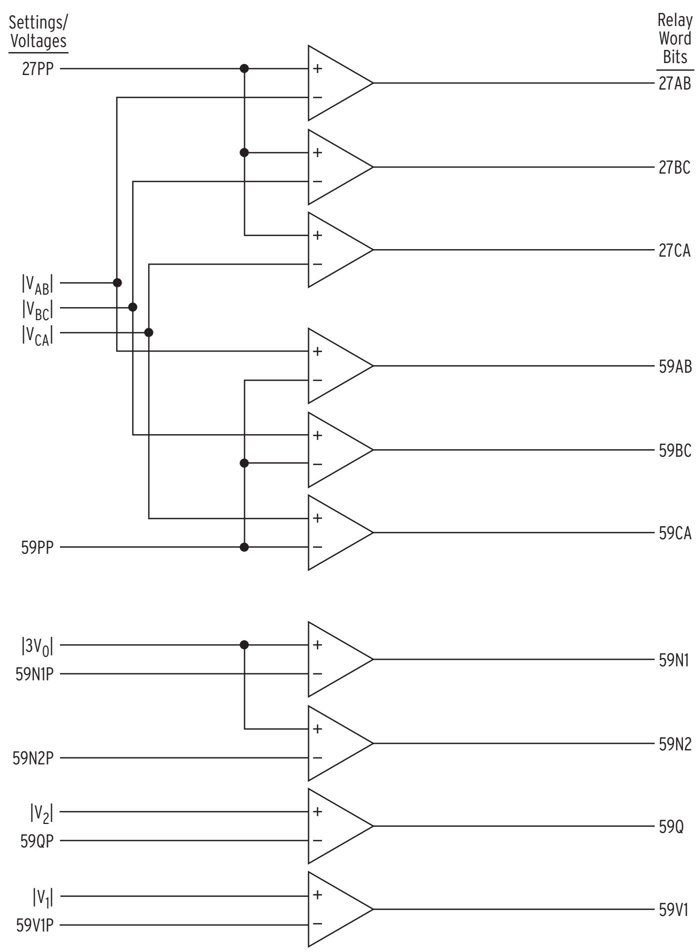


Figure 3.35 Phase-to-Phase and Sequence Voltage Elements (Wye-Connected PTs)

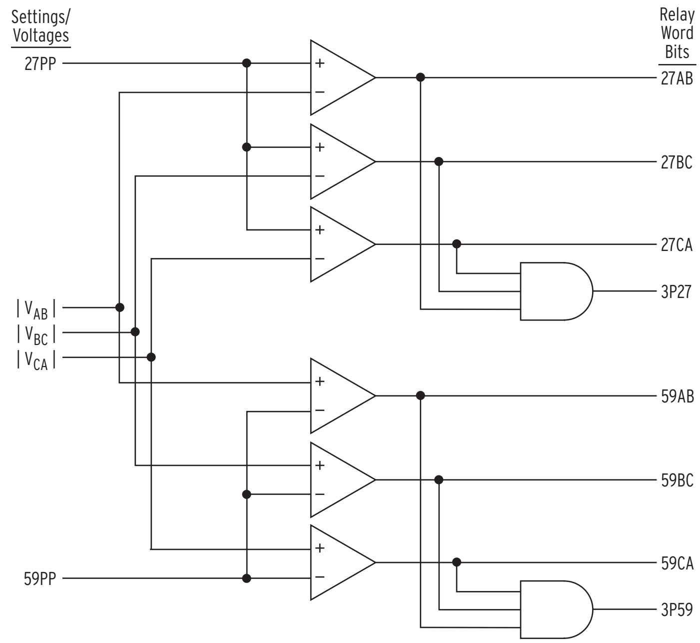


Figure 3.36 Phase-to-Phase Voltage Elements (Delta-Connected PTs)

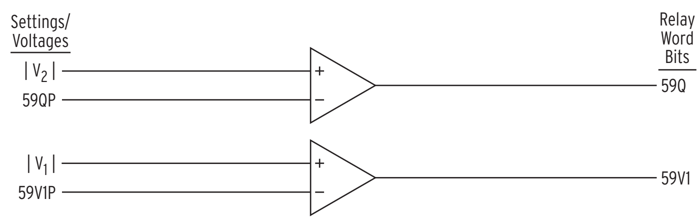


Figure 3.37 Sequence Voltage Elements (Delta-Connected PTs)

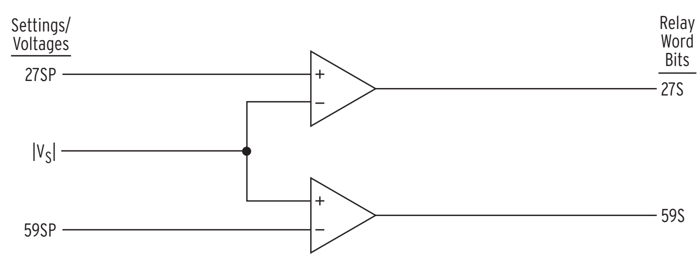


Figure 3.38 Channel VS Voltage Elements (Wye- or Delta-Connected PTs)

Voltage Element Operation

Note that the voltage elements in *Table 3.19* through *Table 3.21*, and *Figure 3.34* through *Figure 3.38* are a combination of "undervoltage" (Device 27) and "overvoltage" (Device 59) type elements. Undervoltage elements (Device 27) assert when the operating voltage goes *below* the corresponding pickup setting. Overvoltage elements (Device 59) assert when the operating voltage goes *above* the corresponding pickup setting.

Undervoltage Element Operation Example

Refer to *Figure 3.34* (top of the figure).

Pickup setting 27P is compared to the magnitudes of the individual phase voltages V_A, V_B, and V_C. The logic outputs in *Figure 3.34* are the following Relay Word bits.

27A	=	1 (logical 1), if V_A < pickup setting 27P
	=	0 (logical 0), if $V_A \geq$ pickup setting 27P
27B	=	1 (logical 1), if V_B < pickup setting 27P
	=	0 (logical 0), if $V_B \geq$ pickup setting 27P
27C	=	1 (logical 1), if V_C < pickup setting 27P
	=	0 (logical 0), if $V_C \geq$ pickup setting 27P
3P27	=	1 (logical 1), if all three Relay Word bits 27A, 27B, and 27C are asserted (27A = 1, 27B = 1, and 27C = 1)
	=	0 (logical 0), if at least one of the Relay Word bits 27A, 27B, or 27C is deasserted (e.g., 27A = 0)

Overvoltage Element Operation Example

Refer to *Figure 3.34* (bottom of the figure).

Pickup setting 59P is compared to the magnitudes of the individual phase voltages V_A, V_B, and V_C. The logic outputs in *Figure 3.34* are the following Relay Word bits:

59A	=	1 (logical 1), if V_A > pickup setting 59P
	=	0 (logical 0), if $V_A \leq$ pickup setting 59P
59B	=	1 (logical 1), if V_B > pickup setting 59P
	=	0 (logical 0), if $V_B \leq$ pickup setting 59P
59C	=	1 (logical 1), if V_C > pickup setting 59P
	=	0 (logical 0), if $V_C \leq$ pickup setting 59P
3P59	=	1 (logical 1), if all three Relay Word bits 59A, 59B, and 59C are asserted (59A = 1, 59B = 1, and 59C = 1)
	=	0 (logical 0), if at least one of the Relay Word bits 59A, 59B, or 59C is deasserted (e.g., 59A = 0)

Synchronism Check Elements

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

E25 = **Y**

NOTE: If Global setting VSCONN = 3V0, the synchronism check elements are unavailable, and E25 = N is the only possible setting. See Broken-Delta VS Connection (Global Setting VSCONN = 3V0) on page 2.12 for details.

Figure 2.13–*Figure 2.15* and *Figure 2.17* show examples where synchronism check can be applied. Synchronism check voltage input **VS** is connected to one side of the circuit breaker, on any desired phase. The other synchronizing phase (**VA**, **VB**, or **VC** voltage inputs) on the other side of the circuit breaker is setting selected.

The two synchronism check elements use the same voltage window (to assure healthy voltage) and slip frequency settings (see *Figure 3.39*). They have separate angle settings (see *Figure 3.40*). A ratio correction factor setting is available to allow the voltage window settings to be used on systems that have different secondary voltage levels on the **VS** terminal and the **VA**, **VB**, and **VC** terminals.

If the voltages are static (voltages not slipping with respect to one another) or setting TCLOSD = 0.00, the two synchronism check elements operate as shown in the top of *Figure 3.40*. The angle settings are checked for synchronism check closing.

If the voltages are not static (voltages slipping with respect to one another), the two synchronism check elements operate as shown in the bottom of *Figure 3.40*. The angle difference is compensated by breaker close time, and the breaker is ideally closed at a zero degree phase angle difference, to minimize system shock.

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

Synchronism Check Elements Settings

Table 3.22 Synchronism Check Elements Settings and Settings Ranges

Setting	Definition	Range
25VLO	low voltage threshold for "healthy voltage" window	0.00–300.00 V secondary
25VHI	high voltage threshold for "healthy voltage" window	0.00–300.00 V secondary
25RCF	voltage ratio correction factor	0.50–2.00, unitless
25SF	maximum slip frequency	0.005–0.500 Hz
25ANG1	synchronism check element 25A1 maximum angle	0°–80°
25ANG2	synchronism check element 25A2 maximum angle	0°–80°
SYNCP[a]	synchronizing phase or	VA, VB, or VC (wye-connected voltages) VAB, VBC, or VCA (delta-connected voltages)
	the number of degrees that synchronism check voltage V_S constantly lags voltage V_A (wye-connected) or V_{AB} (delta-connected voltages)	0°–330°, in 30° steps (any voltage connection)
TCLOSD	breaker close time for angle compensation	0.00–60.00 cycles, in 0.25 cycle steps
BSYNCH	SELOGIC control equation block synchronism check setting	Relay Word bits referenced in *Table D.1*

[a] Unlike some previous SEL-311 relays, SYNCP selections VAB, VBC, and VCA are not available when PTCONN = WYE; use an equivalent numeric setting instead.

NOTE: Setting TCLOSD = 0.00 is equivalent to TCLOSD = OFF in legacy SEL-311C relays.

Setting SYNCP

Wye-Connected Voltages

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

The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCP are referenced to V_A, and they indicate how many degrees V_S constantly lags V_A. In any synchronism check application, voltage input **VA-N** always has to be connected to determine system frequency on one side of the circuit breaker (to determine the slip between V_S and V_A). V_A always has to meet the "healthy voltage" criteria (settings 25VHI, 25VLO, and 25RCF—see *Figure 3.39*). Thus, for situations where V_S cannot be in phase with V_A, V_B, or V_C, it is most straightforward to have the angle setting choices (0, 30, …, 300, or 330 degrees) referenced to V_A.

Delta-Connected Voltages

The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNC are referenced to V_{AB}, and they indicate how many degrees V_S constantly lags

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

V_{AB}. In any synchronism check application, voltage input **VA-VB** always has to be connected to determine system frequency on one side of the circuit breaker (to determine the slip between V_S and V_{AB}). V_{AB} always has to meet the "healthy voltage" criteria (settings 25VHI, 25VLO, and 25RCF—see *Figure 3.39*). Thus, for situations where V_S cannot be in phase with V_{AB}, V_{BC}, or V_{CA}, it is most straightforward to have the angle setting choices (0, 30, …, 300, or 330 degrees) referenced to V_{AB}.

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

Sometimes synchronism check voltage V_S cannot be in phase with voltage V_A, V_B, or V_C (wye connected PTs); V_{AB}, V_{BC}, or V_{CA} (delta-connected PTs). This happens in applications where voltage input **VS** is connected:

➤ Phase-to-phase when using a wye-connected relay

➤ Phase-to-neutral when using a delta-connected relay

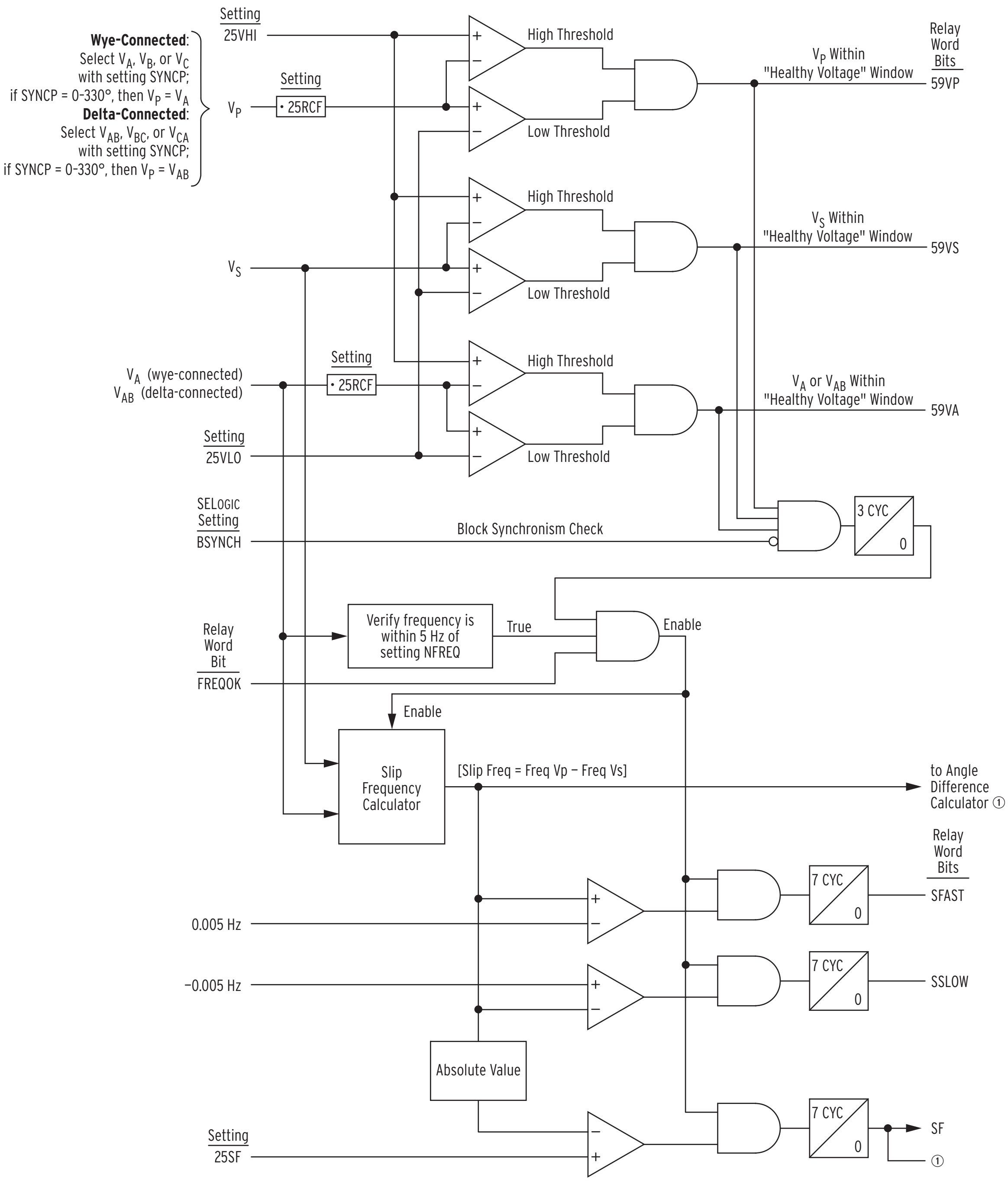
➤ Beyond a delta-wye transformer

For such applications, make a numerical angle selection with the SYNCP setting (see *Table 3.22* and *Setting SYNCP*).

Use the voltage ratio correction factor (setting 25RCF) to compensate magnitude of the phase voltage to match the synch voltage VS. See *Voltage Window and SYNCP Settings Example on page 3.59* for an example application.

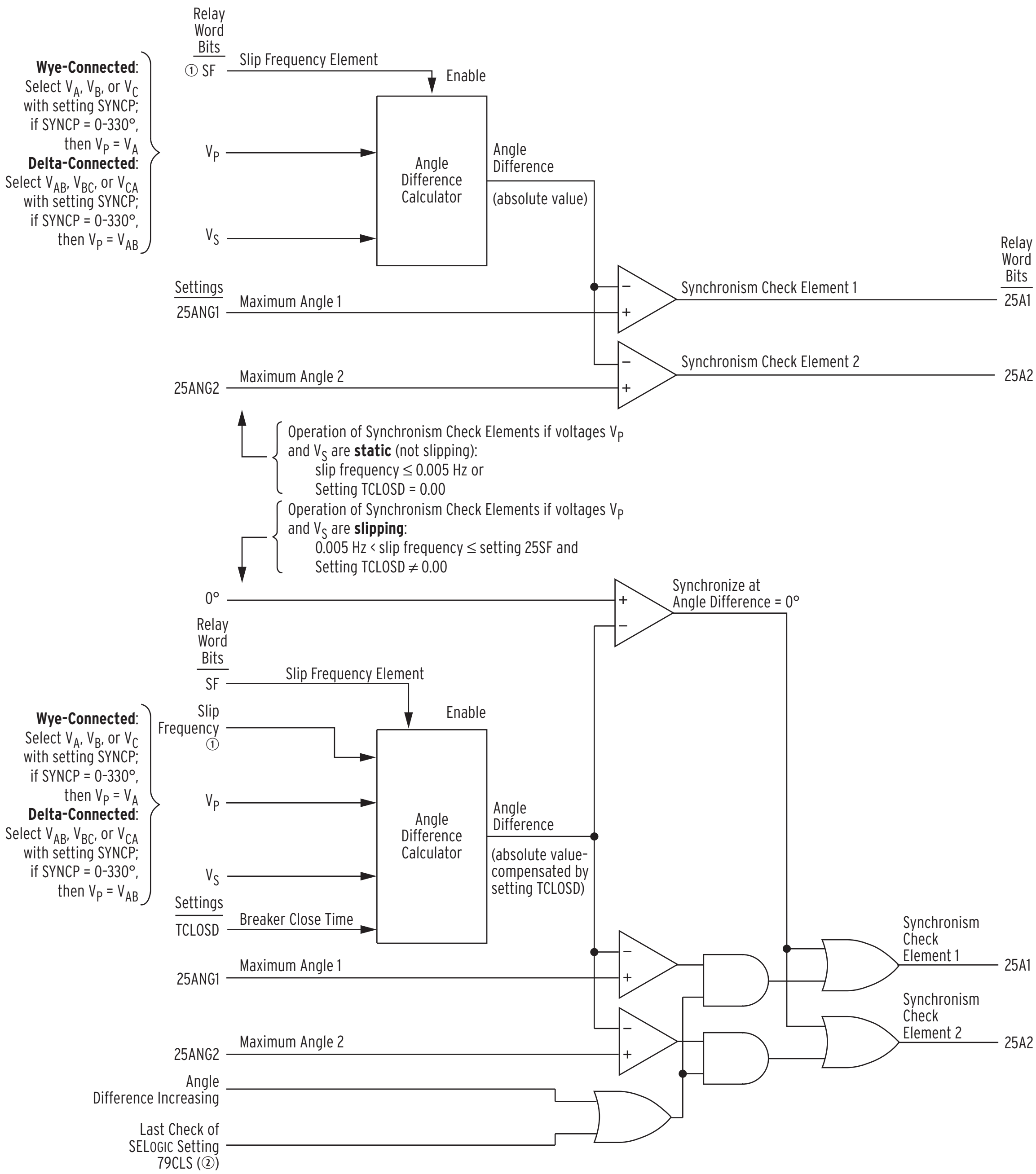
Synchronism Check Logic Diagrams

The Synchronism Check logic is shown in *Figure 3.39* and *Figure 3.40*. Make Group setting E25 = Y to access the settings and to enable this logic.



① To Figure 3.40.

Figure 3.39 Synchronism Check Voltage Window and Slip Frequency Elements



① From Figure 3.39; ② See Figure 6.3.

Figure 3.40 Synchronism Check Elements

Synchronism Check Elements Voltage Inputs

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

V_P Phase input voltage:

- V_A, V_B, or V_C for wye-connected voltages
- V_{AB}, V_{BC}, V_{CA} for delta-connected voltages

when designated by an alphabetic setting SYNCP (e.g., if SYNCP = VB, then V_P = VB),

or

- V_A for wye-connected voltages
- V_{AB} for delta-connected voltages

when designated by a numeric setting SYNCP (e.g., if SYNCP = 210 degrees, then $V_P = V_A$ when PTCONN = WYE; $V_P = V_{AB}$ when PTCONN = DELTA

VS Synchronism check voltage, from SEL-311C rear-panel voltage input **VS**

For example, if V_P is designated as phase input voltage V_B (setting SYNCP = VB) [or VBC (setting SYNCP = VBC) for delta], then rear-panel voltage input **VS-NS** is connected to B-phase (or BC phase-to-phase for delta) on the other side of the circuit breaker. The voltage across terminals **VB-N** (or **VB-VC** for delta) is synchronism checked with the voltage across terminals **VS-NS** (see *Figure 2.10*, *Figure 2.13*–*Figure 2.15*, and *Figure 2.17*).

System Frequencies Determined from Voltages V_A (or V_{AB} for Delta) and V_S

To determine slip frequency, the relay determines the system frequencies on both sides of the circuit breaker. Voltage V_S determines the frequency on one side. Voltage V_A (for wye-connected voltage inputs) or voltage V_{AB} (for delta-connected voltage inputs) determines the frequency on the other side. Thus, voltage terminals **VA-N**(or **VA-VB** for delta) have to be connected, even if another voltage (e.g., voltage V_B for wye or V_{BC} for delta) is to be synchronized with voltage V_S.

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

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

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

For delta-connected relays (synchronism check voltage input **VS-NS** connected to V_{BC}), make setting SYNCP = 120 (the number of degrees that synchronism check voltage V_S constantly lags voltage V_{AB}) and connect voltage inputs **VA-VB** to V_{AB}. Voltage input **VC** does not have to be connected.

System Rotation Can Affect Setting SYNCP

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

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

Synchronism Check Elements Operation

Refer to *Figure 3.39* and *Figure 3.40*.

Voltage Window and SYNCP Settings Example

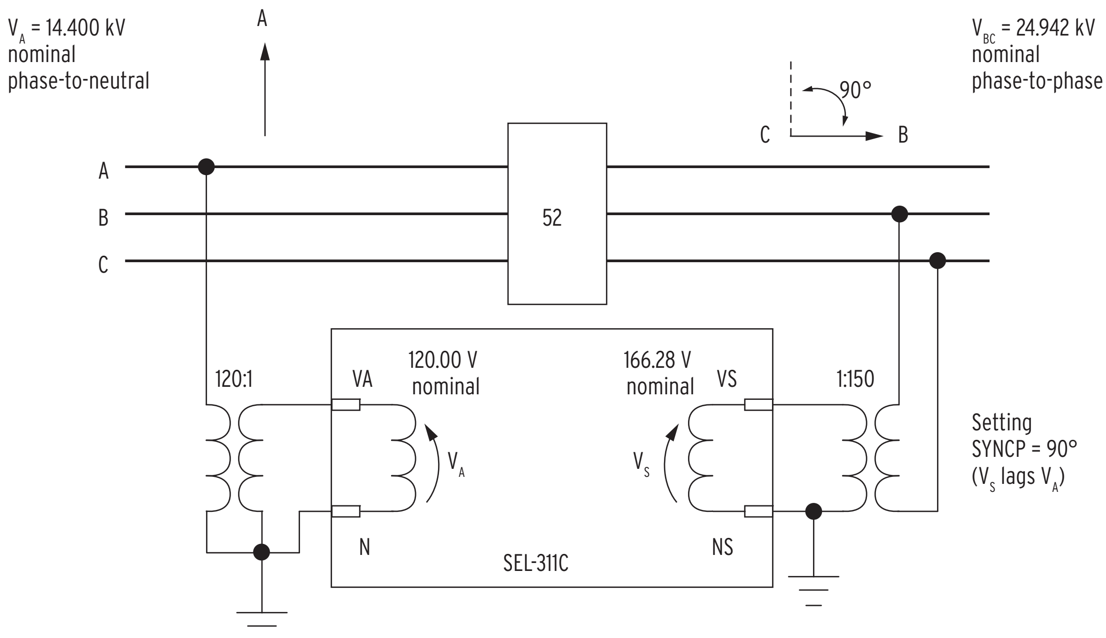


Figure 3.41 Example System with Synchronism Check Voltage Connected Phase-To-Phase

The example system in *Figure 3.41* illustrates two problems at one time:

- There are different voltage connections between VP (= VA) and VS.
- There are different PT ratios between VP (= VA) and VS.

The SEL-311C has settings to simplify the use of Synchronism Check elements on this example system.

Use SYNCP to Account for Voltage Angle Differences

In the *Figure 3.41* example, voltage input **VA-N** is connected phase-to-neutral on one side of the breaker, but synchronism-check voltage input **VS-NS** is connected phase-to-phase on the other side of the breaker. When the circuit breaker is closed (representing an ideal synchronism check condition) the resultant voltage VS constantly lags voltage VA by 90° for a system with ABC phase rotation. Thus, setting SYNCP is set:

SYNCP = 90

The SYNCP = 90 setting accounts for this constant 90° phase angle difference (voltage VS lags voltage VA) in checking synchronism between voltage VA and voltage VS.

The SYNCP setting can bet set in 30° increments, from 0° to 330°, to handle various connection combinations. For more examples, see *SEL Application Guide AG2002-02, Compensate for Constant Phase Angle Difference in Synchronism Check with the SEL-351 Relay Family*, available on the SEL website.

Use 25RCF to Account for Voltage Magnitude Differences

In the *Figure 3.41* example, the voltage sources have different nominal magnitudes. Part of the difference is from the connection type (phase-to-neutral versus phase-to-phase), and part of the difference is from the PT ratios (120:1 vs. 150:1).

To determine the required ratio correction, it is easiest to express the voltages in secondary units:

$$\text{VA-N nominal}_{\text{secondary}} = \frac{\text{VA-N}_{\text{primary}}}{\text{PT ratio}} = \frac{14.400\ \text{kV} \bullet 1000\ \text{V/kV}}{120/1} = 120.00\ \text{V sec}$$

$$\text{VS-NS nominal}_{\text{secondary}} = \frac{\text{VS-NS}_{\text{primary}}}{\text{PT ratio\_VS}} = \frac{24.942\ \text{kV} \bullet 1000}{150/1} = 166.28\ \text{V sec}$$

NOTE: In applications where SYNCP is set to VA, VB, VC (or VAB, VBC, VCA when PTCONN = DELTA) the selected signal is routed to V_P, and V_P is also scaled by the 25RCF setting.

The SEL-311C provides a ratio-correction factor setting, 25RCF, to scale the VA voltage to the VS voltage base. The synchronism check "healthy voltage" window settings may then be represented on the common scaling base.

The required ratio correction factor setting may be calculated from the nominal voltages:

$$25\text{RCF} = \frac{\text{VS nominal}}{\text{VA-N nominal}} = \frac{166.28}{120.00} = 1.386$$

Round the value to two decimals: **1.39**

The setting range for 25RCF is 0.50 to 2.00. If the calculated correction factor falls outside the 25RCF setting range, consider changing potential transformer taps or using auxiliary PTs to bring one or both of the voltage signals to a different base. Additionally, the expected input voltages must be kept within the relay voltage input ratings, as listed in *Specifications on page 1.2*.

For this example, the desired operation range for the Synchronism Check logic is the nominal voltage plus or minus 10%. The settings 25VHI and 25VLO must be entered for the VS-NS terminal voltage.

$$\begin{aligned} 25VHI &= V_S \text{ nominal} \bullet 110\% \\ &= 166.28 \text{ V nominal} \bullet 110\% \\ &= 182.91 \text{ V} \end{aligned}$$

$$\begin{aligned} 25VLO &= V_S \text{ nominal} \bullet 90\% \\ &= 166.28 \text{ V nominal} \bullet 90\% \\ &= 149.65 \text{ V} \end{aligned}$$

When V_S is between the 25VLO and 25VHI settings, the SEL-311C asserts Relay Word bit 59VS.

As shown in *Figure 3.42*, the VA signal is automatically scaled to be compared against the same 25VHI and 25VLO settings.

$$\begin{aligned} 25VHI \text{ equivalent for VA} &= \frac{25VHI}{25RCF} \\ &= \frac{182.91V}{1.39} \\ &= 131.59V \end{aligned}$$

$$\begin{aligned} 25VLO \text{ equivalent for VA} &= \frac{25VLO}{25RCF} \\ &= \frac{149.65V}{1.39} \\ &= 107.66V \end{aligned}$$

During operation, the ratio corrected VA signal will satisfy the 25VLO setting when VA > 107.66 V sec and will satisfy the 25VHI threshold when VA < 131.59 V sec. When VA is in this range, the SEL-311C will assert Relay Word bits 59VA and 59VP.

Outside the example case, when SYNCP = VB or VC {wye-connected} or VBC or VCA {delta-connected}, the selected signal (VP) is also scaled by 25RCF, and the relay operates the 59VP Relay Word bit with the same thresholds as 59VA. When SYNCP is set to VA (or VAB for delta) or a numeric setting 0–330 degrees (as in the *Figure 3.41* example), VA is scaled by 25RCF and is used for both the 59VA and 59VP logic.

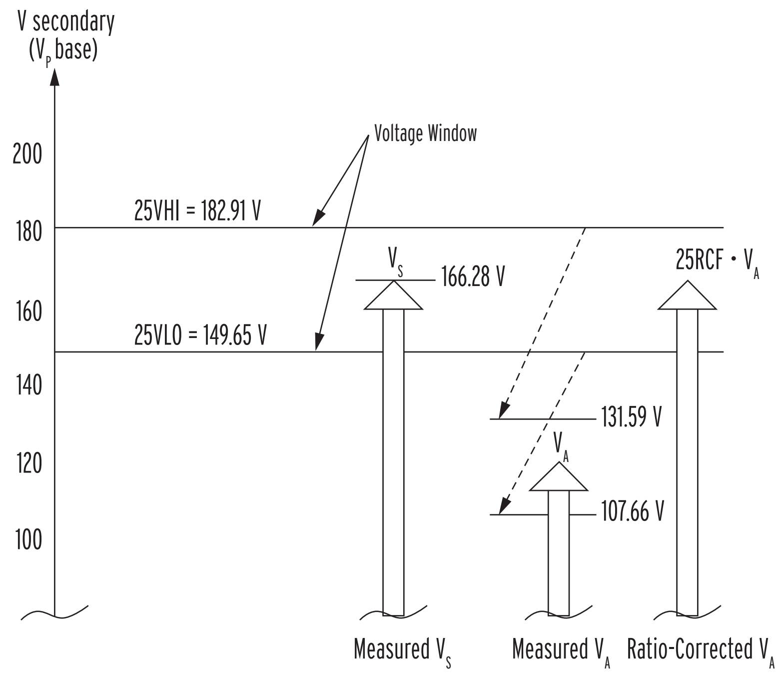


Figure 3.42 25RCF Settings Example Showing V_A Adjustment

The 25RCF setting only affects the synchronism check logic. The SEL-311C metering and protection functions do not use the corrected value for V_A (or V_{AB}).

Here are some other settings related to the example voltage connections.

PTR = 120.00

PTRS = 150.00

VNOM = 120.00

These settings are included here for completeness, and have no effect on the synchronism check logic.

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

59VP indicates that voltage V_P (ratio corrected) is within voltage window setting limits 25VLO and 25VHI

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

As discussed previously, voltage V_A (or V_{AB} for delta-connected voltage inputs) determines the frequency on the voltage V_P side of the circuit breaker. Voltage V_A (ratio corrected) is also run through voltage limits 25VLO and 25VHI to assure "healthy voltage" for frequency determination, with corresponding Relay Word bit output 59VA.

Other Uses for Voltage Window Elements

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

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

Block Synchronism Check Conditions

Refer to *Figure 3.39*.

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

BSYNCH = **52A** (see *Figure 6.2*)

In addition, synchronism check operation can be blocked when the relay is tripping.

BSYNCH = **... + TRIP**

Slip Frequency Calculator

Refer to *Figure 3.39*.

The synchronism check element Slip Frequency Calculator in *Figure 3.39* runs if voltages V_P, V_S, and V_A (or V_{AB} for delta) are healthy (59VP, 59VS, and 59VA asserted to logical 1) *and* the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). The Slip Frequency Calculator output is defined below.

Slip Frequency = $f_P – f_S$ (in units of Hz = slip cycles/second)

f_P = frequency of voltage V_P (in units of Hz = cycles/second) [determined from V_A (or V_{AB} for delta)]

f_S = frequency of voltage V_S (in units of Hz = cycles/second)

A complete slip cycle is one single 360-degree revolution of one voltage (e.g., V_S) by another voltage (e.g., V_P). Both voltages are thought of as revolving phasor-wise, so the “slipping” of V_S past V_P is the *relative* revolving of V_S past V_P.

For example, in *Figure 3.39*, if voltage V_P has a frequency of 59.95 Hz and voltage V_S has a frequency of 60.05 Hz, the difference between them is the slip frequency.

Slip Frequency = 59.95 Hz – 60.05 Hz = –0.10 Hz = –0.10 slip cycles/second

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

0.10 slip cycles/second • (360°/slip cycle) • 1 second = 36°

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

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

The SF Relay Word bit may not operate if the VP (= VA) frequency is changing too quickly. This will not be an issue when the synchronism check elements are being used to verify phase alignment across breakers in transmission systems with multiple paths. However, if one side of the circuit breaker is expected to vary in frequency (perhaps it is connected to an intertie line) the best configuration for using the synchronism check element is to connect the VA, VB, VC terminals (and thus VP) to the more stable system (e.g., the power grid), while the VS terminal (VS) is connected to the intertie with the smaller power system.

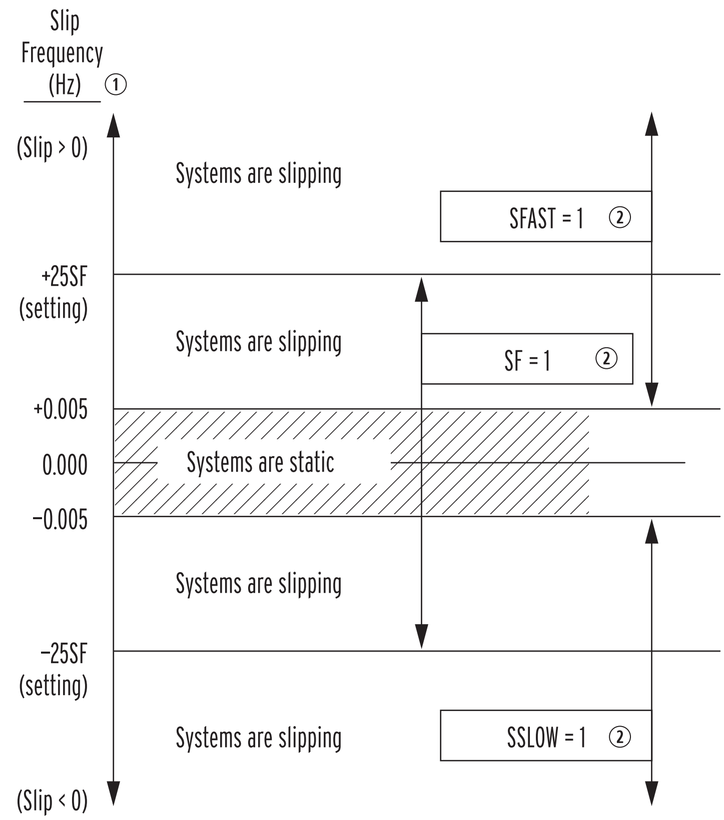
Generator Application for SSLOW and SFAST

Relay Word bits SSLOW and SFAST in *Figure 3.39* indicate the relative slip of voltages V_P (= V_A), and V_S.

The SFAST, SSLOW, and SF operation over various slip frequencies is summarized in *Table 3.23* and *Figure 3.43*.

Table 3.23 SSLOW and SFAST Relay Word Bit Operating Range

Slip Frequency Range	Relay Word Bit SSLOW	Relay Word Bit SFAST
$(f_P – f_S) < –0.005$ Hz	logical 1	logical 0
$–0.005 < (f_P – f_S) < 0.005$	logical 0	logical 0
$(f_P – f_S) > 0.005$ Hz	logical 0	logical 1



① Slip Frequency = Frequency of **VA-N** signal−Frequency of **VS-NS** signal ② From Figure 3.39.

Figure 3.43 Graphical Depiction of SFAST, SSLOW, and SF Operation Range

An application idea for SSLOW and SFAST is a small generator installation.

> With some logic (perhaps to create pulsing signals), SSLOW and SFAST might be used as signals (via output contacts) to the generator governor. SSLOW indicates that the V_P (=V_A) frequency is lower than the V_S frequency, while SFAST indicates that the V_P (=V_A) frequency is higher than the V_S frequency. If the enable into the slip frequency calculator in *Figure 3.39* is disabled (e.g., SELOGIC setting BSYNCH asserts because the breaker closes; BSYNCH = 52A + …), then both SSLOW = logical 0 and SFAST = logical 0, regardless of slip frequency.

The SEL-311C SSLOW and SFAST outputs are available over a larger slip frequency range than the synchronism check element, and are independent of the SF Relay Word bit. If the slip frequency is greater than the 25SF setting, Relay Word bit SF will be deasserted (logical 0), and one of the SSLOW or SFAST Relay Word bits may operate to indicate the polarity of the slip frequency.

The SSLOW and SFAST Relay Word bits may not operate reliably if the V_P (= V_A) frequency is changing too quickly. The best configuration for using the SSLOW and SFAST outputs is when the VA, VB, VC terminals (and thus V_P) are connected to the most stable system (e.g., the power grid), while the VS terminal (V_S) is connected to the “machine” side of the circuit breaker.

Angle Difference Calculator

The synchronism check element Angle Difference Calculator in *Figure 3.40* runs if the slip frequency is less than the maximum slip frequency setting 25SF (Relay Word bit SF is asserted).

Voltages V_P and V_S Are "Static"

Refer to top of *Figure 3.40*.

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

$$\text{Angle Difference} = |(\angle V_P - \angle V_S)|$$

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

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

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

Voltages V_P and V_S Are "Slipping"

Refer to bottom of *Figure 3.40*.

If the slip frequency is greater than 0.005 Hz and breaker close time setting TCLOSD ≠ 0.00, the Angle Difference Calculator takes the breaker close time into account with breaker close time setting TCLOSD (set in cycles; see *Figure 3.44*). The Angle Difference Calculator calculates the Angle Difference between voltages V_P and V_S, compensated with the breaker close time.

$$\text{Angle Difference} = |(\angle V_P - \angle V_S) + [(f_P - f_S) \bullet \text{TCLOSD} \bullet (1/\text{NFREQ}) \bullet (360°/\text{slip cycle})]|$$

NFREQ is the Global setting that defines the nominal system frequency as 50 or 60 Hz.

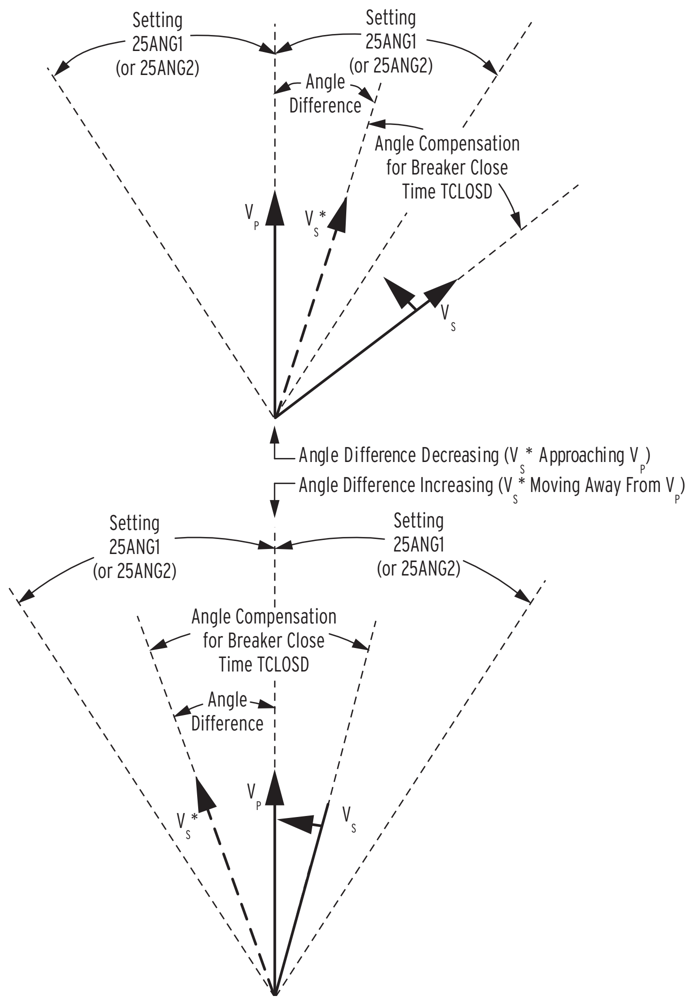


Figure 3.44 Angle Difference Between V_P and V_S Compensated by Breaker Close Time ($f_P < f_S$ and V_P shown as reference in this example)

Angle Difference Example (Voltages V_P and V_S Are "Slipping")

Refer to bottom of *Figure 3.40*.

For example, for a 60 Hz nominal system, if the breaker close time is 10 cycles, set TCLOSD = 10 and NFREQ = 60. Presume the slip frequency is the example slip frequency calculated previously. The Angle Difference Calculator calculates the angle difference between voltages V_P and V_S, compensated with the breaker close time.

Angle Difference = $|(\angle V_P - \angle V_S) + [(f_P - f_S) \cdot \text{TCLOSD} \cdot (1 \text{ second}/60 \text{ cycles}) \cdot (360°/\text{slip cycle})]|$

Intermediate calculations.

$(f_P - f_S)$ = (59.95 Hz – 60.05 Hz) = –0.10 Hz = –0.10 slip cycles/second
TCLOSD • (1 second/60 cycles) = 10 cycles • (1 second/60 cycles) = 0.167 second

Resulting in:

Angle Difference

$= |(\angle V_P - \angle V_S) + [(f_P - f_S) \cdot TCLOSD \cdot (1\ second/60\ cycles) \cdot (360°/slip\ cycle)]|$

$= |(\angle V_P - \angle V_S) + [-0.10 \cdot 0.167 \cdot 360°]|$
$= |(\angle V_P - \angle V_S) - 6°|$

NOTE: The angle compensation in Figure 3.44 appears much greater than 6 degrees. Figure 3.44 is for general illustrative purposes only.

During the breaker close time (TCLOSD), the voltage angle difference between voltages V_P and V_S changes by 6 degrees. This 6 degree angle compensation is applied to voltage V_S, resulting in derived voltage V_S*, as shown in *Figure 3.44*.

The top of *Figure 3.44* shows the Angle Difference *decreasing*—V_S* is approaching V_P. Ideally, circuit breaker closing is initiated when V_S* is in phase with V_P (Angle Difference = 0 degrees). Then when the circuit breaker main contacts finally close, V_S is in phase with V_P, minimizing system shock.

The bottom of *Figure 3.44* shows the Angle Difference *increasing*—V_S* is moving away from V_P. Ideally, circuit breaker closing is initiated when V_S* is in phase with V_P (Angle Difference = 0 degrees). Then when the circuit breaker main contacts finally close, V_S is in phase with V_P. But in this case, V_S* has already moved past V_P. In order to initiate circuit breaker closing when V_S* is in phase with V_P (Angle Difference = 0 degrees), V_S* has to slip around another revolution, relative to V_P.

Synchronism Check Element Outputs

Synchronism check element outputs (Relay Word bits 25A1 and 25A2 in *Figure 3.40*) assert to logical 1 for the conditions explained in the following text.

Voltages V_P and V_S Are "Static" or Setting TCLOSD = 0.00

Refer to the top of *Figure 3.40*.

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

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

Voltages V_P and V_S Are "Slipping" and Setting TCLOSD ≠ 0.00

Refer to bottom of *Figure 3.40*. If V_P and V_S are "slipping" with respect to one another and breaker close time setting TCLOSD ≠ 0.00, the Angle Difference (compensated by breaker close time TCLOSD) changes through time. Synchronism check element 25A1 or 25A2 asserts to logical 1 for any one of the following three scenarios.

1. The top of *Figure 3.44* shows the Angle Difference *decreasing*—V_S* is approaching V_P. When V_S* is in phase with V_P (Angle Difference = 0 degrees), synchronism check elements 25A1 and 25A2 assert to logical 1.

2. The bottom of *Figure 3.44* shows the Angle Difference *increasing*—V_S* is moving away from V_P. V_S* was in phase with V_P (Angle Difference = 0 degrees), but has now moved past V_P. If the Angle Difference is *increasing*, but the Angle Difference is still less than maximum angle settings 25ANG1 or 25ANG2, then corresponding synchronism check elements 25A1 or 25A2 assert to logical 1.

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

3. Refer to *Reclose Supervision Logic on page 6.5*.

   Refer to the bottom of *Figure 6.4*. If timer 79CLSD is set greater than zero (e.g., 79CLSD = 60.00 cycles) and it times out without SELOGIC control equation setting 79CLS (Reclose Supervision) asserting to logical 1, the relay goes to the Lockout State (see top of *Figure 6.5*).

   Refer to the top of *Figure 6.4*. If timer 79CLSD is set to zero (79CLSD = 0.00), SELOGIC control equation setting 79CLS (Reclose Supervision) is checked only once to see if it is asserted to logical 1. If it is not asserted to logical 1, the relay goes to the Lockout State.

   Refer to the top of *Figure 3.44*. Ideally, circuit breaker closing is initiated when V_S* is in phase with V_P (Angle Difference = 0 degrees). Then when the circuit breaker main contacts finally close, V_S is in phase with V_P, minimizing system shock. But with time limitations imposed by timer 79CLSD, this may not be possible. To try to avoid going to the Lockout State, the following logic is employed:

   > If 79CLS has not asserted to logical 1 while timer 79CLSD is timing (or timer 79CLSD is set to zero and only one check of 79CLS is made), the synchronism check logic at the bottom of *Figure 3.40* becomes *less restrictive* at the “instant” timer 79CLSD is going to time out (or make the single check). It drops the requirement of waiting until the *decreasing* Angle Difference (V_S* approaching V_P) brings V_S* in phase with V_P (Angle Difference = 0 degrees). Instead, it just checks to see that the Angle Difference is less than angle settings 25ANG1 or 25ANG2.
   >
   > If the Angle Difference is less than angle setting 25ANG1 or 25ANG2, then the corresponding Relay Word bit, 25A1 or 25A2, asserts to logical 1 for that “instant” (asserts for 1/4 cycle).

For example, if SELOGIC control equation setting 79CLS (Reclose Supervision) is set as follows:

79CLS = **25A1 + ...**

and the angle difference is less than angle setting 25ANG1 at that "instant," setting 79CLS asserts to logical 1 for 1/4 cycle, allowing the sealed-in open interval time-out to propagate on to the close logic in *Figure 6.3*. Element 25A2 operates similarly.

Synchronism Check Applications for Automatic Reclosing and Manual Closing

Refer to *Close Logic on page 6.2* and *Reclose Supervision Logic on page 6.5*.

For example, set 25ANG1 = 15 degrees and use the resultant synchronism check element in the reclosing relay logic to supervise automatic reclosing.

79CLS = **25A1 + ...** (see *Figure 6.4*)

Set 25ANG2 = 25° and use the resultant synchronism check element in manual close logic to supervise manual closing (for example, assert IN106 or issue the **CLO** command to initiate manual close) as shown below.

SV1 = **(/IN106 + CC) * !TRIP + SV1 * !SV1T * !TRIP * !CLOSE**

CL = **(SV1 * 25A2 + ...)** (see *Figure 6.4*)

Set SV1PU = N cycles, and SV1DO = 0.00 cycles. Choose N to represent the maximum period that a manual close may be attempted. A typical setting for N might be 50 to 600 cycles (approximately 1 to 10 seconds).

The timer effectively stretches the one processing interval CC pulse (asserted by the **CLOSE** command, or via DNP, Modbus, or SEL Fast Operate protocols—see *Section 10*) to improve the chances of closing if the synch check element is not asserted at the instant the command is received. Other possible inputs to initiate manual closing include using a local bit (/LB*n*) or remote bit (/RB*n*), or programmable operator control bit (PB*n*PUL), when available.

The rising edge operator "/" on IN106 prevents a maintained assertion to logical 1 from creating a standing close condition. The !TRIP terms defeat the manual close window if a relay trip is detected. The !CLOSE term cancels the timing once the close logic is activated. Other conditions could be added to defeat the manual close.

In this example, the angular difference across the circuit breaker can be greater for a manual close (25 degrees) than for an automatic reclose (15 degrees).

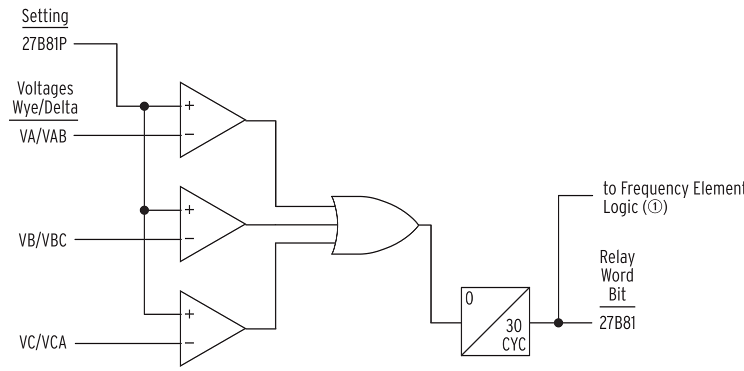
A single output contact (e.g., OUT102 = CLOSE) can provide the close function for both automatic reclosing and manual closing (see *Figure 6.3* logic output).

Frequency Elements

Six frequency elements are available. The desired number of frequency elements are enabled with the E81 enable setting as shown in *Figure 3.46*.

E81 = **N** (none), 1 through 6

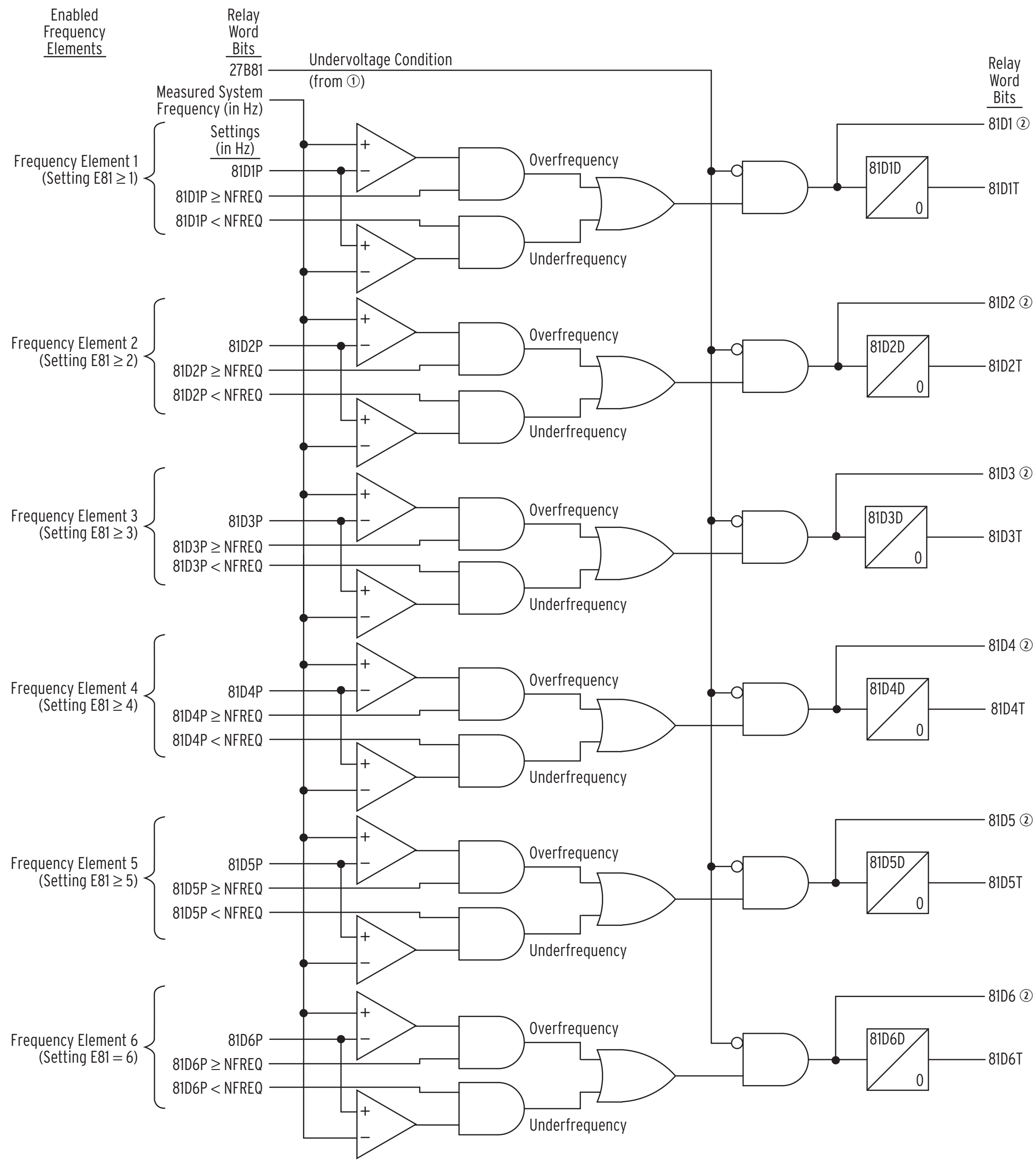
Frequency is determined from the voltage connected to voltage terminals **VA-N**.



① Figure 3.46.

Figure 3.45 Undervoltage Block for Frequency Elements

Frequency element accuracy information is listed in *Specifications on page 1.2*.



① From Figure 3.45; ② 81D1–81D6 are for testing purposes only.

Figure 3.46 Levels 1 Through 6 Frequency Elements

Table 3.24 Frequency Elements Settings and Settings Ranges (Sheet 1 of 2)

Setting	Definition	Range
27B81P	undervoltage frequency element block (responds to V_{LN} when Global setting PTCONN = WYE, responds to V_{LL} when Global setting PTCONN = DELTA)	20.00–300.00 V secondary
81D1P	frequency element 1 pickup	40.10–65.00 Hz
81D1D[a]	frequency element 1 time delay	2.00–16000.00 cycles, in 0.25-cycle steps
81D2P	frequency element 2 pickup	40.10–65 .00 Hz
81D2D[a]	frequency element 2 time delay	2.00–16000.00 cycles, in 0.25-cycle steps

Table 3.24 Frequency Elements Settings and Settings Ranges (Sheet 2 of 2)

Setting	Definition	Range
81D3P	frequency element 3 pickup	40.10–65.00 Hz
81D3D[a]	frequency element 3 time delay	2.00–16000.00 cycles, in 0.25-cycle steps
81D4P	frequency element 4 pickup	40.10–65.00 Hz
81D4D[a]	frequency element 4 time delay	2.00–16000.00 cycles, in 0.25-cycle steps
81D5P	frequency element 5 pickup	40.10–65.00 Hz
81D5D[a]	frequency element 5 time delay	2.00–16000.00 cycles, in 0.25-cycle steps
81D6P	frequency element 6 pickup	40.10–65.00 Hz
81D6D[a]	frequency element 6 time delay	2.00–16000.00 cycles, in 0.25-cycle steps

[a] Frequency is determined by a zero-crossing technique on voltage V_A. If voltage waveform offset occurs (e.g., because of a fault), then the frequency measurement can be disturbed for a few cycles. A 4-cycle or greater time delay (e.g., 81D1D = 5.00 cycles) overrides this occurrence. As with any protection, more sensitive settings (e.g., 81DnP set close to nominal frequency) may require more delay.

Create Over- and Underfrequency Elements

Refer to *Figure 3.46*.

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

Overfrequency Element

For example, make settings:

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

E81 ≥ **1** (enable frequency element 1)

81D1P = **61.25 Hz** (frequency element 1 pickup)

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

Underfrequency Element

For example, make settings:

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

E81 ≥ **2** (enable frequency element 2)

81D2P = **59.65 Hz** (frequency element 2 pickup)

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

Frequency Element Operation

Overfrequency Element Operation

NOTE: Refer to Figure 3.46.

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

81D1 = logical 0 (instantaneous element)
81D1T = logical 0 (time delayed element)

If system frequency is *greater than* 61.25 Hz (81D1P = 61.25 Hz), frequency element 1 outputs are as shown below.

81D1 = logical 1 (instantaneous element)
81D1T = logical 1 (time delayed element)

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

Underfrequency Element Operation

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

81D2 = logical 1 (instantaneous element)
81D2T = logical 1 (time delayed element)

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

If system frequency is *greater than* 59.65 Hz (81D2P = 59.65 Hz), frequency element 2 outputs are as shown below.

81D2 = logical 0 (instantaneous element)
81D2T = logical 0 (time delayed element)

Frequency Element Time Delay Considerations

The SEL-311C frequency element time delay settings are specified in cycles, as shown in *Table 3.24*. When determining the time delay settings appropriate for an application, keep in mind that the power system frequency will not be at the nominal value (50 Hz or 60 Hz) when an overfrequency or underfrequency element times-out. The relay adjusts the processing algorithms to track the system frequency, and this can make the time delay seem shorter or longer than anticipated.

For pickup settings that are close to the nominal frequency, or with short duration delays, the nominal frequency may be used to convert the desired time delay from seconds into cycles with negligible error.

However, for elements that have pickup settings (81D*n*P) set further from the nominal frequency, or elements set with long time delays (81D*n*D), the over- or underfrequency pickup setting may be used for the time-base conversion instead.

The observed time delay will depend on the frequency of the power system or test set during the excursion, and whether the frequency change is applied as step-change, a ramp, or some other function.

Overfrequency Element Settings Example

On a 60 Hz nominal system, the planner requires an overfrequency trip to occur if the frequency exceeds 60.60 Hz for 30 seconds.

Convert the time delay from seconds to cycles using the pickup setting.

$$\begin{aligned}\text{Delay} &= 30\text{ s} \cdot 60.60\text{ Hz}\\ &= 30\text{ s} \cdot 60.60\text{ cycles/s}\\ &= 1818\text{ cycles}\end{aligned}$$

Required settings.

81D1P = **60.60 Hz**

81D1D = **1818.00 cycles**

Using the example settings, if a 60.80 Hz signal is applied for testing, the SEL-311C would be expected to assert 81D1T approximately

1818 cycles / 60.80 cycles/s = 29.90 s

after the instantaneous element (81D1) pickup.

If the nominal frequency 60 Hz conversion factor has been used instead, the time delay setting would have been 1800 cycles, and the same 60.80 Hz test signal would be expected to assert 81D1T approximately 1800 cycles / 60.80 cycles/s = 29.61 s after the instantaneous element (81D1) pickup.

In this test example, the time delay settings adjustment improves the timing accuracy by about 1 percent.

Frequency Element Voltage Control

Refer to *Figure 3.45* and *Figure 3.46*.

Note that all six frequency elements are controlled by the same undervoltage element (Relay Word bit 27B81). For example, when Global setting PTCONN = WYE, Relay Word bit 27B81 asserts to logical 1 and blocks the frequency element operation if any voltage (V_A, V_B, or V_C) goes below voltage pickup 27B81P. This control prevents erroneous frequency element operation following fault inception.

The SEL-311C frequency measurement algorithm contains logic that monitors line-side PT voltage signals for signs of frequency decay, such as line ring-down after a breaker operation. In applications with bus-bar potential transformers, the voltage signals are available even when the circuit breaker is open. Set Loss-of-Potential logic setting EBBPT = Y to ensure proper frequency element operation during open pole conditions.

Other Uses for Undervoltage Element 27B81

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

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

Frequency Element Uses

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

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

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Section 4

Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic

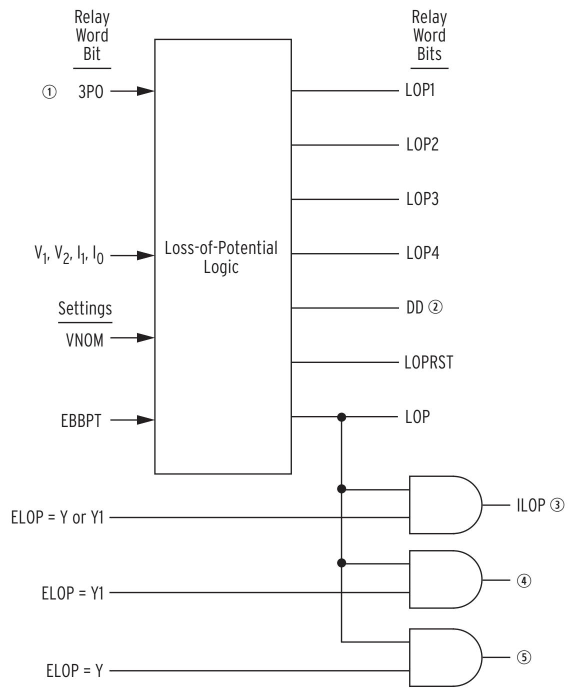
Overview

This section gives a detailed description of the operation and settings for the loss-of-potential logic, load encroachment logic, and directional control logic for overcurrent elements.

The following functions are discussed in this section:

Loss-of-Potential Logic

The loss-of-potential (LOP) logic in the SEL-311C relay is used to detect blown potential transformer fuses. The loss-of-potential Relay Word bits (LOP and ILOP) can be used to disable distance elements, directional elements and other logic that is affected by voltage elements or polarizing voltage. *Figure 4.1* shows how the logic outputs are routed to the other areas of the relay.



① From Figure 5.3; ② to Figure 5.1; ③ to Figure 3.4– Figure 3.10, Figure 4.13, Figure 4.14, and Figure 4.21; ④ to Figure 5.6; ⑤ to Figure 4.18 and Figure 4.20.

Figure 4.1 Loss-of-Potential Logic Signal Routing

Inputs into the LOP logic are described in *Table 4.1*.

Table 4.1 LOP Logic Inputs

Inputs	Description
3PO	Three-pole open condition (indicates circuit breaker open condition see *Figure 5.3*)
V_1	Positive-sequence voltage (V secondary)
I_1	Positive-sequence current (A secondary)
I_0	Zero-sequence current (A secondary)
V_2	Negative-sequence voltage (V secondary)
VNOM	PT nominal voltage setting (line-to-neutral, [wye-connected PTs] or line-to-line [delta connected PTs], secondary)
ELOP	Loss-of-potential enable setting
EBBPT	Enable bus-bar PT setting

Figure 4.2 shows the full LOP logic diagram, and *Table 4.2* lists the output Relay Word bits.

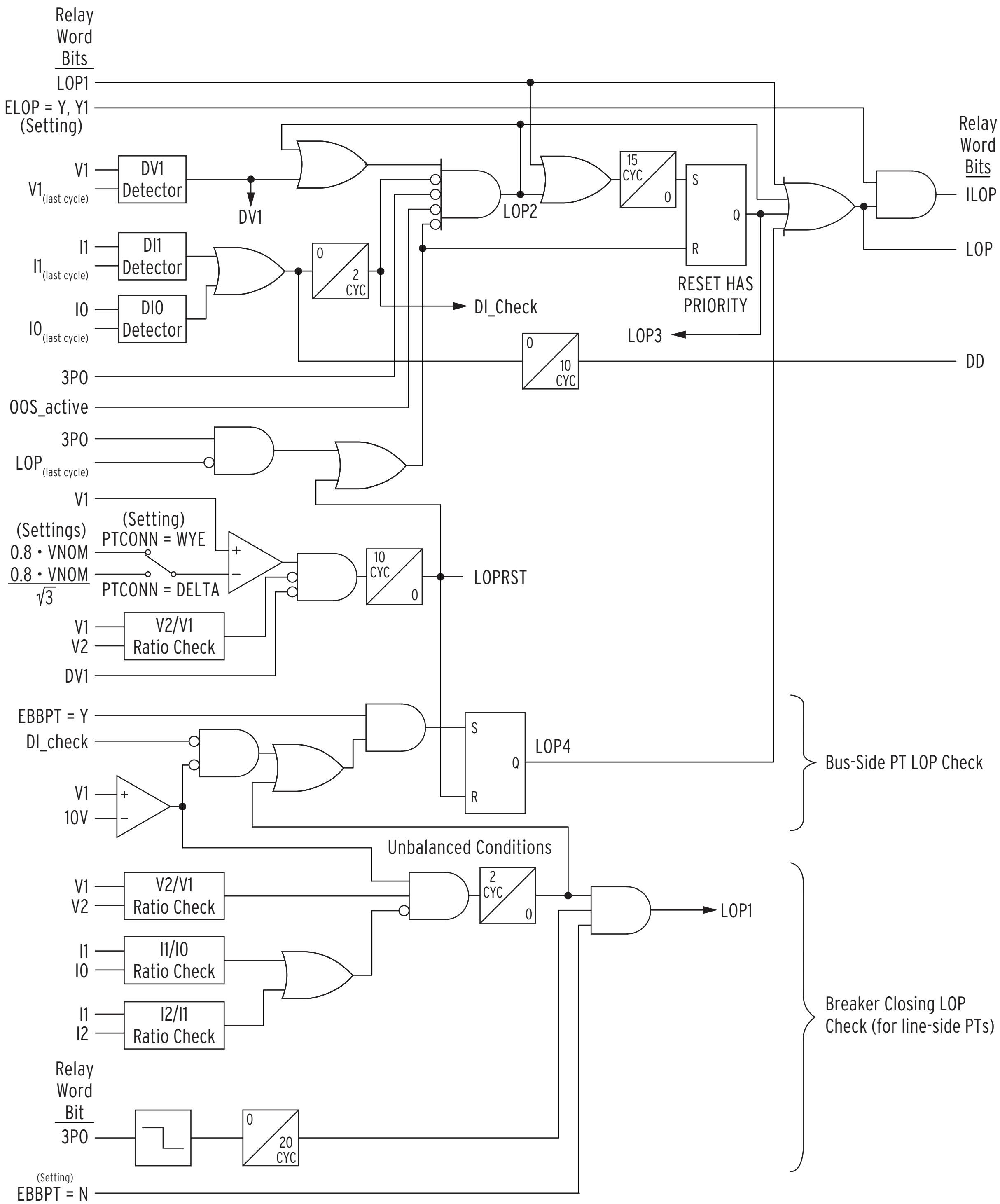


Figure 4.2 Overall LOP Logic Diagram

LOP asserts immediately when LOP1, LOP2, or LOP4 assert. LOP latches if LOP1 or LOP2 stay asserted for 15 cycles (indicated by LOP3). LOP deasserts (or is prevented from asserting) if voltages are healthy for 10 cycles (indicated by LOPRST).

Table 4.2 Loss-of-Potential Logic Outputs

Relay Word bit	Full Name	Description
LOP	Loss-of-potential	Loss-of-potential status. This output is always available, regardless of ELOP setting.
ILOP	Internal loss-of-potential	Disables distance elements and certain directional elements when asserted. Requires setting ELOP = Y or Y1.
LOP1	Loss-of-potential point 1	Breaker closing LOP logic asserted. Only available when setting EBBPT = N.
LOP2	Loss-of-potential point 2	Drop in voltage without change in current LOP logic asserted
LOP3	Loss-of-potential point 3	LOP latched
LOP4	Loss-of-potential point 4	Busbar PT LOP logic asserted. Only available when setting EBBPT = Y.
DD	Disturbance Detector	Change in current detected during last 10 cycle period. Used for enhancing protection security through TRQUAL setting and EDDSOTF setting. See Trip Logic on page 5.xx.
LOPRST	LOP Reset	LOP Reset condition based on detection of healthy voltages

NOTE: The term "voltage transformer" (VT) may be used in place of "potential transformer" (PT).

In order to better understand the logic, the following subsections describe the purpose of each part of the logic.

Relay Word Bit LOP1: Breaker Closing LOP Logic

Refer to the bottom of *Figure 4.2* and *Figure 4.3*.

Line Side PTs

If the system uses line side PTs, as shown in the example in *Figure 2.15* , set EBBPT = N (the default setting), which enables the LOP1 logic.

The breaker closing logic is armed for 20 cycles after detecting the breaker closing (\3PO). During this time, if the loss of a voltage signal is detected, and no fault is detected, LOP asserts.

In normal situations with no fault and no problems with the potential transformers, when the breaker closes, balanced voltages and balanced currents are expected to appear, and LOP1 stays deasserted for the entire 20-cycle window.

If instead the breaker closes with one phase of the PT circuit out of service, the V2/V1 check and the V1 > 10 V check will both assert, and neither of the imbalanced current checks I0/I1 nor I2/I1 will assert. After a two cycle qualification time, LOP1 will assert.

The current checks prevent LOP1 from asserting during imbalanced current conditions and low current conditions.

This breaker closing logic was not designed to detect situations where all potential transformers are out of service, when the positive-sequence voltage is less than 10 V secondary. See *Switch-Onto-Fault (SOTF) Trip Logic on page 5.8* for methods of covering this case.

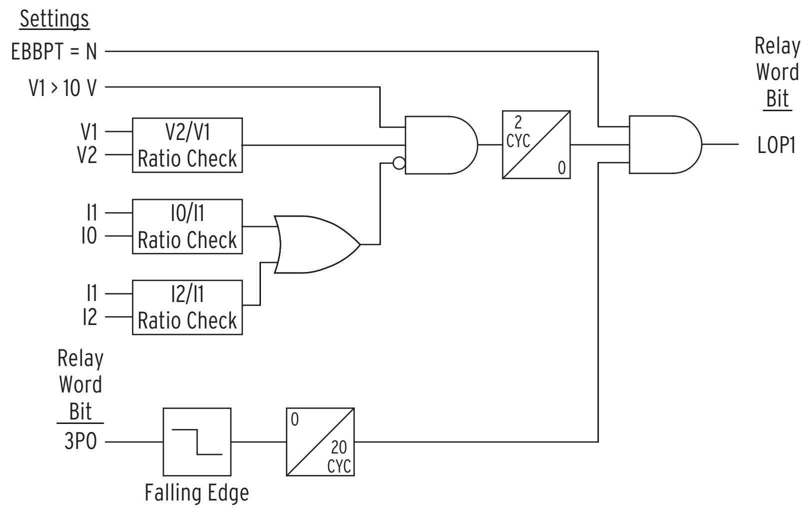


Figure 4.3 Breaker Closing LOP Logic (Relay Word Bit LOP1)

Bus Side PTs

If bus-side (bus-bar) PTs are being used, as shown in *Figure 2.13*, *Figure 2.14*, *Figure 2.16*, and *Figure 2.17* for example, potential signals are not related to the circuit breaker or line status. In these systems, set EBBPT = Y to disable the LOP1 logic. This setting also affects the SEL-311C frequency measurement subsystem, and can indirectly affect frequency elements (81D*n*T) and the synchronism check elements (25A*n*).

Setting EBBPT = Y enables the LOP4 logic, which is described below.

Relay Word Bit LOP2: Drop in Voltage With No Change in Current

Refer to the top of *Figure 4.2*.

The main LOP logic (LOP2) is based upon measuring a decrease in the magnitude of positive-sequence voltage without a simultaneous change (magnitude or angle) in either the positive-sequence or the zero sequence currents. *Figure 4.4* shows a processing flow chart of the logic.

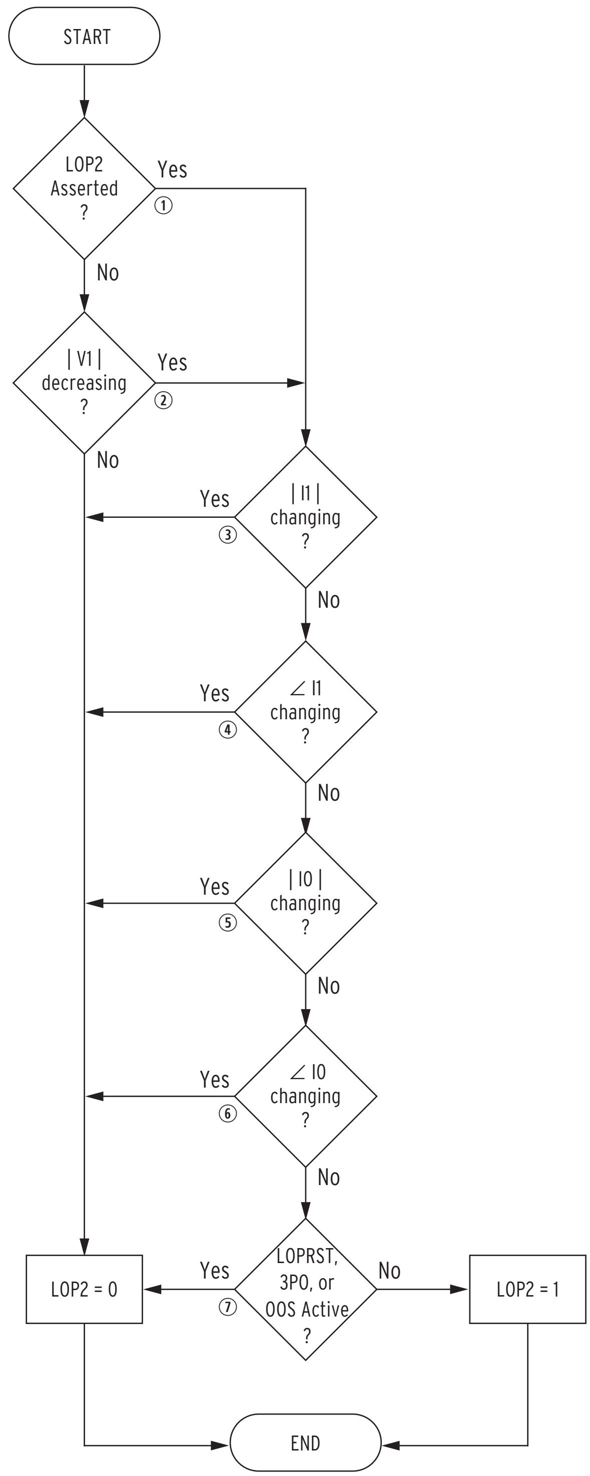


Figure 4.4 LOP2 Logic Processing Overview (Relay Word Bit LOP2)

The following text gives additional description of the steps in *Figure 4.4*:

Step 1. Is LOP2 asserted?

NO. Go to *Step 2*.

YES. Keep LOP2 asserted until one of *Step 3*–*Step 7* have a true result. This "seal-in" function memorizes the change in positive-sequence in voltage.

Step 2. Magnitude of positive-sequence voltage is decreasing.

Measure positive-sequence voltage magnitude (called $|V_{1(k)}|$, where k represents the present processing interval result) and compare it to $|V_1|$ from one power system cycle earlier (called $|V_{1(k–1\ cycle)}|$).

If $|V_{1(k)}| \bullet 0.9 \bullet |V_{1(k\ -\ 1\ cycle)}|$, then assert LOP2 if all of the conditions in the next steps (*Step 3*–*Step 7*) are satisfied.

Otherwise, jump to the end (LOP2 remains deasserted).

Step 3. Positive-sequence current magnitude not changing, and has not changed in the last two cycles.

Measure positive-sequence current magnitude ($|I_{1(k)}|$) and compare it to $|I_{1(k\ -\ 1\ cycle)}|$ from one cycle earlier. If this difference is greater than 10% of nominal current, deassert LOP2.

Otherwise, continue with *Step 4*.

This condition is memorized for two cycles.

Step 4. Positive-sequence current angle is not changing, and has not changed in the last two cycles.

Measure positive-sequence current angle ($\angle I_{1k}$) and compare it to $\angle I_{1(k–1\ cycle)}$ from one cycle earlier. If this difference is greater than 5°, deassert LOP2.

Otherwise, continue with *Step 5*.

This condition is memorized for two cycles. If $|I1| < 0.05 \bullet I_{NOM}$, this angle check does not block LOP2.

Step 5. Zero-sequence current magnitude is not changing, and has not changed in the last two cycles.

Measure zero-sequence current magnitude ($|I_{0k}|$) and compare it to $|I_{0(k–1\ cycle)}|$ from one cycle earlier. If this difference is greater than 10% of nominal, deassert LOP2.

Otherwise, continue with *Step 6*.

This condition is memorized for two cycles.

Step 6. Zero-sequence current angle is not changing, and has not changed in the last two cycles.

Measure zero-sequence current angle ($\angle I_{0k}$) and compare it to $\angle I_{0(k–1\ cycle)}$. If this difference is greater than 5°, deassert LOP2.

Otherwise, continue with *Step 7*.

This condition is memorized for two cycles. For security this declaration requires that |I0| be greater than 1.6% of INOM to override the LOP2 declaration.

Step 7. Is LOPRST or 3PO asserted, or is out-of-step active?

NO. Assert LOP2.

YES. Deassert LOP2 (LOPRST is described below).

If LOP2 is asserted, we declare a loss-of-potential condition (LOP asserts) as shown in *Figure 4.2*.

Relay Word Bit LOP3: LOP Latch Conditions

LOP asserts immediately when LOP1, LOP2, or LOP4 assert. However, we delay latching LOP for 15 cycles to allow LOP1 and LOP2 transient conditions to settle. Once voltages are healthy, we reset the latch. *Figure 4.5* shows the LOP Latch logic.

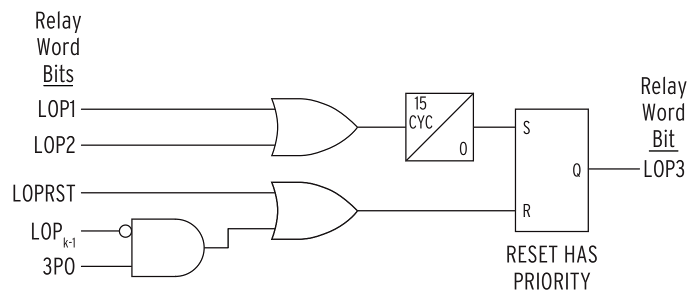


Figure 4.5 LOP Latch Logic (Relay Word Bit LOP3)

Relay Word Bit LOPRST: LOP Reset Conditions

Once LOP is declared or LOP is latched, the logic can be reset once voltages are healthy for 10 cycles.

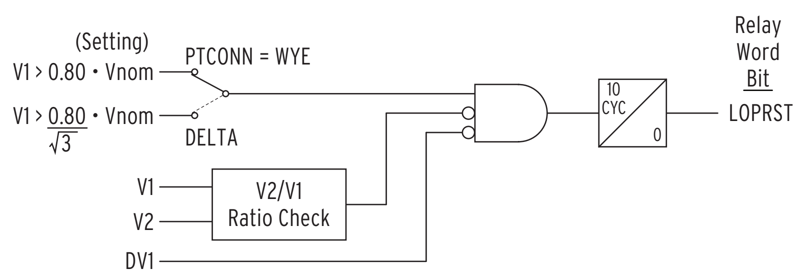


Figure 4.6 LOP Reset Logic (Relay Word Bit LOPRST)

Relay Word Bit LOP4: LOP Logic for Busbar PT Applications

SEL-311C setting EBBPT was introduced to separate Bus and Line PT applications. When set to Y, the relay enables the logic in *Figure 4.8*. We can apply this logic on any bus PT application. As shown in *Figure 4.2*, the operation of LOP4 directly affects the LOP output Relay Word bit, regardless of breaker status 3PO.

When applying LOP Logic with bus-side PTs, including some unique schemes (for example, switching PTs in a Breaker-and-a-Half Scheme), the EBBPT = Y setting has some additional advantages.

Consider the breaker-and-a-half scheme in *Figure 4.7*.

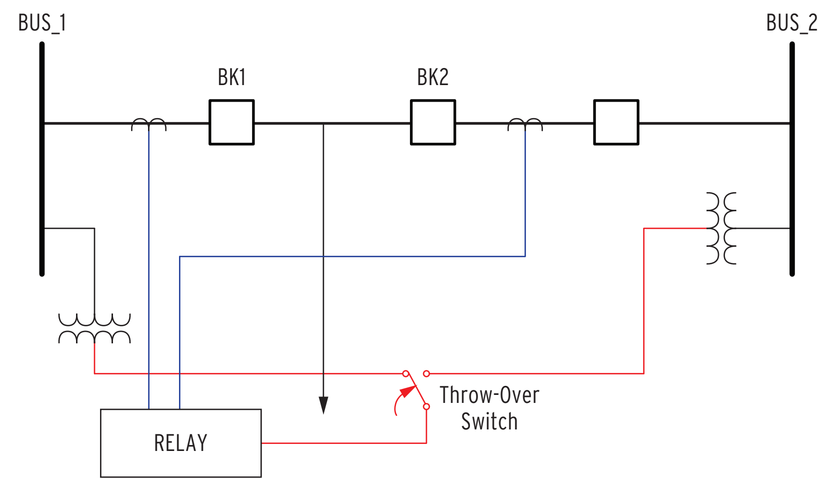


Figure 4.7 Breaker-and-a-Half Scheme with PT Throw-Over Switch

Consider what could happen if we set EBBPT = N for the system in *Figure 4.7*, and a fault occurs on BUS_1, with the relay getting its polarizing voltage from the BUS_1 PT. In this case, LOP does not assert because fault current is present. Once BK1 opens, LOP asserts, unless the fault is a three-phase fault. Note that for a three-phase fault, the voltages are already 0, so there is no change in voltage. This means that distance elements could operate before the PTs are switched if current is above load.

If EBBPT = Y, LOP asserts when BK1 opens, regardless of fault type, which eliminates the possibility of an undesired operation during the PT switching.

With EBBPT = Y, LOP4 asserts and stays asserted when voltages are near zero and no change in current is detected. The LOP4 condition is reset when voltages are restored and are healthy for at least 10 cycles (LOPRST).

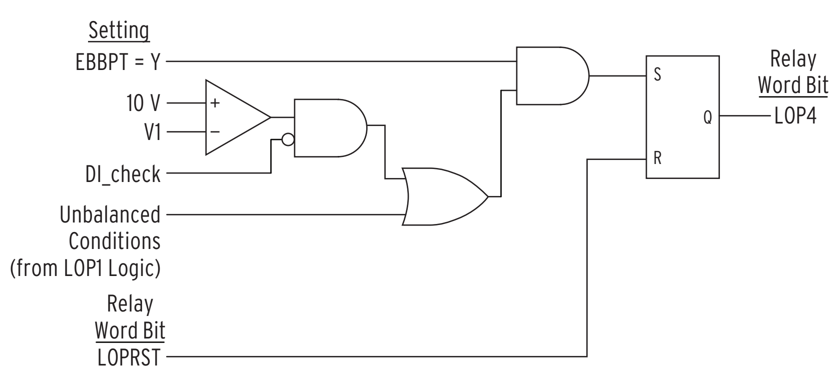


Figure 4.8 Busbar PT Logic (Relay Word Bit LOP4)

Source Outages when using EBBPT = Y

In installations where source outages are expected (perhaps in a radial system), using setting EBBPT = Y will assert LOP4 (and LOP) during every bus outage. When the bus is subsequently energized, LOP4 will remain asserted for at least 10 cycles. During this time, distance protection and most directional elements will be disabled. Depending on the substation bus configuration and the relay location, it may be possible to implement a scheme that opens the controlled breaker when the station bus is de-energized, and then automatically close the breaker only after LOP deasserts and VPOLV asserts, ensuring that directional and distance protection is available.

Otherwise, consider leaving setting EBBPT = N where source outages are likely.

Setting ELOP = Y or Y1

If setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit LOP asserts to logical 1), directional element enable Relay Word bits 32QE, 32QGE, and 32VE, plus the positive-sequence voltage-polarized directional element and all distance elements are disabled, except as discussed in NOTE 1 (see *Figure 4.13*, *Figure 4.14*, *Figure 4.21*, and *Figure 3.4*–*Figure 3.12*). The loss-of-potential condition makes the voltage-polarized directional elements controlled by these internal enables unreliable. The overcurrent elements controlled by these voltage-polarized directional elements are also disabled unless overridden by conditions explained in *Setting ELOP = Y*.

The channel IN current-polarized directional element (*Figure 4.17*) is controlled by internal enable 32IE (*Figure 4.14*). This directional element is not voltage polarized and thus a loss-of-potential condition does not disable the element.

In *Figure 5.6*, if setting ELOP = Y1 and LOP asserts, keying and echo keying in the permissive overreaching transfer trip (POTT) logic are blocked.

NOTE 1: When Global setting VSCONN = 3V0, the zero-sequence voltage polarized ground directional element (ORDER setting V) is not disabled by a loss-of-potential condition on relay inputs **VA**, **VB**, and **VC** because this directional element uses the $3V_0$ zero-sequence voltage that comes directly from voltage input **VS**. This difference is shown in *Figure 4.14* and *Figure 4.18*, where Relay Word bit 3V0 is used as a block signal for the loss-of-potential signal. Relay Word bit 3V0 is asserted (= logical 1) whenever Global setting VSCONN = 3V0. Refer to *Settings for Voltage Input Configuration on page 9.16*.

Setting ELOP = Y

Additionally, if setting ELOP = Y and a loss-of-potential condition occurs (Relay Word bit LOP asserts to logical 1), overcurrent elements set direction forward are enabled, except as discussed in NOTE 2 (see *Figure 4.18* and *Figure 4.20*). These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

As detailed previously, voltage-based directional elements are disabled during a loss-of-potential condition. Thus, the overcurrent elements controlled by these voltage-based directional elements are also disabled. However, this disable condition is overridden for the overcurrent elements set direction forward if setting ELOP = Y.

NOTE 2: When Global setting VSCONN = 3V0, the zero-sequence voltage polarized ground directional element (ORDER setting V) is not affected by a loss-of-potential condition on relay inputs **VA**, **VB**, and **VC** because this directional element uses the $3V_0$ zero-sequence voltage that comes directly from voltage input **VS**. Therefore, even if LOP is asserted and setting ELOP = Y when Relay Word bit 3V0 is asserted (= logical 1), the relay will not force an enable of ground elements set direction forward when the zero-sequence voltage-polarized ground directional element enable (32VE) is asserted. This difference is shown in *Figure 4.18*, where Relay Word bit 3V0 is combined with Relay Word bit 32VE to create a block signal for the loss-of-potential signal. Refer to *Settings for Voltage Input Configuration on page 9.16*.

Setting ELOP = N

If setting ELOP = N, the loss-of-potential logic still operates (Relay Word bit LOP asserts to logical 1 for a loss-of-potential condition) but does not disable any voltage-based directional elements (as occurs with ELOP = Y or Y1) or enable overcurrent elements set direction forward (as occurs with ELOP = Y).

Using LOP to Supervise Undervoltage Elements

The LOP logic is intended to supervise distance, directional, and load encroachment elements. Exercise caution when using the loss-of-potential logic to supervise undervoltage elements. Under certain low load conditions, undervoltage can cause LOP to assert and block undervoltage elements unexpectedly. If it is necessary to use Relay Word bit LOP to supervise an undervoltage element (27A1, for example) when phase secondary current may be less than 50LP (load detector pickup), consider using logic similar to the following:

... + 27A1 * (!LOP + !50LA + !50LB * !50LC) + ...

where 50LP is set at the minimum setting. With this logic, if any phase current is below the 50LP setting, when a loss of voltage occurs, Relay Word bit LOP may assert, but one or more of 50LA, 50LB or 50LC will be deasserted and the undervoltage trip will be allowed. Keep in mind that if a true Loss-of-Potential event occurs because of a blown fuse when the current is less than 50LP amps, the undervoltage element will not be blocked.

CCVT Transient Detection Logic

The SEL-311C detects CCVT transients that may cause Zone 1 distance overreach. If CCVT transient blocking is enabled (setting ECCVT = Y), and the relay detects an SIR greater than five during a Zone 1 fault, the relay delays Zone 1 distance element operation for up to 1.5 cycles, allowing the CCVT output to stabilize.

Other than making the enable setting ECCVT = Y, no extra settings are required. The relay automatically adapts to different system SIR conditions by monitoring voltage and current.

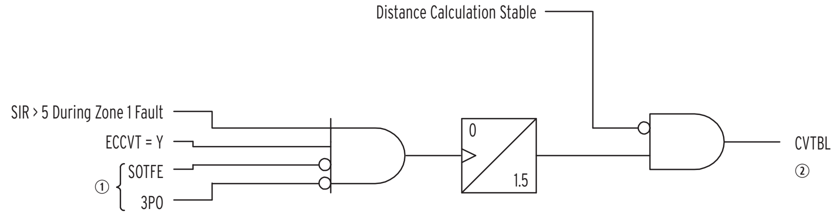
Consider using CCVT transient detection logic when you have either of the following conditions:

- CCVTs with active ferroresonance-suppression circuits (AFSC)
- The possibility of a source-to-line impedance ratio (SIR) greater than 5

CCVT transients may be aggravated when you have:

- A CCVT secondary with a mostly inductive burden
- A low C-value CCVT as defined by the manufacturer

For a description of CCVT transients and transient detection, see the following technical paper available on www.selinc.com: *Capacitive Voltage Transformer: Transient Overreach Concerns and Solutions for Distance Relaying*.



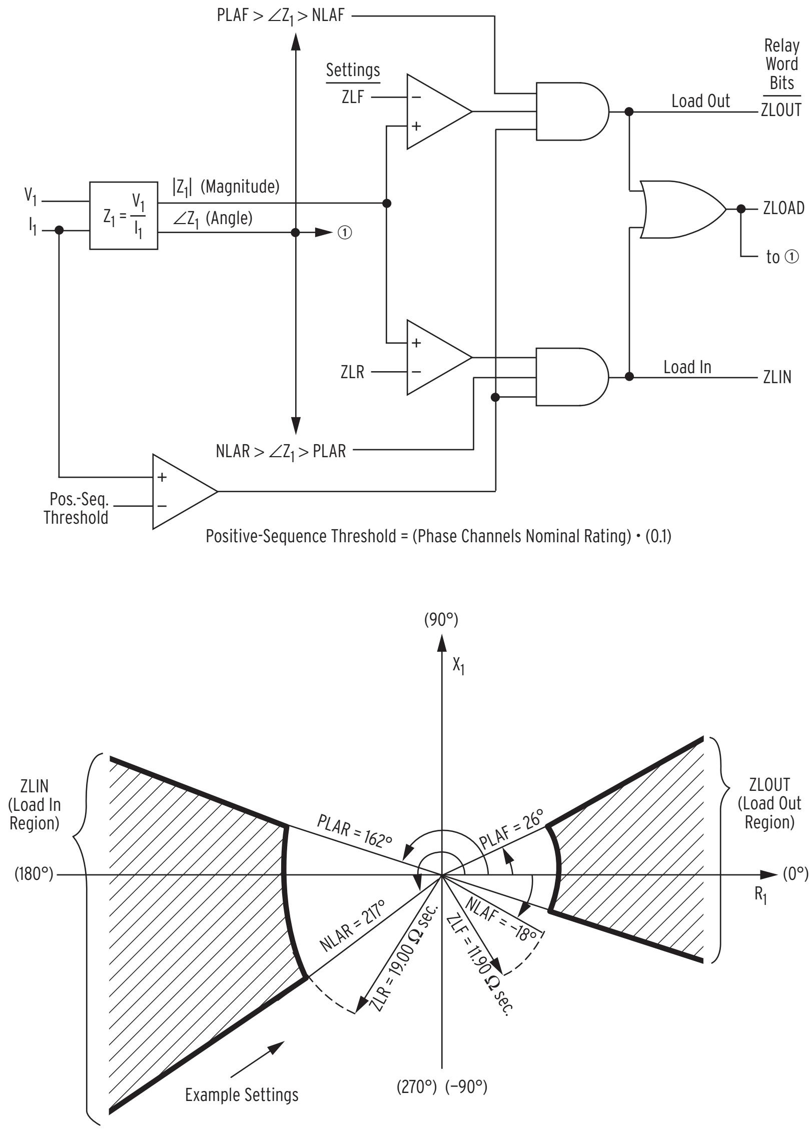
① From Figure 5.3; ② To Figure 3.4, Figure 3.7, and Figure 3.10

Figure 4.9 CCVT Transient Blocking Logic

Load-Encroachment Logic

The load-encroachment logic (see *Figure 4.10*) and settings are enabled/disabled with setting ELOAD.

The load-encroachment feature allows distance and phase overcurrent elements to be set without regard for and independent of load levels. Relay Word bit ZLOAD is used to block the positive-sequence, voltage-polarized directional element (see *Figure 4.21*), which otherwise might assert for three-phase load. The distance elements, M1P–M4P, will not operate without directional control.



① To Figure 4.21.

Figure 4.10 Load-Encroachment Logic

Note that a positive-sequence impedance calculation (Z_1) is made in the load-encroachment logic in *Figure 4.10*. Load is largely a balanced condition; so apparent positive-sequence impedance is a good load measure. The load-encroachment logic only operates if the positive-sequence current (I_1) is greater than the Positive-Sequence Threshold defined in *Figure 4.10*. For a balanced load condition, I_1 = phase current magnitude.

Forward load (load flowing out) lies within the hatched region labeled ZLOUT. Relay Word bit ZLOUT asserts to logical 1 when the load lies within this hatched region.

Reverse load (load flowing in) lies within the hatched region labeled ZLIN. Relay Word bit ZLIN asserts to logical 1 when the load lies within this hatched region.

Relay Word bit ZLOAD is the OR-combination of ZLOUT and ZLIN:

ZLOAD = **ZLOUT + ZLIN**

Settings Ranges

Refer to *Figure 4.10*.

Table 4.3 Load-Encroachment Settings Ranges

Setting	Description and Range
ZLF	Forward Minimum Load Impedance—corresponding to maximum load flowing out
ZLR	Reverse Minimum Load Impedance—corresponding to maximum load flowing in
	0.09–64.00 Ω secondary (5 A nominal phase current inputs, IA, IB, IC)
	0.45–320.00 Ω secondary (1 A nominal phase current inputs, IA, IB, IC)
PLAF	Maximum Positive Load Angle Forward (–90° to +90°)
NLAF	Maximum Negative Load Angle Forward (–90° to +90°)
PLAR	Maximum Positive Load Angle Reverse (+90° to +270°)
NLAR	Maximum Negative Load Angle Reverse (+90° to +270°)

Load-Encroachment Setting Example

Example system conditions are shown in the following table:

Nominal Line-Line Voltage:	230 kV
Maximum Forward Load:	800 MVA
Maximum Reverse Load:	500 MVA
Power Factor (Forward Load):	0.90 lag to 0.95 lead
Power Factor (Reverse Load):	0.80 lag to 0.95 lead
CT ratio:	2000/5 = 400
PT ratio:	134000/67 = 2000

The PTs are connected line-to-neutral.

Convert Maximum Loads to Equivalent Secondary Impedances

Start with maximum forward load:

$$\begin{aligned}
800\text{ MVA} \bullet (1/3) &= 267\text{ MVA per phase} \\
230\text{ kV} \bullet (1/\sqrt{3}) &= 132.8\text{ kV line-to-neutral} \\
267\text{ MVA} \bullet (1/132.8\text{ kV}) \bullet (1000\text{kV/MV}) &= 2010\text{ A primary} \\
2010\text{ A primary} \bullet (1/\text{CT ratio}) &= 2010\text{ A primary} \bullet (1\text{ A secondary}/400\text{ A primary}) \\
&= 5.03\text{ A secondary} \\
132.8\text{ kV} \bullet (1000\text{ V/kV}) &= 132800\text{ V primary} \\
132800\text{ V primary} \bullet (1/\text{PT ratio}) &= 132800\text{ V primary} \bullet (1\text{ V secondary}/2000\text{ V primary}) \\
&= 66.4\text{ V secondary}
\end{aligned}$$

Now, calculate the equivalent secondary impedance:

$$\frac{66.4\text{ V secondary}}{5.03\text{ A secondary}} = 13.2\ \Omega\text{ secondary}$$

This secondary value can be calculated more expediently with the following equation:

$$\frac{(\text{line-line voltage in kV})^2 \bullet \text{ CT ratio}}{\text{3-phase load in MVA} \bullet \text{ PT ratio}}$$

Again, for the maximum forward load:

$$\frac{230^2 \cdot 400}{800 \cdot 2000} = 13.2\ \Omega \text{ secondary}$$

To provide a margin for setting ZLF, multiply by a factor of 0.9:

$$\begin{aligned} ZLF &= 13.2\ \Omega \text{ secondary} \cdot 0.9 \\ &= 11.90\ \Omega \text{ secondary} \end{aligned}$$

For the maximum reverse load:

$$\frac{230^2 \cdot 400}{500 \cdot 2000} = 21.1\ \Omega \text{ secondary}$$

Again, to provide a margin for setting ZLR:

$$\begin{aligned} ZLR &= 21.1 \text{ secondary} \cdot 0.9 \\ &= 19.00\ \Omega \text{ secondary} \end{aligned}$$

Convert Power Factors to Equivalent Load Angles

The power factor (forward load) can vary from 0.90 lag to 0.95 lead.

Setting PLAF = $\cos^{-1}$ (0.90) = 26°

Setting NLAF = $\cos^{-1}$ (0.95) = –18°

The power factor (reverse load) can vary from 0.80 lag to 0.95 lead.

Setting PLAR = 180° – $\cos^{-1}$ (0.95) = 180° – 18° = 162°

Setting NLAR = 180° + $\cos^{-1}$ (0.80) = 180° + 37° = 217°

Apply Load-Encroachment Logic to Phase Overcurrent Elements

Again, from *Figure 4.10*:

ZLOAD = **ZLOUT + ZLIN**

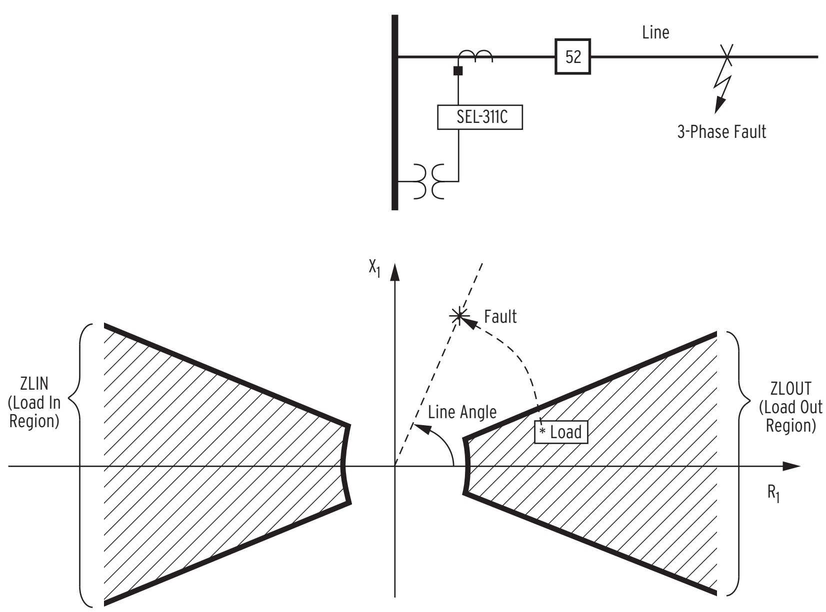


Figure 4.11 Migration of Apparent Positive-Sequence Impedance for a Fault Condition

Refer to *Figure 4.11*. In a load condition, the apparent positive-sequence impedance is *within* the ZLOUT area, resulting in:

ZLOAD = **ZLOUT + ZLIN** = logical 1 + ZLIN = logical 1

If a fault occurs, the apparent positive-sequence impedance moves *outside* the ZLOUT area (and stays outside the ZLIN area, too), resulting in:

ZLOAD = **ZLOUT + ZLIN** = logical 0 + logical 0 = logical 0

Load Encroachment for Directional Elements

Embedded logic handles load encroachment concerns for phase directional elements. In *Figure 4.21*, notice that the "!ZLOAD" condition is embedded in the positive-sequence voltage-polarized directional element logic. This logic prevents the directional element from operating when the measured positive sequence impedance is within the Load In or Load Out regions.

Load Encroachment for Nondirectional Elements

It is possible to use SELOGIC® control equation torque control settings to apply load encroachment supervision for nondirectional overcurrent elements. However, keep in mind that load encroachment is not a valid representation of the positive-sequence impedance during unbalanced faults, and ZLOAD may assert during certain unbalanced faults. This means that a torque control equation intended to prevent operation of a phase overcurrent element for load conditions may also prevent operation of the element for unbalanced faults. Therefore, when using load encroachment to control phase overcurrent elements, residual ground overcurrent elements must be used to detect phase-ground faults. Similarly negative-sequence overcurrent elements must be used to detect phase-phase faults (see *Appendix G: Setting Negative-Sequence Overcurrent Elements*). These phase-ground and phase-phase elements must be at least as sensitive as the phase overcurrent elements.

Example

If it is acceptable for the phase overcurrent element to operate for some unbalanced fault conditions, refer to *Figure 3.31* and make the following SELOGIC control equation torque control setting:

51PTC = **!ZLOAD * !LOP + 50P4** (= NOT[ZLOAD] * NOT[LOP] + 50P4)

As shown in *Figure 4.10*, load-encroachment logic is a positive-sequence calculation. During LOP conditions (loss-of-potential; see *Figure 4.1*), positive-sequence voltage (V_1) can be substantially depressed in magnitude or changed in angle. This change in V_1 can possibly cause ZLOAD to deassert (= logical 0), erroneously indicating that a "fault condition" exists. Thus, !ZLOAD should be supervised by !LOP in a torque control setting. This also effectively happens in the directional element in *Figure 4.21*, where ZLOAD and LOP are part of the logic.

In the above setting example, phase instantaneous overcurrent element 50P4 is set above any maximum load current level—if 50P4 picks up, there is assuredly a fault. For faults below the pickup level of 50P4, but above the pickup of phase time-overcurrent element 51PT, the !ZLOAD * !LOP logic discriminates between high load and fault current. If an LOP condition occurs (LOP = logical 1), the pickup level of 50P4 becomes the effective pickup of phase time-overcurrent element 51PT. In other words, 51PT loses its sensitivity when an LOP condition occurs:

51PTC = **!ZLOAD * !LOP + 50P4** = !ZLOAD * NOT[LOP] + 50P4 =
!ZLOAD * NOT[logical 1] + 50P4 = 50P4

Use SEL-321 Relay Application Guide for the SEL-311C Relay

The load-encroachment logic and settings in the SEL-311C are the same as those in the SEL-321. Refer to SEL Application Guide *AG93-10, SEL-321 Relay Load-Encroachment Function Setting Guidelines* for applying the load-encroachment logic in the SEL-311C.

Directional Control for Ground Distance and Residual-Ground Overcurrent Elements

Setting E32 and other directional control settings are described in *Directional Control Settings on page 4.29*.

Three directional elements are available to control the ground distance and residual ground overcurrent elements. These three directional elements are:

- ➤ Negative-sequence voltage-polarized directional element
- ➤ Zero-sequence voltage-polarized directional element
- ➤ Channel IN current-polarized directional element

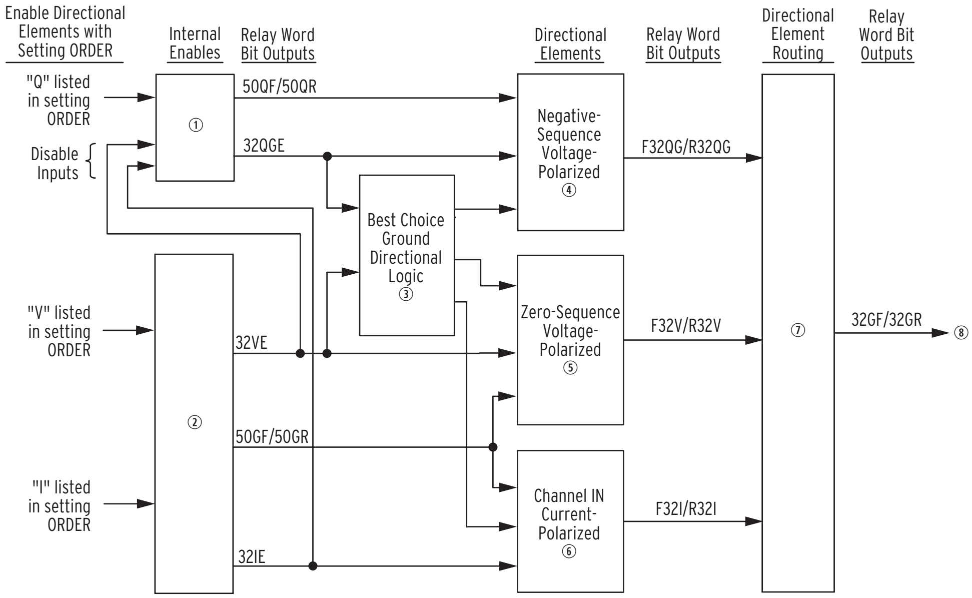
NOTE: Channel IN was called Channel IP in legacy SEL-311 models. See SEL-311C Models on page 1.1 for a summary of differences.

Figure 4.12 gives an overview of how these directional elements are enabled and routed to control the ground distance and residual ground overcurrent elements.

Note in *Figure 4.12* that setting ORDER enables the directional elements. Setting ORDER can be set with the elements listed and defined in *Table 4.4*, subject to the setting combination constraints in *Table 4.5*.

Table 4.6 details the availability of the ground directional elements for the various combinations of the PTCONN and VSCONN settings. Refer to *Settings for Voltage Input Configuration on page 9.16* for information on these settings.

The order that these directional elements are listed in setting ORDER determines the priority in which they operate to provide Best Choice Ground Directional Element® logic control. See the discussion on setting ORDER in *Directional Control Settings on page 4.29*.



① Figure 4.13; ② Figure 4.14; ③ Table 4.4 and Table 4.5; ④ Figure 4.15; ⑤ Figure 4.16; ⑥ Figure 4.17; ⑦ Figure 4.18;
⑧ Figure 3.7–Figure 3.12 and Figure 3.29.

Figure 4.12 General Logic Flow of Directional Control for Ground Distance and Residual Ground Overcurrent Elements

Table 4.4 Available Ground Directional Elements

ORDER Setting Choices	Corresponding Ground Directional Element	Corresponding Internal Enables	Corresponding Figures
Q	Negative-sequence voltage-polarized	32QGE	*Figure 4.13*, *Figure 4.15*
V	Zero-sequence voltage-polarized	32VE	*Figure 4.14*, *Figure 4.16*
I	Channel IN current polarized	32IE	*Figure 4.14*, *Figure 4.17*

Table 4.5 Best Choice Ground Directional Element® Logic (Sheet 1 of 2)

ORDER Setting Combinations	Resultant ground directional element preference (indicated below with corresponding internal enables; run element that corresponds to highest choice internal enable that is asserted		
	1st Choice	**2nd Choice**	**3rd Choice**
Q	32QGE		
QV	32QGE	32VE	
V	32VE		
VQ	32VE	32QGE	
I	32IE		
IQ	32IE	32QGE	
IQV	32IE	32QGE	32VE
IV	32IE	32VE	
IVQ	32IE	32VE	32QGE
QI	32QGE	32IE	
QIV	32QGE	32IE	32VE

Table 4.5 Best Choice Ground Directional Element® Logic (Sheet 2 of 2)

ORDER Setting Combinations	Resultant ground directional element preference (indicated below with corresponding internal enables; run element that corresponds to highest choice internal enable that is asserted		
	1st Choice	2nd Choice	3rd Choice
QVI	32QGE	32VE	32IE
VI	32VE	32IE	
VIQ	32VE	32IE	32QGE
VQI	32VE	32QGE	32IE

Table 4.6 Ground Directional Element Availability by Voltage Connection Settings

Element Designation in ORDER Setting	Availability When VSCONN = VS		Availability When VSCONN = 3V0
	PTCONN = WYE	PTCONN = DELTA	PTCONN = DELTA
Q	Yes	Yes	Yes
V	Yes	No	Yes
I	Yes	Yes	Yes

Internal Enables

Refer to *Figure 4.12*, *Figure 4.13* and *Figure 4.14*.

Table 4.4 lists the internal enables and their correspondence to the ground directional elements.

Note that *Figure 4.13* has extra internal enable 32QE, which is used in the directional element logic that controls negative-sequence and phase overcurrent elements (see *Figure 4.19*).

Also, note that if enable setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit LOP asserts), all the internal directional enables (except for 32IE) are disabled (see *Figure 4.13* and *Figure 4.14*), unless VSCONN = 3V0. In that case, the directional element enables in *Figure 4.14* are not affected by LOP. This is explained in *Loss-of-Potential Logic on page 4.1*.

The channel IN current-polarized directional element (with corresponding internal enable 32IE; *Figure 4.14*) does not use voltage in making direction decisions, thus a loss-of-potential condition does not disable the element. Refer to *Figure 4.1* and accompanying text for more information on loss-of-potential.

The settings involved with the internal enables (e.g., settings a2, k2, a0) are explained in *Directional Control Settings on page 4.29*.

Zero-Sequence Voltage Sources

The zero-sequence voltage polarized directional element relies on zero-sequence voltage $3V_0$ (ORDER setting choice “V” as shown in *Figure 4.16*) and may use either a calculated $3V_0$ from the wye-connected voltages V_A, V_B, and V_C, or a measured $3V_0$ from the VS channel, which is typically connected to a broken-delta PT secondary. The Global setting VSCONN selects the zero-sequence voltage source to be used by the affected directional elements.

NOTE: When PTCONN = WYE, the VSCONN setting is internally set to VS and not reported with the relay settings.

When VSCONN = 3V0, the measured voltage on terminals **VS-NS** is scaled by the ratio of Group settings PTRS/PTR to convert it to the same voltage base as the **VA**, **VB**, and **VC** terminals, and the resulting signal is applied to the directional element "$3V_0$" inputs.

When VSCONN = VS, the calculated zero-sequence voltage from terminals **VA**, **VB**, and **VC** is applied to the directional element "$3V_0$" inputs, provided that the relay is connected to wye-connected PTs (Global setting PTCONN = WYE). If the relay is connected to open-delta PTs (Global setting PTCONN = DELTA), $3V_0$ cannot be calculated from the **VA**, **VB**, and **VC** terminals, and the zero-sequence voltage polarized directional element is unavailable.

When testing the relay, it is important to note that the **METER** command 3V0 quantity, when available, is always the calculated value from the wye-connected PT inputs, even when VSCONN = 3V0. The **METER** command VS quantity is always the measured value from the **VS-NS** terminals.

See *Broken-Delta VS Connection (Global Setting VSCONN = 3V0) on page 2.12*, and *Settings for Voltage Input Configuration on page 9.16*.

Best Choice Ground Directional Element Logic

The Best Choice Ground Directional Element logic determines which directional element should be enabled to operate. The ground distance elements and residual ground directional overcurrent elements are then controlled by this enabled directional element.

Table 4.5 describes how the ORDER setting controls the Best Choice Ground Directional Element logic. Relay Word bits 32QGE, 32VE, and 32IE and setting ORDER are used in the Best Choice Ground Directional logic in *Table 4.4*. The Best Choice Ground Directional logic determines the order that the directional element should be enabled to operate. The ground distance and residual ground overcurrent elements set for directional control are then controlled by this directional element. See the discussion on setting ORDER in *Directional Control Settings on page 4.29*.

Directional Element Routing

Refer to *Figure 4.12* and *Figure 4.18*.

The directional element outputs are routed to the forward (Relay Word bit 32GF) and reverse (Relay Word bit 32GR) logic points and then on to the ground distance elements in *Figure 3.7* through *Figure 3.12* and the residual ground directional overcurrent elements in *Figure 3.29*.

Loss of Potential

Note in *Figure 4.18* that if *all* the following are true:

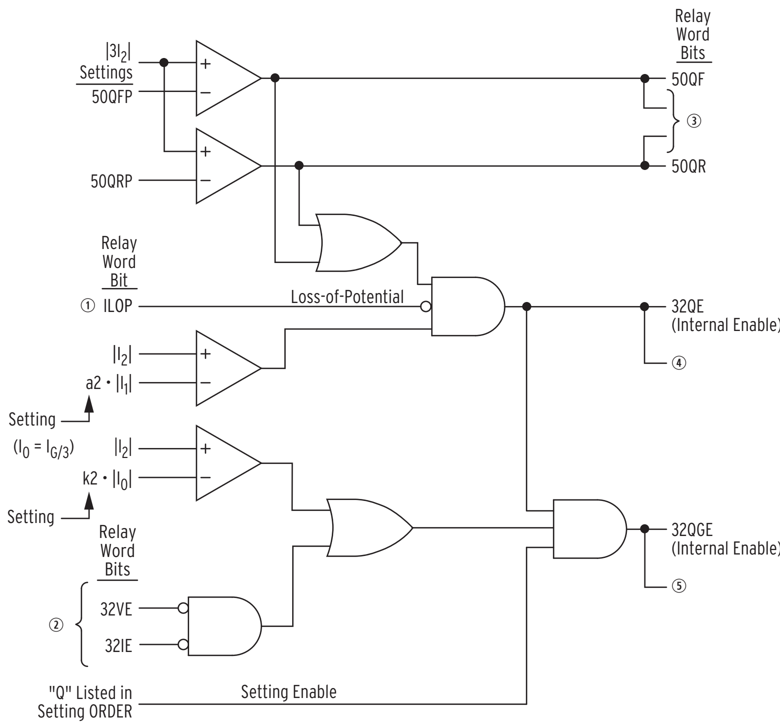
- Enable setting ELOP = Y,
- Global setting VSCONN = VS,
- A loss-of-potential condition occurs (Relay Word bit LOP asserts),
- And internal enable 32IE (for channel IN current-polarized directional element) is not asserted

then the forward logic point (Relay Word bit 32GF) asserts to logical 1, thus, enabling the residual ground directional overcurrent elements that are internally defined as forward acting (67G1 and 67G2) or set forward (with setting DIR3 = F and/or DIR4 = F). These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

If Global setting VSCONN = 3V0 and Group setting ELOP = Y, the LOP condition will not cause the forward directional outputs to assert when the directional element enable 32VE is asserted, as shown at the top of *Figure 4.18*. In this situation, the element that is enabled by 32VE is still able to operate reliably during a loss-of-potential condition, so there is no need to force the forward output to assert. However, when 32VE is not asserted, a standing LOP condition will force the forward output to assert continuously. Consider this when determining residual-ground overcurrent element pickup settings and time delay settings, so that “load conditions” do not cause a forward-set ground directional overcurrent element to pick up and start timing.

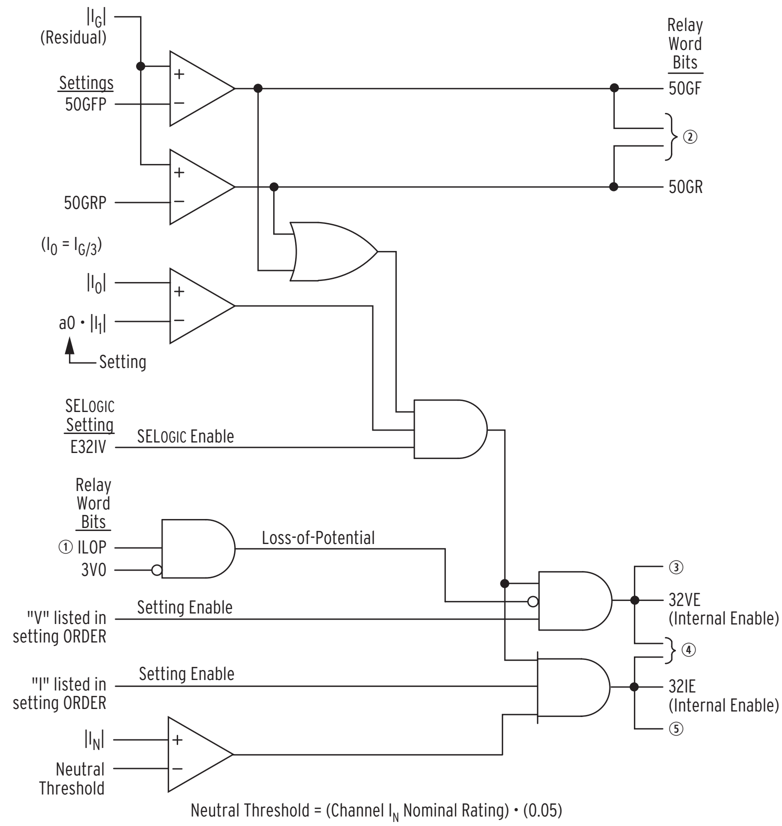
Refer to *Figure 4.1* and accompanying text for more information on loss-of-potential.

As shown in *Figure 3.4* through *Figure 3.12*, ILOP also disables all distance elements.



① From Figure 4.1; ② from Figure 4.14; ③ to Figure 4.15 and Figure 4.20; ④ to Figure 4.20; ⑤ to Figure 4.15, Table 4.4, and Table 4.5.

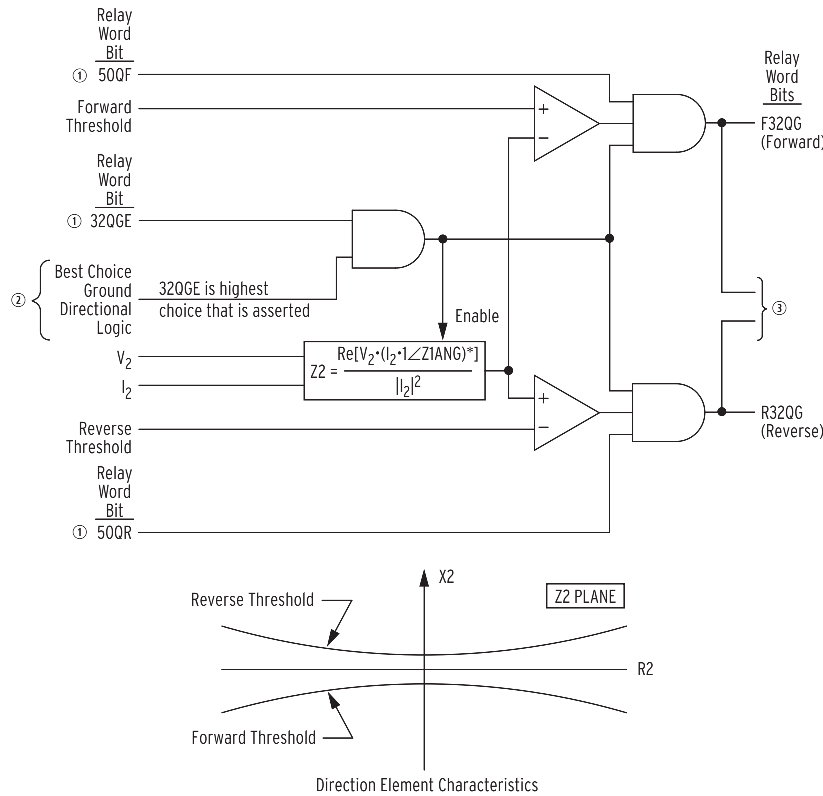
Figure 4.13 Internal Enables (32QE and 32QGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements



① From Figure 4.1; ② to Figure 4.16; ③ to Figure 4.16; ④ to Figure 4.13, Figure 4.18, Table 4.4, and Table 4.5; ⑤ to Figure 4.17.

Figure 4.14 Internal Enables (32VE and 32IE) Logic for Zero-Sequence Voltage-Polarized and Channel IN Current-Polarized Directional Elements

Refer to *E32IV—SELOGIC Control Equation Enable on page 4.37* for information on using SELOGIC setting E32IV.



Forward Threshold:

If Z2F Setting ≤ 0, Forward Threshold = $0.75 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2F Setting > 0, Forward Threshold = $1.25 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

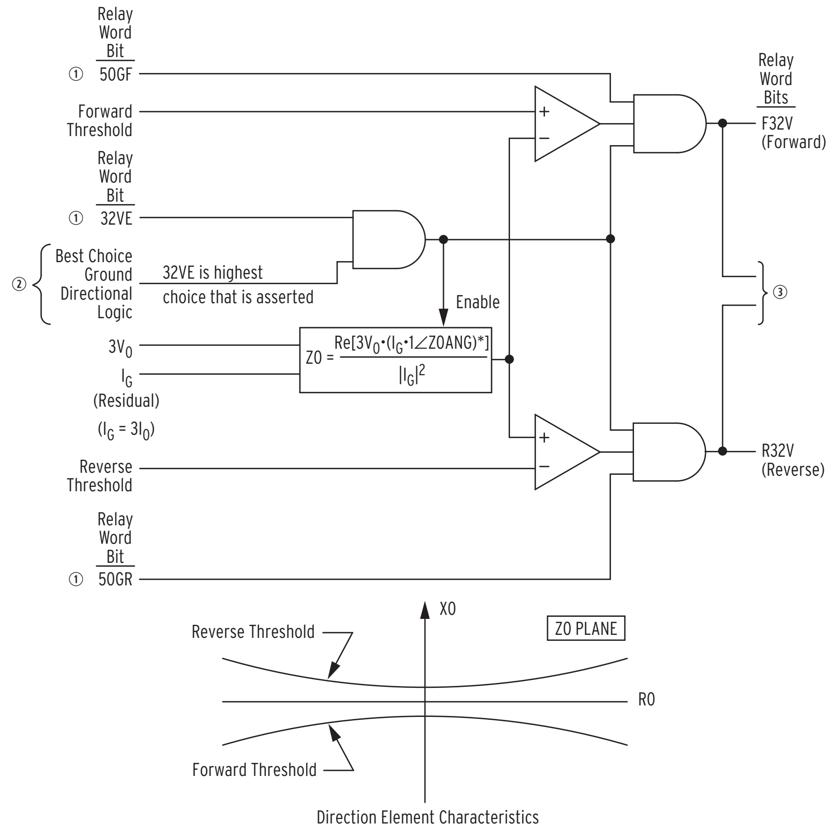
Reverse Threshold:

If Z2R Setting ≥ 0, Reverse Threshold = $0.75 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2R Setting < 0, Reverse Threshold = $1.25 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

① from Figure 4.13; ② From Table 4.5; ③ to Figure 4.18.

Figure 4.15 Negative-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements



Forward Threshold:

If Z0F Setting ≤ 0, Forward Threshold = $0.75 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

If Z0F Setting > 0, Forward Threshold = $1.25 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

Reverse Threshold:

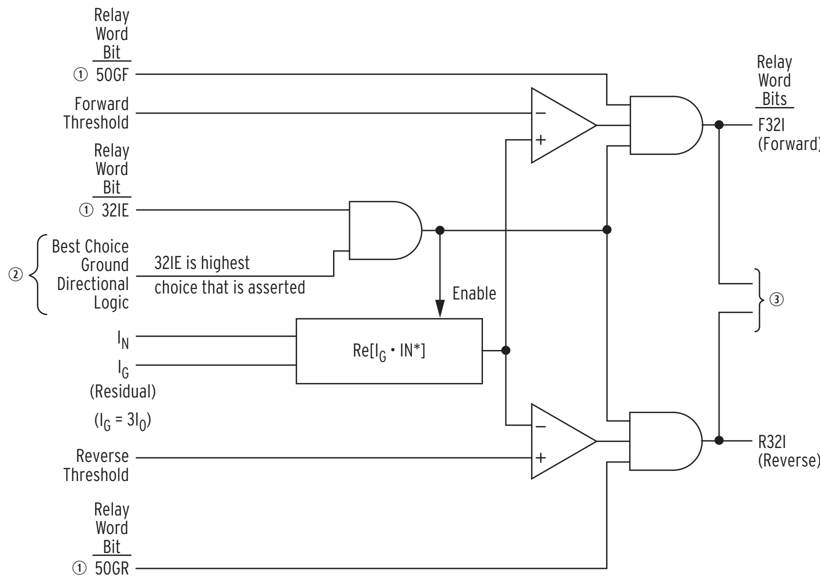
If Z0R Setting ≥ 0, Reverse Threshold = $0.75 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

If Z0R Setting < 0, Reverse Threshold = $1.25 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

① from Figure 4.14; ② From Table 4.5; ③ to Figure 4.18.

Figure 4.16 Zero-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements

The $3V_0$ input to *Figure 4.16* may be either a calculated value (when Global settings VSCONN = VS and PTCONN = WYE) or a measured value (when Global setting VSCONN = 3V0). See *Zero-Sequence Voltage Sources on page 4.19*.



Forward Threshold:

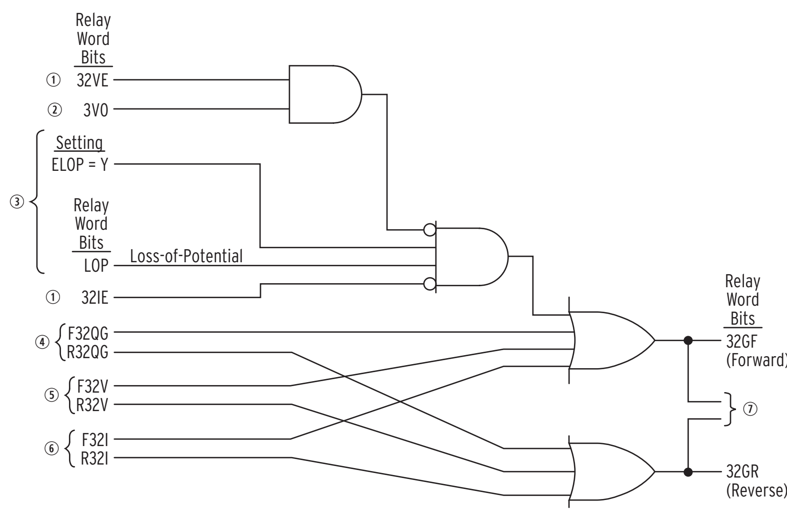
Forward Threshold = (Channel I_N Nominal Rating) • (Phase Channels Nominal Rating) • $(0.05)^2$

Reverse Threshold:

Reverse Threshold = −(Channel I_N Nominal Rating) • (Phase Channels Nominal Rating) • $(0.05)^2$

① from Figure 4.14; ② From Table 4.5; ③ to Figure 4.18.

Figure 4.17 Channel IN Current-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements



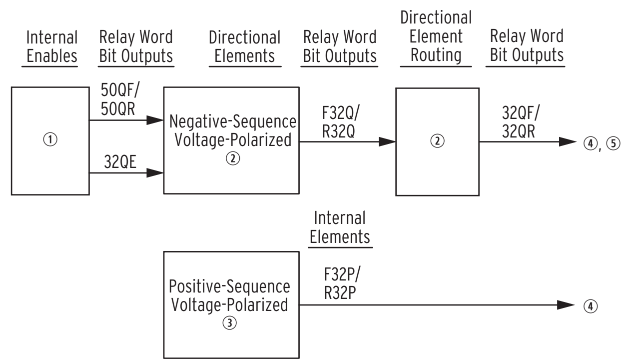
① From Figure 4.14; ② from Figure 4.1; ③ from Figure 4.15; ④ from Figure 4.16;
⑤ from Figure 4.17; ⑥ to Figure 3.7 through Figure 3.12 and Figure 3.29.

Figure 4.18 Ground Distance and Residual Ground Directional Logic

Directional Control for Phase Distance and Negative-Sequence Overcurrent Elements

The directional control for phase distance and negative-sequence overcurrent elements is enabled by making directional control enable setting E32. Setting E32 and other directional control settings are described in *Directional Control Settings on page 4.29*.

The negative-sequence voltage-polarized directional element controls the negative-sequence overcurrent elements. Negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements control the phase distance elements. *Figure 4.19* gives an overview of how the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements are enabled and routed to control the negative-sequence overcurrent and phase distance elements.



① Figure 4.13; ② Figure 4.20; ③ Figure 4.21; ④ Figure 3.4–Figure 3.6; ⑤ Figure 3.30.

Figure 4.19 General Logic Flow of Directional Control for Negative-Sequence Overcurrent and Phase Distance Elements

Internal Enables

Refer to *Figure 4.13* and *Figure 4.19*.

The internal enable 32QE corresponds to the negative-sequence voltage-polarized directional element.

Note that *Figure 4.13* has extra internal enable 32QGE, which is used in the directional element logic that controls the ground distance and residual ground overcurrent elements (see *Figure 4.12*).

The settings involved with internal enable 32QE in *Figure 4.13* (e.g., setting a2) are explained in *Directional Control Settings on page 4.29*.

Directional Elements

Refer to *Figure 4.19*, *Figure 4.20*, and *Figure 4.21*.

If enable setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit LOP asserts), the negative-sequence voltage-polarized, positive-sequence voltage-polarized directional elements, and the phase distance elements are disabled (see *Figure 4.13* and *Figure 4.21*).

Refer to *Figure 4.1* and accompanying text for more information on loss-of-potential.

The negative-sequence voltage-polarized directional element operates for unbalanced faults while the positive-sequence voltage-polarized directional element operates for three-phase faults.

Note also in *Figure 4.21* that the assertion of ZLOAD disables the positive-sequence voltage-polarized directional element. ZLOAD asserts when the relay is operating in a user-defined load region (see *Figure 4.10*).

Directional Element Routing

Refer to *Figure 4.19* and *Figure 4.20*.

The directional element outputs F32Q and R32Q are routed to the forward (Relay Word bit 32QF) and reverse (Relay Word bit 32QR) logic points and then on to the negative-sequence overcurrent elements and phase distance elements.

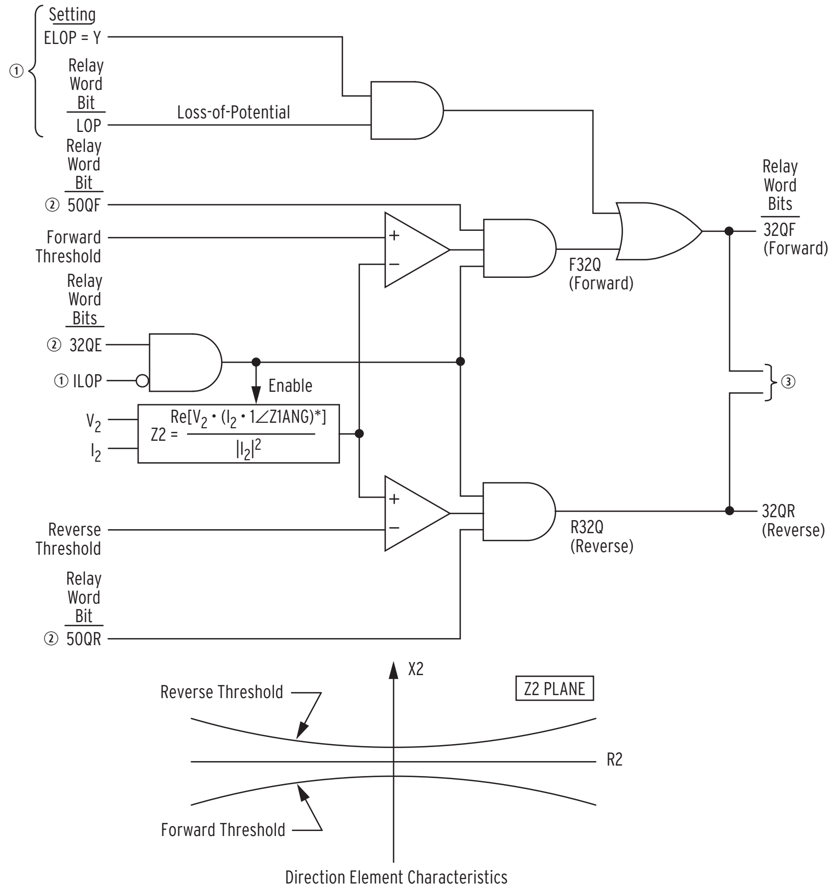
Loss-of-Potential

Note if *both* the following are true:

- Enable setting ELOP = Y,
- A loss-of-potential condition occurs (Relay Word bit LOP asserts),

then the forward logic point (Relay Word bit 32QF) asserts to logical 1, thus enabling the negative-sequence and phase overcurrent elements that are defined as direction forward (e.g., 67Q1; 67Q2; and 67Q3 if setting DIR3 = F, or 67Q4 if setting DIR4 = F). These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

Refer to *Figure 4.1* and accompanying text for more information on loss-of-potential.



Forward Threshold:

If Z2F Setting ≤ 0, Forward Thres hold = $0.75 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2F Setting > 0, Forward Threshold = $1.25 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

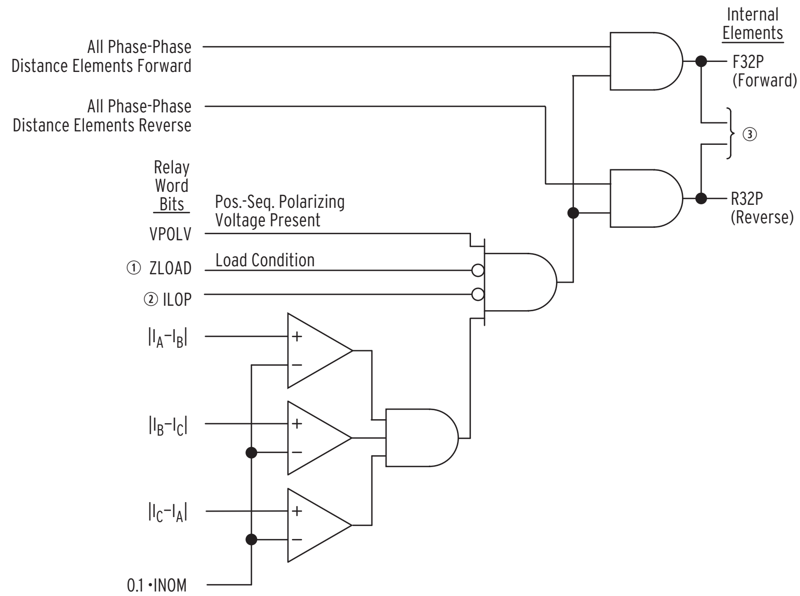
Reverse Threshold:

If Z2R Setting ≥ 0, Reverse Threshold = $0.75 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2R Setting < 0, Reverse Threshold = $1.25 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

① from Figure 4.1; ② from Figure 4.13; ③ to Figure 3.4–Figure 3.6 and Figure 3.30.

Figure 4.20 Negative-Sequence Voltage-Polarized Directional Element for Phase Distance and Negative-Sequence Elements



① From Figure 4.10; ② from Figure 4.1; ③ to Figure 3.4–Figure 3.6.

Figure 4.21 Positive-Sequence Voltage-Polarized Directional Element for Phase Distance Elements

Directional Control Settings

The directional control for overcurrent elements is enabled by making directional control enable setting E32. Setting E32 has setting choices:

- Y enable directional control
- AUTO enable directional control and set many of the directional element settings automatically

Settings Made Automatically

If the directional control enable setting E32 is set as shown below,

E32 = **AUTO**

then the following directional control settings are calculated and set automatically:

Z2F, Z2R, 50QFP, 50QRP, a2, k2, 50GFP, 50GRP, a0, Z0F, and Z0R

NOTE: Settings Z2F, Z2R, Z0F, and Z0R are calculated based on the line impedance settings Z1MAG and Z0MAG. Enter Z1MAG and Z0MAG values appropriate for the application when E32 = AUTO.

Once these settings are calculated automatically, they can only be modified if the user goes back and changes the directional control enable setting to E32 = Y.

The remaining directional control settings are *not* set automatically if setting E32 = AUTO. They have to be set by the user, whether setting E32 = AUTO or Y. These settings are:

DIR3, DIR4, ORDER, and E32IV (E32IV is a SELOGIC setting)

All these settings are explained in detail in the remainder of this subsection.

Not all these directional control settings (set automatically or by the user) are used in every application. The following are directional control settings that are hidden/not made for particular conditions:

Table 4.7 Directional Control Settings Not Made for Particular Conditions

Settings hidden/not made:	for condition:
50GFP, 50GRP, a0	setting ORDER does not contain V or I
Z0F, Z0R	setting ORDER does not contain V

Settings

DIR3—Zone 3/Level 3 Overcurrent Element Direction Setting
DIR4—Zone 4/Level 4 Overcurrent Element Direction Setting

NOTE: DIR3 must be set to R when ECOMM ≠ N. See *Communications-Assisted Trip Logic—General Overview on page 5.12*.

Setting Range:

F = Direction Forward

R = Direction Reverse

Table 4.8 shows the overcurrent elements that are controlled by each level direction setting.

Table 4.8 Elements Controlled by Zone/Level Direction Settings (Corresponding Overcurrent and Directional Element Figure Numbers in Parentheses)

Level Direction Settings	Phase Distance	Ground Distance	Residual Ground	Negative-Sequence
Forward	M1P (*Figure 3.4*) M1PT (*Figure 3.21*)	Z1G (*Figure 3.7*, *Figure 3.10*) Z1GT (*Figure 3.21*)	67G1 (*Figure 3.29*) 67G1T (*Figure 3.29*)	67Q1 (*Figure 3.30*) 67Q1T (*Figure 3.30*)
Forward	M2P (*Figure 3.5*) M2PT (*Figure 3.21*)	Z2G (*Figure 3.8*, *Figure 3.11*) Z2GT (*Figure 3.21*)	67G2 (*Figure 3.29*) 67G2T (*Figure 3.29*)	67Q2 (*Figure 3.30*) 67Q2T (*Figure 3.30*)
DIR3 = F or R	M3P (*Figure 3.6*) M3PT (*Figure 3.21*)	Z3G (*Figure 3.9*, *Figure 3.12*) Z3GT (*Figure 3.21*)	67G3 (*Figure 3.29*) 67G3T (*Figure 3.29*)	67Q3 (*Figure 3.30*) 67Q3T (*Figure 3.30*)
DIR4 = F or R	M4P (*Figure 3.6*) M4PT (*Figure 3.21*)	Z4G (*Figure 3.9*, *Figure 3.12*) Z4GT (*Figure 3.21*)	67G4 (*Figure 3.29*) 67G4T (*Figure 3.29*)	67Q4 (*Figure 3.30*) 67Q4T (*Figure 3.30*)

In communications-assisted trip schemes, the levels are defined as follows (see *Figure 5.4*):

- ➤ Zone 1 distance elements are fixed as direction forward
- ➤ Zone 2 distance elements are fixed as direction forward
- ➤ Zone 3 distance elements set direction reverse (DIR3 = R)

ORDER—Ground Directional Element Priority Setting

Setting ORDER can be set with the elements listed and defined in *Table 4.4*, subject to the setting combination constraints in *Table 4.5* and *Table 4.6*. *Table 4.6* lists the ground directional element availability as a result of the voltage connection settings.

The *order* in which the directional elements are listed in setting ORDER determines the priority in which these elements operate to provide Best Choice Ground Directional Element logic control.

For example, if setting:

ORDER = **QVI**

then the first listed directional element (Q = negative-sequence voltage-polarized directional element; see *Figure 4.15*) is the first priority directional element to provide directional control for the ground distance and residual ground overcurrent elements.

If the negative-sequence voltage-polarized directional element is not operable (i.e., it does not have sufficient operating quantity as indicated by its internal enable, 32QGE, not being asserted; see *Figure 4.13*), then the second listed directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.16*) provides directional control for the ground distance and residual ground overcurrent elements.

If the zero-sequence voltage-polarized directional element is not operable (i.e., it does not have sufficient operating quantity as indicated by its internal enable, 32VE, not being asserted; see *Figure 4.14*), then the third listed directional element (I = Channel IN Current-Polarized Directional Element; see *Figure 4.17*) provides directional control for the neutral ground and residual ground distance overcurrent elements.

If Channel IN Current-Polarized Directional Element is not operable (i.e., it does not have sufficient operating quantity as indicated by its internal enable, 32IE, not being asserted; see *Figure 4.17*), then no directional control is available. The ground distance and residual ground directional overcurrent elements will not operate.

Another example, if setting:

ORDER = **V**

then the zero-sequence voltage-polarized directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.16*) provides directional control for the ground distance and residual ground overcurrent elements at all times (assuming it has sufficient operating quantity). If there is not sufficient operating quantity during an event (i.e., internal enable 32VE is not asserted; see *Figure 4.14*), then no directional control is available. The ground distance and residual ground overcurrent elements will not operate.

Setting ORDER can be set with any element combination (e.g., ORDER = IQV, ORDER = QVI, ORDER = IV, ORDER = VQ, ORDER = I, ORDER = Q).

If ground quadrilateral distance elements are used, the first entry in the ORDER setting should be as shown in *Table 4.9*.

Table 4.9 First Entry in ORDER Setting if Ground Quadrilateral Distance Elements Are Used

Setting XGPOL	First Element of ORDER
IG	Q or V
I2	Q

Z2F—Forward Directional Z2 Threshold
Z2R—Reverse Directional Z2 Threshold

Setting Range:

–64.00 to 64.00 Ω secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

–320.00 to 320.00 Ω secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

Z2F and Z2R are used to calculate the Forward and Reverse Thresholds, respectively, for the negative-sequence voltage-polarized directional elements (see *Figure 4.15* and *Figure 4.20*).

If enable setting E32 = Y, settings Z2F and Z2R (negative-sequence impedance values) are calculated and entered by the user, but setting Z2R must be greater in value than setting Z2F by 0.2 Ω secondary (for 5 A nominal relays) or 1 Ω secondary (for 1 A nominal relays).

Z2F and Z2R Set Automatically

NOTE: If Z2F or Z2R exceeds the setting range, the quantity is set to the upper limit of the setting range.

If enable setting E32 = AUTO, settings Z2F and Z2R (negative-sequence impedance values) are calculated automatically, using the positive-sequence line impedance magnitude setting Z1MAG as follows:

Z2F = **Z1MAG/2** (Ω secondary)

Z2R = **Z1MAG/2 + z** (Ω secondary; “z” listed in table below)

Relay Configuration	z (Ω secondary)
5 A nominal current	0.2
1 A nominal current	1.0

Figure 4.23 and *Figure 4.24* and supporting text concern the zero-sequence impedance network, relay polarity, and the derivation of settings Z0F and Z0R. The same general approach outlined for deriving settings Z0F and Z0R can also be applied to deriving settings Z2F and Z2R in the negative-sequence impedance network, though the preceding method of automatically making settings Z2F and Z2R usually suffices.

50QFP—Forward Directional Negative-Sequence Current Pickup
50QRP—Reverse Directional Negative-Sequence Current Pickup

Setting Range:

0.25–5.00 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

0.05–1.00 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

The 50QFP setting ($3I_2$ current value) is the pickup for the forward fault detector 50QF of the negative-sequence voltage-polarized directional elements (see *Figure 4.13*). Ideally, the setting is above normal load unbalance and below the lowest expected negative-sequence current magnitude for unbalanced forward faults.

The 50QRP setting ($3I_2$ current value) is the pickup for the reverse fault detector 50QR of the negative-sequence voltage-polarized directional elements (see *Figure 4.13*). Ideally, the setting is above normal load unbalance and below the lowest expected negative-sequence current magnitude for unbalanced reverse faults.

50QFP and 50QRP Set Automatically

If enable setting E32 = AUTO, settings 50QFP and 50QRP are set automatically at:

50QFP = 0.50 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50QRP = 0.25 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50QFP = 0.10 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

50QRP = 0.05 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

a2—Positive-Sequence Current Restraint Factor, I_2/I_1

Setting Range:

0.02–0.50 (unitless)

Refer to *Figure 4.13*.

The a2 factor increases the security of the negative-sequence voltage-polarized directional elements. It keeps the elements from operating for negative-sequence current (system unbalance), which circulates due to line asymmetries, CT saturation during three-phase faults, etc.

a2 Set Automatically

If enable setting E32 = AUTO, setting a2 is set automatically at:

a2 = **0.1**

For setting a2 = 0.1, the negative-sequence current (I_2) magnitude has to be greater than 1/10 of the positive-sequence current (I_1) magnitude in order for the negative-sequence voltage-polarized directional elements to be enabled ($|I_2| > 0.1 \cdot |I_1|$).

k2—Zero-Sequence Current Restraint Factor, I_2/I_0

Setting Range:

0.10–1.20 (unitless)

Note the internal enable logic outputs in *Figure 4.13*:

- 32QE—internal enable for the negative-sequence voltage-polarized directional element that controls the phase distance and negative-sequence and phase overcurrent elements
- 32QGE—internal enable for the negative-sequence voltage-polarized directional element that controls the ground distance and residual ground overcurrent elements

The k2 factor is applied to internal enable 32QGE. The negative-sequence current (I_2) magnitude has to be greater than the zero-sequence current (I_0) magnitude multiplied by k2 in order for the 32QGE internal enable (and following negative-sequence voltage-polarized directional element in *Figure 4.15*) to be enabled:

$$|I_2| > k2 \cdot |I_0| \quad \textbf{Equation 4.1}$$

This check assures that the relay uses the most robust analog quantities in making directional decisions for the ground distance and residual-ground overcurrent elements.

The zero-sequence current (I_0), referred to in the above application of the k2 factor, is from the residual current (I_G), which is derived from phase currents I_A, I_B, and I_C:

$$I_0 = \frac{I_G}{3}$$

$$3I_0 = I_G = I_A + I_B + I_C \quad \textbf{Equation 4.2}$$

If both of the internal enables are deasserted, then factor k2 is ignored as a logic enable for the 32QGE internal enable. This effectively puts less restrictions on the operation of the negative-sequence voltage-polarized directional element.

- 32VE—internal enable for the zero-sequence voltage-polarized directional element that controls the ground distance and residual-ground overcurrent elements
- 32IE—internal enable for the channel **IN** current-polarized directional element that controls the ground distance and residual-ground overcurrent elements

k2 Set Automatically

If enable setting E32 = AUTO, setting k2 is set automatically at:

k2 = **0.2**

For setting k2 = 0.2, the negative-sequence current (I_2) magnitude has to be greater than 1/5 of the zero-sequence current (I_0) magnitude in order for the negative-sequence voltage-polarized directional elements to be enabled ($|I_2| > 0.2 \cdot |I_0|$). Again, this presumes at least one of the internal enables 32VE or 32IE is asserted.

50GFP—Forward Directional Residual Ground Current Pickup
50GRP—Reverse Directional Residual Ground Current Pickup

Setting Range:

0.25–5.00 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

0.05–1.00 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

If setting ORDER does not contain V or I (no zero-sequence voltage-polarized or channel IN current-polarized directional elements are enabled), then settings 50GFP and 50GRP are not made or displayed.

The 50GFP setting ($3I_0$ current value) is the pickup for the forward fault detector 50GF of the zero-sequence voltage-polarized and channel IN current-polarized directional elements (see *Figure 4.14*). Ideally, this setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced forward faults.

The 50GRP setting ($3I_0$ current value) is the pickup for the reverse fault detector 50GR of the zero-sequence voltage-polarized and channel IN current-polarized directional elements (see *Figure 4.14*). Ideally, this setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced reverse faults.

50GFP and 50GRP Set Automatically

If enable setting E32 = AUTO, settings 50GFP and 50GRP are set automatically at:

50GFP = 0.50 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50GRP = 0.25 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50GFP = 0.10 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

50GRP = 0.05 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

Operation of the Channel IN Current-Polarized Directional Element

Figure 4.17 shows the logic for the current polarized directional element for ground faults. The relay uses the directional characteristic shown in *Figure 4.22*, where the maximum torque line of the element is in phase with the polarizing current, I_N. This is suitable for solidly-grounded and most low-impedance grounded systems.

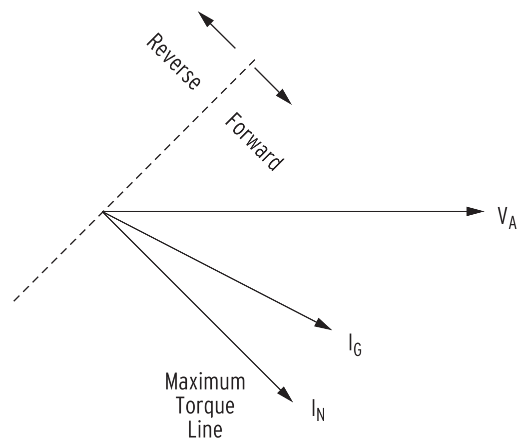


Figure 4.22 Traditional Channel IN Current-Polarized Directional Element

a0—Positive-Sequence Current Restraint Factor, I_0/I_1

Setting Range:

0.02–0.50 (unitless)

If setting ORDER does not contain V or I (no zero-sequence voltage-polarized or channel IN current-polarized directional elements are enabled), then setting a0 is not made or displayed.

Refer to *Figure 4.14*.

The a0 factor increases the security of the zero-sequence voltage-polarized and channel IN current-polarized directional elements. This factor keeps the elements from operating for zero-sequence current (system unbalance), which circulates due to line asymmetries, CT saturation during three-phase faults, etc.

The zero-sequence current (I_0), referred to in the application of the a0 factor, is from the residual current (I_G), which is derived from phase currents I_A, I_B, and I_C:

$$I_0 = \frac{I_G}{3}$$

$$3I_0 = I_G = I_A + I_B + I_C$$

Equation 4.3

a0 Set Automatically

If enable setting E32 = AUTO, setting a0 is set automatically at:

a0 = **0.1**

For setting a0 = 0.1, the zero-sequence current (I_0) magnitude has to be greater than 1/10 of the positive-sequence current (I_1) magnitude in order for the zero-sequence voltage-polarized and channel IN current-polarized directional elements to be enabled ($|I_0| > 0.1 \cdot |I_1|$).

Z0F—Forward Directional Z0 Threshold
Z0R—Reverse Directional Z0 Threshold

Setting Range:

–64.00 to 64.00 Ω secondary (300 V voltage inputs, **VA**, **VB**, **VC**; 5 A nominal phase current inputs, **IA**, **IB**, **IC**)

–320.00 to 320.00 Ω secondary (300 V voltage inputs, **VA**, **VB**, **VC**; 1 A nominal phase current inputs, **IA**, **IB**, **IC**)

If setting ORDER does not contain V (no zero-sequence voltage-polarized directional element is enabled), then settings Z0F and Z0R are not made by the user or displayed.

Z0F and Z0R are used to calculate the Forward and Reverse Thresholds, respectively, for the zero-sequence voltage-polarized directional element (see *Figure 4.16*).

If enable setting E32 = Y, settings Z0F and Z0R (zero-sequence impedance values) are calculated by the user and entered by the user, but setting Z0R must be greater in value than setting Z0F by 0.2 Ω secondary (for 5 A nominal relays) or 1 Ω secondary (for 1 A nominal relays).

Z0F and Z0R Set Automatically

NOTE: If Z0F or Z0R exceeds the setting range, the quantity is set to the upper limit of the setting range.

If enable setting E32 = AUTO, settings Z0F and Z0R (zero-sequence impedance values) are calculated automatically, using the zero-sequence line impedance magnitude setting Z0MAG as follows:

Z0F = **Z0MAG/2** (Ω secondary)

Z0R = **Z0MAG/2 + z** (Ω secondary; “z” listed in table below)

Relay Configuration	z (Ω secondary)
5 A nominal current	0.2
1 A nominal current	1.0

Deriving Z0F and Z0R Settings

Figure 4.23 shows the voltage and current polarity for an SEL-311C in a zero-sequence impedance network (the same approach can be instructive for negative-sequence impedance analysis, too). For a forward fault, the SEL-311C effectively sees the sequence impedance behind it as:

$Z_M = V_0/(-I_0) = -(V_0/I_0)$

$V_0/I_0 = -Z_M$ (what the relay sees for a forward fault)

For a reverse fault, the SEL-311C effectively sees the sequence impedance in front of it:

$Z_N = V_0/I_0$

$V_0/I_0 = Z_N$ (what the relay sees for a reverse fault)

If the system in *Figure 4.23* is a solidly-grounded system (mostly inductive; presume uniform system angle), and the load is connected line-to-neutral, the impedance plot (in the R + jX plane) would appear as in *Figure 4.24a*, with resultant Z0F and Z0R settings as in *Figure 4.24b*. The zero-sequence line angle noted in *Figure 4.24a* (∠Z0ANG) is the same angle found in *Figure 4.16* (in the equation box with the Enable line).

The preceding method of automatically making settings Z0F and Z0R (where both Z0F and Z0R are positive values and Z0R > Z0F) usually suffices for mostly inductive systems—*Figure 4.23* and *Figure 4.24* just provide a theoretical background.

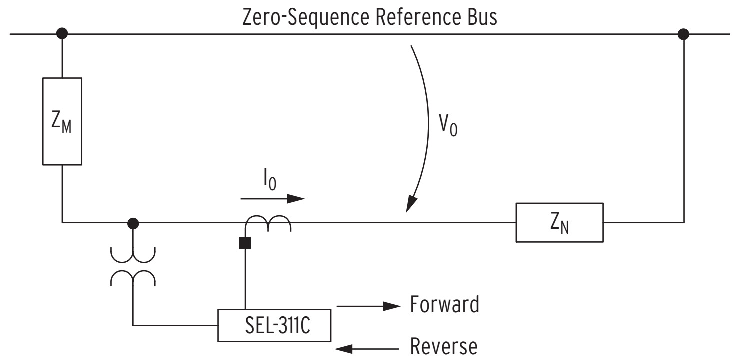


Figure 4.23 Zero-Sequence Impedance Network and Relay Polarity

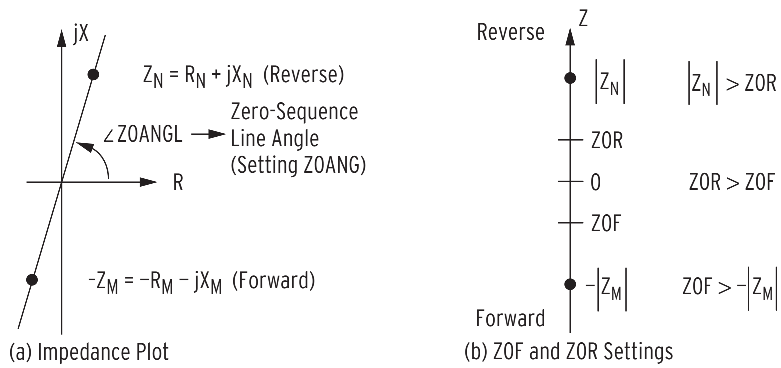


Figure 4.24 Zero-Sequence Impedance Plot for Solidly-Grounded, Mostly Inductive System

E32IV—SELOGIC Control Equation Enable

Refer to *Figure 4.14*.

SELOGIC control equation setting E32IV must be asserted to logical 1 to enable the zero-sequence voltage-polarized and channel IN current-polarized directional elements for directional control of ground distance and residual ground overcurrent elements.

For most applications, set E32IV directly to logical 1:

E32IV = **1** (numeral 1)

For situations where zero-sequence source isolation can occur (e.g., by opening a circuit breaker) and result in possible mutual coupling problems for the zero-sequence voltage-polarized and channel IN current-polarized directional elements, SELOGIC control equation setting E32IV should be deasserted to logical 0. In this example, connect a circuit breaker auxiliary contact from the isolating circuit breaker to the SEL-311C:

E32IV = **IN106** (52a connected to optoisolated input **IN106**)

Almost any desired control can be set in SELOGIC control equation setting E32IV.

Overcurrent Directional Control Provided by Torque Control Settings

Directional and additional control for phase, ground, and negative-sequence overcurrent elements is available with SELOGIC torque control settings. Elements that do not have directional control, such as 67P1, may be directionally controlled with SELOGIC control equations.

For example, the SELOGIC control equation

67P1TC = **M2P + ILOP**

will enable 67P1 and 67P1T when the Zone 2 phase distance element asserts (forward), or during a loss-of-potential condition (ILOP = logical 1).

The default settings for all torque control equations is logic “1,” or “enabled.” Torque control equations may not be set directly to logic “0.”

Table 4.10 Torque Control Settings and Elements

Torque Control Setting	Controlled Element	Directional and Additional Control Settings	Reference
67P1TC	67P1/67P1T	Torque Control	*Figure 3.25*
67P2TC	67P2/67P2T	Torque Control	
67P3TC	67P3/67P3T	Torque Control	
67P4TC	67P4/67P4T	Torque Control	
67G1TC	67G1/67G1T	Forward and Torque Control	*Figure 3.29*
67G2TC	67G2/67G2T	Forward and Torque Control	
67G3TC	67G3/67G3T	DIR3 = F or R and Torque Control	
67G4TC	67G4/67G4T	DIR4 = F or R and Torque Control	
67Q1TC	67Q1/67Q1T	Forward and Torque Control	*Figure 3.30*
67Q2TC	67Q2/67Q2T	Forward and Torque Control	
67Q3TC	67Q3/67Q3T	DIR3 = F or R and Torque Control	
67Q4TC	67Q4/67Q4T	DIR4 = F or R and Torque Control	
51PTC	51P/51PT	Torque Control	*Figure 3.31*
51GTC	51G/51GT	Torque Control	*Figure 3.32*
51QTC	51Q/51QT	Torque Control	*Figure 3.33*

Section 5
Trip and Target Logic

Overview

This section provides a detailed explanation for the SEL-311C trip and targeting functions, including logic diagrams for the communications-assisted tripping schemes. Each subsection provides an explanation of the function, along with a list of the corresponding settings and Relay Word bits, and a description of the factory default values for certain settings.

The target logic subsection explains both the traditional fixed target behavior and the optional programmable target and status LED functionality.

The logic is described in the following subsections:

Trip Logic

Trip Logic Settings

NOTE: Trip logic is also used in the relay to illuminate front panel trip target LEDs and generate an oscillographic event report record.

The trip logic in *Figure 5.1*provides flexible tripping with SELOGIC control equation settings:

TRCOMM Communications-Assisted Trip Conditions—Setting TRCOMM is supervised by communications-assisted trip logic. See *Communications-Assisted Trip Logic—General Overview on page 5.12* for more information on communications-assisted tripping.

DTT Direct Transfer Trip Conditions—Note in *Figure 5.1* that setting DTT is unsupervised. Any element that asserts in setting DTT will cause Relay Word bit TRIP to assert to logical 1.

Although setting TR and TRQUAL are also unsupervised, setting DTT is provided separately from setting TR and TRQUAL for target LED purposes (the default **COMM** target LED on the front panel illuminates when DTT asserts to logical 1; see *COMM Target LED on page 5.34*).

A typical setting for DTT is:

DTT = **IN106**

or

DTT = **RMB1A**

where input **IN106** is connected to the output of direct transfer trip communications equipment or receive MIRRORED BIT RMB1A is asserted by the transfer trip condition in a remote SEL relay.

Setting DTT is also used for Direct Underreaching Transfer Trip (DUTT) schemes.

TRSOTF Switch-Onto-Fault Trip Conditions—Setting TRSOTF is supervised by the switch-onto-fault logic enable SOTFE and optionally, the disturbance detector when EDDSOFT = Y. See *Switch-Onto-Fault (SOTF) Trip Logic on page 5.8* for more information on switch-onto-fault logic.

TR Other Trip Conditions—Setting TR is the SELOGIC control equation trip setting most often used for general protection if tripping does not involve communications-assisted (settings TRCOMM and DTT) or switch-onto-fault (setting TRSOTF) trip logic, or instantaneous elements (often used in the TRQUAL equation).

Note in *Figure 5.1* that setting TR is unsupervised. Any element that asserts in setting TR will cause Relay Word bit TRIP to assert to logical 1.

The TR equation is appropriate for automation and control trips, such as breaker open commands, operator control pushbuttons, or out-of-step trip conditions. These conditions may be present for only one processing interval, but the SEL-311C issues a TRIP immediately upon evaluating the TR equation to logical 1.

TRQUAL Qualified Trip Conditions—The SEL-311C has self-test functions to detect most hardware problems and prevent misoperation. A small number of transient memory or processor errors may not be detected. The TRQUAL equation and EDDSOTF Switch-Onto-Fault supervision improve security for these transient conditions without increasing relay operating time under most fault conditions. Setting TRQUAL is supervised by the disturbance detector logic, as shown in *Figure 5.1*. The disturbance detector (DD) logic detail is shown in *Figure 4.2*.

When the SEL-311C evaluates the TRQUAL equation to logical 1, the relay trips immediately if the DD Relay Word bit is already asserted. If DD is not asserted, the relay waits up to two cycles for DD to assert. If the TRQUAL equation remains asserted the relay trips after the timer expires.

The disturbance detector is very sensitive to fault conditions, and will almost always assert before a Zone 1 element asserts for a new fault condition. The DD element also contains a 10-cycle dropout timer to maintain a logical 1 for a reasonable period after a disturbance is detected. Using the TRQUAL equation for Zone 1 elements or instantaneous overcurrent elements will almost never increase operating time.

Security is improved when the TRQUAL equation is asserted momentarily because of a transient memory or processor error, but the disturbance detector does not assert. If the TRQUAL equation resets before the two-cycle timer expires, no TRIP is issued.

Use the TRQUAL setting with instantaneous elements, such as in the setting:

TRQUAL = **M1P + Z1G**

Overcurrent or distance elements that contain an intentional time delay may be used in the TRQUAL equation. In certain conditions, such as during bench testing with delays set longer than 10 cycles, the disturbance detector element may deassert before the time-delayed element asserts in the TRQUAL equation. This adds two cycles to the overall trip time.

For example, if setting TRQUAL contains a negative-sequence time-overcurrent element:

TRQUAL = **... + 51QT**

the observed trip time may be up to two cycles longer than the expected time-overcurrent characteristic. For backup protection delays lasting several seconds, this extra time is of no consequence. If this extra delay is not desirable, use the time-delayed elements in the TR equation instead.

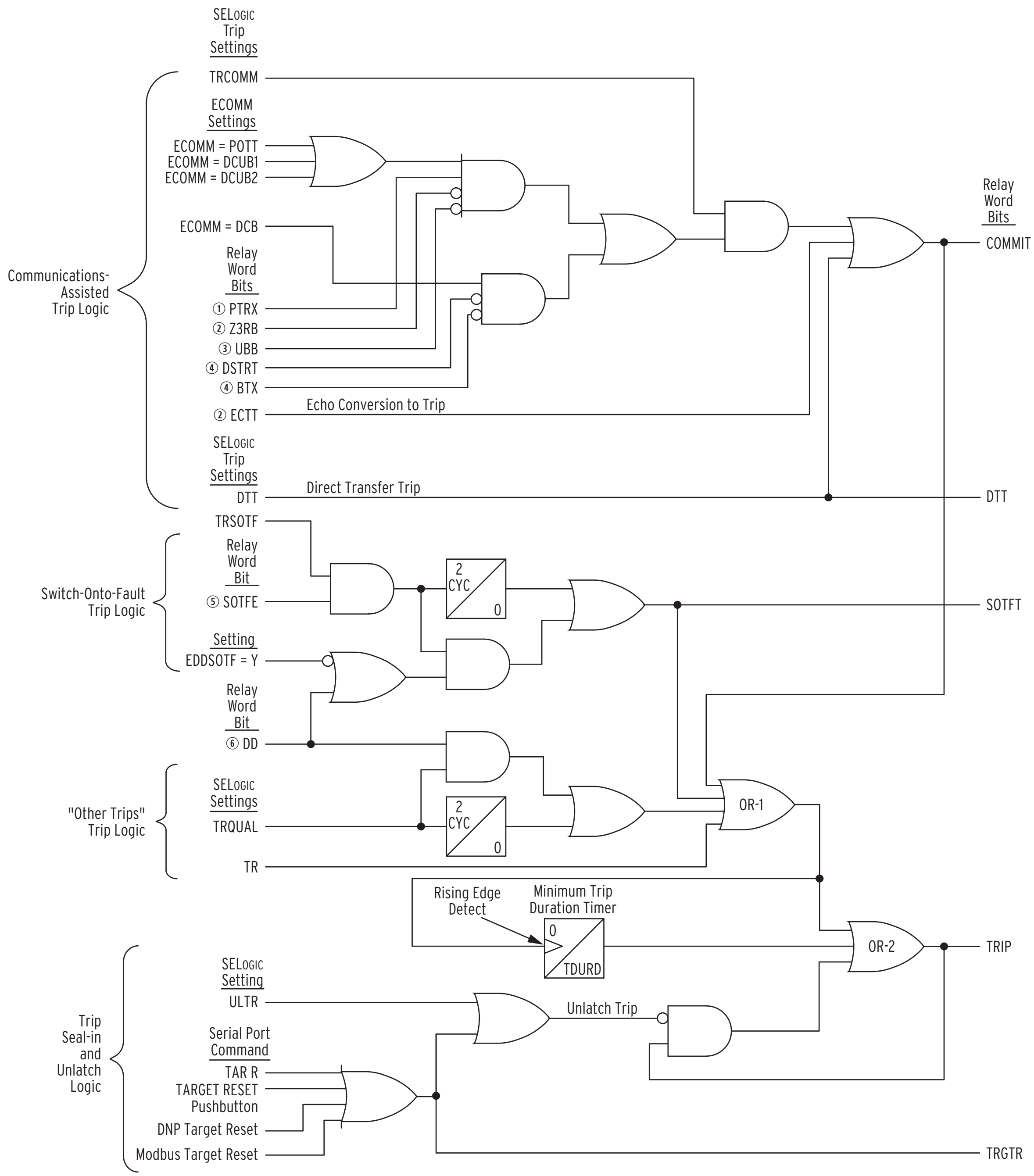
Elements that assert for nonfault conditions, such as breaker open commands, operator control pushbuttons, or out-of-step trip conditions, should not be used in the TRQUAL equation. The reason is that the asserted condition may only exist for one processing interval, and the DD bit will often be quiescent. This situation will sometimes result in a nontrip. Use the unsupervised TR setting for automation or control tripping instead.

Setting EDDSOTF = Y enables similar supervision for the switch-onto-fault logic.

ULTR Unlatch Trip Conditions—The ULTR SELOGIC control equation defines the conditions that must be true before the TRIP bit can reset. Most often this is set with the inverted current elements to indicate that the breaker is open when they deassert, or the inverted 52A breaker status bit, or a combination of current and breaker status elements.

TDURD Minimum Trip Duration Time—This timer establishes the minimum time duration for which the TRIP Relay Word bit asserts. This is a rising-edge initiated timer. The settable range for this timer is 4–16,000 cycles. See *Figure 5.2*.

More than one trip setting (or all five trip settings TRCOMM, DTT, TRSOTF, TR, and TRQUAL) can be set. For example, in a communications-assisted trip scheme, TRCOMM is set with direction forward overreaching Level 2 distance elements, TRQUAL is set with direction forward underreaching Level 1 distance elements and other time delayed elements (e.g., Zone 2 definite-time distance elements), and TRSOTF is set with instantaneous directional and nondirectional elements.



① From Figure 5.7; ② from Figure 5.6; ③ Figure 5.11; ④ from Figure 5.14; ⑤ from Figure 5.3; ⑥ from Figure 4.1.

Figure 5.1 Trip Logic

Set Trip

Refer to *Figure 5.1*. All trip conditions:

- ➤ Communications-Assisted Trip
- ➤ Direct Transfer Trip
- ➤ Switch-Onto-Fault Trip
- ➤ Breaker Manual Trip
- ➤ Other Trips

are combined into OR-1 gate. The output of OR-1 gate asserts Relay Word bit TRIP to logical 1, regardless of other trip logic conditions. It also is routed into the Minimum Trip Duration Timer (setting TDURD).

As shown in the time line example in *Figure 5.2*, the Minimum Trip Duration Timer (with 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 (timer is reset). The TDURD timer assures that the TRIP Relay Word bit remains asserted at logical 1 for a *minimum* of "TDURD" cycles. If the output of OR-1 gate is logical 1 beyond the TDURD time, Relay Word bit TRIP remains asserted at logical 1 for as long as the output of OR-1 gate remains at logical 1, regardless of other trip logic conditions.

The Minimum Trip Duration Timer can be set no less than 4 cycles.

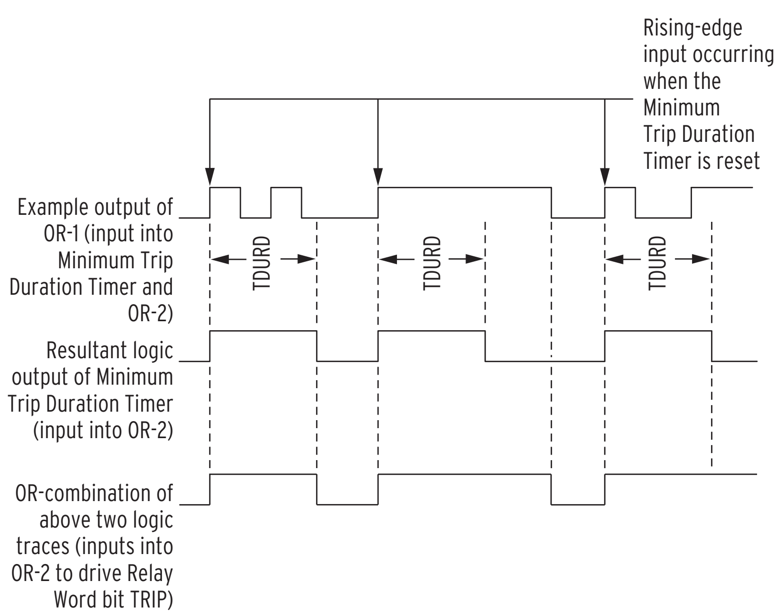


Figure 5.2 Minimum Trip Duration Timer Operation (See Bottom of Figure 5.1)

Unlatch Trip

Once Relay Word bit TRIP is asserted to logical 1, it remains asserted at logical 1 until all the following conditions come true:

- Minimum Trip Duration Timer stops timing (logic output of the TDURD timer goes to logical 0)
- Output of OR-1 gate deasserts to logical 0
- One of the following occurs:
  - SELOGIC control equation setting ULTR asserts to logical 1
  - The front-panel **TARGET RESET** pushbutton is pressed
  - The **TAR R** (Target Reset) command is executed via the serial port
  - A Target Reset command is received from a DNP or Modbus master

The front-panel **TARGET RESET** pushbutton, the **TAR R** (Target Reset) serial port command, and the DNP or Modbus target reset commands are used to force the TRIP Relay Word bit to logical 0 if setting ULTR does not assert to unlatch the trip. This might occur during testing or when ULTR has been set to logical 0. Setting ULTR = 0 allows TRIP to stay asserted until the targets are reset by the front-panel **TARGET RESET** pushbutton, the **TAR R** command, or the DNP or Modbus Target Reset. This allows the relay to provide a lockout function.

SELOGIC control equation RSTTRGT (see *SELOGIC Control Equation Setting RSTTRGT on page 5.41*) does not unlatch TRIP. See *Optional Logic to Clear Trip Seal-In and Reset Targets on page 5.42* for more information.

Other Applications for the Target Reset Function

Refer to the bottom of *Figure 5.1*. Note that the combination of the **TARGET RESET** pushbutton, the DNP and Modbus target reset inputs, and the **TAR R** (Target Reset) serial port command is also available as Relay Word bit TRGTR. See *Figure 5.18* and accompanying text for applications for Relay Word bit TRGTR.

Factory Settings Example (Using Setting TR and TRQUAL)

In this example the “communications-assisted” and “switch-onto-fault” trip logic at the top of *Figure 5.1* are not used. The SELOGIC control equation trip settings TR and TRQUAL are now the only inputs into OR-1 gate and flow into the “seal-in and unlatch” logic for Relay Word bit TRIP.

The factory settings for the trip logic SELOGIC control equation settings depend on the potential transformer configuration.

For wye-connected PTs (Global setting PTCONN = WYE):

TR = **M2PT + Z2GT + 51GT + 51QT + OC** (time-delayed and control trip conditions)

TRQUAL = **M1P + Z1G** (instantaneous trip conditions)

ULTR = **!(50L + 51G)** (unlatch trip conditions)

For delta-connected PTs (Global setting PTCONN = DELTA):

TR = **M2PT + 51GT + 51QT + OC** (time delayed and control trip conditions)

TRQUAL = **M1P** (instantaneous trip conditions)

ULTR = **!(50L + 51G)** (unlatch trip conditions)

The factory setting for the Minimum Trip Duration Timer setting is shown below:

TDURD = **9.00 cycles**

See the settings sheets in *Section 9: Setting the Relay* for setting ranges.

Set Trip (Wye-connected PT settings shown)

In SELOGIC control equation setting TR = **M2PT + Z2GT + 51GT + 51QT + OC**

- ➤ Distance elements M2PT and Z2GT and time-overcurrent elements 51GT and 51QT trip directly. Time-overcurrent and definite-time overcurrent elements can be torque controlled (e.g., elements 51GT and 51QT are torque-controlled by SELOGIC control equation settings 51GTC and 51QTC, respectively). Check torque control settings to see if any control is applied to time-overcurrent and definite-time-overcurrent elements. Such control is not apparent by mere inspection of trip setting TR or any other SELOGIC control equation trip setting.
- ➤ Relay Word bit OC asserts for execution of the **OPEN** Command. See **OPE** Command (Open Breaker) on page 10.36 for more information on the **OPEN** Command.

NOTE: Do not use Relay Word bits that assert momentarily in the TRQUAL equation. For example, the open breaker command Relay Word bit OC, or optional operator control pushbuttons (e.g., PB10PUL) only assert for one processing interval, and may not cause a trip using the TRQUAL equation in some situations. Use these types of Relay Word bits in the TR equation instead.

In SELOGIC control equation setting TRQUAL = **M1P + Z1G**

- ➤ Distance elements M1P and Z1G trip directly, subject to supervision by the Disturbance Detector Relay Word bit (DD) as described in *TRQUAL Qualified Trip Conditions on page 5.2*.

With setting TDURD = 9.00 cycles, once the TRIP Relay Word bit asserts via the trip logic, it remains asserted for a minimum of 9 cycles.

Unlatch Trip

In SELOGIC control equation setting ULTR = !(50L + 51G), both elements must be deasserted before the trip logic unlatches and the TRIP Relay Word bit deasserts to logical 0.

Additional Settings Examples

The factory setting for SELOGIC control equation setting ULTR is a current-based trip unlatch condition. A circuit breaker status unlatch trip condition can be programmed as shown in the following examples.

Unlatch Trip With 52a Circuit Breaker Auxiliary Contact

A 52a circuit breaker auxiliary contact is wired to optoisolated input **IN101**.

52A = **IN101** (SELOGIC control equation circuit breaker status setting—see *Optoisolated Inputs on page 7.2*)

ULTR = **!52A**

Input **IN101** has to be de-energized (52a circuit breaker auxiliary contact has to be open) before the trip logic unlatches and the TRIP Relay Word bit deasserts to logical 0.

ULTR = **!52A** = NOT(52A)

Unlatch Trip With 52b Circuit Breaker Auxiliary Contact

A 52b circuit breaker auxiliary contact is wired to optoisolated input **IN101**.

52A = **!IN101** (SELOGIC control equation circuit breaker status setting—see *Optoisolated Inputs on page 7.2*)

ULTR = **!52A**

Input **IN101** must be energized (52b circuit breaker auxiliary contact has to be closed) before the trip logic unlatches and the TRIP Relay Word bit deasserts to logical 0.

Program Output Contacts for Tripping

In the factory settings, the result of the trip logic in *Figure 5.1* is routed to output contacts OUT101 and OUT102 with the following SELOGIC control equation settings:

OUT101 = **TRIP**

OUT102 = **TRIP**

If more than two TRIP output contacts are needed, program other output contacts with the TRIP Relay Word bit. Examples of uses for additional TRIP output contacts:

- Tripping more than one breaker
- Keying an external breaker failure relay
- Keying communication equipment in a Direct Transfer Trip scheme

See *Output Contacts on page 7.33* for more information on programming output contacts.

TRIP Used in Other Settings

Besides operating a trip output contact (e.g., OUT101 = TRIP), the TRIP Relay Word bit is used in a number of other factory-default SELOGIC control equations settings:

ULCL = **TRIP** unlatch close—see *Figure 6.3*

79RI = **TRIP** reclose initiate—see *Table 6.4* and following explanation

79STL = **TRIP** stall open interval timing—see *Table 6.4* and following explanation

79BRS = **TRIP** block reset timing—see *Table 6.4* and following explanation

BKMON = **TRIP** breaker monitor initiation—see *Breaker Monitor on page 8.1*

Switch-Onto-Fault (SOTF) Trip Logic

Switch-Onto-Fault (SOTF) trip logic provides a programmable time window for selected elements to trip right after the circuit breaker closes. “Switch-onto-fault” implies that a circuit breaker is closed into an existing fault condition, such as when safety grounds are accidentally left attached to a line. If the circuit breaker is closed into such a condition, the resulting fault needs to be cleared right away and reclosing blocked. An instantaneous element is usually set to trip in the SOTF trip logic.

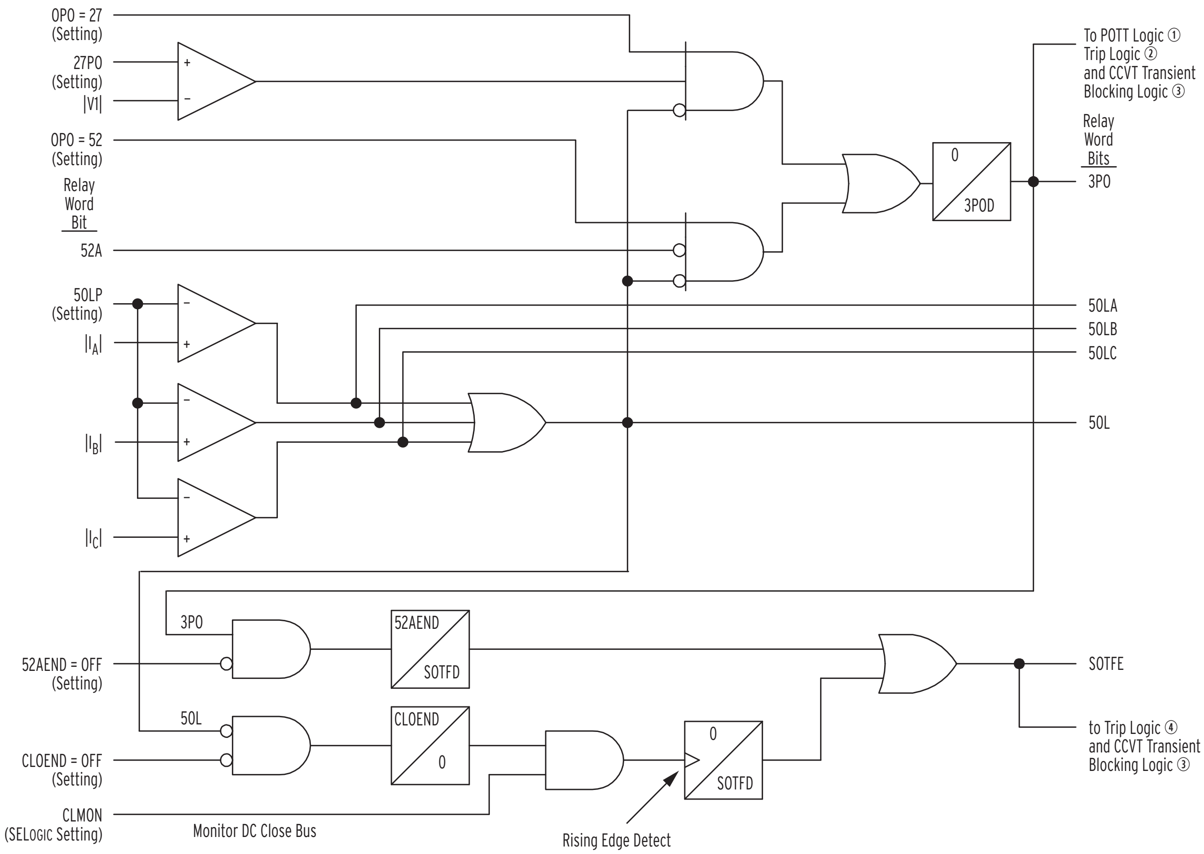
For added security, the SEL-311C features a selectable disturbance detector supervision function on the switch-onto-fault trip condition. Enable this logic by setting EDDSOTF = Y. The operation is described below.

Refer to the switch-onto-fault trip logic in *Figure 5.1* (middle of figure). The SOTF trip logic permits tripping if *both* the following occur:

- ➤ An element asserts in SELOGIC control equation trip setting TRSOTF
- ➤ Relay Word bit SOTFE is asserted to logical 1

The SEL-311C asserts Relay Word bit SOTFT to indicate that a switch-onto-fault trip has been initiated.

Relay Word bit SOTFE (the output of the SOTF logic) provides the effective time window for an element in trip setting TRSOTF (e.g., TRSOTF = 50P2) to trip after the circuit breaker closes. *Figure 5.3* and the following discussion describe the three-pole open (3PO) logic and the SOTF logic.



① To Figure 5.6; ② to Figure 4.1; ③ to Figure 4.9; ④ to Figure 5.1.

Figure 5.3 Three-Pole Open Logic (Top) and Switch-Onto-Fault Logic (Bottom)

Three-Pole Open Logic

Three-pole open (3PO) logic is the top half of *Figure 5.3*. It is not affected by enable setting ESOTF (see *Other Enable Settings on page SET.7*).

The open circuit breaker condition is determined by load current (50L) and either one of:

- ➤ Circuit breaker status (52A = logical 0)
- ➤ Positive-sequence voltage (|V1| < 27PO)

Select OPO = 52 if 3PO is to be determined by circuit breaker status. Select OPO = 27 if 3PO is to be determined by positive-sequence voltage.

If OPO = 52, *and* the circuit breaker is open (52A = logical 0), and the currents on all three phases are below phase pickup 50LP (50L = logical 0), then the three-pole open (3PO) condition is true:

3PO = **logical 1** (circuit breaker open)

If OPO = 27, *and* |V1| is less than setting 27PO, *and* current is below phase pickup 50LP (50L = logical 0), then the three-pole open (3PO) condition is true:

3PO = **logical 1** (circuit breaker open)

The 3POD dropout time qualifies circuit breaker closure, whether detected by circuit breaker status (52A), positive-sequence voltage, or load current level (50L). When the circuit breaker is closed:

3PO = **logical 0** (circuit breaker closed)

Note that the 3PO condition is also routed to the permissive overreaching transfer trip (POTT) logic (see *Figure 5.6*) and the loss-of-potential (LOP) logic (see *Figure 4.1*).

Determining Three-Pole Open Condition Without Circuit Breaker Auxiliary Contact (OPO = 52)

If a circuit breaker auxiliary contact is not connected to the SEL-311C and OPO = 52, SELOGIC control equation setting 52A may be set:

52A = **0** (numeral 0)

With SELOGIC control equation setting 52A continually at logical 0, 3PO logic is controlled solely by load detection element 50L. Phase pickup 50LP is set below load current levels.

When the circuit breaker is open, Relay Word bit 50L drops out (= logical 0) and the 3PO condition asserts:

3PO = **logical 1** (circuit breaker open)

When the circuit breaker is closed, Relay Word bit 50L picks up (= logical 0; current above phase pickup 50LP) and the 3PO condition deasserts after the 3POD dropout time:

3PO = **logical 0** (circuit breaker closed)

Circuit Breaker Operated Switch-Onto-Fault Logic

Circuit breaker operated switch-onto-fault logic is enabled by making time setting 52AEND (52AEND ≠ OFF). Time setting 52AEND qualifies the three-pole open (3PO) condition and then asserts Relay Word bit SOTFE:

SOTFE = **logical 1**

Note that SOTFE is asserted when the circuit breaker is open. This allows elements set in the SELOGIC control equation trip setting TRSOTF to operate if a fault occurs when the circuit breaker is open (see *Figure 5.1*). In such a scenario (e.g., flashover inside the circuit breaker tank), the tripping via setting TRSOTF cannot help in tripping the circuit breaker (the circuit breaker is already open), but can initiate breaker failure protection, if a breaker failure scheme is implemented in the SEL-311C or externally (see example in *Figure 7.26*).

When the circuit breaker is closed, the 3PO condition deasserts (3PO = logical 0) after the 3POD dropout time (setting 3POD is usually set for no more than a cycle). The SOTF logic output, SOTFE, continues to remain asserted at logical 1 for dropout time SOTFD time.

Close Bus Operated Switch-Onto-Fault Logic

Close bus operated switch-onto-fault logic is enabled by making time setting CLOEND (CLOEND ≠ OFF). Time setting CLOEND qualifies the deassertion of the load detection element 50L (indicating that the circuit breaker is open).

Circuit breaker closure is detected by monitoring the dc close bus. This is accomplished by wiring an optoisolated input on the SEL-311C (e.g., **IN105**) to the dc close bus. When a manual close or automatic reclosure occurs, optoisolated input **IN105** is energized. SELOGIC control equation setting CLMON (close bus monitor) monitors the optoisolated input **IN105**:

CLMON = **IN105**

When optoisolated input **IN105** is energized, CLMON asserts to logical 1. At the instant that optoisolated input **IN105** is energized (close bus is energized), the circuit breaker is still open so the output of the CLOEND timer continues to be asserted to logical 1. Thus, the ANDed combination of these conditions latches in the SOTFD timer. The SOTFD timer outputs a logical 1 for a time duration of "SOTFD" cycles any time it sees a *rising edge* on its input (logical 0 to logical 1 transition), if it is not already timing. The SOTF logic output, SOTFE, asserts to logical 1 for SOTFD time.

Switch-Onto-Fault Logic Output (SOTFE)

Relay Word bit SOTFE is the output of the circuit breaker operated SOTF logic or the close bus operated SOTF logic described previously. Time setting SOTFD in each of these logic paths provides the effective time window for the instantaneous elements in SELOGIC control equation trip setting TRSOTF to trip after the circuit breaker closes (see *Figure 5.1*—middle of figure). Time setting SOTFD is usually set around 30 cycles.

Relay Word bit SOTFT asserts when a switch-onto-fault trip has been generated. SOTFT may be helpful for programmable target logic, testing, and reporting functions.

A SOTF trip illuminates the **SOTF** default front-panel LED.

Disturbance Detector Supervision for Switch-Onto-Fault Logic

The SEL-311C features a selectable disturbance detector supervision function on the switch-onto-fault trip condition. Enable this logic by setting EDDSOTF = Y, which is the factory default selection.

Refer to *Figure 5.1* for the EDDSOTF influence on the SOTF logic.

When EDDSOTF = N, the switch-onto-fault logic works with no DD supervision, and the relay immediately asserts SOTFT and issues a TRIP when TRSOTF evaluates to logical 1 with SOTFE asserted.

When EDDSOTF = Y, the relay checks the state of the Disturbance Detector (DD) Relay Word bit when TRSOTF evaluates to logical 1 with SOTFE asserted.

- If DD is asserted, the relay immediately asserts the SOTFT output, which causes an immediate trip.
- If DD is not asserted, and the TRSOTF and SOTFE conditions remain asserted, the relay delays the SOTFT assertion for up to 2 cycles (until the DD element asserts, or until the 2-cycle wait time expires).
- If one of the TRSOTF or SOTFE conditions deassert before the 2 cycle timer expires, and the DD bit does not assert, no trip is issued. This provides a security improvement in cases where an element in the TRSOTF equation was transient.

The relay also uses the disturbance detector in the TRQUAL equation, as described in *TRQUAL Qualified Trip Conditions on page 5.2*.
The disturbance detector is very sensitive to fault conditions, and will almost always assert before a high-set overcurrent element asserts for a new fault condition. The DD element also contains a 10-cycle dropout timer to maintain a logical 1 for a reasonable period after a disturbance is detected. Using the EDDSOTF= Y setting while using instantaneous overcurrent elements or distance elements in the SOTF equation will almost never increase operating time.

Use the TRSOTF setting with instantaneous elements, such as in the factory default setting:

TRSOTF = **M2P+Z2G+50P1** (when PTCONN = WYE; wye-connected PTs)

TRSOTF = **M2P+ 50P1** (when PTCONN = DELTA; delta-connected PTs)

Switch-Onto-Fault Trip Logic Trip Setting (TRSOTF)

An instantaneous element is usually set to trip in the SELOGIC control equation trip setting TRSOTF (e.g., TRSOTF = M2P + Z2G + 50P1).

If the voltage potential for the relay is from the line-side of the circuit breaker, the instantaneous overcurrent element in the SELOGIC control equation trip setting TRSOTF should be nondirectional. When the circuit breaker is open and the line is de-energized, the relay sees zero voltage. If a close-in three-phase fault condition exists on the line (e.g., safety grounds accidentally left attached to the line after a clearance) and then the circuit breaker is closed, the relay continues to see zero voltage. The directional elements have no voltage for reference and cannot operate. The disturbance detector is very sensitive to fault conditions, and will almost always be asserted before a high-set overcurrent element asserts for a new fault condition. The DD element also contains a 10-cycle dropout timer to maintain a logical 1 for a reasonable period after a disturbance is detected. In other words, using the EDDSOTF= Y setting while using instantaneous overcurrent elements or distance elements in the SOTF equation will almost never impair protection speed.

Communications-Assisted Trip Logic—General Overview

The SEL-311C includes communications-assisted tripping schemes that provide unit-protection for transmission lines with the help of communications. No external coordination devices are required.

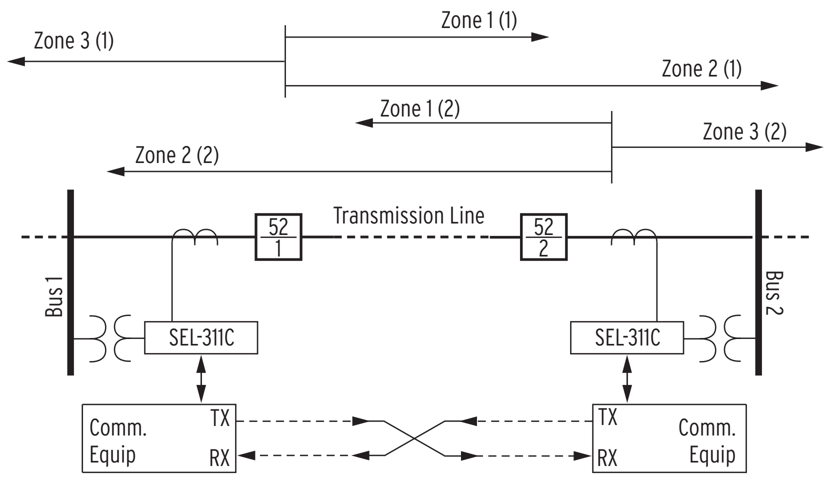


Figure 5.4 Communications-Assisted Tripping Scheme

Refer to *Figure 5.4* and the top of *Figure 5.1* .

The six available tripping schemes are:

- ➤ Direct Transfer Trip (DTT)
- ➤ Direct Underreaching Transfer Trip (DUTT)
- ➤ Permissive Overreaching Transfer Trip (POTT)
- ➤ Directional Comparison Unblocking (DCUB)
- ➤ Directional Comparison Blocking (DCB)

Enable Setting ECOMM

The POTT, PUTT, DCUB, and DCB tripping schemes are enabled with setting ECOMM. Setting choices are:

ECOMM = **N** [no communications-assisted trip scheme enabled]

ECOMM = **POTT** [POTT or PUTT scheme]

ECOMM = **DCUB1** [DCUB scheme for two-terminal line (communications from *one* remote terminal)]

ECOMM = **DCUB2** [DCUB scheme for three-terminal line (communications from *two* remote terminals)]

ECOMM = **DCB** [DCB scheme]

These tripping schemes can all work in two-terminal or three-terminal line applications. The DCUB scheme requires separate settings choices for these applications (ECOMM = DCUB1 or DCUB2) because of unique DCUB logic considerations.

These tripping schemes require Zone/Level 3 elements set direction reverse (setting DIR3 = R). Note that Zone 1 and Zone 2 are fixed in the forward direction.

See *Directional Control Settings on page 4.29* for more information on Zone/Level direction settings DIR3 and DIR4.

POTT, PUTT, DCUB, and DCB communications-assisted tripping schemes are explained in subsections that follow.

Trip Setting TRCOMM

The POTT, PUTT, DCUB, and DCB tripping schemes use SELOGIC control equation trip setting TRCOMM for those tripping elements that are supervised by the communications-assisted trip logic (see top of *Figure 5.1*). Setting TRCOMM is typically set with Level 2 overreaching distance elements (fixed direction forward):

M2P Zone 2 phase distance instantaneous element

Z2G Zone 2 ground distance instantaneous element

The exception is a DCB scheme (see *Figure 5.14*), where Zone 2 overreaching distance elements (set direction forward) with a short delay are used instead. The short delays provide necessary carrier coordination delays (waiting for the block trip signal). These elements are entered in trip setting TRCOMM.

Trip Settings TRSOTF, TRQUAL, and TR

In a communications-assisted trip scheme, the SELOGIC control equation trip settings TRSOTF, TRQUAL, and TR can also be used, in addition to setting TRCOMM.

Setting TRSOTF can be set as described in *Switch-Onto-Fault (SOTF) Trip Logic on page 5.8*.

Setting TRQUAL is typically set with unsupervised Level 1 underreaching elements (fixed direction forward):

M1P Zone 1 phase distance instantaneous element

Z1G Zone 1 ground distance instantaneous element

67G1 Level 1 directional residual ground instantaneous overcurrent element

67Q1 Level 1 directional negative-sequence instantaneous overcurrent element

The SEL-311C allows instantaneous tripping for elements in the TRQUAL equation when Relay Word bit DD is asserted. If an element in the TRQUAL setting asserts in isolation from a disturbance detector operation, the trip will be delayed for two cycles. See *TRQUAL Qualified Trip Conditions on page 5.2* for full details.

Trip Setting DTT

The DTT and DUTT tripping schemes are realized with SELOGIC control equation trip setting DTT, discussed at the beginning of this section.

Use Existing SEL-321 Application Guides for the SEL-311C

The communications-assisted tripping schemes settings in the SEL-311C are very similar to those in the SEL-321. Existing SEL-321 application guides can also be used in setting up these schemes in the SEL-311C. The following application guides are available from SEL:

- ➤ AG93-06 *Applying the SEL-321 Relay to Directional Comparison Blocking (DCB) Schemes*
- ➤ AG95-29 *Applying the SEL-321 Relay to Permissive Overreaching Transfer Trip (POTT) Schemes*
- ➤ AG96-19 *Applying the SEL-321 Relay to Directional Comparison Unblocking (DCUB) Schemes*

The major differences are how the optoisolated input settings and the trip settings are made. The following explanations describe these differences.

Optoisolated Input Settings Differences Between the SEL-321 and SEL-311C Relays

The SEL-311C does not have optoisolated input settings like the SEL-321. Rather, the optoisolated inputs of the SEL-311C are available because Relay Word bits are used in SELOGIC control equations. The following optoisolated input setting example is for a Permissive Overreaching Transfer Trip (POTT) scheme.

SEL-321	SEL-311C	
IN102 = PT	PT1 = IN102	(received permissive trip)

In the above SEL-311C setting example, Relay Word bit IN102 is set in the PT1 SELOGIC control equation. Optoisolated input **IN102** is wired to a communications equipment receiver output contact. Relay Word bit IN102 can also be used in other SELOGIC control equations in the SEL-311C. See *Optoisolated Inputs on page 7.2* for more information on optoisolated inputs.

Trip Settings Differences Between the SEL-321 and SEL-311C Relays

Some of the SELOGIC control equation trip settings of the SEL-321 and SEL-311C relays are not operationally different, just labeled differently. The correspondence is:

SEL-321	SEL-311C	
MTCS	TRCOMM	(Communications-Assisted Trip Conditions)
MTO	TRSOTF	(Switch-Onto-Fault Trip Conditions)
MTU	TR or TRQUAL	(Unconditional or Other Trip Conditions)

The SEL-321 handles trip unlatching with setting TULO. The SEL-311C described in this manual handles trip unlatching with SELOGIC control equation setting ULTR.

The SEL-321 has single-pole trip logic. The SEL-311C described in this manual does not have single-pole trip logic.

Using MIRRORED BITS to Implement Communications-Assisted Tripping Schemes

The MIRRORED BITS® relay-to-relay communications protocol is available in SEL-311C relays, in addition to many other SEL products. MIRRORED BITS implementations have these advantages over traditional communications equipment:

- Less equipment (increases reliability)
- Increased speed (no contact closure delay)
- Better security (through built-in channel monitoring)
- Reduced wiring complexity

Use MIRRORED BITS communications to implement any of these tripping schemes efficiently and economically. MIRRORED BITS technology is generally used with either POTT or DCUB tripping schemes. If the communications channel is reliable and noise-free, e.g., dedicated fiber optic, then POTT gives unsurpassed security and very good dependability. If the communications channel is less than perfect, but communications channel failures are not likely to be coincident with external faults, then DCUB gives a very good combination of security and dependability.

The subsections that follow use traditional communications equipment in the examples. If using MIRRORED BITS communications, change some of the SELOGIC control equations to use Transmit MIRRORED BITS instead of output contacts, and Receive MIRRORED BITS instead of optoisolated inputs. Also, MIRRORED BITS communications do not require dc wiring between the relay and communications equipment.

See *Appendix H: MIRRORED BITS Communications* for details on configuring a relay port to communicate using MIRRORED BITS.

Several Application Guides available on the SEL website (www.selinc.com) give application examples of MIRRORED BITS in communications-assisted tripping schemes. Although some of the guides were written for the SEL-321-1 distance relays, these relays are similar to SEL-311C relays, so the guides will still be helpful in designing SEL-311C applications.

Permissive Overreaching Transfer Trip (POTT) Logic

Enable the POTT logic by setting ECOMM = POTT. The POTT logic in *Figure 5.6* is also enabled for directional comparison unblocking schemes (ECOMM = DCUB1 or ECOMM = DCUB2). The POTT logic performs the following tasks:

- Keys communication equipment to send permissive trip when any element included in the SELOGIC control equation communications-assisted trip equation TRCOMM asserts and the current reversal logic is not asserted.
- Prevents keying and tripping by the POTT logic following a current reversal.
- Echoes the received permissive signal to the remote terminal.
- Prevents channel lockup during echo and test.
- Provides a secure means of tripping for weak- and/or zero-infeed line terminals.

Use Existing SEL-321 POTT Application Guide for the SEL-311C

Use the existing SEL-321 POTT application guide (AG95-29) to help set up the SEL-311C in a POTT scheme (see *Use Existing SEL-321 Application Guides for the SEL-311C on page 5.14* for more setting comparison information on the SEL-321/SEL-311C relays).

External Inputs

See *Optoisolated Inputs on page 7.2* for more information on optoisolated inputs.

PT1—Received Permissive Trip Signal(s)

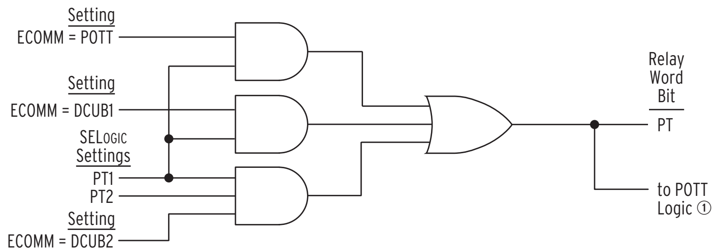
In two-terminal line POTT applications, a permissive trip signal is received from one remote terminal. One optoisolated input on the SEL-311C (e.g., input **IN104**) is driven by a communications equipment receiver output (see *Figure 5.8*). Make SELOGIC control equation setting PT1:

PT1 = **IN104** (two-terminal line application)

In three-terminal line POTT applications, permissive trip signals are received from two remote terminals. Two optoisolated inputs on the SEL-311C (e.g., inputs **IN104** and **IN106**) are driven by communications equipment receiver outputs (see *Figure 5.9*). Make SELOGIC control equation setting PT1 as follows:

PT1 = **IN104 * IN106** (three-terminal line application)

SELOGIC control equation setting PT1 in *Figure 5.5* is routed to control Relay Word bit PT if enable setting ECOMM = POTT. Relay Word bit PT is then an input into the POTT logic in *Figure 5.6* (for echo keying).



① Figure 5.6.

Figure 5.5 Permissive Input Logic Routing to POTT Logic

Also note that SELOGIC control equation setting PT1 in *Figure 5.7* is routed to control Relay Word bit PTRX if enable setting ECOMM = POTT. Relay Word bit PTRX is the permissive trip receive input into the trip logic in *Figure 5.1*.

Timer Settings

See *Section 9: Setting the Relay* for setting ranges.

Z3RBD–Zone (Level) 3 Reverse Block Delay

Current-reversal guard timer—typically set at 5 cycles.

EBLKD–Echo Block Delay

Prevents echoing of received PT for settable delay after dropout of local permissive elements in trip setting TRCOMM—typically set at 10 cycles. Set to OFF to defeat EBLKD.

ETDPU–Echo Time Delay Pickup

Sets minimum time requirement for received PT, before echo begins—typically set at 2 cycles. Set to OFF for no echo.

EDURD–Echo Duration

Limits echo duration to prevent channel lockup—typically set at 4 cycles.

Logic Outputs

The following logic outputs can be tested by assigning them to output contacts. See *Output Contacts on page 7.33* for more information on output contacts.

Z3RB–Zone (Level) 3 Reverse Block

Current-reversal guard asserted (operates as an input into the trip logic in *Figure 5.1* and the DCUB logic in *Figure 5.10*).

ECTT–Echo Conversion to Trip

PT received, converted to a trip condition for a Weak-Infeed Condition (operates as an input into the trip logic in *Figure 5.1*).

KEY—Key Permissive Trip

Signals communications equipment to transmit permissive trip. For example, SELOGIC control equation setting **OUT105** is set:

OUT105 = **KEY**

Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.8*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.9*):

OUT107 = **KEY**

EKEY—Echo Key Permissive Trip

Permissive trip signal keyed by Echo logic (used in testing).

Weak-Infeed Logic

In some applications, with all sources in service, one terminal may not contribute enough fault current to operate the protective elements. If the fault lies within the Zone 1 reach of the strong terminal, the fault currents may redistribute after the strong terminal line breaker opens, and this current redistribution may permit sequential tripping of the weak-infeed terminal line breaker. If currents do not redistribute sufficiently to operate the protective elements at the weak-infeed terminal, it is still desirable to open the local breaker. This prevents the low level currents from maintaining the fault arc and allows successful autoreclosure from the strong terminal. When the fault location is near the weak terminal, the Zone 1 elements of the strong terminal do not pick up, and the fault is not cleared rapidly. This is because the weak terminal protective elements do not operate.

Note that while the weak-infeed terminal contributes little fault current, the phase voltage(s) are depressed.

The weak-infeed logic and settings are available for ECOMM = POTT, DCUB1, or DCUB2 applications.

SEL-311C Weak-Infeed Logic Settings

Enable the weak-infeed logic by setting EWFC = Y. Making this setting exposes additional settings 27PPW, and 59NW or 59QW for wye-connected and delta connected systems, respectively.

Disable the weak-infeed logic by setting EWFC = N.

The SEL-311C provides additional logic (see *Figure 5.6*) for weak-infeed terminals to permit rapid tripping of both line terminals for internal faults near the weak terminal. The strong terminal is permitted to trip via the permissive signal echoed back from the weak terminal. The weak-infeed logic generates a trip at the weak terminal if all of the following are true:

- A permissive trip (PT) signal is received (from the strong terminal) for ETDPU time.
- A phase-to-phase undervoltage or residual overvoltage element is picked up (when Global setting PTCONN = WYE) or a phase-to-phase undervoltage or negative-sequence overvoltage element is picked up (when Global setting PTCONN = DELTA)
- No reverse-looking elements are picked up.

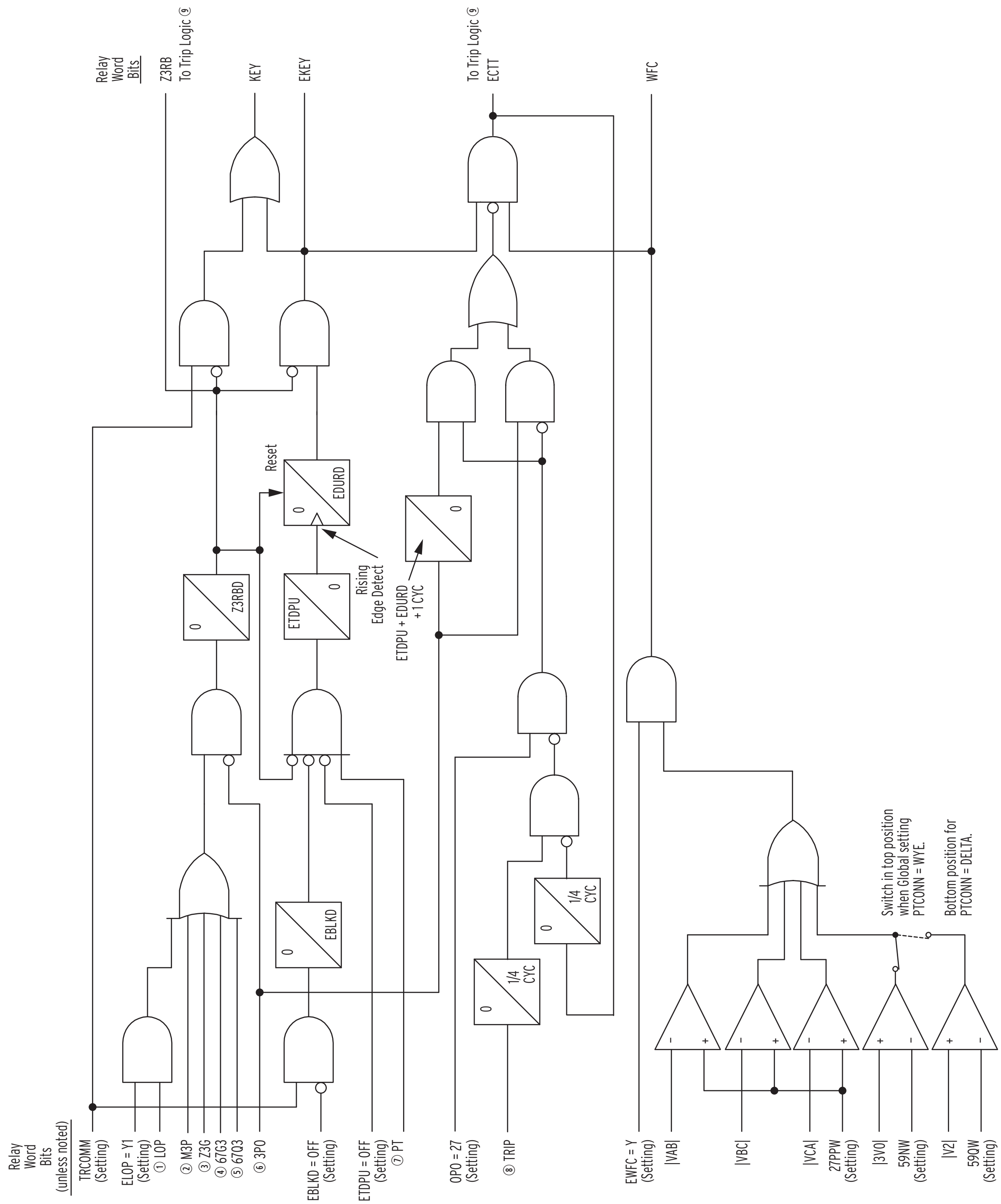
- The circuit breaker is closed.
- No loss-of-potential (LOP) condition is present when ELOP = Y1.

After these conditions are met, the weak-infeed logic sets the Echo-Conversion-To-Trip (ECTT) bit in the Relay Word. The ECTT bit is included in the trip logic (see *Figure 5.1*) and a trip signal is issued to the local breaker when the conditions described above are true.

Typical phase-to-phase undervoltage setting (27PPW) is 70–80 percent of the lowest expected system operating voltage, on a phase-to-phase basis.

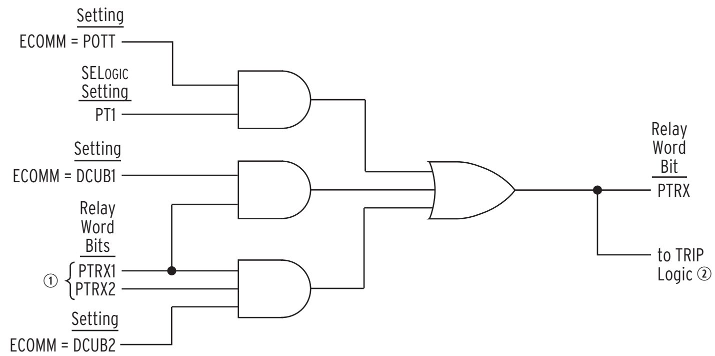
For wye-connected PT applications (when Global setting PTCONN = WYE), the residual overvoltage setting should be set to approximately twice the expected standing 3V0 voltage. With the 59NW element set at twice the nominal standing 3V0 voltage, the instrument measures only fault-induced zero-sequence voltage.

For delta-connected PT applications (when Global setting PTCONN = DELTA), the negative-sequence overvoltage setting should be set to approximately twice the expected standing V2 voltage. With the 59QW element set at twice the nominal standing V2 voltage, the instrument measures only fault-induced negative-sequence voltage.



① From Figure 4.1; ② from Figure 3.6; ③ from Figure 3.9; ④ from Figure 3.25; ⑤ from Figure 3.26; ⑥ from Figure 5.3; ⑦ from Figure 5.5; ⑧ from Figure 5.1; ⑨ Figure 5.1.

Figure 5.6 POTT Logic



① Figure 5.10; ② Figure 5.1.

Figure 5.7 Permissive Input Logic Routing to Trip Logic

Variations for Permissive Underreaching Transfer Trip (PUTT) Scheme

Refer to *Figure 5.4* and *Figure 5.6*. In a PUTT scheme, keying is provided by Level 1 underreaching elements (fixed direction forward), instead of with Relay Word bit KEY. This is accomplished by setting the output contact used to key permissive trip, **OUT105** for example, with these elements:

M1P Zone 1 phase distance instantaneous element

Z1G Zone 1 ground distance instantaneous element

67G1 Zone 1 directional residual ground instantaneous overcurrent element

67Q1 Zone 1 directional negative-sequence instantaneous overcurrent element

instead of with element KEY (see *Figure 5.8*):

OUT105 = **M1P + Z1G + 67G1 + 67Q1** (Note: only use enabled elements)

If echo keying is desired, add the echo key permissive trip logic output, as follows:

OUT105 = **M1P + Z1G + 67G1 + 67Q1 + EKEY**

In a three-terminal line scheme, another output contact (e.g., **OUT107**) is set the same as **OUT105** (see *Figure 5.9*).

Installation Variations

Figure 5.9 shows output contacts **OUT105** and **OUT107** connected to separate communications equipment, for the two remote terminals. Both output contacts are programmed the same (OUT105 = KEY and OUT107 = KEY).

Depending on the installation, perhaps one output contact (e.g., OUT105 = KEY) could be connected in parallel to both transmitter inputs (**TX**) on the communications equipment in *Figure 5.9*. Then output contact **OUT107** can be used for another function.

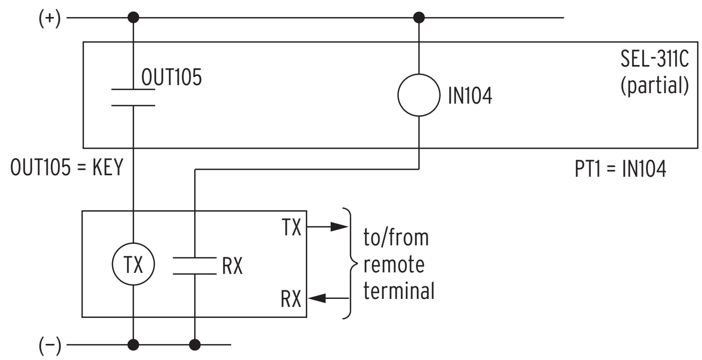


Figure 5.8 SEL-311C Connections to Communications Equipment for a Two-Terminal Line POTT Scheme

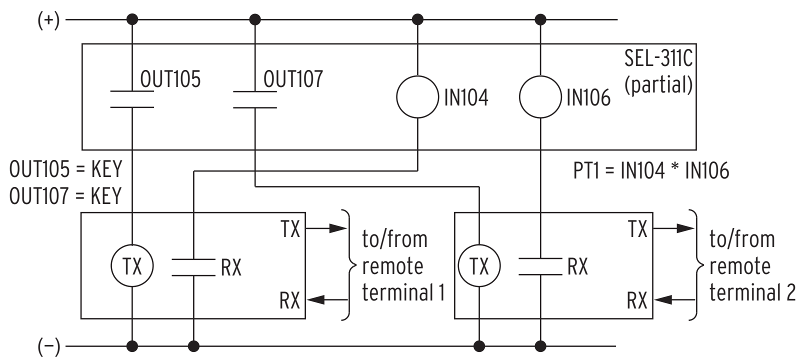


Figure 5.9 SEL-311C Connections to Communications Equipment for a Three-Terminal Line POTT Scheme

Directional Comparison Unblocking (DCUB) Logic

NOTE: When using power line carrier communications equipment that includes DCUB logic, it is typically better to enable the DCUB logic in the communication equipment and not in the relay. In that case, simply enable POTT logic in the relay. Some communications equipment will indicate loss-of-guard due to a fault or noise. The DCUB logic of the relay is unable to discriminate between loss-of-carrier because of a line fault and that caused by noise. The DCUB logic within the communication equipment is better equipped to differentiate between the causes of the loss-of-guard.

Enable the DCUB logic by setting ECOMM = DCUB1 or ECOMM = DCUB2. The DCUB logic in *Figure 5.10* is an extension of the POTT logic in *Figure 5.6*. Thus, the relay requires *all* the POTT settings and logic, *plus* exclusive DCUB settings and logic. The difference between setting choices DCUB1 and DCUB2 is:

DCUB1 directional comparison unblocking scheme for two-terminal line (communications from *one* remote terminal)

DCUB2 directional comparison unblocking scheme for three-terminal line (communications from *two* remote terminals)

The DCUB logic in *Figure 5.10* takes in the loss-of-guard and permissive trip outputs from the communication receivers (see *Figure 5.12* and *Figure 5.13*) and makes permissive (PTRX1/PTRX2) and unblocking block (UBB1/UBB2) logic output decisions.

DCUB schemes are typically implemented with FSK (frequency shift keying) on power line carrier communications medium where there is a direct logical relationship between the loss of carrier signal and a fault on the protected line segment.

Use Existing SEL-321 DCUB Application Guide for the SEL-311C

Use the existing SEL-321 DCUB application guide (AG96-19) to help set up the SEL-311C in a DCUB scheme (see *Use Existing SEL-321 Application Guides for the SEL-311C on page 5.14* for more setting comparison information on the SEL-321/SEL-311C relays).

External Inputs

See *Optoisolated Inputs on page 7.2* for more information on optoisolated inputs.

PT1, PT2—Received Permissive Trip Signal(s)

In two-terminal line DCUB applications (setting ECOMM = DCUB1), a permissive trip signal is received from one remote terminal. One optoisolated input on the SEL-311C (e.g., input **IN104**) is driven by a communications equipment receiver output (see *Figure 5.12*). Make SELOGIC control equation setting PT1:

PT1 = **IN104** (two-terminal line application)

In three-terminal line DCUB applications (setting ECOMM = DCUB2), permissive trip signals are received from *two* remote terminals. Two optoisolated inputs on the SEL-311C (e.g., inputs **IN104** and **IN106**) are driven by communications equipment receiver outputs (see *Figure 5.13*). Make SELOGIC control equation settings PT1 and PT2 as follows:

PT1 = **IN104** (three-terminal line application)

PT2 = **IN106**

SELOGIC control equation settings PT1 and PT2 are routed into the DCUB logic in *Figure 5.10* for "unblocking block" and "permissive trip receive" logic decisions.

As explained in *Permissive Overreaching Transfer Trip (POTT) Logic on page 5.16*, the SELOGIC control equation settings PT1 and PT2 in *Figure 5.5* are routed in various combinations to control Relay Word bit PT, depending on enable setting ECOMM = DCUB1 or DCUB2. Relay Word bit PT is then an input into the POTT logic in *Figure 5.6* (for echo keying).

LOG1, LOG2—Loss-of-Guard Signal(s)

In two-terminal line DCUB applications (setting ECOMM = DCUB1), a loss-of-guard signal is received from *one* remote terminal. One optoisolated input on the SEL-311C (e.g., input **IN105**) is driven by a communications equipment receiver output (see *Figure 5.12*). Make SELOGIC control equation setting LOG1:

LOG1 = **IN105** (two-terminal line application)

In three-terminal line DCUB applications (setting ECOMM = DCUB2), loss-of-guard signals are received from *two* remote terminals. Two optoisolated inputs on the SEL-311C (e.g., input **IN105** and **IN207**) are driven by communications equipment receiver outputs (see *Figure 5.13*). Make SELOGIC control equation settings LOG1 and LOG2 as follows:

LOG1 = **IN105** (three-terminal line application)

LOG2 = **IN207**

SELOGIC control equation settings LOG1 and LOG2 are routed into the DCUB logic in *Figure 5.10* for "unblocking block" and "permissive trip receive" logic decisions.

Timer Settings

See *Section 9: Setting the Relay* for setting ranges.

GARD1D—Guard-Present Delay

Sets minimum time requirement for reinstating permissive tripping following a loss-of-channel condition—typically set at 10 cycles. Channel 1 and 2 logic use separate timers but have this same delay setting.

UBDURD—DCUB Disable Delay

Prevents tripping by POTT logic after a settable time following a loss-of-channel condition—typically set at 9 cycles (150 ms). Channel 1 and 2 logic use separate timers but have this same delay setting.

UBEND—DCUB Duration Delay

Sets minimum time required to declare a loss-of-channel condition—typically set at 0.5 cycles. Channel 1 and 2 logic use separate timers but have this same delay setting.

Logic Outputs

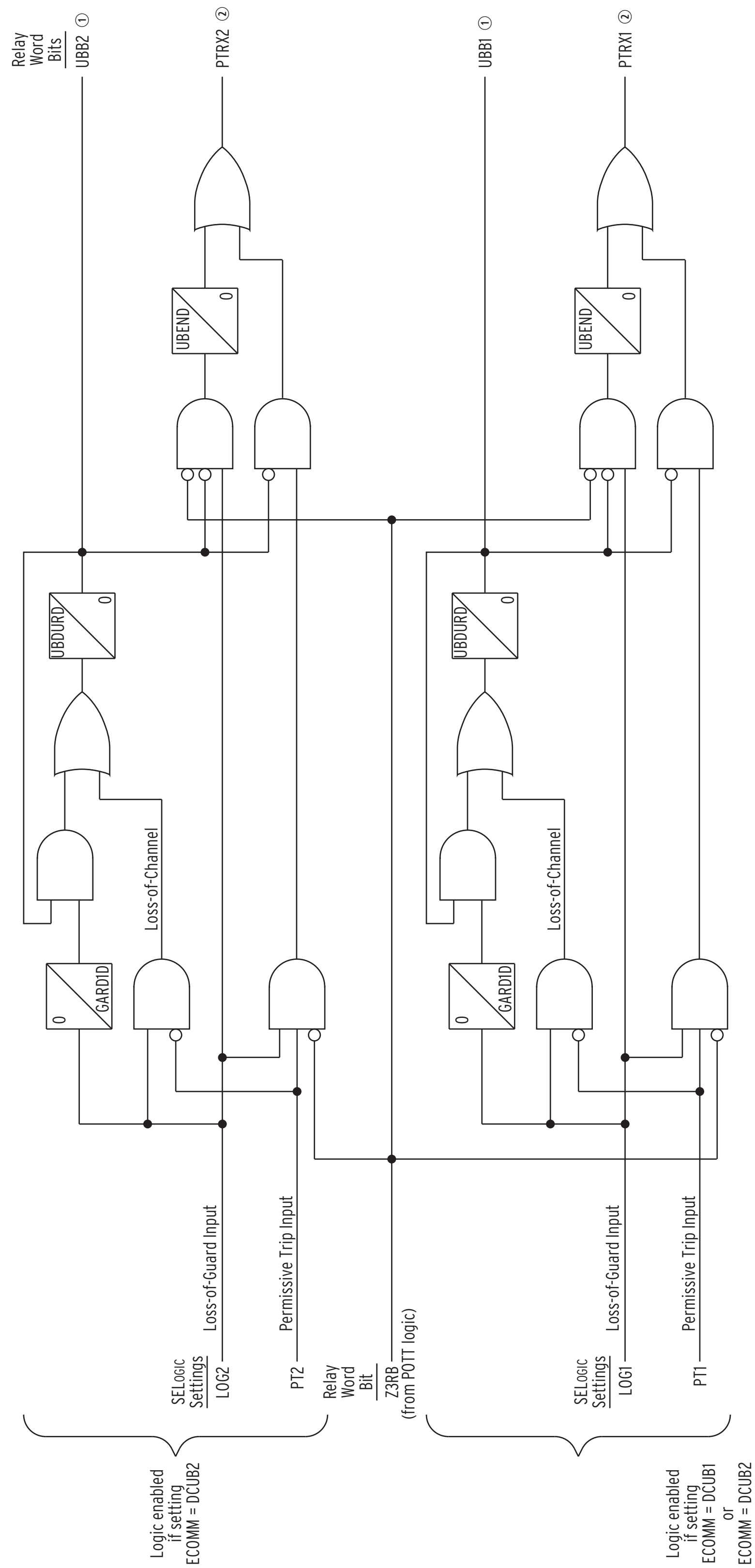
The following logic outputs can be tested by assigning them to output contacts. See *Output Contacts on page 7.33* for more information on output contacts.

UBB1, UBB2—Unblocking Block Output(s)

In two-terminal line DCUB applications (setting ECOMM = DCUB1), UBB1 disables tripping if the loss-of-channel condition continues for longer than time UBDURD.

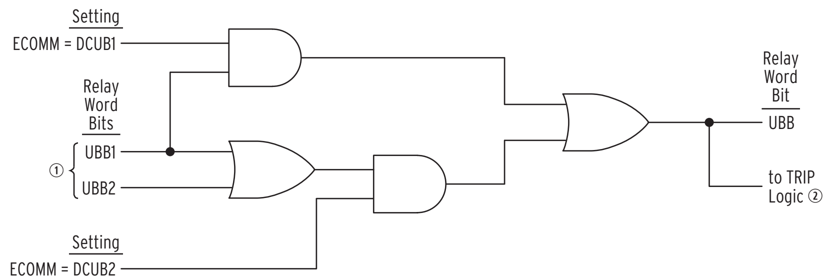
In three-terminal line DCUB applications (setting ECOMM = DCUB2), UBB1 or UBB2 disable tripping if the loss-of-channel condition (for the respective Channel 1 or 2) continues for longer than time UBDURD.

The UBB1 and UBB2 are routed in various combinations in *Figure 5.11* to control Relay Word bit UBB, depending on enable setting ECOMM = DCUB1 or DCUB2. Relay Word bit UBB is the unblock block input into the trip logic in *Figure 5.1*. When UBB asserts to logical 1, tripping is blocked.



① To Figure 5.11; ② to Figure 5.7.

Figure 5.10 DCUB Logic



① From Figure 5.10; ② Figure 5.1.

Figure 5.11 Unblocking Block Logic Routing to Trip Logic

PTRX1, PTRX2—Permissive Trip Receive Outputs

In two-terminal line DCUB applications (setting ECOMM = DCUB1), PTRX1 asserts for loss-of-channel or an actual received permissive trip.

In three-terminal line DCUB applications (setting ECOMM = DCUB2), PTRX1 or PTRX2 assert for loss-of-channel or an actual received permissive trip (for the respective Channel 1 or 2).

The PTRX1/PTRX2 Relay Word bits are then routed in various combinations in *Figure 5.7* to control Relay Word bit PTRX, depending on enable setting ECOMM = DCUB1 or DCUB2. Relay Word bit PTRX is the permissive trip receive input into the trip logic in *Figure 5.1*.

Installation Variations

Figure 5.13 shows output contacts **OUT105** and **OUT107** connected to separate communication equipment, for the two remote terminals. Both output contacts are programmed the same (OUT105 = KEY and OUT107 = KEY).

Depending on the installation, perhaps one output contact (e.g., OUT105 = KEY) could be connected in parallel to both transmitter inputs (**TX**) on the communication equipment in *Figure 5.13*. Then output contact **OUT107** can be used for another function.

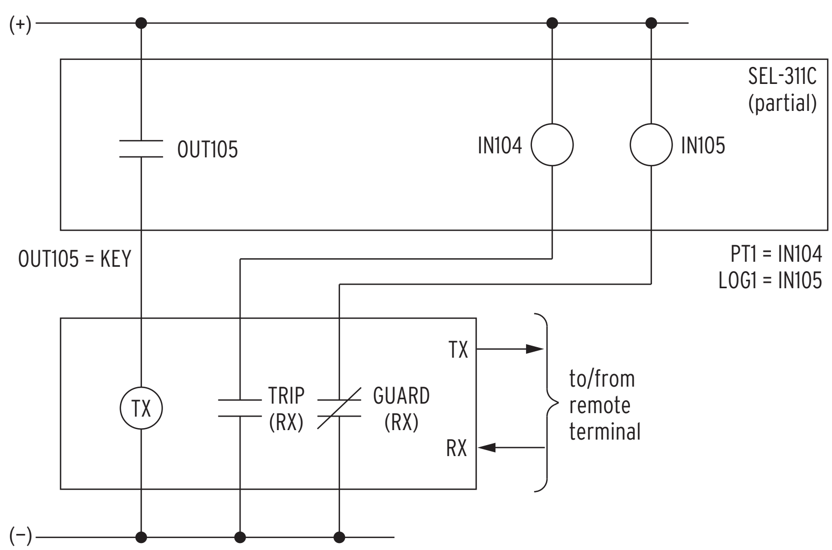


Figure 5.12 Connections to Communications Equipment for a Two-Terminal Line DCUB Scheme (Setting ECOMM = DCUB1)

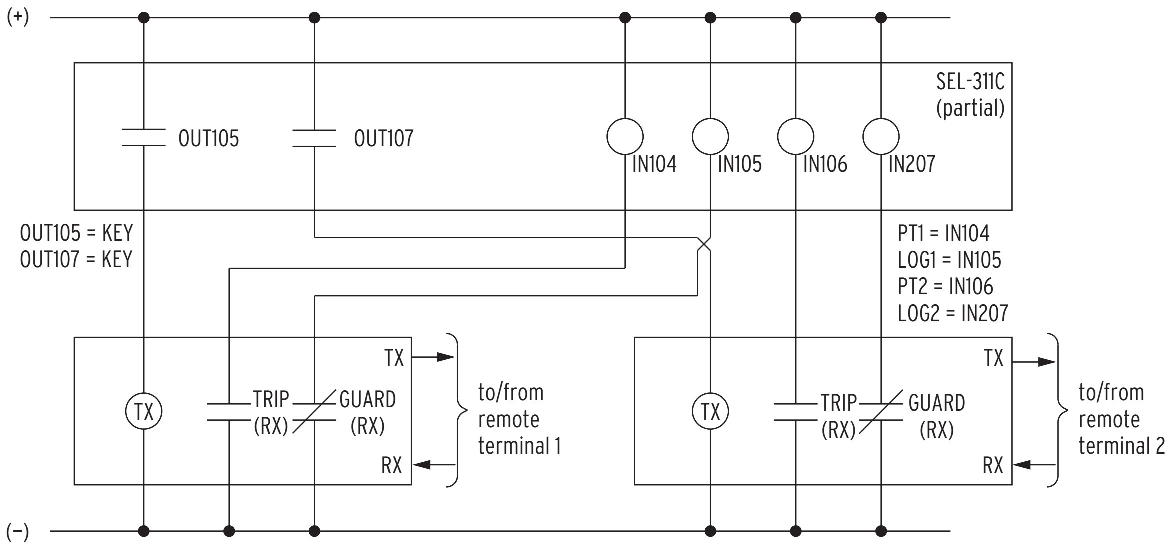


Figure 5.13 Connections to Communications Equipment for a Three-Terminal Line DCUB Scheme (Setting ECOMM = DCUB2)

Directional Comparison Blocking (DCB) Logic

Enable the DCB logic by setting ECOMM = DCB. The DCB logic in *Figure 5.14* performs the following tasks:

- Provides the individual carrier coordination timers for the Level 2 directional elements M2P, Z2G, 67G2, and 67Q2 via the Z2PGS and 67QG2S Relay Word bits. These delays allow time for the block trip signal to arrive from the remote terminal. For example:

  TRCOMM = **Z2PGS + 67QG2S**

- Instantaneously keys the communications equipment to transmit block trip for reverse faults and extends this signal for a settable time following the dropout of all Level 3 directional elements (M3P, Z3G, 67G3, and 67Q3).
- Latches a block trip signal generated by the Zone 3 distance element if the polarizing memory expires. This prevents the block trip signal from resetting for a close-in three-phase fault where the memory expires. The latch is removed when the polarizing memory voltage returns or current is removed.
- Extends the received block signal by a settable time.

Use Existing SEL-321 DCB Application Guide for the SEL-311C

Use the existing SEL-321 DCB application guide (AG93-06) to help set up the SEL-311C in a DCB scheme (see *Use Existing SEL-321 Application Guides for the SEL-311C on page 5.14* for more setting comparison information on the SEL-321/SEL-311C relays).

External Inputs

See *Optoisolated Inputs on page 7.2* for more information on optoisolated inputs.

BT–Received Block Trip Signal(s)

In two-terminal line DCB applications, a block trip signal is received from *one* remote terminal. One optoisolated input on the SEL-311C (e.g., input **IN104**) is driven by a communications equipment receiver output (see *Figure 5.15*). Make SELOGIC control equation setting BT:

BT = **IN104** (two-terminal line application)

In three-terminal line DCB applications, block trip signals are received from *two* remote terminals. Two optoisolated inputs on the SEL-311C (e.g., input **IN104** and **IN106**) are driven by communications equipment receiver outputs (see *Figure 5.16*). Make SELOGIC control equation setting BT as follows:

BT = **IN104 + IN106** (three-terminal line application)

SELOGIC control equation setting BT is routed through a dropout timer (BTXD) in the DCB logic in *Figure 5.14*. The timer output, Relay Word bit BTX, is routed to the trip logic in *Figure 5.1*.

Timer Settings

See *Section 9: Setting the Relay* for setting ranges.

Z3XPU–Zone (Level) 3 Reverse Pickup Time Delay

Current-reversal guard pickup timer—typically set at 2 cycles.

Z3XD–Zone (Level) 3 Reverse Dropout Extension

Current-reversal guard dropout timer—typically set at 5 cycles.

BTXD–Block Trip Receive Extension

Sets reset time of block trip received condition (BTX) after the reset of block trip input BT.

21SD and 67SD–Zone 2 Short Delay

Carrier coordination delays for the output of Zone 2 overreaching distance elements 21SD and 67SD are typically set at 1 cycle..

Logic Outputs

The following logic outputs can be tested by assigning them to output contacts. See *Output Contacts on page 7.33* for more information on output contacts.

DSTRT–Directional Carrier Start

Program an output contact for directional carrier start. For example, SELOGIC control equation setting **OUT105** is set:

OUT105 = **DSTRT**

Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.15*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.16*):

OUT107 = **DSTRT**

DSTRT includes current reversal guard logic.

NSTRT—Nondirectional Carrier Start

Program an output contact to include nondirectional carrier start, in addition to directional start. For example, SELOGIC control equation setting **OUT105** is set:

OUT105 = **DSTRT + NSTRT**

Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.15*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.16*):

OUT107 = **DSTRT + NSTRT**

STOP—Stop Carrier

Program to an output contact to stop carrier. For example, SELOGIC control equation setting OUT106 is set:

OUT106 = **STOP**

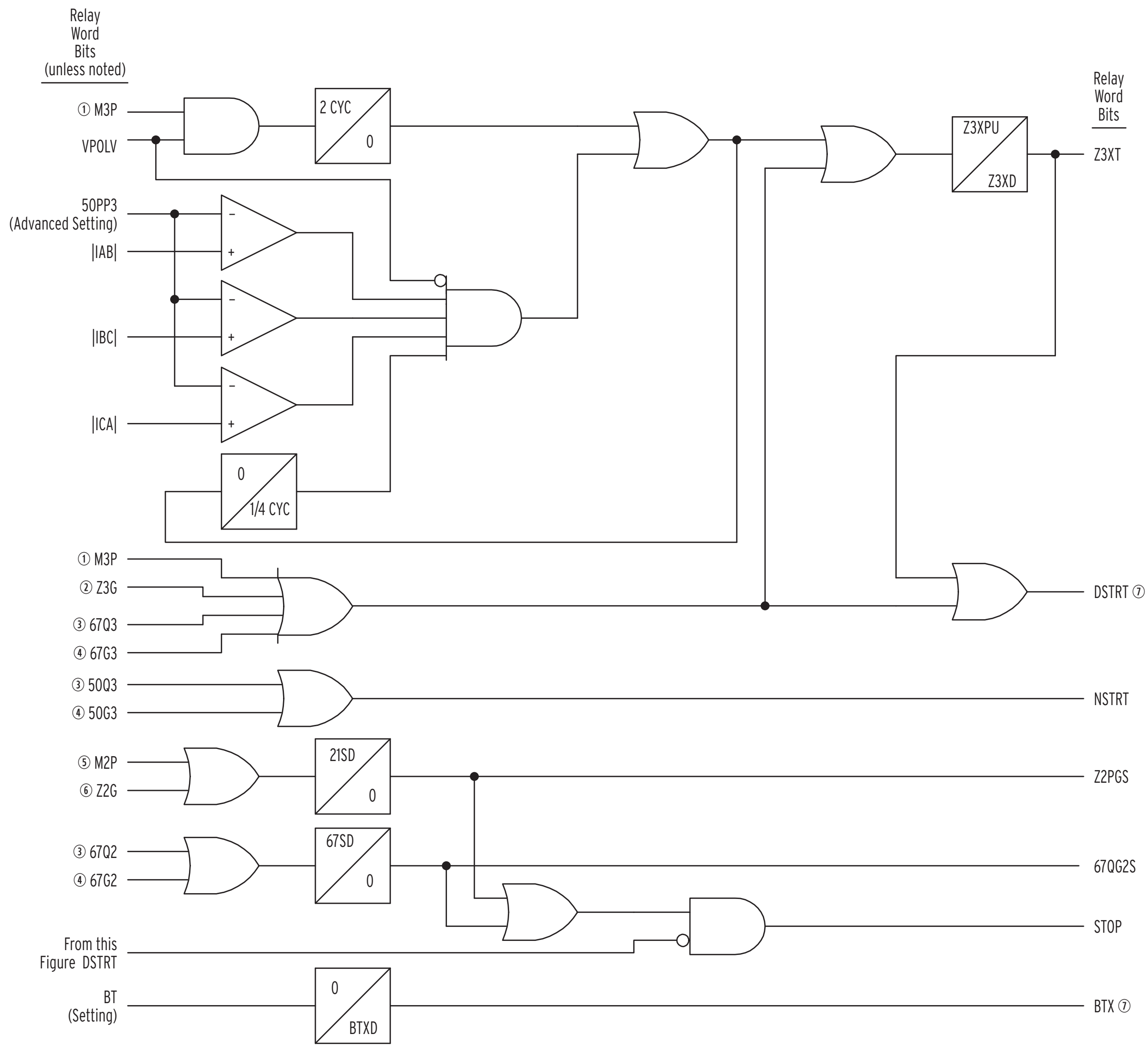
Output contact **OUT106** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.15*).

In a three-terminal line scheme, output contact **OUT208** is set the same as **OUT106** (see *Figure 5.16*):

OUT208 = **STOP**

BTX—Block Trip Extension

The received block trip input (e.g., BT = IN104) is routed through a dropout timer (BTXD) in the DCB logic in *Figure 5.14*. The timer output (BTX) is routed to the trip logic in *Figure 5.1*.



① From Figure 3.6; ② from Figure 3.9; ③ from Figure 3.26; ④ from Figure 3.25; ⑤ from Figure 3.5; ⑥ from Figure 3.8; ⑦ to Figure 5.1.

Figure 5.14 DCB Logic

Installation Variations

Figure 5.16 shows output contacts **OUT105**, **OUT106**, **OUT107**, and **OUT208** connected to separate communication equipment, for the two remote terminals. Both output contact pairs are programmed the same:

OUT105 = **DSTRT + NSTRT**

OUT107 = **DSTRT + NSTRT**

OUT106 = **STOP**

OUT208 = **STOP**

Depending on the installation, perhaps one output contact (e.g., OUT105 = DSTRT + NSTRT) can be connected in parallel to both **START** inputs on the communication equipment in *Figure 5.16*. Then output contact **OUT107** can be used for another function.

Depending on the installation, perhaps one output contact (e.g., OUT106 = STOP) can be connected in parallel to both **STOP** inputs on the communication equipment in *Figure 5.16*. Then output contact **OUT208** can be used for another function.

Figure 5.16 also shows communication equipment **RX** (receive) output contacts from each remote terminal connected to separate inputs **IN104** and **IN106** on the SEL-311C. The inputs operate as block trip receive inputs for the two remote terminals and are used in the SELOGIC control equation setting:

BT = **IN104 + IN106**

Depending on the installation, perhaps one input (e.g., **IN104**) can be connected in parallel to both communication equipment **RX** (receive) output contacts in *Figure 5.16*. Then setting BT would be programmed as:

BT = **IN104**

and input **IN106** can be used for another function.

In *Figure 5.15* and *Figure 5.16*, the carrier scheme cutout switch contact (85CO) should be closed when the communications equipment is taken out of service so that the **BT** input of the relay remains asserted. An alternative to asserting the **BT** input is to change to a setting group where the DCB logic is not enabled.

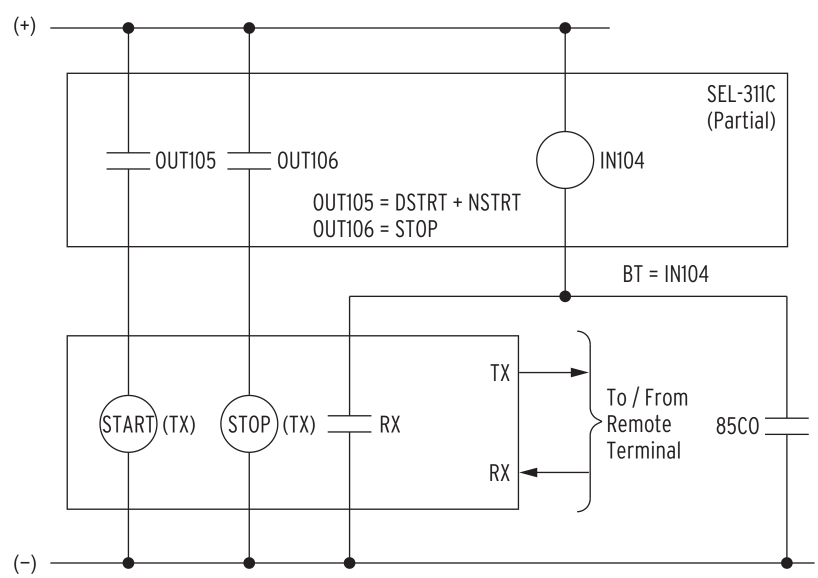


Figure 5.15 Connections to Communications Equipment for a Two-Terminal Line DCB Scheme

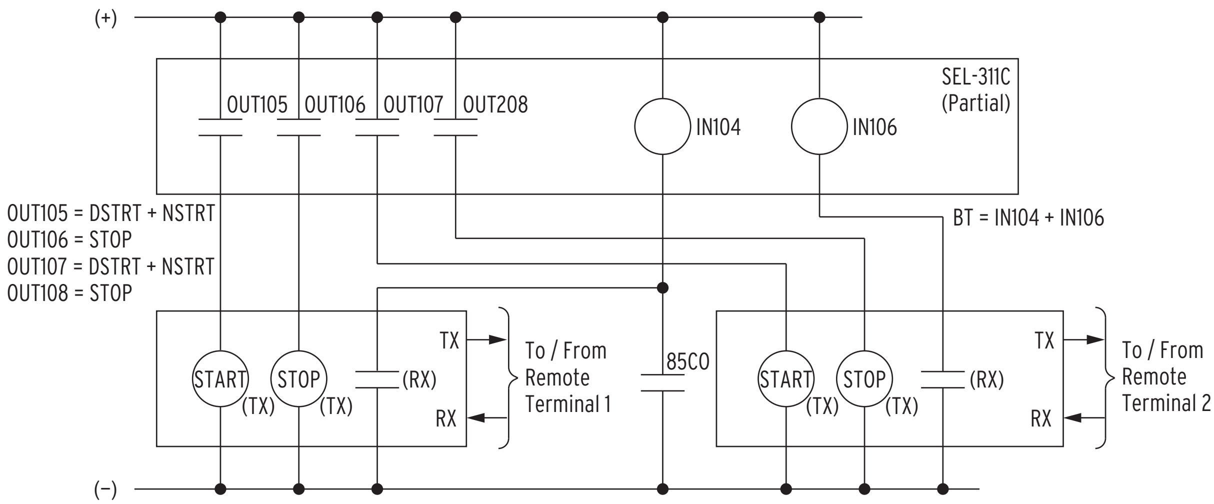


Figure 5.16 Connections to Communications Equipment for a Three-Terminal Line DCB Scheme

Front-Panel Target LEDs

Overview

All SEL-311C models feature target and status LEDs. These are either factory defined (fixed function), or programmable LEDs in certain ordering configurations.

For simplicity, Target and Status LEDs are called Target LEDs in the other sections of this manual, and in this section where the distinction between target and status LED is not important.

Here is a summary of two types of front-panel target and status LEDs:

NOTE: Do not use this Instruction Manual information to order a relay. Please refer to the up-to-date product configuration available online, or contact your SEL Customer Service Representative.

- ➤ Fixed target logic and status LEDs that mimic the target LEDs found in previous SEL-311C relays.
- ➤ Programmable target and status LEDs which can be customized through Global and Logic settings changes. With default settings, the programmable LEDs mimic the fixed target LEDs.

Both types of target and status LEDs are specified in this section, with differences highlighted.

Front-Panel Features

The SEL-311C target and status LEDs are prominently displayed on the front-panel of the relay, adjacent to the human-machine interface (HMI). See *Figure 2.2* through *Figure 2.6* for sample front-panel configurations.

The target and status LEDs are separate from the other components of the front-panel interface. These other features are covered in other sections of this instruction manual:

- ➤ The ten available operator control pushbuttons and indication LEDs (shown in *Figure 2.4* and *Figure 2.6*) are described in *Section 11: Front-Panel Interface*.
- ➤ The two-line liquid crystal display (LCD) and associated front-panel pushbuttons are described in *Section 11: Front-Panel Interface*.

- ➤ The use of Rotating Display Points to automatically display status messages and certain analog information is described in *Rotating Display on page 7.37*.
- ➤ The optional **SafeLock® Trip/Close** pushbuttons and indicator LEDs are described in *Section 2: Installation*.

Fixed Target Logic

The SEL-311C fixed target logic is listed in *Table 5.1*. See *Figure 2.2*, *Figure 2.3*, and *Figure 2.5* for example front-panels with fixed target logic.

Table 5.1 Fixed Target and Status LED Definitions

Relay Word Bit (TAR 0 and TAR 1)	LED Label	Definition	Type
TLED11	**EN**	Relay Enabled—see *Relay Self-Tests on page 13.7*	Status
TLED12	**TRIP**	Indication that a trip occurred, by a protection or control element	Target
TLED13	**TIME**	Time-delayed trip	Target
TLED14	**COMM**	Communications-assisted trip	Target
TLED15	**SOTF**	Switch-onto-fault trip	Target
TLED16	**RS**	Reclosing relay in reset state	Status
TLED17	**LO**	Reclosing relay in lockout state	Status
TLED18	**51**	Time-overcurrent element trip	Target
TLED19	**A**	Phase A involved in the fault	Target
TLED20	**B**	Phase B involved in the fault	Target
TLED21	**C**	Phase C involved in the fault	Target
TLED22	**G**	Ground distance or residual ground element picked up at a time of trip	Target
TLED23	**1**	Zone/Level 1 element picked up at time of trip	Target
TLED24	**2**	Zone/Level 2 element picked up at time of trip	Target
TLED25	**3**	Zone/Level 3 element picked up at time of trip	Target
TLED26	**4**	Zone/Level 4 element picked up at time of trip	Target

NOTE: Unlike legacy SEL-311C models, the **TAR** command response shows the Relay Word bit name (e.g., TLED11, TLED12) rather than the LED labels (EN, TRIP, etc.).

For remote operations, the status of the LEDs can be checked using the **TAR 0** and **TAR 1** command. See *Table 5.2* for a cross reference, and *TAR Command (Display Relay Element Status) on page 10.60* for more command options.

Table 5.2 SEL-311C Status/Target LED Cross Reference for TAR Command (Fixed Target Logic)

TAR Command	Relay Word Bit (Corresponding LED Label)							
TAR 0	TLED11	TLED12	TLED13	TLED14	TLED15	TLED16	TLED17	TLED18
	(EN)	**(TRIP)**	**(TIME)**	**(COMM)**	**(SOTF)**	**(RS)**	**(LO)**	**(51)**
TAR 1	TLED19	TLED20	TLED21	TLED22	TLED23	TLED24	TLED25	TLED26
	(A)	**(B)**	**(C)**	**(G)**	**(ZONE1)**	**(ZONE2)**	**(ZONE3)**	**(ZONE4)**

The LEDs designated as Target Type LEDs in *Table 5.1* are updated and then latched for every new assertion (rising edge) of the TRIP Relay Word bit. The TRIP Relay Word bit is an output of the trip logic (see *Figure 5.1*).

Further target LED information follows.

Additional Target LED Information

TRIP Target LED

The **TRIP** target LED illuminates at the rising edge of trip (the new assertion of the TRIP Relay Word bit).

The **TRIP** target LED is especially helpful in providing front-panel indication for tripping that does not involve the other targeting elements. If the trip is not a distance or overcurrent element generated trip, none of the other target LEDs (TLED13–TLED15 and TLED18–TLED26) in *Table 5.1* illuminate, but the **TRIP** target LED still illuminates. Thus, tripping via the front-panel local control (local bits), serial port (remote bits or **OPEN** command), or voltage elements is indicated only by the illumination of the **TRIP** target LED.

TIME Target LED

The **TIME** target LED illuminates at the rising edge of trip if SELOGIC control equation setting FAULT has been asserted for more than three cycles and the trip is not the direct result of SELOGIC control equations TRCOMM, TRSOFT, or a direct transfer trip. FAULT is usually set with distance and time-overcurrent element pickups (e.g., FAULT = 51G + 51Q + M2P + Z2G) to detect fault inception. If tripping occurs more than three cycles after fault inception, the **TIME** target illuminates.

SELOGIC control equation setting FAULT also controls other relay functions. See *SELOGIC Control Equation Setting FAULT on page 5.43*.

COMM Target LED

The **COMM** target LED illuminates at the rising edge of trip if the trip is the sole and direct result of SELOGIC control equation setting TRCOMM and associated communications-assisted trip logic, Relay Word bit ECTT, or SELOGIC control equation setting DTT (as indicated by the COMMT Relay Word bit in the top half of *Figure 5.1*).

Another Application for the COMM Target LED

If none of the traditional communications-assisted trip logic is used (i.e., SELOGIC control equation setting TRCOMM is not used, consideration can be given to using the **COMM** target LED to indicate tripping via remote communications channels (e.g., via serial port commands or SCADA asserting optoisolated inputs). Use SELOGIC control equation setting DTT (Direct Transfer Trip) to accomplish this (indicated by the COMMT Relay Word bit in *Figure 5.1*).

For example, if the **OPEN** command or remote bit RB1 (see *CON Command (Control Remote Bit) on page 10.31*) are used to trip via the serial port and should illuminate the **COMM** target LED include the Relay Word bits in SELOGIC control equation setting DTT:

DTT = **... + OC + RB1**

Relay Word bits set in SELOGIC control equation setting DTT do not have to be set in SELOGIC control equation setting TR—both settings directly assert the TRIP Relay Word bit. The only difference between settings DTT and TR is that setting DTT causes the **COMM** target LED to illuminate.

Many other variations of the above DTT settings examples are possible.

SOTF Target LED

The **SOTF** target LED illuminates at the rising edge of the TRIP Relay Word bit if the trip is the sole and direct result of the SELOGIC control equation setting TRSOTF and associated switch-onto-fault trip logic.

Recloser RS and LO Status LEDs

The RS and LO LEDs follow the state of the 79RS and 79LO Relay Word bits, respectively. If the reclosing relay is turned off (enable setting E79 = N or 79OI1 = 0), all the Device **79** (reclosing relay) status LEDs are extinguished.

51 Target LED

The **51** target LED illuminates at the rising edge of trip if a time-overcurrent element (51PT, 51GT, or 51QT) is present and asserted in the SELOGIC control equation that caused the trip.

FAULT TYPE Target LEDs

A, B, and C Target LEDs

A (Phase A) target LED is illuminated one cycle after the rising edge of TRIP if a protection element causes the trip, and Phase A is involved in the fault (likewise for **B** [Phase B] and **C** [Phase C] target LEDs).

During single pole open conditions (Relay Word bit SPO = logical 1), the target logic considers the two phases that remain closed, and may also assert G if the relay determines that ground was involved in the fault.

G Target LED

G target LED is illuminated at the rising edge of trip if the fault involved ground or if a ground overcurrent element caused the trip.

Zone LEDs

Zone/Level LEDs illuminate at the rising edge of trip for the lowest zone number in the SELOGIC control equation that caused the trip. The elements considered are M*n*P, M*n*PT, Z*n*G, Z*n*GT, Z*n*T, 67P*n*, 67P*n*T, 67G*n*, 67G*n*T, 67Q*n*, 67Q*n*T (where *n* = 1 to 4), Z2SEQT, M2PSEQT, Z2GSEQT, Z2PG2S, and 67QG2S.

These elements need only be present in the SELOGIC control equation that causes the trip in order to participate in the illuminating of front panel targets. No consideration is made as to how the element is used. For example, assume the SELOGIC control equation TRQUAL = IN101 * Z1G + Z2G. In this case, if the Z1G element is asserted at the rising edge of TRIP, the ZONE1 target will light even if IN101 was not asserted and the cause of the trip was Z2G.

Programmable Target Logic

Selected SEL-311C models are available with Programmable Target Logic. The programmable target logic is listed in *Table 5.3*. See *Figure 2.4* and *Figure 2.6* for example front-panels with programmable target logic. These models feature configurable labels, where the default LED labels are printed on a card inside a pocket on the relay front-panel. To change the labels, the default card may be removed, and a new card printed and inserted to change the target and status LED labels.

The SEL-311C ships with factory default target settings and a default slide-in card that gives it the same behavior as models with the fixed target logic. Up to eleven of the sixteen LED definitions can be changed. There are no settings associated with the five permanent function LEDs, which have internal logic.

Table 5.3 Programmable Target and Status LED Settings and Default Definitions

SELogic Setting and Default	Latch in on TRIP? (Global Setting)	Relay Word Bit (TAR 0 and TAR 1)	Default LED Label	Factory Default Definition	Default Target Alias for Event Summaries (Global Setting)
Internal[a]	No	TLED11	ENABLED	Relay Enabled—see *Relay Self-Tests on page 13.7*)	None
LED12 = **LTRIP**	LED12L = Y	TLED12	TRIP	Indication that a trip occurred, by a protection or control element	LED12A = TRIP
LED13 = **LTIME**	LED13L = Y	TLED13	TIME	Time-delayed trip	LED13A = TIME
LED14 = **LCOMM**	LED14L = Y	TLED14	COMM	Communications-assisted trip	LED14A = COMM
LED15 = **LSOTF**	LED15L = Y	TLED15	SOTF	Switch-onto-fault trip	LED15A = SOTF
LED16 = **79RS**	LED16L = N	TLED16	RS	Reclosing relay in reset state	LED16A = RS[b]
LED17 = **79LO**	LED17L = N	TLED17	LO	Reclosing relay in lockout state	LED17A = LO[b]
LED18 = **L51**	LED18L = Y	TLED18	51	Time-overcurrent element trip	LED18A = 51
Internal[a]	Yes	TLED19	A	Phase A involved in the fault	None
Internal[a]	Yes	TLED20	B	Phase B involved in the fault	None
Internal[a]	Yes	TLED21	C	Phase C involved in the fault	None
Internal[a]	Yes	TLED22	G	Ground involved in the fault or ground overcurrent element caused the trip	None
LED23 = **LZONE1**	LED23L = Y	TLED23	1	Zone/Level 1 element picked up at time of trip	LED23A = ZONE1
LED24 = **LZONE2**	LED24L = Y	TLED24	2	Zone/Level 2 element picked up at time of trip	LED24A = ZONE2
LED25 = **LZONE3**	LED25L = Y	TLED25	3	Zone/Level 3 element picked up at time of trip	LED25A = ZONE3
LED26 = **LZONE4**	LED26L = Y	TLED26	4	Zone/Level 4 element picked up at time of trip	LED26A = ZONE4

[a] Definition cannot be changed.
[b] Status LED alias settings LEDxxA (corresponding to settings LEDxxL = N) are not used in event summaries.

For remote operations, the status of the LEDs can be checked using the **TAR 0** and **TAR 1** command. The SEL-311C **TAR** command response shows the Relay Word bit name (e.g., TLED11, TLED12) rather than the programmable LED labels (e.g., EN, TRIP).

See *Table 5.2* for a cross reference for relays with factory default LED settings, and *TAR Command (Display Relay Element Status) on page 10.xx* for more command options.

If the LED definitions are changed from the default settings, a copy of *Table 5.4* can filled-in to be used in your documentation and training materials.

Table 5.4 SEL-311C Status/Target LED Cross Reference for TAR Command (Customized Target Logic)

TAR Command	Relay Word Bit (Corresponding LED Label)							
TAR 0	TLED11	TLED12	TLED13	TLED14	TLED15	TLED16	TLED17	TLED18
	( )	( )	( )	( )	( )	( )	( )	( )
TAR 1	TLED19	TLED20	TLED21	TLED22	TLED23	TLED24	TLED25	TLED26
	( )	( )	( )	( )	( )	( )	( )	( )

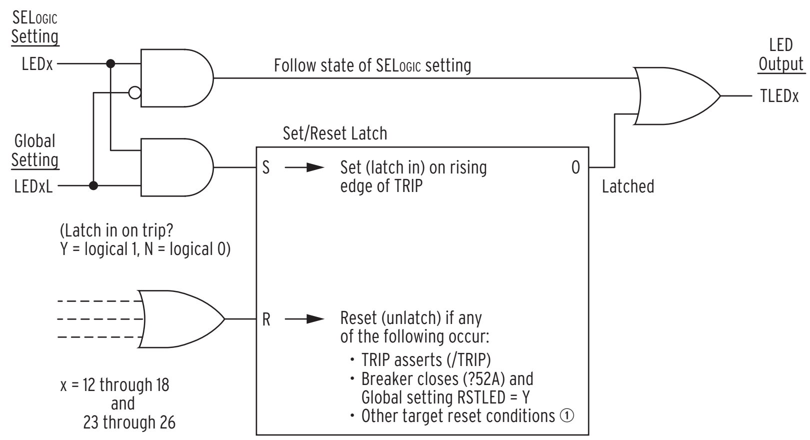
NOTE: The Global settings for Target LED Alias names (for example, LED12A = TRIP) do not affect the **TAR** command response. These alias settings are used in the event summary target reporting.

The function of TLED11 and TLED19 through TLED22 cannot be changed. However, the configurable labels (slide-in card) can be customized, and these fields are shown with blanks in *Table 5.4*.

Programmable Target/Status Logic Details

Refer to *Table 5.3* and *Figure 5.17*.

TLED12–TLED18 (default names TRIP–51), and TLED23–TLED26 (default names ZONE1–ZONE4) are programmable via the SELOGIC control equation settings and Global settings shown in *Table 5.3*. They either latch-in on the rising-edge of trip (new assertion of Relay Word bit TRIP—see logic output of *Figure 5.1*) or follow the state of the corresponding SELOGIC control equation setting (illuminated = logical 1; extinguished =logical 0).



① see Resetting Front-Panel Target LEDs on page 5.40

Figure 5.17 Programmable Front-Panel Target LED Logic

TLED11 (ENABLED) and TLED19–TLED22 (A, B, C, and G) do not have settings—they are fixed-function LEDs.

LEDs A, B, C, and G always latch-in on trip, if the corresponding phase is involved with the fault. See the description under *Fixed Target Logic on page 5.33*.

LEDs A, B, C, and G reset (unlatch) similar to the other target LEDs set to latch-in on trip.

The LED logic output (Relay Word bits TLED11–TLED26) that actually drives the front-panel LEDs is observed via the **TAR 0** and **TAR 1** commands.

Changing Target/Status LED Operation

In SEL-311C models with programmable target and status logic, the definition of up to 11 of the 16 target/status LEDs can be changed.

The initial settings may be left in place and the relay targeting will behave the same as a relay ordered without programmable target and status LEDs.

In many protection applications, several of the SEL-311C features may be unused, and some of the LEDs will never illuminate with the default front-panel assignments. Instead of leaving a target or status LED unused, consider programming it for a different function.

EXAMPLE 5.1 Target and Status LED Change (Changing and Moving LED Functions)

A transmission line application uses only three out of four available distance element zones, freeing-up the **ZONE/LEVEL 4** LED for other functions. Assume for this example the reclosing relay is being used in the application, and the operating staff want to know when the reclosing relay is in the 79CY (cycle) state.

In Table 5.5, the easiest change to program would be to redefine the **ZONE/LEVEL 4** Target LED as a **79 CY** Status LED, but this would not be clear when implemented on the front panel. The **4** LED is not adjacent to the **RS** and **LO** LEDs, and it would be difficult to print a label with **RECLOSER CY** in that position.

Instead, the SEL-311C Logic and Global Settings can be used to "move" the 51 LED function down to the second row (in place of **4**), and then move LO to the previous **51** location, and finally, defining a new **CY** LED where **LO** was located. This layout is shown in Table 5.6.

Table 5.5 Front Panel Before Example Changes

ENABLED	TRIP	TIME	COMM	SOTF	RS	LO	51
					RECLOSER		
A	B	C	G	1	2	3	4
	FAULT TYPE				ZONE/LEVEL		

Table 5.6 Front Panel After Example Changes

ENABLED	TRIP	TIME	COMM	SOTF	RS	CY	LO
						RECLOSER	
A	B	C	G	1	2	3	51
	FAULT TYPE				ZONE/LEVEL		

Required setting changes, starting from factory default settings.

In Global Settings (SET G or via ACSELERATOR QuickSet® SEL-5030):

LED17L = **N** {no change, LED17 shall still be a status LED}

LED18L = **N** {the LO LED shall be a status LED, and shall not be included in event summary Target fields}

LED26L = **Y** {no change, LED26 shall still be a target (latch on trip) LED}

LED17A = **CY** {change the alias for the new LED function}[1]

LED18A = **LO** {move to the new position}[1]

LED26A = **51** {new location for 51 Target, alias shall be used in event summary Target fields}

In all six settings groups (SET L n, [n = 1 to 6] or via ACSELERATOR QuickSet):

LED17 = **N** {new function, Relay Word bit 79CY}

LED18 = **N** {new position for Relay Word bit 79LO}

LED26 = **Y** {new position for legacy target logic Relay Word bit L51}

Except in special applications, it is easiest to make the LEDnn logic settings the same in all six setting groups.

[1] As described in the footnotes of Table 5.2, the LEDnnA (alias) settings for status type LEDs (when LEDnnL = N) are not used by the SEL-311C. It is good practice to populate these settings with a meaningful label, 7 characters maximum length.

Other Programmable Target/Status LED Features

In SEL-311C models with programmable target and status logic, the factory default target logic settings use a set of Relay Word bits as shown in the left-hand column of *Table 5.3*. These Relay Word bits (LTRIP, LTIME, etc.) are provided to mimic the fixed target logic found in other models of the SEL-311C.

These legacy target Relay Word bits are nonvolatile, meaning their state will be retained after the relay loses power and is then powered up or if the active settings group is changed. Additionally, any LED*nn* can be configured to latch on TRIP with the appropriate Global setting LED*nn*L = Y. This action also creates a nonvolatile LED, even if the logic expression programmed in the LED*nn* SELOGIC Equation is not a Legacy Target logic element.

As performed in *Example 5.1*, these legacy functions can be moved (as done with L51), or not used (as done with LZONE4).

Because the LED*nn* settings are standard SELOGIC equations, the usual operators and Relay Word bits can be used in place of the legacy target Relay Word bits. In *Example 5.1*, the 79 CY function was added merely by including Relay Word bit 79CY in the appropriate LED*nn* setting.

EXAMPLE 5.2 Using SELOGIC Equations in Target/Status LED Settings

This example demonstrates a few methods of programming LED settings, focusing on three target LEDs.

Logic settings (in all 6 groups):

SET16 = **TRIP**

RST16 = **TRGTR + PB7PUL**

LED12 = **LZONE1 + LZONE2**

LED13 = **LZONE3 * LT16**

LED14 = **51GT * SV5T**

Notice that the last sample equation (for LED14) contains no legacy target logic Relay Word bits.

Make the Global settings as follows:

LED12L = **Y**

LED13L = **N**

LED14L = **Y**

LED12A = **ZONE1_2**

LED13A = **ZONE3**

LED14A = **GND_TOC**

A relay TRIP will seal-in the LED12 and LED14 logic states through the normal LED logic, and the status of these LEDs are retained in nonvolatile memory.

In this example LED13 is configured as a status type LED, but is given a latch-type behavior by using latch bit LT16 in the LED13 setting. This allows LED13 to seal-in like a regular target LED, and will have a nonvolatile behavior provided by the latch bit LT16 and the legacy target bit LZONE3. This example allows LED13 to be reset independently of the remaining target LEDs by pressing pushbutton **7** (resetting LT16). The legacy target Relay Word bit LZONE3 is not affected by the status of LT16.

In this example, the LED13 target can also be reset by the **TARGET RESET** pushbutton or **TAR R** command, via the TRGTR Relay Word bit (these actions also clear LED12 and LED13). Because Global setting LED13L = N, the alias setting LED13A will not appear in the target information inside event summaries.

EXAMPLE 5.3 Make a Target LED Flash

If a particular LED requires more visibility, it might be programmed to flash when asserted. We will change LED13 in the previous example to make the LED flash when a trip includes LZONE3.

Logic settings (in all 6 groups):

SV16 = **!SV16T**

LED13 = **LZONE3 * SV16T**

Group settings (in all 6 groups):

SV16PU = **25.00 cycles**

SV16DO = **25.00 cycles**

Make the Global settings as follows:

LED13L = **N**

LED13A = **ZONE3**

A relay TRIP that asserts the LZONE3 legacy target bit will cause LED13 to flash. In this example, SELOGIC variable/timer SV16 is programmed to oscillate with a period of 50 cycles. The LED13 setting logic setting logically ANDs the oscillating bit with the legacy target bit.

This example requires LED13 to be configured as a status type LED, otherwise it would not be allowed to change state. The target will have nonvolatile behavior through the legacy bit LZONE3. Because Global setting LED13L = N, the alias setting LED13A will not appear in the target information inside event summaries.

When LED13 is flashing, issuing a TAR 0 command will show TLED13 as either asserted or deasserted, which might be misleading. If a remote system is configured to check relay status, it should instead check the status of Relay Word bit LZONE3, which is unaffected by the oscillating behavior. Similarly, it would be better to use LZONE3 in the Sequential Events Recorder (SER) settings instead of TLED13, which would create a pair of entries each time the LED flashes.

Resetting Front-Panel Target LEDs

The front-panel target LEDs reset during the following conditions:

- TRIP newly asserts (/TRIP).
- The **TARGET RESET/LAMP TEST** pushbutton is pressed and TRIP is not asserted.
- The **TAR R** command is entered and TRIP is not asserted.
- A DNP or Modbus target reset command is received and TRIP is not asserted.
- The SELOGIC equation RSTTRGT newly asserts and TRIP is not asserted.
- On relays with programmable targets—when Global setting RSTLED = Y or Y1, and the circuit breaker closes, as detected by rising edge of 52A.

When a new TRIP condition is present, the relay first clears the previous targets and then rapidly refreshes them with the updated target information. The relay locks-out the other target reset methods while TRIP is still active.

The **TARGET RESET/LAMP TEST** pushbutton, **TAR R** command, and Modbus/DNP target reset methods assert the TRGTR Relay Word bit for one processing interval.

Targets are maintained in nonvolatile memory so their status is available even after relay power is lost and then restored.

TARGET RESET/LAMP TEST Front-Panel Pushbutton

When the **TARGET RESET/LAMP TEST** front-panel pushbutton is pressed:

- ➤ All front-panel LEDs illuminate for one (1) second.
- ➤ All latch-type target LEDs (LEDs labeled TLED12 through TLED26 in Table 5.1 or Table 5.3) are extinguished (unlatched), unless a trip condition is present in which case the latched target LEDs reappear in their previous state.

Other Applications for the Target Reset Function

Refer to the bottom of *Figure 5.1*. The combination of the **TARGET RESET** pushbutton, DNP and Modbus target reset inputs, and the **TAR R** (Target Reset) serial port command is available as Relay Word bit TRGTR.

Relay Word bit TRGTR can be used to unlatch logic. For example, refer to the breaker failure logic in *Figure 7.26*. If a breaker failure trip occurs (SV7T asserts), the occurrence can be displayed on the front panel with seal-in logic and a rotating display (see *Rotating Display on page 7.37* and *Rotating Display on page 11.11*):

SV8 = **(SV8 + SV7T) * !TRGTR**

DP3 = **SV8**

DP3_1 = **BREAKER FAILURE**

DP3_0 = NA (blank)

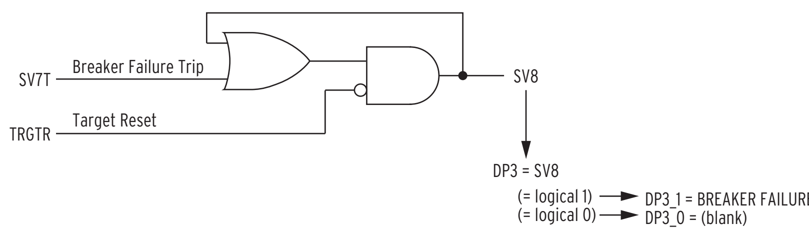
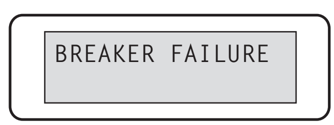


Figure 5.18 Seal-in of Breaker Failure Occurrence for Message Display

If a breaker failure trip has occurred, the momentary assertion of SV7T (breaker failure trip) will cause SV8 in *Figure 5.18* to seal-in. Asserted SV8 in turn asserts DP3, causing the message:



to display in the rotating default display.

This message can be removed from the display rotation by pushing the **TARGET RESET** pushbutton (Relay Word bit TRGTR pulses to logical 1, unlatching SV8 and in turn deasserting DP3). Thus, front-panel rotating default displays can be easily reset along with the front-panel targets by pushing the **TARGET RESET** pushbutton.

SELOGIC Control Equation Setting RSTTRGT

The SELOGIC Equation RSTTRGT may be used to perform a target reset on a programmable basis. The SEL-311C responds to the rising edge of the RSTTRGT equation, and resets the target LEDs provided that TRIP is not asserted.

For example, to reset the targets upon receipt of a control input pulse on IN106, set

RSTTRGT = **IN106**

The built-in rising edge requirement ensures that leaving IN106 asserted does not continually reset the targets.

However, if RSTTRGT is asserted at relay power-up, the relay resets the targets. If there is any chance the controlling condition can remain asserted, insert a rising-edge operator in the setting to eliminate the chance for an unwanted reset. Continuing with the same example, set

RSTTRGT = **/IN106**

NOTE: The RSTTRGT function does not assert the TRGTR Relay Word bit.

Other control methods could use a SELOGIC timer or a remote bit to initiate the target reset.

RSTTRGT is also available as a Relay Word bit, and can be added to the SER trigger settings and monitored in the SER. See *Sequential Events Recorder (SER) Report on page 12.26*.

Optional Logic to Clear Trip Seal-In and Reset Targets

As previously noted, if the ULTR (unlatch trip) setting is not asserted, a sealed-in TRIP Relay Word bit can be cleared by one of the target reset conditions that asserts the TRGTR Relay Word bit, as shown in *Figure 5.1*.

Note that the RSTTRGT SELOGIC equation does not drive the TRGTR Relay Word bit. If an application requires a trip unlatch function based on the RSTTRGT setting, the logic used in the RSTTRGT SELOGIC control equation setting may be added to the ULTR setting. Continuing from the previous example with RSTTRGT = /IN106, an appropriate ULTR setting is:

ULTR = **IN106 + (existing unlatch trip settings)**

Because of the relay logic processing order, including Relay Word bit RSTTRGT in SELOGIC control equation ULTR will unlatch a sealed-in TRIP but will not reset the targets.

Using RSTLED Setting in Auto-Reclose Applications (models with programmable Target Logic)

NOTE: The RSTLED setting (Y, Y1, N, N1) also affects the behavior of pushbutton 5 and LED5, as described in Programmable Operator Controls on page 11.14.

When using RSTLED = Y or Y1, the target-type LEDs are reset upon breaker closure (determined by the rising edge of Relay Word bit 52A). This function works for any manual or automatic close operation, as long as the TRIP Relay Word bit is not asserted.

In the SEL-311C, the event summary subsystem collects the target LED status from the last row of an event report and places the target alias text for each asserted target LED in the target field. With default settings, if the ZONE 1 target LED is asserted for a trip operation, the LED23A = ZONE1 setting causes ZONE1 to appear in the TARGETS field of the **SUM** command and **HIS** command.

If the LER setting (length of event report) is longer than the recloser open interval time (e.g., 79OI1 = 120.00 cycles, and LER = 180 cycles), it is possible for the breaker to trip and reclose during a single event report. In this situation, using RSTLED = Y or Y1 will cause the target LEDs to reset as soon as the closed breaker condition is detected (/52A). This causes the event summary logic to miss the targets when it scans the final row of the event report.

To preserve targeting information, consider one of these solutions:

1. Use a shorter LER setting to make the length of the event report less than the reclosing relay open interval time.
2. Use longer open interval time(s).
3. Change RSTLED to N or N1 and manually reset targets.
4. Change RSTLED to N or N1 and automatically reset targets using a time delay.

Solution 1 is the best if there is any chance of a trip – reclose – trip sequence appearing in the same event report. The fault locator can only operate on the first fault, and if targets are reported, they would be from the second fault.

Solution 4 can be programmed this way:

Group settings (in all 6 groups):

SV2PU = 200.00 cycles (must be longer than the LER setting)

SV2DO = 0.00 cycles

Logic settings (in all 6 groups):

SV2 = 52A

RSTTRGT = /SV2T

SELOGIC Control Equation Setting FAULT

SELOGIC control equation setting FAULT has control over or is used in the following:

- Front-panel target LED **TIME**. See *Front-Panel Target LEDs on page 5.32*.
- Demand Metering—FAULT is used to suspend demand metering peak recording. See *Demand Metering on page 8.17*.
- Maximum/Minimum Metering—FAULT is used to block Maximum/Minimum metering updating. See *Maximum/Minimum Metering on page 8.27*.

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Section 6

Close and Reclose Logic

Overview

This section is made up of the following topics:

Figure 6.1 provides an overview of the close logic and reclosing relay logic described in this section.

Figure 6.1 shows a logic migration:

- From main reclosing relay logic
- To reclose supervision logic
- To close logic

In this section, these logic subsections are discussed in reverse order, starting with Breaker Status Logic. If you are not using the SEL-311C for automatic reclosing, but using it to close the breaker for other conditions (such as manual close initiation via serial port or optoisolated outputs), focus on the Breaker Status Logic and Close Logic subsections. Note particularly the description of SELOGIC® control equation setting CL in the Close Logic subsection.

Breaker Status Logic—Breaker Status Logic shows how the breaker status (Relay Word bit 52A) is derived.

Close Logic—This subsection describes the final logic that controls the close output contact (e.g., OUT103 = CLOSE). This output contact closes the circuit breaker for automatic reclosures and other conditions (e.g., manual close initiation via serial port or optoisolated inputs).

NOTE: Reclose enable setting E79 = N defeats the reclosing relay, but does not defeat the ability of the close logic described in the first subsection (Figure 6.1) to close the circuit breaker for other conditions via SELOGIC control equation setting CL.

Reclose Supervision Logic—Reclose Supervision Logic describes the logic that supervises automatic reclosing when an open-interval time times out: a final condition check right before the close logic asserts the close output.

Reclosing Relay Logic—This subsection describes the remaining reclosing relay settings and logic needed for automatic reclosing. The reclose enable setting, E79, has setting choices N, 1, 2, 3, and 4. The default setting E79 = N defeats the reclosing relay. Setting choices 1–4 are the number of desired automatic reclosures.

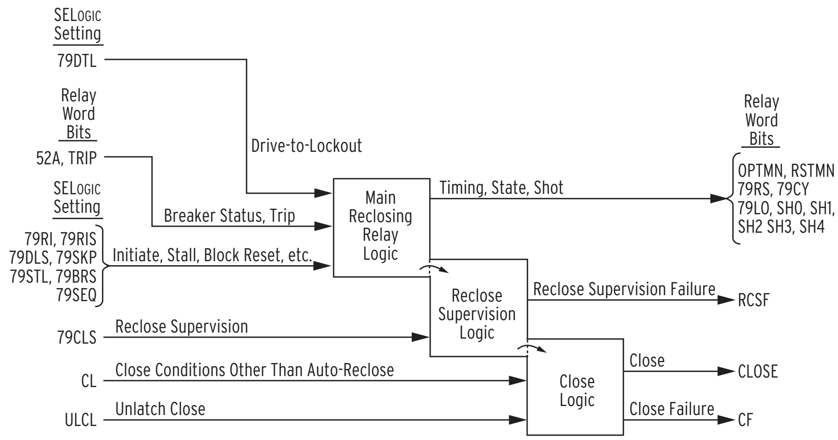


Figure 6.1 Close Logic and Reclosing Relay Logic Overview

Breaker Status Logic

The SEL-311C breaker status logic consists of a single SELOGIC control equation setting 52A, and the Relay Word bit 52A, as shown in *Figure 6.2*.

If 52A is set with numeral 0, all internal close logic is inoperable4 and the reclosing relay is defeated.

NOTE: The available SafeLock™ CLOSE pushbutton is electrically separate from the rest of the relay and not part of the close logic in Figure 6.2. It provides separate closing capability as shown in Figure 2.18.

The factory default setting is:

52A = **IN101**

The pickup and dropout operation of Relay Word bit 52A is affected by the Global debounce timer setting IN101D, and the dropout operation is additionally affected by the 0.5 cycle timer shown in *Figure 6.2*.

See *Optoisolated Inputs on page 7.2* for information on the debounce timers. See *Figure 2.13* for a typical breaker status input wiring connection.

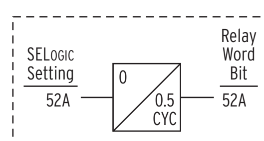


Figure 6.2 Breaker Status Logic

Close Logic

The close logic in *Figure 6.3* provides flexible circuit breaker closing/automatic reclosing with SELOGIC control equation settings:

52A (breaker status)

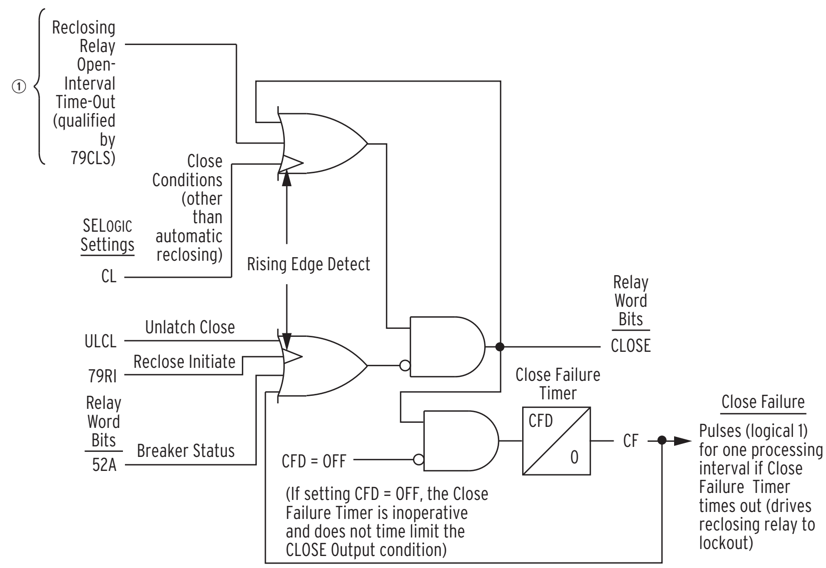
CL (close conditions, other than automatic reclosing)

ULCL (unlatch close conditions, other than circuit breaker status, close failure, or reclose initiation)

and setting:

CFD (Close Failure Time)

See the *SEL-311C Settings Sheets* for setting ranges.



① From Figure 6.4.

Figure 6.3 Close Logic

> **⚠WARNING**
> Setting CFD = OFF can create an indefinite "standing close" condition. This is usually not desirable in practice.

Set Close

If *all* the following are true:

- ➤ The unlatch close condition is not asserted (ULCL = logical 0).
- ➤ Relay Word bit 52A indicates that the circuit breaker is open (52A = logical 0).
- ➤ The reclose initiation condition (79RI) is not making a rising-edge (logical 0 to logical 1) transition.
- ➤ A close failure condition does not exist (Relay Word bit CF = 0).

Then the CLOSE Relay Word bit can be asserted if either of the following occurs:

- ➤ A reclosing relay open interval times out (qualified by SELOGIC control equation setting 79CLS—see *Figure 6.4*).
- ➤ SELOGIC control equation setting CL goes from logical 0 to logical 1 (rising-edge transition).

Relay Word bit CC asserts for execution of the **CLOSE** command. See *CON Command (Control Remote Bit) on page 10.31* for more information on the **CLOSE** command. More discussion follows later on the factory settings for setting CL.

If a user wants to supervise the **CLOSE** command with optoisolated input IN106, the following setting is made:

CL = **... + CC * IN106**

With this setting, the **CLOSE** command can provide a close only if optoisolated input IN106 is asserted. This is just one **CLOSE** command supervision example—many variations are possible.

> **NOTE:** The available **CLOSE** command that asserts Relay Word bit CC for one processing interval is not embedded in the close logic. It is included in the factory SELOGIC control equation settings:
> CL = CC

> **NOTE:** The available SafeLock **CLOSE** pushbutton is electrically separate from the rest of the relay and not part of the close logic in Figure 6.3. It provides separate closing capability as shown in Figure 2.18.

Unlatch Close

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

- ➤ The unlatch close condition asserts (ULCL = logical 1).
- ➤ Relay Word bit 52A indicates that the circuit breaker is closed (52A = logical 1). With factory default logic, 52A=logical 1 when at all poles of the circuit breaker are closed.
- ➤ The reclose initiation condition (79RI) makes a rising-edge (logical 0 to logical 1) transition.
- ➤ The Close Failure Timer times out (Relay Word bit CF = 1).

The Close Failure Timer does not operate if setting CFD = OFF.

Factory Settings Example

The factory settings for the close logic SELOGIC control equation settings are:

52A = **IN101**

CL = **CC**

ULCL = **TRIP**

The factory setting for the Close Failure Timer setting is:

CFD = **60.00 cycles**

See the *SEL-311C Settings Sheets* for setting ranges.

Set Close

If the Reclosing Relay Open Interval Time-Out logic input at the top of *Figure 6.3* is ignored (reclosing is discussed in detail in a following subsection), then SELOGIC control equation setting CL is the only logic input that can set the CLOSE Relay Word bit.

In SELOGIC control equation setting CL = CC, Relay Word bit CC asserts for execution of the **CLOSE** command. See *CLO Command (Close Breaker) on page 10.29* for more information on the **CLOSE** command.

Unlatch Close

SELOGIC control equation setting ULCL is set with the TRIP 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 on page 5.1*.

SELOGIC control equation setting 52A is set as shown in *Breaker Status Logic on page 6.2*. The resulting 52A Relay Word bit is asserted when the circuit breaker is closed. When 52A is asserted, the CLOSE Relay Word bit is deasserted to logical 0.

With setting CFD = 60.00 cycles, once the CLOSE Relay Word bit asserts, it remains asserted at logical 1 no longer than 60 cycles. If the Close Failure Timer times out, Relay Word bit CF asserts, forcing the CLOSE Relay Word bit to logical 0.

Defeat the Close Logic

The close logic is inoperable and the reclosing relay is defeated (see *Reclosing Relay on page 6.11*) if any of the following are true:

- SELOGIC control equation setting 52A is set with numeral 0 (52A = 0)
- Unlatch close logic SELOGIC setting ULCL is set with numeral 1 (ULCL = 1)
- SELOGIC setting ULCL is set to a SELOGIC condition that is always logical 1

Circuit Breaker Status

Refer to *Figure 6.2*. Note that SELOGIC control equation setting 52A (circuit breaker status) is available as Relay Word bit 52A, which makes setting other SELOGIC control equations more convenient. For example, if the following setting is made:

52A = **IN101** (52a auxiliary contact wired to input **IN101**)

or

52A = **!IN101** (52b auxiliary contact wired to input **IN101**)

then if breaker status is used in other SELOGIC control equations, it can be entered as 52A—the user does not have to enter IN101 (for a 52a) or !IN101 (for a 52b). For example, refer to *Rotating Display on page 7.37*. In the factory settings, circuit breaker status indication is controlled by display point setting DP1:

DP1 = **52A**

Program an Output Contact for Closing

In the factory settings, the result of the close logic in *Figure 6.3* is routed to output contact **OUT103** with the following SELOGIC control equation:

OUT103 = **CLOSE**

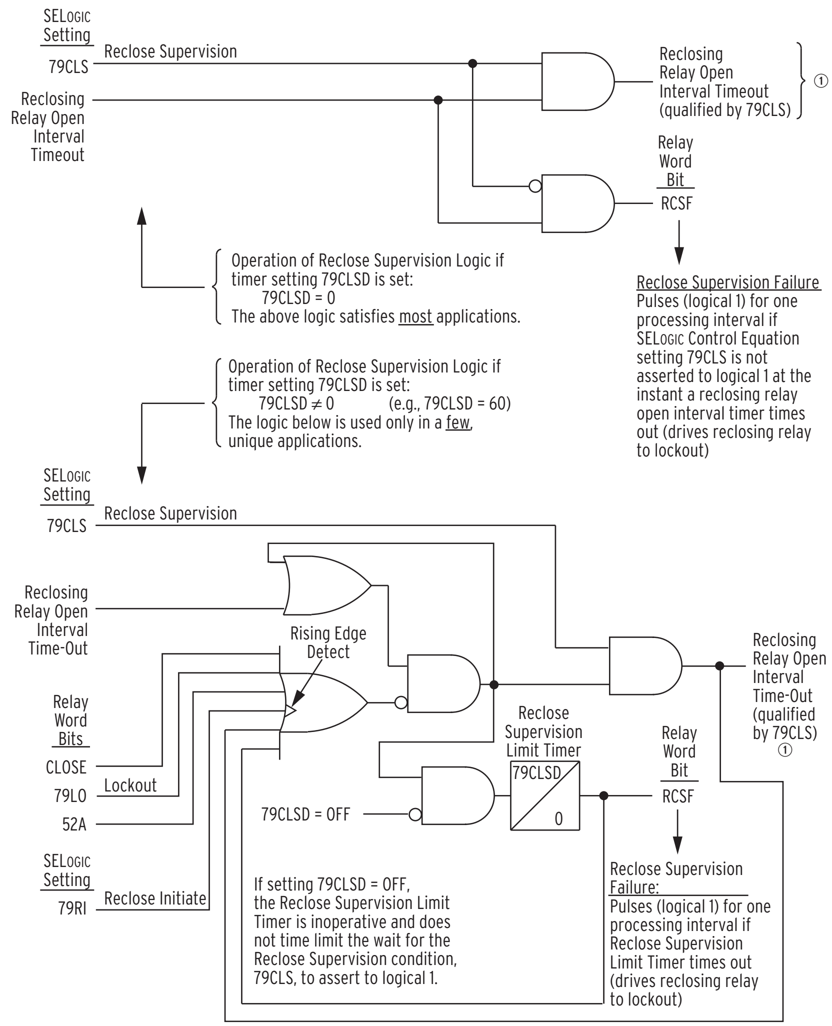
See *Output Contacts on page 7.33* for more information on programming output contacts.

Reclose Supervision Logic

Note that one of the inputs into the close logic in *Figure 6.3* is:

Reclosing Relay Open Interval Time-Out (qualified by 79CLS)

This input into the close logic in *Figure 6.3* is the indication that a reclosing relay open interval has timed out (see *Figure 6.8*), a qualifying condition (SELOGIC control equation setting 79CLS) has been met, and thus automatic reclosing of the circuit breaker should proceed by asserting the CLOSE Relay Word bit to logical 1. This input into the close logic in *Figure 6.3* is an output of the reclose supervision logic in the following *Figure 6.4*.



① To Figure 6.3.

Figure 6.4 Reclose Supervision Logic (Following Open Interval Time-Out)

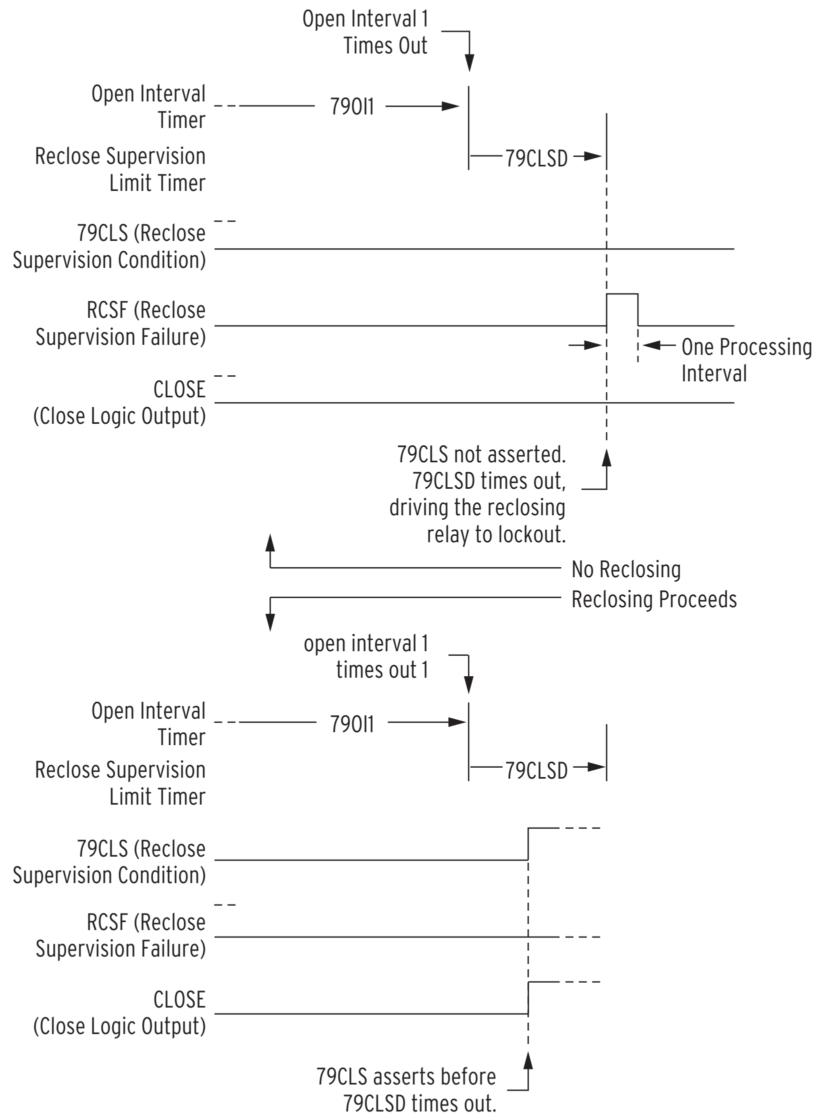


Figure 6.5 Reclose Supervision Limit Timer Operation (Refer to Bottom of Figure 6.4)

Settings and General Operation

Figure 6.4 contains the following SELOGIC control equation setting:

79CLS (reclose supervision conditions—checked after reclosing relay open interval time-out)

and setting:

79CLSD (Reclose Supervision Limit Time)

See the *SEL-311C Settings Sheets* for setting ranges.

For Most Applications (Top of Figure 6.4)

For most applications, the Reclose Supervision Limit Time setting should be set to zero cycles:

79CLSD = **0.00**

With this setting, the logic in the top of *Figure 6.4* is operative. When an open interval times out, the SELOGIC control equation reclose supervision setting 79CLS is *checked just once*.

If 79CLS is *asserted* to logical 1 at the instant of an open interval time-out, then the now-qualified open interval time-out will propagate onto the final close logic in *Figure 6.3* to automatically reclose the circuit breaker.

If 79CLS is *deasserted* to logical 0 at the instant of an open interval time-out, the following occurs:

- No automatic reclosing takes place.
- Relay Word bit RCSF (Reclose Supervision Failure indication) asserts to logical 1 for one processing interval.
- The reclosing relay is driven to Lockout State.

See *Factory Settings Example on page 6.9* and *Additional Settings Example 1 on page 6.9*.

For a Few, Unique Applications (Bottom of Figure 6.4 and Figure 6.5)

For a few unique applications, the Reclose Supervision Limit Time setting is *not* set equal to zero cycles, e.g.,

79CLSD = **60.00**

With this setting, the logic in the bottom of *Figure 6.4* is operative. When an open interval times out, the SELOGIC control equation reclose supervision setting 79CLS is then *checked for a time window* equal to setting 79CLSD.

If 79CLS *asserts* to logical 1 at any time during this 79CLSD time window, then the now-qualified open interval time-out will propagate onto the final close logic in *Figure 6.3* to automatically reclose the circuit breaker.

If 79CLS remains *deasserted* to logical 0 during this entire 79CLSD time window, when the time window times out, the following occurs:

- No automatic reclosing takes place.
- Relay Word bit RCSF (Reclose Supervision Failure indication) asserts to logical 1 for one processing interval.
- The reclosing relay is driven to Lockout State.

The logic in the bottom of *Figure 6.4* is explained in more detail in the following text.

Set Reclose Supervision Logic (Bottom of Figure 6.4)

Refer to the bottom of *Figure 6.4*. If *all* the following are true:

- The close logic output CLOSE (also see *Figure 6.3*) is *not* asserted (Relay Word bit CLOSE = logical 0).
- The reclosing relay is *not* in the Lockout State (Relay Word bit 79LO = logical 0).
- The circuit breaker is open (52A = logical 0).
- The reclose initiation condition (79RI) is *not* making a rising edge (logical 0 to logical 1) transition.
- The Reclose Supervision Limit Timer is *not* timed out (Relay Word bit RCSF = logical 0).

then a reclosing relay open interval time-out seals-in as shown in *Figure 6.4*. Then, when 79CLS asserts to logical 1, the sealed-in reclosing relay open interval time-out condition will propagate through *Figure 6.4* and on to the close logic in *Figure 6.3*.

Unlatch Reclose Supervision Logic (Bottom of Figure 6.4)

Refer to the bottom of *Figure 6.4*. If the reclosing relay open interval time-out condition is sealed-in, it stays sealed-in until *one* of the following occurs:

- The close logic output CLOSE (also see *Figure 6.4*) asserts (Relay Word bit CLOSE = logical 1).
- The reclosing relay goes to the Lockout State (Relay Word bit 79LO = logical 1).
- The circuit breaker closes (52A = logical 1).
- The reclose initiation condition (79RI) makes a rising-edge (logical 0 to logical 1) transition.
- SELOGIC control equation setting 79CLS asserts (79CLS = logical 1).
- The Reclose Supervision Limit Timer times out (Relay Word bit RCSF = logical 1 for one processing interval).

⚠WARNING
Setting 79CLSD = OFF can create an indefinite "standing close" condition. This is usually not desirable in practice.

The Reclose Supervision Limit Timer is inoperative if setting 79CLSD = OFF. With 79CLSD = OFF, reclose supervision condition 79CLS is not time limited. When an open interval times out, reclose supervision condition 79CLS is checked indefinitely until one of the other unlatch conditions comes true.

The unlatching of the sealed-in reclosing relay open interval time-out condition by the assertion of SELOGIC control equation setting 79CLS indicates successful propagation of a reclosing relay open interval time-out condition on to the close logic in *Figure 6.3*.

See *Additional Settings Example 2 on page 6.11*.

Factory Settings Example

Refer to the top of *Figure 6.4*.

The factory setting for the SELOGIC control equation reclose supervision setting is:

79CLS = **1** (numeral 1)

The factory setting for the Reclose Supervision Limit Timer setting is:

79CLSD = **0.00 cycles**

Any time a reclosing relay open interval times out, it propagates immediately through *Figure 6.4* and then on to *Figure 6.3*, because SELOGIC control equation setting 79CLS is always asserted to logical 1. Effectively, there is no special reclose supervision.

Additional Settings Example 1

Refer to the top of *Figure 6.4* and *Figure 6.6*.

SEL-311C relays are installed at both ends of a transmission line in a high-speed reclose scheme. After both circuit breakers open for a transmission line fault, the SEL-311C(1) recloses circuit breaker 52/1 first, followed by the SEL-311C(2) reclosing circuit breaker 52/2, after a synchronism check across circuit breaker 52/2.

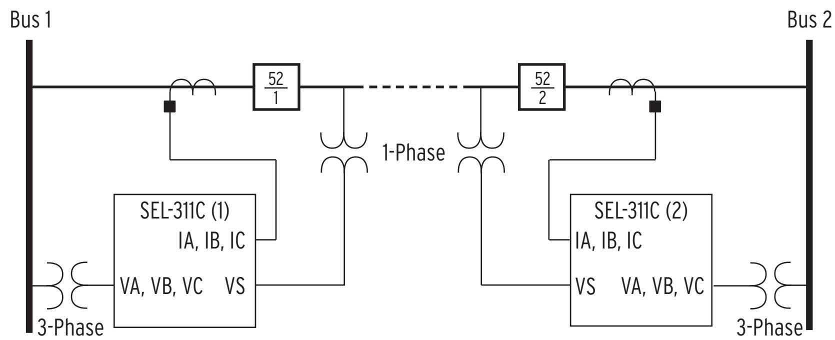


Figure 6.6 SEL-311C Relays Installed at Both Ends of a Transmission Line in a High-Speed Reclose Scheme

SEL-311C(1) Relay

Before allowing circuit breaker 52/1 to be reclosed after an open interval time-out, the SEL-311C(1) checks that Bus 1 voltage is hot and the transmission line voltage is dead.This requires reclose supervision settings:

79CLSD = **0.00 cycles** (only one check)

79CLS = **3P59 * 27S**

where:

3P59 = all three Bus 1 phase voltages (VA, VB, and VC) are hot

27S = monitored single-phase transmission line voltage (channel VS) is dead

SEL-311C(2) Relay

The SEL-311C(2) checks that Bus 2 voltage is hot, the transmission line voltage is hot, and both voltages satisfy the synchronism check logic requirements after the reclosing relay open interval times out, before allowing circuit breaker 52/2 to be reclosed.

This requires reclose supervision settings: 79CLSD = **0.00 cycles** (only one check)

79CLS =

where:

25A1 = selected Bus 2 phase voltage (VA, VB, or VC) is in synchronism with monitored single-phase transmission line voltage (channel VS) and both are hot.

Other Setting Considerations for SEL-311C(1) and SEL-311C(2) Relays

Refer to *Skip Shot and Stall Open-Interval Timing Settings (79SKP and 79STL, Respectively) on page 6.22*.

SELOGIC control equation setting 79STL stalls open interval timing if it asserts. If setting 79STL is deasserted, open interval timing can continue. The SEL-311C(1) has no intentional open interval timing stall condition (circuit breaker 52/1 closes first after a transmission line fault):

79STL = **0** (numeral 0)

The SEL-311C(2) starts open interval timing after circuit breaker 52/1 at the remote end has reenergized the line. The SEL-311C(2) has to see Bus 2 hot, transmission line hot, and both voltages satisfy the synchronism check logic requirements across open circuit breaker 52/2 for open interval timing to begin. Thus, SEL-311C(2) open interval timing is stalled when the transmission line voltage and Bus 2 voltage are *not* in synchronism across open circuit breaker 52/2:

79STL = **!25A1** [=NOT(25A1)]

A transient condition that meets the synchronism check requirements across a three pole-open open circuit breaker 52/2 could possibly occur if circuit breaker 52/1 recloses into a fault on one phase of the transmission line. The other two unfaulted phases would be briefly energized until circuit breaker 52/1 is tripped again. If channel VS of the SEL-311C(2) is connected to one of these briefly energized phases, synchronism check element 25A1 could momentarily assert to logical 1.

So that this possible momentary assertion of synchronism check element 25A1 does not cause any inadvertent reclose of circuit breaker 52/2, make sure the open interval timers in the SEL-311C(2) are set with some appreciable time greater than the momentary energization time of the faulted transmission line. Or, run the synchronism check element 25A1 through a programmable timer before using it in the preceding 79CLS and 79STL settings for the SEL-311C(2) (see *Figure 7.24* and *Figure 7.25*). Note the built-in 3 cycle qualification of the synchronism check voltages shown in *Figure 3.39*.

Additional Settings Example 2

Refer to *Synchronism Check Elements on page 3.53*. Also refer to *Figure 6.5* and *Figure 6.6*.

If the synchronizing voltages across open circuit breaker 52/2 are “slipping” with respect to one another, the Reclose Supervision Limit Timer setting 79CLSD should be set greater than zero so there is time for the slipping voltages to come into synchronism. For example:

79CLSD = **60.00 cycles**

79CLS = **25A1**

The status of synchronism check element 25A1 is checked continuously during the 60-cycle window. If the slipping voltages come into synchronism while timer 79CLSD is timing, synchronism check element 25A1 asserts to logical 1 and reclosing proceeds.

If the slipping voltages fail to come into synchronism while timer 79CLSD is timing (resulting in a reclose supervision failure, causing RCSF to assert for one processing interval), then the reclosing relay goes to the Lockout State.

In *Synchronism Check Elements*, note item 3 under *Synchronism Check Element Outputs on page 3.68*, Voltages V_P and V_S are “Slipping.” Item 3 describes a last attempt for a synchronism check reclose before timer 79CLSD times out (or setting 79CLSD = 0.00 and only one check is made).

Reclosing Relay

Note that input:

Reclosing Relay Open Interval Time-Out

in *Figure 6.4* is the logic input that is qualified by SELOGIC control equation setting 79CLS, and then propagated on to the close logic in *Figure 6.3* to automatically reclose a circuit breaker. The explanation that follows in this reclosing relay subsection describes all the reclosing relay settings and logic that eventually result in this open interval time-out logic input into *Figure 6.4*. Other aspects of the reclosing relay are also explained.

The reclose enable setting, E79, has setting choices N, 1, 2, 3, and 4. Setting E79 = N defeats the reclosing relay. Setting choices 1 through 4 are the number of desired automatic reclosures (see *Open Interval Timers on page 6.15*).

Reclosing Relay States and General Operation

The SEL-311C reclosing relay is a state machine, as depicted in *Figure 6.7*. When running in the reclose cycle state (79CY) it can provide up to four reclose attempts or "shots."

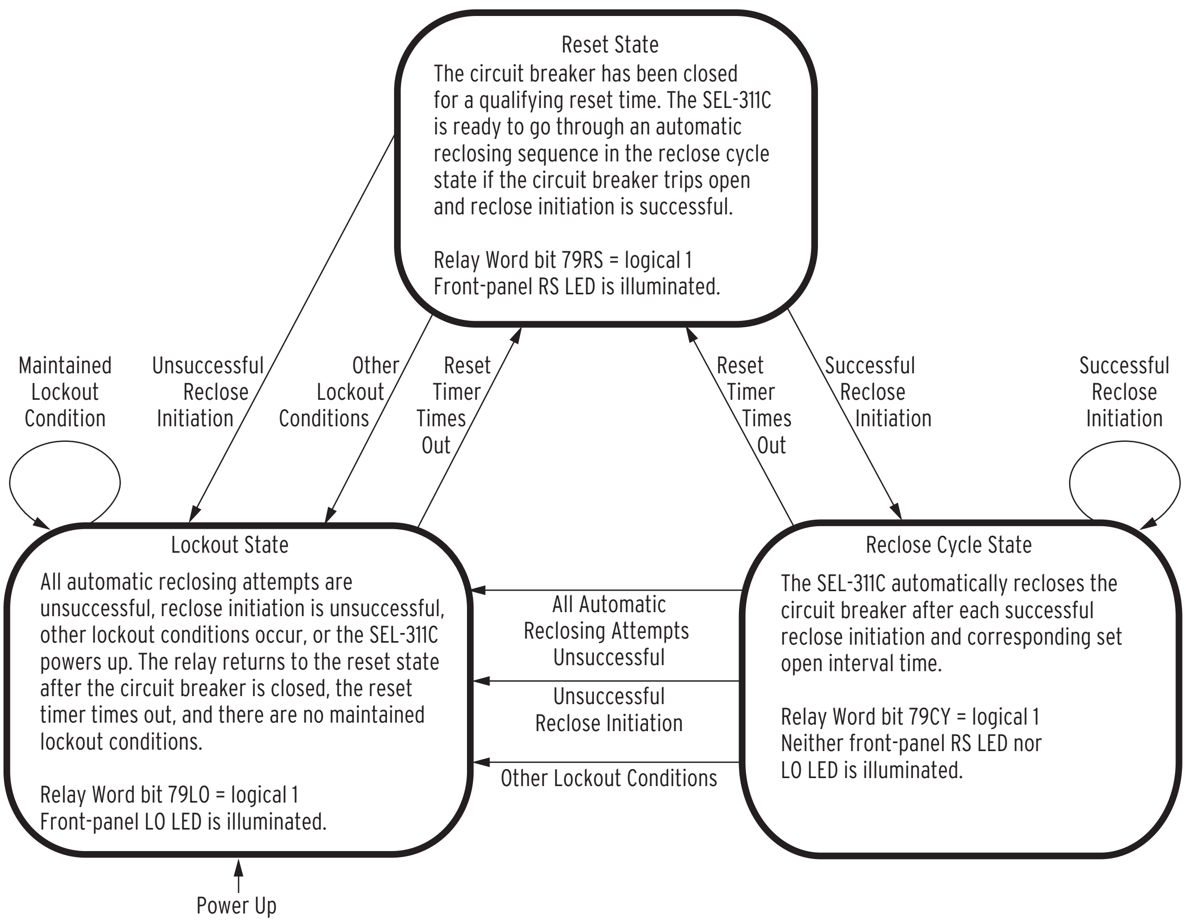


Figure 6.7 Reclosing Relay States and General Operation

Table 6.1 Relay Word Bit and Front-Panel Correspondence to Reclosing Relay States

Reclosing Relay State	Corresponding Relay Word Bit	Corresponding Front-Panel LED[a]
Reset	79RS	RS
Reclose Cycle	79CY	none
Lockout	79LO	LO

[a] Factory default on relays with programmable front-panel LEDs.

The reclosing relay is in one (and only one) of these states (listed in *Table 6.1*) at any time. When in a given state, the corresponding Relay Word bit asserts to logical 1, and the LED illuminates (or none illuminate for the case of 79RS). Automatic reclosing only takes place when the relay is in the Reclose Cycle State.

Lockout State

The reclosing relay goes to the Lockout State if any *one* of the following occurs:

- ➤ The shot counter is equal to or greater than the last shot at time of reclose initiation (e.g., all automatic reclosing attempts are unsuccessful—see *Figure 6.8*).
- ➤ Reclose initiation is unsuccessful because of SELOGIC control equation setting 79RIS (see *Reclose Initiate and Reclose Initiate Supervision Settings (79RI and 79RIS, Respectively) on page 6.18*).
- ➤ The circuit breaker opens without reclose initiation (e.g., an external trip).

  If a trip is issued via the optional front-panel SafeLock trip pushbutton and it is wired similarly to *Figure 2.18*, then this trip appears as an external trip to the relay and the relay goes to the lockout state.
- ➤ The shot counter is equal to or greater than last shot, and the circuit breaker is open (e.g., the shot counter is driven to last shot with SELOGIC control equation setting 79DLS while open interval timing is in progress. See *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 6.20*).
- ➤ The close failure timer (setting CFD) times out (see *Figure 6.3*).
- ➤ SELOGIC control equation setting 79DTL = logical 1 (see *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively)*).
- ➤ The Reclose Supervision Limit Timer (setting 79CLSD) times out (see *Figure 6.4* and top of *Figure 6.5*) and the reclose enable setting, E79, is set to 1, 2, 3, or 4.
- ➤ A new reclose initiation occurs while the reclosing relay is timing on an open interval (e.g., flashover in the tank while breaker is open).

The **OPEN** command is included in the reclosing relay logic via the factory SELOGIC control equation setting:

79DTL = **... + OC** (drive-to-lockout)

Relay Word bit OC asserts for execution of the **OPEN** command. See *OPE Command (Open Breaker) on page 10.46* for more information on the **OPEN** command. Also, see *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 6.20*.

In the factory settings, the **OPEN** command is set to trip (TR = … + OC), and the following reclosing relay SELOGIC control equation settings ensure that that an **OPEN** command trip cannot initiate reclosing:

79RI = **TRIP** (reclose initiate)

79DTL = **... + OC** (drive-to-lockout)

Reclosing Relay States and Settings/Setting Group Changes

If individual settings are changed for the active setting group *or* the active setting group is changed, *all* of the following occur:

- ➤ The reclosing relay remains in the state it was in before the settings change.
- ➤ The shot counter is driven to last shot (last shot corresponding to the new settings; see discussion on last shot that follows).
- ➤ The reset timer is loaded with reset time setting 79RSLD (see discussion on reset timing later in this section).

If the relay happened to be in the Reclose Cycle State and was timing on an open interval before the settings change, the relay would be in the Reclose Cycle State after the settings change, but the relay would immediately go to the Lockout State. This is because the breaker is open, and the relay is at last shot after the settings change, and thus no more automatic reclosures are available.

If the circuit breaker remains closed through the settings change, the reset timer times out on reset time setting 79RSLD after the settings change and goes to the Reset State (if it is not already in the Reset State), and the shot counter returns to shot = 0. If the relay happens to trip during this reset timing, the relay will immediately go to the Lockout State, because shot = last shot.

Defeat the Reclosing Relay

If *any one* of the following reclosing relay settings are made:

- ➤ Reclose enable setting E79 = N.
- ➤ Open Interval 1 time setting 79OI1 = 0.00.

then the reclosing relay is defeated, and no automatic reclosing can occur. These settings are explained later in this section. See also the *SEL-311C Settings Sheets*.

If the reclosing relay is defeated, the following also occur:

- ➤ All three reclosing relay state Relay Word bits (79RS, 79CY, and 79LO) are forced to logical 0 (see *Table 6.1*).
- ➤ All shot counter Relay Word bits (SH0, SH1, SH2, SH3, and SH4) are forced to logical 0 (the shot counter is explained later in this section).
- ➤ The factory default front-panel LEDs **RS** and **LO** are both extinguished, providing a visible indication that the recloser is defeated. (This indication is not definitive because these two LEDs are also extinguished during a reclose cycle state).
- ➤ The front-panel Reclosing Relay Shot Counter Screen displays `No Reclosing Set`. See *Functions Unique to the Front-Panel Interface on page 11.5*.

Close Logic Can Still Operate When the Reclosing Relay Is Defeated

If the reclosing relay is defeated, the close logic (see *Figure 6.3*) can still operate if the following settings are *not* true:

- ➤ 52A = 0
- ➤ ULCL = logical 1

Making 52A = 0 or ULCL = 1 (or setting ULCL to a SELOGIC condition that is always logical 1) defeats the close logic *and* also defeats the reclosing relay.

For example, if 52A = IN101, a 52a circuit breaker auxiliary contact is connected to input **IN101**. If the reclosing has been defeated, the close logic still operates, allowing closing to take place via SELOGIC control equation setting CL (close conditions, other than automatic reclosing). See *Breaker Status Logic on page 6.2* and *Close Logic on page 6.2* for more discussion on SELOGIC control equation settings 52A and CL. Also see *Optoisolated Inputs on page 7.2* for more discussion on SELOGIC control equation setting 52A.

Reclosing Relay Timer Settings

The open interval and reset timer factory settings are shown in *Table 6.2*:

Table 6.2 Reclosing Relay Timer Settings and Setting Ranges

Timer Setting[a] (range)	Factory Setting (in cycles)	Definition
79OI1 (0.00–999999 cyc)	0.00	open interval 1 time
79OI2 (0.00–999999 cyc)	0.00	open interval 2 time
79OI3 (0.00–999999 cyc)	0.00	open interval 3 time
79OI4 (0.00–999999 cyc)	0.00	open interval 4 time
79RSD (0.00–999999 cyc)	1800.00	reset time from reclose cycle state
79RSLD (0.00–999999 cyc)	300.00	reset time from lockout state

[a] These settings are not visible when enable setting E79 = N, which is the factory default.

The operation of these timers is affected by SELOGIC control equation settings discussed later in this section. Also, see the *SEL-311C Settings Sheets*.

Open Interval Timers

The reclose enable setting, E79, determines the number of open interval time settings that can be set. For example, if setting E79 = 3, the first three open interval time settings in *Table 6.2* are made available for setting.

If an open interval time is set to zero, then that open interval time is not operable, *and* neither are the open interval times that follow it.

In the factory settings in *Table 6.2*, the open interval 1 time setting 79OI1 is the first open interval time setting set equal to zero:

79OI1 = **0.00 cycles**

Thus, open interval times 79OI1, 79OI2, 79OI3, and 79OI4 are not operable. If E79 = 3, and the open interval timer settings were:

79OI1 = **180.00 cycles**

79OI2 = **0.00 cycles**

79OI3 = **900.00 cycles** (set to some value other than zero)

open interval time 79OI3 would still be inoperative, because a preceding open interval time is set to zero (i.e., 79OI2 = 0.00).

The open interval timers time consecutively; they do not have the same beginning time reference point. For example, with settings 79OI1 = 30.00 cycles, and 79OI2 = 600.00 cycles, open interval 1 time setting, 79OI1, times first. If subsequent first reclosure is not successful, then open interval 2 time setting, 79OI2, starts timing. If the subsequent second reclosure is not successful, the relay goes to the Lockout State. See the example time line in *Figure 6.8*. The open interval timer starts timing when the 52A status deasserts (logical 0) following a valid reclose initiation, unless the open interval timing is suspended because the SELOGIC equation 79STL is asserted (logical 1).

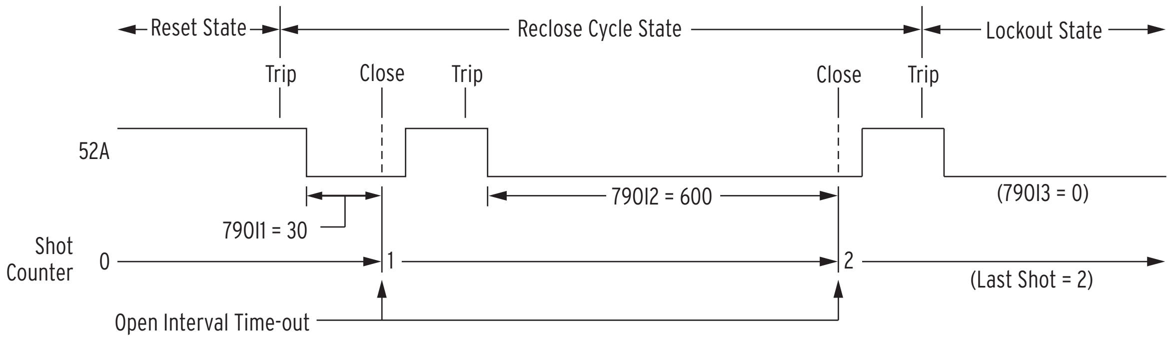


Figure 6.8 Reclosing Sequence From Reset to Lockout With Example Settings

SELOGIC control equation setting 79STL (stall open interval timing) can be set to control open interval timing (see *Skip Shot and Stall Open-Interval Timing Settings (79SKP and 79STL, Respectively) on page 6.22*).

Determination of Number of Reclosures (Last Shot)

The number of reclosures is equal to the number of open interval time settings that precede the first open interval time setting set equal to zero. The "last shot" value is also equal to the number of reclosures.

In the above example settings, two set open interval times precede open interval 3 time, which is set to zero (79OI3 = 0.00):

79OI1 = **30.00**

79OI2 = **600.00**

79OI3 = **0.00**

For this example:

Number of reclosures (last shot) = 2 = the number of set open interval times that precede the first open interval set to zero.

Observe Shot Counter Operation

Observe the reclosing relay shot counter operation, especially during testing, with the front-panel shot counter screen (accessed via the **OTHER** pushbutton). See *Functions Unique to the Front-Panel Interface on page 11.5*.

Reset Timer

Reset timers qualify circuit breaker closure before taking the relay to the Reset State from the Reclose Cycle State or the Lockout State. Circuit breaker status is determined by the SELOGIC control equation setting 52A. (See *Breaker Status Logic on page 6.2* for more discussion on SELOGIC control equation setting 52A.)

Setting 79RSD

Qualifies closures when the relay is in the Reclose Cycle State. These closures are usually automatic reclosures resulting from open interval time-out.

It is also the reset time used in sequence coordination schemes (see *Sequence Coordination Setting (79SEQ) on page 6.25*).

Setting 79RSLD

Qualifies closures when the relay is in the Lockout State. These closures are usually manual closures. These manual closures can originate external to the relay, via the **CLOSE** command, or via the SELOGIC control equation setting CL (see *Figure 6.3*).

Setting 79RSLD is also the reset timer used when the relay powers up, when settings are changed in the active setting group, or the active setting group is changed (see *Reclosing Relay States and Settings/Setting Group Changes on page 6.14*).

Setting 79RSD and Setting 79RSLD Are Independent

Typically, setting 79RSLD is set less than setting 79RSD. Setting 79RSLD emulates reclosing relays with motor-driven timers that have a relatively short reset time from the lockout position to the reset position.

The 79RSD and 79RSLD settings are set independently (setting 79RSLD can even be set greater than setting 79RSD, if desired). SELOGIC control equation setting 79BRS (block reset timing) can be set to control reset timing (see *Block Reset Timing Setting (79BRS) on page 6.24*).

Monitoring Open-Interval and Reset Timing

Open-interval and reset timing can be monitored with the following Relay Word bits:

Relay Word Bits	Definition
OPTMN	Indicates that the open interval timer is *actively* timing
RSTMN	Indicates that the reset timer is *actively* timing

If the open-interval timer is actively timing, OPTMN asserts. When the relay is not timing on an open interval (e.g., it is in the Reset State or in the Lockout State), OPTMN deasserts. The relay can only time on an open interval when it is in the Reclose Cycle State, but just because the relay is in the Reclose Cycle State does not necessarily mean the relay is timing on an open interval. When the next open interval is enabled, the relay only times on the open interval after successful reclose initiation, the breaker is open (52A = logical 0), and no stall conditions are present (see *Skip Shot and Stall Open-Interval Timing Settings (79SKP and 79STL, Respectively) on page 6.22*).

If the reset timer is actively timing, RSTMN asserts. If the reset timer is not timing, RSTMN deasserts. See *Block Reset Timing Setting (79BRS) on page 6.24*.

Reclosing Relay Shot Counter

Refer to *Figure 6.8*.

The shot counter increments for each reclose operation. For example, when the relay is timing on open interval 1, 79OI1, it is at shot = 0. When the open interval times out, the shot counter increments to shot = 1 and so forth for the set open intervals that follow. The shot counter cannot increment beyond the last shot for automatic reclosing (see *Determination of Number of Reclosures (Last Shot) on page 6.16*). The shot counter resets back to shot = 0 when the reclosing relay returns to the Reset State.

Table 6.3 Shot Counter Correspondence to Relay Word Bits and Open Interval Times

Shot	Corresponding Relay Word Bit	Corresponding Open Interval
0	SH0	79OI1
1	SH1	79OI2
2	SH2	79OI3
3	SH3	79OI4
4	SH4	

When the shot counter is at a particular shot value (e.g., shot = 2), the corresponding Relay Word bit asserts to logical 1 (e.g., SH2 = logical 1).

The shot counter also increments for sequence coordination operation. The shot counter can increment beyond the last shot for sequence coordination (see *Sequence Coordination Setting (79SEQ) on page 6.25*).

Reclosing Relay SELogic Control Equation Settings Overview

Table 6.4 Example Reclosing Relay SELogic Control Equation Settings

SELogic Control Equation Setting	Example Setting	Definition
79RI	TRIP	Reclose Initiate
79RIS	52A + 79CY	Reclose Initiate Supervision
79DTL	OC + !IN105 + LB3	Drive-to-Lockout
79DLS	79LO	Drive-to-Last Shot
79SKP	0	Skip Shot
79STL	TRIP	Stall Open Interval Timing
79BRS	TRIP	Block Reset Timing
79SEQ	0	Sequence Coordination
79CLS	1	Reclose Supervision

These example settings are discussed in detail in the remainder of this subsection.

Reclose Initiate and Reclose Initiate Supervision Settings (79RI and 79RIS, Respectively)

The reclose initiate setting 79RI is a rising-edge detect setting. The reclose initiate supervision setting 79RIS supervises setting 79RI. When setting 79RI senses a rising edge (logical 0 to logical 1 transition), setting 79RIS has to be at logical 1 (79RIS = logical 1) in order for open interval timing to be initiated.

If 79RIS = logical 0 when setting 79RI senses a rising edge (logical 0 to logical 1 transition), the relay goes to the Lockout State.

Settings Example

With the settings in *Table 6.4*:

79RI = **TRIP**

79RIS = **52A + 79CY**

the transition of the TRIP Relay Word bit from logical 0 to logical 1 enables the next open-interval only if Relay Word bits 52A or 79CY are logical 1. Input **IN101** is assigned as the breaker status input in the factory settings (52A = IN101).

The circuit breaker has to be closed (circuit breaker status 52A = logical 1) at the instant of the first trip of the autoreclose cycle in order for the SEL-311C to successfully initiate reclosing and start timing on the first open interval. The SEL-311C is not yet in the reclose cycle state (79CY = logical 0) at the instant of the first trip.

Then for any subsequent trip operations in the autoreclose cycle, the SEL-311C is in the reclose cycle state (79CY = logical 1) and the SEL-311C successfully initiates reclosing for each trip. Because of factory setting 79RIS = 52A + 79CY, successful reclose initiation in the reclose cycle state (79CY = logical 1) is not dependent on the circuit breaker status (52A). This allows successful reclose initiation for the case of an instantaneous trip when the circuit breaker status indication is slow—the instantaneous trip (reclose initiation) occurs before the SEL-311C sees the circuit breaker close.

If a flashover occurs in a circuit breaker tank during an open interval (circuit breaker open and the SEL-311C calls for a trip), the SEL-311C goes immediately to lockout.

Additional Settings Example

The preceding settings example initiates open interval timing on rising edge of the TRIP Relay Word bit. The following is an example of reclose initiation on the opening of the circuit breaker.

Presume input **IN101** is connected to a 52a circuit breaker auxiliary contact (52A = IN101).

With setting:

79RI = **!52A**

the transition of the 52A Relay Word bit from logical 1 to logical 0 (breaker opening) enables the next open interval. Setting 79RI looks for a logical 0 to logical 1 transition, thus Relay Word bit 52A is inverted in the 79RI setting [!52A = NOT(52A)].

The reclose initiate supervision setting 79RIS supervises setting 79RI. With settings:

79RI = **!52A**

79RIS = **TRIP**

the transition of the 52A Relay Word bit from logical 1 to logical 0 enables the next open interval only if the TRIP Relay Word bit is at logical 1 (TRIP = logical 1). Thus, the TRIP Relay Word bit has to be asserted when the circuit breaker opens in order to initiate open interval timing. With a long enough setting of the Minimum Trip Duration Timer (TDURD), the TRIP Relay Word bit will still be asserted to logical 1 when the circuit breaker opens (see *Figure 5.1* and *Figure 5.2*).

If the TRIP Relay Word bit is at logical 0 (TRIP = logical 0) when the circuit breaker opens (79RI transitions from logical 0 to logical 1), the relay goes to the Lockout State. This helps prevent reclose initiation when the circuit breaker is opened by a signal external to the relay, such as when using the optional front-panel SafeLock trip pushbutton, wired similarly to *Figure 2.18*.

If circuit breaker status indication (52A) is slow, the TRIP Relay Word bit should be removed from unlatch close setting ULCL (*Figure 6.3*) when setting 79RI = !52A. This keeps the SEL-311C from going to lockout prematurely for an instantaneous trip after an auto-reclose. This setting allows CLOSE to remain asserted until the circuit breaker status indication confirms that the breaker is closed. The circuit breaker anti-pump circuitry should take care of the TRIP and CLOSE being on together for a short period of time.

Other Settings Considerations

1. If no reclose initiate supervision is desired, make the following setting:

   79RIS = **1** (numeral 1)

   Setting 79RIS = logical 1 at all times. Any time a logical 0 to logical 1 transition is detected by setting 79RI, the next open interval will be enabled (unless prevented by other means).

2. If the following setting is made:

   79RI = **0** (numeral 0)

   reclosing will never take place. The reclosing relay is effectively inoperative because there is no way to initiate the autoreclose cycle. However, the relay reclose state might still transition between RESET (79RS = 1) and LOCKOUT (79LO = 1), depending on 52A status.

3. If the following setting is made:

   79RIS = **0** (numeral 0)

   reclosing will never take place (the reclosing relay goes directly to the lockout state any time reclosing is initiated). The reclosing relay is effectively inoperative.

Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively)

When 79DTL = logical 1, the reclosing relay goes to the Lockout State (Relay Word bit 79LO = logical 1), and the factory default front-panel **LO** (Lockout) LED illuminates.

79DTL has a built-in 60-cycle dropout time. This keeps the drive-to-lockout condition up 60 more cycles after the 79DTL equation has deasserted. This is useful for situations where both of the following are true:

- ➤ Any of the trip and drive-to-lockout conditions are “pulsed” conditions (e.g., the **OPEN** command Relay Word bit, OC, asserts for only 1/4 cycle—refer to *Settings Example on page 6.20*).
- ➤ Reclose initiation is by the breaker contact opening (e.g., 79RI = !52A—refer to *Additional Settings Example on page 6.19*).

Then the drive-to-lockout condition overlaps reclose initiation and the SEL-311C stays in lockout after the breaker trips open.

When 79DLS = logical 1, the reclosing relay goes to the last shot, if the shot counter is not already at a shot value greater than or equal to the calculated last shot (see *Reclosing Relay Shot Counter on page 6.17*).

Settings Example

The drive-to-lockout *Table 6.4* example setting is:

79DTL = **OC + !IN105 + LB3**

Optoisolated input **IN105** is set to operate as a reclose enable switch (see *Optoisolated Inputs on page 7.2*). When Relay Word bit IN105 = logical 1 (reclosing enabled), the relay is *not* driven to the Lockout State (assuming local bit LB3 = logical 0, too):

!IN105 = **!(logical 1)** = NOT(logical 1) = logical 0

79DTL = **OC + !IN105 + LB3** = OC + (logical 0) + LB3 = OC + LB3

When Relay Word bit IN105 = logical 0 (reclosing disabled), the relay is driven to the Lockout State:

!IN105 = **!(logical 0)** = NOT(logical 0) = logical 1

79DTL = **OC + !IN105 + LB3** = OC + (logical 1) + LB3 = logical 1

Local bit LB3 is set to operate as a manual trip switch (see *Local Control Switches on page 7.6* and *Trip Logic on page 5.1*). When Relay Word bit LB3 = logical 0 (no manual trip), the relay is *not* driven to the Lockout State (assuming optoisolated input IN102 = logical 1, too):

79DTL = **OC + !IN105 + LB3** = OC + NOT(IN105) + (logical 0) = OC + NOT(IN105)

When Relay Word bit LB3 = logical 1 (manual trip), the relay is driven to the Lockout State:

79DTL = **OC + !IN105 + LB3** = OC + NOT(IN105) + (logical 1) = logical 1

Relay Word bit OC asserts for execution of the **OPEN** command. See the discussion at the end of *Lockout State on page 6.13*.

The drive-to-last shot factory setting is:

79DLS = **79LO**

One open interval is also set in the factory settings, resulting in last shot = 1. Any time the relay is in the lockout state (Relay Word bit 79LO = logical 1), the relay is driven to last shot (if the shot counter is not already at a shot value greater than or equal to shot = 1):

79DLS = **79LO** = logical 1

Thus, if optoisolated input **IN105** (reclose enable switch) is in the “disable reclosing” position (Relay Word bit IN105 = logical 0) or local bit LB3 (manual trip switch) is operated, then the relay is driven to the Lockout State (by setting 79DTL) and, subsequently, last shot (by setting 79DLS).

Additional Settings Example 1

The preceding drive-to-lockout factory settings example drives the relay to the Lockout State immediately when the reclose enable switch (optoisolated input **IN105**) is put in the “reclosing disabled” position (Relay Word bit IN105 = logical 0):

79DTL = **!IN105 + ...** = NOT(IN105) + ... = NOT(logical 0) + ... = logical 1

To disable reclosing, but not drive the relay to the Lockout State until the relay trips, make settings similar to the following:

79DTL = **!IN105 * TRIP + ...**

Additional Settings Example 2

To drive the relay to the Lockout State for fault current above a certain level when tripping (e.g., level of phase instantaneous overcurrent element 50P3), make settings similar to the following:

79DTL = **TRIP * 50P3 + ...**

Additionally, if the reclosing relay should go to the Lockout State for an underfrequency trip, make settings similar to the following:

79DTL = **TRIP * 81D1T + ...**

Other Settings Considerations

If no special drive-to-lockout or drive-to-last shot conditions are desired, make the following settings:

79DTL = **0** (numeral 0)

79DLS = **0** (numeral 0)

With settings 79DTL and 79DLS inoperative, the relay still goes to the Lockout State (and to last shot) if an entire automatic reclose sequence is unsuccessful.

Overall, settings 79DTL or 79DLS are needed to take the relay to the Lockout State (or to last shot) for immediate circumstances.

Skip Shot and Stall Open-Interval Timing Settings (79SKP and 79STL, Respectively)

The skip shot setting 79SKP causes a reclose shot to be skipped. Thus, an open interval time is skipped, and the next open interval time is used instead.

If 79SKP = logical 1 at the instant of successful reclose initiation (see preceding discussion on settings 79RI and 79RIS), the relay increments the shot counter to the next shot and then loads the open interval time corresponding to the new shot (see *Table 6.3*). If the new shot is the “last shot,” no open interval timing takes place, and the relay goes to the Lockout State if the circuit breaker is open (see *Lockout State on page 6.13*).

After successful reclose initiation, open interval timing does not start until allowed by the stall open interval timing setting 79STL. If 79STL = logical 1, open interval timing is stalled. If 79STL = logical 0, open interval timing can proceed.

If an open interval time has not yet started timing (79STL remains at logical 1), the 79SKP setting is still processed. In such conditions (open interval timing has not yet started), if 79SKP = logical 1, the relay increments the shot counter to the next shot and then loads the open interval time corresponding to the new shot (see *Table 6.3*). If the new shot turns out to be the “last shot,” no open interval timing takes place, and the relay goes to the Lockout State if the circuit breaker is open (see *Lockout State on page 6.13*).

If the relay is in the middle of timing on an open interval and 79STL changes state to 79STL = logical 1, open interval timing stops where it is. If 79STL changes state back to 79STL = logical 0, open interval timing resumes where it left off. Use the OPTMN Relay Word bit to monitor open interval timing (see *Monitoring Open-Interval and Reset Timing on page 6.17*).

Factory Settings Example

The skip shot function is not enabled in the factory settings:

79SKP = **0** (numeral 0)

The stall open interval timing factory setting is:

79STL = **TRIP**

After successful reclose initiation, open interval timing does not start as long as the trip condition is present (Relay Word bit TRIP = logical 1). As discussed previously, if an open interval time has not yet started timing (79STL = logical 1 still), the 79SKP setting is still processed. Once the trip condition goes away (Relay Word bit TRIP = logical 0), open interval timing can proceed.

Additional Settings Example 1

With skip shot setting:

79SKP = **50P2 * SH0**

if shot = 0 (Relay Word bit SH0 = logical 1) and phase current is above the phase instantaneous overcurrent element 50P2 threshold (Relay Word bit 50P2 = logical 1), at the instant of successful reclose initiation, the shot counter is incremented from shot = 0 to shot = 1. Then, open interval 1 time (setting 79OI1) is skipped, and the relay times on the open interval 2 time (setting 79OI2) instead.

Table 6.5 Open Interval Time Example Settings

Shot	Corresponding Relay Word Bit	Corresponding Open Interval	Open Interval Time Example Setting
0	SH0	79OI1	30 cycles
1	SH1	79OI2	600 cycles

In *Table 6.5*, note that the open interval 1 time (setting 79OI1) is a short time, while the following open interval 2 time (setting 79OI2) is significantly longer. For a high magnitude fault (greater than the phase instantaneous overcurrent element 50P2 threshold), open interval 1 time is skipped, and open interval timing proceeds on the following open interval 2 time.

Once the shot is incremented to shot = 1, Relay Word bit SH0 = logical 0 and then setting 79SKP = logical 0, regardless of Relay Word bit 50P2.

Additional Settings Example 2

If the SEL-311C Relay is used on a feeder with a line-side independent power producer (cogenerator), the utility should not reclose into a line still energized by an islanded generator. To monitor line voltage and block reclosing, connect a line-side single-phase potential transformer to channel VS on the SEL-311C as shown in *Figure 6.9*.

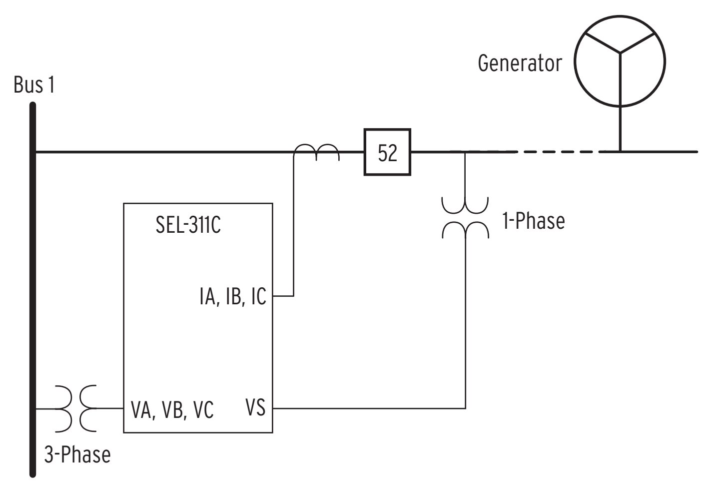


Figure 6.9 Reclose Blocking for Islanded Generator

If the line is energized, channel VS overvoltage element 59S1 can be set to assert. Make the following setting:

79STL = **59S1 + ...**

If line voltage is present, Relay Word bit 59S1 asserts, stalling open interval timing (reclose block). If line voltage is not present, Relay Word bit 59S1 deasserts, allowing open interval timing to proceed (unless some other set condition stalls open interval timing).

Additional Settings Example 3

Refer to *Figure 6.6* and accompanying setting example, showing an application for setting 79STL.

Other Settings Considerations

If no special skip shot or stall open interval timing conditions are desired, make the following settings:

79SKP = **0** (numeral 0)

79STL = **0** (numeral 0)

Block Reset Timing Setting (79BRS)

The block reset timing setting 79BRS keeps the reset timer from timing. Depending on the reclosing relay state, the reset timer can be loaded with either reset time:

79RSD (Reset Time from Reclose Cycle)

or

79RSLD (Reset Time from Lockout)

Depending on how setting 79BRS is set, none, one, or both of these reset times can be controlled. If the reset timer is timing and then 79BRS asserts to:

79BRS = logical 1

reset timing is stopped and does not begin timing again until 79BRS deasserts to:

79BRS = logical 0

When reset timing starts again, the reset timer is fully loaded. Thus, successful reset timing has to be continuous. Use the RSTMN Relay Word bit to monitor reset timing (see *Monitoring Open-Interval and Reset Timing on page 6.17*).

Factory Settings Example

The block reset timing factory setting is:

79BRS = **TRIP**

The block reset timing factory setting (79BRS = TRIP) keeps the reset timer (setting 79RSD) from starting to time during the brief interval that the circuit breaker is in the process of opening after the trip coil is energized.

At the instant of reclose initiation (factory reclose initiate setting 79RI = TRIP), one of the following starts timing, unless otherwise inhibited:

- Reset timing (setting 79RSD) if the circuit breaker is closed
- Open interval timing (setting 79OIn) if the circuit breaker is open

At the instant of tripping/reclose initiation, the circuit breaker is still closed and thus reset timer setting 79RSD starts timing, however briefly, if 79BRS = logical 0. This is mostly a nuisance in the Time column of the event report, where an “r” appears for a few cycles in the column (indicating the reset timer is timing), until the circuit breaker opens. Once the circuit breaker opens, the reset timer stops timing. When the circuit breaker recloses later, the reset timer starts timing anew, with full setting value 79RSD.

TRIP remains asserted for at least TDURD time (see *Figure 5.2*)—long enough to encompass this brief time period (waiting for the circuit breaker to open after the trip coil is energized). Thus, factory setting 79BRS = TRIP is used in most applications.

Additional Settings Example 1

The block reset timing setting is:

79BRS = **(51P + 51G) * 79CY**

Relay Word bit 79CY corresponds to the Reclose Cycle State. The reclosing relay is in one of the three reclosing relay states at any one time (see *Figure 6.7* and *Table 6.1*).

When the relay is in the Reset or Lockout States, Relay Word bit 79CY is deasserted to logical 0. Thus, the 79BRS setting has no effect when the relay is in the Reset or Lockout States. When a circuit breaker is closed from lockout, there could be cold load inrush current that momentarily picks up a time-overcurrent element (e.g., phase time-overcurrent element 51PT pickup (51P) asserts momentarily). But, this assertion of pickup 51P has no effect on reset timing because the relay is in the Lockout State (79CY = logical 0). The relay will time immediately on reset time 79RSLD and take the relay from the Lockout State to the Reset State with no additional delay because 79BRS is deasserted to logical 0.

When the relay is in the Reclose Cycle State, Relay Word bit 79CY is asserted to logical 1. Thus, the factory 79BRS setting can function to block reset timing if time-overcurrent pickup 51P or 51G is picked up while the relay is in the Reclose Cycle State. This helps prevent repetitive "trip-reclose" cycling for low-magnitude faults where the inverse time-overcurrent tripping time might be greater than the reset time from reclose cycle, 79RSD.

Additional Settings Example 2

If the block reset timing setting is:

79BRS = **51P + 51G**

then reset timing is blocked if time-overcurrent pickup 51P or 51G is picked up, regardless of the reclosing relay state.

Sequence Coordination Setting (79SEQ)

The 79SEQ setting is applicable to distribution applications; for transmission system applications set 79SEQ = 0. See the *SEL-351 Instruction Manual* for a description of setting 79SEQ.

Factory Settings

Sequence coordination is not enabled in the factory settings:

79SEQ = **0**

Reclose Supervision Setting (79CLS)

See *Reclose Supervision Logic on page 6.5*.

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Section 7
Inputs, Outputs, Timers, and Other Control Logic

Overview

This section contains the following topics:

This section explains the settings and operation of all the programmable logic functions of the relay, including control input and output functions. They are combined with the distance, overcurrent, voltage, frequency, and reclosing elements in SELOGIC® control equation settings to realize numerous protection and control schemes.

Relay Word bits and SELOGIC control equation setting examples are used throughout this section.

See *Section 9: Setting the Relay* for more information on relay setting procedures, and see *Appendix D: Relay Word Bits* for a list of Relay Word bits in the SEL-311C.

See *Section 10: Communications* for more information on viewing and making SELOGIC control equation settings (commands **SHO L** and **SET L**).

Optoisolated Inputs

NOTE: Optoisolated inputs are level-sensitive, meaning that they require more than one-half of rated voltage to assert. Refer to Specifications on page 1.2 for proper ac and dc voltages required for secure and dependable input operation.

Figure 7.1 and *Figure 7.2* show the resultant Relay Word bits (e.g., Relay Word bits IN101–IN106 in *Figure 7.1*) that follow corresponding optoisolated inputs (e.g., optoisolated inputs **IN101–IN106** in *Figure 7.1*) for the different SEL-311C Relay models. The figures show examples of energized and de-energized optoisolated inputs and corresponding Relay Word bit states. To assert an input, apply rated control voltage to the appropriate terminal pair (see *Figure 2.2*–*Figure 2.6*).

Figure 7.1, showing mainboard inputs IN101 to IN106, is used for the following discussion and examples. The optoisolated inputs in *Figure 7.2*, showing extra I/O board inputs IN201 to IN208, operate similarly.

NOTE: Optoisolated inputs are not polarity sensitive.

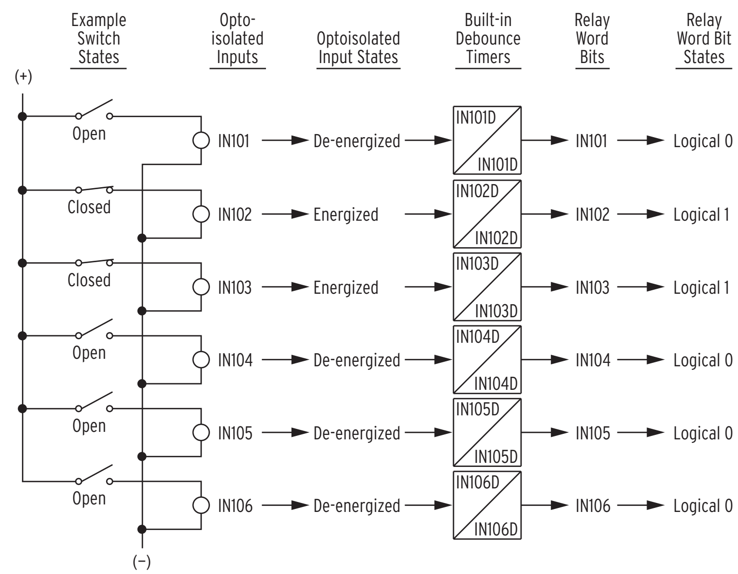


Figure 7.1 Example Operation of Optoisolated Inputs IN101–IN106 (All Models)

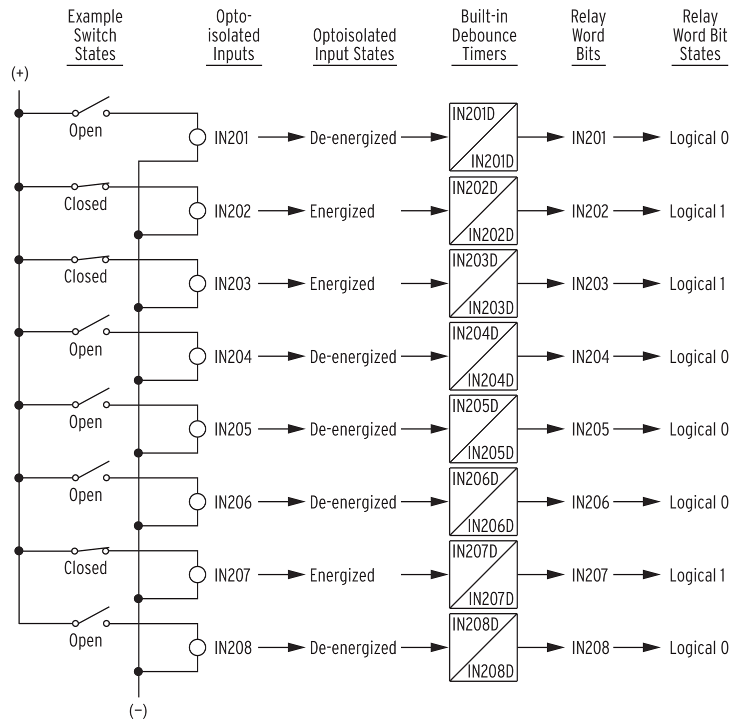


Figure 7.2 Example Operation of Optoisolated Inputs IN201–IN208 (Models With Extra I/O Board)

Input Debounce Timers

Each input has settable pickup/dropout timers for input energization/de-energization debounce. These timers are IN101D–IN106D (see *Figure 7.1*) and IN201D–IN208D (models with extra I/O board; see *Figure 7.2*). Note that a given time setting (e.g., IN101D = 0.50) is applied to both the pickup and dropout time for the corresponding input.

Debounce timer settings are adjustable from 0.00 to 2.00 cycles, or AC. The relay takes the entered time setting and internally runs the timer at the nearest 1/16 cycle. For example, if setting IN105D = 0.80, internally the timer runs at the nearest 1/16 cycle: 13/16 cycles (13/16 = 0.8125).

The AC setting allows the input to sense ac control signals. The input has a maximum pickup time of 0.75 cycles and a maximum dropout time of 1.25 cycles. The AC setting qualifies the input by not asserting until two successive 1/16 cycle samples are higher than the optoisolated input voltage threshold and not deasserting until sixteen successive 1/16 cycle samples are lower than the optoisolated input voltage threshold.

For *most dc applications*, the input pickup/dropout debounce timers should be set in 1/4 cycle increments.

Only a *few applications* (e.g., communications-assisted tripping schemes) might require input pickup/dropout debounce timers set less than 1/4 cycle [e.g., if setting IN105D = 0.13, internally the timer runs at the nearest 1/16 cycle: 2/16 cycles (2/16 = 0.1250)].

See SEL Application Guide *AG2003-08, Guidelines for Using Optoisolated Inputs in SEL Relays* on the SEL website for more information about debounce timers and optoisolated input security.

The relay processing interval is 1/4 cycle, so Relay Word bits IN101–IN106 and IN201–IN208 are updated every 1/4 cycle. The optoisolated input status may have made it through the pickup/dropout debounce timer (for settings less than 1/4 cycle) because these timers run each 1/16 cycle, but Relay Word bits IN101–IN106 and IN201–IN208 are updated every 1/4 cycle.

If more than two cycles of debounce is needed, run the Relay Word bit (for example, IN101) through a SELOGIC control equation variable timer and use the output of the timer for input functions (see *Figure 7.24* and *Figure 7.25*).

View Raw Input Status

For system testing and analysis, the status of the **IN101–IN106** and **IN201–IN208** inputs before the debounce timer is applied can be viewed in an event report by using the **EVE R** or **CEV R** commands. This type of event report is helpful for analyzing contact bounce problems with connected equipment. See *Filtered and Unfiltered Event Reports on page 12.14* for more information.

Input Functions

Optoisolated inputs are used by including the corresponding Relay Word bits (for example, IN101 or IN102) in SELOGIC control equations.

Factory Settings Examples

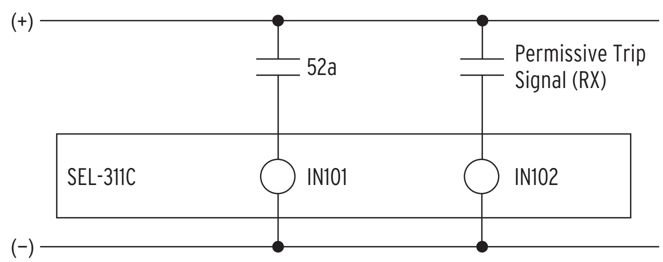


Figure 7.3 Circuit Breaker Auxiliary Contact and Received Permissive Trip Contact Connected to Optoisolated Inputs IN101 and IN102

The functions for inputs **IN101** and **IN102** are described in the following discussions.

Input IN101

Relay Word bit IN101 is used in the factory settings for the SELOGIC control equation circuit breaker status setting:

52A = **IN101**

Connect input **IN101** to a 52a circuit breaker auxiliary contact.

If a 52b circuit breaker auxiliary contact is connected to input **IN101**, the setting is changed to:

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

See *Close Logic on page 6.2* for more information on SELOGIC control equation setting 52A.

It is recommended that the pickup/dropout timer for input **IN101** (IN101D) be set as follows:

IN101D = **0.50 cycles**

These settings provide input energization/de-energization debounce and may be adjusted to suit the application.

Input **IN101** is indirectly used via the 52A Relay Word bit for other factory settings (e.g., SELOGIC control equation settings BSYNCH (see *Synchronism Check Elements on page 3.53*), 79RIS (see *Reclosing Relay on page 6.11*), and DP1 (see *Rotating Display on page 7.37*)).

Using Relay Word bit IN101 for the circuit breaker status setting 52A does *not* prevent using Relay Word bit IN101 in other SELOGIC control equation settings.

Input IN102

Relay Word bit IN102 is used in the factory settings for the SELOGIC control equation received permissive trip setting:

PT1 = **IN102**

Connect input **IN102** to the communications receiver permissive trip output.

When the permissive trip (RX) output contact is open, input **IN102** is de-energized and the permissive trip input is deasserted:

PT1 = **IN102** = logical 0

When the permissive trip (RX) output contact is closed, input **IN102** is energized and the permissive trip input is asserted:

PT1 = **IN102** = logical 1

See *Section 5: Trip and Target Logic* for more information on SELOGIC control equation setting PT1 in communications-assisted tripping schemes.

The pickup/dropout timer for input **IN102** (IN102D) could be set at:

IN102D = **0.13 cycles**

to provide a minimal delay (two samples) input energization/de-energization debounce. This is a Global setting, and would need to be changed from the factory default of 0.00 cycles.

Local Control Switches

NOTE: Local control switches are available only on models with an LCD.

The local control switch feature of this relay replaces traditional panel-mounted control switches. Operate the sixteen (16) local control switches using the **CNTRL** pushbutton on the front-panel keyboard/display (see *Section 11: Front-Panel Interface*).

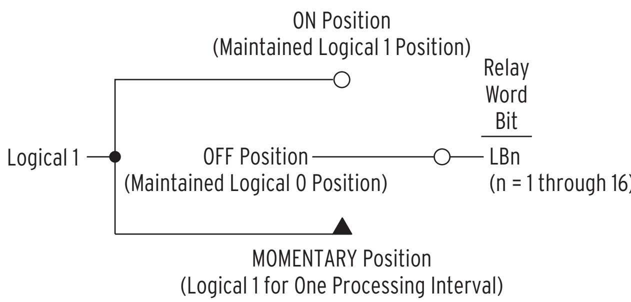


Figure 7.4 Local Control Switches Drive Local Bits LB1 Through LB16

NOTE: When one or more local switch label settings are entered, the front-panel rotating display will include the message `Push CNTRL for Local Control`. This message is not displayed when all local control switches are disabled.

The output of the local control switch in *Figure 7.4* is a Relay Word bit LB*n* (*n* = 1 through 16), called a local bit. The local control switch logic in *Figure 7.4* repeats for each local bit LB1–LB16. Use these local bits in SELOGIC control equations.

For a given local control switch, the local control switch positions are enabled by making corresponding label settings. Pressing the **CNTRL** button on the front panel displays a menu of local control switch functions. Follow the display menu to operate (set, pulse, or clear) the local bit associated with desired local control switch. The local bit must be used in the appropriate SELOGIC control equation to produce the desired result.

NOTE: On relays without an LCD, Relay Word bits LB1–LB16 are always deasserted (= logical 0).

Table 7.1 Correspondence Between Local Control Switch Positions and Label Settings

Switch Position	Label Setting	Setting Definition	Logic State
not applicable	NLB*n*	Name of Local Control Switch	not applicable
ON	SLB*n*	"Set" Local bit LB*n*	logical 1
OFF	CLB*n*	"Clear" Local bit LB*n*	logical 0
MOMENTARY	PLB*n*	"Pulse" Local bit LB*n*	logical 1 for one processing interval

Note the first setting in *Table 7.1* (NLB*n*) is the overall switch name setting that appears in the front-panel **CNTRL** display menu. Make each label setting through the serial port using the command **SET T**. View these settings using the serial port command **SHO T** (see *Section 9: Setting the Relay* and *Section 10: Communications*) or by reading the Text settings with ACSELERATOR QuickSet® SEL-5030 software.

Local Control Switch Types

Configure any local control switch as one of the following three switch types:

ON/OFF Switch

Local bit LB*n* is in either the ON (LB*n* = logical 1) or OFF (LB*n* = logical 0) position.

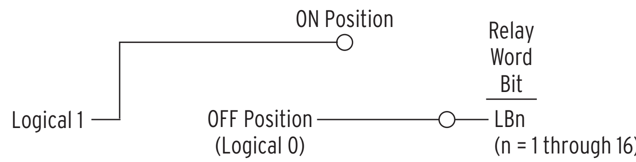


Figure 7.5 Local Control Switch Configured as an ON/OFF Switch

OFF/MOMENTARY Switch

The local bit LB*n* is maintained in the OFF (LB*n* = logical 0) position and pulses to the MOMENTARY (LB*n* = logical 1) position for one processing interval (1/4 cycle).

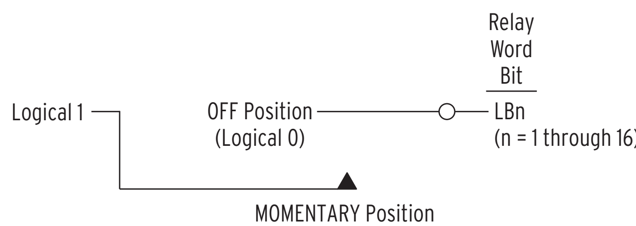


Figure 7.6 Local Control Switch Configured as an OFF/MOMENTARY Switch

ON/OFF/MOMENTARY Switch

The local bit LB*n*:

is in either the ON (LB*n* = logical 1) or OFF (LB*n* = logical 0) position

or

is in the OFF (LB*n* = logical 0) position and pulses to the MOMENTARY (LB*n* = logical 1) position for one processing interval (1/4 cycle).

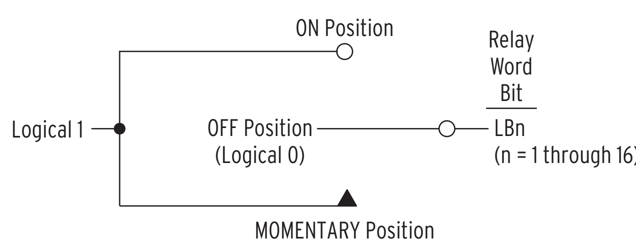


Figure 7.7 Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

Settings Determine Switch Type

Table 7.2 Correspondence Between 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

Disable local control switches by entering NA at the prompt for all the label settings for that switch (see *Section 9: Setting the Relay*). The local bit associated with this disabled local control switch is then fixed at logical 0.

Settings Examples

Local bits LB3 and LB4 might be used for manual trip and close functions. Their corresponding local control switch position labels are set to configure the switches as OFF/MOMENTARY switches:

Local Bit	Label Settings	Function
LB3	NLB3 = MANUAL TRIP	trips breaker and drives reclosing relay to lockout
	CLB3 = RETURN	OFF position ("return" from MOMENTARY position)
	SLB3 =	ON position—not used (left "blank")
	PLB3 = TRIP	MOMENTARY position
LB4	NLB4 = MANUAL CLOSE	closes breaker, separate from automatic reclosing
	CLB4 = RETURN	OFF position ("return" from MOMENTARY position)
	SLB4 =	ON position—not used (left "blank")
	PLB4 = CLOSE	MOMENTARY position

Following *Figure 7.8* and *Figure 7.9* show local control switches with example settings.

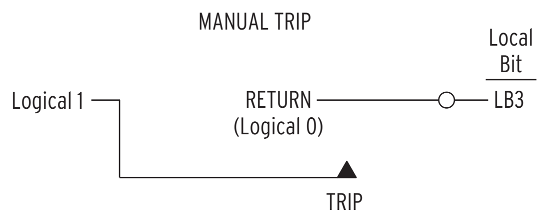


Figure 7.8 Configured Manual Trip Switch Drives Local Bit LB3

Local bit LB3 is set to trip in the following SELOGIC control equation manual trip setting (see *Figure 5.1*):

TR = **... + LB3 + ...**

To keep reclosing from being initiated for this trip, set local bit LB3 to drive the reclosing relay to lockout for a manual trip (see *Section 6: Close and Reclose Logic*):

79DTL = **... + LB3**

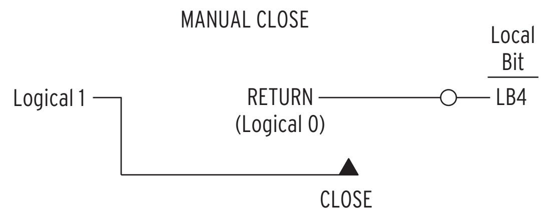


Figure 7.9 Configured Manual Close Switch Drives Local Bit LB4

Local bit LB4 is set to close the circuit breaker in the following SELOGIC control equation setting:

CL = **CC + LB4**

SELOGIC control equation setting CL is for close conditions other than automatic reclosing (see *Figure 6.3*).

Additional Local Control Switch Application Ideas

The preceding settings examples are OFF/MOMENTARY switches. Local control switches configured as ON/OFF switches can be used for such applications as:

- Reclosing relay enable/disable
- Ground relay enable/disable
- Remote control supervision

Local control switches can also be configured as ON/OFF/MOMENTARY switches for applications that require such. Local control switches can be applied to almost any control scheme that traditionally requires front-panel switches.

Local Control Switch States Retained

Power Loss

The states of the local bits (Relay Word bits LB1–LB16) 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 comes 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 comes back in the OFF position (corresponding local bit is still deasserted to logical 0) when power is restored. This feature makes local bits behave the same as a traditional installation with panel-mounted control switches. If power is lost to the panel, the front-panel control switch positions remain unchanged.

If a local bit is routed to a programmable output contact and control power is lost, the state of the local bit is stored in nonvolatile memory but the output contact will go to its de-energized state. When the control power is reapplied to the relay, the programmed output contact will go back to the state of the local bit after relay initialization.

Settings Change or Active Setting Group Change

If settings are changed (for the active setting group or one of the other setting groups) or the active setting group is changed, the states of the local bits (Relay Word bits LB1–LB16) are retained, much like in the preceding *Power Loss on page 7.9* explanation.

If a local control switch is made inoperable because of a settings change (i.e., the corresponding label settings are nulled), the corresponding local bit is then fixed at logical 0, regardless of the local bit state before the settings change. If a local control switch is made newly operable because of a settings change (i.e., the corresponding label settings are set), the corresponding local bit starts out at logical 0.

Remote Control Switches

Remote control switches are operated via the communications ports (see *CON Command (Control Remote Bit) on page 10.31*, *HMI Control Window on page C.7*, *Appendix J: Configuration, Fast Meter, and Fast Operate Commands*, *Appendix L: DNP3 Communications*, *Appendix O: Modbus RTU and TCP Communications*, and *Appendix P: IEC 61850*).

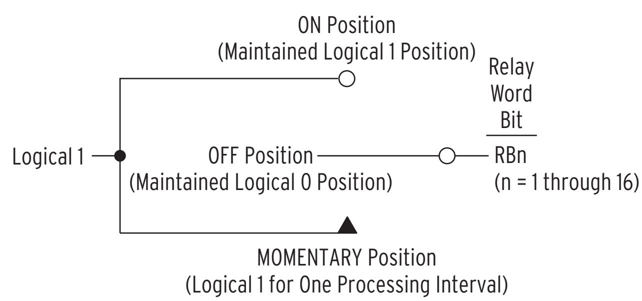


Figure 7.10 Remote Control Switches Drive Remote Bits RB1–RB16

The outputs of the remote control switches in *Figure 7.10* are Relay Word bits RB*n* (*n* = 1 to 16), called remote bits. Use these remote bits in SELOGIC control equations.

Any given 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)

Remote Bit Application Ideas

With SELOGIC control equations, the remote bits can be used in applications similar to those that local bits are used in (see preceding local control switch discussion).

Also, remote bits can be used much as optoisolated inputs are used in operating latch control switches (see discussion following *Figure 7.15*). Pulse (momentarily operate) the remote bits for this application.

Remote Bit States Not Retained When Power Is Lost

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

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

The state of each remote bit (Relay Word bits RB1–RB16) is retained if relay settings are changed (for the active setting group or one of the other setting groups) or the active setting group is changed. If a remote control switch is in the ON position (corresponding remote bit is asserted to logical 1) before a setting change or an active setting group change, it comes back in the ON position (corresponding remote bit is still asserted to logical 1) after the change. If a remote control switch is in the OFF position (corresponding remote bit is deasserted to logical 0) before a settings change or an active setting group change, it comes back in the OFF position (corresponding remote bit is still deasserted to logical 0) after the change.

Details on the Remote Control Switch MOMENTARY Position

This subsection describes remote control switch 3, which is also called remote bit 3 (RB3). All of the remote bits, RB1–RB16, operate in the same way.

See *CON Command (Control Remote Bit) on page 10.31*.

The **CON 3** command and **PRB 3** subcommand place the remote control switch 3 into the MOMENTARY position for one processing interval, regardless of its initial state. Remote control switch 3 is then placed in the OFF position.

If RB3 is initially at logical 0, pulsing it with the **CON 3** command and **PRB 3** subcommand will change RB3 to a logical 1 for one processing interval, and then return it to a logical 0. In this situation, the /RB3 (rising-edge operator) will also assert for one processing interval, followed by the \RB3 (falling-edge operator) one processing interval later.

If RB3 is initially at logical 1 instead, pulsing it with the **CON 3** command and **PRB 3** subcommand will change RB3 to a logical 0. In this situation, the /RB3 (rising-edge operator) will *not* assert, but the \RB3 (falling-edge operator) will assert for one processing interval.

See *Appendix F: Setting SELOGIC Control Equations* for more details on using the rising- and falling-edge operators in SELOGIC control equations.

Latch Control Switches

NOTE: The SEL-311C model described in this manual does not include an ELAT setting. All 16 latch control switch settings are always available. See SEL-311C Models on page 1.1 for more information.

The latch control switch feature of this relay replaces latching relays. Traditional latching relays maintain their output contact state when set.

The state of a traditional latching relay output contact is changed by pulsing the latching relay inputs (see *Figure 7.11*). Pulse the set input to close (“set”) the latching relay output contact. Pulse the reset input to open (“reset”) the latching relay output contact. Often the external contacts wired to the latching relay inputs are from remote control equipment (e.g., SCADA, RTU).

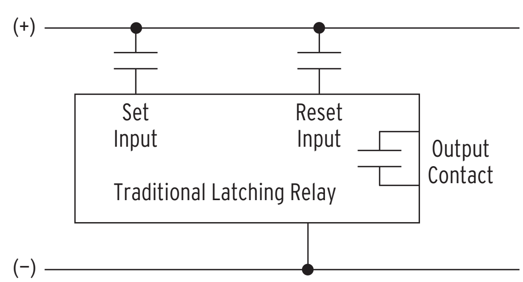


Figure 7.11 Traditional Latching Relay

The sixteen (16) latch control switches in the SEL-311C provide latching relay type functions.

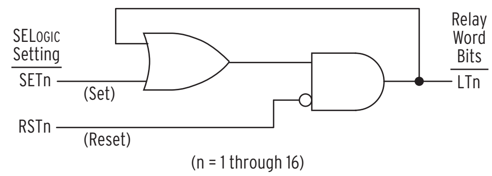


Figure 7.12 Latch Control Switches Drive Latch Bits LT1–LT16

The output of the latch control switch in *Figure 7.12* is a Relay Word bit LT*n* (*n* = 1 through 16), called a latch bit. The latch control switch logic in *Figure 7.12* repeats for each latch bit LT1–LT16. Use these latch bits in SELOGIC control equations.

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

SET*n* (set latch bit LT*n* to logical 1)

RST*n* (reset latch bit LT*n* to logical 0)

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

Latch Control Switch Application Ideas

Latch control switches can be used for such applications as:

- ➤ Reclosing relay enable/disable
- ➤ Ground relay enable/disable

Latch control switches can be applied to almost any control scheme. The following is an example of using a latch control switch to enable/disable the reclosing relay in the SEL-311C.

Reclosing Relay Enable/Disable Setting Example

Use a latch control switch to enable/disable the reclosing relay in the SEL-311C. In this example, a SCADA contact is connected to optoisolated input **IN204**. Each pulse of the SCADA contact changes the state of the reclosing relay. The SCADA contact is not maintained, just pulsed to enable/disable the reclosing relay.

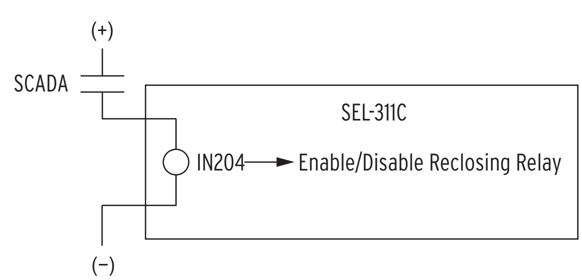


Figure 7.13 SCADA Contact Pulses Input IN204 to Enable/Disable Reclosing Relay

If the reclosing relay is enabled and the SCADA contact is pulsed, the reclosing relay is then disabled. If the SCADA contact is pulsed again, the reclosing relay is enabled again. The control operates in a cyclic manner:

pulse to enable ... pulse to disable ... pulse to enable ... pulse to disable ...

This reclosing relay logic is implemented in the following SELOGIC control equation settings and displayed in *Figure 7.14*.

SET1 = **/IN204 * !LT1** [= (rising edge of input IN204) AND NOT(LT1)]

RST1 = **/IN204 * LT1** [= (rising edge of input IN204) AND LT1]

79DTL = **!LT1** [= NOT(LT1); drive-to-lockout setting]

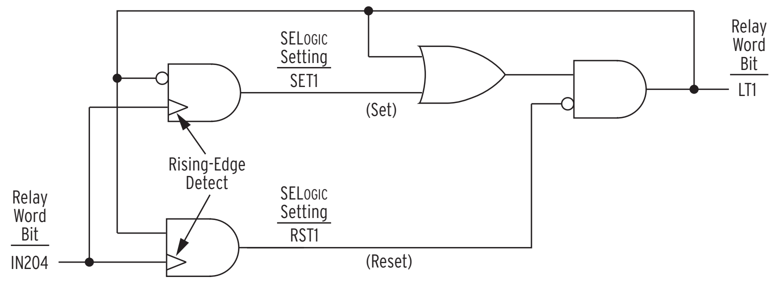


Figure 7.14 Latch Control Switch Controlled by a Single Input to Enable/Disable Reclosing

Feedback Control

Note in *Figure 7.14* that the latch control switch output (latch bit LT1) is effectively used as feedback for SELOGIC control equation settings SET1 and RST1. The feedback of latch bit LT1 "guides" input **IN204** to the correct latch control switch input.

If latch bit LT1 = logical 0, input **IN204** is routed to setting SET1 (set latch bit LT1):

SET1 = **/IN204 * !LT1** = /IN204 * NOT(LT1) = /IN204 * NOT(logical 0) = /IN204 = rising edge of input IN204

RST1 = **/IN204 * LT1** = /IN204 * (logical 0) = logical 0

If latch bit LT1 = logical 1, input **IN204** is routed to setting RST1 (reset latch bit LT1):

SET1 = **/IN204 * !LT1** = /IN204 * NOT(LT1) = /IN204 * NOT(logical 1) = /IN204 * (logical 0) = logical 0

RST1 = **/IN204 * LT1** = /IN204 * (logical 1) = /IN204 = rising edge of input IN204

Rising-Edge Operators

Refer to *Figure 7.14* and *Figure 7.15*.

The rising-edge operator in front of Relay Word bit IN204 (/IN204) sees a logical 0 to logical 1 transition as a "rising edge," and /IN204 asserts to logical 1 for one processing interval. For more details on rising-edge operators, see *Appendix F: Setting SELOGIC Control Equations*.

The rising-edge operator on input **IN204** is necessary because any single assertion of optoisolated input **IN204** by the SCADA contact will last for at least a few cycles, and each individual assertion of input **IN204** should only change the state of the latch control switch once (e.g., latch bit LT1 changes state from logical 0 to logical 1).

For example in *Figure 7.14*, if:

LT1 = logical 0

input **IN204** is routed to setting SET1 (as discussed previously):

SET1 = **/IN204** = rising edge of input **IN204**

If input IN204 is then asserted for a few cycles by the SCADA contact (see Pulse 1 in *Figure 7.15*), SET1 is asserted to logical 1 for one processing interval. This causes latch bit LT1 to change state to:

LT1 = logical 1

the next processing interval.

With latch bit LT1 now at logical 1 for the next processing interval, input IN204 is routed to setting RST1 (as discussed previously):

RST1 = **/IN204** = rising edge of input **IN204**

NOTE: Refer to Optoisolated Inputs on page 7.2 and Figure 7.1. Relay Word bit IN204 shows the state of optoisolated input **IN204 after** the input pickup/dropout debounce timer IN204D. Thus, when using Relay Word bit IN204 in Figure 7.13 and Figure 7.14 and associated SELogic control equations, keep in mind any time delay produced by the input pickup/dropout debounce timer.

This would then appear to enable the "reset" input (setting RST1) the next processing interval. But the "rising-edge" condition occurred the preceding processing interval. /IN204 is now at logical 0, so setting RST1 does not assert, even though input **IN204** remains asserted for at least a few cycles by the SCADA contact.

If the SCADA contact deasserts and then asserts again (new rising edge—see Pulse 2 in *Figure 7.15*), the "reset" input (setting RST1) asserts and latch bit LT1 deasserts back to logical 0 again. Thus, each individual assertion of input IN204 (Pulse 1, Pulse 2, Pulse 3, and Pulse 4 in *Figure 7.15*) changes the state of latch control switch just once.

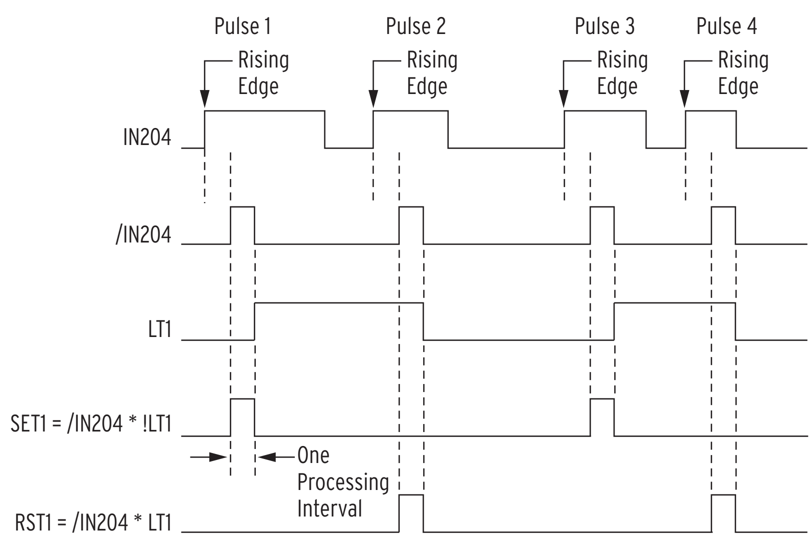


Figure 7.15 Latch Control Switch Operation Time Line

Use a Remote Bit Instead to Enable/Disable the Reclosing Relay

Use a remote bit to enable/disable the reclosing relay, instead of an optoisolated input. For example, substitute remote bit RB1 for optoisolated input **IN204** in the settings accompanying *Figure 7.14*:

SET1 = **/RB1 * !LT1** [= (rising edge of remote bit RB1) AND NOT(LT1)]

RST1 = **/RB1 * LT1** [= (rising edge of remote bit RB1) AND LT1]

79DTL = **!LT1** [= NOT(LT1); drive-to-lockout setting]

Pulse remote bit RB1 to enable reclosing, pulse remote bit RB1 to disable reclosing, etc.—much like the operation of optoisolated input **IN204** in the previous example. Remote bits (Relay Word bits RB1–RB16) are operated through the serial port. See *Remote Control Switches on page 7.10* for more information on remote bits.

These are just a few control logic examples—many variations are possible.

Latch Control Switch States Retained

Power Loss

NOTE: If a latch bit is set to a programmable output contact (e.g., OUT103 = LT2) and power to the relay is lost, the state of the latch bit is stored in nonvolatile memory but the output contact will go to its de-energized state. When power to the relay is restored, the programmable output contact will go back to the state of the latch bit after relay initialization.

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

Settings Change or Active Setting Group Change

If individual settings are changed (for the active setting group or one of the other setting groups) or the active setting group is changed, the states of the latch bits (Relay Word bits LT1–LT16) are retained, much like in the preceding *Power Loss on page 7.15* explanation.

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

Reset Latch Bits for Active Setting Group Change

If desired, the latch bits can be reset to logical 0 right after a settings group change, using SELOGIC control equation setting RST*n* (*n* = 1 through 16). Relay Word bits SG1–SG6 indicate the active setting Group 1 through 6, respectively (see *Table 7.3*).

For example, an application requires that when setting Group 4 becomes the active setting group, latch bit LT2 gets reset. Make the following SELOGIC control equation settings in setting Group 4:

RST2 = **/SG4 + ...** [other logic]

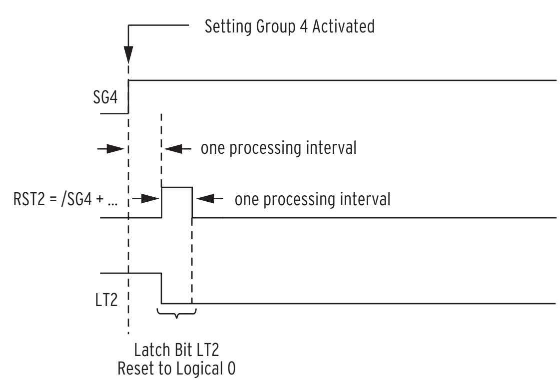


Figure 7.16 Time Line for Reset of Latch Bit LT2 After Active Setting Group Change

In *Figure 7.16*, the rising edge operator /SG4 creates a pulse (logical 1) for one quarter cycle after setting group 4 is newly entered. Latch bit LT2 is reset (deasserted to logical 0) when setting RST2 briefly asserts to logical 1 right after setting Group 4 is activated. This logic only clears LT2 after a setting group change from another group to Group 4—it does not clear the latch when the relay is powered-up into setting Group 4. This logic can be repeated for other latch bits.

Note: Make Latch Control Switch Settings With Care

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

This requires that SELOGIC control equation settings SETn and RSTn for any given latch bit LTn (n = 1 through 16) be set with care. Settings SET*n* and RST*n* cannot result in continuous cyclical operation of latch bit LT*n*. Use timers to qualify conditions set in settings SET*n* and RST*n*. If any optoisolated inputs IN101–IN106 or IN201–IN208 are used in settings SET*n* and RST*n*, the inputs have their own debounce timer that can help in providing the necessary time qualification (see *Figure 7.1* and *Figure 7.2*).

In the preceding reclosing relay enable/disable example application (*Figure 7.14* and *Figure 7.15*), the SCADA contact cannot be asserting/deasserting continuously, thus causing latch bit LT1 to change state continuously. Note that the rising-edge operators in the SET1 and RST1 settings keep latch bit LT1 from cyclically operating for any single assertion of the SCADA contact.

Another variation to the example application in *Figure 7.14* and *Figure 7.15* that adds more security is a timer with pickup/dropout times set the same (see *Figure 7.17* and *Figure 7.18*). Suppose that SV6PU and SV6DO are both set to 300 cycles. Then the SV6T timer keeps the state of latch bit LT1 from being able to be changed at a rate faster than once every 300 cycles (5 seconds at 60 Hz).

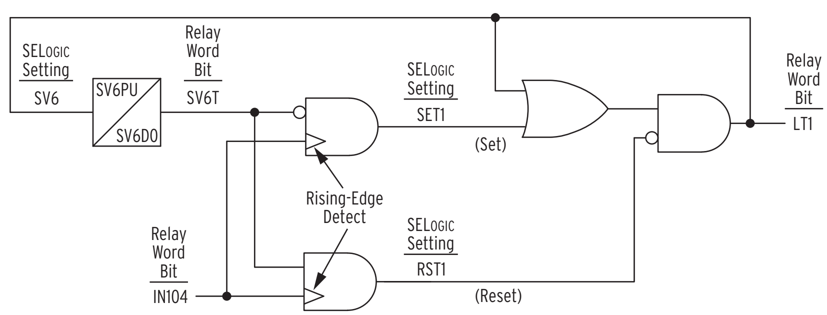


Figure 7.17 Latch Control Switch (With Time Delay Feedback) Controlled by a Single Input to Enable/Disable Reclosing

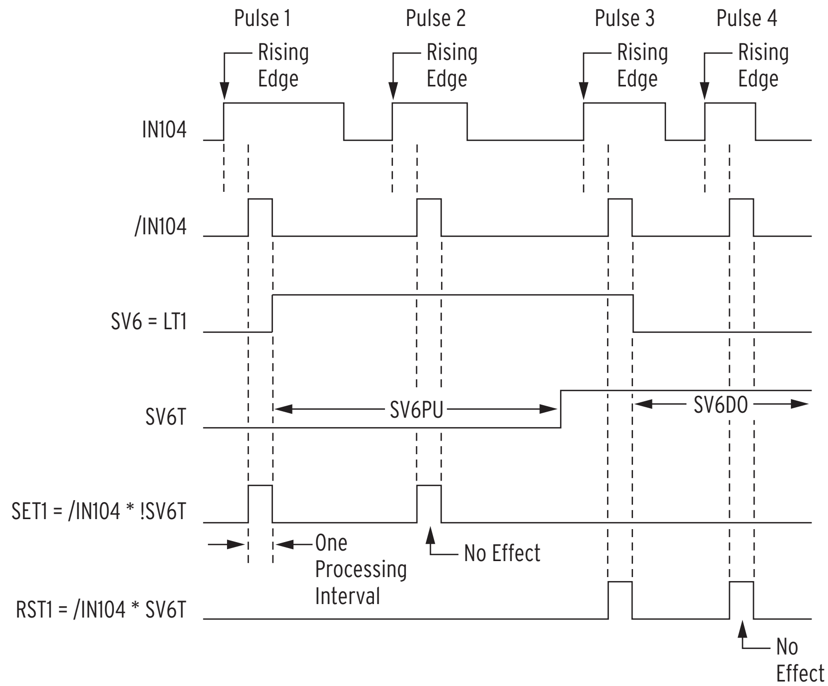


Figure 7.18 Latch Control Switch (With Time Delay Feedback) Operation Time Line

Multiple Setting Groups

The relay has six (6) independent setting groups. Each setting group has complete relay (distance, overcurrent, reclosing, frequency, etc.) and SELOGIC control equation settings.

Active Setting Group Indication

Only one setting group can be active at a time. Relay Word bits SG1–SG6 indicate the active setting group:

Table 7.3 Definitions for Active Setting Group Indication Relay Word Bits SG1 Through SG6

Relay Word Bit	Definition
SG1	Indication that setting Group 1 is the active setting group
SG2	Indication that setting Group 2 is the active setting group
SG3	Indication that setting Group 3 is the active setting group
SG4	Indication that setting Group 4 is the active setting group
SG5	Indication that setting Group 5 is the active setting group
SG6	Indication that setting Group 6 is the active setting group

For example, if setting Group 4 is the active setting group, Relay Word bit SG4 asserts to logical 1, and the other Relay Word bits SG1, SG2, SG3, SG5, and SG6 are all deasserted to logical 0.

Selecting the Active Setting Group

The active setting group is selected with:

- SELOGIC control equation settings SS1–SS6
- The serial port **GROUP** command (see *Section 10: Communications*)
- The front-panel **GROUP** pushbutton (see *Section 11: Front-Panel Interface*)
- DNP analog output ACTGRP (see *Appendix L: DNP3 Communications*)
- Modbus® function code 06 or 10 write to ACTGRP (see *Appendix O: Modbus RTU and TCP Communications*)

SELOGIC control equation settings SS1–SS6 have priority over the serial port **GROUP** command and the front-panel **GROUP** pushbutton in selecting the active setting group.

Operation of SELOGIC Control Equation Settings SS1–SS6

Each setting group has its own set of SELOGIC control equation settings SS1–SS6.

Table 7.4 Definitions for Active Setting Group Switching SELOGIC Control Equation Settings SS1 Through SS6

Setting	Definition
SS1	go to (or remain in) setting Group 1
SS2	go to (or remain in) setting Group 2
SS3	go to (or remain in) setting Group 3
SS4	go to (or remain in) setting Group 4
SS5	go to (or remain in) setting Group 5
SS6	go to (or remain in) setting Group 6

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

Assume the active setting group starts out as setting Group 3. Corresponding Relay Word bit SG3 is asserted to logical 1 as an indication that setting Group 3 is the active setting group (see *Table 7.3*).

With setting Group 3 as the active setting group, setting SS3 has priority. If setting SS3 is asserted to logical 1, setting Group 3 remains the active setting group, regardless of the activity of settings SS1, SS2, SS4, SS5, and SS6. With settings SS1 through SS6 all deasserted to logical 0, setting Group 3 still remains the active setting group.

With setting Group 3 as the active setting group, if setting SS3 is deasserted to logical 0 and one of the other settings (e.g., setting SS5) asserts to logical 1, the relay switches from setting Group 3 as the active setting group to another setting group (e.g., setting Group 5) as the active setting group, after qualifying time setting TGR:

> TGR Group Change Delay Setting (settable from 0.00 to 16000.00 cycles)

In this example, TGR qualifies the assertion of setting SS5 before it can change the active setting group.

Operation of Serial Port GROUP Command and Front-Panel GROUP Pushbutton

SELOGIC control equation settings SS1–SS6 have priority over the serial port **GROUP** command, the front-panel **GROUP** pushbutton, DNP3, and Modbus in selecting the active setting group. If any *one* of SS1–SS6 asserts to logical 1, neither the serial port **GROUP** command nor the front-panel **GROUP** pushbutton can be used to switch the active setting group. But if SS1–SS6 *all* deassert to logical 0, the serial port **GROUP** command or the front-panel **GROUP** pushbutton can be used to switch the active setting group.

See *Section 10: Communications* for more information on the serial port **GROUP** command. See *Section 11: Front-Panel Interface* for more information on the front-panel **GROUP** pushbutton.

Relay Disabled Momentarily During Active Setting Group Change

The relay is disabled for a *few seconds* while the relay is in the process of changing active setting groups. Relay elements, timers, and logic are reset, unless indicated otherwise in specific logic description [e.g., local bit (LB1– LB16), remote bit (RB1–RB16), and latch bit (LT1– LT16) states are retained during a active setting group change]. The output contacts do not change state until the relay enables in the new settings group and the SELOGIC control equations are processed to determine the output contact status for the new group.

For instance, if setting OUT105 = logical 1 in Group 2, and setting OUT105 = logical 1 in Group 3, and the relay is switched from Group 2 to Group 3, **OUT105** stays energized before, during, and after the group change. However, if the Group 3 setting was OUT105 = logical 0 instead, then **OUT105** remains energized until the relay enables in Group 3, solves the SELOGIC control equations, and causes **OUT105** to de-energize. See *Figure 7.28*, *Figure 7.29*, and *Figure 7.30* for examples of output contacts in the de-energized state (i.e., corresponding output contact coils de-energized).

Active Setting Group Switching Example 1

Use a single optoisolated input to switch between two setting groups in the SEL-311C. In this example, optoisolated input **IN105** on the relay is connected to a SCADA contact in *Figure 7.19*. Each pulse of the SCADA contact changes the active setting group from one setting group (e.g., setting Group 1) to another (e.g., setting Group 4). The SCADA contact is not maintained, just pulsed to switch from one active setting group to another.

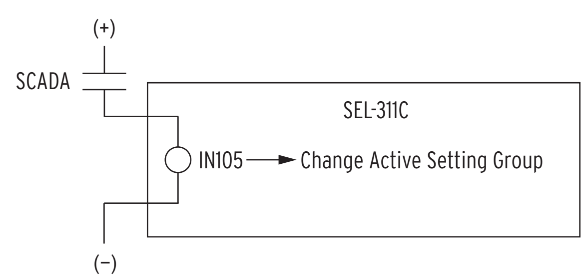


Figure 7.19 SCADA Contact Pulses Input IN105 to Switch Active Setting Group Between Setting Groups 1 and 4

If setting Group 1 is the active setting group and the SCADA contact is pulsed, setting Group 4 becomes the active setting group. If the SCADA contact is pulsed again, setting Group 1 becomes the active setting group again. The setting group control operates in a cyclical manner:

> pulse to activate setting Group 4 ... pulse to activate setting Group 1 ...
> pulse to activate setting Group 4 ... pulse to activate setting Group 1 ...

This logic is implemented in the SELOGIC control equation settings in *Table 7.5*.

Table 7.5 SELogic Control Equation Settings for Switching Active Setting Group Between Setting Groups 1 and 4

Setting Group 1	Setting Group 4
SV8PU = 1.5 • SCADA pulse width (in cycles)	SV8PU = 1.5 • SCADA pulse width (in cycles)
SV8DO = 0.00	SV8DO = 0.00
SV8 = SG1 * !/SG1	SV8 = SG4 * !/SG4
SS1 = 0	SS1 = IN105 * SV8T
SS2 = 0	SS2 = 0
SS3 = 0	SS3 = 0
SS4 = IN105 * SV8T	SS4 = 0
SS5 = 0	SS5 = 0
SS6 = 0	SS6 = 0
Global Setting	
TGR = 1.00 cycle	

SELogic control equation timer input setting SV8 in *Table 7.5* has logic output SV8T, shown in operation in *Figure 7.20* for both setting Groups 1 and 4.

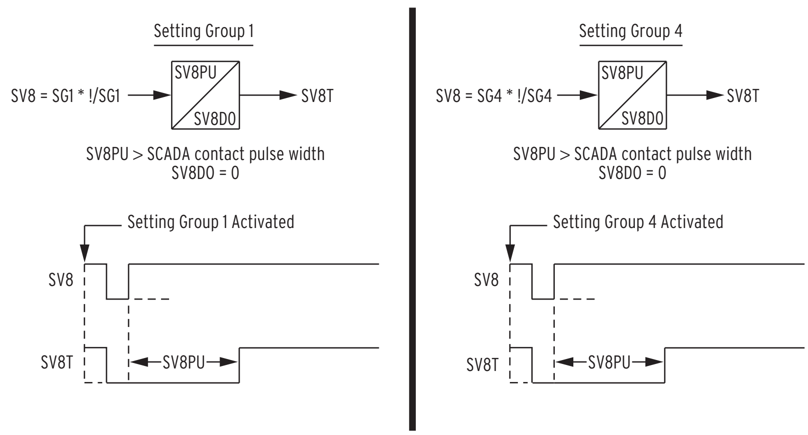


Figure 7.20 SELogic Control Equation Variable Timer SV8T Used in Setting Group Switching

In this example, timer SV8T is used in both setting groups; different timers could have been used with the same operational result. The SELogic variables do not reset during the setting group change, so special programming considerations are required to allow the same timer to be used in both setting groups.

Timer pickup setting SV8PU is set greater than the pulse width of the SCADA contact (*Figure 7.19*). This allows only one active setting group change (e.g., from setting Group 1 to 4) for each pulse of the SCADA contact (and subsequent assertion of input **IN105**). The function of the SELogic control equations in *Table 7.5* becomes more apparent in the following example scenario.

Start Out in Setting Group 1

Refer to *Figure 7.21*.

The relay has been in setting Group 1 for some time, with timer logic output SV8T asserted to logical 1, thus enabling SELOGIC control equation setting SS4 for the assertion of input **IN105**.

Switch to Setting Group 4

Refer to *Figure 7.21*.

The SCADA contact pulses input **IN105**, and the active setting group changes to setting Group 4 after qualifying time setting TGR (set at 1.00 cycle to qualify the assertion of setting SS4). Optoisolated input **IN105** also has its own built-in debounce timer (IN105D) available (see *Figure 7.1*).

Note that *Figure 7.21* shows both setting Group 1 and setting Group 4 settings. The setting Group 1 settings (top of *Figure 7.21*) are enabled only when setting Group 1 is the active setting group and likewise for the setting Group 4 settings at the bottom of the figure.

Setting Group 4 is now the active setting group, and Relay Word bit SG4 asserts to logical 1. One processing interval later, the expression /SG4 asserts to logical 1 for one processing interval, and then deasserts to logical 0. The expression SV8 = SG4 * !/SG4 deasserts for once processing interval because the NOT operator "!" is inverting the rising edge operator "/". This action resets the timer SV8T, which must then time for SV8PU cycles in order to assert again. See *Appendix F: Setting SELOGIC Control Equations* for more details on the rising edge operator.

The TGR setting of 1.00 cycle prevents the brief assertion of SV8T in setting Group 4 from prematurely initiating a group change.

After the relay has been in setting Group 4 for a time period equal to SV8PU, the timer logic output SV8T asserts to logical 1, thus enabling SELOGIC control equation setting SS1 for a new assertion of input **IN105**.

Note that input **IN105** is still asserted as setting Group 4 is activated. Pickup time SV8PU keeps the continued assertion of input **IN105** from causing the active setting group to revert back again to setting Group 1 for a single assertion of input **IN105**. This keeps the active setting group from being changed at a time interval less than time SV8PU.

Switch Back to Setting Group 1

Refer to *Figure 7.21*.

The SCADA contact pulses input **IN105** a second time, and the active setting group changes back to setting Group 1 after qualifying time setting TGR (set at 1.00 cycle to qualify the assertion of setting SS1). Optoisolated input **IN105** also has its own built-in debounce timer (IN105D) available (see *Figure 7.1*).

Similar logic settings operate in setting Group 1 to deassert SV8T quickly, before the TGR timer expires, and then allow **IN105** to deassert before SV8T asserts again.

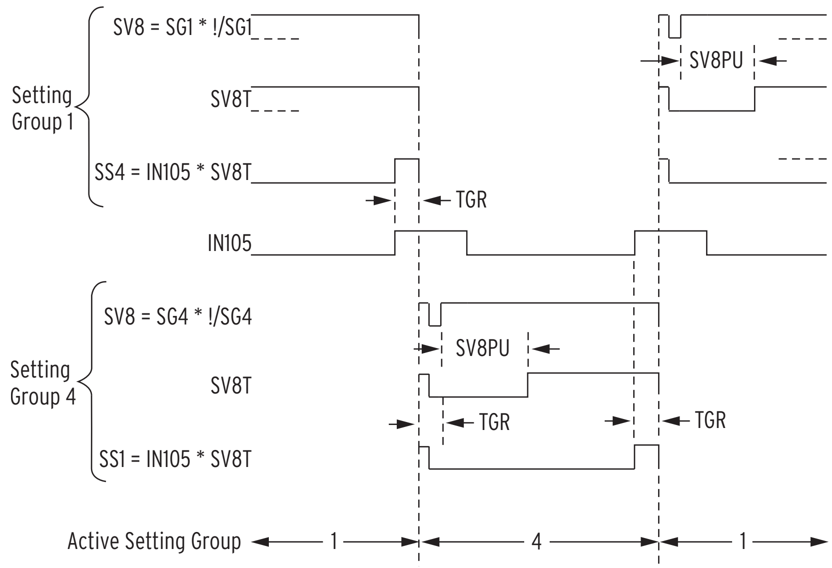


Figure 7.21 Active Setting Group Switching (With Single Input) Time Line

Active Setting Group Switching Example 2

Previous SEL relays (e.g., SEL-321 and SEL-251 relays) have multiple settings groups controlled by the assertion of three optoisolated inputs (e.g., IN101, IN102, and IN103) in different combinations as shown in *Table 7.6*.

Table 7.6 Active Setting Group Switching Input Logic

Input States			Active Setting Group
IN103	IN102	IN101	
0	0	0	Remote
0	0	1	Group 1
0	1	0	Group 2
0	1	1	Group 3
1	0	0	Group 4
1	0	1	Group 5
1	1	0	Group 6

The SEL-311C can be programmed to operate similarly. Use three optoisolated inputs to switch between the six setting groups in the SEL-311C. In this example, optoisolated inputs IN101, IN102, and IN103 on the relay are connected to a rotating selector switch in *Figure 7.22*.

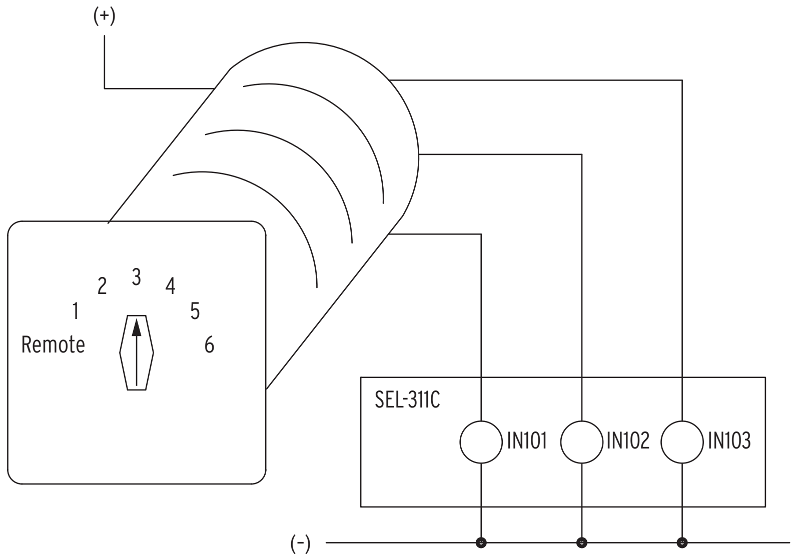


Figure 7.22 Rotating Selector Switch Connected to Inputs IN101, IN102, and IN103 for Active Setting Group Switching

The selector switch has multiple internal contacts arranged to assert inputs IN101, IN102, and IN103, dependent on the switch position. As shown in *Table 7.7*, as the selector switch is moved from one position to another, a different setting group is activated. The logic in *Table 7.6* is implemented in the SELOGIC control equation settings in *Table 7.7*.

Table 7.7 SELOGIC Control Equation Settings for Rotating Selector Switch Active Setting Group Switching

SS1 = !IN103 * !IN102 * IN101	= NOT(IN103) * NOT(IN102) * IN101
SS2 = !IN103 * IN102 * !IN101	= NOT(IN103) * IN102 * NOT(IN101)
SS3 = !IN103 * IN102 * IN101	= NOT(IN103) * IN102 * IN101
SS4 = IN103 * !IN102 * !IN101	= IN103 * NOT(IN102) * NOT(IN101)
SS5 = IN103 * !IN102 * IN101	= IN103 * NOT(IN102) * IN101
SS6 = IN103 * IN102 * !IN101	= IN103 * IN102 * NOT(IN101)

The settings in *Table 7.7* are made in each setting Group 1 through 6.

Selector Switch Starts Out in Position 3

Refer to *Table 7.7* and *Figure 7.23*.

If the selector switch is in position 3 in *Figure 7.22*, setting Group 3 is the active setting group (Relay Word bit SG3 = logical 1). Inputs IN101 and IN102 are energized and IN103 is de-energized:

SS3 = **!IN103 * IN102 * IN101** = NOT(IN103) * IN102 * IN101
= NOT(logical 0) * logical 1 * logical 1 = logical 1

To get from position 3 to position 5 on the selector switch, the switch passes through position 4. The switch is only briefly in position 4:

SS4 = **IN103 * !IN102 * !IN101** = IN103 * NOT(IN102) * NOT(IN101)
= logical 1 * NOT(logical 0) * NOT(logical 0) = logical 1

but not long enough to be qualified by time setting TGR in order to change the active setting group to setting Group 4. For such a rotating selector switch application, qualifying time setting TGR is typically set at 180 to 300 cycles.

Set TGR long enough to allow the selector switch to pass through intermediate positions without changing the active setting group, until the switch rests on the desired setting group position.

Selector Switch Switched to Position 5

Refer to *Figure 7.23*.

If the selector switch is rested on position 5 in *Figure 7.22*, setting Group 5 becomes the active setting group (after qualifying time setting TGR; Relay Word bit SG5 = logical 1). Inputs IN101 and IN103 are energized and IN102 is de-energized:

SS5 = **IN103 * !IN102 * IN101** = IN103 * NOT(IN102) * IN101 = logical 1 * NOT(logical 0) * logical 1 = logical 1

To get from position 5 to position REMOTE on the selector switch, the switch passes through the positions 4, 3, 2, and 1. The switch is only briefly in these positions, but not long enough to be qualified by time setting TGR in order to change the active setting group to any one of these setting groups.

Selector Switch Now Rests on Position REMOTE

Refer to *Figure 7.23*.

If the selector switch is rested on position REMOTE in *Figure 7.22*, all inputs IN101, IN102, and IN103 are de-energized and all settings SS1 through SS6 in *Table 7.7* are at logical 0. The last active setting group (Group 5 in this example) remains the active setting group (Relay Word bit SG5 = logical 1).

With settings SS1–SS6 all at logical 0, the serial port **GROUP** command or the front-panel GROUP pushbutton can be used to switch the active setting group from Group 5, in this example, to another desired setting group.

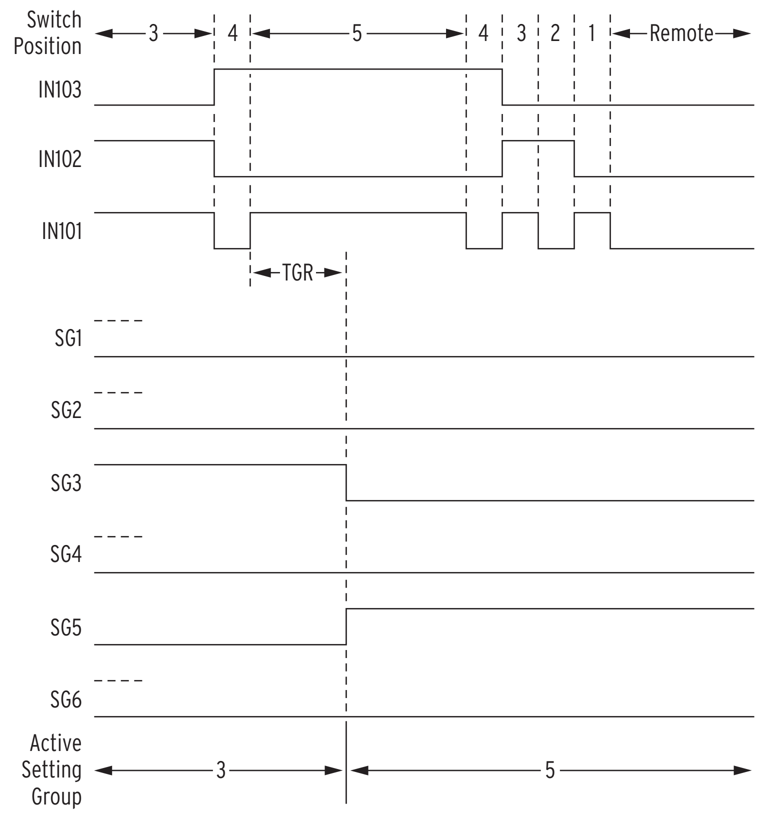


Figure 7.23 Active Setting Group Switching (With Rotating Selector Switch) Time Line

Active Setting Group Retained

Power Loss

The active setting group is retained if power to the relay is lost and then restored. If a particular setting group is active (e.g., setting Group 5) when power is lost, it comes back with the same setting group active when power is restored.

Settings Change

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

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

If the individual settings change causes a change in one or more currently active SELOGIC control equation settings SS1–SS6, the active setting group can be changed, subject to the newly enabled SS1–SS6 settings.

Note: Make Active Setting Group Switching Settings With Care

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

This requires that SELOGIC control equation settings SS1 through SS6 (see Table 7.4) be set with care. Settings SS1–SS6 cannot result in continuous cyclical changing of the active setting group. Time setting TGR qualifies settings SS1–SS6 before changing the active setting group. If optoisolated inputs IN101 through IN106 are used in settings SS1–SS6, the inputs have their own built-in debounce timer that can help in providing the necessary time qualification (see *Figure 7.1*).

SELOGIC Control Equation Variables/Timers

NOTE: Unlike legacy SEL-311 relays, the SEL-311C ESV setting does **not** hide the Logic settings class SV1–SV16 SELOGIC control equation settings. All of the SELOGIC control equation settings (SV1–SV16) may be used, even when the associated timer settings are hidden by the ESV setting.

See SEL-311C Models on page 1.1 for a list of differences between relay models.

Sixteen (16) SELOGIC control equation variables/timers are available. Each SELOGIC control equation variable/timer has a SELOGIC control equation setting input and variable/timer outputs as shown in *Figure 7.24* and *Figure 7.25*.

The SELOGIC variable pickup (SV1PU–SV16PU) and dropout (SV1DO–SV16DO) times are individually programmed in the Group settings class. The number of timer settings is controlled by the ESV setting, with setting choices (N, 1–16). The factory default setting is ESV = N, which hides all timer settings. When hidden, the pickup and dropout times are internally set to 0.00 cycles. Enable one to sixteen time-delay settings by changing ESV = 1, 2, 3 … 16.

See *Section 9: Setting the Relay* for more information on settings classes, and enable settings.

Timers SV1T–SV6T in *Figure 7.24* have a setting range of a little over 4.5 hours:

0.00–999999.00 cycles in 0.25-cycle increments

Timers SV7T–SV16T in *Figure 7.25* have a setting range of almost 4.5 minutes:

0.00–16000.00 cycles in 0.25-cycle increments

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

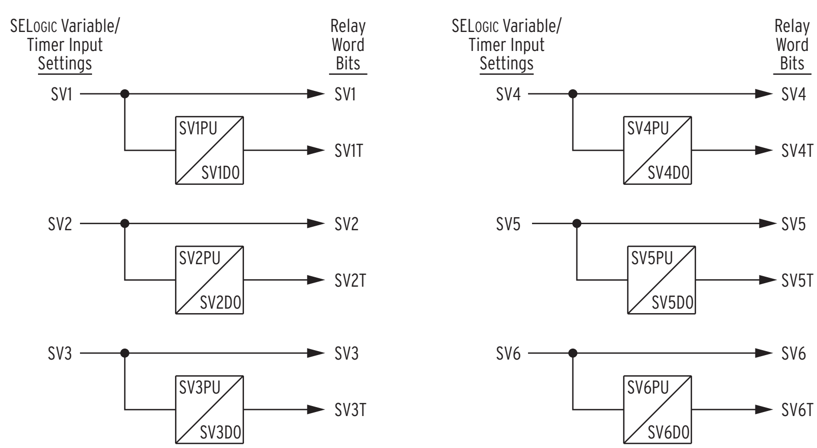


Figure 7.24 SELOGIC Control Equation Variables/Timers SV1/SV1T Through SV6/SV6T

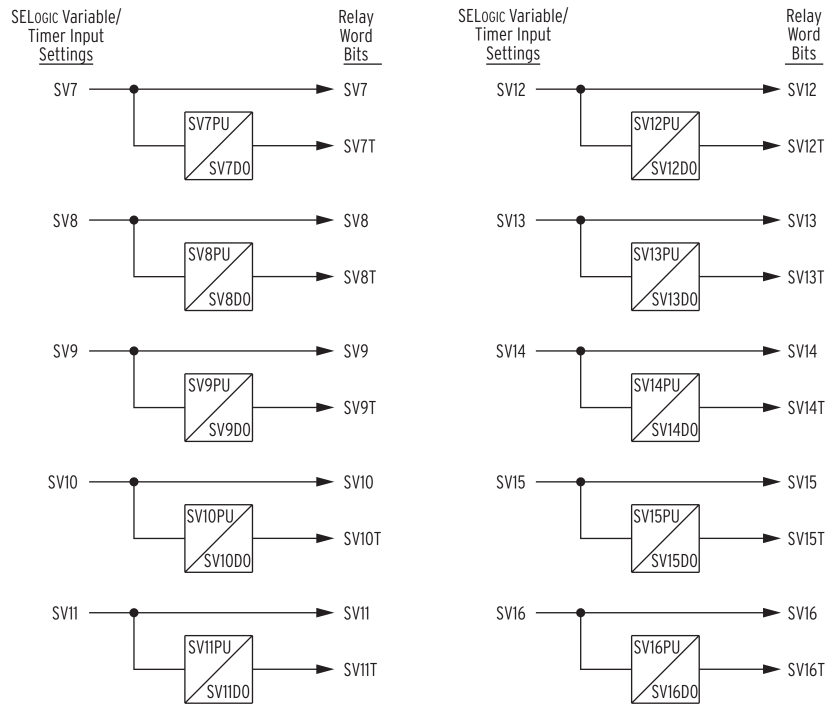


Figure 7.25 SELOGIC Control Equation Variables/Timers SV7/SV7T Through SV16/SV16T

Settings Example

In the SELOGIC control equation settings, a SELOGIC control equation timer is used for a simple breaker failure scheme:

SV1 = **TRIP**

The TRIP Relay Word bit is run through a timer for breaker failure timing. Timer pickup setting SV1PU is set to the breaker failure time (SV1PU = 12 cycles). SV1PU must be set longer than the trip duration timer setting TDURD. Timer dropout setting SV1DO is set for a 2-cycle dropout (SV1DO = 2 cycles). The output of the timer (Relay Word bit SV1T) operates output contact OUT103.

OUT103 = **SV1T**

Additional Settings Example 1

Another application idea is dedicated breaker failure protection (see *Figure 7.26*):

SV6 = **IN106** (breaker failure initiate)

SV7 = **(SV7 + IN106) * (50P1 + 50G1)**

OUT106 = **SV6T** (retrip)

OUT107 = **SV7T** (breaker failure trip)

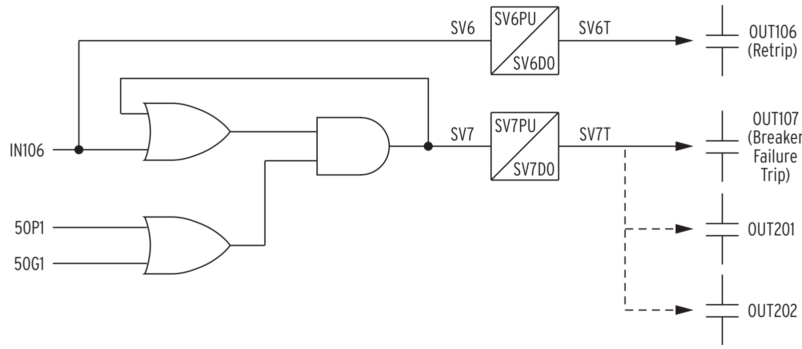


Figure 7.26 Dedicated Breaker Failure Scheme Created With SELOGIC Control Equation Variables/Timers

Note that the above SELOGIC control equation setting SV7 creates a seal-in logic circuit (as shown in *Figure 7.26*) by virtue of SELOGIC control equation setting SV7 containing Relay Word bit SV7 (SELOGIC control equation variable SV7):

SV7 = **(SV7 + IN106) * (50P1 + 50G1)**

Optoisolated input **IN106** functions as a breaker failure initiate input. Phase instantaneous overcurrent element 50P1 and residual ground instantaneous overcurrent element 50G1 function as fault detectors.

Timer pickup setting SV6PU provides retrip delay, if desired (can be set to zero). Timer dropout setting SV6DO holds the retrip output (output contact **OUT106**) closed for extra time if needed after the breaker failure initiate signal (IN106) goes away.

Timer pickup setting SV7PU provides breaker failure timing. Timer dropout setting SV7DO holds the breaker failure trip output (output contact **OUT107**) closed for extra time if needed after the breaker failure logic unlatches (fault detectors 50P1 and 50G1 dropout).

Note that *Figure 7.26* suggests the option of having output contacts **OUT201** and **OUT202** operate as additional breaker failure trip outputs. This is done by making the following SELOGIC control equation settings:

OUT201 = **SV7T** (breaker failure trip)

OUT202 = **SV7T** (breaker failure trip)

If SV6T and SV7T are programmed to output relays to operate high-current loads such as breaker trip coils, SV6DO and SV7DO should be set equal to Group setting TDURD.

Additional Settings Example 2

The seal-in logic circuit in the dedicated breaker failure scheme in *Figure 7.26* can be removed by changing the SELOGIC control equation setting SV7 to:

SV7 = **IN106 * (50P1 + 50G1)**

If the seal-in logic circuit is removed, optoisolated input **IN106** (breaker failure initiate) has to be continually asserted for a breaker failure time-out.

SELOGIC Variable and Timer Behavior After Power Loss, Settings Change, or Group Change

Power Loss

If power is lost to the relay, all SELOGIC Variables and Timers are in an initial state of logical 0, and the timer counts are all at zero when the relay is powered back up.

Settings Change or Active Group Change

NOTE: The logical condition immediately after an active setting group change must be considered when developing relay settings for multiple settings groups. See Processing Order Considerations on page F.12 for more information.

If settings are changed (for the active setting group), or the active setting group is changed, the SELOGIC control equation variables/timers logical states are retained when the relay enables, and they will exhibit this carried-through state in any SELOGIC control equation that appears earlier in the processing order, shown in *Table F.4*. The next state of the variables/timers depends on which scenario is encountered. The following examples cover the various possibilities.

Example 1: Both SV7 and SV7T Asserted Before Group Change

If SV7 and SV7T are both asserted in Group 5, they are still asserted immediately after switching to another setting group. Once the new setting group logic is processed, the SV7 variable is updated with the newly evaluated SV7 equation result.

If the SV7 equation evaluates to logical 0 in the new settings group, SV7 and SV7T immediately deassert.

If the SV7 equation evaluates to logical 1 in the new settings group, SV7 and SV7T remain asserted.

Example 2: SV7 Asserted, SV7T Not Asserted Before Group Change

If SV7 is asserted in Group 5, but SV7T has not yet asserted (because it is still timing on the group 5 SV7PU setting), SV7 is still asserted immediately after switching to another setting group, and SV7T is deasserted. Once the new setting group logic is processed, the SV7 variable is updated with the newly evaluated SV7 equation result.

If the SV7 equation evaluates to logical 0 in the new settings group, SV7 deasserts immediately, SV7T remains deasserted, and the timer fully resets.

If the SV7 equation evaluates to logical 1 in the new settings group, SV7 remains asserted, and SV7T starts timing anew on its pickup setting SV7PU from the newly enabled setting group. If the SV7 equation remains at logical 1, SV7T asserts after SV7PU cycles have elapsed (from the time the new settings group started running).

Example 3: SV7 Deasserted, SV7T Asserted Before Group Change

If SV7 is deasserted in Group 5, but SV7T has not yet deasserted (because it is still timing on the group 5 SV7DO setting), SV7 is still deasserted immediately after switching to another setting group, and SV7T stays asserted. Once the new setting group logic is processed, the SV7 variable is updated with the newly evaluated SV7 equation result.

If the SV7 equation evaluates to logical 0 in the new settings group, SV7 stays deasserted and SV7T deasserts immediately, regardless of the SV7DO setting.

If the SV7 equation evaluates to logical 1 in the new settings group, SV7 asserts and SV7T remains asserted.

Example 4: Both SV7 and SV7T Deasserted Before Group Change

If SV7 and SV7T are both deasserted in Group 5, they remain deasserted immediately after switching to another setting group. Once the new setting group logic is processed, the SV7 variable is updated with the newly evaluated SV7 equation result.

If the SV7 equation evaluates to logical 0 in the new settings group, SV7 and SV7T remain deasserted.

If the SV7 equation evaluates to logical 1 in the new settings group, SV7 asserts, and SV7T starts timing on its pickup setting SV7PU from the newly enabled setting group. If the SV7 equation remains at logical 1, SV7T asserts after SV7PU cycles have elapsed (from the time the new settings group started running).

Seal-In Behavior and Methods for Breaking Seal-In

Figure 7.26 shows an effective seal-in logic circuit, created by use of Relay Word bit SV7 (SELOGIC control equation variable SV7) in SELOGIC control equation SV7:

SV7 = **(SV7 + IN106) * (50P1 + 50G1)**

This seal-in example is not cleared by a group change or settings group change. The only actions that clear this seal-in are the drop-out (deassertion to logical 0) of both current detectors 50G1 and 50P1, or powering-down the relay.

Here are a few setting examples that can be employed to change this behavior.

Assuming the seal-in logic is in active Group 6:

1. In Group 5, make setting

   SV7 = **0** (effectively)

   Switch to Group 5, and then back to Group 6 to break the seal-in condition.

2. In Group 6, make setting

   SV7 = **(SV7 + IN106) * (50P1 + 50G1) * !/SG6**

   In Group 5:

   SV7 = **(SV7 + IN106) * (50P1 + 50G1) * !/SG5**

   - •
   - •
   - •

   In Group 1:

   SV7 = **(SV7 + IN106) * (50P1 + 50G1) * !/SG1**

   Switch to any settings group to break the seal-in condition, and the logic is armed and available for a new breaker failure initiate condition (assuming the other related settings are the same in each group).

3. In Group 6, make setting

   SV7 = **(SV7 + IN106) * (50P1 + 50G1) * !/TRGTR**

   Press the **TARGET RESET** button to assert Relay Word bit TRGTR and break the seal-in.

4. In Group 6, make setting

   SV7 = **(SV7 + IN106) * (50P1 + 50G1) * !/IN203**

   Assert control input **IN203** to break the seal-in.

Logic Variables

The SEL-311C supports 32 logic variables (LV1 through LV32). These logic variables are similar to SELOGIC control equation Variables/Timers (SV1–SV16, and SV1T–SV16T), except the LVs do not have associated pickup/dropout timers. Use logic variables as intermediate SELOGIC terms to help break a long SELOGIC control equation into smaller, simpler equations.

Each logic variable has a SELOGIC control equation (LV1, LV2, … LV32), and a Relay Word bit with the same label (LV1, LV2, … LV32) as shown in *Figure 7.27*.

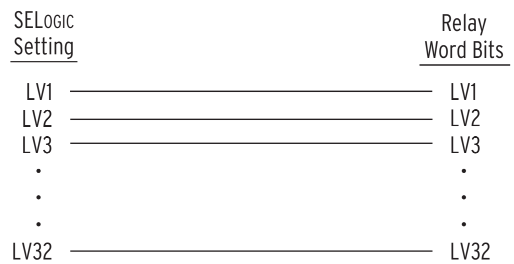


Figure 7.27 Logic Variables

There is no enable setting for the logic variables. The settings for the logic variables are accessed through 32 SELOGIC control equations in the Logic Settings class, and each setting has a factory default value of logical 0.

See *Section 9: Setting the Relay* for more information on setting classes, modifying settings, and displaying settings.

Logic Variable Application Ideas

Example 1: Simplify Logic Expressions

Use logic variables to consolidate settings into functional blocks. For example, if a protection application requires the same logic expression in several places, a logic variable can make the resulting settings easier to read.

Example settings without a logic variable:

Four torque control settings requiring a common expression:

67Q1TC = IN203 * LB2 + LT9 + 50P1

67G1TC = IN203 * LB2 + LT9 + 50P1

51QTC = IN203 * LB2 + LT9

51GTC = IN203 * LB2 + LT9

NOTE: The example settings are not from a real application.

Same example settings using a logic variable:

67Q1TC = LV1 + 50P1

67G1TC = LV1 + 50P1

51QTC = LV1

51GTC = LV1

LV1 = IN203 * LB2 + LT9

See *Table F.4* for details on the processing order of SELOGIC equations. In this example, logic variable LV1 is evaluated after the torque control equations each processing interval, and any state change of LV1 will be delayed one processing interval when used in the torque control equations. For many situations this one-quarter-cycle delay is not significant, but should be considered when designing settings.

Example 2: Free Up SELOGIC Control Equation Variables/Timers

Use logic variables LV1–LV32 for non-timing functions to free up SELOGIC variables/timers SV1T–SV16T.

Example settings without a logic variable:

In this design, SV14 is being used as a variable only:

SV14 = **(IN106 * SV13T + RB7 * LT5) * LT3 + (!59V1 + IN105 * SV13T) * !LT3**

SV15 = **/SV14 * LB7 + \SV14**

NOTE: The example settings are not from a real application.

Same example settings using a logic variable:

Now SV14 is available for use as a timer:

LV6 = **(IN106 * SV13T + RB7 * LT5) * LT3 + (!59V1 + IN105 * SV13T) * !LT3**

SV14 = **available**

SV15 = **/LV6 * LB7 + \LV6**

View Logic Variables in CEV Reports or SER

Logic variables LV1–LV32 are not shown in standard event reports (**EVE** command), but are present in Compressed Event Reports (**CEV** command).

For easier analysis, any of the logic variables LV1–LV32 may be included in the Sequential Events Recorder (SER) trigger list. See *Section 12: Standard Event Reports and SER* for details on event reports and SER.

Logic Variable Behavior After Power Loss, Settings Change, or Group Change

Power Loss

If power is lost to the relay, when the relay is powered back up all logic variables are forced to an initial state of logical 0.

Settings Change or Active Group Change Does Not Clear Logic Variables

If settings are changed (for the active setting group), or the active setting group is changed, the relay keeps the logical states of the logic variable Relay Word bits from before the change. When the relay re-enables, the Relay Word bits LV1–LV32 are held at their previous logic states until the relay evaluates the LV1–LV32 equations and updates the Relay Word bits.

This is only important to consider when the LV1–LV32 Relay Word bit(s) are part of a SELOGIC control equation that is evaluated earlier in the processing order than the LV1–LV32 settings, and the variables are being used for different purposes in two or more settings groups.

As shown in *Table F.4*, in the SEL-311C processing order, equations 52A, SET1–SET16, RST1–RST16, BSYNCH, E32IV, Z1XPEC, Z1XGEC, 67*xx*TC, 51*xx*TC, and CLMON are processed before the logic variable equations.

Virtual Bits

The SEL-311C supports 128 virtual bits, VB001–VB128 for the IEC 61850 protocol.

These Relay Word bits are active only in relays ordered with IEC 61850.

When IEC 61850 is enabled, the relay uses the externally-created CID file to define the behavior of these virtual bits (received GOOSE messages can be mapped to these bits).

Once defined, the virtual bits can be used in SELOGIC control equations like any other Relay Word bit.

The CID file also defines what information gets transmitted in GOOSE messages. See *Appendix P: IEC 61850* for details on the IEC 61850 protocol.

Output Contacts

Figure 7.28–*Figure 7.30* show the example operation of output contact Relay Word bits (e.g., Relay Word bits OUT101–OUT107 in *Figure 7.28*) as a result of one of the following:

NOTE: Do not use Figure 7.28, Figure 7.29, or Figure 7.30 to create relay wiring diagrams. See Output Contacts on page 2.8 for wiring considerations.

- SELOGIC control equation operation (e.g., SELOGIC control equation settings OUT101–OUT107 in *Figure 7.28*)
- **PULSE** command execution
- Modbus command (see *Appendix O: Modbus RTU and TCP Communications*)

The output contact Relay Word bits in turn control the output contacts (e.g., output contacts **OUT101**–**OUT107** in *Figure 7.28*).

Alarm logic/circuitry controls the **ALARM** output contact (see *Figure 7.28*)

Figure 7.28 is used for following discussion/examples. The output contacts in *Figure 7.29* and *Figure 7.30* operate similarly.

Factory Settings Example

In the factory SELOGIC control equation settings, four output contacts are used:

OUT101 = **TRIP** (automatic tripping/manual tripping; see *Section 5: Trip and Target Logic*)

OUT102 = **TRIP** (duplicate trip contact)

OUT103 = **CLOSE** (automatic reclosing/manual closing; see *Section 6: Close and Reclose Logic*)

OUT104 = **KEY** (POTT scheme key permissive trip; see *Section 5: Trip and Target Logic*)

OUT105 = **0** (output contact **OUT105** not used—set equal to zero)

OUT106 = **0** (output contact **OUT106** not used—set equal to zero)

OUT107 = **0** (output contact **OUT107** not used—set equal to zero)

Operation of Output Contacts for Different Output Contact Types

Output Contacts OUT101–OUT107

Refer to *Figure 7.28*.

The execution of the serial port command **PULSE *n*** (*n* = OUT101–OUT107) asserts the corresponding Relay Word bit (OUT101–OUT107) to logical 1. The assertion of SELOGIC control equation setting OUT*m* (*m* = 101–107) to logical 1 also asserts the corresponding Relay Word bit OUT*m* (*m* = 101–107) to logical 1.

The assertion of Relay Word bit OUT*m* (*m* = 101–107) 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 7.28*. 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 7.28* 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 2.27* for output contact type options.

ALARM Output Contact

Refer to *Figure 7.28* and *Relay Self-Tests on page 13.7*.

When the relay is operational, the **ALARM** output contact coil is energized. The alarm logic/circuitry keeps the **ALARM** output contact coil energized. Depending on the **ALARM** output contact type (a or b), the **ALARM** output contact closes or opens as demonstrated in *Figure 7.28*. 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.

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

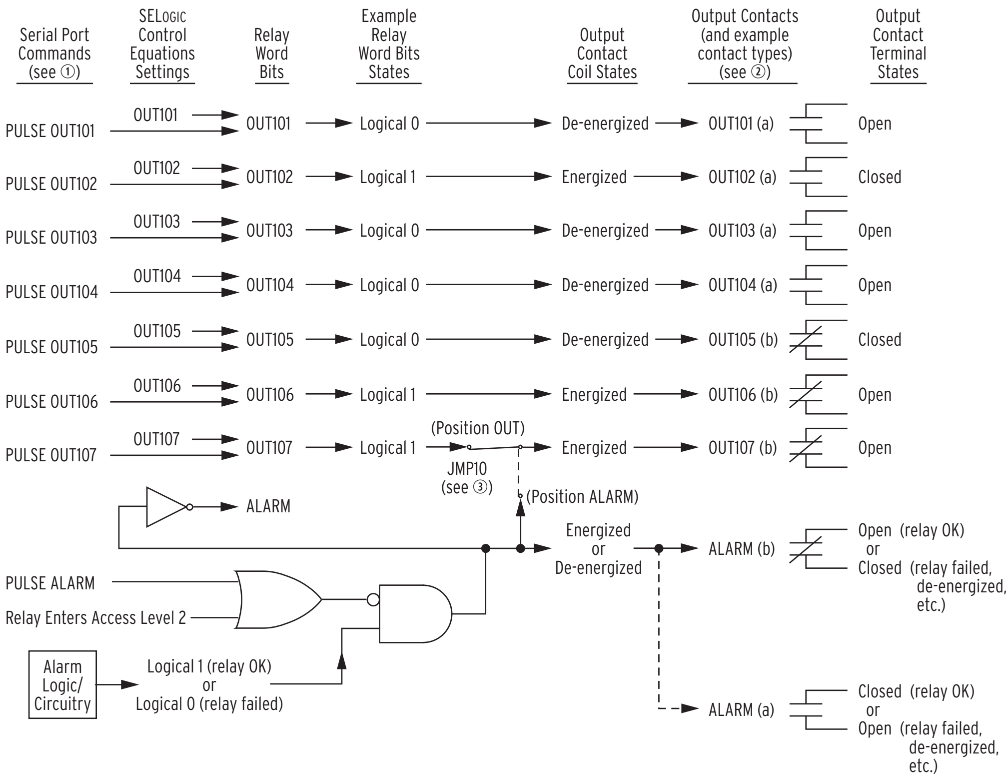
The Relay Word bit ALARM is deasserted to logical 0 when the relay is operational. When the serial port command **PULSE ALARM** is executed, the ALARM Relay Word bit momentarily asserts to logical 1. Also, when the relay enters Access Level 2, the ALARM Relay Word bit momentarily asserts to logical 1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

Notice in *Figure 7.28* that all possible combinations of **ALARM** output contact coil states (energized or de-energized) and output contact types (a or b) are demonstrated. See *Output Contact Jumpers on page 2.27* for output contact type options.

Output Contacts OUT201–OUT2xx (On Relays With Optional Extra Input/Output Board)

Refer to *Figure 7.29* and *Figure 7.30*.

The various input/output board choices have eight or twelve outputs that act in a similar fashion to those described in *Output Contacts OUT101–OUT107*. However, not all I/O boards support type b contact configuration on all outputs. See *Output Contact Jumpers on page 2.27* for full information.

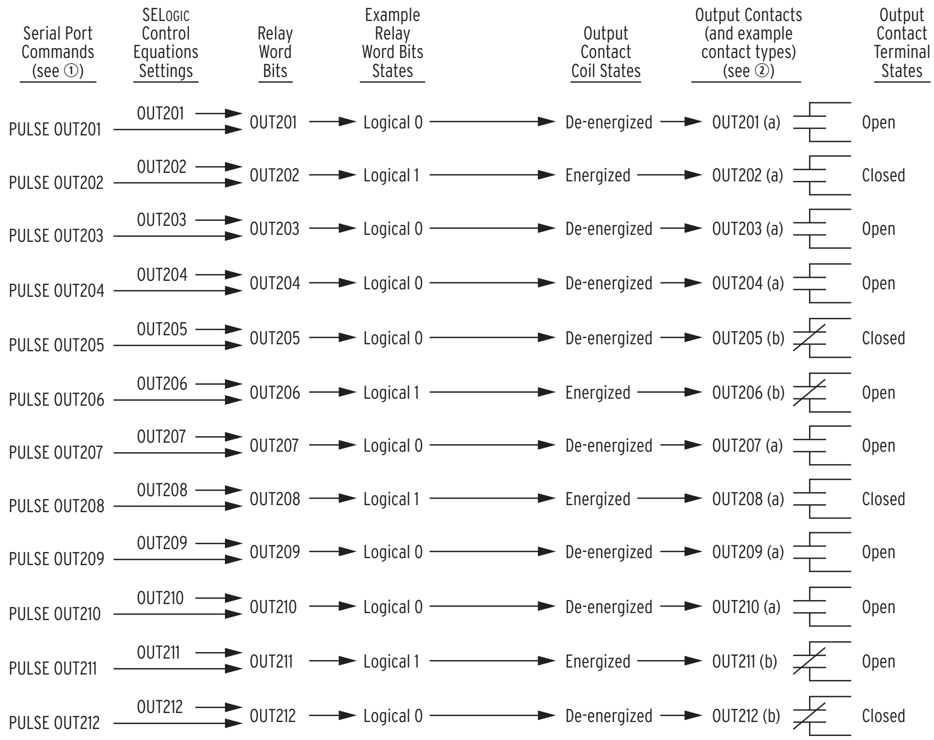


① **PULSE** command is also available via the front panel (**CNTRL** pushbutton, `Output Contact Testing` option). Execution of the **PULSE** command results in a logical 1 input into the above logic (one-second default pulse width).

② Output contacts **OUT101–ALARM** are configurable as form a or form b output contacts. See Output Contact Jumpers on page 2.27 for more information on selecting output contact type. **OUT101–OUT107** are shipped as form a contacts and **ALARM** is shipped as a form b contact in the standard relay configuration.

③ Main I/O board jumper JMP10 allows output contact OUT107 to operate as a regular output contact OUT107 or an extra Alarm output contact. See "Extra Alarm" Output Contact Control Jumper on page 2.27 for more information on jumper JMP10.

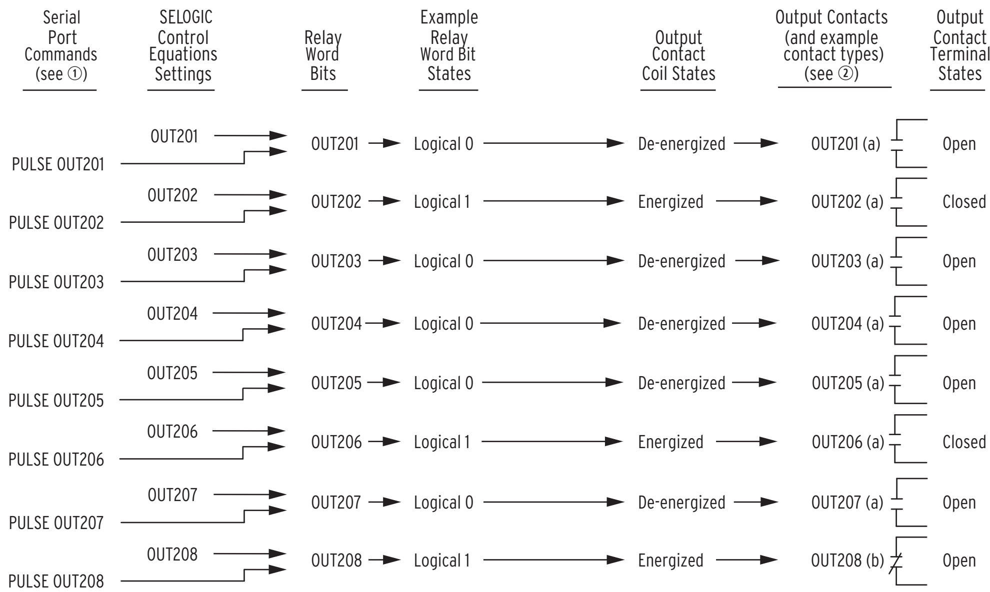
Figure 7.28 Logic Flow for Example Output Contact Operation (All Models)



① **PULSE** command is also available via the front panel (**CNTRL** pushbutton, `Output Contact Testing` option). Execution of the **PULSE** command results in a logical 1 input into the above logic (one-second default pulse width).

② All 12 output contacts are configurable as form a or form b output contacts. See Output Contact Jumpers on page 2.27 for more information on selecting output contact type. **OUT201–OUT212** are shipped as form a contacts in the standard relay configuration.

Figure 7.29 Logic Flow for Example Output Contact Operation—Extra I/O Board (Models 0311Cxxxxxxxx2x and 0311Cxxxxxxxx6x)



① The **PULSE** command is also available via the front-panel **CNTRL** pushbutton, "output contact testing" option. Execution of the **PULSE** command results in a logical 1 input into the above logic (one-second default pulse width).

② Only OUT208 is configurable as a or b type output contact. See Output Contact Jumpers on page 2.27 for more information on selecting output contact type. OUT208 is shipped as form a contact in the standard relay configuration.

Figure 7.30 Logic Flow for Example Output Contact Operation—Extra I/O Board (Model 0311Cxxxxxxxx5x)

Rotating Display

NOTE: This section only applies to SEL-311C relay models with an LCD. Disregard this section for vertical two rack unit relays, which have no LCD.

The rotating display on the relay front-panel replaces indicating panel lights. Traditional indicating panel lights are turned on and off by circuit breaker auxiliary contacts, front-panel switches, SCADA contacts, etc. They indicate such conditions as:

- circuit breaker open/closed
- reclosing relay enabled/disabled

Traditional Indicating Panel Lights

Figure 7.31 shows traditional indicating panel lights wired in parallel with SEL-311C optoisolated inputs. Input **IN101** provides circuit breaker status to the relay, and input **IN102** enables/disables reclosing in the relay via the following example SELOGIC control equation settings:

52A =

79DTL = **!IN102** [= NOT(IN102); drive-to-lockout setting]

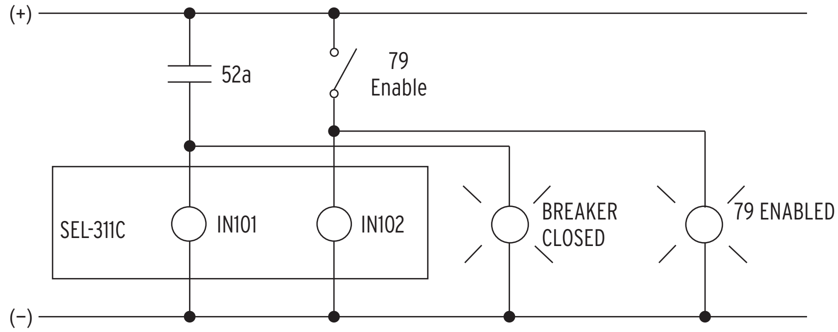


Figure 7.31 Traditional Panel Light Installations

Reclosing Relay Status Indication

In *Figure 7.31*, the **79 ENABLED** panel light illuminates when the “79 Enable” switch is closed. When the “79 Enable” switch is open, the **79 ENABLED** panel light extinguishes, and it is understood that the reclosing relay is disabled.

Circuit Breaker Status Indication

In *Figure 7.31*, the **BREAKER CLOSED** panel light illuminates when the 52a circuit breaker auxiliary contact is closed. When the 52a circuit breaker auxiliary contact is open, the **BREAKER CLOSED** panel light extinguishes, and it is understood that the breaker is open.

Traditional Indicating Panel Lights Replaced With Rotating Display

The indicating panel lights are not needed if the rotating display feature in the SEL-311C Relay is used. *Figure 7.32* shows the elimination of the indicating panel lights by using the rotating display.

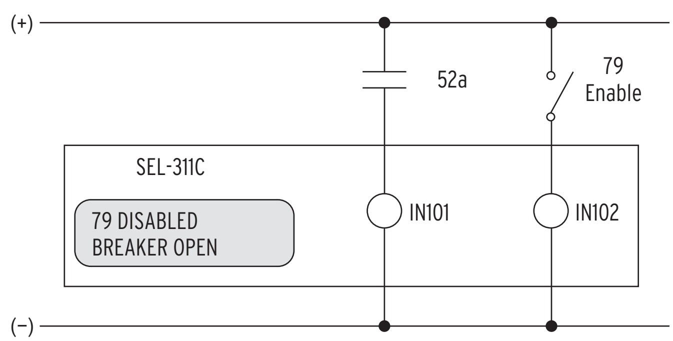


Figure 7.32 Rotating Default Display Replaces Traditional Panel Light Installations

There are sixteen (16) of these displays available in the SEL-311C. Each display has two complementary screens (e.g., BREAKER CLOSED and BREAKER OPEN) available.

General Operation of Rotating Display Settings

NOTE: The SEL-311C model described in this manual does not include an EDP setting. All 16 display point settings are always available in the logic and text settings classes. See SEL-311C Models on page 1.1 for more information.

SELOGIC control equation display point setting DP*n* (*n* = 1 through 16) controls the display of corresponding, complementary text settings:

DP*n*_1 (displayed when DP*n* = logical 1)

DP*n*_0 (displayed when DP*n* = logical 0)

Make each text setting through the serial port using the command **SET T** or the Text settings in ACSELERATOR QuickSet. View these text settings using the serial port command **SHO T** (see *Section 9: Setting the Relay* and *Section 10: Communications*) or the Text settings in ACSELERATOR QuickSet.

These text settings are displayed on the SEL-311C front-panel display on a time-variable rotation using Global setting SCROLD (see *Rotating Display on page 11.11* for more specific operation information).

The following settings examples use Relay Word bits 52A and IN102 in the display points settings. Local bits (LB1–LB16), latch bits (LT1–LT16), remote bits (RB1–RB16), setting group indicators (SG1–SG6), and any other combination of Relay Word bits in a SELOGIC control equation setting can also be used in display point setting DP*n*.

Settings Examples

The example settings provide the replacement solution shown in *Figure 7.32* for the traditional indicating panel lights in *Figure 7.31*.

Reclosing Relay Status Indication

Make SELOGIC control equation display point setting DP1: (**SET L**)

DP1 = **IN102**

Make corresponding, complementary text settings: (**SET T**)

DP1_1 = **79 ENABLED**

DP1_0 = **79 DISABLED**

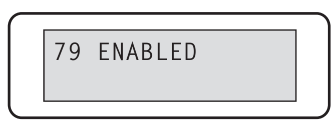
Display point setting DP1 controls the display of the text settings.

Reclosing Relay Enabled

In *Figure 7.32*, optoisolated input IN102 is energized to enable the reclosing relay, resulting in:

DP1 = **IN102** = logical 1

This results in the display of corresponding text setting DP1_1 on the front-panel display:

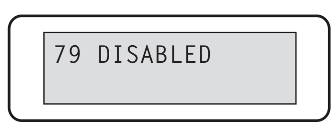


Reclosing Relay Disabled

In *Figure 7.32*, optoisolated input IN102 is de-energized to disable the reclosing relay, resulting in:

DP1 = **IN102** = logical 0

This results in the display of corresponding text setting DP1_0 on the front-panel display:



Circuit Breaker Status Indication

Make SELOGIC control equation display point setting DP2 (and 52A):

52A = **IN101** (see *Figure 7.31*)

DP2 = **52A**

Make corresponding, complementary text settings:

DP2_1 = **BREAKER CLOSED**

DP2_0 = **BREAKER OPEN**

Display point setting DP2 controls the display of the text settings.

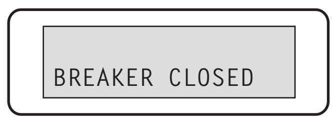
Circuit Breaker Closed

In *Figure 7.32*, optoisolated input **IN101** is energized when the 52a circuit breaker auxiliary contact is closed, resulting in:

52A = **IN101** = logical 1

DP2 = **52A** = logical 1

This results in the display of corresponding text setting DP2_1 on the front-panel display:



Circuit Breaker Open

In *Figure 7.32*, optoisolated input **IN101** is de-energized when the 52a circuit breaker auxiliary contact is open, resulting in:

52A = **IN101** = logical 0

DP2 = **52A** = logical 0

This results in the display of corresponding text setting DP2_0 on the front-panel display:

Factory Display Point Settings

One display point is used in the SEL-311C-1 relay factory default settings, as follows.

In the logic settings class:

DP1 = **52A**

DP2 = **0**

•

•

•

DP16 = **0**

In the text settings class:

DP1_1 = **BREAKER CLOSED**

DP1_0 = **BREAKER OPEN**

(Remaining display point settings = NA)

The operation of the relay with default settings will be similar to the previous Settings Examples, except the BREAKER OPEN/BREAKER CLOSED messages will appear on the first line of the front-panel display.

Additional Settings Examples

Display Only One Message

To display just one screen, but not its complement, set only one of the text settings. For example, to display just the "breaker closed" condition, but not the "breaker open" condition, make the following settings:

52A = **IN101** (52a circuit breaker auxiliary contact connected to input IN101—see *Figure 7.32*)

DP2 = **52A**

DP2_1 = **BREAKER CLOSED** (displays when DP2 = logical 1)

DP2_0 = (blank)

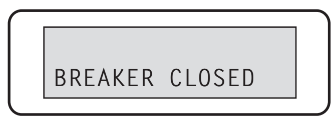
Circuit Breaker Closed

In *Figure 7.32*, optoisolated input **IN101** is energized when the 52a circuit breaker auxiliary contact is open, resulting in:

52A = **IN101** = logical 1

DP2 = **52A** = logical 1

This results in the display of corresponding text setting DP2_1 on the front-panel display.



Circuit Breaker Open

In *Figure 7.32*, optoisolated input **IN101** is de-energized when the 52a circuit breaker auxiliary contact is open, resulting in:

52A = **IN101** = logical 0

DP2 = **52A** = logical 0

Corresponding text setting DP2_0 is not set (it is "blank"), so no message is displayed on the front-panel display.

Continually Display a Message

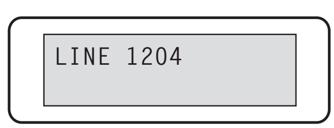
To permanently include a message in the rotation, set the SELOGIC control equation display point setting directly to 0 (logical 0) or 1 (logical 1) and the corresponding text setting. For example, if an SEL-311C is protecting a 230 kV transmission line, labeled "Line 1204," the line name can be permanently included in the display with the following settings:

DP5 = **1** (set directly to logical 1)

DP5_1 = **LINE 1204** (displays when DP5 = logical 1)

DP5_0 = ("blank")

This results in the display of text setting DP5_1 on the front-panel display:



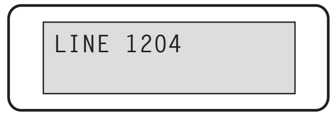
This can also be realized with the following settings:

DP5 = **0** (set directly to logical 0)

DP5_1 = (“blank”)

DP5_0 = **LINE 1204** (displays when DP5 = logical 0)

This results in the display of text setting DP5_0 on the front-panel display:



Active Setting Group Switching Considerations

The SELOGIC control equation display point settings DP*n* (*n* = 1 through 16) are available separately in each setting group. The corresponding text settings DP*n*_1 and DP*n*_0 are made only once and used in all setting groups.

Refer to *Figure 7.32* and the following example setting group switching discussion.

Setting Group 1 Is the Active Setting Group

When setting Group 1 is the active setting group, optoisolated input IN102 operates as a reclose enable/disable switch with the following settings:

SELOGIC control equation settings:

79DTL = **... + !IN102 + ...** [= ... + NOT(IN102) + ...; drive-to-lockout setting]

DP1 = **IN102**

Text settings:

DP1_1 = **79 ENABLED** (displayed when DP1 = logical 1)

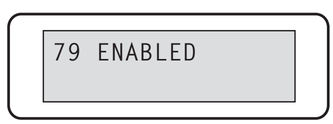
DP1_0 = **79 DISABLED** (displayed when DP1 = logical 0)

Reclosing Relay Enabled

In *Figure 7.32*, optoisolated input IN102 is energized to enable the reclosing relay, resulting in:

DP1 = **IN102** = logical 1

This results in the display of corresponding text setting DP1_1 on the front-panel display:



Reclosing Relay Disabled

In *Figure 7.32*, optoisolated input IN102 is de-energized to disable the reclosing relay, resulting in:

DP1 = **IN102** = logical 0

This results in the display of corresponding text setting DP1_0 on the front-panel display:

```
79 DISABLED
```

Now the active setting group is switched from setting Group 1 to 4.

Switch to Setting Group 4 as the Active Setting Group

When setting Group 4 is the active setting group, the reclosing relay is always disabled and optoisolated input **IN102** has no control over the reclosing relay. The text settings cannot be changed (they are used in all setting groups), but the SELOGIC control equation settings can be changed:

SELOGIC control equation settings:

79DTL = **1** (set directly to logical 1—reclosing relay permanently "driven-to-lockout")

DP1 = **0** (set directly to logical 0)

Text settings (remain the same for all setting groups):

DP1_1 = **79 ENABLED** (displayed when DP1 = logical 1)

DP1_0 = **79 DISABLED** (displayed when DP1 = logical 0)

Because SELOGIC control equation display point setting DP1 is always at logical 0, the corresponding text setting DP1_0 is permanently included in the rotating displays:

```
79 DISABLED
```

Additional Rotating Display Example

See *Figure 5.18* and accompanying text in *Section 5: Trip and Target Logic* for an example of resetting a rotating display with the **TARGET RESET** pushbutton.

Displaying Analog Values on the Rotating Display

Several analog quantities are available for display using display points. These quantities are indicated with an "x" mark in the Display Points column in *Table E.1*.

The available analog values cover metering, breaker wear monitor, and time-overcurrent element pickup values.

In general, any of these values can be selected for the rotating display with a leading two-character sequence:

"::" (double colon)

followed by the analog quantity name (mnemonic) in the display point text setting DP*n*_1 or DP*n*_0. For example, to display peak demand currents for currents IA, IB, IC, and IN, make the following text (**SET T** command) and logic (**SET L** command) settings:

SET T	SET L
DP1_0 = ::IAPK	DP1 = 0
DP2_0 = ::IBPK	DP2 = 0
DP3_0 = ::ICPK	DP3 = 0
DP4_0 = ::INPK	DP4 = 0

Logic settings DP1–DP4 are permanently set to logical 0 in this example. This causes the corresponding DP*n*_0 value to permanently rotate in the display (the mnemonics in the DP*n*_0 settings indicate the value displayed, per *Table E.1*):

```
IA   PEAK = 603.5
IB   PEAK = 598.7
```

then,

```
IC   PEAK = 605.1
IN   PEAK = 88.2
```

Values Displayed for Incorrect Settings

If the display point setting does not match the correct format (using the leading two-character sequence "::" followed by the correct mnemonic), the relay will display the setting text string as it was actually entered, without substituting the display value. For example:

SET T	SET L
DP1_0 = :IAPK (missing ":")	DP1 = 0
DP2_0=::IBPJ (misspelled mnemonic)	DP2 = 0

Again, logic settings DP1 and DP2 are permanently set to logical 0. This causes the corresponding DP*n*_0 value to permanently rotate in the display. With the DP*n*_0 setting problems just discussed, the relay displays the setting text string as it was actually entered, without substituting the intended display value from *Table E.1*:

```
:IAPK
::IBPJ
```

Extra Details for Displaying Metering Values on the Rotating Display

Table E.1 lists all the available metering values that can be configured to rotate on the default display, subject to the number of available display points. These values correspond to the primary metering values available via the **METER** command [**MET** (Instantaneous), **MET X** (Extended Instantaneous), **MET D** (Demand), and **MET E** (Energy); see *Section 10: Communications* for serial port commands].

Automatic Decimal Point

Many of the magnitude values are displayed with up to three digits behind the decimal point. For example, to display the ::IA value in *Table E.1* the relay uses a magnitude field and a phase-angle field. The relay automatically selects the number of decimal digits to fit in the magnitude display as shown in these sample screens.

Magnitudes less than 10 display with three digits behind the decimal point:

```
IA= 8.372A    0°
```

Magnitudes greater than or equal to 10 display with two or fewer digits behind the decimal point:

```
IA= 52.37A    0°
IB= 635.8A -120°
```

```
IC= 1173A   120°
```

Quantities Not Always Available for Display

Some of the analog quantities marked as Display Points in *Table E.1* are marked with table footnotes, for example, ::VA is not valid when Global setting PTCONN = DELTA. If ::VA is used in a display point setting when PTCONN = DELTA, the relay displays the setting as entered.

Example settings (when PTCONN = DELTA):

DP1_0 = **::VA**

DP2_0 = **::VAB**

DP1 = **0**

DP2 = **0**

Then the front-panel displays:

```
::VA
VAB= 34.76kV  0°
```

in sequence with any other defined display points and the default screens.

Other *Table E.1* footnotes indicate when a Display Point analog quantity is reported as 0.00 (zero). For example, ::3V0 is displayed as 0.000 when Global setting PTCONN = DELTA. If ::3V0 is used in a display point setting when PTCONN = DELTA, the relay displays the value as:

```
3V0=0.000kV   0°
```

Extra Details for Displaying Breaker Wear Monitor Quantities on the Rotating Default Display

Table E.1 lists all the available breaker wear monitor values that can be configured to rotate on the display, subject to the number of available display points. These values correspond to the breaker monitor values available via the **BRE** (Breaker) command (see *Section 10: Communications* for serial port commands).

See *Breaker Monitor on page 8.1* details on configuring the breaker monitor function.

This example demonstrates use of the rotating display to show breaker wear monitor quantities automatically on the rotating display. This example will set the EXTTR, INTTR, INTIA, EXTIA, and WEARA quantities to display in the rotating display.

Set the following:

NOTE: Some of the labels for breaker monitor quantities differ between relays. For example, the SEL-311C uses the labels ::INTTR and ::INTIB, where legacy SEL-311 relays have used ::CTRLTR and ::CTRLIB instead. See the notes after Table E.1 for details.

SET T	SET L
DP1_0 = ::EXTTR	DP1 = 0
DP2_0 = ::INTTR	DP2 = 0
DP3_0 = ::INTIA	DP3 = 0
DP4_0 = ::EXTIA	DP4 = 0
DP5_0 = ::WEARA	DP5 = 0

Setting DP*n* = 0 and using the DP*n*_0 in the text settings allows the setting to permanently rotate in the display. The DP*n* logic equation can be set to control the text display—turning it on and off under certain conditions. With the relay set as shown previously, the LCD will show the following:

```
EXT TRIPS=    4
INT TRIPS=   67
```

then,

```
INT IA=      2 kA
EXT IA=    122 kA
```

and then,

```
WEAR A=     16 %
```

Extra Details for Displaying Time-Overcurrent Elements on the Rotating Display

Table E.1 lists all the available Time-Overcurrent Element pickup values that can be configured to rotate on the display, subject to the number of available display points. As with the previously described display points, the operator does not need to press any buttons to see this information.

To program a display point to show the pickup setting of a time-overcurrent element, first enter the two-character sequence "::" (double colon) followed by the name of the desired time-overcurrent element pickup setting (e.g., 51PP, 51GP, or 51QP).

For example, with the factory default settings for 51GP and CTR, setting DP4_0 =::51GP will display `150.00 A pri`.

The relay calculates the value to display by multiplying the 51GP setting (0.75 A secondary) by the CTR setting (200), arriving at 150.00 A primary. The relay displays the display point DP4_0 because the factory default SELOGIC control equation DP4 = 0 (logical 0).

The calculations for the remaining time-overcurrent elements are similar.

If the display point setting does not match the correct format, the relay will display the setting text string as it actually entered, without substituting the time-overcurrent element setting value.

Displaying Time-Overcurrent Elements Example

This example demonstrates use of the rotating display to show time-overcurrent elements in primary units. This example will set the 51PP and 51GP to display in the rotating display.

Set the following:

SET	SET T	SET L
CTR = 100	DP1_0 = PHASE TRIPS AT	DP1 = 0
	DP2_0 = ::51PP	DP2 = 0
E51P = Y	DP3_0 = GROUND TRIPS AT	DP3 = 0
E51G = Y	DP4_0 = ::51GP	DP4 = 0
51PP = 5		
51GP = 1		

Setting DP*n* = 0 and using the DP*n*_0 in the text settings allows the setting to permanently rotate in the display. The DP*n* logic equation can be set to control the text display—turning it on and off under certain conditions. With the relay set as shown above, the LCD will show the following:

```
PHASE TRIPS AT
   500.00 A pri
```

then,

```
GROUND TRIPS AT
  100.00 A pri
```

With the control string set on the even display points "DP2, DP4, DP6, …" and the description set on the odd display points "DP1, DP3, …," each screen the relay scrolls through will have a description with the value below it.

Additional Format for Displaying Time-Overcurrent Elements on the Rotating Display

The previous method for displaying Time-Overcurrent Element pickup values required two display points per overcurrent element: one display points acts as the title, and the other contains the data. Because this reduces the number of display points available for other reporting functions, a special one-line format is available for the Time-Overcurrent Element pickup values.

NOTE: Some of the labels for time overcurrent element ";;;"quantities shown in Table 7.8 differ between relays. For example, the SEL-311C described in this manual uses the labels ;;;003, ;;;004, ;;;005, where legacy SEL-311 relays have used ;;;000, ;;;001, and ;;;002, respectively. See SEL-311C Models on page 1.1 for a list of differences between relay models.

Instead of the double colon operator (e.g., ::51PP), the special formatting options use a double or triple semi-colon operator (e.g. ;;51PP or ;;;51PP), and descriptive text may be entered.

To set the description and the control string of time-overcurrent element on one display point, use the following **SET T** format:

DPi_j = **XXX;;[;]ABCDE;YYY**

where:

i is a display point number from 1 to 16.

j is either 1 or 0 (logic high or low).

XXX is an optional prelabel consisting of any characters that you wish to add for labeling the setting value.

[;] signifies an optional ";" for the ";;;" control string to make more characters available for labeling purposes.

The label character count is the sum of the characters used in the pre- and postlabels. For example, three characters at the beginning and three characters at the end of the string equal six total characters used for labeling.

ABCDE is a relay setting variable from *Table 7.8*.

YYY is an optional postlabel, preceded by a single semicolon (;) character. If no trailing semicolon and label text is added, the relay does not display a post-setting label. Refer to *Table 7.8* to determine the maximum characters allowed for use in pre- and postlabel text.

Table 7.8 Mnemonic Settings for Time-Overcurrent (TOC) Element Pickups Using the Same-Line-Label Format on the Rotating Display

SET T Setting Variable	Displays Relay Setting Value	Display Format/Resolution	Maximum Label Characters
;;51PP	51PP	xxxxxxx.xx	6
;;51GP	51GP	xxxxxxx.xx	6
;;51QP	51QP	xxxxxxx.xx	6
;;;003	51PP	xxxxxxx	9
;;;004	51GP	xxxxxxx	9
;;;005	51QP	xxxxxxx	9

Examples With “;; ;” Control Strings

SET L

DP1 = **IN101**
DP2 = **IN101**

SET T

DP1_1 = **PTO=;;51PP;Ap**

The pre- and postlabel characters for DP1_1, are “P,” “T,” “O,” “=,” “A,” “p,” a total of six characters. The relay setting to be displayed is 51PP, as indicated after the control string “;;”. The relay converts lowercase “p” to upper case when the setting is saved.

DP1_0 = **NA**
DP2_1 = **GND PU;;51GP;B1**

The characters for DP2_1, consist of six pre characters “G,” “N,” “D,” “ “, “P,” “U,” and two post characters “B,” “1.” The maximum number of label characters is six, so the “B1” will be ignored. The relay setting to be displayed is 51GP, as indicated after the control string “;;”.

DP2_0 = **N SEQ=;;51QP;A**

The characters for DP2_0, consist of six pre characters “N,” “ “, “S,” “E,” “Q,” “=” and one post character “A.” The “A” will be ignored. The relay setting to be displayed is 51QP, as indicated after the control string “;;”.

When IN101 = 1, the following will display on the front-panel display (assuming 51PP= 720 A primary, and 51GP = 121.2 A primary):

```
PTO=   720.00AP
GND PU    121.20
```

When IN101 = 0, the following will display on the front-panel display (assuming 51QP = OFF):

```

N SEQ=  OFF
```

If the prelabel is longer than six characters, the string is processed as if there were only six precharacters.

To illustrate this, continuing from the above example:

DP2_0 = **NEG SQ=;;51NP;A**

with IN101 deasserted, will display:

```

NEG SQ  OFF
```

The addition of the “=” sign caused the number of precharacters to exceed six, so the processing logic stops there, and will display the first six characters followed by the setting values. The post character(s), “A” in this case, are ignored.

Examples With “;;; ;” Control Strings

Use the “;;;” control string to decrease the display resolution, and make more characters available for labeling purposes. Use the table above to determine the appropriate numerical setting variable. The following setting example allows nine characters of label text.

SET L

DP1 = **IN101**
DP2 = **IN101**

SET T

DP1_0 = **51THXYZ=;;;003;A**

(The prelabel characters are: “5, 1, T, H, X, Y, Z, =”. The post-label character is “A.” The total number of label characters is 9.)

DP2_0 = **51ABCD=;;;004;AP**

When IN101 = 0, the following will display on the front-panel display (assuming 51AP = 720 A primary, and 51GP = 600 A primary):

```
51THXYZ=   720A
51ABCD=    600AP
```

Section 8
Metering and Monitoring

Overview

This section covers the reporting and metering functions of the SEL-311C, in the following subsections:

Breaker Monitor

The breaker monitor in the SEL-311C helps in scheduling circuit breaker maintenance. The breaker monitor is enabled with the enable setting:

EBMON = **Y**

The breaker monitor settings in *Table 8.2* are available via the **SET G** and **SET L** commands (see *Table 9.2* and also *Breaker Monitor Settings (see Breaker Monitor on page 8.1) on page SET.2*). Also, refer to *BRE Command (Breaker Monitor Data) on page 10.27*.

The breaker monitor is set with breaker maintenance information provided by circuit breaker manufacturers. This breaker maintenance information lists the number of close/open operations that are permitted for a given current interruption level. The following is an example of breaker maintenance information for a 25 kV circuit breaker.

Table 8.1 Breaker Maintenance Information for a 25 kV Circuit Breaker

Current Interruption Level (kA)	Permissible Number of Close/Open Operations[a]
0.00–1.20	10,000
2.00	3,700
3.00	1,500
5.00	400
8.00	150
10.00	85
20.00	12

[a] The action of a circuit breaker closing and then later opening is counted as **one** close/open operation.

The breaker maintenance information in *Table 8.1* is plotted in *Figure 8.1*.

Connect the plotted points in *Figure 8.1* for a breaker maintenance curve. To estimate this breaker maintenance curve in the SEL-311C breaker monitor, three set points are entered:

- Set Point 1—maximum number of close/open operations with corresponding current interruption level.
- Set Point 2—number of close/open operations that correspond to some midpoint current interruption level.
- Set Point 3—number of close/open operations that correspond to the maximum current interruption level.

These three points are entered with the settings in *Table 8.2*.

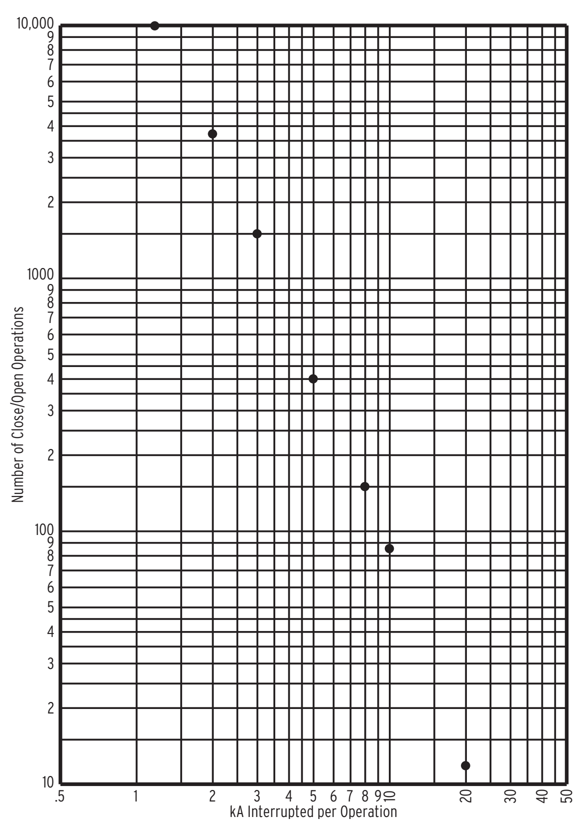


Figure 8.1 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

Breaker Monitor Setting Example

Table 8.2 Breaker Monitor Settings and Settings Ranges

Setting	Definition	Range
COSP1	Close/Open set point 1—maximum	0–65000 close/open operations
COSP2	Close/Open set point 2—middle	0–65000 close/open operations
COSP3	Close/Open set point 3—minimum	0–65000 close/open operations
KASP1	kA Interrupted set point 1—minimum	0.00–999.00 kA in 0.01 kA steps
KASP2	kA Interrupted set point 1—middle	0.00–999.00 kA in 0.01 kA steps
KASP3	kA Interrupted set point 1—maximum	0.00–999.00 kA in 0.01 kA steps
BKMON	SELOGIC® control equation breaker monitor initiation setting	Relay Word bits referenced in *Table D.1*

Setting notes:

- COSP1 must be set greater than COSP2.
- COSP2 must be set greater than or equal to COSP3.
- KASP1 must be set less than KASP2.
- If COSP2 is set the same as COSP3, then KASP2 must be set the same as KASP3.
- KASP3 must be set at least 5 times (but no more than 100 times) the KASP1 setting value.

The following settings are made from the breaker maintenance information in *Table 8.1* and *Figure 8.1*:

COSP1 = **10000**

COSP2 = **150**

COSP3 = **12**

KASP1 = **1.20**

KASP2 = **8.00**

KASP3 = **20.00**

Figure 8.2 shows the resultant breaker maintenance curve.

Breaker Maintenance Curve Details

In *Figure 8.2*, note that set points KASP1, COSP1 and KASP3, COSP3 are set with breaker maintenance information from the two extremes in *Table 8.1* and *Figure 8.1*.

In this example, set point KASP2, COSP2 happens to be from an in-between breaker maintenance point in the breaker maintenance information in *Table 8.1* and *Figure 8.1*, but it does not have to be. Set point KASP2, COSP2 should be set to provide the best “curve-fit” with the plotted breaker maintenance points in *Figure 8.1*.

Each phase (A, B, and C) has its own breaker maintenance curve (like that in *Figure 8.2*), because the separate circuit breaker interrupting contacts for phases A, B, and C do not necessarily interrupt the same magnitude current (depending on fault type and loading).

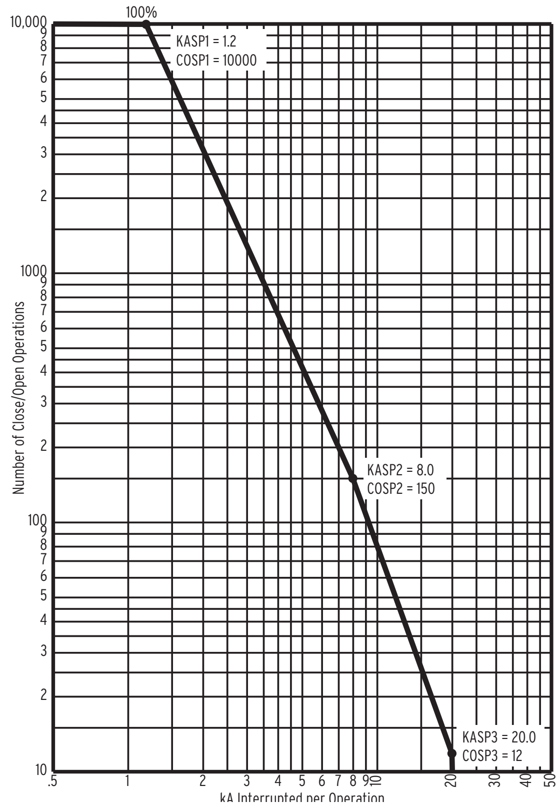


Figure 8.2 Breaker Maintenance Curve for a 25 kV Circuit Breaker

In *Figure 8.2*, note that the breaker maintenance curve levels off horizontally below set point KASP1, COSP1. This is the close/open operation limit of the circuit breaker (COSP1 = 10000), regardless of interrupted current value.

Also, note that the breaker maintenance curve falls vertically above set point KASP3, COSP3. This is the maximum interrupted current limit of the circuit breaker (KASP3 = 20.0 kA). If the interrupted current is greater than setting KASP3, the interrupted current is accumulated as a current value equal to setting KASP3.

Operation of SELogic Control Equation Breaker Monitor Initiation Setting BKMON

The SELogic control equation breaker monitor initiation setting BKMON in *Table 8.2* determines when the breaker monitor reads in current values (Phases A, B, and C) for the breaker maintenance curve (see *Figure 8.2*) and the breaker monitor accumulated currents/trips (see *BRE Command (Breaker Monitor Data) on page 10.27*).

The BKMON setting looks for a rising edge (logical 0 to logical 1 transition) as the indication to read in current values. The acquired current values are then applied to the breaker maintenance curve and the breaker monitor accumulated currents/trips (see references in previous paragraph).

In the factory default settings, the SELogic control equation breaker monitor initiation setting is:

BKMON = **TRIP** (TRIP is the logic output of *Figure 5.1*)

Refer to *Figure 8.3*. When BKMON asserts (Relay Word bit TRIP goes from logical 0 to logical 1), the breaker monitor reads in current values and applies them to the breaker monitor maintenance curve and the breaker monitor accumulated currents/trips.

As detailed in *Figure 8.3*, the breaker monitor actually reads in the current values 1.5 cycles after the assertion of BKMON. This helps especially if an instantaneous trip occurs. The instantaneous element trips when the fault current reaches its pickup setting level. The fault current may still be “climbing” to its full value and then level off. The 1.5-cycle delay on reading in the current values allows time for the fault current to level off.

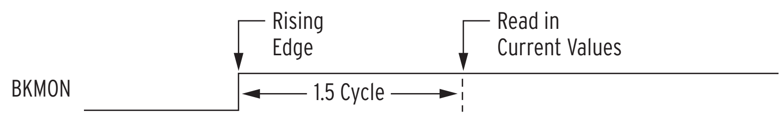


Figure 8.3 Operation of SELogic Control Equation Breaker Monitor Initiation Setting

See *Figure 8.8* and accompanying text for more information on setting BKMON. The operation of the breaker monitor maintenance curve, when new current values are read in, is explained in the following example.

Breaker Monitor Operation Example

As stated earlier, each phase (A, B, and C) has its own breaker maintenance curve. For this example, presume that the interrupted current values occur on a single phase in *Figure 8.4*–*Figure 8.7*. Also, presume that the circuit breaker interrupting contacts have no wear at first (brand new or recent maintenance performed).

Note in the following four figures (*Figure 8.4*–*Figure 8.7*) that the interrupted current in a given figure is the same magnitude for all the interruptions (e.g., in *Figure 8.5*, 2.5 kA is interrupted 290 times). This is not realistic, but helps in demonstrating the operation of the breaker maintenance curve and how it integrates for varying current levels.

0 Percent to 10 Percent Breaker Wear

Refer to *Figure 8.4*. 7.0 kA is interrupted 20 times (20 close/open operations = 20 – 0), pushing the breaker maintenance curve from the 0 percent wear level to the 10 percent wear level.

Compare the 100 percent and 10 percent curves and note that for a given current value, the 10 percent curve has only 1/10 of the close/open operations of the 100 percent curve.

10 Percent to 25 Percent Breaker Wear

Refer to *Figure 8.5*. The current value changes from 7.0 kA to 2.5 kA. 2.5 kA is interrupted 290 times (290 close/open operations = 480 – 190), pushing the breaker maintenance curve from the 10 percent wear level to the 25 percent wear level.

Compare the 100 percent and 25 percent curves and note that for a given current value, the 25 percent curve has only 1/4 of the close/open operations of the 100 percent curve.

25 Percent to 50 Percent Breaker Wear

Refer to *Figure 8.6*. The current value changes from 2.5 kA to 12.0 kA. 12.0 kA is interrupted 11 times (11 close/open operations = 24–13), pushing the breaker maintenance curve from the 25 percent wear level to the 50 percent wear level.

Compare the 100 percent and 50 percent curves and note that for a given current value, the 50 percent curve has only 1/2 of the close/open operations of the 100 percent curve.

50 Percent to 100 Percent Breaker Wear

Refer to *Figure 8.7*. The current value changes from 12.0 kA to 1.5 kA. 1.5 kA is interrupted 3000 times (3000 close/open operations = 6000 –3000), pushing the breaker maintenance curve from the 50 percent wear level to the 100 percent wear level.

When the breaker maintenance curve reaches 100 percent for a particular phase, the percentage wear remains at 100 percent (even if additional current is interrupted), until reset by the **BRE R** command (see *View or Reset Breaker Monitor Information on page 8.8*). But the current and trip counts continue to be accumulated, until reset by the **BRE R** command.

Additionally, logic outputs assert for alarm or other control applications—see the following discussion.

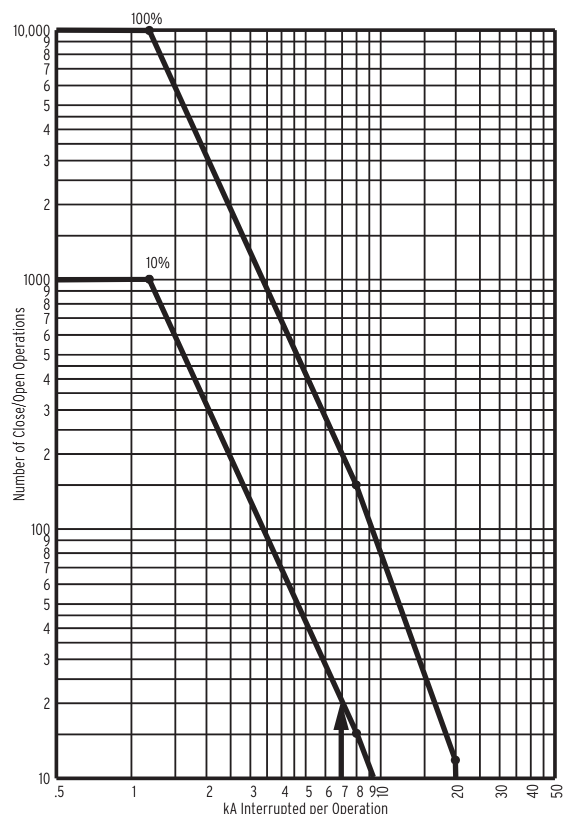


Figure 8.4 Breaker Monitor Accumulates 10 Percent Wear

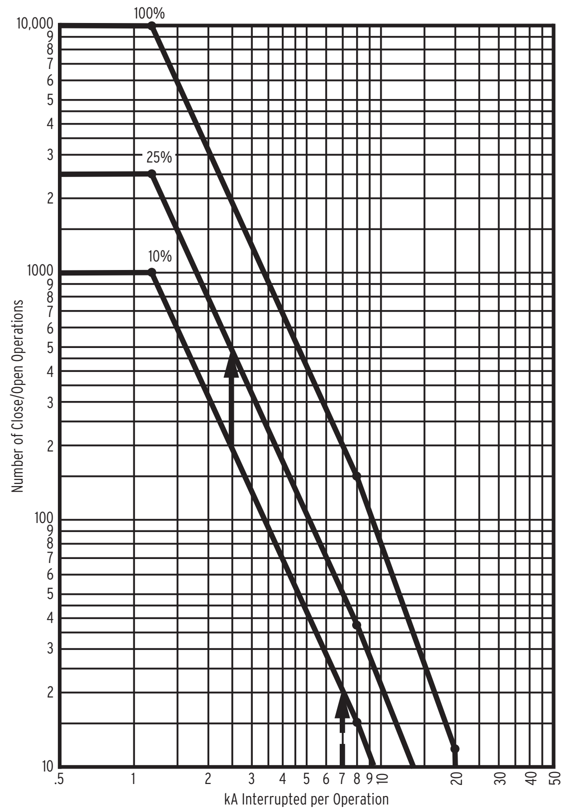


Figure 8.5 Breaker Monitor Accumulates 25 Percent Wear

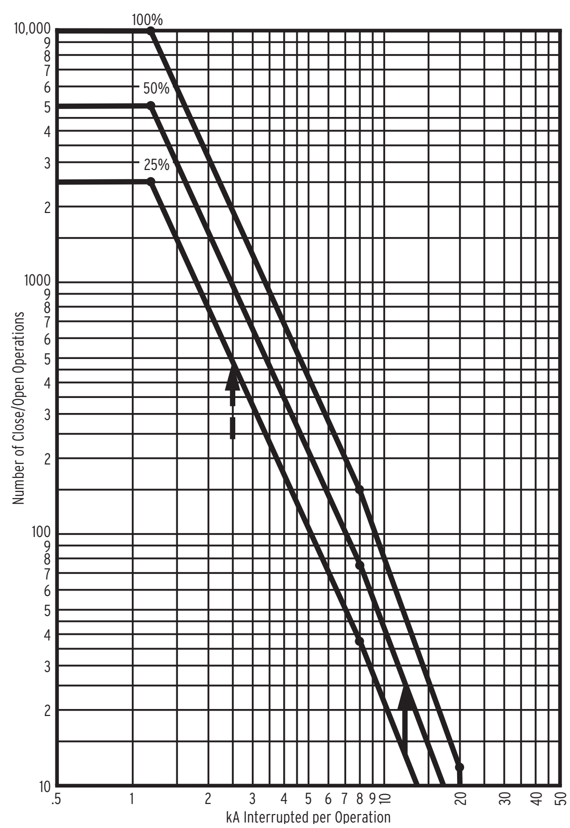


Figure 8.6 Breaker Monitor Accumulates 50 Percent Wear

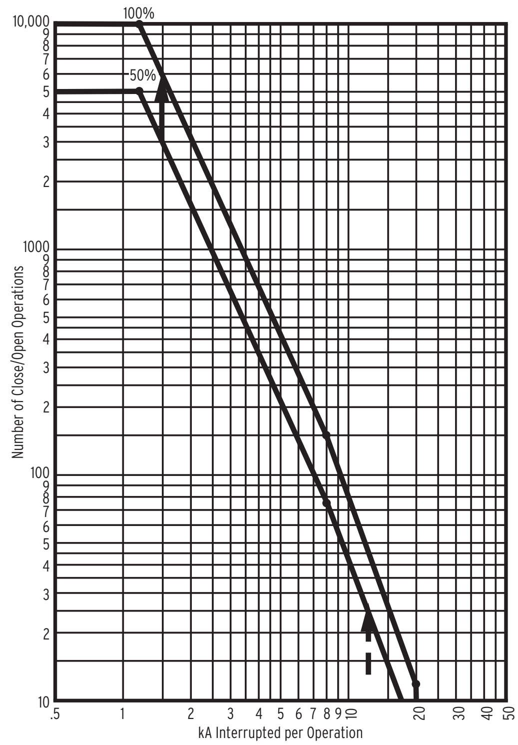


Figure 8.7 Breaker Monitor Accumulates 100 Percent Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100 percent wear level (see *Figure 8.7*), a corresponding Relay Word bit (BCWA, BCWB, or BCWC) asserts.

Relay Word Bits	Definition
BCWA	Phase A breaker contact wear has reached the 100 percent wear level
BCWB	Phase B breaker contact wear has reached the 100 percent wear level
BCWC	Phase C breaker contact wear has reached the 100 percent wear level
BCW	BCWA + BCWB + BCWC

Example Applications

These logic outputs can be used to alarm:

OUT105 = **BCW**

or drive the relay to lockout the next time the relay trips:

79DTL = **TRIP * BCW**

View or Reset Breaker Monitor Information

Accumulated breaker wear/operations data is retained if the relay loses power or the breaker monitor is disabled (setting EBMON = N). The accumulated data can only be reset if the **BRE R** command is executed (see the following discussion on the **BRE R** command).

Via Serial Port

See *BRE Command (Breaker Monitor Data) on page 10.27*. The **BRE** command displays the following information:

- Accumulated number of relay initiated trips
- Accumulated interrupted current from relay initiated trips
- Accumulated number of externally initiated trips
- Accumulated interrupted current from externally initiated trips
- Percent circuit breaker contact wear for each phase
- Date when the preceding items were last reset (via the **BRE R** command)

See *BRE n Command (Preload/Reset Breaker Wear) on page 10.27*. The **BRE W** command allows the trip counters, accumulated values, and percent breaker wear to be preloaded for each individual phase.

The **BRE R** command resets the accumulated values and the percent wear for all three phases. For example, if breaker contact wear has reached the 100 percent wear level for A-phase, the corresponding Relay Word bit BCWA asserts (BCWA = logical 1). Execution of the **BRE R** command resets the wear levels for all three phases back to 0 percent and consequently causes Relay Word bit BCWA to deassert (BCWA = logical 0).

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **BRE** and **BRE R** are also available via the front-panel OTHER pushbutton. See *Figure 11.3*.

Via DNP or Modbus

The internal and external trips counters and breaker wear data are available via DNP and Modbus®. See the Breaker Monitor section of *Table E.1*.

The DNP binary output DRST_BK can be used to reset the breaker monitor data, and is similar in function to the **BRE R** command. See *Appendix L: DNP3 Communications* for more details.

The Modbus protocol can be used to reset the breaker monitor data, and is similar in function to the **BRE R** command. There are two methods available:

- Writing to the Reset Breaker Monitor output coil.
- Writing a specific analog value to the RSTDAT register.

See *Appendix O: Modbus RTU and TCP Communications* for details.

Via IEC 61850

The internal trip counter is available via 61850. See the Breaker Monitor section of *Table E.1*.

Reset Via SELogic Equation

The RST_BK SELogic control equation setting can be used to reset the breaker monitor data, similar in function to the **BRE R** command. The relay resets the function when the setting first asserts (rising edge, e.g., a logical 0 to a logical 1 transition). For an example of how to use the RST_BK setting, see the similar function *View or Reset Energy Metering Information on page 8.26*.

Determination of Relay Initiated Trips and Externally Initiated Trips

See *BRE Command (Breaker Monitor Data) on page 10.27*. Note in the **BRE** command response that the accumulated number of trips and accumulated interrupted current are separated into two groups of data: that generated by *relay initiated trips* (Rly Trip Count) and that generated by *externally initiated trips* (Ext Trip Count). The categorization of this data is determined by the status of the TRIP Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON operates.

Refer to *Figure 8.3* and accompanying explanation. If BKMON newly asserts (logical 0 to logical 1 transition), the relay reads in the current values (Phases A, B, and C). Now the decision has to be made: where is this current and trip count information accumulated? Under *relay initiated trips* or *externally initiated trips*?

To make this determination, the status of the TRIP Relay Word bit is checked at the instant BKMON newly asserts (TRIP is the logic output of *Figure 5.1*). If TRIP is asserted (TRIP = logical 1), the current and trip count information is accumulated under *relay initiated trips* (Rly Trip Count and Rly Accum Pri Current [kA]). If TRIP is deasserted (TRIP = logical 0), the current and trip count information is accumulated under *externally initiated trips* (Ext Trip Count and Ext Accum Pri Current [kA]).

Regardless of whether the current and trip count information is accumulated under relay initiated trips or externally initiated trips, this same information is routed to the breaker maintenance curve for continued breaker wear integration (see *Figure 8.4*–*Figure 8.7*).

Relay initiated trips (Rly Trip Count) are also referred to as *internally initiated trips* (Internal Trip Counter) in the course of this manual; the terms are interchangeable.

Factory Default Setting Example

As discussed previously, the SELOGIC control equation breaker monitor initiation factory default setting is:

BKMON = **TRIP**

Thus, any new assertion of BKMON will be deemed a relay trip, and the current and trip count information is accumulated under *relay initiated trips* (Rly Trip Count).

Additional Example

Refer to *Figure 8.8*. Output contact **OUT101** is set to provide tripping:

OUT101 = **TRIP**

Note that optoisolated input **IN106** monitors the trip bus. If the trip bus is energized by output contact **OUT101**, an external control switch, or some other external trip, then **IN106** is asserted.

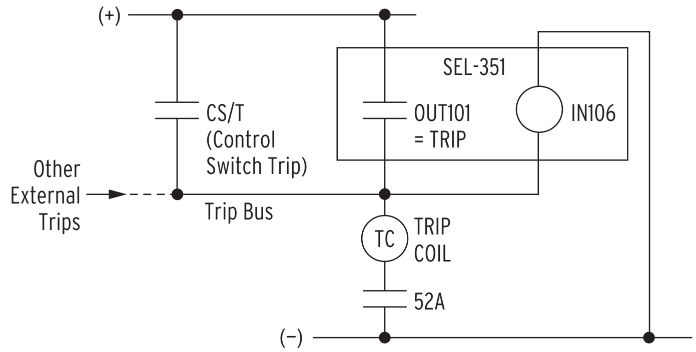


Figure 8.8 Input IN106 Connected to Trip Bus for Breaker Monitor Initiation

If the SELOGIC control equation breaker monitor initiation setting is set:

BKMON = **IN106**

then the SEL-311C breaker monitor sees all trips.

If output contact **OUT101** asserts, energizing the trip bus, the breaker monitor will deem it a *relay initiated trip*. This is because when BKMON is newly asserted (input **IN106** energized), the TRIP Relay Word bit is asserted. Thus, the current and trip count information is accumulated under *relay initiated trips* (Rly Trip Count and Rly Accum Pri Current [kA]).

If the control switch trip (or some other external trip) asserts, energizing the trip bus, the breaker monitor will deem it an *externally initiated trip*. This is because when BKMON is newly asserted (input **IN106** energized), the TRIP Relay Word bit is deasserted. Thus, the current and trip count information is accumulated under *externally initiated trips* (Ext Trip Count and Ext Accum Pri Current [kA]).

Station DC Battery Monitor

The station dc battery monitor in the SEL-311C can alarm for under- or overvoltage dc battery conditions and give a view of how much the station dc battery voltage dips when tripping, closing, and other dc control functions take place. The monitor measures the station dc battery voltage applied to the rear-panel terminals labeled **POWER** (see *Figure 2.2* through *Figure 2.6*). The station dc battery monitor settings (DCLOP and DCHIP) are available via the **SET G** command (see *Table 9.2* and also *Breaker Monitor Settings (see Breaker Monitor on page 8.1) on page SET.2*).

DC Under- and Overvoltage Elements

Refer to *Figure 8.9*. The station dc battery monitor compares the measured station battery voltage (Vdc) to the undervoltage (low) and overvoltage (high) pickups DCLOP and DCHIP. The setting range for pickup settings DCLOP and DCHIP is shown below:

20 to 300 Vdc, 0.02 Vdc increments

This range allows the SEL-311C to monitor nominal battery voltages of 24, 48, 110, 125, 220, and 250 V. When testing the pickup settings DCLOP and DCHIP, *do not* operate the SEL-311C outside of its power supply limits. See the Specifications subsection *General on page 1.2* for the various power supply specifications. The power supply rating is located on the serial number sticker on the relay rear panel.

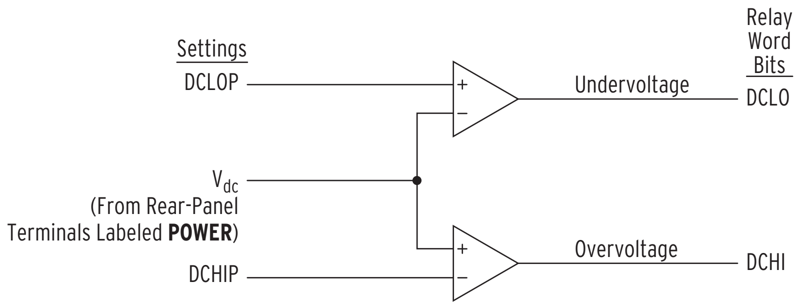


Figure 8.9 DC Under- and Overvoltage Elements

Logic outputs DCLO and DCHI in *Figure 8.9* operate as follows:

DCLO = 1 (logical 1), if $V_{dc} \leq$ pickup setting DCLOP
= 0 (logical 0), if $V_{dc} >$ pickup setting DCLOP
DCHI = 1 (logical 1), if $V_{dc} \geq$ pickup setting DCHIP
= 0 (logical 0), if Vdc < pickup setting DCHIP

Create Desired Logic for DC Under- and Overvoltage Alarming

Pickup settings DCLOP and DCHIP are set independently. Thus, they can be set:

DCLOP < DCHIP or DCLOP > DCHIP

Figure 8.10 shows the resultant dc voltage elements that can be created with SELOGIC control equations for these two setting cases. In these two examples, the resultant dc voltage elements are time-qualified by timer SV4T and then routed to output contact **OUT106** for alarm purposes.

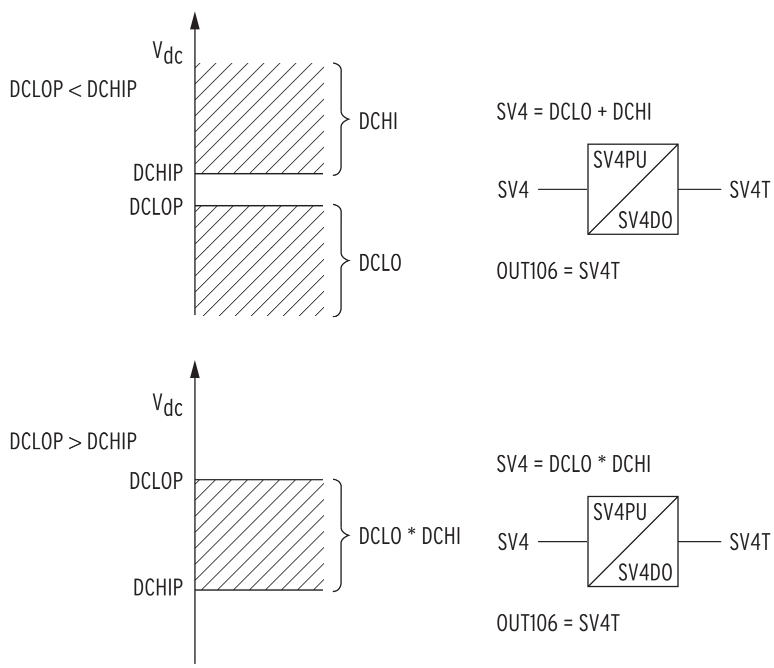


Figure 8.10 Create DC Voltage Elements With SELOGIC Control Equations

DCLO < DCHI (Top of *Figure 8.10*)

Output contact **OUT106** asserts when:

$$V_{dc} \leq \text{DCLOP or } V_{dc} \geq \text{DCHIP}$$

Pickup settings DCLOP and DCHIP are set such that output contact **OUT106** asserts when dc battery voltage goes below or above allowable limits.

If the relay loses power entirely (V_{dc} = 0 Vdc)

$V_{dc} \leq$ DCLOP

then output contact **OUT106** should logically assert (according to top of *Figure 8.10*), but cannot because of the total loss of power (all output contacts deassert on total loss of power). Thus, the resultant dc voltage element at the bottom of *Figure 8.10* would probably be a better choice—see following discussion.

DCLO > DCHI (Bottom of Figure 8.10)

Output contact **OUT106** asserts when:

DCHIP $\leq V_{dc} \leq$ DCLOP

Pickup settings DCLOP and DCHIP are set such that output contact **OUT106** asserts when dc battery voltage stays between allowable limits.

If the relay loses power entirely (V_{dc} = 0 Vdc)

$V_{dc} \leq$ DCHIP

then output contact **OUT106** should logically deassert (according to bottom of *Figure 8.10*), and this is surely what happens for a total loss of power (all output contacts deassert on total loss of power).

Output Contact Type Considerations (a or b)

Refer to *Output Contacts on page 7.33* (especially *Note 2* in *Figure 7.28*, *Figure 7.29*, and *Figure 7.30*). Consider the output contact type (a or b) needed for output contact **OUT106** in the bottom of *Figure 8.10* (dc voltage alarm example).

If SELOGIC control equation setting OUT106 is asserted (OUT106 = SV4T = logical 1; dc voltage OK), the state of output contact **OUT106** (according to contact type) is:

- closed (a-type output contact)
- open (b-type output contact)

If SELOGIC control equation setting OUT106 is deasserted (OUT106 = SV4T = logical 0; dc voltage *not* OK), the state of output contact **OUT106** (according to contact type) is:

- open (a-type output contact)
- closed (b-type output contact)

If the relay loses power entirely, all output contacts deassert, and the state of output contact **OUT106** (according to contact type) is:

- open (a-type output contact)
- closed (b-type output contact)

Additional Application

Other than alarming, the dc voltage elements can be used to disable reclosing.

For example, if the station dc batteries have a problem and the station dc battery voltage is declining, drive the reclosing relay to lockout:

79DTL = **!SV4T + ...** [= NOT(SV4T) + ...]

Timer output SV4T is from the bottom of *Figure 8.10*. When dc voltage falls below pickup DCHIP, timer output SV4T drops out (= logical 0), driving the relay to lockout:

79DTL = **!SV4T + ...** = NOT(SV4T) + ... = NOT(logical 0) + ... = logical 1

Circuit breaker tripping and closing requires station dc battery energy. If the station dc batteries are having a problem and the station dc battery voltage is declining, the relay should not reclose after a trip because there might not be enough dc battery energy to trip a second time after a reclose.

View Station DC Battery Voltage

Via Serial Port

See *MET Command (Metering Data) on page 10.39*. The **MET** command displays the station dc battery voltage (labeled VDC).

Via Front Panel

The information available via the previously discussed **MET** serial port command is also available via the front-panel **METER** pushbutton. See *Figure 11.3*.

Via DNP, Modbus, or IEC 61850

The station dc battery voltage reading VDC is available via DNP, Modbus, and IEC 61850. See the Instantaneous Metering section of *Table E.1*.

Analyze Station DC Battery Voltage

See *Standard 15/30/60/180-Cycle Event Reports on page 12.2*. The station dc battery voltage is displayed in column `Vdc` in the example event report in *Figure 12.5*. Changes in station dc battery voltage for an event (e.g., circuit breaker tripping) can be observed. Use the **EVE** command to retrieve event reports as discussed in *Section 12*.

Station DC Battery Voltage Dips During Circuit Breaker Tripping

Event reports are automatically generated when the TRIP Relay Word bit asserts (TRIP is the logic output of *Figure 5.1*). For example, output contact **OUT101** is set to trip:

OUT101 = **TRIP**

Anytime output contact **OUT101** closes and energizes the circuit breaker trip coil. Any dip in station dc battery voltage can be observed in column `Vdc` in the event report.

To generate an event report for external trips, make connections similar to *Figure 8.8* and program optoisolated input **IN106** (monitoring the trip bus) in the SELOGIC control equation event report generation setting, e.g.,

ER = **/IN106 + ...**

Anytime the trip bus is energized, any dip in station dc battery voltage can be observed in column `Vdc` in the event report.

Station DC Battery Voltage Dips During Circuit Breaker Closing

To generate an event report when the SEL-311C closes the circuit breaker, make the SELOGIC control equation event report generation setting:

ER = **/OUT102 + ...**

In this example, output contact **OUT102** is set to close:

OUT102 = **CLOSE** (CLOSE is the logic output of *Figure 6.3*)

Anytime output contact **OUT102** closes and energizes the circuit breaker close coil, any dip in station dc battery voltage can be observed in column `Vdc` in the event report.

This event report generation setting (ER = /OUT102 + ...) might be made just as a testing setting. Generate several event reports when doing circuit breaker close testing and observe the "signature" of the station dc battery voltage in column `Vdc` in the event reports.

Station DC Battery Voltage Dips Anytime

To generate an event report anytime there is a station dc battery voltage dip, set the dc voltage element directly in the SELOGIC control equation event report generation setting:

ER = **\SV4T + ...**

Timer output SV4T is an example dc voltage element from the bottom of *Figure 8.10*. Anytime dc voltage falls below pickup DCHIP, timer output SV4T drops out (logical 1 to logical 0 transition), creating a falling-edge condition that generates an event report.

Also, the Sequential Event Recorder (SER) report can be used to time-tag station dc battery voltage dips (see *Sequential Events Recorder (SER) Report on page 12.26*).

Operation of Station DC Battery Monitor When AC Voltage Is Powering the Relay

If the SEL-311C has a power supply that can be powered by ac voltage, when powering the relay with ac voltage, the dc voltage elements in *Figure 8.9* see the *average* of the sampled ac voltage powering the relay, which is very near zero volts (as displayed in column `Vdc` in event reports). Thus, pickup settings DCLOP and DCHIP should be set off (DCLOP = OFF, DCHIP = OFF). They are of no real use.

If a "raw" event report is displayed (with the **EVE R** command), column `Vdc` will display the sampled ac voltage waveform, rather than the average.

Fundamental (Instantaneous) Metering

The SEL-311C performs current, voltage, symmetrical component, and power metering using the fundamental (filtered) signals obtained from the same cosine filter that is used in the protective relay algorithms. These values respond to the fundamental signal at the measured system frequency, which is usually near 50 Hz or 60 Hz. Frequency tracking ensures that frequency variations do not adversely affect metering accuracy.

The fundamental metering function updates the metering values approximately twice per second.

The relay converts the metered values to primary units using the current transformer ratio Group settings CTR and CTRN, and potential transformer ratio Group settings PTR and PTRS.

The metered values are available through several interfaces:

- Serial port ASCII communications; see *MET Command (Metering Data) on page 10.39*
- Serial port Fast Meter communications; see *Appendix J: Configuration, Fast Meter, and Fast Operate Commands*
- DNP (Serial Port or Ethernet); see *Appendix L: DNP3 Communications*
- Modbus (Serial Port or Ethernet); see *Appendix O: Modbus RTU and TCP Communications*
- IEC 61850 (Ethernet); see *Appendix P: IEC 61850*
- Front-panel LCD; see *Front-Panel Pushbutton Operation on page 11.1*
- Display points; see *Displaying Analog Values on the Rotating Display on page 7.43*

See *Specifications on page 1.2* for a listing of the fundamental metering accuracy in the SEL-311C.

These fundamental quantities are used in the Instantaneous Metering quantities, as well as the Demand/Peak Demand, Energy, and Maximum/Minimum Metering functions, described later in this section.

Because the fundamental quantities are filtered to the power system frequency, they are immune to signal energy at dc and harmonic frequencies.

Wye- and Delta-Voltage Connections for Metering

Description

- The SEL-311C supports metering from the following PT connections:Three-phase voltage connection from wye-connected Potential Transformers (PTs)
- Three-phase voltage connection from open-delta connected PTs
- Synchronism check or broken-delta 3V0 PT voltage connection to **VS-NS** terminals.

See *Potential Transformer Inputs on page 2.11* for terminal designations and wiring details.

The PT selection (except for the VS terminal) is made via Global setting PTCONN = WYE or DELTA and is fully described in *Settings for Voltage Input Configuration on page 9.16*.

When either of the three-phase connections (wye or delta) is selected, the relay automatically configures the metering functions to calculate and display the quantities as listed in *Table 8.3*.

The synchronism check or broken-delta PT connection is selected by Global setting VSCONN = VS or 3V0, respectively, and is fully discussed in *Settings for Voltage Input Configuration on page 9.16*. The only instance that this setting affects metering is when PTCONN = DELTA and VSCONN = 3V0, and in this situation the broken-delta signal is used in the three-phase power calculations, as shown in *Table 9.6*.

Metering Quantities Available for Various Voltage Connections

The SEL-311C metering output values are available as Analog Quantities, and a full listing appears in *Table E.1*.

Use *Table 8.3* to identify which metering outputs are available for each voltage input configuration. To make *Table 8.3* easier to read, the Analog Quantity names are not fully listed for the Demand, Peak Demand, Energy and Maximum/Minimum Metering functions. The full names appear in *Table E.1* under the appropriate table section.

Table 8.3 Fundamental Metering Quantities Available for Various PTCONN Settings

Global Settings	Currents[a]	Voltages[a]	Power	Demand and Peak Demand IN and OUT[b]	Energy IN and OUT[b]	Maximum/ Minimum
Command:	**MET**	**MET**	**MET**	**MET D**	**MET E**	**MET M**
PTCONN = WYE	IA, IB, IC, IN, IG, I1, 3I2, 3I0	VA, VB, VC, VS, V1, V2, 3V0, VAB[c], VBC[c], VCA[c]	MWA, MWB, MWC, MW3, MVARA, MVARB, MVARC, MVAR3, PFA, PFB, PFC, PF3	IA, IB, IC, IN, IG, 3I2, MWA, MWB, MWC, MW3, MVARA, MVARB, MVARC, MVAR3	MWHA, MWHB, MWHC, MWH3, MVRHA, MVRHB, MVRHC, MVRH3	IA, IB, IC, IN, IG, VA, VB, VC, VS, MW3, MVAR3
PTCONN = DELTA	IA, IB, IC, IN, IG, I1, 3I2, 3I0	VAB, VBC, VCA, VS, V1, V2	MW3, MVAR3, PF3	IA, IB, IC, IN, IG, 3I2, MW3, MVAR3	MWH3, MVRH3	IA, IB, IC, IN, IG, VAB, VBC, VCA, VS, MW3, MVAR3

[a] For clarity, the corresponding angle quantities are not shown in table (e.g., IAFA, VBFA, etc.)
[b] For clarity, not all values are shown. See Table E.1 for a complete listing and proper Analog Quantity labels.
[c] Available via **MET X** command.

Demand Metering

The SEL-311C offers the choice between two types of demand metering, settable with the enable setting:

- EDEM = THM (Thermal Demand Meter)
- EDEM = ROL (Rolling Demand Meter)

The demand metering settings (in *Table 8.4*) are available via the **SET** command (see *Table 9.2* and also *Demand Metering Settings (see Figure 8.11 and Figure 8.13) on page SET.22*). Also refer to *MET Command (Metering Data) on page 10.39*).

The SEL-311C provides demand and peak demand metering for the following values:

Currents

$I_{A,B,C,N}$	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)

Power (with separate IN and OUT values)

$MW_{A,B,C}$	Single-phase megawatts (not available with delta-connected voltages)
$MVAR_{A,B,C}$	Single-phase megavars (not available with delta-connected voltages)

MW_{3P}	Three-phase megawatts
$MVAR_{3P}$	Three-phase megavars

Depending on enable setting EDEM, these demand and peak demand values are thermal demand or rolling demand values. The thermal demand method is well-suited to monitoring equipment loading, and the demand results are updated regularly. The rolling demand method is available to match legacy metering systems used by some electrical utilities, and the demand results are updated every five minutes.

The differences between thermal and rolling demand metering are explained in the following discussion.

Comparison of Thermal and Rolling Demand Meters

The example in *Figure 8.11* shows the response of thermal and rolling demand meters 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”).

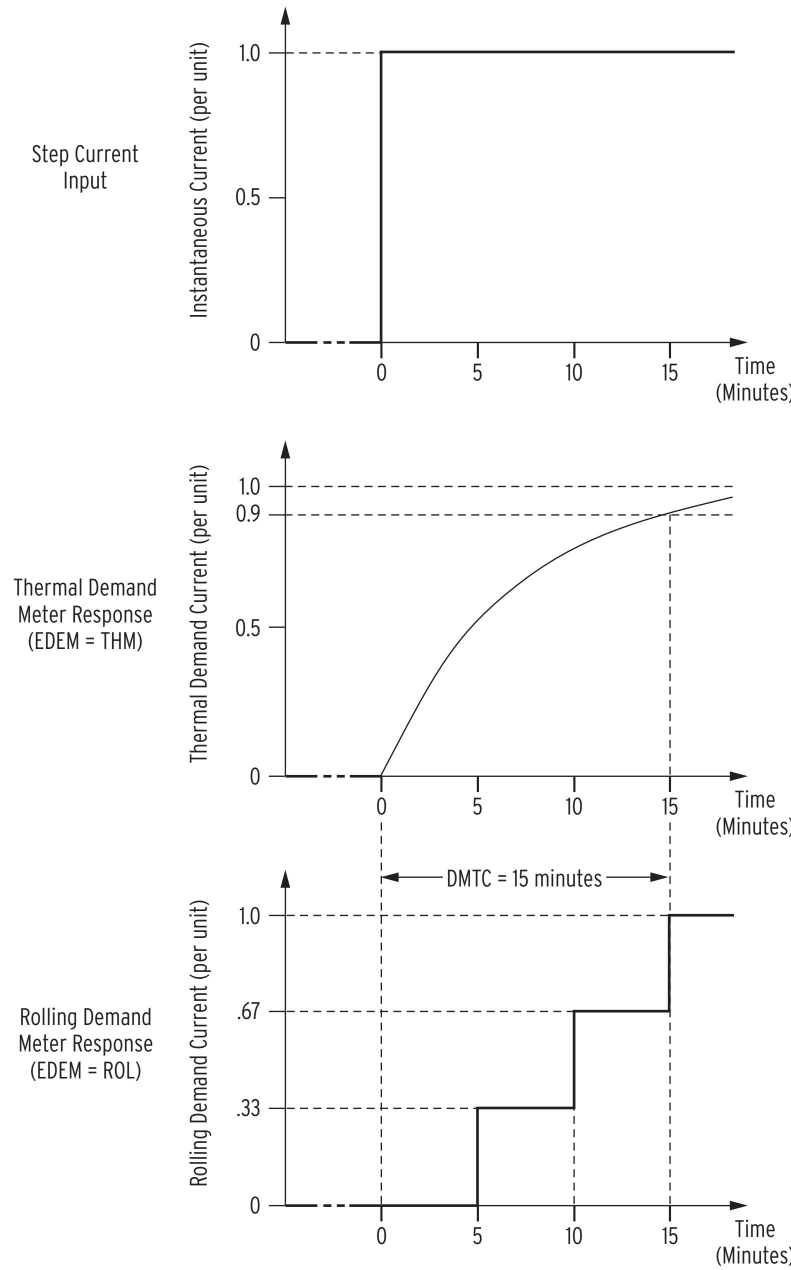


Figure 8.11 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 Minutes)

Thermal Demand Meter Response (EDEM = THM)

The response of the thermal demand meter in Figure 8.11 (middle) to the step current input (top) is analogous to the series RC circuit in Figure 8.12.

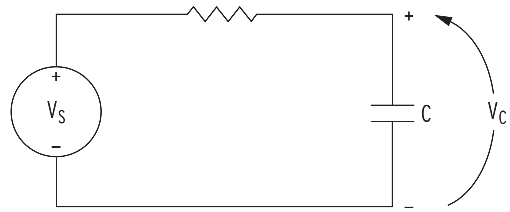


Figure 8.12 Voltage V_S Applied to Series RC Circuit

In the analogy:

Voltage V_S in Figure 8.12 corresponds to the step current input in Figure 8.11 (top).

Voltage V_C across the capacitor in Figure 8.12 corresponds to the response of the thermal demand meter in Figure 8.11 (middle).

If voltage V_S in Figure 8.12 has been at zero (V_S = 0.0 per unit) for some time, voltage V_C across the capacitor in Figure 8.12 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 meter in Figure 8.11 (middle) to the step current input (top).

In general, as voltage V_C across the capacitor in Figure 8.12 cannot change instantaneously, the thermal demand meter response is not immediate either for the increasing or decreasing applied instantaneous current. The thermal demand meter response time is based on the demand meter time constant setting DMTC (see Table 8.4). Note in Figure 8.11, the thermal demand meter response (middle) 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-311C updates thermal demand values approximately every two seconds.

Rolling Demand Meter Response (EDEM = ROL)

The response of the rolling demand meter in Figure 8.11 (bottom) to the step current input (top) is calculated with a sliding time-window arithmetic average calculation. The width of the sliding time-window is equal to the demand meter time constant setting DMTC (see Table 8.4). Note in Figure 8.11, the rolling demand meter response (bottom) is at 100 percent (1.0 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 rolling demand meter integrates the applied signal (e.g., step current) input in five-minute intervals. The integration is performed approximately every two seconds. The average value for an integrated five-minute interval is derived and stored as a five-minute total. The rolling demand meter then averages a number of the five-minute totals to produce the rolling demand meter response. In the Figure 8.11 example, the rolling demand meter averages the three latest five-minute totals because setting DMTC = 15 (15/5 = 3). The rolling demand meter response is updated every five minutes, after a new five-minute total is calculated.

The following is a step-by-step calculation of the rolling demand response example in Figure 8.11 (bottom).

Time = 0 Minutes

Presume that the instantaneous current has been at zero for quite some time before “Time = 0 minutes” (or the demand meters were reset). The three 5-minute intervals in the sliding time-window at “Time = 0 minutes” each integrate into the following 5-minute totals:

Five-Minute Totals	Corresponding Five-Minute Interval
0.0 per unit	–15 to –10 minutes
0.0 per unit	–10 to –5 minutes
0.0 per unit	–5 to 0 minutes
0.0 per unit	

Rolling demand meter response at “Time = 0 minutes” = 0.0/3 = 0.0 per unit

Time = 5 Minutes

The three 5-minute intervals in the sliding time-window at “Time = 5 minutes” each integrate into the following 5-minute totals:

Five-Minute Totals	Corresponding Five-Minute Interval
0.0 per unit	–10 to –5 minutes
0.0 per unit	–5 to 0 minutes
1.0 per unit	0 to 5 minutes
1.0 per unit	

Rolling demand meter response at “Time = 5 minutes” = 1.0/3 = 0.33 per unit

Time = 10 Minutes

The three 5-minute intervals in the sliding time-window at “Time = 10 minutes” each integrate into the following 5-minute totals:

Five-Minute Totals	Corresponding Five-Minute Interval
0.0 per unit	–5 to 0 minutes
1.0 per unit	0 to 5 minutes
1.0 per unit	5 to 10 minutes
2.0 per unit	

Rolling demand meter response at “Time = 10 minutes” = 2.0/3 = 0.67 per unit.

Time = 15 Minutes

The three five-minute intervals in the sliding time-window at “Time = 15 minutes” each integrate into the following 5-minute totals:

Five-Minute Totals	Corresponding Five-Minute Interval
1.0 per unit	0 to 5 minutes
1.0 per unit	5 to 10 minutes
1.0 per unit	10 to 15 minutes
3.0 per unit	

Rolling demand meter response at “Time = 15 minutes” = 3.0/3 = 1.0 per unit.

Demand Meter Settings

NOTE: Changing setting EDEM or DMTC resets the demand meter values to zero. This also applies to changing the active setting group, and setting EDEM or DMTC is different in the new active setting group. Demand current pickup settings PDEMP, NDEMP, GDEMP, and QDEMP can be changed without affecting the demand meters.

The examples in this section discuss demand current, but MW and MVAR demand values are also available, as stated at the beginning of Demand Metering on page 8.17.

Table 8.4 Demand Meter Settings and Settings Range

Setting	Definition	Range
EDEM	Demand meter type	THM = thermal ROL = rolling
DMTC	Demand meter time constant	5, 10, 15, 30, or 60 minutes
PDEMP	Phase demand current pickup	OFF, 0.50–16.00 A sec (5 A nominal) OFF, 0.10–3.20 A sec (1 A nominal)
NDEMP	Neutral ground demand current pickup	OFF, 0.50–16.00 A sec (5 A nominal IN channel) OFF, 0.10–3.20 A sec (1 A nominal IN channel)
GDEMP	Residual ground demand current pickup	OFF, 0.10–16.00 A sec (5 A nominal) OFF, 0.02–3.20 A sec (1 A nominal)
QDEMP	Negative-sequence demand current pickup	OFF, 0.50–16.00 A sec (5 A nominal) OFF, 0.10–3.20 A sec (1 A nominal)

The demand current pickup settings in *Table 8.4* are applied to demand current meter outputs as shown in *Figure 8.13*. For example, when residual ground demand current $I_{G(DEM)}$ goes above corresponding demand pickup GDEMP, Relay Word bit GDEM asserts to logical 1. Use these demand current logic outputs (PDEM, NDEM, GDEM, and QDEM) to alarm for high loading or unbalance conditions. Use in other schemes such as the following example.

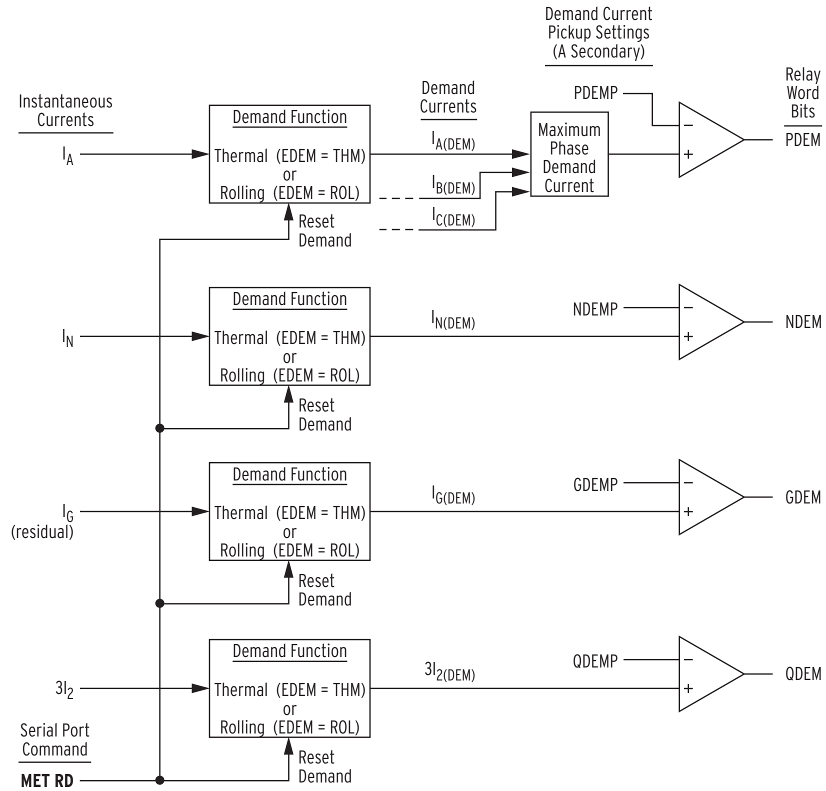


Figure 8.13 Demand Current Logic Outputs

Demand Current Logic Output Application—Raise Pickup for Unbalance Current

During times of high loading, the residual ground overcurrent elements can see relatively high unbalance current I_G ($I_G = 3I_0$). To avoid tripping on unbalance current I_G, use Relay Word bit GDEM to detect the residual ground (unbalance) demand current $I_{G(DEM)}$ and effectively raise the pickup of the residual ground time-overcurrent element 51GT. This is accomplished with the following settings from *Table 8.4*, pertinent residual ground overcurrent element settings, and SELOGIC control equation torque control setting 51GTC:

EDEM = **THM**

DMTC = **5**

GDEMP = **1.0**

51GP = **1.50**

50G2P = **2.30**

51GTC = **!GDEM + GDEM * 50G2**

Refer to *Figure 8.13*, *Figure 8.14*, and *Figure 3.32*.

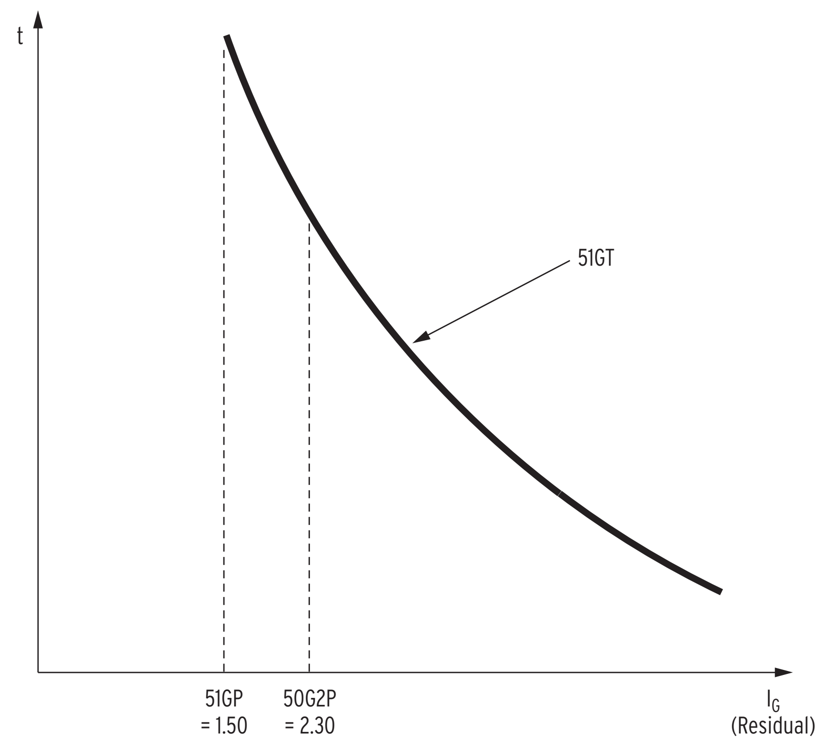


Figure 8.14 Raise Pickup of Residual Ground Time-Overcurrent Element for Unbalance Current

Residual Ground Demand Current Below Pickup GDEMP

When unbalance current I_G is low, unbalance demand current $I_{G(DEM)}$ is below corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM is deasserted to logical 0. This results in SELOGIC control equation torque control setting 51GTC being in the state:

51GTC = **!GDEM + GDEM * 50G2** = NOT(GDEM) + GDEM * 50G2
= NOT(logical 0) + (logical 0) * 50G2 = logical 1

Thus, the residual ground time-overcurrent element 51GT operates on its standard pickup:

51GP = **1.50 A secondary**

If a ground fault occurs, the residual ground time-overcurrent element 51GT operates with the sensitivity provided by pickup 51GP = 1.50 A secondary. The thermal demand meter, even with setting DMTC = 5 minutes, does not respond fast enough to the ground fault to make a change to the effective residual ground time-overcurrent element pickup—it remains at 1.50 A secondary. Demand meters respond to more “slow moving” general trends.

Residual Ground Demand Current Goes Above Pickup GDEMP

When unbalance current I_G increases, unbalance demand current $I_{G(DEM)}$ follows, going above corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM asserts to logical 1. This results in SELOGIC control equation torque control setting 51GTC being in the state:

51GTC = **!GDEM + GDEM * 50G2** = NOT(GDEM) + GDEM * 50G2
= NOT(logical 1) + (logical 1) * 50G2 = logical 0 + 50G2 = 50G2

Thus, the residual ground time-overcurrent element 51GT operates with an effective, less-sensitive pickup:

50G2P = **2.30 A secondary**

The reduced sensitivity keeps the residual ground time-overcurrent element 51GT from tripping on higher unbalance current I_G.

Residual Ground Demand Current Goes Below Pickup GDEMP Again

When unbalance current I_G decreases again, unbalance demand current $I_{G(DEM)}$ follows, going below corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM deasserts to logical 0. This results in SELOGIC control equation torque control setting 51GTC being in the state:

51GTC = **!GDEM + GDEM * 50G2** = NOT(GDEM) + GDEM * 50G2 =
NOT(logical 0) + (logical 0) * 50G2 = logical 1

Thus, the residual ground time-overcurrent element 51GT operates on its standard pickup again:

51GP = **1.50 A secondary**

View or Reset Demand Metering Information

Via Serial Port

See *MET Command (Metering Data) on page 10.39*. The **MET D** command displays demand and peak demand metering for the following values:

Currents

$I_{A,B,C,N}$	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)

Power

$MW_{A,B,C}$	Single-phase megawatts (not available with delta-connected voltage)
$MVAR_{A,B,C}$	Single-phase megavars (not available with delta-connected voltage)
MW_{3P}	Three-phase megawatts
$MVAR_{3P}$	Three-phase megavars

The **MET RD** command resets the demand metering values. The **MET RP** command resets the peak demand metering values.

If setting EDEM = ROL, after resetting the demand values, there may be a delay of up to two times the DMTC setting before the demand values are updated.

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **MET D**, **MET RD**, and **MET RP** are also available via the front-panel **METER** pushbutton. See *Figure 11.2*.

Via DNP or Modbus

The demand and peak demand metering values are available via DNP and Modbus. See the Demand Metering and Peak (Demand) Metering section of *Table E.1*.

The DNP binary outputs DRST_DEM and DRST_PDM can be used to reset the demand metering and peak demand metering, respectively. These controls are similar in function to the **MET RD** and **MET RP** commands. See *Appendix L: DNP3 Communications* for more details.

The Modbus protocol can be used to reset the demand metering and peak demand metering, with functions similar to the **MET RD** and **MET RP** commands. Two methods are available:

- Writing to the Reset Demands or Reset Demand Peaks output coil.
- Writing a specific analog value to the RSTDAT register.

See *Appendix O: Modbus RTU and TCP Communications* for details.

Via Fast Metering or IEC 61850

The demand and peak demand metering values are available via Fast Metering and IEC 61850. See the Demand Metering and Peak (Demand) Metering section of *Table E.1*.

Reset Via SELOGIC Control Equation

The RST_DEM and RST_PDM SELOGIC control equation settings can be used to reset the demand metering and peak demand metering respectively. The relay resets the function when the setting first asserts (rising edge, e.g., a logical 0 to a logical 1 transition).

Example Application of RST_DEM and RST_PDM:

A control scheme requires:

- Demand metering to be reset when control input IN106 asserts, or when SV12T asserts
- Peak demand metering to be reset when control input IN106 asserts, or when remote bit RB14 asserts.

Make the logic settings in each settings group that will be used (e.g., use **SET L 1**, for setting group 1):

RST_DEM = **/IN106 + /SV12T**

RST_PDM = **/IN106 + /RB14**

NOTE: To avoid unexpected clearing of metering data, the proposed SELOGIC equations should be tested to ensure they do not assert after a group change or after relay power-up.

The “/” rising edge operators ensure that a maintained logical 1 on IN106 does not prevent SV12T from resetting the demand metering, and does not prevent RB14 from resetting the peak demand metering.

Demand Metering Updating and Storage

The SEL-311C updates demand values approximately every two seconds.

The relay stores peak demand values to nonvolatile storage once per day. The previously stored value is overwritten if it is exceeded. Should the relay lose control power, it will restore the peak demand values saved by the relay at 23:50 hours on the previous day.

Demand metering peak recording is momentarily suspended when SELOGIC control equation setting FAULT is asserted (= logical 1). See the explanation for the FAULT setting in *Maximum/Minimum Metering on page 8.27*.

Energy Metering

The SEL-311C provides energy metering for the following values:

$MWH_{A,B,C,3P}$ IN Single-phase and three-phase MegaWatt-hours, primary

$MWH_{A,B,C,3P}$ OUT Single-phase and three-phase MegaWatt-hours, primary

$MVARH_{A,B,C,3P}$ IN Single-phase and three-phase MegaVAr-hours, primary

$MVARH_{A,B,C,3P}$ OUT Single-phase and three-phase MegaVAr-hours, primary

where IN and OUT correspond to the standard relay convention of OUT for positive power, and IN for negative power.

See *Table E.1* for a listing of the Analog Quantities for energy metering.

The single-phase energy values are not available with a delta voltage connection (Global setting PTCONN = DELTA).

View or Reset Energy Metering Information

Via Serial Port

NOTE: Single-phase quantities are only available when Global setting PTCONN = WYE.

See *MET Command (Metering Data) on page 10.39*. The **MET E** command displays accumulated single- and three-phase megawatt and megavar hours. The **MET RE** command resets the accumulated single- and three-phase megawatt and megavar hours.

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **MET E** and **MET RE** are also available via the front-panel **METER** pushbutton. See *Figure 11.2*.

Via DNP or Modbus

The energy metering values are available via DNP and Modbus. See the Energy Metering section of *Table E.1*.

The DNP binary output DRST_ENE can be used to reset the energy metering, and is similar in function to the **MET RE** command. See *Appendix L: DNP3 Communications* for more details.

The Modbus protocol can be used to reset the energy metering, with functions similar to the **MET RE** command. Two methods are available:

- Writing to the Reset Energy Data output coil.
- Writing a specific analog value to the RSTDAT register.

See *Appendix O: Modbus RTU and TCP Communications* for details.

Via IEC 61850

The energy metering values are available via IEC 61850. See the Energy Metering section of *Table E.1*.

Reset Via SELOGIC Equation

The RST_ENE SELOGIC control equation setting can be used to reset the energy metering. The relay resets the function when the setting first asserts (rising edge, e.g., a logical 0 to a logical 1 transition).

Example Application of RST_ENE

A control scheme requires energy metering to be reset when control input IN105 asserts, or when SV11T asserts.

NOTE: To avoid unexpected clearing of metering data, the proposed SELOGIC equation should be tested to ensure it does not assert after a group change or after relay power-up.

Make the logic settings in each settings group that will be used (e.g., use **SET L 1**, for setting group 1):

RST_ENE = **/IN105 + /SV11T**

The "/" rising edge operators ensure that a maintained logical 1 on IN105 does not prevent SV11T from resetting the energy metering.

Energy Metering Updating and Storage

The SEL-311C updates energy values approximately every two seconds.

The relay stores energy values to nonvolatile storage once per day. The previously stored value is overwritten if it is exceeded. Should the relay lose control power, it will restore the energy values saved by the relay at 23:50 hours on the previous day.

Accumulated energy metering values function like those in an electromechanical energy meter. When the energy meter reaches 99999.999 MWh or 99999.999 MVARh, it starts over at zero.

Maximum/Minimum Metering

The SEL-311C provides maximum/minimum metering for the following values:

Currents

$I_{A,B,C,N}$	Input currents (A primary)
I_G	Residual ground current (A primary; $I_G = 3I_0$)

Voltages

$V_{A,B,C}$	Input voltages (kV primary, not available with delta-connected voltages)
$V_{AB,BC,CA}$	Input voltages (kV primary, delta-connected voltage only)
V_S	Input voltage (kV primary)

Power

MW_{3P}	Three-phase megawatts
$MVAR_{3P}$	Three-phase megavars

The power maximum and minimum values can be negative or positive, indicating the range of power flow that has occurred since the last reset command. These functions simulate analog meter drag-hands, with the maximum value representing the upper drag-hand and the minimum value representing the lower drag-hand.

Table 8.5 shows the values that the relay would record for various power flow directions (either MW3P or MVAR3P).

Table 8.5 Operation of Maximum/Minimum Metering With Directional Power Quantities[a]

If Power Varies		Recorded MAX	Recorded MIN
From:	To:		
9.7	16.2	16.2	9.7
–4.2	1.4	1.4	–4.2
–25.3	–17.4	–17.4	–25.3
–6.2	27.4	27.4	–6.2

[a] For simplicity, the date and time stamps are not shown here.

View or Reset Maximum/Minimum Metering Information

Via Serial Port

See *MET M—Maximum/Minimum Metering on page 10.44* . The **MET M** command displays maximum/minimum metering values. The **MET RM** command resets the maximum/minimum metering values.

Via Front Panel

The metering and reset functions available via serial port commands **MET M** and **MET RM** are also available via the front-panel METER pushbutton. See *Figure 11.2*.

Reset Via DNP or Modbus Control

The DNP binary output DRST_MML can be used to reset the Max/Min metering, and is similar in function to the **MET RM** command. See *Appendix L: DNP3 Communications* for more details.

The Modbus protocol can be used to reset the Max/Min metering, with methods that are similar in function to the **MET RM** command. Two methods are available:

- Writing to the Reset Max/Min output coil.
- Writing a specific analog value to the RSTDAT register.

See *Appendix O: Modbus RTU and TCP Communications* for details.

Reset Via SELogic Equation

The RST_MML SELogic control equation setting can be used to reset the Maximum/Minimum metering. The relay resets the function when the setting first asserts (rising edge, e.g., a logical 0 to a logical 1 transition).

Example Application of RST_MML

A control scheme requires Maximum/Minimum metering to be reset when control input IN104 asserts, or when SV10T asserts.

NOTE: To avoid unexpected clearing of metering data, the proposed SELogic equation should be tested to ensure it does not assert after a group change or after relay power-up.

Make the logic settings in each settings group that will be used (e.g., use **SET L 1**, for setting group 1):

RST_MML = **/IN104 + /SV10T**

The "/" rising edge operators ensure that a maintained logical 1 on IN104 does not prevent SV10T from resetting the energy metering.

Maximum/Minimum Metering Update and Storage

NOTE: SELOGIC control equation setting FAULT also controls other relay functions; see SELOGIC Control Equation Setting FAULT on page 5.43.

NOTE: If PTCONN = DELTA, factory default setting is set with: FAULT = 51G + 51Q + M2P.

The maximum/minimum metering function is intended to reflect normal load variations rather than fault conditions or outages. Therefore, the SEL-311C updates maximum/minimum values only if SELOGIC control equation setting FAULT is deasserted (= logical 0) and has been deasserted for at least 3600 cycles.

The factory default setting is set with time-overcurrent and distance element pickups:

FAULT = **51G + 51Q + M2P + Z2G**

If there is a fault, 51G, 51Q, M2P, or Z2G asserts and blocks updating of maximum/minimum metering values.

In addition to FAULT being deasserted for at least 3600 cycles, the following conditions must also be met:

- For wye-connected voltage values (V_A, V_B, V_C, V_S), or delta-connected voltage values (V_{AB}, V_{BC}, V_{CA}, V_S), the voltage is above the corresponding threshold:

  25.0 V secondary (300 V voltage inputs)

- For current values $I_{A,B,C,N}$ the current is above the corresponding threshold:

  25.0 mA secondary (5 A nominal current inputs)

  5.0 mA secondary (1 A nominal current inputs)

- For the residual current value I_G:

  All three phase currents I_A, I_B, I_C are above threshold.

- For power values MW_{3P} and $MVAR_{3P}$:

  All three phase currents I_A, I_B, I_C are above threshold and all three voltages V_A, V_B, V_C (or V_{AB}, V_{BC}, V_{CA}) are above threshold.

- The metering value is above the previous maximum or below the previous minimum for approximately four seconds.

NOTE: The values used by the maximum/minimum metering are the same values used by the regular **MET** command (serial port or instantaneous, front panel), which are eight-cycle averaged values. The maximum/minimum metering function updates every two seconds (approximately). These values should be relatively immune to transient conditions.

The SEL-311C stores maximum/minimum values to nonvolatile storage once per day and overwrites the previous stored value if that is exceeded. If the relay loses control power, it will restore the maximum/minimum values saved at 23:50 hours on the previous day.

Small Signal Cutoff for Metering

The current inputs to the energy meter and power demand meter are forced to zero while 52A = 0 if the metered current is less than 0.5 percent of nominal current (25 mA for 5 A nominal, and 5 mA for 1 A nominal). This prevents the energy meter from accumulating when the breaker is open and also allows the power demand meter to eventually reset to zero.

When PTCONN = WYE, the 0.5 percent threshold comparison is performed on a phase-by-phase basis. For example, if IA is less than 0.5 percent of nominal current and 52A = 0, then only the A-phase input to the energy and power demand calculations is forced to zero. The B- and C-phase inputs to the energy and power demand calculations are not forced to zero.

When PTCONN = DELTA the input to the three-phase energy and power demand calculations are forced to zero only if 52A = 0 and all three-phase currents are less than 0.5 percent of nominal current.

No values are forced to zero when 52A = 1 even if the applied current is less than 0.5 percent of nominal current.

Forcing the energy and power demand meter current input to zero does not impact any other meter report and does not impact protection, event reporting, or synchrophasors.

Synchrophasor Metering

View Synchrophasor Metering Information Via Serial Port

See *MET Command (Metering Data) on page 10.39*. The **MET PM** command displays the synchrophasor measurements. For more information, see *View Synchrophasors by Using the MET PM Command on page N.15*.

Section 9
Setting the Relay

Overview

This section explains the SEL-311C settings, how to view settings, and how to modify the settings in the following subsections:

- *Introduction on page 9.1*
- *Time-Overcurrent Curves on page 9.4*
- *Settings Explanations on page 9.16*
- *Settings Sheets on page 9.23*

Settings specific to MIRRORED BITS® communications are fully described in *Appendix H: MIRRORED BITS Communications*.

Settings specific to the Phasor Measurement Unit (Synchrophasor) operation are fully described in *Appendix N: Synchrophasors*.

Settings specific to the DNP3 Communications protocol are fully described in *Appendix L: DNP3 Communications*.

Settings specific to the Modbus® Communications protocol are fully described in *Appendix O: Modbus RTU and TCP Communications*.

Other than a pair of enable settings, there are no relay settings associated with the optional IEC 61850 protocol. To configure IEC 61850, use the SEL Architect PC Software to create and download a CID file to the relay. For more information, see *Appendix P: IEC 61850*.

Introduction

The SEL-311C stores customer-entered settings in nonvolatile memory. Settings are divided into the following eight setting classes:

1. Global
2. Group *n* (where *n* = 1–6)
3. Logic *n* (where *n* = 1–6)
4. Report (settings for Sequential Events Recorder
5. Text (settings for the front panel)
6. Port *n* (where *n* = 1, 2, 3, 5, or F)
7. DNP Map *n* (where *n* = 1–3)
8. Modbus Map

Some settings classes have multiple instances. For example, in the above list, there are six "setting groups" for Group and Logic settings and five Port setting instances, one for each communications port (except the optional USB port).

Settings may be viewed or modified in several ways, as shown in *Table 9.1*.

Table 9.1 Methods of Accessing Settings

	Serial Port Commands	Front-Panel Interface Set/ Show Menu	ACSELERATOR QuickSet	Web Server
Display Settings	All settings (**SHO** command)	Some settings[a]	All settings	All settings
Modify Settings	All settings (**SET** command)	Some settings[a]	All settings	

[a] Only Global, Group, and Port setting classes can be accessed using the front-panel.

View settings with the respective serial port **SHOW** commands (**SHO**, **SHO L**, **SHO G**, **SHO R**, **SHO T**, **SHO P**). Because the SEL-311C only uses the first three letters of a command, **SHOW** can be shortened to **SHO** as above.

See *SHO Command (Show/View Settings) on page 10.49* for examples of the **SHO** command, including the SEL-311C factory default settings.

The **SET** command is described in a later subsection. *Table 9.2* lists the settings classes with a brief description, and the page numbers for the Settings Sheets included at the end of this section. The order of the setting sheets matches the numbered list, above.

See *Front-Panel Pushbutton Operation on page 11.1* for details on accessing settings via the front-panel HMI.

See *Appendix C: PC Software* for ACSELERATOR QuickSet® SEL-5030 Software information.

Table 9.2 Serial Port SET Commands

Command	Settings Type	Description	Settings Sheets[a]
SET G	Global	Battery and breaker monitors, optoisolated input debounce timers, synchrophasors, etc.	SET.1–SET.5
SET *n*	Group	Overcurrent and voltage elements, reclosing relay, timers, etc., for settings Group *n* (*n* = 1, 2, 3, 4, 5, 6).	SET.6–SET.22
SET L *n*	Logic	SELOGIC® control equations for settings Group *n* (*n* = 1, 2, 3, 4, 5, 6).	SET.23–SET.30
SET R	Report	Sequential Events Recorder (SER) trigger conditions.	SET.31
SET T	Text	Front-panel default display and local control text.	SET.32–SET.35
SET P *n*	Port	Port *n* settings *n* = 1: optional EIA-485 serial port *n* = 2, 3, or F: EIA-232 serial ports *n* = 5: single or optional dual Ethernet	SET.36–SET.46
SET D *n*	DNP	DNP map *n* settings (n = 1, 2, or 3).	See *Appendix L*
SET M	Modbus	Modbus map settings.	See *Appendix O*

[a] Located at the end of this section.

NOTE: Although there is no dedicated settings class for the optional USB port, the Port F settings class contains two settings that affect the USB port. See Port Enable Settings on page 9.21.

See *Using the Embedded Web Server (HTTP) on page 10.18* for information on reading settings using a standard web browser.

Make Global Settings (SET G) First

Make Global settings (*Global Settings (Serial Port Command SET G and Front Panel) on page SET.1*) before making other relay settings, especially for applications that involve delta-connected or single-phase PTs, or applications requiring an external zero-sequence voltage source to be connected to the relay. Changing Global settings PTCONN or VSCONN automatically resets many of the remaining relay settings to default values and these settings will need to be re-entered.

The relay provides two confirmation prompts prior to accepting a change to either PTCONN or VSCONN. See *Settings for Voltage Input Configuration on page 9.16*.

Settings Changes Via PC Software

ACSELERATOR QuickSet provides easy-to-use settings management tools, including the ability to develop settings off-line. This software application is a great way to transfer settings between devices, or develop new settings based on an existing settings database.

Refer to *Appendix C: PC Software* for more information on using ACSELERATOR QuickSet.

Settings Changes Via the Front Panel

The relay front-panel **SET** pushbutton provides view and modify access to the Global, Group, and Port settings only. Thus, the corresponding Global, Relay, and Port settings sheets that follow in this section can also be used when making these settings via the front panel. Refer to *Front-Panel Pushbutton Operation on page 11.1* for information on the front-panel functions.

Settings Changes Via the Serial Port

See *Section 10: Communications* for information on serial port communications and relay access levels. The **SET** commands in *Table 9.2* operate at Access Level 2 (screen prompt: =>>). To change a specific setting, enter the command:

SET *c n* s TERSE

where:

c = *class*:
(G, 1–6, L, R, T, P, D, or M) Choices 1–6 select the Group (relay) settings 1 through 6. If *class* is not specified, the relay selects the Group settings for the active settings group.

n = *instance number* (only valid for class L, P, and D):
- (1–6) for *c* = L (logic) class. If *n* is not specified, the relay selects the logic settings from the active settings group.
- (1, 2, 3, 5, or F) for *c* = P (port) class. If *n* is not specified, the relay selects the present port. If this session is via the USB port, *n* must be specified.
- (1–3) for *c* = D (DNP) class. If *n* is not specified, the relay selects DNP map 1.

s = setting name to jump to at start of session.
Enter the name of the setting you wish to jump to and begin session. If *s* is not specified, the relay starts from the first setting.

TERSE = instructs the relay to skip the **SHO** display after the last setting. Use this parameter to speed up the **SET** command. If you wish to review the settings before saving, do not use the TERSE option.

When you issue the **SET** command, the relay presents a list of settings, one at a time. Enter a new setting, or press **<Enter>** to accept the existing setting. Editing keystrokes are shown in *Table 9.3*.

Table 9.3 Set Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains setting and moves to the next setting.
^ **<Enter>**	Returns to previous setting.
< **<Enter>**	Returns to previous setting section.
> **<Enter>**	Moves to next setting section.
End <Enter>	Exits editing session, then prompts you to save the settings.
<Ctrl+X>	Aborts editing session without saving changes.

The relay checks each entry to ensure that it is within the setting range. If it is not, an `Out of Range` message is generated, and the relay prompts for the setting again.

At the end of the setting session, the relay displays the new settings and prompts for approval to save them. Answer **Y <Enter>** to save the new settings. The relay performs a final check of all settings, and if no problems are detected, the settings are saved to nonvolatile memory. If a problem is detected, the settings are not saved and the relay indicates a setting that needs attention. This final check ensures that settings from every class are compatible with the recent settings edit.

If changes are made to Global, SER, or Text settings (see *Table 9.2*), the relay is disabled while it saves the new settings. If changes are made to the Group or Logic settings for the active setting group (see *Table 9.2*), the relay is disabled while it saves the new settings. The **ALARM** contact closes momentarily (for form b contact, opens for a form a contact; see *Figure 7.28*) and the **EN** LED extinguishes (see *Table 5.1*) while the relay is disabled. The relay is disabled for less than two seconds.

If changes are made to the Group or Logic settings for a setting group other than the active setting group (see *Table 9.2*), the relay is not disabled while it saves the new settings. The **ALARM** contact closes momentarily (for a form b contact, opens for a form a contact; see *Figure 7.28*), but the **EN** LED remains on (see *Table 5.1*) while the new settings are saved.

Time-Overcurrent Curves

The following information describes the curve timing for the curve and time-dial settings made for the time-overcurrent elements (see *Figure 3.31*–*Figure 3.33*). The U.S. and IEC time-overcurrent relay curves are shown in *Figure 9.1* –*Figure 9.10*

Curves U1, U2, and U3 (*Figure 9.1*–*Figure 9.3*) conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

Definitions:

T_p = Operating time in seconds

T_R = Electromechanical induction-disk emulation reset time in seconds (if you select electromechanical reset setting)

Definitions:

TD = Time-dial setting

M = Applied multiples of pickup current [for operating time (T_p), M > 1; for reset time (T_R), M ≤ 1]

Table 9.4 Equations Associated With U.S. Curves

Curve Type	Operating Time	Reset Time	Figure
U1 (Moderately Inverse)	$T_p = TD \bullet \left(0.0226 + \frac{0.0104}{M^{0.02} - 1}\right)$	$T_R = TD \bullet \left(\frac{1.08}{1 - M^2}\right)$	*Figure 9.1*
U2 (Inverse)	$T_p = TD \bullet \left(0.180 + \frac{5.95}{M^2 - 1}\right)$	$T_R = TD \bullet \left(\frac{5.95}{1 - M^2}\right)$	*Figure 9.2*
U3 (Very Inverse)	$T_p = TD \bullet \left(0.0963 + \frac{3.88}{M^2 - 1}\right)$	$T_R = TD \bullet \left(\frac{3.88}{1 - M^2}\right)$	*Figure 9.3*
U4 (Extremely Inverse)	$T_p = TD \bullet \left(0.0352 + \frac{5.67}{M^2 - 1}\right)$	$T_R = TD \bullet \left(\frac{5.67}{1 - M^2}\right)$	*Figure 9.4*
U5 (Short-Time Inverse)	$T_p = TD \bullet \left(0.00262 + \frac{0.00342}{M^{0.02} - 1}\right)$	$T_R = TD \bullet \left(\frac{0.323}{1 - M^2}\right)$	*Figure 9.5*

Table 9.5 Equations Associated With IEC Curves

Curve Type	Operating Time	Reset Time	Figure
C1 (Standard Inverse)	$T_p = TD \bullet \left(\frac{0.14}{M^{0.02} - 1}\right)$	$T_R = TD \bullet \left(\frac{13.5}{1 - M^2}\right)$	*Figure 9.6*
C2 (Very Inverse)	$T_p = TD \bullet \left(\frac{13.5}{M - 1}\right)$	$T_R = TD \bullet \left(\frac{47.3}{1 - M^2}\right)$	*Figure 9.7*
C3 (Extremely Inverse)	$T_p = TD \bullet \left(\frac{80}{M^2 - 1}\right)$	$T_R = TD \bullet \left(\frac{80}{1 - M^2}\right)$	*Figure 9.8*
C4 (Long-Time Inverse)	$T_p = TD \bullet \left(\frac{120}{M - 1}\right)$	$T_R = TD \bullet \left(\frac{120}{1 - M}\right)$	*Figure 9.9*
C5 (Short-Time Inverse)	$T_p = TD \bullet \left(\frac{0.05}{M^{0.04} - 1}\right)$	$T_R = TD \bullet \left(\frac{4.85}{1 - M^2}\right)$	*Figure 9.10*

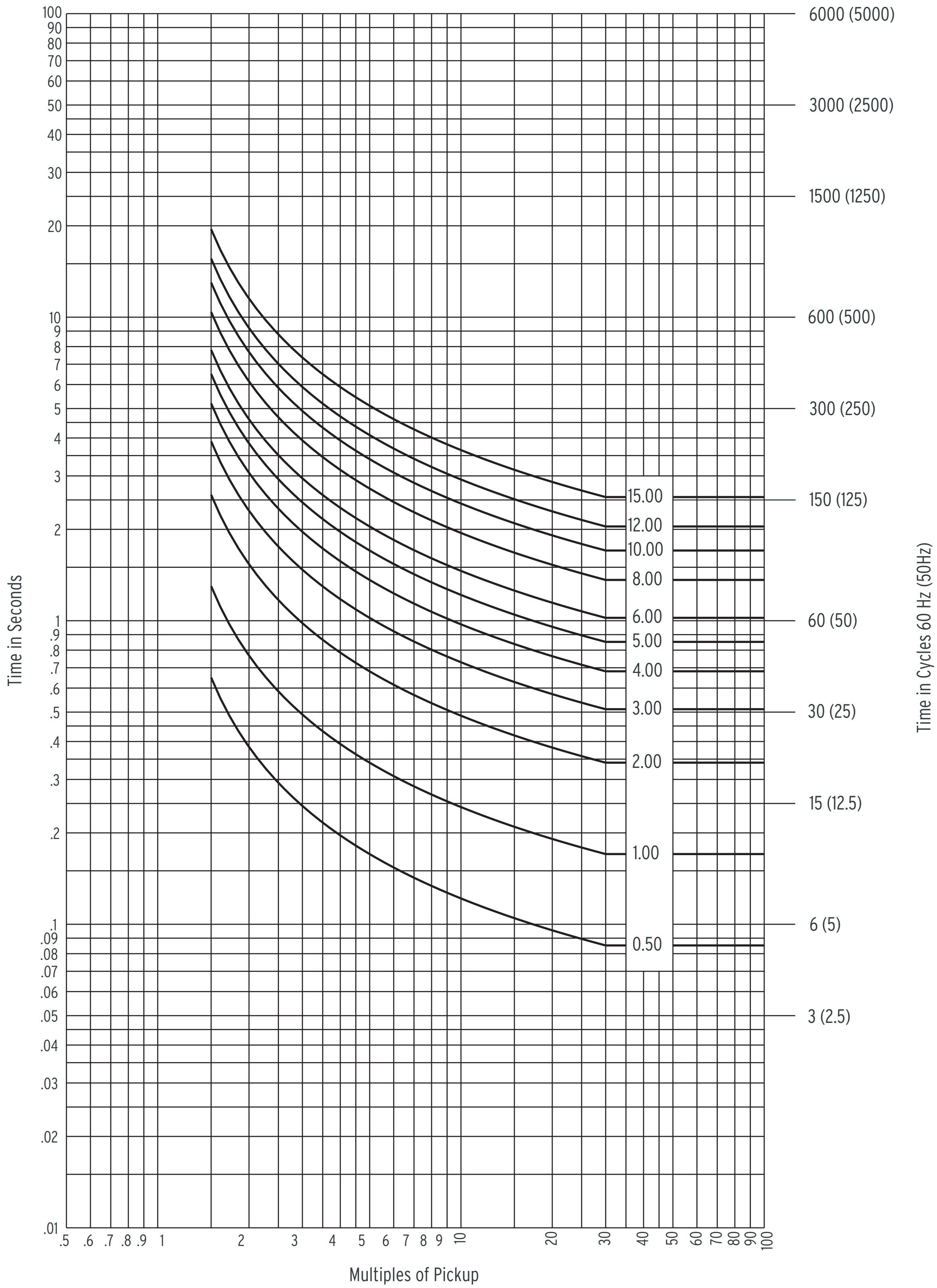


Figure 9.1 U.S. Moderately Inverse Curve: U1

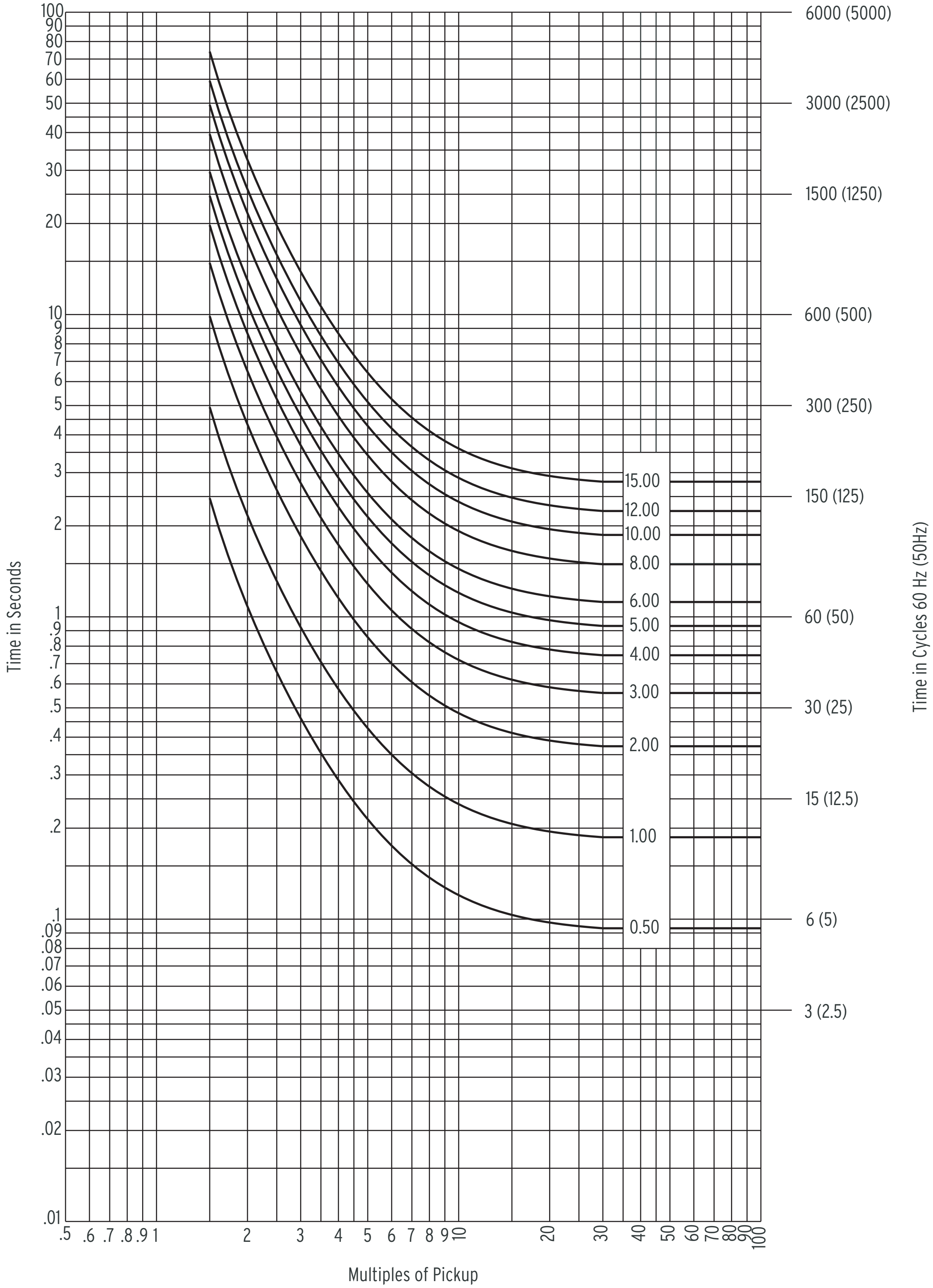


Figure 9.2 U.S. Inverse Curve: U2

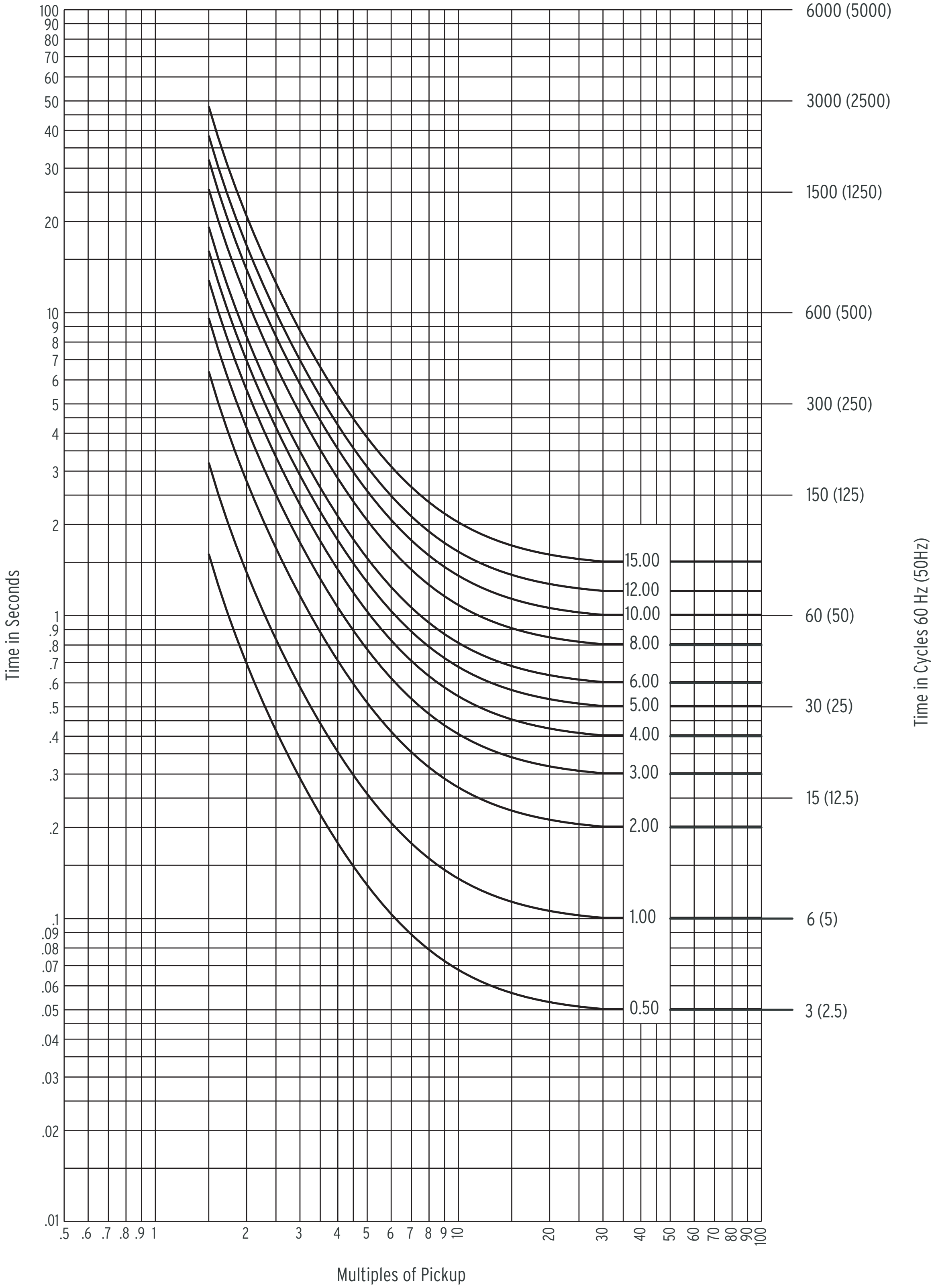


Figure 9.3 U.S. Very Inverse Curve: U3

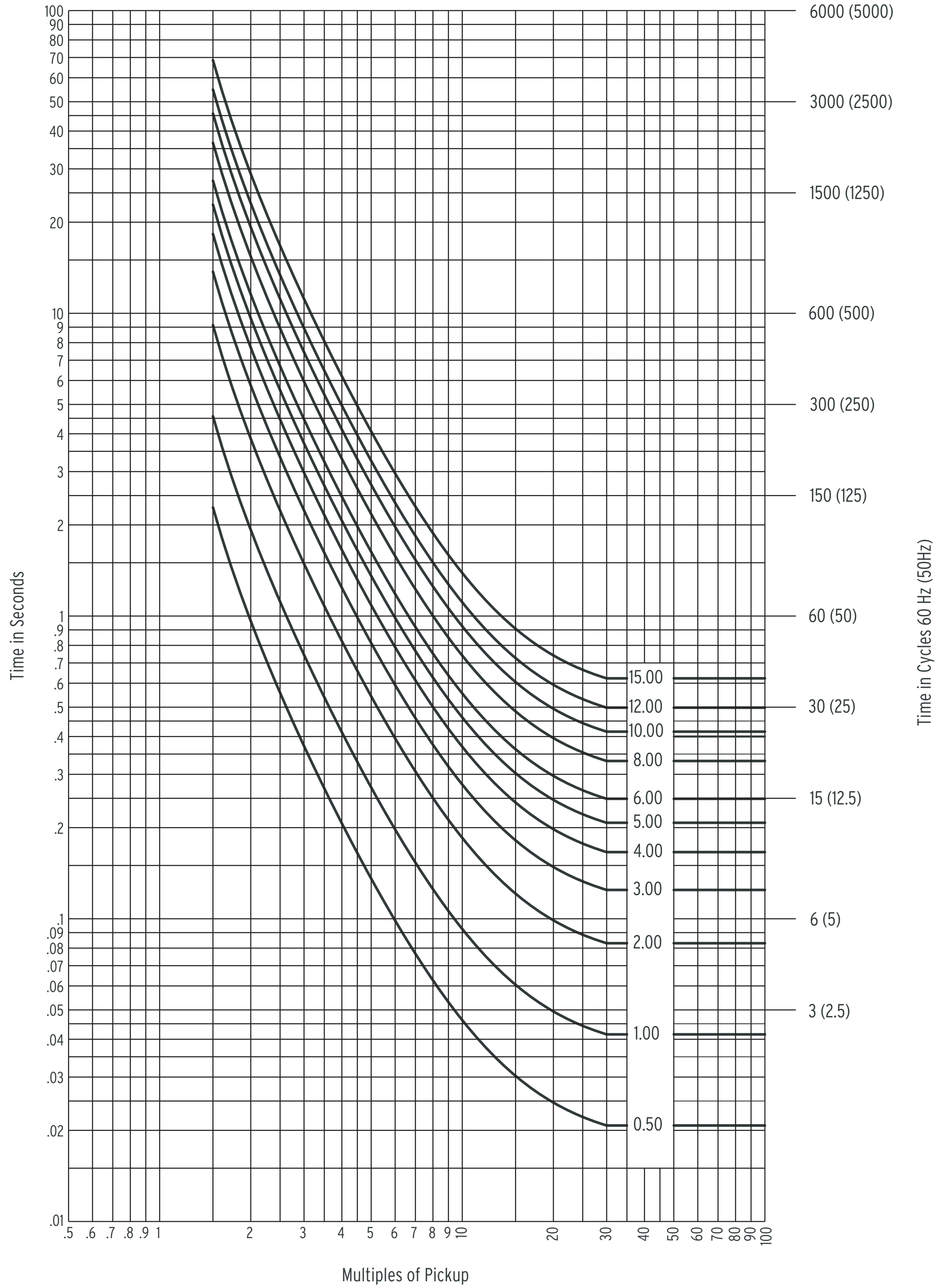


Figure 9.4 U.S. Extremely Inverse Curve: U4

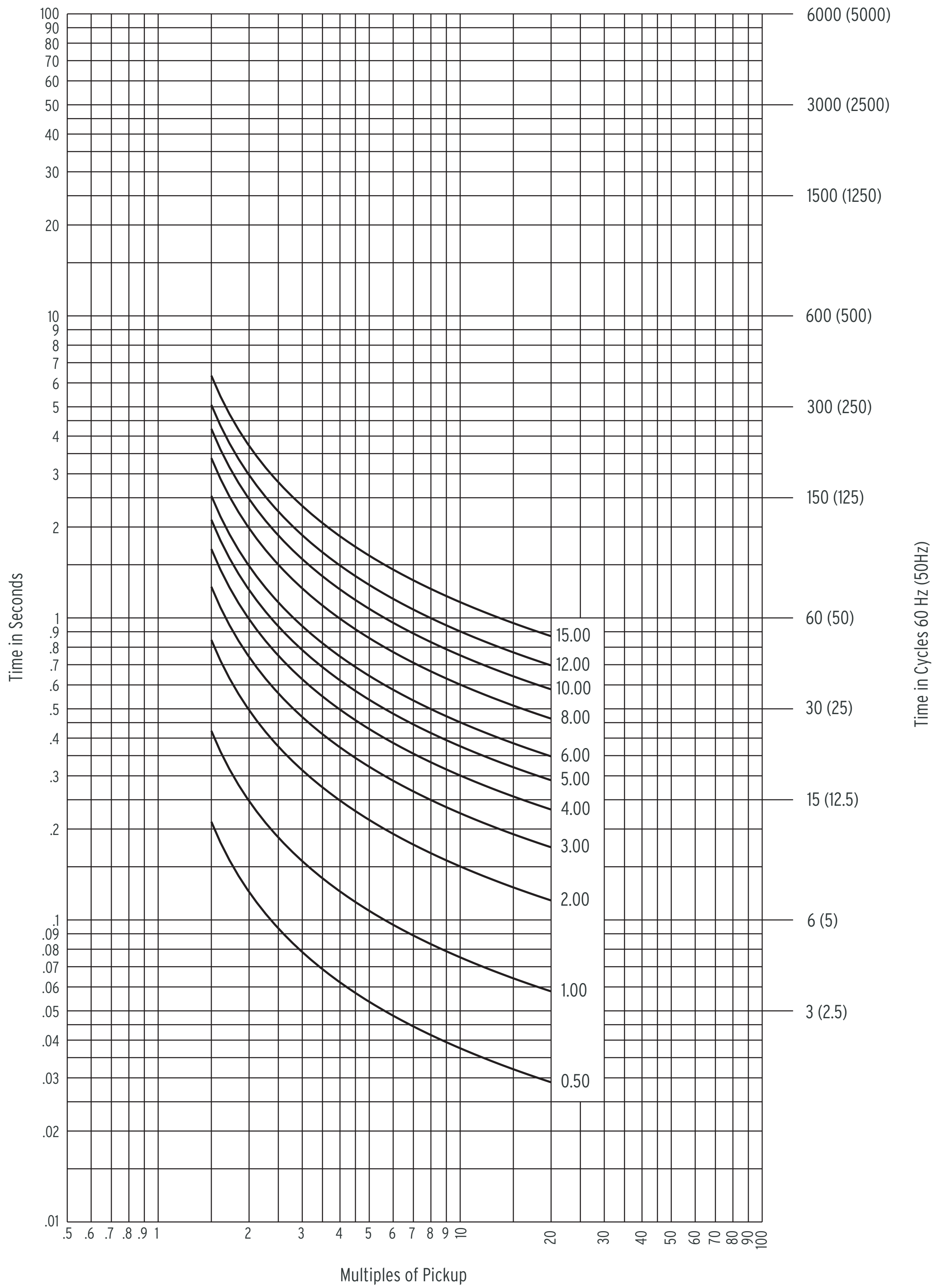


Figure 9.5 U.S. Short-Time Inverse Curve: U5

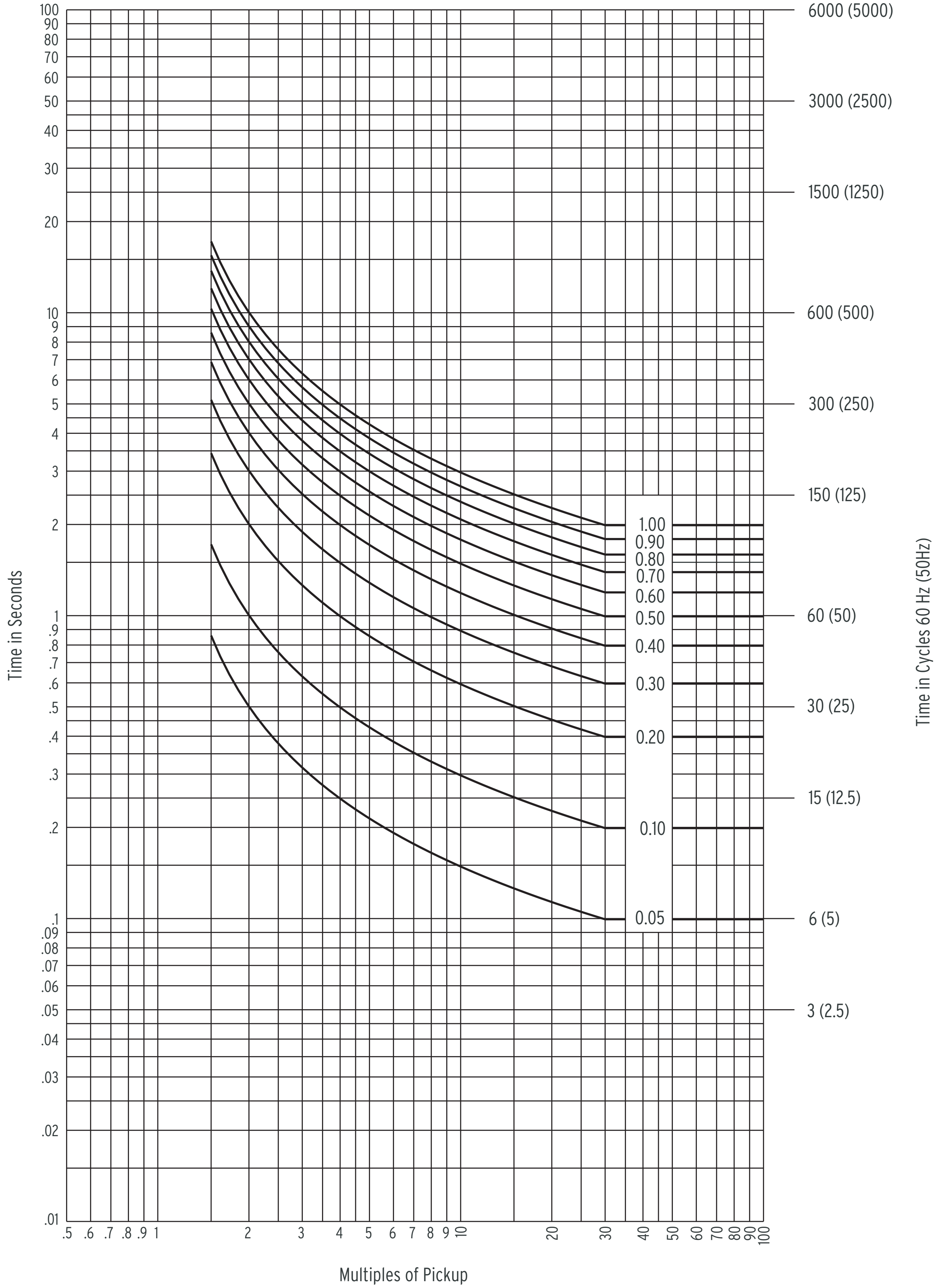


Figure 9.6 IEC Standard Inverse (Class A) Curve (C1)

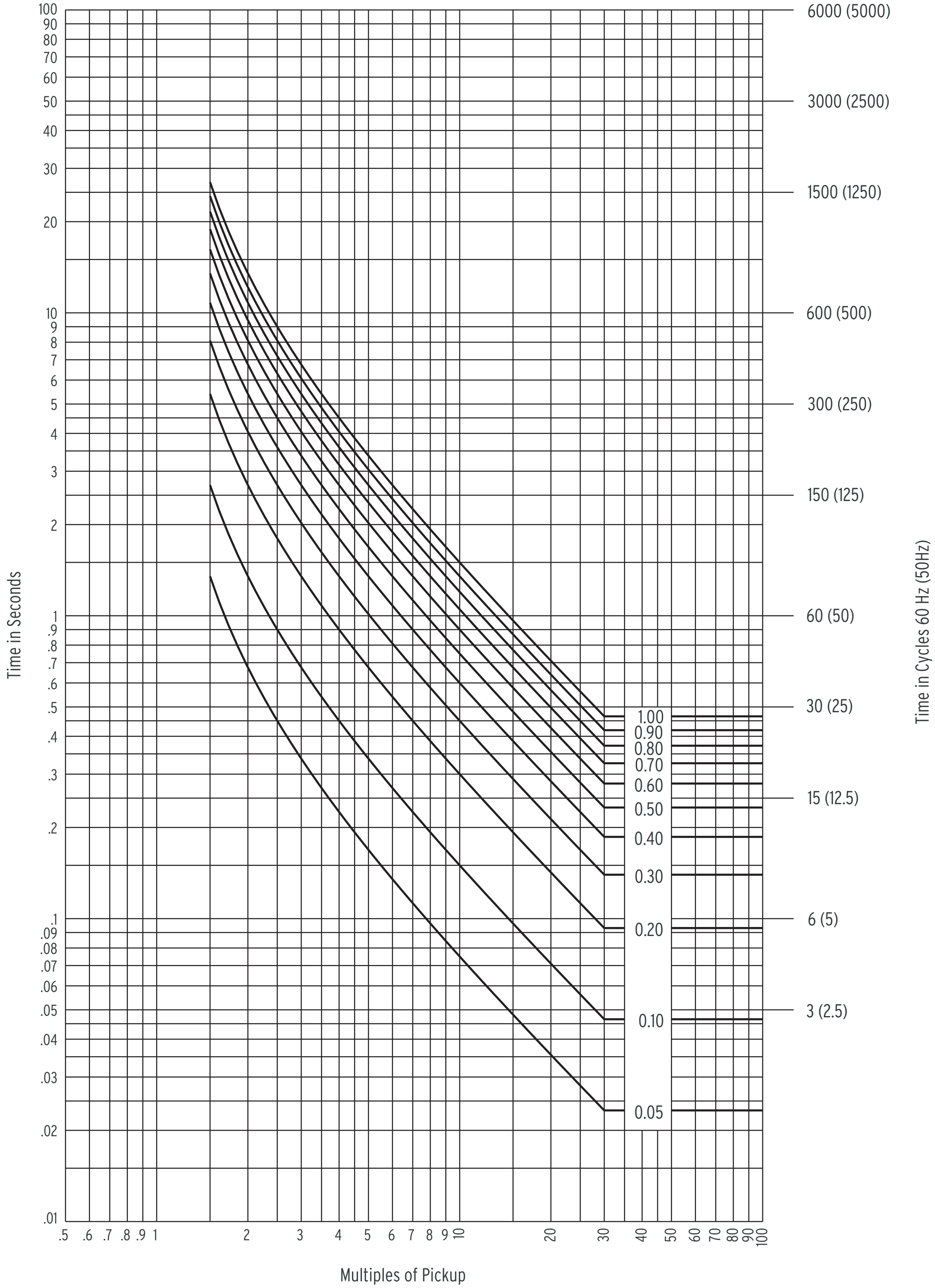


Figure 9.7 IEC Very Inverse (Class B) Curve (C2)

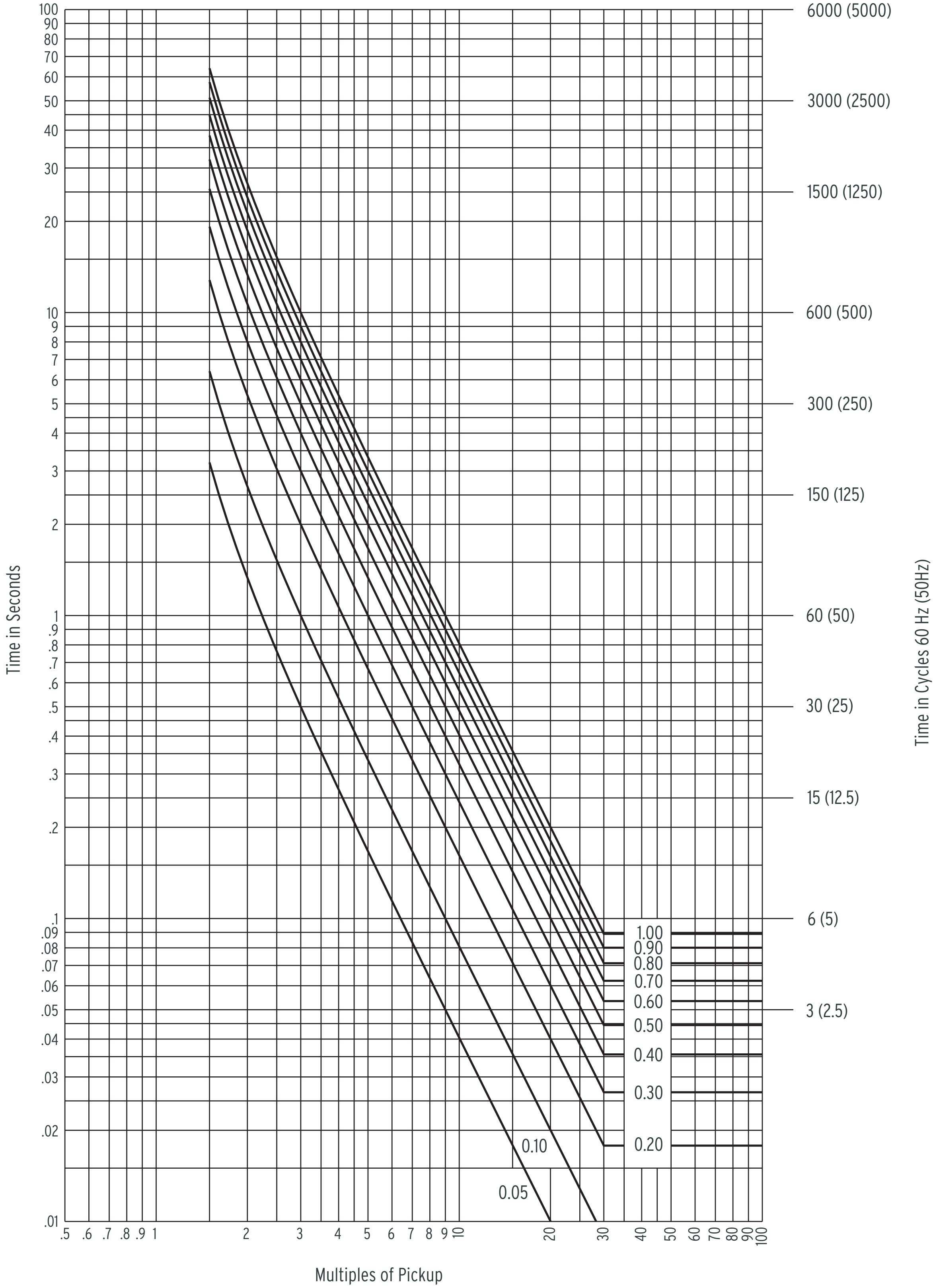


Figure 9.8 IEC Extremely Inverse (Class C) Curve (C3)

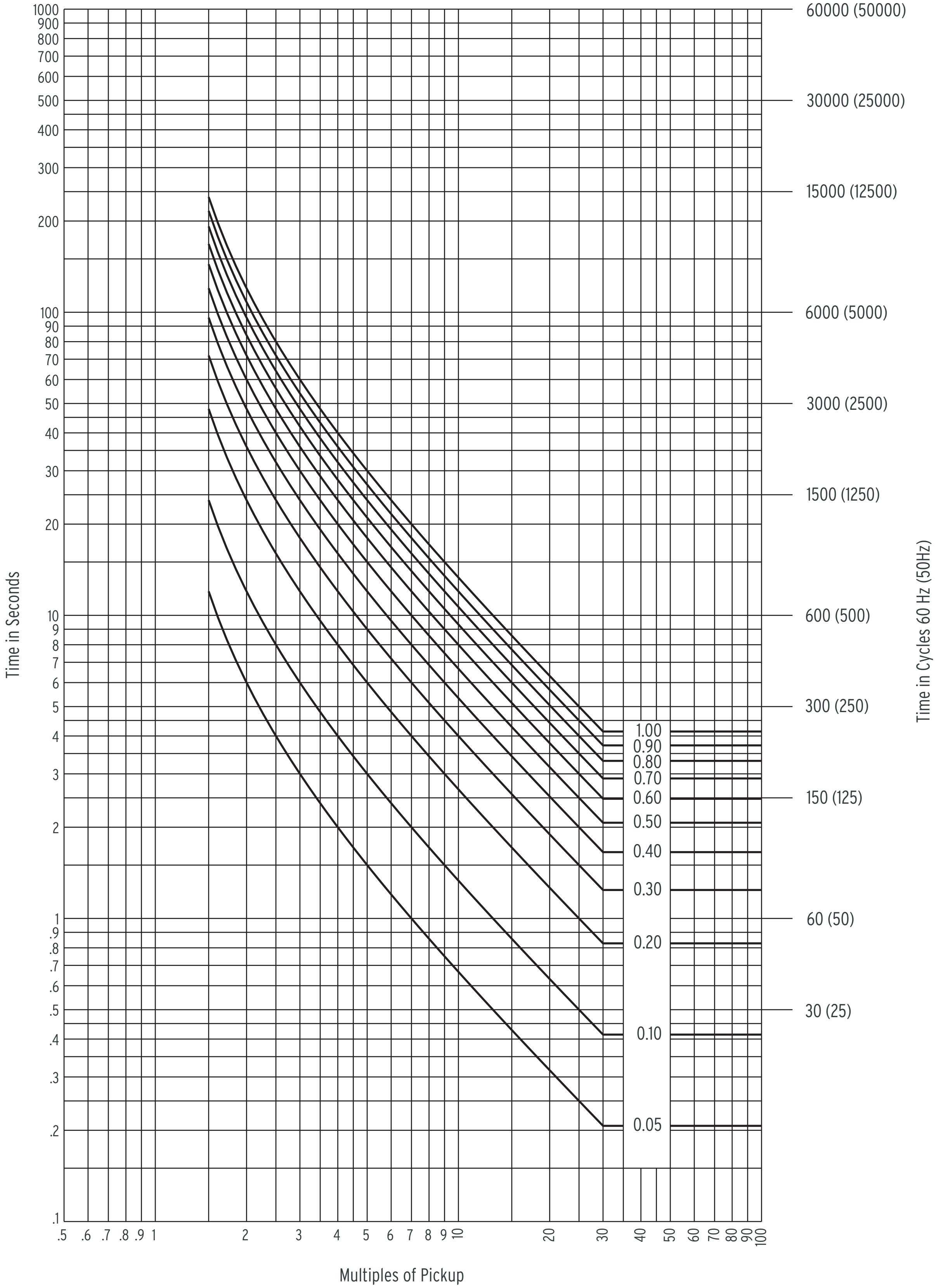


Figure 9.9 IEC Long-Time Inverse Curve (C4)

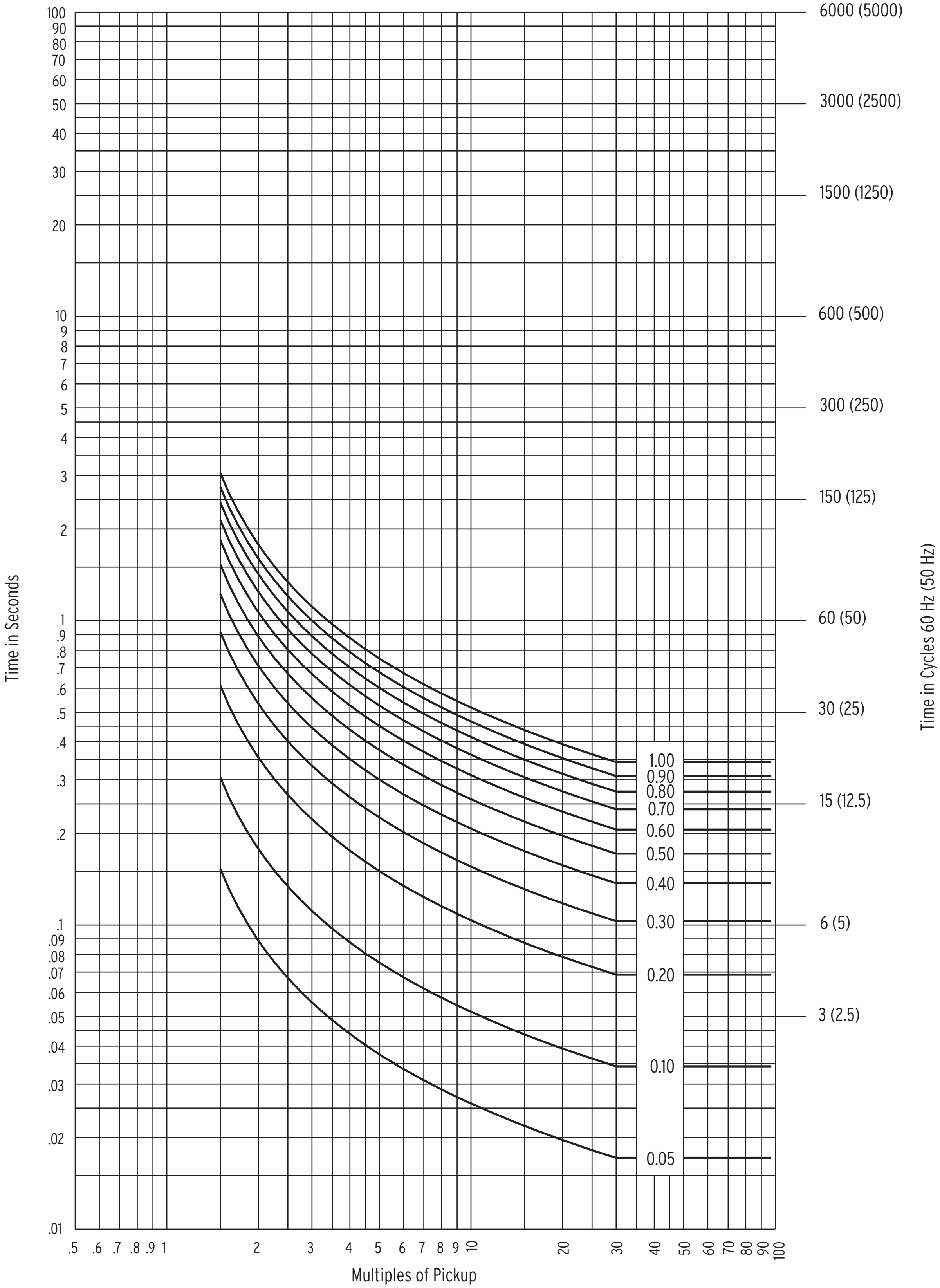


Figure 9.10 IEC Short-Time Inverse Curve (C5)

Settings Explanations

Note that most of the settings in the settings sheets that follow include references for additional information. The following explanations are for settings that do not have reference information anywhere else in the instruction manual.

Identifier Labels

Refer to *Identifier Labels (see Identifier Labels on page 9.16) on page SET.6*.

The SEL-311C Relay has two identifier labels:

- the Relay Identifier (RID)
- the Terminal Identifier (TID)

The Relay Identifier is typically 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 allows you to 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. These two settings cannot be made via the front-panel interface.

Current Transformer Ratios

Refer to *Current and Potential Transformer Ratios (see Settings Explanations on page 9.16) on page SET.6*.

Phase and neutral current transformer ratios are set independently. If neutral channel **IN** is connected residually with **IA**, **IB**, and **IC**, then set CTR and CTRN the same. Relay settings CTR and CTRN are used in relay event reports and metering functions to scale secondary current quantities into primary values.

Settings for Voltage Input Configuration

The SEL-311C has two Global settings and one Group setting related to the voltage connection to the power system. These provide flexibility by allowing the relay to be connected to potential transformers in several configurations, as explained below. *Table 9.6* summarizes the relay differences for each of these settings.

Refer to *Global Settings (Serial Port Command SET G and Front Panel) on page SET.1*.

PTCONN = (DELTA, WYE) selects the configuration for the voltage terminals **VA**, **VB**, **VC**, and **N**. See *Delta-Connected Voltages (Global Setting PTCONN = DELTA) on page 2.12* for connection details.

- PTCONN = WYE is the factory default setting, and is the proper choice for connecting to systems with (three) wye-connected PTs. When selected, Relay Word bit WYE asserts.
- PTCONN = DELTA configures the relay for connection to (two) open-delta connected PTs. Some relay elements are unavailable when PTCONN = DELTA. When selected, Relay Word bit DELTA asserts.

VSCONN = (VS, 3V0) selects the configuration for the voltage terminals **VS-NS**. See *Potential Transformer Inputs on page 2.11* for wiring details.

- ➤ VSCONN = VS is the factory default setting, and is the proper choice for applications that have a synchronizing reference voltage, or no voltage connected to the **VS-NS** terminals.
- ➤ VSCONN = 3V0 configures the relay to accept a zero-sequence voltage connection on the **VS-NS** terminals. This type of configuration is for broken-delta connected PTs. Some relay functions are unavailable when VSCONN = 3V0. When selected, Relay Word bit 3V0 asserts. Global Setting VSCONN is available only when Global setting PTCONN = DELTA.

Refer to *Group n (Relay) Settings (Serial Port Command SET n and Front Panel) on page SET.6*.

VNOM = (25.00–300.00 V sec) selects the nominal system voltage, as seen by the relay inputs **VA**, **VB**, **VC**, and **N** in V secondary. The relay uses this setting to determine the thresholds for the loss-of-potential logic, and the exact value entered does not affect metering or protection accuracy.

- ➤ VNOM = 67.00 is the factory default setting when PTCONN = WYE. Enter the nominal line-to-neutral secondary voltage of your system.
- ➤ VNOM = 116.05 is the factory default setting when PTCONN = DELTA. Enter the nominal line-to-line secondary voltage of your system.

Table 9.6 Main Relay Functions That Change With VSCONN When PTCONN = DELTA

Relay Function	When VSCONN=VS	When VSCONN=3V0
Zero-sequence voltage-polarized ground directional elements (ORDER setting choice “V”)	Not available	Uses VS • (PTRS/PTR) as $3V_0$[a].
Synchronism check elements	Available	Not available
Three-phase power metering (MW3P, MVAR3P, etc.)	Uses a three-phase power formula, without $3V_0$ (primary value).[b]	Uses a three-phase power formula, including VS as $3V_0$ (primary value).
Quantity “3V0” in Metering, Fast Meter, Modbus, Distributed Network Protocol (DNP) and IEC 61850	No difference	“3V0” is not shown or not available in **METER** command. Fast Meter, Modbus, and DNP return 3V0 = 0.00 kV
Quantity “VS” in Metering, Fast Meter, Modbus, and DNP	No difference	Uses V_S as VS (primary value)

[a] The PTRS/PTR adjustment brings the broken-delta $3V_0$ quantity to the same base voltage as the relay impedance settings, which are based on the V_A, V_B, V_C voltage base.
[b] The three-phase power formula requires a 3V0 quantity to correct for unbalanced conditions. In the absence of this quantity, metering element accuracy will be reduced when system voltages are unbalanced.

Potential Transformer Ratios and PT Nominal Secondary Voltage Settings

Refer to *Current and Potential Transformer Ratios (see Settings Explanations on page 9.16) on page SET.6*.

Relay setting PTR is the overall potential ratio from the primary system to the relay phase voltage inputs **VA**, **VB**, **VC**, and **N**. For example, on a 12.5 kV phase-to-phase primary system with wye-connected 7200:120 V PTs, the correct PTR setting is 60.

For the same 12.5 kV system connected through 12470:115 V PTs in an open-delta configuration (Global setting PTCONN = DELTA, and the relay wired as shown in *Figure 2.17*), the correct PTR setting is 108.44.

Relay setting PTRS is the overall potential ratio from the synchronizing or broken-delta voltage source to the relay **VS-NS** voltage inputs. For example, in a synchronism check application (Global setting VSCONN = VS), with phase-to-ground voltage connected from a 12.5 kV phase-to-phase primary system through a 7200:120 V PT, the correct PTRS setting is 60.

In an application that uses a broken-delta PT connection to create a $3V_0$ zero-sequence voltage signal (Global setting VSCONN = 3V0, and the relay **VS-NS** terminals wired as shown in *Figure 2.11*), the step-down transformer, if present, must also be included in the overall PTRS ratio calculation. For example, if there are three PTs connected wye (primary)/broken delta (secondary) with ratios of 7200:120, and a 400:250 step-down instrumentation transformer in the circuit, the correct PTRS setting is 60 • 1.6 = 96.00.

Settings PTR and PTRS are used in event report and **METER** commands so that power system values can be reported in primary units.

Settings PTR and PTRS are also used when Global setting VSCONN = 3V0, to scale the measured VS voltage into the same voltage base as voltage inputs **VA-VB–VC-N** for certain functions, as shown in *Table 9.6*.

The ratio of the PTRS and PTR settings (PTRS/PTR) must be less than 1000 and greater than 0.001 when VSCONN = 3V0.

Relay setting VNOM is the nominal secondary voltage connected to voltage inputs **VA-VB–VC-N**. For wye-connected PTs, VNOM is a phase-to-neutral secondary voltage value. For open-delta connected PTs, VNOM is a phase-to-phase secondary voltage value.

For example, for a 10 kV (phase-to-phase) system with wye-connected PTs rated 7200:120 V (PTR = 60), the setting for VNOM would be:

$$10000 \text{ V}/ (\sqrt{3} \cdot 60) = 96.22 \text{ V}$$

For a 12.5 kV (phase-to-phase) system with open-delta connected PTs rated 14000:115 V (PTR = 121.74), the setting for VNOM would be

$$12500 \text{ V}/121.74 = 102.68 \text{ V}$$

In the loss-of-potential logic (see *Figure 4.1* and accompanying text), setting VNOM scales certain voltage thresholds for voltage measurement comparisons.

Time and Date Management Settings

The SEL-311C supports several methods of updating the relay date and time.

For IRIG-B and Phasor Measurement Unit (PMU) synchrophasor applications, refer to *Configuring High-Accuracy Timekeeping on page N.25*.

For Simple Network Time Protocol (SNTP) applications, refer to *Simple Network Time Protocol (SNTP) on page 10.16*.

For time update from a DNP Master, see *Time Synchronization on page L.9*.

Coordinated Universal Time (UTC) Offset Setting

The SEL-311C has a Global setting UTC_OFF, settable from –24.00 to 24.00 hours, in 0.25 hour increments.

The relay HTTP (Web) Server uses the UTC_OFF setting to calculate UTC timestamps in request headers.

The relay also uses the UTC_OFF setting to calculate local (relay) time from the UTC source when configured for Simple Network Time Protocol (SNTP) updating via Ethernet. When a time source other than SNTP is updating the relay time, the UTC_OFF setting is not considered because the other time sources are defined as local time. When using IEEE C37.118 compliant IRIG-B signals (e.g., Global setting IRIGC = C37.118), the relay uses the UTC to local time offset provided as part of the time message to determine the local time. If the IRIG signal is lost, Global setting UTC_OFF will be used.

Set UTC_OFF properly even if you expect some other time source, such as IRIG-B, to correct for the offset. If the time source fails, the relay will revert to SNTP or internal time, and UTC_OFF will allow the relay to record and report the correct local time. If UTC_OFF is not set properly, some relay reports may show unexpected results.

Automatic Daylight-Saving Time Settings

The SEL-311C can automatically switch to and from daylight-saving time, as specified by the eight Global settings DST_BEGM through DST_ENDH. The first four settings control the month, week, day, and time that daylight-saving time shall commence, while the last four settings control the month, week, day, and time that daylight-saving time shall cease.

Once configured, the SEL-311C will change to and from daylight-saving time every year at the specified time. Device Word bit DST asserts when daylight saving time is active.

The SEL-311C interprets the week number settings DST_BEGW and DST_ENDW (1–3, L = Last) as follows:

- The first seven days of the month are considered to be in week 1.
- The second seven days of the month are considered to be in week 2.
- The third seven days of the month are considered to be in week 3.
- The last seven days of the month are considered to be in week “L”.

This method of counting of the weeks allows easy programming of statements like “the first Sunday”, “the second Saturday”, or “the last Tuesday” of a month.

As an example, consider the following settings:

DST_BEGM = **3**

DST_BEGW = **L**

DST_BEGD = **SUN**

DST_BEGH = **2**

DST_ENDM = **10**

DST_ENDW = **3**

DST_ENDD = **WED**

DST_ENDH = **3**

With these example settings, the relay will enter daylight-saving time on the last Sunday in March at 0200 h, and leave daylight-saving time on the third Wednesday in October at 0300 h. The relay asserts Relay Word bit DST when daylight-saving time is active.

When an IRIG-B time source is being used, the relay time follows the IRIG-B time, including daylight-saving time start and end, as commanded by the time source. If there is a discrepancy between the daylight-saving time settings and the received IRIG-B signal, the relay follows the IRIG-B signal.

When using IEEE C37.118 compliant IRIG-B signals (e.g., Global setting IRIGC = C37.118), the relay automatically populates the DST Relay Word bit, regardless of the daylight-saving time settings.

When using regular IRIG-B signals (e.g., Global setting IRIGC = NONE), the relay only populates the DST Relay Word bit if the daylight-saving time settings are properly configured.

Set daylight savings times properly even if you expect some other time source, such as IRIG-B, to correct for daylight savings time offset. The relay relies on these settings for correct time should the time source fail (for IRIGC = C37.118) and to calculate UTC time correctly (when IRIGC = NONE). If daylight savings time settings are not correct, some relay reports may show unexpected results.

Line Settings

Refer to *Line Settings (see Line Settings on page 9.20) on page SET.6*.

Line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG are used in the fault locator (see *Fault Location on page 12.7*) and in automatically making directional element settings Z2F, Z2R, Z0F, and Z0R (see *Settings Made Automatically on page 4.29*). A corresponding line length setting (LL) is also used in the fault locator.

Z0ANG must be set to the actual zero-sequence line angle to allow correct fault locator operation for forward faults involving ground.

The line impedance settings Z1MAG and Z0MAG are set in Ω secondary. Line impedance (Ω primary) is converted to Ω secondary:

Ω primary • (CTR/PTR) = Ω secondary

where:

CTR = phase (IA, IB, IC) current transformer ratio
PTR = phase (VA, VB, VC) potential transformer ratio

Line length setting LL is unitless and corresponds to the line impedance settings. For example, if a particular line length is 15 miles, enter the line impedance values (Ω secondary) and then enter the corresponding line length:

LL = **15.00** (miles)

If this length of line is measured in kilometers rather than miles, then enter:

LL = **24.14** (kilometers)

Delta-Connected PTs (PTCONN = DELTA)

NOTE: If Global setting VSCONN = 3V0, settings Z0SMAG and Z0SANG are not required.

Additional zero-sequence source impedance settings Z0SMAG (magnitude, Ω secondary) and Z0SANG (angle, degrees) are required so that zero-sequence voltage can be derived for fault locating.

Enable Settings

Refer to *Global Settings (Serial Port Command SET G and Front Panel) on page SET.1* and *Group n (Relay) Settings (Serial Port Command SET n and Front Panel) on page SET.6*.

The SEL-311C includes enable settings in the Global, Group, and Port settings classes. Several of these enable settings help limit the number of settings that must be entered when a feature is not required.

Global Enable Settings

The Global settings class contains five enable settings. These settings control other Global settings as follows:

- PTCONN: Phase PT Connection (DELTA,WYE). Affects some Global settings, and several Group settings.
- VSCONN: VS Channel Input (VS, 3V0). Affects some Group settings.
- EBMON: Breaker Monitor (Y, N). Hides six settings when set to N.
- EPMU: Synchronized Phasor Measurement (Y, N). Hides up to 21 settings when set to N. Also affects Port enable settings PROTO and EPMIP.
- DST_BEGM: Month to Begin DST (NA, 1–12). Hides seven settings when set to NA.

Group (Relay) Enable Settings

Each Group settings class contains as many as 29 enable settings, depending on model. See *Group n (Relay) Settings (Serial Port Command SET n and Front Panel) on page SET.6* for a full listing of the relay settings, and associated enable settings. The Relay enable settings are as follows:

- EADVS: Advanced Settings.
- E21P, E21MG, E21XG: Distance Elements
- E50P, E50G, E50Q: Instantaneous/Definite-Time Overcurrent Elements
- E51P, E51G, E51Q: Time-Overcurrent Elements
- E32: Directional Control
- EOOS: Out-of-Step
- ELOAD: Load Encroachment
- ESOTF and EDDSOTF: Switch-Onto-Fault
- EVOLT: Voltage Elements
- E25: Synchronism Check
- EFLOC: Fault Location (does not hide any settings)
- ELOP and EBBPT: Loss-Of-Potential
- ECOMM: Communications-Assisted Trip Scheme
- E81: Frequency Elements
- E79: Reclosures
- EZ1EXT, EZ1EXTP, EZ1EXTG: Zone 1 extension
- ECCVT: CCVT Transient Detection
- ESV: SELOGIC Variable/Timers
- EDEM: Demand Metering (does not hide any settings)

Port Enable Settings

Each Port settings class contains up to five enable settings. These settings control other Port settings as follows.

Serial Port Settings (Port 1, 2, 3, or F)

NOTE: The Access jumper overrides the EPORT = N setting for the front-panel ports. Installing the Access jumper also causes the front-panel EIA-232 port to revert to factory default settings for PROTO, SPEED, BITS, PARITY, STOP, and RTSCTS when EPORT = N.

NOTE: The Access jumper overrides the MAXACC setting for any enabled ports, and allows the highest access level (C = Calibration).

- EPORT: Enable Port (Y, N). Disables the port and hides all port settings when set to N. The EPORT setting for Port F controls both the front-panel EIA-232 serial port F and the optional USB port.
- PROTO: Protocol. Controls availability of subsequent settings. When PROTO is set to SEL or LMD, another enable setting appears:

  MAXACC: Maximum Access Level (1,B,2). Selects highest access level allowed on port by limiting the availability of commands **ACC**, **BAC**, or **2AC**. The MAXACC for Port F (only) can be set to 1, B, 2, or C, where C is the Calibration access level, command **CAL**, and affects both serial port F and the optional USB port.

Ethernet Port Settings (Port 5)

NOTE: When ETELNET = Y, the Access jumper overrides the MAXACC setting, and allows the Telnet session(s) to attain the highest access level (C = Calibration).

- EPORT: Enable Port (Y,N). Hides all port settings when set to N.
- ETELNET: Enable Telnet (Y,N). Hides five settings when set to N. When ETELNET is set to Y, another enable setting appears:

  MAXACC: Maximum Access Level (1,B,2). Selects highest access level allowed on a Telnet session by limiting the availability of commands **ACC**, **BAC**, or **2AC**.
- EFTPSERV: Enable FTP (Y, N). Hides three settings when set to N.
- EHTTP: Enable HTTP Server (Y, N). Hides two settings when set to N.
- E61850: Enable IEC 61850 Protocol (Y, N). Hides one setting when set to N (setting only present on relays ordered with IEC 61850).
- EDNP: Enable DNP Sessions (0–6). Controls availability of subsequent settings (up to 27 settings per session).
- EPMIP: Enable PMU Processing (Y,N). Controls availability of up to six subsequent settings.
- EMODBUS: Enable Modbus (0–3). Controls availability of up to seven subsequent settings.
- ESNTP: Enable SNTP client (OFF, UNICAST, MANYCAST, BROADCAST). Controls availability of up to five subsequent settings.

PC Software

These enable settings are also present in the SEL-311C driver for ACSELERATOR QuickSet SEL-5030 (PC software). The effect of changing an enable setting is easy to see, because the associated setting field turns grey when it is unavailable. See *Appendix C: PC Software* for more information on ACSELERATOR QuickSet.

Optional USB Port

No port settings are required for the optional USB port. However, the USB port is controlled by the previously described Port F (front-panel EIA-232 serial port) settings EPORT and MAXACC.

The PC operating system should prompt for a USB driver when a PC is connected to the relay. See *Establishing Communications Using the USB Port on page 10.2* for further details on using the USB port.

Other System Parameters

Refer to *Power System Configuration and Date Format (see Other System Parameters on page 9.23) on page SET.1*.

The Global settings NFREQ and PHROT allow you to configure the SEL-311C 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.

Set DATE_F to format the date displayed in relay reports and the front-panel display. Set DATE_F to MDY to display dates in Month/Day/Year format; set DATE_F to YMD to display dates in Year/Month/Day format.

Settings Sheets

The settings sheets that follow include the definition and input range for each setting in the relay. Refer to *Specifications on page 1.2* for information on 5 A nominal and 1 A nominal ordering options.

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SEL-311C Settings Sheets

Global Settings (Serial Port Command SET G and Front Panel)

To avoid losing settings, enter Global settings first. Refer to Make Global Settings (SET G) First on page 9.3.

Voltage Input Configuration (see Settings for Voltage Input Configuration on page 9.16)

NOTE: Changing the setting value of PTCONN or VSCONN will cause the relay to display the following message:

```
WARNING!  The PTCONN or VSCONN setting was changed, which will cause
the Group, Logic, and Report settings to be reset to default values.
Save Changes(Y/N)? Y <Enter>
Are you sure (Y/N)? _
```

Phase Potential Transformer Connection (DELTA, WYE)	**PTCONN**	= ________

Make the following setting when PTCONN = DELTA.

VS Channel Input (VS, 3V0)	**VSCONN**	= ________

Settings Group Change Delay (see Multiple Setting Groups on page 7.17)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps)	**TGR**	= ________

Power System Configuration and Date Format (see Other System Parameters on page 9.23)

Nominal frequency (50 Hz, 60 Hz)	**NFREQ**	= ________
Phase rotation (ABC, ACB)	**PHROT**	= ________
Date format (MDY, YMD)	**DATE_F**	= ________

Front-Panel Display Operation (Only on models with LCD; see Section 11)

Front-panel display time-out (OFF, 1–30 minutes in 1-minute steps)	**FP_TO**	= ________

NOTE: If FP_TO = OFF, no time-out occurs and display remains on last display screen (e.g., continually display metering).

Display update rate (1–60 seconds)	**SCROLD**	= ________
Front-panel neutral/ground display (OFF, IN, IG)	**FPNGD**	= ________

Event Report Parameters (see Section 12)

Length of event report (15, 30, 60, 180 cycles)	**LER**	=	________
Length of prefault in event report (1 to LER-1 cycles in 1-cycle steps)	**PRE**	=	________

Station DC Battery Monitor (see Figure 8.9 and Figure 8.10)

DC battery instantaneous undervoltage pickup (OFF, 20.00–300.00 Vdc in 0.02 V steps)	**DCLOP**	=	________
DC battery instantaneous overvoltage pickup (OFF, 20.00–300.00 Vdc in 0.02 V steps)	**DCHIP**	=	________

Optoisolated Input Timers (see Figure 7.1)

Input IN101 debounce time (AC, 0.00–2.00 cycles)	**IN101D**	=	________
Input IN102 debounce time (AC, 0.00–2.00 cycles)	**IN102D**	=	________
Input IN103 debounce time (AC, 0.00–2.00 cycles)	**IN103D**	=	________
Input IN104 debounce time (AC, 0.00–2.00 cycles)	**IN104D**	=	________
Input IN105 debounce time (AC, 0.00–2.00 cycles)	**IN105D**	=	________
Input IN106 debounce time (AC, 0.00–2.00 cycles)	**IN106D**	=	________

Optoisolated Input Timers—Extra I/O Board (see Figure 7.2)

Input IN201 debounce time (AC, 0.00–2.00 cycles)	**IN201D**	=	________
Input IN202 debounce time (AC, 0.00–2.00 cycles)	**IN202D**	=	________
Input IN203 debounce time (AC, 0.00–2.00 cycles)	**IN203D**	=	________
Input IN204 debounce time (AC, 0.00–2.00 cycles)	**IN204D**	=	________
Input IN205 debounce time (AC, 0.00–2.00 cycles)	**IN205D**	=	________
Input IN206 debounce time (AC, 0.00–2.00 cycles)	**IN206D**	=	________
Input IN207 debounce time (AC, 0.00–2.00 cycles)	**IN207D**	=	________
Input IN208 debounce time (AC, 0.00–2.00 cycles)	**IN208D**	=	________

Breaker Monitor Settings (see Breaker Monitor on page 8.1)

Breaker monitor enable (Y, N)	**EBMON**	=	________

Make the following settings if EBMON = Y.

Close/Open set point 1-max. (0–65000 operations)	**COSP1**	=	________
Close/Open set point 2-mid. (0–65000 operations)	**COSP2**	=	________
Close/Open set point 3-min. (0–65000 operations)	**COSP3**	=	________

kA Interrupted set point 1-min. (0.00–999.00 kA primary)	**KASP1**	= ________
kA Interrupted set point 2-mid. (0.00–999.00 kA primary)	**KASP2**	= ________
kA Interrupted set point 3-max. (0.00–999.00 kA primary)	**KASP3**	= ________

Notes:

- COSP1 must be set greater than COSP2.
- COSP2 must be set greater than or equal to COSP3.
- KASP1 must be set less than KASP2.
- KASP2 must be less than or equal to KASP3.
- If KASP2 is set the same as KASP3, then COSP2 must be set the same as COSP3.
- KASP3 must be set at least 5 times (but no more than 100 times) the KASP1 setting value.

Trip Latch LED Settings (Only on models with programmable LEDs; see Table 5.3)

Trip Latch LED 12 (Y, N)	**LED12L**	= ________
Trip Latch LED 13 (Y, N)	**LED13L**	= ________
Trip Latch LED 14 (Y, N)	**LED14L**	= ________
Trip Latch LED 15 (Y, N)	**LED15L**	= ________
Trip Latch LED 16 (Y, N)	**LED16L**	= ________
Trip Latch LED 17 (Y, N)	**LED17L**	= ________
Trip Latch LED 18 (Y, N)	**LED18L**	= ________
Trip Latch LED 23 (Y, N)	**LED23L**	= ________
Trip Latch LED 24 (Y, N)	**LED24L**	= ________
Trip Latch LED 25 (Y, N)	**LED25L**	= ________
Trip Latch LED 26 (Y, N)	**LED26L**	= ________

Enter up to seven of the following characters: 0-9, A-Z, _.

LED 12 Alias	**LED12A**	= ________
LED 13 Alias	**LED13A**	= ________
LED 14 Alias	**LED14A**	= ________
LED 15 Alias	**LED15A**	= ________
LED 16 Alias	**LED16A**	= ________
LED 17 Alias	**LED17A**	= ________
LED 18 Alias	**LED18A**	= ________
LED 23 Alias	**LED23A**	= ________

LED 24 Alias **LED24A** = ________

LED 25 Alias **LED25A** = ________

LED 26 Alias **LED26A** = ________

Reset trip-latched LEDs when breaker closes (Y, Y1, N, N1) **RSTLED** = ________
The numeral "1" appended to setting options "Y1" and "N1" disables the embedded 3-second qualifying time delay on pushbutton **PB5** (**PB5** effectively operates as the other operator controls, with no time delay).

Synchronized Phasor Settings (see Appendix N)

Synchronized Phasor Measurement (Y, N) **EPMU** = ________

NOTE: Make the following setting if EPMU = Y and PTCONN = WYE.

Message Format (C37.118, FM) **MFRMT** = ________

NOTE: C37.118 is an IEEE Standard. "FM" is SEL Fast Message. When PTCONN = DELTA, MFRMT is automatically set to "C37.118."

C37.118 Settings

Make the following settings when EPMU = Y and MFRMT = C37.118.

Message Rate (messages per second) **MRATE** = ________
(1, 2, 4, 5, 10, 12, 15, 20, 30, 60 when NFREQ = 60)
(1, 2, 5, 10, 25, 50 when NFREQ = 50)

NOTE: MRATE is limited when serial port setting PROTO = PMU.

Phasor Measurement Unit (PMU) Application (F, N) **PMAPP** = ________

NOTE: F = Fast Response, N = Narrow Bandwidth

Frequency Based Phasor Compensation (Y, N) **PHCOMP** = ________

Station Name (16 characters) **PMSTN** = ________

NOTE: Cannot contain the following characters: ? / \ < > * | : ; [ ] $ % { }.

Phasor Measurement Unit (PMU) Hardware ID (1–65534) **PMID** = ________

Phasor Data Set, Voltages (V1, PH, ALL, NA) **PHDATAV** = ________

NOTE: PHDATAV is limited when serial port setting PROTO = PMU.

Phase Voltage Angle Compensation Factor (–179.99 to +180.00 degrees) **VPCOMP** = ________

VS Voltage Angle Compensation Factor (–179.99 to +180.00 degrees) **VSCOMP** = ________

Phasor Data Set, Currents (I1, PH, ALL, NA) **PHDATAI** = ________

NOTE: PHDATAI is not available when PHDATAV = V1. PHDATAI is limited when serial port setting PROTO = PMU.

Phase Current Angle Compensation Factor (–179.99 to +180.00 degrees) **IPCOMP** = ________

Neutral (IN) Current Angle Compensation Factor (–179.99 to +180.00 degrees) **INCOMP** = ________

Make settings PHNR and PHFMT when PHDATAV ≠ NA or PHDATAI ≠ NA.

Phasor Numeric Representation (I = Integer, F = Floating Point)	**PHNR**	= ________
Phasor Format (R = Rectangular coordinates, P = Polar coordinates)	**PHFMT**	= ________
Frequency Numeric Representation (I = Integer, F = Floating Point)	**FNR**	= ________
Number of 16-bit Digital Status Words (0, 1)	**NUMDSW**	= ________

SEL Fast Message Settings

Make the following settings when EPMU = Y and MFRMT = FM.

Phasor Measurement Unit (PMU) Hardware ID (0 to 4294967295)	**PMID**	= ________
Phasor Data Set, Voltages (V1, ALL)	**PHDATAV**	= ________
Voltage Angle Compensation Factor (–179.99 to +180.00 deg)	**VCOMP**	= ________

Make setting PHDATAI when PHDATAV = ALL.

Phasor Data Set, Currents (ALL, NA)	**PHDATAI**	= ________
Current Angle Compensation Factor (–179.99 to +180.00 deg)	**ICOMP**	= ________

DNP (see Appendix L)

Event Summary Lock Period (0 to 1000 seconds)	**EVELOCK**	= ________
DNP Session Time Base (LOCAL, UTC)	**DNPSRC**	= ________

Time and Date Management (see Section 10 and Appendix N)

IRIG-B Control Bits Definition (NONE, C37.118)	**IRIGC**	= ________

NOTE: When MFRMT = C37.118, IRIGC is automatically set to "C37.118".

Offset from UTC (–24.00 to 24.00 hours)	**UTC_OFF**	= ________

Daylight-Saving Time Settings (see Automatic Daylight-Saving Time Settings on page 9.19)

NOTE: Daylight-Saving Time Settings do not apply when IRIGC = C37.118. Daylight-Saving beginning and ending must be set at least two weeks apart.

Month to Begin DST (NA, 1–12)	**DST_BEGM**	= ________

Make the following settings when DST_BEGM ≠ NA.

Week of the Month to Begin DST (1–3, L = Last)	**DST_BEGW**	= ________
Day of the Week to Begin DST (SUN–SAT)	**DST_BEGD**	= ________
Local Hour to Begin DST (0–23)	**DST_BEGH**	= ________
Month to End DST (1–12)	**DST_ENDM**	= ________

Week of the Month to End DST (1–3, L = Last)	**DST_ENDW**	= ________
Day of the Week to End DST (SUN–SAT)	**DST_ENDD**	= ________
Local Hour to End DST (0–23)	**DST_ENDH**	= ________

Group n (Relay) Settings (Serial Port Command SET n and Front Panel)

To avoid losing settings, enter Global settings first. Refer to Make Global Settings (SET G) First on page 9.3.

Identifier Labels (see Identifier Labels on page 9.16)

Relay Identifier (30 characters) (0–9, A–Z, -, /, ., space)

RID = ____

Terminal Identifier (30 characters) (0–9, A–Z, -, /, ., space)

TID = ____

Current and Potential Transformer Ratios (see Settings Explanations on page 9.16)

Phase (IA, IB, IC) Current Transformer Ratio (1–6000 in steps of 1)	**CTR**	= ________
Neutral (IN) Current Transformer Ratio (1–10000 in steps of 1)	**CTRN**	= ________
Phase (VA, VB, VC; wye-connected) or Phase-to-Phase (VAB, VBC, VCA; delta-connected) Potential Transformer Ratio (1.00–10000.00 in steps of 0.01)	**PTR**	= ________
Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00 in steps of 0.01)	**PTRS**	= ________
PT Nominal Voltage (line-to-neutral [wye-connected] or line-to-line [delta-connected]) (25.00–300.00 V secondary in 0.013 V steps)	**VNOM**	= ________

Line Settings (see Line Settings on page 9.20)

Positive-sequence line impedance magnitude (0.10–255.00 Ω secondary [5 A nom.]; 0.50–1275.00 Ω secondary [1 A nom.] in 0.01 Ω steps)	**Z1MAG**	= ________
Positive-sequence line impedance angle (5.00–90.00 degrees in 0.01 degree steps)	**Z1ANG**	= ________
Zero-sequence line impedance magnitude (0.10–255.00 Ω secondary [5 A nom.]; 0.50–1275.00 Ω secondary [1 A nom.] in 0.01 Ω steps)	**Z0MAG**	= ________
Zero-sequence line impedance angle (5.00–90.00 degrees in 0.01 degree steps)	**Z0ANG**	= ________

Make settings Z0SMAG and Z0SANG when Global settings PTCONN = DELTA and VSCONN = VS.

Zero-sequence source impedance magnitude (delta-connected voltages) (0.10–255.00 Ω secondary [5 A nom.]; 0.50–1275.00 Ω secondary [1 A nom.] in 0.01 Ω steps)	**Z0SMAG**	= ________
Zero-sequence source impedance angle (delta-connected voltages) (0.00–90.00 degrees in 0.01 degree steps)	**Z0SANG**	= ________
Line length (0.10–999.00, unitless in steps of 0.01)	**LL**	= ________

Enable Settings

Advanced settings (Y, N)	**EADVS**	= ________

Distance Element Enable Settings

Mho phase distance element zones (N, 1–4, 1C–4C when PTCONN = WYE or PTCONN = DELTA and EADVS = Y); (N,1C-4C—when PTCONN = DELTA and EADVS = N) (see *Figure 3.4–Figure 3.3*)	**E21P**	= ________

Make the following settings when PTCONN = WYE.

Mho ground distance element zones (N, 1–4) (see *Figure 3.7–Figure 3.9*)	**E21MG**	= ________
Quadrilateral ground distance element zones (N, 1–4) (see *Figure 3.10–Figure 3.12*)	**E21XG**	= ________

Instantaneous/Definite-Time Overcurrent Enable Settings

Phase element levels (N, 1–4) (see *Figure 3.24* and *Figure 3.25*)	**E50P**	= ________
Residual ground element levels (N, 1–4) (see *Figure 3.29*)	**E50G**	= ________
Negative-sequence element levels (N, 1–4) (see *Figure 3.30*)	**E50Q**	= ________

Time-Overcurrent Enable Settings

Phase elements (Y, N) (see *Figure 3.31*)	**E51P**	= ________
Residual ground elements (Y, N) (see *Figure 3.32*)	**E51G**	= ________
Negative-sequence elements (Y, N) (see *Figure 3.33*)	**E51Q**	= ________

Other Enable Settings

Directional control (Y, AUTO) (see *Directional Control Settings on page 4.29*)	**E32**	= ________
Out-of-Step (Y, N)	**EOOS**	= ________

NOTE: Out-of-Step logic cannot be used when Z1ANG is less than 45 degrees.

Load encroachment (Y, N) (see *Figure 4.10*)	**ELOAD**	= ________
Switch-onto-fault (Y, N) (see *Figure 5.3*)	**ESOTF**	= ________

Make the following setting when ESOFT = Y.

Switch-onto-fault disturbance detector supervision (Y, N) (see *Figure 5.1*)	**EDDSOTF**	= ________
Voltage elements (Y, N) (see *Figure 3.34–Figure 3.38*)	**EVOLT**	= ________
Synchronism check (Y, N) (see *Figure 3.39* and *Figure 3.40*)	**E25**	= ________

NOTE: When Global setting VSCONN = 3V0, setting E25 can only be set to "N".

Fault location (Y, N) (see *Fault Location on page 12.7*)	**EFLOC**	= ________
Loss-of-potential (Y, Y1, N) (see *Figure 4.1* and *Figure 4.2*)	**ELOP**	= ________
Bus Bar PT LOP Logic (Y, N) (see *Figure 4.1* and *Figure 4.2*)	**EBBPT**	= ________
Communications-assisted trip scheme (N, DCB, POTT, DCUB1, DCUB2) (see *Communications-Assisted Trip Logic—General Overview on page 5.12*)	**ECOMM**	= ________

NOTE: If ECOMM is enabled, then at least three distance zones must be enabled.

Frequency elements (N, 1–6) (see *Figure 3.46*)	**E81**	= ________
Reclosures (N, 1– 4) (see *Reclosing Relay on page 6.11*)	**E79**	= ________
Zone 1 extension (Y, I, N) (see *Figure 3.19* and *Figure 3.20*)	**EZ1EXT**	= ________

Make settings EZ1EXTP and EZ1EXTG if EZ1EXT = I.

Zone 1 phase element extension (Y, N) (see *Figure 3.20*)	**EZ1EXTP**	= ________

Make settings EZ1EXTG if PTCONN = WYE.

Zone 1 ground element extension (Y, N) (see *Figure 3.20*)	**EZ1EXTG**	= ________
CCVT Transient Detection (Y, N) (see *Figure 4.9*)	**ECCVT**	= ________
SELOGIC® Control Equation Variable Timers (N, 1–16) (see *Figure 7.24* and *Figure 7.25*)	**ESV**	= ________
Demand Metering (THM = Thermal, ROL = Rolling) (see *Figure 8.11*)	**EDEM**	= ________

Mho Phase Distance Elements

Number of mho phase distance element settings dependent on preceding enable setting E21P = 1–4.

Zone 1 (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.4*)	**Z1P**	= ________
Zone 2 (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.5*)	**Z2P**	= ________

Zone 3 (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.6*)	**Z3P**	=	________
Zone 4 (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.6*)	**Z4P**	=	________

Mho Phase Distance Fault Detector Settings

Zone 1 phase-to-phase current FD (0.5–170.00 A secondary [5 A nom.]; 0.1–34.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.4*)	**50PP1**	=	________
Zone 2 phase-to-phase current FD *Setting is active when advanced user setting enables EADVS = Y. Otherwise, setting is made automatically.* (0.5–170.00 A secondary [5 A nom.]; 0.1–34.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.5*)	**50PP2**	=	________
Zone 3 phase-to-phase current FD *Setting is active when advanced user setting enables EADVS = Y. Otherwise, setting is made automatically* (0.5–170.00 A secondary [5 A nom.]; 0.1–34.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.6*)	**50PP3**	=	________
Zone 4 phase-to-phase current FD *Setting is active when advanced user setting enables EADVS = Y. Otherwise, setting is made automatically* (0.5–170.00 A secondary [5 A nom.]; 0.1–34.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.6*)	**50PP4**	=	________

Mho Ground Distance Elements

Number of mho phase distance element settings dependent on preceding enable setting E21MG = 1–4.

Zone 1 (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.7*)	**Z1MG**	=	________
Zone 2 (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.8*)	**Z2MG**	=	________
Zone 3 (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.9*)	**Z3MG**	=	________
Zone 4 (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.9*)	**Z4MG**	=	________

Quadrilateral Ground Distance Elements

Number of mho phase distance element settings dependent on preceding enable setting E21XG = 1–4.

Zone 1 reactance (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.10*)	**XG1**	= ________
Zone 2 reactance (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.11*)	**XG2**	= ________
Zone 3 reactance (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.12*)	**XG3**	= ________
Zone 4 reactance (OFF, 0.05–64.00 Ω secondary [5 A nom.]; 0.25–320.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.12*)	**XG4**	= ________
Zone 1 resistance (0.05–50.00 Ω secondary [5 A nom.]; 0.25–250.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.10*)	**RG1**	= ________
Zone 2 resistance (0.05–50.00 Ω secondary [5 A nom.]; 0.25–250.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.11*)	**RG2**	= ________
Zone 3 resistance (0.05–50.00 Ω secondary [5 A nom.]; 0.25–250.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.12*)	**RG3**	= ________
Zone 4 resistance (0.05–50.00 Ω secondary [5 A nom.]; 0.25–250.00 Ω secondary [1 A nom.] in 0.01 A steps) (see *Figure 3.12*)	**RG4**	= ________
Quadrilateral ground polarizing quantity (I2, IG) *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (See *Figure 3.10*–*Figure 3.12*)	**XGPOL**	= ________
Nonhomogeneous correction angle (–45.0° to +45.0° in 0.1 degree steps) *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.*	**TANG**	= ________

Quadrilateral and Mho Ground Distance Fault Detector Settings

Number of quadrilateral and mho ground distance element settings dependent on the larger of preceding enable settings E21MG = 1–4 or E21XG = 1–4.

Zone 1 phase current FD (0.5–100.00 A secondary [5 A nom]; 0.1–20.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.7* and *Figure 3.10*)	**50L1**	= ________
Zone 2 phase current FD *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (0.5–100.00 A secondary [5 A nom]; 0.1–20.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.8* and *Figure 3.11*)	**50L2**	= ________

Zone 3 phase current FD *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (0.5–100.00 A secondary [5 A nom]; 0.1–20.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.9* and *Figure 3.12*)	**50L3**	= ________
Zone 4 phase current FD *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (0.5–100.00 A secondary [5 A nom]; 0.1–20.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.9* and *Figure 3.12*)	**50L4**	= ________
Zone 1 residual current FD (0.5–100.00 A secondary [5 A nom]; 0.1–20.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.7* and *Figure 3.10*)	**50GZ1**	= ________
Zone 2 residual current FD *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (0.5–100.00 A secondary [5 A nom]; 0.1–20.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.8* and *Figure 3.11*)	**50GZ2**	= ________
Zone 3 residual current FD *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (0.5–100.00 A secondary [5 A nom]; 0.1–20.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.9* and *Figure 3.12*)	**50GZ3**	= ________
Zone 4 residual current FD *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (0.5–100.00 A secondary [5 A nom]; 0.1–20.00 A secondary [1 A nom.]) in 0.01 A steps) (see *Figure 3.9* and *Figure 3.12*)	**50GZ4**	= ________

Zero Sequence Compensation (ZSC) Settings (see Ground Distance Elements on page 3.12)

Zone 1 ZSC factor magnitude (0.000–6.000 unitless in steps of 0.001)	**k0M1**	= ________
Zone 1 ZSC factor angle (–180.0° to +180.0° in 0.01 degree steps)	**k0A1**	= ________
Zones 2, 3, and 4 ZSC factor magnitude *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (0.000–6.000 unitless in steps of 0.001)	**k0M**	= ________
Zones 2, 3, and 4 ZSC factor angle *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (–180.0° to +180.0° in 0.01 degree steps)	**k0A**	= ________

Mho Phase Distance Element Time Delays (See Figure 3.21)

Number of mho phase distance element time delay settings dependent on preceding enable setting E21P = 1-4.

Zone 1 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z1PD**	= ________
Zone 2 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z2PD**	= ________
Zone 3 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z3PD**	= ________
Zone 4 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z4PD**	= ________

Quadrilateral and Mho Ground Distance Element Time Delays (See Figure 3.21)

Number of mho phase distance element time delay settings dependent on preceding enable setting E21MG = 1-4 or E21XG = 1-4.

Zone 1 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z1GD**	= ________
Zone 2 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z2GD**	= ________
Zone 3 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z3GD**	= ________
Zone 4 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z4GD**	= ________

Common Phase/Ground Distance Element Time Delay (See Figure 3.21)

Number of mho phase distance element time delay settings dependent on preceding enable setting E21P = 1–4 or E21MG = 1–4 or E21XG = 1–4.

Zone 1 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z1D**	= ________
Zone 2 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z2D**	= ________
Zone 3 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z3D**	= ________
Zone 4 time delay (OFF, 0–16000 cycles in 0.25 cycle steps)	**Z4D**	= ________

Phase Instantaneous/Definite-Time Overcurrent Elements (see Figure 3.24)

NOTE: Number of phase element pickup settings dependent on E50P = 1–4.

Pickup (OFF, 0.25–100.00 A secondary [5 A nom.]; 0.05–20.00 A secondary [1 A nom.] in 0.01 A steps)	**50P1P**	= ________
Pickup (OFF, 0.25–100.00 A secondary [5 A nom.]; 0.05–20.00 A secondary [1 A nom.] in 0.01 A steps)	**50P2P**	= ________
Pickup (OFF, 0.25–100.00 A secondary [5 A nom.]; 0.05–20.00 A secondary [1 A nom.] in 0.01 A steps)	**50P3P**	= ________
Pickup (OFF, 0.25–100.00 A secondary [5 A nom.]; 0.05–20.00 A secondary [1 A nom.] in 0.01 A steps)	**50P4P**	= ________

Phase Definite-Time Overcurrent Elements (see Figure 3.25)

NOTE: Number of phase element time delay settings dependent on E50P = 1–4.

Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67P1D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67P2D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67P3D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67P4D**	= ________

Residual Ground Instantaneous/Definite-Time Overcurrent Elements (see Figure 3.29)

NOTE: Number of residual ground element pickup settings dependent on E50G = 1–4.

NOTE: 50G1P–50G4P setting step size 0.010 A [5 A nom.], 0.002 A [1 A nom.]

Pickup (OFF, 0.050–100.000 A secondary in 0.01 A steps [5 A nom.]; 0.010–20.000 A secondary in 0.002 A steps [1 A nom.])	**50G1P**	= ________
Pickup (OFF, 0.050–100.000 A secondary in 0.01 A steps [5 A nom.]; 0.010–20.000 A secondary in 0.002 A steps [1 A nom.])	**50G2P**	= ________
Pickup (OFF, 0.050–100.000 A secondary in 0.01 A steps [5 A nom.]; 0.010–20.000 A secondary in 0.002 A steps [1 A nom.])	**50G3P**	= ________
Pickup (OFF, 0.050–100.000 A secondary in 0.01 A steps [5 A nom.]; 0.010–20.000 A secondary in 0.002 A steps [1 A nom.])	**50G4P**	= ________

Residual Ground Definite-Time Overcurrent Elements (see Figure 3.29)

NOTE: Number of residual ground element time delay settings dependent on E50G = 1–4.

Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67G1D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67G2D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67G3D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67G4D**	= ________

Negative-Sequence Instantaneous/Definite-Time Overcurrent Elements (see Figure 3.30)

IMPORTANT: See Appendix G: Setting Negative-Sequence Overcurrent Elements for information on setting negative-sequence overcurrent elements.

NOTE: Number of negative-sequence element time delay settings dependent on E50Q = 1–4.

Pickup (OFF, 0.25–100.00 A secondary [5 A nom.]; 0.05–20.00 A secondary [1 A nom.] in 0.01 A steps)	**50Q1P**	= ________
Pickup (OFF, 0.25–100.00 A secondary [5 A nom.]; 0.05–20.00 A secondary [1 A nom.] in 0.01 A steps)	**50Q2P**	= ________
Pickup (OFF, 0.25–100.00 A secondary [5 A nom.]; 0.05–20.00 A secondary [1 A nom.] in 0.01 A steps)	**50Q3P**	= ________
Pickup (OFF, 0.25–100.00 A secondary [5 A nom.]; 0.05–20.00 A secondary [1 A nom.] in 0.01 A steps)	**50Q4P**	= ________

Negative-Sequence Definite-Time Overcurrent Elements (see Figure 3.30)

IMPORTANT: See Appendix G: Setting Negative-Sequence Overcurrent Elements for information on setting negative-sequence overcurrent elements.

NOTE: Number of negative-sequence element time delay settings dependent on preceding enable setting E50Q = 1–4.

Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q1D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q2D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q3D**	= ________
Time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q4D**	= ________

Phase Time-Overcurrent Element (see Figure 3.31)

Make the following settings if E51P = Y.

Pickup (OFF, 0.25–16.00 A secondary [5 A nom.]; 0.05–3.20 A secondary [1 A nom.] in 0.01 A steps)	**51PP**	= ________
Curve (U1–U5, C1–C5; see *Figure 9.1–Figure 9.10*)	**51PC**	= ________
Time-Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5 in steps of 0.01)	**51PTD**	= ________
Electromechanical Reset Delay (Y, N)	**51PRS**	= ________

Residual Ground Time-Overcurrent Elements (see Figure 3.32)

Make the following settings if E51G = Y.

Pickup (OFF, 0.10–16.00 A secondary [5 A nom.]; 0.02–3.20 A secondary [1 A nom] in 0.01 A steps)	**51GP**	= ________
Curve (U1–U5, C1–C5; see *Figure 9.1*–*Figure 9.10*)	**51GC**	= ________
Time-Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5 in steps of 0.01)	**51GTD**	= ________
Electromechanical Reset Delay (Y, N)	**51GRS**	= ________

Negative-Sequence Time-Overcurrent Element (see Figure 3.33)

IMPORTANT: See Appendix G: Setting Negative-Sequence Overcurrent Elements for information on setting negative-sequence overcurrent elements.

Make the following settings if E51Q = Y.

Pickup (OFF, 0.25–16.00 A secondary [5 A nom.]; 0.05–3.20 A secondary [1 A nom.] in 0.01 A steps)	**51QP**	= ________
Curve (U1–U5, C1–C5; see *Figure 9.1*–*Figure 9.10*)	**51QC**	= ________
Time-Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5 in steps of 0.01)	**51QTD**	= ________
Electromechanical Reset Delay (Y, N)	**51QRS**	= ________

Out-of-Step Settings (See Figure 3.22 and Figure 3.23)

Make the following settings if preceding enable setting EOOS = Y.

Block Zone 1 (Y, N)	**OOSB1**	= ________
Block Zone 2 (Y, N)	**OOSB2**	= ________
Block Zone 3 (Y, N)	**OOSB3**	= ________
Block Zone 4 (Y, N)	**OOSB4**	= ________
Out-of-Step block time delay (0.5–8000.0 cycles in 0.25 cycle steps)	**OSBD**	= ________

NOTE: The OSBD timer must be greater than the OSTD timer by 0.5 cycles.

Enable Out-of-Step tripping (N, I, O)	**EOOST**	= ________
Out-of-Step trip delay (0.5–8000.0 cycles in 0.25 cycle steps)	**OSTD**	= ________
Zone 6 reactance—Top (0.05 to 96.00 Ω secondary [5 A nom.]; 0.25 to 480.00 Ω secondary [1 A nom.] in 0.01 Ω steps)	**X1T6**	= ________

Zone 5 reactance—Top (0.05 to 96.00 Ω secondary [5 A nom.]; 0.25 to 480.00 Ω secondary [1 A nom.] in 0.01 Ω steps)	**X1T5**	= ________
Zone 6 resistance—Right (0.05 to 70.00 Ω secondary [5 A nom.]; 0.25 to 350.00 Ω secondary [1 A nom.] in 0.01 Ω steps)	**R1R6**	= ________
Zone 5 resistance—Right (0.05 to 70.00 Ω secondary [5 A nom.]; 0.25 to 350.00 Ω secondary [1 A nom.] in 0.01 Ω steps)	**R1R5**	= ________
Zone 6 reactance—Bottom *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (–96.00 to –05.00 Ω secondary [5 A nom.]; –480.00 to –0.25 Ω secondary [1 A nom.] in 0.01 Ω steps)	**X1B6**	= ________
Zone 5 reactance—Bottom *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (–96.00 to –05.00 Ω secondary [5 A nom.]; –480.00 to –0.25 Ω secondary [1 A nom.] in 0.01 Ω steps)	**X1B5**	= ________
Zone 6 resistance—Left *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (–70.00 to –05.00 Ω secondary [5 A nom.]; –350.00 to –0.25 Ω secondary [1 A nom.] in 0.01 Ω steps)	**R1L6**	= ________
Zone 5 resistance—Left *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (–70.00 to –05.00 Ω secondary [5 A nom.]; –350.00 to –0.25 Ω secondary [1 A nom.] in 0.01 Ω steps)	**R1L5**	= ________
Positive-Sequence current supervision (1.00–100.00 A secondary [5 A nom.]; 0.20–20.00 A secondary [1 A nom.] in 0.01 A steps)	**50ABCP**	= ________
Negative-Sequence current unblock delay (0.5–120.0 cycles in 0.25 cycle steps)	**UBD**	= ________
Out-of-Step angle change unblock rate *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (1.00–10.00 unitless in steps of 0.01)	**UBOSBF**	= ________

Load-Encroachment Elements (see Figure 4.10)

Make the following settings if ELOAD = Y.

Forward load impedance (0.09–64.00 Ω secondary [5 A nom.] in 0.016 Ω steps) (0.45–320.00 Ω secondary [1 A nom.] in 0.078 Ω steps)	**ZLF**	= ________
Reverse load impedance (0.09–64.00 Ω secondary [5 A nom.] in 0.016 Ω steps) (0.45–320.00 Ω secondary [1 A nom.] in 0.078 Ω steps)	**ZLR**	= ________
Positive forward load angle (–90.00 to +90.00 degrees in 0.015 degree steps)	**PLAF**	= ________
Negative forward load angle (–90.00 to +90.00 degrees in 0.015 degree steps)	**NLAF**	= ________

Positive reverse load angle (+90.00 to +270.00 degrees in 0.015 degree steps) **PLAR** = ________

NOTE: PLAR must be less than or equal to NLAR.

Negative reverse load angle (+90.00 to +270.00 degrees in 0.015 degree steps) **NLAR** = ________

Zone/Level3 and 4 Directional Control

Zone/Level 3 direction: Forward, Reverse (F, R) **DIR3** = ________

NOTE: If ECOMM is enabled then DIR must be set to reverse.

Zone/Level 4 direction: Forward, Reverse (F, R) **DIR4** = ________

Directional Elements (see Directional Control Settings on page 4.29)

Ground directional element priority (combination of Q, V, I) **ORDER** = ________

NOTE: Option V is not available when PTCONN = DELTA and VSCONN = VS.

Make the following settings if E32 = Y. If E32 = AUTO, these settings are made automatically.

Forward directional Z2 threshold (–64.00–64.00 Ω secondary [5 A nom.] in 0.02 Ω steps) (–320.00–320.00 Ω secondary [1 A nom.] in 0.10 Ω steps) **Z2F** = ________

Reverse directional Z2 threshold (–64.00–64.00 Ω secondary [5 A nom.] in 0.02 Ω steps) (–320.00–320.00 Ω secondary [1 A nom.] in 0.10 Ω steps) **Z2R** = ________

NOTE: Z2R must be less than Z2F by at least 0.2 ohms (5 A nom.) or at least 1 ohm (1 A nom.)

Forward directional negative-sequence current pickup (0.25–5.00 A secondary [5 A nom.]; 0.05–1.00 A secondary [1 A nom.] in 0.01 A steps) **50QFP** = ________

Reverse directional negative-sequence current pickup (0.25–5.00 A secondary [5 A nom.]; 0.05–1.00 A secondary [1 A nom.] in 0.01 A steps) **50QRP** = ________

Positive-sequence current restraint factor, I2/I1 (0.02–0.50, unitless in steps of 0.01) **a2** = ________

Zero-sequence current restraint factor, I2/I0 (0.10–1.20, unitless in steps of 0.01) **k2** = ________

Make settings 50GFP, 50GRP, and a0 if E32 = Y and ORDER contains V or I. If E32 = AUTO and ORDER contains V or I, these settings are made automatically.

Forward directional residual ground pickup (0.25–5.00 A secondary [5 A nom.] 0.05–1.00 A secondary [1 A nom.] in 0.01 A steps) **50GFP** = ________

Reverse directional residual ground pickup (0.25–5.00 A secondary [5 A nom.]: 0.05–1.00 A secondary [1 A nom.] in 0.01 A steps) **50GRP** = ________

Positive-sequence current restraint factor, I0/I1 (0.020–0.500, unitless in steps of 0.01) **a0** = ________

Make settings Z0F and Z0R if E32 = Y and ORDER contains V. If E32 = AUTO and ORDER contains V, these settings are made automatically.

NOTE: Z0F and Z0R setting step size is 0.02 (5 A nominal), 0.10 A (1 A nominal).

Forward directional Z0 threshold (–64.00–64.00 Ω secondary [5 A nom.] in 0.02 Ω steps) (–320.00–320.00 Ω secondary [1 A nom.] in 0.10 Ω steps)	**Z0F**	= ________
Reverse directional Z0 threshold (–64.00–64.00 Ω secondary [5 A nom.] in 0.02 Ω steps) (–320.00–320.00 Ω secondary [1 A nom.] in 0.10 Ω steps)	**Z0R**	= ________

Voltage Elements (see Figure 3.34–Figure 3.38)

Make the following settings if EVOLT = Y and Global setting PTCONN = WYE.

Phase undervoltage pickup (OFF, 0.00–300.00 V secondary in 0.01 V steps)	**27P**	= ________
Phase overvoltage pickup (OFF, 0.00–300.00 V secondary in 0.01 V steps)	**59P**	= ________
Zero-sequence (3V0) overvoltage pickup (OFF, 0.00–300.00 V secondary, in 0.02 V steps)	**59N1P**	= ________
Zero-sequence (3V0) overvoltage pickup (OFF, 0.00–300.00 V secondary, in 0.02 V steps)	**59N2P**	= ________

Make the following settings if EVOLT = Y.

Negative-sequence (V2) overvoltage pickup (OFF, 0.00–200.00 V secondary in 0.01 V steps if PTCONN = WYE) (OFF, 0.00–120.00 V secondary in 0.01 V steps if PTCONN = DELTA)	**59QP**	= ________
Positive-sequence (V1) overvoltage pickup (OFF, 0.00–300.00 V secondary in 0.013 V steps if PTCONN = WYE) (OFF, 0.00–170.00 V secondary in 0.013 V steps if PTCONN = DELTA)	**59V1P**	= ________
Channel VS undervoltage pickup (OFF, 0.00–300.00 V secondary in 0.01 V steps)	**27SP**	= ________
Channel VS overvoltage pickup (OFF, 0.00–300.00 V secondary in 0.01 V steps)	**59SP**	= ________
Phase-to-phase undervoltage pickup (OFF, 0.00–520.00 V secondary in 0.02 V steps if PTCONN =WYE) (OFF, 0.00–300.00 V secondary in 0.01 V steps if PTCONN = DELTA)	**27PP**	= ________
Phase-to-phase overvoltage pickup (OFF, 0.00–520.00 V secondary in 0.02 V steps if PTCONN =WYE) (OFF, 0.00–300.00 V secondary in 0.01 V steps if PTCONN = DELTA)	**59PP**	= ________

Synchronism Check Elements (see Figure 3.39 and Figure 3.40)

Make the following settings if E25 = Y.

Voltage window—low threshold (0.00–300.00 V secondary in 0.01 V steps)	**25VLO**	= ________
Voltage window—high threshold (0.00–300.00 V secondary in 0.01 V steps)	**25VHI**	= ________
Voltage ratio correction factor (0.50–2.00 unitless in steps of 0.01)	**25RCF**	= ________
Maximum slip frequency (0.005–0.500 Hz in 0.001 Hz steps)	**25SF**	= ________
Maximum angle 1 (0–80 degrees in 1 degree steps)	**25ANG1**	= ________
Maximum angle 2 (0–80 degrees 1 degree steps)	**25ANG2**	= ________
Synchronizing phase	**SYNCP**	= ________

(Global setting PTCONN = WYE: VA, VB, VC or 0° to 330° in 30° steps; degree option is for VS not in phase with VA, VB, or VC—set with respect to VS constantly lagging VA)

(Global setting PTCONN = DELTA: VAB, VBC, VCA or 0° to 330° in 30° steps; degree option is for VS not in phase with VAB, VBC, or VCA—set with respect to VS constantly lagging VAB)

Breaker close time for angle compensation (0.00–60.00 cycles in 0.25-cycle steps)	**TCLOSD**	= ________

Frequency Elements (see Figure 3.45–Figure 3.46)

Make the following settings if E81 = 1–6.

Phase undervoltage block (20.00–300.00 V secondary in 0.01 V steps)	**27B81P**	= ________
Level 1 pickup (OFF, 40.10–65.00 Hz in 0.01 Hz steps)	**81D1P**	= ________
Level 1 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D1D**	= ________
Level 2 pickup (OFF, 40.10–65.00 Hz in 0.01 Hz steps)	**81D2P**	= ________
Level 2 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D2D**	= ________
Level 3 pickup (OFF, 40.10–65.00 Hz in 0.01 Hz steps)	**81D3P**	= ________
Level 3 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D3D**	= ________
Level 4 pickup (OFF, 40.10–65.00 Hz in 0.01 Hz steps)	**81D4P**	= ________
Level 4 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D4D**	= ________
Level 5 pickup (OFF, 40.10–65.00 Hz in 0.01 Hz steps)	**81D5P**	= ________
Level 5 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D5D**	= ________
Level 6 pickup (OFF, 40.10–65.00 Hz in 0.01 Hz steps)	**81D6P**	= ________
Level 6 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D6D**	= ________

Reclosing Relay (see Table 6.2)

Make the following settings if E79 = 1–4.

Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps)	**79OI1**	= ________
Open interval 2 time (0.00–999999.00 cycles in 0.25-cycle steps)	**79OI2**	= ________
Open interval 3 time (0.00–999999.00 cycles in 0.25-cycle steps)	**79OI3**	= ________
Open interval 4 time (0.00–999999.00 cycles in 0.25-cycle steps)	**79OI4**	= ________
Reset time from reclose cycle (0.00–999999.00 cycles in 0.25-cycle steps)	**79RSD**	= ________
Reset time from lockout (0.00–999999.00 cycles in 0.25-cycle steps)	**79RSLD**	= ________
Reclose supervision time limit (OFF, 0.00–999999.00 cycles in 0.25-cycle steps) (set 79CLSD = 0.00 for most applications; see *Figure 6.4*)	**79CLSD**	= ________

Switch-Onto-Fault (see Figure 5.3)

Make the following settings if ESOTF = Y.

Close enable time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)	**CLOEND**	= ________
52A enable time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)	**52AEND**	= ________
SOTF duration (0.50–16000.00 cycles in 0.25-cycle steps)	**SOTFD**	= ________

POTT Trip Scheme Settings (Also Used in DCUB Trip Schemes; see Figure 5.6)

Make the following settings if preceding enable setting ECOMM = POTT, DCUB1, or DCUB2.

Zone (level) 3 reverse block time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**Z3RBD**	= ________
Echo block time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)	**EBLKD**	= ________
Echo time delay pickup (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)	**ETDPU**	= ________
Echo duration time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**EDURD**	= ________
Weak-infeed enable (Y, N)	**EWFC**	= ________

Make settings 27PPW and 59NW if EWFC = Y and PTCONN = WYE.

WIF phase-to-phase undervoltage (0.00–520.00 V secondary in 0.02 V steps)	**27PPW**	= ________
WIF zero-sequence (3V0) overvoltage (0.00–300.00 V secondary in 0.02 V steps)	**59NW**	= ________

Make settings 27PPW and 59QW if EWFC = Y and PTCONN = DELTA.

WIF phase-to-phase undervoltage (0.00–300.00 V secondary in 0.01 V steps)	**27PPW**	= ________
WIF negative-sequence (V2) overvoltage (0.00–120.00 V secondary in 0.01 V steps)	**59QW**	= ________

Additional DCUB Trip Scheme Settings (See Figure 5.10)

Make the following settings if preceding enable setting ECOMM = DCUB1 or DCUB2.

Guard present security time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**GARD1D**	= ________
DCUB disabling time delay (0.25–16000.00 cycles in 0.25-cycle steps)	**UBDURD**	= ________
DCUB duration time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**UBEND**	= ________

DCB Trip Scheme Settings (See Figure 5.14)

Make the following settings if preceding enable setting ECOMM = DCB.

Zone (level) 3 reverse pickup time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**Z3XPU**	= ________
Zone (level) 3 reverse dropout extension (0.00–16000.00 cycles in 0.25-cycle steps)	**Z3XD**	= ________
Block trip receive extension (0.00–16000.00 cycles in 0.25-cycle steps)	**BTXD**	= ________
Zone 2 distance short delay (0.00–60.00 cycles in 0.25-cycle steps)	**21SD**	= ________
Level 2 overcurrent short delay (0.00–60.00 cycles in 0.25-cycle steps)	**67SD**	= ________

Channel A Mirrored Bits® Settings

These settings are available when a Serial Port Protocol Setting has been set to MBGA.

Channel A Mirrored Bits Enable (Y, N)	**EMBA**	= ________
Channel A Mirrored Bits Receive ID (1–4)	**RXIDA**	= ________
Channel A Mirrored Bits Transmit ID (1–4)	**TXIDA**	= ________

Channel B Mirrored Bits Settings

These settings are available when a Serial Port Protocol Setting has been set to MBGB.

Channel B Mirrored Bits Enable (Y, N)	**EMBB**	= ________
Channel B Mirrored Bits Receive ID (1–4)	**RXIDB**	= ________
Channel B Mirrored Bits Transmit ID (1–4)	**TXIDB**	= ________

Zone 1 Extension Scheme Settings (See Figure 3.19)

Make setting Z1EXTD if EZ1EXT = Y, or if EZ1EXT = I and either EX1EXTP or EZ1EXTG = Y.

Zone 1 extension delay time (0.00–16000.00 cycles in 0.25-cycle steps)	**Z1EXTD**	= ________

Make setting Z1EXTM if EZ1EXT = Y.

Zone 1 common distance multiplier (1.00–4.00 in steps of 0.01)	**Z1EXTM**	= ________

Make settings Z1EXTMP and Z1EXTMG if EZ1EXT = I.

Zone 1 phase distance multiplier (1.00–4.00 in steps of 0.01)	**Z1EXTMP**	= ________

Make setting Z1EXTMG if PTCONN = WYE.

Zone 1 ground distance multiplier (1.00–4.00 in steps of 0.01)	**Z1EXTMG**	= ________

Demand Metering Settings (see Figure 8.11 and Figure 8.13)

Make the following settings, whether preceding enable setting EDEM = THM or ROL.

Time constant (5, 10, 15, 30, 60 minutes)	**DMTC**	= ________
Phase pickup (OFF, 0.50–16.00 A secondary [5 A nom.]; 0.10–3.20 A secondary [1 A nom.] in 0.01 A steps)	**PDEMP**	= ________
Neutral ground pickup-channel **IN** (OFF, 0.500–16.000 A secondary in 0.005 A steps [5 A nom.]; 0.100–3.200 A secondary in 0.001 A steps [1 A nom.])	**NDEMP**	= ________
Residual ground pickup (OFF, 0.10–16.00 A secondary [5 A nom.]; 0.02–3.20 A secondary [1 A nom.] in 0.01 A steps)	**GDEMP**	= ________
Negative-sequence pickup (OFF, 0.50–16.00 A secondary [5 A nom.]; 0.10–3.20 A secondary [1 A nom.] in 0.01 A steps)	**QDEMP**	= ________

Other Settings

Minimum trip duration time (2.00–16000.00 cycles in 0.25-cycle steps; see *Figure 5.1*)	**TDURD**	= ________
Close failure time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) (see *Figure 6.3*)	**CFD**	= ________
Three-pole open time delay (0.00–60.00 cycles in 0.25-cycle steps) (usually set for no more than a few cycles; see *Figure 5.3*)	**3POD**	= ________
Open pole option (52, 27)	**OPO**	= ________
Three-pole open undervoltage (0.0–150.0 V secondary in 0.013 V steps)	**27PO**	= ________
Load detection phase pickup (OFF, 0.25–100.00 A secondary [5 A nom.] 0.05–20.00 A secondary [1 A nom.] in 0.01 A steps) (see *Figure 5.3*)	**50LP**	= ________

SELOGIC Control Equation Variable Timers (see Figure 7.24 and Figure 7.25)

The number of timer pickup/dropout settings is dependent on ESV = 1–16.

SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1PU**	= ________
SV1 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1DO**	= ________
SV2 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2PU**	= ________
SV2 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2DO**	= ________
SV3 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3PU**	= ________
SV3 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3DO**	= ________
SV4 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4PU**	= ________
SV4 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4DO**	= ________
SV5 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5PU**	= ________
SV5 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5DO**	= ________
SV6 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6PU**	= ________
SV6 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6DO**	= ________
SV7 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7PU**	= ________
SV7 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7DO**	= ________
SV8 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8PU**	= ________
SV8 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8DO**	= ________
SV9 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9PU**	= ________
SV9 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9DO**	= ________
SV10 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10PU**	= ________
SV10 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10DO**	= ________
SV11 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11PU**	= ________
SV11 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11DO**	= ________
SV12 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12PU**	= ________
SV12 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12DO**	= ________
SV13 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13PU**	= ________
SV13 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13DO**	= ________
SV14 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14PU**	= ________
SV14 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14DO**	= ________
SV15 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15PU**	= ________

SV15 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15DO**	= ________
SV16 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16PU**	= ________
SV16 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16DO**	= ________

SELOGIC Control Equation Settings (Serial Port Command SET L)

SELOGIC control equation settings consist of Relay Word bits (see Table D.2) and SELOGIC control equation operators * (AND), + (OR), ! (NOT), / (rising edge), \ (falling edge), and ( ) (parentheses). Numerous SELOGIC control equation settings examples are given in Section 3: Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements-Section 8: Metering and Monitoring. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). Appendix F: Setting SELOGIC Control Equations gives SELOGIC control equation details, examples, and limitations.

Trip Logic Equations (see Figure 5.1)

Other trip conditions	**TR**	= ________________
Trip conditions qualified by disturbance detection	**TRQUAL**	= ________________
Communications-assisted trip conditions	**TRCOMM**	= ________________
Switch-onto-fault trip conditions	**TRSOTF**	= ________________
Direct transfer trip conditions	**DTT**	= ________________
Unlatch trip conditions	**ULTR**	= ________________

Communications-Assisted Trip Scheme Input Equations

Permissive trip 1 (used for ECOMM = POTT, DCUB1, or DCUB2; see *Figure 5.5*, *Figure 5.7*, and *Figure 5.10*)	**PT1**	= ________________
Loss-of-guard 1 (used for ECOMM = DCUB1 or DCUB2; see *Figure 5.10*)	**LOG1**	= ________________
Permissive trip 2 (used for ECOMM = DCUB2; see *Figure 5.5* and *Figure 5.10*)	**PT2**	= ________________
Loss of guard 2 (used for ECOMM = DCUB2; see *Figure 5.10*)	**LOG2**	= ________________
Block trip (used for ECOMM = DCB; see *Figure 5.14*)	**BT**	= ________________

Close Logic Equations (see Figure 6.3)

Circuit breaker status (see *Figure 6.2*)	**52A**	= ________________
Close conditions (other than automatic reclosing or **CLOSE** command)	**CL**	= ________________
Unlatch close conditions	**ULCL**	= ________________

Reclosing Relay Equations (see Reclosing Relay on page 6.11)

Reclose initiate	**79RI**	=	______________
Reclose initiate supervision	**79RIS**	=	______________
Drive-to-lockout	**79DTL**	=	______________
Drive-to-last shot	**79DLS**	=	______________
Skip shot	**79SKP**	=	______________
Stall open interval timing	**79STL**	=	______________
Block reset timing	**79BRS**	=	______________
Sequence coordination	**79SEQ**	=	______________
Reclose supervision (see *Figure 6.4*)	**79CLS**	=	______________

Latch Bits Set/Reset Equations (see Figure 7.12)

Set Latch Bit LT1	**SET1**	=	______________
Reset Latch Bit LT1	**RST1**	=	______________
Set Latch Bit LT2	**SET2**	=	______________
Reset Latch Bit LT2	**RST2**	=	______________
Set Latch Bit LT3	**SET3**	=	______________
Reset Latch Bit LT3	**RST3**	=	______________
Set Latch Bit LT4	**SET4**	=	______________
Reset Latch Bit LT4	**RST4**	=	______________
Set Latch Bit LT5	**SET5**	=	______________
Reset Latch Bit LT5	**RST5**	=	______________
Set Latch Bit LT6	**SET6**	=	______________
Reset latch Bit LT6	**RST6**	=	______________
Set Latch Bit LT7	**SET7**	=	______________
Reset Latch Bit LT7	**RST7**	=	______________
Set Latch Bit LT8	**SET8**	=	______________
Reset Latch Bit LT8	**RST8**	=	______________
Set Latch Bit LT9	**SET9**	=	______________
Reset Latch Bit LT9	**RST9**	=	______________
Set Latch Bit LT10	**SET10**	=	______________
Reset Latch Bit LT10	**RST10**	=	______________
Set Latch Bit LT11	**SET11**	=	______________

Reset Latch Bit LT11	**RST11**	=	________________
Set Latch Bit LT12	**SET12**	=	________________
Reset Latch Bit LT12	**RST12**	=	________________
Set Latch Bit LT13	**SET13**	=	________________
Reset Latch Bit LT13	**RST13**	=	________________
Set Latch Bit LT14	**SET14**	=	________________
Reset latch Bit LT14	**RST14**	=	________________
Set Latch Bit LT15	**SET15**	=	________________
Reset Latch Bit LT15	**RST15**	=	________________
Set Latch Bit LT16	**SET16**	=	________________
Reset Latch Bit LT16	**RST16**	=	________________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements

NOTE: Torque control equation settings cannot be set directly to logical 0.

Level 1 phase (see *Figure 3.25*)	**67P1TC**	=	________________
Level 2 phase (see *Figure 3.25*)	**67P2TC**	=	________________
Level 3 phase (see *Figure 3.25*)	**67P3TC**	=	________________
Level 4 phase (see *Figure 3.25*)	**67P4TC**	=	________________
Level 1 residual ground (see *Figure 3.29*)	**67G1TC**	=	________________
Level 2 residual ground (see *Figure 3.29*)	**67G2TC**	=	________________
Level 3 residual ground (see *Figure 3.29*)	**67G3TC**	=	________________
Level 4 residual ground (see *Figure 3.29*)	**67G4TC**	=	________________
Level 1 negative-sequence (see *Figure 3.30*)	**67Q1TC**	=	________________
Level 2 negative-sequence (see *Figure 3.30*)	**67Q2TC**	=	________________
Level 3 negative-sequence (see *Figure 3.30*)	**67Q3TC**	=	________________
Level 4 negative-sequence (see *Figure 3.30*)	**67Q4TC**	=	________________

Torque Control Equations for Time-Overcurrent Elements

NOTE: Torque control equation settings cannot be set directly to logical 0.

Phase (see *Figure 3.31*)	**51PTC**	=	________________
Residual Ground (see *Figure 3.32*)	**51GTC**	=	________________
Negative-Sequence (see *Figure 3.33*)	**51QTC**	=	________________

Logic Variable Equations (see Figure 7.27)

Logic Variable LV1	**LV1**	=	________
Logic Variable LV2	**LV2**	=	________
Logic Variable LV3	**LV3**	=	________
Logic Variable LV4	**LV4**	=	________
Logic Variable LV5	**LV5**	=	________
Logic Variable LV6	**LV6**	=	________
Logic Variable LV7	**LV7**	=	________
Logic Variable LV8	**LV8**	=	________
Logic Variable LV9	**LV9**	=	________
Logic Variable LV10	**LV10**	=	________
Logic Variable LV11	**LV11**	=	________
Logic Variable LV12	**LV12**	=	________
Logic Variable LV13	**LV13**	=	________
Logic Variable LV14	**LV14**	=	________
Logic Variable LV15	**LV15**	=	________
Logic Variable LV16	**LV16**	=	________
Logic Variable LV17	**LV17**	=	________
Logic Variable LV18	**LV18**	=	________
Logic Variable LV19	**LV19**	=	________
Logic Variable LV20	**LV20**	=	________
Logic Variable LV21	**LV21**	=	________
Logic Variable LV22	**LV22**	=	________
Logic Variable LV23	**LV23**	=	________
Logic Variable LV24	**LV24**	=	________
Logic Variable LV25	**LV25**	=	________
Logic Variable LV26	**LV26**	=	________
Logic Variable LV27	**LV27**	=	________
Logic Variable LV28	**LV28**	=	________
Logic Variable LV29	**LV29**	=	________
Logic Variable LV30	**LV30**	=	________
Logic Variable LV31	**LV31**	=	________
Logic Variable LV32	**LV32**	=	________

Date ___________
Group___________

SELOGIC Control Equation Variable Timer Input Equations (see Figure 7.24 and Figure 7.25)

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

Output Contact Equations (see Figure 7.28)

Output Contact **OUT101**	**OUT101**	= ____________
Output Contact **OUT102**	**OUT102**	= ____________
Output Contact **OUT103**	**OUT103**	= ____________
Output Contact **OUT104**	**OUT104**	= ____________
Output Contact **OUT105**	**OUT105**	= ____________
Output Contact **OUT106**	**OUT106**	= ____________
Output Contact **OUT107**	**OUT107**	= ____________

Output Contact Equations—Extra I/O Board (see Figure 7.29)

Output Contact **OUT201**	**OUT201**	= ____________
Output Contact **OUT202**	**OUT202**	= ____________
Output Contact **OUT203**	**OUT203**	= ____________
Output Contact **OUT204**	**OUT204**	= ____________

Output Contact OUT205	**OUT205**	=	________
Output Contact OUT206	**OUT206**	=	________
Output Contact OUT207	**OUT207**	=	________
Output Contact OUT208	**OUT208**	=	________
Output Contact OUT209	**OUT209**	=	________
Output Contact OUT210	**OUT210**	=	________
Output Contact OUT211	**OUT211**	=	________
Output Contact OUT212	**OUT212**	=	________

Operator Control LED Equations (only on models with Programmable Operator Controls; see Figure 11.9)

LED1 (TOP LEFT)	**LED1**	=	________
LED2	**LED2**	=	________
LED3	**LED3**	=	________
LED4	**LED4**	=	________
LED5 (BOTTOM LEFT)	**LED5**	=	________
LED6 (TOP RIGHT)	**LED6**	=	________
LED7	**LED7**	=	________
LED8	**LED8**	=	________
LED9	**LED9**	=	________
LED10 (BOTTOM RIGHT)	**LED10**	=	________

Target Equations (only on models with Programmable Target Logic; see Table 5.3)

LED12 (TRIP)	**LED12**	=	________
LED13 (TIME)	**LED13**	=	________
LED14 (COMM)	**LED14**	=	________
LED15 (SOTF)	**LED15**	=	________
LED16 (RESET)	**LED16**	=	________
LED17 (LOCKOUT)	**LED17**	=	________
LED18 (51)	**LED18**	=	________
LED23 (ZONE 1)	**LED23**	=	________

Date ___________
Group___________

LED24 (ZONE 2)	**LED24**	=	____________
LED25 (ZONE 3)	**LED25**	=	____________
LED26 (ZONE 4)	**LED26**	=	____________

Display Point Equations (only on models with LCD; see Rotating Display on page 7.37 and Rotating Display on page 11.11)

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**	=	____________
Display Point DP9	**DP9**	=	____________
Display Point DP10	**DP10**	=	____________
Display Point DP11	**DP11**	=	____________
Display Point DP12	**DP12**	=	____________
Display Point DP13	**DP13**	=	____________
Display Point DP14	**DP14**	=	____________
Display Point DP15	**DP15**	=	____________
Display Point DP16	**DP16**	=	____________

Setting Group Selection Equations (see Table 7.4)

Select Setting Group 1	**SS1**	=	____________
Select Setting Group 2	**SS2**	=	____________
Select Setting Group 3	**SS3**	=	____________
Select Setting Group 4	**SS4**	=	____________
Select Setting Group 5	**SS5**	=	____________
Select Setting Group 6	**SS6**	=	____________

Other Equations

Event report trigger conditions (see *Section 12: Standard Event Reports and SER*)	**ER**	=	____________
Fault indication (used in INST, A, B, and C target logic and other relay functions, see *SELOGIC Control Equation Setting FAULT on page 5.43*)	**FAULT**	=	____________

Block synchronism check elements (see *Figure 3.39*)	**BSYNCH**	= ________________
Close bus monitor (see *Figure 5.3*)	**CLMON**	= ________________
Breaker monitor initiation (see *Figure 8.3*)	**BKMON**	= ________________
Enable for zero-sequence voltage-polarized and channel IN current-polarized directional elements (see *Figure 4.14*)	**E32IV**	= ________________
Zone 1 phase distance extension external control	**Z1XPEC**	= ________________
Zone 1 ground distance extension external control	**Z1XGEC**	= ________________

Reset Equations (see Section 5, Section 8, and Section 12)

Reset Targets	**RSTTRGT**	= ________________
Reset Demand Metering	**RST_DEM**	= ________________
Reset Peak Demand Metering	**RST_PDM**	= ________________
Reset Breaker Monitor	**RST_BK**	= ________________
Reset Event History	**RST_HIS**	= ________________
Reset Energy Metering	**RST_ENE**	= ________________
Reset Max/Min Metering	**RST_MML**	= ________________

Phasor Measurement Unit (PMU) Trigger Equations (see Appendix N)

PMU Trigger	**PMTRIG**	= ________________
Trigger Reason Bit 1	**TREA1**	= ________________
Trigger Reason Bit 2	**TREA2**	= ________________
Trigger Reason Bit 3	**TREA3**	= ________________
Trigger Reason Bit 4	**TREA4**	= ________________

MIRRORED BITS Transmit Equations (see Appendix H)

Channel A, transmit bit 1	**TMB1A**	= ________________
Channel A, transmit bit 2	**TMB2A**	= ________________
Channel A, transmit bit 3	**TMB3A**	= ________________
Channel A, transmit bit 4	**TMB4A**	= ________________
Channel A, transmit bit 5	**TMB5A**	= ________________
Channel A, transmit bit 6	**TMB6A**	= ________________
Channel A, transmit bit 7	**TMB7A**	= ________________
Channel A, transmit bit 8	**TMB8A**	= ________________
Channel B, transmit bit 1	**TMB1B**	= ________________
Channel B, transmit bit 2	**TMB2B**	= ________________

Channel B, transmit bit 3	**TMB3B**	=	___
Channel B, transmit bit 4	**TMB4B**	=	___
Channel B, transmit bit 5	**TMB5B**	=	___
Channel B, transmit bit 6	**TMB6B**	=	___
Channel B, transmit bit 7	**TMB7B**	=	___
Channel B, transmit bit 8	**TMB8B**	=	___

Report Settings (Serial Port Command SET R)

Sequential Events Recorder (SER) Trigger Lists (see Standard Event Reports and SER on page 12.1)

Sequential Events Recorder settings are comprised of three trigger lists. Each trigger list can include up to 24 Relay Word bits (see Table D.2) delimited by commas or spaces. Enter NA to remove a list of these Relay Word bit settings.

SER Trigger List 1
SER1 = ___

SER Trigger List 2
SER2 = ___

SER Trigger List 3
SER3 = ___

Text Label Settings (Serial Port Command SET T)

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 (see Table 7.1 and Table 7.2)

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**	=	________
Local Bit LB9 Name (14 characters)	**NLB9**	=	________
Clear Local Bit LB9 Label (7 characters)	**CLB9**	=	________
Set Local Bit LB9 Label (7 characters)	**SLB9**	=	________
Pulse Local Bit LB9 Label (7 characters)	**PLB9**	=	________

Local Bit LB10 Name (14 characters)	**NLB10**	=	______
Clear Local Bit LB10 Label (7 characters)	**CLB10**	=	______
Set Local Bit LB10 Label (7 characters)	**SLB10**	=	______
Pulse Local Bit LB10 Label (7 characters)	**PLB10**	=	______
Local Bit LB11 Name (14 characters)	**NLB11**	=	______
Clear Local Bit LB11 Label (7 characters)	**CLB11**	=	______
Set Local Bit LB11 Label (7 characters)	**SLB11**	=	______
Pulse Local Bit LB11 Label (7 characters)	**PLB11**	=	______
Local Bit LB12 Name (14 characters)	**NLB12**	=	______
Clear Local Bit LB12 Label (7 characters)	**CLB12**	=	______
Set Local Bit LB12 Label (7 characters)	**SLB12**	=	______
Pulse Local Bit LB12 Label (7 characters)	**PLB12**	=	______
Local Bit LB13 Name (14 characters)	**NLB13**	=	______
Clear Local Bit LB13 Label (7 characters)	**CLB13**	=	______
Set Local Bit LB13 Label (7 characters)	**SLB13**	=	______
Pulse Local Bit LB13 Label (7 characters)	**PLB13**	=	______
Local Bit LB14 Name (14 characters)	**NLB14**	=	______
Clear Local Bit LB14 Label (7 characters)	**CLB14**	=	______
Set Local Bit LB14 Label (7 characters)	**SLB14**	=	______
Pulse Local Bit LB14 Label (7 characters)	**PLB14**	=	______
Local Bit LB15 Name (14 characters)	**NLB15**	=	______
Clear Local Bit LB15 Label (7 characters)	**CLB15**	=	______
Set Local Bit LB15 Label (7 characters)	**SLB15**	=	______
Pulse Local Bit LB15 Label (7 characters)	**PLB15**	=	______
Local Bit LB16 Name (14 characters)	**NLB16**	=	______
Clear Local Bit LB16 Label (7 characters)	**CLB16**	=	______
Set Local Bit LB16 Label (7 characters)	**SLB16**	=	______
Pulse Local Bit LB16 Label (7 characters)	**PLB16**	=	______

Display Point Labels (only on models with LCD; see Rotating Display on page 7.37 and Rotating Display on page 11.11)

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**	=	________
Display if DP9 = logical 1 (16 characters)	**DP9_1**	=	________
Display if DP9 = logical 0 (16 characters)	**DP9_0**	=	________
Display if DP10 = logical 1 (16 characters)	**DP10_1**	=	________
Display if DP10 = logical 0 (16 characters)	**DP10_0**	=	________
Display if DP11 = logical 1 (16 characters)	**DP11_1**	=	________
Display if DP11 = logical 0 (16 characters)	**DP11_0**	=	________
Display if DP12 = logical 1 (16 characters)	**DP12_1**	=	________
Display if DP12 = logical 0 (16 characters)	**DP12_0**	=	________
Display if DP13 = logical 1 (16 characters)	**DP13_1**	=	________
Display if DP13 = logical 0 (16 characters)	**DP13_0**	=	________
Display if DP14 = logical 1 (16 characters)	**DP14_1**	=	________
Display if DP14 = logical 0 (16 characters)	**DP14_0**	=	________
Display if DP15 = logical 1 (16 characters)	**DP15_1**	=	________
Display if DP15 = logical 0 (16 characters)	**DP15_0**	=	________
Display if DP16 = logical 1 (16 characters)	**DP16_1**	=	________
Display if DP16 = logical 0 (16 characters)	**DP16_0**	=	________

Reclosing Relay Labels (see Functions Unique to the Front-Panel Interface on page 11.5)

Reclosing Relay Last Shot Label (14 char.)	**79LL**	=	________
Reclosing Relay Shot Counter Label (14 char.)	**79SL**	=	________

Port n Settings (for Serial Ports 1, 2, 3 and F Serial Port SET P n Command and Front Panel)

Make Port 1 settings only if the relay is ordered with the optional EIA-485 port.

Port Enable Settings

Enable Port (Y, N)	**EPORT**	= ________

NOTE: Setting EPORT = N completely disables the serial port, and hides all remaining port settings.

NOTE: The front-panel (Port F) EPORT setting controls both the EIA-232 serial port and the optional USB port.

NOTE: If the Password Jumper is not installed when EPORT is set to "N" on the front port and all other ports are disabled, or MAXACC < 2 on all enabled ports, the port can only be re-enabled via the HMI or by installing the Password Jumper and cycling power.

Protocol Selection

Protocol (SEL, LMD, DNP, MOD, MBA, MBB, MB8A, MB8B, MBGA, MBGB, PMU)	**PROTO**	= ________

NOTE: Modbus® protocol (PROTO = MOD) cannot be selected for the front-panel serial port (Port F).

Set PROTO = SEL for standard SEL ASCII protocol. Refer to Section 10: Communications for details on SEL ASCII protocol.

Set PROTO = LMD for SEL Distributed Port Switch Protocol (LMD). Refer to Appendix I: SEL Distributed Port Switch Protocol for details on the LMD protocol.

Set PROTO = DNP for Distributed Network Protocol (DNP). Up to six DNP sessions are available, shared between the serial ports and the Ethernet port. Refer to Appendix L: DNP3 Communications for details on DNP protocol.

Set PROTO = MOD for Modbus communications. Up to three Modbus sessions are available, shared between the serial ports and the Ethernet port. Refer to Appendix O: Modbus RTU and TCP Communications for details on Modbus protocol.

Set PROTO = MBA, MBB, MB8A, MB8B, MBGA, or MBGB for MIRRORED BITS. Only one port can be set to MBA, MB8A, or MBGA at a time. Only one port can be set to MBB, MB8B, or MBGB at a time. Refer to Appendix H: MIRRORED BITS Communications for details on MIRRORED BITS.

Set PROTO = PMU for IEEE C37.118 Synchrophasors. You must first make Global setting EPMU = Y and MFRMT = C37.118 to make this setting available. For SEL Fast Message Synchrophasors (MFRMT = FM), use PROTO = SEL instead. See Appendix N: Synchrophasors for details.

Make the following setting when PROTO = SEL or LMD on Port 1, 2, or 3.

Maximum Access Level (1, B, 2)	**MAXACC**	= ________

NOTE: The MAXACC setting controls the availability of **ACC**, **BAC**, and **2AC** commands on this port.

NOTE: MAXACC for Port F (only) can be set to 1, B, 2, or C, where C is the Calibration access level, command **CAL**, and affects both serial port F and the optional USB port.

SEL Protocol Settings

Make the following settings when PROTO = SEL.

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400, 57600)	**SPEED**	= ________
Data Bits (6, 7, 8)	**BITS**	= ________
Parity (O, E, N) {Odd, Even, None}	**PARITY**	= ________
Stop Bits (1, 2)	**STOP**	= ________
Enable Hardware Handshaking (Y, N)	**RTSCTS**	= ________

Set RTSCTS = Y to enable hardware handshaking. With RTSCTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line (see Hardware Handshaking on page 10.10).

NOTE: The RTSCTS setting is not available on Port 1.

Minutes to Port Time-out (0–30 minutes)	**T_OUT**	= ________

Set T_OUT to the number of minutes of serial port inactivity for an automatic log out. Set T_OUT = 0 for no port time out.

Send Auto Messages to Port (Y, N, DTA)	**AUTO**	= ________

Set AUTO = Y to allow automatic messages at the serial port. Set AUTO = DTA to use the serial port with an SEL-DTA2 Display/Transducer Adapter. See Serial Port and Telnet Session Automatic Messages on page 10.20.

Fast Operate Enable (Y, N)	**FASTOP**	= ________

Set FASTOP = Y to enable binary Fast Operate messages at the serial port. Set FASTOP = N to block binary Fast Operate messages. Refer to Appendix J: Configuration, Fast Meter, and Fast Operate Commands for the description of the SEL-311C Relay Fast Operate commands.

SEL LMD Protocol Settings

Make the following settings when PROTO = LMD.

LMD Prefix (@, #, $, %, &)	**PREFIX**	= ________
LMD Address (1–99)	**ADDR**	= ________
LMD Settling Time (0.00–30.00 seconds)	**SETTLE**	= ________
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400, 57600)	**SPEED**	= ________
Data Bits (6, 7, 8)	**BITS**	= ________
Parity (O, E, N) {Odd, Even, None}	**PARITY**	= ________
Stop Bits (1, 2)	**STOP**	= ________
Minutes to Port Time-out (0–30 minutes)	**T_OUT**	= ________

Set T_OUT to the number of minutes of serial port inactivity for an automatic log out. Set T_OUT = 0 for no port time out.

Send Auto Messages to Port (Y, N, DTA) **AUTO** = ________

Set AUTO = Y to allow automatic messages at the serial port. Set AUTO = DTA to use the serial port with an SEL-DTA2 Display/Transducer Adapter. See Serial Port and Telnet Session Automatic Messages on page 10.20.

Fast Operate Enable (Y, N) **FASTOP** = ________

Set FASTOP = Y to enable binary Fast Operate messages at the serial port. Set FASTOP = N to block binary Fast Operate messages. Refer to Appendix J: Configuration, Fast Meter, and Fast Operate Commands for the description of the SEL-311C Relay Fast Operate commands.

PMU Protocol Port Settings

Make the following settings when PROTO = PMU.

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400, 57600) **SPEED** = ________

NOTE: Global Synchrophasor settings for message size and rate may restrict the minimum SPEED setting. See Appendix N: Synchrophasors for details.

Stop Bits (1, 2) **STOP** = ________

Enable Hardware Handshaking (Y, N) **RTSCTS** = ________

Set RTSCTS = Y to enable hardware handshaking. With RTSCTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line (see Hardware Handshaking on page 10.10).

NOTE: The RTSCTS setting is not available on Port 1.

Fast Operate Enable (Y, N) **FASTOP** = ________

Set FASTOP = Y to enable binary Fast Operate messages at the serial port. Set FASTOP = N to block binary Fast Operate messages. Refer to Appendix J: Configuration, Fast Meter, and Fast Operate Commands for the description of the SEL-311C Relay Fast Operate commands.

SEL MIRRORED BITS Protocol Settings

Make the following settings when PROTO = MBA, MBB, MB8A, MB8B, MBGA, MBGB.

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400, 57600) **SPEED** = ________

Enable Hardware Handshaking (N, MBT) **RTSCTS** = ________

See Appendix H: MIRRORED BITS Communications for information on the MBT setting choice.

NOTE: The RTSCTS setting is not available on Port 1. The MBT setting option is only available when PROTO = MBA or MBB and SPEED = 9600.

NOTE: Settings TXID and RXID are not available if PROTO = MBGA or MBGB.

MIRRORED BITS Transmit Identifier (1–4) **TXID** = ________

MIRRORED BITS Receive Identifier (1–4) **RXID** = ________

NOTE: Settings TXID and RXID cannot be the same.

MIRRORED BITS Rx Bad Pickup Time (1–10000 seconds) **RBADPU** = ________

PPM MIRRORED BITS Channel Bad Pickup (1–10000) **CBADPU** = ________

MIRRORED BITS Receive Default String (string of 1s, 0s, or Xs) **RXDFLT** = ________
Display order: 87654321

MIRRORED BITS RMB1 Pickup Debounce Message	**RMB1PU**	=	________
MIRRORED BITS RMB1 Dropout Debounce Message	**RMB1DO**	=	________
MIRRORED BITS RMB2 Pickup Debounce Message	**RMB2PU**	=	________
MIRRORED BITS RMB2 Dropout Debounce Message	**RMB2DO**	=	________
MIRRORED BITS RMB3 Pickup Debounce Message	**RMB3PU**	=	________
MIRRORED BITS RMB3 Dropout Debounce Message	**RMB3DO**	=	________
MIRRORED BITS RMB4 Pickup Debounce Message	**RMB4PU**	=	________
MIRRORED BITS RMB4 Dropout Debounce Message	**RMB4DO**	=	________
MIRRORED BITS RMB5 Pickup Debounce Message	**RMB5PU**	=	________
MIRRORED BITS RMB5 Dropout Debounce Message	**RMB5DO**	=	________
MIRRORED BITS RMB6 Pickup Debounce Message	**RMB6PU**	=	________
MIRRORED BITS RMB6 Dropout Debounce Message	**RMB6DO**	=	________
MIRRORED BITS RMB7 Pickup Debounce Message	**RMB7PU**	=	________
MIRRORED BITS RMB7 Dropout Debounce Message	**RMB7DO**	=	________
MIRRORED BITS RMB8 Pickup Debounce Message	**RMB8PU**	=	________
MIRRORED BITS RMB8 Dropout Debounce Message	**RMB8DO**	=	________

See Appendix H: MIRRORED BITS Communications for full settings explanations and other required settings.

DNP Settings

Make the following settings when PROTO = DNP.

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400, 57600)	**SPEED**	=	________
Parity (O, E, N) {Odd, Even, None}	**PARITY**	=	________
Stop Bits (1, 2)	**STOP**	=	________
DNP Address (0–65519)	**DNPADR**	=	________
DNP Address to Report to (0–65519)	**REPADR**	=	________
DNP Session Map (1–3)	**DNPMAP**	=	________
Analog Input Default Variation (1–6)	**DVARAI**	=	________
Class for Binary Event Data (0–3)	**ECLASSB**	=	________
Class for Counter Event Data (0–3)	**ECLASSC**	=	________
Class for Analog Event Data (0–3)	**ECLASSA**	=	________
Currents Scaling Decimal Places (0–3)	**DECPLA**	=	________
Voltages Scaling Decimal Places (0–3)	**DECPLV**	=	________
Miscellaneous Data Scaling Decimal Places (0–3)	**DECPLM**	=	________

Make the following two settings when ECLASSA > 0.

Amps Reporting Deadband Counts (0–32767)	**ANADBA**	= ________
Volts Reporting Deadband Counts (0–32767)	**ANADBV**	= ________

Make the following setting when ECLASSA > 0 or ECLASSC > 0.

Miscellaneous Data Reporting Deadband Counts (0–32767)	**ANADBM**	= ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ**	= ________

NOTE: TIMERQ = I: Disables time sync requests and ignores syncs from master.

NOTE: TIMERQ = M: Disables time sync requests and processes time syncs from master.

NOTE: TIMERQ = m = 1-32767: Relay requests a time sync every m minutes.

Seconds to Select/Operate Time-out (0.0–30.0)	**STIMEO**	= ________
Data Link Retries (0–15)	**DRETRY**	= ________

Make the following setting when DRETRY > 0.

Seconds to Data Link Time-out (0–5)	**DTIMEO**	= ________
Event Message Confirm Time-out (1–50 seconds)	**ETIMEO**	= ________

Make the following setting when ECLASSB > 0, ECLASSC > 0 or ECLASSA > 0.

Enable Unsolicited Reporting (Y, N)	**UNSOL**	= ________

Make the following five settings when UNSOL = Y.

Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL**	= ________
Number of Events to Transmit On (1–200)	**NUM1EVE**	= ________
Oldest Event to Transmit On (0.0–99999.0 seconds)	**AGE1EVE**	= ________
Unsolicited Message Maximum Retry Attempts (2–10)	**URETRY**	= ________
Unsolicited Message Offline Time-out (1–5000 seconds)	**UTIMEO**	= ________

NOTE: UTIMEO must be greater than ETIMEO.

Minimum Seconds from DCD to Transmit (0.00–1.00)	**MINDLY**	= ________
Maximum Seconds from DCD to Transmit (0.00–1.00)	**MAXDLY**	= ________

NOTE: MAXDLY must be greater than MINDLY.

Settle Time from RTS ON to Transmit (OFF, 0.00–30.00 seconds)	**PREDLY**	= ________

Make the following setting when PREDLY ≠ OFF.

Settle Time from Transmit to RTS OFF (0.00–30.00 seconds)	**PSTDLY**	= ________

See Appendix L: DNP3 Communications for full settings explanations and other required settings.

Modbus Protocol Settings

Make the following settings when PROTO = MOD.

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400, 57600)	**SPEED**	= ________
Parity (O, E, N) {Odd, Even, None}	**PARITY**	= ________
Modbus Slave ID (1–247)	**SLAVEID**	= ________

See Appendix O: Modbus RTU and TCP Communications for full settings explanations and other required settings.

Port 5 Settings (for Ethernet Port 5, or 5A and 5B) (Serial Port SET P 5 Command)

Port Enable Setting

Enable Port (Y, N)	**EPORT**	= ________

NOTE: Setting EPORT = N completely disables the Ethernet port, and hides all remaining port settings.

Ethernet Port Settings

Device IP Address (zzz.yyy.xxx.www)	**IPADDR**	= ________________
Subnet Mask (zzz.yyy.xxx.www)	**SUBNETM**	= ________________
Default Router (zzz.yyy.xxx.www)	**DEFRTR**	= ________________

NOTE: Setting DEFRTR = 0.0.0.0 acts to disable the default router.

Enable TCP Keep-Alive (Y, N)	**ETCPKA**	= ________

Make the following three settings when ETCPKA = Y.

TCP Keep-Alive Idle Range (1–20 seconds)	**KAIDLE**	= ________
TCP Keep-Alive Interval Range (1–20 seconds)	**KAINTV**	= ________
TCP Keep-Alive Count Range (1–20 seconds)	**KACNT**	= ________

Make the following setting when the relay has dual Ethernet.

Operating Mode (FIXED, FAILOVER, SWITCHED)	**NETMODE**	= ________

Make the following setting when NETMODE = FAILOVER.

Failover Time-out (OFF, 0.10–65.00 seconds)	**FTIME**	= ________

Make the following setting when NETMODE = FIXED or FAILOVER.

Primary Net Port (A, B)	**NETPORT**	= ________

Make the following settings for each enabled port when the relay has dual 100BASE-TX (copper).

Port 5A Speed (AUTO, 10, 100 Mbps) **NET5ASPD** = ________

Port 5B Speed (AUTO, 10, 100 Mbps) **NET5BSPD** = ________

Make the following setting when the relay has single 100BASE-TX (copper).

Port 5 Speed (AUTO, 10, 100 Mbps) **NET5SPD** = ________

Telnet Settings

Enable Telnet (Y, N) **ETELNET** = ________

Make the following settings when ETELNET = Y.

Maximum Access Level (1, B, 2) **MAXACC** = ________

NOTE: The MAXACC setting controls the availability of the ACC, BAC, and 2AC commands in the Telnet session.

Telnet Port (23, 1025–65534) **TPORT** = ________

Telnet Port Time-out (1–30 minutes) **TIDLE** = ________

Send Auto Messages to Port (Y, N) **AUTO** = ________

Set AUTO = Y to allow automatic messages on the Telnet session (similar to serial port auto message—see Serial Port and Telnet Session Automatic Messages on page 10.20).

Fast Operate Enable (Y, N) **FASTOP** = ________

Set FASTOP = Y to enable binary Fast Operate messages on the Telnet session. Set FASTOP = N to block binary Fast Operate messages. Refer to Appendix J: Configuration, Fast Meter, and Fast Operate Commands for the description of the SEL-311C Relay Fast Operate commands.

See Section 10: Communications for full settings explanations and other required settings.

File Transfer Protocol (FTP) Server Settings

Enable FTP (Y, N) **EFTPSERV** = ________

Make the following settings when EFTPSERV = Y.

FTP User Name (20 characters maximum) **FTPUSER** = ____________________

FTP Connect Banner (64 characters maximum. Use "\n" to create a new line.)

FTPCBAN = ____

____

FTP Idle Timeout (5–255 minutes) **FTPIDLE** = ________

Hypertext Transfer Protocol (HTTP) Web Server Settings

Enable HTTP Server (Y, N) **EHTTP** = ________

Make the following settings when EHTTP = Y.

TCP/IP Port (1–65535) **HTTPPORT** = ________

NOTE: HTTPPORT may not be set to reserved port numbers 20, 21, 102, 502, or the same as other settings listed in Table SET.1.

HTTP Web Server Timeout (1–30 min) **HTTPIDLE** = ________

IEC 61850 Protocol Settings (Ordering Option)

Enable IEC 61850 Protocol (Y, N) **E61850** = ________

Make the following setting when E61850 = Y.

Enable IEC 61850 GSE (Y, N) **EGSE** = ________

Ethernet DNP Settings

Enable DNP Sessions (0–6) **EDNP** = ________

NOTE: As many as six total serial and Ethernet DNP sessions are allowed. When EDNP > 3, no Ethernet Modbus sessions are allowed.

Make the following settings when EDNP ≥ 1.

DNP TCP and UDP Port (1-65534) **DNPNUM** = ________

NOTE: DNPNUM may not be set to reserved port numbers 20, 21, 102, 502, or the same as other settings listed in Table SET.1.

DNP Address (0–65519) **DNPADR** = ________

DNP Master n Settings (Repeat for n = 1, 2, ... to EDNP Value)

Make the following settings when EDNP > 0.

IP Address (zzz.yyy.xxx.www) **DNPIP*n*** = ____________________

The DNP IP Address of each session (DNPIP1, DNPIP2, etc.) must be unique.

Transport Protocol (UDP, TCP) **DNPTR*n*** = ________

Make the following setting when DNPTRn = UDP.

UDP Response Port (REQ, 1–65534) **DNPUDP*n*** = ________

NOTE: DNPUDPn = REQ directs response to same port message was received from.

DNP Address to Report to (0–65519) **REPADR*n*** = ________

DNP Session Map (1–3) **DNPMAP*n*** = ________

Analog Input Default Variation (1–6) **DVARAI*n*** = ________

Class for Binary Event Data (0–3) **ECLASSB*n*** = ________

Class for Counter Event Data (0–3) **ECLASSC*n*** = ________

Class for Analog Event Data (0–3) **ECLASSA*n*** = ________

Currents Scaling Decimal Places (0–3) **DECPLA*n*** = ________

Voltages Scaling Decimal Places (0–3) **DECPLV*n*** = ________

Miscellaneous Data Scaling Decimal Places (0–3) **DECPLM*n*** = ________

Make the following two setting when ECLASSAn > 0.

Amps Reporting Deadband Counts (0–32767) **ANADBA*n*** = ________

Volts Reporting Deadband Counts (0–32767) **ANADBV*n*** = ________

Make the following setting when ECLASSAn > 0 or ECLASSCn > 0.

Miscellaneous Data Reporting Deadband Counts (0–32767) **ANADBM*n*** = ________

Minutes for Request Interval (I,M,1–32767) **TIMERQ*n*** = ________

NOTE: TIMERQn = I: Disables time sync requests and ignores syncs from master.

NOTE: TIMERQn = M: Disables time sync requests and processes time syncs from master.

NOTE: TIMERQn = m = 1–32767: Relay shall request a time sync every m minutes.

Seconds to Select/Operate Time-out (0.0–30.0) **STIMEO*n*** = ________

Make the following setting when DNPTRn = TCP.

Seconds to Send Data Link Heartbeat (0–7200) **DNPINA*n*** = ________

Event Message Confirm Time-out (1–50 seconds) **ETIMEO*n*** = ________

Make the following setting when ECLASSBn > 0, ECLASSCn > 0, or ECLASSAn > 0.

Enable Unsolicited Reporting (Y, N) **UNSOL*n*** = ________

Make the following five settings when UNSOLn = Y.

Enable Unsolicited Reporting at Power-Up (Y, N) **PUNSOL*n*** = ________

Number of Events to Transmit On (1–200) **NUM1EVE*n*** = ________

Oldest Event to Tx On (0.0–99999.0 seconds) **AGE1EVE*n*** = ________

Unsolicited Message Max Retry Attempts (2–10) **URETRY*n*** = ________

Unsolicited Message Offline Time-out (1–5000 seconds) **UTIMEO*n*** = ________

NOTE: UTIMEOn must be greater than ETIMEOn.

Ethernet Synchrophasor Settings

Make the following settings when Global settings EPMU = Y and MFRMT = C37.118.

Enable PMU Processing (Y, N) **EPMIP** = ________

PMU Output 1 Settings

Make the following setting when EPMIP = Y.

PMU Output 1 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U) **PMOTS1** = ________

Make the following settings when PMOTS1 ≠ OFF.

PMU Output 1 Client IP (Remote) Address (zzz.yyy.xxx.www) **PMOIPA1** = ____________________

NOTE: PMOIPA1 cannot be set to the same address as IPADDR.

Make the following setting when PMOTS1 ≠ UDP_S.

PMU Output 1 TCP/IP (Local) Port Number (1–65534) **PMOTCP1** = ________

NOTE: PMOTCP1 cannot be set to the same number as PMOTCP2.

NOTE: PMOTCP1 cannot be set to 20, 21, 102, 502, or the same as the other settings listed in Table SET.1.

Make the following setting when PMOTS1 = UDP_S, UDP_T, or UDP_U.

PMU Output 1 UDP/IP Data (Remote) Port Number (1–65534) **PMOUDP1** = ________

PMU Output 2 Settings

NOTE: Make the following setting when EPMIP = Y (and E61850 = N on relays ordered with IEC 61850 protocol).

PMU Output 2 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U) **PMOTS2** = ________

Make the following settings when PMOTS2 ≠ OFF.

PMU Output 2 Client IP (Remote) Address (zzz.yyy.xxx.www) **PMOIPA2** = ________________

NOTE: PMOIPA2 cannot be set to the same address as IPADDR.

Make the following setting when PMOTS2 ≠ UDP_S.

PMU Output 2 TCP/IP (Local) Port Number (1–65534) **PMOTCP2** = ________

NOTE: PMOTCP2 cannot be set to the same number as PMOTCP1.

NOTE: PMOTCP2 cannot be set to 20, 21, 102, 502, or the same as the other settings listed in Table SET.1.

Make the following setting when PMOTS2 = UDP_S, UDP_T, or UDP_U.

PMU Output 2 UDP/IP Data (Remote) Port Number (1–65534) **PMOUDP2** = ________

Ethernet Modbus Settings

Enable Modbus (0–3) **EMODBUS** = ________

NOTE: As many as three total serial and Ethernet Modbus sessions are allowed. EMODBUS must be set to 0 when EDNP > 3.

Make the following settings when EMODBUS ≥ 1.

Ethernet Modbus Settings: Master 1

IP Address (zzz.yyy.xxx.www) **MODIP1** = ________________

NOTE: MODIP11, MODIP2, and MODIP3 cannot share an address (except 0.0.0.0). Setting MODIP1, MODIP2, or MODIP3 to 0.0.0.0 will disable the security, allowing any host to talk to that Modbus session.

Modbus Session Time-out (15–900 seconds) **MTIMEO1** = ________

Make the following settings when EMODBUS ≥ 2.

Ethernet Modbus Settings: Master 2

IP Address (zzz.yyy.xxx.www) **MODIP2** = ________________

NOTE: MODIP11, MODIP2, and MODIP3 cannot share an address (except 0.0.0.0).

Modbus Session Time-out (15–900 seconds) **MTIMEO2** = ________

Make the following settings when EMODBUS = 3.

Ethernet Modbus Settings: Master 3

IP Address (zzz.yyy.xxx.www) **MODIP3** = ____________

NOTE: MODIP11, MODIP2, and MODIP3 cannot share an address (except 0.0.0.0).

Modbus Session Time-out (15–900 seconds) **MTIMEO3** = ______

SNTP Client Protocol Settings

Enable SNTP Client (OFF, UNICAST, MANYCAST, BROADCAST) **ESNTP** = ____________

Make the following settings when ESNTP ≠ OFF.

Primary Server IP Address (zzz.yyy.xxx.www) **SNTPPSIP** = ____________

NOTE: To accept updates from any server when ESNTP = BROADCAST, set SNTPPSIP to 0.0.0.0.

Make the following setting when ESNTP = UNICAST.

Backup Server IP Address (zzz.yyy.xxx.www) **SNTPBSIP** = ____________

SNTP IP (Local) Port Number (1–65534) **SNTPPORT** = ______

NOTE: SNTPPORT cannot be set to 20, 21, 102, 502, or the same as other settings listed in Table SET.1.

SNTP Update Rate (15–3600 seconds) **SNTPRATE** = ______

Make the following setting when ESNTP = UNICAST or MANYCAST.

SNTP Timeout (5–20 seconds) **SNTPTO** = ______

NOTE: SNTPTO must be less than setting SNTPRATE.

Port Number Settings Must Be Unique

When making the SEL-311C Port 5 settings, port number settings cannot be used for more than one protocol. The relay checks all of the settings shown in *Table SET.1* before saving changes. If a port number is used more than once, the relay will display an error message, and return to the first setting that contains the duplicate value.

Table SET.1 Port Number Settings That Must Be Unique

Setting	Name	Setting Required When...
TPORT	Telnet Port	ETELNET = Y
HTTPPORT	TCP/IP Port	EHTTP = Y
DNPNUM	DNP TCP and UDP Port	EDNP > 0
PMOTCP1	PMU Output 1 TCP/IP (Local) Port Number	PMOTS1 = TCP, UDP_T, or UDP_U
PMOTCP2	PMU Output 2 TCP/IP (Local) Port Number	PMOTS2 = TCP, UDP_T, or UDP_U
SNTPPORT	SNTP IP (Local) Port Number	ESNTP = Y

Section 10
Communications

Introduction

The SEL-311C Relay has up to seven communications ports as shown in *Table 10.1*. Use the communications ports to establish local and remote communications with the relay using numerous communications protocols.

Table 10.1 SEL-311C Communications Ports

Port Number	Type	Location	Standard/Optional
1	EIA-485 Serial	Rear	Optional
2	EIA-232 Serial	Rear	Standard
3	EIA-232 Serial	Rear	Standard
4 or F	EIA-232 Serial	Front	Standard
5	Single Ethernet	Rear	Standard
5A/5B	Dual Ethernet	Rear	Optional
N/A	USB	Front	Optional

The first part of this section shows how to establish local communications with the relay using serial, USB, Ethernet ports and the SEL ASCII communications protocol, or the built-in, read-only web server. Other parts of this section provide reference information to help you use relay communications ports to establish local and remote communications for engineering access, SCADA communications, teleprotection, and synchrophasor data collection. Use of actual communications protocols such as IEC 61850, DNP, Modbus®, or SEL MIRRORED BITS® is covered in various appendices of this manual.

Establishing Communications Using a Serial Port

Use the front serial port and any terminal emulation program or the ACSELERATOR QuickSet® SEL-5030 Software to begin communicating with the relay. Connect SEL cable C234A between the relay and a personal computer. The serial port default communications parameters are:

- Baud Rate = 9600
- Data Bits = 8
- Parity = N
- Stop Bits = 1

Use the **SET P** command to change the relay communications port parameters.

Establishing Communications Using the USB Port

USB Port Overview

The USB port has no settings, and is faster than the serial ports, especially for operations requiring transport of large blocks of data such as long event reports or firmware upgrades.

Each time you connect a relay to your PC USB port, Windows determines if a driver has already been installed and is ready for use. There are three possibilities:

1. Connect a PC for the first time to a relay USB port.

   Windows launches the **Found New Hardware Wizard**. The wizard guides you through the USB driver installation process and creates a new virtual COM port (e.g., COM 4).

   See *Detailed Instructions for USB Port Driver Installation on page 10.3* below before connecting the relay to your PC USB port.

2. Reconnect a PC to a relay USB port using a different physical USB port on a PC (i.e., same PC, different physical USB port on the PC).

   Windows launches the **Found New Hardware Wizard**. Select **Install the software automatically (Recommended)** and click **Next**. Windows locates the required INF file and driver, and creates a new virtual COM port (e.g., COM 5).

   Windows creates a new virtual COM port (e.g., COM 6, COM 7) each time you connect a relay to a physical USB port that has not previously been connected to a relay. The virtual COM port number remains associated with the same physical USB port until you uninstall the driver.

3. Reconnect a PC to a relay USB port using a physical USB port on the PC that has already been connected to a relay (i.e., same PC, same physical USB port on the PC).

   Windows recognizes that the driver is already installed, and creates the same virtual COM port created the first time you connected a relay to that particular physical USB port (e.g., COM 4). No action is required on your part.

The USB driver exposes normal communications port settings to the personal computer operating system, such as baud rate, parity, etc. to maintain compatibility with many PC applications. Changing these settings in the PC does not change how the relay USB port operates. You may use a PC Terminal Emulator program or dedicated software to connect to the SEL-311C via USB port. The USB port offers a subset of the functionality of a standard serial port—see *Table 10.6* for details.

USB uses a connection based protocol. Under certain circumstances, such as power cycling the relay, the USB connection may be terminated. If the USB connection is terminated it may be necessary to reconnect to the relay using the PC application software, or disconnect and then reconnect the USB connector at either the PC or the relay.

ACSELERATOR QuickSet is more tolerant to unexpected USB device disconnections than most other PC applications. While using ACSELERATOR QuickSet, it is possible to disconnect the USB cable from one relay and move it to another relay without the need to restart the application, reselect the COM port, or even disconnect and reconnect at the application level.

Detailed Instructions for USB Port Driver Installation

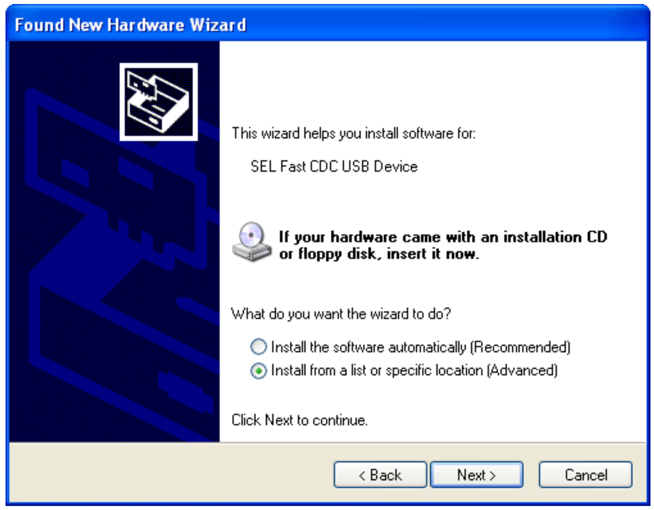
The following detailed instructions for USB driver installation are specifically for the Windows XP operating system. Some steps may be different and some screens may be changed for other Windows operating systems.

Step 1. Retrieve the USB driver file "SEL Fast CDC USB Device.INF" from the SEL-311C product page on the SEL website (www.selinc.com), from the SEL-311C Product Literature CD, or from the ACSELERATOR QuickSet SEL-5030 Installation CD. Place the INF file in any convenient directory, such as C:\SEL\Drivers\Relay_USB.

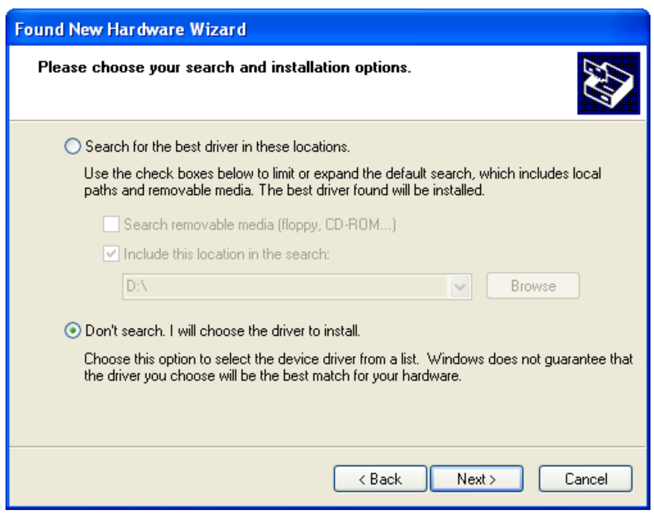
NOTE: The SEL-311 USB driver is different than the driver used for SEL EIA-232 serial to USB converter cable C662, and is different from the driver used for the SEL-2440 Discrete Programmable Automation Controller.

Step 2. Connect the relay to your PC with SEL Cable C664, or any standard A to B USB cable. Your PC will recognize that a new device has been connected, and will start the **Found New Hardware Wizard**. Select **No, not this time** and click **Next**. Some Windows XP systems will skip this screen and go to the screen shown in *Step 3*.

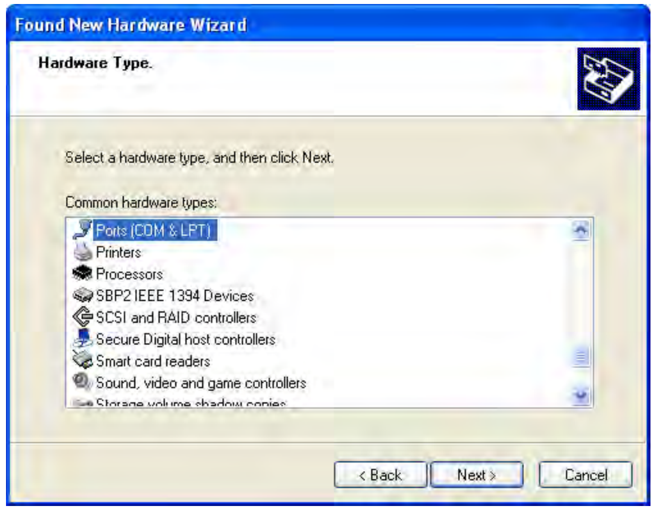
Step 3. Select **Install from a list or specific location (Advanced)**. Click **Next**.



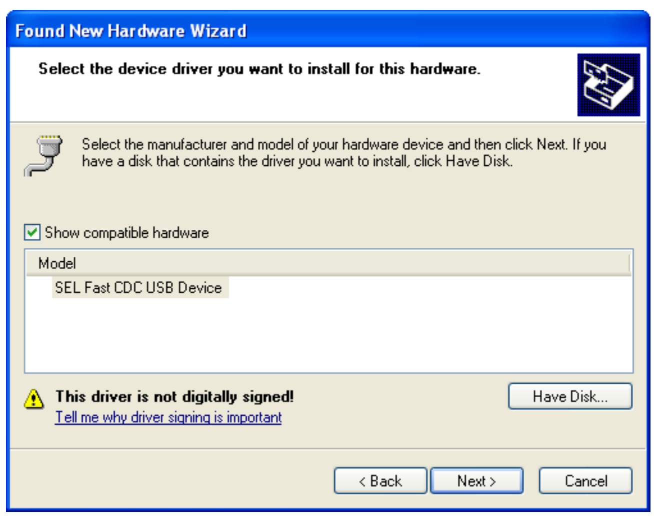
Step 4. Select **Don't search. I will choose the driver to install**. Click **Next**.



Step 5. If prompted for a hardware type select **Ports (COM & LPT)** and click **Next**. Some Windows XP systems will skip this screen and go to the next screen.



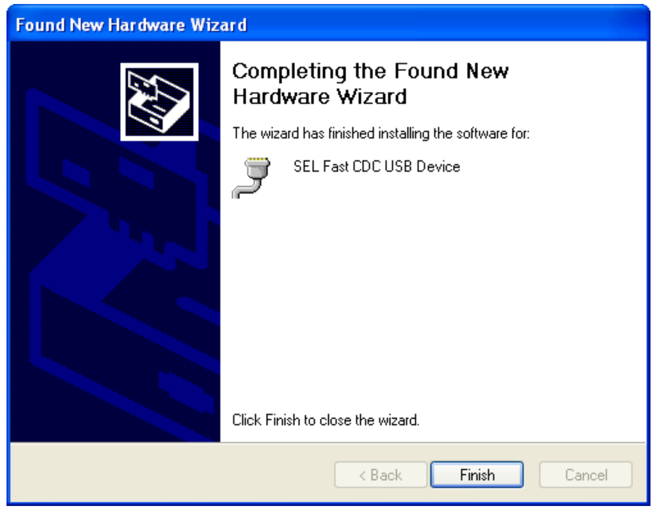
Step 6. If necessary, use the **Have Disk** button and direct the wizard to the folder containing the INF file you copied to your local drive in *Step 1*. After you locate the INF file, the **Found New Hardware Wizard** will return to the screen shown below. Verify the selected **Model** is **SEL Fast USB CDC Device**. Click **Next**.



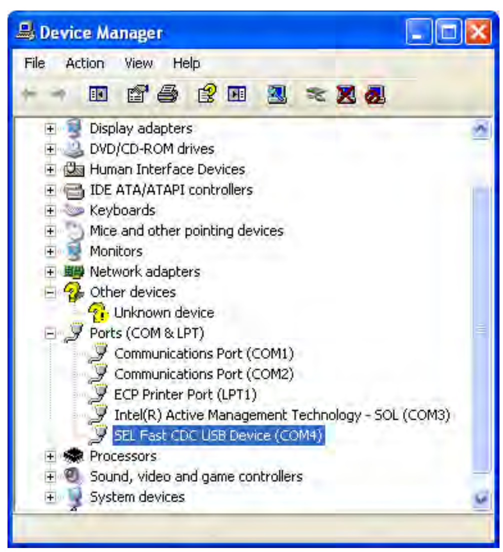
Step 7. If Windows warns that the driver has not passed Windows Logo testing, verify that the name **SEL Fast CDC USB Device** matches the Model selected in *Step 6*, and then click **Continue Anyway**.

Step 8. Wait while the wizard installs the driver software.

Step 9. Click **Finish** to finish the installation process.



The USB port driver is now installed, and a new virtual COM port (e.g., COM 4) is ready for use. To see what virtual COM port has been created, launch any communications program that allows selection of a COM port, and view the available ports, or go to the Windows Device Manager and inspect the available COM ports as shown below. Use Device Manager to verify which virtual COM port is associated with a particular physical USB port. Device Manager updates the available COM ports each time a cable is inserted or removed.



To test the USB port and the newly installed driver follow these steps:

Step 1. Launch ACSELERATOR QuickSet, and select **Communications** > **Parameters** from the menu, or click the **Communications Parameters** icon from the opening screen. See *Appendix C: PC Software* for more information on ACSELERATOR QuickSet. Select the new COM port created by the driver installation process, e.g., COM 4 in the screen capture. Ignore other settings like parity and baud rate. They have no effect on how the USB port operates, and are only presented to the operating system to retain compatibility with certain applications.

Step 2. Select **Communications > Terminal** from the menu, or click the terminal icon on the tool bar. Log into the relay normally. The USB port should work similarly to an EIA-232 port, only much faster. See *Table 10.6* for a list of features available from the USB port.

Establishing Communications Using an Ethernet Port and Telnet or the Read-Only Web Server

Factory default settings for the Ethernet ports disable all Ethernet protocols except PING. Enable the Telnet and web server protocols with the **SET P 5** command using any of the serial ports or the USB port. Command **SET P 5** accesses settings for all Ethernet ports on the SEL-311C relay: Port 5, Port 5A and Port 5B.

See *SHO Command (Show/View Settings) on page 10.49* for a sample of the **SHO 5** command, with factory default settings. See *Port 5 Settings (for Ethernet Port 5, or 5A and 5B) (Serial Port SET P 5 Command) on page SET.41* for the Port 5 settings sheets.

Make the following settings using the **SET P 5** command:

- IPADDR = IP Address assigned by network administrator
- SUBNETM = Subnet mask assigned by network administrator
- DEFRTR = Default router IP Address assigned by network administrator
- NETMODE = SWITCHED (available with dual Ethernet ports)
- ETELNET = Y
- EHTTP = Y

NOTE: Telnet and the read-only web server work with other NETMODE settings also, but NETMODE = SWITCHED is easiest to begin communications. The relay hides setting NETMODE when equipped with a single Ethernet port.

Leave all other settings at their default values.

Connect an Ethernet cable between your PC or a network switch and any Ethernet port on the relay. Verify that the amber **Link** LED illuminates on the connected relay port. Many computers and most Ethernet switches support autocrossover, so nearly any CAT5 Ethernet cable with RJ45 connectors, such as SEL cable C627 will work. When the computer does not support autocrossover, use a crossover cable, such as SEL cable C628. For fiber-optic Ethernet ports use SEL cable C807 62.5 µm fiber optic cable with LC connectors. If your relay is equipped with dual Ethernet ports, connect to either port. Use a Telnet application or ACSELERATOR QuickSet on the host PC to communicate with the relay. To terminate a Telnet session, use the command **EXI <Enter>** from any access level.

Launch a web browser and browse address http://IPADDR, where IPADDR is the Port 5 IPADDR setting. To terminate the session, simply close the web browser.

Using Redundant Ethernet Ports

The SEL-311C is optionally equipped with two 100BASE-TX copper or 100BASE-FX fiber-optic Ethernet ports. Use two Ethernet ports in redundant network architectures, or force the relay to use a single Ethernet port even though it is equipped with two ports.

Redundant Ethernet Network Using SWITCHED Mode

Make Port 5 setting NETMODE = SWITCHED to activate the internal Ethernet switch. The internal switch connects a single Ethernet stack inside the relay to the two external Ethernet ports. The combination of relay and internal switch operate the same as if a single Ethernet port on a relay were connected to an external unmanaged Ethernet switch. Use the internal switch to create "self-healing rings" as shown in *Figure 10.1*.

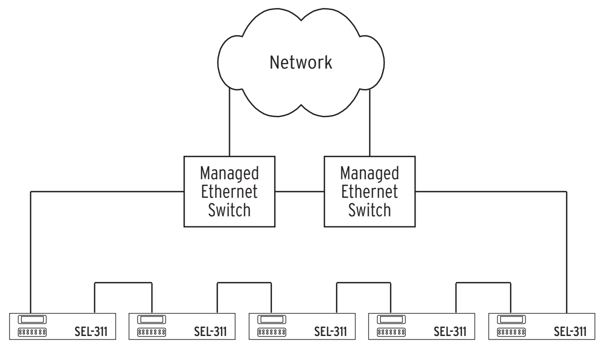


Figure 10.1 Self-Healing Ring Using Internal Ethernet Switch

Using this topology the network can still connect to any relay even if another relay, cable, or switch fails. The external managed network switches select which of the two relay Ethernet ports are used for what purpose. That selection is invisible to the relay, and does not require special relay configuration, other than making setting NETMODE = SWITCHED.

Redundant Ethernet Network Using FAILOVER Mode

Make the following settings in Port 5 to configure the relay for FAILOVER mode.

- NETMODE = FAILOVER
- FTIME = desired timeout for the active port before failover to the backup port (0.10–65.00 seconds and OFF)
- NETPORT = the preferred network interface (A for Port 5A, B for Port 5B)

Use the internal failover switch to connect the relay to redundant networks as shown in *Figure 10.2*.

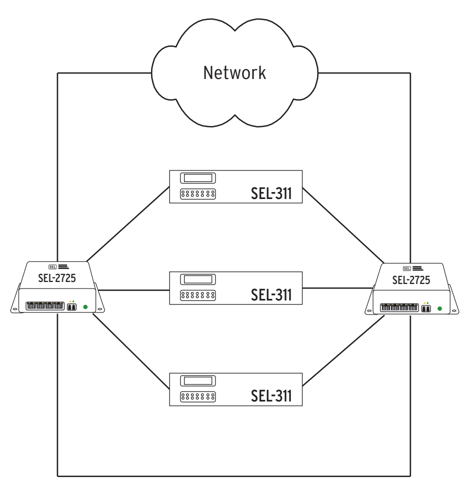


Figure 10.2 Failover Network Topology

On startup the relay communicates using the primary network interface selected by the NETPORT setting. If the relay detects a link failure on the primary interface, and the link status on the standby interface is healthy, the relay activates the standby network interface after time FTIME. If the link status on the primary interface returns to normal before time FTIME, the failover timer resets and operation continues on the primary network interface.

Setting FTIME = OFF allows fast port switching (with no intentional delay). Fast port switching can occur within one processing interval (typically 4 ms to 5 ms) and can help with IEC 61850 GOOSE performance.

After failover, while communicating via the standby interface, if the relay detects a link failure on the standby interface, and the link status on the primary interface is healthy, the relay activates the primary network interface after time FTIME. The choice of active port is reevaluated after settings change, and after relay restart.

Network Connection Using Fixed Connection Mode

Force the relay to use a single Ethernet port even when it is equipped with two Ethernet ports by making settings NETMODE = FIXED. When NETMODE = FIXED, only the interface selected by NETPORT is active. The other interface is disabled.

Ethernet Status Relay Word Bits

The SEL-311C Ethernet status is available through the Relay Word bits shown in *Table 10.2*.

Table 10.2 Ethernet Status Indicators

Relay Word Bit	Available by Relay Model	Description	Valid When
LINK5	Single Ethernet	Asserts when a valid Ethernet link is detected on Port 5	Port 5 setting EPORT = Y
LINK5A	Dual Ethernet	Asserts when a valid Ethernet link is detected on Port 5A	Port 5 setting EPORT = Y
LINK5B	Dual Ethernet	Asserts when a valid Ethernet link is detected on Port 5B	Port 5 setting EPORT = Y
LNKFAIL	Single or Dual Ethernet	Asserts when the active port is down	Port 5 setting EPORT = Y
P5ASEL	Dual Ethernet	Asserts when Port 5A is selected	Port 5 setting NETMODE = FAILOVER
P5BSEL	Dual Ethernet	Asserts when Port 5B is selected	Port 5 setting NETMODE = FAILOVER

Port Connector and Communications Cables

Hardware Handshaking

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

To enable hardware handshaking, use the **SET P** command (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.

Communications Port Pinouts

Figure 10.3 and *Table 10.3* through *Table 10.5* show the functions of the pins and terminals of the serial ports.

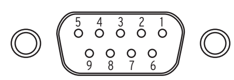


Figure 10.3 DB-9 Connector Pinout for EIA-232 Serial Ports

Table 10.3 Pinout Functions for EIA-232 Serial Ports 2, 3, and F

Pin	PORT 2	PORT 3	PORT F
1	N/C or +5 Vdc[a]	N/C or +5 Vdc[a]	N/C
2	RXD	RXD	RXD
3	TXD	TXD	TXD
4	+IRIG-B	N/C	N/C
5, 9	GND	GND	GND
6	–IRIG-B	N/C	N/C
7	RTS	RTS	RTS
8	CTS	CTS	CTS

[a] See EIA-232 Serial Port Voltage Jumpers on page 2.28.

Table 10.4 Terminal Functions for EIA-485 Serial Port 1

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

Table 10.5 Serial Communications Port Pin/Terminal Function Definitions

Pin Function	Definition
N/C	No Connection
+5 Vdc (0.5 A combined limit)	5 Vdc Power Connection
RXD, RX	Receive Data
TXD, TX	Transmit Data
IRIG-B	IRIG-B Time-Code Input
GND	Ground
SHIELD	Shielded Ground
RTS	Request To Send
CTS	Clear To Send
DCD	Data Carrier Detect
DTR	Data Terminal Ready
DSR	Data Set Ready

IRIG-B

Demodulated IRIG-B time code can be input into the IRIG-B BNC connector on at the rear or the relay (see *Figure 2.2* through *Figure 2.6*). Connect the IRIG-B BNC input to a high-quality time source such at the SEL-2407® Satellite Synchronized Clock to enable microsecond accurate time synchronization, and to enable the SEL-311C to create C37.118 Sychrophasors (see *Appendix N: Synchrophasors*).

Demodulated IRIG-B time code can be input into Serial Port 2 (pin functions +IRIG-B and –IRIG-B, see *Table 10.3*). This is handled adeptly by connecting Serial Port 2 of the SEL-311C to an SEL-2032 with Cable C273A (see cable diagrams that follow in this section).

If IRIG-B is input at both Serial Port 2 and the IRIG-B BNC connector, the relay uses the IRIG-B time code received on the BNC connector.

Relay Word Bit TIRIG

TIRIG asserts when the relay time is based on an IRIG-B time source. If the relay is not synchronized to a connected IRIG-B time source, TIRIG deasserts. See *Configuring High-Accuracy Timekeeping on page N.25* for more details on TIRIG.

Relay Word Bit TSOK

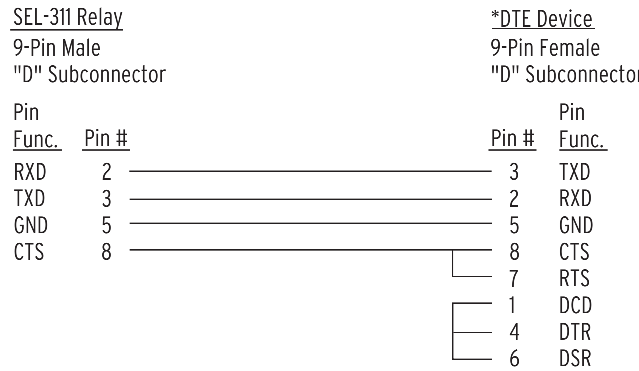
TSOK asserts to indicate that the IRIG-B time source is of a sufficient accuracy for synchrophasor measurement. See *Appendix N: Synchrophasors*.

Communications Cables

The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-311C to other devices. These and other cables are available from SEL. Contact the factory for more information.

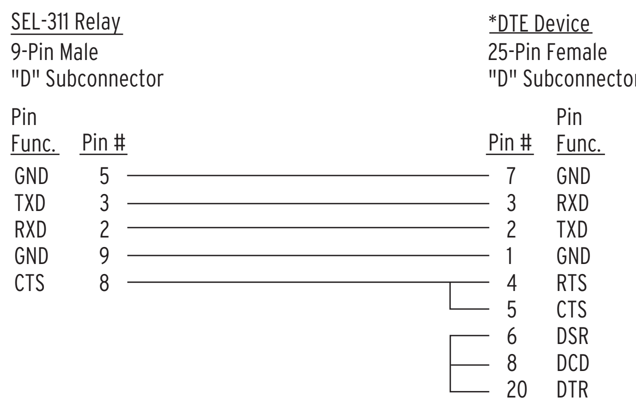
SEL-311C to Computer

Cable SEL-C234A



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

Cable SEL-C227A

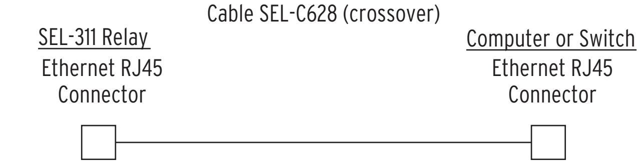


*DTE = Data Terminal Equipment (Computer, Terminal, Printer, etc.)

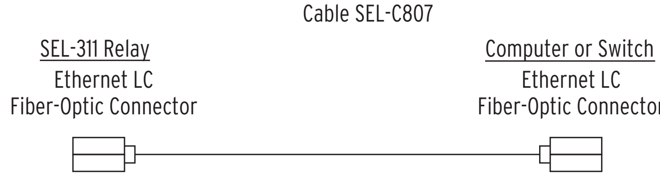
Cable SEL-C664

SEL-311C to Network

Cable SEL-C627 (straight-through)
Cable SEL-C628 (crossover)



Cable SEL-C807



SEL-311C to Modem

Cable SEL-C222

SEL-311 Relay 9-Pin Male "D" Subconnector			**DCE Device 25-Pin Female "D" Subconnector	
Pin Func.	Pin #		Pin #	Pin Func.
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.)

SEL-311C to SEL-PRTU

Cable SEL-C231

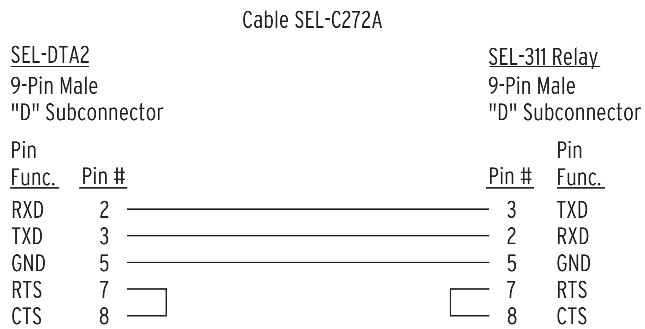
SEL-PRTU 9-Pin Male Round Conxall			SEL-311 Relay 9-Pin Male "D" Subconnector	
Pin Func.	Pin #		Pin #	Pin Func.
GND	1	—	5	GND
TXD	2	—	2	RXD
RXD	4	—	3	TXD
CTS	5	—	7	RTS
+12	7	—	8	CTS
GND	9	—	9	GND

SEL-311C to SEL Communications Processor or to SEL-2100

Cable SEL-C273A

SEL Communications Processors and SEL-2100 9-Pin Male "D" Subconnector			SEL-311 Relay 9-Pin Male "D" Subconnector	
Pin Func.	Pin #		Pin #	Pin Func.
RXD	2	—	3	TXD
TXD	3	—	2	RXD
IRIG+	4	—	4	IRIG+
GND	5	—	5	GND
IRIG-	6	—	6	IRIG-
RTS	7	—	8	CTS
CTS	8	—	7	RTS

SEL-311C to SEL-DTA2



For long-distance communications up to 500 meters and for electrical isolation of communications ports, use the SEL-2800 family of Fiber-Optic Transceivers. For IRIG-B connections and cable details, refer to the instruction manuals for the SEL-2407 Satellite-Synchronized Clock, SEL-2401 Satellite-Synchronized Clock, and other clocks. Contact SEL for more details on these devices.

Communications Protocols

The SEL-311C supports many communications protocols, as shown in *Table 10.6*.

Table 10.6 Supported SEL-311C Communications Protocols

	Port 1 EIA-485	Port 2 EIA-232	Port 3 EIA-232	Port 4, F EIA-232	USB	5, 5A, 5B Ethernet	Section
DNP3 Level 2	X	X	X	X		X	*Appendix L*
IEC 61850						X[a]	*Appendix P*
Modbus	X	X	X			X	*Appendix O*
FTP						X	*Section 10*
Telnet						X	*Section 10*
Web Server (HTTP)						X	*Section 10*
C37.118 Synchrophasors	X	X	X	X		X	*Appendix N*
SNTP						X	*Section 10*
SEL ASCII and Compressed ASCII	X	X	X	X	X	Telnet	*Section 10*, *Appendix K*
SEL Fast Synchrophasors	X	X	X	X			*Appendix J*, *Appendix N*
SEL Fast Operate	X	X	X	X		Telnet	*Appendix J*
Other SEL Fast Message (Meter, SER,...)	X	X	X	X	X	Telnet	*Appendix J*, *Appendix M*
SEL MIRRORED BITS	X	X	X	X			*Appendix H*
SEL LMD	X	X	X	X			*Appendix I*
SEL DTA	X	X	X	X			*Section 10*

[a] Not available with single copper Ethernet port.

SEL ASCII, Compressed ASCII, and Fast protocols are available when the serial port PROTO setting is either SEL or LMD, and when using Telnet.

Session Limits

The SEL-311C supports multiple simultaneous sessions of many of the protocols listed in *Table 10.6*. The number of allowed protocol sessions depends on what other protocols are enabled, as shown in *Table 10.7*.

Table 10.7 Protocol Session Limits

Protocol	Sessions Supported[a]
DNP3	The relay supports six total DNP sessions (combined serial and Ethernet sessions).
IEC 61850	The relay supports six simultaneous sessions of IEC 61850.
Modbus	The relay supports three total Modbus sessions (combined serial and Ethernet). If the number of Ethernet DNP sessions is greater than three (EDNP > 3), no Ethernet Modbus sessions are supported.
FTP	The relay supports one session of File Transfer Protocol on Port 5.
Telnet	The number of available simultaneous Telnet sessions depends on Port 5 relay settings E61850, EHTTP (read-only web server), EDNP (DNP over Ethernet), and EMODBUS (Modbus TCP) as follows: ➤ When Port 5 setting E61850 = N, the relay supports three simultaneous Telnet sessions. ➤ When Port 5 settings E61850 = Y, EHTTP = N, EDNP = 0, and EMODBUS = 0, the relay supports three simultaneous Telnet sessions. ➤ When Port 5 settings E61850 = Y, EHTTP = Y, EDNP = 0, and EMODBUS = 0, the relay supports two simultaneous Telnet sessions. ➤ When Port 5 settings E61850 = Y, EHTTP = N, and one or both of EDNP > 0, EMODBUS > 0, the relay supports two simultaneous Telnet sessions. ➤ When Port 5 settings E61850 = Y, EHTTP = Y, and one or both of EDNP > 0, EMODBUS > 0, the relay supports one Telnet session.
Web Server (HTTP)	The relay always supports three simultaneous web server sessions.
C37.118 Synchrophasors	The relay supports two C37.118 synchrophasor sessions on Port 5 if Port 5 setting E61850 = N. When Port 5 setting E61850 = Y, the relay supports one C37.118 synchrophasor session on Port 5.
SNTP	The relay supports one session of SNTP on Port 5. Some operation modes of SNTP allow the relay to synchronize to one of multiple NTP servers.

[a] When properly configured (enable settings, IP addresses, etc.)

SEL Distributed Port Switch Protocol (LMD)

The SEL Distributed Port Switch Protocol (LMD) permits multiple SEL relays to share a common communications channel. The protocol is selected by setting the port setting PROTO = LMD. See *Appendix I: SEL Distributed Port Switch Protocol* for more information.

SEL Fast Meter Protocol

SEL Fast Meter protocol supports binary messages to transfer metering and control messages. The protocol is described in *Appendix J: Configuration, Fast Meter, and Fast Operate Commands*.

SEL Compressed ASCII Protocol

SEL Compressed ASCII protocol provides compressed versions of some of the relay ASCII commands. The protocol is described in *Appendix K: Compressed ASCII Commands*.

SEL Fast Sequential Events Recorder (SER) Protocol

SEL Fast Sequential Events Recorder (SER) Protocol, also known as SEL Unsolicited Sequential Events Recorder, provides SER events to an automated data collection system. SEL Fast SER Protocol is available on any serial or Ethernet port. The protocol is described in *Appendix M: Fast SER Protocol*.

Distributed Network Protocol (DNP3)

The relay provides Distributed Network Protocol (DNP3) slave support. DNP is described in *Appendix L: DNP3 Communications*.

Modbus Protocol

The relay provides Modbus protocol as described in *Appendix O: Modbus RTU and TCP Communications*.

MIRRORED BITS Communications

The SEL-311C supports MIRRORED BITS relay-to-relay communications on two ports simultaneously (see *Appendix H: MIRRORED BITS Communications*).

IEEE C37.118 Synchrophasor Protocol

The relay supports the C37.118 protocol at up to 60 messages per second as described in *Appendix N: Synchrophasors*.

IEC 61850 Protocol

The relay supports IEC 61850 protocol, including GOOSE, as described in *Appendix P: IEC 61850*. The IEC 61850 protocol is only available on relays with two copper Ethernet ports, or with one or two fiber copper Ethernet ports.

SEL Fast Message Synchrophasor Protocol

SEL Fast Message Synchrophasor protocol has a maximum message rate of one per second, and is provided for compatibility with legacy installations. The protocol is described in *Appendix N: Synchrophasors*.

Simple Network Time Protocol (SNTP)

When Port 5 setting ESNTP is not OFF, the relay internal clock conditionally synchronizes to the time of day served by a Network Time Protocol (NTP) server. The relay uses a simplified version of NTP called the Simple Network Time Protocol (SNTP). SNTP is not as accurate as IRIG-B (see *Configuring High-Accuracy Timekeeping on page N.25*). The relay can use SNTP as a less accurate primary time source, or as a backup to the higher accuracy IRIG-B time source.

SNTP as Primary or Backup Time Source

If an IRIG-B time source is connected and either Relay Word bits TSOK or TIRIG assert, then the relay synchronizes the internal time-of-day clock to the incoming IRIB-G time code signal, even if SNTP is configured in the relay and an NTP server is available. If the IRIG-B source is disconnected (if either TSOK or TIRIG deassert) then the relay synchronizes the internal time-of-day clock to the NTP server if available. In this way an NTP server acts as either the primary time source, or as a backup time source to the more accurate IRIG-B time source.

Creating an NTP Server

Three SEL application notes available from the SEL web site describe how to create an NTP server.

- AN2009-10: *Using an SEL-2401, SEL-2404, or SEL-2407 to Serve NTP Via the SEL-3530 RTAC*
- AN2009-32: *Using SEL Satellite-Synchronized Clocks With the SEL-3332 or SEL-3351 to Output NTP*
- *Using an SEL-2401, SEL-2404, or SEL-2407 to Create a Stratum 1 Linux NTP Server*

Configuring SNTP Client in the Relay

To enable SNTP in the relay make Port 5 setting ESNTP = UNICAST, MANYCAST, or BROADCAST. *Table 10.8* shows each setting associated with SNTP.

Table 10.8 Settings Associated With SNTP

Setting	Range	Description
ESNTP	UNICAST, MANYCAST, BROADCAST	Selects the mode of operation of SNTP. See descriptions in *SNTP Operation Modes*.
SNTPPSIP	Valid IP Address	Selects primary NTP server when ENSTP = UNICAST, or broadcast address when ESNTP = MANYCAST or BROADCAST.
SNTPPSIB	Valid IP Address	Selects backup NTP server when ESNTP = UNICAST.
SNTPPORT	1–65534	Ethernet port used by SNTP. Leave at default value unless otherwise required.
SNTPRATE	15–3600 seconds	Determines the rate at which the relay asks for updated time from the NTP server when ESNTP = UNICAST or MANYCAST. Determines the time the relay will wait for an NTP broadcast when ENSTP = BROADCAST.
SNTPTO	5–20 seconds	Determines the time the relay will wait for the NTP master to respond when ENSTP = UNICAST or MANYCAST.

SNTP Operation Modes

The following sections explain the settings associated with each SNTP operation mode (UNICAST, MANYCAST, and BROADCAST).

ESNTP = UNICAST

In the unicast mode of operation the SNTP client in the relay requests time updates from the primary (IP address setting SNTPPSIP) or backup (IP address setting SNTPBSIP) NTP server at a rate defined by setting SNTPRATE. If the NTP server does not respond with the period defined by setting SNTPTO then the relay tries the other SNTP server. When the relay successfully synchronizes to the primary NTP time server, Relay Word bit TSNTPP asserts. When the relay successfully synchronizes to the backup NTP time server, Relay Word bit TSNTPB asserts.

ESNTP = MANYCAST

In manycast mode of operation the relay initially sends an NTP request to the broadcast address contained in setting SNTPPSIP. The relay continues to broadcast requests at a rate defined by setting SNTPRATE. When a server replies, the relay considers that server to be the primary NTP server, and switches to UNICAST mode, asserts Relay Word bit TSNTPP, and thereafter requests updates from the primary server. If the NTP server stops responding for time SNTPTO, the relay deasserts TSNTPP and begins to broadcast requests again until that or another server responds.

ESNTP = BROADCAST

If setting SNTPPSIP = 0.0.0.0 while setting ESNTP = BROADCAST, the relay will listen for and synchronize to any broadcasting NTP server. If setting SNTPPSIP is set to a specific IP address while setting ESNTP = BROADCAST, then the relay will listen for and synchronize to only NTP server broadcasts from that address. When synchronized the relay asserts

Relay Word bit TSNTPP. Relay Word bit TNSTPP deasserts if the relay does not receive a valid broadcast within five seconds after the period defined by setting SNTPRATE.

SNTP Accuracy Considerations

SNTP time synchronization accuracy is limited by the accuracy of the NTP Server and by the networking environment. The highest degree of SNTP time synchronization can be achieved by minimizing the number of switches and routers between the NTP Server and the SEL-311C. Network monitoring software can also be used to ensure average and worst-case network bandwidth utilization is moderate.

When installed on a network configured with one Ethernet switch between the SEL-311C and the NTP Server, and when using ESNTP = UNICAST or MANYCAST, the relay time synchronization error with the NTP server is typically less than ±1 millisecond.

Using the Embedded Web Server (HTTP)

When Port 5 setting EHTTP = Y, the relay serves read-only web pages displaying certain settings, metering, and status reports. The relay embedded web server has been optimized and tested to work with the most popular web browsers, but should work with any standard web browser. Up to three users can access the embedded web server simultaneously. To begin using the embedded read-only web server, launch your web browser, and browse to http://IPADDR, where IPADDR is the Port 5 setting IPADDR (e.g., http://192.168.1.2). The relay responds with a login screen as shown in *Figure 10.4*.

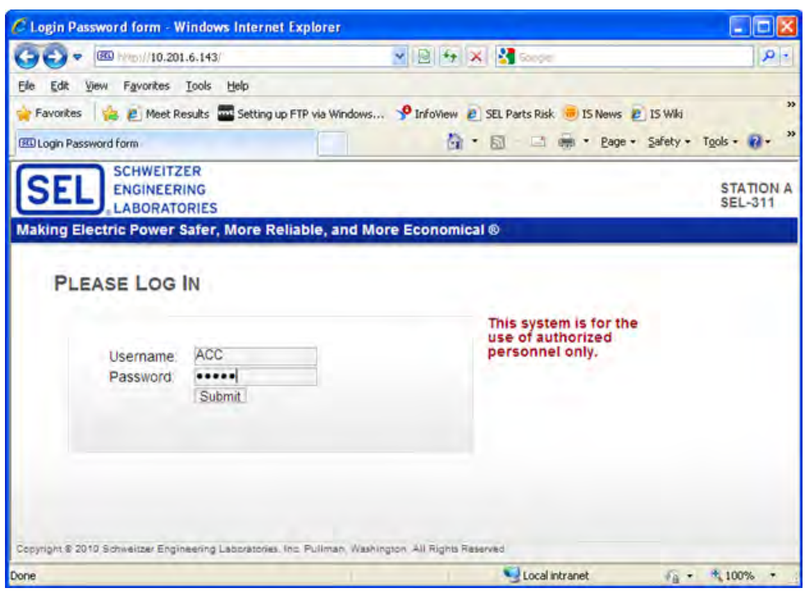


Figure 10.4 Web Server Login Screen

Enter **ACC** for the Username, and type in the relay Access Level 1 password, then click `Submit`. The only username allowed is **ACC**. The relay responds with the home page shown in *Figure 10.5*. While you remain logged into the relay, the web page displays the approximate time as determined by the relay time-of-day clock, and increments the displayed time once per second based on the clock contained in your PC.

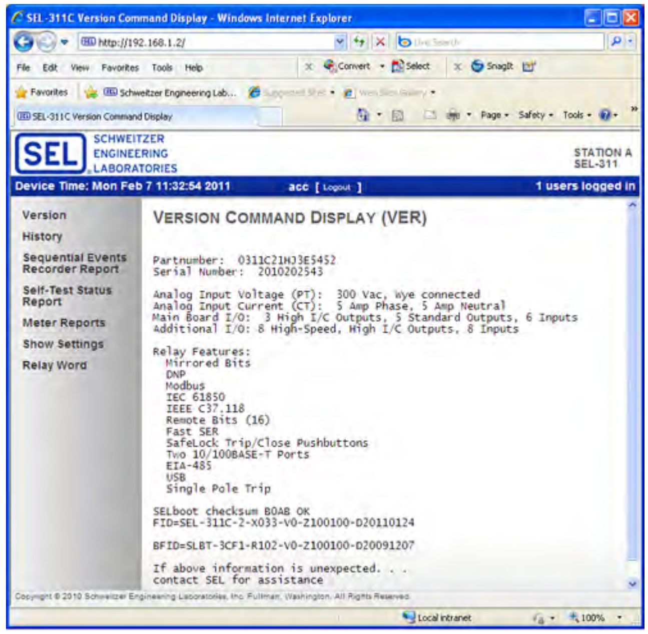


Figure 10.5 Web Server Home Page and Response to Version Menu Selection

Click on any menu selection from the left pane to retrieve various reports. Some menus expand to reveal more menus, such as the **Show Settings** menu shown in *Figure 10.6*.

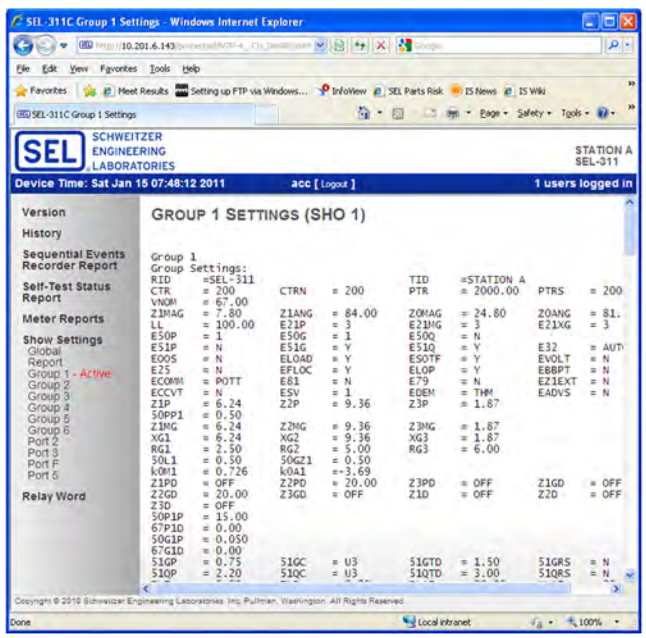


Figure 10.6 Web Server Show Settings Screen

The Meter Reports screens update automatically about every five seconds.

To log out, either close the web browser window or click on **[Logout]** in the banner bar near the top of the web page.

SEL ASCII Protocol

SEL ASCII protocol is designed for manual and automatic communications.

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

```
<command><CR>    or    <command><CRLF>
```

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

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

Software Flow Control

The SEL-311C implements XON/XOFF flow control. 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 relay transmits XON (ASCII hex 11) and asserts the RTS output (if hardware handshaking is enabled) when the relay input buffer drops below 25 percent full.

The relay transmits XOFF (ASCII hex 13) when the buffer is more than 75 percent full. Automatic transmission sources should monitor for the XOFF character to avoid overwriting the buffer. Transmission should terminate at the end of the message in progress when XOFF is received and can resume when the relay sends XON.

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

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

- XOFF: **<Ctrl+S>** (hold down the **<Ctrl>** key and press **S**)
- XON: **<Ctrl+Q>** (hold down the **<Ctrl>** key and press **Q**)
- CAN: **<Ctrl+X>** (hold down the **<Ctrl>** key and press **X**)

If hardware handshaking is enabled, the relay deasserts the RTS output when the buffer is approximately 95 percent full.

Serial Port and Telnet Session Automatic Messages

When the Telnet or serial port AUTO setting is Y, the relay sends automatic messages to indicate specific conditions. The automatic messages are described in *Table 10.9*.

When a serial port AUTO setting is DTA, the SEL-311C is compatible with the SEL-DTA2 on that port.

Table 10.9 Serial Port Automatic Messages (Sheet 1 of 2)

Condition	Description
Power Up	The relay sends a message containing the present date and time, Relay and Terminal Identifiers, and the Access Level 0 prompt when the relay is turned on.
Event Trigger	The relay sends an event summary each time an event report is triggered. See *Section 12: Standard Event Reports and SER*.

Table 10.9 Serial Port Automatic Messages (Sheet 2 of 2)

Condition	Description
Group Switch	The relay displays the active settings group after a group switch occurs. See *GRO Command (Display Active Setting Group Number) on page 10.36*.
Self-Test Warning or Failure	The relay sends a status report each time a self-test warning or failure condition is detected. See *STA Command (Relay Self-Test Status) on page 10.57*.

Port Access Levels

Commands can be issued to the relay via the serial port, USB port, or Telnet session to view metering values, change relay settings, etc. The available serial port commands are listed in *Table 10.10*. The commands can be accessed only from the corresponding access level as shown in *Table 10.10*. The access levels are:

- Access Level 0 (the lowest access level)
- Access Level 1
- Access Level B
- Access Level 2 (the highest access level)
- Access Level C (restricted access level, should be used under direction of SEL only)

Limit Maximum Access Level or Disable Any Rear Port

Disable any port using the EPORT setting. For example, if EPORT = N on Port 5, then Port 5, 5A, and 5B will be nonresponsive.

Limit the maximum allowable access level on any enabled port configured for Telnet, SEL ASCII, or LMD protocols using the MAXACC setting. For example, if MAXACC = 1 on port 5, then the maximum access level attainable from a Telnet session on Port 5, 5A, and 5B is limited to Level 1. The MAXACC setting on Port 5 does not limit FTP. FTP is always able to read and write settings files even if MAXACC = 1.

For serial port sessions and Ethernet port Telnet sessions, changing a port MAXACC setting to a lower access level will cause the relay to terminate any active session(s) on that port that exceed the new MAXACC level. Any new access level attempts on the port are only granted up to the MAXACC allowed level.

For the optional USB port, changing the Port F MAXACC setting to a lower access level does not terminate a USB session in progress. After a **QUIT** command or timeout, any new access level attempts on the USB port are only granted up to the Port F MAXACC allowed level.

See *Port Enable Settings on page 9.21* for more information about these and other port settings.

Access Level 0

Once ASCII communications are established with the relay, the relay sends the following prompt:

```
=
```

This is referred to as Access Level 0. Enter the **ACC** command at the Access Level 0 prompt:

```
=ACC <Enter>
```

The **ACC** command takes the relay to Access Level 1 (see *ACC, BAC, 2AC, and CAL Commands (Go to Access Level 1, B, 2, or C) on page 10.25* for more detail).

Access Level 1

When the relay is in Access Level 1, the relay sends the following prompt:

```
=>
```

Commands available from Access Level 1 are shown in *Table 10.10*. For example, enter the **MET** command at the Access Level 1 prompt to view metering data:

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

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

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

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

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

Access Level B

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

```
==>
```

Commands available from Access Level B are shown in *Table 10.10*. For example, enter the **CLO** command at the Access Level B prompt to close the circuit breaker:

```
==>CLO <Enter>
```

While in Access Level B, any of the Access Level 1 commands are also available.

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

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

Access Level 2

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

```
=>>
```

Commands available from Access Level 2 are shown in *Table 10.10*. For example, enter the **SET** command at the Access Level 2 prompt to make relay settings:

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

While in Access Level 2, any of the Access Level 1 and Access Level B commands are also available.

Access Level C

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

The **CAL** command allows the relay to go to Access Level C (see *ACC, BAC, 2AC, and CAL Commands (Go to Access Level 1, B, 2, or C) on page 10.25* for more detail). Enter the **CAL** command at the Access Level 2 prompt:

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

Command Summary

Table 10.10 alphabetically lists ASCII commands, the required access level, and the corresponding front-panel pushbuttons. See *Section 11: Front-Panel Interface* for more information on the front-panel pushbuttons. All commands available at lower access levels are also available from higher access levels.

Table 10.10 includes some commands not normally issued by operators. These commands are used during the firmware upgrade process or are used by SEL communications processors or PC software to communicate with intelligent electronic devices (IEDs), and are covered in *Appendix B: Firmware Upgrade Instructions for SEL-351/311C Relays With Ethernet*, *Appendix J: Configuration, Fast Meter, and Fast Operate Commands*, and *Appendix K: Compressed ASCII Commands*.

Table 10.10 ASCII Command Summary (Sheet 1 of 3)

Access Level	Prompt	ASCII Command	Command Description	Corresponding Front-Panel Pushbutton
1	=>	**2AC**	Go to Access Level 2	
0	=	**ACC**	Go to Access Level 1	
1	=>	**BAC**	Go to Access Level B	
1	=>	**BNA**	Displays information useful for autoconfiguration of data gathering equipment	
1	=>	**BRE**	Breaker monitor data	OTHER
B	==>	**BRE *x***	Preload/reset breaker wear	OTHER

Table 10.10 ASCII Command Summary (Sheet 2 of 3)

Access Level	Prompt	ASCII Command	Command Description	Corresponding Front-Panel Pushbutton
2	=>>	**CAL**	Go to Access Level C	
0	=	**CAS**	Displays information useful for autoconfiguration of data gathering equipment	
1	=>	**CEV**	Compressed event reports	
1	=>	**CHI**	Compressed history reports	
B	==>	**CLO**	Close breaker	
1	=>	**COM**	MIRRORED BITS communications statistics	
B	==>	**CON**	Control remote bit	
2	=>>	**COP**	Copy setting group	
1	=>	**CST**	Compressed status report	
1	=>	**CSU**	Compressed event summary	
1	=>	**DAT**	View/change date	OTHER
1	=>	**DNA T/X**	Displays information useful for autoconfiguration of data gathering equipment. Either “X” or “T” is mandatory and are identical.	
1	=>	**ETH**	Displays information about Ethernet port(s)	
1	=>	**EVE**	Event reports	
0	=	**EXI**	Terminate Telnet session	
1	=>	**FIL**	List or read available files	
2	=>>	**FIL WRI**	Write file	
1	=>	**GOO**	Display GOOSE transmit and receive information	
1	=>	**GRO**	Display active setting group number	GROUP
B	==>	**GRO *n***	Change active setting group	GROUP
1	=>	**HIS**	Event summaries/histories	EVENTS
0	=	**ID**	Display configuration information about the relay	
2	=>>	**L_D**	Prepares the relay to receive new firmware	
2	=>>	**LOO**	Loopback	
1	=>	**MAC**	Display Ethernet port MAC address	
1	=>	**MET**	Metering data	METER
B	==>	**OPE**	Open breaker	
2	=>>	**PAS**	Change passwords	SET
2	=>>	**PAR**	Change the device part number. Use only under direction from SEL	
B	==>	**PUL**	Pulse output contact	CNTRL
2	=>>	**R_S**	Restore factory default settings. Only available under certain conditions	
0	=>	**QUI**	Return to Access Level 0	
1	=>	**SER**	Sequential Events Recorder report	
2	=>>	**SET**	Change settings	SET
1	=>	**SHO**	Show/view settings	SET
1	=>	**SNS**	Displays information useful for autoconfiguration of data gathering equipment	
1	=>	**STA**	Relay self-test status	STATUS
2	=>>	**STA C**	Clear self-test status and restart relay	
1	=>	**SUM**	Display event summary	

Table 10.10 ASCII Command Summary (Sheet 3 of 3)

Access Level	Prompt	ASCII Command	Command Description	Corresponding Front-Panel Pushbutton
1	=>	**TAR**	Display relay element status	OTHER
B	==>	**TES DB**	Force protocol binary and analog values. Used for protocol testing	
1	=>	**TIM**	View/change time	OTHER
1	=>	**TRI**	Trigger an event report	
2	=>>	**VEC**	Displays information useful to the factory in troubleshooting	
1	=>	**VER**	Show relay configuration and firmware version	

The relay responds with `Invalid Access Level` if a command is entered from an access level lower than the specified access level for the command. The relay responds with `Invalid Command` to commands not listed above or entered incorrectly.

Many of the command responses display the following header at the beginning:

```
SEL-311                              Date: 10/15/10    Time: 17:03:26.484
STATION A
```

The definitions are:

`SEL-311`: This is the RID setting (the relay is shipped with the default setting RID = SEL-311; see *Identifier Labels on page 9.16*).

`STATION A`: This is the TID setting (the relay is shipped with the default setting TID = STATION A; see *Identifier Labels on page 9.16*).

`Date`: This is the date the command response was given (except for relay response to the **EVE** command [Event], where it is the date the event occurred). You can modify the date display format (Month/Day/Year or Year/Month/Day) by changing the DATE_F relay setting.

`Time`: This is the time the command response was given (except for relay response to the **EVE** command, where it is the time the event occurred).

Command Explanations

ACC, BAC, 2AC, and CAL Commands (Go to Access Level 1, B, 2, or C)

The **ACC**, **BAC**, **2AC**, and **CAL** commands provide entry to the multiple access levels. Different commands are available at the different access levels as shown in *Table 10.10*. Commands **ACC**, **BAC**, **2AC**, and **CAL** are explained together because they operate similarly.

Command	Description
ACC	Moves from Access Level 0 to Access Level 1
BAC	Moves from Access Level 1 to Access Level B
2AC	Moves from Access Level 1 or B to Access Level 2
CAL	Moves from Access Level 2 to Access Level C

Password Requirements

Passwords are required if the main board Access jumper is *not* in place (Access jumper = OFF). Passwords are not required if the main board Access jumper is in place (Access jumper = ON). Refer to *Figure 2.19* for Access jumper information. See *PAS Command (Change Passwords) on page 10.46* for the list of default passwords and for more information on changing passwords.

Access Level Attempt (Password Required)

Assume the following conditions: Access jumper = OFF (not in place), Access Level = 0.

At the Access Level 0 prompt, enter the **ACC** command:

```
=ACC <Enter>
```

Because the Access jumper is not in place, the relay asks for the Access Level 1 password to be entered:

```
Password: ?
```

The relay is shipped with the default Access Level 1 password shown in the table under *PAS Command (Change Passwords) on page 10.46*. At the prompt above, enter the default password and press the **<Enter>** key. The relay responds:

```
SEL-311                          Date: 10/15/10    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, the relay closes the **ALARM** contact for one second. After three attempts, the relay displays an invalid access message and prevents further access attempts for 30 seconds.

Access Level Attempt (Password Not Required)

Assume the following conditions: Access jumper = ON (in place), Access Level = 0.

At the Access Level 0 prompt, enter the **ACC** command:

```
=ACC <Enter>
```

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

```
SEL-311                          Date: 10/15/10    Time: 08:31:10.361
STATION A

Level 1
=>
```

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

The relay closes the **ALARM** contact for one second after a successful Level B, Level 2, or Level C access. If access is denied, the **ALARM** contact closes for one second. The above two examples demonstrate how to go from Access Level 0 to Access Level 1. Refer to *Port Access Levels on page 10.21* for more access level examples.

BRE Command (Breaker Monitor Data)

Use the **BRE** command to view the breaker monitor report.

Command	Description	Access Level
BRE	Display the breaker monitor report.	1
BRE W	Preload breaker/recloser contact wear monitor data.	B
BRE R	Reset breaker/recloser contact wear monitor.	B

```
=>>BRE <Enter>

SEL-311                          Date: 1/4/2011      Time: 08:40:14.802
STATION A

                                  A-phase     B-phase     C-phase
Accum Contact Wear (%)                  6           6          10

Rly Accum Pri Current (kA)          168.2       241.0       250.0
Ext Accum Pri Current (kA)            0.0         0.0         0.0

Rly Trip Count                          9
Ext Trip Count                          0

LAST RESET 01/03/11 00:39:58
=>>
```

See *BRE n Command (Preload/Reset Breaker Wear)* and *Breaker Monitor on page 8.1* for further details on the breaker monitor.

BRE n Command (Preload/Reset Breaker Wear)

Use the **BRE W** command to preload breaker monitor data.

```
==>BRE W <Enter>

Breaker Wear Preload
Relay/Internal Trip Counter (0-65535)        = 0         ? 14 <ENTER>

Internal Current (0.0-999999 kA)      IA      = 0.0       ? 32.4 <ENTER>
                                      IB      = 0.0       ? 18.6 <ENTER>
                                      IC      = 0.0       ? 22.6 <ENTER>

External Trip Counter (0-65535)               = 0         ? 2 <ENTER>

External Current (0.0-999999 kA)      IA      = 0.0       ? 0.8 <ENTER>
                                      IB      = 0.0       ? 0.6 <ENTER>
                                      IC      = 0.0       ? 0.7 <ENTER>

Percent Wear (0-100%)                 A-phase = 0         ? 22 <ENTER>
                                      B-phase = 0         ? 28 <ENTER>
                                      C-phase = 0         ? 25 <ENTER>

Last Reset                            Date    = 11/11/10  ? 01/03/11 <Enter>
                                      Time    = 13:57:42  ? 00:39:58 <Enter>
Save Changes(Y/N)? Y <ENTER>

FEEDER 1                        Date: 01/04/11  Time: 16:14:32.655
STATION A

                                A-phase     B-phase     C-phase
Accum Contact Wear (%)               22          28          25

Rly Accum Pri Current (kA)         32.4        18.6        22.6
Ext Accum Pri Current (kA)          0.8         0.6         0.7

Rly Trip Count                       14
Ext Trip Count                        2

LAST RESET 01/03/11 00:39:58
==>
```

The **BRE W** command only saves new settings after the `Save Changes (Y/N)?` message. If a data entry error is made using the **BRE W** command, the values echoed after the `Invalid format, changes not saved` message are the previous **BRE** values, unchanged by the aborted **BRE W** attempt.

```
==>BRE W <Enter>

Breaker Wear Preload
Relay/Internal Trip Counter (0-65535)        = 0         ? 14 <ENTER>

Internal Current (0.0-999999 kA)      IA      = 0.0       ? 32.4 <ENTER>
                                      IB      = 0.0       ? 18.6 <ENTER>
                                      IC      = 0.0       ? 22.6 <ENTER>

External Trip Counter (0-65535)               = 0         ? -22 <ENTER>

Invalid format, changes not saved

SEL-311                          Date: 01/04/11      Time: 08:40:14.802
STATION A

                                  A-phase     B-phase     C-phase
Accum Contact Wear (%)                  6           6          10

Rly Accum Pri Current (kA)          168.2       241.0       250.0
Ext Accum Pri Current (kA)            0.0         0.0         0.0

Rly Trip Count                          9
Ext Trip Count                          0

LAST RESET 01/03/11 00:39:58
==>
```

Use the **BRE R** command to reset the breaker monitor:

```
==>BRE R <Enter>

Reset Trip Counters and Accumulated Currents/Wear
Are you sure (Y/N)? Y

SEL-311                          Date: 01/10/11    Time: 10:10:15.042
STATION A

                                 A-phase     B-phase     C-phase
Accum Contact Wear (%)                 0           0           0

Rly Accum Pri Current (kA)           0.0         0.0         0.0
Ext Accum Pri Current (kA)           0.0         0.0         0.0

Rly Trip Count                         0
Ext Trip Count                         0

LAST RESET 01/10/11 10:10:15
```

See *Breaker Monitor on page 8.1* for further details on the breaker monitor.

CEV Command (Compressed Event Reports)

Use the **CEV** command to retrieve event reports in compressed format. See *Section 12: Standard Event Reports and SER* for details on retrieving event reports.

Command (Parameter n Is Optional)	Description	Access Level
CEV *n*	Return event report *n* in compressed format at full length with 4-samples/cycle data. Parameter *n* can correspond to the number from the **HIS** command or the unique event number from the **HIS E** command.	1

CLO Command (Close Breaker)

The **CLO** (**CLOSE**) command asserts Relay Word bit CC for 1/4 cycle when it is executed. Relay Word bit CC can then be programmed into the CL SELOGIC control equation to assert the CLOSE Relay Word bit, which in turn asserts an output contact (e.g., OUT102 = CLOSE) to close a circuit breaker. See *Figure 6.3*.

Command	Description	Access Level
CLO	This command asserts the close command Relay Word bit CC.	B

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

```
==>CLO <Enter>

Close 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 **CLO** command is supervised by the main board Breaker jumper (see *Figure 2.19*). If the Breaker jumper is not in place (Breaker jumper = OFF), the relay does not execute the **CLO** command and responds:

```
Aborted: No Breaker Jumper
```

COM Command (Communication Data)

The **COM** command displays integral relay-to-relay (MIRRORED BITS) communications data. For more information on MIRRORED BITS communications, see *Appendix H: MIRRORED BITS Communications*. To get a summary report, enter the command with the channel parameter (**A** or **B**).

Command	Description	Access Level
COM *n* **COM *n row1 row2*** **COM *n date1 date2***	Return a summary report of the records in the communications buffer.	1
COM *n* L	Display all available records. The most recent record is row 1 (at the top of the report) and the oldest record is at the bottom of the report.	1
COM *n* C	Clear/reset communications buffer data for MIRRORED BITS channel *n* (or both channels if *n* is not specified).	1

Parameter	Description
n	Parameter ***n*** is A for Channel A, and B for Channel B. If only one MIRRORED BITS port is enabled the channel specifier may be omitted.
row1 row2	Append *row1* to return a chronological progression of the first *row1* rows. Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with *row1* and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows.
date1 date2	Append *date1* to return all rows with this date. Append *date1* and *date2* to return all rows between *date1* and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F.

```
=>COM A <Enter>

SEL-311                          Date: 01/28/11    Time: 18:01:16.620
STATION A

FID=SEL-311C-1-Rxxx-V0-Z1xx1xx-D20xxxxxx       CID=xxxx
Summary for Mirrored Bits channel A

For 01/28/11 17:29:23.148 to 01/28/11 18:01:16.620

    Total failures      4                   Last error  Re-Sync
    Relay Disabled      2
    Data error          1                   Longest Failure     1.875 sec.
    Re-Sync             1
    Underrun            0                   Unavailability  0.001150
    Overrun             0
    Parity error        0
    Framing error       0                   Loop-back     0
    Bad Re-Sync         0

=>
```

If only one MIRRORED BITS port is enabled, the channel specifier may be omitted. Use the **L** parameter to get a summary report, followed by a listing of the COM records.

```
=>COM L <Enter>

SEL-311                          Date: 01/28/11    Time: 18:01:20.206
STATION A

FID=SEL-311C-1-Rxxx-V0-Z1xx1xx-D20xxxxxx       CID=xxxx
Summary for Mirrored Bits channel A

For 01/28/11 17:29:23.148 to 01/28/11 18:01:20.205

    Total failures      4                   Last error  Re-Sync
    Relay Disabled      2
    Data error          1                   Longest Failure     1.875 sec.
    Re-Sync             1
    Underrun            0                   Unavailability  0.001148
    Overrun             0
    Parity error        0
    Framing error       0                   Loop-back     0
    Bad Re-Sync         0


    Failure                Recovery
#   Date     Time          Date     Time          Duration  Cause
1   01/28/11 17:53:55.4433 01/28/11 17:53:57.3182    1.875  Re-Sync
2   01/28/11 17:53:54.3734 01/28/11 17:53:54.5234    0.150  Data error
3   01/28/11 17:30:07.3011 01/28/11 17:30:07.4561    0.155  Relay Disabled
4   01/28/11 17:29:23.1486 01/28/11 17:29:23.1686    0.020  Relay Disabled

=>
```

There may be up to 255 records in the extended report.

CON Command (Control Remote Bit)

The **CON** command is a two-step command that allows you to control Relay Word bits RB1–RB16 (see Rows 7 and 8 in *Table D.1*).

Command	Description	Access Level
CON *n*[a]	First step of a two-command sequence. The SEL-311C will prompt for the second step (subcommand), shown below.	B

[a] Parameter n is a number from 1 to 16 representing RB1–RB16.

Step 1. At the Access Level B prompt, type:

a. **CON**

b. a space

c. the number of the remote bit you wish to control (1–16)

Step 2. Press the <**Enter**> key on your computer.

The relay responds by repeating your command followed by a colon.

Step 3. At the colon, type the Control subcommand you wish to perform (see *Table 10.11*).

The following example 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 10.11 SEL-311C Control Subcommand

Subcommand	Description
SRB *n*	Set Remote Bit *n* (“ON” position)
CRB *n*	Clear Remote Bit *n* (“OFF” position)
PRB *n*	Pulse Remote Bit *n* for 1/4 cycle (“MOMENTARY” position)

See *Remote Control Switches on page 7.10* for more information.

COP Command (Copy Setting Group or DNP Map)

Copy relay and SELOGIC control equation settings from setting Group *m* to setting Group *n* with the **COP *m n*** command. Copy DNP Map settings from Map *m* to Map *n* with the **COP D *m n*** command. Setting group numbers range from 1 to 6 and DNP maps range from 1 to 3. After entering settings into one setting group or map with the **SET** command, copy them to the other group(s) or map with the **COP** command. Use the **SET** command to modify the copied settings. The relay disables for a few seconds and the ALARM output pulses if you copy settings into the active group. This is similar to a Group Change (see *Multiple Setting Groups on page 7.17*).

Command	Description	Access Level
COPY *m n*	Copy relay and logic settings from group *m* to group *n*.	2
COPY D *m n*	Copy DNP Map *m* into Map *n*.	2

Parameter	Description
m	Parameter *m* is a group number from 1 to 6 or a map number from 1 to 3.
n	Parameter *n* is a group number from 1 to 6 or a map number from 1 to 3.

For example, to copy settings from Group 1 to Group 3 issue the following command:

```
=>>COP 1 3 <Enter>

Copy 1 to 3
Are you sure (Y/N) ? Y <Enter>

Please wait...
Settings copied
=>>
```

DAT Command (View/Change Date)

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

Command	Description	Access Level
DATE	Display the internal clock date.	1
DATE *date*	Set the internal clock date (DATE_F set to MDY or YMD).	1

NOTE: After setting the date, allow at least 60 seconds before powering down the relay or the new setting may be lost.

To set the date:

Step 1. Type **DATE mm/dd/yy <Enter>** if the DATE_F setting is MDY.

Step 2. If the DATE_F is set to YMD, enter **DATE yy/mm/dd <Enter>**.

To set the date to October 15, 2010, enter:

```
=>DATE 10/15/10 <Enter>

10/15/10
=>
```

You can separate the month, day, and year parameters with spaces, commas, slashes, colons, and semicolons. The year can be entered with four digits (e.g., 2010), and the SEL-311C displays it in a two-digit format (e.g., 10).

If an IRIG-B or SNTP time synchronization signal is connected to the relay, the **DAT** command cannot alter the month or day portion of the date. If the IRIG-B or SNTP time source is IEEE C37.118 compliant and Global setting IRIGC = C37.118, or if an SNTP time source is connected, the **DAT** command cannot alter the year. See *Configuring High-Accuracy Timekeeping on page N.25* for more details on IRIG time sources.

ETH Command (View Ethernet Port Information)

Use the **ETH** command when troubleshooting Ethernet connections. The report shown is for a relay with dual copper Ethernet ports with Global setting NETMODE = FAILOVER. Different Ethernet configurations and different NETMODE settings result in slightly different information being displayed. See *Establishing Communications Using an Ethernet Port and Telnet or the Read-Only Web Server on page 10.7* for a description of the settings and operating modes associated with the Ethernet port.

Command	Description	Access Level
ETH	Displays information about Ethernet port(s)	1

```
=>ETH <Enter>
SEL-311                         Date: 10/15/10    Time: 10:32:03.275
STATION A

MAC: 00-30-A7-00-E1-94
IP ADDRESS: 192.168.1.2
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 192.168.1.1

NETMODE: FAILOVER

PRIMARY PORT:  5A
ACTIVE PORT:   5A

             LINK   SPEED  DUPLEX MEDIA
PORT 5A       Up     100M   Full   TX
PORT 5B       Up     100M   Full   TX

=>
```

EVE Command (Event Reports)

Use the **EVE** command to view event reports. See *Section 12: Standard Event Reports and SER* for further details on retrieving event reports, including additional parameters.

Command (Parameter n Is Optional)	Description	Access Level
EVE *n*	Return event report *n* (including settings and summary) t full length with 4-samples/cycle data. Parameter *n* can correspond to the number from the **HIS** command or the unique event number from the **HIS E** command.	1

EXI Command

Use the **EXI** command to exit a Telnet session on any of the Ethernet ports.

Command	Description	Access Level
EXI	Exit active Telnet session	0

FIL Command

The **FILE** command provides an efficient means of transferring files between the relay and a PC. Software applications, such as ACSELERATOR QuickSet, use the **FILE** commands to send and receive settings files to and from the relay.

The **FILE** command uses Ymodem transfer protocol to transfer setting files.

Command	Description	Access Level
FILE DIR	Return a list of files.	1
FILE READ *filename*	Transfer settings file *filename* from the relay to the PC.	1
FILE WRITE *filename*	Transfer settings file *filename* from the PC to the relay.	2
FILE SHOW *filename*	Displays contents of the file *filename*.	1

GOO Command

Use the **GOOSE** command to display transmit and receive GOOSE messaging information, which can be used for troubleshooting. The **GOOSE** command variants and options are shown below.

Command Variant	Description	Access Level
GOOSE	Display GOOSE information.	1
GOOSE *k*	Display GOOSE information *k* times.	1

The information displayed for each GOOSE IED is described in the following table.

IED	Description
`Transmit GOOSE Control Reference`	This field represents the GOOSE control reference information that includes the IED name, ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and GSEControl name (GSE Control Block Name) (e.g., SEL_311C/LLN0GOGooseDSet13).
`Receive GOOSE Control Reference`	This field represents the goCbRef (GOOSE Control Block Reference) information that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and cbName (GSE Control Block Name) (e.g., SEL_311C/LLN0GOGooseDSet13).
`MultiCastAddr` (Multicast Address)	This hexadecimal field represents the GOOSE multicast address.
`Ptag`	This three-bit decimal field represents the priority tag value, where spaces are used if the priority tag is unknown.
`Vlan`	This 12-bit decimal field represents the virtual LAN (Local Area Network) value, where spaces are used if the virtual LAN is unknown.
`StNum` (State Number)	This hexadecimal field represents the state number that increments with each state change.
`SqNum` (Sequence Number)	This hexadecimal field represents the sequence number that increments with each GOOSE message sent.
`TTL` (Time to Live)	This field contains the time (in ms) before the next message is expected.
`Code`	When appropriate, this text field contains warning or error condition text that is abbreviated as follows: **Code Abbreviation** — **Explanation** OUT OF SEQUENC — Out of sequence error CONF REV MISMA — Configuration Revision mismatch NEED COMMISSIO — Needs Commissioning TEST MODE — Test Mode MSG CORRUPTED — Message Corrupted TTL EXPIRED — Time to live expired HOST DISABLED — Optional code for when the host is disabled or becomes unresponsive after the **GOOSE** command has been issued
`Transmit Data Set Reference`	This field represents the DataSetReference (Data Set Reference) that includes the IED name, LN0 lnClass (Logical Node Class), and GSEControl datSet (Data Set Name) (e.g., SEL_311C/LLN0$DSet13).
Receive Data Set Reference	This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and datSet (Data Set Name) (e.g., SEL_311C/LLN0$DSet13).

An example response to the **GOOSE** commands is shown in *Figure 10.7*.

```
#>GOOSE <Enter>

GOOSE Transmit Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
SEL_311C_1/LLN0$GO$GooseDSet13
   01-0C-CD-01-00-04  4:1      2          20376      50
   Data Set: SEL_787_2CFG/LLN0$DSet13
GOOSE Receive Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
SEL_787_1CFG/LLN0$GO$NewGOOSEMessage5
   01-0C-CD-01-00-05  4:0      1          100425     160
   Data Set: SEL_787_1CFG/LLN0$DSet10

SEL_787_1CFG/LLN0$GO$NewGOOSEMessage3
   01-0C-CD-01-00-03  4:0      1          98531      120
   Data Set: SEL_787_1CFG/LLN0$DSet05

SEL_787_1CFG/LLN0$GO$NewGOOSEMessage2
   01-0C-CD-01-00-02  4:0      1          97486      200
   Data Set: SEL_787_1CFG/LLN0$DSet04

SEL_787_1CFG/LLN0$GO$NewGOOSEMessage1
   01-0C-CD-01-00-01  4:0      1          96412      190
   Data Set: SEL_787_1CFG/LLN0$DSet03

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage5
   01-0C-CD-01-00-06  4:0      1          116156     140
   Data Set: SEL_387E_1CFG/LLN0$DSet10

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage4
   01-0C-CD-01-00-05  4:0      1          116041     130
   Data Set: SEL_387E_1CFG/LLN0$DSet06

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage2
   01-0C-CD-01-00-02  4:0      1          115848     120
   Data Set: SEL_387E_1CFG/LLN0$DSet04

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage1
   01-0C-CD-01-00-01 4:0      1          115798     150
   Data Set: SEL_387E_1CFG/LLN0$DSet03
=>
```

Figure 10.7 GOOSE Command Response

GRO Command (Display Active Setting Group Number)

Use the **GRO** command to display the active settings group number. The **GRO *n*** command changes the active setting group to setting Group *n*.

Command	Description	Access Level
GRO	Display the presently active group	1
GRO *n*	Change the active group to Group *n*.	B

See *Multiple Setting Groups on page 7.17* for further details on settings groups.

To change to settings Group 2, enter the following:

```
==>GRO 2 <Enter>

Change to Group 2
Are you sure (Y/N) ? Y <Enter>
Active Group = 2
==>
```

The relay switches to Group 2 and pulses the **ALARM** contact. If the serial port AUTO setting = Y, the relay sends the group switch report:

```
==>

SEL-311                          Date: 10/15/10    Time: 09:40:34.611
STATION A

Active Group = 2
==>
```

If any of the SELOGIC control equations settings SS1 through SS6 are asserted to logical 1, the active setting group may not be changed with the **GRO** command—SELOGIC control equations settings SS1 through SS6 have priority over the **GRO** command in active setting group control.

For example, assume setting Group 1 is the active setting group and the SS1 setting is asserted to logical 1 (e.g., SS1 = IN101 and optoisolated input **IN101** is asserted). An attempt to change to setting Group 2 with the **GRO 2** command will not be accepted:

```
==>GRO 2 <Enter>

No group change (see manual)
Active Group = 1
==>
```

For more information on setting group selection, see *Multiple Setting Groups on page 7.17*.

HIS Command (Event Summaries/History)

HIS *n* displays event summaries or allows you to clear event summaries (and corresponding event reports) from nonvolatile memory.

Command	Description	Access Level
HIS	Return event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS *n*	Return event histories with the oldest at the bottom of the list and the most recent at the top of the list beginning at event *n*.	1
HIS E	Same as **HIS** but events are identified with a unique number in the range 10000 to 65535.	
HIS C	Clear/reset the event history and all corresponding event reports from nonvolatile memory.	1

If no parameters are specified with the **HIS** command:

```
=>HIS <Enter>
```

the relay displays the most recent event summaries in reverse chronological order.

If ***n*** is a number:

```
=>HIS n <Enter>
```

the relay displays the ***n*** most recent event summaries. The maximum number of available event summaries is a function of the LER (length of event report) setting.

HIS E identifies each summary with a unique number in the range 10000 to 65535. Use the unique number to display the same event using the **CEV** or **EVE** commands.

If ***n*** is "C" or "c", the relay clears the event summaries and all corresponding event reports from nonvolatile memory.

The event summaries include an identifier, the date and time the event was triggered, the type of event, the fault location, the event phase current, the power system frequency, the number of the active setting group, the reclose shot count, and the front-panel targets.

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

```
=>HIS <Enter>

SEL-311                          Date: 10/15/10    Time: 08:40:16.740
STATION A

#     DATE      TIME     EVENT   LOCAT  CURR  FREQ GRP SHOT TARGETS

1  10/15/10 08:33:00.365 TRIG  $$$$$$$     1 60.00  3    2
2  10/14/10 20:32:58.361 ER    $$$$$$$   231 60.00  2    2
3  10/13/10 07:30:11.055 AG T     9.65  2279 60.00  3    2   TIME 51

=>
```

The fault locator has influence over information in the EVENT and LOCAT columns. If the fault locator is enabled (enable setting EFLOC = Y), the fault locator will attempt to run if the event report is generated by a trip (assertion of TRIP Relay Word bit) or other programmable event report trigger condition (SELOGIC control equation setting ER).

If the fault locator runs successfully, the location is listed in the LOCAT column, and the event type is listed in the EVENT column:

AG for A-phase to ground faults
BG for B-phase to ground faults
CG for C-phase to ground faults
AB for A–B phase-to-phase faults
BC for B–C phase-to-phase faults
CA for C–A phase-to-phase faults
ABG for A–B phase-to-phase to ground faults
BCG for B–C phase-to-phase to ground faults
CAG for C–A phase-to-phase to ground faults
ABC for three-phase faults

If a trip occurs in the same event report, a T is appended to the event type (e.g., AG T).

If the fault locator does not run successfully, $$$$$$$ is listed in the LOCAT column. If the fault locator is disabled (enable setting EFLOC = N), the LOCAT column is left blank. For either of these cases where the fault locator does not run, the event type listed in the EVENT column is one of the following:

TRIP event report generated by assertion of Relay Word bit TRIP
ER event report generated by assertion of SELOGIC control equation event report trigger condition setting ER
PULSE event report generated by execution of the **PUL** (Pulse) command
TRIG event report generated by execution of the **TRI** (Trigger) command

The TARGETS column displays the front panel target LED status during the event. If the relay is configured with programmable target LEDs, then the LED alias names are displayed.

For example, TIME 51 under the TARGETS column is interpreted as follows:

TIME → LED with alias "**TIME**" illuminated
51 → LED with alias "**51**" illuminated

If the relay is configured with programmable LEDs, set LED alias names with Global settings LED13A–LED26A.

For more information on front-panel target LEDs, see *Section 5: Trip and Target Logic*. For more information on event reports, see *Section 12: Standard Event Reports and SER*.

LOO Command (Loop Back)

The **LOO** (LOOP) command is used for testing the MIRRORED BITS communications channel. For more information on MIRRORED BITS, see *Appendix H: MIRRORED BITS Communications*.

Command	Description	Access Level
LOOP *c t*	Begin loopback of a single enabled MIRRORED BITS communications channel (either Channel A or Channel B); ignore input data and force receive bits (RMB) to defaults.	2
LOOP *c t* DATA	Begin loopback of a single MIRRORED BITS communications channel (either Channel A or Channel B): pass input data to receive data as in nonloopback mode.	2
LOOP *c* R	Cease loopback on MIRRORED BITS communications channel *c*. Reset the channel to normal use.	2

Parameter	Description
c	Append this parameter (*c* = A or B) to specify which channel to use if more than one MIRRORED BITS communications channel is enabled
t	Append this parameter to specify the timeout period in *t* minutes; *t* range is 1–5000 minutes. Defaults to 5 minutes if unspecified.

With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing will be wrong and ROK will deassert. The **LOO** command tells the MIRRORED BITS software to temporarily expect to see its own data looped back as its input. In this mode, Relay Word bit LBOK will assert if error-free data is received. The **LOO** command with just the channel specifier enables looped back mode on that channel for five minutes, while the inputs are forced to the default values.

MAC Command

The **MAC** command returns the Media Access Control (MAC) address of the Ethernet port. If IEC-61850 GOOSE messaging is enabled, an additional GOOSE MAC address is also displayed.

Command	Description	Access Level
MAC	Display Ethernet port MAC address	1

```
=>MAC <Enter>

Port 5 MAC Address: 00-30-A7-00-00-00
```

MET Command (Metering Data)

The **MET** commands provide access to the relay metering data. Metered quantities include phase voltages and currents, sequence component voltages and currents, power, frequency, substation battery voltage, energy, demand, and maximum/minimum logging of selected quantities. To make the extensive

NOTE: If the serial port AUTO setting is DTA, the SEL-311C response for **MET**, **MET X**, and **MET D** will be formatted differently on that serial port than shown below. Setting AUTO = DTA is not available on Ethernet or USB ports.

amount of meter information manageable, the relay divides the displayed information into five reports: Instantaneous, Demand, Energy, Maximum/Minimum, and Synchrophasors.

See *Section 8: Metering and Monitoring* for more information on metering.

MET k—Instantaneous Metering

Use the **MET *k*** command to display fundamental metering data.

Command	Description	Access Level
MET *k*	Display instantaneous metering data *k* times.	1

The **MET *k*** command displays instantaneous magnitudes (and angles if applicable) of the following quantities:

Type	Symbol	Description/Units
Currents	$I_{A,B,C,N}$	Input currents (A primary)
	I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C,S}$	Wye-connected voltage inputs (kV primary)
	$V_{AB,BC,CA,S}$	Delta-connected voltage inputs (kV primary)
Power	$MW_{A,B,C}$	Single-phase megawatts (wye-connected voltage inputs only)
	MW_{3P}	Three-phase megawatts
	$MVAR_{A,B,C}$	Single-phase megavars (wye-connected voltage inputs only)
	$MVAR_{3P}$	Three-phase megavars
Power Factor	$PF_{A,B,C}$	Single-phase power factor; leading or lagging (wye-connected voltage inputs only)
	PF_{3P}	Three-phase power factor; leading or lagging
Sequence	I_1, $3I_2$, $3I_0$	Positive-, negative-, and zero-sequence currents (A primary)
	V_1, V_2	Positive- and negative-sequence voltages (kV primary)
	$3V_0$	Zero-sequence voltage (kV primary, wye-connected voltage inputs only)
Frequency	FREQ	Instantaneous power system frequency (measured in Hz on voltage channel VA or from current I1)
Station DC	VDC	Voltage (V) at POWER terminals (input into station battery monitor)

The angles are referenced to voltage V_A (wye-connected) or V_{AB} (delta-connected) if the reference voltage is greater than 13 V secondary; otherwise, the angles are referenced to A-phase current. The angles range from –179.99 to 180.00 degrees.

To view instantaneous metering values, enter the command:

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

where *k* is an optional parameter to specify the number of times (1–32767) to repeat the meter display. If *k* is not specified, the meter report is displayed once.

The output from an SEL-311C with wye-connected voltage inputs is shown:

```
=>MET <Enter>
SEL-311                          Date: 10/15/10    Time: 15:00:52.615
STATION A
                 A         B         C         N         G
I MAG (A)      195.146   192.614   198.090     0.302     4.880
I ANG (DEG)     -8.03   -128.02    111.89     52.98     81.22
                 A         B         C         S
V MAG (KV)      11.691    11.686    11.669    11.695
V ANG (DEG)      0.00   -119.79    120.15      0.05
                 A         B         C         3P
MW               2.259     2.228     2.288     6.774
MVAR             0.319     0.322     0.332     0.973
PF               0.990     0.990     0.990     0.990
                 LAG       LAG       LAG       LAG
                 I1        3I2       3I0       V1        V2        3V0
MAG            195.283     4.630     4.880    11.682     0.007     0.056
ANG   (DEG)     -8.06   -103.93     81.22      0.12    -80.25    -65.83
FREQ (Hz)      60.00               VDC (V)      129.5
=>
```

MET X k—Extended Instantaneous Metering

The **MET X *k*** command displays the same data as the **MET *k*** command with the addition of calculated phase-to-phase voltage quantities V_{AB}, V_{BC}, V_{CA}.

Command	Description	Access Level
MET X *k*	Display instantaneous metering data and calculated phase-to-phase voltage quantities *k* times.	1

Type	Symbol	Description/Units
Currents	$I_{A,B,C,N}$	Input currents (A primary)
	I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C,S}$	Phase-to-neutral voltage inputs (kV primary) (wye-connected)
	$V_{AB,BC,CA,S}$	Phase-to-phase voltages (kV primary) (delta-connected)
	$V_{AB,BC,CA}$	Calculated phase-to-phase voltages (kV primary) (wye-connected)
Power	$MW_{A,B,C}$	Single-phase megawatts (wye-connected voltage inputs only)
	MW_{3P}	Three-phase megawatts
	$MVAR_{A,B,C}$	Single-phase megavars (wye-connected voltage inputs only)
	$MVAR_{3P}$	Three-phase megavars
Power Factor	$PF_{A,B,C}$	Single-phase power factor; leading or lagging (wye-connected voltage inputs only)
	PF_{3P}	Three-phase power factor; leading or lagging
Sequence	I_1, $3I_2$, $3I_0$	Positive-, negative-, and zero-sequence currents (A primary)
	V_1, V_2	Positive- and negative-sequence voltages (kV primary)
	$3V_0$	Zero-sequence voltage (kV primary) (wye-connected voltage inputs only)
Frequency	FREQ (Hz)	Instantaneous power system frequency (measured in Hz on voltage channel **VA** or from current I1)
Station DC	VDC	Voltage (V) at **POWER** terminals (input into station battery monitor)

The angles are referenced to voltage V_A (wye-connected) or V_{AB} (delta-connected) if the reference voltage is greater than 13 V secondary; otherwise, the angles are referenced to A-phase current. The angles range from –179.99 to 180.00 degrees.

To view instantaneous metering values, enter the command:

```
=>MET X k <Enter>
```

where *k* is an optional parameter to specify the number of times (1–32767) to repeat the meter display. If *k* is not specified, the meter report is displayed once.

The output from an SEL-311C with wye-connected voltage inputs is shown:

```
=>MET X <Enter>

LINE 2                         Date: 10/15/10    Time: 11:31:22.626
SUB B
                 A         B         C         N         G
I MAG (A)       30.302    36.558    29.254     7.454     7.526
I ANG (DEG)     -2.02   -121.88    119.60   -115.20   -117.52

                 A         B         C         S
V MAG (KV)      14.761    14.636    14.880    15.235
V ANG (DEG)      0.00   -119.95    120.94     29.93

                 AB        BC        CA
V MAG (KV)      25.452    25.448    25.790
V ANG (DEG)     29.89    -89.23    150.34

                 A         B         C         3P
MW               0.447     0.535     0.435     1.417
MVAR             0.016     0.018     0.010     0.044
PF               0.999     0.999     1.000     1.000
                 LAG       LAG       LAG       LAG

                 I1       3I2       3I0        V1        V2       3V0
MAG             32.036     6.196     7.526    14.759     0.131     0.212
ANG   (DEG)     -1.47    106.38   -117.52      0.33    -59.08    157.40

FREQ (Hz)      60.00                VDC (V)      125.6

=>
```

MET D—Demand Metering

Use the following command to view or reset demand and peak demand metering values.

Command	Description	Access Level
MET D	Display demand metering data.	1

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

Type	Symbol	Description/Units
Currents	$I_{A,B,C,N}$	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)
Power	$MW_{A,B,C}$	Single-phase megawatts (wye-connected voltage inputs only)
	MW_{3P}	Three-phase megawatts
	$MVAR_{A,B,C}$	Single-phase megavars (wye-connected voltage inputs only)
	$MVAR_{3P}$	Three-phase megavars
Reset Time	Demand, Peak	Last time the demands and peak demands were reset

To view demand metering values, enter the command:

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

The output from an SEL-311C with wye-connected voltage inputs is shown:

```
=>MET D <Enter>

SEL-311                          Date: 10/15/10    Time: 15:08:05.615
STATION A
            IA         IB         IC         IN         IG         3I2
DEMAND      188.6      186.6      191.8      0.2        4.5        4.7
PEAK        188.6      186.6      191.8      0.3        4.5        4.7
                MWA     MWB     MWC     MW3P    MVARA   MVARB   MVARC   MVAR3P
DEMAND IN       0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
PEAK IN         0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
DEMAND OUT      2.2     2.2     2.2     6.6     0.3     0.3     0.3     0.9
PEAK OUT        3.1     3.1     3.1     9.3     0.4     0.4     0.4     1.2
LAST DEMAND RESET 10/10/10 15:31:51.238   LAST PEAK RESET 10/10/10 15:31:56.239

=>
```

NOTE: See Small Signal Cutoff for Metering on page 8.29 for metering behavior with small signals.

Reset the accumulated demand values using the **MET RD** command. Reset the peak demand values using the **MET RP** command. For more information on demand metering, see *Demand Metering on page 8.17*.

MET E—Energy Metering

The **MET E** command displays the following quantities:

Command	Description	Access Level
MET E	Display energy metering data.	1
MET RE	Reset energy metering data.	1

Type	Symbol	Description/Units
Energy	$MWh_{A,B,C}$	Single-phase megawatt hours (in and out; wye-connected voltage inputs only)
	MWh_{3P}	Three-phase megawatt hours (in and out)
	$MVARh_{A,B,C}$	Single-phase megavar hours (in and out; wye-connected voltage inputs only)
	$MVARh_{3P}$	Three-phase megavar hours (in and out)
Reset Time		Last time the energy meter was reset

To view energy metering values, enter the command:

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

The output from an SEL-311C with wye-connected voltage inputs is shown:

```
=>MET E <Enter>

SEL-311                          Date: 10/15/10    Time: 15:11:24.056
STATION A
        MWhA     MWhB     MWhC     MWh3P    MVARhA   MVARhB   MVARhC   MVARh3P
IN      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
OUT     36.0     36.6     36.7     109.2    5.1      5.2      5.3      15.6
LAST RESET 10/14/10 23:31:28.864

=>
```

NOTE: See Small Signal Cutoff for Metering on page 8.29 for metering behavior with small signals.

Reset the energy values using the **MET RE** command. For more information on energy metering, see *Energy Metering on page 8.26*.

Accumulated energy metering values function like those in an electromechanical energy meter. When the energy meter reaches 99999 MWh or 99999 MVARh, it starts over at zero.

MET M—Maximum/Minimum Metering

Use the following commands to view or reset maximum and minimum metering values.

Command	Description	Access Level
MET M	Display maximum and minimum metering data.	1
MET RM	Reset maximum and minimum metering data. All values will display RESET until new maximum/minimum values are recorded.	1

The **MET M** command displays the maximum and minimum values of the following quantities:

Type	Symbol	Description/Units
Currents	$I_{A,B,C,N}$	Input currents (A primary)
	I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C,S}$	Wye-connected voltage inputs (kV primary)
	$V_{AB,BC,CA,S}$	Delta-connected voltage inputs (kV primary)
Power	MW_{3P}	Three-phase megawatts
	$MVAR_{3P}$	Three-phase megavars
Reset Time		Last time the maximum/minimum meter was reset

To view maximum/minimum metering values, enter the command:

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

The output from an SEL-311C with wye-connected voltage inputs is shown:

```
=>MET M <Enter>
SEL-311                          Date: 10/15/10    Time: 15:16:00.239

STATION A
           Max    Date      Time             Min    Date      Time
IA(A)      196.8  10/15/10  15:00:42.574     30.0   10/15/10  14:51:02.391
IB(A)      195.0  10/15/10  15:05:19.558     31.8   10/15/10  14:50:55.536
IC(A)      200.4  10/15/10  15:00:42.578     52.2   10/15/10  14:51:02.332
IN(A)       42.6  10/15/10  14:51:02.328     42.6   10/15/10  14:51:02.328
IG(A)       42.0  10/15/10  14:50:55.294     42.0   10/15/10  14:50:55.294
VA(kV)      11.7  10/15/10  15:01:01.576      3.4   10/15/10  15:00:42.545
VB(kV)      11.7  10/15/10  15:00:42.937      2.4   10/15/10  15:00:42.541
VC(kV)      11.7  10/15/10  15:00:42.578      3.1   10/15/10  15:00:42.545
VS(kV)      11.7  10/15/10  15:01:01.576      3.4   10/15/10  15:00:42.545
MW3P         6.9  10/15/10  15:00:44.095      0.4   10/15/10  15:00:42.545
MVAR3P       1.0  10/15/10  15:00:42.578      0.1   10/15/10  15:00:42.545
LAST RESET 10/14/10 15:31:41.237
=>
```

Reset the maximum/minimum values using the **MET RM** command. All values will display RESET until new maximum/minimum values are recorded. For more information on maximum/minimum metering, see *Maximum/Minimum Metering on page 8.27*.

MET PM—Synchrophasor Metering

The **MET PM** command (available when TSOK = logical 1 and EPMU = Y) displays the synchrophasor measurements. For more information, see *View Synchrophasors by Using the MET PM Command on page N.15*.

Command	Description	Access Level
MET PM	Display synchrophasor measurements.	1
MET PM *time*	Display synchrophasor measurements at specific time.	1
MET PM HIS	Display the most recent **MET PM** synchrophasor report.	1

Use the **MET PM** command to help with commissioning. The command:

```
=>MET PM time <Enter>
```

triggers a synchrophasor meter command at precisely the time specified. Parameter `time` must be in 24-hour format, e.g., 15:11:00.000. Compare magnitudes and phases of quantities displayed in response to the **MET PM** command to reports from other relays triggered at the same instant to verify correct phasing and polarity of current and voltage connections. To help facilitate comparing meter reports between several relays, the command:

```
=>MET PM HIS <Enter>
```

NOTE: The values reported by the **MET PM HIS** command are only valid if settings are not changed after the trigger.

recalls the most recently triggered synchrophasor meter report. For exploratory testing, the command:

```
=>MET PM k <Enter>
```

repeats the **MET PM** command *k* times. The trigger times of the *k* reports are not carefully controlled, but the trigger times are still accurately displayed in the reports.

The output from an SEL-311C is shown:

```
=>MET PM <Enter>

SEL-311                         Date: 10/15/10    Time: 10:33:59.000
STATION A

                                                                 PMDOK = 1
Time Quality   Maximum time synchronization error:     0.000 (ms)  TSOK = 1

Synchrophasors
                   Phase Voltages          Synch Voltage    Pos.-Seq. Voltage
               VA        VB        VC          VS                V1
MAG (kV)     12.045    12.037    12.038      12.042            12.040
ANG (DEG)   139.563    19.756  -100.109     140.066           139.737

                   Phase Currents         Neutral Current   Pos.-Seq. Current
               IA        IB        IC          IN                I1
MAG (A)     120.865   121.026   120.477       0.625           106.448
ANG (DEG)   140.109    20.452  -159.931     139.213           121.169

FREQ (Hz) 59.991
Rate-of-change of FREQ (Hz/s)    0.00

Digitals

SV1    SV2    SV3    SV4    SV5    SV6    SV7    SV8
 0      0      0      0      0      0      0      0
SV9    SV10   SV11   SV12   SV13   SV14   SV15   SV16
 0      0      0      0      0      0      0      0
=>
```

OPE Command (Open Breaker)

The **OPE** command asserts Relay Word bit OC for 1/4 cycle when it is executed. Relay Word bit OC can then be programmed into the TR SELOGIC control equation to assert the TRIP Relay Word bit, which in turn asserts an output contact (e.g., OUT101 = TRIP) to trip a circuit breaker.

Command	Description	Access Level
OPE	Assert the open command Relay Word bit OC.	B

The OC Relay Word bit appears in the factory-default SELOGIC settings for TR and 79DTL. See *Trip Logic on page 5.1* and *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 6.20*.

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 the main board Breaker jumper (see *Figure 2.19*). If the Breaker jumper is not in place (Breaker jumper = OFF), the relay does not execute the **OPE** command and responds:

```
Aborted: No Breaker Jumper
```

PAS Command (Change Passwords)

The relay is shipped with factory default passwords for Access Levels 1, B, 2, and C. These passwords are shown in *Table 10.12*.

Command	Description	Access Level
PAS *level*	Set a password for Access Level *level*.	2

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

Table 10.12 Factory Default Passwords for Access Levels 1, B, 2, and C

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

The **PAS**sword command allows you to change existing Level 1, B, and 2 passwords at Access Level 2 and allows you to change the Level C password from Level C. To change passwords, enter **PAS *x***, where ***x*** is the access level whose password is being changed. The relay will prompt for the old password, new password, and a confirmation of the new password.

To change the password for Access Level 1, enter the following:

```
=>>PAS 1 <Enter>

Old Password: *********

New Password: ******
Confirm New Password: ******

Password Changed
=>>
```

The new password will not echo on the screen, and passwords cannot be viewed from the device. Record the new password in a safe place for future reference.

If the passwords are lost or you wish to operate the relay without password protection, put the main board Access jumper in place (Access jumper = ON). Refer to *Figure 2.19* for Access jumper information. With the Access jumper in place, issue the **PAS *x*** command at Access Level 2. The relay will prompt for a new password and a confirmation of the new password.

Passwords may include up to 12 characters. See *Table 10.13* for valid characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 characters, with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks. Examples of valid, distinct strong passwords include:

- Ot3579A24.68
- Ih2d&s4u-Iwg
- .351s.Nt9g-t

Table 10.13 Valid Password Characters

Alpha	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz
Numeric	0123456789
Special	! " # $ % & ' ( ) * , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~

The relay issues a weak password warning if the new password does not include at least one special character, number, lowercase letter, and uppercase letter.

```
=>>PAS 1 <Enter>

Old Password: *********

New Password: ******
Confirm New Password: ******

Password Changed
=>>

CAUTION:  This password can be strengthened.  Strong passwords do not include a name,
    date, acronym, or word.  They consist of the maximum allowable characters, with
    at least one special character, number, lower-case letter, and upper-case
    letter.  A change in password is recommended.

=>>
```

PUL Command (Pulse Output Contact)

The **PUL** command allows you to pulse any of the output contacts for a specified length of time. The selected contact will close or open depending on the output contact type (a or b). See *Output Contacts on page 7.33*.

Command	Description	Access Level
PUL *x y*	Pulse output *x* for *y* second. (*x* = output name; *y* = 1–30 seconds)	B

To pulse OUT101 for five seconds:

```
==>PUL OUT101 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 (see *Figure 2.19*). If the Breaker is not in place (Breaker jumper = OFF), the relay does not execute the **PUL** command and responds:

```
Aborted:  No Breaker Jumper
```

The relay generates an event report if any output contact is pulsed. The **PUL** command is primarily used for testing purposes.

QUI Command (Quit Access Level)

The **QUI** command returns the relay to Access Level 0.

Command	Description	Access Level
QUI	Go to Access Level 0.	0

To return to Access Level 0, enter the command:

```
=>QUI <Enter>
```

The relay sets the port access level to 0 and responds:

```
SEL-311                          Date: 10/15/10     Time: 08:55:33.986
STATION A

=
```

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

The **QUI** command terminates the SEL Distributed Port Switch Protocol (LMD) connection if it is established (see *Appendix I: SEL Distributed Port Switch Protocol* for more information).

SER Command (Sequential Events Recorder Report)

Use the **SER** command to view the Sequential Events Recorder report. For more information on SER reports, see *Section 12: Standard Event Reports and SER*.

Command	Description	Access Level
SER	Use the **SER** command to display a chronological progression of all available SER rows (up to 1024 rows). Row 1 is the most recently triggered row and row 1024 is the oldest.	1
SER *row1* **SER *row1 row2*** **SER *date1*** **SER *date1 date2***	Use the **SER** command with parameters to display a chronological or reverse chronological subset of the SER rows.	1
SER C	Use this command to clear/reset the SER records.	1

SET Command (Change Settings)

The **SET** command allows the user to view or change the relay settings—see *Table 9.2*.

Command	Description	Access Level
SET *n*	Set the Group *n* settings, beginning at the first setting in each instance (*n* = 1–6); *n* defaults to the active setting group if not listed.	2
SET D *n*	Set DNP settings (*n* = 1–3); *n* defaults to DNP Map 1 if *n* is not included.	2
SET G	Set Global settings.	2
SET L *n*	Set Logic settings for setting group *n* (*n* = 1, 2, 3, 4, 5, or 6); *n* defaults to the active setting group if not listed.	2
SET M	Set Modbus settings.	2
SET P *n*	Set Port settings. *n* specifies the port (1, 2, 3, F, or 5); *n* defaults to the active port if not listed.	2
SET R	Set Report settings.	2
SET T	Set Text Label settings.	2

SHO Command (Show/View Settings)

Use the **SHO** command to view relay settings, SELOGIC control equations, Global Settings, Serial Port settings, Sequential Events Recorder (SER) settings, and Text Label settings.

Command	Description	Access Level
SHO *n*	Show Group *n* settings. *n* specifies the setting group (1, 2, 3, 4, 5, or 6); *n* defaults to the active setting group if not listed.	1
SHO D *n*	Show DNP settings (*n* = 1–3); *n* defaults to DNP Map 1 if *n* is not included.	1
SHO G	Show Global settings.	1
SHO L *n*	Show Logic settings for setting group *n* (*n* = 1, 2, 3, 4, 5, or 6); *n* defaults to the active setting group if not listed.	1
SHO M	Show Modbus settings.	1
SHO P *n*	Show Port settings. *n* specifies the port (1, 2, 3, F, or 5); *n* defaults to the active port if not listed.	1
SHO R	Show Report settings.	1
SHO T	Show Text Label settings.	1

You may append a setting name to each of the commands to specify the first setting to display (e.g., **SHO 1 E50P** displays the setting Group 1 relay settings starting with setting E50P). The default is the first setting.

The **SHO** commands display only the enabled settings. To display all settings, including disabled/hidden settings, append an **A** to the **SHO** command (e.g., **SHO 1 A**).

Below are sample **SHO** commands for the SEL-311C, showing the *factory default settings* for a particular model. The factory default settings for the other SEL-311C models are similar.

```
=>>SHO <Enter>

Group 1
Group Settings:
RID     =SEL-311                    TID     =STATION A
CTR     = 200       CTRN    = 200   PTR     = 2000.00   PTRS    = 2000.00
VNOM    = 67.00
Z1MAG   = 7.80      Z1ANG   = 84.00     Z0MAG   = 24.80     Z0ANG   = 81.50
LL      = 100.00    EADVS   = N         E21P    = 3         E21MG   = 3
E21XG   = 3         E50P    = 1         E50G    = N         E50Q    = N
E51P    = N         E51G    = Y         E51Q    = Y         E32     = AUTO
EOOS    = N         ELOAD   = Y         ESOTF   = Y         EDDSOTF = Y
EVOLT   = N         E25     = N         EFLOC   = Y         ELOP    = Y
EBBPT   = N         ECOMM   = POTT      E81     = N         E79     = N
EZ1EXT  = N         ECCVT   = N         ESV     = 1         EDEM    = THM
Z1P     = 6.24      Z2P     = 9.36      Z3P     = 1.87
50PP1   = 0.50
Z1MG    = 6.24      Z2MG    = 9.36      Z3MG    = 1.87
XG1     = 6.24      XG2     = 9.36      XG3     = 1.87
RG1     = 2.50      RG2     = 5.00      RG3     = 6.00
50L1    = 0.50      50GZ1   = 0.50
k0M1    = 0.726     k0A1    =-3.69

Press RETURN to continue

Z1PD    = OFF       Z2PD    = 20.00     Z3PD    = OFF       Z1GD    = OFF
Z2GD    = 20.00     Z3GD    = OFF       Z1D     = OFF       Z2D     = OFF
Z3D     = OFF
50P1P   = 15.00
67P1D   = 0.00
51GP    = 0.75      51GC    = U3        51GTD   = 1.50      51GRS   = N
51QP    = 2.20      51QC    = U3        51QTD   = 3.00      51QRS   = N
ZLF     = 6.50      ZLR     = 6.50      PLAF    = 30.00     NLAF    =-30.00
PLAR    = 150.00    NLAR    = 210.00
DIR3    = R         DIR4    = F
ORDER   = QVI       Z2F     = 3.90      Z2R     = 4.10      50QFP   = 0.50
50QRP   = 0.25      a2      = 0.10      k2      = 0.20      50GFP   = 0.50
50GRP   = 0.25      a0      = 0.10      Z0F     = 12.40     Z0R     = 12.60
CLOEND  = OFF       52AEND  = 10.00     SOTFD   = 30.00
Z3RBD   = 5.00      EBLKD   = 10.00     ETDPU   = 2.00      EDURD   = 4.00
EWFC    = N
DMTC    = 5         PDEMP   = 5.00      NDEMP   = OFF       GDEMP   = 1.50
QDEMP   = 1.50
TDURD   = 9.00      CFD     = 60.00     3POD    = 0.50      OPO     = 52
50LP    = 0.25

Press RETURN to continue

SV1PU   = 0.00      SV1DO   = 0.00

=>
```

```
=>>SHO L <Enter>
SELogic group 1

SELogic Control Equations:
TR       = M2PT + Z2GT + 51GT + 51QT + OC
TRQUAL   = M1P + Z1G
TRCOMM   = M2P + Z2G
TRSOTF   = M2P + Z2G + 50P1
DTT      = 0
ULTR     = !(50L + 51G)
PT1      = IN102
LOG1     = 0
PT2      = 0
LOG2     = 0
BT       = 0
52A      = IN101
CL       = CC
ULCL     = TRIP
79RI     = TRIP
79RIS    = 52A + 79CY
79DTL    = OC
79DLS    = 79LO
79SKP    = 0
79STL    = TRIP
79BRS    = TRIP
79SEQ    = 0
79CLS    = 1
SET1     = 0
RST1     = 0
SET2     = 0
RST2     = 0
SET3     = 0
RST3     = 0
SET4     = 0
RST4     = 0
SET5     = 0
RST5     = 0
SET6     = 0
RST6     = 0
SET7     = 0
RST7     = 0
SET8     = 0
RST8     = 0
SET9     = 0
RST9     = 0
SET10    = 0
RST10    = 0
SET11    = 0
RST11    = 0
SET12    = 0
RST12    = 0
SET13    = 0
RST13    = 0
SET14    = 0
RST14    = 0
SET15    = 0
RST15    = 0
SET16    = 0
RST16    = 0
67P1TC   = 1
67P2TC   = 1
67P3TC   = 1
67P4TC   = 1
67G1TC   = 1
67G2TC   = 1
67G3TC   = 1
67G4TC   = 1
67Q1TC   = 1
67Q2TC   = 1
67Q3TC   = 1
67Q4TC   = 1
51PTC    = 1
51GTC    = 1
51QTC    = 1
LV1      = 0
LV2      = 0
LV3      = 0
LV4      = 0
LV5      = 0
LV6      = 0
LV7      = 0
LV8      = 0
LV9      = 0
LV10     = 0
LV11     = 0
LV12     = 0
LV13     = 0
LV14     = 0
```

```
LV15     = 0
LV16     = 0
LV17     = 0
LV18     = 0
LV19     = 0
LV20     = 0
LV21     = 0
LV22     = 0
LV23     = 0
LV24     = 0
LV25     = 0
LV26     = 0
LV27     = 0
LV28     = 0
LV29     = 0
LV30     = 0
LV31     = 0
LV32     = 0
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
SV15     = 0
SV16     = 0
OUT101   = TRIP
OUT102   = TRIP
OUT103   = CLOSE
OUT104   = KEY
OUT105   = 0
OUT106   = 0
OUT107   = 0
OUT201   = 0
OUT202   = 0
OUT203   = 0
OUT204   = 0
OUT205   = 0
OUT206   = 0
OUT207   = 0
OUT208   = 0
OUT209   = 0
OUT210   = 0
OUT211   = 0
OUT212   = 0
LED1     = 0
LED2     = 0
LED3     = 0
LED4     = 0
LED5     = 0
LED6     = 0
LED7     = 0
LED8     = 0
LED9     = 0
LED10    = 0
LED12    = LTRIP
LED13    = LTIME
LED14    = LCOMM
LED15    = LSOTF
LED16    = 79RS
LED17    = 79LO
LED18    = L51
LED23    = LZONE1
LED24    = LZONE2
LED25    = LZONE3
LED26    = LZONE4
DP1      = 52A
DP2      = 0
DP3      = 0
DP4      = 0
DP5      = 0
DP6      = 0
DP7      = 0
DP8      = 0
DP9      = 0
DP10     = 0
DP11     = 0
DP12     = 0
DP13     = 0
DP14     = 0
DP15     = 0
```

```
DP16    = 0
SS1     = 0
SS2     = 0
SS3     = 0
SS4     = 0
SS5     = 0
SS6     = 0
ER      = /M2P + /Z2G + /51G + /51Q + /50P1 + /LOP
FAULT   = 51G + 51Q + M2P + Z2G
BSYNCH  = 52A
CLMON   = 0
BKMON   = TRIP
E32IV   = 1
Z1XPEC  = 0
Z1XGEC  = 0
RSTTRGT = 0
RST_DEM = 0
RST_PDM = 0
RST_BK  = 0
RST_HIS = 0
RST_ENE = 0
RST_MML = 0
PMTRIG  = 0
TREA1   = 0
TREA2   = 0
TREA3   = 0
TREA4   = 0
TMB1A   = 0
TMB2A   = 0
TMB3A   = 0
TMB4A   = 0
TMB5A   = 0
TMB6A   = 0
TMB7A   = 0
TMB8A   = 0
TMB1B   = 0
TMB2B   = 0
TMB3B   = 0
TMB4B   = 0
TMB5B   = 0
TMB6B   = 0
TMB7B   = 0
TMB8B   = 0

=>>
```

```
=>>SHO G <Enter>

Global Settings:
PTCONN  = WYE       TGR     = 0.00
NFREQ   = 60        PHROT   = ABC       DATE_F  = MDY
FP_TO   = 15        SCROLD  = 2         FPNGD   = IG
LER     = 15        PRE     = 4         DCLOP   = OFF       DCHIP   = OFF
IN101D  = 0.00      IN102D  = 0.00      IN103D  = 0.00      IN104D  = 0.00
IN105D  = 0.00      IN106D  = 0.00
IN201D  = 0.00      IN202D  = 0.00      IN203D  = 0.00      IN204D  = 0.00
IN205D  = 0.00      IN206D  = 0.00      IN207D  = 0.00      IN208D  = 0.00
EBMON   = Y         COSP1   = 10000     COSP2   = 150       COSP3   = 12
KASP1   = 1.20      KASP2   = 8.00      KASP3   = 20.00
LED12L  = Y         LED13L  = Y         LED14L  = Y         LED15L  = Y
LED16L  = N         LED17L  = N         LED18L  = Y         LED23L  = Y
LED24L  = Y         LED25L  = Y         LED26L  = Y
LED12A  = TRIP
LED13A  = TIME
LED14A  = COMM
LED15A  = SOTF
LED16A  = RS
LED17A  = LO
LED18A  = 51
LED23A  = ZONE1
LED24A  = ZONE2
LED25A  = ZONE3
LED26A  = ZONE4
RSTLED  = N
EPMU    = N         EVELOCK = 0         DNPSRC  = UTC       IRIGC   = NONE
UTC_OFF = 0.00
DST_BEGM= NA

=>>
```

```
=>>SHO P <Enter>

Port F

EPORT   = Y
PROTO   = SEL       MAXACC  = C
SPEED   = 9600      BITS    = 8         PARITY  = N         STOP    = 1
RTSCTS  = N         T_OUT   = 15
AUTO    = N         FASTOP  = N

=>>
```

```
=>>SHO P 5 <Enter>

Port 5

EPORT   = Y         IPADDR  = 192.168.1.2
SUBNETM = 255.255.255.0
DEFRTR  = 192.168.1.1
ETCPKA  = Y         KAIDLE  = 10        KAINTV  = 10        KACNT   = 5

NET5SPD = AUTO
ETELNET = N
EFTPSERV= N         EHTTP   = N

EDNP    = 0
EMODBUS = 0
ESNTP   = OFF

=>>
```

```
=>>SHO R <Enter>

Sequential Events Recorder trigger lists:
SER1    = M1P,Z1G,M2P,Z2G,M3P,Z3G,51G,51Q,50P1
SER2    = IN101,IN102,OUT101,OUT102,OUT103,OUT104,LOP
SER3    = KEY,Z3RB,PTRX

=>>
```

```
=>>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    =
NLB9    =               CLB9    =         SLB9    =         PLB9    =
NLB10   =               CLB10   =         SLB10   =         PLB10   =
NLB11   =               CLB11   =         SLB11   =         PLB11   =
NLB12   =               CLB12   =         SLB12   =         PLB12   =
NLB13   =               CLB13   =         SLB13   =         PLB13   =
NLB14   =               CLB14   =         SLB14   =         PLB14   =
NLB15   =               CLB15   =         SLB15   =         PLB15   =
NLB16   =               CLB16   =         SLB16   =         PLB16   =
DP1_1   = BREAKER CLOSED   DP1_0   = BREAKER OPEN
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   =
DP9_1   =                  DP9_0   =
DP10_1  =                  DP10_0  =
DP11_1  =                  DP11_0  =
DP12_1  =                  DP12_0  =
DP13_1  =                  DP13_0  =
DP14_1  =                  DP14_0  =
DP15_1  =                  DP15_0  =
DP16_1  =                  DP16_0  =
79LL    = SET RECLOSURES 79SL    = RECLOSE COUNT

=>>
```

```
=>>SHO M <Enter>

MOD_001 = IA       MOD_002 = IAFA     MOD_003 = IB       MOD_004 = IBFA
MOD_005 = IC       MOD_006 = ICFA     MOD_007 = IG       MOD_008 = IGFA
MOD_009 = IN       MOD_010 = INFA     MOD_011 = VA       MOD_013 = VAFA
MOD_014 = VB       MOD_016 = VBFA     MOD_017 = VC       MOD_019 = VCFA
MOD_020 = VS       MOD_022 = VSFA     MOD_023 = KW3      MOD_025 = KVAR3
MOD_027 = PF3      MOD_028 = LDPF3    MOD_029 = FREQ     MOD_030 = VDC
MOD_031 = MWH3I    MOD_033 = MWH3O    MOD_035 = MVRH3I   MOD_037 = MVRH3O
MOD_039 = ACTGRP   MOD_040 = ROW_0    MOD_041 = ROW_1    MOD_042 = ROW_31
MOD_043 = ROW_19   MOD_044 = NA       MOD_045 = NA       MOD_046 = NA
MOD_047 = NA       MOD_048 = NA       MOD_049 = NA       MOD_050 = NA
MOD_051 = NA       MOD_052 = NA       MOD_053 = NA       MOD_054 = NA
MOD_055 = NA       MOD_056 = NA       MOD_057 = NA       MOD_058 = NA
MOD_059 = NA       MOD_060 = NA       MOD_061 = NA       MOD_062 = NA
MOD_063 = NA       MOD_064 = NA       MOD_065 = NA       MOD_066 = NA
MOD_067 = NA       MOD_068 = NA       MOD_069 = NA       MOD_070 = NA
MOD_071 = NA       MOD_072 = NA       MOD_073 = NA       MOD_074 = NA
MOD_075 = NA       MOD_076 = NA       MOD_077 = NA       MOD_078 = NA
MOD_079 = NA       MOD_080 = NA       MOD_081 = NA       MOD_082 = NA
MOD_083 = NA       MOD_084 = NA       MOD_085 = NA       MOD_086 = NA
MOD_087 = NA       MOD_088 = NA       MOD_089 = NA       MOD_090 = NA
MOD_091 = NA       MOD_092 = NA       MOD_093 = NA       MOD_094 = NA
MOD_095 = NA       MOD_096 = NA       MOD_097 = NA       MOD_098 = NA
MOD_099 = NA       MOD_100 = NA       MOD_101 = NA       MOD_102 = NA
MOD_103 = NA       MOD_104 = NA       MOD_105 = NA       MOD_106 = NA
MOD_107 = NA       MOD_108 = NA       MOD_109 = NA       MOD_110 = NA
MOD_111 = NA       MOD_112 = NA       MOD_113 = NA       MOD_114 = NA
MOD_115 = NA       MOD_116 = NA       MOD_117 = NA       MOD_118 = NA
MOD_119 = NA       MOD_120 = NA       MOD_121 = NA       MOD_122 = NA
MOD_123 = NA       MOD_124 = NA       MOD_125 = NA

MOD_126 = NA       MOD_127 = NA       MOD_128 = NA       MOD_129 = NA
MOD_130 = NA       MOD_131 = NA       MOD_132 = NA       MOD_133 = NA
MOD_134 = NA       MOD_135 = NA       MOD_136 = NA       MOD_137 = NA
MOD_138 = NA       MOD_139 = NA       MOD_140 = NA       MOD_141 = NA
MOD_142 = NA       MOD_143 = NA       MOD_144 = NA       MOD_145 = NA
MOD_146 = NA       MOD_147 = NA       MOD_148 = NA       MOD_149 = NA
MOD_150 = NA       MOD_151 = NA       MOD_152 = NA       MOD_153 = NA
MOD_154 = NA       MOD_155 = NA       MOD_156 = NA       MOD_157 = NA
MOD_158 = NA       MOD_159 = NA       MOD_160 = NA       MOD_161 = NA
MOD_162 = NA       MOD_163 = NA       MOD_164 = NA       MOD_165 = NA
MOD_166 = NA       MOD_167 = NA       MOD_168 = NA       MOD_169 = NA
MOD_170 = NA       MOD_171 = NA       MOD_172 = NA       MOD_173 = NA
MOD_174 = NA       MOD_175 = NA       MOD_176 = NA       MOD_177 = NA
MOD_178 = NA       MOD_179 = NA       MOD_180 = NA       MOD_181 = NA
MOD_182 = NA       MOD_183 = NA       MOD_184 = NA       MOD_185 = NA
MOD_186 = NA       MOD_187 = NA       MOD_188 = NA       MOD_189 = NA
MOD_190 = NA       MOD_191 = NA       MOD_192 = NA       MOD_193 = NA
MOD_194 = NA       MOD_195 = NA       MOD_196 = NA       MOD_197 = NA
MOD_198 = NA       MOD_199 = NA       MOD_200 = NA       MOD_201 = NA
MOD_202 = NA       MOD_203 = NA       MOD_204 = NA       MOD_205 = NA
MOD_206 = NA       MOD_207 = NA       MOD_208 = NA       MOD_209 = NA
MOD_210 = NA       MOD_211 = NA       MOD_212 = NA       MOD_213 = NA
MOD_214 = NA       MOD_215 = NA       MOD_216 = NA       MOD_217 = NA
MOD_218 = NA       MOD_219 = NA       MOD_220 = NA       MOD_221 = NA
MOD_222 = NA       MOD_223 = NA       MOD_224 = NA       MOD_225 = NA
MOD_226 = NA       MOD_227 = NA       MOD_228 = NA       MOD_229 = NA
MOD_230 = NA       MOD_231 = NA       MOD_232 = NA       MOD_233 = NA
MOD_234 = NA       MOD_235 = NA       MOD_236 = NA       MOD_237 = NA
MOD_238 = NA       MOD_239 = NA       MOD_240 = NA       MOD_241 = NA
MOD_242 = NA       MOD_243 = NA       MOD_244 = NA       MOD_245 = NA
MOD_246 = NA       MOD_247 = NA       MOD_248 = NA       MOD_249 = NA
MOD_250 = NA

=>>
```

```
=>>SHO D <Enter>

DNP Map Settings 1
BI_000  = 52A      BI_001  = 79RS     BI_002  = 79LO     BI_003  = TLED18
BI_004  = TLED17   BI_005  = TLED16   BI_006  = TLED15   BI_007  = TLED14
BI_008  = TLED13   BI_009  = TLED12   BI_010  = TLED11   BI_011  = TLED26
BI_012  = TLED25   BI_013  = TLED24   BI_014  = TLED23   BI_015  = TLED22
BI_016  = TLED21   BI_017  = TLED20   BI_018  = TLED19   BI_019  = LDPF3
BI_020  = RLYDIS   BI_021  = STFAIL   BI_022  = STWARN   BI_023  = UNRDEV
BI_024  = NA       BI_025  = NA       BI_026  = NA       BI_027  = NA
BI_028  = NA       BI_029  = NA       BI_030  = NA       BI_031  = NA
BI_032  = NA       BI_033  = NA       BI_034  = NA       BI_035  = NA
BI_036  = NA       BI_037  = NA       BI_038  = NA       BI_039  = NA
BI_040  = NA       BI_041  = NA       BI_042  = NA       BI_043  = NA
BI_044  = NA       BI_045  = NA       BI_046  = NA       BI_047  = NA
BI_048  = NA       BI_049  = NA       BI_050  = NA       BI_051  = NA
BI_052  = NA       BI_053  = NA       BI_054  = NA       BI_055  = NA
BI_056  = NA       BI_057  = NA       BI_058  = NA       BI_059  = NA
BI_060  = NA       BI_061  = NA       BI_062  = NA       BI_063  = NA
```

```
BI_064  = NA      BI_065  = NA      BI_066  = NA      BI_067  = NA
BI_068  = NA      BI_069  = NA      BI_070  = NA      BI_071  = NA
BI_072  = NA      BI_073  = NA      BI_074  = NA      BI_075  = NA
BI_076  = NA      BI_077  = NA      BI_078  = NA      BI_079  = NA
BI_080  = NA      BI_081  = NA      BI_082  = NA      BI_083  = NA
BI_084  = NA      BI_085  = NA      BI_086  = NA      BI_087  = NA
BI_088  = NA      BI_089  = NA      BI_090  = NA      BI_091  = NA
BI_092  = NA      BI_093  = NA      BI_094  = NA      BI_095  = NA
BI_096  = NA      BI_097  = NA      BI_098  = NA      BI_099  = NA
BI_100  = NA      BI_101  = NA      BI_102  = NA      BI_103  = NA
BI_104  = NA      BI_105  = NA      BI_106  = NA      BI_107  = NA
BI_108  = NA      BI_109  = NA      BI_110  = NA      BI_111  = NA
BI_112  = NA      BI_113  = NA      BI_114  = NA      BI_115  = NA
BI_116  = NA      BI_117  = NA      BI_118  = NA      BI_119  = NA
BI_120  = NA      BI_121  = NA      BI_122  = NA      BI_123  = NA
BI_124  = NA      BI_125  = NA      BI_126  = NA      BI_127  = NA
BI_128  = NA      BI_129  = NA      BI_130  = NA      BI_131  = NA
BI_132  = NA      BI_133  = NA      BI_134  = NA      BI_135  = NA
BI_136  = NA      BI_137  = NA      BI_138  = NA      BI_139  = NA
BI_140  = NA      BI_141  = NA      BI_142  = NA      BI_143  = NA
BI_144  = NA      BI_145  = NA      BI_146  = NA      BI_147  = NA
BI_148  = NA      BI_149  = NA      BI_150  = NA      BI_151  = NA
BI_152  = NA      BI_153  = NA      BI_154  = NA      BI_155  = NA
BI_156  = NA      BI_157  = NA      BI_158  = NA      BI_159  = NA
BI_160  = NA      BI_161  = NA      BI_162  = NA      BI_163  = NA
BI_164  = NA      BI_165  = NA      BI_166  = NA      BI_167  = NA
BI_168  = NA      BI_169  = NA      BI_170  = NA      BI_171  = NA
BI_172  = NA      BI_173  = NA      BI_174  = NA      BI_175  = NA
BI_176  = NA      BI_177  = NA      BI_178  = NA      BI_179  = NA
BI_180  = NA      BI_181  = NA      BI_182  = NA      BI_183  = NA
BI_184  = NA      BI_185  = NA      BI_186  = NA      BI_187  = NA
BI_188  = NA      BI_189  = NA      BI_190  = NA      BI_191  = NA
BI_192  = NA      BI_193  = NA      BI_194  = NA      BI_195  = NA
BI_196  = NA      BI_197  = NA      BI_198  = NA      BI_199  = NA

BO_000  = RB1             BO_001  = RB2             BO_002  = RB3
BO_003  = RB4             BO_004  = RB5             BO_005  = RB6
BO_006  = RB7             BO_007  = RB8             BO_008  = RB9
BO_009  = RB10            BO_010  = RB11            BO_011  = RB12
BO_012  = RB13            BO_013  = RB14            BO_014  = RB15
BO_015  = RB16            BO_016  = OC              BO_017  = CC
BO_018  = DRST_DEM        BO_019  = DRST_PDM        BO_020  = DRST_ENE
BO_021  = DRST_BK         BO_022  = DRST_TAR        BO_023  = NXTEVE
BO_024  = RB1:RB2         BO_025  = RB3:RB4         BO_026  = RB5:RB6
BO_027  = RB7:RB8         BO_028  = RB9:RB10        BO_029  = RB11:RB12
BO_030  = RB13:RB14       BO_031  = RB15:RB16       BO_032  = OC:CC


AI_000  = IA                      AI_001  = IAFA::500
AI_002  = IB                      AI_003  = IBFA::500
AI_004  = IC                      AI_005  = ICFA::500
AI_006  = IN                      AI_007  = INFA::500
AI_008  = VA                      AI_009  = VAFA::500
AI_010  = VB                      AI_011  = VBFA::500
AI_012  = VC                      AI_013  = VCFA::500
AI_014  = VS                      AI_015  = VSFA::500
AI_016  = IG                      AI_017  = IGFA::500
AI_018  = MW3                     AI_019  = MVAR3
AI_020  = PF3                     AI_021  = FREQ
AI_022  = VDC                     AI_023  = MWH3I
AI_024  = MWH3O                   AI_025  = MVRH3I
AI_026  = MVRH3O                  AI_027  = WEARA
AI_028  = WEARB                   AI_029  = WEARC
AI_030  = FTYPE                   AI_031  = FLOC
AI_032  = FI                      AI_033  = FFREQ
AI_034  = FGRP                    AI_035  = FSHO
AI_036  = FTIMEH                  AI_037  = FTIMEM
AI_038  = FTIMEL                  AI_039  = FUNR
AI_040  = NA                      AI_041  = NA
AI_042  = NA                      AI_043  = NA
AI_044  = NA                      AI_045  = NA
AI_046  = NA                      AI_047  = NA
AI_048  = NA                      AI_049  = NA
AI_050  = NA                      AI_051  = NA
AI_052  = NA                      AI_053  = NA
AI_054  = NA                      AI_055  = NA
AI_056  = NA                      AI_057  = NA
AI_058  = NA                      AI_059  = NA
AI_060  = NA                      AI_061  = NA
AI_062  = NA                      AI_063  = NA
AI_064  = NA                      AI_065  = NA
AI_066  = NA                      AI_067  = NA
AI_068  = NA                      AI_069  = NA
AI_070  = NA                      AI_071  = NA
AI_072  = NA                      AI_073  = NA
AI_074  = NA                      AI_075  = NA
AI_076  = NA                      AI_077  = NA
AI_078  = NA                      AI_079  = NA
AI_080  = NA                      AI_081  = NA
```

```
AI_082   = NA                        AI_083   = NA
AI_084   = NA                        AI_085   = NA
AI_086   = NA                        AI_087   = NA
AI_088   = NA                        AI_089   = NA
AI_090   = NA                        AI_091   = NA
AI_092   = NA                        AI_093   = NA
AI_094   = NA                        AI_095   = NA
AI_096   = NA                        AI_097   = NA
AI_098   = NA                        AI_099   = NA
AI_100   = NA                        AI_101   = NA
AI_102   = NA                        AI_103   = NA
AI_104   = NA                        AI_105   = NA
AI_106   = NA                        AI_107   = NA
AI_108   = NA                        AI_109   = NA
AI_110   = NA                        AI_111   = NA
AI_112   = NA                        AI_113   = NA
AI_114   = NA                        AI_115   = NA
AI_116   = NA                        AI_117   = NA
AI_118   = NA                        AI_119   = NA
AI_120   = NA                        AI_121   = NA
AI_122   = NA                        AI_123   = NA
AI_124   = NA                        AI_125   = NA
AI_126   = NA                        AI_127   = NA
AI_128   = NA                        AI_129   = NA
AI_130   = NA                        AI_131   = NA
AI_132   = NA                        AI_133   = NA
AI_134   = NA                        AI_135   = NA
AI_136   = NA                        AI_137   = NA
AI_138   = NA                        AI_139   = NA
AI_140   = NA                        AI_141   = NA
AI_142   = NA                        AI_143   = NA
AI_144   = NA                        AI_145   = NA
AI_146   = NA                        AI_147   = NA
AI_148   = NA                        AI_149   = NA
AI_150   = NA                        AI_151   = NA
AI_152   = NA                        AI_153   = NA
AI_154   = NA                        AI_155   = NA
AI_156   = NA                        AI_157   = NA
AI_158   = NA                        AI_159   = NA
AI_160   = NA                        AI_161   = NA
AI_162   = NA                        AI_163   = NA
AI_164   = NA                        AI_165   = NA
AI_166   = NA                        AI_167   = NA
AI_168   = NA                        AI_169   = NA
AI_170   = NA                        AI_171   = NA
AI_172   = NA                        AI_173   = NA
AI_174   = NA                        AI_175   = NA
AI_176   = NA                        AI_177   = NA
AI_178   = NA                        AI_179   = NA
AI_180   = NA                        AI_181   = NA
AI_182   = NA                        AI_183   = NA
AI_184   = NA                        AI_185   = NA
AI_186   = NA                        AI_187   = NA
AI_188   = NA                        AI_189   = NA
AI_190   = NA                        AI_191   = NA
AI_192   = NA                        AI_193   = NA
AI_194   = NA                        AI_195   = NA
AI_196   = NA                        AI_197   = NA
AI_198   = NA                        AI_199   = NA

AO_000   = ACTGRP   AO_001   = NA       AO_002   = NA       AO_003   = NA
AO_004   = NA       AO_005   = NA       AO_006   = NA       AO_007   = NA

CO_000   = ACTGRP          CO_001   = INTTR          CO_002   = EXTTR
CO_003   = NA              CO_004   = NA             CO_005   = NA
CO_006   = NA              CO_007   = NA

=>>
```

STA Command (Relay Self-Test Status)

The **STA** command displays the status report, showing the relay self-test information.

Command	Description	Access Level
STA *n*	Display the relay self-test information *n* times (*n* = 1–32767). Defaults to 1 if *n* is not specified.	1
STA C	Clear all relay self-test warnings and failures and restart the relay.	2

To view a status report, enter the command:

```
=>STA n <Enter>
```

where *n* is an optional parameter to specify the number of times (1–32767) to repeat the status display. If *n* is not specified, the status report is displayed once.

A sample output of an SEL-311C is shown:

```
=>STA <Enter>
SEL-311                           Date: 10/15/10    Time: 23:19:50.339
STATION A

FID=SEL-311-1-R500-V0-Z100100-D20xxxxxx       CID=83ED

SELF TESTS

W=Warn    F=Fail

      IA      IB      IC      IN      VA      VB      VC      VS      MOF
OS    -1      1       1       1       2       0       1       2       0
OSH   -1      0       0       1

      15V_PS  5V_REG  3.3V_REG
PS    14.93   4.99    3.27

      RAM     ROM     FPGA    EEPROM  FLASH   A/D     USB_BRD COM_BRD IO_BRD
      OK      OK      OK      OK      OK      OK      OK      OK      OK

      TEMP    RTC     HMI
      32.2    OK      OK

Relay Enabled

=>
```

STA Command Row and Column Definitions

FID	FID is the firmware identifier string. It identifies the firmware revision.
CID	CID is the firmware checksum identifier.
OS	OS = Offset; displays measured dc offset voltages in millivolts for the current and voltage channels. The MOF (master) status is the dc offset in the A/D circuit when a grounded input is selected.
OSH	Similar to OS, but for high-gain current channels.
PS	PS = Power Supply; displays power supply voltages in Vdc for the power supply outputs.
RAM, ROM, EEPROM, FLASH	These tests verify the relay memory components.
FPGA	Displays health of FPGA.
A/D	Analog to Digital convert status.
USB_BRD	USB port status, if supplied.
COM_BRD	Dual copper, and dual or single fiber-optic Ethernet ports status, if supplied.
IO_BRD	Extra I/O board status.
TEMP	Displays the internal relay temperature in degrees Celsius.
RTC	Battery backed time-of-day clock status.
HMI	Front-panel board status.
W or F	W (Warning) or F (Failure) is appended to the values to indicate an out-of-tolerance condition.

The relay latches all self-test warnings and failures in order to capture transient out-of-tolerance conditions. To reset the self-test statuses, use the **STA C** command from Access Level 2:

```
=>>STA C <Enter>
```

The relay responds:

```
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 rerun before the relay is enabled.

Refer to *Table 13.2* for self-test thresholds and corrective actions.

SUM Command (Long Summary Event Report)

The **SUM** command displays a long summary event report. The long summary contains more information than available from the **HIS** command, but is shorter than the full event report retrieved with the **EVE** or **CEV** commands. The long summary event report is displayed on all ports with AUTO = Y whenever a new event report is generated.

Command	Description	Access Level
SUM *n*	Displays the summary event report for event *n*, where *n* is either the event number from the **HIS** report, or the unique event number in the range 10000 to 65535 from the **HIS E** report. **SUM** with no *n* displays the most recent summary event report.	1
SUM ACK *n*	Acknowledge the summary event report for event *n*, where *n* must be the unique event number in the range 10000 to 65535 from the **HIS E** report. **SUM ACK** with no *n* acknowledges the oldest unacknowledged event report. Each serial port remembers which reports have been acknowledged on that port. Reports acknowledged within a Telnet session are acknowledged for all Telnet sessions on the Ethernet port.	
SUM N	Displays the oldest unacknowledged summary event report.	

Issue the **SUM N** and **SUM ACK** command repeatedly to step through the available event summaries from oldest to newest. When all reports have been acknowledged, the next **SUM N** command returns:

```
No unacknowledged event summaries exist.
```

A sample report is shown below. MIRRORED BITS channel status is only displayed when MIRRORED BITS are enabled. *Section 12: Standard Event Reports and SER* describes the various fields of information available in the summary event report.

```
=>>SUM <Enter>

SEL-311                          Date: 07/02/10    Time: 20:32:44.519
STATION A

Event: ABC T      Location:   64.93           Trip Time: 20:32:44.531
#: 10022  Shot:    Freq:  60.00  Group: 1     Close Time: --:--:--.---
Targets: ZONE1
Breaker: Open

PreFault:     IA      IB      IC      IN      IG     3I2       VA       VB       VC
MAG(A/kV)    501     501     501       1       3       2  120.150  120.090  120.140
ANG(DEG)  119.34   -0.44-120.37  -83.99   12.01   50.39     0.00  -119.84   120.29
Fault:
MAG(A/kV)   1811    1830    1819       1      22      12  112.910  112.900  112.910
ANG(DEG)   55.51  -64.40  175.70-176.77  -82.67-153.19   119.56    -0.27  -120.23

                                                   L C R      L C R
                                                   B B B R    B B B R
                                                   O A A O    O A A O
                                                   K D D K    K D D K
MB:8->1      RMBA       TMBA       RMBB       TMBB     A A A A    B B B B

  TRIG      00000000   00000000   00000000   00000000   0 0 0 0    0 0 0 0
  TRIP      00000000   00000000   00000000   00000000   0 0 0 0    0 0 0 0


=>>
```

TAR Command (Display Relay Element Status)

The **TAR** command displays the status of front-panel target LEDs or relay elements, whether they are asserted or deasserted.

Command	Description	Access Level
TAR	Use **TARGET** without parameters to display Relay Word row 0 or last displayed target row.	1
TAR *name k*	Display the target row containing *name*. Repeat the display *k* times.	1
TAR *n k*	Display target row number *n*. Repeat the display *k* times.	1
TAR LIST	Display all target rows. If ROW is specified, the relay includes the target row number on each line.	1
TAR R	Clears front-panel tripping targets. Shows Relay Word Row 0.	1

The target row elements are listed in rows of eight. The first two rows (0 and 1) correspond to the relay front-panel target LEDs. The target row elements are asserted when the corresponding front-panel target LED is illuminated.

The remaining target rows (2–99) correspond to the Relay Word as described in *Table D.1*. A Relay Word bit is either at a logical 1 (asserted) or a logical 0 (deasserted). Relay Word bits are used in SELOGIC control equations. See *Appendix F: Setting SELOGIC Control Equations*.

The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL relays. But the execution of the equivalent **TAR** command via the front-panel display does remap the bottom row of the front-panel target LEDs (see *Figure 11.3*, pushbutton OTHER).

The **TAR** command options are:

`TAR n k`
or
`TAR ROW n k`
	Shows Relay Word row number *n* (0–93). *k* is an optional parameter to specify the number of times (1–32767) to repeat the Relay Word row display. If *k* is not specified, the Relay Word row is displayed once. Adding **ROW** to the command displays the Relay Word Row number at the start of each line.

`TAR name k`
or
`TAR ROW name k`
	Shows Relay Word row containing Relay Word bit name (e.g., TAR 50C displays Relay Word Row 5). *k* is an optional parameter to specify the number of times (1–32767) to repeat the Relay Word row display. If *k* is not specified, the Relay Word row is displayed once. Adding **ROW** to the command displays the Relay Word Row number at the start of each line.

`TAR LIST`
or
`TAR ROW LIST`
	Shows all the Relay Word bits in all of the rows. Adding **ROW** to the command displays the Relay Word Row number at the start of each line.

`TAR R`	Clears latching front-panel tripping target LEDs. Unlatches the trip logic for testing purposes (see *Figure 5.1*). Shows Relay Word Row 0.

NOTE: The **TAR R** command cannot reset the latched Targets if a TRIP condition is present.

Command **TAR SH1 10** is executed in the following example:

```
=>TAR SH1 10 <Enter>

79RS   79CY   79LO   SH0    SH1    SH2    SH3    SH4
0      0      1      0      1      0      0      0
0      0      1      0      1      0      0      0
0      0      1      0      1      0      0      0
0      0      1      0      1      0      0      0
0      0      1      0      1      0      0      0
0      0      1      0      1      0      0      0
0      0      1      0      1      0      0      0
0      0      1      0      1      0      0      0

79RS   79CY   79LO   SH0    SH1    SH2    SH3    SH4
0      0      1      0      1      0      0      0
0      0      1      0      1      0      0      0

=>
```

Note that Relay Word row containing the SH1 bit is repeated 10 times. In this example, the reclosing relay is in the Lockout State (79LO = logical 1), and the shot is at shot = 1 (SH1 = logical 1). Command **TAR 31** will report the same data since the SH1 bit is in Row 31 of the Relay Word.

Command **TAR ROW LIST** is executed in the following example (SEL-311C with dual Ethernet).

```
==>TAR ROW LIST <Enter>


Row   TLED11   TLED12   TLED13   TLED14   TLED15   TLED16   TLED17   TLED18
0     1        0        0        0        0        0        0        0

Row   TLED19   TLED20   TLED21   TLED22   TLED23   TLED24   TLED25   TLED26
1     0        0        0        0        0        0        0        0

Row   M1P      M1PT     Z1G      Z1GT     M2P      M2PT     Z2G      Z2GT
2     0        0        0        0        0        0        0        0

Row   Z1T      Z2T      50P1     67P1     67P1T    50G1     67G1     67G1T
3     0        0        0        0        0        0        0        0

Row   51G      51GT     51GR     LOP      ILOP     ZLOAD    ZLOUT    ZLIN
4     0        0        1        0        0        0        0        0


(92 rows not shown)


Row   VB105    VB106    VB107    VB108    VB109    VB110    VB111    VB112
97    0        0        0        0        0        0        0        0

Row   VB113    VB114    VB115    VB116    VB117    VB118    VB119    VB120
98    0        0        0        0        0        0        0        0

Row   VB121    VB122    VB123    VB124    VB125    VB126    VB127    VB128
99    0        0        0        0        0        0        0        0

=>>
```

TEST DB Command

Use the **TEST DB** command to temporarily force the relay to send fixed analog and/or digital values over communications interfaces for protocol testing.

Command	Description	Access Level
TEST DB	Display the present status of digital and analog overrides.	B
TEST DB A *name value*	Force protocol analog element *name* to override *value*.	B
TEST DB A Row_*x value*	Force protocol digital elements in an entire Relay Word row number *x* to override *value*.	B
TEST DB D *name value*	Force protocol digital element *name* to override *value* (Modbus or DNP only).	B
TEST DB *name* OFF	Clear (analog or digital) override for element *name*.	B
TEST DB OFF	Clear all analog and digital overrides.	B

⚠WARNING
To reduce the chance of a false operating decision when using the **TEST DB** command, ensure that protocol master device(s) flag the data as "forced or test data". One possible method is to monitor the TESTDB Relay Word bit.

The **TEST DB** command provides a method to override Relay Word bits or analog values to aid testing of communications interfaces. The command overrides values in the communications interfaces (SEL Fast Message, DNP, Modbus, and IEC 61850) only. The actual values used by the relay for protection and control are not changed. However, remote devices may use these analog and digital signals to make control decisions. Ensure that remote devices are properly configured to receive the overridden data before using the **TEST DB** command.

To override analog data in a communications interface, enter the following from Access Level B or higher:

```
=>>TEST DB A name value <Enter>
```

NOTE: When using the **TEST DB** command to generate values for Fast Meter testing, you may need to override all current and voltage angles (IAFA, VAFA, etc.) to ensure the expected phase relationship.

NOTE: When using the **TEST DB** command, specifying a negative value may yield an unexpected display in some instances.

where *value* is a numerical value and *name* is an analog label from *Table E.1*, Analog Quantities, with an “x” in the DNP, Modbus, Fast Meter, or IEC 61850 column.

For example, the **TEST DB** command can be used to force the value of Phase A current magnitude transmitted to a remote device to 100 amps:

```
=>>TEST DB A IA 100 <Enter>
```

To override digital data in a Modbus, DNP, or IEC 61850 communications interface, enter the following from Access Level B or higher:

```
=>>TEST DB D name value <Enter>
```

where *name* is a Relay Word bit (see *Table D.1*) and *value* is 1 or 0.

For example, if Relay Word bit 51PT = logical 0, the **TEST DB** command can be used to effectively force the communicated status of this Relay Word bit to logical 1 to test the communications interface:

```
=>>TEST DB D 51PT 1 <Enter>
```

Values listed in the SER triggers SER1, SER2, and SER3 cannot be overridden.

To override digital data in a Modbus, DNP, SEL Fast Messaging, or IEC 61850 communications interface, enter the following from Access Level B or higher:

```
=>>TEST DB A Row_x value <Enter>
```

where Row_*x* is a Relay Word row number (see *Table D.1*) and *value* is 1 to 255 (the integer sum of the individual Relay Word bits to be set).

For example, Relay Word bits 51PR and 51PT are bits 1 and 2, respectively, of Relay Word Row 6. The **TEST DB** command can be used to effectively force the communicated status of these Relay Word bits to logical 1 to test the communications interface:

```
=>>TEST DB A Row_6 6 <Enter>
```

where the value of 6 is the integer value to set bits 1 and 2 of the Relay Word row ($2^1 + 2^2 = 6$).

Values listed in the SER triggers SER1, SER2, and SER3 cannot be overridden.

When the relay is not in Test Mode, the relay responds to either the digital or analog override request with the following message:

```
WARNING:  TEST MODE is not a regular operation.
Communication outputs of the device will be overridden by simulated values.

Are you sure (Y/N)? Y <Enter>
```

The relay responds:

```
Test Mode Active.  Use Test DB OFF command to exit Test Mode.

Override Added
```

Relay Word bit TESTDB will also assert to indicate that Test Mode is active. If the relay is already in the test mode (overrides are already active), the relay responds:

```
Override Added
```

The **TEST DB** command alone displays the present status of digital and analog overrides. An example **TEST DB** response after two analogs follows:

```
==>TEST DB <Enter>

SEL-311                          Date: 10/15/10    Time: 16:24:38.764
STATION A

NAME          OVERRIDE VALUE
IA                 100.0000
FREQ                60.0000

==>
```

Individual overrides are cleared using the **TEST DB** command with the OFF parameter:

```
=>>TEST DB D or A name OFF <Enter>
```

Entering **TEST DB OFF** without name will clear all overrides. The relay will automatically exit the Test Mode and clear all overrides if there are no **TEST DB** commands entered for 30 minutes.

TIM Command (View/Change Time)

TIM displays the relay clock. If a valid IRIG-B or SNTP time synchronization signal is connected to the relay, the **TIM** command cannot be used to set the relay time. See *Configuring High-Accuracy Timekeeping on page N.25* for more details on IRIG time sources.

Command	Description	Access Level
TIME	Display the present internal clock time.	1
TIME *hh:mm*	Set the internal clock to *hh:mm*.	1
TIME *hh:mm:ss*	Set the internal clock to *hh:mm:ss*.	1

NOTE: After setting the date, allow at least 60 seconds before powering down the relay or the new setting may be lost.

Step 1. To set the clock, type **TIM**.

Step 2. Type the desired setting.

Step 3. Press **<Enter>**.

Step 4. 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 Command (Trigger Event Report)

Command	Description	Access Level
TRI	Trigger event report data capture.	1
TRI ***time***	Trigger an event report data capture at specified time.	1
TRI STA	Display the status of a previous **TRI** ***time*** command.	1

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

```
=>TRI <Enter>

Triggered
=>
```

Use the optional *time* parameter to specify the exact time to trigger an event. If *time* is not specified, the event is triggered at the current time. The *time* should be input in 24-hour format (i.e., 15:11:00). If fractional seconds are input, they will be ignored.

```
=>TRI 16:00:00 <Enter>

An event will trigger at 16:00:00
=>
```

One **TRI** ***time*** command may be pending on a single port at any one time. If a **TRI** ***time*** command is entered while another command is pending, the old request will be cancelled and the new request will be pending. **TRI** commands entered without the time parameter will not effect any pending **TRI** ***time*** commands.

A **TRI STA** command may be used if a **TRI** ***time*** command is pending.

The following shows the output from an SEL-311C:

```
=>TRI STA <Enter>

An event will trigger at 16:00:00
=>
```

If the trigger has already been executed, or no trigger was set, the relay responds as follows:

```
=>TRI STA <Enter>

No trigger time set
=>
```

If the serial port AUTO setting = Y, the relay sends the summary event report:

```
SEL-311                          Date: 10/15/10    Time: 12:57:01.737
STATION A

Event: ABC T      Location:   64.93          Trip Time: 20:32:44.531
#: 10022  Shot:    Freq:  60.00  Group: 1     Close Time: --:--:--.---
Targets: ZONE1
Breaker: Open

PreFault:     IA      IB      IC      IN      IG     3I2       VA       VB       VC
MAG(A/kV)    501     501     501       1       3       2  120.150  120.090  120.140
ANG(DEG)  119.34  -0.44-120.37 -83.99  12.01   50.39     0.00  -119.84   120.29
Fault:
MAG(A/kV)   1811    1830    1819       1      22      12  112.910  112.900  112.910
ANG(DEG)   55.51  -64.40 175.70-176.77 -82.67-153.19   119.56    -0.27  -120.23

                                                   L C R     L C R
                                                   B B B R   B B B R
                                                   O A A O   O A A O
                                                   K D D K   K D D K
MB:8->1       RMBA       TMBA       RMBB       TMBB    A A A A   B B B B

  TRIG      00000000  00000000  00000000  00000000   0 0 0 0   0 0 0 0
  TRIP      00000000  00000000  00000000  00000000   0 0 0 0   0 0 0 0
=>>
```

See *Section 12: Standard Event Reports and SER* for more information on event reports.

VEC Command (Show Diagnostic Information)

Issue the **VEC** command under SEL's direction.

Command	Description	Access Level
VEC D	Display the standard Vector Report.	2
VEC E	Display the Extended Vector Report.	2

The information contained in a vector report is formatted for SEL in-house use only. Your SEL application engineer or the factory may request a **VEC** command capture to help diagnose a relay or system problem.

VER Command (Show Relay Configuration and Firmware Version)

The **VER** command provides relay configuration and information such as nominal current input ratings.

Command	Description	Access Level
VER	Display information about the configuration of the relay.	1

An example printout of the **VER** command for an SEL-311C follows:

```
=>VER <Enter>

Partnumber:  0311C10HA3A54X1
Serial Number:  2010XXXXXX

Analog Input Voltage (PT):  300 Vac, Wye or Delta connected
Analog Input Current (CT):  5 Amp Phase, 5 Amp Neutral
Main Board I/O:  3 High I/C Outputs, 5 Standard Outputs, 6 Inputs

Relay Features:
  Mirrored Bits
  DNP
  Modbus
  IEEE C37.118
  Remote Bits (16)
  Fast SER
  One 10/100BASE-T Port

SELboot checksum B0AB OK
FID=SEL-311C-1-R500-V0-Z100100-D20100609

BFID=SLBT-3CF1-R102-V0-Z100100-D20091207

If above information is unexpected. . .
contact SEL for assistance

=>
```

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SEL-311C Command Summary

Command	Description
2AC	Enter Access Level 2. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level 2 password.
ACC	Enter Access Level 1. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level 1 password.
BAC	Enter Breaker Access Level (Access Level B). If the main board Access jumper is not in place, the relay prompts the user for the Access Level B password.
BNA	Display names of status bits in the A5D1 Fast Meter Message.
BRE	Display breaker monitor data (trips, interrupted current, wear).
BRE *n*	Enter **BRE W** to preload breaker wear. Enter **BRE R** to reset breaker monitor data.
CAL	Enter Access Level C. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CAS	Display compressed ASCII configuration message.
CEV *n*	Display event report *n* in compressed ASCII format.
CHI	Display history data in compressed ASCII format.
CLO	Close circuit breaker (assert Relay Word bit CC).
COM *n*	Show communications summary report (COM report) on MIRRORED BITS® channel *n* (where *n* = A or B) using all failure records in the channel calculations.
COM *n row1*	Show a COM report for MIRRORED BITS channel *n* using the latest *row1* failure records (*row1* = 1–255, where 1 is the most recent entry).
COM *n row1 row2*	Show COM report for MIRRORED BITS channel *n* using failure records *row1–row2* (*row1* = 1–255).
COM *n date1*	Show COM report for MIRRORED BITS channel *n* using failures recorded on date *date1* (see **DAT** command for date format).
COM *n date1 date2*	Show COM report for MIRRORED BITS BITS channel *n* using failures recorded between dates *date1* and *date2* inclusive.
COM . . . L	For all **COM** commands, L causes the specified COM report records to be listed after the summary.
COM *n* C	Clears communications records for MIRRORED BITS channel *n* (or both channels if *n* is not specified, **COM C** command).
CON *n*	Control Relay Word bit RB*n* (Remote Bit *n*; *n* = 1–16). Execute **CON *n*** and the relay responds: CONTROL RB*n*. Then reply with one of the following: **SRB *n*** set Remote Bit *n* (assert RB*n*). **CRB *n*** clear Remote Bit *n* (deassert RB*n*). **PRB *n*** pulse Remote Bit *n* (assert RB*n* for 1/4 cycle).
COP *m n*	Copy relay and logic settings from group *m* to group *n* (*m* and *n* are numbers 1–6).
COP D *m n*	Copy DNP Map *m* into Map *n* (*m* and *n* are numbers 1–3).
CST	Display relay status in compressed ASCII format.
CSU	Display summary event report in compressed ASCII format.
DAT	Show date.
DAT mm/dd/yy	Enter date in this manner if Global Date Format setting, DATE_F, is set to MDY.
DAT yy/mm/dd	Enter date in this manner if Global Date Format setting, DATE_F, is set to YMD.
DNA T/X	Display names of Relay Word bits included in the A5D1 Fast Meter message. Either “T” or “X” are mandatory and are identical.
ETH	Displays the Ethernet port configuration and status.

Command	Description
EVE *n*	Show event report *n* with 4 samples per cycle (*n* = 1 to highest numbered event report, where 1 is the most recent report: see **HIS** command). If *n* is omitted (**EVE** command), most recent report is displayed.
EVE *n* A	Show event report *n* with analog section only.
EVE *n* C	Show event report *n* in compressed ASCII format with 16 samples-per-cycle analog resolution and 4 samples-per-cycle digital resolution.
EVE *n* D	Show event report *n* with digital section only.
EVE *n* L	Show event report *n* with 32 samples per cycle (similar to **EVE *n* S32**).
EVE *n* L*y*	Show first *y* cycles of event report *n* (*y* = 1 to Global setting LER).
EVE *n* M	Show event report *n* with communications section only.
EVE *n* P	Show event report *n* with synchrophasor-level accuracy time adjustment.
EVE *n* R	Show event report *n* in raw (unfiltered) format with 32 samples-per-cycle resolution.
EVE *n* S*x*	Show event report *n* with *x* samples per cycle (*x* = 4, 16, 32, or 128). Must append R parameter for S128 (**EVE S128 R**)
EVE *n* V	Show event report *n* with variable scaling for analog values.
EXI	Terminate Telnet session.
FIL DIR	Display a list of available files.
FILE READ *filename*	Transfer settings file *filename* from the relay to the PC.
FILE SHOW *filename*	Display contents of file *filename*.
FILE WRITE *filename*	Transfer settings file *filename* from the PC to the relay.
GOO	Display GOOSE transmit and receive information.
GRO	Display active group number.
GRO *n*	Change active group to group *n* (*n* = 1–6).
HIS *n*	Show brief summary of *n* latest event reports, where 1 is the most recent entry. If *n* is not specified, (**HIS** command) all event summaries are displayed.
HIS C	Clear all event reports from nonvolatile memory.
HIS E	Same as **HIS** command except reports have unique identification numbers in the range 10000 to 65535.
ID	Display relay configuration.
L_D	Prepares the relay to receive new firmware.
LOO *n t*	Set MIRRORED BITS channel *n* to loopback (*n* = A or B). The received MIRRORED BITS elements are forced to default values during the loopback test; *t* specifies the loopback duration in minutes (*t* = 1–5000, default is 5).
LOO *n* DATA	Set MIRRORED BITS channel *n* to loopback. DATA allows the received MIRRORED BITS elements to change during the loopback test.
LOO *n* R	Cease loopback on MIRRORED BITS channel *n* and return the channel to normal operation.
MAC	Display Ethernet MAC address.
MET *k*	Display instantaneous metering data. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
MET X *k*	Display same as **MET** command with phase-to-phase voltages. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
MET D	Display demand and peak demand data. Select **MET RD** or **MET RP** to reset.
MET E	Display energy metering data. Select **MET RE** to reset.
MET M	Display maximum/minimum metering data. Select **MET RM** to reset.
MET PM *time k*	Display synchrophasor measurements (available when TSOK = logical 1). Enter *time* to display the synchrophasor for an exact specified time, in 24-hour format. Enter *k* for repeat count.
MET PM HIS	Display the most recent **MET PM** synchrophasor report.
OPE	Open circuit breaker (assert Relay Word bit OC).

Command	Description
PAR	Change the device part number. Use only under the direction of SEL.
PAS 1	Change Access Level 1 password.
PAS B	Change Access Level B password.
PAS 2	Change Access Level 2 password.
PAS C	Change the Access Level C password.
PUL *n k*	Pulse output contact *n* (where *n* is one of ALARM, OUT101–OUT107, OUT201–OUT212) for *k* seconds. *k* = 1–30 seconds; if not specified, default is 1.
QUI	Quit. Returns to Access Level 0.
R_S	Restore factory default settings. Use only under the direction of SEL. Only available under certain conditions.
SER	Show entire Sequential Events Recorder (SER) report.
SER *row1*	Show latest *row1* rows in the SER report (*row1* = 1–1024, where 1 is the most recent entry).
SER *row1 row2*	Show rows *row1*–*row2* in the SER report.
SER *date1*	Show all rows in the SER report recorded on the specified date (see **DAT** command for date format).
SER *date1 date2*	Show all rows in the SER report recorded between dates *date1* and *date2*, inclusive.
SER C	Clears SER report from nonvolatile memory.
SET *n*	Change relay settings (overcurrent, reclosing, timers, etc.) for Group *n* (*n* = 1–6, if not specified, default is active setting group).
SET *n* L	Change SELOGIC® control equation settings for Group *n* (*n* = 1–6, if not specified, default is the SELOGIC control equations for the active setting group).
SET D	Change DNP settings.
SET G	Change Global settings.
SET M	Change Modbus® settings.
SET P *p*	Change serial port *p* settings (*p* = 1, 2, 3, F, or 5; if not specified, default is active port).
SET R	Change SER and LDP Recorder settings.
SET T	Change text label settings.
SET . . . *name*	For all **SET** commands, jump ahead to specific setting by entering setting name.
SET . . . TERSE	For all **SET** commands, TERSE disables the automatic **SHO** command after settings entry.
SHO *n*	Show relay settings (overcurrent, reclosing, timers, etc.) for Group *n* (*n* = 1–6, if not specified, default is active setting group).
SHO *n* L	Show SELOGIC control equation settings for Group *n* (*n* = 1–6, if not specified, default is the SELOGIC control equations for the active setting group).
SHO D	Show DNP settings.
SHO G	Show Global settings.
SHO M	Show Modbus settings.
SHO P *p*	Show serial port *p* settings (*p* = 1, 2, 3, or F; if not specified, default is active port).
SHO R	Show SER and LDP Recorder settings.
SHO T	Show text label settings.
SHO . . . *name*	For all **SHO** commands, jump ahead to specific setting by entering setting name.
SNS	Display the Fast Message name string of the SER settings.
STA	Show relay self-test status.
STA C	Resets self-test warnings/failures and reboots the relay.
SUM *n*	Shows event report summary for event *n*.
SUM ACK	Acknowledge oldest unacknowledged summary event report.

Command	Description
SUM N	Shows event report summary for oldest unacknowledged report.
TAR *n k*	Display Relay Word row. If *n* = 0–67, display row *n*. If *n* is an element name (e.g., 50A1), display row containing element *n*. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
TAR LIST	Shows all the Relay Word bits in all of the rows.
TAR R	Reset front-panel tripping targets.
TAR ROW. . .	Shows the Relay Word row number at the start of each line, with other selected **TARGET** commands as described above, such as *n*, *name*, *k*, and LIST.
TEST DB A *name value*	Override analog label *name* with *value* in communications interface.
TEST DB D *name value*	Override Relay Word bit *name* with *value* in communications interface, where *value* = 0 or 1.
TIM	Show or set time (24-hour time). Show current relay time by entering **TIM**. Set the current time by entering **TIM** followed by the time of day (e.g., set time 22:47:36 by entering **TIM 22:47:36**).
TRI [*time*]	Trigger an event report. Enter *time* to trigger an event at an exact specified time, in 24-hour format.
VEC	Display standard vector troubleshooting report (useful to the factory in troubleshooting).
VER	Show relay configuration and firmware version.

Key Stroke Commands

Key Stroke	Description	Key Stroke When Using SET Command	Description
Ctrl + Q	Send **XON** command to restart communications port output previously halted by XOFF.	**<Enter>**	Retains setting and moves on to next setting.
Ctrl + S	Send **XOFF** command to pause communications port output.	**^<Enter>**	Returns to previous setting.
Ctrl + X	Send **CANCEL** command to abort current command and return to current access level prompt.	**<<Enter>**	Returns to previous setting section.
		><Enter>	Skips to next setting section.
		END <Enter>	Exits setting editing session, then prompts user to save settings.
		Ctrl + X	Aborts setting editing session without saving changes.

Section 11

Front-Panel Interface

Overview

NOTE: This section only applies to SEL-311C Relay models with an LCD. Disregard this section for vertical two-rack unit relays, which have no LCD.

NOTE: The available SafeLock™ TRIP/CLOSE pushbuttons are electrically separate from the rest of the relay. See SafeLock Trip and Close Pushbuttons on page 2.10 for details.

This section describes how to get information, make settings, and execute control operations from the relay front panel. It also describes the default displays.

This section discusses the following functions in detail:

- *Front-Panel Pushbutton Operation on page 11.1*
- *Functions Unique to the Front-Panel Interface on page 11.5*
- *Rotating Display on page 11.11*
- *Programmable Operator Controls on page 11.14*

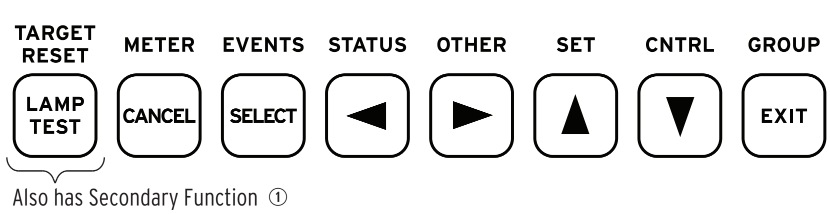
Front-Panel Pushbutton Operation

Overview

Note in *Figure 11.1* that most of the pushbuttons have dual functions (primary/secondary).

The primary functions are shown above the buttons. A primary function is selected first (e.g., **METER** pushbutton).

After a primary function is selected, the pushbuttons operate on their secondary functions, which are shown on the face of the buttons (**CANCEL**, **SELECT**, left/right arrows, up/down arrows, **EXIT**). For example, after the **METER** pushbutton is pressed, the up/down arrows are used to scroll through the front-panel metering screens. The primary functions are active again when the selected function (metering) is exited by pressing the **EXIT** pushbutton. The front panel reverts to the default display and the primary functions are active after there is no front-panel activity for a time determined by Global setting FP_TO (see *Front-Panel Display Operation (Only on models with LCD; see Section 11) on page SET.1*). The relay is shipped with FP_TO = 15 minutes.



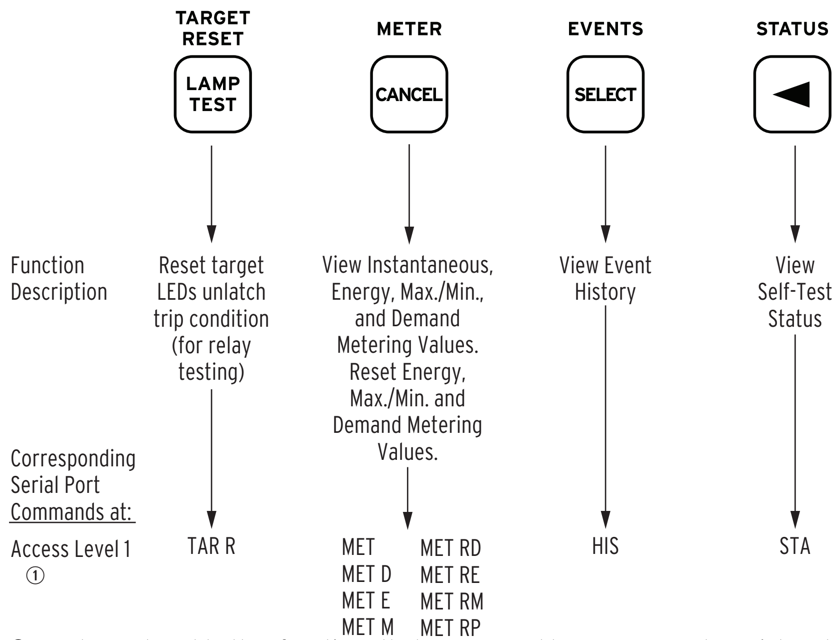
① See Figure 11.4.

Figure 11.1 Front-Panel Pushbuttons—Overview

Primary Functions

Note in *Figure 11.2* and *Figure 11.3* that the front-panel pushbutton primary functions correspond to serial port commands—both retrieve the same information or perform the same function. To get more detail on the information provided by the front-panel pushbutton primary functions, refer to the corresponding serial port commands in *Table 10.10*. For example, to get more information on the metering values available via the front-panel **METER** pushbutton, refer to *MET Command (Metering Data) on page 10.39*.

Some of the front-panel primary functions do *not* have serial port command equivalents. These are discussed in *Functions Unique to the Front-Panel Interface on page 11.5*.



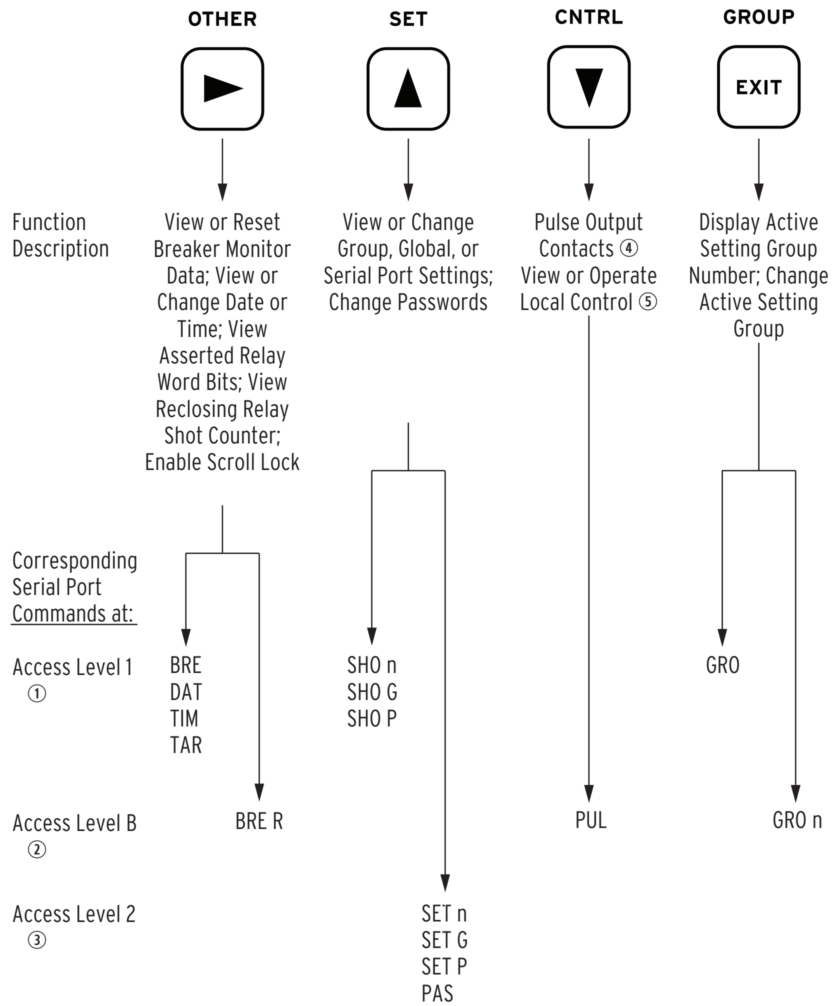
① Front-panel pushbutton functions that correspond to Access Level 1 serial port commands do **not** require the entry of the Access Level 1 password through the front panel.

Figure 11.2 Front-Panel Pushbuttons—Primary Functions

Front-Panel Password Security

Certain front-panel operations require a password. Refer to the comments at the bottom of *Figure 11.3* concerning Access Level B and Access Level 2 passwords. See *PAS Command (Change Passwords) on page 10.46* for the list of default passwords and for more information on changing passwords.

The relay will prompt for the password when required. To enter the Access Level B and Access Level 2 passwords from the front panel, use the left/right arrow pushbuttons to underscore a password character position. Use the up/down arrow pushbuttons to change the character. Advance to the next character positions using the right arrow pushbutton. Once the last character has been selected, press the **SELECT** pushbutton to enter the password.



① Front-panel pushbutton functions that correspond to Access Level 1 serial port commands do **not** require the entry of the Access Level 1 password through the front panel.

② Front-panel pushbutton functions that correspond to Access Level B serial port commands **do** require the entry of the Access Level B or Access Level 2 passwords through the front panel **if** the main board access jumper is not in place (see Access and Breaker Jumpers on page 2.27).

③ Front-panel pushbutton functions that correspond to Access Level 2 serial port commands **do** require the entry of the Access Level 2 password through the front panel **if** the main board passboard jumper is not in place (see Access and Breaker Jumpers on page 2.27).

④ Output contacts are pulsed for only one second from the front panel.

⑤ Local control is **not** available through the serial port and does **not** require the entry of a password.

Figure 11.3 Front-Panel Pushbuttons—Primary Functions (continued)

Secondary Functions

After a primary function is selected (see *Figure 11.2* and *Figure 11.3*), the pushbuttons then revert to operating on their secondary functions (see *Figure 11.4*).

Use the left/right arrows to underscore a desired function, then press the **SELECT** pushbutton to select the function.

Use the left/right arrows to underscore a desired setting digit or underscore a desired function, then use the up/down arrows to change the setting digit or scroll up or down in the display. Press the **SELECT** pushbutton to enter the setting or select the displayed option.

Press the **CANCEL** pushbutton to abort a setting change procedure or escape to a higher menu level. Press the **EXIT** pushbutton to return to the default display and have the primary pushbutton functions activated again (see *Figure 11.2* and *Figure 11.3*).

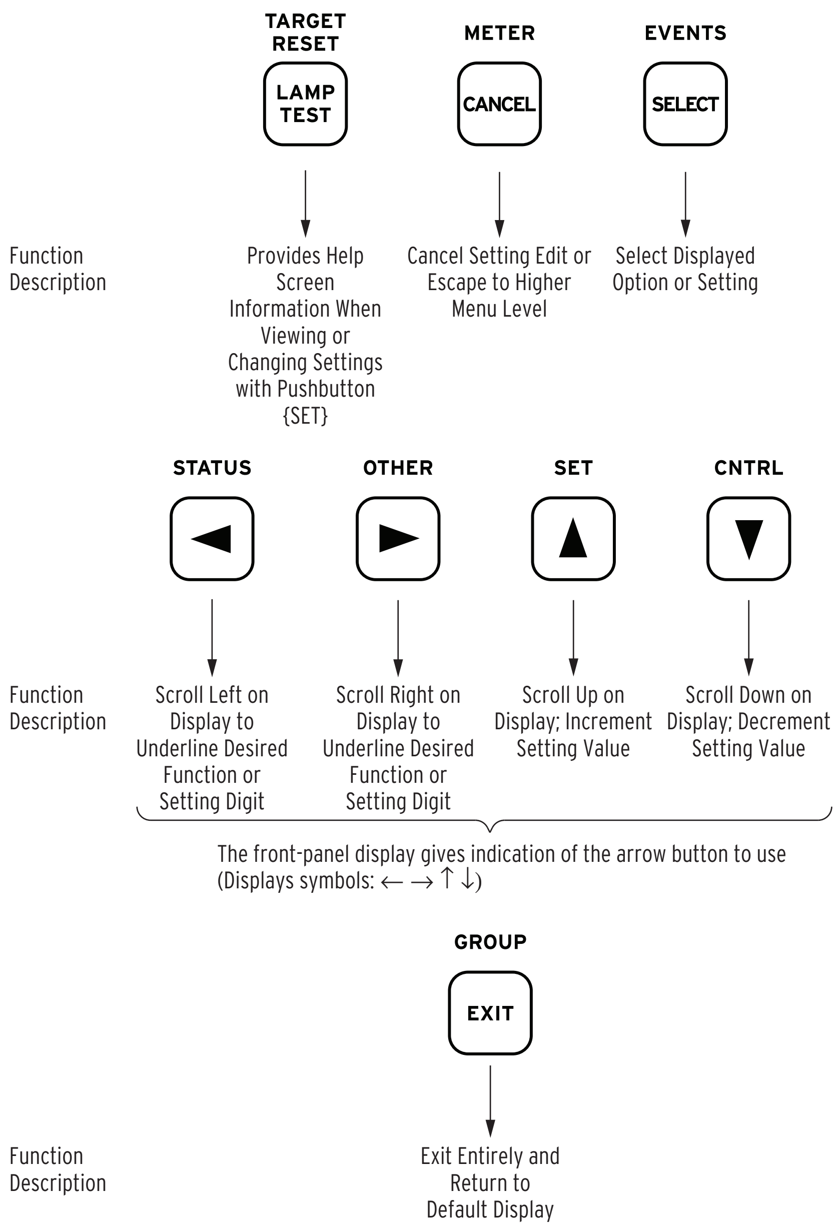


Figure 11.4 Front-Panel Pushbuttons—Secondary Functions

Functions Unique to the Front-Panel Interface

Three front-panel primary functions do *not* have serial port command equivalents. These functions are listed below:

- Reclosing relay shot counter screen (accessed via the **OTHER** pushbutton)
- Local control (accessed via the **CNTRL** pushbutton)
- Modified rotating display with scroll lock control (accessed via the **OTHER** pushbutton)

Reclosing Relay Shot Counter Screen

Use this screen to see the progression of the shot counter during reclosing relay testing.

Access the reclosing relay shot counter screen via the **OTHER** pushbutton. The following screen appears:

```
DATE   TIME  79
TAR BRK_MON LCD
```

Scroll right with the right arrow pushbutton and select function 79 using the **SELECT** pushbutton. Upon selecting function 79, the following screen appears (shown here with example settings):

```
SET RECLOSURES=2
RECLOSE COUNT =0
```

or

```
SET RECLOSURES=2
RECLOSE COUNT =2
```

If the reclosing relay does not exist (see *Reclosing Relay on page 6.11*), the following screen appears:

```
No Reclosing set
```

The corresponding text label settings (shown with factory default settings) are:

79LL = **SET RECLOSURES** (Last Shot Label—limited to 14 characters)

79SL = **RECLOSE COUNT** (Shot Counter Label—limited to 14 characters)

These text label settings are set with the **SET T** command or viewed with the **SHO T** command via the serial port (see *Section 9: Setting the Relay* and *SHO Command (Show/View Settings) on page 10.49*).

The top numeral in the above example screen (SET RECLOSURES=2) corresponds to the “last shot” value, which is a function of the number of set open intervals. There are two set open intervals in the example settings, thus two reclosures (shots) are possible in a reclose sequence.

The bottom numeral in the above example screen [RECLOSE COUNT = 0 (or = 2)] corresponds to the "present shot" value. If the breaker is closed and the reclosing relay is reset (**RS** LED on front panel is illuminated), RECLOSE COUNT = 0. If the breaker is open and the reclosing relay is locked out after a reclose sequence (**LO** LED on front panel is illuminated), RECLOSE COUNT = 2.

Reclosing Relay Shot Counter Screen Operation (With Example Settings)

The Group settings used for the following example are:

- ➤ E79 = 2
- ➤ 79OI1 = 30 cycles
- ➤ 79OI2 = 600 cycles

With the breaker closed and the reclosing relay in the reset state (front-panel **RS** LED illuminated), the reclosing relay shot counter screen appears as:

```
SET RECLOSURES=2
RECLOSE COUNT =0
```

The relay trips the breaker open, and the reclosing relay goes to the reclose cycle state (front-panel **RS** LED extinguishes). The reclosing relay shot counter screen still appears as:

```
SET RECLOSURES=2
RECLOSE COUNT =0
```

The first open interval (e.g., 79OI1 = 30) times out, the shot counter increments from 0 to 1, and the relay recloses the breaker. The reclosing relay shot counter screen shows the incremented shot counter:

```
SET RECLOSURES=2
RECLOSE COUNT =1
```

The relay trips the breaker open again. The reclosing relay shot counter screen still appears as:

```
SET RECLOSURES=2
RECLOSE COUNT =1
```

The second open interval (e.g., 79OI2 = 600) times out, the shot counter increments from 1 to 2, and the relay recloses the breaker. The reclosing relay shot counter screen shows the incremented shot counter:

```
SET RECLOSURES=2
RECLOSE COUNT =2
```

If the relay trips the breaker open again, the reclosing relay goes to the lockout state (front-panel **LO** LED illuminates). The reclosing relay shot counter screen still appears as:

```
SET RECLOSURES=2
RECLOSE COUNT =2
```

If the breaker is manually closed, the reclosing relay reset timer 79RSLD times out, the relay goes to the reset state (front-panel **LO** LED extinguishes and **RS** LED illuminates), and the shot counter returns to 0. The reclosing relay shot counter screen appears as:

```
SET RECLOSURES=2
RECLOSE COUNT =0
```

Local Control

Use local control to enable/disable schemes, trip/close breakers, etc., via the front panel.

In more specific terms, local control asserts (sets to logical 1) or deasserts (sets to logical 0) what are called local bits LB1 through LB16. These local bits are available as Relay Word bits and are used in SELOGIC® control equations (see Rows 5 and 6 in *Table D.1*).

Local control can emulate the following switch types in *Figure 11.5* through *Figure 11.7*.

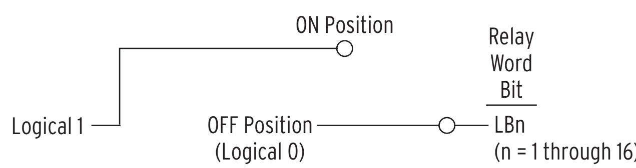


Figure 11.5 Local Control Switch Configured as an ON/OFF Switch

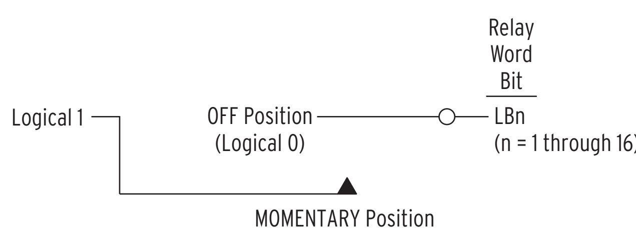


Figure 11.6 Local Control Switch Configured as an OFF/MOMENTARY Switch

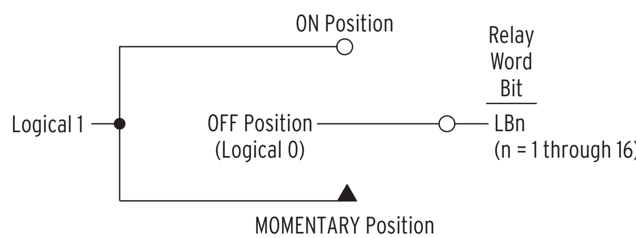


Figure 11.7 Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

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 **SHO T** command via the serial port (see *Section 9: Setting the Relay* and *SHO Command (Show/View Settings) on page 10.49*). See *Local Control Switches on page 7.6* for more information on local control.

View Local Control (With Example Settings)

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
```

Assume the following settings:

TR = **...+LB3 +...** (Trip setting includes LB3)

CL = **...+ LB4 +...** (Close setting includes LB4)

NLB3 = **MANUAL TRIP**

CLB3 = **RETURN**

PLB3 = **TRIP**

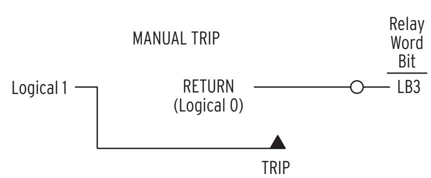
NLB4 = **MANUAL CLOSE**

CLB4 = **RETURN**

PLB4 = **CLOSE**

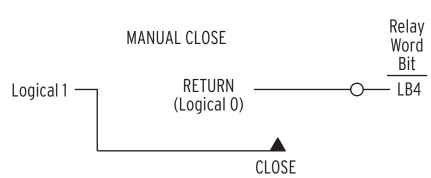
Press the **CNTRL** pushbutton, and the first set local control switch displays (shown here with example settings):

```
MANUAL TRIP    ⟷
Position: RETURN
```



Press the right arrow pushbutton, and scroll to the next example local control switch:

```
MANUAL CLOSE   ⟷
Position: RETURN
```



The `MANUAL TRIP: RETURN/TRIP` and `MANUAL CLOSE: RETURN/CLOSE` switches are both OFF/MOMENTARY switches (see *Figure 11.6*).

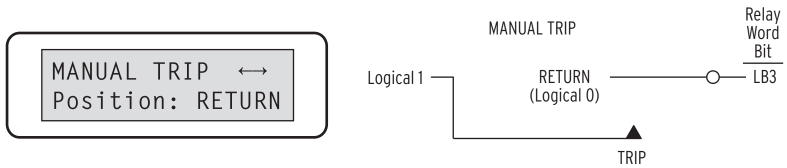
There are no more local control switches in the example settings. Press the right arrow pushbutton, and scroll to the `Output Contact Testing` function:

```
Output Contact ⟷
Testing
```

This front-panel function provides the same function as the serial port **PUL** command (see *Figure 11.3*).

Operate Local Control (With Example Settings)

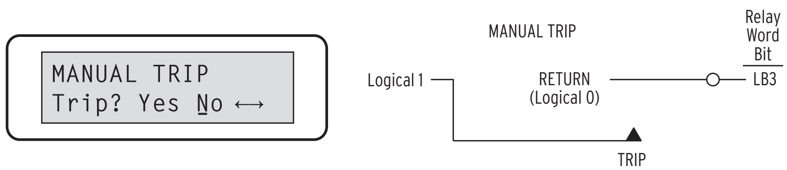
Press the right arrow pushbutton, and scroll back to the first set local control switch in the example settings:



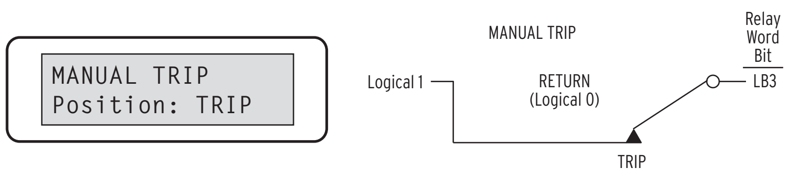
NOTE: See Local Control Availability on page 11.10 for conditions where local control switch operations are not allowed.

NOTE: You can abort a control operation by pressing the **CANCEL** pushbutton or by using the right arrow pushbutton to underline `No` and then press `SELECT`.

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:



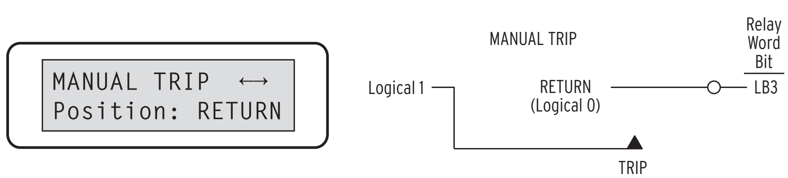
Because this is an OFF/MOMENTARY type switch, the `MANUAL TRIP` switch returns to the `RETURN` position after momentarily being in the `TRIP` position. Technically, the `MANUAL TRIP` switch (being an OFF/MOMENTARY type switch) is in the:

> `TRIP` position for one processing interval (1/4 cycle) which is 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), and then it returns to the `RETURN` position:



NOTE: If a **SET** command is being used on a communications port when the **SELECT** local control switch pushbutton is pressed, the relay will display a `Command Unavailable` message on the LCD.

The `MANUAL CLOSE` switch is an OFF/MOMENTARY type switch, like the `MANUAL TRIP` switch, and operates similarly.

See *Local Control Switches on page 7.6* for details on how local bit outputs LB3 and LB4 may be set in SELOGIC control equation settings to respectively trip and close a circuit breaker.

Local Control Availability

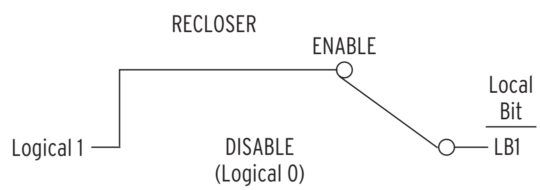
It is not possible to operate a local control switch while a settings change session is in progress, for example, while another technician is using a **SET** command or a PC software application to send settings to the relay over a communications port. In this situation, if the front-panel **SELECT** key is pressed while a set local control switch is being displayed, the relay will display a `Command Unavailable` error message on the LCD, and then return to the display of the first set local control switch.

After the SET session has been completed, the local control switches can be operated.

Local Control State Retained When Relay De-Energized

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, suppose the local control switch with local bit output LB1 is configured as an ON/OFF type switch (see *Figure 11.5*). Additionally, suppose it is used to enable/disable reclosing. If local bit LB1 is at logical 1, reclosing is enabled:



If power to the relay is turned off and then turned on again, local bit LB1 remains at logical 1, and reclosing is still enabled. This is akin to 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 again, the switch positions are still in place. If the reclosing switch is in the enable position (switch closed) before the power outage, it will be in the same position after the outage when power is restored.

Continuing from the previous example settings, suppose the traditional reclose enable/disable function is provided by optoisolated input **IN102** with the following SELOGIC control equation drive-to-lockout setting:

79DTL = **OC + !IN102 + LB3** =OC + NOT(IN102) + LB3

Local bit LB3 is the output of the previously discussed local control switch configured as a manual trip switch. The relay is driven to lockout for any manual trip via LB3.

Relay Word bit OC asserts when the serial port **OPEN** command is executed. Assuming that an **OPEN** command has not been executed and LB3 has not asserted, when input **IN102** is energized (IN102 = logical 1), reclosing is enabled (not driven-to-lockout):

79DTL = **OC + !IN102 + LB3** = logical 0 + !(logical 1) + logical 0 = logical 0

If local bit LB1 is substituted for input **IN102** to provide the reclose enable/disable function, the SELOGIC control equation drive-to-lockout setting is set as follows:

79DTL = **OC + !LB1 + LB3** [=OC + NOT(LB1) + LB3]

Notice that local bit 1 is inverted [!LB1 = NOT(LB1)] in the SELOGIC equation to match the sense of the previous !IN102 term.

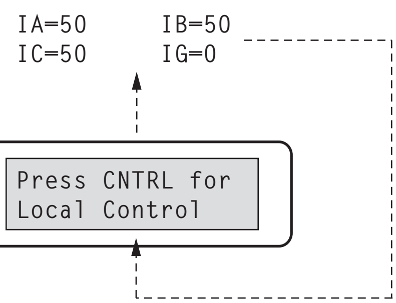
See *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 6.20* for more information on setting 79DTL.

Rotating Display

With factory default settings, the channel **IA**, **IB**, **IC**, and **IG** current values (in A primary) display continually if no local control is operational (i.e., no local control switches are enabled) and no display point labels are enabled for display.

Global setting FPNGD determines whether **IN** (current channel IN) or **IG** (residual ground current) displays in the lower right-hand corner, or whether the lower right-hand corner is blank. See *Front-Panel Neutral/Ground Current Display on page 11.13*.

The `Press CNTRL for Local Control` message displays in rotation with the default metering screen 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 on page 7.6* for more information on local control.



If display point labels (e.g., `79 DISABLED` and `BREAKER OPEN`) are enabled for display, they also enter into the display rotation.

Global setting SCROLD determines how long each message is displayed, settable from 1 to 60 seconds, with a factory default of 2 seconds.

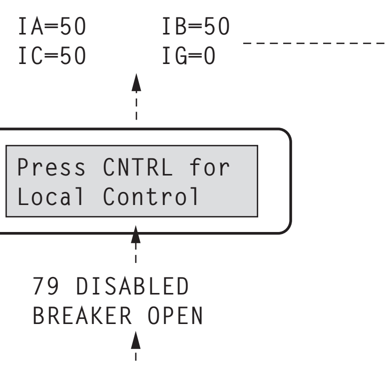


Figure 11.8 illustrates the correspondence between display point logic equations (e.g., DP1 and DP2) and enabled display point labels (DP1_1/DP1_0 and DP2_1/DP2_0, respectively).

The display point example settings are:

DP1 = **IN102** (optoisolated input **IN102**)

DP2 = **52A** (breaker status, see *Figure 7.3*)

In this example, optoisolated input **IN102** is used to enable/disable the reclosing relays, and 52A is the circuit breaker status. See *Optoisolated Inputs on page 7.2*.

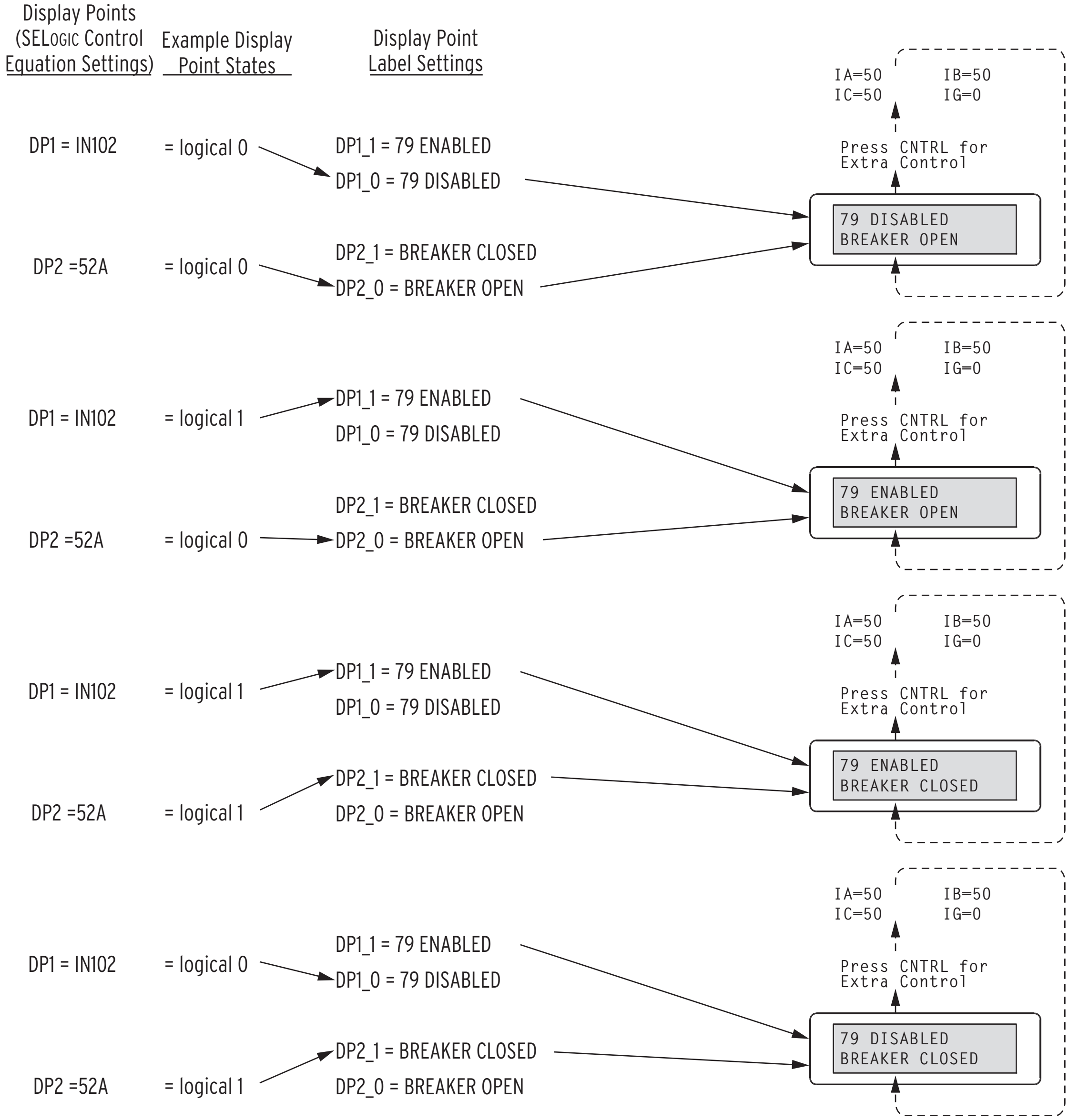


Figure 11.8 Correspondence Between Changing Display Point States and Enabled Display Point Labels

In the preceding example, only two display points (DP1 and DP2) and their corresponding display point labels are set. If additional display points and corresponding display point labels are set, the additional enabled display point labels join the rotation on the front-panel display.

Display point label settings are set with the **SET T** command or viewed with the **SHO T** command (see *Section 9: Setting the Relay*).

For more detailed information on the logic behind the rotating default display, and to learn about displaying analog values, see *Rotating Display on page 7.37*.

Scroll Lock Control of Front-Panel LCD

The rotating default display can be locked on a single screen. Access the scroll lock control with the **OTHER** pushbutton.

```
DATE   TIME  79
TAR BRK_MON LCD
```

Select LCD for Scroll Lock Control mode. The rotating display will then appear, and the scroll mode reminder screen will appear for one second every eight seconds as a reminder that the display is in Scroll Lock Control mode.

```
Scroll lock OFF
SELECT to Lock
```

Stop Scrolling (Lock)

When in the Scroll Lock Control mode, press the **SELECT** key to stop display rotation. Scrolling can be stopped on any of the display point screens, or on the current-meter display screen. While rotation is stopped, the active display is updated continuously so that current or display point changes can be seen. If no button is pressed for eight seconds, the reminder message will appear for one second, followed by the active screen.

```
Scroll lock ON
SELECT to Unlock
```

Restart Scrolling (Unlock)

The **SELECT** key unlocks the LCD and resumes the rotating display.

Single Step

From the Scroll Locked state, single-step through the display screens by pressing the **SELECT** key twice. After the first press wait for the next screen to display, then press the **SELECT** key a second time to freeze scrolling.

Exit

Press the **EXIT** key to leave Scroll Lock Control and return the rotating display to normal operation.

Cancel

Press the **CANCEL** key to return to the **OTHER** menu.

```
DATE   TIME  79
TAR BRK_MON LCD
```

Front-Panel Neutral/Ground Current Display

Global setting FPNGD (Front-Panel Neutral/Ground Display) selects whether IG (residual current), IN (channel IN current), or neither is displayed on the front-panel rotating display. Setting choices follow below:

FPNGD = **IN**

```
IA=   1  IB=   1
IC=   1  IN=   1
```

FPNGD = **IG**

```
IA=    1  IB=    1
IC=    1  IG=    1
```

FPNGD = **OFF**

```
IA=    1  IB=    1
IC=    1
```

Additional Rotating Default Display Example

See *Figure 5.18* and accompanying text for an example of resetting a rotating default display with the **TARGET RESET** pushbutton.

Programmable Operator Controls

SEL-311C relays that are three rack units high can be ordered with 10 programmable operator controls, or pushbuttons, each with an associated programmable LED, as shown in *Figure 11.9*.

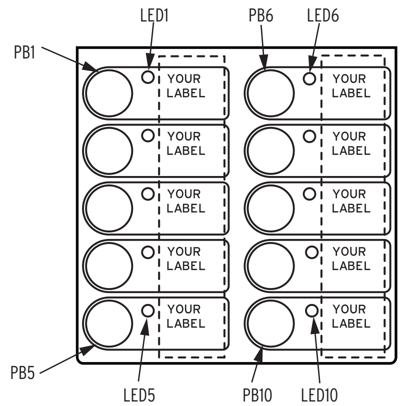


Figure 11.9 Programmable Operator Controls Optional on Three-Rack Unit SEL-311C Relays

Indicate the function of each pushbutton on user printable labels inserted behind the dashed rectangular boxes shown in *Figure 11.9*. The pushbuttons and LEDs have no default function in a standard relay shipment.

Each of the 10 pushbuttons controls a corresponding Relay Word bit. For example, pushbutton **PB1** controls Relay Word bit PB1PUL. Relay Word bit PB1PUL asserts for one processing interval each time pushbutton **PB1** is pressed.

Each of the 10 LEDs associated with the pushbuttons are controlled by SELOGIC control equations. For example **LED1** is controlled by SELOGIC control equation LED1. **LED1** illuminates when SELOGIC control equation LED1 asserts (evaluates to logical true or binary one).

Operation of **PB5** and **LED5** depend on Global Setting RSTLED. If RSTLED = Y1 or N1 then **PB5** and **LED5** operate the same as the other pushbuttons and LEDs described above. However, if RSTLED = Y or N then Relay Word bit

PB5PUL asserts for one processing interval only if pushbutton **PB5** is pressed and held continuously for three seconds. **LED5** flashes during those three seconds, regardless of the state of SELOGIC control equation LED5. After the button has been held for three seconds continually, **LED5** follows SELOGIC control equation **LED5**.

Programmable Operator Control Application Example

This example uses programmable operator control **PB2** to enable and disable reclosing, and uses **LED2** to indicate if reclosing is enabled or disabled. Assume reclosing has been enabled by setting E79 = Y and also setting 79OI1 is not set to zero. Also assume that **LED2** has been labeled "Reclose Enabled." This example temporarily disables reclosing by asserting SELOGIC equation 79DTL using pushbutton **PB2** to activate latch LT2. *Figure 11.10* shows the latch-bit control logic.

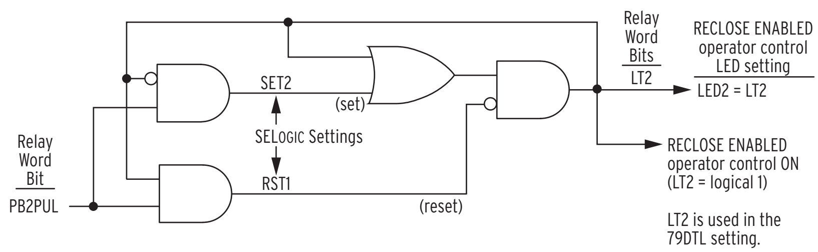


Figure 11.10 GROUND ENABLED Operator Control LED and Logic

Every press of **PB2** causes Relay Word bit PB2PUL to assert for one processing interval. In *Figure 11.10*, when PB2PUL asserts the output of latch bit LT2 toggles. Include the output of LT2 in the 79DTL SELOGIC control equation along with other conditions that drive the recloser to lockout:

79DTL = **OC + !LT2 + ...** Other conditions that drive the recloser to lockout.

Also use the output of LT2 to illuminate **LED2**:

LED2 = **LT2**

See *Latch Control Switches on page 7.11* for more information on latch bits.

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Section 12
Standard Event Reports and SER

Overview

This section covers the event reporting, and sequential events recorder (SER) reporting functions of the SEL-311C, in the following subsections:

Introduction

The SEL-311C Relay offers three styles of event reports:

Event (EVE) Reports and Compressed ASCII Event (CEV) Reports

Standard ASCII event reports capture highly detailed information over a specified time period (selectable as 15, 30, 60, or 180 power system cycles) in an easy to read format. Compressed ASCII event reports are in a computer readable format, suitable for SEL-5601 Analytic Assistant or ACSELERATOR QuickSet® SEL-5030 Software.

Event reports are useful in commissioning tests, system disturbance analysis, and protective device or scheme performance analysis.

Event report data is stored to nonvolatile memory just after it is generated.

Event report information includes:

- ➤ Unique event identification number.
- ➤ Date and time of the event report trigger with 1 ms resolution.
- ➤ Individual sample analog input oscillography (currents and voltages) at 4, 16, 32, or 128 samples per cycle.
- ➤ System frequency.
- ➤ EVE: Digital element states of selected Relay Word bits (listed in *Table 12.4*) at 4 samples per cycle.
- ➤ CEV: Digital element states of all Relay Word bits at 4 samples per cycle.
- ➤ Event summary, including the front-panel target states at the time of tripping, fault current, fault location, and fault type.

- Group, Logic, and Global settings that were active at time of the event trigger.
- 10 µs precision trigger time stamps and relative sample times (available when a high-accuracy IRIG-B time source is connected to the relay).

An adjustable prefault recording period allows system conditions to be captured prior to the actual event report trigger.

Use the SEL-5601 Analytic Assistant Software and ACSELERATOR QuickSet to analyze a Compressed ASCII version of the event report. With this software, you can easily do the following:

- View or print oscillographic traces and digital element traces.
- Perform step-by-step phasor analysis of the prefault, fault, and post-fault intervals.
- View power system harmonic data.

Sequential Events Recorder (SER)

The SER report captures detailed digital element state changes over a long time period. Programmable trigger lists allow up to 72 Relay Word bits to be monitored, in addition to the automatically generated triggers for relay power-up, settings changes, and active setting group changes. State changes are time-tagged to the nearest millisecond.

SER report data is useful in commissioning tests and during operation for system monitoring and control.

SER information is stored to nonvolatile memory when state changes occur.

Standard 15/30/60/180-Cycle Event Reports

NOTE: *Figure 12.5* is on multiple pages.

See *Figure 12.5* for an example event report.

Event Report Length (Settings LER and PRE)

The SEL-311C provides user-programmable event report length and prefault length. Event report length is either 15, 30, 60, or 180 cycles. Prefault length ranges from 1 to 179 cycles. Prefault length is the first part of the event report that precedes the event report triggering point.

Set the event report length with the LER setting. Set the prefault length with the PRE setting. See the **SET G** command in *Table 9.2* and corresponding *Event Report Parameters (see Section 12) on page SET.2* for instructions on setting the LER and PRE settings.

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

Event Report Capacity

The SEL-311C event report capacity depends on the selected event report length (LER setting), as shown in *Table 12.1*.

Table 12.1 Event Report Capacity

LER Setting	Number of Event Reports Stored
15 cycles (factory default)	43
30 cycles	25
60 cycles	13
180 cycles	4

The SEL-311C stores event reports in nonvolatile memory soon after the events are captured. If the power supply is interrupted during the saving of an event report, the relay will report `Invalid Data` for the event that was not fully stored.

Standard Event Report Triggering

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

- ➤ Relay Word bit TRIP asserts
- ➤ Programmable SELOGIC® control equation setting ER asserts to logical 1
- ➤ **TRI** (Trigger Event Reports) serial port command executed
- ➤ Any output contact is pulsed via Modbus® or the serial port/front-panel **PUL** (Pulse Output Contact) command

Relay Word Bit TRIP

Refer to *Figure 5.1*. If Relay Word bit TRIP asserts, an event report is automatically generated. Thus, any condition that causes a trip does not have to be entered in SELOGIC control equation setting ER.

NOTE: If PTCONN = DELTA, the factory settings for trip equations TR and TRQUAL are:
TR = **M2PT + 51GT + 51QT + OC**
TRQUAL = **M1P**

For example, SELOGIC control equations trip settings TR and TRQUAL are unsupervised. Any trip element that asserts in TR causes the TRIP Relay Word bit to assert immediately. Any trip element that asserts in TRQUAL causes the TRIP bit to assert immediately if there is a system disturbance detected (see *Figure 4.2*) or after a 2-cycle delay (see *Figure 5.1*) if a system disturbance is not detected. The factory settings for trip equations TR and TRQUAL are:

TR = **M2PT + Z2GT + 51GT + 51QT + OC**

TRQUAL = **M1P + Z1G**

If any of the individual conditions M1P, Z1G, M2PT, Z2GT, 51GT, 51QT, or OC assert, Relay Word bit TRIP asserts, and an event report is automatically generated. Thus, these conditions do not have to be entered in SELOGIC control equation setting ER.

Relay Word bit TRIP (in *Figure 5.1*) is usually assigned to an output contact for tripping a circuit breaker (e.g., SELOGIC control equation setting OUT101 = TRIP).

Programmable SELOGIC Control Equation Setting ER

The programmable SELOGIC control equation event report trigger setting ER is set to trigger standard event reports for conditions other than trip conditions. When setting ER sees a logical 0 to logical 1 transition, it generates an event report (if the SEL-311C is not already generating a report that encompasses the new transition). The factory setting for the SEL-311C relay is:

ER = **/M2P + /Z2G + /51G + /51Q + /50P1 + /LOP**

The elements in this example setting are:

M2P	Zone 2 phase-distance element asserted.
Z2G	Zone 2 ground-distance element asserted
51G	Residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see *Figure 3.32*).
51Q	Maximum phase current above pickup setting 51QP for phase time-overcurrent element 51QT (see *Figure 3.33*).
50P1	Phase current above pickup setting 50P1P for phase overcurrent element 50P1.
LOP	Loss-of-potential (LOP) asserts.

Note the rising-edge operator / in front of each of these elements. See *Appendix F: Setting SELOGIC Control Equations* for more information on rising-edge operators and SELOGIC control equations in general.

Rising-edge operators are especially useful in generating an event report at fault inception and then generating another later if a breaker failure condition occurs. For example, at the inception of a ground fault, pickup indicator 51G asserts and an event report is generated:

ER = **... + /51G + ... = logical 1** (for one processing interval)

Even though the 51G pickup indicator will remain asserted for the duration of the ground fault, the rising-edge operator / in front of 51G (/51G) causes setting ER to be asserted for only one processing interval. In this example, if there was no rising-edge operator on 51G, the ER equation would remain at logical 1 while a fault is present. This would prevent the relay from seeing a subsequent logical 0 to logical 1 transition for a new trigger condition, such as 51Q asserting.

Falling-edge operators \ are also used to generate event reports. See *Figure F.2* for more information on falling-edge operators.

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

NOTE: The Modbus "pulse output" contact function also triggers an event report.

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

The **PUL** command asserts the output contacts for testing purposes or for remote control. If any output contact asserts via the **PUL** command, the relay triggers a standard event report. The **PUL** command is available at the serial port and the relay front-panel **CNTRL** pushbutton.

See *Section 10: Communications* and *Figure 11.3* for more information on the **TRI** (Trigger Event Report) and **PUL** (Pulse Output Contact) commands.

Back-to-Back Event Report Capability

The SEL-311C is capable of recording successive "back-to-back" event reports for up to 360 cycles. When back-to-back events are triggered, the relay shortens the prefault portion of the latter event report(s).

Figure 12.1 shows an example of back-to-back event report behavior with factory default Global settings LER = 15 cycles and PRE = 4 cycles. When the first event report is triggered, the relay records data from 4-cycles before the trigger to 11 cycles after the trigger. An additional event report trigger received during the 15 cycle event report time is ignored. The next event report trigger received after the end of the 11 cycle post trigger recording period is processed in one of two ways.

- If the next trigger processed is within the 4-cycle (PRE) period from the end of the previous event report, the second event report shall contain less than 4-cycles of pretrigger data, and the second event report analog data shall be a continuation of the first event report.
- If the next trigger is processed beyond the 4-cycle (PRE) period from the end of the previous event report, the second event report shall contain the usual 4 cycles of PRE data, and there will be an unrecorded period between the event reports.

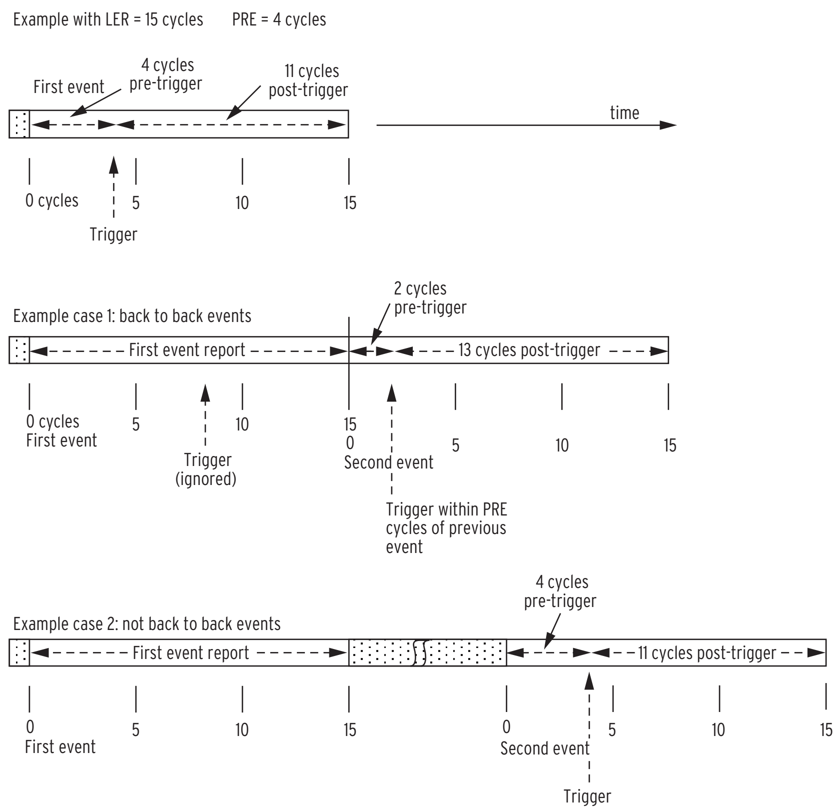


Figure 12.1 Example Behavior for Back-to-Back Event Reports

Standard Event Report Summary

Each time the relay generates a standard event report, it also generates a corresponding event summary (see *Figure 12.2*). Event summaries contain the following information:

- Relay and terminal identifiers (settings RID and TID)
- Date and time when the event was triggered
- Unique event identification number
- Event type
- Fault location
- Recloser shot count at the trigger time
- System frequency at the trigger time
- Front-panel fault type targets at the time of trip
- Phase (IA, IB, IC), neutral ground (IN), calculated residual ground ($I_G = 3I_0$), and negative-sequence ($3I_2$) current magnitudes in amps primary.

The currents displayed are from the event report row used to calculate fault location, or from the row one and one quarter cycle after the event trigger if the fault locator does not operate.

NOTE: Figure 12.5 is on multiple pages.

The relay includes the event summary in the standard event report. The identifiers, date, time and unique event identification number information is at the top of the standard event report, and the other information follows at the end. See *Figure 12.5*.

Event Summary Number

NOTE: If programmable targets are being used, it is possible the TARGETS field in an event summary could exceed the usual limit of 80 characters (1 line). In order to support all SEL software, the display of TARGETS continues on the same line past the 80 character limit.

The `Event Number =` field shows the unique event identification number of the event. The unique event identification number of any event can be found by issuing a **HIS E** command (see *HIS Command (Event Summaries/History) on page 10.37* for details).

The example event summary in *Figure 12.2* corresponds to the full-length standard 15-cycle event report in *Figure 12.5*.

```
SEL-311                                  Date: 10/14/10 Time: 08:53:34.926
STATION A
FID=SEL-311C-1-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx       CID=xxxx
Event Number = 10522

   •
   •
   •

Event: BCG T Location: 48.84  Shot:    Frequency:  60.01
Targets: ZONE1
Currents (A Pri), ABCNGQ:    200  2478  2480     0   212  4294
```

Figure 12.2 Example Event Summary

The relay sends long event summaries to all serial ports with setting AUTO = Y each time an event triggers. The long event summary contains more information than the standard event report summary. See *SUM Command (Long Summary Event Report) on page 10.59*.

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

Event Type

The `Event:` field shows the event type. The possible event types and their descriptions are shown in the table below. Note the correspondence to the preceding event report triggering conditions (see *Standard Event Report Triggering on page 12.3*).

Table 12.2 Event Types (Sheet 1 of 2)

Event Type	Description
AG, BG, CG	Single phase-to-ground faults. Appends T if TRIP asserted.
ABC	Three-phase faults. Appends T if TRIP asserted.
AB, BC, CA	Phase-to-phase faults. Appends T if TRIP asserted.
ABG, BCG, CAG	Phase-to-phase-to-ground faults. Appends T if TRIP asserted.
TRIP	Assertion of Relay Word bit TRIP (fault locator could not operate successfully to determine the phase involvement, so just TRIP is displayed).
ER	SELOGIC control equation setting ER. Phase involvement is indeterminate.

Table 12.2 Event Types (Sheet 2 of 2)

Event Type	Description
TRIG	Execution of **TRIGGER** command.
PULSE	Execution of **PULSE** command.

The event type designations AG through CAG in *Table 12.2* are only entered in the Event: field if the fault locator operates successfully. If the fault locator does not operate successfully, just TRIP or ER is displayed.

The event type logic uses the Fault Identification Selection (FIDS) logic Relay Word bits FSA, FSB, and FSC to help determine the fault type, and to select the appropriate fault location method. See *Front-Panel Target LEDs on page 5.32* for a description of LEDs **A**, **B**, and **C**, and for more information on the target logic function.

Fault Location

NOTE: The fault locator will not operate properly unless three-phase voltages are connected.

NOTE: The fault locator is most accurate when the fault currents last longer than two cycles.

The relay reports the fault location if the EFLOC setting = Y and the fault locator operates successfully after an event report is generated. If the fault locator does not operate successfully, $$$$$$ is listed in the field. If EFLOC = N, the field is blank. Fault location is based upon the line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG; source impedance settings Z0SMAG and Z0SANG; and corresponding line length setting LL. See the **SET** command in *Table 9.2* and corresponding *Line Settings (see Line Settings on page 9.20) on page SET.6* for information on the line parameter settings.

Fault Detector Elements

The fault locator algorithm uses the distance elements plus overcurrent elements 50P1–50P4, 50G1–50G4, 67Q1–67Q4, 51P, 51G, and 51Q as fault detectors. If any of these overcurrent elements are set to low pickup values for use as load indicators, they may be asserted during non-fault conditions. In this situation, even though these elements are not being used for tripping the relay, they may still affect the operation of the fault locator, because the start of the disturbance may be unclear.

Fault Locator Operating Window

The SEL-311C uses a 15-cycle subset of the event report data to calculate the event type and fault location. For Global setting LER = 30, LER = 60, and LER = 180 the relay processes the portion of stored data that includes the event report trigger. For LER = 15, the entire event report is available for calculation of the event type and fault location.

It is possible for the event type or fault location to be calculated from a different portion of the event report than expected. For example (with default settings), when the event report is first triggered by overcurrent element pickup (ER = /M2P+/Z2G+/51G+/51Q+/50P1+/LOP), but the trip occurs more than 12 cycles later, the conditions at the time of trip are not considered (unless covered by a new event report). If the fault type changed between pickup and tripping, the event type may not match the front-panel target LEDs. See *Front-Panel Target LEDs on page 5.32* for details on the target LED operation.

Targets

The relay displays the front-panel targets that are asserted at the end of the event report if a trip occurred during the event. If the relay does not support programmable targets, the targets that can be reported include: TIME, COMM, SOTF, 51, ZONE1, ZONE2, ZONE3, and ZONE4.

If the relay supports with programmable target LEDs, the alias of only those LEDs set to latch-in on trip (LED*n*L=Y) will be displayed.

If there is no rising edge of TRIP in the report, the Targets field is blank. See *Front-Panel Target LEDs on page 5.32*.

Currents

The `Currents (A pri), ABCNGQ:` field shows the currents present in the event report row that was used to calculate fault location or one and one quarter cycle after the event trigger if the fault locator does not operate. The listed currents are:

- Phase (A = channel IA, B = channel IB, C = channel IC)
- Neutral ground (N = channel IN)
- Calculated residual (G = I_G = $3I_0$; calculated from channels IA, IB, and IC)
- Negative-sequence (Q = $3I_2$; calculated from channels IA, IB, and IC)

Event History (HIS)

The event history gives you a quick look at recent relay activity. The SEL-311C labels each new event in reverse chronological order with 1 as the most recent event. If the E parameter is used with the **HIS** command the event number is replaced by a unique event identification number from 10000 to 65535 and events are displayed in chronological order (see *HIS Command (Event Summaries/History) on page 10.37* for details). The unique identifier increments by 1 for each new event. See *Figure 12.3* for a sample event history.

The event history contains the following:

- Standard report header
  - Relay and terminal identification
  - Date and time of report
- Event history data for each stored event report. Column heading text shown in (parenthesis).
  - Event number (#) or unique event identification (#)
  - Event date and time (`DATE`, `TIME`)
  - Event type (`EVENT`)
  - Location of fault (`LOCAT`) (if applicable)
  - Maximum phase current from summary fault data (`CURR`)
  - Power system frequency at the time of the event report trigger (`FREQ`)
  - Active group at the trigger instant (`GRP`)
  - Reclosing relay shot count (`SHOT`)
  - Targets recorded with the event (`TARGETS`). Relays with programmable target LEDs display the alias (Global Settings LED12A–LED18A and LED23A–LED26A). See *Targets on page 12.7*.

Figure 12.3 is a sample event history from a terminal. Event #3 (unique event 10379) shows user-defined target alias LINETRP and BUSTRP.

```
=>HIS <Enter>


SEL-311C                          Date: 12/03/10    Time: 09:01:10.354
STATION A

#     DATE      TIME      EVENT   LOCAT  CURR  FREQ GRP SHOT TARGETS
1  11/07/10 05:32:24.062 ABG T   94.95 10000 60.00  1    0  INST SOTF 50 51 81
2  Invalid History Data
3  10/17/10 19:01:38.302 TRIP  $$$$$$$  8455 60.00  1    0  TRIP ZONE1
                                                            LINETRP BUSTRP
4  09/28/10 11:10:49.220 PULSE   26.92  2144 60.00  1    0  TRIP SOTF

=>HIS E<ENTER>

[RID setting]                     Date: mm/dd/yy    Time: hh:mm:ss.sss
[TID setting]

#     DATE      TIME      EVENT   LOCAT  CURR  FREQ GRP SHOT TARGETS
10381 11/07 05:32:24.062 ABG T   94.95 10000 60.00  1    0  INST SOTF 50 51 81
      Invalid History Data
10379 10/17 19:01:38.302 TRIP  $$$$$$$  8455 60.00  1    0  TRIP ZONE1
                                                            LINETRP BUSTRP
10378 09/28 11:10:49.220 PULSE   26.92  2144 60.00  1    0  TRIP SOTF
```

Figure 12.3 Sample Event History

The event number (#) or the unique identification number is used in the **EVE**, **CEV**, and **SUM** commands to select the desired event report. The event types in the event history are the same as the event types in the event summary. See *Table 12.2* for event types.

Viewing the Event History

Access the history report from the communications ports or the front-panel. View and download history reports from Access Level 1 and higher. You can also clear or reset history data from Access Levels 1 and higher. Clear/reset history data at any communications port.

Use the **HIS** command from a terminal to obtain the event history. See *HIS Command (Event Summaries/History) on page 10.37* for information on the **HIS** command.

Use the front-panel EVENTS menu to display event history data on the SEL-311C LCD. See *Front-Panel Pushbutton Operation on page 11.1* for information on the front-panel interface.

Use the ACSELERATOR QuickSet software to retrieve the relay event history via the **Tool** > **Event** > **Get Event Files**... menu. *Appendix C: PC Software* provides more details.

SUM Command (Long Summary Event Report)

The **SUM** command displays a long summary event report (see *Section 10: Communications* for command details). The long event report contains more information than is available from the **HIS** command, but is shorter than the full event report retrieved with the **EVE** or **CEV** commands. The long summary event report contains the following information:

- Standard report header
  - Relay and terminal identifiers (settings RID and TID)
  - Date and time when the event was triggered
- Event Information
  - Event Type
  - Fault location
  - Breaker Trip Time

- Unique event identification number from the **HIS E** command
- Recloser shot count at the trigger time
- System frequency at trigger time
- Active Settings Group
- Breaker Close Time
- Targets
- Breaker Status (Open or closed)
- Phase currents (IA, IB, IC), phase voltages (VA, VB, VC), calculated residual ground (IG = 3I0), current IN, and negative-sequence (3I2) currents, along with phase angles for prefault and fault quantities.
- MIRRORED BITS® status if MIRRORED BITS are enabled

Event Type

The `Event:` field shows the event type (see *Event Type on page 12.6* for details).

Fault Location

The `Location:` field displays the fault location determined by the relay. If EFLOC = Y and the fault locator operates successfully after an event report is generated, the relay displays the event location. If the fault locator does not operate successfully, the relay displays $$$$$$$ (see *Fault Location on page 12.7* for details.

Breaker Trip Time

The `Trip Time:` field displays the breaker trip time. If Relay Word bit TRIP is asserted when the event is triggered, the trip time is equivalent to the trigger time. If TRIP asserts after the event is triggered, the assertion time of TRIP is displayed as the trip time. If TRIP does not assert during an event, the trip time is displayed as `--:--:--.---`.

Unique Event Identification Number

The event summary field displays the unique event identification number.

Recloser Shot Count

The `Shot:` field displays the shot count at the time of the event trigger. If reclosing is not enabled or is not active this field is blank.

System Frequency

The `Freq:` field displays the system frequency at the time the event is triggered.

Active Settings Group

The `Group:` field displays the number of the active settings group at the time the event is triggered.

Breaker Close Time

The `Close Time:` field displays the breaker close time. If Relay Word bit CLOSE is asserted when the event is triggered, the close time is equivalent to the trigger time. If CLOSE asserts after the event is triggered, the assertion time of CLOSE is reported as the close time. If CLOSE does not assert during an event, the close time is reported as `--:--:--.---`.

Targets

The Targets: field displays the front-panel targets that are asserted at the end of the event report if a trip occurred during the event. If the relay is equipped with programmable target LEDs, the alias of only those LEDs set to latch-in on trip (LED*n*L=Y) will be displayed (see *Targets on page 12.7* for details).

Breaker Status

The Breaker: field displays the status of the breaker at the end of the event. If Relay Word bit 52A is asserted, the relay reports the breaker Closed. If Relay Word bit 52A is not asserted, the relay reports the breaker Open.

Analog Phase Quantities

The Prefault: field displays the IA, IB, IC, IN, IG, 3I2, and voltages from the first row of the event report.

The Fault: field displays IA, IB, IC, IN, IG, 3I2, VA, VB, and VC that correspond to the event report rows used for fault location, or, if the fault locator does not operate successfully, from the event report rows 1.25 cycles after the event report is triggered. All angles are referenced to the prefault A-phase voltage if it is greater than 13V secondary. Otherwise, angles are referenced to the prefault A-phase current.

MIRRORED BITS Status

The status of MIRRORED BITS channels are displayed by the **SUM** command. The MIRRORED BITS display includes channel A and B transmit/receive bits at the time the event was triggered, channel A and B transmit/receive bits at the time the relay tripped (if a trip occurred during the event), and channel A and B Mirrored Bits channel indicators (LBOKA, LBOKB, CBADA, CBADB, RBADA, RBADB, ROKA, and ROKB). If MIRRORED BITS are not enabled, this section is omitted from the **SUM** command response. If only one MIRRORED BITS channel is enabled, MIRRORED BITS information for both channels, A and B, is displayed (see *Appendix H: MIRRORED BITS Communications* for details on MIRRORED BITS.

Retrieving Full-Length Standard Event Reports

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

- ➤ Current, voltage, memory voltage, station battery, and frequency
- ➤ Protection, control, and communications elements
- ➤ Event summary
- ➤ Group, SELOGIC control equations, and Global settings from the time of event trigger

NOTE: Compressed ASCII Event Reports contain all of the Relay Word bits and automatic variable analog scaling, and are easily analyzed using no-charge software. Regular, uncompressed event reports only contain a subset of the Relay Word bits, do not have automatic variable scaling, and are not fully supported by software. SEL recommends that you use compressed event reports for all event analysis. See Compressed ASCII Event Reports on page 12.14.

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

EVE [*n* S*x* L*y* L R A D V C M P]

where:

n Event number (*n* = 1, 2, 3... to number of events stored) or unique event identifier (*n* = 10000–65535). Defaults to 1 if not listed, where 1 is the most recent event.

S*x* Display *x* samples per cycle (4, 16, 32, or 128); defaults to 4 if not listed. S128 is only available for unfiltered (raw) event reports and must be accompanied by the R parameter (**EVE S128 R**).

L*y* Display *y* cycles of data (1–LER). Defaults to LER value if not listed. Unfiltered reports (R parameter) display one extra cycle of data, and S128 unfiltered reports display two extra cycles of data.

L Display 32 samples per cycle; same as the S32 parameter.

R Specifies the unfiltered (raw) event report. Defaults to 32 samples per cycle unless overridden with the S*x* parameter.

A Specifies that only the analog section of the event is displayed (current, voltage, memory voltage, station battery, and frequency).

D Specifies that only the digital section (Protection and Control Elements) of the event is displayed.

V Specifies variable scaling for analog values.

C Display the report in Compressed ASCII format, with analog data at 16 samples per cycle, and digital data at 4 samples per cycle default.

M Specifies only the Communication element section of the event is displayed.

P Precise to synchrophasor level accuracy for signal content at nominal frequency. This option is available only for event triggered when TSOK = logical 1. The P option implies R as only raw analog data is available with this accuracy. When M or D are specified with P, then the P option is ignored since it only pertains to analog data.

Below are example **EVE** commands.

Serial Port Command	Description
EVE	Display the most recent event report at 1/4 cycle resolution.
EVE 2	Display the second event report at 1/4 cycle resolution.
EVE S16 L10	Display 10 cycles of the most recent report at 1/16 cycle resolution.
EVE C 2	Display the second report in Compressed ASCII format at, with analog data at 16 samples per cycle, and digital data at 4 samples per cycle.
EVE L	Display most recent report at 1/32-cycle resolution.
EVE R	Display most recent report at 1/32-cycle resolution; analog data and digital data (for optoisolated inputs) are unfiltered (raw).
EVE 2 D L10	Display 10 cycles of the protection and control elements section of the second event report at 1/4-cycle resolution.
EVE 2 A R S4 V	Display the unfiltered analog section of the second event report at 1/4-cycle resolution, with variable scaling of the analog values.

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

```
Invalid Event
```

If the Sx parameter is entered and x is not 4, 16, 32, or 128, the relay responds:

```
Only 4, 16, 32, or 128 samples per cycle allowed
```

If the Ly parameter is entered and y = 0 or y > LER, the relay shall responds:

```
Event report length exceeded
```

Synchrophasor-Level Accuracy in Event Reports

The SEL-311C provides the option to display event report data aligned to a high-accuracy time source by adding the P parameter. The header indicates the availability of a high-accuracy time source by displaying the status of Relay Word bit TSOK. The `Time:` value in the header includes three additional digits. These represent 100 µs, 10 µs, and 1 µs. The `Time:` value contains the time stamp of the analog value associated with the trigger point.

Furthermore, the `FREQ` column in the analog section of the report is replaced by a `DT` column. DT means "difference time." It represents the difference time in units of microseconds from another row. The trigger point shall have a DT value of 0000 because the trigger time corresponds to the time displayed in the event report header. The DT value for rows preceding the trigger point is referenced to the following row (so they increment backwards in time). The DT value for rows following the trigger point is referenced to the previous row (so they increment forwards in time). If TSOK = logical 0, this event report display option is not available.

Figure 12.4 shows how an event report is modified with the P parameter. Because event report information is stored at a sample rate that depends on the power system frequency, the DT column data will show a minimally changing number when the power system frequency is stable. If the power system frequency changes during the event reporting window and the relay is connected to a voltage reference, the sample rate may vary during the event report, and the DT values may vary accordingly.

```
=>>EVE P<Enter>

=>>EVE P<Enter>
SEL-311C                         Date: 7/12/10  Time: 08:54:29.577
STATION A

FID=SEL-311C-1-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx     CID=[XXXX]
Event Number=10526


      Currents (Amps Pri)            Voltages (kV Pri)        V1
    IA    IB    IC    IN    IG    VA    VB    VC     VS    Mem  FREQ Vdc
[0]
   130   781  -941    -8   -30  76.8  54.9 -131.2  -0.0    ...  1043  23
  -317   963  -701   -10   -54  31.5  93.9 -127.1  -0.0    ...  1041  23
  -607   979  -393    -8   -21 -20.8 123.1 -100.8  -0.0    ...  1046  23
  -896   828    17    -9   -51 -68.0 131.3  -65.8   0.0  -90.4  1040  23
  -996   594   372   -10   -29 -106.5 119.4 -11.5   0.0    ...  1040  23
  -956   201   712    -9   -43 -127.6  91.9  33.9   0.0    ...  1044  23
  -802  -146   907    -8   -41 -129.9  45.9  84.2   0.0    ...  1043  23
  -459  -553   979    -9   -33 -112.7  -1.4 113.5  -0.0  -95.6  1040  23
.
.
.
[4]
   158   763  -953   -10   -31  79.8  51.5 -130.8  -0.0    ...  1040  23
  -291   955  -724   -11   -60  34.9  91.3 -128.0  -0.0    ...  1039  23
  -291   955  -724   -11   -60  34.9  91.3 -128.0  -0.0    ...  1039  23
  -585   982  -419    -8   -21 -17.2 121.8 -103.1   0.0    ...  1043  23
  -884   843   -12    -9   -52 -64.8 131.3  -68.9   0.0  -87.7  1041  23
  -991   617   347    -8   -27 -104.3 120.9 -15.1  -0.0    ...  1043  23
  -963   230   692    -7   -41 -126.7  94.5  30.3   0.0    ...  1042  23
  -819  -118   896    -9   -40 -130.4  49.2  81.5   0.0    ...  1044  23
  -482  -528   980    -9   -30 -114.6   2.4 111.6   0.0  -98.1  1046  23
  -170  -790   912    -8   -48 -80.4 -51.2 130.3   0.0    ...  1039  23
   279  -985   683    -9   -23 -35.5 -91.2 127.6   0.0    ...  1040  23
   574 -1012   380   -10   -58  16.6 -121.8 102.8  -0.0    ...  1041  23
   872  -875   -29   -11   -32  64.2 -131.4  68.9  -0.0   87.3  1043  23
   981  -650  -383    -9   -51 103.6 -121.2  15.3   0.0    ...  1042  23
   955  -263  -731   -10   -40 126.3 -95.0  -30.3  -0.0    ...  1041  23
   811    85  -936    -9   -40 130.2 -49.7  -81.6  -0.0    ...  1046  23
   476   497 -1022   -10   -49 114.6  -3.0 -111.9  -0.0   98.4  0000  23>
[5]
   165   759  -956   -10   -32  80.6  50.6 -130.7  -0.0    ...  1040  23
  -283   955  -726   -10   -54  35.8  90.7 -128.2  -0.0    ...  1043  23
  -580   982  -424    -9   -22 -16.5 121.5 -103.6   0.0    ...  1038  23
  -881   847   -17    -9   -51 -64.0 131.3  -69.7  -0.0  -87.0  1043  23
.
.
.
=>>
```

Figure 12.4 Example Synchrophasor-Level Precise Event Report 1/16-Cycle Resolution

Compressed ASCII Event Reports

NOTE: Compressed ASCII Event Reports contain all of the Relay Word bits and automatic variable analog scaling, and are easily analyzed using no-charge software. Regular, uncompressed event reports only contain a subset of the Relay Word bits, do not have automatic variable scaling, and are not fully supported by software. SEL recommends that you use compressed event reports for all event analysis.

The SEL-311C provides Compressed ASCII event reports to facilitate event report storage and display. The SEL Communications Processors, ACSELERATOR QuickSet, and the SEL-5601 Analytic Assistant software take advantage of the Compressed ASCII format. Use the **EVE C** command or **CEVENT** command to display Compressed ASCII event reports. See the **CEVENT** command discussion in *Appendix K: Compressed ASCII Commands* for further information. You can also use the **Tools > Events > Get Events** menu in ACSELERATOR QuickSet to collect events.

Compressed ASCII event reports are the preferred method for retrieving event data, because the machine-readable format allows the use of time-saving software. Standard ASCII event reports are best-suited for rapid analysis, and for situations where only a portion of the event data is under study.

Filtered and Unfiltered Event Reports

The SEL-311C samples the basic power system measurands (ac voltage and ac current) 128 times per power system cycle. The relay filters the measurands at 32 samples per cycle to remove transient signals. The relay operates on the filtered values and reports them in the event report.

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

> **NOTE:** When a properly rated ac control signal is applied to an optoisolated input (IN101–IN106 or IN201–IN2xx), the unfiltered event report column for that input has an asserting/deasserting pattern at twice the applied signal frequency. See Input Debounce Timers on page 7.3.

- Power system harmonics on channels IA, IB, IC, IN, VA, VB, VC, VS
- Decaying dc offset during fault conditions on IA, IB, IC
- Optoisolated input contact bounce on channels IN101–IN106 and IN201–IN2xx
- Transients on the station dc battery channel Vdc (power input terminals Z25 and Z26), updated at 16 samples /cycle

The filters for ac current and voltage and station battery are fixed. You can adjust the optoisolated input debounce via debounce settings (see *Figure 7.1* and *Figure 7.2*).

Raw event reports display one extra cycle of data at the beginning of the report (or two extra cycles when S128 is specified).

Unfiltered Event Reports With PTCONN = DELTA

When Global setting PTCONN = DELTA, the raw event report voltage columns reflect the signals applied to relay terminals **VA-N**, **VB-N**, **VC-N**, even though the relay is configured for an open-delta PT connection (see *Figure 2.17*). If the relay is properly wired, the value shown in column VB should be at or near 0 kV, because input terminal **VB** is tied to terminal **N**. Column VA should reflect power system voltage V_{AB}, and column VC should reflect power system voltage V_{CB} (or $-V_{BC}$).

Clearing Standard Event Report Buffer

Via Serial Port

> **NOTE:** The unique event identification number cannot be reset.

The **HIS C** command clears the event summaries and corresponding standard event reports from nonvolatile memory. The **HIS C** command does not reset the unique event identification number to 10000. See *Section 10: Communications* for more information on the **HIS** (Event Summaries/History) command.

Via DNP or Modbus

The DNP binary output DRST_HIS can be used to reset the event summaries and corresponding standard event reports from nonvolatile memory, and is similar in function to the **HIS C** command. See *Appendix L: DNP3 Communications* for more details.

The Modbus protocol can be used to reset the event summaries and corresponding standard event reports from nonvolatile memory, with functions similar to the **HIS C** command. Two methods are available:

- Writing to the Reset History Data output coil.
- Writing a specific analog value to the RSTDAT register.

See *Appendix O: Modbus RTU and TCP Communications* for details.

Reset Via SELogic Equation

The RST_HIS SELogic control equation setting can be used to reset the event summaries and corresponding standard event reports from nonvolatile memory. The relay resets the function when the setting first asserts (rising edge, e.g., a logical 0 to a logical 1 transition).

Standard Event Report Column Definitions

Refer to the example event report in *Figure 12.5* to view event report columns. This example event report displays rows of information each 1/4 cycle and was retrieved with the **EVE** command.

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

Current, Voltage, and Frequency Columns

NOTE: Figure 12.5 is on multiple pages.

Table 12.3 summarizes the event report current, voltage, and frequency columns.

Table 12.3 Standard Event Report Current, Voltage, and Frequency Columns

Column Heading	Definition
IA	Current measured by channel IA (primary A)
IB	Current measured by channel IB (primary A)
IC	Current measured by channel IC (primary A)
IN	Current measured by channel IN (primary A)
IG	Calculated residual current IG = $3I_0$ = IA + IB + IC (primary A)
VA	Voltage measured by channel VA (primary kV, PTCONN = WYE)[a]
VB	Voltage measured by channel VB (primary kV, PTCONN = WYE)[a]
VC	Voltage measured by channel VC (primary kV, PTCONN = WYE)[a]
VAB	Power system phase-to-phase voltage V_{AB} (primary kV, PTCONN = DELTA)[b]
VBC	Power system phase-to-phase voltage V_{BC} (primary kV, PTCONN = DELTA)[b]
VCA	Power system phase-to-phase voltage V_{CA} (primary kV, PTCONN = DELTA)[b]
VS	Voltage measured by channel VS (primary kV)
V1MEM	Positive-sequence memory voltage
Vdc	Voltage measured at power input terminals Z25 and Z26 (Vdc)
Freq[c]	System frequency (Hz)
DT[d]	Difference time referenced to previous row (microseconds)

[a] Also for Global setting PTCONN = DELTA when viewing unfiltered (raw) event reports.
[b] When Global setting PTCONN = DELTA, and relay terminals VA, VB, VC, and N are properly wired as shown in Figure 2.17, the filtered event report voltage values are determined as follows:
VAB reflects the measured value from relay terminals VA-N
VBC reflects the measured value from relay terminals VC-N rotated by 180° ($V_{BC} = -V_{CB}$)
VCA reflects the value derived from the subtraction of the measured value from relay terminals VA-N from the measured value from relay terminals VC-N ($V_{CA} = V_{CB} - V_{AB}$).
[c] Not available with P parameter.
[d] Only available with P parameter. See Synchrophasor-Level Accuracy in Event Reports on page 12.13.

Note that the ac values change from plus to minus (–) values in *Figure 12.5*, indicating the sinusoidal nature of the waveforms.

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

Figure 12.7: shows how event report current column data relates to the actual sampled current waveform and RMS current values.

Figure 12.8: shows how event report current column data can be converted to phasor rms current values.

Variable Scaling for Analog Values

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

Example without variable scaling (**EVE**), wye-connected:

```
=>>EVE <Enter>
SEL-311                              Date: 05/16/10    Time: 13:13:14.233
STATION A
FID=SEL-311C-1-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx       CID=xxxx
Event Number=18195
      Currents (Amps Pri)            Voltages (kV Pri)        V1
    IA    IB    IC    IN    IG     VA     VB     VC     VS    Mem  FREQ Vdc
[1]
   -37    -1    34    -1    -4  -13.9   -0.1   12.2   -1.4    0.0 60.00  0
    20   -41    20     0    -1    8.0  -16.0    6.9 -134.2    0.0 60.00  0
    36     0   -34     1     2   13.9    0.1  -12.2    1.3    0.0 60.00  0
   -21    40   -20    -0    -1   -8.1   16.0   -6.9  134.1    0.0 60.00  0
[2]
   -37    -1    34    -1    -4  -13.9   -0.1   12.2   -1.4    0.0 60.00  0
    20   -40    20     0     0    8.0  -16.0    6.9 -134.2    0.0 60.00  0
    36     0   -34     1     2   13.8    0.1  -12.2    1.3    0.0 60.00  0
   -21    40   -20    -0    -1   -8.1   16.0   -6.9  134.2    0.0 60.00  0
```

NOTE: The "V" option has no effect for compressed event reports (**EVE C**) because the analog values automatically have variable scaling. Variable scaling for compressed data displays both currents less than 1000 A and voltages less than 1000 kV with three decimal places.

Example with variable scaling (**EVE V**), wye-connected:

```
=>>EVE V <Enter>

SEL-311                              Date: 05/16/05    Time: 13:13:14.233
STATION A

FID=SEL-311C-1-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx       CID=xxxx
Event Number=18195


      Currents (Amps Pri)            Voltages (kV Pri)        V1
    IA    IB    IC    IN    IG     VA     VB     VC     VS    Mem  FREQ Vdc
[1]
   -37 -1.00    34 -1.28 -3.69  -13.9 -0.060   12.2 -1.360    0.0 60.00  0
    20   -41    20  0.09 -0.84  8.040  -16.0  6.920 -134.2    0.0 60.00  0
    36  0.00   -34  1.16  1.62   13.9  0.060  -12.2  1.340    0.0 60.00  0
   -21    40   -20 -0.16 -1.16 -8.060   16.0 -6.940  134.1    0.0 60.00  0
[2]
   -37 -1.00    34 -1.09 -3.59  -13.9 -0.080   12.2 -1.360    0.0 60.00  0
    20   -40    20  0.22  0.16  8.040  -16.0  6.920 -134.2    0.0 60.00  0
    36  0.00   -34  1.09  1.53   13.8  0.060  -12.2  1.340    0.0 60.00  0
   -21    40   -20 -0.25 -1.19 -8.060   16.0 -6.940  134.2    0.0 60.00  0
```

Output, Input, Protection and Control, and Communication Columns

Table 12.4 summarizes the event report output, input, protection and control, and communication columns. See *Table D.2* for more information on Relay Word bits shown in *Table 12.4*.

Some of the column definitions are different for wye-connected PT applications (Global setting PTCONN = WYE), and delta-connected PT applications (Global setting PTCONN = DELTA). These differences are noted in *Table 12.4*. *Figure 12.5* shows a wye-connected example event report, and *Figure 12.6* shows a delta-connected example event report.

To limit report size, the SEL-311C does not include all Relay Word bits in a standard ASCII event report. Some examples are logic variables LV1–LV32 and virtual bits VB001–VB128. These and all other Relay Word bits are available in compressed ASCII event reports, and are viewable using PC software. See *Compressed ASCII Event Reports on page 12.14* and *ACSELERATOR QuickSet Event Analysis on page C.15* for more information.

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 1 of 9)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
All columns		.	Element/input/output not picked up or not asserted, unless otherwise stated.
21 ZAB[a]	MAB1	1	If Zone 1 AB phase-phase distance element (MAB1) set
	MAB2	2	If Zone 2 AB phase-phase distance element (MAB2) set, not MAB1
	MAB3	3	If Zone 3 AB phase-phase distance element (MAB3) set, not MAB1 or MAB2
	MAB4	4	If Zone 4 AB phase-phase distance element (MAB4) set, not MAB1 or MAB2 or MAB3
21 PP[b]	MPP1	1	If Zone 1 phase-phase distance element (MPP1) set
	MPP2	2	If Zone 2 phase-phase distance element (MPP2) set, not MPP1
	MPP3	3	If Zone 3 phase-phase distance element (MPP2) set, not MPP1 or MPP2
	MPP4	4	If Zone 4 phase-phase distance element (MPP4) set, not MPP1, MPP2, or MPP3
21 ZBC[a]	MBC1	1	If Zone 1 BC phase-phase distance element (MBC1) set
	MBC2	2	If Zone 2 BC phase-phase distance element (MBC2) set, not MBC1
	MBC3	3	If Zone 3 BC phase-phase distance element (MBC3) set, not MBC1 or MBC2
	MBC4	4	If Zone 4 BC phase-phase distance element (MBC4) set, not MBC1 or MBC2 or MBC3
21 3P[b]	MABC1	1	If Zone 1 3-phase distance element (MABC1) set
	MABC2	2	If Zone 2 3-phase distance element (MABC2) set, not MABC1
	MABC3	3	If Zone 3 3-phase distance element (MABC3) set, not MABC1 or MABC2
	MABC4	4	If Zone 4 3-phase distance element (MABC4) set, not MABC1 or MABC2, or MABC3
21 ZCA[a]	MCA1	1	If Zone 1 CA phase-phase distance element (MCA1) set
	MCA2	2	If Zone 2 CA phase-phase distance element (MCA2) set, not MCA1
	MCA3	3	If Zone 3 CA phase-phase distance element (MCA3) set, not MCA1 or MCA2
	MCA4	4	If Zone 4 CA phase-phase distance element (MCA4) set, not MCA1 or MCA2 or MCA3
21 ZAG	XAG1 or MAG1	1	If Zone 1 AG element (XAG1 or MAG1) set
	XAG2 or MAG2	2	If Zone 2 AG element (XAG2 or MAG2) set, not Zone 1
	XAG3 or MAG3	3	If Zone 3 AG element (XAG3 or MAG3) set, not Zone 1 or Zone 2
	XAG4 or MAG4	4	If Zone 4 AG element (XAG4 or MAG4) set, not Zone 1 or Zone 2 or Zone 3
21 ZBG	XBG1 or MBG1	1	If Zone 1 BG element (XBG1 or MBG1) set
	XBG2 or MBG2	2	If Zone 2 BG element (XBG2 or MBG2) set, not Zone 1
	XBG3 or MBG3	3	If Zone 3 BG element (XBG3 or MBG3) set, not Zone 1 or Zone 2
	XBG4 or MBG4	4	If Zone 4 BG element (XBG4 or MBG4) set, not Zone 1 or Zone 2 or Zone 3

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 2 of 9)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
21 ZCG	XCG1 or MCG1	1	If Zone 1 CG element (XCG1 or MCG1) set
	XCG2 or MCG2	2	If Zone 2 CG element (XCG2 or MCG2) set, not Zone 1
	XCG3 or MCG3	3	If Zone 3 CG element (XCG3 or MCG3) set, not Zone 1 or Zone 2
	XCG4 or MCG4	4	If Zone 4 CG element (XCG4 or MCG4) set, not Zone 1 or Zone 2 or Zone 3
OOS	OSB	t	OOS timing
	OST	B	OOS Block (OSB*!OST)
		T	OOS Trip (OST)
VPOL	VPOLV	V	VPOLV asserted
		.	Time-overcurrent element reset (51_R)
51 P	51P, 51PT, 51PR	p	Time-overcurrent element picked up and timing
51 G	51G , 51GT, 51GR	T	Time-overcurrent element timed out
51 Q	51Q, 51QT, 51QR	r	Time-overcurrent element timing to reset
		1	Time-overcurrent element timing to reset (when element reset is set for 1 cycle, not electromechanical reset)
50P 1 2	50P1, 50P2	1	50P1 asserted
		2	50P2 asserted
		b	both 50P1 and 50P2 asserted
50P 3 4	50P3, 50P4	3	50P3 asserted
		4	50P4 asserted
		b	both 50P3 and 50P4 asserted
50G 1 2	50G1, 50G2	1	50G1 asserted
		2	50G2 asserted
		b	both 50G1 and 50G2 asserted
50G 3 4	50G3, 50G4	3	50G3 asserted
		4	50G4 asserted
		b	both 50G3 and 50G4 asserted
50Q 1 2	50Q1, 50Q2	1	50Q1 asserted
		2	50Q2 asserted
		b	both 50Q1 and 50Q2 asserted
50Q 3 4	50Q3, 50Q4	3	50Q3 asserted
		4	50Q4 asserted
		b	both 50Q3 and 50Q4 asserted
32 Q	F32Q	Q	Forward negative-sequence directional element F32Q picked up.
	R32Q	q	Reverse negative-sequence directional element R32Q picked up.
32 G	F32QG	Q	Forward negative-sequence ground directional element F32Q picked up.
	R32QG	q	Reverse negative-sequence ground directional element R32Q picked up.
	F32V	V	Forward zero-sequence ground directional element F32V picked up.
	R32V	v	Reverse zero-sequence ground directional element R32V picked up.
	F32I	I	Forward current polarized ground directional element F32I picked up.
	R32I	i	Reverse current polarized ground directional element R32I picked up.
67P 1 2	67P1, 67P2	1	67P1 asserted
		2	67P2 asserted
		b	both 67P1 and 67P2 asserted
67P 3 4	67P3, 67P4	3	67P3 asserted
		4	67P4 asserted
		b	both 67P3 and 67P4 asserted

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 3 of 9)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
67G 1 2	67G1, 67G2	1	67G1 asserted
		2	67G2 asserted
		b	both 67G1 and 67G2 asserted
67G 3 4	67G3, 67G4	3	67G3 asserted
		4	67G4 asserted
		b	both 67G3 and 67G4 asserted
67Q 1 2	67Q1, 67Q2	1	67Q1 asserted
		2	67Q2 asserted
		b	both 67Q1 and 67Q2 asserted
67Q 3 4	67Q3, 67Q4	3	67Q3 asserted
		4	67Q4 asserted
		b	both 67Q3 and 67Q4 asserted
DM P Q	PDEM, QDEM	P	Phase demand ammeter element PDEM picked up.
		Q	Negative-sequence demand ammeter element QDEM picked up.
		b	Both PDEM and QDEM picked up.
DM G	GDEM	*	Residual ground demand ammeter element GDEM picked up.
27 P (wye-connected)	27A, 27B, 27C	A	A-phase instantaneous undervoltage element 27A picked up.
		B	B-phase instantaneous undervoltage element 27B picked up.
		C	C-phase instantaneous undervoltage element 27C picked up.
		a	27A and 27B elements picked up.
		b	27B and 27C elements picked up.
		c	27C and 27A elements picked up.
		3	27A, 27B, and 27C elements picked up.
27 PP	27AB, 27BC, 27CA	A	AB phase-to-phase instantaneous undervoltage element 27AB picked up.
		B	BC phase-to-phase instantaneous undervoltage element 27BC picked up.
		C	CA phase-to-phase instantaneous undervoltage element 27CA picked up.
		a	27AB and 27CA elements picked up.
		b	27AB and 27BC elements picked up.
		c	27BC and 27CA elements picked up.
		3	27AB, 27BC and 27CA elements picked up.
27 S	27S	*	Channel VS instantaneous undervoltage element 27S picked up.
59 P (wye-connected)	59A, 59B, 59C	A	A-phase instantaneous overvoltage element 59A picked up.
		B	B-phase instantaneous overvoltage element 59B picked up.
		C	C-phase instantaneous overvoltage element 59C picked up.
		a	59A and 59B elements picked up.
		b	59B and 59C elements picked up.
		c	59C and 59A elements picked up.
		3	59A, 59B and 59C elements picked up.

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 4 of 9)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
59 PP	59AB, 59BC, 59CA	A	AB phase-to-phase instantaneous overvoltage element 59AB picked up.
		B	BC phase-to-phase instantaneous overvoltage element 59BC picked up.
		C	CA phase-to-phase instantaneous overvoltage element 59CA picked up.
		a	59AB and 59CA elements picked up.
		b	59AB and 59BC elements picked up.
		c	59BC and 59CA elements picked up.
		3	59AB, 59BC and 59CA elements picked up.
59 S	59S	*	VS instantaneous overvoltage element 59S picked up.
59 V1 Q	59V1, 59Q	1	Positive-sequence instantaneous overvoltage element 59V1 picked up.
		Q	Negative-sequence instantaneous overvoltage element 59Q picked up.
		b	Both 59V1 and 59Q picked up.
59 N (wye-connected)	59N1, 59N2	1	First ground instantaneous overvoltage element 59N1 picked up.
		2	Second ground instantaneous overvoltage element 59N2 picked up.
		b	Both 59N1 and 59N2 picked up.
25 59 V	59VP, 59VS	P	Phase voltage window element 59VP picked up (used in synchronism check).
		S	Channel VS voltage window element 59VS picked up (used in synchronism check).
		b	Both 59VP and 59VS picked up.
25 SF	SF	*	Slip frequency element SF picked up (used in synchronism check).
25 A	25A1, 25A2	1	First synchronism check element 25A1 picked up.
		2	Second synchronism check element 25A2 picked up.
		b	Both 25A1 and 25A2 picked up.
27B	27B81	*	Undervoltage element for frequency element blocking (any phase) asserted.
81 1 2	81D1, 81D2	1	Level 1 instantaneous frequency element asserted.
		2	Level 2 instantaneous frequency element asserted.
		b	Level 1 and 2 instantaneous frequency elements asserted.
81 3 4	81D3, 81D4	3	Level 3 instantaneous frequency element asserted.
		4	Level 4 instantaneous frequency element asserted.
		b	Level 3 and 4 instantaneous frequency elements asserted.
81 5 6	81D5, 81D6	5	Level 5 instantaneous frequency element asserted.
		6	Level 6 instantaneous frequency element asserted.
		b	Level 5 and 6 instantaneous frequency elements asserted.
79	RCSF, CF, 79RS, 79CY, 79LO	.	Reclosing relay nonexistent.
		S	Reclose supervision failure condition (RCSF asserts for only 1/4 cycle).
		F	Close failure condition (CF asserts for only 1/4 cycle).
		R	Reclosing relay in Reset State (79RS).
		C	Reclosing relay in Reclose Cycle State (79CY).
		L	Reclosing relay in Lockout State (79LO).

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 5 of 9)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
Time	OPTMN, RSTMN	o	Recloser open interval timer is timing.
		r	Recloser reset interval timer is timing.
Shot	SH0, SH1, SH2 SH3, SH4	.	Reclosing relay nonexistent.
		0	shot = 0 (SH0).
		1	shot = 1 (SH1).
		2	shot = 2 (SH2).
		3	shot = 3 (SH3).
		4	shot = 4 (SH4).
Zld	ZLIN, ZLOUT	i	Load encroachment “load in” element ZLIN picked up.
		o	Load encroachment “load out” element ZLOUT picked up.
LOP	LOP	*	Loss-of-potential element LOP picked up.
Vdc	DCHI, DCLO	H	Station battery instantaneous overvoltage element DCHI picked up.
		L	Station battery instantaneous undervoltage element DCLO picked up.
		b	Both DCHI and DCLO asserted.
Out1 1 2[c]	OUT101[d], OUT102[d]	1	Output contact OUT101 asserted.
		2	Output contact OUT102 asserted.
		b	Both OUT101 and OUT102 asserted.
Out1 3 4[c]	OUT103[d], OUT104[d]	3	Output contact OUT103 asserted.
		4	Output contact OUT104 asserted.
		b	Both OUT103 and OUT104 asserted.
Out1 5 6[c]	OUT105[d], OUT106[d]	5	Output contact OUT105 asserted.
		6	Output contact OUT106 asserted.
		b	Both OUT105 and OUT106 asserted.
Out1 7 A[c]	OUT107[d], ALARM[d]	7	Output contact OUT107 asserted.
		A	Output contact ALARM asserted.
		b	Both OUT107 and ALARM asserted.
Out2 1 2[c]	OUT201[e], OUT202[e]	1	Output contact OUT201 asserted.
		2	Output contact OUT202 asserted.
		b	Both OUT201 and OUT202 asserted.
Out2 3 4[c]	OUT203[e], OUT204[e]	3	Output contact OUT203 asserted.
		4	Output contact OUT204 asserted.
		b	Both OUT203 and OUT204 asserted.
Out2 5 6[c]	OUT205[e], OUT206[e]	5	Output contact OUT205 asserted.
		6	Output contact OUT206 asserted.
		b	Both OUT205 and OUT206 asserted.
Out2 7 8[c]	OUT207[e], OUT208[e]	7	Output contact OUT207 asserted.
		8	Output contact OUT208 asserted.
		b	Both OUT207 and OUT208 asserted.
Out2 9 0[c]	OUT209[e], OUT210[e]	9	Output contact OUT209 asserted.
		0	Output contact OUT210 asserted.
		b	Both OUT209 and OUT210 asserted.
Out2 1 2[c]	OUT211[e], OUT212[e]	1	Output contact OUT211 asserted.
		2	Output contact OUT212 asserted.
		b	Both OUT211 and OUT212 asserted.

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 6 of 9)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
In1 1 2	IN101[d], IN102[d]	1 2 b	Optoisolated input IN101 asserted. Optoisolated input IN102 asserted. Both IN101 and IN102 asserted.
In1 3 4	IN103[d], IN104[d]	3 4 b	Optoisolated input IN103 asserted. Optoisolated input IN104 asserted. Both IN103 and IN104 asserted.
In1 5 6	IN105[d], IN106[d]	5 6 b	Optoisolated input IN105 asserted. Optoisolated input IN106 asserted. Both IN105 and IN106 asserted.
In2 1 2	IN201[e], IN202[e]	1 2 b	Optoisolated input IN201 asserted. Optoisolated input IN202 asserted. Both IN201 and IN202 asserted.
In2 3 4	IN203[e], IN204[e]	3 4 b	Optoisolated input IN203 asserted. Optoisolated input IN204 asserted. Both IN203 and IN204 asserted.
In2 5 6	IN205[e], IN206[e]	5 6 b	Optoisolated input IN205 asserted. Optoisolated input IN206 asserted. Both IN205 and IN206 asserted.
In2 7 8	IN207[e], IN208[e]	7 8 b	Optoisolated input IN207 asserted. Optoisolated input IN208 asserted. Both IN207 and IN208 asserted.
PO	3PO, SPOA, SPOB, SPOC	3	Three pole open condition 3PO asserted.
SOTF	SOTFT	*	Switch-onto-fault condition SOTFT asserted.
PT	PT	*	Permissive trip signal to POTT logic PT asserted.
PTRX	PTRX1, PTRX2	1 2 b	Permissive trip 1 signal from DCUB logic PTRX1 asserted. Permissive trip 2 signal from DCUB logic PTRX2 asserted. Both PTRX1 and PTRX2 asserted
Z3RB	Z3RB	*	Zone /Level 3 reverse block Z3RB asserted.
KEY	KEY	*	Key permissive trip signal KEY asserted.
EKEY	EKEY	*	Echo key EKEY asserted.
ECTT	ECTT	*	Echo conversion to trip condition ECTT asserted.
WFC	WFC	*	Weak-infeed condition WFC asserted.
UBB	UBB1, UBB2	1 2 b	Unblocking block 1 from DCUB logic UBB1 asserted. Unblocking block 2 from DCUB logic UBB2 asserted. Both UBB1 and UBB2 asserted.
Z3XT	Z3XT	*	Logic output from Zone/Level 3 extension timer Z3XT asserted.
DSTR	DSTRT	*	Directional carrier start DSTRT asserted.
NSTR	NSTRT	*	Nondirectional carrier start NSTRT asserted.
STOP	STOP	*	Carrier stop STOP asserted.
BTX	BTX	*	Block trip input extension BTX asserted.

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 7 of 9)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
TMB A 1 2	TMB1A, TMB2A	1	MIRRORED BITS channel A transmit bit 1 TMB1A asserted.
		2	MIRRORED BITS channel A transmit bit 2 TMB2A asserted.
		b	Both TMB1A and TMB2A asserted.
TMB A 3 4	TMB3A, TMB4A	3	MIRRORED BITS channel A transmit bit 3 TMB3A asserted.
		4	MIRRORED BITS channel A transmit bit 4 TMB4A asserted.
		b	Both TMB3A and TMB4A asserted.
TMB A 5 6	TMB5A, TMB6A	5	MIRRORED BITS channel A transmit bit 5 TMB5A asserted.
		6	MIRRORED BITS channel A transmit bit 6 TMB6A asserted.
		b	Both TMB5A and TMB6A asserted.
TMB A 7 8	TMB7A, TMB8A	7	MIRRORED BITS channel A transmit bit 7 TMB7A asserted.
		8	MIRRORED BITS channel A transmit bit 8 TMB8A asserted.
		b	Both TMB7A and TMB8A asserted.
RMB A 1 2	RMB1A, RMB2A	1	MIRRORED BITS channel A receive bit 1 RMB1A asserted.
		2	MIRRORED BITS channel A receive bit 2 RMB2A asserted.
		b	Both RMB1A and RMB2A asserted.
RMB A 3 4	RMB3A, RMB4A	3	MIRRORED BITS channel A receive bit 3 RMB3A asserted.
		4	MIRRORED BITS channel A receive bit 4 RMB4A asserted.
		b	Both RMB3A and RMB4A asserted.
RMB A 5 6	RMB5A, RMB6A	5	MIRRORED BITS channel A receive bit 5 RMB5A asserted.
		6	MIRRORED BITS channel A receive bit 6 RMB6A asserted.
		b	Both RMB5A and RMB6A asserted.
RMB A 7 8	RMB7A, RMB8A	7	MIRRORED BITS channel A receive bit 7 RMB7A asserted.
		8	MIRRORED BITS channel A receive bit 8 RMB8A asserted.
		b	Both RMB7A and RMB8A asserted.
TMB B 1 2	TMB1B, TMB2B	1	MIRRORED BITS channel B transmit bit 1 TMB1B asserted.
		2	MIRRORED BITS channel B transmit bit 2 bit TMB2B asserted.
		b	Both TMB1B and TMB2B asserted.
TMB B 3 4	TMB3B, TMB4B	3	MIRRORED BITS channel B transmit bit 3 TMB3B asserted.
		4	MIRRORED BITS channel B transmit bit 4 TMB4B asserted.
		b	Both TMB3B and TMB4B asserted.
TMB B 5 6	TMB5B, TMB6B	5	MIRRORED BITS channel B transmit bit 5 TMB5B asserted.
		6	MIRRORED BITS channel B transmit bit 6 TMB6B asserted.
		b	Both TMB5B and TMB6B asserted.
TMB B 7 8	TMB7B, TMB8B	7	MIRRORED BITS channel B transmit bit 7 TMB7B asserted.
		8	MIRRORED BITS channel B transmit bit 8 TMB8B asserted.
		b	Both TMB7B and TMB8B asserted.
RMB B 1 2	RMB1B, RMB2B	1	MIRRORED BITS channel B receive bit 1 RMB1B asserted.
		2	MIRRORED BITS channel B receive bit 2 RMB2B asserted.
		b	Both RMB1B and RMB2B asserted.

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 8 of 9)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
RMB B 3 4	RMB3B, RMB4B	3	MIRRORED BITS channel B receive bit 3 RMB3B asserted.
		4	MIRRORED BITS channel B receive bit 4 RMB4B asserted.
		b	Both RMB3B and RMB4B asserted.
RMB B 5 6	RMB5B, RMB6B	5	MIRRORED BITS channel B receive bit 5 RMB5B asserted.
		6	MIRRORED BITS channel B receive bit 6 RMB6B asserted.
		b	Both RMB5B and RMB6B asserted.
RMB B 7 8	RMB7B, RMB8B	7	MIRRORED BITS channel B receive bit 7 RMB7B asserted.
		8	MIRRORED BITS channel B receive bit 8 RMB8B asserted.
		b	Both RMB7B and RMB8B asserted.
ROK	ROKA, ROKB	A	MIRRORED BITS channel A receive OK ROKA asserted.
		B	MIRRORED BITS channel B receive OK ROKB asserted.
		b	Both ROKA and ROKB asserted.
RBAD	RBADA, RBADB	A	MIRRORED BITS channel A extended outage RBADA asserted.
		B	MIRRORED BITS channel B extended outage RBADB asserted.
		b	Both RBADA and RBADB asserted.
CBAD	CBADA, CBADB	A	MIRRORED BITS channel A unavailability CBADA asserted.
		B	MIRRORED BITS channel B unavailability CBADB asserted.
		b	Both CBADA and CBADB asserted.
LBOK	LBOKA, LBOKB	A	MIRRORED BITS channel A loop back OK LBOKA asserted.
		B	MIRRORED BITS channel B loop back OK LBOKB asserted.
		b	Both LBOKA and LBOKB asserted.
OC	OC, CC	o	**OPE** (Open) command executed.
		c	**CLO** (Close) command executed.
Lcl RW 5	LB1–LB8	00–FF Hex[f]	Hex value of Relay Word Row 5, LB1–LB8, Local Bits
Lcl RW 6	LB9–LB16	00–FF Hex[f]	Hex value of Relay Word Row 6, LB9–LB16, Local Bits
Rem RW 7	RB1–RB8	00–FF Hex[f]	Hex value of Relay Word Row 7, RB1–RB8, Remote Bits
Rem RW 8	RB9–RB16	00–FF Hex[f]	Hex value of Relay Word Row 8, RB9–RB16, Remote Bits
Ltch RW 9	LT1–LT8	00–FF Hex[f]	Hex value of Relay Word Row 9, LT1–LT8, Latch Bits
Ltch RW 10	LT9–LT16	00–FF Hex[f]	Hex value of Relay Word Row 10, LT9–LT16, Latch Bits

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 9 of 9)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
SELOGIC			
1	SV1, SV1T	p	SELOGIC control equation variable timer input SV_ asserted; timer timing on pickup time; timer output SV_T not asserted.
2	SV2, SV2T		
3	SV3, SV3T		
4	SV4, SV4T		
5	SV5, SV5T	T	SELOGIC control equation variable timer input SV_ asserted; timer timed out on pickup time; timer output SV_T asserted.
6	SV6, SV6T		
7	SV7, SV7T		
8	SV8, SV8T		
9	SV9, SV9T		
10	SV10, SV10T	d	SELOGIC control equation variable timer input SV_ not asserted; timer previously timed out on pickup time; timer output SV_T remains asserted while timer timing on dropout time.
11	SV11, SV11T		
12	SV12, SV12T		
13	SV13, SV13T		
14	SV14, SV14T		
15	SV15, SV15T		
16	SV16, SV16T		

[a] This column is visible only when positive-sequence, polarized phase mho elements are enabled (E21P does not contain "C").
[b] This column is visible only when compensator distance mho elements are enabled (E21P contains "C").
[c] Output contacts can be A or B type contacts (see Figure 7.28 through Figure 7.30).
[d] Models 311C10x, 311C11x, 311C12x, and 311C13x.
[e] Model 311C11x and 311C13x.
[f] The hexadecimal value displayed in the local, remote, and latch bit fields of the event report are created by converting the combined binary values of the involved bits (LB1–LB8, LB9–LB16, RB1–RB8, RB9–RB16, LT1–LT8, or LT9–LT16) into a hexadecimal representation. The below example shows that "8A" would be displayed in the event report for local bits 1–8 if LB1, LB5, and LB7 are the only bits asserted. The highest numbered bit (e.g., LB8) is the least significant, as follows.
1000 in binary is represented in hexadecimal as 8, and 1010 in binary is represented in hexadecimal as A.

LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8	
1	0	0	0	1	0	1	0	= 8A Hex

Sequential Events Recorder (SER) Report

See *Figure 12.9* for an example SER report.

SER Triggering

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

SER1 = **M1P, Z1G, M2P, Z2G, M3P, Z3G, 51G, 51Q, 50P1**

SER2 = **IN101, IN102, OUT101, OUT102, OUT103, OUT104, LOP**

SER3 = **KEY, Z3RB, PTRX**

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

- time-overcurrent element pickups (51Q and 51G)
- instantaneous overcurrent element (50P1)

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

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

Automatic SER Triggers

The SEL-311C automatically logs special SER entries as shown in *Table 12.5*. There are no SER trigger settings associated with these automatic SER trigger entries.

Table 12.5 Automatic SER Triggers

Event	SER Entry	Reference
Power-up	`Relay newly powered up`	*Section 9: Setting the Relay*
Settings change, active group change, or CID file uploaded	`Relay settings changed`	*Section 9: Setting the Relay*, *Section 7: Inputs, Outputs, Timers, and Other Control Logic*, and *Appendix P: IEC 61850*
SER C command issued	`SER archive cleared`	*Clearing SER Report on page 12.29*
Start of SER data loss	`SER data loss begin`	*SER Memory Operation on page 12.29*
End of SER data loss	`SER data loss end`	
Invalid SER data	`Invalid Data`	
Diagnostic restart	`Diagnostic restart`	*Section 13: Testing and Troubleshooting*

All of the automatic SER entries except “Invalid Data” include a date and time stamp.

Making SER Trigger Settings

Enter up to 24 element names in each of the SER settings via the **SET R** command. See *Table D.1* for references to valid relay element (Relay Word bit) names. See the **SET R** command in *Table 9.2* and corresponding *Report Settings (Serial Port Command SET R) on page SET.32*. Use commas or spaces to delimit the elements. For example, if you enter setting SER1 as:

SER1 = **51P,51G,51PT,,51GT , 50P1, , 50P2**

The relay displays the setting as:

```
SER1 = 51P,51G,51PT,51GT,50P1,50P2
```

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

Make Sequential Events Recorder (SER) Settings With Care

The relay triggers a row in the Sequential Events Recorder (SER) event report for any change of state in any one of the elements listed in the SER1, SER2, or SER3 trigger settings. Nonvolatile memory is used to store the latest 1024 rows of the SER event report so they can be retained during power loss. The nonvolatile memory is rated for a finite number of “writes.” Exceeding the limit can result in an EEPROM self-test failure. An average of one state change every three minutes can be made for a 25-year relay service life.

Retrieving SER Reports

The relay saves the latest 1024 rows of the SER in nonvolatile memory. Row 1 is the most recently triggered row, and row 1024 is the oldest. View the SER report by date or SER row number as outlined in the examples below.

Example SER Serial Port Commands	Format
SER	If **SER** is entered with no numbers following it, all available rows are displayed (up to row number 1024). They display with the oldest row at the beginning (top) of the report and the latest row (row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 17	If **SER** is entered with a single number following it (**17** in this example), the first 17 rows are displayed, if they exist. They display with the oldest row (row 17) at the beginning (top) of the report and the latest row (row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 10 33	If **SER** is entered with two numbers following it (**10** and **33** in this example; 10 < 33), all the rows between (and including) rows 10 and 33 are displayed, if they exist. They display with the oldest row (row 33) at the beginning (top) of the report and the latest row (row 10) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 47 22	If **SER** is entered with two numbers following it (**47** and **22** in this example; 47 > 22), all the rows between (and including) rows 47 and 22 are displayed, if they exist. They display with the newest row (row 22) at the beginning (top) of the report and the oldest row (row 47) at the end (bottom) of the report. *Reverse* chronological progression through the report is down the page and in ascending row number.
SER 3/30/2009	If **SER** is entered with one date following it (date **3/30/2009** 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 2/17/2009 3/23/2009	If **SER** is entered with two dates following it (date **2/17/2009** chronologically *precedes* date **3/23/2009** in this example), all the rows between (and including) dates 2/17/2009 and 3/23/2009 are displayed, if they exist. They display with the oldest row (date 2/17/2009) at the beginning (top) of the report and the latest row (date 3/23/2009) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 3/16/2009 1/5/2009	If **SER** is entered with two dates following it (date **3/16/2009** chronologically *follows* date **1/5/2009** in this example), all the rows between (and including) dates 1/5/2009 and 3/16/2009 are displayed, if they exist. They display with the latest row (date 3/16/2009) at the beginning (top) of the report and the oldest row (date 1/5/2009) at the end (bottom) of the report. *Reverse* chronological progression through the report is down the page and in ascending row number.

NOTE: The SEL-311C accepts two or four digit years in the **SER** command. For example, **SER 3/30/09** is treated the same as **SER 3/30/2009**. In either case, the SER report only displays two digit years in the Date column.

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

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

```
No SER Data
```

Clearing SER Report

Clear the SER report from nonvolatile memory with the **SER C** command as shown in the following example:

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

To indicate when the SER memory was cleared, an entry is added to the SER as shown in *Table 12.5*.

SER Memory Operation

The Sequential Events Recorder (SER) nonvolatile memory is updated soon after new SER data is generated. During some conditions, such as during event report capture, the update of SER data is momentarily interrupted, and then SER updating of nonvolatile memory resumes.

In rare cases with rapidly occurring SER triggers, the new SER information may arrive faster than the memory system can store it. When this occurs, the relay inserts a pair of entries in the SER to indicate the start and end of data loss, as shown in *Table 12.5*. This is normally seen only during testing. Normal SER operation resumes after the data loss.

Another situation that can affect SER data storage is when the power supply to the SEL-311C is interrupted while data is being recorded. If this results in incomplete data, the SER Command may report `Invalid Data` for the incomplete entry, as shown in *Table 12.5*. Normal SER operation resumes after the relay is powered-up.

Example Standard 15-Cycle Event Report

The following example standard 15-cycle event report in *Figure 12.5* also corresponds to the example sequential events recorder (SER) report in *Figure 12.9*. The circled numbers in *Figure 12.5* correspond to the SER row numbers in *Figure 12.9*. The row explanations follow *Figure 12.9*.

In *Figure 12.5*, the arrow (`>`) in the column following the `Vdc` column identifies the “trigger” row. This row corresponds to the `Date` and `Time` values at the top of the event report.

The asterisk (`*`) in the column following the `Vdc` column identifies the row corresponding to the “fault” values, which are determined from the filtered values. The phase currents are calculated from the row identified with the asterisk and the row one quarter-cycle previous (see *Figure 12.7* and *Figure 12.8*). These currents are listed at the end of the event report in the event summary. If the “trigger” row (`>`) and the faulted phase current row (`*`) are the same row, the (`*`) symbol takes precedence.

Since the phase currents are determined from the filtered values, the asterisk (*) is not displayed in the unfiltered (raw) event report.

```
=>>EVE <Enter>

SEL-311                            Date: 10/14/10    Time: 08:53:34.926
STATION A

FID=SEL-311C-1-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx     CID=xxxx
Event Number = 10522

       Currents (Amps Pri)            Voltages (kV Pri)             V1   FREQ Vdc
     IA     IB     IC     IN IG     VA     VB     VC     VS     Mem
[1]
    102   -200     98      0      0   67.4 -131.6   64.3   67.4   67.1 60.00  27
    171      2   -176      0     -3  112.9    1.9 -115.0  113.2  113.2 60.00  27
   -103    199    -99     -1     -3  -67.5  131.6  -64.2  -67.5  -67.2 60.00  27
   -173     -3    174      0     -2 -112.9   -2.0  115.0 -113.2 -113.1 60.00  27
[2]
    102   -200     97      0     -1   67.6 -131.6   64.1   67.6   67.3 60.00  27
    171      2   -175     -1     -2  112.8    2.0 -115.1  113.1  113.1 60.00  27
   -103    199    -98      0     -2  -67.7  131.6  -64.0  -67.7  -67.4 60.00  27
   -172     -3    175     -1      0 -112.8   -2.1  115.1 -113.1 -113.0 60.00  27
[3]
    102   -201     97      0     -2   67.8 -131.6   63.9   67.8   67.5 60.00  27
    171      2   -176     -1     -3  112.7    2.2 -115.2  113.0  113.0 60.00  27
   -104    200    -97     -1     -1  -67.9  131.6  -63.9  -67.9  -67.5 60.00  27
   -172     -4    175      0     -1 -112.6   -2.4  115.2 -112.9 -112.9 60.00  27
[4]
    103   -270    165      0     -2   68.0 -130.8   63.0   68.0   67.6 60.00  27
    171   -686    576     -1     61  112.6    3.2 -114.7  112.9  112.7 60.00  27
   -104    936   -867     -1    -35  -68.1  121.8  -55.0  -68.1  -67.7 60.01  27
   -172   1661  -1653      0   -164 -112.5    0.9  108.8 -112.8 -111.2 60.01  27>
[5]
    103  -1532   1499      0     70   68.2 -113.8   47.9   68.2   67.0 60.01  27
    171  -1948   1976     -1    199  112.5   -5.6 -103.5  112.8  109.0 60.01  27
   -104   1531  -1500      0    -73  -68.3  113.8  -47.8  -68.3  -65.7 60.01  27
   -171   1945  -1975      0   -201 -112.4    5.5  103.5 -112.7 -107.3 60.01  27
[6]
    104  -1533   1500     -1     71   68.4 -113.8   47.7   68.3   64.8 60.01  27*
    170  -1945   1973      0    198  112.4   -5.4 -103.6  112.7  106.1 60.01  27
   -105   1533  -1503     -1    -75  -68.4  113.8  -47.7  -68.4  -64.2 60.01  27
   -172   1944  -1973     -1   -201 -112.4    5.3  103.6 -112.6 -105.1 60.01  27
[7]
    104  -1536   1504      0     72   68.5 -113.8   47.5   68.5   63.7 60.01  27
    171  -1944   1971      0    198  112.3   -5.3 -103.6  112.6  104.4 60.01  27
   -105   1538  -1507     -1    -74  -68.6  113.8  -47.5  -68.6  -63.3 60.01  27
   -171   1940  -1970      0   -201 -112.2    5.1  103.7 -112.5 -103.8 60.01  27
[8]
    104  -1539   1506     -1     71   68.7 -113.8   47.4   68.7   63.1 60.01  27
    170  -1941   1968     -1    197  112.2   -5.1 -103.7  112.4  103.4 60.01  27
   -105   1540  -1509     -1    -74  -68.8  113.8  -47.3  -68.8  -63.0 60.01  27
   -171   1939  -1968      0   -200 -112.1    5.0  103.7 -112.4 -103.0 60.01  27
[9]
    104  -1543   1510      0     71   68.9 -113.8   47.2   68.9   62.9 60.01  27
    170  -1938   1965     -1    197  112.0   -4.9 -103.8  112.3  102.7 60.01  27
   -106   1543  -1513     -1    -76  -69.0  113.8  -47.2  -69.0  -62.8 60.01  27
   -171   1936  -1964      0   -199 -112.0    4.8  103.8 -112.3 -102.5 60.01  27
[10]
    105  -1546   1513      0     72   69.1 -113.9   47.1   69.1   62.8 60.01  27
    158  -1803   1835      0    190  111.9   -4.4 -104.3  112.2  102.4 60.01  27
   -105   1446  -1429     -1    -88  -69.2  119.6  -52.8  -69.2  -62.9 60.01  27
    -73    827   -847     -1    -93 -111.9    0.1  110.4 -112.2 -103.1 60.01  27
[11]
     51   -673    671      0     49   69.2 -128.5   60.4   69.2   63.7 60.01  27
     -1      7     -8      0     -2  111.8    4.0 -116.0  112.1  105.0 60.01  27
     -1     -1      0     -1     -2  -69.3  131.6  -62.3  -69.3  -65.1 60.01  27
      0     -1     -1      0     -2 -111.8   -4.1  116.0 -112.1 -106.7 60.01  27
[12]
      0      0     -1      0     -1   69.4 -131.6   62.2   69.4   66.2 60.01  27
     -1      0      0      0     -1  111.7    4.2 -116.1  112.0  108.0 60.01  27
      0     -1      0     -1     -1  -69.5  131.6  -62.2  -69.5  -67.0 60.01  27
      0     -1     -1      0     -2 -111.7   -4.3  116.1 -111.9 -108.9 60.01  27
[13]
     -1      0      0      0     -1   69.6 -131.6   62.1   69.6   67.6 60.01  27
     -1      0      0     -1     -1  111.6    4.4 -116.2  111.9  109.6 60.01  27
      0     -1      0     -1     -1  -69.7  131.6  -62.0  -69.7  -68.1 60.01  27
      0     -1      0      0     -1 -111.5   -4.5  116.2 -111.8 -110.1 60.01  27
[14]
      0      0      0      0      0   69.8 -131.6   61.9   69.8   68.5 60.01  27
     -1     -1     -1      0     -3  111.4    4.6 -116.3  111.7  110.5 60.01  27
      0     -1      0      0     -1  -69.9  131.6  -61.8  -69.9  -68.9 60.01  27
      0      0     -1     -1     -1 -111.4   -4.7  116.3 -111.7 -110.8 60.01  27
[15]
     -1      0      0      0     -1   70.0 -131.6   61.7   70.0   69.1 60.01  27
     -1      0      0      0     -1  111.3    4.8 -116.4  111.6  110.9 60.01  27
      0     -1     -1     -1     -2  -70.1  131.5  -61.6  -70.1  -69.3 60.01  27
      0     -1      0     -1     -1 -111.3   -4.9  116.4 -111.6 -111.1 60.01  27
```

see Figure 12.2

firmware identifier

firmware checksum identifier

unique event indentification number

one cycle of data

see Figure 12.7 and Figure 12.8 for details on this one cycle of Phase B (Channel IB) current.

```
Protection and Contact I/O Elements

21       V 51  50     32 67     Dm 27  59    25  81  TS
ZZZZZZ O P     P G Q     P G Q            V  5  2    ih ZLV Out1   Out2 In1 In2
ABCABC O O     131313    131313 P   P   P 1  9S 71357mo 10d 1357 135791 135 1357
BCAGGG S L PGQ 242424 QG 242424 QG PPS PPSQN VFAB2469et dPc 246A 246802 246 2468
[1]
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
[2]
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
[3]
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
[4]
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
...... . V ... ...... .. ...... .. ... ..... .......... ... .... ...... 1.. ....          ⑬
...... . V ..p ...... QQ ...... .. ... ..... .......... ... .... ...... 1.. ....
...... . V .pp ...... QQ ...... .. ... ..... ...*...... ... .... ...... 1.. ....>
[5]
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....          ⑪, ⑩
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....          ⑨, ⑧
[6]
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....          ⑫
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
[7]
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
[8]
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
[9]
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
[10]
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....          ⑥
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.2.... . V .rp ...... QQ ...... .. ... ..... ...*...... ... b4.. ...... 1.. ....          ⑤
[11]
...... . V .rp ...... QQ ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .rp ...... QQ ...... .. ... ..... ...*...... o.. b... ...... ... ....          ③
...... . V .rp ...... QQ ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .rr ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
[12]
...... . V .rr ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .rr ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....          ⑦
...... . V .rr ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
[13]
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....          ④
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
[14]
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... .... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... .... ...... ... ....          ①, ②
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... .... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... .... ...... ... ....
[15]
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... .... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... .... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... .... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... .... ...... ... ....
```

```
Communication Elements

 S  PZ EE   ZDNS  TMB  RMB  TMB  RMB  RRCL   Lcl   Rem   Ltch  SELOGIC
3O  T3KKCWU 3SSTB A    A    B    B    OBBB
PT PRREETFB XTTOT 1357 1357 1357 1357 KAAO O RW RW RW RW RW RW        1111111
OF TXBYYTCB TRRPX 2468 2468 2468 2468  DDK C  5  6  7  8  9 10 1234567890123456
[1]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[2]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[3]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[4]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................>
[5]
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[6]
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[7]
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[8]
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[9]
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[10]
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ...*.... ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[11]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[12]
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[13]
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[14]
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
[15]
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
3. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
```

```
Event: BCG T  Location:   48.84  Shot:    Frequency:  60.01
Targets: ZONE1
Currents (A Pri), ABCNGQ:    200  2478  2480     0   212  4294

Group 1
Group Settings:
RID     =SEL-311                        TID     =STATION A
CTR     = 200       CTRN    = 200       PTR     = 2000.00   PTRS    = 2000.00
VNOM    = 67.00
Z1MAG   = 7.80      Z1ANG   = 84.00     Z0MAG   = 24.80     Z0ANG   = 81.50
LL      = 100.00    EADVS   = N         E21P    = 3         E21MG   = 3
E21XG   = 3         E50P    = 1         E50G    = N         E50Q    = N
E51P    = N         E51G    = Y         E51Q    = Y         E32     = AUTO
EOOS    = N         ELOAD   = Y         ESOTF   = Y         EDDSOTF = Y
EVOLT   = N         E25     = N         EFLOC   = Y         ELOP    = Y
EBBPT   = N         ECOMM   = POTT      E81     = N         E79     = N
EZ1EXT  = N         ECCVT   = N         ESV     = 1         EDEM    = THM
Z1P     = 6.24      Z2P     = 9.36      Z3P     = 1.87
50PP1   = 0.50
Z1MG    = 6.24      Z2MG    = 9.36      Z3MG    = 1.87
XG1     = 6.24      XG2     = 9.36      XG3     = 1.87
RG1     = 2.50      RG2     = 5.00      RG3     = 6.00
50L1    = 0.50      50GZ1   = 0.50
k0M1    = 0.726     k0A1    =-3.69
Z1PD    = OFF       Z2PD    = 20.00     Z3PD    = OFF       Z1GD    = OFF
Z2GD    = 20.00     Z3GD    = OFF       Z1D     = OFF       Z2D     = OFF
Z3D     = OFF
50P1P   = 15.00
67P1D   = 0.00
51GP    = 0.75      51GC    = U3        51GTD   = 1.50      51GRS   = N
51QP    = 2.20      51QC    = U3        51QTD   = 3.00      51QRS   = N
ZLF     = 6.50      ZLR     = 6.50      PLAF    = 30.00     NLAF    =-30.00
PLAR    = 150.00    NLAR    = 210.00
DIR3    = R         DIR4    = F
ORDER   = QVI       Z2F     = 3.90      Z2R     = 4.10      50QFP   = 0.50
50QRP   = 0.25      a2      = 0.10      k2      = 0.20      50GFP   = 0.50
50GRP   = 0.25      a0      = 0.10      Z0F     = 12.40     Z0R     = 12.60
CLOEND  = OFF       52AEND  = 10.00     SOTFD   = 30.00
Z3RBD   = 5.00      EBLKD   = 10.00     ETDPU   = 2.00      EDURD   = 4.00
EWFC    = N
DMTC    = 5         PDEMP   = 5.00      NDEMP   = OFF       GDEMP   = 1.50
QDEMP   = 1.50
TDURD   = 9.00      CFD     = 60.00     3POD    = 0.50      OPO     = 52
50LP    = 0.25
SV1PU   = 0.00      SV1DO   = 0.00
SELogic group 1

SELogic Control Equations:
TR      = M2PT + Z2GT + 51GT + 51QT + OC
TRQUAL  = M1P + Z1G
TRCOMM  = M2P + Z2G
TRSOTF  = M2P + Z2G + 50P1
DTT     = 0
ULTR    = !(50L + 51G)
PT1     = IN102
LOG1    = 0
PT2     = 0
LOG2    = 0
BT      = 0
52A     = IN101
CL      = CC
ULCL    = TRIP
79RI    = TRIP
79RIS   = 52A + 79CY
79DTL   = OC
79DLS   = 79LO
79SKP   = 0
79STL   = TRIP
79BRS   = TRIP
79SEQ   = 0
79CLS   = 1
SET1    = 0
RST1    = 0
SET2    = 0
RST2    = 0
SET3    = 0
RST3    = 0
SET4    = 0
RST4    = 0
SET5    = 0
RST5    = 0
SET6    = 0
RST6    = 0
SET7    = 0
RST7    = 0
SET8    = 0
RST8    = 0
```

see Figure 12.2

```
SET9    = 0
RST9    = 0
SET10   = 0
RST10   = 0
SET11   = 0
RST11   = 0
SET12   = 0
RST12   = 0
SET13   = 0
RST13   = 0
SET14   = 0
RST14   = 0
SET15   = 0
RST15   = 0
SET16   = 0
RST16   = 0
67P1TC  = 1
67P2TC  = 1
67P3TC  = 1
67P4TC  = 1
67G1TC  = 1
67G2TC  = 1
67G3TC  = 1
67G4TC  = 1
67Q1TC  = 1
67Q2TC  = 1
67Q3TC  = 1
67Q4TC  = 1
51PTC   = 1
51GTC   = 1
51QTC   = 1
LV1     = 0
LV2     = 0
LV3     = 0
LV4     = 0
LV5     = 0
LV6     = 0
LV7     = 0
LV8     = 0
LV9     = 0
LV10    = 0
LV11    = 0
LV12    = 0
LV13    = 0
LV14    = 0
LV15    = 0
LV16    = 0
LV17    = 0
LV18    = 0
LV19    = 0
LV20    = 0
LV21    = 0
LV22    = 0
LV23    = 0
LV24    = 0
LV25    = 0
LV26    = 0
LV27    = 0
LV28    = 0
LV29    = 0
LV30    = 0
LV31    = 0
LV32    = 0
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
SV15    = 0
SV16    = 0
OUT101  = TRIP
OUT102  = TRIP
OUT103  = CLOSE
OUT104  = KEY
OUT105  = 0
OUT106  = 0
OUT107  = 0
OUT201  = 0
OUT202  = 0
OUT203  = 0
```

```
OUT204   = 0
OUT205   = 0
OUT206   = 0
OUT207   = 0
OUT208   = 0
OUT209   = 0
OUT210   = 0
OUT211   = 0
OUT212   = 0
LED1     = 0
LED2     = 0
LED3     = 0
LED4     = 0
LED5     = 0
LED6     = 0
LED7     = 0
LED8     = 0
LED9     = 0
LED10    = 0
LED12    = LTRIP
LED13    = LTIME
LED14    = LCOMM
LED15    = LSOTF
LED16    = 79RS
LED17    = 79LO
LED18    = L51
LED23    = LZONE1
LED24    = LZONE2
LED25    = LZONE3
LED26    = LZONE4
DP1      = 52A
DP2      = 0
DP3      = 0
DP4      = 0
DP5      = 0
DP6      = 0
DP7      = 0
DP8      = 0
DP9      = 0
DP10     = 0
DP11     = 0
DP12     = 0
DP13     = 0
DP14     = 0
DP15     = 0
DP16     = 0
SS1      = 0
SS2      = 0
SS3      = 0
SS4      = 0
SS5      = 0
SS6      = 0
ER       = /M2P + /Z2G + /51G + /51Q + /50P1 + /LOP
FAULT    = 51G + 51Q + M2P + Z2G
BSYNCH   = 52A
CLMON    = 0
BKMON    = TRIP
E32IV    = 1
Z1XPEC   = 0
Z1XGEC   = 0
RSTTRGT  = 0
RST_DEM  = 0
RST_PDM  = 0
RST_BK   = 0
RST_HIS  = 0
RST_ENE  = 0
RST_MML  = 0
PMTRIG   = 0
TREA1    = 0
TREA2    = 0
TREA3    = 0
TREA4    = 0
TMB1A    = 0
TMB2A    = 0
TMB3A    = 0
TMB4A    = 0
TMB5A    = 0
TMB6A    = 0
TMB7A    = 0
TMB8A    = 0
TMB1B    = 0
TMB2B    = 0
TMB3B    = 0
TMB4B    = 0
TMB5B    = 0
TMB6B    = 0
TMB7B    = 0
TMB8B    = 0
```

```
Global Settings:
PTCONN  = WYE        TGR     = 0.00
NFREQ   = 60         PHROT   = ABC        DATE_F  = MDY
FP_TO   = 15         SCROLD  = 2          FPNGD   = IG
LER     = 15         PRE     = 4          DCLOP   = OFF        DCHIP   = OFF
IN101D  = 0.00       IN102D  = 0.00       IN103D  = 0.00       IN104D  = 0.00
IN105D  = 0.00       IN106D  = 0.00
IN201D  = 0.00       IN202D  = 0.00       IN203D  = 0.00       IN204D  = 0.00
IN205D  = 0.00       IN206D  = 0.00       IN207D  = 0.00       IN208D  = 0.00
EBMON   = Y          COSP1   = 10000      COSP2   = 150        COSP3   = 12
KASP1   = 1.20       KASP2   = 8.00       KASP3   = 20.00
LED12L  = Y          LED13L  = Y          LED14L  = Y          LED15L  = Y
LED16L  = N          LED17L  = N          LED18L  = Y          LED23L  = Y
LED24L  = Y          LED25L  = Y          LED26L  = Y
LED12A  = TRIP
LED13A  = TIME
LED14A  = COMM
LED15A  = SOTF
LED16A  = RS
LED17A  = LO
LED18A  = 51
LED23A  = ZONE1
LED24A  = ZONE2
LED25A  = ZONE3
LED26A  = ZONE4
RSTLED  = N
EPMU    = N          EVELOCK = 0          DNPSRC  = UTC        IRIGC   = NONE
UTC_OFF = 0.00
DST_BEGM= NA

=>>
```

Figure 12.5 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution

NOTE: Phase to neutral voltages are displayed when PTCONN = WYE, and phase to phase voltages are displayed when PTCONN = DELTA. When PTCONN = DELTA, some elements in the digital section of the event report will never assert (See Table 12.4).

Figure 12.7 and *Figure 12.8* look in detail at one cycle of B-phase current (channel IB) identified in *Figure 12.5*. *Figure 12.7* shows how the event report ac current column data relates to the actual sampled waveform and rms values. *Figure 12.8* shows how the event report current column data can be converted to phasor rms values. Voltages are processed similarly.

```
=>>EVE <Enter>

SEL-311                          Date: 05/17/10    Time: 07:35:07.097
STATION A

FID=SEL-311C-1-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx       CID=xxxx
Event Number=18199


      Currents (Amps Pri)           Voltages (kV Pri)         V1
    IA    IB    IC    IN    IG    VAB    VBC    VCA     VS    Mem  FREQ Vdc
[1]
    13    87    61     1   161   16.8  -92.3   75.5    0.0    0.0 59.99   1
    48   308   196    -1   552   57.6   97.4 -155.0   -0.0    0.0 59.99   0
   -14   -88   -61    -1  -163  -16.8   92.3  -75.5   -0.0    0.0 59.99   0
   -49  -308  -196     1  -553  -57.7  -97.3  155.0    0.0    0.0 59.99   0
[2]
    13    86    61     1   160   16.8  -92.3   75.6    0.0    0.0 59.99   1
    48   307   196    -1   551   57.6   97.3 -155.0   -0.0    0.0 59.99   0
   -14   -87   -61    -1  -162  -16.8   92.4  -75.6   -0.0    0.0 59.99   0
   -49  -308  -196     1  -553  -57.7  -97.3  155.0    0.0    0.0 59.99   0


Protection and Contact I/O Elements

21        V 51   50      32 67      Dm 27 59    25  81   TS
   ZZZ O P      P G Q      P G Q           V  5  2     ih ZLV Out1   Out2 In1 In2
P3 ABC O O      131313     131313 P    P   P 1  9S 71357mo lOd 1357 135791 135 1357
PP GGG S L PGQ 242424 QG 242424 QG PPSPPSQN VFAB2469et dPc 246A 246802 246 2468
[1]
.. ... . V r.. ...... .. ...... .. ........ .......... ... .... ...... ... ....
.. ... . V r.. ...... .. ...... .. ........ .......... ... .... ...... ... ....
.. ... . V r.. ...... .. ...... .. ........ .......... ... .... ...... ... ....
.. ... . V r.. ...... .. ...... .. ........ .......... ... .... ...... ... ....
[2]
.. ... . V r.. ...... .. ...... .. ........ .......... ... .... ...... ... ....
.. ... . V r.. ...... .. ...... .. ........ .......... ... .... ...... ... ....
.. ... . V r.. ...... .. ...... .. ........ .......... ... .... ...... ... ....
.. ... . V r.. ...... .. ...... .. ........ .......... ... .... ...... ... ....


Communication Elements                     Control Elements
```

```
 S  PZ EE    ZDNS  TMB  RMB  TMB  RMB  RRCL   Lcl   Rem   Ltch  SELogic
 O  T3KKCWU 3SSTB A    A    B    B    OBBB
PT PRREETFB XTTOT 1357 1357 1357 1357 KAAO O RW RW RW RW RW RW         1111111
OF TXBYYTCB TRRPX 2468 2468 2468 2468  DDK C  5  6  7  8  9 10 1234567890123456
[1]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[2]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
```

Figure 12.6 Example Partial Event Report With Delta-Connected PTs

The event report in *Figure 12.6* displays filtered analog data. If the **EVE R** command had been used instead, the analog voltage column headings would be VA, VB, VC, as described in *Filtered and Unfiltered Event Reports on page 12.14*.

The event report sample in *Figure 12.6* is not related to the event report sample in *Figure 12.5*, or to the SER sample in *Figure 12.9*.

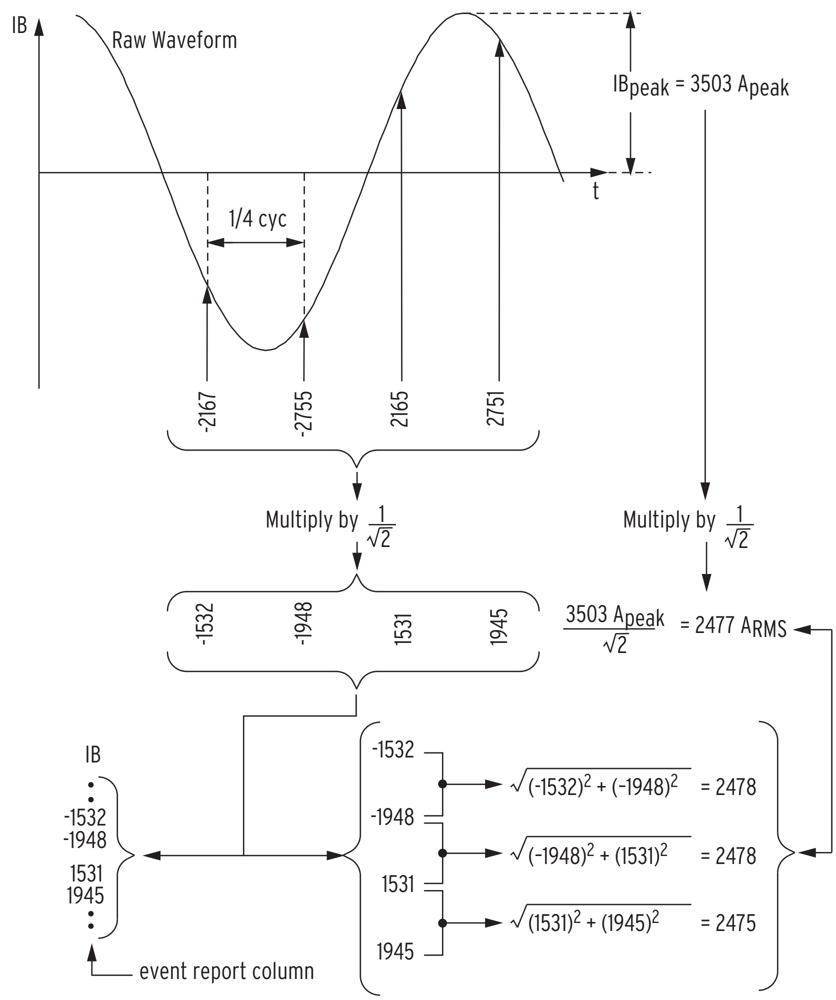
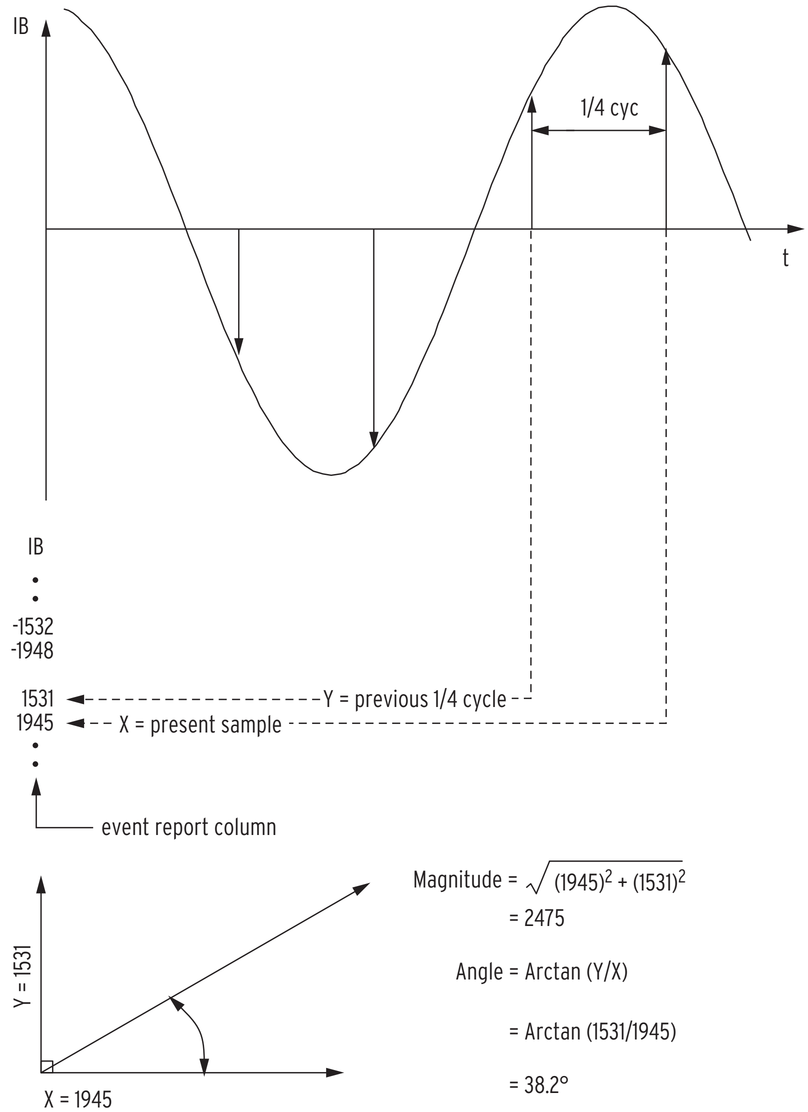


Figure 12.7 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 12.7*, note that any two rows of current data from the event report in *Figure 12.5*, 1/4 cycle apart, can be used to calculate rms current values.



NOTE: The arctan function on many calculators and computing programs does not return the correct angle for the second and third quadrants when X is negative. When in doubt, graph the X and Y quantities to confirm that the calculated angle is correct.

Figure 12.8 Derivation of Phasor RMS Current Values From Event Report Current Values

In *Figure 12.8*, note that two rows of current data from the event report in *Figure 12.5*, 1/4 cycle apart, can be used to calculate phasor rms current values. In *Figure 12.8*, at the present sample, the phasor rms current value is:

$$IB = 2475 \text{ A} \angle 38.2°$$

The present sample (IB = 1945 A) is a real rms current value that relates to the phasor rms current value:

$$2475 \text{ A} * \cos(38.2°) = 1945 \text{ A}$$

Example Sequential Recorder (SER) Report

The following example sequential events recorder (SER) report in *Figure 12.9* also corresponds to the example standard 15-cycle event report in *Figure 12.5*.

```
=>>SER <Enter>

SEL-311C POTT                    Date: 10/14/99    Time: 08:56:47.400
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311C-1-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx        CID=xxxx

#     DATE      TIME           ELEMENT           STATE

14    10/14/99  08:53:34.083   IN101             Asserted
13    10/14/99  08:53:34.926   51G               Asserted
12    10/14/99  08:53:34.930   50P1              Asserted
11    10/14/99  08:53:34.930   M2P               Asserted
10    10/14/99  08:53:34.930   M1P               Asserted
9     10/14/99  08:53:34.930   OUT101            Asserted
8     10/14/99  08:53:34.930   OUT102            Asserted
7     10/14/99  08:53:35.026   50P1              Deasserted
6     10/14/99  08:53:35.026   M1P               Deasserted
5     10/14/99  08:53:35.026   51G               Deasserted
4     10/14/99  08:53:35.030   M2P               Deasserted
3     10/14/99  08:53:35.030   IN101             Deasserted
2     10/14/99  08:53:35.079   OUT101            Deasserted
1     10/14/99  08:53:35.079   OUT102            Deasserted

=>>
```

Figure 12.9 Example Sequential Events Recorder (SER) Event Report

The SER event report rows in *Figure 12.9* are explained in the following text, numbered in correspondence to the # column. The boxed, numbered comments in *Figure 12.5* also correspond to the # column numbers in *Figure 12.9*. The SER event report in *Figure 12.9* contains records of events that occurred before and after the standard event report in *Figure 12.5*.

SER Row No.	Explanation
14	**IN101** is asserted when the circuit breaker closes. Related Setting: 52A = IN101
13	Time-overcurrent element 51G asserts.
12	Instantaneous-overcurrent element 50P1 asserts.
11	Phase-distance element M2P asserts.
10	Phase-distance element M1P asserts. This is an instantaneous trip condition. Related setting: TR = M1P + Z1G + M2PT + Z2GT + 51GT + 51QT
9, 8	Outputs **OUT101** and **OUT102** assert. Related setting: OUT101 = TRIP OUT102 = TRIP
7, 6, 5, 4	Elements 50P1, M1P, 51G, and M2P deassert as the circuit breaker opens.
3	**IN101** deasserts when the circuit breaker opens. Related Setting: 52A = IN101
2, 1	Outputs **OUT101** and **OUT102** deassert.

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Section 13
Testing and Troubleshooting

Overview

This section provides guidelines for determining and establishing test routines for the SEL-311C Relay. Included are discussions on testing philosophies, methods, and tools. Relay self-tests and troubleshooting procedures are shown at the end of the section.

The topics discussed in this section include the following:

Testing Philosophy

Protective relay testing may be divided into three categories: acceptance, commissioning, and maintenance.

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

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

Acceptance Testing

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

Goals:

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

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

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

Timed Trip Tests

The SEL-311C supervises some trips for as many as two cycles with a disturbance detector. This can affect trip times for elements not associated with a change of current, for manual trips, and for elements with intentional delays. See *Section 5: Trip and Target Logic* for more information about disturbance detector supervision.

Commissioning Testing

When: When installing a new protection system.

Goals:

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

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

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

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

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

Maintenance Testing

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

Goals:

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

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

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

1. Use the SEL relay reporting functions as maintenance tools.

   Periodically verify that the relay is making correct and accurate current and voltage measurements by comparing the relay METER output to other meter readings on that line.

2. Review relay event reports in detail after each fault.

   Using the event report current, voltage, and relay element data, you can determine that the relay protection elements are operating properly.

   Using the event report input and output data, you can determine that the relay is asserting outputs at the correct instants, that all contact inputs are operating, and that auxiliary equipment is operating properly.

3. At the end of your maintenance interval, the only items that need testing are those that have not operated during the maintenance interval.

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

Each time a fault occurs the protection system is tested. Use event report data to determine areas requiring attention. Slow breaker auxiliary contact operations and increasing or varying breaker operating time can be detected through detailed analysis of relay event reports.

Because SEL relays are microprocessor-based, their operating characteristics do not change over time. Time-overcurrent operating times are affected only by the relay settings and applied signals. It is not necessary to verify operating characteristics as part of maintenance checks.

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

Testing Methods and Tools

Test Features Provided by the Relay

The features shown in *Table 13.1* assist you during relay testing.

Table 13.1 Helpful Commands for Relay Testing

Command	Description
METER	The **METER** command shows the ac currents and voltages (magnitude and phase angle) presented to the relay in primary values. In addition, the command shows power system frequency (FREQ) and the voltage input to the relay power supply terminals (VDC). Compare these quantities against other devices of known accuracy. The **METER** command is available at the communications ports and front-panel display. See *Section 10: Communications* and *Section 11: Front-Panel Interface*. Metering data are also available through the ACSELERATOR QuickSet® SEL-5030 software and the web server. See *ACSELERATOR QuickSet HMI on page C.6* and *Using the Embedded Web Server (HTTP) on page 10.18*.
EVENT	The relay generates a 15-, 30-, 60-, or 180-cycle event report in response to faults or disturbances. Each report contains current and voltage information, relay element states, and input/output contact information. If you question the relay response or your test method, use the event report for more information. The **EVENT** command is available at the communications ports. See *Section 12: Standard Event Reports and SER*. Event reports can also be gathered using ACSELERATOR QuickSet. See *ACSELERATOR QuickSet Event Analysis on page C.15*.
SER	The relay provides a Sequential Events Recorder (SER) event report that time tags changes in relay element and input/output contact states. The SER provides a convenient means to verify the pickup/dropout of any element in the relay. The **SER** command is available at the communications ports. See *Section 12: Standard Event Reports and SER*. SER data can also be gathered using ACSELERATOR QuickSet or the web server. See *ACSELERATOR QuickSet HMI on page C.6* and *Using the Embedded Web Server (HTTP) on page 10.18*.
TARGET	Use the **TARGET** command to view the state of relay control inputs, relay outputs, and relay elements individually during a test. The **TARGET** command is available at the communications ports and the front panel. See *Section 10: Communications* and *Section 11: Front-Panel Interface*. Relay element status can also be viewed using the **Targets** screen of the ACSELERATOR QuickSet HMI or the web server. See *ACSELERATOR QuickSet HMI on page C.6* and *Using the Embedded Web Server (HTTP) on page 10.18*.
PULSE	Use the **PULSE** command to test the contact output circuits. The **PULSE** command is available at the communications ports and the front panel. *Section 10: Communications*. Contact outputs can also be pulsed through the **Control** window of the ACSELERATOR QuickSet HMI. See *ACSELERATOR QuickSet HMI on page C.6*.

Low-Level Test Interface

NOTE: The SEL-4000 Relay Test System, which includes the SEL Adaptive Multichannel Source, appropriate cables, and PC software, is specifically designed for use with the low-level test interface.

⚠**CAUTION**
The relay contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with the front panel removed, work surfaces and personnel must be properly grounded or equipment damage may result.

⚠**CAUTION**
Never apply voltage signals greater than 9 V peak-peak to the low-level test interface (**J12**) or equipment damage may result.

The SEL-311C has a low-level test interface between the calibrated input module and the separately calibrated processing module. You may test the relay in either of two ways:

- ➤ By applying ac current signals to the relay inputs
- ➤ By applying low magnitude ac voltage signals to the low-level test interface

Access the test interface of the processing module by removing the relay front panel.

Figure 2.19 shows the location of the processing module input connector (J12) for low-level test interface connections. The output connector (J2) of the input module is below connector J12.

Figure 13.1 shows the low-level test interface (J2 and J12) connector information. *Table 13.2* shows the output (J2) value of the input module (for a given input value into the relay rear panel). The processing module input (J12) has a maximum 9 V p-p voltage damage threshold. Remove the ribbon cable between the two modules to access the outputs (J2) of the input module and the inputs (J12) to the processing module (relay main board).

You can test the relay-processing module (via input J12) using signals from the SEL-4000 Relay Test System. The power supply for the relay mainboard is provided through the ribbon cable between J2 and J12. SEL cable C724 is used to connect one, two, or three relays to the SEL-4000 Relay Test System while maintaining the power supply connection. The cable has six connectors: three connectors with 10 conductors (power supply connector), two connectors with 12 conductors, and one connector with 34 conductors (analog connectors). Each power supply connector is connected to one of the three analog connectors through a 10-conductor ribbon cable. For each relay, install one of the power supply connectors into **J2** of the input module. Install the corresponding analog connector into **J12** of the relay main board. Connect the male DB-25 connector to the SEL Adaptive Multichannel Source. *Table 13.2* shows the resultant signal scale factor information for the calibrated input module. These scale factors are used in the SEL-5401 program, which is part of the SEL-4000.

You can test the input module two different ways:

1. Remove the ribbon cable from the input module (output **J1**). Measure the outputs from the input module with an accurate voltmeter (measure signal pin to GND pin), and compare the readings to accurate instruments in the relay input circuits, or
2. Replace the ribbon cable, press the front-panel **METER** pushbutton, and compare the relay readings to other accurate instruments in the relay input circuits.

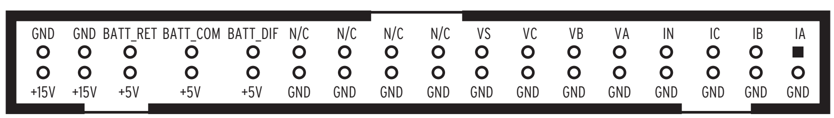

Figure 13.1 Low-Level Test Interface (J2 or J12) Connector

Table 13.2 Resultant Scale Factors for Input Module

Input Channels (Relay Rear Panel)	Input Channel Nominal Rating	Input Value	Corresponding J1 Output Value	Scale Factor (Input/Output)
IA, IB, IC, IN	1 A	1 A	45.6 mV	21.92 A/V
IA, IB, IC, IN	5A	5 A	45.2 mV	110.60 A/V
VA, VB, VC, VS	300 V	67 V_{LN}	299.1 mV	223.97 V/V

Scale factor calculation examples:

$$\frac{67\text{ V}}{0.2911\text{ V}} = 223.97\left(\frac{\text{V}}{\text{V}}\right)$$

$$\frac{5\text{ A}}{0.045\text{ V}} = 110.60\left(\frac{\text{A}}{\text{V}}\right)$$

Using the Low-Level Test Interface When Global Setting PTCONN = DELTA

When simulating a delta PT connection with the low-level test interface referenced in *Figure 13.1*, apply the following signals:

- ➤ Apply low-level test signal V_{AB} to pin VA.
- ➤ Apply low-level test signal $-V_{BC}$ (equivalent to V_{CB}) to pin VC.
- ➤ Do not apply any signal to pin VB.

Refer to *Delta-Connected Voltages (Global Setting PTCONN = DELTA) on page 2.12* for more information on the delta connection.

Logic and Protection Element Test Methods

Test the pickup and dropout of relay elements using one of three methods: target command indication, output contact closure, or sequential events recorder (SER).

The examples below show the settings necessary to route the phase time-overcurrent element 51PT to the output contacts and the SER. The 51PT element, like many in the SEL-311C, is controlled by enable settings and/or torque control SELOGIC control equations. To enable the 51PT element, set the E51P enable setting and 51PTC torque control settings to the following:

E51P = **Y** (via the **SET** command)

51PTC = **1** (set directly to logical 1, via the **SET L** command)

Testing Via Target Commands

Display the state of relay elements, inputs, and outputs using the front-panel or communications port **TAR** commands. Use this method to verify the pickup settings of protection elements.

Testing With the Front-Panel TAR Command

Access the front-panel TAR command from the front-panel **OTHER** pushbutton menu. To display the state of the 51PT element on the front-panel display, press the **OTHER** pushbutton, cursor to the TAR option, and press **SELECT**. Press the **Up Arrow** pushbutton until TAR 28 is displayed on the top row of the LCD. The bottom row of the LCD displays all elements asserted in Relay Word Row 28. The relay maps the state of the elements in Relay Word Row 28 on the bottom row of LEDs. The 51PT element state is reflected on the LED labeled **RS**. See *Table D.1* for the correspondence between the Relay Word elements and the **TAR** command.

Testing With the Communications Port TAR Command

To view the 51PT element status from the communications port, issue the **TAR 51PT** command. The relay will display the state of all elements in the Relay Word row containing the 51PT element.

Review **TAR** command descriptions in *Section 10: Communications* and *Section 11: Front-Panel Interface* for further details on displaying element status via the **TAR** commands.

Relay element status can also be viewed using the Targets screen of the ACSELERATOR QuickSet HMI or on the web server. See *ACSELERATOR QuickSet HMI Features on page C.7* and *Using the Embedded Web Server (HTTP) on page 10.18*.

Testing Via Output Contacts

You can set the relay to operate an output contact for testing a single element. Use the **SET L** command (SELOGIC control equations) to set an output contact (e.g., **OUT101–OUT107**) to the element under test. The available elements are the Relay Word bits referenced in *Table D.1*.

Use this method especially for time testing time-overcurrent elements. For example, to test the phase time-overcurrent element 51PT via output contact **OUT104**, make the following setting:

OUT104 = **51PT**

Time-overcurrent curve and time-dial information can be found in *Section 9: Setting the Relay*.

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

Testing Via Sequential Events Recorder

You can set the relay to generate an entry in the Sequential Events Recorder (SER) for testing relay elements. Use the **SET R** command to include the element(s) under test in any of the SER trigger lists (SER1 through SER3). See *Section 12: Standard Event Reports and SER*.

To test the phase time-overcurrent element 51PT with the SER, make the following setting:

SER1 = **51P 51PT**

Element 51P asserts when phase current is above the pickup of the phase time-overcurrent element. Element 51PT asserts when the phase time-overcurrent element times out. The assertion and deassertion of these elements is time-stamped in the SER report. Use this method to verify timing associated with time-overcurrent elements, reclosing relay operation, etc.

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

Communications Test Methods

The **TEST DB** command provides a method to override Relay Word bits or analog values to facilitate testing of communications interfaces. The command overwrites values in the communications interfaces (SEL Fast Messages, DNP, Modbus®, and IEC 61850) only. The actual values used by the relay for protection and control are not overridden. See *TEST DB Command on page 10.62*.

Relay Self-Tests

The relay runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see *Table 13.3*):

➤ Protection Disabled: The relay disables protection and control elements and trip/close logic. All output contacts are de-energized. The **EN** front-panel LED is extinguished.

NOTE: The SEL-311C is shipped from the factory with the ALARM output configured as a B contact.

➤ **ALARM** Output: The **ALARM** output contact signals an alarm condition by going to its 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 a single five-second pulse (Pulsed) or permanent (Latched).

➤ The relay generates automatic STATUS reports at the communications port for warnings and failures (ports with setting AUTO = Y).

- ➤ The relay displays failure messages on the relay LCD display for failures.
- ➤ For certain failures, the relay will automatically restart up to three times. In many instances, this will correct the failure. The failure message might not be fully displayed before automatic restart occurs. Indication that the relay restarted will be recorded in the Sequential Events Recorder (SER).

Use the communications port **STATUS** command or front-panel **STATUS** pushbutton to view relay self-test status. Based on the self-test type, issue the **STA C** command as directed in the Corrective Actions column. Contact SEL if this does not correct the problem or if the relay directs you to do so in response to the **STA C**.

Relay Troubleshooting

Inspection Procedure

Complete the following procedure before disturbing the relay. After you finish the inspection, proceed to *Troubleshooting Procedure on page 13.10*.

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.

Table 13.3 Relay Self-Tests (Sheet 1 of 3)

Self Test	Description	Normal Range	Alarm	Protection Disabled on Failure	Port Auto Message on Failure	Front Panel Message on Failure	Corrective Action
I/O Board Failure	Invalid interface board ID or relay settings do not match installed interface boards		Latched	Yes	Yes	STATUS FAIL IO_BRD FAIL	**STA C**
I/O Board Warning	Actual and expected board IDs do not match.		Pulsed	No	Yes	STATUS WARNING IO_BRD WARNING	**STA C**
Temperature		–40°C to 100°C	Pulsed	No	Yes		
Communications Board Warning	Installed communications card does not match relay Part Number			No	Yes	STATUS WARNING COM BRD WARNING	**STA C**
Communications Board Failure	Communications board has failed			No	Yes	STATUS FAIL COM BRD WARNING	**STA C**
USB Board Warning	Installed USB board does not match relay Part Number			No	No	STATUS WARNING USB WARNING	**STA C**
USB Board Failure	USB communications board has failed			No	No	STATUS FAIL USB FAILURE	**STA C**
FPGA	FPGA fails to program		Latched	Yes	Yes		

Table 13.3 Relay Self-Tests (Sheet 2 of 3)

Self Test	Description	Normal Range	Alarm	Protection Disabled on Failure	Port Auto Message on Failure	Front Panel Message on Failure	Corrective Action
FPGA	FPGA failure		Latched	Yes	Yes	STATUS FAIL FPGA FAILURE	Automatic restart. Contact SEL if failure returns.
RTC Chip	Unable to communicate with clock, or clock fails time keeping test		Pulsed	No	No		
HMI	Invalid HMI board ID		Pulsed	No	Yes	STATUS WARNING HMI WARNING	
HMI	HMI timeout		Pulsed	No	Yes		
External Ram	Failure of read/write test on system RAM		Latched	Yes	No		
Internal/External RAM	Failure of internal or external RAM		Latched	Yes	Yes	STATUS FAIL RAM FAILURE	Automatic restart. Contact SEL if failure returns.
Code Flash Failure	Failure of checksum test on firmware code		Latched	Yes	No		
Code Flash Failure	Firmware relay type code does not match part number		Latched	Yes	Yes	STATUS FAIL ROM FAILURE	Verify correct version of firmware installed
Operating System	Operating System check fails		Latched	Yes	Yes	CPU ERROR/RELAY DISABLED	Automatic restart. Contact SEL if failure returns.
Data Flash Failure	Failure of checksum test on relay settings		Latched	Yes	Yes	STATUS FAIL FLASH FAILURE	
EEPROM Failure	Failure to determine latch bit status on power-up		Latched	Yes	Yes	STATUS FAIL EEPROM FAILURE	
EEPROM Warning	Failure of read/write to EEPROM		Pulsed	No	Yes		
Exception Failure	CPU Error		Latched	Yes	Yes	CPU ERROR RELAY DISABLED	Automatic restart. Contact SEL if failure returns.
A/D Offset Warning	DC offset on A/D channel outside of normal range	<30 mV	Pulsed	No	Yes		

Table 13.3 Relay Self-Tests (Sheet 3 of 3)

Self Test	Description	Normal Range	Alarm	Protection Disabled on Failure	Port Auto Message on Failure	Front Panel Message on Failure	Corrective Action
Master Offset	DC offset in A/D ground channel outside of normal range	<10 mV	Pulsed	No	Yes		
A/D Failure	Analog to digital converter failure		Latched	Yes	Yes	STATUS FAIL A/D FAILURE	Automatic restart for some failures. Contact SEL if failure returns.
+15 V Warning	+15 V Power supply outside of warning range	14.25 V to 15.75 V	Pulsed	No	Yes		
+15 V Failure	+15 V Power supply outside of failure range	14.00 V to 16.00 V	Latched	Yes	Yes	STATUS FAIL +15V FAILURE	
+5 V Warning	+5 V Power supply outside of warning range	4.76 V to 5.23 V	Pulsed	No	Yes	N/A	
+3.3 V Warning	+3.3 V Power supply outside of warning range	3.16 V to 3.46 V	Pulsed	No	Yes	N/A	

Troubleshooting Procedure

All Front-Panel LEDs Dark

1. Input power not present or internal power supply fuse is blown.
2. Self-test failure.

Cannot See Characters on Relay LCD Screen

1. Relay is de-energized. Check to see if the **ALARM** contact is closed.
2. LCD contrast is out of adjustment. Use the steps below to adjust the contrast.
   a. Press and hold down the **OTHER** front-panel pushbutton.
   b. Use the UP and DOWN arrow pushbuttons to adjust the contrast.
3. Ribbon cable between main board and front panel loose or damaged.

Relay Does Not Respond to Commands From Device Connected to Communications Port

1. Communications device not connected to relay.
2. Relay or communications device at incorrect baud rate or other communication parameter incompatibility, including cabling error.

NOTE: The SEL-311C default baud rate (SPEED setting) is 9600 on all serial ports. This is different than legacy SEL-311C relays.

3. Relay communications port has received an XOFF, halting communications. Type **<Ctrl+Q>** to send relay an XON and restart communications.

4. The relay communications port is disabled (setting EPORT = N). Change the setting using the **SET P *n*** command from another communications interface (serial port, USB, or Telnet session) or using the front-panel interface. When Port F is disabled, the USB port is also disabled and cannot be used to change the EPORT setting. See *Port Enable Settings on page 9.21*.

Relay Does Not Respond to Commands From Device Connected to USB Port

1. The USB driver is not installed on the PC, or an incorrect driver was installed.

2. The USB cable was disconnected while a PC application was communicating with the relay.

3. The relay USB port is disabled (Port F setting EPORT = N). Change the setting using the **SET P F** command from another communications interface (serial port or Telnet session) or using the front-panel interface. See *Port Enable Settings on page 9.21*.

4. The USB cable is faulty or is not USB 2.0 compliant.

5. The relay USB Board has failed. Use steps below to attempt to correct the problem:

   a. Check USB Board status using the **STATUS** command using serial port or Ethernet connection.

   b. If STATUS is FAIL, issue **STA C** command to attempt to clear the condition.

   c. If STATUS is OK, connect the USB cable between the PC and the relay and use Windows Device Manager to verify the Schweitzer Engineering Laboratories Fast CDC USB device appears under **Ports**.

   d. Use the Task Manager (if necessary) to confirm any PC application that was using the port has terminated. If any such application remains running, close the application.

   e. Disconnect the USB cable. Use Windows Device Manager to verify the Schweitzer Engineering Laboratories Fast CDC USB device does not appear under **Ports**. Reconnect the USB cable and verify that Schweitzer Engineering Laboratories Fast CDC USB device appears under **Ports**.

   f. If these steps fail to correct the problem, contact SEL for further assistance.

Relay Does Not Respond Via Telnet or HTTP (Web Server) Interface

1. Communications device not connected to relay.

2. The relay Ethernet port is disabled (setting EPORT = N). Change the setting using the **SET P 5** command from another communications interface (serial port or USB session) or using the front-panel interface. See *Port Enable Settings on page 9.21*.

3. Relay or communications device not properly configured for Ethernet connection. Check the relay settings for the port, including ETELNET or EHTTP and associated settings.
4. Maximum number of sessions exceeded. See *Session Limits on page 10.15*.

Relay Does Not Respond to Faults

1. Relay improperly set.
2. Improper test source settings.
3. CT or PT input wiring error.
4. Analog input cable between transformer secondary and main board loose or defective.
5. Failed relay self-test.

Relay Meter Command Does Not Respond as Expected

1. Global settings PTCONN, VSCONN, NFREQ, or PHROT not set correctly.
2. Group Settings CTR, CTRN, PTR or PTRN not set correctly.
3. Relay analog inputs not connected correctly.
4. External jumper not installed between VB (Terminal **Z10**) and N (Terminal **Z12**) for delta potential transformers.

Relay Optoisolated Inputs Not Operating

1. Applied voltage not correct for input ratings. See *Specifications on page 1.2*.
2. AC voltage applied. Set input debounce setting IN*xxx*D = AC, where IN*xxx* is the input number. See *Input Debounce Timers on page 7.3*.

SafeLock Pushbuttons Appear to Be Closed Continuously

1. AC voltage applied with arc suppression enabled. Apply dc voltages or disable arc suppression.
2. DC voltage applied with incorrect polarity. See *SafeLock Trip and Close Pushbuttons on page 2.10*.

Breaker Open/Closed Indication Lights Associated With SafeLock Pushbuttons Not Operating Properly

1. Lights not wired properly. These indication lights require external voltage.
2. **BREAKER OPEN** LED or **BREAKER CLOSED** LED jumpers not configured properly for applied voltage.
3. Connection between **SafeLock**® pushbutton board and front panel loose or damaged.

Output Contacts Appear to Be Closed Continuously

1. AC voltage applied to High-Current Interrupting Output contact. Apply dc voltage only.
2. DC voltage applied with incorrect polarity. See *High-Current Interrupting Output Contacts on page 2.9*.
3. Applied voltage exceeds rating of output contact MOV protection. See *Specifications on page 1.2*.
4. Peak applied voltage from capacitor trip unit exceeds rating of output contact MOV protection. See *Specifications on page 1.2*.

Protection Elements Appear to Be Out of Tolerance

Verify tolerance used in test acceptance criteria matches published tolerance. Protection element tolerances include a fixed tolerance and a percentage tolerance. These tolerances are additive and both must be included when establishing test acceptance criteria.

Relay Time Stamp Entries Appear Out of Order for Fast Changes in SER

1. Simple Network Time Protocol (SNTP) is changing the system time too frequently, and that time source is not sufficiently accurate. Consider changes to SNTP configuration—see *Section 10: Communications* for information on SNTP.
2. DNP is updating the system time too frequently, and that time source is not sufficiently accurate. Consider changes to TIMERQ and TIMERQ*n* settings—See *Appendix L: DNP3 Communications*.

Relay Calibration

The SEL-311C is factory-calibrated. If you suspect that the relay is out of calibration, 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 99163-5603 USA
Phone: +1.509.332.1890
Fax: +1.509.332.7990
Internet: www.selinc.com
E-mail: info@selinc.com

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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. The FID label will appear as follows with the Part/Revision number in bold:

FID=**SEL-311C-x-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx**

The firmware revision number follows the "R" and the release date follows the "D." The settings version number, or SVN, is the three digits after the "Z". For example:

FID=**SEL-311C-1-R500-V0-Z100100-D20110224**

is settings version number 100, firmware revision number R500, release date February 24, 2011.

Table A.1 lists the firmware versions, a description of modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first. Relays with firmware revisions earlier than R500 are not covered by this instruction manual. See *SEL-311C Models on page 1.1* for details.

Table A.1 Firmware Revision History

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-311C-1-R502-V0-Z100100-D20120111	➤ Communications board failure is no longer indicated when EPORT = N for Port 5. ➤ IPADDR setting now accepts all valid IP addresses when settings PMOIPA1 or PMOIPA2 are hidden. ➤ Relay Word bits SG1–SG6 are now reported properly via Fast SER protocol.	20120111
SEL-311C-1-R501-V0-Z100100-D20110420	➤ Manual change only.	20110614
SEL-311C-1-R501-V0-Z100100-D20110420	➤ Changes for manufacturing process improvements.	20110420
SEL-311C-1-R500-V0-Z100100-D20110224	➤ Initial version. Note: This firmware revision was not released. See R501 above.	20110224

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
20120111	Section 5 ➤ Updated *Figure 5.14: DCB Logic*. Section 12 ➤ Corrected SOTFT Relay Word bit label in *Table 12.4: Output, Input, Protection, and Control Element Event Report Columns*. Appendix A ➤ Updated for firmware version R502. Appendix C ➤ Corrected SOTFT Relay Word bit label in *Table C.6: Relay Word Bits and DNP Indices (Firmware Prior to R500)*.
20110614	Section 1 ➤ Added CSA Certification information to Specifications. Section 5 ➤ Updated *Figure 4.8: Busbar PT Logic (Relay Word Bit LOP4*). Appendix P ➤ Updated *Table P.16: Logic Device PRO (Protection)*.
20110420	Appendix A ➤ Updated for firmware version R501.
20110224	➤ Initial version.

Appendix B
Firmware Upgrade Instructions for SEL-351/311C Relays With Ethernet

Overview

From time to time, SEL issues firmware upgrades. The instructions which follow explain how you can install new firmware in your SEL-351/311C relay with Ethernet. These instructions are for firmware upgrades only and do not provide complete instructions for part number changes. If a part number change is required (for example, to change an SEL-351S-6 to an SEL-351S-7), contact SEL for assistance.

This appendix contains the following subsections:

Relay Firmware Upgrade Methods

Introduction

These firmware upgrade instructions apply to SEL-351/311C relays with at least one Ethernet port.

SEL occasionally offers firmware upgrades to improve the performance of your relay. Changing physical components is unnecessary because the 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 the USB port or a serial port.

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

The firmware upgrade can be performed one of two ways:

- Method One: Use the Firmware Loader provided within ACSELERATOR QuickSet® SEL-5030 Software. The Firmware Loader automates the firmware upgrade process and is the preferred method.
- Method Two: Connect to the relay in a terminal session and upgrade the firmware using the steps documented in *Method Two: Using a Terminal Emulator on page B.7*.

The same basic actions are required in either method:

A. Obtain the firmware file
B. Remove relay from service
C. Establish communications with the relay
D. Prepare the relay (save settings and other data)
E. Start SELBOOT
F. Maximize port baud rate (EIA-232 ports only)
G. Upload new firmware
H. Check relay self-tests
I. Verify relay settings
J. Return the relay to service

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- Personal computer
- To use Method One, ACSELERATOR QuickSet
- To use Method Two, terminal emulation software that supports 1K Xmodem or Xmodem (these instructions use HyperTerminal® from a Microsoft® Windows® operating system)
- Serial communications cable (SEL Cable C234A, SEL C662 USB-to-232 converter, or equivalent) or USB cable (SEL C664 or equivalent)
- Disk containing the firmware upgrade (.s19) file
- Firmware Upgrade Instructions (these instructions)
- Your relay instruction manual

Method One: Using ACSELERATOR QuickSet Firmware Loader

To use the ACSELERATOR QuickSet Firmware Loader, you must have ACSELERATOR QuickSet. See *Appendix C: PC Software* for instructions on how to obtain and install the software. Once the software is installed, perform the firmware upgrade as follows.

A. Obtain Firmware File

The firmware file is usually provided on a CD-ROM. Locate the firmware file on the disk. The file name will be of the form, for example, Rxxx351S.s19, where Rxxx is the firmware revision number, 351S indicates the relay type, and .s19 is the firmware file extension. Copy the firmware file to an easily accessible location on the PC.

Firmware is designed to be used with specific relays. A list of relay serial numbers is provided as part of the firmware upgrade package. The firmware provided is for use with the listed relays only. Attempts to upgrade relays not listed might not be successful and can result in relay failure.

B. Remove Relay From Service

Step 1. If the relay is in use, 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 the relay.

Step 3. Connect a communications cable and determine the port speed.

If using the EIA-232 front port to upgrade firmware, determine the port speed as follows:

a. From the relay front panel, press the **SET** pushbutton.

b. Use the arrow pushbuttons to navigate to **PORT**.

c. Press the **SELECT** pushbutton.

d. Use the arrow pushbuttons to navigate to the relay serial port you plan to use (usually the front port).

e. Press the **SELECT** pushbutton.

f. With **SHO** selected, press the **SELECT** pushbutton.

g. Press the down arrow pushbutton to scroll through the port settings; write down the value for each setting.

h. Connect an SEL C234A EIA-232 serial cable, SEL C662 USB-to-232 converter, or equivalent communications cable to the relay serial port and to the PC.

NOTE: When using the Firmware Loader for upgrading an SEL-351 model from firmware version R504 or an earlier (lower numbered) version, the relay USB port should not be used. Use one of the available EIA-232 ports instead.

If using the relay front panel USB port to upgrade firmware, connect an SEL C664 cable between the relay and the PC. The USB port appears as a serial connection. Any baud rate will be accepted by the relay.

C. Establish Communications With the Relay

Use the **Communications > Parameters** menu of ACSELERATOR QuickSet to establish a connection. See *Appendix C: PC Software* for additional information.

D. Prepare the Relay (Save Relay Settings and Other Data)

It is possible for data to be lost during the firmware upgrade process. Follow the steps in this section carefully to ensure that important data are saved.

Step 1. Select **Tools > Firmware Loader** and follow the on-screen prompts.

Step 2. In the Step 1 of 4 window of the Firmware Loader, click the ellipsis button and browse to the location of the firmware file. Select the file and click **Open**. See *Figure B.1*.

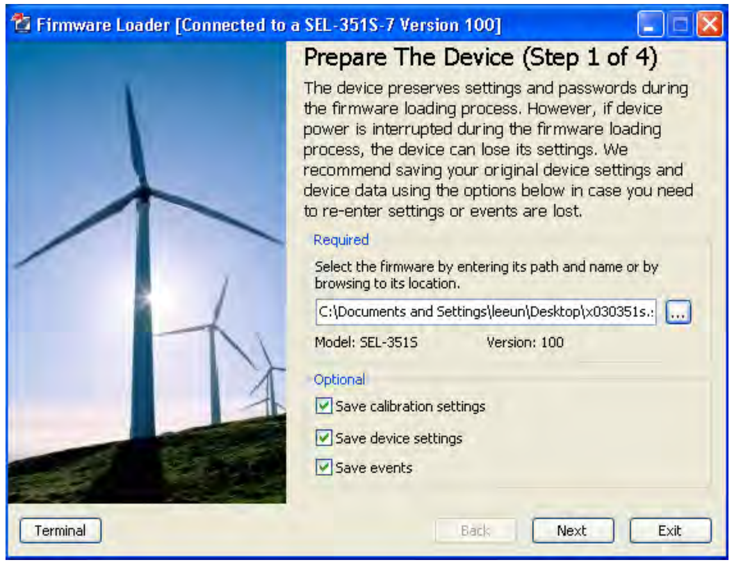


Figure B.1 Prepare the Device (Step 1 of 4)

Step 3. Check the **Save calibration settings** box in the Step 1 of 4 window of the Firmware Loader. These factory settings are required for proper operation of the relay and must be reentered in the unlikely event they are erased during the firmware upgrade process. The Firmware Loader saves the settings in a text file on the PC.

Step 4. Check the **Save device settings** box if you do not have a copy of the relay settings. It is possible for relay settings to be lost during the upgrade process.

NOTE: If upgrading an SEL-351 model from firmware version R504 or an earlier (lower numbered) version, ensure all serial ports are enabled (EPORT = Y) before continuing with the firmware upgrade procedure. Enable ports as necessary by issuing **SET P n**, where n = 2, 3, F, (and 1 on relays equipped with the optional EIA-485 port) and setting EPORT = Y. You may also use the front-panel **SET** pushbutton as described in Step 3 on page B.3.

Step 5. Check the **Save events** box if there are any event reports that have not been previously saved. It is possible for event reports to be lost during the upgrade process.

Step 6. Click **Next**.

The Firmware Loader reads the calibration settings and saves them in a text file on the PC. Make note of the file name and the location.

If **Save device settings** was selected, the Firmware Loader reads all of the settings from the relay. The software may ask if you wish to merge the settings read from the relay with existing design templates on the PC. Click **No, do not merge settings with Design Template**. The Firmware Loader will suggest a name for the settings, but the suggested name can be modified as desired.

If **Save events** was selected, the Event History window will open to allow the events to be saved. See *ACSELERATOR QuickSet Event Analysis on page C.15* for more information.

Step 7. If you use the Breaker Wear Monitor, click the **Terminal** button in the lower left portion of the Firmware Loader to open the terminal window. From the Access Level 1 prompt, issue the **BRE** command and record the internal and external trip counters, internal and external trip currents for each phase, and breaker wear percentages for each phase.

Step 8. Enable Terminal Logging capture (see *ACSELERATOR QuickSet Terminal on page C.5*) and issue the following commands to save stored data. It is possible for this data to be lost during the firmware upgrade process. (Some of these features are not available on all relay models.)

a. **MET E**—accumulated energy metering

b. **MET D**—demand and peak demand

c. **MET M**—maximum/minimum metering

d. **COMM A** and **COMM B**—MIRRORED BITS® communications logs

e. **LDP**—Load Profile

f. **SSI**—Voltage sag, swell, interrupt recorder

g. **SER**—Sequential Events Report

E. Start SELBOOT

In the Step 2 of 4 window of the Firmware Loader, click **Next** to disable the relay and enter SELBOOT. See *Figure B.2*.

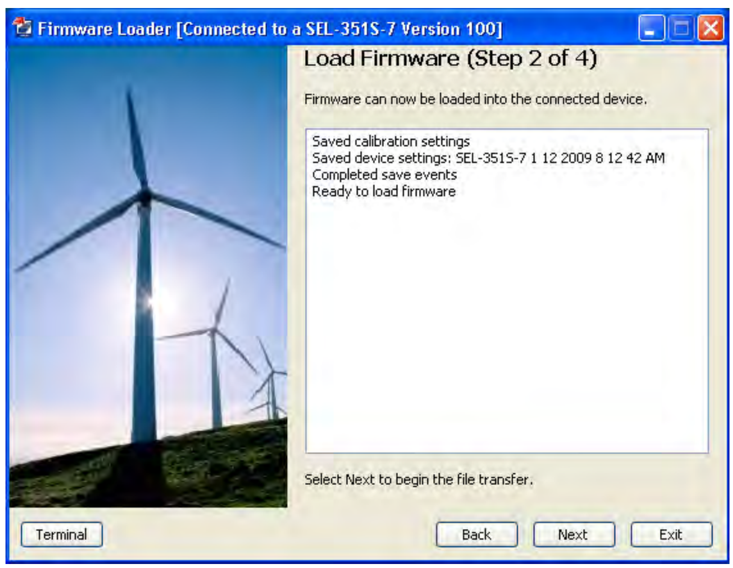


Figure B.2 Load Firmware (Step 2 of 4)

F. Maximize Port Baud Rate

This step is performed automatically by the software.

G. Upload New Firmware

This step is performed automatically by the software. The software will erase the existing firmware and start the file transfer to upload the new firmware. Upload progress will be shown in the **Transfer Status** window.

When the firmware upload is complete, the relay will restart. The Firmware Loader will automatically re-establish communications and issue a **STA** command to the relay.

In cases where the relay does not restart within two minutes of the firmware upload completion (as indicated by the PC application), and no error messages appear on the relay HMI, cycle power to the relay. The firmware loader application should then resume. Answer **Yes** if the Firmware Loader prompts you to continue.

H. Check Relay Self-Tests

The Step 3 of 4 window of the Firmware Loader will indicate that it is checking the device status and when the check is complete (see *Figure B.3*). The software will notify you if any problems are detected. You can view the relay status by opening the terminal using the Terminal button in the lower left portion of the Firmware Loader. If status failures are shown, open the terminal and see *Solving Firmware Upgrade Issues on page B.19*.

Click **Next** to go to the completion step.

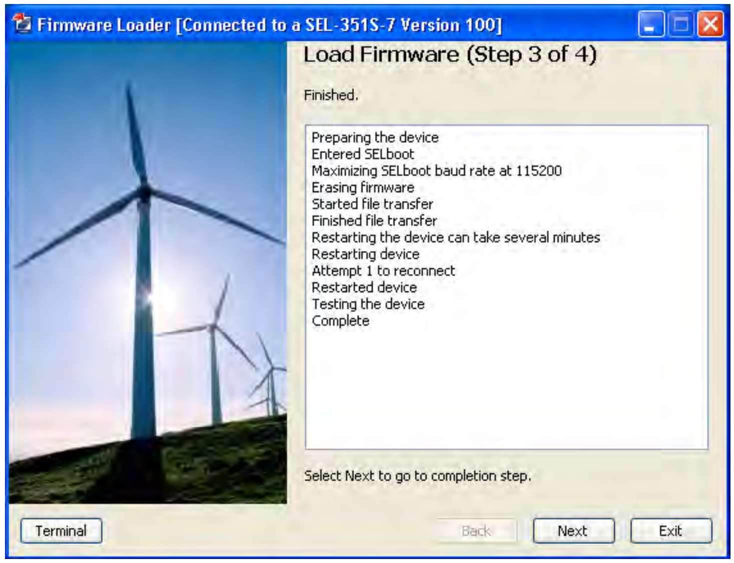


Figure B.3 Load Firmware (Step 3 of 4)

I. Verify Relay Settings

If there are no failures, the relay will enable. In the Step 4 of 4 window (see *Figure B.4*), the Firmware Loader will give you the option to compare the device settings. If any differences are found, the software will provide the opportunity to restore the settings.

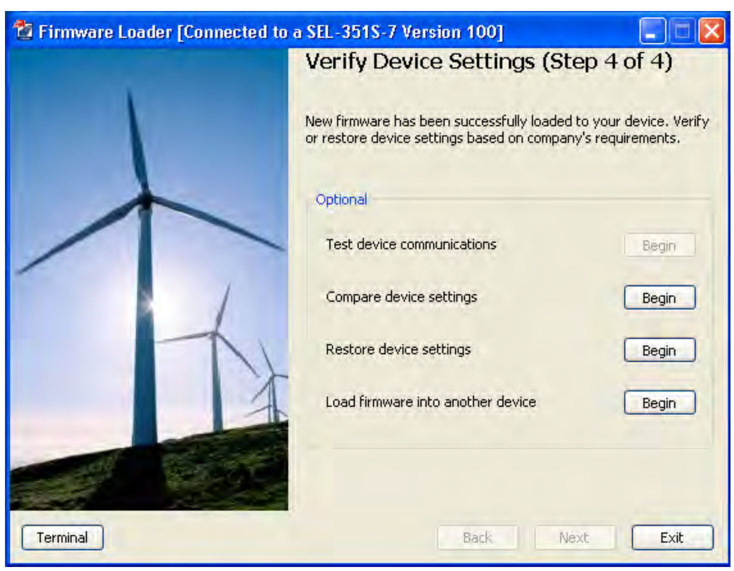


Figure B.4 Verify Device Settings (Step 4 of 4)

J. Return Relay to Service

Step 1. Open the terminal window using the **Terminal** button in the lower left portion of the Firmware Loader.

Step 2. Use the **ACC** command with the associated password to enter Access Level 1.

Step 3. Issue the **ID** command and compare the firmware revision (Rxxx) displayed in the FID string against the number from the firmware envelope label. If the numbers match, proceed to Step 5.

Step 4. For a mismatch between a displayed FID and the firmware envelope label, reattempt the upgrade or contact SEL for assistance.

Step 5. If you use the Breaker Wear Monitor, type **BRE <Enter>** to check the data to see if the relay retained breaker wear data through the upgrade procedure. If the relay did not retain this data, use the **BRE W** command to reload the percent contact wear values recorded in *D. Prepare the Relay (Save Relay Settings and Other Data) on page B.3*.

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

Step 7. Type **MET <Enter>** or use the ACSELERATOR QuickSet HMI to verify that the current and voltage signals are correct.

Step 8. Use the **TRI** and **EVE**/**CEV** commands or **Tools > Events > Get Events** menu in ACSELERATOR QuickSet to verify that the magnitudes of the current and voltage signals you applied to the relay match those displayed in the event report. If these values do not match, check the relay settings and wiring.

Step 9. Autoconfigure the SEL communications processor port if you have an SEL communications processor connected to the relay. This step reestablishes automatic data collection between the SEL communications processor and the relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

Step 10. Follow your company procedures for returning a relay to service.

Method Two: Using a Terminal Emulator

A. Obtain Firmware File

The firmware file is usually provided on a CD-ROM. Locate the firmware file on the disk. The file name will be of the form, for example, Rxxx351S.s19, where Rxxx is the firmware revision number, 351S indicates the relay type, and .s19 is the standard firmware file extension. Copy the firmware file to an easily accessible location on the PC.

Firmware is designed to be used with specific relays. A list of relay serial numbers is provided as part of the firmware upgrade package. The firmware provided is for use with the listed relays only. Attempts to upgrade relays not listed might not be successful and can result in relay failure.

B. Remove Relay From Service

Step 1. If the relay is in use, 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 the relay.

Step 3. Connect a communications cable and determine the port speed.

If using the EIA-232 front port to upgrade firmware, determine the port speed as follows:

a. From the relay front panel, press the **SET** pushbutton.

b. Use the arrow pushbuttons to navigate to PORT.

c. Press the **SELECT** pushbutton.

d. Use the arrow pushbuttons to navigate to the relay serial port you plan to use (usually the front port).

e. Press the **SELECT** pushbutton.

f. With SHO selected, press the **SELECT** pushbutton.

g. Press the down pushbutton to scroll through the port settings; write down the value for each setting.

h. Connect an SEL C234A EIA-232 serial cable, SEL C662 USB-to-232 converter, or equivalent communications cable to the relay serial port and to the PC.

If using the relay front-panel USB port to upgrade firmware, connect an SEL C664 cable between the relay and the PC. The USB port appears as a serial connection. Any baud rate will be accepted by the relay.

C. Establish Communications With the Relay

To establish communication between the relay and a personal computer, you must be able to modify the computer serial communications parameters (i.e., data transmission rate, data bits, parity) and set the file transfer protocol to 1K Xmodem or Xmodem protocol.

Step 1. From the computer, open HyperTerminal or other terminal emulation software.

On a personal computer running Windows, you would typically click the **Start** > **Programs** > **Accessories** > **Communications**.

Step 2. Enter a name, select any icon, and click **OK** (*Figure B.5*).

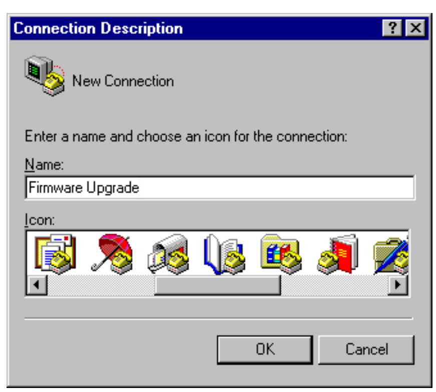


Figure B.5 Establishing a Connection

Step 3. Select the computer serial port you are using to communicate with the relay (*Figure B.7*) and click **OK**.

If using the relay front-panel USB port, a port driver must be installed on the PC. See *Establishing Communications Using the USB Port on page 10.2*. To see what virtual COM port has been created, launch any communications program that allows selection of a COM port and view all available ports, or go to the Windows Device Manager and inspect the available COM ports as shown in *Figure B.6*. Use Device Manager to verify which virtual COM port is associated with a particular physical USB port. Device Manager updates the available COM ports each time a cable is inserted or removed.

Figure B.6 Inspect Available COM Ports

Figure B.7 Determining the Computer Serial Port

Step 4. Establish serial port communications parameters.

If using the EIA-232 front port to upgrade firmware, the settings for the computer (*Figure B.8*) must match the relay settings you recorded earlier.

a. Enter the serial port communications parameters (*Figure B.8*) that correspond to the relay settings you recorded in *B. Remove Relay From Service on page B.7*.

b. Click **OK**.

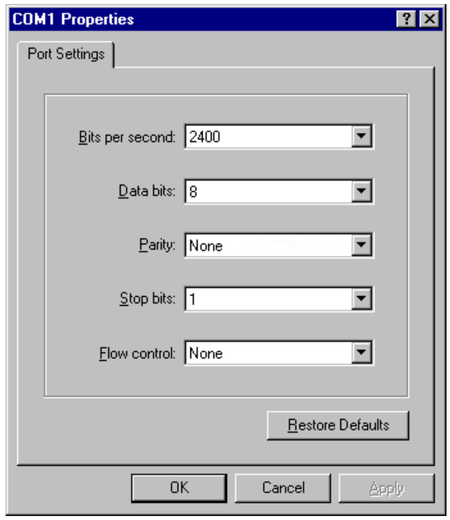


Figure B.8 Determining Communications Parameters for the Computer

If using the relay front-panel USB port, the relay will accept any baud rate. SEL suggests the use of the following parameters:

➢ Bits per second: 57600
➢ Data bits: 8
➢ Parity: None
➢ Stop bits: 1
➢ Flow control: XON/OFF

Step 5. Set the terminal emulation to VT100:

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

b. Select the **Settings** tab in the **Properties** dialog box (*Figure B.9*).

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

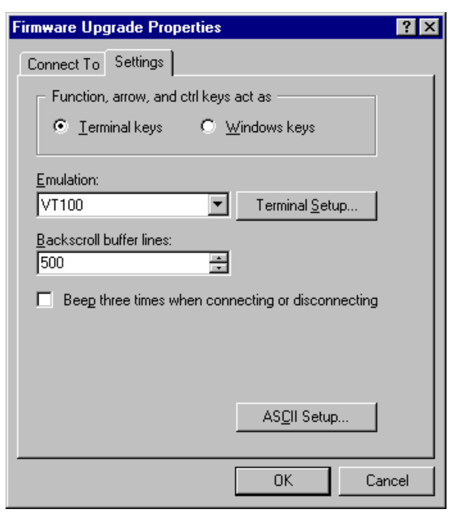


Figure B.9 Setting Terminal Emulation

Step 6. Confirm serial communication.

Press <**Enter**>. In the terminal emulation window, you should see the Access Level 0 = prompt, similar to that in *Figure B.10*.

If this is successful, proceed to *D. Prepare the Relay (Save Relay Settings and Other Data) on page B.12*.

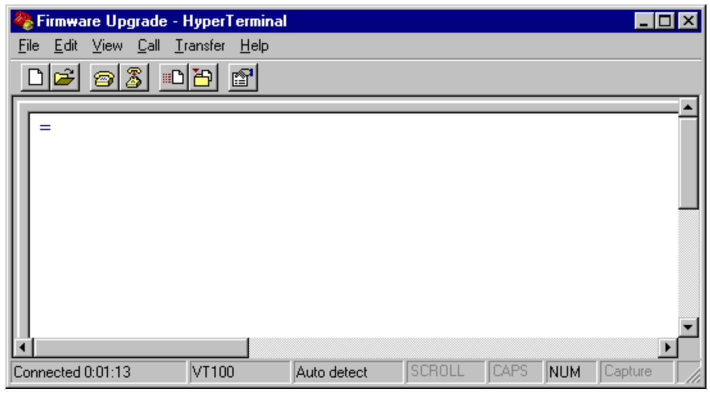


Figure B.10 Terminal Emulation Startup Prompt

Failure to Connect

If you do not see the Access Level 0 = prompt, press <**Enter**> again. If you still do not see the Access Level 0 = prompt, you have either selected the incorrect serial communications port on the computer, or the computer speed setting does not match the data transmission rate of the relay. Perform the following steps to reattempt a connection:

Step 7. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 8. Correct the port setting:

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

You should see a dialog box similar to *Figure B.11*.

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

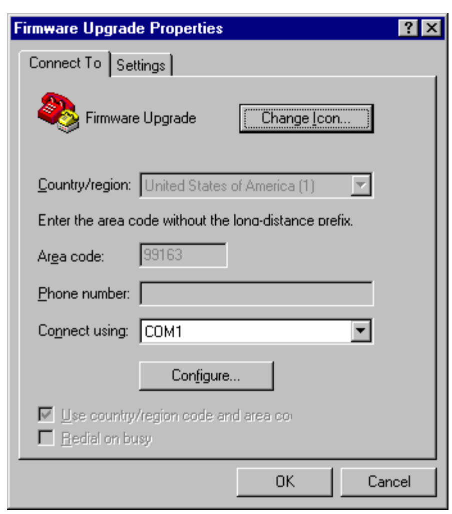


Figure B.11 Correcting the Port Setting

Step 9. Correct the communications parameters:

a. From the filename **Properties** dialog box shown in *Figure B.11*, click **Configure**.

You will see a dialog box similar to *Figure B.12*.

b. Change the settings in the appropriate list boxes to match the settings you recorded in *B. Remove Relay From Service on page B.7* and click **OK** twice to return to the terminal emulation window.

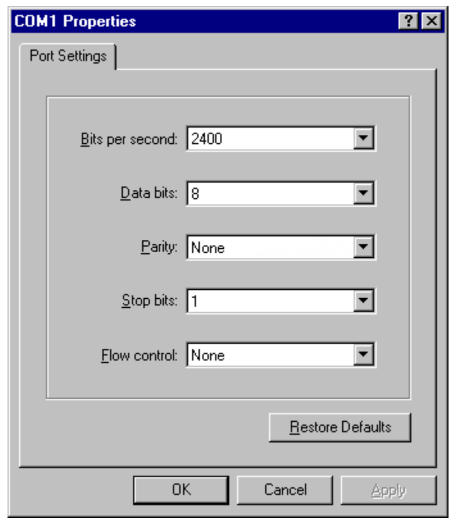


Figure B.12 Correcting the Communications Parameters

Step 10. Press <**Enter**>. In the terminal emulation window, you should see the Access Level 0 = prompt, similar to that in *Figure B.10*.

If using the relay front-panel USB port, see *Troubleshooting Procedure on page 13.10* for additional troubleshooting tips.

D. Prepare the Relay (Save Relay Settings and Other Data)

It is possible for data to be lost during the firmware upgrade process. Follow the steps in this section carefully to ensure that important data are saved.

Before upgrading firmware, retrieve and record any History (**HIS**) or Event (**EVE**) data that you want to retain (see *Section 10: Communications* for an explanation of the commands). During this process, you may find it helpful to use the Capture Text feature of HyperTerminal, which is available in the **Transfer** menu. See additional instructions for using Capture Text in *Backup Relay Settings and Other Data*.

Enter Access Level 2

NOTE: If the relay does not prompt you for Access Level 1 and Access Level 2 passwords, check whether the relay Access jumper is in place. With this jumper in place, the relay is unprotected from unauthorized access (see Section 2: Installation).

Step 1. Type **ACC** <**Enter**> at the Access Level 0 = prompt.

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

You will see the Access Level 1 => prompt.

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

Step 4. Type the Access Level 2 password and press <**Enter**>.

You will see the Access Level 2 =>> prompt.

Backup Relay Settings and Other Data

The relay preserves settings and passwords during the firmware upgrade process. However, interruption of relay power during the upgrade process can cause the relay to lose settings. Make a copy of the original relay settings in case you need to reenter the settings. Use either the SEL-5010 Relay Assistant software or ACSELERATOR QuickSet to record the existing relay settings and proceed to *E. Start SELBOOT on page B.14*. Otherwise, perform the following steps:

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

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

Step 3. Click **Start**.

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

Step 4. Execute the Show Calibration (**SHO C**) command to retrieve the relay calibration settings.

Use the following Show commands to retrieve the relay settings: **SHO G**, **SHO 1**, **SHO L 1**, **SHO 2**, **SHO L 2**, **SHO 3**, **SHO L 3**, **SHO 4**, **SHO L 4**, **SHO 5**, **SHO L 5**, **SHO 6**, **SHO L 6**, **SHO P 1**, **SHO P 2**, **SHO P 3**, **SHO P F**, **SHO R**, **SHO T**, **SHO D 1**, **SHO D 2**, **SHO D 3**, and **SHO M**.

Step 5. Issue the following commands to save stored data. It is possible for this data to be lost during the firmware upgrade process. (Some of these features are not available on all relay models.)

a. **MET E**—accumulated energy metering

b. **MET D**—demand and peak demand

c. **MET M**—maximum/minimum metering

d. **COMM A** and **COMM B**—MIRRORED BITS communications logs

e. **LDP**—Load Profile

f. **SSI**—Voltage sag, swell, interrupt recorder

g. **SER**—Sequential Events Report

h. **BRE**—Breaker Wear Monitor data

Step 6. From the **Transfer** menu in **HyperTerminal**, select **Capture Text** and click **Stop**.

NOTE: If upgrading an SEL-351 model from firmware version R504 or an earlier (lower numbered) version, ensure all serial ports are enabled (EPORT = Y) before continuing with the firmware upgrade procedure. Enable ports as necessary by issuing **SET P n**, where n = 2, 3, F, (and 1 on relays equipped with the optional EIA-485 port) and setting EPORT = Y.

Step 7. The computer saves the text file you created to the directory you specified in Step 2.

Step 8. Write down the present relay data transmission setting (SPEED) for the port to be used for the firmware upgrade.

The SPEED setting is included in the **SHO P** relay settings output. The SPEED value should be the same as the value you recorded in *B. Remove Relay From Service on page B.7*.

E. Start SELBOOT

NOTE: A message similar to the following may be displayed when you type **L_D <Enter>**: "WARNING: Settings were not properly saved – Settings upgrade may fail. Please contact an SEL representative if assistance is required." Some relays have an automatic settings backup routine. This message indicates that the backup was not successful. If you saved settings as instructed in Backup Relay Settings and Other Data on page B.13, continue with the firmware upgrade process. Otherwise, type **EXI** at the prompt to exit SELBOOT. Follow the instructions under Backup Relay Settings and Other Data on page B.13 to ensure that the existing settings are available after the firmware upgrade.

Step 1. From the computer, start the SELBOOT program:

a. From the Access Level 2 =>> prompt, type **L_D <Enter>**.

The relay responds with the following:

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

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

The relay responds with the following:

```
Are you sure (Y/N)?
```

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

The relay responds with the following:

```
Relay Disabled
```

Step 2. Wait for the SELBOOT program to load.

The front-panel LCD screen displays SEL`boot`. The computer will display the SELBOOT `!>` prompt after SELBOOT loads.

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

You will see another SELBOOT `!>` prompt.

Commands Available in SELBOOT

For a listing of commands available in SELBOOT, type **HELP <Enter>**. You should see a screen similar to *Figure B.13*.

```
!>HELP <Enter>

BFID=SLBT-3CF1-R100-V0-Z100100-D20081222
USBID=FID string not found.


Baud            - Set to a standard baud rate from 300 to 115200 bps.
Erase           - Erase the existing firmware.
Exit            - Exit this program and restart the device.
FID             - Display the firmware identification (FID).
Receive [BOOT]  - Receive new firmware for the device using Xmodem.
Help            - Print this help list.

Program Memory Size: 01000000
Firmware Checksum = 1935   OK
```

Figure B.13 List of Commands Available in SELBOOT

F. Maximize Port Baud Rate for EIA-232 Ports

NOTE: The USB port speed is fixed. If you are using the USB port for the firmware upgrade, continue to G. Upload New Firmware on page B.15.

Step 1. Type **BAU 115200 <Enter>** at the SELBOOT `!>` prompt.

Step 2. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 3. Correct the communications parameters:

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

b. Choose **Configure**.

c. Change the computer communications speed to match the new data transmission rate in the relay (*Figure B.14*).

d. Click **OK** twice.

Step 4. Press **<Enter>** to check for the SELBOOT `!>` prompt indicating that serial communication is successful.

Figure B.14 Matching Computer to Relay Parameters

G. Upload New Firmware

Step 1. Type **REC <Enter>** at the SELBOOT !> prompt to command the relay to receive new 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.
```

The relay asks whether you want to erase the existing firmware.

```
Are you sure you wish to erase the existing firmware? (Y/N) Y
```

Step 2. Type **Y** to erase the existing firmware and load new firmware. (To abort, type **N** or press **<Enter>**).

The relay responds with the following:

```
Erasing

Erase successful
Press any key to begin transfer, then start transfer at the PC <Enter>
```

Step 3. Press **<Enter>** to start the file transfer routine.

Step 4. Send new firmware to the relay.

a. From the **Transfer** menu in HyperTerminal, choose **Send File** (*Figure B.15*).

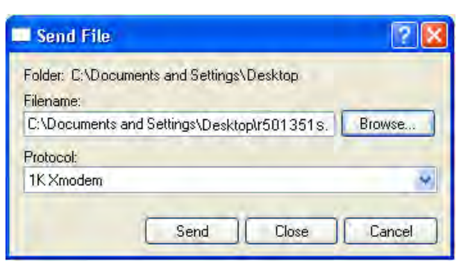


Figure B.15 Selecting New Firmware to Send to the Relay

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

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

If the computer does not have **1K Xmodem**, select **Xmodem**.

d. Click **Send** to send the file containing the new firmware.

NOTE: The relay restarts in SELBOOT if relay power fails while receiving new firmware. Upon power-up, the relay serial port will be at the default 9600 baud. Perform the steps beginning in C. Establish Communications With the Relay on page B.8 to increase the serial connection data speed. Then resume the firmware upgrade process at G. Upload New Firmware on page B.15.

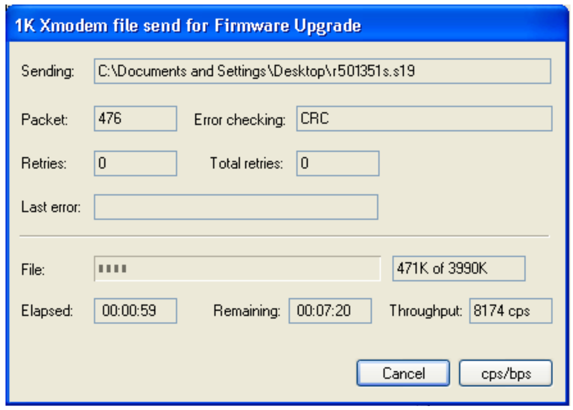


Figure B.16 Transferring New Firmware to the Relay

You should see a dialog box similar to *Figure B.16*. Incrementing numbers in the **Packet** box and a bar advancing from left to right in the **File** box indicate that a transfer is in progress.

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.

Step 5. Wait for the transfer to be completed.

a. If you are using an EIA-232 port, the relay displays the following:

```
Upload completed successfully. Attempting a restart.
```

b. If you are using the front-panel USB port, the relay displays the following after the transfer is completed:

```
Upload completed successfully. Press any key to restart.
```

After a key is pressed, the relay displays:

```
Close the USB port and remove the USB cable.
Attempting a restart in 5 seconds.
```

From the **Call** menu of HyperTerminal, choose **Disconnect** and remove the USB cable from the front of the relay.

NOTE: Unsuccessful uploads can result from Xmodem time-out, a power failure, loss of communication between the relay and the computer, or voluntary cancellation. Check connections, reestablish communication, and start again at Step 1 on page B.15.

Step 6. Wait for relay to restart.

A successful restart sequence can take as long as two minutes, after which time the relay leaves SELBOOT. You will see no display on your PC to indicate a successful restart. A successful restart is indicated when the **ENABLED** LED illuminates. This LED is labeled either **EN** or **ENABLED**, depending on the relay model.

In cases where the relay does not restart within two minutes of the firmware upload completion (as indicated by the PC terminal emulator), and no error messages appear on the relay HMI, cycle power to the relay. Re-establish your connection in HyperTerminal, and then continue with Step 7.

In some cases, the **ENABLED** LED might not illuminate, and a `FAIL` message will be displayed on the relay LCD screen, if equipped.

Step 7. Press **<Enter>** and confirm that the Access Level 0 = prompt appears on the computer screen.

If you are using the relay front-panel USB port, you will need to reestablish the connection.

a. Reinstall the cable.

b. From the **Call** menu of Hyperterminal, choose **Call** and press **<Enter>** several times, until you see the Access Level 0 = prompt.

Step 8. If you see the Access Level 0 = prompt, proceed to *H. Check Relay Self-Tests on page B.18*.

No Access Level 0 = Prompt

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

Table B.1 Troubleshooting New Firmware Upload (Sheet 1 of 2)

Problem	Solution
The restart was successful, but the relay data transmission rate reverted to the rate at which the relay was operating prior to entering SELBOOT (the rate you recorded in *B. Remove Relay From Service on page B.7*).	Change the computer terminal speed to match the relay data transmission rate you recorded in *B. Remove Relay From Service on page B.7*. Step 1. From the **Call** menu, choose **Disconnect** to terminate relay communication. Step 2. Change the communications software settings to the values you recorded in *B. Remove Relay From Service on page B.7*. Step 3. From the **Call** menu, choose **Call** to reestablish communication. Step 4. Press **<Enter>** to check for the Access Level 0 = prompt indicating that serial communication is successful.
The restart was successful, but the relay data transmission rate reverted to 9600 bps (the settings have been reset to default).	Match the computer terminal speed to a relay data transmission rate of 9600 bps. Step 1. From the **Call** menu, choose **Disconnect** to terminate relay communication. Step 2. Change the communications software settings to 9600 bps, 8 data bits, no parity, and 1 stop bit (see *F. Maximize Port Baud Rate for EIA-232 Ports on page B.14*). Step 3. From the **Call** menu, choose **Call** to reestablish communication. Step 4. Press **<Enter>** to check for the Access Level 0 = prompt indicating successful serial communication.

Table B.1 Troubleshooting New Firmware Upload (Sheet 2 of 2)

Problem	Solution
The restart was unsuccessful, in which case the relay is in SELBOOT, indicated by a SELBOOT !> prompt.	If you see a SELBOOT !> prompt, type **EXI <Enter>** to exit SELBOOT. Check for the Access Level 0 = prompt. If you see the Access Level 0 = prompt, proceed to *H. Check Relay Self-Tests*. If the relay will not exit SELBOOT, reattempt to upload the new firmware (beginning at Step 1 under *G. Upload New Firmware on page B.15*) or contact the factory for assistance.
Cannot communicate with relay via front-panel USB port.	From the **Call** menu of HyperTerminal, choose Disconnect and remove the USB cable from the front of the relay. Reinstall the cable and see *C. Establish Communications With the Relay on page B.8*. See *Troubleshooting Procedure on page 13.10* for additional troubleshooting tips.

H. Check Relay Self-Tests

The relay can display various self-test fail status messages. The troubleshooting procedures that follow depend upon the status message the relay displays.

Step 1. Type **ACC <Enter>**.

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

You will see the Access Level 1 => prompt.

Step 3. Enter the **STATUS** command (**STA <Enter>**) to view relay status messages.

If the relay displays no fail status message, proceed to *I. Verify Relay Settings on page B.18*.

If failures are displayed in the status message, proceed to *Solving Firmware Upgrade Issues on page B.19*.

I. Verify Relay Settings

Step 1. Use the **ACC** and **2AC** commands with the associated passwords to enter Access Level 2.

Step 2. Use the **SHO** command to view the relay settings and verify that these match the settings you saved earlier (see *Backup Relay Settings and Other Data on page B.13*).

If the settings do not match, reenter the settings you saved earlier.

J. Return the Relay to Service

Step 1. Open the terminal window.

Step 2. Use the **ACC** command with the associated password to enter Access Level 1.

Step 3. Issue the **ID** command and compare the firmware revision (Rxxx) displayed in the FID string against the number from the firmware envelope label. If the numbers match, proceed to Step 5.

Step 4. For a mismatch between a displayed FID and the firmware envelope label, reattempt the upgrade or contact SEL for assistance.

Step 5. If you use the Breaker Wear Monitor, type **BRE <Enter>** to check the data and see if the relay retained breaker wear data through the upgrade procedure. If the relay did not retain these data, use the **BRE W** command to reload the percent contact wear values recorded in *D. Prepare the Relay (Save Relay Settings and Other Data) on page B.3*.

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

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

Step 8. Use the **TRI** and **EVE**/**CEV** commands to verify that the magnitudes of the current and voltage signals you applied to the relay match those displayed in the event report. If these values do not match, check the relay settings and wiring.

Step 9. Autoconfigure the SEL communications processor port if you have an SEL communications processor connected to the relay. This step reestablishes automatic data collection between the SEL communications processor and the relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

Step 10. Follow your company procedures for returning a relay to service.

Solving Firmware Upgrade Issues

If a `FAIL` message is returned in response to the **STA** command, perform the following steps.

Step 1. Use the **ACC** and **2AC** commands with the associated passwords to enter Access Level 2.

Step 2. Type **STA C <Enter>**. Answer **Y <Enter>** to the `Reboot the relay and clear status` prompt. The relay will respond with `Rebooting the relay`. Wait for about 30 seconds, then press **<Enter>** until you see the Access Level 0 = prompt.

Step 3. Use the **ACC** command with the associated password to enter Access Level 1.

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

If there are no fail messages and you are using Method One, click **Next** in Step 3 of 4 of the Firmware Loader and go to *I. Verify Relay Settings on page B.6*.

If there are no fail messages and you are using Method Two, go to *I. Verify Relay Settings on page B.18*.

If there are fail messages, continue with Step 5.

⚠CAUTION
Step 6 will cause the loss of settings and other important data. Be sure to retain relay settings and other data downloaded from the relay at the start of the firmware upgrade process.

Step 5. Use the **2AC** command with the associated password to enter Access Level 2.

Step 6. Type **R_S <Enter>** to restore factory default settings in the relay.

The relay asks whether to restore default settings. If the relay does not accept the **R_S** command, contact SEL for assistance.

Step 7. Type **Y <Enter>**.

The relay can take as long as two minutes to restore default settings. The relay then reinitializes, and the **ENABLED** LED illuminates. This LED is labeled either **EN** or **ENABLED**, depending on the relay model. Contact SEL for assistance if the relay does not enable.

Step 8. Press **<Enter>** to check for the Access Level 0 = prompt indicating that serial communication is successful.

Step 9. Use the **ACC** and **2AC** commands and type the corresponding passwords to reenter Access Level 2.

Step 10. Type **SHO C <Enter>** to verify the relay calibration settings.

If using Method One and the settings do not match the settings contained in the text file you recorded in *D. Prepare the Relay (Save Relay Settings and Other Data) on page B.3*, contact SEL for assistance.

If using Method Two and the settings do not match the settings contained in the text file you recorded in *D. Prepare the Relay (Save Relay Settings and Other Data) on page B.12*, contact SEL for assistance.

Step 11. Use the **PAS** command to set the relay passwords.

Step 12. Restore the relay settings:

a. If you have SEL-5010 Relay Assistant software or ACSELERATOR QuickSet, restore the original settings by following the instructions for the respective software.

b. If you do not have the SEL-5010 Relay Assistant software or ACSELERATOR QuickSet, restore the original settings by issuing the necessary **SET *n*** commands.

Step 13. If any failure status messages still appear on the relay display, see *Section 13: Testing and Troubleshooting* or contact SEL for assistance.

Appendix C
PC Software

Overview

NOTE: PC software is updated more frequently than relay firmware. As a result, the descriptions and figures shown in this section may differ slightly from the software. Select **Help** in the PC software for information.

NOTE: Figures may show features or settings not available in all relays.

This appendix contains the following sections:

SEL provides many PC software solutions (applications) that support SEL devices. These software solutions are listed in *Table C.1*.

Table C.1 SEL Software Solutions

Product Name	Description
SEL Compass®	This application provides an interface for web-based notification of product updates and automatic software updating.
ACSELERATOR QuickSet® SEL-5030 Software	See *Table C.2*.
ACSELERATOR QuickSet Designer® SEL-5031 Software	This application allows you to customize relay settings to particular applications, instead of dealing with all settings in the device. These custom settings are stored in QuickSet Design Templates. You can lock settings to match your standards or lock and hide settings that are not used. This makes installation of a new device simple and helps ensure that new devices are applied according to your organization's standards.
ACSELERATOR Architect® SEL-5032 Software	Use this application to design and commission SEL IEDs in IEC 61850 substations, create and map GOOSE messages, utilize predefined reports, create and edit datasets, and read in SCD, ICD, and CID files.
ACSELERATOR TEAM™ SEL-5045 Software	The TEAM system provides custom data collection and movement of a wide variety of device information. The system provides tools for device communication, automatic collection of data, and creation of reports, warnings and alarms.
ACSELERATOR Analytic Assistant® SEL-5601 Software	Converts SEL compressed ASCII event reports files to oscillography
Cable Selector SEL-5801 Software	Selects the proper SEL cables for your application.

ACSELERATOR QuickSet is a powerful setting, event analysis, and measurement tool that aids in applying and using the relay. *Table C.2* shows the suite of ACSELERATOR QuickSet applications. This section describes how to get started with ACSELERATOR QuickSet.

Table C.2 ACSELERATOR QuickSet Applications

Application	Description
Terminal	Provides a direct connection to the SEL device. Use this feature to ensure proper communications and directly interface with the device.
HMI	Provides a summary view of device operation. Use this feature to simplify commissioning testing.
Rules Based Settings Editor	Provides on-line or off-line device settings that include interdependency checks. Use this feature to create and manage settings for multiple devices in a database.
Event Analysis	Provides oscillography and other event analysis tools.
Settings Database Mgmt	ACSELERATOR QuickSet uses a database to manage the settings of multiple devices.
Help	Provides general ACSELERATOR QuickSet and device specific ACSELERATOR QuickSet context sensitive help.

Obtaining ACSELERATOR QuickSet

ACSELERATOR QuickSet can be obtained from the Software Solutions area of the SEL website. In order to have the software automatically update as new relay drivers are released, download and install SEL Compass Software, then use Compass to download and install ACSELERATOR QuickSet. When you download ACSELERATOR QuickSet within Compass, you will be asked to select which relay drivers you wish to include. Select drivers for all SEL relays that you may be required to set. If later you find that additional drivers are required, ACSELERATOR QuickSet provides an easy method to request new drivers and updates. See *Updating ACSELERATOR QuickSet on page C.14*.

ACSELERATOR QuickSet is also available on CD upon request.

ACSELERATOR QuickSet Main Menu

The main menu provides the following options and submenu options. Selected submenu options are explained in detail in *Table C.3*.

Table C.3 ACSELERATOR QuickSet Submenu Options (Sheet 1 of 2)

File	➤ New—Create new settings for a connected device or offline ➤ Open—Open existing settings stored in a Relay Database (RDB) file ➤ Close—Close settings instance that is open in the ACSELERATOR QuickSet window ➤ Save/Save As—Save settings instance that is open in the ACSELERATOR QuickSet window to the active Relay Database (RDB) file ➤ Print Device Settings—Print standard or custom settings reports ➤ Read—Read settings from a connected device and display the settings in the ACSELERATOR QuickSet window ➤ Send—Send settings instance that is open in the ACSELERATOR QuickSet window to a connected device ➤ Active Database—Change which Relay Database (RDB) file is used for the Open and Save/Save As commands. ➤ Database Manager—Open Database Manager to create a new Relay Database (RDB) file, copy settings within the active Relay Database (RDB) file, add descriptions to settings within the database, and copy and move settings between different databases. ➤ Exit—Quit the ACSELERATOR QuickSet software
Edit	➤ Copy—Copy settings from one Settings Group to another ➤ Search—Search for a text string within the settings instance ➤ Compare—Compare the settings instance that is open in the ACSELERATOR QuickSet window to another settings instance in the Relay Database file ➤ Merge—Merge the settings instance that is open in the ACSELERATOR QuickSet window with another settings instance in the Relay Database file ➤ Part Number—Change the current part number for the settings instance that is open in the ACSELERATOR QuickSet window

Table C.3 ACSELERATOR QuickSet Submenu Options (Sheet 2 of 2)

Communications	➤ Connect—Request ACSELERATOR QuickSet to attempt to connect to a device using the current Connection Parameters ➤ Parameters—Modify the Communications Parameters, including connection type (Serial, Network, or Modem), PC port numbers, speed, and settings, device passwords, IP addresses, ports, and file transfer options, and modem phone numbers and speeds. ➤ Network Address Book—Select from a list of Ethernet-connected devices. Add or modify devices by specifying the Connection Name, IP Address, Telnet Port Number, User ID, and Password. ➤ Terminal—Open terminal window to issue ASCII commands directly to a connected relay. ➤ Logging—Initiate terminal logging to record terminal communications. View and clear the connection log.
Tools	➤ Settings—Convert settings between settings versions. Import and export settings from and to text files. ➤ HMI—Open HMI for connected device and manage custom HMI Device Overviews. ➤ Events—Collect event and view reports from connected devices. ➤ Options—Control ACSELERATOR QuickSet options, including Settings Prompt and Layout Options, Event Viewer, Terminal Options, and Advanced Communications Settings. ➤ Firmware Loader—Upgrade relay firmware. ➤ Commissioning Assistant, Motor Start Viewer, Chart Viewer- Plugin applications that support commissioning and data analysis for specific relays.
Windows	➤ Cascade, Tile Horizontally, Tile Vertically—Arrange multiple QuickSet windows for easy viewing.
Help	➤ Access program and settings help ➤ Check for software updates.

ACSELERATOR QuickSet Setup

Follow the steps outlined in *Section 2: Installation* to prepare the relay for use. Perform the following steps to initiate communications:

Step 1. Connect the appropriate communications cable between the relay and the PC.

Step 2. Apply power to the relay.

Step 3. Start ACSELERATOR QuickSet.

When ACSELERATOR QuickSet starts, the initial screen presents the following icons:

New—Create new settings for a connected or unconnected device

Read—Read settings from a connected device

Open—Open previously saved settings

Communications Parameters—Configure serial and network connections

Manage Databases—Manage offline settings and databases

Update—Install and update ACSELERATOR QuickSet software and drivers

The functions represented by these six icons are also included in the menu items. See the discussions of the individual menu items in this section for a description of these functions.

Communications Parameters

ACSELERATOR QuickSet can communicate with a relay via any relay serial port set to SEL protocol, via the front-panel USB port, or via Ethernet. Perform the following steps to configure ACSELERATOR QuickSet to communicate with the relay.

Step 1. Select **Communications > Parameters** from the ACSELERATOR QuickSet main menu bar to open the **Communication Parameters** dialog box, or select **Communications Parameters** from the startup screen.

Step 2. Select the type of connection to be used: Serial, Network, or Modem. To use the relay front panel USB port, select Serial. Communications parameters can be defined simultaneously for Serial, Network, and Modem connections. The connection to be used is selected in the **Active Connection Type** drop-down menu.

Step 3. Configure the PC port.

If **Serial** is selected as the connection type:

a. Select the port number of the PC from the Device drop-down box.

b. Select the Data Speed for the relay serial port, or select Auto detect to allow the software to automatically determine the Data Speed. The default Data Speed for the relay is 9600.

c. Select appropriate settings for Data Bits, Stop Bits, Parity, and RTS/CTS (Hardware Handshaking) according to the settings of the relay serial port. Default settings are Data Bits = 8, Stop Bits = 1, Parity = N, and RTS/CTS = OFF.

d. Enter the relay Access Level One and Access Level Two passwords in the respective text boxes.

If **Network** is selected as the connection type:

a. Enter the IP address of the relay Ethernet port as the Host IP Address

b. Enter the Telnet port number

c. Select **Telnet** as the File Transfer Option.

d. Enter the relay Access Level One and Access Level Two passwords in the respective text boxes.

e. Use the **Save to Address Book** button to save the entered information with a Connection Name for later use.

f. Relay Ethernet port setting ETELNET must be set to Y.

If **Modem** is selected as the connection type:

a. Select the port number of the PC modem from the **Device** drop-down box.

b. Enter the phone number of the remote modem.

c. Select the data speed for the modem, or select Auto detect to allow the software to automatically determine the data speed.

d. Enter the relay Access Level One and Access Level Two passwords in the respective text boxes.

Step 4. Click **OK** when finished.

ACSELERATOR QuickSet Terminal

Terminal Window

The terminal window is an ASCII interface with the relay. This is a basic terminal emulation with no file transfer capabilities. Many third-party terminal emulation programs are available with file transfer encoding schemes.

Open the terminal window by either clicking **Communication > Terminal**, clicking on the Terminal icon on the toolbar, or by pressing **<Ctrl+T>**.

Verify proper communications with the relay by opening a terminal window, pressing **<Enter>** a few times, and verifying that an = (equal) prompt is received, as shown in *Figure C.1*. If a prompt is not received, verify proper setup.

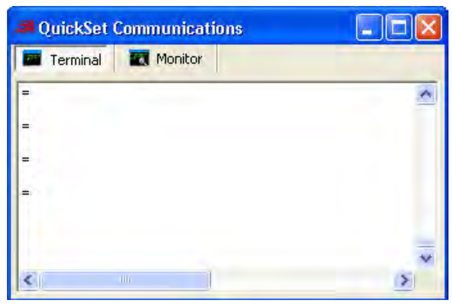


Figure C.1 Terminal Prompt

Terminal Logging

If the **Terminal Logging** item in the **Communication** menu is selected, ACSELERATOR QuickSet records all communications between the relay and the PC in a log file.

Drivers

Enter Access Level 1 and issue the **STA** command to view the Firmware Identification (FID) string.
Locate and record the Z-number in the FID string. It will look similar to *Figure C.2*. The first portion of the Z-number (Z001xxx, for example) determines the ACSELERATOR QuickSet relay settings driver version when you are creating or editing relay settings files. The later portion of the Z number (Zxxx001, for example) determines the HMI version number. These numbers are used by the applications to ensure proper interaction between the relay and ACSELERATOR QuickSet. The use of the driver version will be discussed in more detail later in this section.

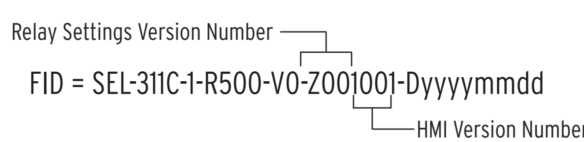
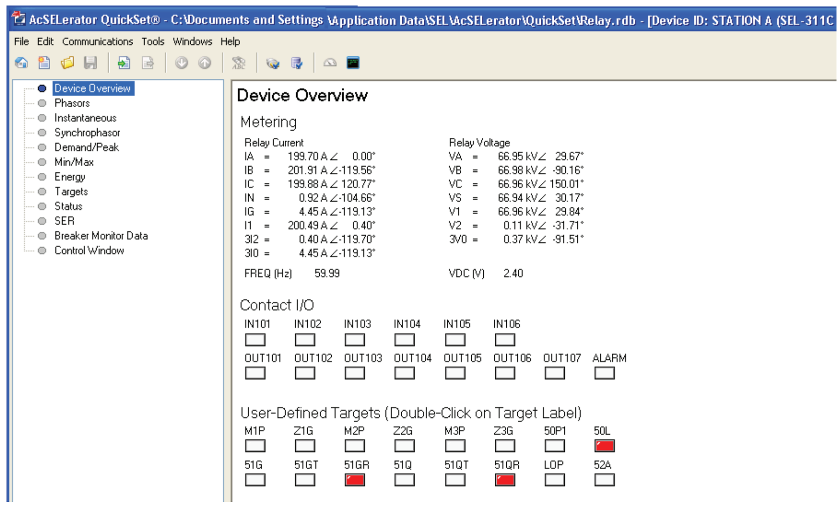


Figure C.2 ACSELERATOR QuickSet Driver Information in the FID String

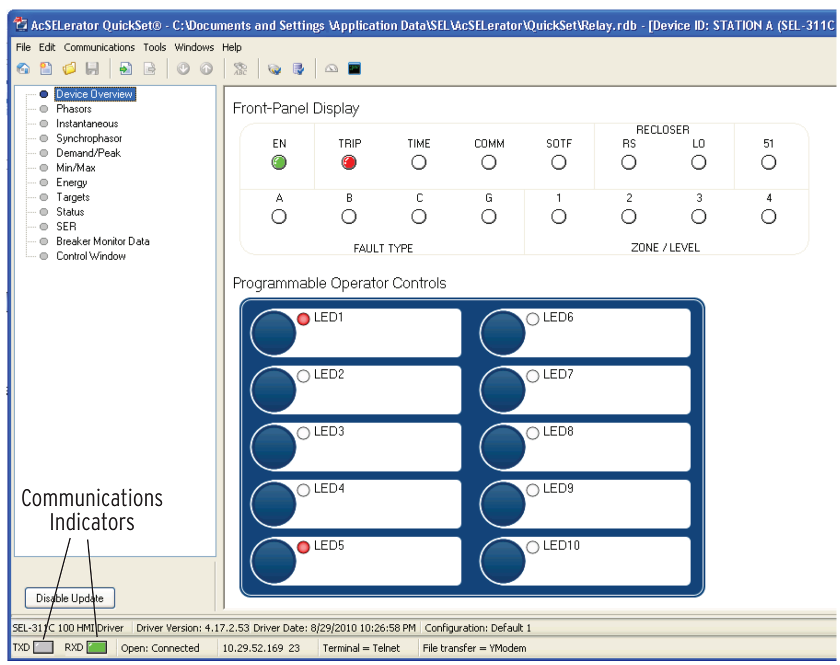
ACSELERATOR QuickSet reads the latter portion of the Z-number to determine the correct HMI to display when you select the menu. See *Open the ACSELERATOR QuickSet HMI on page C.6* for instructions.

ACSELERATOR QuickSet HMI

Use the ACSELERATOR QuickSet HMI feature to view real-time relay information in a graphical format. Use the virtual relay front panel to read metering and targets (see *Figure C.3*).



(a)



(b)

Figure C.3 Virtual Relay Front Panel

Open the ACSELERATOR QuickSet HMI

Select **Tools** > **HMI** > **HMI** in the ACSELERATOR QuickSet menu bar. ACSELERATOR QuickSet opens the HMI window and downloads the interface data. The HMI can also be accessed using the Human Machine Interface icon.

ACSELERATOR QuickSet HMI Features

Table C.4 lists the functions in the HMI tree view and a brief explanation of each function.

Table C.4 ACSELERATOR QuickSet HMI Tree View Functions

Function	Description
Device Overview	View general metering, selected targets, control input, control outputs, and the virtual front panel.
Phasors	A graphical and textual representation of phase and sequence voltages and currents.
Instantaneous	A table of instantaneous voltages, currents, powers, and frequency.
Synchrophasor	A table of synchrophasor data.
Demand/Peak	A table showing demand and peak demand values. This display also allows demand and peak demand values to be reset.
Min/Max	A table showing maximum/minimum metering quantities. This display also allows maximum/minimum metering quantities to be reset.
Energy	A table showing energy import/export. This display also allows energy values to be reset.
Targets	View Relay Word bits in a row/column format.
Status	A list of relay status conditions.
SER	Sequential Events Recorder data listed oldest to newest, top to bottom. Set the range of SER records with the dialog boxes at the bottom of the display.
Breaker Monitor Data	A table showing the latest circuit breaker monitor data.
Control Window	Metering and records reset buttons, trip and close control, output pulsing, target reset, time and date set, group switch, and remote bit control.

The flashing LED representation in the lower left of the ACSELERATOR QuickSet window indicates an active data update via the communications channel (see *Figure C.3(b)*). Click the button marked **Disable Update** to suspend HMI use of the communications channel.

HMI Device Overview

Select the **Device Overview** branch to display an overview of the relay operation. This view includes a summary of information from many of the other HMI branches, including fundamental metering, contact input/output status, and front-panel LED status.

The **Device Overview** colors and text can be customized. White LED symbols indicate a deasserted condition and LED symbols with any other color indicate an asserted condition. Click an LED symbol to change its assert color. Double-click the LED label to change the label.

HMI Control Window

Select the **Control Window** branch to reset metering values, clear event records, trip and close reclosers/breakers, pulse output contacts, and set and clear remote bits (see *Figure C.4*).

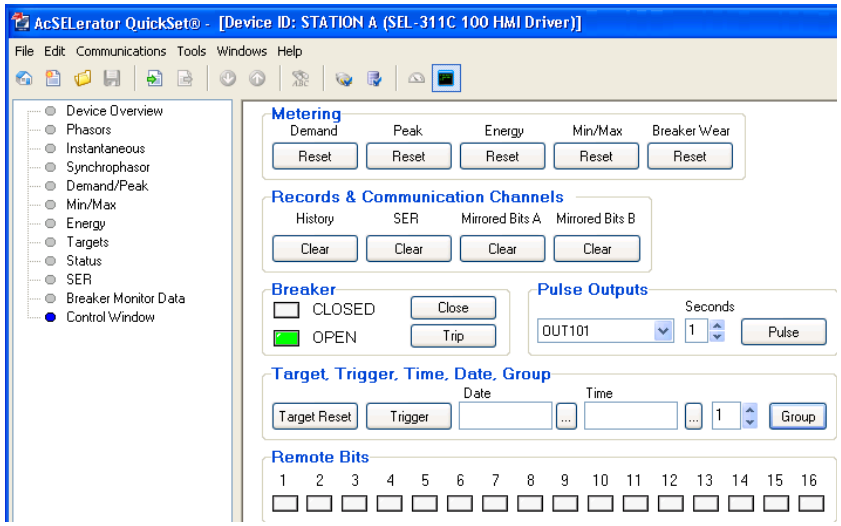


Figure C.4 Control Window

Other HMI Branches

The remaining HMI branches display metering, targets, status, reporting, and monitoring information.

HMI Configurations

Customized **Device Overviews** can be saved as HMI Configurations. To save the current configuration, select **Tools > HMI > Save Configuration** to save the configuration under the current name, or **Tools > HMI > Save Configuration As** to specify a configuration name.

HMI configurations are identified by relay type and a configuration name. To use an existing configuration, select **Tools > HMI > Select Configuration**. To view available configurations, select **Tools > HMI > Manage Configurations**. To make an existing configuration the default configuration for a given relay type, select the configuration in the **Manage Configurations** window, select **Edit**, and select the **Default** check box.

ACSELERATOR QuickSet Settings

ACSELERATOR QuickSet provides the ability to create settings for many relays, or download and store settings from existing relays (see *Database Manager on page C.20*). You can then modify and upload these settings from the settings library to a relay.

SEL provides ACSELERATOR QuickSet for easier, more efficient configuration of relay settings. However, you do not have to use ACSELERATOR QuickSet to configure relays; you can use an ASCII terminal or a computer running terminal emulation software. ACSELERATOR QuickSet provides the advantages of rules-based settings checks, SELOGIC® Control Equation Expression Builder, event analysis, and help.

File Menu

ACSELERATOR QuickSet uses a database to store and manage SEL device settings. Each unique device has its own record of settings. Use the **Settings** menu to create **New** settings, to **Open** an existing record, and **Read** device settings.

File > New

To get started creating relay settings, select **File** > **New** from the main menu. ACSELERATOR QuickSet will display the **Settings Editor Section** window as shown in *Figure C.5*. Select SEL-311 from the **Device Family** menu, and the appropriate model (for example, SEL-311C-1 Transmission Protection System) from the **Device Model** menu. Finally, select the Z-number from the **Versions** menu. Click **OK**.

If the device family, device model, or version for the relay are not present, select **Install Devices** and follow the on-screen instructions to add the appropriate drivers.

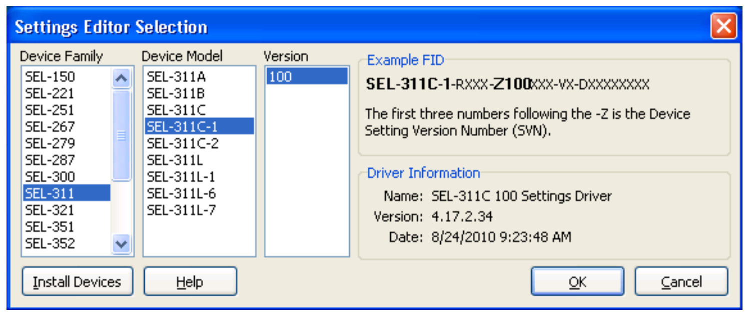


Figure C.5 Settings Editor Selection

NOTE: Fields marked with * in the **Device Part Number** dialog box are of no consequence to the ACSELERATOR QuickSet rules-based editor.

After the relay model and settings driver are selected, ACSELERATOR QuickSet presents the **Device Part Number** dialog box (shown in *Figure C.6*). Use the drop-down menus within the **Device Part Number** dialog box to select the part number of the relay. Click **OK**.

View the bottom of the **Settings Editor** window to check the **Settings Driver** number (see *Figure C.7*). Compare the ACSELERATOR QuickSet driver number and the first portion of the Z-number in the FID string. These numbers must match. ACSELERATOR QuickSet uses this first portion of the Z-number to determine the correct **Settings Editor** to display.

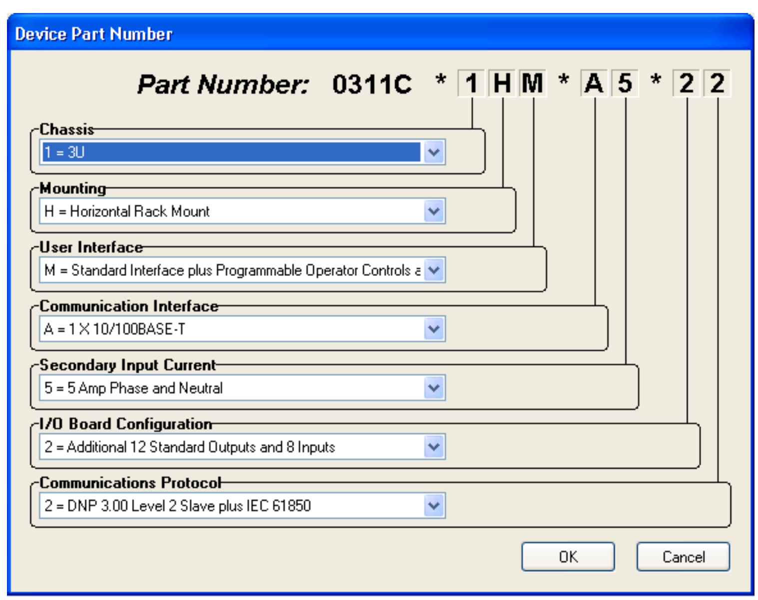


Figure C.6 Setting the Part Number

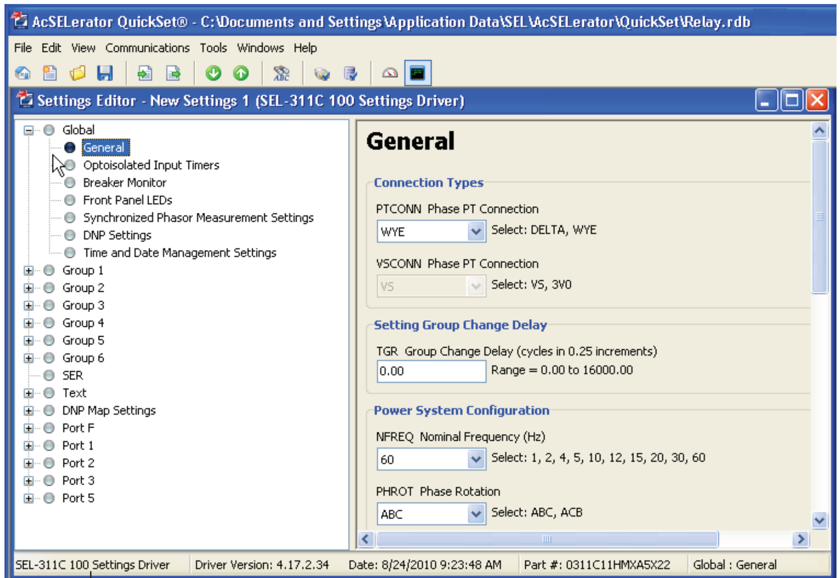


Figure C.7 Settings Driver

File > Open

The **Open** menu item opens existing relay settings from the active database folder (see *Figure C.8*). ACSELERATOR QuickSet displays the **Select Settings to Open** window and prompts for a device to load into the **Settings Editor**. The **Show settings with design templates** and **Show settings without design** templates check boxes allow settings with or without SEL-5031 Design Templates to be included in or excluded from the **Select Settings to Open** window.

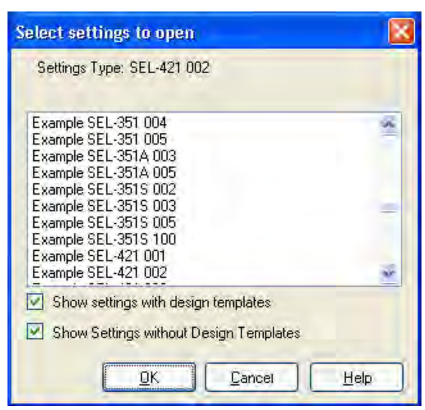


Figure C.8 Opening Settings

Highlight the relay settings to be opened and click **OK**.

File > Read

When the **Read** menu item is selected, ACSELERATOR QuickSet displays the **Settings Group/Class Select** window (see *Figure C.9*). Select the check boxes to specify which settings groups or classes are to be read from the connected device. Click **OK**. Note that settings not read from the device will be populated with the default settings. As ACSELERATOR QuickSet reads the device, a **Transfer Status** window appears.

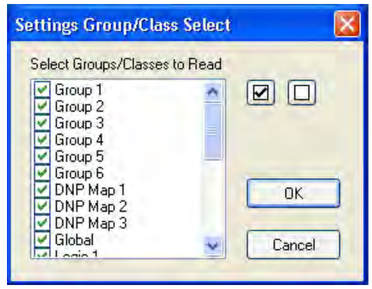


Figure C.9 Reading Settings

Device Editor

The SEL-311C settings structure makes setting the relay easy and efficient. Settings are grouped logically, and relay elements that are not used in the selected protection scheme are not visible. For example, if settings are entered using the **SET** command and only three levels of a particular type of overcurrent protection are enabled, the Level 4, Level 5, and Level 6 overcurrent element settings do not appear on the communications terminal screen. Hiding unused elements and settings that are not enabled greatly simplifies the task of setting the relay.

ACSELERATOR QuickSet uses a similar method to focus attention on the active settings. Unused relay elements and inactive settings are dimmed (grayed) in the ACSELERATOR QuickSet menus.

ACSELERATOR QuickSet shows all of the settings categories in the settings tree view. The settings tree view does not change when settings categories are enabled or disabled. However, any disabled settings are dimmed. *Figure C.10* illustrates this feature of ACSELERATOR QuickSet.

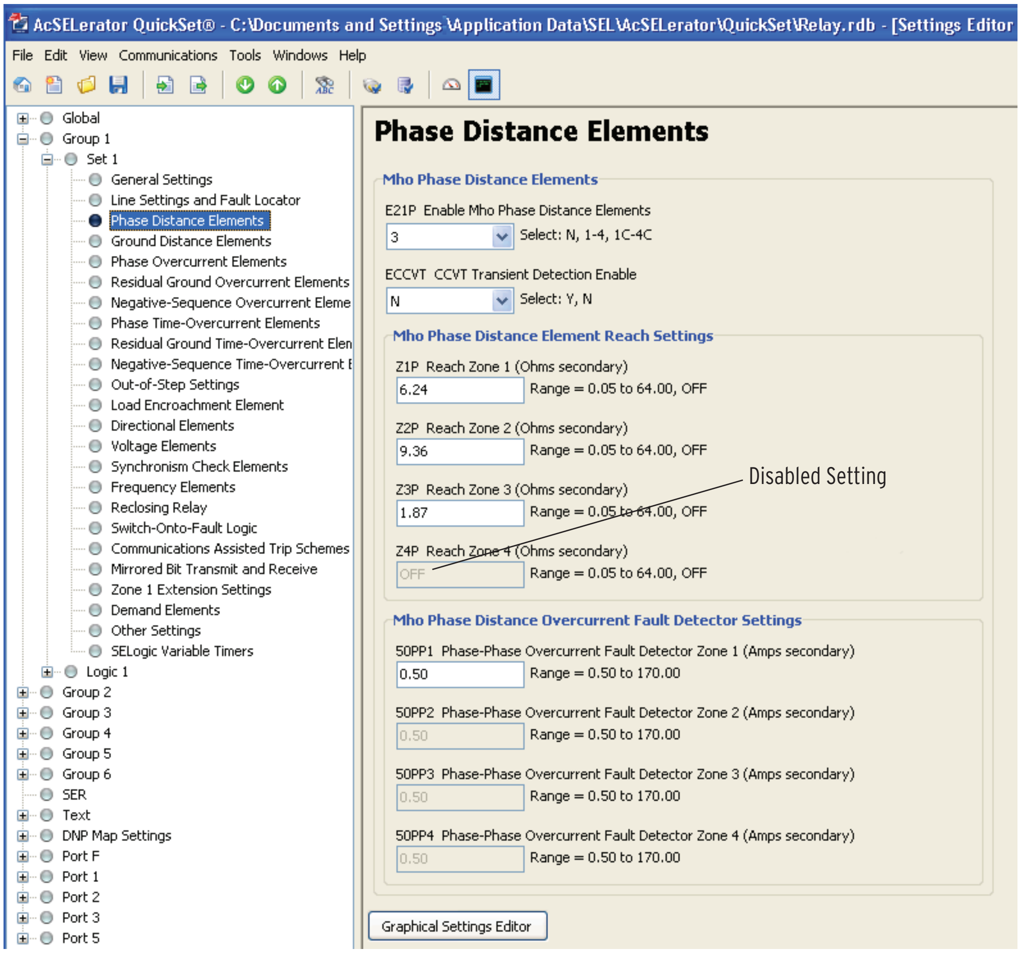


Figure C.10 Relay Editor

Entering Settings

Click the + marks and the buttons in the Settings Tree View to expand and select the settings you want to change. Use the **Tab** key to navigate through the settings, or click on a setting.

To restore the previous value for a setting, right-click the mouse over the setting and select **Previous Value**. To restore the factory default setting value, right-click in the setting dialog box and select **Default Value**.

If you enter a setting that is out of range or has an error, ACSELERATOR QuickSet shows the error at the bottom of the **Settings Editor**. Double-click the error listing to go to the setting to enter a valid input.

Expression Builder

SELOGIC control equations are a powerful means for customizing relay operation. ACSELERATOR QuickSet simplifies this process with the Expression Builder, a rules-based editor for programming SELOGIC control equations. The Expression Builder organizes relay elements and SELOGIC control equation variables and focuses equation decision-making.

Access the Expression Builder

Click the ellipsis button to the right of each logic setting in the Settings Editor window to start the Expression Builder (see *Figure C.11*).

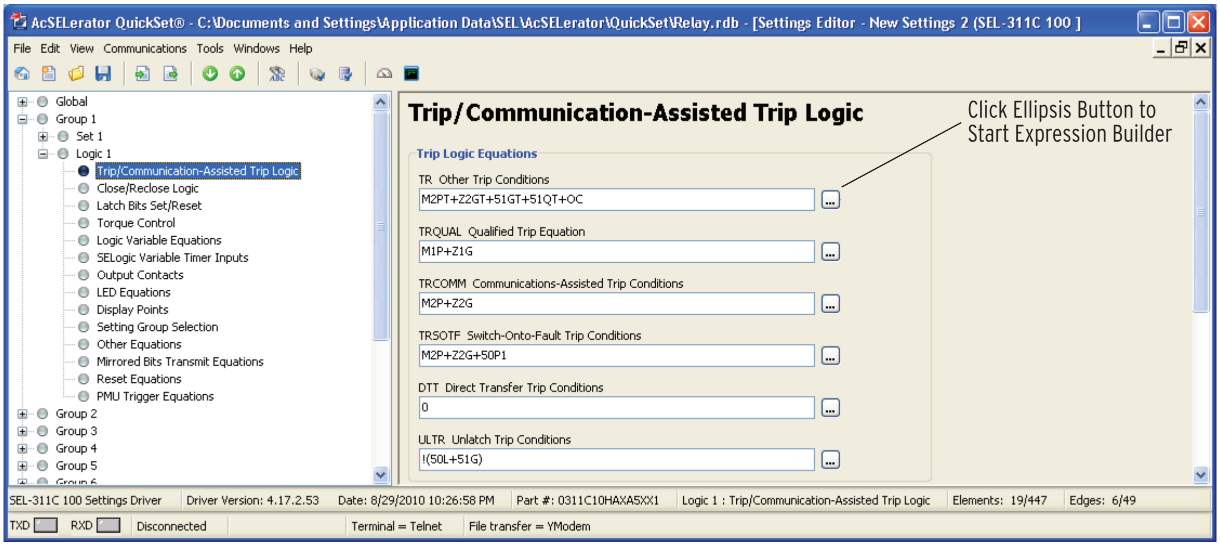


Figure C.11 Settings Editor Window

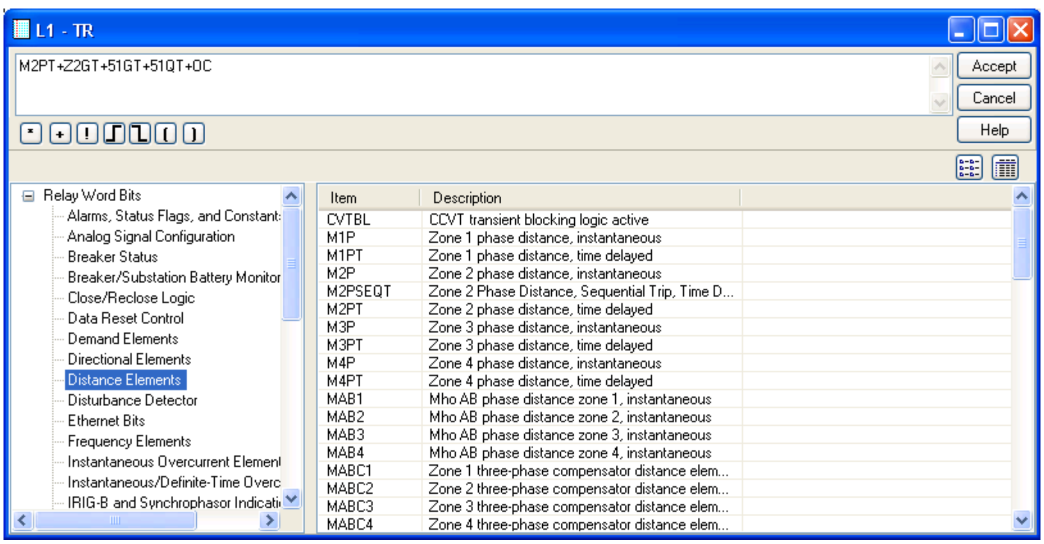


Figure C.12 Expression Builder

Using the Expression Builder

SELOGIC equations can be built from a list of Relay Word bits. Select the + for Relay Word bits in the lower left box of the Expression Builder to expand the Relay Word bit tree. Relay Word bits are arranged in categories. Select the individual categories to view the associated Relay Word bits within the lower right box of the Expression builder. Double-click a Relay Word bit to place it in the equation box at the top of the Expression Builder. Single-click the SELOGIC operators below the equation box to add operators to the equation. Equations may also be typed directly in the equation box. Click **Accept** to exit the Expression Builder and save the equation, or **Cancel** to exit without saving.

For more information on programming SELOGIC control equations, see *Appendix F: Setting SELOGIC Control Equations*.

File > Save

Select **Save** or **Save As...** from the **File** menu once settings are entered into ACSELERATOR QuickSet. This will help ensure the settings are not lost.

File > Send

Select the **Send** menu item from the **File** menu to send the settings to a connected device. Select which setting group you wish to send and click **OK**.

Edit Menu

The Edit menu includes selections that aid in the creation and viewing of settings.

Edit > Copy

Use this menu item to copy group (set and logic) settings.

Edit > Search

Use this menu item to search for a particular setting or Relay Word bit.

Edit > Compare

Use this menu item to compare the open record with another record.

Edit > Merge

Use this menu item to merge the open record with another record.

Edit > Part Number

Use this menu item to change the part number if it was entered incorrectly during an earlier step.

Tools Menu

The **Tools** menu provides access to the HMI menus (see *ACSELERATOR QuickSet HMI on page C.6*), to event analysis tools (see *ACSELERATOR QuickSet Event Analysis on page C.15*), and to Settings Conversion and Options menus.

Tools > Settings > Convert

Use the **Tools > Settings > Convert** menu item to convert from one settings version to another. Typically this utility is used to upgrade an existing settings file to a newer version when installed relays have a newer setting version number. In all settings conversions, settings which are new in the latest settings version are populated with the default settings unless otherwise indicated in this section. ACSELERATOR QuickSet provides a **Convert Settings** report that shows missed, changed, and invalid settings created as a result of the conversion. Review this report to determine whether changes are required.

See *Special Settings Conversion Considerations on page C.22* for additional information about converting settings for relays with firmware prior to R500 to settings for firmware R500 and higher.

Updating ACSELERATOR QuickSet

The ACSELERATOR QuickSet software consists of a core application plus driver files for individual devices. As new device firmware versions are released, you may need to update ACSELERATOR QuickSet to add new driver files. This may be accomplished several ways:

- When **Enable Update Notifications** is checked in the **Tools > Options** menu of SEL Compass, the Compass software will automatically check for updates on a specified schedule and facilitate the update process.

- The **Update** icon on the ACSELERATOR QuickSet startup screen starts SEL Compass and checks for updates.
- The **Install Devices** button on the Settings Editor Selection window starts SEL Compass and presents a menu of available drivers.
- **Check for updates…** in the **Help** menu starts SEL Compass and checks for updates.

An internet connection is required to add new drivers and to receive update notifications.

ACSELERATOR QuickSet Event Analysis

ACSELERATOR QuickSet has integrated analysis tools that help you retrieve information about protection system operations quickly and easily. Use the protection system event information that relays store to evaluate the performance of a protection system.

Event Waveforms

Relays record power system events for all trip situations and for other operating conditions programmed with SELOGIC control equations (see *Section 12: Standard Event Reports and SER*).

The relays provide two types of event data captures:

- event report oscillography that uses filtered sample per cycle data
- unfiltered (raw) data

See *Section 12: Standard Event Reports and SER* for information on recording events. Use ACSELERATOR QuickSet to view event report oscillograms, phasor diagrams, harmonic analysis, and settings.

Read History

You can retrieve event files stored in the relay and transfer these files to a computer. To download event files from the relay, open the ACSELERATOR QuickSet **Tools > Events** menu on the ACSELERATOR QuickSet toolbar and click **Get Event Files**. The **Event History** dialog box will appear (similar to *Figure C.13*).

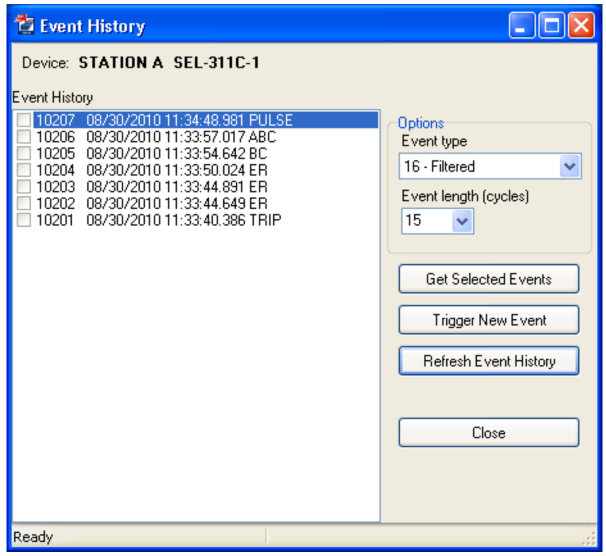


Figure C.13 Retrieving an Event History

Get Event

Highlight the event you want to view and click the **Get Selected Event** button. The **Event Options** dialog box allows selection of Event Type and Event Length. When downloading is complete, ACSELERATOR QuickSet asks for a location to save the file on your computer. Select **Tools** > **Events**> **View Event Files** and select an event file to view events saved on your computer. ACSELERATOR QuickSet displays the **Event Waveform** dialog box and the event oscillogram (see *Figure C.14* and *Figure C.15*).

When viewing the event oscillogram, use keyboard function keys to measure the time of oscillogram occurrences. These function keys and related functions help in event analysis.

- <**F2**>: go to trigger
- <**F3**>: Cursor 1
- <**F4**>: Cursor 2

The display shows the time difference between Cursor 1 and Cursor 2.

To see high-accuracy time-stamp information on the event oscillogram, click the **Pref** button at the bottom of the oscillogram and select **Time** (under **Time Units, Starting/Ending Row**); click **OK**. Click on any point in a graph to observe the **Event Time** in microseconds of that data point at the bottom of the oscillogram.

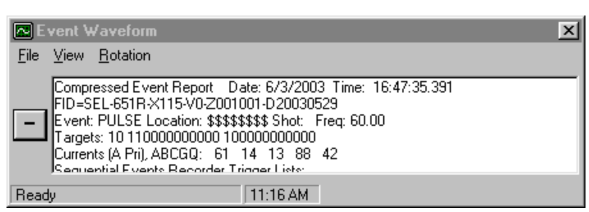


Figure C.14 Event Waveform Window

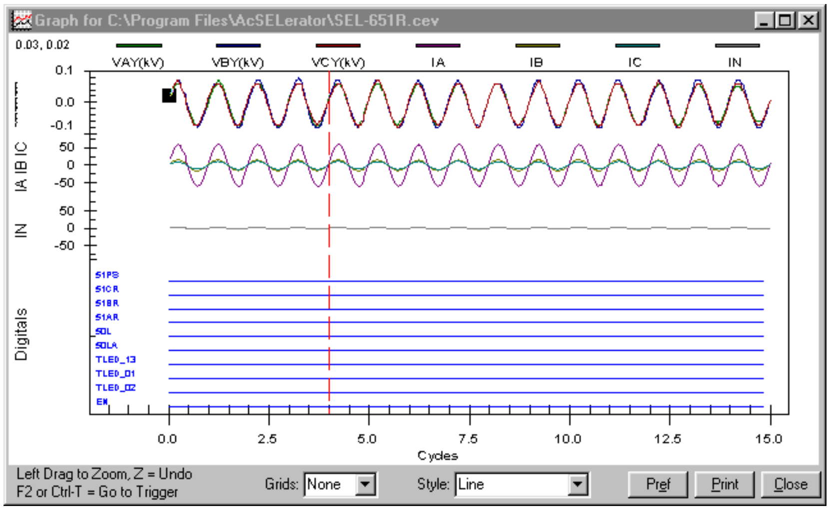


Figure C.15 Sample Event Oscillogram

Other event displays are available through the **Event Waveform** dialog box. Select the **View** menu and click **Phasors**, as shown in *Figure C.16*, to view a sample-by-sample phasor display. The phasor display should be similar to *Figure C.17*.

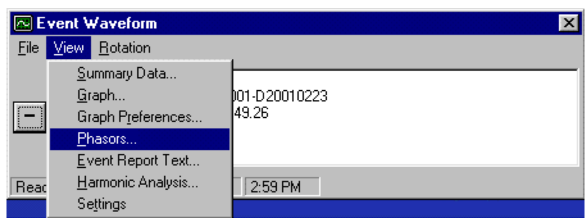


Figure C.16 Retrieving Event Report Waveforms

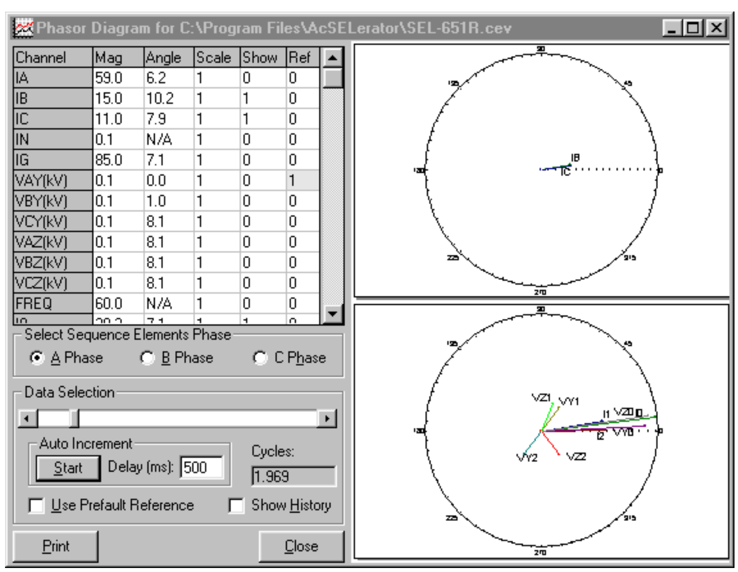


Figure C.17 Sample Phasors Event Waveform Screen

ACSELERATOR QuickSet also presents a harmonic analysis of power system data for raw data event captures. From the **View** menu, click **Harmonic Analysis**. The window will be similar to *Figure C.18*. On the left side of the

Harmonic Analysis screen, choose the relay voltage and current channels to monitor for harmonic content. Click the arrows of the **Data Scroll** box or the **# Cycles** box to change the data analysis range.

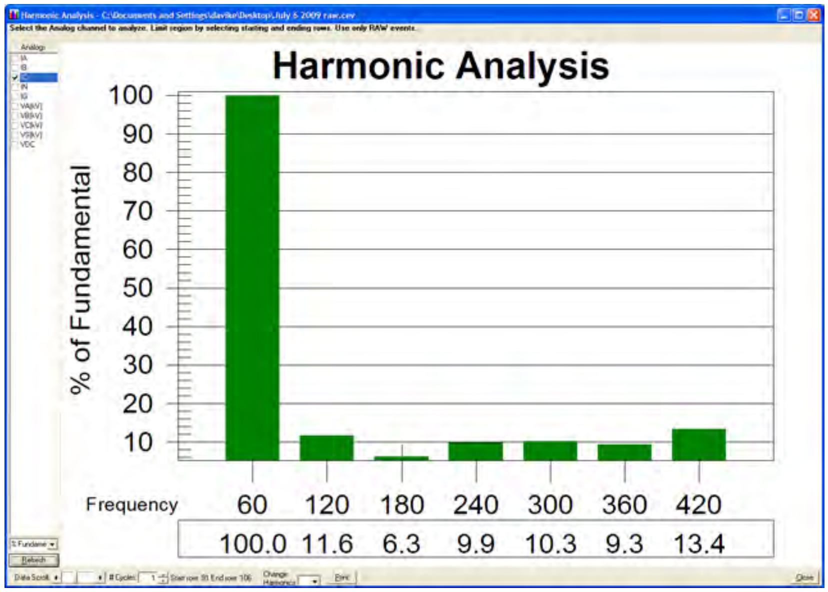


Figure C.18 Sample Harmonic Analysis Event Waveform Screen

Click **Summary Data** on the **View** menu to see event summary information and to confirm that you are viewing the correct event. *Figure C.19* shows a sample ACSELERATOR QuickSet **Event Report Summary** screen.

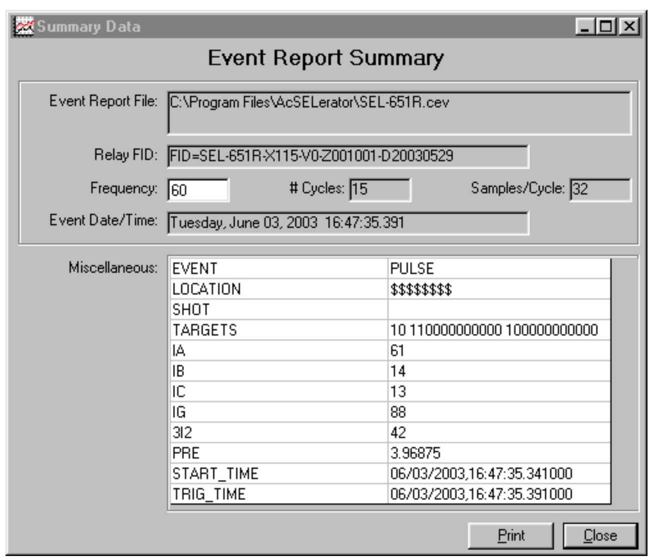


Figure C.19 Sample Event Report Summary Screen

Click **Relay Settings** on the **View** menu to view the relay settings that were active at the time of the event. *Figure C.20* shows a sample CEV-type event **Settings** screen.

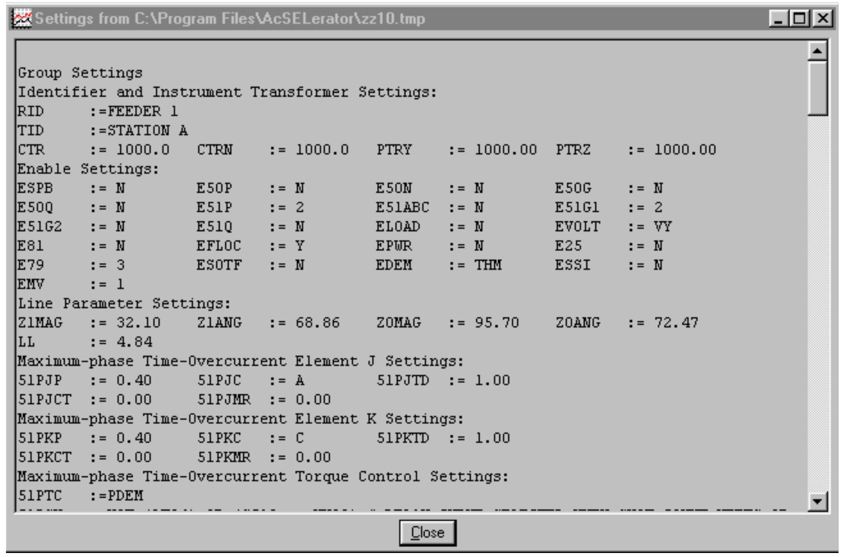


Figure C.20 Sample Event Waveform Settings Screen

ACSELERATOR QuickSet Settings Database Management

ACSELERATOR QuickSet uses a database to save device settings. ACSELERATOR QuickSet contains sets of all settings files for each device specified in the **Database Manager**. Choose appropriate storage backup methods and a secure location for storing database files.

Active Database

Change the active database to the one that needs to be modified by selecting **File > Active Database** on the main menu bar.

Database Manager

Select **File > Database Manager** on the main menu bar to create new databases and manage records within existing databases.

Relay Database

Open the **Database Manager** to access the database by clicking **File** > **Database Manager**. A dialog box similar to *Figure C.21* appears.

The default database file already configured in ACSELERATOR QuickSet is **Relay.rdb**. Enter descriptions for the database and for each relay in the database in the **Database Description** and **Relay Description** dialog boxes.

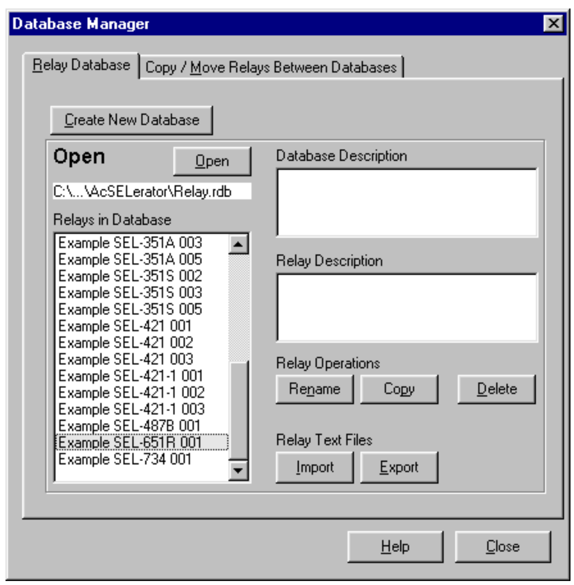


Figure C.21 Database Manager

Highlight one of the devices listed in **Relays in Database** and select the **Copy** button to create a new collection of settings. ACSELERATOR QuickSet prompts for a new name. Be sure to enter a new description in **Relay Description**.

Copy/Move Relays Between Databases

Select the **Copy/Move Relays Between Databases** tab to create multiple databases with the **Database Manager**; these databases are useful for grouping similar protection schemes or geographic areas. The dialog box is shown in *Figure C.22*. Click the **Open B** option button to open a database. Type a filename and click **Open**; for example, Relay2.rdb is the **B** relay in *Figure C.22*.

Highlight a relay setting in the **A** database, select **Copy** or **Move**, and click the “>” button to create a new relay setting in the **B** database. Reverse this process to take relay settings from the **B** database to the **A** database. **Copy** creates identical relay settings that appear in both databases. **Move** removes the relay settings from one database and places the settings in another database.

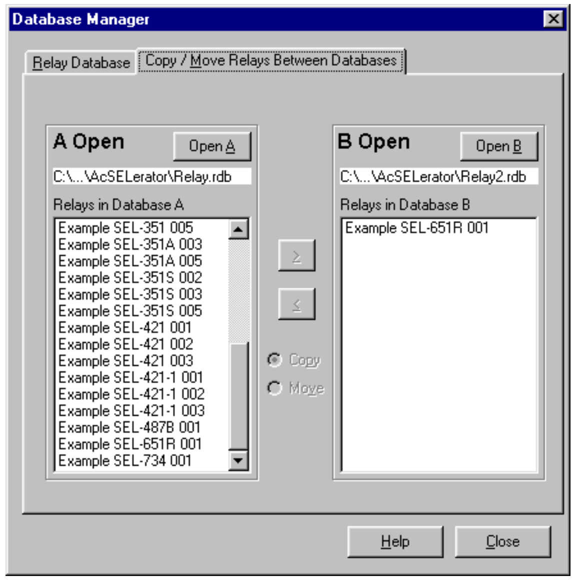


Figure C.22 Database Manager Copy/Move

Create a New Database

To create and copy an existing database of relays to a new database, click **File > Database Manager** and select the **Copy / Move Relays Between Databases** tab on the **Database Manager** dialog box. ACSELERATOR QuickSet opens the last active database and assigns it as Database **A** (as shown in *Figure C.22*).

Click the **Open B** button; ACSELERATOR QuickSet prompts you for a file location. Type a new database name, click the **Open** button, and answer **Yes**; the program creates a new empty database. Load relay settings into the new database as in **Copy /Move Relays Between Databases**.

ACSELERATOR QuickSet Help

Various forms of ACSELERATOR QuickSet help are available as shown in *Table C.5*. Press **<F1>** to open a context-sensitive help file with the appropriate topic as the default. Other ways to access help are shown in *Table C.5*.

Table C.5 Help (Sheet 1 of 2)

Help	Description
General ACSELERATOR QuickSet	Select **Help > Contents** from the main menu bar.
HMI Application	Select **Help > HMI Help** from the main menu bar.
Relay Settings	Select **Help > Settings Help** from the from the main menu bar.

Table C.5 Help (Sheet 2 of 2)

Help	Description
Database Manager	Select **Help** from the bottom of the **Database Manager** window.
Communications Parameters	Select **Help** from the bottom of the **Communications Parameters** window.

Special Settings Conversion Considerations

SEL-311C relays with firmware revisions prior to R500 and relays with firmware R500 and higher have very similar settings. ACSELERATOR QuickSet automatically converts most of the settings from the earlier relays, but due to enhancements in R500 and higher revisions, a few settings need to be converted manually. The following detailed instructions explain how to perform this conversion. Throughout these instructions, the settings for SEL-311C relays with firmware revisions prior to R500 are called the existing settings, and settings for SEL-311C relays with firmware R500 and higher are called the new settings.

DNP Settings Conversion

a. **DNP Map Settings > DNP Analog Map** in the existing settings file. Be sure to record the indices in the order in which they appear in the settings.

b. Locate each index in the Index (for firmware prior to R500) column of *Table L.10*.

c. Record the Label that corresponds to each index.

d. Open the new setting file and select **DNP Map *n* > Analog Input Map**, where **DNP Map *n*** is one of the three DNP Maps available.

e. Find the labels of the analog quantities recorded in *Step c* in the Available Elements column, and use the arrow buttons to copy these quantities into the Mapped Elements column. Use the up and down arrows to place the elements in the same order as in the existing setting file.

f. Print or record the binary input indices from **DNP Map Settings > DNP Binary Map** in the existing settings file. Be sure to record the indices in the order in which they appear in the settings.

g. Locate each index in the Index (for firmware prior to R500) column of *Table L.10* and record the Label that corresponds to each index. For indices with labels from the Relay Word, find each index in *Table C.6* and record the associated Relay Word bit.

Table C.6 Relay Word Bits and DNP Indices (Firmware Prior to R500) (Sheet 1 of 4)

Row	Relay Word Bits With Associated Indices															
0	TLED11		TLED12		TLED13		TLED14		TLED15		TLED16		TLED17		TLED18	
	7	507	6	506	5	505	4	504	3	503	2	502	1	501	0	500
1	TLED19		TLED20		TLED21		TLED22		TLED23		TLED24		TLED25		TLED26	
	15	515	14	514	13	513	12	512	11	511	10	510	9	509	8	508

Table C.6 Relay Word Bits and DNP Indices (Firmware Prior to R500) (Sheet 2 of 4)

Row	Relay Word Bits With Associated Indices							
2	M1P 23 523	M1PT 22 522	Z1G 21 521	Z1GT 20 520	M2P 19 519	M2PT 18 518	Z2G 17 517	Z2GT 16 516
3	Z1T 31 531	Z2T 30 530	50P1 29 529	67P1 28 528	67P1T 27 527	50G1 26 526	67G1 25 525	67G1T 24 524
4	51G 39 539	51GT 38 538	51GR 37 537	LOP 36 536	ILOP 35 535	ZLOAD 34 534	ZLOUT 33 533	ZLIN 32 532
5	LB1 47 547	LB2 46 546	LB3 45 545	LB4 44 544	LB5 43 543	LB6 42 542	LB7 41 541	LB8 40 540
6	LB9 55 555	LB10 54 554	LB11 53 553	LB12 52 552	LB13 51 551	LB14 50 550	LB15 49 549	LB16 48 548
7	RB1 63 563	RB2 62 562	RB3 61 561	RB4 60 560	RB5 59 559	RB6 58 558	RB7 57 557	RB8 56 556
8	RB9 71 571	RB10 70 570	RB11 69 569	RB12 68 568	RB13 67 567	RB14 66 566	RB15 65 565	RB16 64 564
9	LT1 79 579	LT2 78 578	LT3 77 577	LT4 76 576	LT5 75 575	LT6 74 574	LT7 73 573	LT8 72 572
10	LT9 87 587	LT10 86 586	LT11 85 585	LT12 84 584	LT13 83 583	LT14 82 582	LT15 81 581	LT16 80 580
11	SV1 95 595	SV2 94 594	SV3 93 593	SV4 92 592	SV1T 91 591	SV2T 90 590	SV3T 89 589	SV4T 88 588
12	SV5 103 603	SV6 102 602	SV7 101 601	SV8 100 600	SV5T 99 599	SV6T 98 598	SV7T 97 597	SV8T 96 596
13	SV9 111 611	SV10 110 610	SV11 109 609	SV12 108 608	SV9T 107 607	SV10T 106 606	SV11T 105 605	SV12T 104 604
14	SV13 119 619	SV14 118 618	SV15 117 617	SV16 116 616	SV13T 115 615	SV14T 114 614	SV15T 113 613	SV16T 112 612
15	MAB1 127 627	MBC1 126 626	MCA1 125 625	MAB2 124 624	MBC2 123 623	MCA2 122 622	CVTBL 121 621	SOTFT 120 620
16	MAG1 135 635	MBG1 134 634	MCG1 133 633	MAG2 132 632	MBG2 131 631	MCG2 130 630	DCHI 129 629	DCLO 128 628
17	BCW 143 643	BCWA 142 642	BCWB 141 641	BCWC 140 640	FIDEN 139 639	FSA 138 638	FSB 137 637	FSC 136 636
18	SG1 151 651	SG2 150 650	SG3 149 649	SG4 148 648	SG5 147 647	SG6 146 646	OC 145 645	CC 144 644
19	CLOSE 159 659	CF 158 658	TRGTR 157 657	52A 156 656	3PO 155 655	SOTFT 154 654	VPOLV 153 653	50L 152 652
20	PDEM 167 667	GDEM 166 666	QDEM 165 665	TRIP 164 664	50QF 163 663	50QR 162 662	50GF 161 661	50GR 160 660
21	32QF 175 675	32QR 174 674	32GF 173 673	32GR 172 672	32VE 171 671	32QGE 170 670	32IE 169 669	32QE 168 668

Table C.6 Relay Word Bits and DNP Indices (Firmware Prior to R500) (Sheet 3 of 4)

Row	Relay Word Bits With Associated Indices							
22	F32I	R32I	F32Q	R32Q	F32QG	R32QG	F32V	R32V
	183 683	182 682	181 681	180 680	179 679	178 678	177 677	176 676
23	*	*	IN106	IN105	IN104	IN103	IN102	IN101
	191 691	190 690	189 689	188 688	187 687	186 686	185 685	184 684
24	ALARM	OUT107	OUT106	OUT105	OUT104	OUT103	OUT102	OUT101
	199 699	198 698	197 697	196 696	195 695	194 694	193 693	192 692
25	M3P	M3PT	Z3G	Z3GT	M4P	M4PT	Z4G	Z4GT
	207 707	206 706	205 705	204 704	203 703	202 702	201 701	200 700
26	Z3T	Z4T	50P2	67P2	67P2T	50P3	67P3	67P3T
	215 715	214 714	213 713	212 712	211 711	210 710	209 709	208 708
27	50G2	67G2	67G2T	50G3	67G3	67G3T		
	223 723	222 722	221 721	220 720	219 719	218 718	217 717	216 716
28	51	51PT	51PR	Z1X	59VA	MAB3	MBC3	MCA3
	231 731	230 730	229 729	228 728	227 727	226 726	225 725	224 724
29	MAG3	MBG3	MCG3	27S	59S	*	59VP	59VS
	239 739	238 738	237 737	236 736	235 735	234 734	233 733	232 732
30	SF	25A1	25A2	RCSF	OPTMN	RSTMN	*	PMDOK
	247 747	246 746	245 745	244 744	243 743	242 742	241 741	240 740
31	79RS	79CY	79LO	SH0	SH1	SH2	SH3	SH4
	255 755	254 754	253 753	252 752	251 751	250 750	249 749	248 748
32	MAB4	MBC4	MCA4	MAG4	MBG4	MCG4	TSOK	TIRIG
	263 763	262 762	261 761	260 760	259 759	258 758	257 757	256 756
33	XAG1	XBG1	XCG1	XAG2	XBG2	XCG2	XAG3	XBG3
	271 771	270 770	269 769	268 768	267 767	266 766	265 765	264 764
34	XCG3	XAG4	XBG4	XCG4	OSTI	OSTO	OST	50ABC
	279 779	278 778	277 777	276 776	275 775	274 774	273 773	272 772
35	X5ABC	X6ABC	OSB	OSB1	OSB2	OSB3	OSB4	UBOSB
	287 787	286 786	285 785	284 784	283 783	282 782	281 781	280 780
36	50G4	67G4	67G4T	*	MPP1	MABC1	MPP2	MABC2
	295 795	294 794	293 793	292 792	291 791	290 790	289 789	288 788
37	50Q1	67Q1	67Q1T	50Q2	67Q2	67Q2T	59N1	59N2
	303 803	302 802	301 801	300 800	299 799	298 798	297 797	296 796
38	50Q3	67Q3	67Q3T	50Q4	67Q4	67Q4T	59Q	59V1
	311 811	310 810	309 809	308 808	307 807	306 806	305 805	304 804
39	51Q	51QT	51QR	*	*	Z2PGS	67QG2S	BTX
	319 819	318 818	317 817	316 816	315 815	314 814	313 813	312 812
40	Z3XT	DSTRT	NSTRT	STOP	Z3RB	KEY	EKEY	ECTT
	327 827	326 826	325 825	324 824	323 823	322 822	321 821	320 820
41	PTRX	UBB1	UBB2	UBB	WFC	PT	PTRX1	PTRX2
	335 835	334 834	333 833	332 832	331 831	330 830	329 829	328 828

Table C.6 Relay Word Bits and DNP Indices (Firmware Prior to R500) (Sheet 4 of 4)

Row	Relay Word Bits With Associated Indices							
42	27A	27B	27C	59A	59B	59C	3P27	3P59
	343 843	342 842	341 841	340 840	339 839	338 838	337 837	336 836
43	27AB	27BC	27CA	59AB	59BC	59CA	LOPFDP	LOPFD
	351 851	350 850	349 849	348 848	347 847	346 846	345 845	344 844
44	OUT201	OUT202	OUT203	OUT204	OUT205	OUT206	OUT207	OUT208
	359 859	358 858	357 857	356 856	355 855	354 854	353 853	352 852
45	OUT209	OUT210	OUT211	OUT212	MPP3	MABC3	MPP4	MABC4
	367 867	366 866	365 865	364 864	363 863	362 862	361 861	360 860
46	IN208	IN207	IN206	IN205	IN204	IN203	IN202	IN201
	375 875	374 874	373 873	372 872	371 871	370 870	369 869	368 868
47	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
	383 883	382 882	381 881	380 880	379 879	378 878	377 877	376 876
48	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
	391 891	390 890	389 889	388 888	387 887	386 886	385 885	384 884
49	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
	399 899	398 898	397 897	396 896	395 895	394 894	393 893	392 892
50	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B
	407 907	406 906	405 905	404 904	403 903	402 902	401 901	400 900
51	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
	415 915	414 914	413 913	412 912	411 911	410 910	409 909	408 908
52	81D1	81D2	81D3	81D4	81D5	81D6	27B81	LOPRST
	423 923	422 922	421 921	420 920	419 919	418 918	417 917	416 916
53	81D1T	81D2T	81D3T	81D4T	81D5T	81D6T		
	431 931	430 930	429 929	428 928	427 927	426 926	425 925	424 924

Each Relay Word bit has two associated indices, as shown in *Table C.6*. In order to retrieve SER-quality binary inputs, SEL-311C models prior to firmware R500 require mapping points within the range of indexes 500 – 999. Indices in the range 000–499 return the current state of the Relay Word bit. Indices in the range of 500 – 999 return data from the SER along with a time-stamp.

It is not necessary to specify a special index for SER-quality data for SEL-311C relays with firmware R500 or higher. If a Relay Word bit is included in the SER, it will automatically have an SER timestamp when the Relay Word bit is included as a label in the DNP Binary Input map.

h. Open the new setting file and select **DNP Map *n* > Binary Input Map**, where **DNP Map *n*** is one of the three DNP Maps available.

i. Find the labels of the binary quantities recorded in *Step g* in the Available Elements column, and use the arrow buttons to copy these quantities into the Mapped Elements column. Use the up and down arrows to place the elements in the same order as in the existing setting file.

j. In SEL-311C relays with firmware prior to R500, indices 1000–1015 are used for front panel targets. *Table C.7* shows the correspondence between the indices, the Legacy target name used in relays with firmware prior to R500, and the DNP Label used in firmware R500 and higher. Use the DNP Label in the Mapped Elements column of the DNP map.

Table C.7 DNP Labels for Legacy Target Indices

Row	Legacy Target	DNP Label	Legacy Target	DNP Label	Legacy Target	DNP Label	Legacy Target	DNP Label	Legacy Target	DNP Label	Legacy Target	DNP Label	Legacy Target	DNP Label	Legacy Target	DNP Label
0	EN	TLED11	TRP	TLED12	TIME	TLED13	COMM	TLED14	SOTF	TLED15	RCRS	TLED16	RCLO	TLED17	51	TLED18
	1007		1006		1005		1004		1003		1002		1001		1000	
1	A	TLED19	B	TLED20	C	TLED21	G	TLED22	ZONE1	TLED23	ZONE2	TLED24	ZONE3	TLED25	ZONE4	TLED26
	1015		1014		1013		1012		1011		1010		1009		1008	

See *DNP3 Settings on page L.9* for additional information.

5. If Port setting TIMERQ = 0 in the existing settings, ACSELERATOR QuickSet will indicate an error upon conversion, as 0 is no longer an allowed value for TIMERQ. TIMERQ is the time-set request interval, in minutes, and controls how often the relay requests the time from the Master. The values allowed in relays with firmware R500 and higher are:
   a. 1–32767= number of minutes between time sync requests
   b. M = disable time sync requests but still accept and apply time syncs from Master
   c. I = ignore time syncs from Master

   Set TIMERQ = I to achieve the same function provided by TIMERQ = 0 in the existing settings. See *DNP3 Settings on page L.9* for additional information.

6. In SEL-311C relays with firmware prior to R500, Port setting ECLASS assigns the event class for all DNP events.

   R500 and higher firmware revisions allow separate event classes to be assigned for binary, counter, and analog data, via Port settings ECLASSB, ECLASSC, and ECLASSA, respectively. Convert the event class settings as shown in *Table C.8*.

Table C.8 ECLASS Event Class Settings Conversion

Firmware prior to R500	R500 or higher firmware
ECLASS = *n*[a]	ECLASSB = *n*
	ECLASSC = *n*
	ECLASSA = *n*

[a] n is a setting (0, 1, 2, or 3) recorded from the existing settings.

See *DNP3 Settings on page L.9* for additional information.

7. In SEL-311C relays with firmware prior to R500, Port setting ANADB assigns the number of counts for deadband of all analog inputs.

   R500 and higher firmware revisions allow separate deadbands to be assigned for amps, volts, and miscellaneous analog values via settings ANADBA, ANADBV, and ANADBM respectively. Convert the event class settings as shown in *Table C.9*.

Table C.9 ANADB Event Class Settings Conversion

Firmware prior to R500	R500 or higher firmware
ANADB = *nnnnn*[a]	ANADBA = *nnnnn*
	ANADBV = *nnnnn*
	ANADBM = *nnnnn*

[a] nnnnn is the setting (1–32767) for ANADB recorded from the existing settings.

   DNP3 Settings on page L.9DNP3 Settings on page L.9 for additional information.

8. SEL-311C relays with firmware revisions prior to R500 use the UTIMEO setting to determine how long to wait for confirmation of an unsolicited message before sending the message again.

   In firmware R500 and higher, if the SEL-311C does not receive a confirmation in response to unsolicited data, it will wait for ETIMEO seconds and then repeat the unsolicited message. In order to prevent clogging of the network with unsolicited data retries, the SEL-311C uses the URETRY and UTIMEO settings to increase retry time when the number of retries set in URETRY is exceeded. After URETRY has been exceeded, the SEL-311C pauses UTIMEO seconds and then transmits the unsolicited data again. Thus, the function provided by UTIMEO in relays with firmware revisions prior to R500 is most closely matched by the new setting ETIMEO. To convert the settings, simply enter the value from UTIMEO in the existing settings into the ETIMEO setting field in the new settings. Setting UTIMEO in the new setting file can be left on the default value or modified as desired. See *DNP3 Settings on page L.9* for additional information.

Synchrophasor and Time Management Settings Conversion

1. SEL-311C relays with firmware revisions prior to R500 support SEL Fast Message synchrophasors. Relays with firmware revisions R500 and higher support IEEE C37.118 and SEL Fast Message synchrophasors. The protocol used is controlled by Global setting MFRMT. If Global setting EPMU = Y in the existing settings, ACSELERATOR QuickSet will set EPMU = Y in the new settings upon conversion. However, upon conversion, MFRMT = C37.118, which may not be compatible with the synchrophasor data collection system. To convert the setting, change the value of MFRMT to FM in the new setting file, or change the synchrophasor data collection system to accept IEEE C37.118 protocol. See *SEL-311C Fast Message Synchrophasor Settings on page N.22* for additional information.

2. SEL-311C relays with firmware revisions prior to R500 use Global setting TS_TYPE to determine if the connected IRIG-B signal contains time quality information defined by IEEE C37.118. In relays with firmware R500 and higher, this same function is provided by Global setting IRIGC.

   To convert the settings, if TS_TYPE = IRIG in the existing settings, make Global setting IRIGC = NONE in the new settings file. If TS_TYPE = IEEE in the existing settings, make Global setting IRIGC = C37.118 in the new settings file. See *Configuring High-Accuracy Timekeeping on page N.25* for additional information.

Other Settings

1. The SEL-311C can adjust the operation of synchronism check elements based on breaker closing time. In SEL-311C relays with firmware revisions prior to R500, setting TCLOSD = OFF disables breaker close time compensation. In relays with firmware R500 and higher, breaker close time compensation is disabled by setting TCLOSD = 0.
2. In SEL-311C relays with firmware revisions prior to R500, the following settings have minimum allowed value of 0.05 (5 A relays) or 0.25 (1 A relays): Z1ANG, Z0ANG, ZLF, and ZLR. In relays with firmware R500 and higher, the minimum allowed value for these settings is 0.1 (5 A relays) or 0.5 (1 A relays).
3. In SEL-311C relays with firmware revisions prior to R500, display point variables ;;;000 (or ;;;0), ;;;001 (or ;;;1), and ;;;002 (or ;;;2) may have been used to display the settings of time-overcurrent elements 51PP, 51GP, and 51QP on the LCD. In relays with firmware R500 and higher, these setting variables are replaced with ;;;003 for 51PP, ;;;004 for 51GP, and ;;;005 for 51QP.
4. In SEL-311C relays with firmware revisions prior to R500, display point variables IP, IPDEM, and IPPK may have been used to display polarizing input current, polarizing current demand, and polarizing current peak demand. In relays with firmware R500 and higher, these variables are replaced with IN, INDEM, and INPK.
5. In SEL-311C relays with firmware revisions prior to R500, display point variables CTRLTR and OPSCNTR may have been used to display the number of internal breaker trips. The two variables allowed the same information to be displayed in different formats. In relays with firmware R500 and higher, these setting variables are replaced with the single variable INTTR.
6. In SEL-311C relays with firmware revisions prior to R500, the values available for setting SYNCP are VA, VB, VC, VAB, VBC, and VCA. In relays with firmware R500 and higher, when PTCONN = WYE, the available values are VA, VB, VC, and 0–330 degrees in 30-degree increments. See *Setting SYNCP on page 3.54* for a discussion of numerical SYNCP settings.

Table C.10 contains a summary of these conversion rules.

7. SEL-311C relays with firmware revisions prior to R500 provide an Application setting, APP, which helps convert

settings from SEL-221 series relays. This setting is not available in relays with firmware R500 and higher. If APP is set to 311C in the existing settings, no special settings are required. If APP is set to one of the SEL-221 series setting, use the "Application Settings for SEL-221 Series Relays" section of the Legacy SEL-311C relay instruction manuals to convert SEL-221 series settings for use in SEL-311C relays. These same instructions list default logic equations which make SEL-311C relays behave like various SEL-221 series relays.

Summary of Settings Conversion Rules

Table C.10 Settings Conversion Rules (Sheet 1 of 2)

Existing Setting (Firmware prior to R500)	New Setting (Firmware R500 and higher)
Index-based DNP analog input map	Analog Labels from *Table L.10*
Index-based DNP binary input map	Binary Labels from *Table L.10* (use *Table C.6* to simplify conversion)
TIMERQ = 0	TIMERQ = I
ECLASS = *n*	ECLASSB = *n* ECLASSC = *n* ECLASSA = *n*
ANADB = *nnnnn*	ANADBA = *nnnnn* ANADBV = *nnnnn* ANADBM = *nnnnn*
NUMEVE = *nn*	NUM1EVE = *nn*
AGEEVE = *ss*	AGE1EVE = *ss*
UTIMEO = *ss*	ETIMEO = *ss*
EPMU = Y	EPMU = Y, MFRMT = FM
TS_TYPE = IRIG	IRIGC = NONE
TS_TYPE = IEEE	IRIGC = C37.118
TCLOSD = OFF	TCLOSD = 0
Display Point text setting DPn_0 or DPn_1 contains ;;;000 (or ;;;0)	Replace with ;;;003
Display Point text setting DPn_0 or DPn_1 contains ;;;001 (or ;;;1)	Replace with ;;;004
Display Point text setting DPn_0 or DPn_1 contains ;;;002 (or ;;;2)	Replace with ;;;005
Display Point text setting DPn_0 or DPn_1 contains IP	Replace with IN
Display Point text setting DPn_0 or DPn_1 contains IPDEM	Replace with INDEM
Display Point text setting DPn_0 or DPn_1 contains IPPK	Replace with INPK
Display Point text setting DPn_0 or DPn_1 contains CTRLTR	Replace with INTTR
Display Point text setting DPn_0 or DPn_1 contains OPSCNTR	Replace with INTTR
SYNCP = VAB, VBC, or VCA	See *Setting SYNCP on page 3.54*

Table C.10 Settings Conversion Rules (Sheet 2 of 2)

Existing Setting (Firmware prior to R500)	New Setting (Firmware R500 and higher)
APP = 311C	No special settings required.
APP = 221G, 221G5, 221H, 221F, 221F3, 221C, 221-16, or 2PG10	Use "Application Settings for SEL-221 Series Relays" in Legacy SEL-311C instruction manual to convert settings and program SELOGIC equations.

Appendix D
Relay Word Bits

Overview

Relay Word bits show the status of functions within the relay. The bits are available via communications protocols and the front panel.

Relay Word bits are used in SELOGIC control equation settings. Numerous SELOGIC control equation settings examples are given in *Section 3: Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements* through *Section 8: Metering and Monitoring*. SELOGIC control equation settings can also be *set directly* to 1 (logical 1) or 0 (logical 0). *Appendix F: Setting SELOGIC Control Equations* gives SELOGIC control equation details, examples, and limitations.

The Relay Word bit row numbers correspond to the row numbers used in the **TAR** command (see *TAR Command (Display Relay Element Status) on page 10.60*).

Table D.2 provides an alphanumeric listing of the Relay Word bits that includes a description of each bit.

Table D.1 and *Table D.2* include cross-reference information for most Relay Word bits. *Table D.3* describes Relay Word bits that are not described elsewhere in the manual.

Relay Word

Table D.1 Relay Word Bit Mapping (Sheet 1 of 5)

Row	Relay Word Bits[a]							
Front-Panel Target/Status LED Indication (see Section 5)								
0	TLED11	TLED12	TLED13	TLED14	TLED15	TLED16	TLED17	TLED18
1	TLED19	TLED20	TLED21	TLED22	TLED23	TLED24	TLED25	TLED26
Distance Elements, Instantaneous and Definite-Time Overcurrent Elements (see Section 3)								
2	M1P	M1PT	Z1G	Z1GT	M2P	M2PT	Z2G	Z2GT
3	Z1T	Z2T	50P1	67P1	67P1T	50G1	67G1	67G1T
Time-Overcurrent (See Section 3), Loss-of-Potential, and Load Encroachment (See Section 4)								
4	51G	51GT	51GR	LOP	ILOP	ZLOAD	ZLOUT	ZLIN
Local Bits, Remote Bits, and Latch Bits (see Section 7)								
5	LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8
6	LB9	LB10	LB11	LB12	LB13	LB14	LB15	LB16
7	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8

Table D.1 Relay Word Bit Mapping (Sheet 2 of 5)

Row	Relay Word Bits[a]							
8	RB9	RB10	RB11	RB12	RB13	RB14	RB15	RB16
9	LT1	LT2	LT3	LT4	LT5	LT6	LT7	LT8
10	LT9	LT10	LT11	LT12	LT13	LT14	LT15	LT16
SELogic Control Equation Variables/Timers (See Section 7)								
11	SV1	SV2	SV3	SV4	SV1T	SV2T	SV3T	SV4T
12	SV5	SV6	SV7	SV8	SV5T	SV6T	SV7T	SV8T
13	SV9	SV10	SV11	SV12	SV9T	SV10T	SV11T	SV12T
14	SV13	SV14	SV15	SV16	SV13T	SV14T	SV15T	SV16T
Distance Elements (see Section 3), CCVT transient logic (see Section 4), and Switch-onto-fault trip (see Section 5)								
15	MAB1	MBC1	MCA1	MAB2	MBC2	MCA2	CVTBL	SOTFT
Distance Elements (see Section 3) and Station Battery monitoring (see Section 8)								
16	MAG1	MBG1	MCG1	MAG2	MBG2	MCG2	DCHI	DCLO
Breaker Wear (see Section 8) and Fault Identification (see Section 5)								
17	BCW	BCWA	BCWB	BCWC	FIDEN	FSA	FSB	FSC
Setting Group Bits (see Section 7) and Breaker Operate Controls (see Section 5)								
18	SG1	SG2	SG3	SG4	SG5	SG6	OC	CC
Close/Reclose Logic (see Section 6), Trip/Target Logic (see Section 5), Breaker Status (see Section 6)								
19	CLOSE	CF	TRGTR	52A	3PO	SOTFE	VPOLV	50L
Demand Elements (see Section 8), Trip/Target Logic (see Section 5), and Directional Elements (see Section 4)								
20	PDEM	GDEM	QDEM	TRIP	50QF	50QR	50GF	50GR
Directional Elements (see Section 4)								
21	32QF	32QR	32GF	32GR	32VE	32QGE	32IE	32QE
22	F32I	R32I	F32Q	R32Q	F32QG	R32QG	F32V	R32V
Optoisolated Inputs (see Section 7)								
23	*	*	IN106	IN105	IN104	IN103	IN102	IN101
Output Contacts (see Section 7)								
24[b]	ALARM	OUT107	OUT106	OUT105	OUT104	OUT103	OUT102	OUT101
Distance Elements (see Section 3)								
25	M3P	M3PT	Z3G	Z3GT	M4P	M4PT	Z4G	Z4GT
Distance Elements, Instantaneous and Definite-Time Overcurrent Elements (see Section 3)								
26	Z3T	Z4T	50P2	67P2	67P2T	50P3	67P3	67P3T
27	50G2	67G2	67G2T	50G3	67G3	67G3T	*	*
Time-Overcurrent Elements, Distance Elements, and Synchronism Check Elements (see Section 3)								
28	51P	51PT	51PR	Z1X	59VA	MAB3	MBC3	MCA3
Distance Elements, Voltage Elements, and Synchronism Check Elements (see Section 3)								
29	MAG3	MBG3	MCG3	27S	59S	*	59VP	59VS
Synchronism Check Elements (see Section 3), Close/Reclose Logic (see Section 6) and IRIG-B/Synchrophasor Indication (see Appendix N)								
30	SF	25A1	25A2	RCSF	OPTMN	RSTMN	*	PMDOK
Close/Reclose Logic (see Section 6)								
31	79RS	79CY	79LO	SH0	SH1	SH2	SH3	SH4

Table D.1 Relay Word Bit Mapping (Sheet 3 of 5)

Row	Relay Word Bits[a]							
Distance Elements (see Section 3) and IRIG-B/Synchrophasor Indication (see Appendix N)								
32	MAB4	MBC4	MCA4	MAG4	MBG4	MCG4	TSOK	TIRIG
Distance Elements and Out of Step (see Section 3)								
33	XAG1	XBG1	XCG1	XAG2	XBG2	XCG2	XAG3	XBG3
34	XCG3	XAG4	XBG4	XCG4	OSTI	OSTO	OST	50ABC
35	X5ABC	X6ABC	OSB	OSB1	OSB2	OSB3	OSB4	UBOSB
Distance Elements, Instantaneous and Definite-Time Overcurrent Elements (see Section 3)								
36	50G4	67G4	67G4T	*	MPP1	MABC1	MPP2	MABC2
Voltage Elements, Instantaneous and Definite-Time Overcurrent Elements (see Section 3)								
37	50Q1	67Q1	67Q1T	50Q2	67Q2	67Q2T	59N1	59N2
38	50Q3	67Q3	67Q3T	50Q4	67Q4	67Q4T	59Q	59V1
Time Overcurrent Elements (see Section 3) and Communications-Assisted Trip Logic (see Section 5)								
39	51Q	51QT	51QR	*	*	Z2PGS	67QG2S	BTX
40	Z3XT	DSTRT	NSTRT	STOP	Z3RB	KEY	EKEY	ECTT
41	PTRX	UBB1	UBB2	UBB	WFC	PT	PTRX1	PTRX2
Voltage Elements (see Section 3)								
42	27A	27B	27C	59A	59B	59C	3P27	3P59
43	27AB	27BC	27CA	59AB	59BC	59CA	*	*
Extra I/O Board Output Contacts (see Section 7) and Distance Elements (see Section 3)								
44[b,c]	OUT201	OUT202	OUT203	OUT204	OUT205	OUT206	OUT207	OUT208
45[b,c]	OUT209	OUT210	OUT211	OUT212	MPP3	MABC3	MPP4	MABC4
Extra I/O Board Optoisolated Inputs (see Section 7)								
46[c]	IN208	IN207	IN206	IN205	IN204	IN203	IN202	IN201
Mirrored Bits (see Appendix H)								
47	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
48	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
49	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
50	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B
51	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
Frequency Elements (see Section 3)								
52	81D1	81D2	81D3	81D4	81D5	81D6	27B81	*
53	81D1T	81D2T	81D3T	81D4T	81D5T	81D6T	*	*
Instantaneous Overcurrent Elements (see Section 3)								
54	50A1	50B1	50C1	50A2	50B2	50C2	50A3	50B3
55	50C3	50A4	50B4	50C4	*	50A	50B	50C
Analog Configuration (see Section 9)								
56	*	*	*	*	*	3V0	DELTA	WYE
Instantaneous and Definite-Time Overcurrent Elements (see Section 3) and Analog Configuration (see Table D.3)								
57	50P4	67P4	67P4T	*	*	*	*	FREQOK

Table D.1 Relay Word Bit Mapping (Sheet 4 of 5)

Row	Relay Word Bits[a]							
Distance Elements (see Section 3) and Loss-of-Potential (Section 4)								
58	*	*	*	*	Z2SEQT	M2PSEQT	Z2GSEQT	*
59	Z1XP	Z1XG	*	*	*	*	*	DD
Ethernet Status (see Section 10)								
60	LINK5[d]	LINK5A[e]	LINK5B[e]	LNKFAIL	P5ASEL[e]	P5BSEL[e]	TSNTPP	TSNTPB
IRIG-B and Synchrophasor Indication (see Appendix N)								
61	DST	DSTP	LPSEC	LPSECP	TQUAL4	TQUAL3	TQUAL2	TQUAL1
Analog Scaling (see Table D.3), Demand (see Section 8), and TEST DB Indication (see Section 10)								
62	*	V0GAIN	INMET	ICMET	IBMET	IAMET	NDEM	TESTDB
Target Reset Control (see Section 5) and Metering Reset Control (see Section 8)								
63	*	RSTTRGT	RST_MML	RST_ENE	RST_HIS	RST_BK	RST_PDM	RST_DEM
Synchronism Check Elements (see Section 3), LOP (see Section 4), and PMU Trigger Status (see Appendix N)								
64	SFAST	SSLOW	LOPRST	PMTRIG	TREA1	TREA2	TREA3	TREA4
Loss-of-Potential Logic (see Section 4)								
65	LOP1	LOP2	LOP3	LOP4	*	*	*	*
Reserved for Future Expansion								
66	*	*	*	*	*	*	*	*
67	*	*	*	*	*	*	*	*
68	*	*	*	*	*	*	*	*
69	*	*	*	*	*	*	*	*
70	*	*	*	*	*	*	*	*
71	*	*	*	*	*	*	*	*
Breaker Status (see Section 5)								
72	*	*	*	*	50LA	50LB	50LC	*
Trip/Target Logic (see Section 5)								
73	*	COMMT	*	*	*	*	DTT	*
Operator Control Pushbuttons and LEDs (see Section 11)								
74[f]	PB1PUL	PB2PUL	PB3PUL	PB4PUL	PB5PUL	PB6PUL	PB7PUL	PB8PUL
75[f]	LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
76[f]	LED9	*	LED10	*	*	*	PB10PUL	PB9PUL
77	*	*	*	*	*	*	*	*
Target Logic Outputs (see Section 5)								
78[g]	LTRIP	LTIME	LCOMM	LSOTF	LZONE1	LZONE2	LZONE3	LZONE4
79[g]	L51	*	*	*	*	*	*	*
Logic Variable Equations (see Section 7)								
80	LV1	LV2	LV3	LV4	LV5	LV6	LV7	LV8
81	LV9	LV10	LV11	LV12	LV13	LV14	LV15	LV16
82	LV17	LV18	LV19	LV20	LV21	LV22	LV23	LV24
83	LV25	LV26	LV27	LV28	LV29	LV30	LV31	LV32

Table D.1 Relay Word Bit Mapping (Sheet 5 of 5)

Row	Relay Word Bits[a]							
Virtual Bits (see Appendix P)								
84[h]	VB001	VB002	VB003	VB004	VB005	VB006	VB007	VB008
85[h]	VB009	VB010	VB011	VB012	VB013	VB014	VB015	VB016
86[h]	VB017	VB018	VB019	VB020	VB021	VB022	VB023	VB024
87[h]	VB025	VB026	VB027	VB028	VB029	VB030	VB031	VB032
88[h]	VB033	VB034	VB035	VB036	VB037	VB038	VB039	VB040
89[h]	VB041	VB042	VB043	VB044	VB045	VB046	VB047	VB048
90[h]	VB049	VB050	VB051	VB052	VB053	VB054	VB055	VB056
91[h]	VB057	VB058	VB059	VB060	VB061	VB062	VB063	VB064
92[h]	VB065	VB066	VB067	VB068	VB069	VB070	VB071	VB072
93[h]	VB073	VB074	VB075	VB076	VB077	VB078	VB079	VB080
94[h]	VB081	VB082	VB083	VB084	VB085	VB086	VB087	VB088
95[h]	VB089	VB090	VB091	VB092	VB093	VB094	VB095	VB096
96[h]	VB097	VB098	VB099	VB100	VB101	VB102	VB103	VB104
97[h]	VB105	VB106	VB107	VB108	VB109	VB110	VB111	VB112
98[h]	VB113	VB114	VB115	VB116	VB117	VB118	VB119	VB120
99[h]	VB121	VB122	VB123	VB124	VB125	VB126	VB127	VB128

[a] "*" indicates not used
[b] Some output contacts can be either "a" or "b" type contacts. See Operation of Output Contacts for Different Output Contact Types on page 7.34 for details.
[c] OUT201–OUT212 and IN201–IN208 are only available when the appropriate optional I/O board is present.
[d] LINK5 is replaced by "*" when dual Ethernet connectors are present.
[e] Relay Word bits (for Ethernet ports) are replaced by "*" when a single Ethernet connector is present.
[f] Relay Word bits for Operator Control pushbuttons and LEDs are replaced by "*" when not supported by the relay.
[g] Relay Word Bits For Programmable Targets are replaced by "*" when not supported by the relay.
[h] Virtual bits VB001–VB128 are only present in relays ordered with IEC 61850 protocol.

Table D.2 Alphabetic List of Relay Word Bits (Sheet 1 of 10)

Name	Description	Usage	Row (Table D.1)
25A1, 25A2	Synchronism check elements 1 and 2 (see *Figure 3.40*)	Control	30
27A	A-phase instantaneous undervoltage element (A-phase voltage below pickup setting 27P; see *Figure 3.34*)	Control	42
27AB	AB-phase-to-phase instantaneous undervoltage element (AB-phase-to-phase voltage below pickup setting 27PP; see *Figure 3.35* and *Figure 3.36*)	Control	43
27B	B-phase instantaneous undervoltage element (B-phase voltage below pickup setting 27P; see *Figure 3.34*)	Control	42
27B81	Undervoltage element for frequency element blocking (voltage below pickup setting 27B81P; see *Figure 3.45*)	Testing	52
27BC	BC-phase-to-phase instantaneous undervoltage element (BC-phase-to-phase voltage below pickup setting 27PP; see *Figure 3.35* and *Figure 3.36*)	Control	43
27C	C-phase instantaneous undervoltage element (C-phase voltage below pickup setting 27P; see *Figure 3.34*)	Control	42
27CA	CA-phase-to-phase instantaneous undervoltage element (CA-phase-to-phase voltage below pickup setting 27PP; see *Figure 3.35* and *Figure 3.36*)	Control	43
27S	Channel VS instantaneous undervoltage element (channel VS voltage below pickup setting 27SP; see *Figure 3.35*)	Control	29

Table D.2 Alphabetic List of Relay Word Bits (Sheet 2 of 10)

Name	Description	Usage	Row (Table D.1)
32GF, 32GR	Forward or Reverse directional control routed to residual ground overcurrent elements (see *Figure 4.18*)	Testing, Special directional control schemes	21
32IE	Internal enable for channel IN current-polarized directional element (see *Figure 4.14*)	Testing	21
32QE	Internal enable for negative-sequence voltage-polarized directional element (see *Figure 4.13*)	Testing	21
32QF	Forward directional control routed to negative-sequence overcurrent elements (see *Figure 4.20*)	Testing, Special directional control schemes	21
32QGE	Internal enable for negative-sequence voltage-polarized directional element (for ground; see *Figure 4.13*)	Testing	21
32QR	Reverse directional control routed to negative-sequence overcurrent elements (see *Figure 4.20*)	Testing, Special directional control schemes	21
32VE	Internal enable for zero-sequence voltage-polarized directional element (see *Figure 4.14*)	Testing	21
3P27	= 27A1 * 27B1 * 27C1 (see *Figure 3.34* and *Figure 3.36*)	Control	42
3P59	= 59A1 * 59B1 * 59C1 (see *Figure 3.34* and *Figure 3.36*)	Control	42
3PO	Three pole open condition (see *Figure 5.3*)	Testing	19
3V0	3V0 configuration element (asserts when Global setting VSCONN = 3V0)	Indication	56
50A	= 50A1 + 50A2 + 50A3 + 50A4 (see *Figure 3.26*)	Tripping, Control	55
50A1–50A4	Level 1 through Level 4 A-phase instantaneous overcurrent elements (see *Figure 3.24*)	Tripping, Control	54, 55
50ABC	Positive-Sequence current above threshold to enable OOS logic (see *Figure 3.22*)	Indication	34
50B	= 50B1 + 50B2 + 50B3 + 50B4 (see *Figure 3.26*)	Tripping, Control	55
50B1–50B4	Level 1 through Level 4 B-phase instantaneous overcurrent elements (see *Figure 3.24*)	Tripping, Control	54, 55
50C	= 50C1 + 50C2 + 50C3 + 50C4 (see *Figure 3.26*)	Tripping, Control	55
50C1–50C4	Level 1 through Level 4 C-phase instantaneous overcurrent elements (see *Figure 3.24*)	Tripping, Control	54, 55
50G1–50G4	Level 1 through Level 4 residual ground instantaneous overcurrent elements (see *Figure 3.29*)	Tripping, Testing, Control	3, 27, 36
50GF, 50GR	Forward or Reverse direction residual ground overcurrent threshold exceeded (see *Figure 4.14*)	Testing	20
50L	Phase instantaneous overcurrent element for load detection (maximum phase current above pickup setting 50LP; see *Figure 5.3*)	Testing	19
50LA	Phase instantaneous overcurrent element for closed breaker detection (A-phase current above pickup setting 50LP; see *Figure 5.3*)	Testing	72
50LB	Phase instantaneous overcurrent element for closed breaker detection (B-phase current above pickup setting 50LP; see *Figure 5.3*)	Testing	72
50LC	Phase instantaneous overcurrent element for closed breaker detection (C-phase current above pickup setting 50LP; see *Figure 5.3*)	Testing	72
50P1–50P4	Level 1 through Level 4 phase instantaneous overcurrent elements (see *Figure 3.24*)	Tripping, Testing, Control	3, 26, 57
50Q1–50Q4	Level 1 through Level 4 negative-sequence instantaneous overcurrent elements (see *Figure 3.30*)	Testing Control	37, 38

Table D.2 Alphabetic List of Relay Word Bits (Sheet 3 of 10)

Name	Description	Usage	Row (Table D.1)
50QF, 50QR	Forward or Reverse direction negative-sequence overcurrent threshold exceeded (see *Figure 4.13*)	Testing	20
51G	Residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see *Figure 3.32*)	Testing, Control	4
51GR	Residual ground time-overcurrent element 51GT reset (see *Figure 3.32*)	Testing	4
51GT	Residual ground time-overcurrent element 51GT timed out (see *Figure 3.32*)	Tripping	4
51P	Maximum phase current above pickup setting 51PP for phase time-overcurrent element 51PT (see *Figure 3.31*)	Testing, Control	28
51PR	Phase time-overcurrent element 51PT reset (see *Figure 3.31*)	Testing	28
51PT	Phase time-overcurrent element 51PT timed out (see *Figure 3.31*)	Tripping	28
51Q	Negative-sequence current above pickup setting 51QP for negative-sequence time-overcurrent element 51QT (see *Figure 3.33*)	Testing, Control	39
51QR	Negative-sequence time-overcurrent element 51QT reset (see *Figure 3.33*)	Testing	39
51QT	Negative-sequence time-overcurrent element 51QT timed out (see *Figure 3.33*)	Tripping	39
52A	Circuit breaker status (asserts to logical 1 when circuit breaker is closed; see *Breaker Status Logic on page 6.2*)	Indication	19
59A	A-phase instantaneous overvoltage element (A-phase voltage above pickup setting 59P; see *Figure 3.34*)	Control	42
59AB	AB-phase-to-phase instantaneous overvoltage element (AB-phase-to-phase voltage above pickup setting 59PP; see *Figure 3.35* and *Figure 3.36*)	Control	43
59B	B-phase instantaneous overvoltage element (B-phase voltage above pickup setting 59P; see *Figure 3.34*)	Control	42
59BC	BC-phase-to-phase instantaneous overvoltage element (BC-phase-to-phase voltage above pickup setting 59PP; see *Figure 3.35* and *Figure 3.36*)	Control	43
59C	C-phase instantaneous overvoltage element (C-phase voltage above pickup setting 59P; see *Figure 3.34*)	Control	42
59CA	CA-phase-to-phase instantaneous overvoltage element (CA-phase-to-phase voltage above pickup setting 59PP; see *Figure 3.35* and *Figure 3.36*)	Control	43
59N1	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N1P; see *Figure 3.35*)	Control	37
59N2	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N2P; see *Figure 3.35*)	Control	37
59Q	Negative-sequence instantaneous overvoltage element (negative-sequence voltage above pickup setting 59QP; see *Figure 3.35* and *Figure 3.37*)	Control	38
59S	Channel VS instantaneous overvoltage element (channel VS voltage above pickup setting 59SP; see *Figure 3.38*)	Control	29
59V1	Positive-sequence instantaneous overvoltage element (positive-sequence voltage above pickup setting 59V1P; see *Figure 3.35* and *Figure 3.37*)	Control	38
59VA	Channel VA voltage window element (channel VA voltage between threshold settings 25VLO and 25VHI; see *Figure 3.39*)	Testing	28
59VP	Phase voltage window element (selected phase voltage [VP] between threshold settings 25VLO and 25VHI; see *Figure 3.39*)	Testing	29
59VS	Channel VS voltage window element (channel VS voltage between threshold settings 25VLO and 25VHI; see *Figure 3.39*)	Testing	29
67G1–67G4	Level 1 through Level 4 residual ground instantaneous overcurrent elements with directional control option (derived from 50G1–50G4; see *Figure 3.29*)	Tripping, Testing, Control	3, 27, 36

Table D.2 Alphabetic List of Relay Word Bits (Sheet 4 of 10)

Name	Description	Usage	Row (Table D.1)
67G1T–67G4T	Level 1 through Level 4 residual ground definite-time overcurrent elements (derived from 67G1–67G4; see *Figure 3.29*)	Tripping	3, 27, 36
67P1–67P4	Level 1 through Level 4 phase instantaneous overcurrent elements with torque control (derived from 50P1–50P4; see *Figure 3.25*)	Tripping, Testing, Control	3, 26, 57
67P1T–67P4T	Level 1 through Level 4 phase definite-time overcurrent elements (derived from 67P1–67P4; see *Figure 3.25*)	Tripping	3, 26, 57
67Q1–67Q4	Level 1 through Level 4 negative-sequence instantaneous overcurrent elements with directional control option (derived from 50Q1–50Q4; see *Figure 3.30*)	Testing, Control	37, 38
67Q1T–67Q4T	Level 1 through Level 4 negative-sequence definite-time overcurrent elements (derived from 67Q1–67Q4; see *Figure 3.30*)	Tripping	37, 38
67QG2S	Negative-sequence and residual directional overcurrent short delay element (see *Figure 5.14*)	Tripping in DCB logic	39
79CY	Reclosing relay in the Reclose Cycle State (see *Figure 6.7*)	Control	31
79LO	Reclosing relay in the Lockout State (see *Figure 6.7*)	Control	31
79RS	Reclosing relay in the Reset State (see *Figure 6.7*)	Control	31
81D1–81D6	Level 1 through Level 6 instantaneous frequency elements (see *Figure 3.46*)	Testing	52
81D1T–81D6T	Level 1 through Level 6 definite-time frequency elements (derived from 81D1–81D6; see *Figure 3.46*)	Tripping, Control	53
ALARM	ALARM output contact indicating settings change, elevated access level, relay diagnostic warning, or **PULSE ALARM** command executed (see *Figure 7.28*)	Indication	24
BCW	= BCWA + BCWB + BCWC (see *Breaker Monitor on page 8.1*)	Indication	17
BCWA	A-phase breaker contact wear has reached 100% wear level (see *Breaker Monitor on page 8.1*)	Indication	17
BCWB	B-phase breaker contact wear has reached 100% wear level (see *Breaker Monitor on page 8.1*)	Indication	17
BCWC	C-phase breaker contact wear has reached 100% wear level (see *Breaker Monitor on page 8.1*)	Indication	17
BTX	Block trip input extension (see *Figure 5.14*)	Testing	39
CBADA, CBADB	MIRRORED BITS® channel unavailability over threshold, Channels A and B (see *Appendix H: MIRRORED BITS Communications*)	Indication	51
CC	Asserts 1/4 cycle for CLOSE command execution (see *Set Close on page 6.3*)	Testing, Control	18
CF	Close Failure condition (asserts for 1/4 cycle; see *Figure 6.3*)	Indication	19
CLOSE	Close logic output asserted (see *Figure 6.3*)	Output contact assignment	19
COMMT	Communications-assisted trip (See *Figure 5.1*)	Tripping	73
CVTBL	CCVT transient blocking logic active (see *Figure 4.9*)	Indication	15
DCHI	Station dc battery instantaneous overvoltage element (see *Figure 8.9*)	Indication	16
DCLO	Station dc battery instantaneous undervoltage element (see *Figure 8.9*)	Indication	16
DD	Disturbance Detector (see *Figure 4.2*)	Indication	59
DELTA	Delta-connected configuration element (asserts when Global setting PTCONN = DELTA)	Indication	56
DST	Daylight-saving time active (see *Configuring High-Accuracy Timekeeping on page N.25*).	Indication	61

Table D.2 Alphabetic List of Relay Word Bits (Sheet 5 of 10)

Name	Description	Usage	Row (Table D.1)
DSTP	Daylight-saving time change pending. Asserts up to a minute before daylight-saving time change (see *Configuring High-Accuracy Timekeeping on page N.25*).	Indication	61
DSTRT	Directional carrier start (see *Figure 5.14*)	Testing	40
DTT	Direct transfer trip conditions (see *Figure 5.1*)	Indication, Testing	73
ECTT	Echo conversion to trip condition (see *Figure 5.6*)	Testing	40
EKEY	Echo key (see *Figure 5.6*)	Testing	40
F32I	Forward channel IN current-polarized directional element (see *Figure 4.17*)	Testing, Special directional control schemes	22
F32Q	Forward negative-sequence voltage-polarized directional element (see *Figure 4.20*)	Testing, Special directional control schemes	22
F32QG	Forward negative-sequence voltage-polarized directional element (for ground; see *Figure 4.15*)	Testing, Special directional control schemes	22
F32V	Forward zero-sequence voltage-polarized directional element (see *Figure 4.16*)	Testing, Special directional control schemes	22
FIDEN	Fault Identification Logic Enabled (see *Section 5*)	Indication	17
FREQOK	Frequency measurement source valid. See *Analog Scaling and Frequency Indicators on page D.15*.	Indication, Testing	57
FSA, FSB, FSC	Fault identification logic outputs used in targeting (see *Additional Distance Element Supervision on page 3.21*)	Control	17
GDEM	Residual ground demand current above pickup setting GDEMP (see *Figure 8.13*)	Indication	20
IAMET	Channel IA high-gain mode active. See *Analog Scaling and Frequency Indicators on page D.15*.	Event Report	62
IBMET	Channel IB high-gain mode active. See *Analog Scaling and Frequency Indicators on page D.15*.	Event Report	62
ICMET	Channel IC high-gain mode active. See *Analog Scaling and Frequency Indicators on page D.15*.	Event Report	62
ILOP	Internal loss-of-potential (asserts when a loss-of-potential condition exists; see *Figure 4.1*)	Indication, Testing	4
IN101–IN106	Optoisolated inputs IN101 through IN106, asserted (see *Figure 7.1*)	Status sensing or control via optoisolated inputs	23
IN201–IN208	Optoisolated inputs IN201 through IN208, asserted (see *Figure 7.2*)	Status sensing or control via optoisolated inputs (only operable if optional I/O board installed)	46, 66
INMET	Channel IN high-gain mode active. See *Analog Scaling and Frequency Indicators on page D.15*.	Event Report	62
KEY	Key permissive trip signal start (see *Figure 5.6*)	Testing	40
L51	Time-overcurrent trip target bit (see *Table 5.3*)	Event Targeting	79

Table D.2 Alphabetic List of Relay Word Bits (Sheet 6 of 10)

Name	Description	Usage	Row (Table D.1)
LB1–LB16	Local Bits 1 through 16 asserted (see *Figure 7.4*)	Control via front panel—replacing traditional panel-mounted control switches	5, 6
LBOKA, LBOKB	MIRRORED BITS channel looped back OK, Channels A and B (see *Appendix H: MIRRORED BITS Communications*)	Indication	51
LCOMM	Communications-assisted trip target bit (see *Table 5.3*)	Event Targeting	78
LED1–LED10	Operator control pushbutton LEDs 1 through 10. Driven by associated SELOGIC settings LED1 through LED10 (see *Programmable Operator Controls on page 11.14*)	Indication	75, 76
LINK5	Asserted when a valid link is detected on port 5 (see *Section 10: Communications*) (only on relays with a single Ethernet connector)	Indication, Testing	60
LINKA, LINKB	Asserted when a valid Ethernet link is detected on port 5A or 5B (see *Section 10: Communications*) (only on relays with dual Ethernet connectors)	Indication, Testing	60
LNKFAIL	Asserted when a valid link is not detected on the active port(s) (see *Section 10: Communications*)	Indication, Testing	60
LOP	Loss-of-potential (see *Figure 4.1*)	Testing, Special directional control schemes	4
LOP1	Breaker closing LOP logic asserted (see *Figure 4.2*)	Testing	65
LOP2	Drop in voltage without change in current LOP logic asserted (see *Figure 4.2*)	Testing	65
LOP3	LOP latched (see *Figure 4.2*)	Testing	65
LOP4	Busbar VT LOP logic asserted (see *Figure 4.2*)	Testing	65
LOPRST	LOP Reset condition based on detection of healthy voltages (see *Figure 4.2*)	Testing	64
LPSEC	Leap Second direction. Add second if deasserted, delete if asserted. Only available when Global setting IRIGC = C37.118 and a proper IRIG signal is decoded (see *Configuring High-Accuracy Timekeeping on page N.25*).	Indication	61
LPSECP	Leap Second Pending. Asserts up to a minute prior to leap second insertion (see *Configuring High-Accuracy Timekeeping on page N.25*).	Indication	61
LSOTF	Switch-onto-fault trip target bit (see *Table 5.3*)	Event Targeting	78
LT1–LT16	Latch Bits 1 through 16, asserted (see *Figure 7.12*)	Control—replacing traditional latching relays	9, 10
LTIME	Time delayed trip target bit (see *Table 5.3*)	Event Targeting	78
LTRIP	Trip target bit (see *Table 5.3*)	Event Targeting	78
LV1–LV32	Logic Variables 1 through 32. Logic variables follow the states of SELOGIC settings with the same name, as shown in *Figure 7.27*.	Testing, Seal-in functions, etc.	80–83
LZONE1	Fault in Zone 1 / Level 1 target bit (see *Table 5.3*)	Event Targeting	78
LZONE2	Fault in Zone 2 / Level 2 target bit (see *Table 5.3*)	Event Targeting	78
LZONE3	Fault in Zone 3 / Level 3 target bit (see *Table 5.3*)	Event Targeting	78
LZONE4	Fault in Zone 4 / Level 4 target bit (see *Table 5.3*)	Event Targeting	78
M1P–M4P	Zone 1 through Zone 4 phase distance instantaneous elements (see *Figure 3.4*–*Figure 3.6*)	Tripping, Control	2, 25
M1PT–M4PT	Zone 1 through Zone 4 phase distance time delayed elements (see *Figure 3.21*)	Tripping, Control	2, 25

Table D.2 Alphabetic List of Relay Word Bits (Sheet 7 of 10)

Name	Description	Usage	Row (Table D.1)
M2PSEQT	Zone 2 phase distance, sequential trip, time delayed element (see *Figure 3.21*)	Tripping, Control	58
MAB1–MAB4	Zone 1 through Zone 4 mho AB phase distance instantaneous elements (see *Figure 3.4–Figure 3.6*)	Testing	15, 28, 32
MABC1–MABC4	Zone 1 through Zone 4 three-phase compensator distance elements (see *Figure 3.4–Figure 3.6*)	Tripping	36, 45
MAG1–MAG4	Zone 1 through Zone 4 mho ground distance A-phase instantaneous elements (see *Figure 3.7–Figure 3.9*)	Testing	16, 29, 32
MBC1–MBC4	Zone 1 through Zone 4 mho BC phase distance instantaneous elements (see *Figure 3.4–Figure 3.6*)	Testing	15, 28, 32
MBG1–MBG4	Zone 1 through Zone 4 mho ground distance B-phase instantaneous elements (see *Figure 3.7–Figure 3.9*)	Testing	16, 29, 32
MCA1–MCA4	Zone 1 through Zone 4 mho CA phase distance instantaneous elements (see *Figure 3.4–Figure 3.6*)	Testing	15, 28, 32
MCG1–MCG4	Zone 1 through Zone 4 mho ground distance C-phase instantaneous elements (see *Figure 3.7–Figure 3.9*)	Testing	16, 29, 32
MPP1–MPP4	Zone 1 through Zone 4 phase-to-phase compensator distance elements (see *Figure 3.4–Figure 3.6*)	Tripping	36, 45
NDEM	Neutral ground demand current above pickup setting NDEMP (see *Figure 8.13*)	Indication	62
NSTRT	Nondirectional carrier start (see *Figure 5.14*)	Testing	40
OC	Asserts 1/4 cycle for OPEN command execution (see *Factory Settings Example (Using Setting TR and TRQUAL) on page 5.6*)	Testing, Control	18
OPTMN	Open interval timer is timing (see *Reclosing Relay on page 6.11*)	Testing	30
OSB	Out-of-step block condition declaration (see *Figure 3.23*)	Testing	35
OSB1–OSB4	Zone 1 through Zone 4 out-of-step block condition declaration (see *Figure 3.23*)	Testing	35
OST	Out-of-step trip condition declaration (see *Figure 3.23*)	Tripping	34
OSTI	Out-of-step trip entering Zone 5 (see *Figure 3.23*)	Testing	34
OSTO	Out-of-step trip exiting Zone 5 (see *Figure 3.23*)	Testing	34
OUT101–OUT107	Output contacts OUT101 through OUT107, asserted (see *Figure 7.28*)	Indication	24
OUT201–OUT212	Output contacts OUT201 through OUT212, asserted (see *Figure 7.29* and *Figure 7.30*)	Indication (only operable if optional I/O board installed)	44, 45, 67
P5ASEL	Asserted when port 5A is active (see *Section 10: Communications*) (only on relays with dual Ethernet connectors)	Indication, Testing	60
P5BSEL	Asserted when port 5B is active (see *Section 10: Communications*) (only on relays with dual Ethernet connectors)	Indication, Testing	60
PB1PUL–PB10PUL	Pushbutton 1–10 pressed (pulses for one processing interval; see *Programmable Operator Controls on page 11.14*)	Indication	74, 76
PDEM	Phase demand current above pickup setting PDEMP (see *Figure 8.13*)	Indication	20
PMDOK	Phasor measurement data OK (see *Synchrophasor Relay Word Bits on page N.14*)	Synchrophasors	30
PMTRIG	Phasor Measurement Unit SELOGIC control equation trigger (see *Synchrophasor Relay Word Bits on page N.14*). Sent with C37.118 synchrophasor message.	Indication, Synchrophasors	64
PT	Permissive trip signal to POTT logic (see *Figure 5.5*)	Testing	41

Table D.2 Alphabetic List of Relay Word Bits (Sheet 8 of 10)

Name	Description	Usage	Row (Table D.1)
PTRX	Permissive trip signal to Trip logic (see *Figure 5.7*)	Testing	41
PTRX1, PTRX2	Permissive trip signals 1 or 2 from DCUB logic (see *Figure 5.10*)	Testing	41
QDEM	Negative-sequence demand current above pickup setting QDEMP (see *Figure 8.13*)	Indication	20
R32I	Reverse channel IN current-polarized directional element (see *Figure 4.17*)	Testing, Special directional control schemes	22
R32Q	Reverse negative-sequence voltage-polarized directional element (see *Figure 4.20*)	Testing, Special directional control schemes	22
R32QG	Reverse negative-sequence voltage-polarized directional element (for ground; see *Figure 4.15*)	Testing, Special directional control schemes	22
R32V	Reverse zero-sequence voltage-polarized directional element (see *Figure 4.16*)	Testing, Special directional control schemes	22
RB1–RB16	Remote Bits 1 through 16, asserted (see *Figure 7.10*)	Control via serial port	7, 8
RBADA, RBADB	MIRRORED BITS outage duration over threshold, Channels A and B. See *Appendix H: MIRRORED BITS Communications*.	Indication	51
RCSF	Reclose supervision failure (asserts for 1/4 cycle; see *Figure 6.4*)	Indication	30
RMB1A–RMB8A	Received MIRRORED BITS 1 through 8, channel A (see *Appendix H: MIRRORED BITS Communications*)	Control	47
RMB1B–RMB8B	Received MIRRORED BITS 1 through 8, channel B (see *Appendix H: MIRRORED BITS Communications*)	Control	49
ROKA, ROKB	MIRRORED BITS received data OK, Channels A and B (see *Appendix H: MIRRORED BITS Communications*)	Indication	51
RST_BK	Reset Breaker Monitor SELOGIC control equation (see *Section 8: Metering and Monitoring*). The relay resets the breaker monitor accumulators when a rising edge is detected on RST_BK.	Indication, Control	63
RST_DEM	Reset Demand Metering SELOGIC control equation (see *Section 8: Metering and Monitoring*). The relay resets the demand metering registers when a rising edge is detected on RST_DEM.	Indication, Control	63
RST_ENE	Reset Energy Metering SELOGIC control equation (see *Section 8: Metering and Monitoring*). The relay resets the energy metering registers when a rising edge is detected on RST_ENE.	Indication, Control	63
RST_HIS	Reset Event History SELOGIC control equation (see *Section 12: Standard Event Reports and SER*). The relay clears the event history archive when a rising edge is detected on RST_HIS.	Indication, Control	63
RST_MML	Reset Max/Min Metering SELOGIC control equation (see *Section 8: Metering and Monitoring*). The relay resets the max/min metering registers when a rising edge is detected on RST_MML.	Indication, Control	63
RST_PDM	Reset Peak Demand Metering SELOGIC control equation (see *Section 8: Metering and Monitoring*). The relay resets the peak demand metering registers when a rising edge is detected on RST_PDM.	Indication, Control	63
RSTMN	Recloser reset timer is timing (see *Reclosing Relay on page 6.11*).	Testing	30
RSTTRGT	Reset Target SELOGIC equation (see *SELOGIC Control Equation Setting RSTTRGT on page 5.41*). The relay resets the front panel target LEDs when a rising edge is detected on RSTTRGT.	Indication, Control	63

Table D.2 Alphabetic List of Relay Word Bits (Sheet 9 of 10)

Name	Description	Usage	Row (Table D.1)
SF	Synchronism check element, slip frequency less than setting 25SF (see *Figure 3.39*)	Testing	30
SFAST	Synchronism check element, frequency VP > frequency VS (see *Figure 3.39*)	Special control schemes	64
SG1–SG6	Setting group indication, Group 1 through 6, asserted for active group (see *Table 7.3*)	Indication	18
SH0–SH4	Reclosing relay shot counter = 0, 1, 2, 3, or 4 (see *Table 6.3*)	Control	31
SOTFE	Switch-onto-fault logic enable (see *Figure 5.3*)	Testing	19
SOTFT	Switch-onto-fault trip condition (see *Figure 5.1*)	Testing, Indication	15
SSLOW	Synchronism check element, frequency VP < frequency VS (see *Figure 3.39*)	Special control schemes	64
STOP	Carrier stop (see *Figure 5.14*)	Testing	40
SV1–SV16	SELOGIC variables 1 through 16. Associated timers (below) are picked-up when variable is asserted (see *Figure 7.24* and *Figure 7.25*)	Testing, Seal-in functions, etc. (see Figure 7.28)	11, 12, 13, 14
SV1T–SV16T	SELOGIC timers 1 through 16, timed-out when asserted (see *Figure 7.24* and *Figure 7.25*)	Testing, Seal-in functions, etc. (see Figure 7.28)	11, 12, 13, 14
TESTDB	Test DataBase command active. Asserts when analog and digital values reported via DNP, Modbus, IEC 61850, or Fast Meter protocol may be overridden (see *Section 10: Communications*).	Testing	62
TIRIG	Relay Time is based on IRIG-B time source (see *Synchrophasor Relay Word Bits on page N.14*)	Synchrophasors	32
TLED11–TLED26	Front panel target LEDs 11–26 (see *Front-Panel Target LEDs on page 5.32*)	Indication	0, 1
TMB1A–TMB8A	Transmit MIRRORED BITS 1 through 8, channel A (see *Appendix H: MIRRORED BITS Communications*)	Control	48
TMB1B–TMB8B	Transmit MIRRORED BITS 1 through 8, channel B (see *Appendix H: MIRRORED BITS Communications*)	Control	50
TQUAL1–TQUAL4	Encoded IRIG time quality bits 1 through 4. Only available when Global setting IRIGC = C37.118 and a proper IRIG signal is decoded.	Indication	61
TREA1–TREA4	Trigger Reason bits 1 through 4 (follow SELOGIC control equations of same name—see *Appendix N: Synchrophasors*. Sent with C37.118 synchrophasor message.	Indication, Synchrophasors	64
TRGTR	Target Reset. TRGTR pulses to logical 1 for one processing interval when either the TARGET RESET pushbutton is pushed or the TAR R (Target Reset) serial port command is executed (see *Figure 5.1* and *TARGET RESET/LAMP TEST Front-Panel Pushbutton on page 5.41*)	Control	19
TRIP	Trip logic output asserted (see *Figure 5.1*)	Output contact assignment	20
TSNTPB	Asserted when relay time is based on Simple Network Time Protocol (SNTP) backup server (see *Simple Network Time Protocol (SNTP) on page 10.16*).	Indication	60
TSNTPP	Asserted when relay time is based on Simple Network Time Protocol (SNTP) primary server (see *Simple Network Time Protocol (SNTP) on page 10.16*).	Indication	60
TSOK	Time synchronization OK (see *Synchrophasor Relay Word Bits on page N.14*)	Synchrophasors	32
UBB	Unblocking block to Trip logic (see *Figure 5.11*)	Testing	41

Table D.2 Alphabetic List of Relay Word Bits (Sheet 10 of 10)

Name	Description	Usage	Row (Table D.1)
UBB1, UBB2	Unblocking block 1 and 2 from DCUB logic (see *Figure 5.10*)	Testing	41
UBOSB	Unblock out-of-step blocking (see *Figure 3.22*)	Testing	35
V0GAIN	3V0 high-gain mode active (see *Analog Scaling and Frequency Indicators on page D.15*)	Testing	62
VB001–VB128	Virtual bits 001 through 128. Virtual bit configuration is controlled by loaded CID file (IEC 61850 relay models only). Virtual bits can be configured to follow received GOOSE messages (see *Appendix P: IEC 61850*).	Control	84–99
VPOLV	Positive-sequence polarization voltage valid (see *Figure 4.21*)	Testing	19
WFC	Weak-infeed condition (see *Figure 5.6*)	Testing	41
WYE	Wye-connected configuration element (asserts when Global setting PTCONN = WYE)	Indication	56
X5ABC	Zone 5 out-of-step instantaneous distance element (see *Figure 3.22*)	Testing	35
X6ABC	Zone 6 out-of-step instantaneous distance element (see *Figure 3.22*)	Testing	35
XAG1–XAG4	Zone 1 through Zone 4 quadrilateral ground distance instantaneous A-phase elements (see *Figure 3.10–Figure 3.12*)	Testing	33, 34
XBG1–XBG4	Zone 1 through Zone 4 quadrilateral ground distance instantaneous B-phase elements (see *Figure 3.10–Figure 3.12*)	Testing	33, 34
XCG1–XCG4	Zone 1 through Zone 4 quadrilateral ground distance instantaneous C-phase elements (see *Figure 3.10–Figure 3.12*)	Testing	33, 34
Z1GT–Z4GT	Zone 1 through Zone 4 ground distance time delayed elements (see *Figure 3.21*)	Tripping, Control	2, 25
Z1G–Z4G	Zone 1 through Zone 4 mho and/or quadrilateral, instantaneous ground distance elements (see *Figure 3.7–Figure 3.9*)	Tripping, Control	2, 25
Z1T–Z4T	Zone 1 through Zone 4 phase and/or ground distance elements timed out (see *Figure 3.21*)	Tripping, Control	3, 26
Z1X	Zone 1 extension element picked up (see *Figure 3.19* and *Figure 3.20*)	Indication	28
Z1XG	Zone 1 ground extension element picked up (see *Figure 3.19* and *Figure 3.20*)	Indication	59
Z1XP	Zone 1 phase extension element picked up (see *Figure 3.19* and *Figure 3.20*)	Indication	59
Z2GSEQT	Zone 2 phase or ground distance, sequential trip, time delayed element (see *Figure 3.21*)	Tripping, Control	58
Z2PGS	Zone 2 phase and ground short delay element (see *Figure 5.14*)	Testing	39
Z2SEQT	Zone 2 ground distance, sequential trip, time delayed element (see *Figure 3.21*)	Tripping, Control	58
Z3RB	Zone/level 3 reverse block (see *Figure 5.6*)	Testing	40
Z3XT	Logic output from zone/level 3 extension timer (see *Figure 5.14*)	Testing	40
ZLIN	Load-encroachment "load in" element (see *Figure 4.10*)	Special phase over-current element control	4
ZLOAD	= ZLOUT + ZLIN (see *Figure 4.10*)	Special phase over-current element control	4
ZLOUT	Load-encroachment "load out" element (see *Figure 4.10*)	Special phase over-current element control	4

Analog Scaling and Frequency Indicators

The SEL-311C uses the Relay Word bits listed in *Table D.3* for internal operations, such as event report preparation and phasor measurement. The operating criteria for these elements is not exact, so they should not be included in commissioning tests.

Table D.3 Analog Scaling and Frequency Indicators

Relay Word Bit	Description	Asserts When:
V0GAIN	3V0 high-gain mode active	Zero-sequence voltage $3V_0$ is less than approximately 80 V sec.
INMET	Channel IN high-gain mode active	Channel IN current signal is less than the nominal current rating (5 A or 1 A sec)
ICMET	Channel IC high-gain mode active	Channel IC current signal is less than the nominal current rating (5 A or 1 A sec)
IBMET	Channel IB high-gain mode active	Channel IB current signal is less than the nominal current rating (5 A or 1 A sec)
IAMET	Channel IA high-gain mode active	Channel IA current signal is less than the nominal current rating (5 A or 1 A sec)
FREQOK	System frequency and tracking frequency valid	System frequency measurement source is healthy (V_A > 10 V secondary or I1 > 5% of nominal current), the frequency is between 40 Hz and 65 Hz, and the rate of change of frequency is small. Also used as an input to PMDOK (see *Appendix N: Synchrophasors*).

Appendix E
Analog Quantities

Overview

The SEL-311C Relay contains several analog quantities that can be used for more than one function.

Analog quantities are typically generated and used by a primary function, such as metering, and selected analog quantities are made available for one or more supplemental functions, such as the load profile recorder.

SEL-311C analog quantities are generated by the following:

- Metering functions (see *Section 8: Metering and Monitoring*)
- Breaker monitor (see *Section 8: Metering and Monitoring*)
- Self-test diagnostics (see *Section 13: Testing and Troubleshooting*)
- Modbus® (see *Appendix O: Modbus RTU and TCP Communications*)
- Relay settings (see *Section 9: Setting the Relay*)
- Event history (see *Section 12: Standard Event Reports and SER*)
- System date and time (see *Section 10: Communications*)
- Reclosing relay logic (see *Section 6: Close and Reclose Logic*)

Table E.1 provides a complete list of analog quantities that can be used in the following interfaces (when marked with an “x”):

- Display points (see *Rotating Display on page 7.37*)
- DNP3 (see *Appendix L: DNP3 Communications*)
- Modbus (see *Appendix O: Modbus RTU and TCP Communications*)
- SEL Fast Meter protocol (see *Appendix J: Configuration, Fast Meter, and Fast Operate Commands*)
- IEC 61850 protocol (see *Appendix P: IEC 61850*)

Analog Quantities Table

Table E.1 SEL-311C Analog Quantities (Sheet 1 of 6)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
Instantaneous Metering							
IA, IB, IC	Phase (A, B, C) Current Magnitudes	A pri	x	x	x	x	x
IAFA, IBFA, ICFA	Phase (A, B, C) Current Angles	degrees	[b]	x	x	x	x
IN	Neutral (channel IN) Current Magnitude	A pri	x	x	x	x	x
INFA	Neutral (channel IN) Current Angle	degrees	[b]	x	x	x	x
IG	Residual Ground ($3I_0$) Current Magnitude	A pri	x	x	x		x
IGFA	Residual Ground ($3I_0$) Current Angle	degrees	[b]	x	x		x
I1	Positive-Sequence (I_1) Current Magnitude	A pri	x	x	x	[c]	x
I1FA	Positive-Sequence (I_1) Current Angle	degrees	[b]	x	x	[c]	x
3I2	Negative-Sequence ($3I_2$) Current Magnitude	A pri	x	x	x	[c]	x
3I2FA	Negative-Sequence ($3I_2$) Current Angle	degrees	[b]	x	x	[c]	x
3I0	Zero-Sequence ($3I_0$) Current Magnitude	A pri	x	x	x	[c]	x
3I0FA	Zero-Sequence ($3I_0$) Current Angle	degrees	[b]	x	x	[c]	x
VA, VB, VC	Phase (A, B, C) Voltage Magnitudes	kV pri	x[d]	x[e]			x[e]
VA, VB, VC	Phase (A, B, C) Voltage Magnitudes	V pri			x[e]	x[e]	
VAFA, VBFA, VCFA	Phase (A, B, C) Voltage Angles	degrees	[b, d]	x[e]	x[e]	x[e]	x[e]
VS	Channel VS Voltage Magnitude	kV pri	x	x			
VS	Channel VS Voltage Magnitude	V pri			x	x	
VSFA	Channel VS Voltage Angle	degrees	[b]	x	x	x	
VAB, VBC, VCA	Phase-to-Phase (AB, BC, CA) Voltage Magnitudes	kV pri	x	x[f]		[c]	x
VAB, VBC, VCA	Phase-to-Phase (AB, BC, CA) Voltage Magnitudes	V pri			x[f]	[c]x[c, e]	
VABFA, VBCFA, VCAFA	Phase-to-Phase (AB, BC, CA) Voltage Angles	degrees	[b]	x[f]	x[f]	[c]x[c, e]	x
V1	Positive-Sequence (V_1) Voltage Magnitude	kV pri	x	x			x
V1	Positive-Sequence (V_1) Voltage Magnitude	V pri			x	[c]	
V1FA	Positive-Sequence (V_1) Voltage Angle	degrees	[b]	x	x	[c]	x
V2	Negative-Sequence (V_2) Voltage Magnitude	kV pri	x	x			x
V2	Negative -Sequence (V_2) Voltage Magnitude	V pri			x	[c]	
V2FA	Negative -Sequence (V_2) Voltage Angle	degrees	[b]	x	x	[c]	x
3V0[g]	Zero-Sequence ($3V_0$) Voltage Magnitude	kV pri	x				
3V0_MAG[g]	Zero-Sequence ($3V_0$) Voltage Magnitude	kV pri		x			x
3V0_MAG[g]	Zero-Sequence ($3V_0$) Voltage Magnitude	V pri			x	[c]	
3V0FA[g]	Zero-Sequence ($3V_0$) Voltage Angle	degrees	[b]	x	x	[c]	x
MWA, MWB, MWC[g]	Phase (A, B, C) Real Power	MW	x	x		[c]	
KWA, KWB, KWC[g]	Phase (A, B, C) Real Power	kW			x		x

Table E.1 SEL-311C Analog Quantities (Sheet 2 of 6)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
MW3	3-phase Real Power	MW	x	x		[c]	
KW3	3-phase Real Power	kW			x		x
MVARA, MVARB, MVARC[g]	Phase (A, B, C) Reactive Power	MVAr	x	x		[c]	
KVARA, KVARB, KVARC[g]	Phase (A, B, C) Reactive Power	kVAr			x		x
MVAR3	3-phase Reactive Power	MVAr	x	x		[c]	
kVAR3	3-phase Reactive Power	kVAr			x		x
PFA, PFB, PFC[g]	Phase (A, B, C) Power Factor	per unit	x	x	x		x
PF3	3-phase Power Factor	per unit	x	x	x		x
LDPFA, LDPFB, LDPFC[g]	Phase (A, B, C) Power Factor Leading (1 indicates leading PF)	0 or 1	[h]	x	x		
LDPF3	3-Phase Power Factor Leading (1 indicates leading PF)	0 or 1	[h]	x	x		
VDC	Station DC Battery Voltage	V	x	x	x	x	x
FREQ	System Frequency	Hz	x	x	x	x	x
Demand Metering							
IADEM, IBDEM, ICDEM	Phase (A, B, C) Demand Current	A pri	x	x	x	x	x
INDEM	Neutral (channel IN) Demand Current	A pri	x	x	x	x	x
IGDEM	Residual Ground ($3I_0$) Demand Current	A pri	x	x	x	x	x
3I2DEM	Negative-Sequence ($3I_2$) Demand Current	A pri	x	x	x	x	x
MWADI, MWBDI, MWCDI[g]	Phase (A, B, C) Real Power Demand—IN	MW	x	x		x	
KWADI, KWBDI, KWCDI[g]	Phase (A, B, C) Real Power Demand—IN	kW			x		
MW3DI	3-Phase Real Power Demand—IN	MW	x	x		x	
KW3DI	3-Phase Real Power Demand—IN	kW			x		
MWADO, MWBDO, MWCDO[g]	Phase (A, B, C) Real Power Demand—OUT	MW	x	x		x	
KWADO, KWBDO, KWCDO[g]	Phase (A, B, C) Real Power Demand—OUT	kW			x		
MW3DO	3-Phase Real Power Demand—OUT	MW	x	x		x	
KW3DO	3-Phase Real Power Demand—OUT	kW			x		
MVRADI, MVRBDI, MVRCDI[g]	Phase (A, B, C) Reactive Power Demand—IN	MVAr	x	x		x	
KVRADI, KVRBDI, KVRCDI[g]	Phase (A, B, C) Reactive Power Demand—IN	kVAr			x		
MVR3DI	3-Phase Reactive Power Demand—IN	MVAr	x	x		x	
KVR3DI	3-Phase Reactive Power Demand—IN	kVAr			x		

Table E.1 SEL-311C Analog Quantities (Sheet 3 of 6)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
MVRADO, MVRBDO, MVRCDO[g]	Phase (A, B, C) Reactive Power Demand—OUT	MVAr	x	x		x	
KVRADO, KVRBDO, KVRCDO[g]	Phase (A, B, C) Reactive Power Demand—OUT	kVAr			x		
MVR3DO	3-Phase Reactive Power Demand—OUT	MVAr	x	x		x	
KVR3DO	3-Phase Reactive Power Demand—OUT	kVAr			x		
Peak (Demand) Metering							
IAPK, IBPK, ICPK	Phase (A, B, C) Peak Demand Current	A pri	x	x	x	x	x
INPK	Neutral (channel IN) Peak Demand Current	A pri	x	x	x	x	x
IGPK	Residual Ground ($3I_0$) Peak Demand Current	A pri	x	x	x	x	x
3I2PK	Negative-Sequence ($3I_2$) Peak Demand Current	A pri	x	x	x	x	x
MWAPI, MWBPI, MWCPI[g]	Phase (A, B, C) Real Power Peak Demand—IN	MW	x	x		x	
KWAPI, KWBPI, KWCPI[g]	Phase (A, B, C) Real Power Peak Demand—IN	kW			x		
MW3PI	3-Phase Real Power Peak Demand—IN	MW	x	x		x	
KW3PI	3-Phase Real Power Peak Demand—IN	kW			x		
MWAPO, MWBPO, MWCPO[g]	Phase (A, B, C) Real Power Peak Demand—OUT	MW	x	x		x	
KWAPO, KWBPO, KWCPO[g]	Phase (A, B, C) Real Power Peak Demand—OUT	kW			x		
MW3PO	3-Phase Real Power Peak Demand—OUT	MW	x	x		x	
KW3PO	3-Phase Real Power Peak Demand—OUT	kW			x		
MVRAPI, MVRBPI, MVRCPI[g]	Phase (A, B, C) Reactive Power Peak Demand—IN	MVAr	x	x		x	
KVRAPI, KVRBPI, KVRCPI[g]	Phase (A, B, C) Reactive Power Peak Demand—IN	kVAr			x		
MVR3PI	3-Phase Reactive Power Peak Demand—IN	MVAr	x	x		x	
KVR3PI	3-Phase Reactive Power Peak Demand—IN	kVAr			x		
MVRAPO, MVRBPO, MVRCPO[g]	Phase (A, B, C) Reactive Power Peak Demand—OUT	MVAr	x	x		x	
KVRAPO, KVRBPO, KVRCPO[g]	Phase (A, B, C) Reactive Power Peak Demand—OUT	kVAr			x		
MVR3PO	3-Phase Reactive Power Peak Demand—OUT	MVAr	x	x		x	
KVR3PO	3-Phase Reactive Power Peak Demand—OUT	kVAr			x		

Table E.1 SEL-311C Analog Quantities (Sheet 4 of 6)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
Energy Metering							
MWHAI, MWHBI, MWHCI[g]	Phase (A, B, C) Real Energy—IN	MWh	x	x	x		
MWH3I	3-Phase Real Energy—IN	MWh	x	x	x		x
MWHAO, MWHBO, MWHCO[g]	Phase (A, B, C) Real Energy—OUT	MWh	x	x	x		
MWH3O	3-Phase Real Energy—OUT	MWh	x	x	x		x
MVRHAI, MVRHBI, MVRHCI[g]	Phase (A, B, C) Reactive Energy—IN	MVArh	x	x	x		
MVRH3I	3-Phase Reactive Energy—IN	MVArh	x	x	x		x
MVRHAO, MVRHBO, MVRHCO[g]	Phase (A, B, C) Reactive Energy—OUT	MVArh	x	x	x		
MVRH3O	3-Phase Reactive Energy—OUT	MVArh	x	x	x		x
Breaker Monitor							
BRKDAT	Last Reset Date	date	x				
BRKTIM	Last Reset Time	time	x				
INTTR[i]	Internal Trip Counter	count	x	x[j]	x		x
EXTTR	External Trip Counter	count	x	x[j]	x		
OPSCTR	Combined Operations Counter = (INTTR + EXTTR)	count	x				
INTIA, INTIB, INTIC[k]	Accumulated current—internal trips, A-, B-, and C-phase	kA	x				
EXTIA, EXTIB, EXTIC	Accumulated current—external trips, A-, B-, and C-phase	kA	x				
WEARA, WEARB, WEARC	Breaker Wear %—A-, B-, and C-phase	percent	x	x	x		
Event History							
NUMEVE	Event History Number	count			x		
EVESEL	Selected History Number	count			x		
FDATE_Y	Fault date—Year portion	year			x		
FDATE_M	Fault date—Month portion	month			x		
FDATE_D	Fault date—Day portion	day			x		
FTIME_H	Fault time—Hour portion	hour			x		
FTIME_M	Fault time—Minute portion	minute			x		
FTIME_S	Fault time—Second portion	second			x		
FTIMEH	Fault date/time stamp—High word	binary		x			
FTIMEH16	Fault date/time stamp—High word formatted as a 16-bit signed value	binary		x			
FTIMEM	Fault date/time stamp—Middle word	binary		x			
FTIMEM16	Fault date/time stamp—Middle word formatted as a 16-bit signed value	binary		x			

Table E.1 SEL-311C Analog Quantities (Sheet 5 of 6)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
FTIMEL	Fault date/time stamp—Low word	binary		x			
FTIMEL16	Fault date/time stamp—Low word formatted as a 16-bit signed value	binary		x			
FTYPE[l]	Fault Type			x			
FTYPE16[l]	Fault Type formatted as a 16-bit signed value			x			
EVE_TYPE[l]	Event Type				x		
FLOC	Fault Location	LL units		x	x		
FI	Fault Current Maximum of IA, IB, IC	A pri		x	x		
FIA, FIB, FIC	Fault Current, A, B, or C-phase	A pri		x	x		
FIN	Fault Current, IN channel	A pri		x	x		
FIG	Fault Current, Residual Ground (IG = $3I_0$)	A pri		x	x		
FIQ	Fault Current, Negative-Sequence ($3I_2$)	A pri		x	x		
FFREQ	Event Frequency	Hz		x	x		
FGRP	Setting group active at event trigger	count		x	x		
FSHO	Reclosing relay Shot Counter at event trigger	count99		x	x		
FUNR	Number of Unread faults	count		x			
Time-Overcurrent Element (TOC) Pickup Settings							
51PP	Pickup for maximum-phase TOC element 51PT	A pri	x[m]	x			
51GP	Pickup for residual ground (IG = $3I_0$) TOC element 51GT	A pri	x[m]	x			
51QP	Pickup for negative-sequence ($3I_2$) TOC element 51QT	A pri	x[m]	x			
Setting Group, Date, Time, and Internal Temperature							
ACTGRP	Active Settings Group	count		x[n]	x		
DATE	Present Date from relay clock	date				x	
TIME	Present Time from relay clock	time				x	
DATE_Y	Present date—Year portion	year			x		
DATE_M	Present date—Month portion	month			x		
DATE_D	Present date—Day portion	day			x		
TIME_H	Present time—Hour portion	hour			x		
TIME_M	Present time—Minute portion	minute			x		
TIME_S	Present time—Second portion	second			x		
	Combined Date/Time (DNP Object 50). No label required.	binary		x			
TEMP	Relay internal temperature	degrees C		x	x		
Modbus Communications Counters							
MSGRCD	Number of Messages Received	count			x		
MSGOID	Number of Messages to Other devices (Other ID)	count			x		
ILLADDR	Illegal Address count	count			x		
BADCRC	Bad CRC count	count			x		

Table E.1 SEL-311C Analog Quantities (Sheet 6 of 6)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
UARTER	Uart Error count	count			x		
ILLFUNC	Illegal Function count	count			x		
ILLREG	Illegal Register count	count			x		
ILLDATA	Illegal Data count	count			x		
BADPF	Bad Packet Format count	count			x		
BADPL	Bad Packet Length count	count			x		

a Display points analog quantities must be preceded by "::" in the DPn_0 and DPn_1 text settings (n = 1–16).
b Angles are automatically included in Display Points when the corresponding magnitude is selected. For example, Setting "DP1_0 = ::IB" will display `IB= 256.2A-121°` as display point 1 when DP1 = logical 0.
c Quantity calculated from other Fast Meter data in SEL Communications Processor 20METER data region. The label used in the 20METER data region may differ.
d Per-phase voltage values are not available when PTCONN = DELTA.
e When PTCONN = DELTA, the relay returns phase-to-phase values for voltage labels VA, VB, VC, VAFA, VBFA, VCFA for DNP3, Modbus, and IEC 61850 protocols. i.e., VA returns VAB, VB returns VBC, and VC returns VCA. The Fast Meter protocol automatically changes the label in the configuration message to indicate phase-to-phase values when PTCONN = DELTA.
f Phase-to-phase voltage labels VAB, VBC, VCA, VABFA, VBCFA, and VCAFB are available for DNP, Modbus, and IEC 61850 protocols when PTCONN = WYE or DELTA.
g Zero-sequence voltage, and per-phase power, power factor, demand power, peak demand power, and energy values are not available when PTCONN = DELTA. DNP and Modbus maps may contain these labels, and the relay will return values of 0.00, except for power factors which will be reported as 1.00.
h Lag or lead is automatically included in Display Points for power factor. For example, Setting "DP2_0 = ::LDPF3" will display `PF 3P = 0.76 LAG` as display point 2 when DP2 = logical 0.
i In legacy SEL-311C relays, the internal trip counter is identified using CTRLTR or OPSCNTR.
j Available in DNP as a counter input.
k In legacy SEL-311C relays, accumulated phase currents for internal trips are identified using CTRLIA, CTRLIB, and CTRLIC.
l Refer to Section 12: Standard Event Reports and SER for definitions of FTYPE and EVE_TYPE values.
m See Additional Format for Displaying Time-Overcurrent Elements on the Rotating Display on page 7.48 for full display point formatting options.
n Available in DNP as both a counter input and analog output.

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Appendix F
Setting SELOGIC Control Equations

Overview

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

Additional SELOGIC control equation setting details are available in *Section 9: Setting the Relay* (see also *SELOGIC Control Equation Settings (Serial Port Command SET L) on page SET.24*). See the *SHO Command (Show/View Settings) on page 10.49* for a list of the factory default settings.

Relay Word Bits

Most of the protection and control element *logic outputs* shown in the various figures in *Section 3* through *Section 8* are Relay Word bits (labeled as such in the figures). Each Relay Word bit has a label name and can be in either of the following states:

- 1 (logical 1)
- or 0 (logical 0)

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

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

A complete listing of Relay Word bits and their descriptions are referenced in *Table D.2*.

Relay Word Bit Operation Example—Phase Time-Overcurrent Element 51PT

As an example of protection element operation via the logic output of Relay Word bits, a phase time-overcurrent element is examined. Refer to phase time-overcurrent element 51PT in *Figure 3.31*. Read the text that accompanies *Figure 3.31*.

The following Relay Word bits are the logic outputs of the phase time-overcurrent element:

Table F.1 Logic Outputs of the Phase Time-Overcurrent Element

Logic Output	Description
51P	indication that the maximum phase current magnitude is above the level of the phase time-overcurrent pickup setting 51PP
51PT	indication that the phase time-overcurrent element has timed out on its curve
51PR	indication that the phase time-overcurrent element is fully reset

Phase Time-Overcurrent Element 51PT Pickup Indication

If the maximum phase current is *at or below* the level of the phase time-overcurrent pickup setting 51PP, Relay Word bit 51P is in the following state:

51P = 0 (logical 0)

If the maximum phase current is *above* the level of the phase time-overcurrent pickup setting 51PP, Relay Word bit 51P is in the following state:

51P = 1 (logical 1)

If the maximum phase current is *above* the level of the phase time-overcurrent pickup setting 51PP, phase time-overcurrent element 51PT is either timing on its curve or is already timed out.

Phase Time-Overcurrent Element 51PT Time-Out Indication

If phase time-overcurrent element 51PT is *not timed out* on its curve, Relay Word bit 51PT is in the following state:

51PT = 0 (logical 0)

If phase time-overcurrent element 51PT is *timed out* on its curve, Relay Word bit 51PT is in the following state:

51PT = 1 (logical 1)

Phase Time-Overcurrent Element 51PT Reset Indication

If phase time-overcurrent element 51PT is *not fully reset*, Relay Word bit 51PR is in the following state:

51PR = 0 (logical 0)

If phase time-overcurrent element is *fully reset*, Relay Word bit 51PR is in the following state:

51PR = 1 (logical 1)

If phase time-overcurrent element 51PT is *not fully reset*, the element is either:

- Timing on its curve
- Already timed out
- Is timing to reset (one-cycle reset or electromechanical emulation—see setting 51PRS)

Relay Word Bit Application Examples—Phase Time-Overcurrent Element 51PT

Table F.2 describes common uses for Relay Word bits 51P, 51PT, and 51PR:

Table F.2 Common uses for Relay Word bits 51P, 51PT, and 51PR

Relay Word Bit	Common Uses
51P	testing (e.g., assign to an output contact for pickup testing) trip unlatch logic (see *Example of NOT Operator ! Applied to Multiple Elements (Within Parentheses) on page F.7*)
51PT	trip logic (see *SELOGIC Control Equation Operation Example—Tripping on page F.7*)
51PR	used in testing (e.g., assign to an output contact for reset indication)

Other Relay Word Bits

The preceding example was for a phase time-overcurrent element, demonstrating Relay Word bit operation for pickup, time-out, and reset conditions. Other Relay Word bits (e.g., those for definite-time overcurrent elements, voltage elements, frequency elements) behave similarly in their assertion or deassertion to logical 1 or logical 0, respectively. The time-overcurrent elements (like the preceding phase time-overcurrent element example) are rather unique because they have a Relay Word bit (e.g., 51PR) that asserts for the reset state of the element.

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

SELOGIC Control Equations

Many of the protection and control element *logic inputs* shown in the various figures in Section 3 through Section 8 are SELOGIC control equations (labeled “SELOGIC Settings” in most of the figures). SELOGIC control equations are set with combinations of Relay Word bits to accomplish functions such as those listed below:

NOTE: In legacy SEL-311C relays, some SELOGIC control equations are hidden based on other settings. In SEL-311C relays with firmware R500 and greater, SELOGIC settings are not hidden.

- ➤ Tripping circuit breakers
- ➤ Assigning functions to optoisolated inputs
- ➤ Operating output contacts
- ➤ Torque-controlling overcurrent elements
- ➤ Switching active setting groups
- ➤ Enabling/disabling reclosing

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

SELOGIC Control Equation Operators

SELOGIC control equation settings use logic similar to Boolean algebra logic, combining Relay Word bits together using one or more of the six SELOGIC control equation operators listed in Table F.3.

Table F.3 SELOGIC Control Equation Operators (Listed in Processing Order)

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

Operators in a SELOGIC control equation setting are processed in the order shown in *Table F.3*.

SELOGIC Control Equation Rising-Edge Operator /

The rising-edge operator / is applied to individual Relay Word bits only—not to groups of elements within parentheses. For example, the SELOGIC control equation event report generation setting typically uses rising edge operators, as shown in the following example:

ER =**/51P + /51G + /OUT103**

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

Relay Word Bit	Description
51P	Maximum phase current above pickup setting 51PP for phase time-overcurrent element 51PT (see *Figure 3.31*)
51G	Residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see *Figure 3.32*)
OUT103	Output contact **OUT103** is set as a breaker failure trip output (see *Output Contacts on page 7.33*)

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

Suppose a ground fault occurs and a breaker failure condition finally results. *Figure F.1* demonstrates the action of the rising-edge operator / on the individual elements in setting ER.

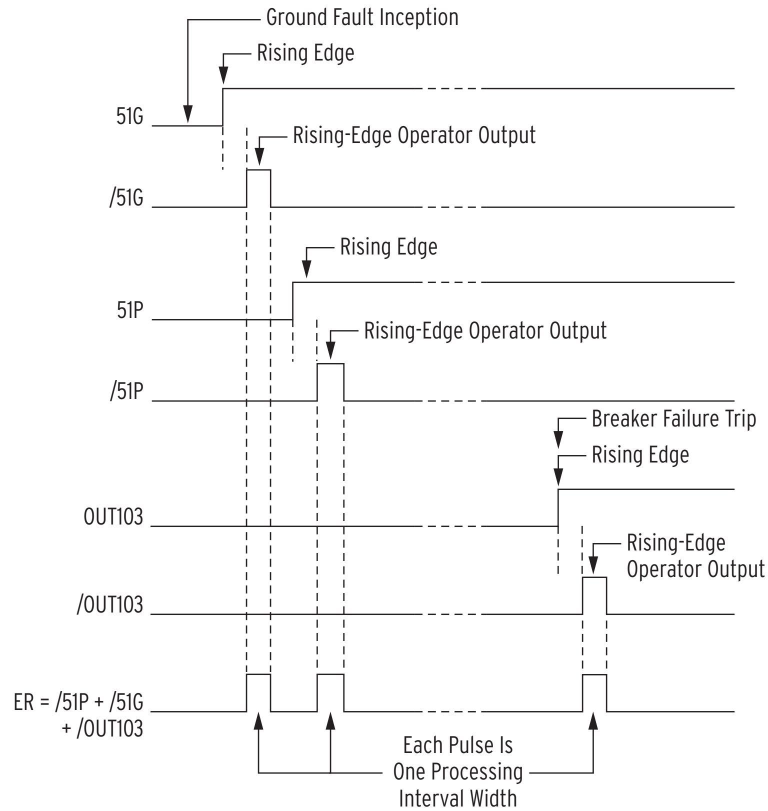


Figure F.1 Result of Rising-Edge Operators on Individual Elements in Setting ER

Note in *Figure F.1* that setting ER sees three separate rising edges because of the application of rising-edge operators /. The rising-edge operator / in front of a Relay Word bit sees this logical 0 to logical 1 transition as a "rising edge" and the resultant asserts to logical 1 for one processing interval. The assertions of 51G and 51P are close enough that they will be on the same event report (generated by 51G asserting first). The assertion of OUT103 for a breaker failure condition is some appreciable time later and will generate another event report, if the first event report capture has ended when OUT103 asserts.

If the rising-edge operators / were not applied and setting ER was

ER = **51P + 51G + OUT103**

the ER setting would not see the assertion of OUT103, because 51G and 51P would continue to be asserted at logical 1, as shown in *Figure F.1*.

SELogic Control Equation Falling-Edge Operator \

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

For example, suppose the SELogic control equation event report generation setting is set with the detection of the falling edge of an underfrequency element:

ER = **... + \81D1T**

When frequency goes above the corresponding pickup level 81D1P, Relay Word bit 81D1T deasserts and an event report is generated (if the relay is not already generating a report that encompasses the new transition). This allows a recovery from an underfrequency condition to be observed. See *Figure 3.46* and *Table 3.24*. *Figure F.2* demonstrates the action of the falling-edge operator \ on the underfrequency element in setting ER.

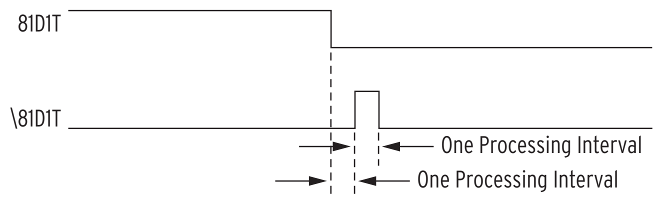


Figure F.2 Result of Falling-Edge Operator on a Deasserting Underfrequency Element

SELogic Control Equation Parentheses Operator ( )

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

SV7 = **(SV7 + IN106) * (50P1 + 50G1)**

In the above example, the logic within the parentheses is processed first and then the two parentheses resultants are ANDed together. The above example is from *Figure 7.26*. Parentheses cannot be “nested” (parentheses within parentheses) in an SEL-311C SELogic control equation setting.

SELogic Control Equation NOT Operator !

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

Example of NOT Operator ! Applied to Single Element

The internal circuit breaker status logic in the SEL-311C operates on 52a circuit breaker auxiliary contact logic. The SELogic control equation circuit breaker status setting is labeled 52A. See *Optoisolated Inputs on page 7.2* and *Close Logic on page 6.2* for more information on SELogic control equation circuit breaker status setting 52A.

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

The opposite is true for a 52b circuit breaker auxiliary contact. When a circuit breaker is closed, the 52b circuit breaker auxiliary contact is open. When the circuit breaker is open, the 52b contact is closed.

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

52A = **IN101**

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

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

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

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

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

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

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

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

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

The SELOGIC control equation trip unlatch setting is set as follows:

ULTR = **!(50L + 51G)**

Refer also to *Trip Logic on page 5.1*.

In this factory setting example, the unlatch condition comes true only when *both* the 50L (phase time-overcurrent element pickup indication) and 51G (residual ground time-overcurrent element pickup indication) Relay Word bits deassert:

ULTR = **!(50L + 51G)** = NOT(50L + 51G)

As stated previously, the logic within the parentheses is performed first. In this example, the states of Relay Word bits 50L and 51G are ORed together. Then the NOT operator is applied to the logic resultant from the parentheses.

If either one of 50L or 51G is still asserted [e.g., 51G = 1 (logical 1)], the unlatch condition is not true:

ULTR = **NOT(50L + 51G)** = NOT(0 + 1) = NOT(1) = 0

If *both* 50L and 51G are deasserted [i.e., 50L = 0 and 51G = 0 (logical 0)], the unlatch condition is true:

ULTR = **NOT(50L + 51G)** = NOT(0 + 0) = NOT(0) = 1

and the trip condition can unlatch, subject to other conditions in the trip logic (see *Figure 5.1*).

SELOGIC Control Equation Operation Example—Tripping

If tripping does not involve communications-assisted or switch-onto-fault trip logic, the SELOGIC control equation trip settings TR or TRQUAL are the only trip settings needed. Refer to *Trip Logic on page 5.1*.

Note that *Figure 5.1* appears quite complex. But since tripping does not involve communications-assisted or switch-onto-fault trip logic in this example, respective SELOGIC control equation trip settings TRCOMM and TRSOTF are not used. The only effective inputs into logic gate OR-1 in *Figure 5.1* are SELOGIC control equation trip settings TR and TRQUAL. The following example is intended to illustrate the use of various SELOGIC Control Equation operators and not to recommend trip logic for any particular application.

TR = **M1P + Z1G + M2PT + Z2GT + 51GT + 51QT + 50P1 * SHO**

TRQUAL = **0**

TRCOMM = **0** (not used—set directly to logical 0)

TRSOTF = **0** (not used—set directly to logical 0)

ULTR = **!(50L + 51G)** (discussed in preceding subsection)

Analysis of SELogic Control Equation Trip Setting TR

Again, the example trip equation is:

TR = **M1P + Z1G + M2PT + Z2GT + 51GT + 51QT + 50P1 * SH0**

The Relay Word bit definitions are shown below:

Relay Word Bit	Description
M1P	Zone 1 phase distance, instantaneous
Z1G	Zone 1 mho and/or quad, ground distance, instantaneous
M2PT	Zone 2 phase distance, time delayed
Z2GT	Zone 2 ground distance, time delayed
51GT	Residual ground time-overcurrent element timed out
51QT	Negative-sequence time-overcurrent element timed out
50P1	Phase instantaneous overcurrent element asserted
SH0	Reclosing relay shot counter at shot = 0

In the trip equation, the AND operator * is executed before the OR operators +, as shown in *Table F.3*:

50P1 * SH0

Element 50P1 can only cause a trip if the reclosing relay shot counter is at shot = 0. When the reclosing relay shot counter is at shot = 0 (see *Table 6.3*), Relay Word bit SH0 is in the following state:

SH0 = **1** (logical 1)

If maximum phase current is *above* the phase instantaneous overcurrent element pickup setting 50P1P (see *Figure 3.24*), Relay Word bit 50P1 is in the following state:

50P1 = **1** (logical 1)

With SH0 = 1 and 50P1 = 1, the ANDed combination result is shown below:

50P1 * SH0 = **1 * 1 = 1** (logical 1)

An instantaneous trip results. This logic is commonly used in fuse saving schemes for distribution feeders.

If the reclosing relay shot counter advances to shot = 1 for the reclose that follows the trip, Relay Word bit SH0 is in the following state:

SH0 = **0** (logical 0)

If maximum phase current is *above* the phase instantaneous overcurrent element pickup setting 50P1P for the reoccurring fault, Relay Word bit 50P1 is in the following state:

50P1 = **1** (logical 1)

With SH0 = 0 and 50P1 = 1, the ANDed combination result is shown below:

50P1 * SH0 = **1 * 0 = 0** (logical 0)

No trip results from phase instantaneous overcurrent element 50P1.

A trip will eventually result if time-overcurrent element 51QT or 51GT times out, if time-delayed distance elements M2PT or Z2GT time out, or distance elements M1P or Z1G operate. If time delayed distance element Z2GT times out, Relay Word bit Z2GT is in the following state:

Z2GT = **1** (logical 1)

When shot = 1, SH0 = 0 and the result is shown below:

TR = **M1P + Z1G + M2PT + Z2GT + 51GT + 51QT + 50P1 * SH0**
= 0 + 0 + 0 + 1 + 0 + 0 + 1 * 0 = 1

A time-delayed trip results from Zone 2 time-delayed distance element Z2GT.

Set an Output Contact for Tripping

To assert output contact **OUT101** to trip a circuit breaker, make the following SELOGIC control equation output contact setting (see *Output Contacts on page 7.33*):

OUT101 = **TRIP**

All SELOGIC Control Equations Must Be Set

All SELOGIC control equations must be set in one of the following ways (they cannot be “blank”):

- ➤ Single Relay Word bit (e.g., 52A = IN101)
- ➤ Combination of Relay Word bits (e.g., TR = M1P + Z1G + M2PT + Z2GT + 51GT + 51QT)
- ➤ Directly to logical 1 (e.g., 67P1TC = 1)
- ➤ Directly to logical 0 (e.g., TRCOMM = 0)

Set SELOGIC Control Equations Directly to 1 or 0

NOTE: SELOGIC control equation torque control settings (e.g., 67P1TC, 51PTC) cannot be set directly to logical 0.

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

Under the *SHO Command (Show/View Settings) on page 10.49*, note that a number of the factory SELOGIC control equation settings are set directly to 1 or 0.

The individual SELOGIC control equation settings explanations (referenced in *SELOGIC Control Equation Settings (Serial Port Command SET L) on page SET.24*) discuss whether it makes logical sense to set the given SELOGIC control equation setting to 0 or 1 for certain criteria.

Set SELOGIC Control Equations Directly to 1 or 0 (Example)

Of special concern are the SELOGIC control equation torque control settings 67P1TC–51QTC for the overcurrent elements. In the default factory settings, these are all set directly to logical 1. See these factory settings in *SHO Command (Show/View Settings) on page 10.49*.

If one of these torque control settings is set directly to logical 1 as shown in the example below,

67G1TC = **1** (set directly to logical 1)

then the corresponding overcurrent element (e.g., residual ground overcurrent element 67G1) is subject only to the directional control. See *Figure 3.29* for phase overcurrent element 67G1 logic.

Use Logic Variables to Create a Seal-In Function

In some applications, a transient condition should be sealed-in until intentionally reset. One method of doing this is to use a logic variable Relay Word bit LV*n* in its own equation.

In this example system, the protection designer wants an output contact to be closed only after the relay trips for a ground fault. If the relay trips for another reason, the output contact should remain open, even if the ground overcurrent element picks up shortly after. The output should remain asserted until a TARGET RESET is performed (e.g., the pushbutton is pressed, or relay processes an appropriate reset command).

Example Settings

TR = other trip settings + 67P1T + LV11

LV11 = 67G1T * LT1

LV12 = LV11 * !TRIP + LV12 * !TRGTR

OUT105 = LT12

These settings are also shown in a logic diagram in *Figure F.3*. The dashed lines and circled numbers represent the processing order of the SELOGIC equations, as defined in *Table F.4*,

1. LV11
2. LV12
3. TR
4. OUT105

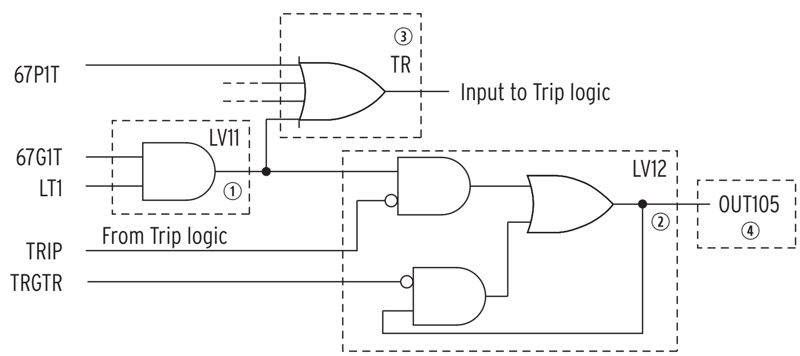
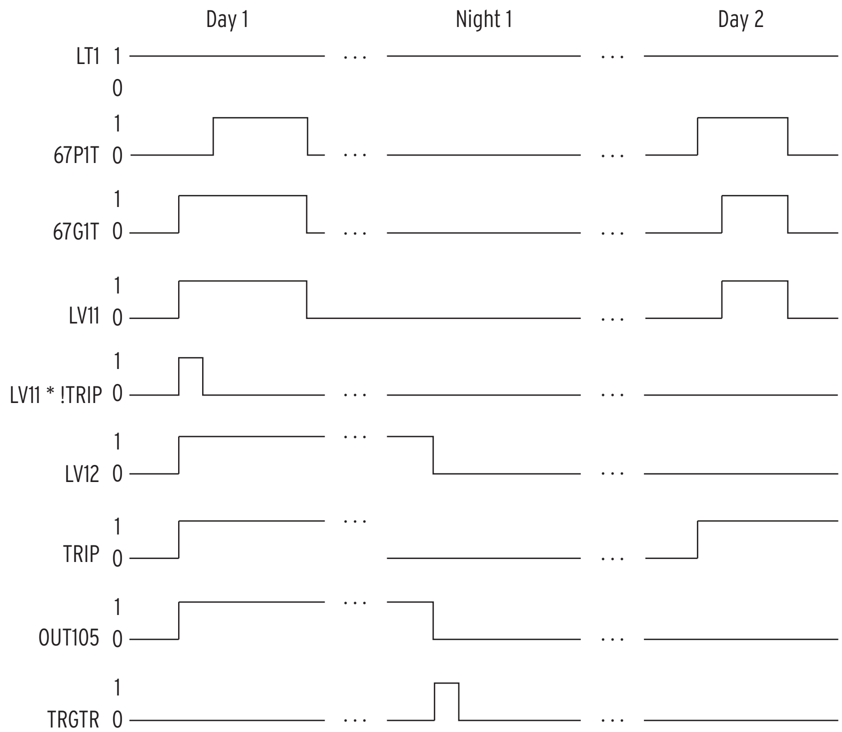


Figure F.3 Logic Diagram of LV12 Seal-In Example

Figure F.4 shows a timing diagram of this logic. On Day 1, a ground fault trips the relay, and the phase element asserts soon after. During Night 1, the **TARGET RESET** button is pressed. On Day 2, a phase fault trips the relay, and the ground element asserts soon after.



Listed in order of processing, from top to bottom.

Figure F.4 Timing Diagram of LV12 Seal-In Example

This example contains a few details that are not apparent at first inspection:

- Although the SELogic control equation setting TR appears first in the logic settings class, it is processed after the LV*n* settings, as shown in *Table F.4*. With these example settings, the SEL-311C will trip just as fast for a 67G1T assertion as if 67G1T * LT1 appeared directly in the TR equation.
- When the SEL-311C is powered up, Relay Word bits LV11 and LV12 are both at logical 0.
- LV11 is processed before LV12.
- LT1 is being used as a ground trip enable. If latch LT1 is deasserted, LV11 cannot assert, and neither can LV12.

Timeline Description for Figure F.4

Day 1: The first part of the LV12 equation (LV11 * !TRIP) works like a fast rising edge detector, evaluating to logical 1 only when LV11 asserts to trip the relay. This works because the TRIP Relay Word bit is still at logical 0 when LV11 first asserts and LV12 is evaluated. In effect, LV12 is processed between LV11 and the TR equation. As shown in *Figure F.4*, the expression LV11 * !TRIP is only logical 1 for one processing interval.

Night 1: Once asserted, LV12 remains asserted until TRGTR asserts to break the seal-in condition created by LV12 * !TRGTR. One way to assert TRGTR is to press the TARGET RESET pushbutton.

Day 2: The relay trips for 67P1T asserting, and then 67G1T asserts. Because TRIP is already asserted when LV11 asserts, the LV11 * !TRIP term in the LV12 equation does not evaluate to logical 1, and LV12 does not newly assert.

SELOGIC Control Equation Limitations

Maximum Number of Relay Word Bits Allowed in a SELOGIC Equation

Any single SELOGIC control equation setting is *limited to 30 Relay Word bits* that can be combined together with the SELOGIC control equation operators listed in *Table F.3*. If this limit must be exceeded, use a logic variable (SELOGIC control equation settings LV1–LV32) as an intermediate setting step.

For example, assume that the trip equation (SELOGIC control equation trip setting TR) needs more than 30 Relay Word bits in its equation setting. Instead of placing all Relay Word bits into TR, program some of them into the SELOGIC control equation setting LV1. Next use the resultant SELOGIC control equation variable output (Relay Word bit LV1) in the SELOGIC control equation trip setting TR.

Processing Order Considerations

Note in *Table F.4* that the SELOGIC control equation variables (SELOGIC control equation settings SV1–SV16) are processed after the trip equation (SELOGIC control equation trip setting TR). Thus, any tripping via Relay Word bits SV1–SV16 can be delayed as much as 1/4 cycle. For most applications, this is probably of no consequence.

However, if a Relay Word bit listed later in *Table F.4* is used in a SELOGIC equation that is listed earlier in *Table F.4* (e.g., in Group 3, TR = SV7 + …), and multiple setting groups are being considered, the Relay Word bit could remain asserted through a group change operation and evaluate to logical 1 for the first run through the SELOGIC equation processing order in the new setting group.

NOTE: If multiple setting groups are planned for the relay settings scheme, inspect or test any mission-critical SELOGIC settings for desired behavior after a group change.

In this example, if the SV7 Relay Word bit is asserted just before changing to setting Group 3, the SV7 Relay Word bit remains asserted and the TR equation evaluates to logical 1 for one processing interval, causing a relay trip. See *SELOGIC Variable and Timer Behavior After Power Loss, Settings Change, or Group Change on page 7.29*.

A safe method of planning multi-group relay settings is to use variables for the same purpose in each settings group and where critical functions are involved (such as breaker open and close operations).

Maximum Total Number of Elements, Rising-Edge, and Falling-Edge Operators

The SELOGIC control equation settings as a whole in a particular setting group have the following limitations:

- Total number of elements ≤ 466
- Total number of rising-edge or falling-edge operators ≤ 49

SELOGIC control equation settings that are set directly to 1 (logical 1) or 0 (logical 0) also have to be included in these limitations—each such setting is counted as one element. Optional MIRRORED BITS® and extra I/O board SELOGIC settings are also counted as elements, even if not ordered.

After SELOGIC control equation settings changes have been made and the settings are saved, the SEL-311C responds with the following message:

xxx Elements and yy Edges remain available

This indicates that “xxx” Relay Word bits can still be used and “yy” rising- or falling-edge operators can still be applied in the SELOGIC control equations for the particular settings group.

Processing Order and Processing Interval

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

Table F.4 Processing Order of Relay Elements and Logic (Top to Bottom) (Sheet 1 of 2)

Relay Elements and Logic	Order of Processing of the SELOGIC Control Equations (Listed in Parentheses) and Relay Word Bits	Reference Instruction Manual Section
Analog and digital data acquisition	DCLO, DCHI, IN101–IN106, IN201–IN208 (extra I/O board), IAMET, IBMET, ICMET, INMET, V0GAIN	*Section 7*, *Section 8*, *Section 9*
Polarizing Voltage	VPOLV	*Section 4*
Received MIRRORED BITS elements	ROKA, LBOKA, RMB8A–RMB1A, ROKB, LBOKB, RMB8B–RMB1B	*Appendix H*
Virtual bits from received GOOSE	VB001–VB128	*Appendix P*
Local Control Switches	LB8–LB1, LB16–LB9	*Section 7*
Remote Control Switches	RB8–RB1, RB16–RB9	*Section 7*
Instantaneous Overcurrent Elements	50P1–50P4, 50A1–50A4, 50B1–50B4, 50C1–50C4, 50A, 50B, 50C, 50L, 50LA, 50LB, 50LC, 50Q1–50Q4, 50QF, 50QR, 50G1–50G4, 50GF, 50GR	*Section 3*
Open Breaker Logic	(52A), 52A, 3PO	*Section 5*
Loss-of-Potential	LOP, ILOP, LOPR, LOP1–LOP4, LOPRST	*Section 4*
Fault Identification Logic	FSA, FSB, FSC, FIDEN	*Section 5*
Load Encroachment	ZLOAD, ZLOUT, ZLIN	*Section 4*
Latch Control Switches	(SET1–SET16, RST1–RST16) LT1–LT16	*Section 7*
Frequency Elements	27B81, FREQOK, 81D1, 81D1T, 81D2, 81D2T, 81D3, 81D3T, 81D4, 81D4T, 81D5, 81D5T, 81D6, 81D6T	*Section 3*
Voltage Elements	59A, 59B, 59C, 59AB, 59BC, 59CA, 3P59, 27A, 27B, 27C, 27AB, 27BC, 27CA, 3P27, 59S, 59V1, 59Q, 59N1, 59N2, 27S	*Section 3*
Synchronism Check Elements and Vs	(BSYNCH), 59VS, 59VP, 59VA, SSLOW, SFAST, SF, 25A1, 25A2	*Section 3*
Zone 1 Extension Equations	(Z1XPEC, Z1XGEC)	*Section 3*
Directional Elements	(E32IV), 32VE, 32IE, 32QE, 32QGE, F32I, R32I, F32V, R32V, F32QG, R32QG, F32Q, R32Q, 32QR, 32QF, 32GR, 32GF	*Section 4*
Switch-onto-Fault Logic	(CLMON)	*Section 5*
Instantaneous/Definite-Time Overcurrent Elements	(67P1TC–67P4TC, 67G1TC–67G4TC, 67Q1TC–67Q4TC), 67P1, 67P1T, 67P2, 67P2T, 67P3, 67P3T, 67P4, 67P4T, 67G1, 67G1T, 67G2, 67G2T, 67G3, 67G3T, 67G4, 67G4T, 67Q1, 67Q1T, 67Q2, 67Q2S, 67Q2T, 67Q3, 67Q3T, 67Q4, 67Q4T	*Section 3*
Time-Overcurrent Elements	(51PTC, 51GTC, 51QTC), 51P, 51PT, 51PR, 51G, 51GT, 51GR, 51Q, 51QT, 51QR	*Section 3*

Table F.4 Processing Order of Relay Elements and Logic (Top to Bottom) (Sheet 2 of 2)

Relay Elements and Logic	Order of Processing of the SELogic Control Equations (Listed in Parentheses) and Relay Word Bits	Reference Instruction Manual Section
Switch-onto-Fault Logic	SOTFE	*Section 5*
Out-of-Step Logic	50ABC, X5ABC, X6ABC, UBOSB, OSB, OSB1–OSB4, OST, OSTI, OSTO	*Section 3*
Distance Logic	MAB1–MAB4, MBC1–MBC4, MCA1–MCA4, M1P–M4P, MABC1–MABC4, MPP1–MPP4, MAG1–MAG4, MBG1–MBG4, MCG1–MCG4, Z1G–Z4G, XAG1–XAG4, XBG1–XBG4, XCG1–XCG4	*Section 3*
Zone 1 Extension Logic	Z1X, Z1XP, Z1XG	*Section 3*
Zone Time Delay Logic	Z1T– Z4T, M1PT– M4PT, Z1GT–Z4GT, Z2GSEQT, M2PSEQT, Z2SEQT	*Section 3*
Logic Variables	(LV1–LV32) LV1–LV32	*Section 7*
Trip Logic	(TR, TRCOMM, TRSOTF, DTT, ULTR, PT1, LOG1, PT2, LOG2, BT, RSTTRGT), PT, Z3RB, EKEY, KEY, WFC, ECTT, UBB2, PTRX2, UBB1, PTRX1, UBB, DSTRT, 67QG2S, Z2PGS, Z3XT, NSTRT, STOP, BTX, PTRX, COMMT, SOTFT, DTT, TRIP, RSTTRGT	*Section 5*
Close Logic Reclosing Relay	(CL, ULCL, 79RI, 79RIS, 79DTL, 79DLS, 79SKP, 79STL, 79BRS, 79SEQ, 79CLS), 79LO, 79CY, 79RS, RCSF, RSTMN, OPTMN, CLOSE, CF, SH0, SH1, SH2, SH3, SH4	*Section 6*
Breaker Monitor	(BKMON), BCWA, BCWB, BCWC, BCW	*Section 8*
SELogic Control Equation Variables/ Timers	(SV1–SV16) SV1–SV16, SV1T–SV16T	*Section 7*
Contact Outputs	(OUT101–OUT107), OUT101–OUT107, (OUT201–OUT212), OUT201–OUT212 (extra I/O board)	*Section 7*
Display Points	(DP1–DP16)	*Section 7*
Setting Group Control	(SS1–SS6)	*Section 7*
Event Report Trigger	(ER)	*Section 12*
Fault detector for Target Logic and Metering	(FAULT)	*Section 5* and *Section 8*
PMU Trigger Equations	(PMTRIG, TREA1–TREA4), PMTRIG, TREA1–TREA4	*Appendix N*
Transmit Mirrored Bits	(TMB1A–TMB8A) TMB1A–TMB8A (TMB1B–TMB8B) TMB1B–TMB8B	*Appendix H*
Setting Group Control	SG1–SG6	*Section 7*
Reset Equations	(RST_DEM, RST_PDM, RST_BK, RST_HIS, RST_ENE, RST_MML), RST_DEM, RST_PDM, RST_BK, RST_HIS, RST_ENE, RST_MML	*Section 8*
Alarm	ALARM	*Section 13*
Target LEDs	(LED1–LED10[a], LED12–LED18[b], LED23–LED26[b]), TRGTR, LED1–LED10[a], LTRIP[b], LTIME[b], LCOMM[b], LSOTF[b], L51[b], LZONE1[b], LZONE2[b], LZONE3[b], LZONE4[b], TLED11–TLED26	*Section 5* and *Section 11*
Synchrophasor status	PMDOK	*Appendix N*
Transmit GOOSE	Processed according to CID file	*Appendix P*
Configurable Operator Control Pushbuttons	PB1PUL–PB10PUL	*Section 11*
Ethernet Link status	LINK5, LINK5A, LINK5B, LNKFAIL, P5ASEL, P5BSEL	*Section 10*

[a] Models with Programmable Operator Controls
[b] Models with Programmable Target LEDs

The Relay Word bits in the following table are processed separately from the above list. They can be thought of as being processed just before (or just after) *Table F.4*.

Table F.5 Asynchronous Processing Order of Relay Elements

Relay Elements and Logic	Order of processing of the SELogic Control Equations (listed in parentheses) and Relay Word Bits	Reference Instruction Manual Section
Voltage input configuration	WYE, DELTA, 3V0	*Section 9*
IRIG-B and Synchrophasor status	PMDOK, TIRIG, TSOK, TQUAL1–TQUAL4, DST, DSTP, LPSECP, LPSEC	*Appendix N*
Simple Network Time Protocol status	TSNTPP, TSNTPB	*Section 10*
Test Database command	TESTDB	*Section 10*
Breaker remote control bits	CC, OC	*Section 10*
Demand Ammeters	QDEM, GDEM, NDEM, PDEM	*Section 8*
Mirrored Bits element status	RBADA, CBADA, RBADB, CBADB	*Appendix H*

Appendix G
Setting Negative-Sequence Overcurrent Elements

Setting Negative-Sequence Definite-Time Overcurrent Elements

Negative-sequence instantaneous overcurrent elements 50Q1–50Q6 and 67Q1–67Q4 should not be set to trip directly. This is because negative-sequence current can transiently appear when a circuit breaker is closed and balanced load current suddenly appears.

To avoid tripping for this transient condition, use negative-sequence definite-time overcurrent elements 67Q1T–67Q4T with at least 1.5 cycles of time delay (transient condition lasts less than 1.5 cycles). For example, make time delay setting:

67Q1D = **1.50**

for negative-sequence definite-time overcurrent element 67Q1T. Refer to *Figure 3.30* for more information on negative-sequence instantaneous and definite-time overcurrent elements.

Setting Negative-Sequence Time-Overcurrent Elements

Negative-sequence time-overcurrent element 51QT should not be set to trip directly when it is set with a low time-dial setting 51QTD, that results in curve times below 3 cycles (see curves in *Figure 9.1*–*Figure 9.10*). This is because negative-sequence current can transiently appear when a circuit breaker is closed and balanced load current suddenly appears. Refer to *Figure 3.33* for more information on negative-sequence time-overcurrent element 51QT.

To avoid having negative-sequence time-overcurrent element 51QT with such low time-dial settings trip for this transient negative-sequence current condition, make settings similar to the following:

SV6PU = **1.50 cycles** (minimum response time; transient condition lasts less than 1.5 cycles)

SV6 = **51Q** (run pickup of negative-sequence time-overcurrent element 51QT through SELOGIC control equation variable timer SV6)

TR = **... + 51QT * SV6T + ...** (trip conditions; SV6T is the output of the SELOGIC control equation variable timer SV6)

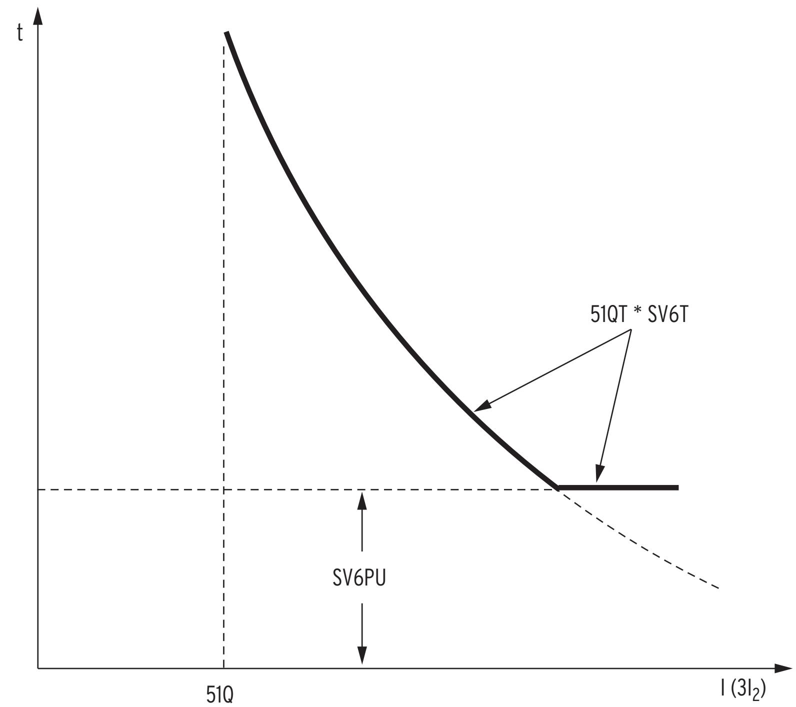


Figure G.1 Minimum Response Time Added to a Negative-Sequence Time-Overcurrent Element 51QT

Other Negative-Sequence Overcurrent Element References

A. F. Elneweihi, E. O. Schweitzer, M. W. Feltis, "Negative-Sequence Overcurrent Element Application and Coordination in Distribution Protection," IEEE Transactions on Power Delivery, Volume 8, Number 3, July 1993, pp. 915–924.

This IEEE paper is the source of the coordination guidelines and example given in this appendix. The paper also contains analyses of system unbalances and faults and the negative-sequence current generated by such conditions.

A. F. Elneweihi, "Useful Applications for Negative-Sequence Overcurrent Relaying," 22nd Annual Western Protective Relay Conference, Spokane, Washington, October 24–26, 1995.

This conference paper gives many good application examples for negative-sequence overcurrent elements. The focus is on the transmission system, where negative-sequence overcurrent elements provide better sensitivity than zero-sequence overcurrent elements in detecting some single-line-to-ground faults.

Appendix H

MIRRORED BITS Communications

Overview

MIRRORED BITS® communications is a direct relay-to-relay communications protocol, which allows protective relays to exchange information quickly and securely, and with minimal expense. Use MIRRORED BITS communications for remote control and remote sensing or communications-assisted protection schemes.

The MIRRORED BITS protocol is available on serial ports 1, 2, 3, or F of SEL-311C relays.

SEL products support several variations of MIRRORED BITS communications protocols. Through port settings, you can set the SEL-311C for compatible operation with SEL-300 series relays, SEL-400 series relays, SEL-600 series relays, SEL-700 series relays, the SEL-2505 Remote I/O Modules, and the SEL-2100 Logic Processors. These devices use MIRRORED BITS communications to exchange the states of eight logic bits.

SEL Application Guide AG2001-12, *Implementing MIRRORED BITS Technology Over Various Communications Media*, provides an overview of the different types of communications channels that might be used for MIRRORED BITS.

Communications Channels and Logical Data Channels

The SEL-311C supports two MIRRORED BITS communications channels, designated A and B. Use the port setting PROTO to assign one of the MIRRORED BITS communications channels to a serial port; PROTO = MB8A, MBA, or MBGA for MIRRORED BITS communications Channel A or PROTO = MB8B, MBB, or MBGB for MIRRORED BITS communications Channel B. See *Settings for MIRRORED BITS on page H.5*.

Transmitted bits include TMB1A–TMB8A and TMB1B–TMB8B. The last letter (A or B) designates the channel with which the bits are associated. These bits are controlled by SELOGIC® control equations. Received bits include RMB1A–RMB8A and RMB1B–RMB8B. You can use received bits as operands in SELOGIC control equations. The channel status bits are ROKA, RBADA, CBADA, LBOKA, ROKB, RBADB, CBADB, and LBOKB. You can also use these bits as operands in SELOGIC control equations. Use the **COM** command for additional channel status information.

Within each MIRRORED BITS communications message for a given channel (A or B), there are eight logical data channels (1–8). Each channel can be used to communicate with either channel A or channel B on another relay, or as TMB1 through TMB8 if connected to a relay with a single MIRRORED BITS communications channel, as shown in *Figure H.1*.

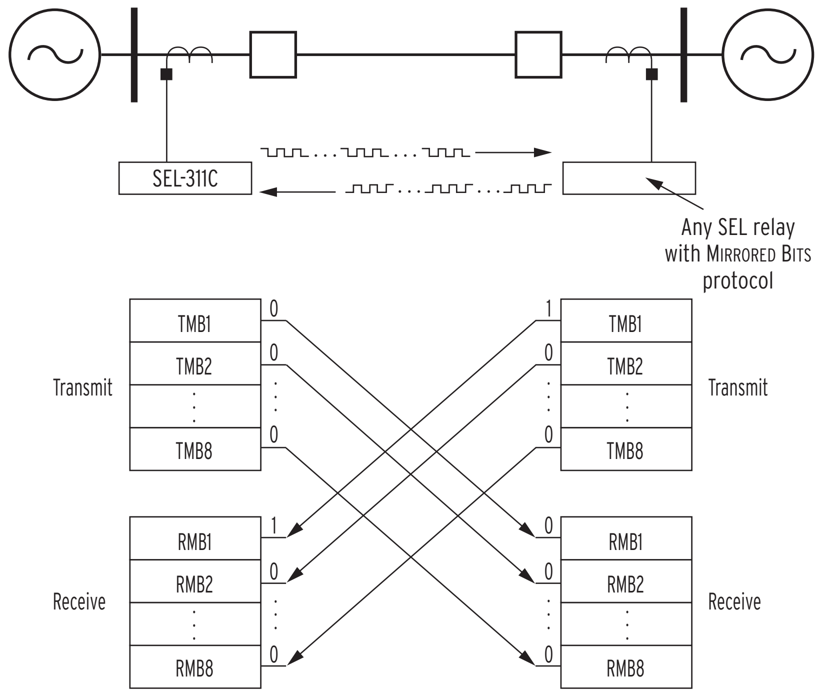


Figure H.1 Relay-to-Relay Logic Communication

Operation

Message Transmission

Depending on the settings, the SEL-311C transmits a MIRRORED BITS communications message every 1/4 to 1/2 of an electrical cycle (see *Table H.2*). Each message contains the most recent values of the transmit bits. All messages are transmitted without idle bits between characters. Idle bits are allowed between messages.

Message Reception

When the devices are synchronized and the MIRRORED BITS communications channel is in a normal state, the relay decodes and checks each received message. If the message is valid, the relay sends each received logic bit (RMB*nc*, where *n* = 1–8, *c* = A or B) to the corresponding pickup and dropout security counters, that in turn set or clear the RMB*nc* relay element bits.

Message Decoding and Integrity Checks

The relay provides indication of the status of each MIRRORED BITS communications channel, with element bits ROKA and ROKB. During normal operation, the relay sets the ROK*c* bit. The relay clears the bit upon detecting any of the following conditions:

- Parity, framing, or overrun errors.
- Receive data redundancy error.
- Receive message identification error.
- No message received in the time three messages have been sent.

The relay will assert ROK*c* only after successful synchronization as described below and two consecutive messages pass all of the data checks described above. After ROK*c* is reasserted, received data may be delayed while passing through the security counters described below.

While ROK*c* is not set, the relay does not transfer new RMB data to the pickup-dropout security counters described below. Instead, the relay sends one of the user-definable default values to the security counter inputs. For each bit RMB1*c*–RMB8*c*, specify the default value with setting RXDFLT, as follows:

- 1
- 0
- X (to use the last valid value)

Pickup/dropout security counters supervise the transfer of received data to RMB1*c*–RMB8*c*. Set these counters between 1 (allow every occurrence to pass) and 8 (require eight consecutive occurrences to pass). The pickup and dropout security count settings are separate.

A pickup/dropout security counter operates identically to a pickup/dropout timer, except that the counter uses units of "counted received messages," instead of time. An SEL-311C communicating with another SEL-311C sends and receives MIRRORED BITS messages four times per power system cycle. Therefore, a security counter set to two counts will delay a bit by about 1/2 power system cycle. You must consider the impact of the security counter settings in the receiving device to determine the channel timing performance.

Things become slightly more complicated when two relays of different processing rates are connected via MIRRORED BITS (for instance, an SEL-321 talking to an SEL-311C). The SEL-321 processes power system information each 1/8 power system cycle but processes the pickup/dropout security counters as messages are received. Since the SEL-321 is receiving messages from the SEL-311C, it will receive a message each 1/4 cycle processing interval. So, a counter set to two will again delay a bit by about 1/2 cycle. However, in that same example, a security counter set to two on the SEL-311C will delay a bit by 1/4 cycle, because the SEL-311C is receiving new MIRRORED BITS messages each 1/8 cycle from the SEL-321.

Channel Synchronization

When an SEL-311C detects a communications error, it deasserts ROK*c*. If a node detects two consecutive communications errors, it transmits an attention message, which includes its TXID setting.

When a node receives an attention message, it checks to see if its TXID is included.

If its own TXID is included and at least one other TXID is included, the node transmits data.

If its own TXID is not included, the node deasserts ROK*c*, includes its TXID in the attention message, and transmits the new attention message.

If its own TXID is the only TXID included, the relay assumes the message is corrupted unless the loopback mode has been enabled. If loopback is not enabled, the node deasserts ROK*c* and transmits the attention message with its TXID included. If loopback is enabled, the relay transmits data.

In summary, when a node detects two consecutive errors, it transmits attention until it receives an attention with its own TXID included. If three or four relays are connected in a ring topology, then the attention message will go all the way around the loop, and eventually will be received by the originating node. It will then be killed and data transmission will resume. This method of synchronization allows the relays to determine reliably which byte is the first byte of the message. It also forces mis-synchronized UARTs to become re-synchronized. On the down side, this method takes down the entire loop for a receive error at any node in the loop. This decreases availability. It also makes one-way communications impossible.

Loopback Testing

Use the **LOO** (loopback) command to enable loopback testing. While in loopback mode, ROK*c* is deasserted, and LBOK*c* asserts and deasserts based on the received data checks. See *LOO Command (Loop Back) on page 10.39* for full details on the **LOO** command.

Channel Monitoring

Based on the results of data checks described above, the relay will collect information regarding the 255 most recent communications errors. Each record contains at least the following fields:

- Dropout Time/Date
- Pickup Time/Date
- Time elapsed during dropout
- Reason for dropout (see *Message Decoding and Integrity Checks on page H.2*)

Use the **COM** command to generate a long or summary report of the communications errors.

There is a single record for each outage, but an outage can evolve. For example, the initial cause could be a data disagreement, but framing errors can extend the outage. If the channel is presently down, the **COM** record will only show the initial cause, but the **COM** summary will display the present cause of failure.

When the duration of an outage on Channel A or B exceeds a user-definable threshold, the relay will assert a user-accessible flag, RBAD*c*.

When channel unavailability exceeds a user-settable threshold, the relay will assert a user accessible flag, hereafter called CBAD*c*.

See *COM Command (Communication Data) on page 10.30* for full details on the **COM** command, including sample reports.

MIRRORED BITS Protocol for the Pulsar 9600 Baud Modem

Setting RTSCTS = MBT indicates that a Pulsar MBT modem is connected. When the user selects MBT, the baud rate setting must be set to 9600 baud.

NOTE: The MBT mode will not work with PROTO = MB8A, MB8B, MBGA, or MBGB.

The MIRRORED BITS protocol compatible with the Pulsar MBT-9600 modem is identical to the standard MIRRORED BITS protocol with the following exceptions:

- The relay injects a delay (idle time) between messages.
- The length of the delay is one relay processing interval.
- The relay resets RTS (to a negative voltage at the EIA-232 connector).

- The relay resets RTS (to a negative voltage at the EIA-232 connector).

  The relay sets RTS (to a positive voltage at the EIA-232 connector) for MIRRORED BITS communications that use the R6 or original R version of MIRRORED BITS.

- The relay monitors the CTS signal on the EIA-232 connector, which the modem will deassert if the channel has too many errors.

NOTE: The Pulsar MBT modem draws power from the relay serial port. See EIA-232 Serial Port Voltage Jumpers on page 2.28.

Settings for MIRRORED BITS

The SEL-311C port settings associated with MIRRORED BITS communications are shown in *Table H.1*.

For convenience, MIRRORED BITS settings are included in the settings sheets. See *Port n Settings (for Serial Ports 1, 2, 3 and F Serial Port SET P n Command and Front Panel) on page SET.36*.

Table H.1 MIRRORED BITS

Name	Description	Range	Default
PROTO	Protocol	SEL, LMD, DNP, MOD, MBA, MBB, MB8A, MB8B, MBGA, MBGB, PMU	SEL[a]
SPEED	Baud Rate	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600	9600 (see *Table H.2*)
RTSCTS	Enable Hardware Handshaking	Y, N, MBT	N
TXID	MIRRORED BITS Transmit Identifier	1–4	2
RXID	MIRRORED BITS Receive Identifier	1–4	1
RBADPU	MIRRORED BITS RX Bad Pickup Time	1–10000 s	60
CBADPU	PPM MIRRORED BITS Channel Bad Pickup	1–10000 s	1000
RXDFLT	MIRRORED BITS Receive Default State	8 character string of 1s, 0s, or *X*s	XXXXXXXX
RMB1PU	MIRRORED BITS RMB_ Pickup Debounce Msgs	1–8	1
RMB1DO	MIRRORED BITS RMB_ Dropout Debounce Msgs	1–8	1
RMB2PU	MIRRORED BITS RMB_ Pickup Debounce Msgs	1–8	1
RMB2DO	MIRRORED BITS RMB_ Dropout Debounce Msgs	1–8	1
RMB3PU	MIRRORED BITS RMB_ Pickup Debounce Msgs	1–8	1
RMB3DO	MIRRORED BITS RMB_ Dropout Debounce Msgs	1–8	1
RMB4PU	MIRRORED BITS RMB_ Pickup Debounce Msgs	1–8	1
RMB4DO	MIRRORED BITS RMB_ Dropout Debounce Msgs	1–8	1
RMB5PU	MIRRORED BITS RMB_ Pickup Debounce Msgs	1–8	1
RMB5DO	MIRRORED BITS RMB_ Dropout Debounce Msgs	1–8	1
RMB6PU	MIRRORED BITS RMB_ Pickup Debounce Msgs	1–8	1
RMB6DO	MIRRORED BITS RMB_ Dropout Debounce Msgs	1–8	1
RMB7PU	MIRRORED BITS RMB_ Pickup Debounce Msgs	1–8	1
RMB7DO	MIRRORED BITS RMB_ Dropout Debounce Msgs	1–8	1
RMB8PU	MIRRORED BITS RMB_ Pickup Debounce Msgs	1–8	1
RMB8DO	MIRRORED BITS RMB_ Dropout Debounce Msgs	1–8	1

[a] Set PROTO = MBA, MBB, MB8A, MB8B, MBGA, or MBGB to access the remaining settings.

Set PROTO = MBA, MB8A, or MBGA to enable the MIRRORED BITS protocol channel A on this port. Set PROTO = MBB, MB8B, or MBGB to enable the MIRRORED BITS protocol channel B on this port. PROTO can be set to MBA, MB8A, or MBGA on only one port at a time. Similarly, PROTO can be set to MBB, MB8B, or MBGB on only one port at a time.

The MIRRORED BITS protocols MBA and MBB use a 7-data bit format for data encoding. These selections are provided for compatibility with existing equipment.

The MB8A, MB8B, MBGA, and MBGB protocols use an 8-data bit format, which allows MIRRORED BITS to operate on communication channels requiring an 8-data bit format. These selections are compatible with more equipment types and are recommended for new installations.

Protocols MBGA and MBGB move RXID and TXID settings from Port settings to Group settings. This allows TXID and RXID to be unique per settings group. See Application Guide AG2005-09, *Using the SEL-2126 Fiber-Optic Transfer Switch and the SEL-321-1 in Bypass-Breaker MIRRORED BITS Communications-Assisted Tripping Schemes*.

As a function of the settings for SPEED, the message transmission periods are shown in *Table H.2*.

Table H.2 Message Transmission Periods

SPEED	SEL-311C
57600	1 message per 1/4 cycle
38400	1 message per 1/4 cycle
19200	1 message per 1/4 cycle
9600	1 message per 1/4 cycle
4800	1 message per 1/2 cycle

Set the RXID of the local relay to match the TXID of the remote relay. For example, for a two-terminal application, where Relay X transmits to Relay Y and Relay Y transmits to Relay X:

	TXID	RXID
Relay X	1	2
Relay Y	2	1

See SEL Application Guide AG96-17, *Three-Terminal Line Protection Using SEL-321-1 Relays With MIRRORED BITS Communications*, for details on three-terminal applications.

Use the RBADPU setting to determine how long a channel error must last before the relay element RBADA is asserted. RBADA is deasserted when the channel error is corrected. RBADPU is accurate to ±1 second.

Use the CBADPU setting to determine the ratio of channel down time to the total channel time before the relay element CBAD*c* is asserted. The times used in the calculation are those that are available in the **COM** records. See the *COM Command (Communication Data) on page 10.30* for a description of the **COM** records.

Use the RXDFLT setting to determine the default state the MIRRORED BITS should use in place of received data if an error condition is detected. The setting is a mask of 1s, 0s and/or *X*s, for RMB1*c*–RMB8*c*, where *X* represents the most recently received valid value. The order of the MIRRORED BITS in the RXDFLT mask setting is 87654321.

Supervise the transfer of received data (or default data) to RMB1*c*–RMB8*c* with the MIRRORED BITS pickup and dropout security counters. Set the pickup and dropout counters individually for each bit.

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Appendix I
SEL Distributed Port Switch Protocol

Overview

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

LMD is often used with EIA-485 serial communications. In the SEL-311C the PROTO = LMD setting choice is allowed on any serial port, even on relays without the optional EIA-485 port.

Settings

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

Settings	Description
PREFIX:	One character to precede the address. This should be a character that does not occur in the course of other communications with the relay. Valid choices are one of the following: "@", "#", "$", "%", "&". The default is "@."
ADDR:	Two-character ASCII address. The range is "01" to "99." The default is "01."
SETTLE:	Time in seconds that transmission is delayed after the request to send (RTS line) asserts. This delay accommodates transmitters with a slow rise time.

See *SEL LMD Protocol Settings on page SET.37* for the full list of settings, including the port time-out setting.

Operation

1. The relay ignores all input from this port 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.

NOTE: You can use the front-panel SET pushbutton, or another communications port, to change the LMD port settings to return to SEL protocol.

4. Until the relay connection terminates, you can use the standard commands that are available when PROTO is set to SEL.
5. The **QUIT** command terminates the connection. If no data are sent to the relay before the port time-out 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.

Appendix J
Configuration, Fast Meter, and Fast Operate Commands

Overview

SEL relays have two separate data streams that share the same serial port. Data communications with the relay consist of ASCII character commands and reports that are intelligible using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information and then allow the ASCII data stream to continue.

This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to exploit this feature. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

SEL Application Guide AG95-10, *Configuration and Fast Meter Messages*, is a comprehensive description of the SEL binary messages. Below is a description of the messages provided in the SEL-311C.

Message Lists

Binary Message List

Table J.1 Binary Message List (Sheet 1 of 2)

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 J.1 Binary Message List (Sheet 2 of 2)

Request to Relay (hex)	Response From Relay
A5CD	Fast Reset Configuration Block
A5ED	Fast Reset Control

ASCII Configuration Message List

Table J.2 ASCII Configuration Message List

Request to Relay (ASCII)	Response From Relay
ID	ASCII Firmware ID String and Terminal ID Setting (TID)
DNA	ASCII Names of Relay Word bits
BNA	ASCII Names of bits in the A5D1 Status Byte
SNS	ASCII Names of bits in the SER SER trigger settings

Message Definitions

A5C0 Relay Definition Block

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

Table J.3 A5C0 Relay Definition Block

Data	Description
A5C0	Command
2A	Message length
07	Support seven protocols: SEL, MIRRORED BITS®, DNP, LMD, Modbus®, IEEE C37.118, and IEC 61850.
03	Support Fast Meter, fast demand, and fast peak
01	Status flag for Settings change
A5C1	Fast Meter configuration
A5D1	Fast Meter message
A5C2	Fast demand configuration
A5D2	Fast demand message
A5C3	Fast peak configuration
A5D3	Fast peak message
0001	Settings change bit
A5C100000000	Reconfigure Fast Meter on settings change
0300	SEL protocol with Fast Operate and fast message (unsolicited SER messaging)
0101	LMD protocol with Fast Operate
0002	Modbus
0005	DNP3
0006	MIRRORED BITS protocol
0007	IEEE C37.118 Synchrophasors
0008	IEC 61850
00	Reserved
xx	Checksum

A5C1 Fast Meter Configuration Block

NOTE: Analog channel names are transmitted by the relay as part of the AC51 message. To support legacy applications, some Fast Meter analog channel names differ from the analog labels used for DNP and Modbus protocols documented in Appendix E: Analog Quantities, Appendix L: DNP3 Communications, and Appendix O: Modbus RTU and TCP Communications. The analog channel names shown in brackets [] in Table J.4 are those contained in the Fast Meter message. The analog labels from Appendix E: Analog Quantities are shown in parentheses.

NOTE: See Appendix E: Analog Quantities for definitions of analog channel names.

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

Table J.4 A5C1 Fast Meter Configuration Block (Sheet 1 of 2)

Data	Description
A5C1	Fast Meter command
84	Length
01	One status flag byte
00	Scale factors in Fast Meter message
00	No scale factors
0A	# of analog input channels
02	# of samples per channel
64	# of digital banks
01	One calculation block
0004	Analog channel offset
0054	Time stamp offset
005C	Digital offset
494100000000	Analog channel name [IA] (IA)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494200000000	Analog channel name [IB] (IB)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494300000000	Analog channel name [IC] (IC)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494E00000000	Analog channel name [IN] (IN)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564100000000[a]	Analog channel name [VA] (VA)
564142000000[b]	Analog channel name [VAB] (VAB)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564200000000[a]	Analog channel name [VB] (VB)
564243000000[b]	Analog channel name [VBC] (VBC)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564300000000[a]	Analog channel name [VC] (VC)

Table J.4 A5C1 Fast Meter Configuration Block (Sheet 2 of 2)

Data	Description
564341000000[b]	Analog channel name [VCA] (VCA)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
565300000000	Analog channel name [VS] (VS)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
465245510000	Analog channel name [FREQ] (FREQ)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564241540000	Analog channel name [VBAT] (VDC)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
00	Line Configuration (00-ABC PTCONN = WYE, 01-ACB PTCONN = WYE, 02-ABC PTCONN = DELTA, 03-ACB PTCONN = DELTA)
00	Power Calculations (00 for PTCONN = WYE, 01 for PTCONN = DELTA)
FFFF	No Deskew angle
FFFF	No Rs compensation (–1)
FFFF	No Xs compensation (–1)
00	**IA** channel index
01	**IB** channel index
02	**IC** channel index
04	**VA** channel index (VAB for PTCONN = DELTA)
05	**VB** channel index (VBC for PTCONN = DELTA)
06	**VC** channel index (VCA for PTCONN = DELTA)
00	Reserved
checksum	1-byte checksum of all preceding bytes

[a] Included in message when Global setting PTCONN = WYE.
[b] Included in message when Global setting PTCONN = DELTA.

A5D1 Fast Meter Data Block

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

Table J.5 A5D1 Fast Meter Data Block

Data	Description
A5D1	Command
C2	Length
1 byte	1 Status Byte
80 bytes	X and Y components of: IA, IB, IC, IN, VA/VAB, VB/VBC, VC/VCA, VS, FREQ and VDC in 4-byte IEEE FPS
8 bytes	Time stamp
100 bytes	Two target LED rows and 98 digital banks: TAR0–TAR99
1 byte	Reserved
checksum	1-byte checksum of all preceding bytes

A5C2/A5C3 Demand/ Peak Demand Fast Meter Configuration Messages

NOTE: Analog channel names are transmitted by the relay as part of the AC52 and AC53 messages. To support legacy applications, some Fast Meter analog channel names differ from the analog labels used for DNP and Modbus protocols documented in Appendix E: Analog Quantities, Appendix L: DNP3 Communications, and Appendix O: Modbus RTU and TCP Communications. The analog channel names shown in brackets [] in Table J.6 are those contained in the Fast Meter message. The analog labels from Appendix E: Analog Quantities are shown in parentheses.

In response to the A5C2 or A5C3 request, the relay sends the following block.

Table J.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 1 of 3)

Data	Description
A5C2 or A5C3	Command; Demand (A5C2) or Peak Demand (A5C3)
EE	Length
01	# of status flag bytes
00	Scale factors in meter message
00	# of scale factors
16	# of analog input channels
01	# of samples per channel
00	# of digital banks
00	# of calculation blocks
0004	Analog channel offset
00B4	Time stamp offset
FFFF	Digital offset
494100000000	Analog channel name [IA] (IADEM or IAPK)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494200000000	Analog channel name [IB] (IBDEM or IBPK)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494300000000	Analog channel name [IC] (ICDEM or ICPK)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494E00000000	Analog channel name [IN] (INDEM or INPK)
02	Analog channel type

Table J.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 2 of 3)

Data	Description
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494700000000	Analog channel name [IG] (IGDEM or IGPK)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
334932000000	Analog channel name [3I2] (3I2DEM or 3I2PK)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50412B000000	Analog channel name [PA+] (MWADO or MWAPO)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50422B000000	Analog channel name [PB+] (MWBDO or MWBPO)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50432B000000	Analog channel name [PC+] (MWCDO or MWCPO)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50332B000000	Analog channel name [P3+] (MW3DO or MW3PO)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51412B000000	Analog channel name [QA+] (MVRADO or MVRAPO)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51422B000000	Analog channel name [QB+] (MVRBDO or MVRBPO)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51432B000000	Analog channel name [QC+] (MVRCDO or MVRCPO)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51332B000000	Analog channel name [Q3+] (MVR3DO or MVR3PO)
02	Analog channel type

Table J.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 3 of 3)

Data	Description
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50412D000000	Analog channel name [PA–] (MWADI or MWAPI)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50422D000000	Analog channel name [PB–] (MWBDI or MWBPI)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50432D000000	Analog channel name [PC–] (MWCDI or MWCPI)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50332D000000	Analog channel name [P3–] (MW3DI or MW3PI)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51412D000000	Analog channel name [QA–] (MVRADI or MVRAPI)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51422D000000	Analog channel name [QB–] (MVRBDI or MVRBPI)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51432D000000	Analog channel name [QC–] (MVRCDI or MVRCPI)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51332D000000	Analog channel name [Q3–] (MVR3DI or MVR3PI)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
00	Reserved
checksum	1-byte checksum of preceding bytes

A5D2/A5D3 Demand/Peak Demand Fast Meter Message

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

Table J.7 A5D2/A5D3 Demand/Peak Demand Fast Meter Message

Data	Description
A5D2 or A5D3	Command
BE	Length
1 byte	1 Status Byte
176-bytes	IADEM/IAPK, IBDEM/IBPK, ICDEM/ICPK, INDEM/INPK, IGDEM/IGPK, 3I2DEM/3I2PK, MWADI/MWAPI, MWBDI/MWBPI, MWCDI/MWCPI, MW3DI/MW3PI, MVRADI/MVRAPI, MVRBDI/MVRBPI, MVRCDI/MVRCPI, MVR3DI/MVR3PI, MWADO/MWAPO, MWBDO/MWBPO, MWCDO/MWCPO, MW3DO/MW3PO, MVRADO/MVRAPO, MVRBDO/MVRBPO, MVRCDO/MVRCPO, MVR3DO/MVR3PO 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-311C Status Byte contains two active bits: STSET (bit 1) and PWRUP (bit 2); both bits are set on power up. The STSET bit is also set 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.

A5CE Fast Operate Configuration Block

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

Table J.8 A5CE Fast Operate Configuration Block (Sheet 1 of 2)

Data	Description
A5CE	Command
3C	Length
01	Support 1 circuit breaker
0010	Support 16 remote bit set/clear commands
0100	Allow remote bit pulse commands
31	Operate code, open breaker 1
11	Operate code, close breaker 1
00	Operate code, clear remote bit RB1
20	Operate code, set remote bit RB1
40	Operate code, pulse remote bit RB1
01	Operate code, clear remote bit RB2
21	Operate code, set remote bit RB2
41	Operate code, pulse remote bit RB2
02	Operate code, clear remote bit RB3
22	Operate code, set remote bit RB3
42	Operate code, pulse remote bit RB3
03	Operate code, clear remote bit RB4

Table J.8 A5CE Fast Operate Configuration Block (Sheet 2 of 2)

Data	Description
23	Operate code, set remote bit RB4
43	Operate code, pulse remote bit RB4
04	Operate code, clear remote bit RB5
24	Operate code, set remote bit RB5
44	Operate code, pulse remote bit RB5
05	Operate code, clear remote bit RB6
25	Operate code, set remote bit RB6
45	Operate code, pulse remote bit RB6
06	Operate code, clear remote bit RB7
26	Operate code, set remote bit RB7
46	Operate code, pulse remote bit RB7
07	Operate code, clear remote bit RB8
27	Operate code, set remote bit RB8
47	Operate code, pulse remote bit RB8
08	Operate code, clear remote bit RB9
28	Operate code, set remote bit RB9
48	Operate code, pulse remote bit RB9
09	Operate code, clear remote bit RB10
29	Operate code, set remote bit RB10
49	Operate code, pulse remote bit RB10
0A	Operate code, clear remote bit RB11
2A	Operate code, set remote bit RB11
4A	Operate code, pulse remote bit RB11
0B	Operate code, clear remote bit RB12
2B	Operate code, set remote bit RB12
4B	Operate code, pulse remote bit RB12
0C	Operate code, clear remote bit RB13
2C	Operate code, set remote bit RB13
4C	Operate code, pulse remote bit RB13
0D	Operate code, clear remote bit RB14
2D	Operate code, set remote bit RB14
4D	Operate code, pulse remote bit RB14
0E	Operate code, clear remote bit RB15
2E	Operate code, set remote bit RB15
4E	Operate code, pulse remote bit RB15
0F	Operate code, clear remote bit RB16
2F	Operate code, set remote bit RB16
4F	Operate code, pulse remote bit RB16
00	Reserved
checksum	1-byte checksum of all preceding bytes

A5E0 Fast Operate Remote Bit Control

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

Table J.9 A5E0 Fast Operate Remote Bit Control

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

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

- ➤ The Operate code is valid.
- ➤ The Operate validation = 4 • Operate code + 1.
- ➤ The message checksum is valid.
- ➤ The FASTOP 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 (1/4 cycle).

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

Via the **SET** command:

ESV = **4** enable 4 SELOGIC control equations

SV4PU = **0** SV4 pickup time = 0

SV4DO = **30** SV4 dropout time is 30 cycles

Via the **SET L** command:

SV4 = **RB4** SV4 input is RB4

OUT104 = **SV4T** route SV4 timer output to **OUT104**

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

A5E3 Fast Operate Breaker Control

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

Table J.10 A5E3 Fast Operate Breaker Control

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

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

- ➤ Conditions 1–5 defined in the A5E0 message are true.
- ➤ The breaker jumper (JMP1B) is in place on the SEL-311C main board.

A5CD Fast Operate Reset Definition Block

In response to an A5CD request, the relay sends the configuration block for the Fast Operate Reset message.

Table J.11 A5CD Fast Operate Reset Definition Block

Data	Description
A5CD	Command
0E	Message length
01	The number of Fast Operate reset codes supported
00	Reserved for future use
00	Fast Operate reset code (“00” for target reset)
54415220520D00	Fast Operate reset description string (“TAR R”)
xx	Checksum

A5ED Fast Operate Reset Command

The Fast Operate Reset commands take the following form.

Table J.12 A5ED Fast Operate Reset Command

Data	Description
A5ED	Command
06	Message Length—always 6
00	Operate Code (“00” for target reset, “TAR R”)
01	Operate Validation—(4 • Operate Code) + 1
xx	Checksum

ID Message

In response to the **ID** command, the relay sends the firmware ID (FID), boot firmware ID (BFID), firmware checksum (CID), relay TID setting (DEVID), Modbus® device code (DEVCODE)—for use by an SEL Communications Processor), relay part number (PARTNO), relay serial number (SERIALNO), and configuration string (CONFIG)—for use by other IEDs or software.

A sample response is shown below; responses will differ depending on relay model, settings, and firmware.

```
<STX>
"FID=SEL-311C-1-R5xx-V0-Zxxxxxx-Dxxxxxxxx","yyyy"<CR><LF>
"BFID=SLBT-3CF1-Rxxx-V0-Zxxxxxx-Dxxxxxxxx","yyyy"<CR><LF>
"CID=xxxx","yyyy"<CR><LF>
"DEVID=STATION A","yyyy"<CR><LF>
"DEVCODE=51","yyyy"<CR><LF>
"PARTNO=0311C11HR3F54C2","yyyy"<CR><LF>
“SERIALNO=2011001001”,”05EF”
"CONFIG=11222201","yyyy"<CR><LF>
"SPECIAL=11000","yyyy"<CR><LF>
"iedName=","yyyy"<CR><LF>
"type=","yyyy"<CR><LF>
"configVersion=","yyyy"<CR><LF>
<ETX>
```

where:

<STX>	is the STX character (02)
<ETX>	is the ETX character (03)
xxxx	is the 4-byte ASCII hex representation of the checksum of the relay firmware
yyyy	is the 4-byte ASCII hex representation of the checksum for each line

The ID message is available from Access Level 0 and higher.

DNA Message

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

In response to the **DNA** command (without T or X modifier), the relay sends the **DNA X** command with all Relay Word bit names replaced with *. This is necessary for compatibility with older communications processors.

The DNA T message for an example SEL-311C is shown below.

```
<STX>
"TLED11","TLED12","TLED13","TLED14","TLED15","TLED16","TLED17","TLED18","0FF4"<CR><LF>
"TLED19","TLED20","TLED21","TLED22","TLED23","TLED24","TLED25","TLED26","0FF5"<CR><LF>
"M1P","M1PT","Z1G","Z1GT","M2P","M2PT","Z2G","Z2GT","0B54"<CR><LF>
"Z1T","Z2T","50P1","67P1","67P1T","50G1","67G1","67G1T","0B50"<CR><LF>
"51G","51GT","51GR","LOP","ILOP","ZLOAD","ZLOUT","ZLIN","0CA1"<CR><LF>
"LB1","LB2","LB3","LB4","LB5","LB6","LB7","LB8","0994"<CR><LF>
"LB9","LB10","LB11","LB12","LB13","LB14","LB15","LB16","0AE5"<CR><LF>
"RB1","RB2","RB3","RB4","RB5","RB6","RB7","RB8","09C4"<CR><LF>
"RB9","RB10","RB11","RB12","RB13","RB14","RB15","RB16","0B15"<CR><LF>
"LT1","LT2","LT3","LT4","LT5","LT6","LT7","LT8","0A24"<CR><LF>
"LT9","LT10","LT11","LT12","LT13","LT14","LT15","LT16","0B75"<CR><LF>
"SV1","SV2","SV3","SV4","SV1T","SV2T","SV3T","SV4T","0BAC"<CR><LF>
"SV5","SV6","SV7","SV8","SV5T","SV6T","SV7T","SV8T","0BCC"<CR><LF>
"SV9","SV10","SV11","SV12","SV9T","SV10T","SV11T","SV12T","0CD6"<CR><LF>
"SV13","SV14","SV15","SV16","SV13T","SV14T","SV15T","SV16T","0D44"<CR><LF>
"MAB1","MBC1","MCA1","MAB2","MBC2","MCA2","CVTBL","SOTFT","0C9A"<CR><LF>
"MAG1","MBG1","MCG1","MAG2","MBG2","MCG2","DCHI","DCLO","0BE7"<CR><LF>
"BCW","BCWA","BCWB","BCWC","FIDEN","FSA","FSB","FSC","0BAD"<CR><LF>
"SG1","SG2","SG3","SG4","SG5","SG6","OC","CC","0969"<CR><LF>
"CLOSE","CF","TRGTR","52A","3PO","SOTFE","VPOLV","50L","0C55"<CR><LF>
"PDEM","GDEM","QDEM","TRIP","50QF","50QR","50GF","50GR","0C1D"<CR><LF>
"32QF","32QR","32GF","32GR","32VE","32QGE","32IE","32QE","0BA4"<CR><LF>
"F32I","R32I","F32Q","R32Q","F32QG","R32QG","F32V","R32V","0C18"<CR><LF>
"*","*","IN106","IN105","IN104","IN103","IN102","IN101","0AD9"<CR><LF>
"ALARM","OUT107","OUT106","OUT105","OUT104","OUT103","OUT102","OUT101","0FC8"<CR><LF>
"M3P","M3PT","Z3G","Z3GT","M4P","M4PT","Z4G","Z4GT","0B64"<CR><LF>
"Z3T","Z4T","50P2","67P2","67P2T","50P3","67P3","67P3T","0B78"<CR><LF>
"50G2","67G2","67G2T","50G3","67G3","67G3T","*","*","09D3"<CR><LF>
"51P","51PT","51PR","Z1X","59VA","MAB3","MBC3","MCA3","0B3C"<CR><LF>
"MAG3","MBG3","MCG3","27S","59S","*","59VP","59VS","0A6D"<CR><LF>
"SF","25A1","25A2","RCSF","OPTMN","RSTMN","*","PMDOK","0BC1"<CR><LF>
"79RS","79CY","79LO","SH0","SH1","SH2","SH3","SH4","0AAD"<CR><LF>
"MAB4","MBC4","MCA4","MAG4","MBG4","MCG4","TSOK","TIRIG","0C6D"<CR><LF>
"XAG1","XBG1","XCG1","XAG2","XBG2","XCG2","XAG3","XBG3","0C16"<CR><LF>
"XCG3","XAG4","XBG4","XCG4","OSTI","OSTO","OST","50ABC","0C79"<CR><LF>
"X5ABC","X6ABC","OSB","OSB1","OSB2","OSB3","OSB4","UBOSB","0CE0"<CR><LF>
"50G4","67G4","67G4T","*","MPP1","MABC1","MPP2","MABC2","0B74"<CR><LF>
"50Q1","67Q1","67Q1T","50Q2","67Q2","67Q2T","59N1","59N2","0B90"<CR><LF>
"50Q3","67Q3","67Q3T","50Q4","67Q4","67Q4T","59Q","59V1","0B75"<CR><LF>
"51Q","51QT","51QR","*","*","Z2PGS","67QG2S","BTX","0A8D"<CR><LF>
"Z3XT","DSTRT","NSTRT","STOP","Z3RB","KEY","EKEY","ECTT","0D93"<CR><LF>
"PTRX","UBB1","UBB2","UBB","WFC","PT","PTRX1","PTRX2","0C3F"<CR><LF>
"27A","27B","27C","59A","59B","59C","3P27","3P59","096E"<CR><LF>
"27AB","27BC","27CA","59AB","59BC","59CA","*","*","0971"<CR><LF>
"*","*","*","*","*","*","*","*","04D0"<CR><LF>
"*","*","*","*","MPP3","MABC3","MPP4","MABC4","08F6"<CR><LF>
"*","*","*","*","*","*","*","*","04D0"<CR><LF>
"RMB8A","RMB7A","RMB6A","RMB5A","RMB4A","RMB3A","RMB2A","RMB1A","0E34"<CR><LF>
"TMB8A","TMB7A","TMB6A","TMB5A","TMB4A","TMB3A","TMB2A","TMB1A","0E44"<CR><LF>
"RMB8B","RMB7B","RMB6B","RMB5B","RMB4B","RMB3B","RMB2B","RMB1B","0E3C"<CR><LF>
"TMB8B","TMB7B","TMB6B","TMB5B","TMB4B","TMB3B","TMB2B","TMB1B","0E4C"<CR><LF>
"LBOKB","CBADB","RBADB","ROKB","LBOKA","CBADA","RBADA","ROKA","0DFA"<CR><LF>
"81D1","81D2","81D3","81D4","81D5","81D6","27B81","*","0A01"<CR><LF>
"81D1T","81D2T","81D3T","81D4T","81D5T","81D6T","*","*","0B0F"<CR><LF>
"50A1","50B1","50C1","50A2","50B2","50C2","50A3","50B3","0A46"<CR><LF>
"50C3","50A4","50B4","50C4","*","50A","50B","50C","090B"<CR><LF>
"*","*","*","*","*","3V0","DELTA","WYE","076A"<CR><LF>
"50P4","67P4","67P4T","*","*","*","*","FREQOK","090F"<CR><LF>
"*","*","*","*","Z2SEQT","M2PSEQT","Z2GSEQT","*","0A37"<CR><LF>
"Z1XP","Z1XG","*","*","*","*","*","*","06D9"<CR><LF>
"*","LINK5A","LINK5B","LNKFAIL","P5ASEL","P5BSEL","TSNTPP","TSNTPB","100D"<CR><LF>
"DST","DSTP","LPSEC","LPSECP","TQUAL4","TQUAL3","TQUAL2","TQUAL1","0FCA"<CR><LF>
"*","V0GAIN","INMET","ICMET","IBMET","IAMET","NDEM","TESTDB","0E09"<CR><LF>
"*","RSTTRGT","RST_MML","RST_ENE","RST_HIS","RST_BK","RST_PDM","RST_DEM","12DA"<CR><LF>
"SFAST","SSLOW","LOPRST","PMTRIG","TREA1","TREA2","TREA3","TREA4","0FCA"<CR><LF>
"LOP1","LOP2","LOP3","LOP4","*","*","*","*","089E"<CR><LF>
"*","*","*","*","*","*","*","*","04D0"<CR><LF>
"*","*","*","*","*","*","*","*","04D0"<CR><LF>
"*","*","*","*","*","*","*","*","04D0"<CR><LF>
"*","*","*","*","*","*","*","*","04D0"<CR><LF>
"*","*","*","*","*","*","*","*","04D0"<CR><LF>
"*","*","*","*","*","*","*","*","04D0"<CR><LF>
"*","*","*","*","50LA","50LB","50LC","*","072B"<CR><LF>
"*","COMMT","*","*","*","*","DTT","*","06E8"<CR><LF>
"PB1PUL","PB2PUL","PB3PUL","PB4PUL","PB5PUL","PB6PUL","PB7PUL","PB8PUL","113C"<CR><LF>
"LED1","LED2","LED3","LED4","LED5","LED6","LED7","LED8","0BCC"<CR><LF>
"LED9","*","LED10","*","*","*","PB10PUL","PB9PUL","0A0C"<CR><LF>
"*","*","*","*","*","*","*","*","04D0"<CR><LF>
"LTRIP","LTIME","LCOMM","LSOTF","LZONE1","LZONE2","LZONE3","LZONE4","1070"<CR><LF>
"L51","*","*","*","*","*","*","*","0558"<CR><LF>
"LV1","LV2","LV3","LV4","LV5","LV6","LV7","LV8","0A34"<CR><LF>
"LV9","LV10","LV11","LV12","LV13","LV14","LV15","LV16","0B85"<CR><LF>
"LV17","LV18","LV19","LV20","LV21","LV22","LV23","LV24","0BBF"<CR><LF>
"LV25","LV26","LV27","LV28","LV29","LV30","LV31","LV32","0BC9"<CR><LF>
"VB001","VB002","VB003","VB004","VB005","VB006","VB007","VB008","0CE4"<CR><LF>
"VB009","VB010","VB011","VB012","VB013","VB014","VB015","VB016","0CE5"<CR><LF>
"VB017","VB018","VB019","VB020","VB021","VB022","VB023","VB024","0CEF"<CR><LF>
```

```
"VB025","VB026","VB027","VB028","VB029","VB030","VB031","VB032","0CF9"<CR><LF>
"VB033","VB034","VB035","VB036","VB037","VB038","VB039","VB040","0D03"<CR><LF>
"VB041","VB042","VB043","VB044","VB045","VB046","VB047","VB048","0D04"<CR><LF>
"VB049","VB050","VB051","VB052","VB053","VB054","VB055","VB056","0D05"<CR><LF>
"VB057","VB058","VB059","VB060","VB061","VB062","VB063","VB064","0D0F"<CR><LF>
"VB065","VB066","VB067","VB068","VB069","VB070","VB071","VB072","0D19"<CR><LF>
"VB073","VB074","VB075","VB076","VB077","VB078","VB079","VB080","0D23"<CR><LF>
"VB081","VB082","VB083","VB084","VB085","VB086","VB087","VB088","0D24"<CR><LF>
"VB089","VB090","VB091","VB092","VB093","VB094","VB095","VB096","0D25"<CR><LF>
"VB097","VB098","VB099","VB100","VB101","VB102","VB103","VB104","0D02"<CR><LF>
"VB105","VB106","VB107","VB108","VB109","VB110","VB111","VB112","0CF1"<CR><LF>
"VB113","VB114","VB115","VB116","VB117","VB118","VB119","VB120","0CFB"<CR><LF>
"VB121","VB122","VB123","VB124","VB125","VB126","VB127","VB128","0CFC"<CR><LF>
<ETX>
```

where:

<STX>	is the STX character (02)
<ETX>	is the ETX character (03)
the last field in each line (yyyy)	is the 4-byte ASCII hex representation of the checksum for the line
"*"	indicates an unused bit location

Messages for other relay models may be derived from the appropriate tables in *Appendix D: Relay Word Bits* of this manual, using the above format.

BNA Message

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

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

where:

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

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

SNS Message

In response to the **SNS** command, the relay sends the name string of the SER (SER1 SER2 SER3) settings. The **SNS** command is available at Access Level 1.

The relay responds to the **SNS** command with the name string in the SER settings. The name string starts with SER1, followed by SER2 and SER3.

For example, if

SER1 = 50A1 OUT101

SER2 = 67P1T 81D1T

SER3 = OUT102 52A

The name string will be

"50A1","OUT101","67P1T","81D1T","OUT102","52A".

If there are more than eight settings in SER, the SNS message will have several rows. Each row will have eight strings, followed by the checksum and carriage return. The last row may have less than eight strings.

The SNS message for the SEL-311C is shown below:

```
<STX>"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR><LF>
     "xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR><LF>
     "xxxx","xxxx","xxxx",<CR><LF><ETX>
```

where:

xxxx is a string from the settings in SER (SER1, SER2 and SER3)

yyyy is the 4-byte ASCII representation of the checksum

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Appendix K
Compressed ASCII Commands

Overview

The SEL-311C Relay provides Compressed ASCII versions of some relay ASCII commands. The Compressed ASCII commands allow an external device to obtain data from the relay, in a format which directly imports into spreadsheet or database programs, and which can be validated with a checksum.

The SEL-311C provides the following Compressed ASCII commands:

Table K.1 Compressed ASCII Commands

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

CASCII Command—General Format

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

CAS <CR>

The relay sends the following:

```
<STX>"CAS",n,"yyyy"<CR>
"COMMAND 1",ll,"yyyy"<CR>
"#H","xxxxx","xxxxx",......,"xxxxx","yyyy"<CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR>
"COMMAND 2",ll,"yyyy"<CR>
"#h","ddd","ddd",......,"ddd","yyyy"<CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR>
   .
   .
   .
"COMMAND n",ll,"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.
ll	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 with the following message:

```
<STX>"No Data Available","0668"<CR><ETX>
```

CASCII Command—SEL-311C

Display the SEL-311C Compressed ASCII configuration message by sending:

CAS <CR>

The relay sends:

```
<STX>
"CAS",6,"yyyy"<CR>
"CST",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","45S","yyyy"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
"1D","I","I","I","I","I","I","I","yyyy"<CR>
"28H","IA_OS","IB_OS","IC_OS","IN_OS","VA_OS","VB_OS","VC_OS","VS_OS","MOF_OS",
"IA_OSH","IB_OSH","IC_OSH","IN_OSH","15V_PS","5V_REG","3.3V_REG","RAM","ROM",
"FPGA","EEPROM","FLASH","A/D","USB_BRD","COM_BRD","IO_BRD","TEMP","RTC","HMI",
"yyyy"<CR>
"1D","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S",
"9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","yyyy"<CR>
"CHI",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","45S","yyyy"<CR>
"16H","REC_NUM","REF_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT",
"LOCATION","CURR","FREQ","GROUP","SHOT","TARGETS","yyyy"<CR>
"44D","I","I","I","I","I","I","I","I","I","6S","F","I","F","I","I","143S",
"yyyy"<CR>
"CEV",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","45S","yyyy"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
"1D","I","I","I","I","I","I","I","yyyy"<CR>
"15H","REF_NUM","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IN","IG","3I2","yyyy"<CR>
"1D","I","F","I","I","I","6S","F","I","143S","I","I","I","I","I","I","yyyy"<CR>
"14H","IA","IB","IC","IN","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","V1MEM","FREQ",
"VDC","TRIG","Names of elements in the relay word separated by spaces","yyyy"<CR>
"60D","I","I","I","I","I","F","F","F","F","F","F","I","2S","198S","yyyy"<CR>
"CEV C",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","45S","yyyy"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
"1D","I","I","I","I","I","I","I","yyyy"<CR>
"15H","REF_NUM","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IN","IG","3I2","yyyy"<CR>
"1D","I","F","I","I","I","6S","F","I","143S","I","I","I","I","I","I","yyyy"<CR>
"14H","IA","IB","IC","IN","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","V1MEM","FREQ",
"VDC","TRIG","Names of elements in the relay word separated by spaces","yyyy"<CR>
"240D","I","I","I","I","I","F","F","F","F","F","F","I","2S","198S","yyyy"<CR>
"CEV R",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","45S","yyyy"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
"1D","I","I","I","I","I","I","I","yyyy"<CR>
"15H","REF_NUM","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IN","IG","3I2","yyyy"<CR>
"1D","I","F","I","I","I","6S","F","I","143S","I","I","I","I","I","I","yyyy"<CR>
"14H","IA","IB","IC","IN","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","V1MEM","FREQ",
"VDC","TRIG","Names of elements in the relay word separated by spaces","yyyy"<CR>
"5792D","I","I","I","I","I","F","F","F","F","F","F","I","2S","198S","yyyy"<CR>
"CSU",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","45S","yyyy"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
"1D","I","I","I","I","I","I","I","yyyy"<CR>
"16H","REF_NUM","EVENT","LOCATION","HOUR_T","MIN_T","SEC_T","MSEC_T","SHOT","FREQ",
"GROUP","HOUR_C","MIN_C","SEC_C","MSEC_C","TARGETS","BREAKER","yyyy"<CR>
"1D","I","6S","F","I","I","I","I","I","F","I","I","I","I","I","143S","6S",
"yyyy"<CR>
"18H","IA_PF","IA_DEG_PF","IB_PF","IB_DEG_PF","IC_PF","IC_DEG_PF","IN_PF",
"IN_DEG_PF","IG_PF","IG_DEG_PF","3I2_PF","3I2_DEG_PF","VA_PF","VA_DEG_PF","VB_PF",
"VB_DEG_PF","VC_PF","VC_DEG_PF","yyyy"<CR>
"1D","I","F","I","F","I","F","I","F","I","F","I","F","F","F","F","F","F","F",
"yyyy"<CR>
"18H","IA","IA_DEG","IB","IB_DEG","IC","IC_DEG","IN","IN_DEG","IG","IG_DEG","3I2",
"3I2_DEG","VA","VA_DEG","VB","VB_DEG","VC","VC_DEG","yyyy"<CR>
"1D","I","F","I","F","I","F","I","F","I","F","I","F","F","F","F","F","F","F",
"yyyy"<CR>
```

```
"2H","TRIG","RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A TMB8A TMB7A TMB6A
TMB5A TMB4A TMB3A TMB2A TMB1A RMB8B RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B
TMB7B TMB6B TMB5B TMB4B TMB3B TMB2B TMB1B LBOKB CBADB RBADB ROKB LBOKA CBADA RBADA
ROKA","yyyy"<CR>
"2D","1S","10S","yyyy"<CR>
<ETX>
```

where:

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

See *CEVENT Command on page K.5* for the definition of the "***Names of elements in the relay word separated by spaces***" field.

CSTATUS Command

Display status data in Compressed ASCII format by sending:

CST <CR>

The relay sends:

```
<STX>"FID","yyyy"<CR>
"Relay FID string","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"IA_OS","IB_OS","IC_OS","IN_OS","VA_OS","VB_OS","VC_OS","VS_OS","MOF_OS",
"IA_OSH","IB_OSH","IC_OSH","IN_OSH",
"15V_PS","5V_REG","3.3V_REG",
"RAM","ROM","FPGA","EEPROM","FLASH","A/D","USB_BRD","COM_BRD","IO_BRD",
"TEMP","RTC","HMI","yyyy" <CR>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","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 = the data values corresponding to the first line labels.

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

CHISTORY Command

Display history data in Compressed ASCII format by sending:

CHI [*n*]<CR> (parameters in [ ] are optional)

The relay sends:

```
<STX>"FID","yyyy"<CR>
"Relay FID string","yyyy"<CR>
"REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC",
"EVENT","LOCATION","CURR","FREQ","GROUP","SHOT","TARGETS","EVE_ID",
"yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,xxxx,xxxx,xxxx,xxxx,
"xxxx","xxxx","yyyy"<CR><ETX>
```

where:

xxxx = the data values corresponding to the first line labels.

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

If the history buffer is empty, the relay responds:

```
<STX>"No Data Available","0668"<CR><ETX>
```

Parameter *n* is an optional numeric parameter that specifies the number of records to return. If *n* is less than or equal to the number of records available in the history, the relay returns *n* records.

CEVENT Command

Display event report in Compressed ASCII format by sending:

CEV [*n* S*x* L*y* L R C P] (parameters in [ ] are optional)

where:

- ***n*** is event number, defaults to 1
- **S*x*** is *x* samples per cycle (4, 16, 32, or 128); defaults to 4. If the S*x* parameter is present, it overrides the L parameter. S128 must be accompanied by the R parameter (**CEV S128 R**)
- **L*y*** is *y* cycles event report length (1 to LER) for filtered event reports, (1 to LER + 1) for raw event reports; defaults to LER if not specified. Raw reports always contain one extra cycle of data, except for raw reports with S128 parameter, which contain two extra cycles of data.
- **L** is 32 samples per cycle; overridden by the S*x* parameter, if present
- **R** specifies raw (unfiltered) data; defaults to 32 samples per cycle unless overridden by the S*x* parameter. Defaults to LER + 1 cycles in length unless overridden with the L*y* parameter.
- **C** specifies 16 samples per cycle analog data, 4 samples per cycle digital data, LER-cycle length, unless overridden by the S*x*, L*y*, L, or R parameters.
- **P** precise to synchrophasor-level accuracy for signal content at nominal frequency. This option is available when TSOK = logical 1 when the event report was triggered.

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

```
<STX>"FID","yyyy"<CR>
"Relay FID string","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT",
"LOCATION","SHOT","TARGETS","IA","IB","IC","IN","IG","3I2","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,xxxx,"xxxx",xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
"yyyy"<CR>
"IA","IB","IC","IN","IG","VAkV","VBkV","VCkV","VSkV","V1MEM","FREQ","VDC",
"TRIG","Names of elements in the relay word separated by spaces","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,z,"HEX-ASCII Relay Word","yyyy"<CR>
"Analog and digital data repeated for each row of event report"
"SETTINGS","yyyy"<CR>
"Relay group, global, and logic settings as displayed with the showset command (surrounded by quotes)","yyyy"<CR><ETX>
```

where:

- `xxxx` are the data values corresponding to the line labels
- `yyyy` is the 4-byte hex ASCII representation of the checksum
- `FREQ` is the power system frequency at the trigger instant

`SAM/CYC_A`	is the number of analog data samples per cycle
`SAM/CYC_D`	is the number of digital data samples per cycle
`NUM_OF_CYC`	is the number of cycles of data in the event report
`EVENT`	is the event type
`LOCATION`	is the fault location
`SHOT`	is the recloser shot counter
`TARGETS`	are the front-panel tripping targets
`IA, IB, IC, IN, IG, 3I2`	is the fault current
`TRIG`	refers to the trigger record
`z`	is “>” for the trigger row, “*” for the fault current row and empty for all others. If the trigger row and fault current row are the same, both characters are included (e.g., “>*”)
`HEX-ASCII Relay Word`	is the hex ASCII format of the Relay Word. The first element in the Relay Word is the most significant bit in the first character.

For filtered events, if samples per cycle are specified as 16, the analog data are displayed at 1/16-cycle intervals and digital data at 1/4-cycle intervals.

If samples per cycle are specified as 32, the analog data are displayed at 1/32-cycle intervals and digital data are displayed at 1/4-cycle intervals.

For raw events, both analog and digital data are displayed at the interval specified by the Sx parameter. Digital data are updated every 1/4 cycle. Optoisolated inputs are updated every 1/16 cycle.

The digital data are displayed as a series of hex ASCII characters. The relay displays digital data only when they are available. When no data are available, the relay sends only the comma delimiter in the digital data field.

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

```
<STX>"No Data Available","0668"<CR><ETX>
```

The “***Names of elements in the relay word separated by spaces***” field is shown below for the SEL-311C.

```
"TLED11 TLED12 TLED13 TLED14 TLED15 TLED16 TLED17 TLED18 TLED19 TLED20 TLED21 TLED22
TLED23 TLED24 TLED25 TLED26 M1P M1PT Z1G Z1GT M2P M2PT Z2G Z2GT Z1T Z2T 50P1 67P1
67P1T 50G1 67G1 67G1T 51G 51GT 51GR LOP ILOP ZLOAD ZLOUT ZLIN LB1 LB2 LB3 LB4 LB5 LB6
LB7 LB8 LB9 LB10 LB11 LB12 LB13 LB14 LB15 LB16 RB1 RB2 RB3 RB4 RB5 RB6 RB7 RB8 RB9
RB10 RB11 RB12 RB13 RB14 RB15 RB16 LT1 LT2 LT3 LT4 LT5 LT6 LT7 LT8 LT9 LT10 LT11 LT12
LT13 LT14 LT15 LT16 SV1 SV2 SV3 SV4 SV1T SV2T SV3T SV4T SV5 SV6 SV7 SV8 SV5T SV6T
SV7T SV8T SV9 SV10 SV11 SV12 SV9T SV10T SV11T SV12T SV13 SV14 SV15 SV16 SV13T SV14T
SV15T SV16T MAB1 MBC1 MCA1 MAB2 MBC2 MCA2 CVTBL SOTFT MAG1 MBG1 MCG1 MAG2 MBG2 MCG2
DCHI DCLO BCW BCWA BCWB BCWC FIDEN FSA FSB FSC SG1 SG2 SG3 SG4 SG5 SG6 OC CC CLOSE CF
TRGTR 52A 3PO SOTFE VPOLV 50L PDEM GDEM QDEM TRIP 50QF 50QR 50GF 50GR 32QF 32QR 32GF
32GR 32VE 32QGE 32IE 32QE F32I R32I F32Q R32Q F32QG R32QG F32V R32V * * IN106 IN105
IN104 IN103 IN102 IN101 ALARM OUT107 OUT106 OUT105 OUT104 OUT103 OUT102 OUT101 M3P
M3PT Z3G Z3GT M4P M4PT Z4G Z4GT Z3T Z4T 50P2 67P2 67P2T 50P3 67P3 67P3T 50G2 67G2
67G2T 50G3 67G3 67G3T * * 51P 51PT 51PR Z1X 59VA MAB3 MBC3 MCA3 MAG3 MBG3 MCG3 27S
59S * 59VP 59VS SF 25A1 25A2 RCSF OPTMN RSTMN * PMDOK 79RS 79CY 79LO SH0 SH1 SH2 SH3
SH4 MAB4 MBC4 MCA4 MAG4 MBG4 MCG4 TSOK TIRIG XAG1 XBG1 XCG1 XAG2 XBG2 XCG2 XAG3 XBG3
XCG3 XAG4 XBG4 XCG4 OSTI OSTO OST 50ABC X5ABC X6ABC OSB OSB1 OSB2 OSB3 OSB4 UBOSB
50G4 67G4 67G4T * * * * * 50Q1 67Q1 67Q1T 50Q2 67Q2 67Q2T 59N1 59N2 50Q3 67Q3 67Q3T
50Q4 67Q4 67Q4T 59Q 59V1 51Q 51QT 51QR * * Z2PGS 67QG2S BTX Z3XT DSTRT NSTRT STOP
Z3RB KEY EKEY ECTT PTRX UBB1 UBB2 UBB WFC PT PTRX1 PTRX2 27A 27B 27C 59A 59B 59C 3P27
3P59 27AB 27BC 27CA 59AB 59BC 59CA * * OUT201 OUT202 OUT203 OUT204 OUT205 OUT206
OUT207 OUT208 * * * * * * * * IN208 IN207 IN206 IN205 IN204 IN203 IN202 IN201 RMB8A
```

```
RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A TMB8A TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A
TMB1A RMB8B RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B TMB7B TMB6B TMB5B TMB4B
TMB3B TMB2B TMB1B LBOKB CBADB RBADB ROKB LBOKA CBADA RBADA ROKA 81D1 81D2 81D3 81D4
81D5 81D6 27B81 * 81D1T 81D2T 81D3T 81D4T 81D5T 81D6T * * 50A1 50B1 50C1 50A2 50B2
50C2 50A3 50B3 50C3 50A4 50B4 50C4 * 50A 50B 50C * * * * * * * WYE 50P4 67P4 67P4T *
* * * FREQOK * * * * Z2SEQT M2PSEQT Z2GSEQT * Z1XP Z1XG * * * * * DD * LINK5A LINK5B
LNKFAIL P5ASEL P5BSEL TSNTPP TSNTPB DST DSTP LPSEC LPSECP TQUAL4 TQUAL3 TQUAL2 TQUAL1
* VOGAIN INMET ICMET IBMET IAMET NDEM TESTDB * RSTTRGT RST_MML RST_ENE RST_HIS RST_BK
RST_PDM RST_DEM SFAST SSLOW LOPRST PMTRIG TREA1 TREA2 TREA3 TREA4 LOP1 LOP2 LOP3 LOP4
* * * * * * * * * * * * * * * * * * * * 3PS APS BPS CPS SPO SPOA SPOB SPOC 27AWI 27BWI
27CWI * * * TRPRM COMPRM DTA DTB DTC ATPA ATPB ATPC A3PT RXPRM ULTRA ULTRB ULTRC TPA
TPB TPC SPT 3PT 52AA 52AB 52AC E3PT 50LA 50LB 50LC TOP DTR * OSBC OSBB OSBA * * BKMTR
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * * * * * LV1 LV2 LV3 LV4 LV5 LV6 LV7 LV8 LV9 LV10 LV11 LV12 LV13 LV14 LV15 LV16
LV17 LV18 LV19 LV20 LV21 LV22 LV23 LV24 LV25 LV26 LV27 LV28 LV29 LV30 LV31 LV32 VB001
VB002 VB003 VB004 VB005 VB006 VB007 VB008 VB009 VB010 VB011 VB012 VB013 VB014 VB015
VB016 VB017 VB018 VB019 VB020 VB021 VB022 VB023 VB024 VB025 VB026 VB027 VB028 VB029
VB030 VB031 VB032 VB033 VB034 VB035 VB036 VB037 VB038 VB039 VB040 VB041 VB042 VB043
VB044 VB045 VB046 VB047 VB048 VB049 VB050 VB051 VB052 VB053 VB054 VB055 VB056 VB057
VB058 VB059 VB060 VB061 VB062 VB063 VB064 VB065 VB066 VB067 VB068 VB069 VB070 VB071
VB072 VB073 VB074 VB075 VB076 VB077 VB078 VB079 VB080 VB081 VB082 VB083 VB084 VB085
VB086 VB087 VB088 VB089 VB090 VB091 VB092 VB093 VB094 VB095 VB096 VB097 VB098 VB099
VB100 VB101 VB102 VB103 VB104 VB105 VB106 VB107 VB108 VB109 VB110 VB111 VB112 VB113
VB114 VB115 VB116 VB117 VB118 VB119 VB120 VB121 VB122 VB123 VB124 VB125 VB126 VB127
VB128 ","yyyy"
```

These names are listed in the Relay Word for the appropriate model of the relay in *Table D.1*. Lists for other relay models may have different Relay Word bits than shown in this example.

A typical HEX-ASCII Relay Word is shown below:

```
810000002000000000000000000000000000800C000000000000000000000000000000000000000020000
00000000000000000000002000000010000004C0F7C0000080000000000000000000000000000000000000
0000000000000000000000000000000000
```

Each bit in the *HEX-ASCII Relay Word* reflects the status of a Relay Word bit. The order of the labels in the "*Names of elements in the relay word separated by spaces*" field matches the order of the *HEX-ASCII Relay Word*. In the example above, the fifth byte in the *HEX-ASCII Relay Word* is "20." In binary, this evaluates to 00100000. Mapping the labels to the bits yields:

Table K.2 Mapping Labels to Bits

Labels	51G	51GT	51GR	LOP	ILOP	ZLOAD	ZLOUT	ZLIN
Bits	0	0	1	0	0	0	0	0

In this example, the 51GR element is asserted (logical 1); all others are deasserted (logical 0).

CSU Command

Display long summary event report in Compressed ASCII format by sending:

CSU [N[EXT]] [TERSE]

CSU [[ACK] | [TERSE]] [*n*]

where:

No parameters	outputs the newest chronological event summary
ACK	acknowledges the oldest unacknowledged event report summary available on this port, or if a number is supplied, acknowledge the specified summary. Reports acknowledged within a Telnet session are acknowledged for all Telnet sessions on the Ethernet port.
N[EXT]	views oldest unacknowledged event report
n	displays (or acknowledge if ACK present) event summary with this corresponding number in the **HIS E** command.
TERSE	does not display label headers

The relay responds to the **CSU** command with the *n*th long summary event report as shown in the example below:

```
<STX>"FID","0143"<CR>
"FID=SEL-311C-1-RXXX-V0-ZXXXXXX-DXXXXXX","0942"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"<CR>
7,9,2010,13,42,15,309,"0433"<CR>
"REF_NUM","EVENT","LOCATION","HOUR_T","MIN_T","SEC_T","MSEC_T","SHOT","FREQ",
"GROUP","HOUR_C","MIN_C","SEC_C","MSEC_C","TARGETS","BREAKER","22B4"<CR>
"TRIG",$$$$$$$, , , , ,10000, , 60.00,1, , , , , ,"Open",,"0AAE"<CR>
"IA_PF","IA_DEG_PF","IB_PF","IB_DEG_PF","IC_PF","IC_DEG_PF","IN_PF","IN_DEG_PF",
"IG_PF","IG_DEG_PF","3I2_PF","3I2_DEG_PF","VA_PF","VA_DEG_PF","VB_PF","VB_DEG_PF",
"VC_PF","VC_DEG_PF","2E3D"<CR>
0,0.00,0,26.57,0,0.00,0,-18.43,0,8.13,0,-56.88,0.020,90.00,0.000,180.00,0.000,
180.00,"0FF2"<CR>
"IA","IA_DEG","IB","IB_DEG","IC","IC_DEG","IN","IN_DEG","IG","IG_DEG","3I2",
"3I2_DEG","VA","VA_DEG","VB","VB_DEG","VC","VC_DEG","1D03"<CR>
0,98.13,0,104.04,0,102.53,0,104.04,0,101.77,0,-80.20,0.020,45.00,0.020,0.00,
0.020,90.00,"1081"<CR>
"TRIG","RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A TMB8A TMB7A TMB6A TMB5A
TMB4A TMB3A TMB2A TMB1A RMB8B RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B TMB7B
TMB6B TMB5B TMB4B TMB3B TMB2B TMB1B LBOKB CBADB RBADB ROKB LBOKA CBADA RBADA
ROKA","3C70"<CR>
">","0000000000","02FE"<CR>
"*","0000000000","02EA"<CR><ETX>
```

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

```
<STX>"No Data Available","067F"<CR><ETX>
```

Appendix L
DNP3 Communications

Overview

The SEL-311C Relay provides a Distributed Network Protocol Version 3.0 (DNP3) Level 2 Outstation interface for direct serial and LAN/WAN network connections to the relay.

This section covers the following topics:

Introduction to DNP3

A Supervisory Control and Data Acquisition (SCADA) manufacturer developed the first versions of DNP from the lower layers of IEC 60870-5. Originally designed for use in telecontrol applications, Version 3.0 of the protocol has also become popular for local substation data collection. DNP3 is one of the protocols included in the IEEE® 1379-7000, Recommended Practice for Data Communication between Remote Terminal Units (RTUs) and Intelligent Electronic Devices (IEDs) in a Substation.

The DNP Users Group maintains and publishes DNP3 standards. See the DNP Users Group website, www.dnp.org, for more information on standards, implementers, and tools for working with DNP3.

DNP3 Specifications

DNP3 is a feature-rich protocol with many ways to accomplish tasks, defined in an eight-volume series of specifications. Volume 8 of the specification, called the Interoperability Specification, simplifies DNP3 implementation by providing four standard interoperable implementation levels. The levels are listed in *Table L.1*.

Table L.1 DNP3 Implementation Levels

Level	Description	Equipment Types
1	Simple: limited communication requirements	Meters, simple IEDs
2	Moderately complex: monitoring and metering devices and multifunction devices that contain more data	Protective relays, RTUs
3	Sophisticated: devices with great amounts of data or complex communication requirements	Large RTUs, SCADA masters
4	Enhanced: additional data types and functionality for more complex requirements	Large RTUs, SCADA masters

Each level is a proper superset of the previous lower-numbered level. A higher-level device can act as a master to a lower-level device, but can only use the data types and functions implemented in the lower level device. For example, a typical SCADA master is a Level 3 device and can use Level 2 (or lower) functions to poll a Level 2 (or lower) device for Level 2 (or lower) data. Similarly, a lower-level device can poll a higher-level device, but the lower level device can only access the features and data available to its level.

In addition to the eight-volume DNP3 specification, the protocol is further refined by conformance requirements, optional features, and a series of technical bulletins. The technical bulletins supplement the specifications with discussion and examples of specific features of DNP3.

Data Handling

Objects

DNP3 uses a system of data references called objects, defined by Volume 6 of the DNP3 specification. Each subset level specification requires a minimum implementation of object types and recommends several optional object types. DNP3 object types, commonly referred to as objects, are specifications for the type of data the object carries. An object can include a single value or more complex data. Some objects serve as shorthand references for special operations, including collections of data, time synchronization, or even all data within the DNP3 device.

Each instance of the object includes an index that makes it unique. For example, each binary status point (Object 1) has an index. If there are 16 binary status points, these points are Object 1, Index 0 through Object 1, Index 15.

Each object also includes multiple versions called variations. For example, Object 1 (binary inputs) has three variations: 0, 1, and 2. You can use variation 0 to request the default variation, variation 1 to specify binary input values only, and variation 2 to specify binary input values with status information.

Each DNP3 device has both a list of objects and a map of object indices. The list of objects defines the available objects, variations, and qualifier codes. The map defines the indices for objects that have multiple instances and defines what data or control points correspond with each index.

A master initiates all DNP3 message exchanges except unsolicited data. DNP3 terminology describes all points from the perspective of the master. Binary points for control that move from the master to the outstation are called Binary Outputs, while binary status points within the outstation are called Binary Inputs.

Function Codes

Each DNP3 message includes a function code. Each object has a limited set of function codes that a master may use to manipulate the object. The object listing for the device shows the permitted function codes for each type of object. The most common DNP3 function codes are listed in *Table L.2*.

Table L.2 Selected DNP3 Function Codes

Function Code	Function	Description
1	Read	Request data from the outstation
2	Write	Send data to the outstation
3	Select	First part of a select-before-operate operation
4	Operate	Second part of a select-before-operate operation
5	Direct operate	One-step operation with reply
6	Direct operate, no reply	One-step operation with no reply

Qualifier Codes and Ranges

DNP3 masters use qualifier codes and ranges to make requests for specific objects by index. Qualifier codes specify the style of range, and the range specifies the indices of the objects of interest. DNP3 masters use qualifier codes to compose the shortest, most concise message possible when requesting points from a DNP3 outstation.

For example, the qualifier code 01 specifies that the request for points will include a start address and a stop address. Each of these two addresses uses two bytes. An example request using qualifier code 01 might have the four hexadecimal byte range field, 00h 04h 00h 10h, which specifies points in the range 4 to 16.

Access Methods

DNP3 has many features that help obtain maximum possible message efficiency. DNP3 masters send requests with the least number of bytes using special objects, variations, and qualifiers that reduce the message size. Other features eliminate the continual exchange of static (unchanging) data values. These features optimize use of bandwidth and maximize performance over a connection of any speed.

DNP3 event data collection eliminates the need to use bandwidth to transmit values that have not changed. Event data are time-stamped records that show when observed measurements changed. For binary points, the remote device (DNP3 outstation) logs changes from logical 1 to logical 0 and from logical 0 to logical 1. For analog points, the outstation device logs changes that exceed a dead band. DNP3 outstation devices collect event data in a buffer that either the master can request or the device can send to the master without a request message. Data sent from the outstation to the master without a polling request are called unsolicited data.

DNP3 data fit into one of four event classes: 0, 1, 2, or 3. Class 0 is reserved for reading the present value (static) data. Classes 1, 2, and 3 are event data classes. The meaning of Classes 1 to 3 is arbitrary and defined by the application at hand. With outstations that contain great amounts of data or in large systems, the three event classes provide a framework for prioritizing different types of data. For example, you can poll once a minute for Class 1 data, once an hour for Class 2 data, and once a day for Class 3 data.

DNP3 also supports static polling: simple polling of the present value of data points within the outstation. By combining event data, unsolicited polling, and static polling, you can operate your system in one of the four access methods shown in *Table L.3*.

The access methods listed in *Table L.3* are listed in order of increasing communication efficiency. With various tradeoffs, each method is less demanding of communication bandwidth than the previous one. For example, unsolicited report-by-exception consumes less communication bandwidth than polled report-by-exception because that method does not require polling messages from the master. In order to properly evaluate which access method provides optimum performance for your application, you should also consider overall system size and the volume of data communication expected.

Table L.3 DNP3 Access Methods

Access Method	Description
Polled static	Master polls for present value (Class 0) data only
Polled report-by-exception	Master polls frequently for event data and occasionally for Class 0 data
Unsolicited report-by-exception	Outstation devices send unsolicited event data to the master, and the master occasionally polls for Class 0 data
Quiescent	Master never polls and relies on unsolicited reports only

Binary Control Operations

DNP3 masters use Object 12, control device output block, to perform DNP3 binary control operations. The control device output block has both a trip/close selection and a code selection. The trip/close selection allows a single DNP3 index to operate two related control points such as trip and close or raise and lower. Trip/close pair operation is not recommended for new DNP3 devices, but is often included for interoperability with older DNP3 master implementations.

The control device output block code selection specifies either a latch or pulse operation on the point. In many cases, DNP3 outstations have only a limited subset of the possible combinations of the code field. Sometimes, DNP3 outstations assign special operation characteristics to the latch and pulse selections.

Conformance Testing

In addition to the protocol specifications, the DNP Users Group has approved conformance-testing requirements for Level 1 and Level 2 devices. Some implementers perform their own conformance specification testing, while some contract with independent companies to perform conformance testing.

Conformance testing does not always guarantee that a master and outstation will be fully interoperable (that is, work together properly for all implemented features). Conformance testing does help to standardize the testing procedure and move the DNP3 implementers toward a higher level of interpretability.

DNP3 Serial Network Issues

Data Link Layer Operation

DNP3 employs a three-layer version of the seven-layer OSI (Open Systems Interconnect) model called the enhanced performance architecture. The layer definition helps to categorize functions and duties of various software components that make up the protocol. The middle layer, the Data Link Layer, includes several functions for error checking and media access control.

A feature called data link confirmation is a mechanism that provides positive confirmation of message receipt by the receiving DNP3 device. While this feature helps you recognize a failed device or failed communications link quickly, it also adds significant overhead to the DNP3 conversation. You should consider whether you require this link integrity function in your application at the expense of overall system speed and performance.

The DNP3 technical bulletin (*DNP Confirmation and Retry Guidelines 9804-002*) on confirmation processes recommends against using data link confirmations because these processes can add to traffic in situations where communications are marginal. The increased traffic will reduce connection throughput further, possibly preventing the system from operating properly.

Network Medium Contention

When more than one device requires access to a single (serial) network medium, you should provide a mechanism to resolve the resulting network medium contention. For example, unsolicited reporting results in network medium contention if you do not design your serial network as a star topology of point-to point connections or use carrier detection on a multidrop network.

To avoid collisions among devices trying to send messages, DNP3 includes a collision avoidance feature. Before sending a message, a DNP3 device listens for a carrier signal to verify that no other node is transmitting data. The device transmits if there is no carrier or waits for a random time before transmitting. However, if two nodes both detect a lack of carrier at the same instant, these two nodes could begin simultaneous transmission of data and cause a data collision. If your serial network allows for spontaneous data transmission including unsolicited event data transmissions, you also should use application confirmation to provide a retry mechanism for messages lost due to data collisions.

DNP3 LAN/WAN Overview

The main process for carrying DNP3 over an Ethernet Network (LAN/WAN) involves encapsulating the DNP3 data link layer data frames within the transport layer frames of the Internet Protocol (IP) suite. This allows the IP stack to deliver the DNP3 data link layer frames to the destination in place of the original DNP3 physical layer.

The DNP User Group Technical Committee has recommended the following guidelines for carrying DNP3 over a network:

NOTE: Link layer confirmations are explicitly disabled for DNP3 LAN/WAN. The IP suite already provides a reliable delivery mechanism, which is backed up at the application layer by confirmations when required.

- DNP3 shall use the IP suite to transport messages over a LAN/WAN
- Ethernet is the recommended physical link, though others may be used
- TCP must be used for WANs
- TCP is strongly recommended for LANs
- User Datagram Protocol (UDP) may be used for highly reliable single segment LANs
- UDP is necessary if broadcast messages are required
- The DNP3 protocol stack shall be retained in full
- Link layer confirmations shall be disabled

The Technical Committee has registered a standard port number, 20000, for DNP3 with the Internet Assigned Numbers Authority (IANA). This port is used for either TCP or UDP.

TCP/UDP Selection

The Committee recommends the selection of TCP or UDP protocol as per the guidelines in *Table L.4*.

Table L.4 TCP/UDP Selection Guidelines

Use in the case of...	TCP	UDP
Most situations	X	
Non-broadcast or multicast	X	
Mesh Topology WAN	X	
Broadcast		X
Multicast		X
High-reliability single-segment LAN		X
Pay-per-byte, nonmesh WAN, for example, Cellular Digital Packet Data (CDPD)		X
Low priority data, for example, data monitor or configuration information		X

DNP3 in the SEL-311C

The SEL-311C is a DNP3 Level 2 remote (outstation) device.

Data Access

NOTE: Because unsolicited messaging is problematic in most circumstances, SEL recommends using the polled report-by-exception access method to maximize performance and minimize risk of configuration problems.

NOTE: In the settings below, the suffix n represents the DNP3 LAN/WAN session number from 1 to 6. This suffix is not present in Serial Port DNP3 settings. All settings with the same numerical suffix comprise the complete DNP3 session configuration.

Table L.5 lists DNP3 data access methods along with corresponding SEL-311C settings. You must select a data access method and configure each DNP3 master for polling as specified.

Table L.5 DNP3 Access Methods

Access Method	Master Polling	SEL-311C Settings
Polled static	Class 0	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to 0; UNSOL*n* to N.
Polled report-by-exception	Class 0 occasionally, Class 1, 2, 3 frequently	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; UNSOL*n* to N.
Unsolicited report-by-exception	Class 0 occasionally, optional Class 1, 2, 3 less frequently; mainly relies on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* to Y and PUNSOL*n* to Y or N.
Quiescent	Class 0, 1, 2, 3 never; relies completely on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* and PUNSOL*n* to Y.

In both the unsolicited report-by-exception and quiescent polling methods shown in *Table L.5*, you must make a selection for the PUNSOL*n* setting. This setting enables or disables unsolicited data reporting at power up. If your DNP3 master can send a message to enable unsolicited reporting on the SEL-311C, you should set PUNSOL*n* to No.

While automatic unsolicited data transmission on power up is convenient, this can cause problems if your DNP3 master is not prepared to start receiving data immediately on power up. If the master does not acknowledge the unsolicited data with an Application Confirm, the device will resend the data until it is acknowledged. On a large system, or in systems where the processing power of the master is limited, you may have problems when several devices simultaneously begin sending data and waiting for acknowledgement messages.

If the SEL-311C does not receive an Application Confirm in response to unsolicited data, it will wait for ETIMEO*n* seconds and then repeat the unsolicited message. In order to prevent clogging of the network with unsolicited data retries, the SEL-311C uses the URETRY*n* and UTIMEO*n* settings to increase retry time when the number of retries set in URETRY*n* is exceeded. After URETRY*n* has been exceeded, the SEL-311C pauses UTIMEO*n* seconds and then transmits the unsolicited data again. *Figure L.1* provides an example with URETRY*n* = 2.

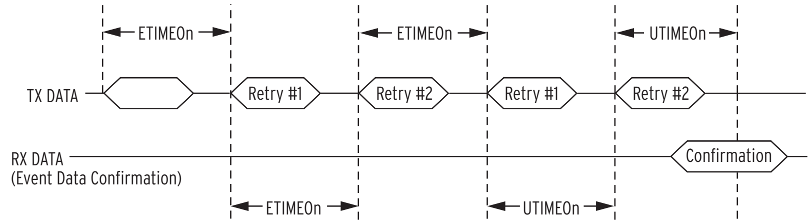

Figure L.1 Application Confirmation Timing With URETRYn = 2

Collision Avoidance

If your application uses unsolicited reporting on a serial network, you must select a half-duplex medium or a medium that includes carrier detection to avoid data collisions. EIA-485 two-wire networks are half-duplex. EIA-485 four-wire networks do not provide carrier detection, while EIA-232 systems can support carrier detection. DNP3 LAN/WAN uses features of the IP suite for collision avoidance, so does not require these settings.

NOTE: MINDLY and MAXDLY settings are only available for EIA-232 and EIA-485 serial port sessions.

The SEL-311C uses Application Confirmation messages to guarantee delivery of unsolicited event data before erasing the local event data buffer. Data collisions are typically resolved when messages are repeated until confirmed.

The SEL-311C pauses for a random delay between the settings MAXDLY and MINDLY when it detects a carrier through data on the receive line or the CTS pin. For example, if you use the settings of 0.10 seconds for MAXDLY and 0.05 seconds for MINDLY, the SEL-311C will insert a random delay of 50 to 100 ms (milliseconds) between the end of carrier detection and the start of data transmission (see *Figure L.2*).

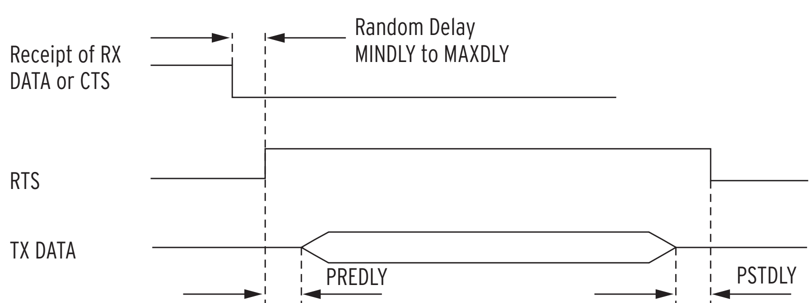

Figure L.2 Message Transmission Timing

Transmission Control

NOTE: PREDLY and POSTDLY settings are only available for EIA-232 and EIA-485 serial port sessions.

If you use a media transceiver (for example, EIA-232 to EIA-485) or a radio system for your DNP3 network, you may need to adjust data transmission properties. Use the PREDLY and POSTDLY settings to provide a delay between RTS signal control and data transmission (see *Figure L.2*). For example, an EIA-485 transceiver typically requires 10 to 20 ms to change from receive to transmit. If you set the predelay to 30 ms, you will avoid data loss resulting from data transmission beginning at the same time as RTS signal assertion.

Event Data

DNP3 event data objects contain change-of-state and time-stamp information that the SEL-311C collects and stores in a buffer. Points assigned in the Binary Input Map that are also assigned in the Sequential Events Recorder

(SER) settings carry the time stamp of actual occurrence. Binary input points not assigned in the SER settings will carry a time stamp based on the DNP map scan time. This may be significantly delayed from when the original source changed and should not be used for sequence-of-events determination. The DNP map is scanned approximately once per second to generate events. You can configure the SEL-311C to either report the data without a polling request from the master (unsolicited data) or hold the data until the master requests it with an event poll message.

NOTE: Most RTUs that act as substation DNP3 masters perform an event poll that collects event data of all classes simultaneously. You must confirm that the polling configuration of your master allows independent polling for each class before implementing separate classes in the SEL-311C.

With the event class settings ECLASSB*n*, ECLASSC*n*, and ECLASSA*n*, you can set the event class for binary, counter, and analog inputs for Ethernet port session *n* (the suffix *n* is not present for serial port event class settings). You can use the classes as a simple priority system for collecting event data. The SEL-311C does not treat data of different classes differently with respect to message scanning, but it does allow the master to perform independent class polls.

For event data collection you must also consider and enter appropriate settings for dead band and scaling operation on analog points shown in *Table L.10*. You can either:

- ➤ set and use default dead band and scaling according to data type, or
- ➤ use a custom data map to select dead bands on a point-by-point basis.

Dead bands for analog inputs can be modified at run-time by writing to Object 34. Dead-band changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 dead-band changes you wish to retain after a change to DNP port settings, issuing a **STA C** command, or a relay cold-start (power-cycle).

The settings ANADBA*n*, ANADBV*n*, and ANADBM*n* control default dead-band operation for each type of analog data. Because DNP3 Objects 30 and 32 use integer data by default, you may have to use scaling to send digits after the decimal point and avoid rounding to a simple integer value.

You can set the default analog value class level scaling with the DECPLA*n*, DECPLV*n*, and DECPLM*n* settings. Application of event reporting dead bands occurs after scaling. For example, if you set DECPLA*n* to 2 and ANADBA*n* to 10, a measured current of 10.14 amps would be scaled to the value 1014 and would have to increase to more than 1024 or decrease to less than 1004 (a change in magnitude of ± 0.1 amps) for the device to report a new event value.

With no scaling and transmitting with the default variation, the value of 12.632 would be truncated and sent as 13. With a class level scaling setting of 1, the value transmitted is 126. With a class level scaling setting of 3, the value transmitted is 12632. You must make certain that the maximum value does not exceed 32767 if you are polling the default 16-bit variations for Objects 30 and 32, but you can send some decimal values using this technique. You must also configure the master to perform the appropriate division on the incoming value to display it properly.

The SEL-311C uses the NUM1EVE*n* and AGE1EVE*n* settings to decide when to send unsolicited data to the master. The device sends an unsolicited report when the total number of events accumulated in the event buffer for master *n* reaches NUM1EVE*n*. The device also sends an unsolicited report if the age of the oldest event in the master n buffer exceeds AGE1EVE*n*. The SEL-311C has the per-session buffer capacities listed in *Table L.6*.

Table L.6 SEL-311C Event Buffer Capacity

Type	Maximum Number of Events
Binary (non-SER)	1024
Binary (SER)	1024
Analog	200
Counters	8

Binary Controls

The SEL-311C provides more than one way to control individual points. The SEL-311C maps incoming control points either to remote bits or to internal command bits that cause circuit breaker operations.

A DNP3 technical bulletin (*Control Relay Output Block Minimum Implementation 9701-002*) recommends that you use one point per Object 12, control block output device. You can use this method to perform Pulse On, Pulse Off, Latch On, and Latch Off operations on selected remote bits.

If your master does not support the single-point-per-index messages or single operation database points, you can use the trip/close operation or use the code field in the DNP3 message to specify operation of the points.

Time Synchronization

The accuracy of DNP3 time synchronization is insufficient for most protection and oscillography needs. DNP3 time synchronization provides backup time synchronization in the event the device loses primary synchronization through the IRIG-B input or the Simple Network Time protocol (SNTP). You can enable time synchronization with the TIMERQ*n* setting and then use Object 50, Variation 1, and Object 52, Variation 2, to set the time via the Session *n* DNP3 master (Object 50, variation 3 for DNP3 LAN/WAN).

By default, the SEL-311C accepts but does not act on time set requests (TIMERQ*n* = I for “ignore”). (This mode allows the SEL-311C to use a high accuracy, IRIG time source, but still interoperate with DNP3 masters that send time synchronization messages.) It can be set to request time synchronization periodically by setting the TIMERQ*n* setting to the desired period. It can also be set to not request, but accept time synchronization requests from the master (TIMERQ*n* = M for “master”).

DNP3 Settings

The DNP3 port configuration settings available on the SEL-311C are shown in *Table L.7*. You can enable DNP3 on any of the EIA-232 serial Ports 1, 2, 3, or F or on Ethernet Port 5, up to a maximum of six concurrent DNP3 sessions.

The SEL-311C allows up to six simultaneous DNP sessions. All six DNP sessions can be on the Ethernet port, or on four separate serial ports, or a combination of the two. See *Table 10.7* for DNP protocol session limitations.

Each session defines the characteristics of the connected DNP3 Master, to which you assign one of the three available custom maps. Some settings only apply to DNP3 LAN/WAN, and are visible only when configuring the Ethernet port. For example, you only have the ability to define multiple sessions (as many as six) on Port 5, the Ethernet port. For this reason, DNP settings for Ethernet sessions have a suffix *n* that indicates the session number from one to six, for example, DNPIP1, ETIMEO2, and AGE1EVE3. Serial DNP3 ports do not support multiple sessions, so they do not have the suffix *n*.

Table L.7 Port DNP3 Protocol Settings (Sheet 1 of 3)

Name	Description	Range	Default
Serial Port 1–4 Settings			
DNPADR	Device DNP3 address	0–65519	0
REPADR	DNP3 address of the Master to send messages to	0–65519	0
DNPMAP	DNP3 Session Custom Map	1–3	1
DVARAI	Analog Input Default Variation	1–6	4
ECLASSB	Class for binary event data, 0 disables	0–3	1
ECLASSC	Class for counter event data, 0 disables	0–3	0
ECLASSA	Class for analog event data, 0 disables	0–3	2
DECPLA	Decimal places scaling for Current data	0–3	1
DECPLV	Decimal places scaling for Voltage data	0–3	1
DECPLM	Decimal places scaling for Miscellaneous data	0–3	1
ANADBA	Analog reporting dead band for current; hidden if ECLASSA set to 0	0–32767	100
ANADBV	Analog reporting dead band for voltages; hidden if ECLASSA set to 0	0–32767	100
ANADBM	Analog reporting dead band for miscellaneous analogs; hidden if ECLASSA and ECLASSC set to 0	0–32767	100
TIMERQ	Time-set request interval, minutes (M = Disables time sync requests, but still accepts and applies time syncs from Master; I = Ignores (does not apply) time syncs from Master)	I, M, 1–32767	I
STIMEO	Select/operate time-out, seconds	0.0–30.0	1.0
DRETRY	Data link retries	0–15	3
DTIMEO	Data link time-out, seconds; hidden if DRETRY set to 0	0.0–5.0	1
ETIMEO	Event message confirm time-out, seconds	1–50	5
UNSOL	Enable unsolicited reporting; hidden and set to N if ECLASSB, ECLASSC, and ECLASSA set to 0	Y, N	N
PUNSOL	Enable unsolicited reporting at power up; hidden and set to N if UNSOL set to N	Y, N	N
NUM1EVE[a]	Number of events to transmit on	1–200	10
AGE1EVE[a]	Oldest event to transmit on, seconds	0.0–99999.0	2.0
URETRY[a]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO[a]	Unsolicited messages offline timeout, seconds	1–5000	60
MINDLY	Minimum delay from DCD to TX, seconds	0.00–1.00	0.05
MAXDLY	Maximum delay from DCD to TX, seconds	0.00–1.00	0.10
PREDLY	Settle time from RTS on to TX; Off disables PSTDLY	OFF, 0.00–30.00	0.00
PSTDLY	Settle time from TX to RTS off; hidden if PREDLY set to Off	0.00–30.00	0.00
Ethernet DNP Settings			
EDNP	Enable DNP3 Sessions	0–6	0
DNPNUM	DNP3 TCP and UDP Port	1–65534	20000
DNPADR	Device DNP3 address	0–65519	0
Session 1 Settings			
DNPIP1[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR1	Transport protocol	UDP, TCP	TCP
DNPUDP1	UDP response port	REQ, 1–65534	20000
REPADR1	DNP3 address of the Master to send messages to	0–65519	0
DNPMAP1	DNP3 Session Custom Map	1–3	1
DVARAI1	Analog Input Default Variation	1–6	4
ECLASSB1	Class for binary event data, 0 disables	0–3	1
ECLASSC1	Class for counter event data, 0 disables	0–3	0
ECLASSA1	Class for analog event data, 0 disables	0–3	2
DECPLA1	Decimal places scaling for Current data	0–3	1

Table L.7 Port DNP3 Protocol Settings (Sheet 2 of 3)

Name	Description	Range	Default
DECPLV1	Decimal places scaling for Voltage data	0–3	1
DECPLM1	Decimal places scaling for Miscellaneous data	0–3	1
ANADBA1	Analog reporting dead band for current; hidden if ECLASSA1 set to 0	0–32767	100
ANADBV1	Analog reporting dead band for voltages; hidden if ECLASSA1 set to 0	0–32767	100
ANADBM1	Analog reporting dead band for miscellaneous analogs; hidden if ECLASSA1 and ECLASSC1 set to 0	0–32767	100
TIMERQ1	Time-set request interval, minutes (M = Disables time sync requests, but still accepts and applies time syncs from Master; I = Ignores (does not apply) time syncs from Master)	I, M, 1–32767	I
STIMEO1	Select/operate time-out, seconds	0.0–30.0	1.0
DNPINA1	Send Data Link Heartbeat, seconds; hidden if DNPTR1 set to UDP	0.0–7200	120
ETIMEO1	Event message confirm time-out, seconds	1–50	5
UNSOL1	Enable unsolicited reporting; hidden and set to N if ECLASSB1, ECLASSC1, and ECLASSA1 set to 0	Y, N	N
PUNSOL1	Enable unsolicited reporting at power up; hid-den and set to N if UNSOL1 set to N	Y, N	N
NUM1EVE1[a]	Number of events to transmit on	1–200	10
AGE1EVE1[a]	Oldest event to transmit on, seconds	0.0–99999.0	2.0
URETRY1[a]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO1[a]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 2 Settings			
DNPIP2[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR2	Transport protocol	UDP, TCP	TCP
•			
•			
•			
URETRY2[a]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO2[a]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 3 Settings			
DNPIP3[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR3	Transport protocol	UDP, TCP	TCP
•			
•			
•			
URETRY3[a]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO3[a]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 4 Settings			
DNPIP4[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR4	Transport protocol	UDP, TCP	TCP
•			
•			
•			
URETRY4[a]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO4[a]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 5 Settings			
DNPIP5[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR5	Transport protocol	UDP, TCP	TCP
•			
•			
•			

Table L.7 Port DNP3 Protocol Settings (Sheet 3 of 3)

Name	Description	Range	Default
URETRY5[a]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO5[a]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 6 Settings			
DNPIP6[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR6	Transport protocol	UDP, TCP	TCP
•			
•			
•			
URETRY6[a]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO6[a]	Unsolicited messages offline timeout, seconds	1–5000	60

[a] Hidden if UNSOLn set to N.
[b] DNP IP Address of each session (DNPIP1, DNPIP2, etc.) must be unique.

DNP3 Documentation

Device Profile

The DNP3 Device Profile XML document, available on the supplied CD or as a download from the SEL website, contains the standard device profile information for the SEL-311C. Please refer to this document for complete information on the DNP3 Protocol support in the SEL-311C.

Table L.8 contains the standard DNP3 device profile information. Rather than checkboxes in the example Device Profile in the DNP3 Subset Definitions, only the relevant selections are shown.

Table L.8 SEL-311C DNP3 Device Profile (Sheet 1 of 2)

Parameter	Value
Vendor name	Schweitzer Engineering Laboratories
Device name	SEL-311C
Highest DNP request level	Level 2
Highest DNP response level	Level 2
Device function	Outstation
Notable objects, functions, and/or qualifiers supported	Analog Dead-Band Objects (object 34)
Maximum data link frame size transmitted/received (octets)	292
Maximum data link retries	Configurable, range 0–15
Requires data link layer confirmation	Configurable by setting
Maximum application fragment size transmitted/received (octets)	2048
Maximum application layer retries	None
Requires application layer confirmation	When reporting Event Data
Data link confirm time-out	Configurable
Complete application fragment time-out	None
Application confirm time-out	Configurable
Complete Application response time-out	None
Executes control WRITE binary outputs	Always
Executes control SELECT/OPERATE	Always
Executes control DIRECT OPERATE	Always
Executes control DIRECT OPERATE-NO ACK	Always
Executes control count greater than 1	Never

Table L.8 SEL-311C DNP3 Device Profile (Sheet 2 of 2)

Parameter	Value
Executes control Pulse On	Always
Executes control Pulse Off	Always
Executes control Latch Off	Always
Executes control Latch On	Always
Executes control Queue	Never
Executes control Clear Queue	Never
Reports binary input change events when no specific variation requested	Only time-tagged
Reports time-tagged binary input change events when no specific variation requested	Binary Input change with time
Sends unsolicited responses	Configurable with unsolicited message enable settings. Increases retry time (configurable) when a maximum retry setting is exceeded.
Sends static data in unsolicited responses	Never
Default counter object/variation	Object 20, Variation 6
Counter roll-over	16 bits
Sends multifragment responses	Yes

In response to the delay measurement function code, the SEL-311C will return a time delay accurate to within 50 milliseconds.

Object List

Table L.9 lists the objects and variations with supported function codes and qualifier codes available in the SEL-311C. The list of supported objects conforms to the format laid out in the DNP specifications and includes both supported and unsupported objects. Those that are supported include the function and qualifier codes. The objects that are not supported are shown without any corresponding function and qualifier codes.

Table L.9 SEL-311C DNP Object List (Sheet 1 of 4)

Obj.	Var.	Description	Request[a]		Response[b]	
			Func. Codes[c]	Qual. Codes[d]	Func. Codes[c]	Qual. Codes[d]
0	211	Device Attributes—User-specific sets of attributes	1	0	129	0, 17
0	212	Device Attributes—Master data set prototypes	1	0	129	0, 17
0	213	Device Attributes—Outstation data set prototypes	1	0	129	0, 17
0	214	Device Attributes—Master data sets	1	0	129	0, 17
0	215	Device Attributes—Outstation data sets	1	0	129	0, 17
0	216	Device Attributes—Max binary outputs per request	1	0	129	0, 17
0	219	Device Attributes—Support for analog output events	1	0	129	0, 17
0	220	Device Attributes—Max analog output index	1	0	129	0, 17
0	221	Device Attributes—Number of analog outputs	1	0	129	0, 17
0	222	Device Attributes—Support for binary output events	1	0	129	0, 17
0	223	Device Attributes—Max binary output index	1	0	129	0, 17
0	224	Device Attributes—Number of binary outputs	1	0	129	0, 17
0	225	Device Attributes—Support for frozen counter events	1	0	129	0, 17
0	226	Device Attributes—Support for frozen counters	1	0	129	0, 17

Table L.9 SEL-311C DNP Object List (Sheet 2 of 4)

Obj.	Var.	Description	Request[a]		Response[b]	
			Func. Codes[c]	Qual. Codes[d]	Func. Codes[c]	Qual. Codes[d]
0	227	Device Attributes—Support for counter events	1	0	129	0, 17
0	228	Device Attributes—Max counter index	1	0	129	0, 17
0	229	Device Attributes—Number of counters	1	0	129	0, 17
0	230	Device Attributes—Support for frozen analog inputs	1	0	129	0, 17
0	231	Device Attributes—Support for analog input events	1	0	129	0, 17
0	232	Device Attributes—Max analog input index	1	0	129	0, 17
0	233	Device Attributes—Number of analog inputs	1	0	129	0, 17
0	234	Device Attributes—Support for double-bit events	1	0	129	0, 17
0	235	Device Attributes—Max double-bit binary index	1	0	129	0, 17
0	236	Device Attributes—Number of double-bit binaries	1	0	129	0, 17
0	237	Device Attributes—Support for binary input events	1	0	129	0, 17
0	238	Device Attributes—Max binary input index	1	0	129	0, 17
0	239	Device Attributes—Number of binary inputs	1	0	129	0, 17
0	240	Device Attributes—Max transmit fragment size	1	0	129	0, 17
0	241	Device Attributes—Max receive fragment size	1	0	129	0, 17
0	242	Device Attributes—Device manufacturer’s software version (FID string)	1	0	129	0, 17
0	243	Device Attributes—Device manufacturer’s hardware version (Part number)	1	0	129	0, 17
0	245	Device Attributes—User-assigned location name (TID setting)	1	0	129	0, 17
0	246	Device Attributes—User assigned ID code/number (RID setting)	1	0	129	0, 17
0	247	Device Attributes—User-assigned device name (RID setting)	1	0	129	0, 17
0	248	Device Attributes—Device serial number	1	0	129	0, 17
0	249	Device Attributes—DNP subset and conformance (e.g., “2:2009”)	1	0	129	0, 17
0	250	Device Attributes—Device manufacturer’s product name and model (e.g., “SEL-311C Relay”)	1	0	129	0, 17
0	252	Device Attributes—Device manufacturer's name (“SEL”)	1	0	129	0, 17
0	254	Device Attributes—Nonspecific all attributes request	1	0	129	0, 17
0	255	Device Attributes—List of attribute variations	1	0	129	0, 17
1	0	Binary Input—Any Variation	1	0, 1, 6, 7, 8, 17, 28		
1	1	Binary Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
1	2[e]	Binary Input With Status	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
2	0	Binary Input Change—Any Variation	1	6, 7, 8		
2	1	Binary Input Change Without Time	1	6, 7, 8	129	17, 28
2	2[e]	Binary Input Change With Time	1	6, 7, 8	129, 130	17, 28
2	3	Binary Input Change With Relative Time	1	6, 7, 8	129	17, 28
10	0	Binary Output—Any Variation	1	0, 1, 6, 7, 8		
10	2[e]	Binary Output Status	1	0, 1, 6, 7, 8	129	0, 1

Table L.9 SEL-311C DNP Object List (Sheet 3 of 4)

Obj.	Var.	Description	Request[a] Func. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Func. Codes[c]	Response[b] Qual. Codes[d]
12	0	Control Block—Any Variation	3, 4, 5, 6	17, 28		
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
12	2	Pattern Control Block	3, 4, 5, 6	17, 28	129	echo of request
12	3	Pattern Mask	3, 4, 5, 6	17, 28	129	echo of request
20	0	Binary Counter—Any Variation	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28		
20	1	32-Bit Binary Counter	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	2	16-Bit Binary Counter	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	5	32-Bit Binary Counter Without Flag	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	6[e]	16-Bit Binary Counter Without Flag	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
21[f]	0	Frozen Counter—Any Variation	1	6, 7, 8		
21[f]	1	32-Bit Frozen Counter	1	6, 7, 8	129	0, 1, 17, 28
21[f]	2	16-Bit Frozen Counter	1	6, 7, 8	129	0, 1, 17, 28
21[f]	5	32-Bit Frozen Counter With Time of Freeze	1	6, 7, 8	129	0, 1, 17, 28
21[f]	6	16-Bit Frozen Counter With Time of Freeze	1	6, 7, 8	129	0, 1, 17, 28
21[f]	9	32-Bit Frozen Counter Without Flag	1	6, 7, 8	129	0, 1, 17, 28
21[f]	10	16-Bit Frozen Counter Without Flag	1	6, 7, 8	129	0, 1, 17, 28
22	0	Counter Change Event—Any Variation	1	6, 7, 8		
22	1	32-Bit Counter Change Event Without Time	1	6, 7, 8	129	17, 28
22	2[e]	16-Bit Counter Change Event Without Time	1	6, 7, 8	129, 130	17, 28
22	5	32-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	6	16-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
30[g]	0	Analog Input—Any Variation	1	0, 1, 6, 7, 8, 17, 28		
30[g]	1	32-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[g]	2	16-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[g]	3	32-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[g]	4	16-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[g]	5	Short Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[g]	6	Long Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
32[g]	0	Analog Change Event—Any Variation	1	6, 7, 8		
32[g]	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130[f]	17, 28
32[g]	2	16-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130	17, 28
32[g]	3	32-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[g]	4	16-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[g]	5	Short Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[g]	6	Long Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[g]	7	Short Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[g]	8	Long Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
34	0	Analog Dead Band—Any Variation	1, 2	0, 1, 6, 7, 8, 17, 28		
34	1[e]	16-Bit Analog Input Reporting Dead-Band Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	2	32-Bit Analog Input Reporting Dead-Band Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	3	Floating Point Analog Input Reporting Dead-Band Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
40	0	Analog Output Status—Any Variation	1	0, 1, 6, 7, 8	129	

Table L.9 SEL-311C DNP Object List (Sheet 4 of 4)

Obj.	Var.	Description	Request[a]		Response[b]	
			Func. Codes[c]	Qual. Codes[d]	Func. Codes[c]	Qual. Codes[d]
40	1	32-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	2[e]	16-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	3	Short Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	4	Long Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
41	0	Analog Output Block—Any Variation	3, 4, 5, 6	17, 28		
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2[e]	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	3	Short Floating Point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	4	Short Floating Point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date—Any Variation	1, 2	7, 8		
50	1	Time and Date	1, 2	7, 8 index = 0	129	07, quantity = 1
50	3	Time and Date Last Recorded	2	7 quantity = 1	129	
51	0	Time and Date CTO—Any Variation				
51	1	Time and Date CTO			129, 130[f]	07, quantity = 1
51	2	Unsynchronized Time and Date CTO			129, 130[f]	07, quantity = 1
52	0	Time Delay—Any Variation				
52	1	Time Delay, Coarse			129, 130[f]	
52	2	Time Delay, Fine			129, 130[f]	07, quantity = 1[f]
60	0	All Classes of Data	1, 20, 21	6, 7, 8		
60	1	Class 0 Data	1	6, 7, 8		
60	2	Class 1 Data	1, 20, 21	6, 7, 8		
60	3	Class 2 Data	1, 20, 21	6, 7, 8		
60	4	Class 3 Data	1, 20, 21	6, 7, 8		
80	1	Internal Indications	2	0, 1 index = 7		
N/A		No object required for the following function codes: 13 cold start, 14 warm start, 23 delay measurement	13, 14, 23			

a Supported in requests from master.
b May generate in response to master.
c Decimal.
d Hexadecimal.
e Default variation.
f DNP3 implementation Level 2 functionality which is not supported by the relay.
g Default variation specified by serial port setting DVARAI (or DVARAIn for Ethernet session n [n = 1–6]).

Reference Data Map

NOTE: Dead-band changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue any Object 34 dead band changes you wish to retain after a change to DNP port settings, issuing a **STA C** command, or a relay cold start (power cycle).

NOTE: In Table L.10, index numbers are provided as a reference to aid in the conversion of settings from relays with firmware prior to R500. See Special Settings Conversion Considerations on page C.22 for additional information about converting settings for relays with firmware prior to R500 to settings for firmware R500 and higher.

Table L.10 shows the SEL-311C reference data map. The reference map shows the data available to a DNP3 master. You can use the default map or the custom DNP3 mapping functions of the SEL-311C to retrieve only the points required by your application.

In order to retrieve SER-quality binary inputs, SEL-311C models prior to firmware R500 required mapping points within the range of indexes (500–999) dedicated to SER inputs. This is not necessary for the SEL-311C relays with firmware R500 or higher. If a point is registered in the SER, it will automatically have an SER timestamp when included in the default or custom data map.

When PTCONN = DELTA, the per phase power values, power factors, and 3V0 are set to 0, but three-phase values are defined and valid. Also, VA, VB, and VC are replaced with values of VAB, VBC, and VCA respectively, so these points do not need to be remapped if you change the PTCONN setting.

The SEL-311C scales analog values by the indicated settings or fixed scaling indicated in the description. Analog dead bands for event reporting use the indicated settings, or ANADBM if you have not specified a setting.

Table L.10 DNP3 Reference Data Map (Sheet 1 of 4)

Obj. Type	Label	Description	Index (for firmware prior to R500)
Binary Inputs			
01, 02	Relay Word	Relay Word Bit label. In legacy SEL-311C relays TLED18 is 0 and 81D1T is 431. See *Appendix D: Relay Word Bits*.	000–499
01, 02	Relay Word	Relay Word Bit label from SER. Encoded same as inputs 0–499 with 500 added. See *Appendix D: Relay Word Bits*.	500–999
01, 02	–	For front-panel target LEDs use label from Relay Word Row 0.	1000
01, 02	–	For front-panel target LEDs use label from Relay Word Row 0.	1001
01, 02	–	For front-panel target LEDs use label from Relay Word Row 0.	1002
01, 02	–	For front-panel target LEDs use label from Relay Word Row 0.	1003
01, 02	–	For front-panel target LEDs use label from Relay Word Row 0.	1004
01, 02	–	For front-panel target LEDs use label from Relay Word Row 0.	1005
01, 02	–	For front-panel target LEDs use label from Relay Word Row 0.	1006
01, 02	–	For front-panel target LEDs use label from Relay Word Row 0.	1007
01, 02	–	For front-panel target LEDs use label from Relay Word Row 1.	1008
01, 02	–	For front-panel target LEDs use label from Relay Word Row 1.	1009
01, 02	–	For front-panel target LEDs use label from Relay Word Row 1.	1010
01, 02	–	For front-panel target LEDs use label from Relay Word Row 1.	1011
01, 02	–	For front-panel target LEDs use label from Relay Word Row 1.	1012
01, 02	–	For front-panel target LEDs use label from Relay Word Row 1.	1013
01, 02	–	For front-panel target LEDs use label from Relay Word Row 1.	1014
01, 02	–	For front-panel target LEDs use label from Relay Word Row 1.	1015
01, 02[a]	LDPFA, LDPFB, LDPFC, LDPF3	Power factor leading for A, B, C and 3 phase.	1016–1019
01, 02	RLYDIS	Relay disabled.	1020
01, 02	STFAIL	Relay diagnostic failure.	1021
01, 02	STWARN	Relay diagnostic warning.	1022
01, 02	UNRDEV	An unread relay event is available.	1023
01, 02	STSET	Settings change or relay restart.	1024
01, 02	NUNREV	A more recent unread relay event is available	–
Binary Outputs			
10, 12	RB1–RB16	Remote bits.	00–15
10, 12	OC	Breaker Pulse Open command OC.	16
10, 12	CC	Breaker Pulse Close command CC.	17
10, 12	DRST_DEM	Reset demands.	18
10, 12	DRST_PDM	Reset peak demands.	19
10, 12	DRST_ENE	Reset energies.	20
10, 12	DRST_BK	Reset breaker monitor.	21
10, 12	DRST_TAR	Reset front panel targets.	22
10, 12	NXTEVE	Read next relay event.	23
10, 12	RB1:RB2, RB3:RB4, RB5:RB6, RB7:RB8, RB9:RB10, RB11:RB12, RB13:RB14, RB15:RB16	Remote bit pairs	24–31

Table L.10 DNP3 Reference Data Map (Sheet 2 of 4)

Obj. Type	Label	Description	Index (for firmware prior to R500)
10, 12	OC:CC	Breaker Open/Close pair OC & CC.	32
10, 12	RBx:RBy	Remote bit pairs, nonsequential (Open bit listed first, followed by Close bit)	–
10, 12	DRST_MML	Reset Max Min	–
10, 12	DRST_HIS	Reset event history.	–
Counter Inputs			
20, 22	ACTGRP	Active settings group.	0
20, 22	INTTR	Internal breaker trips.	1
20, 22	EXTTR	External breaker trips.	2
Analog Inputs			
30, 32	IA[b], IAFA[c]	IA magnitude and angle.	00, 01
30, 32	IB[b], IBFA[c]	IB magnitude and angle.	02, 03
30, 32	IC[b], ICFA[c]	IC magnitude and angle.	04, 05
30, 32	IN[b], INFA[c]	IN magnitude and angle.	06, 07
30, 32	VA[d], VAFA[c]	VA magnitude (kV) and angle. Contains VAB magnitude and angle when PTCONN = Delta.	08, 09
30, 32	VB[d], VBFA[c]	VB magnitude (kV) and angle. Contains VBC magnitude and angle when PTCONN = Delta.	10, 11
30, 32	VC[d], VCFA[c]	VC magnitude (kV) and angle. Contains VCA magnitude and angle when PTCONN = Delta.	12, 13
30, 32	VS[d], VSFA[c]	VS magnitude (kV) and angle.	14, 15
30, 32	VAB[d], VABFA[c]	VAB magnitude (kV) and angle.	–
30, 32	VBC[d], VBCFA[c]	VBC magnitude (kV) and angle.	–
30, 32	VCA[d], VCAFA[c]	VCA magnitude (kV) and angle.	–
30, 32	IG[b], IGFA[c]	IG magnitude and angle.	16, 17
30, 32	3I0[b], 3I0FA[c]	3I0 magnitude (kV) and angle.	–
30, 32	I1[b], I1FA[c]	I1 magnitude and angle.	18, 19
30, 32	3I2[b], 3I2FA[c]	3I2 magnitude and angle.	20, 21
30, 32	3V0_MAG[d], 3V0FA[c]	3V0 magnitude (kV) and angle.	22, 23
30, 32	V1[d], V1FA[c]	V1 magnitude (kV) and angle.	24, 25
30, 32	V2[d], V2FA[c]	V2 magnitude (kV) and angle.	26, 27
30, 32	MWA[e], MWB[e], MWC[e], MW3[e]	MW A, B, C and 3 phase.	28–31
30, 32	MVARA[e], MVARB[e], MVARC[e], MVAR3[e]	MVAR A, B, C and 3 phase.	32–35
30, 32	PFA[c], PFB[c], PFC[c], PF3[c]	Power factor A, B, C and 3 phase.	36–39
30, 32	FREQ[c]	Frequency	40
30, 32	VDC[f]	VDC	41
30, 32	MWHAI[e], MWHAO[e]	A-phase MWhr in and out	42, 43
30, 32	MWHBI[e], MWHBO[e]	B-phase MWhr in and out.	44, 45
30, 32	MWHCI[e], MWHCO[e]	C-phase MWhr in and out.	46, 47
30, 32	MWH3I[e], MWH3O[e]	3-phase MWhr in and out.	48, 49
30, 32	MVRHAI[e], MVRHAO[e]	A-phase MVARhr in and out.	50,51
30, 32	MVRHBI[e], MVRHBO[e]	B-phase MVARhr in and out.	52,53
30, 32	MVRHCI[e], MVRHCO[e]	C-phase MVARhr in and out.	54,55
30, 32	MVRH3I[e], MVRH3O[e]	3-phase MVARhr in and out.	56,57

Table L.10 DNP3 Reference Data Map (Sheet 3 of 4)

Obj. Type	Label	Description	Index (for firmware prior to R500)
30, 32	IADEM[b], IBDEM[b], ICDEM[b], IGDEM[b], 3I2DEM[b]	Demand IA, IB, IC, IG, and 3I2 magnitudes.	58–62
30, 32	INDEM[b]	Demand IN magnitude.	–
30, 32	MWADI[e], MWBDI[e], MWCDI[e], MW3DI[e]	A, B, C and 3 phase demand MW in.	63–66
30, 32	MVRADI[e], MVRBDI[e], MVRCDI[e], MVR3DI[e]	A, B, C and 3 phase demand MVAR in.	67–70
30, 32	MWADO[e], MWBDO[e], MWCDO[e], MW3DO[e]	A, B, C and 3 phase demand MW out.	71–74
30, 32	MVRADO[e], MVRBDO[e], MVRCDO[e], MVR3DO[e]	A, B, C and 3 phase demand MVAR out.	75–78
30, 32	IAPK[b], IBPK[b], ICPK[b], IGPK[b], 3I2PK[b]	Peak demand IA, IB, IC, IG, and 3I2 magnitudes.	79–83
30, 32	INPK[b]	Peak demand IN magnitude.	–
30, 32	MWAPI[e], MWBPI[e], MWCPI[e], MW3PI[e]	A, B, C and 3 phase peak demand MW in.	84–87
30, 32	MVRAPI[e], MVRBPI[e], MVRCPI[e], MVR3PI[e]	A, B, C and 3 phase peak demand MVAR in.	88–91
30, 32	MWAPO[e], MWBPO[e], MWCPO[e], MW3PO[e]	A, B, C and 3 phase peak demand MW out.	92–95
30, 32	MVRAPO[e], MVRBPO[e], MVRCPO[e], MVR3PO[e]	A, B, C and 3 phase peak demand MVAR out.	96–99
30, 32	WEARA[e], WEARB[e], WEARC[e]	Breaker contact wear percentage (A, B, C)	100–102
30, 32[g]	FTYPE	Fault type	103
30, 32[g]	FTYPE16[h]	Fault type (formatted as a 16-bit signed value)	–
30, 32[g]	FLOC[e]	Fault location. If FLOC = $$$$$$, it will be set to –999.9 in DNP.	104
30, 32[g]	FI[b]	Maximum-phase fault current	105
30, 32[g]	FFREQ[c]	Fault frequency	106
30, 32[g]	FGRP	Fault settings group (1–6)	107
30, 32[g]	FSHO	Fault recloser shot counter	108
30, 32[g]	FTIMEH, FTIMEM, FTIMEL	Fault time in DNP format (high, middle, and low 16 bits)	109–111
30, 32[g]	FTIMEH16[h], FTIMEM16[h], FTIMEL16[h]	Fault time in DNP format (high, middle, and low 16 bits formatted as a 16-bit signed value)	–
30, 32	TEMP[f]	Relay Internal Temperature	–
30, 32	FUNR	Number of unread Faults	–
30, 32	51PP[b]	51PP setting in primary units	–
30, 32	51GP[b]	51GP setting in primary units	–
30, 32	51QP[b]	51QP setting in primary units	–
30, 32[g]	FIA[b]	A-phase fault current, A primary	–
30, 32[g]	FIB[b]	B-phase fault current, A primary	–
30, 32[g]	FIC[b]	C-phase fault current, A primary	–
30, 32[g]	FIG[b]	Residual-ground fault current, A primary	–
30, 32[g]	FIN[b]	IN channel fault current, A primary	–
30, 32[g]	FIQ[b]	Negative sequence fault current, A primary	–
30, 32	LDPFA[a]	Power Factor Leading = 1, A-phase	–

Table L.10 DNP3 Reference Data Map (Sheet 4 of 4)

Obj. Type	Label	Description	Index (for firmware prior to R500)
30, 32	LDPFB[a]	Power Factor Leading = 1, B-phase	–
30, 32	LDPFC[a]	Power Factor Leading = 1, C-phase	–
30, 32	LDPF3[a]	Power Factor Leading = 1, 3-phase	–
Analog Outputs			
40, 41	ACTGRP[i]	Active settings group	0

[a] For Delta configuration (setting PTCONN = DELTA), the per-phase power values, power factors, and 3V0 are set to 0. Three-phase values are defined and valid.
[b] Scaled according to the DECPLA setting, dead band according to ANADBA setting.
[c] Scaled by 100, dead band according to ANADBM setting.
[d] Scaled according to the DECPLV setting, dead band according to ANADBV setting.
[e] Scaled according to the DECPLM setting, dead band according to ANADBM setting.
[f] Scaled by 10, dead band according to ANADBM setting.
[g] See the Event Data on page L.29 for a detailed description of these labels.
[h] Required because the DNP library does not support unsigned 16-bit values. Populate these registers with VALUE when VALUE ≤ 32767. Populate with (VALUE−65536) when VALUE > 32767.
[i] The active settings group can be modified by writing the desired settings group number to ACTGRP. If a logic setting has been programmed to control the active settings group, the write will be accepted but the active group will not change.

Default Data Map

The default data map is a subset of the reference map. All data maps are initialized to the default values. *Table L.11* shows the SEL-311C default data map. If the default maps are not appropriate, you can also use the custom DNP mapping commands **SET D *n*** and **SHOW D *n***, where *n* is the map number, to edit or create the map required for your application.

Table L.11 DNP3 Default Data Map (Sheet 1 of 3)

Object	Default Index	Point Label
01, 02	0	52A
	1	79RS
	2	79LO
	3	TLED18
	4	TLED17
	5	TLED16
	6	TLED15
	7	TLED14
	8	TLED13
	9	TLED12
	10	TLED11
	11	TLED26
	12	TLED25
	13	TLED24
	14	TLED23
	15	TLED22
	16	TLED21
	17	TLED20
	18	TLED19
	19	LDPF3
	20	RLYDIS
	21	STFAIL
	22	STWARN

Table L.11 DNP3 Default Data Map (Sheet 2 of 3)

Object	Default Index	Point Label
	23	UNRDEV
	24–199	NA
10, 12	0–15	RB1–RB16 Remote Bits
	16	OC
	17	CC
	18	DRST_DEM
	19	DRST_PDM
	20	DRST_ENE
	21	DRST_BK
	22	DRST_TAR
	23	NXTEVE
	24	RB1:RB2
	25	RB3:RB4
	26	RB5:RB6
	27	RB7:RB8
	28	RB9:RB10
	29	RB11:RB12
	30	RB13:RB14
	31	RB15:RB16
	32	OC:CC
20, 22	0	ACTGRP
	1	INTTR
	2	EXTTR
	3–7	NA
30, 32, 34	0	IA
	1	IAFA::500
	2	IB
	3	IBFA::500
	4	IC
	5	ICFA::500
	6	IN
	7	INFA::500
	8	VA
	9	VAFA::500
	10	VB
	11	VBFA::500
	12	VC
	13	VCFA::500
	14	VS
	15	VSFA::500
	16	IG
	17	IGFA::500
	18	MW3
	19	MVAR3
	20	PF3
	21	FREQ
	22	VDC

Table L.11 DNP3 Default Data Map (Sheet 3 of 3)

Object	Default Index	Point Label
	23	MWH3I
	24	MWH3O
	25	MVRH3I
	26	MVRH3O
	27	WEARA
	28	WEARB
	29	WEARC
	30	FTYPE
	31	FLOC
	32	FI
	33	FFREQ
	34	FGRP
	35	FSHO
	36	FTIMEH
	37	FTIMEM
	38	FTIMEL
	39	FUNR
	40–199	NA
40, 41	0	ACTGRP
	1–7	NA

Configurable Data Mapping

One of the most powerful features of the SEL-311C implementation is the ability to remap DNP3 data and, for analog values, specify per-point scaling and dead bands. Remapping is the process of selecting data from the reference map and organizing it into a data subset optimized for your application. The SEL-311C uses object and point labels, rather than point indices, to streamline the remapping process. This enables you to quickly create a custom map without having to search for each point index in a large reference map.

You may use any of the three available DNP3 maps simultaneously with up to six unique DNP3 masters. Each map is initially populated with default data points, as described in *Default Data Map on page L.20*. You may remap the points in a default map to create a custom map with up to:

- 200 Binary Inputs
- 33 Binary Outputs
- 200 Analog Inputs
- 8 Analog Outputs
- 8 Counters

You can use the **SHOW D** ***x*** **<Enter>** command to view the DNP3 data map settings, where *x* is the DNP3 map number from 1 to 3. See *Figure L.3* for an example display of map 1.

```
=>>SHO D 1 <Enter>

DNP Map Settings 1
BI_000  = 52A      BI_001  = 79RS     BI_002  = 79LO     BI_003  = TLED18
BI_004  = TLED17   BI_005  = TLED16   BI_006  = TLED15   BI_007  = TLED14
BI_008  = TLED13   BI_009  = TLED12   BI_010  = TLED11   BI_011  = TLED26
BI_012  = TLED25   BI_013  = TLED24   BI_014  = TLED23   BI_015  = TLED22
BI_016  = TLED21   BI_017  = TLED20   BI_018  = TLED19   BI_019  = LDPF3
BI_020  = RLYDIS   BI_021  = STFAIL   BI_022  = STWARN   BI_023  = UNRDEV
---
BI_196  = NA       BI_197  = NA       BI_198  = NA       BI_199  = NA

BO_000  = RB1               BO_001  = RB2               BO_002  = RB3
BO_003  = RB4               BO_004  = RB5               BO_005  = RB6
BO_006  = RB7               BO_007  = RB8               BO_008  = RB9
BO_009  = RB10              BO_010  = RB11              BO_011  = RB12
BO_012  = RB13              BO_013  = RB14              BO_014  = RB15
BO_015  = RB16              BO_016  = OC                BO_017  = CC
BO_018  = DRST_DEM          BO_019  = DRST_PDM          BO_020  = DRST_ENE
BO_021  = DRST_BK           BO_022  = DRST_TAR          BO_023  = NXTEVE
BO_024  = RB1:RB2           BO_025  = RB3:RB4           BO_026  = RB5:RB6
BO_027  = RB7:RB8           BO_028  = RB9:RB10          BO_029  = RB11:RB12
BO_030  = RB13:RB14         BO_031  = RB15:RB16         BO_032  = OC:CC

AI_000  = IA                      AI_001  = IAFA::500
AI_002  = IB                      AI_003  = IBFA::500
AI_004  = IC                      AI_005  = ICFA::500
AI_006  = IN                      AI_007  = INFA::500
AI_008  = VA                      AI_009  = VAFA::500
AI_010  = VB                      AI_011  = VBFA::500
AI_012  = VC                      AI_013  = VCFA::500
AI_014  = VS                      AI_015  = VSFA::500
AI_016  = IG                      AI_017  = IGFA::500
AI_018  = MW3                     AI_019  = MVAR3
AI_020  = PF3                     AI_021  = FREQ
AI_022  = VDC                     AI_023  = MWH3I
AI_024  = MWH3O                   AI_025  = MVRH3I
AI_026  = MVRH3O                  AI_027  = WEARA
AI_028  = WEARB                   AI_029  = WEARC
AI_030  = FTYPE                   AI_031  = FLOC
AI_032  = FI                      AI_033  = FFREQ
AI_034  = FGRP                    AI_035  = FSHO
AI_036  = FTIMEH                  AI_037  = FTIMEM
AI_038  = FTIMEL                  AI_039  = FUNR
---
AI_198  = NA                      AI_199  = NA

AO_000  = ACTGRP   AO_001  = NA       AO_002  = NA       AO_003  = NA
AO_004  = NA       AO_005  = NA       AO_006  = NA       AO_007  = NA

CO_000  = ACTGRP         CO_001  = INTTR          CO_002  = EXTTR
CO_003  = NA             CO_004  = NA             CO_005  = NA
CO_006  = NA             CO_007  = NA
=>>
```

Figure L.3 Sample Response to SHO D Command

You can use the command **SET D *x***, where *x* is the map number, to edit or create custom DNP3 data maps. You can also use the ACSELERATOR SEL-5030 Software, which is recommended for this purpose.

The following are valid entries if you choose to use the **SET D** command to create or edit custom maps:

- Binary Inputs—Any Relay Word bit label or additional DNP Binary Input (see *Binary Inputs on page L.28*), the values 0 or 1, or NA
- Binary Outputs—Any Remote bit label or pair, Breaker bit label or pair, or additional DNP Binary Output (see *Binary Outputs on page L.28*), or NA
- Analog Inputs—Any Analog Input Quantity (see *Analog Inputs on page L.29*) with scaling and/or dead-band value, e.g., IA:0.1:50 (see below), the values 0 or 1, or NA
- Analog Outputs—Any Analog Output label (see *Table L.10*), NOOP, or NA
- Counter Inputs—Any counter label (see *Table L.10*)

For the above custom map settings, a label of 0 or 1 shall yield the label value when the point is polled. A NOOP can be used as a placeholder for analog outputs—control of a point with this label does not change any relay values nor respond with an error message. Any gaps left in the custom map between labels (NA) will be removed and the contents packed.

You can customize the DNP3 analog input map with per-point scaling and dead band settings. Class scaling (DECPLA, DECPLV, and DECPLM) and dead-band (ANADBA, ANADBV, and ANADBM) settings are applied to indices that do not have per-point entries. Per-point dead-band settings override any class dead band settings. Per-point scaling overrides any class scaling, and multiplies the analog input by the scaling value. Unlike per-point scaling, class-level scaling is specified by an integer in the range 0–3 (inclusive), which indicates the number of decimal place shifts. In other words, you should select 0 to multiply by 1, 1 for 10, 2 for 100, or 3 for 1000.

Per-point scaling factors allow you to overcome the limitations imposed, by default, of the integer nature of Objects 30 and 32. For example, DNP in the SEL-311C, by default, truncates a value of 11.4 amps to 11 amps. You may use per-point scaling to include decimal point values by multiplying by a power of 10. For example, if you use 10 as a scaling factor, 11.4 amps will be transmitted as 114. You must divide the value by 10 in the master to see the original value including one decimal place.

You can also use per-point scaling to avoid overflowing the 16-bit maximum integer value of 32767. For example, if you have a value that can reach 157834, you cannot send it using DNP3 16-bit analog object variations. You could use a scaling factor of 0.1 so that the maximum value reported is 15783. You can then multiply the value by 10 in the master to see a value of 157830. You will lose some precision as the last digit is truncated off in the scaling process, but you can transmit the scaled value using the default variations for DNP3 Objects 30 and 32.

If your DNP3 master has the capability to request floating-point analog input variations, the SEL-311C will support them. These floating point variations, 5 and 6 for Object 30 and 5 through 8 for Object 32, allow the transmission of 16- or 32-bit floating point values to DNP3 masters. When implemented, these variations eliminate the need for scaling and still maintain the resolution of the relay analog values. Note that this support is greater than DNP3 Level 4 functionality, so you must confirm that your DNP3 master can work with these variations before you consider using unscaled analog values.

If it is important to maintain tight data coherency (that is, all data read of a certain type was sampled or calculated at the same time), then you should group that data together within your custom map. For example, if you want all the currents to be coherent, you should group points IA_MAG, IB_MAG, IC_MAG, and IN_MAG together in the custom map. If points are not grouped together, they might not come from the same data sample.

The following example describes how to create a custom DNP3 map by point type. The example demonstrates the SEL ASCII command **SET D** for each point type, but the entire configuration may be completed without saving changes between point types. To do this, you simply continue entering data and save the entire map at the end. Alternately, you can use the ACSELERATOR software to simplify custom data map creation.

Consider a case where you want to set the AI points in a map as shown in *Table L.12*.

Table L.12 Sample Custom DNP3 AI Map

Desired Point Index	Description	Label	Scaling	Deadband
0	IA magnitude	IA	default	default
1	IB magnitude	IB	default	default
2	IC magnitude	IC	default	default
3	IN magnitude	IN	default	default
4	3 Phase Real Power	MW3	5	default
5	A Phase-to-Neutral Voltage Magnitude	VA	default	default
6	A Phase-to-Neutral Voltage Angle	VAFA	1	15
7	Frequency	FREQ	.01	1

To set these points as part of custom map 1, you can use the command **SET D 1 AI_000 TERSE <Enter>** as shown in *Figure L.4*.

```
=>>SET D 1 AI_000 TERSE <Enter>

DNP Map Settings 1

Analog Input Map
  (DNP Analog Input Label:Scale Factor:Deadband):
DNP Analog Input Label Name
AI_000  = IA
     ? IA <Enter>

DNP Analog Input Label Name
AI_001  = IAFA::500
     ? IB <Enter>

DNP Analog Input Label Name
AI_002  = IB
     ? IC <Enter>

DNP Analog Input Label Name
AI_003  = IBFA::500
     ? IN <Enter>

DNP Analog Input Label Name
AI_004  = IC
     ? MW3:5 <Enter>

DNP Analog Input Label Name
AI_005  = ICFA::500
     ? VA <Enter>

DNP Analog Input Label Name
AI_006  = IN
     ? VAFA:1:15 <Enter>

DNP Analog Input Label Name
AI_007  = INFA::500
     ? FREQ:0.01:1 <Enter>

DNP Analog Input Label Name
AI_008  = VA
     ? END <Enter>

Save Changes(Y/N)? Y <Enter>

Settings saved
=>>
```

Figure L.4 Sample Custom DNP3 AI Map Settings

You can also use ACSELERATOR to enter the above AI map settings as shown in *Figure L.5*. To enter scaling and dead band setting, double-click the AI point and enter the values in the pop-up dialog, as shown in *Figure L.6*.

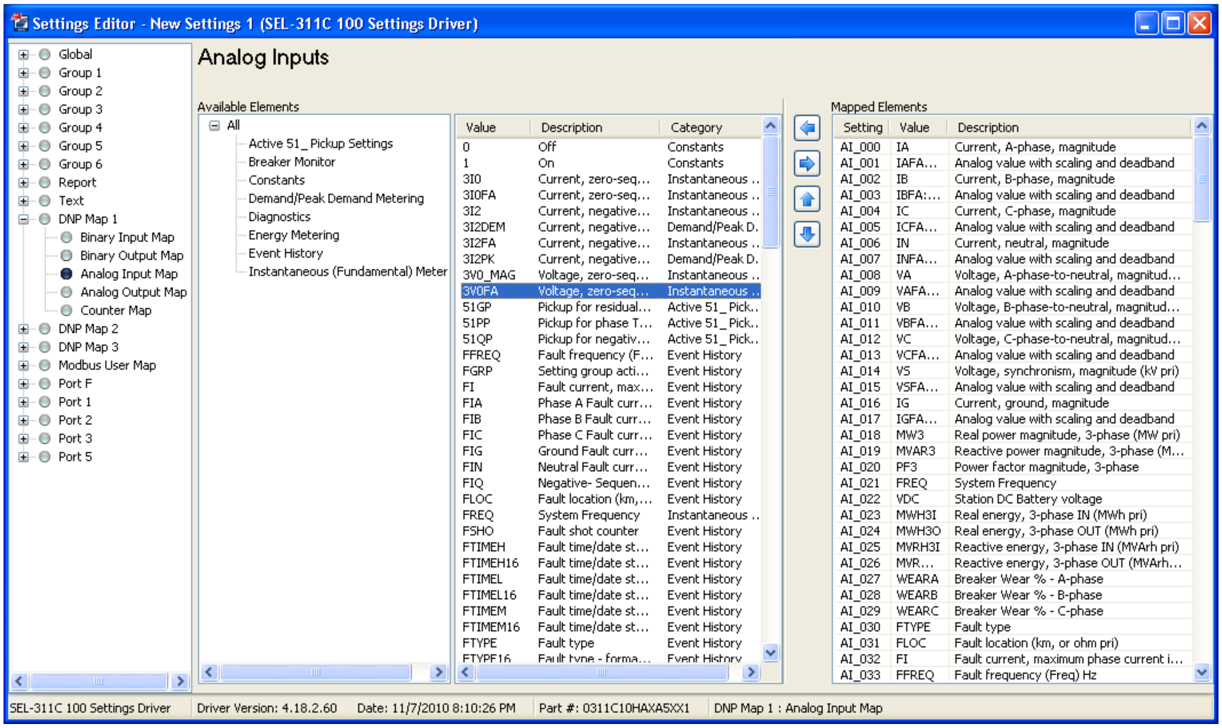

Figure L.5 Analog Input Map Entry in ACSELERATOR Software

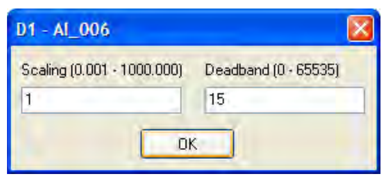

Figure L.6 AI Point Label, Scaling and Dead Band in ACSELERATOR Software

The **SET D x CO_000 TERSE <Enter>** command allows you to populate the DNP counter map and adjust the per-point scaling and dead bands if necessary for your application. Entering these settings is similar to defining the analog input map settings.

You can use the command **SET D *x* BO_000 TERSE <Enter>** to change the binary output map *x* as shown in *Figure L.7*. You may populate the custom BO map with any of the 16 remote bits (RB1–RB16), breaker bits (OC, CC), data reset bits (DRST_DEM, DRST_PDM, DRST_BK, DRST_HIS, DRST_ENE, DRST_MML, DRST_TAR), or the NXTEVE bit. You can define bit pairs for remote bits or breaker bits in BO maps by including a colon (:) between the bit labels.

```
=>>SET D 1 BO_000 TERSE <Enter>

DNP Map Settings 1

Binary Output Map:
DNP Binary Output Label Name
BO_000   = RB1
     ? RB1 <Enter>

DNP Binary Output Label Name
BO_001   = RB2
     ? RB2 <Enter>

DNP Binary Output Label Name
BO_002   = RB3
     ? RB3:RB4 <Enter>

DNP Binary Output Label Name
BO_003   = RB4
     ? RB5:RB6 <Enter>

DNP Binary Output Label Name
BO_004   = RB5
     ? END <Enter>

Save Changes(Y/N)? Y <Enter>

Settings saved
=>>
```

Figure L.7 Sample Custom DNP3 BO Map Settings

You can also use ACSELERATOR to enter the BO map settings as shown in *Figure L.8*.

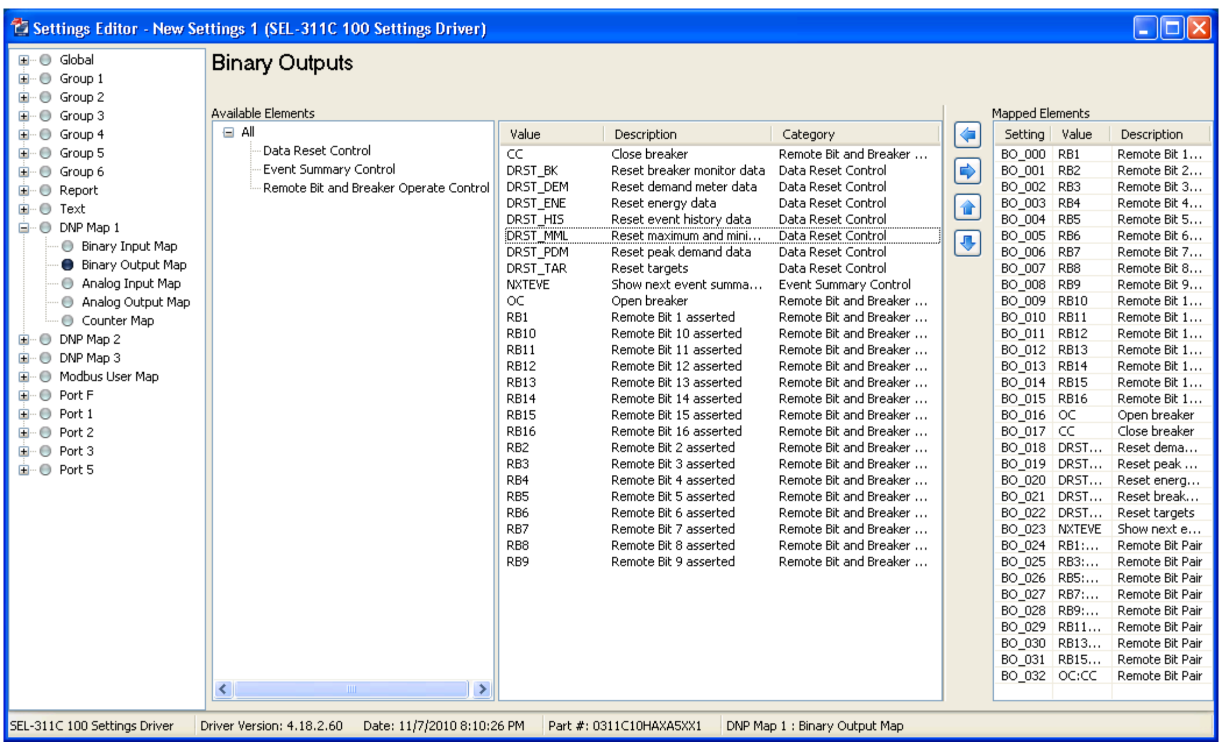

Figure L.8 Binary Output Map Entry in ACSELERATOR Software

The binary input (BI) maps are modified in a similar manner, but pairs are not allowed.

Binary Inputs

Binary Inputs (objects 1 & 2) are supported as defined in *Table L.10*. The default variation for both static and event inputs is 2. Only the Read function code (1) is allowed with these objects. All variations are supported. Object 2, variation 3 will be responded to, but will contain no data.

Binary Inputs are scanned approximately once per second to generate events. When time is reported with these event objects, it is the time at which the scanner observed the bit change. This may be significantly delayed from when the original source changed and should not be used for sequence-of-events determination. Binary inputs registered with SER are derived from the SER and carry the time stamp of actual occurrence. Some additional binary inputs are available only to DNP: RLYDIS is derived from the relay status variable; STWARN and STFAIL are derived from the diagnostic task data; UNRDEV & NUNREV are derived from the event queue. Another binary input, STSET, is derived from the SER and carries the time stamp of actual occurrence. Static reads of this input will always show 0 (or tripped) because of the pulse only control operation of these points.

Binary Outputs

Binary Outputs are supported as defined in *Table L.10*. Binary Output status (Object 10 variation 2) is supported. Static reads of points RB1–RB16 and NXTEVE respond with the on-line bit set and the state-of-the requested bit. Reads from OC, CC, and control-only binary output points (such as the data reset controls DRST_DEM, DRST_ENE) respond with the on-line bit set and a state of 0 (or tripped) because of the pulse only control operation of these points.

Control Relay Output Block objects (object 12, variation 1) are supported. The control relays correspond to the remote bits and other functions as shown above. The Trip/Close bits take precedence over the control field. The control field is interpreted as follows:

Table L.13 Object 12 Control Relay Operations

Label	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
RBx	Pulse	Pulse	Set	Clear	Pulse	Not Supported
OC	Pulse	Pulse	Pulse	Do nothing	Pulse	Not Supported
CC	Pulse	Pulse	Pulse	Do nothing	Pulse	Not Supported
DRST_DEM	Pulse	Pulse	Pulse	Do nothing	Pulse	Not Supported
DRST_ENE	Pulse	Pulse	Pulse	Do nothing	Pulse	Not Supported
DRST_BK	Pulse	Pulse	Pulse	Do nothing	Pulse	Not Supported
DRST_MML	Pulse	Pulse	Pulse	Do nothing	Pulse	Not Supported
DRST_HIS	Pulse	Pulse	Pulse	Do nothing	Pulse	Not Supported
DRST_PDM	Pulse	Pulse	Pulse	Do nothing	Pulse	Not Supported
DRST_TAR	Pulse	Pulse	Pulse	Do nothing	Pulse	Not Supported
NXTEVE	Read Oldest	Read Oldest	Read Oldest	Read Newest	Read Oldest	Not Supported
RBx:RBy	Pulse RBy	Pulse RBx	Pulse RBy	Pulse RBx	Not Supported	Not Supported
OC:CC	Pulse CC	Pulse OC	Pulse CC	Pulse OC	Not Supported	Not Supported

The Status field is used exactly as defined. All other fields are ignored. A pulse operation is asserted for a single processing interval. You should exercise caution if sending multiple remote bit pulses in a single message (i.e., point count > 1), since this may result in some of the pulse commands being ignored and the return of an “already active” status message.

Control Point Operation

You can define any two RB points as a pair for Trip/Close or Code Selection operations with Object 12 control device output block command messages. The SEL-311C assigns some special operations to the code portion of the control device output block command. Because the SEL-311C allows only one control bit to be pulsed at a time, you should send consecutive control bits in consecutive messages. Pulse operations provide a pulse with duration of one protection-processing interval.

Table L.14 Example Object 12 Trip/Close or Code Selection Operation

Control Points	Trip/Close		Code Selection Operation			
	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
RB1:RB2	PULSE RB2	PULSE RB1	PULSE RB2	PULSE RB1	Not Supported	Not Supported
RB3	PULSE RB3	PULSE RB3	SET RB3	CLEAR RB3	PULSE RB3	Not Supported
RB4	PULSE RB4	PULSE RB4	SET RB4	CLEAR RB4	PULSE RB4	Not Supported
RB5:RB6	PULSE RB6	PULSE RB5	PULSE RB6	PULSE RB5	Not Supported	Not Supported
RB0	PULSE RB7	PULSE RB7	SET RB7	CLEAR RB7	PULSE RB7	Not Supported
RB8	PULSE RB8	PULSE RB8	SET RB8	CLEAR RB8	PULSE RB8	Not Supported
RB14:RB15	PULSE RB15	PULSE RB14	PULSE RB15	PULSE RB14	Not Supported	Not Supported
RB18:RB21	PULSE RB21	PULSE RB18	PULSE RB21	PULSE RB18	Not Supported	Not Supported

Analog Inputs

Analog Inputs (30) and Analog Change Events (32) are supported as defined in *Table L.10*. Analog values are reported in primary units. See *Appendix E: Analog Quantities* for a list of all available analog inputs, and the DNP Reference map for default scaling and dead bands. A dead band check is done after any scaling has been applied. Event class messages are generated whenever an input changes beyond the value given by the appropriate dead band setting. The voltage and current phase angles will only generate an event if, in addition to their dead band check, the corresponding magnitude changes beyond its own dead band. Analog inputs are scanned at approximately a 1 second rate, except for Fault analog inputs below. The ANADBA setting applies to the same values as the DECPLA settings. The ANADBV setting applies to the same values as the DECPLV setting. The ANADBM setting applies to all other analog input items. All events generated during a scan will use the time the scan was initiated.

Event Data

The following Fault Analog Inputs are derived from the history queue data for the most recently read event: FTYPE, FTYPE16, FLOC, FI, FIA, FIB, FIC, FIG, FIN, FIQ, FFREQ, FGRP, FSHO, FTIMEH, FTIMEM, FTIMEL, FTIMEH16, FTIMEM16, FTIMEL16, and FUNR. These quantities, also referred to as the event registers, shall generate DNP3 analog change events (Object 32). Because these event registers refer to the same event summary record, the relay creates analog change events for all of these event registers when any one of the registers exceeds its dead band. Events for these inputs will use the time the scan was initiated.

Analog input FLOC is the Fault Location value. If this field contains "$$$$$$" (undetermined location) or is blank (when EFLOC = N), the relay will set the internal value of FLOC to –999.9 for DNP3. As with most of the event register values, FLOC is subject to scaling by the DECPLM setting (1 by default). So by default, a DNP3 poll of this value under the above conditions would yield a value of –9999.0 at the master. This value was chosen to represent an undetermined or blank FLOC that would not create nuisance alarms by presenting an over-range value to a DNP3 master. Note that if DECPLM is changed, this will change the end value of this point at the DNP3 master. If DECPLM is changed, you should set per-point scaling to 1 for FLOC to override the DECPLM scaling and ensure that it is transmitted as expected.

Analog input FUNR is the number of unread relay events and is derived from the history queue. Analog input FTYPE is a 16-bit composite value, where the upper byte is defined as follows:

Value	Event Cause
1	Trigger command
2	Pulse command
4	Trip element
8	ER element

And the lower byte is defined as follows:

Value	Fault Type
0	Indeterminate
1	A Phase
2	B Phase
4	C Phase
8	Ground

The lower byte may contain any combination of the above bits (e.g., a 6 means a B to C fault and a 9 is an A to Ground fault). If input FTYPE is 0, fault information has not yet been read and the fault analog inputs do not contain valid event data.

Settings Data

Analog inputs 51PP, 51GP, and 51QP are derived from the present active group settings. If the associated setting is set to off, the value will be reported as –1. Please note that these values are subject to scaling by the DECPLA setting (i.e., you will see a value of –10 for OFF with the default DECPLA setting). You may override the default scaling by applying per-point scaling to these values in a custom DNP map.

Reading Relay Event Data

The SEL-311C provides protective relay event history information in either single or multiple-event mode. The relay operates in single-event mode after a power-up. To transition to multiple-event mode the session DNP3 master sends a latch-on or latch-off control to the NXTEVE binary output control point. Once in multiple-event mode, the session remains in that mode until the relay restarts, DNP port settings are changed, or the DNP map is modified. In these cases, the relay transitions to single-event mode, and the DNP event data registers are cleared.

The *Event Data on page L.29* describes the analog event registers that are updated for the most recently read event. For single-event mode, the only register that does not update when a new event occurs is FUNR. For multiple-event mode, the only register that will update when a new event occurs is FUNR.

DNP3 masters configured to use multiple-event mode must monitor at least one of the analog event registers to detect if the relay has transitioned to single event mode. If only one of the registers is monitored, that register cannot be

FUNR since FUNR does not update for single-event mode. If changes are detected in the analog event registers, the DNP3 master should latch-on or latch-off NXTEVE to put the relay into multiple-event mode.

Single-Event Mode

Single-event mode provides the most recent event report summary data as it occurs in the relay. When a new event report is triggered, the new event data is stored in event registers, which generates a DNP3 event. The event report summary values are locked into the event registers for the time determined by Global setting EVELOCK. Additional event reports triggered before the EVELOCK timer expires are ignored by DNP3. EVELOCK = 0 defeats the lock function, and allows the event registers to be updated as soon as a new event report is triggered. EVELOCK has no affect when the session is in multiple-event mode.

Multiple-Event Mode

Multiple-event mode provides the most recent event report summary data when the master sends a latch-on or latch-off control to NXTEVE. Anytime there is unread event data, UNRDEV will be asserted and FUNR will represent the number of unread event reports.

When the session DNP3 master sends a latch-on control to NXTEVE, the oldest unread event summary data is transferred to the event registers. To check for more available unread event summary data, read the UNRDEV binary input. If UNRDEV is asserted then more event data exists. Use the NXTEVE binary output and UNRDEV binary input to create an event summary data FIFO: if UNRDEV is asserted, send a latch-on control to NXTEVE, read the event summary data, and read UNRDEV again. Repeat until UNRDEV is cleared. Sending a latch-on control to NXTEVE while UNRDEV is cleared sets the event data registers point to zero.

When the session DNP3 master sends a latch-off control to NXTEVE, the newest unread event summary data is transferred to the event registers. To check for more available unread event summary data. If UNRDEV is asserted then more event data exists. This sequence steps through the event summary data from newest to oldest, forming a LIFO. It is possible that, while stepping through the event summary data from newest to oldest, a new event will be triggered. In that case the binary input NUNREV asserts, and the next event summary is from the most recently triggered event. Subsequent latch-off controls to NXTEVE resume with the next oldest unread event summary, skipping all the event summaries already read. Sending a latch-off control to NXTEVE while UNRDEV is cleared sets the analog event data registers to zero.

In either FIFO or LIFO mode, if the session DNP master latches NXTEVE more often than once per two seconds, some DNP events may not be generated by the new event summary data, and event summary data may be lost.

DNP Settings Sheets

DNP Map Settings (SET DNP n Command)

Use **SET DNP *n*** command with *n* = 1, 2, or 3 to create up to three DNP User Maps. Refer to *Default Data Map on page L.20* for details.

This is DNP Map 1 (DNP Map 2 and DNP Map 3 tables are identical to DNP Map 1 table).

Binary Input Map

DNP Binary Input Label Name	**BI_000**	=	______________
DNP Binary Input Label Name	**BI_001**	=	______________
DNP Binary Input Label Name	**BI_002**	=	______________
DNP Binary Input Label Name	**BI_003**	=	______________
DNP Binary Input Label Name	**BI_004**	=	______________
DNP Binary Input Label Name	**BI_005**	=	______________
DNP Binary Input Label Name	**BI_006**	=	______________
DNP Binary Input Label Name	**BI_007**	=	______________
DNP Binary Input Label Name	**BI_008**	=	______________
DNP Binary Input Label Name	**BI_009**	=	______________
DNP Binary Input Label Name	**BI_010**	=	______________
DNP Binary Input Label Name	**BI_011**	=	______________
DNP Binary Input Label Name	**BI_012**	=	______________
DNP Binary Input Label Name	**BI_013**	=	______________
DNP Binary Input Label Name	**BI_014**	=	______________
DNP Binary Input Label Name	**BI_015**	=	______________
DNP Binary Input Label Name	**BI_016**	=	______________
DNP Binary Input Label Name	**BI_017**	=	______________
DNP Binary Input Label Name	**BI_018**	=	______________
DNP Binary Input Label Name	**BI_019**	=	______________
DNP Binary Input Label Name)	**BI_020**	=	______________
DNP Binary Input Label Name	**BI_021**	=	______________
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DNP Binary Input Label Name	**BI_024**	=	______________
DNP Binary Input Label Name	**BI_025**	=	______________
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DNP Binary Input Label Name	**BI_028**	=	________
DNP Binary Input Label Name	**BI_029**	=	________
DNP Binary Input Label Name	**BI_030**	=	________
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DNP Binary Input Label Name	**BI_034**	=	________
DNP Binary Input Label Name	**BI_035**	=	________
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DNP Binary Input Label Name	**BI_037**	=	________
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DNP Binary Input Label Name	**BI_047**	=	________
DNP Binary Input Label Name	**BI_048**	=	________
DNP Binary Input Label Name	**BI_049**	=	________
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DNP Binary Input Label Name	**BI_074**	= ___________
DNP Binary Input Label Name	**BI_075**	= ___________
DNP Binary Input Label Name	**BI_076**	= ___________
DNP Binary Input Label Name	**BI_077**	= ___________
DNP Binary Input Label Name	**BI_078**	= ___________
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DNP Binary Input Label Name	**BI_103**	=	______
DNP Binary Input Label Name	**BI_104**	=	______
DNP Binary Input Label Name	**BI_105**	=	______
DNP Binary Input Label Name	**BI_106**	=	______
DNP Binary Input Label Name	**BI_107**	=	______
DNP Binary Input Label Name	**BI_108**	=	______
DNP Binary Input Label Name	**BI_109**	=	______
DNP Binary Input Label Name	**BI_110**	=	______
DNP Binary Input Label Name	**BI_111**	=	______
DNP Binary Input Label Name	**BI_112**	=	______
DNP Binary Input Label Name	**BI_113**	=	______
DNP Binary Input Label Name	**BI_114**	=	______
DNP Binary Input Label Name	**BI_115**	=	______
DNP Binary Input Label Name	**BI_116**	=	______
DNP Binary Input Label Name	**BI_117**	=	______
DNP Binary Input Label Name	**BI_118**	=	______
DNP Binary Input Label Name	**BI_119**	=	______
DNP Binary Input Label Name	**BI_120**	=	______
DNP Binary Input Label Name	**BI_121**	=	______
DNP Binary Input Label Name	**BI_122**	=	______
DNP Binary Input Label Name	**BI_123**	=	______
DNP Binary Input Label Name	**BI_124**	=	______
DNP Binary Input Label Name	**BI_125**	=	______
DNP Binary Input Label Name	**BI_126**	=	______
DNP Binary Input Label Name	**BI_127**	=	______
DNP Binary Input Label Name	**BI_128**	=	______
DNP Binary Input Label Name	**BI_129**	=	______
DNP Binary Input Label Name	**BI_130**	=	______
DNP Binary Input Label Name	**BI_131**	=	______
DNP Binary Input Label Name	**BI_132**	=	______
DNP Binary Input Label Name	**BI_133**	=	______
DNP Binary Input Label Name	**BI_134**	=	______
DNP Binary Input Label Name	**BI_135**	=	______
DNP Binary Input Label Name	**BI_136**	=	______
DNP Binary Input Label Name	**BI_137**	=	______

DNP Binary Input Label Name	**BI_138**	= ________________
DNP Binary Input Label Name	**BI_139**	= ________________
DNP Binary Input Label Name	**BI_140**	= ________________
DNP Binary Input Label Name	**BI_141**	= ________________
DNP Binary Input Label Name	**BI_142**	= ________________
DNP Binary Input Label Name	**BI_143**	= ________________
DNP Binary Input Label Name	**BI_144**	= ________________
DNP Binary Input Label Name	**BI_145**	= ________________
DNP Binary Input Label Name	**BI_146**	= ________________
DNP Binary Input Label Name	**BI_147**	= ________________
DNP Binary Input Label Name	**BI_148**	= ________________
DNP Binary Input Label Name	**BI_149**	= ________________
DNP Binary Input Label Name	**BI_150**	= ________________
DNP Binary Input Label Name	**BI_151**	= ________________
DNP Binary Input Label Name	**BI_152**	= ________________
DNP Binary Input Label Name	**BI_153**	= ________________
DNP Binary Input Label Name	**BI_154**	= ________________
DNP Binary Input Label Name	**BI_155**	= ________________
DNP Binary Input Label Name	**BI_156**	= ________________
DNP Binary Input Label Name	**BI_157**	= ________________
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DNP Binary Input Label Name	**BI_166**	= ________________
DNP Binary Input Label Name	**BI_167**	= ________________
DNP Binary Input Label Name	**BI_168**	= ________________
DNP Binary Input Label Name	**BI_169**	= ________________
DNP Binary Input Label Name	**BI_170**	= ________________
DNP Binary Input Label Name	**BI_171**	= ________________
DNP Binary Input Label Name	**BI_172**	= ________________
DNP Binary Input Label Name	**BI_173**	= ________________
DNP Binary Input Label Name	**BI_174**	= ________________

DNP Binary Input Label Name	**BI_175**	= ________
DNP Binary Input Label Name	**BI_176**	= ________
DNP Binary Input Label Name	**BI_177**	= ________
DNP Binary Input Label Name	**BI_178**	= ________
DNP Binary Input Label Name	**BI_179**	= ________
DNP Binary Input Label Name	**BI_180**	= ________
DNP Binary Input Label Name	**BI_181**	= ________
DNP Binary Input Label Name	**BI_182**	= ________
DNP Binary Input Label Name	**BI_183**	= ________
DNP Binary Input Label Name	**BI_184**	= ________
DNP Binary Input Label Name	**BI_185**	= ________
DNP Binary Input Label Name	**BI_186**	= ________
DNP Binary Input Label Name	**BI_187**	= ________
DNP Binary Input Label Name	**BI_188**	= ________
DNP Binary Input Label Name	**BI_189**	= ________
DNP Binary Input Label Name	**BI_190**	= ________
DNP Binary Input Label Name	**BI_191**	= ________
DNP Binary Input Label Name	**BI_192**	= ________
DNP Binary Input Label Name	**BI_193**	= ________
DNP Binary Input Label Name	**BI_194**	= ________
DNP Binary Input Label Name	**BI_195**	= ________
DNP Binary Input Label Name	**BI_196**	= ________
DNP Binary Input Label Name	**BI_197**	= ________
DNP Binary Input Label Name	**BI_198**	= ________
DNP Binary Input Label Name	**BI_199**	= ________

Binary Output Map

DNP Binary Output Label Name	**BO_000**	= ________
DNP Binary Output Label Name	**BO_001**	= ________
DNP Binary Output Label Name	**BO_002**	= ________
DNP Binary Output Label Name	**BO_003**	= ________
DNP Binary Output Label Name	**BO_004**	= ________
DNP Binary Output Label Name	**BO_005**	= ________
DNP Binary Output Label Name	**BO_006**	= ________
DNP Binary Output Label Name	**BO_007**	= ________
DNP Binary Output Label Name	**BO_008**	= ________
DNP Binary Output Label Name	**BO_009**	= ________

DNP Binary Output Label Name	**BO_010**	=	______________
DNP Binary Output Label Name	**BO_011**	=	______________
DNP Binary Output Label Name	**BO_012**	=	______________
DNP Binary Output Label Name	**BO_013**	=	______________
DNP Binary Output Label Name	**BO_014**	=	______________
DNP Binary Output Label Name	**BO_015**	=	______________
DNP Binary Output Label Name	**BO_016**	=	______________
DNP Binary Output Label Name	**BO_017**	=	______________
DNP Binary Output Label Name	**BO_018**	=	______________
DNP Binary Output Label Name	**BO_019**	=	______________
DNP Binary Output Label Name	**BO_020**	=	______________
DNP Binary Output Label Name	**BO_021**	=	______________
DNP Binary Output Label Name	**BO_022**	=	______________
DNP Binary Output Label Name	**BO_023**	=	______________
DNP Binary Output Label Name	**BO_024**	=	______________
DNP Binary Output Label Name	**BO_025**	=	______________
DNP Binary Output Label Name	**BO_026**	=	______________
DNP Binary Output Label Name	**BO_027**	=	______________
DNP Binary Output Label Name	**BO_028**	=	______________
DNP Binary Output Label Name	**BO_029**	=	______________
DNP Binary Output Label Name	**BO_030**	=	______________
DNP Binary Output Label Name	**BO_031**	=	______________
DNP Binary Output Label Name	**BO_032**	=	______________

Analog Input Map

Entry format for Analog Inputs: Analog Label [: optional scaling factor 0.001–1000 : optional dead band 0–65535]. Enter NA to clear a setting.

DNP Analog Input Label Name	**AI_000**	=	______________
DNP Analog Input Label Name	**AI_001**	=	______________
DNP Analog Input Label Name	**AI_002**	=	______________
DNP Analog Input Label Name	**AI_003**	=	______________
DNP Analog Input Label Name	**AI_004**	=	______________
DNP Analog Input Label Name	**AI_005**	=	______________
DNP Analog Input Label Name	**AI_006**	=	______________
DNP Analog Input Label Name	**AI_007**	=	______________
DNP Analog Input Label Name	**AI_008**	=	______________
DNP Analog Input Label Name	**AI_009**	=	______________

DNP Analog Input Label Name	**AI_010**	= ____________
DNP Analog Input Label Name	**AI_011**	= ____________
DNP Analog Input Label Name	**AI_012**	= ____________
DNP Analog Input Label Name	**AI_013**	= ____________
DNP Analog Input Label Name	**AI_014**	= ____________
DNP Analog Input Label Name	**AI_015**	= ____________
DNP Analog Input Label Name	**AI_016**	= ____________
DNP Analog Input Label Name	**AI_017**	= ____________
DNP Analog Input Label Name	**AI_018**	= ____________
DNP Analog Input Label Name	**AI_019**	= ____________
DNP Analog Input Label Name	**AI_020**	= ____________
DNP Analog Input Label Name	**AI_021**	= ____________
DNP Analog Input Label Name	**AI_022**	= ____________
DNP Analog Input Label Name	**AI_023**	= ____________
DNP Analog Input Label Name	**AI_024**	= ____________
DNP Analog Input Label Name	**AI_025**	= ____________
DNP Analog Input Label Name	**AI_026**	= ____________
DNP Analog Input Label Name	**AI_027**	= ____________
DNP Analog Input Label Name	**AI_028**	= ____________
DNP Analog Input Label Name	**AI_029**	= ____________
DNP Analog Input Label Name	**AI_030**	= ____________
DNP Analog Input Label Name	**AI_031**	= ____________
DNP Analog Input Label Name	**AI_032**	= ____________
DNP Analog Input Label Name	**AI_033**	= ____________
DNP Analog Input Label Name	**AI_034**	= ____________
DNP Analog Input Label Name	**AI_035**	= ____________
DNP Analog Input Label Name	**AI_036**	= ____________
DNP Analog Input Label Name	**AI_037**	= ____________
DNP Analog Input Label Name	**AI_038**	= ____________
DNP Analog Input Label Name	**AI_039**	= ____________
DNP Analog Input Label Name	**AI_040**	= ____________
DNP Analog Input Label Name	**AI_041**	= ____________
DNP Analog Input Label Name	**AI_042**	= ____________
DNP Analog Input Label Name	**AI_043**	= ____________
DNP Analog Input Label Name	**AI_044**	= ____________
DNP Analog Input Label Name	**AI_045**	= ____________

DNP Analog Input Label Name	**AI_046**	= ______________
DNP Analog Input Label Name	**AI_047**	= ______________
DNP Analog Input Label Name	**AI_048**	= ______________
DNP Analog Input Label Name	**AI_049**	= ______________
DNP Analog Input Label Name	**AI_050**	= ______________
DNP Analog Input Label Name	**AI_051**	= ______________
DNP Analog Input Label Name	**AI_052**	= ______________
DNP Analog Input Label Name	**AI_053**	= ______________
DNP Analog Input Label Name	**AI_054**	= ______________
DNP Analog Input Label Name	**AI_055**	= ______________
DNP Analog Input Label Name	**AI_056**	= ______________
DNP Analog Input Label Name	**AI_057**	= ______________
DNP Analog Input Label Name	**AI_058**	= ______________
DNP Analog Input Label Name	**AI_059**	= ______________
DNP Analog Input Label Name	**AI_060**	= ______________
DNP Analog Input Label Name	**AI_061**	= ______________
DNP Analog Input Label Name	**AI_062**	= ______________
DNP Analog Input Label Name	**AI_063**	= ______________
DNP Analog Input Label Name	**AI_064**	= ______________
DNP Analog Input Label Name	**AI_065**	= ______________
DNP Analog Input Label Name	**AI_066**	= ______________
DNP Analog Input Label Name	**AI_067**	= ______________
DNP Analog Input Label Name	**AI_068**	= ______________
DNP Analog Input Label Name	**AI_069**	= ______________
DNP Analog Input Label Name	**AI_070**	= ______________
DNP Analog Input Label Name	**AI_071**	= ______________
DNP Analog Input Label Name	**AI_072**	= ______________
DNP Analog Input Label Name	**AI_073**	= ______________
DNP Analog Input Label Name	**AI_074**	= ______________
DNP Analog Input Label Name	**AI_075**	= ______________
DNP Analog Input Label Name	**AI_076**	= ______________
DNP Analog Input Label Name	**AI_077**	= ______________
DNP Analog Input Label Name	**AI_078**	= ______________
DNP Analog Input Label Name	**AI_079**	= ______________
DNP Analog Input Label Name	**AI_080**	= ______________
DNP Analog Input Label Name	**AI_081**	= ______________

DNP Analog Input Label Name	**AI_082**	=	______________
DNP Analog Input Label Name	**AI_083**	=	______________
DNP Analog Input Label Name	**AI_084**	=	______________
DNP Analog Input Label Name	**AI_085**	=	______________
DNP Analog Input Label Name	**AI_086**	=	______________
DNP Analog Input Label Name	**AI_087**	=	______________
DNP Analog Input Label Name	**AI_088**	=	______________
DNP Analog Input Label Name	**AI_089**	=	______________
DNP Analog Input Label Name	**AI_090**	=	______________
DNP Analog Input Label Name	**AI_091**	=	______________
DNP Analog Input Label Name	**AI_092**	=	______________
DNP Analog Input Label Name	**AI_093**	=	______________
DNP Analog Input Label Name	**AI_094**	=	______________
DNP Analog Input Label Name	**AI_095**	=	______________
DNP Analog Input Label Name	**AI_096**	=	______________
DNP Analog Input Label Name	**AI_097**	=	______________
DNP Analog Input Label Name	**AI_098**	=	______________
DNP Analog Input Label Name	**AI_099**	=	______________
DNP Analog Input Label Name	**AI_100**	=	______________
DNP Analog Input Label Name	**AI_101**	=	______________
DNP Analog Input Label Name	**AI_102**	=	______________
DNP Analog Input Label Name	**AI_103**	=	______________
DNP Analog Input Label Name	**AI_104**	=	______________
DNP Analog Input Label Name	**AI_105**	=	______________
DNP Analog Input Label Name	**AI_106**	=	______________
DNP Analog Input Label Name	**AI_107**	=	______________
DNP Analog Input Label Name	**AI_108**	=	______________
DNP Analog Input Label Name	**AI_109**	=	______________
DNP Analog Input Label Name	**AI_110**	=	______________
DNP Analog Input Label Name	**AI_111**	=	______________
DNP Analog Input Label Name	**AI_112**	=	______________
DNP Analog Input Label Name	**AI_113**	=	______________
DNP Analog Input Label Name	**AI_114**	=	______________
DNP Analog Input Label Name	**AI_115**	=	______________
DNP Analog Input Label Name	**AI_116**	=	______________
DNP Analog Input Label Name	**AI_117**	=	______________

DNP Analog Input Label Name	**AI_118**	= ____________
DNP Analog Input Label Name	**AI_119**	= ____________
DNP Analog Input Label Name	**AI_120**	= ____________
DNP Analog Input Label Name	**AI_121**	= ____________
DNP Analog Input Label Name	**AI_122**	= ____________
DNP Analog Input Label Name	**AI_123**	= ____________
DNP Analog Input Label Name	**AI_124**	= ____________
DNP Analog Input Label Name	**AI_125**	= ____________
DNP Analog Input Label Name	**AI_126**	= ____________
DNP Analog Input Label Name	**AI_127**	= ____________
DNP Analog Input Label Name	**AI_128**	= ____________
DNP Analog Input Label Name	**AI_129**	= ____________
DNP Analog Input Label Name	**AI_130**	= ____________
DNP Analog Input Label Name	**AI_131**	= ____________
DNP Analog Input Label Name	**AI_132**	= ____________
DNP Analog Input Label Name	**AI_133**	= ____________
DNP Analog Input Label Name	**AI_134**	= ____________
DNP Analog Input Label Name	**AI_135**	= ____________
DNP Analog Input Label Name	**AI_136**	= ____________
DNP Analog Input Label Name	**AI_137**	= ____________
DNP Analog Input Label Name	**AI_138**	= ____________
DNP Analog Input Label Name	**AI_139**	= ____________
DNP Analog Input Label Name	**AI_140**	= ____________
DNP Analog Input Label Name	**AI_141**	= ____________
DNP Analog Input Label Name	**AI_142**	= ____________
DNP Analog Input Label Name	**AI_143**	= ____________
DNP Analog Input Label Name	**AI_144**	= ____________
DNP Analog Input Label Name	**AI_145**	= ____________
DNP Analog Input Label Name	**AI_146**	= ____________
DNP Analog Input Label Name	**AI_147**	= ____________
DNP Analog Input Label Name	**AI_148**	= ____________
DNP Analog Input Label Name	**AI_149**	= ____________
DNP Analog Input Label Name	**AI_150**	= ____________
DNP Analog Input Label Name	**AI_151**	= ____________
DNP Analog Input Label Name	**AI_152**	= ____________
DNP Analog Input Label Name	**AI_153**	= ____________

DNP Analog Input Label Name	**AI_154**	= ____________
DNP Analog Input Label Name	**AI_155**	= ____________
DNP Analog Input Label Name	**AI_156**	= ____________
DNP Analog Input Label Name	**AI_157**	= ____________
DNP Analog Input Label Name	**AI_158**	= ____________
DNP Analog Input Label Name	**AI_159**	= ____________
DNP Analog Input Label Name	**AI_160**	= ____________
DNP Analog Input Label Name	**AI_161**	= ____________
DNP Analog Input Label Name	**AI_162**	= ____________
DNP Analog Input Label Name	**AI_163**	= ____________
DNP Analog Input Label Name	**AI_164**	= ____________
DNP Analog Input Label Name	**AI_165**	= ____________
DNP Analog Input Label Name	**AI_166**	= ____________
DNP Analog Input Label Name	**AI_167**	= ____________
DNP Analog Input Label Name	**AI_168**	= ____________
DNP Analog Input Label Name	**AI_169**	= ____________
DNP Analog Input Label Name	**AI_170**	= ____________
DNP Analog Input Label Name	**AI_171**	= ____________
DNP Analog Input Label Name	**AI_172**	= ____________
DNP Analog Input Label Name	**AI_173**	= ____________
DNP Analog Input Label Name	**AI_174**	= ____________
DNP Analog Input Label Name	**AI_175**	= ____________
DNP Analog Input Label Name	**AI_176**	= ____________
DNP Analog Input Label Name	**AI_177**	= ____________
DNP Analog Input Label Name	**AI_178**	= ____________
DNP Analog Input Label Name	**AI_179**	= ____________
DNP Analog Input Label Name	**AI_180**	= ____________
DNP Analog Input Label Name	**AI_181**	= ____________
DNP Analog Input Label Name	**AI_182**	= ____________
DNP Analog Input Label Name	**AI_183**	= ____________
DNP Analog Input Label Name	**AI_184**	= ____________
DNP Analog Input Label Name	**AI_185**	= ____________
DNP Analog Input Label Name	**AI_186**	= ____________
DNP Analog Input Label Name	**AI_187**	= ____________
DNP Analog Input Label Name	**AI_188**	= ____________
DNP Analog Input Label Name	**AI_189**	= ____________

DNP Analog Input Label Name	**AI_190**	= ____________
DNP Analog Input Label Name	**AI_191**	= ____________
DNP Analog Input Label Name	**AI_192**	= ____________
DNP Analog Input Label Name	**AI_193**	= ____________
DNP Analog Input Label Name	**AI_194**	= ____________
DNP Analog Input Label Name	**AI_195**	= ____________
DNP Analog Input Label Name	**AI_196**	= ____________
DNP Analog Input Label Name	**AI_197**	= ____________
DNP Analog Input Label Name	**AI_198**	= ____________
DNP Analog Input Label Name	**AI_199**	= ____________

Analog Output Map

DNP Analog Output Label Name	**AO_000**	= ____________
DNP Analog Output Label Name	**AO_001**	= ____________
DNP Analog Output Label Name	**AO_002**	= ____________
DNP Analog Output Label Name	**AO_003**	= ____________
DNP Analog Output Label Name	**AO_004**	= ____________
DNP Analog Output Label Name	**AO_005**	= ____________
DNP Analog Output Label Name	**AO_006**	= ____________
DNP Analog Output Label Name	**AO_007**	= ____________

Counter Map

DNP Counter Label Name	**CO_000**	= ____________
DNP Counter Label Name	**CO_001**	= ____________
DNP Counter Label Name	**CO_002**	= ____________
DNP Counter Label Name	**CO_003**	= ____________
DNP Counter Label Name	**CO_004**	= ____________
DNP Counter Label Name	**CO_005**	= ____________
DNP Counter Label Name	**CO_006**	= ____________
DNP Counter Label Name	**CO_007**	= ____________

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Appendix M
Fast SER Protocol

Overview

This appendix describes special binary Fast Sequential Events Recorder (SER) messages that are not included in *Section 10: Communications*. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary Fast SER messages from the SEL-311C Relay. Unsolicited Fast SER messages can be enabled on multiple serial and Ethernet ports simultaneously, as shown in *Table 10.6*.

SEL relays and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible 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 or SER data. To exploit this feature, the device connected to the other end of the link requires software that uses the separate data streams. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

Sequential Events Recorder (SER) Storage Considerations

The relay captures a record in the Sequential Events Recorder (SER) event report for any change of state in any one of the elements listed in the SER1, SER2, or SER3 trigger settings. Nonvolatile memory is used to store the latest 1024 rows of the SER event report so they can be retained during power loss. The nonvolatile memory is rated for a finite number of writes. Exceeding the limit can result in an EEPROM self-test failure. *An average of one state change every three minutes can be made for a 25-year relay service life*.

The Fast SER event buffer stores the most recent 512 events in volatile memory. If the relay loses power and event messages have not been sent, Fast SER will not send those messages upon power up. An enable message must be sent to the relay to begin the transmission of Fast SER messages.

Recommended Message Usage

Use the following sequence of commands to enable unsolicited binary Fast SER messaging in the SEL-311C:

1. On initial connection, send the **SNS** command (see *Appendix J: Configuration, Fast Meter, and Fast Operate Commands*) to retrieve and store the ASCII names for the digital I/O points assigned to trigger SER records.

   The order of the ASCII names matches the point indices in the unsolicited binary Fast SER messages. Send the "Enable Unsolicited Fast SER Data Transfer" message to enable the SEL-311C to transmit unsolicited binary Fast SER messages.

2. When SER records are triggered in the SEL-311C, the relay responds with an unsolicited binary Fast SER message. If this message has a valid checksum, it must be acknowledged by sending an acknowledge message with the same response number as contained in the original message. The relay will wait approximately 100 ms to 500 ms to receive an acknowledge message, at which time the relay will resend the same unsolicited Fast SER message with the same response number five times before suspending the message transmission. An enable message must be sent to the relay to begin sending the Fast SER messages again.

3. Upon receiving an acknowledge message with a matching response number, the relay increments the response number, and continues to send and seek acknowledgment for unsolicited Fast SER messages, if additional SER records are available. When the response number reaches three it wraps around to zero on the next increment.

Functions and Function Codes

In the messages shown below, all numbers are in hexadecimal, unless otherwise noted.

01—Function Code: Enable Unsolicited Fast SER Data Transfer, Sent From Master to Relay

Upon power-up, the SEL-311C disables its own unsolicited transmissions. This function enables the SEL-311C to begin sending unsolicited data to the device that sent the enable message, if the SEL-311C has such data to transfer. The message format for function code 01 is shown in *Table M.1*.

Table M.1 Function Code 01 Message Format (Sheet 1 of 2)

Data	Description
A546	Message header
12	Message length in bytes (18 decimal)
0000000000	Five bytes reserved for future use as a routing address
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
01	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)

Table M.1 Function Code 01 Message Format (Sheet 2 of 2)

Data	Description
XX	Response number (XX = 00, 01, 02, 03, 00, 01...).
18	Function to enable (18—unsolicited SER messages)
0000	Reserved for future use as function code data
nn	Maximum number of SER records per message, 01–20 hex
cccc	Two byte CRC-16 check code for message

The SEL-311C verifies the message by checking the header, length, function code, and enabled function code against the expected values. It also checks the entire message against the CRC-16 field. If any of the checks fail, except the function code or the function to enable, the message is ignored.

If an acknowledge is requested as indicated by the least significant bit of the status byte, the relay transmits an acknowledge message with the same response number received in the enable message.

The “nn” field is used to set the maximum number of SER records per message. The relay checks for SER records approximately every 500 ms. If there are new records available, the relay immediately creates a new unsolicited Fast SER message and transmits it. If there are more than “nn” new records available, or if the first and last record are separated by more than 16 seconds, the relay will break the transmission into multiple messages so that no message contains more than “nn” records, and the first and last record of each message are separated by no more than 16 seconds.

If the function to enable is not 18 or the function code is not recognized, the relay responds with an acknowledge message containing a response code 01 (function code unrecognized), and no functions are enabled. If the SER triggers are disabled (SER1, SER2, and SER3 are all set to NA), the unsolicited Fast SER messages are still enabled, but the only SER records generated are due to settings changes and power being applied to the relay. If the SER1, SER2, or SER3 settings are subsequently changed to any non-NA value and SER entries are triggered, unsolicited SER messages will be generated with the new SER records.

02—Function Code: Disable Unsolicited Fast SER Data Transfer, Sent From Master to Relay

This function disables the SEL-311C from transferring unsolicited data. The message format for function code 02 is shown in *Table M.2*.

Table M.2 Function Code 02 Message Format

Data	Description
A546	Message header
10	Message length (16 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
02	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
18	Function to disable (18 = Unsolicited SER)
00	Reserved for future use as function code data
cccc	Two byte CRC-16 check code for message

The SEL-311C verifies the message by checking the header, length, function code, and disabled function code against the expected values, and checks the entire message against the CRC-16 field. If any of the checks fail, except the function code or the function to disable, the message is ignored.

If an acknowledge is requested as indicated by the least significant bit of the status byte, the relay transmits an acknowledge message with the same response number received in the enable message.

If the function to disable is not 18 or the function code is not recognized, the relay responds with an acknowledge message containing the response code 01 (function code unrecognized) and no functions are disabled.

18—Function: Unsolicited Fast SER Response, Sent From Relay to Master

The function 18 is used for the transmission of unsolicited Fast Sequential Events Recorder (SER) data from the SEL-311C. This function code is also passed as data in the “Enable Unsolicited Data Transfer” and the “Disable Unsolicited Data Transfer” messages to indicate which type of unsolicited data should be enabled or disabled. The message format for function code 18 is shown in *Table M.3*.

Table M.3 Function Code 18 Message Format (Sheet 1 of 2)

Data	Description
A546	Message header
ZZ	Message length (Up to 34 + 4 • *nn* decimal, where *nn* is the maximum number of SER records allowed per message as indicated in the “Enable Unsolicited Data Transfer” message.)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status Byte (01 = need acknowledgment; 03 = settings changed and need acknowledgment. If YY=03, the master should re-read the SNS data because the element index list may have changed.)
18	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
00000000	Four bytes reserved for future use as a return routing address.
dddd	Two-byte day of year (1–366)
yyyy	Two-byte, four-digit year (e.g., 2009 or 07D9 hex)
mmmmmmmm	Four-byte time of day in milliseconds since midnight
XX	1st element index (match with the response to the SNS command; 00 for 1st element, 01 for second element, and so on)
uuuuuu	Three-byte time tag offset of 1st element in microseconds since time indicated in the time of day field.
XX	2nd element index
uuuuuu	Three-byte time tag offset of 2nd element in microseconds since time indicated in the time of day field.
• • •	
xx	last element index
uuuuuu	Three-byte time tag offset of last element in microseconds since time indicated in the time of day field.
FFFFFFFE	Four-byte end-of-records flag

Table M.3 Function Code 18 Message Format (Sheet 2 of 2)

Data	Description
ssssssss	Packed four-byte element status for up to 32 elements (LSB for the 1st element)
cccc	Two-byte CRC-16 checkcode for message

If the relay determines that SER records have been lost, it sends a message with the following format:

Table M.4 Message Format for Lost SER Records

Data	Description
A546	Message header
22	Message length (34 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status Byte (01 = need acknowledgment; 03 = settings changed and need acknowledgment)
18	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 00, 01, ...)
00000000	Four bytes reserved for future use as a return routing address.
dddd	Two-byte day of year (1–366) of overflow message generation
yyyy	Two-byte, four-digit year (e.g., 2009 or 07D9 hex) of overflow message generation.
mmmmmmmm	Four-byte time of day in milliseconds since midnight
FFFFFFFE	Four-byte end-of-records flag
00000000	Element status (unused)
cccc	Two byte CRC-16 checkcode for message

Acknowledge Message Sent from Master to Relay, and From Relay to Master

The acknowledge message is constructed and transmitted for every received message that contains a status byte with the LSB set (except another acknowledge message), and that passes all other checks, including the CRC. The acknowledge message format is shown in *Table M.5*.

Table M.5 Acknowledge Message Format

Data	Description
A546	Message header
0E	Message length (14 decimal)
0000000000	Five bytes reserved for future use as a routing address.
00	Status byte (always 00)
XX	Function code, echo of acknowledged function code with MSB set.
RR	Response code (see below)
XX	Response number (XX = 00, 01, 02, 03, 00, 01, ...) must match response number from message being acknowledged.)
cccc	Two byte CRC-16 checkcode for message

The SEL-311C supports the response codes in *Table M.6*.

Table M.6 Supported Response Codes

RR	Response
00	Success.
01	Function code not recognized.

Examples

1. Successful acknowledge for “Enable Unsolicited Fast SER Data Transfer” message from a relay with at least one of SER1, SER2, or SER3 not set to NA:

   A5 46 0E 00 00 00 00 00 00 81 00 XX cc cc (XX is the same as the Response Number in the “Enable Unsolicited Data Transfer” message to which it responds)

2. Unsuccessful acknowledge for “Enable Unsolicited Fast SER Data Transfer” message from a relay with all of SER1, SER2, and SER3 set to NA:

   A5 46 0E 00 00 00 00 00 00 81 02 XX cc cc (XX is the same as the response number in the “Enable Unsolicited Data Transfer” message to which it responds.)

3. Disable Unsolicited Fast SER Data Transfer message, acknowledge requested:

   A5 46 10 00 00 00 00 00 01 02 C0 XX 18 00 cc cc (XX = 0, 1, 2, 3)

4. Successful acknowledge from the relay for the “Disable Unsolicited Fast SER Data Transfer” message:

   A5 46 0E 00 00 00 00 00 00 82 00 XX cc cc (XX is the same as the response number in the “Disable Unsolicited Fast SER Data Transfer” message to which it responds.)

5. Successful acknowledge message from the master for an unsolicited Fast SER message:

   A5 46 0E 00 00 00 00 00 00 98 00 XX cccc (XX is the same as the response number in the unsolicited Fast SER message to which it responds.)

Additional Details

1. Once the relay receives an acknowledge with response code 00 from the master, it will clear the settings changed bit (bit 1) in its status byte, if that bit is asserted, and it will clear the settings changed bit in Fast Meter, if that bit is asserted.

2. An element index of FE indicates that the SER record was caused by power up. An element index of FF indicates that the SER record was caused by a setting change. An element index of FD indicates that the element identified in this SER record is no longer in the SER trigger settings. There are other non-Relay Word bits that appear in the SER that are not transmitted in a Fast SER message. These are shown in *Table 12.5*.

3. When the relay sends an SER message packet, it will put a sequential number (0, 1, 2, 3, 0, 1, ...) into the response number. If the relay does not receive an acknowledge from the master

before approximately 500 ms, the relay will resend the same message packet up to five times with the same response number until it receives an acknowledge message with that response number. For the next SER message, the relay will increment the response number (it will wrap around to zero from three).

4. A single Fast SER message packet from the relay can have a maximum number of 32 records and the data may span a time period of no more than 16 seconds. The master can limit the number of records in a packet with the third byte of function code data in the “Enable Unsolicited Data Transfer” message (function code 01). The relay can generate an SER packet with fewer than the requested number of records, if the record time stamps span more than 16 seconds.
5. The relay always requests acknowledgment in unsolicited Fast SER messages (LSB of the status byte is set).

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Appendix N
Synchrophasors

Overview

The SEL-311C provides Phasor Measurement Unit (PMU) capabilities when connected to a suitable IRIG-B time source. Synchrophasor is used as a general term that can refer to data or protocol.

This section covers the following topics:

See *IRIG-B Time-Code Input on page 2.16* for the requirements of the IRIG-B time source. Synchrophasors are still measured if the high-accuracy time source is not connected, however, the data is not time-synchronized to any external reference, as indicated by Relay Word bits TSOK = logical 0 and PMDOK = logical 0.

Introduction

The word synchrophasor is derived from two words: synchronized and phasor. Synchrophasor measurement refers to the concept of providing measurements taken on a synchronized schedule in multiple locations. A high-accuracy clock, commonly a Global Positioning System (GPS) receiver such as the SEL-2407® Satellite-Synchronized Clock, makes synchrophasor measurement possible.

The availability of an accurate time reference over a large geographic area allows multiple devices, such as a number of SEL-311C relays, to synchronize the gathering of power system data. The accurate clock allows precise event report triggering and other off-line analysis functions.

The SEL-311C Global settings contain the synchrophasor settings, including the choice of synchrophasor protocol and the synchrophasor data set the relay will transmit. The Port settings select which serial port(s) are reserved for synchrophasor protocol use and enables synchrophasors on Ethernet ports. See *Settings for IEEE C37.118 Protocol Synchrophasors on page N.5*.

The SEL-311C generates time status Relay Word bits and time-quality information that is important for synchrophasor measurement. Some protection SELOGIC® variables and programmable digital trigger information (C37.118 protocol only) are also added to the Relay Word bits for synchrophasors—see *Synchrophasor Relay Word Bits on page N.14*.

The value of synchrophasor data increases greatly when the data can be shared over a communications network in real time. Two synchrophasor protocols are available in the SEL-311C that allow for a centralized device to collect data efficiently from several phasor measurement units (PMUs). Some possible uses of a system-wide synchrophasor system include the following:

- Power-system state measurement
- Wide-area network protection and control schemes
- Small-signal analysis
- Power-system disturbance analysis

In any installation, the SEL-311C can use only one of the synchrophasor protocols, SEL Fast Message Synchrophasor, or C37.118, as selected by Global setting MFRMT. When MFRMT = FM, SEL Fast Message synchrophasor data is available on multiple serial ports when the port setting PROTO = SEL. When MFRMT = C37.118, IEEE C37.118 compliant synchrophasor data is available on multiple serial ports when the port setting PROTO = PMU and on Ethernet Ports when port setting EPMIP = Y. Use either the SEL or C37.118 protocol to create control schemes by making port setting FASTOP = Y.

You can view synchrophasor data over a serial port set to PROTO = SEL, see *View Synchrophasors by Using the MET PM Command on page N.15*.

SEL Fast Message synchrophasor protocol is able to share the same physical port with separate data streams (see *Overview on page J.1*).

Synchrophasor Measurement

NOTE: The synchrophasor data stream is separate from the other protection and metering functions.

The phasor measurement unit in the SEL-311C measures four voltages and four currents on a constant-time basis. These samples are synchronized to the high-accuracy IRIG-B time source, and occur at a fixed frequency of either 60 Hz or 50 Hz, depending on Global setting NFREQ. The relay then filters the measured samples according to Global setting PMAPP = F or N—see *PMAPP on page N.7*. The phase angle is measured relative to an absolute reference, which is represented by a cosine function in *Figure N.1*. The time-of-day is shown for the two time marks.

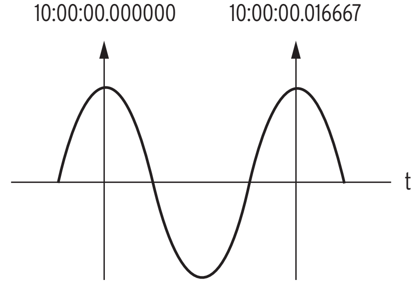

Figure N.1 High-Accuracy Clock Controls Reference Signal (60 Hz System)

The instrument transformers (PTs or CTs) and the interconnecting cables may introduce a time shift in the measured signal. Global settings VPCOMP, VSCOMP, IPCOMP, and INCOMP, entered in degrees, are added to the measured phasor angles to create the corrected phasor angles, as shown in *Figure N.2*. The VPCOMP, VSCOMP, IPCOMP, and INCOMP settings may be positive or negative values. The corrected angles are displayed in the **MET PM** command and transmitted as part of synchrophasor messages.

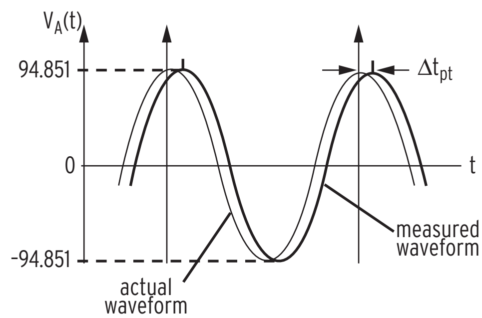

Figure N.2 Waveform at Relay Terminals May Have Phase Shift

$$\text{Compensation Angle} = \frac{\Delta t_{pt}}{\left(\frac{1}{\text{freq}}\right)} \cdot 360^\circ = \Delta t_{pt} \cdot \text{freq} \cdot 360^\circ$$

Equation N.1

If the time shift on the pt measurement path Δt_{pt} = 0.784 ms and the nominal frequency, $freq_{nominal}$ = 60Hz, use *Equation N.2* to obtain the correction angle:

$$0.784 \cdot 10^{-3}\text{s} \cdot 60\text{s}^{-1} \cdot 360^\circ = 16.934^\circ$$

Equation N.2

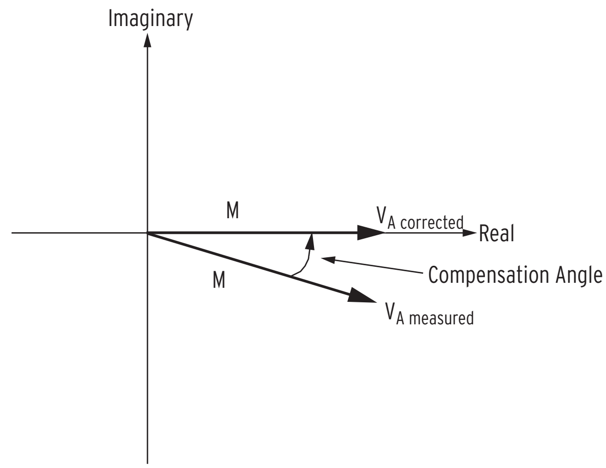

Figure N.3 Correction of Measured Phase Angle

For a sinusoidal signal, the phasor magnitude is calculated as shown in *Equation N.3*. The phasors are rms values scaled in primary units, as determined by Group settings PTR, PTRS, CTR, and CTRN. The SEL-311C then calculates the positive-sequence voltage and currents.

$$\text{Magnitude M} = \frac{V_{pk}}{\sqrt{2}} \bullet PTR_{setting}$$ **Equation N.3**

With PTR = 2000, and the signal in *Figure N.2* (with peak voltage V_{pk} = 94.851 V), use *Equation N.4* to obtain the magnitude, VA_MAG:

$$\begin{aligned} \text{VA\_MAG} &= \frac{94.851}{\sqrt{2}} \bullet 2000 \\ &= 134140\ \text{V} \\ &= 134.140\ \text{kV} \end{aligned}$$ **Equation N.4**

Finally, the magnitude and angle pair for each synchrophasor is converted to a real and imaginary pair using *Equation N.5* and *Equation N.6*. For example, analog quantities VA_MAG and VA_ANG are converted to VA_REAL and VA_IMG. An example phasor with an angle measurement of 104.400° is shown in *Figure N.4*.

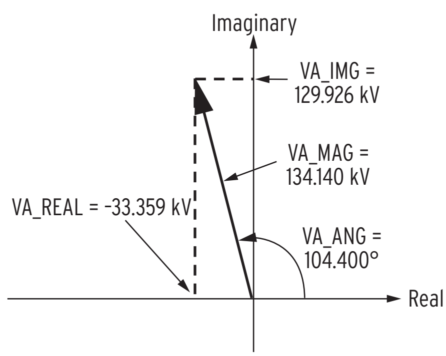

Figure N.4 Example Calculation of Real and Imaginary Components of Synchrophasor

$$\text{Real part} = M \bullet \cos(\text{angle})$$ **Equation N.5**

$$\text{Imaginary part} = M \bullet \sin(\text{angle}) \qquad \textbf{Equation N.6}$$

Using the magnitude M from *Equation N.5*, the real part is given in *Equation N.7*.

$$\begin{aligned} \text{VA\_REAL} &= 134.140\text{ kV} \bullet \cos 104.400° \\ &= -33.359\text{ kV} \end{aligned} \qquad \textbf{Equation N.7}$$

Similarly, the imaginary part is calculated in *Equation N.8*

$$\begin{aligned} \text{VA\_IMG} &= 134.140\text{ kV} \bullet \sin 104.400° \\ &= 129.926\text{ kV} \end{aligned} \qquad \textbf{Equation N.8}$$

Because the sampling reference is based on the GPS clock (IRIG-B signal) and not synchronized to the power system, an examination of successive synchrophasor data sets will almost always show some angular change between samples of the same signal. This is not a malfunction of the relay or the power system, but is merely a result of viewing data from one system with an instrument with an independent time base. In other words, a power system has a nominal frequency of either 50 or 60 Hz, but on closer examination, it is usually running a little faster or slower than nominal.

Settings for IEEE C37.118 Protocol Synchrophasors

NOTE: IEEE C37.118 protocol is recommended for all new applications.

The phasor measurement unit (PMU) settings are listed in *Table N.1*. Make these settings when you want to use the C37.118 synchrophasor protocol.

The Global enable setting EPMU must be set to Y before the remaining SEL-311C synchrophasor settings are available. No synchrophasor data collection can take place when EPMU = N.

You must make the port settings in *Table N.4* or *Table N.5* to transmit data with synchrophasor protocol. It is possible to set EPMU = Y without using any ports for synchrophasor protocols. For example, the serial port **MET PM** ASCII command can still be used.

The Global settings for the SEL Fast Message synchrophasor protocol are a subset of the *Table N.1* settings, and are listed separately (see *SEL Fast Message Synchrophasor Protocol on page N.19*).

Table N.1 PMU Settings in the SEL-311C (Global Settings) (Sheet 1 of 2)

Global Settings	Description	Default
EPMU	Enable Synchronized Phasor Measurement (Y, N)	N[a]
MFRMT	Message Format (C37.118, FM)[b]	C37.118
MRATE	Messages per Second {1, 2, 5, 10, 25, or 50 when NFREQ = 50} {1, 2, 4, 5, 10, 12, 15, 20, 30, or 60 when NFREQ = 60}	2
PMAPP	PMU Application (F = Fast Response, N = Narrow Bandwidth)	N
PHCOMP	Frequency-Based Phasor Compensation (Y, N)	Y
PMSTN	Station Name (16 characters)	STATION A
PMID	PMU Hardware ID (1–65534)	1
PHDATAV	Phasor Data Set, Voltages (V1, PH, ALL, NA)	V1

Table N.1 PMU Settings in the SEL-311C (Global Settings) (Sheet 2 of 2)

Global Settings	Description	Default
VPCOMP	Phase Voltage Angle Compensation Factor (–179.99 to 180 degrees)	0.00
VSCOMP	VS Voltage Angle Compensation Factor (–179.99 to 180 degrees)	0.00
PHDATAI	Phasor Data Set, Currents (I1, PH, ALL, NA)	NA
IPCOMP	Phase Current Angle Compensation Factor (–179.99 to 180 degrees)	0.00
INCOMP	Neutral Current Angle Compensation Factor (–179.99 to 180 degrees)	0.00
PHNR[c]	Phasor Numeric Representation (I = Integer, F = Floating point)	I
PHFMT[c]	Phasor Format (R = Rectangular coordinates, P = Polar coordinates)	R
FNR	Frequency Numeric Representation (I = Integer, F = Float)	I
NUMDSW	Number of 16-bit Digital Status Words (0, 1)	1

[a] Set EPMU = Y to access the remaining settings
[b] C37.118 = IEEE C37.118 Standard; FM = SEL Fast Message—see Table N.18.
[c] Setting hidden when PHDATAV = NA and PHDATAI = NA or MFRMT = FM.

Table N.2 PMU Settings in the SEL-311C (Logic Settings)

Logic Settings	Description	Default
TREA1	Trigger Reason Bit 1 (SELOGIC Equation)	0
TREA2	Trigger Reason Bit 2 (SELOGIC Equation)	0
TREA3	Trigger Reason Bit 3 (SELOGIC Equation)	0
TREA4	Trigger Reason Bit 4 (SELOGIC Equation)	0
PMTRIG	Trigger (SELOGIC Equation)	0

Descriptions of Synchrophasor Settings

Definitions for the settings in *Table N.1* are as follows.

MFRMT

Selects the message format for synchrophasor data streaming on serial ports.

SEL recommends the use of MFRMT = C37.118 for any new PMU applications because of increased setting flexibility and the availability of software and hardware for synchrophasor concentration, processing, and control. The SEL-311C includes the MFRMT = FM setting choice to maintain compatibility in any systems presently using SEL Fast Message synchrophasors.

MRATE

Selects the message rate in messages per second for synchrophasor data streaming on serial ports.

Choose the MRATE setting that suits the needs of your PMU application. This setting is one of six settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth for C37.118 Protocol on page N.13* for detailed information.

PMAPP

Selects the type of digital filters used in the synchrophasor algorithm:

- The Narrow Bandwidth setting (N) represents filters with a cutoff frequency approximately ¼ of MRATE. The response in the frequency domain is narrower, and response in the time domain is slower. This method results in synchrophasor data that are free of aliasing signals and well suited for post-disturbance analysis.
- The Fast Response setting (F) represents filters with a higher cutoff frequency. The response in frequency domain is wider and the response in the time domain is faster. This method results in synchrophasor data that can be used in synchrophasor applications requiring more speed in tracking system parameters.

PHCOMP

Enables or disables frequency-based compensation for synchrophasors.

For most applications, set PHCOMP = Y to activate the algorithm that compensates for the magnitude and angle errors of synchrophasors for frequencies that are off nominal. Use PHCOMP = N if you are concentrating the SEL-311C synchrophasor data with other PMU data that do not employ frequency compensation.

PMSTN and PMID

Defines the name and number of the PMU.

NOTE: The PMSTN setting is not the same as the SEL-311C Group setting TID (Terminal Identifier), even though they share the same factory default value.

The PMSTN setting is an ASCII string with as many as 16 characters. The PMID setting is a numeric value. Use your utility or synchrophasor data concentrator naming convention to determine these settings.

PHDATAV, VPCOMP, and VSCOMP

PHDATAV selects which voltage synchrophasors to include in the data packet. Consider the burden on your synchrophasor processor and offline storage requirements when deciding how much data to transmit. This setting is one of six settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size—see *Communications Bandwidth for C37.118 Protocol on page N.13* for detailed information.

- PHDATAV = V1 will transmit only positive-sequence voltage, V_1
- PHDATAV = PH will transmit VA, VB, and VC when PTCONN = WYE
- PHDATAV = PH will transmit VAB, VBC, and VCA when PTCONN = DELTA
- PHDATAV = ALL will transmit V1, VA, VB, VC, and VS when PTCONN = WYE
- PHDATAV = ALL will transmit V1, VAB, VBC, VCA, and VS when PTCONN = DELTA
- PHDATAV = NA will not transmit any voltages

Table N.3 describes the order of synchrophasors inside the data packet.

The VPCOMP and VSCOMP settings allow correction for any steady-state voltage phase errors (from the potential transformers or wiring characteristics). VPCOMP corrects the VA, VB, VC, and V1 voltages for phase angle error. VSCOMP corrects the VS voltage for phase angle error. See *Synchrophasor Measurement on page N.2* for details on this setting.

PHDATAI, IPCOMP, and INCOMP

PHDATAI selects which current synchrophasors to include in the data packet. Consider the burden on your synchrophasor processor and offline storage requirements when deciding how much data to transmit. This setting is one of six settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size—see *Communications Bandwidth for C37.118 Protocol on page N.13* for detailed information.

- PHDATAI = I1 will transmit only positive-sequence current, I_1
- PHDATAI = PH will transmit IA, IB, and IC
- PHDATAI = ALL will transmit I_1, I_A, I_B, I_C, and I_N
- PHDATAI = NA will not transmit any currents

The IPCOMP and INCOMP settings allow correction for any steady-state phase errors (from the current transformers or wiring characteristics). See *Synchrophasor Measurement on page N.2* for details on these settings.

Table N.3 describes the order of synchrophasors inside the data packet. Synchrophasors are transmitted in the order indicated from the top to the bottom of the table. When PHFMT = R, real values are transmitted first and imaginary values are transmitted second. When PHFMT = P, magnitude values are transmitted first and angle values are transmitted second. Synchrophasors are only transmitted if specified to be included by the PHDATAV and PHDATAI settings. For example, if PHDATAV = ALL and PHDATAI = I1, phase voltages will be transmitted first, followed by VS input voltage, positive-sequence voltage, and positive-sequence current.

Table N.3 Synchrophasor Order in Data Stream (Voltages and Currents)

Synchrophasors[a]	Scaling[b]
Phase A Current	CTR
Phase B Current	CTR
Phase C Current	CTR
Neutral Current	CTRN
Phase A or AB Voltage[c]	PTR
Phase B or BC Voltage[c]	PTR
Phase C or CA Voltage[c]	PTR
VS Input Voltage	PTRS
Positive Sequence Voltage	PTR
Positive Sequence Current	CTR

[a] Synchrophasors are included in the order shown (for example phase currents, if selected, will always precede phase voltage).
[b] Synchrophasors are transmitted as primary values. Relay settings CTR, CTRN, PTR, PTRS are used to scale the values as shown.
[c] When PHDATAV = PH or ALL and PTCONN = WYE, phase voltages VA, VB, and VC are transmitted. Phase voltages VAB, VBC, and VCA are transmitted when PTCONN = DELTA.

PHNR

Selects the numeric representation of voltage and current phasor data in the synchrophasor data stream.

This setting is one of six settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size—see *Communications Bandwidth for C37.118 Protocol on page N.13* for detailed information.

The choices for this setting depend on synchrophasor processor requirements.

Setting PHNR = I sends each voltage and/or current synchrophasor as 2 two-byte integer values.

Setting PHNR = F sends each voltage and/or current synchrophasor as 2 four-byte floating-point values.

PHFMT

Selects the phasor representation of voltage and current phasor data in the synchrophasor data stream.

The choices for this setting depend on synchrophasor processor requirements.

Setting PHFMT = R (rectangular) sends each voltage or current synchrophasor as a pair of signed real and imaginary values.

Setting PHFMT = P (polar) sends each voltage or current synchrophasor as a magnitude and angle pair. The angle is in radians when PHNR = F, and in radians • 10^4 when PHNR = I. The range is as follows:

$$-\pi < \text{angle} \leq \pi.$$

In both the rectangular and polar representations, the values are scaled in rms (root mean square) units. For example, a synchrophasor with a magnitude of 1.0 at an angle of –30 degrees will have a real component of 0.866, and an imaginary component of –0.500. See *Synchrophasor Measurement on page N.2* for an example of conversion between polar and rectangular coordinates.

FNR

Selects the numeric representation of the two frequency values in the synchrophasor data stream.

This setting is one of six settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size—see *Communications Bandwidth for C37.118 Protocol on page N.13* for detailed information.

The choices for this setting depend on synchrophasor processor requirements.

Setting FNR = I sends the frequency data as a difference from nominal frequency, NFREQ, with the following formula:

$$(FREQ_{measured} - NFREQ) \cdot 1000,$$

represented as a signed, two-byte value.

Setting FNR = I also sends the rate-of-change of frequency data with scaling.

$$DFDT_{measured} \cdot 100,$$

represented as a signed, two-byte value.

Setting FNR = F sends the measured frequency data and rate-of-change-of-frequency as two four-byte, floating point values.

NUMDSW

Selects the number of user-definable digital status words to be included in the synchrophasor data stream.

This setting is one of six settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size—see *Communications Bandwidth for C37.118 Protocol on page N.13* for detailed information.

The choices for this setting depend on the synchrophasor system design. The inclusion of digital data can help indicate breaker status or other operational data to the synchrophasor processor. For example, since VS channel synchrophasors are IEEE C37.118 Level 1 compliant only when the frequency is the same as the Phase A voltage, it may be desirable to monitor breaker position to indicate when there might be a frequency difference. See *IEEE C37.118 PMU Setting Example on page N.16* for a suggested use of the digital status word fields.

Setting NUMDSW = 0 sends no user-definable digital status words.

Setting NUMDSW = 1 sends the user-definable digital status words containing Relay Word bits SV1 through SV16.

The digital status words are sent after positive-sequence current in the synchrophasor data packet starting with SV1 and continuing through SV16.

TREA1, TREA2, TREA3, TREA4, and PMTRIG

Defines the programmable trigger bits as allowed by IEEE C37.118.

NOTE: The PM Trigger function is not associated with the SEL-311C Event Report Trigger ER, a SELOGIC control equation in Logic settings.

Each of the four Trigger Reason settings, TREA1–TREA4, and the PMU Trigger setting, PMTRIG, are SELOGIC control equations in Logic settings. The SEL-311C evaluates these equations and places the results in Relay Word bits with the same names: TREA1–TREA4, and PMTRIG.

The trigger reason equations represent the Trigger Reason bits in the STAT field of the data packet. After the trigger reason bits are set to convey a message, the PMTRIG Equation should be asserted for a reasonable amount of time, to allow the synchrophasor processor to read the TREA1–TREA4 fields.

The IEEE C37.118 standard defines the first eight of 16 binary combinations of these trigger reason bits (bits 0–3). The remaining eight binary combinations are available for user definition.

The SEL-311C does not automatically set the TREA1–TREA4 or PMTRIG Relay Word bits—these bits must be programmed even for the eight combinations defined by IEE C37.118.

These bits may be used to send various messages at a low bandwidth via the synchrophasor message stream. Digital Status Words may also be used to send binary information directly, without the need to manage the coding of the trigger reason messages in SELOGIC.

Use these Trigger Reason bits if your synchrophasor system design requires these bits. The SEL-311C synchrophasor processing and protocol transmission are not affected by the status of these bits.

Serial Port Settings for IEEE C37.118 Synchrophasors

IEEE C37.118 compliant synchrophasors are available via serial or Ethernet port. The associated serial port settings are shown in *Table N.4*.

Table N.4 SEL-311C Serial Port Settings for Synchrophasors

Setting	Description	Default
EPORT	Enable Port (Y, N)	Y[a]
MAXACC	Maximum Access Level (1, B, 2)	2
PROTO	Protocol (SEL, LMD, DNP, MOD, MBA, MBB, MB8A, MB8B, PMU)[b]	SEL[c]
SPEED	Data Speed (300 to 57600)	9600
STOPBIT	Stop Bits (1, 2)	1
RTSCTS	Enable Hardware Handshaking (Y, N)	N
FASTOP	Fast Operate Enable (Y, N)[d]	N

[a] Set EPORT = Y to access the remaining settings.
[b] Some of the other PROTO setting choices may not be available.
[c] Set PROTO = PMU to enable C37.118 synchrophasor protocol on this port.
[d] See Synchrophasor Protocols and SEL Fast Operate Commands on page N.27.

The serial port settings for PROTO = PMU, shown in *Table N.4*, do not include the settings BITS and PARITY; these two settings are internally fixed as BITS = 8, PARITY = N.

Serial port setting PROTO cannot be set to PMU (see *Table N.4*) when Global setting EPMU = N. Synchrophasors must be enabled (EPMU = Y) before PROTO can be set to PMU. If the PROTO setting for any serial port is PMU, EMPU cannot be set to N.

If you use a computer terminal session or ACSELERATOR QuickSet® SEL-5030 software connected to a serial port, and then set that same serial port PROTO setting to PMU, you will lose the ability to communicate with the relay through ASCII commands. If this happens, either connect via another serial port (that has PROTO = SEL) or use the front-panel HMI SET/SHOW screen to change the port PROTO setting back to SEL.

Ethernet Port Settings for IEEE C37.118 Synchrophasors

IEEE C37.118 compliant synchrophasors are available via serial or Ethernet port. The associated Ethernet port settings are shown in *Table N.5*.

Two PMU Ethernet Output sessions are available, except when IEC 61850 is enabled. When Port 5 setting E61850 = Y, only one PMU Ethernet output can be used.

Table N.5 SEL-311C Ethernet Port Settings for Synchrophasors

Setting	Description	Default
EPMIP[a]	Enable PMU Processing (Y,N)	N[b]
PMOTS1	PMU Output 1 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U)	OFF
PMOIPA1	PMU Output 1 Client IP (Remote) Address (www.xxx.yyy.zzz)	192.168.1.3
PMOTCP1	PMU Output 1TCP/IP (Local) Port Number (1–65534)	4712
PMOUDP1	PMU Output 1 UDP/IP Data (Remote) Port Number (1–65534)	4713
PMOTS2[c]	PMU Output 2 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U)	OFF
PMOIPA2[c]	PMU Output 2 Client IP (Remote) Address (www.xxx.yyy.zzz)	192.168.1.4
PMOTCP2[c]	PMU Output 2 TCP/IP (Local) Port Number (1–65534)	4722
PMOUDP2[c]	PMU Output 2 UDP/IP Data (Remote) Port Number (1–65534)	4713

[a] Setting is hidden when EPMU = N or when EPMU = Y and MFRMT = FM.
[b] Set EPMIP = Y to access other settings and to enable IEEE C37.118 protocol synchrophasors on this port. Setting EPMIP is not available when Global setting EPMU is set to N. EPMU cannot be set to N if EPMIP=Y on any Ethernet port.
[c] PMU Output 2 settings are not available when IEC 61850 functions are enabled.

Ethernet port setting EPMIR cannot be set to Y (see *Table N.5*) when Global setting EPMU = N or when EPMU = Y and MFRMT = FM. Synchrophasors must be enabled (EPMU = Y) before EPMIP can be set to Y. If EPMIP = Y for any Ethernet port, EPMU cannot be set to N.

C37.118 Synchrophasor Protocol

The SEL-311C complies with *IEEE C37.118, Standard for Synchrophasors for Power Systems*, when Global setting MFRMT = C37.118.

The protocol is available on serial ports 1, 2, 3, and F by setting the corresponding Port setting PROTO = PMU. The protocol is available on any Ethernet port when EPMIP = Y.

This subsection does not cover the details of the protocol, but highlights some of the important features and options that are available.

Settings Affect Message Contents

The SEL-311C allows several options for transmitting synchrophasor data. These are controlled by Global settings described in *Settings for IEEE C37.118 Protocol Synchrophasors on page N.5*. You can select how often to transmit the synchrophasor messages (MRATE), which synchrophasors to transmit (PHDATAV and PHDATAI), which numeric representation to use (PHNR), and which coordinate system to use (PHFMT).

The SEL-311C automatically includes the frequency and rate-of-change-of-frequency in the synchrophasor messages. Global setting FNR selects the numeric format to use for these two quantities.

The relay can include 16 digital status values, as controlled by Global setting NUMDSW.

The SEL-311C always includes the results of four synchrophasor trigger reason SELOGIC equations TREA1, TREA2, TREA3, and TREA4, and the trigger SELOGIC equation result PMTRIG, in the synchrophasor message.

Communications Bandwidth for C37.118 Protocol

A phasor measurement unit (PMU) that is configured to transmit a single synchrophasor (positive-sequence voltage, for example) at a message rate of once per second places little burden on the communications channel. As more synchrophasors or digital status words are added, or if the message rate is increased, some communications channel restrictions come into play.

If the SPEED setting on any serial port set with PROTO = PMU is insufficient for the PMU Global settings, the SEL-311C or SEL-5030 software will display an error message and fail to save settings until the error is corrected.

NOTE: There are no limitations placed on the number of bytes in the synchrophasor message and the message rate if only the Ethernet port is enabled for synchrophasors.

The C37.118 synchrophasor message format always includes 18 bytes for the message header and terminal ID, time information, and status bits. The selection of synchrophasor data, numeric format, and programmable digital data will add to the byte requirements. *Table N.6* can be used to calculate the number of bytes in a synchrophasor message.

Table N.6 Size of a C37.118 Synchrophasor Message

Item	Possible Number of Quantities	Bytes per Quantity	Minimum Number of Bytes	Maximum Number of Bytes
Fixed			18	18
Synchrophasors	0, 1, 2, 3, 4, 5, 6, 8, or 10	4 {PHNR = I} 8 {PHNR = F}	0	80
Frequency	2 (fixed)	2 {FNR = I} 4 {FNR = F}	4	8
Digital Status Words	0–1	2	0	2
Total (Minimum and Maximum)			22	108

Table N.7 lists the baud settings available on any SEL-311C serial port (setting SPEED), and the maximum message size that can fit within the port bandwidth. Blank entries indicate bandwidths of less than 20 bytes.

Table N.7 Serial Port Bandwidth for Synchrophasors (in Bytes)

Global Setting MRATE	Port Setting SPEED							
	300	1200	2400	4800	9600	19200	38400	57600
1	25	103	207	414	829	1658	3316	4974
2		51	103	207	414	829	1658	2487
4 (60 Hz only)		25	51	103	207	414	829	1243
5		20	41	82	165	331	663	994
10			20	41	82	165	331	497
12 (60 Hz only)				34	69	138	276	414
15 (60 Hz only)				27	55	110	221	331
20 (60 Hz only)				20	41	82	165	248
25 (50 Hz only)					33	66	132	198
30 (60 Hz only)					27	55	110	165
50 (50 Hz only)						33	66	99
60 (60 Hz only)						27	55	82

Referring to *Table N.6* and *Table N.7*, it is clear that the lower SPEED settings are very restrictive.

The smallest practical synchrophasor message would be comprised of one synchrophasor, and this message would consume between 26 and 34 bytes, depending on the numeric format settings. This type of message could be sent at any message rate (MRATE) when SPEED = 38400 or 57600, up to MRATE = 50 or 30 when SPEED = 19200, and up to MRATE = 25 or 20 when SPEED = 9600.

Another example application has messages comprised of ten synchrophasors and one digital status word. This type of message would consume between 64 and 108 bytes, depending on the numeric format settings. The 64-byte version, using integer numeric representation, could be sent at any message rate (MRATE) when SPEED = 57600. The 108-byte version, using floating-point numeric representation, could be sent at up to MRATE = 25 or 30 when SPEED = 57600, up to MRATE = 20 or 25 when SPEED = 38400, and up to MRATE = 10 or 12 when SPEED = 19200.

Protocol Operation

The SEL-311C will only transmit synchrophasor messages over serial ports that have setting PROTO = PMU. The connected device will typically be a synchrophasor processor, such as the SEL-3378 Synchrophasor Vector Processor. The synchrophasor processor controls the PMU functions of the SEL-311C, with IEEE C37.118 commands, including commands to start and stop synchrophasor data transmission, and commands to request a configuration block from the relay, so the synchrophasor processor can automatically build a database structure.

Transmit Mode Control

The SEL-311C will not begin transmitting synchrophasors until an enable message is received from the synchrophasor processor. The relay will stop synchrophasor transmission when the appropriate command is received from the synchrophasor processor. The SEL-311C can also indicate when a configuration change occurs, so the synchrophasor processor can request a new configuration block and keep its database up-to-date.

The SEL-311C will only respond to configuration block request messages when it is in the non-transmitting mode.

Independent Ports

Each serial port with the PROTO = PMU setting is independently configured and enabled for synchrophasor commands. The ports are not required to have the same SPEED setting, although the slowest SPEED setting on a PROTO = PMU port will affect the maximum Global MRATE setting that can be used.

Synchrophasor Relay Word Bits

Table N.8 and *Table N.9* list the SEL-311C Relay Word bits that are related to synchrophasor measurement.

The Synchrophasor Trigger Relay Word bits in *Table N.8* follow the state of the SELOGIC control equations of the same name, listed in *Table N.2*. These Relay Word bits are included in the IEEE C37.118 synchrophasor data frame STAT field.

Table N.8 Synchrophasor Trigger Relay Word Bits

Name	Description
PMTRIG	Trigger (SELOGIC Equation).
TREA4	Trigger Reason Bit 4 (SELOGIC Equation)
TREA3	Trigger Reason Bit 3 (SELOGIC Equation)
TREA2	Trigger Reason Bit 2 (SELOGIC Equation)
TREA1	Trigger Reason Bit 1 (SELOGIC Equation)

The Time-Synchronization Relay Word bits in *Table N.9* indicate the present status of the high-accuracy timekeeping function of the SEL-311C. See *Configuring High-Accuracy Timekeeping on page N.25*.

Table N.9 Time-Synchronization Relay Word Bits

Name	Description
TIRIG	Asserts while relay time is based on IRIG-B time source.
TSOK	Time synchronization OK. Asserts while time is based on high-accuracy IRIG-B time source of sufficient accuracy for synchrophasor measurement.
PMDOK	Phasor measurement data OK. Asserts when the SEL-311C is enabled, synchrophasors are enabled (Global Setting EPMU = Y), Relay Word bit TSOK = 1, the relay is properly tracking frequency (FREQOK = 1 and the relay is using voltage for frequency tracking), and the positive-sequence voltage V1 > 10 V secondary. A few seconds may be required for PMDOK to assert when the relay is first powered, after any of the settings in *Table N.1* are changed, or when an IRIG-B time signal is first connected.

View Synchrophasors by Using the MET PM Command

The **MET PM** serial port ASCII command may be used to view the SEL-311C synchrophasor measurements. See *MET Command (Metering Data) on page 10.39* for general information on the **MET** command.

There are multiple ways to use the **MET PM** command:

- As a test tool, to verify connections, phase rotation, and scaling
- As an analytical tool, to capture synchrophasor data at an exact time, in order to compare this information with similar data captured in other phasor measurement unit(s) at the same time.
- As a method of periodically gathering synchrophasor data through a communications processor.

The **MET PM** command displays the same set of analog synchrophasor information, regardless of the Global settings MFRMT, PHDATAV and PHDATAI. The **MET PM** command can function even when no ports are sending synchrophasor data.

The **MET PM** command only displays data when the Relay Word bit TSOK = logical 1. *Figure N.5* shows a sample **MET PM** command response. The synchrophasor data are also available in the ACSELERATOR QuickSet HMI and have a similar format to *Figure N.5*.

The **MET PM *time*** command can be used to direct the SEL-311C to display the synchrophasor for an exact specified time, in 24-hour format. For example, entering the command **MET PM 14:14:12** will result in a response similar to *Figure N.5* occurring just after 14:14:12, with the time stamp 14:14:12.000.

This method of data capture always reports from the exact second, even if the time parameter is entered with fractional seconds. For example, entering **MET PM 14:14:12.200** results in the same data capture as **MET PM 14:14:12**, because the relay ignored the fractional seconds.

See *MET PM—Synchrophasor Metering on page 10.45* for complete command options, and error messages.

When PTCONN = WYE, voltages V1, VA, VB, VC, and VS are displayed, as shown in *Figure N.5*. When PTCONN = DELTA, voltages V1, VAB, VBC, VCA, and VS are displayed.

NOTE: The values reported by the **MET PM HIS** command are only valid if settings are not changed after the trigger.

MET PM HIS recalls the most recently triggered synchrophasor meter report. This is useful when synchrophasor data from multiple relays must be captured on a single PC. For example, connect to each relay and issue the **MET PM 14:14:00** command. At 14:14, each relay will issue a response similar to *Figure N.5*. After 14:14, connect to each relay, issue the **MET PM HIS** command, and capture the results. Since **MET PM HIS** recalls the last MET PM report, the data captured from every relay will be from the same time.

```
=>MET PM <Enter>

SEL-311                            Date: 12/01/08    Time: 10:33:59.000
STATION A

                                                                 PMDOK = 1
Time Quality   Maximum time synchronization error:     0.000 (ms)  TSOK = 1

Synchrophasors
                   Phase Voltages           Synch Voltage    Pos.-Seq. Voltage
               VA        VB        VC            VS                V1
MAG (kV)       12.045    12.037    12.038        12.042            12.040
ANG (DEG)     139.563    19.756  -100.109       140.066           139.737

                   Phase Currents          Neutral Current   Pos.-Seq. Current
               IA        IB        IC            IN                I1
MAG (A)       120.865   121.026   120.477         0.625           106.448
ANG (DEG)     140.109    20.452  -159.931       139.213           121.169

FREQ (Hz) 59.991
Rate-of-change of FREQ (Hz/s)    0.00

Digitals

SV1    SV2    SV3    SV4    SV5    SV6    SV7    SV8
 0      0      0      0      0      0      0      0
SV9    SV10   SV11   SV12   SV13   SV14   SV15   SV16
 0      0      0      0      0      0      0      0

=>
```

Figure N.5 Sample MET PM Command Response When PTCONN = WYE

IEEE C37.118 PMU Setting Example

A utility is upgrading its transmission system to use the SEL-311C relay for line protection. The utility also wants to install phasor measurement units (PMUs) in each substation to collect data to monitor voltages and currents throughout the system.

The PMU data collection requirements call for the following data, collected at 10 messages per second:

- Frequency
- Positive-sequence voltage from the bus in each substation
- Three-phase, positive-sequence, and neutral current for each line
- Indication when the breaker is open
- Indication when the voltage or frequency information is unusable

The utility is able to meet the requirements with the SEL-311C for each line, an SEL-2407 Satellite-Synchronized Clock, and an SEL-3306 Synchrophasor Processor in each substation.

This example will cover the PMU settings in one of the SEL-311C relays.

Some system details:

- The nominal frequency is 60 Hz.
- The bus pts and wiring have a phase error of 4.20 degrees (lagging) at 60 Hz.
- The breaker cts and wiring have a phase error of 3.50 degrees (lagging) at 60 Hz.
- The neutral cts and wiring have a phase error of 5.50 degrees (lagging) at 60 Hz.
- The synchrophasor data will be using port 3, and the maximum baud allowed is 19200.
- The system designer specified floating point numeric representation for the synchrophasor data, and rectangular coordinates.
- The system designer specified integer numeric representation for the frequency data.
- The system designer specified fast synchrophasor response, because the data is being used for system monitoring.

The protection settings will not be shown.

Determining Settings

The protection engineer performs a bandwidth check, using *Table N.6*, and determines the required message size. The system requirements, in order of appearance in *Table N.6*, are:

- 6 Synchrophasors, in floating point representation
- Integer representation for the frequency data
- 3 digital status bits, which require one status word

The message size is 18 + 6 • 8 + 2 • 2 + 1 • 2 = 72 bytes. Using *Table N.7*, the engineer verifies that the port baud of 19200 is adequate for the message, at 10 messages per second.

The Protection SELOGIC Variables SV14, SV15, and SV16 will be used to transmit the breaker status, loss-of-potential alarm, and frequency measurement status, respectively.

Make the Global settings as shown in *Table N.10*.

Table N.10 Example Synchrophasor Global Settings

Setting	Description	Value
NFREQ	Nominal System Frequency (50, 60 Hz)	60
EPMU	Enable Synchronized Phasor Measurement (Y, N)	Y
MFRMT	Message Format (C37.118, FM)	C37.118
MRATE	Messages per Second (1, 2, 4, 5, 10, 12, 15, 20, 30, 60)	10
PMAPP	PMU Application (F = Fast Response, N = Narrow Bandwidth)	F
PHCOMP	Frequency-Based Phasor Compensation (Y, N)	Y
PMSTN	Station Name (16 characters)	SAMPLE1
PMID	PMU Hardware ID (1–65534)	14
PHDATAV	Phasor Data Set, Voltages (V1, PH, ALL, NA)	V1
VCOMP	Phase Voltage Angle Compensation Factor (–179.99 to 180 degrees)	4.20
VSCOMP	VS Voltage Angle Compensation Factor (–179.99 to 180.00 degrees)	0.00
PHDATAI	Phasor Data Set, Currents (I1, PH, ALL, NA)	ALL
IPCOMP	Phase Current Angle Compensation Factor (–179.99 to 180 degrees)	3.50
INCOMP	Neutral Current Angle Compensation Factor (–179.99 to 180 degrees)	5.50
PHNR	Phasor Numeric Representation (I = Integer, F = Floating point)	F
PHFMT	Phasor Format (R = Rectangular coordinates, P = Polar coordinates)	R
FNR	Frequency Numeric Representation (I = Integer, F = Float)	I
NUMDSW	Number of 16-bit Digital Status Words (0 or 1)	1

Table N.11 Example Synchrophasor Logic Settings

Logic Setting	Description	Value
TREA1	Trigger Reason Bit 1 (SELOGIC Equation)	NA
TREA2	Trigger Reason Bit 2 (SELOGIC Equation)	NA
TREA3	Trigger Reason Bit 3 (SELOGIC Equation)	NA
TREA4	Trigger Reason Bit 4 (SELOGIC Equation)	NA
PMTRIG	Trigger (SELOGIC Equation)	NA

The three Relay Word bits required in this example must be placed in certain SELOGIC variables. Make the settings in *Table N.12* in all six setting groups.

Table N.12 Example Synchrophasor SELOGIC Settings

Setting	Value
SV14	52A
SV15	LOP
SV16	FREQOK

Make the *Table N.13* settings for serial port 3, using the **SET P 3** command.

Table N.13 Example Synchrophasor Port Settings

Setting	Description	Value
EPORT	Enable Port (Y, N)	Y
MAXACC	Maximum Access Level (1, B, 2)	1
PROTO	Protocol (SEL, DNP, MBA, MBB, RTD, PMU)	PMU
SPEED	Data Speed (300 to 57600)	19200
STOPBIT	Stop Bits (1, 2 bits)	1
RTSCTS	Enable Hardware Handshaking (Y, N)	N
FASTOP	Fast Operate Enable (Y, N)	N

SEL Fast Message Synchrophasor Protocol

NOTE: If you are converting SEL Fast Message synchrophasor settings from relays with firmware prior to R500, see Special Settings Conversion Considerations on page C.22 for additional information about converting to settings for firmware R500 and higher.

SEL Fast Message Unsolicited Write (synchrophasor) messages are general Fast Messages (A546h) that transport measured synchrophasor information. Fast Message synchrophasors are available through the serial ports, but not through the Ethernet ports. Use Global settings PHDATAV and PHDATAI to select the voltage and current data to include in the Fast Message. *Table N.20* lists analog quantities included in the Fast Message for various Global settings (frequency is included in all messages). Not all messages are supported at all data speeds. If the selected data rate is not sufficient for the given message length, the relay responds with an error message.

Table N.14 lists the Synchrophasor Fast Message Write function codes and the actions the relay takes in response to each command.

Table N.14 Fast Message Command Function Codes for Synchrophasor Fast Write

Function Code (Hex)	Function	Relay Action
01h	Enable unsolicited transfer	Relay transmits Fast Message command acknowledged message (Function Code 81). Relay transmits Synchrophasor Measured Quantities (function to enable: Unsolicited Write broadcast, Function Code 20)
02h	Disable unsolicited transfer	Relay sends Fast Message command acknowledge message (Function Code 82) and discontinues transferring unsolicited synchrophasor messages (function to disable: Unsolicited Write broadcast, Function Code 20)

Fast Message Synchrophasor Implementation

One of the differences between the C37.118 and SEL Fast Message formats relates to data transmission speed. When the C37.118 format is used, Global Setting MRATE determines the message rate—the synchrophasor processor cannot request a data rate via the enable message.

In the SEL Fast Message format, the synchrophasor processor must request a particular data message period, which is embedded in the enable message. If the requested message period can be supported, the SEL-311C will acknowledge the request (if an acknowledge was requested) and begin transmitting synchrophasors. If the requested message period is not permitted, the SEL-311C will respond with a bad data message (if an acknowledge was requested), and will not transmit any synchrophasor data.

Transmit Mode Control

The relay stops synchrophasor transmission on a particular serial port when the disable command is received from the connected device, or when the relay settings are changed. The SEL-311C responds to configuration block request messages regardless of the present transmit status, waiting only as long as it takes for any partially sent messages to be completely transmitted.

Table N.15–*Table N.17* list the Synchrophasor Fast Message protocol formats, including the specific construction of the enable and disable messages. SEL Application Guide *AG2002-08, Using SEL-421 Relay Synchrophasors in Basic Applications* provides additional information on the SEL Fast Message Synchrophasor protocol and example applications. This application guide refers to the SEL-421 Relay and differs slightly from the SEL-311C implementation.

Table N.15 SEL Fast Message Protocol Format

Field	Description	Hex Data
Header	Synchrophasor Fast Message	A546
Frame Size	Synchrophasor Data Size[a]	XX
Routing	Must be 0000000000 for this application	0000000000
Status Byte	Must be 00 for this application	00
Function Code	20h Code for unsolicited write messages	20
Sequence	C0 for single frame messages. Maximum frame size 255 bytes	C0
Response Number	Response Number (always 00)	00
PM Data Address	Address of Synchrophasor Measurement Data (PMID setting)	00000000
Register Count	Data size in registers (1 Register = 2 Bytes)	XXXX
Sample Number	0-based index into SOC of this packet	0000
SOC	Second of century[b]	XXXXXXXX
Frequency	IEEE 32-bit floating point[c]	XXXXXXXX
Phasor Mag.	Synchrophasor Data Magnitude (IEEE 32-bit floating point)[d]	XXXXXXXX
Phasor Angle	Synchrophasor Data Angle ±180° (IEEE 32-bit floating point)[d]	XXXXXXXX
Digital Data	TSOK, Time Synchronization OK. PMDOK, Phasor Measurement Data OK. SV3–SV16 bits	XXXX
Check Word	2-byte CRC-16 check code for message	XXXX

[a] The synchrophasor data size is dependent on the PHDATAV and PHDATAI settings as shown in Table N.20.
[b] Provided as an offset referenced to 1900 A.D.
[c] From ANSI/IEEE Std. 754-1985, The IEEE Standard for Binary Floating-Point Arithmetic.
[d] The number and transmit order of Magnitude and Angle data values are determined by the PHDATAV and PHDATAI setting as shown in Table N.20.

Table N.16 Unsolicited Fast Message Enable Packet

Field	Description	Hex Data
Header	Synchrophasor Fast Message	A546
Frame Size	18 bytes	12
Routing	Must be 0000000000 for this application	0000000000
Status Byte	YY = 00 acknowledge is not requested YY = 01 acknowledge is requested	YY
Function Code	01h Enable unsolicited write messages	01
Sequence	C0 for single frame message. Maximum frame size 255 bytes	C0
Response Number	XX = 00, 01, 02, 03	XX
Application	20h Synchrophasor	20
Message Period	Data message period	nnnn[a]
Check Word	2-byte CRC-16 check code for message	XXXX

[a] See Table N.18 for permissible data message period values.

Table N.17 Unsolicited Fast Message Disable Packet

Field	Description	Hex Data
Header	Synchrophasor Fast Message	A546
Frame Size	16 bytes	10
Routing	Must be 0000000000 for this application	0000000000
Status Byte	YY = 00 acknowledge is not requested YY = 01 acknowledge is requested	YY
Function Code	02h Disable unsolicited write messages	02
Sequence	C0 for single frame message. Maximum frame size 255 bytes	C0
Response Number	XX = 00, 01, 02, 03	XX
Application	20h Synchrophasor	20
Check Word	2-byte CRC-16 check code for message	XXXX

In the SEL Fast Message format, the synchrophasor processor must request a particular data message period, which is embedded in the enable message. If the requested message period can be supported, the SEL-311C will acknowledge the request (if an acknowledgement was requested) and begin transmitting synchrophasors. If the requested message period is not permitted, the SEL-311C will respond with a bad data message (if an acknowledge was requested), and will not transmit any synchrophasor data. *Table N.18* lists the permissible data message periods that can be requested by the enable message. Note that each Fast Message is transmitted at a fixed time after the beginning of each minute.

The SEL-311C will only transmit synchrophasor messages over serial ports that have setting PROTO = SEL. The connected device will typically be a synchrophasor processor or a communications processor, such as the SEL-2032. The connected device controls the PMU functions of the SEL-311C with SEL Fast Message commands, including commands to start and stop synchrophasor data transmission.

Table N.18 Permissible Message Periods Requested by Enable Message

Message Period (Hex)	Fast Messages Sent This Number of Seconds After the Top of Each Minute	Number of Fast Messages per Minute
0064h	0,1,2,3,4,5,...,59	60
00C8h	0,2,4,6,8,10,...58	30
012Ch	0,3,6,9,12,15,...57	20
0190h	0,4,8,12,15,...56	15
01F4h	0,5,10,15,20,...55	12
0258h	0,6,12,18,24,...54	10
03E8h	0,10,20,30,40,50	6
05DCh	0,15,30,45	4
07D0h	0,20,40	3
0BB8h	0,30	2
1770h	0	1

The SEL Fast Message Synchrophasor protocol is able to share the same physical port with separate data streams (see *Overview on page J.1*).

SEL-311C Fast Message Synchrophasor Settings

The settings for SEL Fast Message synchrophasors are listed in *Table N.19*. Many of these settings are identical to the settings for the C37.118 format.

Table N.19 PMU Settings in the SEL-311C for SEL Fast Message Protocol (Global Settings)

Setting	Description	Default
EPMU	Enable Synchronized Phasor Measurement (Y, N)	N[a]
MFRMT	Message Format (C37.118, FM)[b]	C37.118
PMID	PMU Hardware ID (0–4294967295)	1
PHDATAV	Phasor Data Set, Voltages (V1, ALL)	V1
VCOMP	Voltage Angle Compensation Factor (–179.99 to 180 degrees)	0.00
PHDATAI[c]	Phasor Data Set, Currents (ALL, NA)	NA
ICOMP	Current Angle Compensation Factor (–179.99 to 180 degrees)	0.00

[a] Set EPMU = Y to access the remaining settings.
[b] C37.118 = IEEE C37.118 Standard—see Table N.1; FM = SEL Fast Message. Set MFRMT = FM to enter the Fast Message settings. MFRMT cannot be set to FM when PTCONN = DELTA.
[c] When PHDATAV = V1, this setting is forced to NA and cannot be changed.

Descriptions of Fast Message Synchrophasor Settings

Definitions of the settings in *Table N.19* follow.

EPMU

This setting enables synchrophasor operation.

MFRMT

Selects the message format for synchrophasor data streaming on serial ports. SEL recommends the used of MFRMT = C37.118 for any new PMU applications because of increasing setting flexibility and the expected availability of software for synchrophasor processors. The SEL-311C still includes the MFRMT = FM setting choice to maintain compatibility in any system presently using SEL Fast Message synchrophasors.

PMID

This setting defines the four-byte destination address used in the SEL Fast Message Unsolicited Write message.

The PMID setting is a 32-bit numeric value.

When connected to an SEL-2032 or an SEL-2030 Communications Processor, the PMID specifies the memory location for data storage. In this case the upper-most byte indicates the communications processor port and the lower two bytes specify the user region address for that port. See the *SEL-2032 Communications Processor Instruction Manual* for more details.

PHDATAV and VCOMP

PHDATAV selects which voltage synchrophasors to include in the Fast Message data packet. Consider the synchrophasor processor burden and offline storage requirements when deciding how much data to transmit. PHDATAV and PHDATAI determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size—see *Table N.20*.

- PHDATAV = V1 will transmit only positive-sequence voltage, V1
- PHDATAV = ALL will transmit V1, VA, VB, and VC

Note that VS is *not* included when PHDATAV = ALL and MFRMT = FM.

Table N.20 describes the order of synchrophasors inside the data packet.

The VCOMP setting allows correction for any steady-state voltage phase errors (from the potential transformer or wiring characteristics).

PHDATAI and ICOMP

PHDATAI selects which current synchrophasors to include in the data packet. Consider the synchrophasor processor burden and offline storage requirements when deciding how much data to transmit. PHDATAV and PHDATAI determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size—see *Table N.20*.

- PHDATAI = ALL will transmit I1, IA, IB, and IC
- PHDATAI = NA will not transmit any currents

Note that IN is *not* included when PHDATAI = ALL and MFRMT = FM.

Table N.20 describes the order of synchrophasors inside the data packet.

The ICOMP setting allows correction for any steady-state phase errors (from the current transformers or wiring characteristics).

Other Settings Not Present

The SEL Fast Message format does not require the following settings: MRATE, PMAPP, PHCOMP, PMSTN, VPCOMP, VSCOMP, IPCOMP, INCOMP, PHNR, PHFMT, FNR, NUMDSW, TREA1–TREA4, and PMTRIG.

The SEL Fast Message synchrophasor protocol always calculates synchrophasors once per second, uses a Narrow Bandwidth filter (equivalent to PMAPP = N) and no frequency-based compensation (equivalent to PHCOMP = N). The SEL Fast Message synchrophasor protocol always includes the frequency information in floating-point representation, and fourteen user-programmable SELOGIC variables SV3 through SV16.

Communications Bandwidth for Fast Message Protocol

A phasor measurement unit (PMU) that is configured to transmit a single synchrophasor quantity (positive-sequence voltage, for example) at a message period of one second places little burden on the communications channel. As more synchrophasors or interleaved protocols are added, some communications channel restrictions come into play.

The SPEED setting on any serial port set with PROTO = SEL should be set as high as possible to allow for the largest possible number of message period requests to be successful.

The SEL-311C Fast Message synchrophasor format always includes 32 bytes for the message header and terminal ID, time information, frequency, and status bits. The selection of synchrophasor data will add to the byte requirements. Each synchrophasor quantity will add eight bytes to the message length. *Table N.20* shows the effect that adding synchrophasor quantities has on the minimum allowed SPEED setting.

The number of interleaved protocols sharing the same physical port will also impact the minimum allowed SPEED setting. *Table N.20* shows the setting if the Fast Message Synchrophasor format is the only data stream transmitted; additional data streams will necessitate a higher SPEED setting.

Table N.20 SEL Fast Message Voltage and Current Selections Based on PHDATAV and PHDATAI

Global Settings	Number of Synchrophasor Magnitude and Angle Pairs Transmitted	Synchrophasor Magnitude and Angle Pairs to Transmit, and the Transmit Order	Synchrophasor Data Size (Bytes)	Minimum Baud Rate (SPEED Setting) at One Second Message Period
PHDATAV = V1 PHDATAI = NA	1	V1	40	1200 Baud
PHDATAV = ALL PHDATAI = NA	4	VA, VB, VC, V1	64	2400 Baud
PHDATAV = ALL PHDATAI = ALL	8	VA, VB, VC, V1, IA, IB, IC, I1	96	4800 Baud

Independent Ports

Each serial port with the PROTO = SEL setting is independently configured and enabled for synchrophasor commands. For example, if there are two serial ports set to PROTO = SEL, the status of one port has no effect on the other port. One port might be commanded to start transmitting synchrophasor messages, while the other port is idle, responding to a configuration block or Fast Operate request, or transmitting synchrophasors. The ports are not required to have the same SPEED setting, although the SPEED setting on each PROTO = SEL port will affect the minimum synchrophasor message data period that can be used on that port.

Configuring High-Accuracy Timekeeping

The SEL-311C features high-accuracy timekeeping when supplied with an IRIG-B signal. When the supplied clock signal is sufficiently accurate, the SEL-311C can act as a Phasor Measurement Unit (PMU) and transmit synchrophasor data representative of the power system at fixed time periods to an external data processor. The relay can also record event report data using the high-accuracy time stamp (see *Synchrophasor-Level Accuracy in Event Reports on page 12.13*).

IRIG-B

The SEL-311C has two input connectors that accept IRIG-B (Inter-Range Instrumentation Group-B) demodulated time-code format: the IRIG-B pins of Serial Port 2, and the IRIG-B BNC connector.

The IRIG-B connections can be used for high-accuracy timekeeping purposes, with up to 1 µs accuracy with an appropriate time source. Either input can also be used for general-purpose timekeeping, and the relay will have up to 5 ms accuracy. See *Table N.21* for SEL-311C timekeeping mode details.

Table N.21 SEL-311C Timekeeping Modes

Item	Internal Clock	Normal Accuracy IRIG	High-Accuracy IRIG
Best accuracy (condition)	Depends on last method of setting, plus internal clock drift[a]	5 ms (when IRIG-B signal not meeting requirements for high-accuracy IRIG is connected)	1 µs (when time source jitter is less than 500 ns, and time-error is less than 1 µs)[b]
IRIG-B Connection Required	None	BNC connector (preferred), or Serial Port 2	BNC connector (preferred) or Serial Port 2
Relay Word bits	TIRIG = logical 0 TSOK = logical 0	TIRIG = logical 1 TSOK = logical 0	TIRIG = logical 1 TSOK = logical 1

[a] The SEL-311C internal clock can be synchronized via SNTP, DNP3, SEL-2030 Communications Processor, or ASCII TIM command.
[b] The time-error check only applies when Global setting IRIGC = C37.118.

NOTE: If the time-code signal connected to the BNC connector degrades in quality, the SEL-311C will not switch-over to the IRIG-B pins of serial port 2. The SEL-311C will only switch to Serial Port 2 if the signal on the BNC connector completely fails (e.g., the cable is un-plugged).

Only one IRIG-B time source can be used by the SEL-311C, and the signal connected to the IRIG-B BNC connector takes priority over the Serial Port 2 IRIG-B pins. If a signal is detected on the IRIG-B BNC input, the IRIG-B pins of Serial Port 2 will be ignored. If the clock signal is determined to be sufficiently precise, the SEL-311C asserts the TIRIG Relay Word bit.

The SEL-311C determines the suitability of the IRIG-B signal for high-accuracy timekeeping by applying two tests:

- ➤ Measuring whether the jitter between positive-transitions (rising edges) of the clock signal is less than 500 ns.
- ➤ Decoding the time-error information contained in the IRIG-B control field and determining that Analog Quantity TQUAL is less than 10^{-6} seconds (1 µs).

When IRIGC = C37.118 and an appropriate IRIG-B signal is connected, the SEL-311C will assert Relay Word bit TSOK only when these two tests are met. When IRIGC = NONE, the relay will assert TSOK when the first test is met.

NOTE: Set IRIGC = C37.118 only when an IRIG-B000 signal is connected to the relay. Set IRIGC = NONE when an IRIG-B002 (standard IRIG) signal is connected.

Table N.22 Time and Date Management

Label	Prompt	Default Value
IRIGC[a]	IRIG-B Control Bits Definition (None, C37.118)	None

[a] When MFRMT = C37.118, IRIGC is forced to C37.118.

A time quality value is determined based on the four-bit Time Quality indicator code defined in the IEEE C37.118 standard. When Global setting IRIGC = C37.118, the raw time quality information from the IRIG-B signal is placed into four Relay Word bits TQUAL1, TQUAL2, TQUAL3, and TQUAL4. For example, if TQAUL1 = 1, TQUAL2 = 0, TQUAL3 = 1, and TQUAL4 = 0, the binary time quality indicator code received from the clock via the IRIG signal is 0101, which corresponds to 10 microseconds time error. The time quality is shown in the MET PM report beside the label `Time Quality   Maximum time synchronization error`: viewed with the **MET PM** command.

When IRIGC = C37.118, the relay also decodes Leap Second Pending, Leap Second Direction, Daylight Savings Pending, and Daylight Savings control bits that are present in the IRIG-B signal. The status of these control bits is reflected in Relay Word bits LPSECP, LPSEC, DSTP, and DST, respectively.

When IRIGC = NONE, the TQUAL1, TQUAL2, TQUAL3, TQUAL4, LPSECP, LPSEC, DSTP, and DST Relay Word bits are not updated. When Global setting MFRMT = C37.118, IRIGC is forced to C37.118. The relay accepts C37.118 (IRIG-B000) signals with either even or odd parity.

Connecting High-Accuracy Timekeeping

The procedure in the following steps assumes that you have a modern high-accuracy GPS receiver with a BNC connector output for an IRIG-B signal. Use a communications terminal to send commands and receive data from the relay.

This example assumes that you have successfully established communication with the relay. In addition, you must be familiar with relay access levels and passwords.

Step 1. Confirm that the relay is operating.

Step 2. Prepare to control the relay at Access Level 2.

a. Using a communications terminal, type **ACC <Enter>**.

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

You will see the Access Level 1 => prompt.

Step 3. Connect the cable.

Attach the IRIG-B signal with a BNC-to-BNC coaxial jumper cable from the GPS receiver IRIG-B output to the SEL-311C **IRIG-B** BNC connector.

Step 4. Confirm/Enable automatic detection of high-accuracy timekeeping.

a. Wait at least 20 seconds for the SEL-311C to acquire the clock signal, and then, at a communications terminal, type **TAR TIRIG <Enter>**

The relay will return one row from the Relay Word, as shown in *Figure N.6*. Only the state of the TIRIG and TSOK Relay Word bits are discussed in the troubleshooting steps below.

```
=>TAR TIRIG <Enter>

MAB4     MBC4     MCA4     MAG4     MBG4     MCG4     TSOK     TIRIG
0        0        0        0        0        0        1        1
=>
```

Figure N.6 Confirming the High-Accuracy Timekeeping Relay Word Bits

b. The TIRIG and TSOK Relay Word bits should be asserted (logical 1), indicating that the relay is in the high-accuracy IRIG timekeeping mode.

If TSOK is not asserted, but TIRIG is asserted, the relay is in regular IRIG timekeeping mode. Here is a list of possible reasons for not entering high-accuracy mode:

➢ Global setting IRIGC = C37.118, but the IRIG-B clock does not use the IEEE C37.118 Control Bit assignments.

➢ The IRIG-B signal jitter is too high.

➢ The termination resistor, required by some IRIG clocks, is not installed.

➢ Global setting IRIGC = C37.118, but the time-source clock is reporting that its time error is greater than 1 µs.

If neither TSOK nor TIRIG are asserted, the relay is not in an IRIG time-source mode. Here is a list of possible reasons for not entering IRIG mode:

➢ The IRIG-B clock signal is not of sufficient accuracy or is improperly configured.

➢ The termination resistor, required by some IRIG clocks, is not installed.

➢ The time source clock is not connected to an antenna.

Synchrophasor Protocols and SEL Fast Operate Commands

The SEL-311C can be configured to process SEL Fast Operate commands received on serial ports that have Port setting PROTO = PMU, when the Port setting FASTOP = Y.

This functionality can allow a host device to initiate control actions in the PMU without the need for a separate communications interface.

If port setting FASTOP= Y on a serial port set to PROTO = PMU, the SEL-311C will provide Fast Operate support. The host device can request a Fast Operate Configuration Block when the relay is in the nontransmitting mode, and the relay will respond with the message, which includes codes that define the circuit breaker and remote bit control points that are available via Fast Operate commands.

The SEL-311C will process Fast Operate requests regardless of whether synchrophasors are being transmitted, as long as serial port setting FASTOP = Y. When FASTOP = N, the relay will ignore Fast Operate commands. Use the FASTOP = N option to lockout any control actions from that serial port if required by your company operating practices.

The SEL-311C does not acknowledge received Fast Operate commands, however, it is easy to program one or more Relay Word bits to observe the controlled function. For example, a Fast Operate Circuit Breaker close command could be confirmed by monitoring the breaker status bit 52A by assigning SELOGIC setting LV32 = 52A.

Note that only the Fast Operate function is available on ports set to PROTO = PMU. The protocols SEL Fast Meter and SEL Fast SER are unavailable on PROTO = PMU ports.

Appendix O
Modbus RTU and TCP Communications

Overview

This appendix describes Modbus® RTU and TCP communications features supported by the SEL-311C Protection System. Complete specifications for the Modbus protocol are available from the Modbus user's group website at www.modbus.org.

The SEL-311C allows up to three simultaneous Modbus sessions. The number of Ethernet Modbus sessions is limited by the number of enabled Ethernet DNP sessions. See *Session Limits on page 10.15*.

The SEL-311C Modbus communication allows a Modbus master device to do the following:

- ➤ Acquire metering, monitoring, and event data from the relay.
- ➤ Control SEL-311C output contacts and remote bits.
- ➤ Read and switch the Active Setting Group.
- ➤ Read and set the time and date.
- ➤ Reset targets, demand and peak data, energy data, breaker monitor, min/max, and event history data.

Enable Modbus TCP protocol with the Ethernet port setting EMODBUS. The master IP address for each session is selected with the Ethernet port settings MODIP1, MODIP2, and MODIP3. The Master IP address 0.0.0.0 is a valid entry and is used to accept a connection from any master. Use caution when using this address as any Modbus master may connect to the Ethernet port through this connection. When a Modbus TCP master attempts to connect, the relay will first search the valid master IP addresses. If no matching Modbus master IP address is found, and one of the MODIP*x* addresses is 0.0.0.0, the master will be allowed to connect through that connection. The TCP port number is the Modbus TCP registered port 502. Modbus TCP uses the device IP address as the Modbus identifier and accesses the data in the relay using the same function codes and data maps as Modbus RTU.

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.

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

Communications Protocol

Modbus RTU Queries

Modbus master devices initiate all exchanges by sending a query. The query format for Modbus RTU consists of the fields shown in *Table O.1*.

Table O.1 Modbus Query Fields

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

The SEL-311C serial port SLAVEID setting defines the device address. Set this value to a unique number for each device on the Modbus network. For Modbus RTU communication to operate properly, no two slave devices may have the same address.

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

Modbus TCP Queries

The Modbus request or response is encapsulated when carried on a Modbus TCP/IP network. A dedicated header used on TCP/IP identifies the Modbus Application Data Unit (ADU). The header, called the MBAP (Modbus Application Protocol header), contains the following fields:

Field	Number of Bytes
Transaction Identifier	2 Bytes
Protocol Identifier	2 Bytes (0 = MODBUS protocol)
Length	2 Bytes
Unit Identifier	1 Byte

The Modbus TCP Message consists of the MBAP Header, followed by the Modbus function code and the data supporting the function code. The Modbus TCP message does not contain the 2 byte CRC that is included in the RTU message, as the error checking is accomplished through TCP. Otherwise the data following the MBAP header is identical to the Modbus RTU message.

The remainder of this section will cover the Modbus Function codes in terms of the Modbus RTU protocol.

Modbus Responses

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

Supported Modbus Function Codes

The SEL-311C supports the Modbus function codes shown in *Table O.2*.

Table O.2 SEL-311C Modbus Function Codes

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

Modbus Exception Responses

The SEL-311C sends an exception code under the conditions described in *Table O.3*.

Table O.3 SEL-311C Modbus Exception Codes

Exception Code	Error Type	Description
1	Illegal Function Code	The received function code is either undefined or unsupported.
2	Illegal Data Address	The received command contains an unsupported address in the data field.
3	Illegal Data Value	The received command contains a value that is out of range.
4	Device Error	The SEL-311C is in the wrong state for the function a query specifies. The relay is unable to perform the action specified by a query (i.e., cannot write to a read-only register, device is disabled, etc.).
6	Busy	The device is unable to process the command at this time because of a busy resource.

In the event that any of the errors listed in *Table O.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 required data.

Cyclic Redundancy Check

The SEL-311C calculates a 2-byte CRC value through use of the device address, function code, and data region. It appends this value to the end of every Modbus RTU response. When the master device receives the response, it recalculates the CRC. If the calculated CRC matches the CRC sent by the SEL-311C, the master device uses the data received. If there is no match, the check fails and the message is ignored. The devices use a similar process when the master sends queries.

01h Read Discrete Output Coil Status Command

Use function code 01h to read the On/Off status of the selected bits (coils) (see the Output Coils table shown in *Table O.14*). The SEL-311C coil addresses start at 0. The coil status is packed one coil per bit of the data field. The Least Significant Bit (LSB) of the first data byte contains the starting coil address in the query. The other coils follow towards the high order end of this byte and from low order to high order in subsequent bytes.

Table O.4 01h Read Discrete Output 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 SEL-311C 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 device adds one more byte to maintain the balance of bits, padded by zeroes to make an even byte. *Table O.14* includes the coil number and lists all possible coils (identified as Outputs and Remote bits) available in the device.

The relay responses to errors in the query are shown in *Table O.5*.

Table O.5 Responses to 01h Read Discrete Output Coil Query Errors

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

02 Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (inputs), as shown in *Table O.7*. Input addresses start at 0. The input status is packed one input per bit of the data field. The 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 O.6 02h Read Input Status Command (Sheet 1 of 2)

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

Table O.6 02h Read Input Status Command (Sheet 2 of 2)

Bytes	Field
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 device 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 device adds one more byte to maintain the balance of bits, padded by zeroes to make an even byte.

In each row, the input numbers are assigned from the right-most input to the left-most input (i.e., input address 0 is TLED18 and input address 7 is TLED11). Input addresses start at 0000. *Table O.7* includes the input address in decimal and hexadecimal and lists all possible inputs (Relay Word bits) available in the device.

Table O.7 02h SEL-311C Inputs[a] (Sheet 1 of 4)

Discrete Input Address in Decimal	Discrete Input Address in Hex	Function Code Supported	Discrete Address Description	Notes
0–7	0–7	2	Relay Element Status Row 0	The Address numbers are assigned from the right-most Address to the left-most Address in the Relay Word row as shown in the SEL-311C example below. Address 7 = TLED11 Address 6 = TLED12 Address 5 = TLED13 Address 4 = TLED14 Address 3 = TLED15 Address 2 = TLED16 Address 1 = TLED17 Address 0 = TLED18
8–15	8–F	2	Relay Element Status Row 1	Address 15 = TLED19 Address 14 = TLED20 Address 13 = TLED21 Address 12 = TLED22 Address 11 = TLED23 Address 10 = TLED24 Address 9 = TLED25 Address 8 = TLED26
16–23	10–17	2	Relay Element Status Row 2	
24–31	18–1F	2	Relay Element Status Row 3	
32–39	20–27	2	Relay Element Status Row 4	
40–47	28–2F	2	Relay Element Status Row 5	
48–55	30–37	2	Relay Element Status Row 6	
56–63	38–3F	2	Relay Element Status Row 7	
64–71	40–47	2	Relay Element Status Row 8	
72–79	48–4F	2	Relay Element Status Row 9	
80–87	50–57	2	Relay Element Status Row 10	

Table O.7 02h SEL-311C Inputs[a] (Sheet 2 of 4)

Discrete Input Address in Decimal	Discrete Input Address in Hex	Function Code Supported	Discrete Address Description	Notes
88–95	58–5F	2	Relay Element Status Row 11	
96–103	60–67	2	Relay Element Status Row 12	
104–111	68–6F	2	Relay Element Status Row 13	
112–119	70–77	2	Relay Element Status Row 14	
120–127	78–7F	2	Relay Element Status Row 15	
128–135	80–87	2	Relay Element Status Row 16	
136–143	88–8F	2	Relay Element Status Row 17	
144–151	90–97	2	Relay Element Status Row 18	
152–159	98–9F	2	Relay Element Status Row 19	
160–167	A0–A7	2	Relay Element Status Row 20	
168–175	A8–AF	2	Relay Element Status Row 21	
176–183	B0–B7	2	Relay Element Status Row 22	
184–191	B8–BF	2	Relay Element Status Row 23	
192–199	C0–C7	2	Relay Element Status Row 24	
200–207	C8–CF	2	Relay Element Status Row 25	
208–215	D0–D7	2	Relay Element Status Row 26	
216–223	D8–DF	2	Relay Element Status Row 27	
224–231	E0–E7	2	Relay Element Status Row 28	
232–239	E8–EF	2	Relay Element Status Row 29	
240–247	F0–F7	2	Relay Element Status Row 30	
248–255	F8–FF	2	Relay Element Status Row 31	
256–263	100–107	2	Relay Element Status Row 32	
264–271	108–10F	2	Relay Element Status Row 33	
272–279	110–117	2	Relay Element Status Row 34	
280–287	118–11F	2	Relay Element Status Row 35	
288–295	120–127	2	Relay Element Status Row 36	
296–303	128–12F	2	Relay Element Status Row 37	
304–311	130–137	2	Relay Element Status Row 38	
312–319	138–13F	2	Relay Element Status Row 39	
320–327	140–147	2	Relay Element Status Row 40	
328–335	148–14F	2	Relay Element Status Row 41	
336–343	150–157	2	Relay Element Status Row 42	
344–351	158–15F	2	Relay Element Status Row 43	
352–359	160–167	2	Relay Element Status Row 44	
360–367	168–16F	2	Relay Element Status Row 45	
368–375	170–177	2	Relay Element Status Row 46	
376–383	178–17F	2	Relay Element Status Row 47	
384–391	180–187	2	Relay Element Status Row 48	
392–399	188–18F	2	Relay Element Status Row 49	
400–407	190–197	2	Relay Element Status Row 50	

Table O.7 02h SEL-311C Inputs[a] (Sheet 3 of 4)

Discrete Input Address in Decimal	Discrete Input Address in Hex	Function Code Supported	Discrete Address Description	Notes
408–415	198–19F	2	Relay Element Status Row 51	
416–423	1A0–1A7	2	Relay Element Status Row 52	
424–431	1A8–1AF	2	Relay Element Status Row 53	
432–439	1B0–1B7	2	Relay Element Status Row 54	
440–447	1B8–1BF	2	Relay Element Status Row 55	
448–455	1C0–1C7	2	Relay Element Status Row 56	
456–463	1C8–1CF	2	Relay Element Status Row 57	
464–471	1D0–1D7	2	Relay Element Status Row 58	
472–479	1D8–1DF	2	Relay Element Status Row 59	
480–487	1E0–1E7	2	Relay Element Status Row 60	
488–495	1E8–1EF	2	Relay Element Status Row 61	
496–503	1F0–1F7	2	Relay Element Status Row 62	
504–511	1F8–1FF	2	Relay Element Status Row 63	
512–519	200–207	2	Relay Element Status Row 64	
520–527	208–20F	2	Relay Element Status Row 65	
528–535	210–217	2	Relay Element Status Row 66	
536–543	218–21F	2	Relay Element Status Row 67	
544–551	220–227	2	Relay Element Status Row 68	
552–559	228–22F	2	Relay Element Status Row 69	
560-567	230–237	2	Relay Element Status Row 70	
568–575	238–23F	2	Relay Element Status Row 71	
576–583	240–247	2	Relay Element Status Row 72	
584–591	248–24F	2	Relay Element Status Row 73	
592–599	250–257	2	Relay Element Status Row 74	
600–607	258–25F	2	Relay Element Status Row 75	
608–615	260–267	2	Relay Element Status Row 76	
616–623	268–26F	2	Relay Element Status Row 77	
624–631	270–277	2	Relay Element Status Row 78	
632–639	278–27F	2	Relay Element Status Row 79	
640–647	280–287	2	Relay Element Status Row 80	
648–655	288–28F	2	Relay Element Status Row 81	
656–663	290–297	2	Relay Element Status Row 82	
664–671	298–29F	2	Relay Element Status Row 83	
672–679	2A0–2A7	2	Relay Element Status Row 84	
680–687	2A8–2AF	2	Relay Element Status Row 85	
688–695	2B0–2B7	2	Relay Element Status Row 86	
696–703	2B8–2BF	2	Relay Element Status Row 87	
704–711	2C0–2C7	2	Relay Element Status Row 88	
712–719	2C8–2CF	2	Relay Element Status Row 89	
720–727	2D0–2D7	2	Relay Element Status Row 90	

Table O.7 02h SEL-311C Inputs[a] (Sheet 4 of 4)

Discrete Input Address in Decimal	Discrete Input Address in Hex	Function Code Supported	Discrete Address Description	Notes
728–735	2D8–2DF	2	Relay Element Status Row 91	
736–743	2E0–2E7	2	Relay Element Status Row 92	
744–751	2E8–2EF	2	Relay Element Status Row 93	
752–759	2F0–2F7	2	Relay Element Status Row 94	
760–767	2F8–2FF	2	Relay Element Status Row 95	
768–775	300–307	2	Relay Element Status Row 96	
776–783	308–30F	2	Relay Element Status Row 97	
784–791	310–317	2	Relay Element Status Row 98	
792–799	318–31F	2	Relay Element Status Row 99	

[a] See Appendix D: Relay Word Bits for relay element row numbers and definitions.

The relay responses to errors in the query are shown in *Table O.8*.

Table O.8 Responses to 02h Read Input Query Errors

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

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register Map shown in *Table O.23*. Use the **SET M** command (see *User-Defined Modbus Data Region and SET M Command on page O.16*) to configure the map using the register label names shown in *Table O.22*. You can 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 O.9 03h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table O.10*.

Table O.10 Responses to 03h Read Holding Register Query Errors

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

04h Read Input Register Command

Use function code 04h to read directly from the Modbus Register Map shown in *Table O.23*. Use the **SET M** command (see *User-Defined Modbus Data Region and SET M Command on page O.16*) to configure the map using the register label names shown in *Table O.22*. You can read a maximum of 125 registers at once with this function code. Most masters use 3X references with this function code. If you are accustomed to 3X references with this function code, for five-digit addressing, add 30001 to the standard database address.

Table O.11 04h Read Input 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 (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table O.12*.

Table O.12 Responses to 04h Read Input Register Query Errors

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

05h Force Single Coil Command

Use function code 05h to set or clear a coil. The command response is identical to the command request shown in *Table O.13*.

Table O.13 05h Force Single Coil Command (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (05h)

Table O.13 05h Force Single Coil Command (Sheet 2 of 2)

Bytes	Field
2 bytes	Coil Reference
1 byte	Operation Code (FF for bit set, 00 for bit clear)
1 byte	Placeholder (00)
2 bytes	CRC-16

Table O.14 lists the coil numbers supported by the SEL-311C. The physical coils (coils 00–23) are self-resetting. Pulsing a Set remote bit (decimal address 64 through 79) causes the remote bit to be cleared at the end of the pulse.

Table O.14 01h, 05h SEL-311C Output Coils (Sheet 1 of 4)

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description	Coil Function	Duration	Notes
0	0	1, 5	OUT101	Pulse	1 second	
1	1	1, 5	OUT102	Pulse	1 second	
2	2	1, 5	OUT103	Pulse	1 second	
3	3	1, 5	OUT104	Pulse	1 second	
4	4	1, 5	OUT105	Pulse	1 second	
5	5	1, 5	OUT106	Pulse	1 second	
6	6	1, 5	OUT107	Pulse	1 second	
7	7	1, 5	ALARM	Pulse	1 second	
8	8	1, 5	Reserved			
9	9	1, 5	Reserved			
10	A	1, 5	Reserved			
11	B	1, 5	Reserved			
12	C	1, 5	OUT201	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved
13	D	1, 5	OUT202	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved
14	E	1, 5	OUT203	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved
15	F	1, 5	OUT204	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved
16	10	1, 5	OUT205	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved
17	11	1, 5	OUT206	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved
18	12	1, 5	OUT207	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved
19	13	1, 5	OUT208	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved
20	14	1, 5	OUT209	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved
21	15	1, 5	OUT210	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved
22	16	1, 5	OUT211	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved

Table O.14 01h, 05h SEL-311C Output Coils (Sheet 2 of 4)

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description	Coil Function	Duration	Notes
23	17	1, 5	OUT212	Pulse	1 second	Supported in 3U relay with extra I/O board, otherwise Reserved
24	18	1, 5	Reserved			
25	19	1, 5	Reserved			
26	1A	1, 5	Reserved			
27	1B	1, 5	Reserved			
28	1C	1, 5	Reserved			
29	1D	1, 5	Reserved			
30	1E	1, 5	Reserved			
31	1F	1, 5	Reserved			
32	20	1, 5	Reserved			
33	21	1, 5	Reserved			
34	22	1, 5	Reserved			
35	23	1, 5	Reserved			
36	24	1, 5	Reserved			
37	25	1, 5	Reserved			
38	26	1, 5	Reserved			
39	27	1, 5	Reserved			
40	28	1, 5	Reserved			
41	29	1, 5	Reserved			
42	2A	1, 5	Reserved			
43	2B	1, 5	Reserved			
44	2C	1, 5	Reserved			
45	2D	1, 5	Reserved			
46	2E	1, 5	Reserved			
47	2F	1, 5	Reserved			
48	30	1, 5	RB1	Set/Clear		
49	31	1, 5	RB2	Set/Clear		
50	32	1, 5	RB3	Set/Clear		
51	33	1, 5	RB4	Set/Clear		
52	34	1, 5	RB5	Set/Clear		
53	35	1, 5	RB6	Set/Clear		
54	36	1, 5	RB7	Set/Clear		
55	37	1, 5	RB8	Set/Clear		
56	38	1, 5	RB9	Set/Clear		
57	39	1, 5	RB10	Set/Clear		
58	3A	1, 5	RB11	Set/Clear		
59	3B	1, 5	RB12	Set/Clear		
60	3C	1,5	RB13	Set/Clear		
61	3D	1, 5	RB14	Set/Clear		
62	3E	1, 5	RB15	Set/Clear		

Table O.14 01h, 05h SEL-311C Output Coils (Sheet 3 of 4)

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description	Coil Function	Duration	Notes
63	3F	1, 5	RB16	Set/Clear		
64	40	1, 5	RB1	Pulse	1 SELOGIC® Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
65	41	1, 5	RB2	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
66	42	1, 5	RB3	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
67	43	1, 5	RB4	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
68	44	1, 5	RB5	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
69	45	1, 5	RB6	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
70	46	1, 5	RB7	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
71	47	1, 5	RB8	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
72	48	1, 5	RB9	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
73	49	1, 5	RB10	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
74	4A	1, 5	RB11	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
75	4B	1, 5	RB12	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
76	4C	1, 5	RB13	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
77	4D	1, 5	RB14	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
78	4E	1, 5	RB15	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
79	4F	1, 5	RB16	Pulse	1 SELOGIC Processing Interval	Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse.
80	50	1, 5	Reserved			
81	51	1, 5	Reserved			
82	52	1, 5	Reserved			

Table O.14 01h, 05h SEL-311C Output Coils (Sheet 4 of 4)

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description	Coil Function	Duration	Notes
83	53	1, 5	Reserved			
84	54	1, 5	Breaker Open (Relay Word bit OC)	Pulse	1 SELOGIC Processing Interval	If the relay is disabled or the breaker control jumper is removed, the relay returns an error code 06 (Slave Device Busy).
85	55	1, 5	Breaker Close (Relay Word bit CC)	Pulse	1 SELOGIC Processing Interval	If the relay is disabled or the breaker control jumper is removed, the relay returns an error code 06 (Slave Device Busy).
86	56	1, 5	Reserved			
87	57	1, 5	Reserved			
88	58	1, 5	Target Reset	Pulse		
89	59	1, 5	Reset Demands	Pulse		
90	5A	1, 5	Reset Peak Demand	Pulse		
91	5B	1, 5	Reset Energy Data	Pulse		
92	5C	1, 5	Reset Breaker Monitor	Pulse		
93	5D	1, 5	Reset Min/ Max	Pulse		
94	5E	1, 5	Reset Event History	Pulse		
95	5F	1, 5	Reserved			
96	60	1, 5	Reserved			
97	61	1, 5	Reserved			

Coil addresses start at 0000. If a function code 05 operation to coil 84 (OC) or 85(CC) is attempted, and the breaker jumper is not installed, the device will respond with an Error Code 6. If the device is disabled, a function code 05 to any coil will respond with Error Code 4 (Device Error). In addition to Error Code 4, the device responses to errors in the query are shown in *Table O.15*.

Table O.15 Responses to 05h Force Single Coil Query Errors

Error	Error Code Returned	Communication Counter Increments
Invalid bit (coil)	Illegal Data Address (02h)	Invalid Address
Invalid bit state requested	Illegal Data Value (03h)	Illegal Register
Format Error	Illegal Data Value (03h)	Bad Packet Format

06h Preset Single Register Command

The SEL-311C uses this function to allow a Modbus master to write directly to a database register. Refer to the Modbus Quantities Table in *Table O.22* for a list of registers that can be written by using this function code. If you are accustomed to 4X references with this function code, for six-digit addressing, add 400001 to the standard database addresses.

The command response is identical to the command request shown in *Table O.16*.

Table O.16 06h Preset Single Register Command

Bytes	Field
Queries 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 relay responses to errors in the query are shown in *Table O.17*.

Table O.17 Responses to 06h Preset Single Register Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register address	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal register value	Illegal Data Value (03h)	Illegal Write
Format error	Illegal Data Value (03h)	Bad Packet Format

08h Loopback Diagnostic Command

The SEL-311C 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 O.18 08h Loopback Diagnostic Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field (identical to data in Master request)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table O.19*.

Table O.19 Responses to 08h Loopback Diagnostic Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal subfunction code	Illegal Data Value (03h)	Illegal Function Code/Op Code
Format error	Illegal Data Value (03h)	Bad Packet Format

10h Preset Multiple Registers Command

This function code works much like code 06h, except that it allows you to write multiple registers at once, up to 100 per operation. If you are accustomed to 4X references with the function code, for six-digit addressing, simply add 400001 to the standard database addresses.

Table O.20 10h Preset Multiple Registers Command

Bytes	Field
Queries 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	Number of Bytes of Data (*n*)
n bytes	Data
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers
2 bytes	CRC-16

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

Table O.21 10h Preset Multiple Registers Query Error Messages

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

Bit Operations Using Function Codes 06h and 10h

The SEL-311C includes registers for controlling some of the outputs. See LOG_CMD and RSTDAT in *Table O.22*. Use Modbus function codes 06h or 10h to write appropriate flags. Remember that when writing to the Logic command register with output contacts, it is not a bit operation. All the bits in that register need to be written together to reflect the state you want for each of the outputs.

User-Defined Modbus Data Region and SET M Command

The SEL-311C Modbus Register Map defines an area of 250 contiguous addresses whose contents are defined by user-settable labels. This feature allows you to take 250 discrete values from anywhere in the Modbus Quantities Table (*Table O.22*) and place them in contiguous registers that you can then read in a single command. Use the SEL ASCII command **SET M** (or the Modbus User Map settings in ACSELERATOR® SEL-5030 software) to define the user map addresses. A default map is provided with the relay. If the default Modbus map is not appropriate or more data is desired, edit the map as required for your application.

To use the user-defined data region, follow the steps listed below.

Step 1. Define the list of desired quantities (up to 250). Arrange the quantities in any order that is convenient for you to use.

Step 2. Refer to *Table O.22* for a list of the Modbus labels for each quantity.

Step 3. Use the **SET M** command from the command line or ACSELERATOR Modbus User Map to map user registers 001 to 250 (MOD_001 to MOD_250) using the labels in *Table O.22*.

Step 4. Use Modbus function code 03h or 04h to read the desired quantities from addresses 0 through 249 (decimal).

Note that the Modbus addresses begin with zero, which corresponds to Set M setting MOD_001.

As each label is entered in a register via the **SET M** command, the relay will increment to the next valid register.

If a label is entered for a 32-bit quantity register (e.g., VA, VB, VC, KW3), the relay will automatically skip a register in the sequence because two registers are required for the 32-bit quantity. The register with the lower index is the most significant word and the register with the higher index is the least significant word in the 32-bit quantity. In the following example, MOD_015 was previously set to 3I2, which is a 16 bit value and consumes one register. By changing the register label to KW3, a 32 bit value, the next register shown available for setting is MOD_017.

```
=>>SET M MOD_015 <Enter>

Modbus Map, Section 1:
USER REG#015
MOD_015 = 3I2
     ? KW3

USER REG#017
MOD_017 = VA
     ?

USER REG#019
MOD_019 = VAFA
     ?
=>>
```

Similarly, in this example, MOD_017 was previously set to VA, which is a 32 bit value and consumes two registers. By changing the register label to IA, a 16 bit value, the next register shown available for setting is MOD_018. Since MOD_018 was previously not available, as it was the second register used for MOD_017 (VA), there is no label assigned to it and shows NA.

```
=>>SET M MOD_017 <Enter>

Modbus Map, Section 1:
USER REG#017
MOD_017 = VA
     ? IA

USER REG#018
MOD_018 = NA
     ? IAFA

USER REG#019
MOD_019 = VAFA
     ? IB

=>>
```

Table O.22 Modbus Quantities Table (Sheet 1 of 10)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling (X1 unless specified)
Special Quantities						
Constant		0	1	0	0	
Constant		1	1	1	1	
No Operation		NOOP	1	0	0	
Not Assigned		NA	1	0	0	
Reset Bits						
Reset Data	03, 04, 06, 10h	**RSTDAT**	1	0	65535	
Reset Targets		**Bit 0**				
Reserved		**Bit 1**				
Reserved		**Bit 2**				
Reset History Data		**Bit 3**				
Reset Comm Counters		**Bit 4**				
Reset Breaker Monitor		**Bit 5**				
Reset Energy Data		**Bit 6**				
Reset Max/Min Data		**Bit 7**				
Reset Demands		**Bit 8**				
Reset Peak Demand		**Bit 9**				
Reserved		**Bits 10–15**				
Date/Time Set						
Set Seconds	03, 04, 06, 10h	**TIME_S**	1	0	59999	1000
Set Minutes	03, 04, 06, 10h	**TIME_M**	1	0	59	
Set Hour	03, 04, 06, 10h	**TIME_H**	1	0	23	
Set Day	03, 04, 06, 10h	**DATE_D**	1	1	31	
Set Month	03, 04, 06, 10h	**DATE_M**	1	1	12	
Set Year	03, 04, 06, 10h	**DATE_Y**	1	2000	2550	
Historical Data						
No. of Event Logs	03, 04	NUMEVE	1	0	See *Table 12.1*	
Event Selected	03, 04, 06, 10h	**EVESEL**	1	0	See *Table 12.1*	
Fault Time Second	03, 04	FTIME_S	1	0	59999	1000

Table O.22 Modbus Quantities Table (Sheet 2 of 10)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling (X1 unless specified)
Fault Time Minute	03, 04	FTIME_M	1	0	59	
Fault Time Hour	03, 04	FTIME_H	1	0	23	
Fault Time Day	03, 04	FDATE_D	1	1	31	
Fault Time Month	03, 04	FDATE_M	1	1	12	
Fault Time Year	03, 04	FDATE_Y	1	0	9999	
Event Type	03, 04	EVE_TYPE	1			
1 = A Phase Trip						
2 = B Phase Trip						
3 = AB Fault Trip						
4 = C Phase Trip						
5 = CA Fault Trip						
6 = BC Fault Trip						
7 = ABC Fault Trip						
9 = AG Fault Trip						
10 = BG Fault Trip						
11 = ABG Fault Trip						
12 = CG Fault Trip						
13 = CAG Fault Trip						
14 = BCG Fault Trip						
15 = ABCG						
16 = Trigger						
32 = Pulse						
64 = Trip						
128 = ER Trigger						
Fault Location	03, 04	FLOC	1	–32768	32767	
Fault Current	03, 04	FI	1	0	65535	
Phase A Fault Current	03, 04	FIA	1	0	65535	
Phase B Fault Current	03, 04	FIB	1	0	65535	
Phase C Fault Current	03, 04	FIC	1	0	65535	
Ground Fault Current	03, 04	FIG	1	0	65535	
Neutral Fault Current	03, 04	FIN	1	0	65535	
Neg. Seq. Fault Current	03, 04	FIQ	1	0	65535	
Fault Frequency	03, 04	FFREQ	1	4000	7000	100
Fault Group	03, 04	FGRP	1	1	6	
Fault Shot Count	03, 04	FSHO	1	0	4	

Table O.22 Modbus Quantities Table (Sheet 3 of 10)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling (X1 unless specified)
Control I/O Commands						
Logic Command[c]	03, 04, 06, 10h	**LOG_CMD**	1			
Breaker Close (Relay Word bit CC)		**Bit 0**				
Breaker Open (Relay Word bit OC)		**Bit 1**				
Current Data						
Phase A Current Mag.	03, 04	IA	1	0	65535	
Phase A Angle	03, 04	IAFA	1	–18000	18000	100
Phase B Current Mag.	03, 04	IB	1	0	65535	
Phase B Angle	03, 04	IBFA	1	–18000	18000	100
Phase C Current Mag.	03, 04	IC	1	0	65535	
Phase C Angle	03, 04	ICFA	1	–18000	18000	100
Neutral Current Mag.	03, 04	IN	1	0	65535	
Neutral Current Angle	03, 04	INFA	1	–18000	18000	100
Residual Ground Current Mag.	03, 04	IG	1	0	65535	
Residual Ground Current Angle	03, 04	IGFA	1	–18000	18000	100
3I0 Current Mag.	03, 04	3I0	1	0	65535	
3I0 Current Angle	03, 04	3I0FA	1	–18000	18000	100
Positive Seq. Current Mag.	03, 04	I1	1	0	65535	
Positive Seq. Current Angle	03, 04	I1FA	1	–18000	18000	100
Negative Seq. Current Mag.	03, 04	3I2	1	0	65535	
Negative Seq. Current Angle	03, 04	3I2FA	1	–18000	18000	100
Voltage Data						
Phase A Voltage Mag.	03, 04	VA[d]	2	0	4294967295	
Phase A Voltage Angle	03, 04	VAFA[d]	1	–18000	18000	100
Phase B Voltage Mag.	03, 04	VB[d]	2	0	4294967295	
Phase B Voltage Angle	03, 04	VBFA[d]	1	–18000	18000	100
Phase C Voltage Mag.	03, 04	VC[d]	2	0	4294967295	
Phase C Voltage Angle	03, 04	VCFA[d]	1	–18000	18000	100
VS Voltage Mag.	03, 04	VS	2	0	4294967295	
VS Voltage Angle	03, 04	VSFA	1	–18000	18000	100
Phase AB Voltage Mag.	03, 04	VAB	2	0	4294967295	
Phase AB Voltage Angle	03, 04	VABFA	1	–18000	18000	100
Phase BC Voltage Mag.	03, 04	VBC	2	0	4294967295	
Phase BC Voltage Angle	03, 04	VBCFA	1	–18000	18000	100
Phase CA Voltage Mag.	03, 04	VCA	2	0	4294967295	
Phase CA Voltage Angle	03, 04	VCAFA	1	–18000	18000	100

Table O.22 Modbus Quantities Table (Sheet 4 of 10)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling (X1 unless specified)
Pos. Seq. Voltage Mag.	03, 04	V1	2	0	4294967295	
Pos. Seq. Voltage Angle	03, 04	V1FA	1	–18000	18000	100
Neg. Seq. Voltage Mag.	03, 04	V2	2	0	4294967295	
Neg. Seq. Voltage Angle	03, 04	V2FA	1	–18000	18000	100
3V0 Voltage Mag.	03, 04	3V0_MAG[e]	2	0	4294967295	
3V0 Voltage Angle	03, 04	3V0FA[e]	1	–18000	18000	100
Power Data						
Phase A Real Power	03, 04	KWA[e]	2	–2147483648	2147483647	
Phase B Real Power	03, 04	KWB[e]	2	–2147483648	2147483647	
Phase C Real Power	03, 04	KWC[e]	2	–2147483648	2147483647	
3-Phase Real Power	03, 04	KW3	2	–2147483648	2147483647	
Phase A Reactive Power	03, 04	KVARA[e]	2	–2147483648	2147483647	
Phase B Reactive Power	03, 04	KVARB[e]	2	–2147483648	2147483647	
Phase C Reactive Power	03, 04	KVARC[e]	2	–2147483648	2147483647	
3-Phase Reactive Power	03, 04	KVAR3	2	–2147483648	2147483647	
Phase A Power Factor	03, 04	PFA[e]	1	–100	100	
Phase B Power Factor	03, 04	PFB[e]	1	–100	100	
Phase C Power Factor	03, 04	PFC[e]	1	–100	100	
3-Phase Power Factor	03, 04	PF3	1	–100	100	
Phase A PF Leading 0 = Lag 1 = Lead	03, 04	LDPFA[e]	1	0	1	
Phase B PF Leading 0 = Lag 1 = Lead	03, 04	LDPFB[e]	1	0	1	
Phase C PF Leading 0 = Lag 1 = Lead	03, 04	LDPFC[e]	1	0	1	
3-Phase PF Leading 0 = Lag 1 = Lead	03, 04	LDPF3	1	0	1	
Energy Data						
Phase A Real Energy IN	03, 04	MWHAI[e]	2	–2147483648	2147483647	
Phase B Real Energy IN	03, 04	MWHBI[e]	2	–2147483648	2147483647	
Phase C Real Energy IN	03, 04	MWHCI[e]	2	–2147483648	2147483647	
3-Phase Real Energy IN	03, 04	MWH3I	2	–2147483648	2147483647	
Phase A Real Energy OUT	03, 04	MWHAO[e]	2	–2147483648	2147483647	
Phase B Real Energy OUT	03, 04	MWHBO[e]	2	–2147483648	2147483647	
Phase C Real Energy OUT	03, 04	MWHCO[e]	2	–2147483648	2147483647	
3-Phase Real Energy OUT	03, 04	MWH3O	2	–2147483648	2147483647	
Phase A Reactive Energy IN	03, 04	MVRHAI[e]	2	–2147483648	2147483647	

Table O.22 Modbus Quantities Table (Sheet 5 of 10)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling (X1 unless specified)
Phase B Reactive Energy IN	03, 04	MVRHBI[e]	2	–2147483648	2147483647	
Phase C Reactive Energy IN	03, 04	MVRHCI[e]	2	–2147483648	2147483647	
3-Phase Reactive Energy IN	03, 04	MVRH3I	2	–2147483648	2147483647	
Phase A Reactive Energy OUT	03, 04	MVRHAO[e]	2	–2147483648	2147483647	
Phase B Reactive Energy OUT	03, 04	MVRHBO[e]	2	–2147483648	2147483647	
Phase C Reactive Energy OUT	03, 04	MVRHCO[e]	2	–2147483648	2147483647	
3-Phase Reactive Energy OUT	03, 04	MVRH3O	2	–2147483648	2147483647	
Demand Data						
Phase A Demand Current	03, 04	IADEM	1	0	65535	
Phase B Demand Current	03, 04	IBDEM	1	0	65535	
Phase C Demand Current	03, 04	ICDEM	1	0	65535	
Neutral Demand Current	03, 04	INDEM	1	0	65535	
Residual Ground Demand Current	03, 04	IGDEM	1	0	65535	
Neg. Seq. Demand Current	03, 04	3I2DEM	1	0	65535	
Phase A Real Power Demand IN	03, 04	KWADI[e]	2	–2147483648	2147483647	
Phase B Real Power Demand IN	03, 04	KWBDI[e]	2	–2147483648	2147483647	
Phase C Real Power Demand IN	03, 04	KWCDI[e]	2	–2147483648	2147483647	
3-Phase Real Power Demand IN	03, 04	KW3DI	2	–2147483648	2147483647	
Phase A Reactive Power Demand IN	03, 04	KVRADI[e]	2	–2147483648	2147483647	
Phase B Reactive Power Demand IN	03, 04	KVRBDI[e]	2	–2147483648	2147483647	
Phase C Reactive Power Demand IN	03, 04	KVRCDI[e]	2	–2147483648	2147483647	
3-Phase Reactive Power Demand IN	03, 04	KVR3DI	2	–2147483648	2147483647	
Phase A Real Power Demand OUT	03, 04	KWADO[e]	2	–2147483648	2147483647	
Phase B Real Power Demand OUT	03, 04	KWBDO[e]	2	–2147483648	2147483647	
Phase C Real Power Demand OUT	03, 04	KWCDO[e]	2	–2147483648	2147483647	
3-Phase Real Power Demand OUT	03, 04	KW3DO	2	–2147483648	2147483647	
Phase A Reactive Power Demand OUT	03, 04	KVRADO[e]	2	–2147483648	2147483647	

Table 0.22 Modbus Quantities Table (Sheet 6 of 10)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling (X1 unless specified)
Phase B Reactive Power Demand OUT	03, 04	KVRBDO[e]	2	–2147483648	2147483647	
Phase C Reactive Power Demand OUT	03, 04	KVRCDO[e]	2	–2147483648	2147483647	
3-Phase Reactive Power Demand OUT	03, 04	KVR3DO	2	–2147483648	2147483647	
Phase A Peak Demand Current	03, 04	IAPK	1	0	65535	
Phase B Peak Demand Current	03, 04	IBPK	1	0	65535	
Phase C Peak Demand Current	03, 04	ICPK	1	0	65535	
Neutral Peak Demand Current	03, 04	INPK	1	0	65535	
Residual Ground Peak Demand Current	03, 04	IGPK	1	0	65535	
Negative Sequence Peak Demand Current	03, 04	3I2PK	1	0	65535	
Phase A Real Power Peak Demand IN	03, 04	KWAPI[e]	2	–2147483648	2147483647	
Phase B Real Power Peak Demand IN	03, 04	KWBPI[e]	2	–2147483648	2147483647	
Phase C Real Power Peak Demand IN	03, 04	KWCPI[e]	2	–2147483648	2147483647	
3-Phase Real Power Peak Demand IN	03, 04	KW3PI	2	–2147483648	2147483647	
Phase A Reactive Power Peak Demand IN	03, 04	KVRAPI[e]	2	–2147483648	2147483647	
Phase B Reactive Power Peak Demand IN	03, 04	KVRBPI[e]	2	–2147483648	2147483647	
Phase C Reactive Power Peak Demand IN	03, 04	KVRCPI[e]	2	–2147483648	2147483647	
3-Phase Reactive Power Peak Demand IN	03, 04	KVR3PI	2	–2147483648	2147483647	
Phase A Real Power Peak Demand OUT	03, 04	KWAPO[e]	2	–2147483648	2147483647	
Phase B Real Power Peak Demand OUT	03, 04	KWBPO[e]	2	–2147483648	2147483647	
Phase C Real Power Peak Demand OUT	03, 04	KWCPO[e]	2	–2147483648	2147483647	
3-Phase Real Power Peak Demand OUT	03, 04	KW3PO	2	–2147483648	2147483647	
Phase A Reactive Power Peak Demand OUT	03, 04	KVRAPO[e]	2	–2147483648	2147483647	
Phase B Reactive Power Peak Demand OUT	03, 04	KVRBPO[e]	2	–2147483648	2147483647	
Phase C Reactive Power Peak Demand OUT	03, 04	KVRCPO[e]	2	–2147483648	2147483647	

Table O.22 Modbus Quantities Table (Sheet 7 of 10)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling (X1 unless specified)
3-Phase Reactive Power Peak Demand OUT	03, 04	KVR3PO	2	–2147483648	2147483647	
Other Data						
System Frequency	03, 04	FREQ	1	4000	7000	100
Station DC Battery Voltage	03, 04	VDC	1	–5000	5000	10
Relay Internal Temperature	03, 04	TEMP	1	–400	1250	10
Breaker Monitor						
Internal Trip Counter	03, 04	INTTR	1	0	65535	
External Trip Counter	03, 04	EXTTR	1	0	65535	
Breaker Wear A Phase	03, 04	WEARA	1	0	65535	
Breaker Wear B Phase	03, 04	WEARB	1	0	65535	
Breaker Wear C Phase	03, 04	WEARC	1	0	65535	
Modbus Communication Counters						
Num Messages Received	03, 04	MSGRCD	1	0	65535	
Num Msgs to Other devices (Other ID)	03, 04	MSGOID	1	0	65535	
Illegal Address	03, 04	ILLADDR	1	0	65535	
Bad CRC	03, 04	BADCRC	1	0	65535	
Uart Error	03, 04	UARTER	1	0	65535	
Illegal Function	03, 04	ILLFUNC	1	0	65535	
Illegal Register	03, 04	ILLREG	1	0	65535	
Illegal Data	03, 04	ILLDATA	1	0	65535	
Bad Packet Format	03, 04	BADPF	1	0	65535	
Bad Packet Length	03, 04	BADPL	1	0	65535	
Active Group						
Active Settings Group	03, 04, 06, 10h	**ACTGRP**[f]	1	1	6	
Relay Elements (Target Rows) (See Appendix D: Relay Word Bits for relay element row numbers and definitions)						
ROW 0	03, 04	ROW_0	1	0	255	
ROW 1	03, 04	ROW_1	1	0	255	
ROW 2	03, 04	ROW_2	1	0	255	
ROW 3	03, 04	ROW_3	1	0	255	
ROW 4	03, 04	ROW_4	1	0	255	
ROW 5	03, 04	ROW_5	1	0	255	
ROW 6	03, 04	ROW_6	1	0	255	
ROW 7	03, 04	ROW_7	1	0	255	
ROW 8	03, 04	ROW_8	1	0	255	
ROW 9	03, 04	ROW_9	1	0	255	
ROW 10	03, 04	ROW_10	1	0	255	
ROW 11	03, 04	ROW_11	1	0	255	
ROW 12	03, 04	ROW_12	1	0	255	

Table O.22 Modbus Quantities Table (Sheet 8 of 10)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling (X1 unless specified)
ROW 13	03, 04	ROW_13	1	0	255	
ROW 14	03, 04	ROW_14	1	0	255	
ROW 15	03, 04	ROW_15	1	0	255	
ROW 16	03, 04	ROW_16	1	0	255	
ROW 17	03, 04	ROW_17	1	0	255	
ROW 18	03, 04	ROW_18	1	0	255	
ROW 19	03, 04	ROW_19	1	0	255	
ROW 20	03, 04	ROW_20	1	0	255	
ROW 21	03, 04	ROW_21	1	0	255	
ROW 22	03, 04	ROW_22	1	0	255	
ROW 23	03, 04	ROW_23	1	0	255	
ROW 24	03, 04	ROW_24	1	0	255	
ROW 25	03, 04	ROW_25	1	0	255	
ROW 26	03, 04	ROW_26	1	0	255	
ROW 27	03, 04	ROW_27	1	0	255	
ROW 28	03, 04	ROW_28	1	0	255	
ROW 29	03, 04	ROW_29	1	0	255	
ROW 30	03, 04	ROW_30	1	0	255	
ROW 31	03, 04	ROW_31	1	0	255	
ROW 32	03, 04	ROW_32	1	0	255	
ROW 33	03, 04	ROW_33	1	0	255	
ROW 34	03, 04	ROW_34	1	0	255	
ROW 35	03, 04	ROW_35	1	0	255	
ROW 36	03, 04	ROW_36	1	0	255	
ROW 37	03, 04	ROW_37	1	0	255	
ROW 38	03, 04	ROW_38	1	0	255	
ROW 39	03, 04	ROW_39	1	0	255	
ROW 40	03, 04	ROW_40	1	0	255	
ROW 41	03, 04	ROW_41	1	0	255	
ROW 42	03, 04	ROW_42	1	0	255	
ROW 43	03, 04	ROW_43	1	0	255	
ROW 44	03, 04	ROW_44	1	0	255	
ROW 45	03, 04	ROW_45	1	0	255	
ROW 46	03, 04	ROW_46	1	0	255	
ROW 47	03, 04	ROW_47	1	0	255	
ROW 48	03, 04	ROW_48	1	0	255	
ROW 49	03, 04	ROW_49	1	0	255	
ROW 50	03, 04	ROW_50	1	0	255	
ROW 51	03, 04	ROW_51	1	0	255	
ROW 52	03, 04	ROW_52	1	0	255	

Table 0.22 Modbus Quantities Table (Sheet 9 of 10)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling (X1 unless specified)
ROW 53	03, 04	ROW_53	1	0	255	
ROW 54	03, 04	ROW_54	1	0	255	
ROW 55	03, 04	ROW_55	1	0	255	
ROW 56	03, 04	ROW_56	1	0	255	
ROW 57	03, 04	ROW_57	1	0	255	
ROW 58	03, 04	ROW_58	1	0	255	
ROW 59	03, 04	ROW_59	1	0	255	
ROW 60	03, 04	ROW_60	1	0	255	
ROW 61	03, 04	ROW_61	1	0	255	
ROW 62	03, 04	ROW_62	1	0	255	
ROW 63	03, 04	ROW_63	1	0	255	
ROW 64	03, 04	ROW_64	1	0	255	
ROW 65	03, 04	ROW_65	1	0	255	
ROW 66	03, 04	ROW_66	1	0	255	
ROW 67	03, 04	ROW_67	1	0	255	
ROW 68	03, 04	ROW_68	1	0	255	
ROW 69	03, 04	ROW_69	1	0	255	
ROW 70	03, 04	ROW_70	1	0	255	
ROW 71	03, 04	ROW_71	1	0	255	
ROW 72	03, 04	ROW_72	1	0	255	
ROW 73	03, 04	ROW_73	1	0	255	
ROW 74	03, 04	ROW_74	1	0	255	
ROW 75	03, 04	ROW_75	1	0	255	
ROW 76	03, 04	ROW_76	1	0	255	
ROW 77	03, 04	ROW_77	1	0	255	
ROW 78	03, 04	ROW_78	1	0	255	
ROW 79	03, 04	ROW_79	1	0	255	
ROW 80	03, 04	ROW_80	1	0	255	
ROW 81	03, 04	ROW_81	1	0	255	
ROW 82	03, 04	ROW_82	1	0	255	
ROW 83	03, 04	ROW_83	1	0	255	
ROW 84	03, 04	ROW_84	1	0	255	
ROW 85	03, 04	ROW_85	1	0	255	
ROW 86	03, 04	ROW_86	1	0	255	
ROW 87	03, 04	ROW_87	1	0	255	
ROW 88	03, 04	ROW_88	1	0	255	
ROW 89	03, 04	ROW_89	1	0	255	
ROW 90	03, 04	ROW_90	1	0	255	
ROW 91	03, 04	ROW_91	1	0	255	
ROW 92	03, 04	ROW_92	1	0	255	

Table O.22 Modbus Quantities Table (Sheet 10 of 10)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling (X1 unless specified)
ROW 93	03, 04	ROW_93	1	0	255	
ROW 94	03, 04	ROW_94	1	0	255	
ROW 95	03, 04	ROW_95	1	0	255	
ROW 96	03, 04	ROW_96	1	0	255	
ROW 97	03, 04	ROW_97	1	0	255	
ROW 98	03, 04	ROW_98	1	0	255	
ROW 99	03, 04	ROW_99	1	0	255	

[a] Point names appearing in bold can be written with function code 06h or 10h.
[b] For quantities using two 16-bit registers, the register with the lower index is the most significant word and the register with the higher index is the least significant word in the 32-bit quantity.
[c] Breaker Close and Breaker Open are mutually exclusive and the relay asserts neither bit and returns the Exception Response if an attempt is made to write both bits.
[d] When PTCONN = DELTA, the relay returns phase-to-phase values for voltage labels VA, VB, VC, VAFA, VBFA, VCFA (i.e., VA returns VAB, VB returns VBC, and VC returns VCA).
[e] Zero-sequence voltage, and per-phase power, power factor, demand power, peak demand power, and energy values are not available when PTCONN = DELTA. The Modbus map may contain these labels, and the relay will return values of 0.00, except for power factors which will be reported as 1.00.
[f] The active settings group can be modified by writing the desired settings group number to ACTGRP. If a logic setting has been programmed to control the active settings group, the write will be accepted but the active group will not change.

Table O.23 Default Modbus Map (Sheet 1 of 2)

Modbus Address	User Map Register	Mapped Register Label[a]	Notes
000	MOD_001	IA	
001	MOD_002	IAFA	
002	MOD_003	IB	
003	MOD_004	IBFA	
004	MOD_005	IC	
005	MOD_006	ICFA	
006	MOD_007	IG	
007	MOD_008	IGFA	
008	MOD_009	IN	
009	MOD_010	INFA	
010	MOD_011	**VA**	VA contains VAB for PTCONN = DELTA
012	MOD_013	VAFA	VAFA contains VABFA angle for PTCONN = DELTA
013	MOD_014	**VB**	VB contains VBC for PTCONN = DELTA
015	MOD_016	VBFA	VBFA contains VBCFA angle for PTCONN = DELTA
016	MOD_017	**VC**	VC contains VCA for PTCONN = DELTA
018	MOD_019	VCFA	VCFA contains VCAFA angle for PTCONN = DELTA
019	MOD_020	**VS**	
021	MOD_022	VSFA	
022	MOD_023	**KW3**	
024	MOD_025	**KVAR3**	

Table O.23 Default Modbus Map (Sheet 2 of 2)

Modbus Address	User Map Register	Mapped Register Label[a]	Notes
026	MOD_027	PF3	
027	MOD_028	LDPF3	
028	MOD_029	FREQ	
029	MOD_030	VDC	
030	MOD_031	**MWH3I**	
032	MOD_033	**MWH3O**	
034	MOD_035	**MVRH3I**	
036	MOD_037	**MVRH3O**	
038	MOD_039	ACTGRP	
039	MOD_040	ROW_0	Front panel indicator LEDs
040	MOD_041	ROW_1	Front panel indicator LEDs
041	MOD_042	ROW_31	Contains 79RS, 79CY, 79LO
042	MOD_043	ROW_19	Contains 52A
043–249	MOD_044–MOD_250	Not Assigned	
250–1000		Reserved	
1001–1016		RID	Value of setting RID, two characters per register[b]
1017–1032		TID	Value of setting TID, two characters per register[b]
1033–65535		Reserved	

[a] Register labels appearing in bold are 32-bit quantities and consume two registers.
[b] Modbus Addresses 1001–1032 contain string data. Strings are packed 2 characters per register, with the most significant bit containing the character closest to the beginning of the string.

Modbus Settings Sheets

Modbus Map Settings (SET M Command)

Modbus User Map

See *Table O.22* for list of valid labels.

NOTE: 32-bit values, such as VA, VB, and VC consume two registers. When assigning registers, skip the registers following a 32-bit value to avoid errors in settings.

User Map Register Label Name	**MOD_001**	= ______________
User Map Register Label Name	**MOD_002**	= ______________
User Map Register Label Name	**MOD_003**	= ______________
User Map Register Label Name	**MOD_004**	= ______________
User Map Register Label Name	**MOD_005**	= ______________
User Map Register Label Name	**MOD_006**	= ______________
User Map Register Label Name	**MOD_007**	= ______________
User Map Register Label Name	**MOD_008**	= ______________
User Map Register Label Name	**MOD_009**	= ______________
User Map Register Label Name	**MOD_010**	= ______________
User Map Register Label Name	**MOD_011**	= ______________
User Map Register Label Name	**MOD_012**	= ______________
User Map Register Label Name	**MOD_013**	= ______________
User Map Register Label Name	**MOD_014**	= ______________
User Map Register Label Name	**MOD_015**	= ______________
User Map Register Label Name	**MOD_016**	= ______________
User Map Register Label Name	**MOD_017**	= ______________
User Map Register Label Name	**MOD_018**	= ______________
User Map Register Label Name	**MOD_019**	= ______________
User Map Register Label Name	**MOD_020**	= ______________
User Map Register Label Name	**MOD_021**	= ______________
User Map Register Label Name	**MOD_022**	= ______________
User Map Register Label Name	**MOD_023**	= ______________
User Map Register Label Name	**MOD_024**	= ______________
User Map Register Label Name	**MOD_025**	= ______________
User Map Register Label Name	**MOD_026**	= ______________
User Map Register Label Name	**MOD_027**	= ______________
User Map Register Label Name	**MOD_028**	= ______________

User Map Register Label Name	**MOD_029**	=	________________
User Map Register Label Name	**MOD_030**	=	________________
User Map Register Label Name	**MOD_031**	=	________________
User Map Register Label Name	**MOD_032**	=	________________
User Map Register Label Name	**MOD_033**	=	________________
User Map Register Label Name	**MOD_034**	=	________________
User Map Register Label Name	**MOD_035**	=	________________
User Map Register Label Name	**MOD_036**	=	________________
User Map Register Label Name	**MOD_037**	=	________________
User Map Register Label Name	**MOD_038**	=	________________
User Map Register Label Name	**MOD_039**	=	________________
User Map Register Label Name	**MOD_040**	=	________________
User Map Register Label Name	**MOD_041**	=	________________
User Map Register Label Name	**MOD_042**	=	________________
User Map Register Label Name	**MOD_043**	=	________________
User Map Register Label Name	**MOD_044**	=	________________
User Map Register Label Name	**MOD_045**	=	________________
User Map Register Label Name	**MOD_046**	=	________________
User Map Register Label Name	**MOD_047**	=	________________
User Map Register Label Name	**MOD_048**	=	________________
User Map Register Label Name	**MOD_049**	=	________________
User Map Register Label Name	**MOD_050**	=	________________
User Map Register Label Name	**MOD_051**	=	________________
User Map Register Label Name	**MOD_052**	=	________________
User Map Register Label Name	**MOD_053**	=	________________
User Map Register Label Name	**MOD_054**	=	________________
User Map Register Label Name	**MOD_055**	=	________________
User Map Register Label Name	**MOD_056**	=	________________
User Map Register Label Name	**MOD_057**	=	________________
User Map Register Label Name	**MOD_058**	=	________________
User Map Register Label Name	**MOD_059**	=	________________
User Map Register Label Name	**MOD_060**	=	________________
User Map Register Label Name	**MOD_061**	=	________________
User Map Register Label Name	**MOD_062**	=	________________
User Map Register Label Name	**MOD_063**	=	________________
User Map Register Label Name	**MOD_064**	=	________________
User Map Register Label Name	**MOD_065**	=	________________

User Map Register Label Name	**MOD_066**	= ______________
User Map Register Label Name	**MOD_067**	= ______________
User Map Register Label Name	**MOD_068**	= ______________
User Map Register Label Name	**MOD_069**	= ______________
User Map Register Label Name	**MOD_070**	= ______________
User Map Register Label Name	**MOD_071**	= ______________
User Map Register Label Name	**MOD_072**	= ______________
User Map Register Label Name	**MOD_073**	= ______________
User Map Register Label Name	**MOD_074**	= ______________
User Map Register Label Name	**MOD_075**	= ______________
User Map Register Label Name	**MOD_076**	= ______________
User Map Register Label Name	**MOD_077**	= ______________
User Map Register Label Name	**MOD_078**	= ______________
User Map Register Label Name	**MOD_079**	= ______________
User Map Register Label Name	**MOD_080**	= ______________
User Map Register Label Name	**MOD_081**	= ______________
User Map Register Label Name	**MOD_082**	= ______________
User Map Register Label Name	**MOD_083**	= ______________
User Map Register Label Name	**MOD_084**	= ______________
User Map Register Label Name	**MOD_085**	= ______________
User Map Register Label Name	**MOD_086**	= ______________
User Map Register Label Name	**MOD_087**	= ______________
User Map Register Label Name	**MOD_088**	= ______________
User Map Register Label Name	**MOD_089**	= ______________
User Map Register Label Name	**MOD_090**	= ______________
User Map Register Label Name	**MOD_091**	= ______________
User Map Register Label Name	**MOD_092**	= ______________
User Map Register Label Name	**MOD_093**	= ______________
User Map Register Label Name	**MOD_094**	= ______________
User Map Register Label Name	**MOD_095**	= ______________
User Map Register Label Name	**MOD_096**	= ______________
User Map Register Label Name	**MOD_097**	= ______________
User Map Register Label Name	**MOD_098**	= ______________
User Map Register Label Name	**MOD_099**	= ______________
User Map Register Label Name	**MOD_100**	= ______________
User Map Register Label Name	**MOD_101**	= ______________
User Map Register Label Name	**MOD_102**	= ______________

User Map Register Label Name	**MOD_103**	= ____________
User Map Register Label Name	**MOD_104**	= ____________
User Map Register Label Name	**MOD_105**	= ____________
User Map Register Label Name	**MOD_106**	= ____________
User Map Register Label Name	**MOD_107**	= ____________
User Map Register Label Name	**MOD_108**	= ____________
User Map Register Label Name	**MOD_109**	= ____________
User Map Register Label Name	**MOD_110**	= ____________
User Map Register Label Name	**MOD_111**	= ____________
User Map Register Label Name	**MOD_112**	= ____________
User Map Register Label Name	**MOD_113**	= ____________
User Map Register Label Name	**MOD_114**	= ____________
User Map Register Label Name	**MOD_115**	= ____________
User Map Register Label Name	**MOD_116**	= ____________
User Map Register Label Name	**MOD_117**	= ____________
User Map Register Label Name	**MOD_118**	= ____________
User Map Register Label Name	**MOD_119**	= ____________
User Map Register Label Name	**MOD_120**	= ____________
User Map Register Label Name	**MOD_121**	= ____________
User Map Register Label Name	**MOD_122**	= ____________
User Map Register Label Name	**MOD_123**	= ____________
User Map Register Label Name	**MOD_124**	= ____________
User Map Register Label Name	**MOD_125**	= ____________
User Map Register Label Name	**MOD_126**	= ____________
User Map Register Label Name	**MOD_127**	= ____________
User Map Register Label Name	**MOD_128**	= ____________
User Map Register Label Name	**MOD_129**	= ____________
User Map Register Label Name	**MOD_130**	= ____________
User Map Register Label Name	**MOD_131**	= ____________
User Map Register Label Name	**MOD_132**	= ____________
User Map Register Label Name	**MOD_133**	= ____________
User Map Register Label Name	**MOD_134**	= ____________
User Map Register Label Name	**MOD_135**	= ____________
User Map Register Label Name	**MOD_136**	= ____________
User Map Register Label Name	**MOD_137**	= ____________
User Map Register Label Name	**MOD_138**	= ____________
User Map Register Label Name	**MOD_139**	= ____________

User Map Register Label Name	**MOD_140**	= ________
User Map Register Label Name	**MOD_141**	= ________
User Map Register Label Name	**MOD_142**	= ________
User Map Register Label Name	**MOD_143**	= ________
User Map Register Label Name	**MOD_144**	= ________
User Map Register Label Name	**MOD_145**	= ________
User Map Register Label Name	**MOD_146**	= ________
User Map Register Label Name	**MOD_147**	= ________
User Map Register Label Name	**MOD_148**	= ________
User Map Register Label Name	**MOD_149**	= ________
User Map Register Label Name	**MOD_150**	= ________
User Map Register Label Name	**MOD_151**	= ________
User Map Register Label Name	**MOD_152**	= ________
User Map Register Label Name	**MOD_153**	= ________
User Map Register Label Name	**MOD_154**	= ________
User Map Register Label Name	**MOD_155**	= ________
User Map Register Label Name	**MOD_156**	= ________
User Map Register Label Name	**MOD_157**	= ________
User Map Register Label Name	**MOD_158**	= ________
User Map Register Label Name	**MOD_159**	= ________
User Map Register Label Name	**MOD_160**	= ________
User Map Register Label Name	**MOD_161**	= ________
User Map Register Label Name	**MOD_162**	= ________
User Map Register Label Name	**MOD_163**	= ________
User Map Register Label Name	**MOD_164**	= ________
User Map Register Label Name	**MOD_165**	= ________
User Map Register Label Name	**MOD_166**	= ________
User Map Register Label Name	**MOD_167**	= ________
User Map Register Label Name	**MOD_168**	= ________
User Map Register Label Name	**MOD_169**	= ________
User Map Register Label Name	**MOD_170**	= ________
User Map Register Label Name	**MOD_171**	= ________
User Map Register Label Name	**MOD_172**	= ________
User Map Register Label Name	**MOD_173**	= ________
User Map Register Label Name	**MOD_174**	= ________
User Map Register Label Name	**MOD_175**	= ________
User Map Register Label Name	**MOD_176**	= ________

User Map Register Label Name	**MOD_177**	= ____________
User Map Register Label Name	**MOD_178**	= ____________
User Map Register Label Name	**MOD_179**	= ____________
User Map Register Label Name	**MOD_180**	= ____________
User Map Register Label Name	**MOD_181**	= ____________
User Map Register Label Name	**MOD_182**	= ____________
User Map Register Label Name	**MOD_183**	= ____________
User Map Register Label Name	**MOD_184**	= ____________
User Map Register Label Name	**MOD_185**	= ____________
User Map Register Label Name	**MOD_186**	= ____________
User Map Register Label Name	**MOD_187**	= ____________
User Map Register Label Name	**MOD_188**	= ____________
User Map Register Label Name	**MOD_189**	= ____________
User Map Register Label Name	**MOD_190**	= ____________
User Map Register Label Name	**MOD_191**	= ____________
User Map Register Label Name	**MOD_192**	= ____________
User Map Register Label Name	**MOD_193**	= ____________
User Map Register Label Name	**MOD_194**	= ____________
User Map Register Label Name	**MOD_195**	= ____________
User Map Register Label Name	**MOD_196**	= ____________
User Map Register Label Name	**MOD_197**	= ____________
User Map Register Label Name	**MOD_198**	= ____________
User Map Register Label Name	**MOD_199**	= ____________
User Map Register Label Name	**MOD_200**	= ____________
User Map Register Label Name	**MOD_201**	= ____________
User Map Register Label Name	**MOD_202**	= ____________
User Map Register Label Name	**MOD_203**	= ____________
User Map Register Label Name	**MOD_204**	= ____________
User Map Register Label Name	**MOD_205**	= ____________
User Map Register Label Name	**MOD_206**	= ____________
User Map Register Label Name	**MOD_207**	= ____________
User Map Register Label Name	**MOD_208**	= ____________
User Map Register Label Name	**MOD_209**	= ____________
User Map Register Label Name	**MOD_210**	= ____________
User Map Register Label Name	**MOD_211**	= ____________
User Map Register Label Name	**MOD_212**	= ____________
User Map Register Label Name	**MOD_213**	= ____________

User Map Register Label Name	**MOD_214**	= ______________
User Map Register Label Name	**MOD_215**	= ______________
User Map Register Label Name	**MOD_216**	= ______________
User Map Register Label Name	**MOD_217**	= ______________
User Map Register Label Name	**MOD_218**	= ______________
User Map Register Label Name	**MOD_219**	= ______________
User Map Register Label Name	**MOD_220**	= ______________
User Map Register Label Name	**MOD_221**	= ______________
User Map Register Label Name	**MOD_222**	= ______________
User Map Register Label Name	**MOD_223**	= ______________
User Map Register Label Name	**MOD_224**	= ______________
User Map Register Label Name	**MOD_225**	= ______________
User Map Register Label Name	**MOD_226**	= ______________
User Map Register Label Name	**MOD_227**	= ______________
User Map Register Label Name	**MOD_228**	= ______________
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User Map Register Label Name	**MOD_230**	= ______________
User Map Register Label Name	**MOD_231**	= ______________
User Map Register Label Name	**MOD_232**	= ______________
User Map Register Label Name	**MOD_233**	= ______________
User Map Register Label Name	**MOD_234**	= ______________
User Map Register Label Name	**MOD_235**	= ______________
User Map Register Label Name	**MOD_236**	= ______________
User Map Register Label Name	**MOD_237**	= ______________
User Map Register Label Name	**MOD_238**	= ______________
User Map Register Label Name	**MOD_239**	= ______________
User Map Register Label Name	**MOD_240**	= ______________
User Map Register Label Name	**MOD_241**	= ______________
User Map Register Label Name	**MOD_242**	= ______________
User Map Register Label Name	**MOD_243**	= ______________
User Map Register Label Name	**MOD_244**	= ______________
User Map Register Label Name	**MOD_245**	= ______________
User Map Register Label Name	**MOD_246**	= ______________
User Map Register Label Name	**MOD_247**	= ______________
User Map Register Label Name	**MOD_248**	= ______________
User Map Register Label Name	**MOD_249**	= ______________
User Map Register Label Name	**MOD_250**	= ______________

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Appendix P
IEC 61850

Features

NOTE: The SEL-311C supports one CID file, which should be transferred only if a change in the relay configuration is required. If an invalid CID file is transferred, the relay will no longer have a valid IEC 61850 configuration, and the protocol will stop operating. To restart protocol operation, a valid CID must be transferred to the relay.

The SEL-311C Relay supports the following features using Ethernet and IEC 61850:

- **SCADA**—Connect up to six simultaneous IEC 61850 MMS client sessions. The SEL-311C also supports up to six buffered and six unbuffered report control blocks. See the CON Logical Device Table for Logical Node mapping that enables SCADA control via a Manufacturing Messaging Specification (MMS) browser. Controls support the direct control, select before operate control (SBO), and SBO with enhanced security control models.
- **Peer-to-Peer Real-Time Status and Control**—Use GOOSE with as many as 24 incoming (receive) and 8 outgoing (transmit) messages. virtual bits (VB001–VB128) can be mapped from incoming GOOSE messages.
- **Configuration**—Use FTP client software or ACSELERATOR Architect® SEL-5032 Software to transfer the Substation Configuration Language (SCL) Configured IED Description (CID) file to the relay.
- **Commissioning and Troubleshooting**—Use software such as MMS Object Explorer and AX-S4 MMS from Sisco, Inc., to browse the relay logical nodes and verify functionality.

This section presents the information you need to use the IEC 61850 features of the SEL-311C:

- *Introduction to IEC 61850 on page P.1*
- *IEC 61850 Operation on page P.3*
- *IEC 61850 Configuration on page P.18*
- *Logical Nodes on page P.20*
- *ACSI Conformance Statements on page P.36*

Introduction to IEC 61850

In the early 1990s, the Electric Power Research Institute (EPRI) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE) began to define a Utility Communications Architecture (UCA). They initially focused on inter-control center and substation-to-control center communications and produced the Inter-Control Center Communications Protocol (ICCP) specification. This specification, later adopted by the IEC as 60870-6 TASE.2, became the standard protocol for real-time exchange of data between databases.

In 1994, EPRI and IEEE began work on UCA 2.0 for Field Devices (simply referred to as UCA2). In 1997, they combined efforts with Technical Committee 57 of the IEC to create a common international standard. Their joint efforts created the current IEC 61850 standard.

The IEC 61850 standard, a superset of UCA2, contains most of the UCA2 specification, plus additional functionality. The standard describes client/server and peer-to-peer communications, substation design and configuration, testing, and project standards.

The IEC 61850 standard consists of the parts listed in *Table P.1*.

Table P.1 IEC 61850 Document Set

IEC 61850 Sections	Definitions
IEC 61850-1	Introduction and overview
IEC 61850-2	Glossary
IEC 61850-3	General requirements
IEC 61850-4	System and project management
IEC 61850-5	Communication requirements
IEC 61850-6	Configuration description language for substation IEDs
IEC 61850-7-1	Basic communication structure for substations and feeder equipment—Principles and models
IEC 61850-7-2	Basic communication structure for substations and feeder equipment—Abstract communication service interface (ACSI)
IEC 61850-7-3	Basic communication structure for substations and feeder equipment—Common data classes
IEC 61850-7-4	Basic communication structure for substations and feeder equipment—Compatible logical node (LN) classes and data classes
IEC 61850-8-1	SCSM—Mapping to Manufacturing Messaging Specification (MMS) (ISO/IEC 9506-1 and ISO/IEC 9506-2 over ISO/IEC 8802-3)
IEC 61850-9-1	SCSM—Sampled values over serial multidrop point-to-point link
IEC 61850-9-2	SCSM—Sampled values over ISO/IEC 8802-3
IEC 61850-10	Conformance testing

The IEC 61850 document set, available directly from the IEC at http://www.iec.ch, contains information necessary for successful implementation of this protocol. SEL strongly recommends that anyone involved with the design, installation, configuration, or maintenance of IEC 61850 systems be familiar with the appropriate sections of this standard.

IEC 61850 Operation

Ethernet Networking

IEC 61850 and Ethernet networking model options are available when ordering a new SEL-311C and may also be available as field upgrades to relays equipped with dual copper and dual or single fiber-optic Ethernet. In addition to IEC 61850, the relay provides support protocols and data exchange, including FTP and Telnet. Access the SEL-311C Port 5 settings to configure all of the Ethernet settings, including IEC 61850 enable settings.

The SEL-311C supports IEC 61850 services, including transport of Logical Node objects, over TCP/IP. The relay can coordinate a maximum of six concurrent IEC 61850 sessions.

Object Models

The IEC 61850 standard relies heavily on the Abstract Communication Service Interface (ACSI) models to define a set of services and the responses to those services. In terms of network behavior, abstract modeling enables all IEDs to act identically. These abstract models are used to create objects (data items) and services that exist independently of any underlying protocols. These objects are in conformance with the common data class (CDC) specification IEC 61850-7-3, which describes the type and structure of each element within a logical node. CDCs for status, measurements, controllable analogs and statuses, and settings all have unique CDC attributes. Each CDC attribute belongs to a set of functional constraints that groups the attributes into specific categories such as status (ST), description (DC), and substituted value (SV). Functional constraints, CDCs, and CDC attributes are used as building blocks for defining Logical Nodes.

UCA2 used GOMSFE (Generic Object Models for Substation and Feeder Equipment) to present data from station IEDs as a series of objects called models or bricks. The IEC working group has incorporated GOMSFE concepts into the standard, with some modifications to terminology; one change was the renaming of bricks to logical nodes. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function. For example, the MMXU logical node (polyphase measurement unit) contains measurement data and other points associated with three-phase metering including voltages and currents. Each IED may contain many functions such as protection, metering, and control. Multiple logical nodes represent the functions in multifunction devices.

Logical nodes can be organized into logical devices that are similar to directories on a computer disk. As represented in the IEC 61850 network, each physical device can contain many logical devices and each logical device can contain many logical nodes. Many relays, meters, and other IEC 61850 devices contain one primary logical device where all models are organized.

IEC 61850 devices are capable of self-description. You do not need to refer to the specifications for the logical nodes, measurements, and other components to request data from another IEC 61850 device. IEC 61850 clients can request and display a list and description of the data available in an IEC 61850 server device. This process is similar to the autoconfiguration process used within SEL communications processors (SEL-2032 and SEL-2030). Simply run an MMS browser to query devices on an IEC 61850 network and discover what data are available. Self-description also permits extensions to both standard and custom data models. Instead of having to look up data in a profile stored in its database, an IEC 61850 client can simply query an IEC 61850 device and receive a description of all logical devices, logical nodes, and available data.

Unlike other Supervisory Control and Data Acquisition (SCADA) protocols that present data as a list of addresses or indices, IEC 61850 presents data with descriptors in a composite notation made up of components. *Table P.2* shows how the A-phase current expressed as MMXU1AphsA$cVal is broken down into its component parts.

Table P.2 Example IEC 61850 Descriptor Components

Component		Description
METMMXU1	Logical Node	Polyphase measurement unit
A	Data Object	Phase-to-ground amperes
phsA	Sub-Data Object	Phase A
cVal	Data Attribute	Complex value

Data Mapping

Device data is mapped to IEC 61850 Logical Nodes (LN) according to rules defined by SEL. Refer to IEC 61850-5:2003(E) and IEC 61850-7-4:2003(E) for the mandatory content and usage of these LNs. The SEL-311C logical nodes are grouped under Logical Devices for organization based on function. See *Table P.3* for descriptions of the Logical Devices in an SEL-311C. See *Logical Nodes on page P.20* for a description of the LNs that make up these Logical Devices.

Table P.3 SEL-311C Logical Devices

Logical Device	Description
ANN	Annunciator elements—alarms, status values
CFG	Configuration elements—datasets and report control blocks
CON	Control elements—remote bits
MET	Metering or Measurement elements—currents, voltages, power, etc.
PRO	Protection elements—protection functions and breaker control

MMS

Manufacturing Messaging Specification (MMS) provides services for the application-layer transfer of real-time data within a substation LAN. MMS was developed as a network independent data exchange protocol for industrial networks in the 1980s and standardized as ISO 9506.

In theory, you can map IEC 61850 to any protocol. However, it can become unwieldy and quite complicated to map objects and services to a protocol that only provides access to simple data points via registers or index numbers. MMS supports complex named objects and flexible services that enable mapping to IEC 61850 in a straightforward manner. This was why the UCA users group used MMS for UCA from the start, and why the IEC chose to keep it for IEC 61850.

GOOSE

The Generic Object Oriented Substation Event (GOOSE) object within IEC 61850 is for high-speed control messaging. IEC 61850 GOOSE automatically broadcasts messages containing status, controls, and measured values onto the network for use by other devices. IEC 61850 GOOSE sends the message several times, increasing the likelihood that other devices receive the messages. GOOSE message publication is a persistent function. Once GOOSE is enabled, the IED will continuously publish GOOSE messages until they are disabled regardless of the contents. The publication process description indicates when and why the publication rate changes.

IEC 61850 GOOSE objects can quickly and conveniently transfer status, controls, and measured values between peers on an IEC 61850 network. Configure SEL devices to respond to GOOSE messages from other network devices with ACSELERATOR Architect. Also, configure outgoing GOOSE messages for SEL devices in ACSELERATOR Architect. See the ACSELERATOR Architect instruction manual or online help for more information.

Each IEC 61850 GOOSE sender includes a text identification string (GOOSE Control Block Reference), APP ID field, and an Ethernet multicast group address, in each outgoing message. Some devices that receive GOOSE messages use the text identification and multicast group to identify and filter incoming GOOSE messages. The SEL-311C uses only the APP ID and multicast group to identify and filter incoming GOOSE messages.

Virtual bits (VB001–VB128) are control inputs that you can map to GOOSE receive messages using the ACSELERATOR Architect software. See *Table P.19* for details on which logical nodes and attributes are used for these bits. This information can be useful when searching through device data with MMS browsers. If you intend to use any SEL-311C virtual bits for controls, you must create SELOGIC® equations to define these operations.

File Services

The Ethernet File System allows reading or writing data as files. The File System supports FTP. The File System provides:

- A means for the device to transfer data as files.
- A hierarchal file structure for the device data.

SCL Files

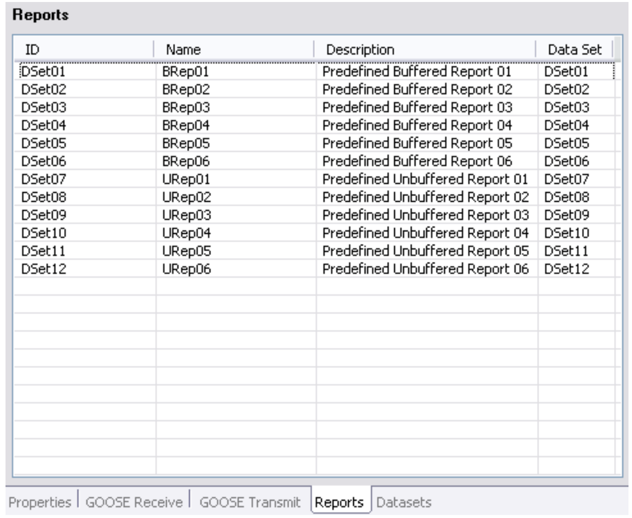
Substation Configuration Language (SCL) is an XML-based configuration language used to support the exchange of database configuration data between different tools, which may come from different manufacturers. There are four types of SCL files:

- Intelligent Electronic Device (IED) Capability Description file (.ICD)
- System Specification Description (.SSD) file
- Substation Configuration Description file (.SCD)
- Configured IED Description file (.CID)

The ICD file describes the capabilities of an IED, including information on LN and GOOSE support. The SSD file describes the single-line diagram of the substation and the required LNs. The SCD file contains information on all IEDs, communications configuration data, and a substation description. The CID file, of which there may be several, describes a single instantiated IED within the project, and includes address information.

Reports

SEL-311C supports buffered and unbuffered report control blocks in the report model as defined in IEC 61850-8-1:2004(E). The predefined reports shown in *Figure P.1* are available by default via IEC 61850.


Reports

ID	Name	Description	Data Set
DSet01	BRep01	Predefined Buffered Report 01	DSet01
DSet02	BRep02	Predefined Buffered Report 02	DSet02
DSet03	BRep03	Predefined Buffered Report 03	DSet03
DSet04	BRep04	Predefined Buffered Report 04	DSet04
DSet05	BRep05	Predefined Buffered Report 05	DSet05
DSet06	BRep06	Predefined Buffered Report 06	DSet06
DSet07	URep01	Predefined Unbuffered Report 01	DSet07
DSet08	URep02	Predefined Unbuffered Report 02	DSet08
DSet09	URep03	Predefined Unbuffered Report 03	DSet09
DSet10	URep04	Predefined Unbuffered Report 04	DSet10
DSet11	URep05	Predefined Unbuffered Report 05	DSet11
DSet12	URep06	Predefined Unbuffered Report 06	DSet12

Properties | GOOSE Receive | GOOSE Transmit | Reports | Datasets

Figure P.1 SEL-311C Predefined Reports

There are twelve report control blocks (six buffered and unbuffered reports). For each buffered report control block, there can be just one client association, i.e., only one client can be associated to a report control block (BRCB) at any given time. The number of reports (12) and the type of reports (buffered or unbuffered) cannot be changed. However, by using ACSELERATOR Architect, you can reallocate data within each report dataset to present different data attributes for each report beyond the predefined datasets.

For buffered reports, connected clients may edit the report parameters shown in *Table P.4*.

Table P.4 Buffered Report Control Block Client Access

RCB Attribute	User Changeable (Report Disabled)	User Changeable (Report Enabled)	Default Values
RptId	YES		FALSE
RptEna	YES	YES	FALSE
OptFlds	YES		segNum
			timeStamp
			dataSet
			reasonCode
			dataRef
BufTm	YES		500
TrgOp	YES		dchg
			qchg
IntgPd	YES		FALSE
GI	YES[a] [b]	YES[a]	FALSE
PurgeBuf	YES[a]		FALSE
EntryId	YES		0

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted will return to zero. Always read as zero.
[b] When disabled, a GI will be processed and the report buffered if a buffer has been previously established. A buffer is established when the report is enabled for the first time.

Similarly, for unbuffered reports, connected clients may edit the report parameters shown in *Table P.5*.

Table P.5 Unbuffered Report Control Block Client Access

RCB Attribute	User Changeable (Report Disabled)	User Changeable (Report Enabled)	Default Values
RptId	YES		FALSE
RptEna	YES	YES	FALSE
Resv	YES		FALSE
OptFlds	YES		segNum
			timeStamp
			dataSet
			reasonCode
			dataRef
BufTm	YES		250
TrgOps	YES		dchg
			qchg
IntgPd	YES		FALSE
GI		YES[a]	0

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted will return to zero. Always read as zero.

For buffered reports, only one client can enable the RptEna attribute of the BRCB at a time resulting in a client association for that BRCB. Once enabled, the associated client has exclusive access to the BRCB until the connection is closed or the client disables the RptEna attribute. Once enabled, all unassociated clients have read only access to the BRCB.

For unbuffered reports, up to six clients can enable the RptEna attribute of an URCB at a time resulting in multiple client associations for that URCB. Once enabled, each client has independent access to a copy of that URCB.

The Resv attribute is writable, however, the SEL-311C does not support reservations. Writing any field of the URCB causes the client to obtain their own copy of the URCB-in essence, acquiring a reservation.

Reports are serviced at a 2 Hz rate. The client can set the IntgPd to any value with a resolution of 1 ms. However, the integrity report is only sent when the period has been detected as having expired. The report service rate of 2 Hz results in a report being sent within 500 ms of expiration of the IntgPd. The new IntgPd will begin at the time that the current report is serviced.

Datasets

The list of datasets in *Figure P.2* are the defaults for an SEL-311C device.

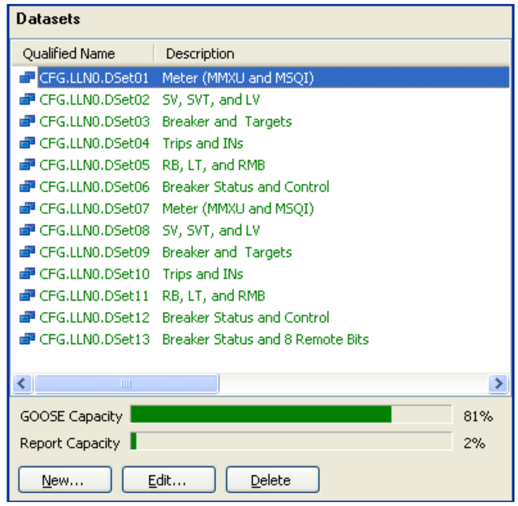


Figure P.2 SEL-311C Datasets

Within ACSELERATOR Architect, IEC 61850 datasets have two main purposes:

- GOOSE: You can use predefined or edited datasets, or create new datasets for outgoing GOOSE transmission.
- Reports: Twelve predefined datasets (DSet01 to DSet12) correspond to the default six buffered and six unbuffered reports. Note that you cannot change the number (12) or type of reports (buffered or unbuffered) within ACSELERATOR Architect. However, you can alter the data attributes that a dataset contains and so define what data an IEC 61850 client receives with a report.

NOTE: Do not edit the dataset names used in reports. Changing or deleting any of those dataset names will cause a failure in generating the corresponding report.

Supplemental Software

Examine the data structure and values of the supported IEC 61850 LNs with an MMS browser such as MMS Object Explorer and AX-S4 MMS from Sisco, Inc.

The settings needed to browse an SEL-311C with an MMS browser are shown below.

OSI-PSEL (Presentation Selector)	00000001
OSI-SSEL (Session Selector)	0001
OSI-TSEL (Transport Selector)	0001

Time Stamps and Quality

In addition to the various data values, the two attributes quality and t (time stamp) are available at any time. The timestamp is determined when data or quality change is detected and is UTC reported as the Second of Century since January 1, 1970, plus fractional seconds.

The timestamp is applied to all data and quality attributes (Boolean, Bstrings, Analogs, etc.) in the same fashion when a data or quality change is detected.

Functionally Constrained Data Attributes mapped to points assigned to the SER report have 4 ms SER-accuracy timestamps for data change events. In order to ensure that you will get SER-quality timestamps for changes to certain points, you must include those points in the SER report. All other

FCDAs are scanned for data changes on a 1/2-second interval and have 1/2-second timestamp accuracy. See *SET Command (Change Settings) on page 10.49* for information on programming the SER report.

The SEL-311C uses GOOSE quality attributes to indicate the quality of the data in its transmitted GOOSE messages. Under normal conditions, all attributes are zero, indicating good quality data. Internal status indicators provide the information necessary for the device to set these attributes. If the device becomes disabled, as shown via status indications (e.g., an internal self-test failure), the SEL-311C will stop transmitting GOOSE messages.

GOOSE Processing and Performance

SEL devices support GOOSE processing as defined by IEC 61850-7-1:2003(E), IEC 61850-7-2:2003(E), and IEC 61850-8-1:2004(E).

Four times per power system cycle, the relay reads inputs, processes protection algorithms, and controls outputs. Each of these quarter-cycle periods is called a processing interval. GOOSE messages are considered inputs and outputs, and are processed with the same priority as contact inputs, contact outputs, and protection algorithms. The relay processes incoming GOOSE messages near the beginning of every processing interval just after it reads the contact inputs, and processes outgoing GOOSE messages near the end of every processing interval after it controls the contact outputs. See *Table F.4* for more information about processing order in the SEL-311C.

GOOSE Construction Tips

- Quality bit strings published from SEL relays are not generally useful in determining the quality of associated data because the SEL IEDs suspend publication of GOOSE messages if any quality attribute fails. Therefore receipt of the message indicates that all quality attributes are normal. Do not include quality bit strings in published GOOSE messages unless required by some other type of IED.
- Make GOOSE publications as small as possible. Include in the GOOSE publication only the information required by subscribing relays.
- Give higher VLAN priority tags to more important GOOSE. This allows the network to preferentially forward those GOOSE to the subscribers, and also gives a subscribing SEL-311C an indication that the more important GOOSE should be decoded before lower priority GOOSE.

GOOSE Construction Example

The dataset shown in *Figure P.3* is used in a GOOSE publication from an SEL-421. It contains information that is not necessary to a subscribing SEL-311C relay. For example, the dataset contains the Mod, Beh, and Health fields (ANN.CCOUTGGIO21.Mod.*, ANN.CCOUTGGIO21.Beh.*, and ANN.CCOUTGGIO21.Health.*) from the CCOUT logical node. In this case, the information in those fields are of no use to a subscribing SEL-311C. Also, each of the two CCOUT contained in the dataset are accompanied by their corresponding quality bit strings and time stamps (ANN.CCOUTGGIO21.Ind01.q, ANN.CCOUTGGIO21.Ind01.t, ...). If the quality field is included in a GOOSE to which the SEL-311C subscribes, then the SEL-311C must spend additional processing time decoding that quality bit string and applying it to the associated data.

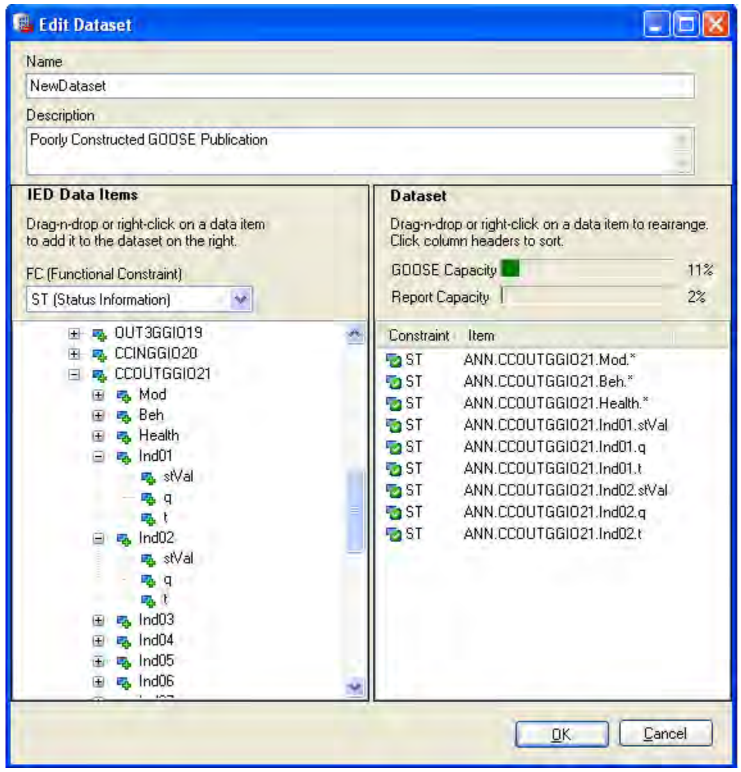


Figure P.3 Example of a Poorly Constructed GOOSE Dataset

Figure P.4 shows an example of a GOOSE publication from an SEL-421 with better construction. This dataset contains only the information required by the subscribing relay(s) to decode the CCOUT status from the publishing SEL-421 (.CCOUTGGIO21.Ind01.stVal and CCOUTGGIO21.Ind02.stVal) and does not include quality bit strings or time stamps.

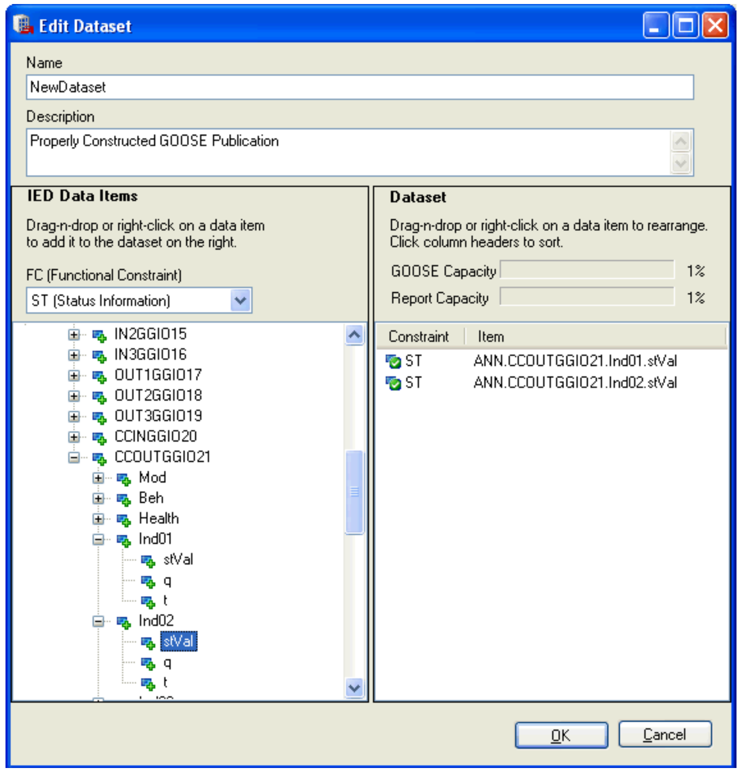


Figure P.4 Example of a Properly Constructed GOOSE Dataset

GOOSE Subscription (Receive) Processing

The relay supports up to 24 GOOSE subscriptions. GOOSE messages which arrive at the relay are subjected to the following processing steps.

Filter

Each message is inspected for proper multicast MAC address and GOOSE App ID. If those parameters match values expected by the relay for one of the up to 24 GOOSE subscriptions, then the message is passed on to the next level of processing. Otherwise the message is discarded. Each message on the LAN must have a unique combination of multicast MAC address and GOOSE App ID.

Buffer

The relay retains the most recent arrival for each of up to 24 subscriptions. If a subsequent GOOSE arrives for a subscription that already has a message buffered, then the earlier arrival is discarded.

Decode

The decoding process consists of several stages. Each decoding stage has an associated processing cost, and the relay limits the total cost of all received GOOSE decoding to reserve enough time to process protection algorithms, programmable logic, outputs, outgoing GOOSE messages, etc. If messages costing more than 80 points to decode are in the receive buffers at the beginning of the processing interval, then some messages will be decoded on subsequent processing intervals. The sections below describe how the relay scores each message as it is decoded.

Header Decoding

Each message contains a header which indicates the status of the message. The relay ignores the remainder of the message if any of four indicators in the message header are true:

- Configuration Mismatch. The configuration number of the incoming GOOSE changes.
- Needs Commissioning. This Boolean parameter of the incoming GOOSE message is true.
- Test Mode. This Boolean parameter of the incoming GOOSE message is true.
- State Number. This parameter is the same as the last time the message was decoded. State Number increments when the contents of the message change, so if the State Number is unchanged, there is no reason to decode the rest of the message.

Whether the header indicates the message should be subjected to further decoding or ignored, decoding the header always costs eight points.

Message Body Decoding

The cost of decoding the message body depends on the structure of the message. *Table P.6* shows the cost of each type of data in the message body, and also shows the cost of decoding the message header.

Table P.6 Point Cost of Decoding GOOSE Messages

Data Type	Description	Point Value	Comments
	Message header	8	Each message counts for at least eight points, regardless of the content of the message.
Message Quality Bit	A Boolean value created in the receiving relay indicating the status of the received message	0	This bit can always be mapped to local virtual bits for zero cost.
Boolean	A Boolean value mapped to a virtual bit	1	Boolean values not mapped to local virtual bits count as zero points.
Quality Bit String	A quality field associated with a data item, where the data item contains data mapped to a virtual bit	1	Quality fields not associated with a data item containing data that is mapped to a virtual bit count as zero points.
Time	Data item time stamp	0	Some data items are accompanied by a time stamp. The time stamp is never used or decoded by the SEL-311C. It counts as zero points.
Bit String (other than Quality)	Several bits packed together in the same data item, where at least one of the bits is mapped to a virtual bit	1 for the bit string, plus 1 per bit in the bit string mapped to a virtual bit	Bit strings are often used for breaker position. A bit string that contains no bits mapped to a virtual bit counts as zero points.
Floating Point	Either single or double precision floating point values	0	Floating point values always count as zero points.
Other types of data	Any data type other than those shown above		The relay will correctly process any valid GOOSE message to which it subscribes. However, some data types are costly for the relay to process even if the data is not used by the receiving relay. Contact the SEL factory if you must configure the SEL-311C to subscribe to GOOSE messages with data types other than those listed above.

Message Point Value Calculation Example

Assume the relay subscribes to a message with 10 Boolean values, five of which are mapped to local virtual bits. Each of the 10 Boolean values is accompanied by a quality indicator. The message also contains one breaker position (a two-bit string) with accompanying quality indicator and time stamp. The two bits of breaker position are mapped to two virtual bits in the SEL-311C. The message also contains one single precision floating point number and one double precision floating point number. In addition, the message quality bit is mapped to a local virtual bit.

The dataset for such a message is shown in *Figure P.5*. As described above not all items from the dataset are mapped to local resources within the receive SEL-351S. Similar to the example GOOSE shown in *Figure P.3*, the GOOSE message show in *Figure P.5* is poorly constructed and is shown only as an example of a GOOSE message containing several types of data.

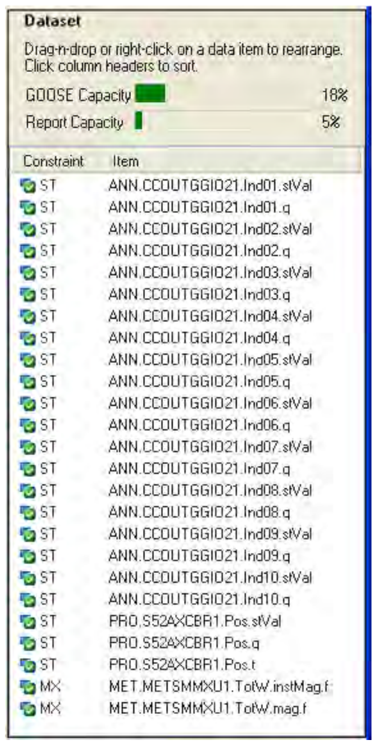


Figure P.5 Example Receive GOOSE Dataset

The score for this message is as follows:

- 8 points for the message
- 0 points for the message quality bit
- 5 points for 5 mapped Booleans
- 5 points for 5 quality fields associated with data items that have data mapped to local virtual bits
- 3 points total for the breaker position indication (one for the bit string and one each for the two bits in the string)
- 1 point for the quality bit string associated with the breaker position bit string
- 0 points for the breaker position bit string time stamp
- 0 points for the single precision floating point data
- 0 points for the double precision floating point number

22 total points in this message

Examples of GOOSE Subscription (Receive) Processing

If the total score for all messages received in a single processing interval is 80 or fewer points, then the relay is guaranteed to process and apply all received data during that processing interval. For example, assume the relay subscribes to messages as shown in *Table P.7*.

Table P.7 Scores for Subscribed Messages Use in Example

Subscription Number	Message Score
1	16
2	20
3	10
4	16
5	18
TOTAL	80

The total score for all of the subscribed messages is 80 points. Even if every message in *Table P.7* arrives every processing interval, and even if the header information from every message indicates that the message must be decoded, the relay is guaranteed to process every message, update the local virtual bits, and use those updated values in programmable logic during that processing interval.

Next, assume that the relay subscribes to messages as shown in *Table P.8*.

Table P.8 Scores for Subscribed Messages Used in Example

Subscription Number	Message Score
1	16
2	28
3	10
4	16
5	16
6	10
7	20
8	10
TOTAL	126

The total score for all of the subscribed message is 126 points. Notice that if all of the message points are due to message headers and mapped Boolean values, then these 8 messages represent 62 Boolean values mapped to local virtual bits or breaker control bits. Assume every message arrives during the same processing interval, but messages 1 through 5 are repeats of messages processed earlier (i.e., those messages do not have changed state numbers). Those 5 repeated messages count as 8 points each, or 40 points total. Assume messages 6, 7, and 8 each contain changed data, so the state number has incremented since the last time the message was processed. The combined score for messages 6, 7, and 8 is 40 points. So the total score for all messages is 80 points. In this case, the relay will process all messages in a single processing interval.

Finally, assume that the relay subscribes to messages as shown in *Table P.9*.

Table P.9 Scores for Subscribed Messages Used in Example

Subscription Number	Message Score
1	16
2	20
3	10
4	16
5	16
6	10
7	12
8	28
9	16
10	20
11	10
12	16
13	10
14	10
15	12
16	16
17	20
18	10
19	16
20	16
21	10
22	12
23	28
24	16
Total	366

The total combined score for all of the subscribed messages is 366 points. As long as messages totalling 80 or fewer points arrive each processing interval, the relay will process all received messages every processing interval. If messages totalling more than 80 points arrive in any processing interval, then the relay will process messages totalling 80 or fewer points, and will continue processing during the next quarter-cycle processing interval.

GOOSE Publication (Transmit) Processing

The relay supports up to eight GOOSE publications. Each publication can contain data from any logical node in the relay. The relay transmits a message from each publication soon after initialization (e.g., after power up). Near the end of each processing interval, the relay transmits one message from as many publications as possible in which the state numbers have incremented. The relay then transmits one message from as many publications as possible in which the transmit interval timers have expired.

State Number

The relay maintains a count of the number of times the contents of a publication have changed. The count is called the state number. If the state number increments, then the relay transmits a message from that publication, and resets to 4 ms the transmit interval discussed below.

Transmit Interval

If the data contained in the messages does not change (i.e., if the state number does not increase), then the relay retransmits the message after a time interval. The time interval increases for each retransmission. The first retransmission is approximately 4 ms after the original transmission. The second retransmission is 8 ms after the first retransmission, which is 12 ms after the original transmission. The intervals between retransmissions double for each retransmission (i.e., 4 ms, 8 ms, 16 ms, 32 ms) until reaching a maximum value specified in the CID file. That maximum value is configured by the user with SEL Architect. The Time-to-Live reported in each transmitted message is three times the present retransmission interval, or twice the present retransmission interval if the maximum retransmission interval has been reached.

The total number of message transmissions possible during each processing interval due to either state number changes or transmit interval timeout depends on the structure of the messages to be transmitted. The relay assigns each message a point value at configuration time (when the relay receives and parses the CID file). Each processing interval the relay processes and transmits messages totaling up to 40 points. If messages totaling more than 40 points are available to be transmitted either because their transmit intervals have timed out or because their state numbers have incremented, then some of the messages will be transmitted on subsequent processing intervals. *Table P.10* shows the point value for different parts of the GOOSE message.

Table P.10 Score For Data Types Contained in Published Messages

Data Type	Description	Point Value	Comments
	Message	8	Each message counts at least 8 points every time it is transmitted, regardless of the content of the message. A message that is not transmitted counts as zero points.
Boolean, Quality Bit Strings, Time, Bit Strings (Other than Quality), Floating Point, Enumerations		1	Each of these data types cost one point to process and transmit.
Other Types of Data	Types of data other than those mentioned above.		The relay will correctly process and transmit any valid GOOSE message. However, some data types are costly for the relay to process. Contact the SEL factory if you must configure the SEL-311C to publish GOOSE messages with data types other than those listed above.

Message Point Value Calculation Example

Assume the relay publishes a message with 10 Boolean values. Each of the 10 Boolean values is accompanied by a Quality indicator and a time stamp. The message contains one single precision floating point number and one double precision floating point number, each with an associated time stamp.

The dataset for such a message is shown in *Figure P.6*. Similar to the example GOOSE shown in *Figure P.3*, the GOOSE message show in *Figure P.6* is poorly constructed and is shown only as an example of a GOOSE message containing several types of data.

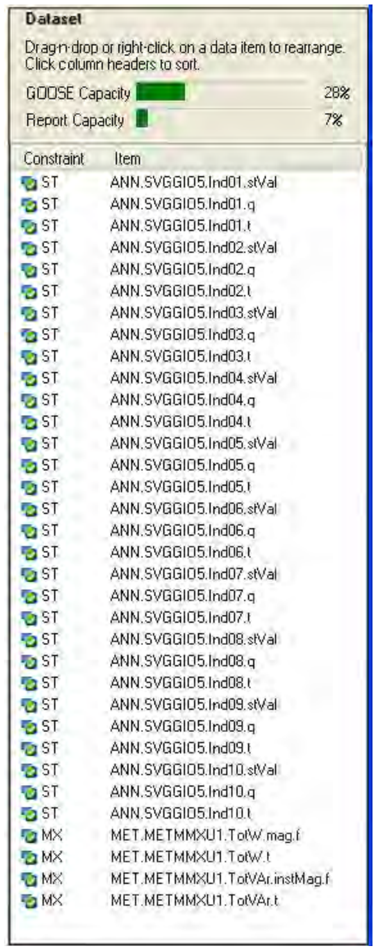


Figure P.6 Example Transmit GOOSE Dataset

The score for this message is as follows:

- 8 points for the message
- 10 points for 10 Boolean values
- 10 points for 10 quality bit strings associated with the Boolean values
- 10 points for 10 time stamps associated with the Boolean values
- 1 point for the single precision floating point number
- 1 point for the time stamp associated with the single precision floating point number
- 1 point for the double precision floating point number
- 1 point for the time stamp associated with the double precision floating point number

42 total points in this message

Message Transmission Example

Assume the relay publishes GOOSE messages as shown in *Table P.11*.

Table P.11 Scores for Published Messages Used In Example

Publication Number	Message Score
1	10
2	10
3	9
4	11
Total	40

The total score for all publications in this example is 40 points. The relay can process and transmit all messages every processing interval if required.

Next assume the relay publishes messages as shown in *Table P.12*.

Table P.12 Scores for Published Messages Used In Example

Publication Number	Message Score
1	32
2	40
3	20
4	32
5	32
6	20
7	24
8	56
Total	256

The total score for all publications in this example is 256 points. If messages totaling more than 40 points are due to be transmitted in any single processing interval, then the relay will transmit messages until the next message transmitted would cause the total score for that processing interval to exceed 40 points. The relay will then continue transmitting during the next quarter-cycle processing interval.

IEC 61850 Configuration

Settings

Table P.13 lists IEC 61850 settings. These settings are only available if your device includes the optional IEC 61850 protocol.

Table P.13 IEC 61850 Settings

Label	Description	Range	Default
E61850	IEC 61850 interface enable	Y, N	N
EGSE	Outgoing IEC 61850 GSE message enable	Y[a], N	N

[a] Requires E61850 set to Y to send IEC 61850 GSE messages.

Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with ACSELERATOR Architect software.

ACSELERATOR Architect

The ACSELERATOR Architect software enables protection and integration engineers to design and commission IEC 61850 substations containing SEL IEDs.

Engineers can use ACSELERATOR Architect to:

- Organize and configure all SEL IEDs in a substation project.
- Configure incoming and outgoing GOOSE messages.
- Edit and create GOOSE datasets.
- Read non-SEL IED Capability Description (ICD) and Configured IED Description (CID) files and determine the available IEC 61850 messaging options.
- Use or edit preconfigured datasets for reports.
- Load IEC 61850 CID files into SEL IEDs.
- Generate ICD files that will provide SEL IED descriptions to other manufacturers' tools so they can use SEL GOOSE messages and reporting features.

ACSELERATOR Architect provides a Graphical User Interface (GUI) for engineers to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, the user first places icons representing IEDs in a substation container, then edits the outgoing GOOSE messages or creates new ones for each IED. The engineer can also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain. ACSELERATOR Architect has the capability to read other manufacturers' ICD and CID files, enabling the user to map the data seamlessly into SEL IED logic. See the ACSELERATOR Architect online help for more information.

Logical Node Extensions

The following Logical Nodes and Data Classes have been added to this device in accordance with IEC 61850 guidelines.

Table P.14 Metering and Measurement

Logical Node	IEC 61850	Description or Comments
Demand Metering	METMDST1	Demand and peak demand values for current and energy.

Demand Metering Data

Table P.15 defines the data class "Demand metering data." This class is a collection of measurements (or evaluations) that represent the demand metering values.

Table P.15 Demand Metering Data Class Definitions(Sheet 1 of 2)

MTHR Class Attribute Name	Attr. Type	Data Source	Explanation	T	M/O
Common Logical Node Information					
LNName			Shall be inherited from Logical-Node Class (see IEC 61850-7-2).		M
Measured Values					
DmdA.nseq	WYE	3I2DEM	Demand, negative sequence current		O
PkDmdA.nseq	WYE	3I2PK	Peak demand, negative sequence current		O
DmdA.phsA	MV	IADEM	Demand, phase A current		O

Table P.15 Demand Metering Data Class Definitions(Sheet 2 of 2)

MTHR Class Attribute Name	Attr. Type	Data Source	Explanation	T	M/O
PkDmdA.phsA	MV	IAPK	Peak demand, phase A current		O
DmdA.phsB	MV	IBDEM	Demand, phase B current		O
PkDmdA.phsB	MV	IBPK	Peak demand, phase B current		O
DmdA.phsC	MV	ICDEM	Demand, phase C current		O
PkDmdA.phsC	MV	ICPK	Peak demand, phase C current		O
DmdA.res	MV	IGDEM	Demand, residual current		O
PkDmdA.res	MV	IGPK	Peak demand, residual current		O
DmdA.neut	MV	INDEM	Demand, neutral current		O
PkDmdA.neut	MV	INPK	Peak demand, neutral current		O
SupVArh	MV	MVRH3I	Energy, reactive (MVARh), supply direction toward busbar		O
DmdVArh	MV	MVRH3O	Energy, reactive (MVARh), supply direction away from busbar		O
SupWh	MV	MWH3I	Energy, real (MWh), supply direction toward busbar		O
DmdWh	MV	MWH3O	Energy, real (MWh), supply direction away from busbar		O

Logical Nodes

NOTE: Not all quantities are available in all settings configurations.

Table P.16 through *Table P.19* show the logical nodes (LNs) supported in the SEL-311C and the Relay Word bits or Measured Values mapped to those LNs.

Table P.16 shows the LNs associated with protection elements, defined as Logical Device PRO. See *Appendix D: Relay Word Bits* for descriptions.

Table P.16 Logical Device: PRO (Protection) (Sheet 1 of 7)

Logical Node	Attribute	Relay Word Bit	Comment
PPIOC1	Op.general	50P1	Instantaneous phase overcurrent, level 1
GPIOC1	Op.general	50G1	Instantaneous residual overcurrent, level 1
QPIOC1	Op.general	50Q1	Instantaneous negative-sequence overcurrent, level 1
PPIOC2	Op.general	50P2	Instantaneous phase overcurrent, level 2
GPIOC2	Op.general	50G2	Instantaneous residual overcurrent, level 2
QPIOC2	Op.general	50Q2	Instantaneous negative-sequence overcurrent, level 2
PPIOC3	Op.general	50P3	Instantaneous phase overcurrent, level 3
GPIOC3	Op.general	50G3	Instantaneous residual overcurrent, level 3
QPIOC3	Op.general	50Q3	Instantaneous negative-sequence overcurrent, level 3
PPIOC4	Op.general	50P4	Instantaneous phase overcurrent, level 4
GPIOC4	Op.general	50G4	Instantaneous residual overcurrent, level 4
QPIOC4	Op.general	50Q4	Instantaneous negative-sequence overcurrent, level 4
APIOC1	Op.general	50A1	Instantaneous phase A overcurrent, level 1
BPIOC1	Op.general	50B1	Instantaneous phase B overcurrent, level 1
CPIOC1	Op.general	50C1	Instantaneous phase C overcurrent, level 1
APIOC2	Op.general	50A2	Instantaneous phase A overcurrent, level 2
BPIOC2	Op.general	50B2	Instantaneous phase B overcurrent, level 2

Table P.16 Logical Device: PRO (Protection) (Sheet 2 of 7)

Logical Node	Attribute	Relay Word Bit	Comment
CPIOC2	Op.general	50C2	Instantaneous phase C overcurrent, level 2
APIOC3	Op.general	50A3	Instantaneous phase A overcurrent, level 3
BPIOC3	Op.general	50B3	Instantaneous phase B overcurrent, level 3
CPIOC3	Op.general	50C3	Instantaneous phase C overcurrent, level 3
APIOC4	Op.general	50A4	Instantaneous phase A overcurrent, level 4
BPIOC4	Op.general	50B4	Instantaneous phase B overcurrent, level 4
CPIOC4	Op.general	50C4	Instantaneous phase C overcurrent, level 4
APIOC5	Op.general	50A	Instantaneous phase A combined overcurrent, levels 1–4
BPIOC5	Op.general	50B	Instantaneous phase B combined overcurrent, levels 1–4
CPIOC5	Op.general	50C	Instantaneous phase C combined overcurrent, levels 1–4
LPIOC1	Op.general	50L	Instantaneous phase overcurrent, open breaker detection
LAPIOC1	Op.general	50LA	Instantaneous phase A overcurrent, open breaker detection
LBPIOC1	Op.general	50LB	Instantaneous phase B overcurrent, open breaker detection
LCPIOC1	Op.general	50LC	Instantaneous phase C overcurrent, open breaker detection
QFPIOC1	Op.general	50QF	Negative-sequence forward direction decision supervision
QRPIOC1	Op.general	50QR	Negative-sequence reverse direction decision supervision
GFPIOC1	Op.general	50GF	Residual forward direction decision supervision
GRPIOC1	Op.general	50GR	Residual reverse direction decision supervision
P67PTOC1	Str.general	67P1	Torque controlled 50P1
P67PTOC1	Op.general	67P1T	Definite time, torque controlled 50P1
G67PTOC1	Str.general	67G1	Torque controlled 50G1
G67PTOC1	Op.general	67G1T	Definite time, torque controlled 50G1
Q67PTOC1	Str.general	67Q1	Torque controlled 50Q1
Q67PTOC1	Op.general	67Q1T	Definite time, torque controlled 50Q1
P67PTOC2	Str.general	67P2	Torque controlled 50P2
P67PTOC2	Op.general	67P2T	Definite time, torque controlled 50P2
G67PTOC2	Str.general	67G2	Torque controlled 50G2
G67PTOC2	Op.general	67G2T	Definite time, torque controlled 50G2
Q67PTOC2	Str.general	67Q2	Torque controlled 50Q2
Q67PTOC2	Op.general	67Q2T	Definite time, torque controlled 50Q2
P67PTOC3	Str.general	67P3	Torque controlled 50P3
P67PTOC3	Op.general	67P3T	Definite time, torque controlled 50P3
G67PTOC3	Str.general	67G3	Torque controlled 50G3
G67PTOC3	Op.general	67G3T	Definite time, torque controlled 50G3
Q67PTOC3	Str.general	67Q3	Torque controlled 50Q3
Q67PTOC3	Op.general	67Q3T	Definite time, torque controlled 50Q3
P67PTOC4	Str.general	67P4	Torque controlled 50P4
P67PTOC4	Op.general	67P4T	Definite time, torque controlled 50P4
G67PTOC4	Str.general	67G4	Torque controlled 50G4
G67PTOC4	Op.general	67G4T	Definite time, torque controlled 50G4
Q67PTOC4	Str.general	67Q4	Torque controlled 50Q4

Table P.16 Logical Device: PRO (Protection) (Sheet 3 of 7)

Logical Node	Attribute	Relay Word Bit	Comment
Q67PTOC4	Op.general	67Q4T	Definite time, torque controlled 50Q4
P51PTOC1	Str.general	51P	Phase time-overcurrent pickup
P51PTOC1	Op.general	51PT	Phase time-overcurrent operate
G51PTOC1	Str.general	51G	Residual time-overcurrent pickup
G51PTOC1	Op.general	51GT	Residual time-overcurrent operate
Q51PTOC1	Str.general	51Q	Negative-sequence time-overcurrent pickup
Q51PTOC1	Op.general	51QT	Negative-sequence time-overcurrent operate
LOPPTUV1	Str.general	LOP	Loss of potential
LOPPTUV1	Op.general	LOP	Loss of potential
APTUV1	Str.general	27A	Phase A undervoltage
APTUV1	Op.general	27A	Phase A undervoltage
BPTUV1	Str.general	27B	Phase B undervoltage
BPTUV1	Op.general	27B	Phase B undervoltage
CPTUV1	Str.general	27C	Phase C undervoltage
CPTUV1	Op.general	27C	Phase C undervoltage
ABPTUV1	Str.general	27AB	Phase-phase AB undervoltage
ABPTUV1	Op.general	27AB	Phase-phase AB undervoltage
BCPTUV1	Str.general	27BC	Phase-phase BC undervoltage
BCPTUV1	Op.general	27BC	Phase-phase BC undervoltage
CAPTUV1	Str.general	27CA	Phase-phase CA undervoltage
CAPTUV1	Op.general	27CA	Phase-phase CA undervoltage
PH3PTUV1	Str.general	3P27	Three-phase undervoltage
PH3PTUV1	Op.general	3P27	Three-phase undervoltage
SPTUV1	Str.general	27S	VS undervoltage
SPTUV1	Op.general	27S	VS undervoltage
APTOV1	Str.general	59A	Phase A overvoltage
BPTOV1	Str.general	59B	Phase B overvoltage
CPTOV1	Str.general	59C	Phase C overvoltage
ABPTOV1	Str.general	59AB	Phase-phase AB overvoltage
BCPTOV1	Str.general	59BC	Phase-phase BC overvoltage
CAPTOV1	Str.general	59CA	Phase-phase BC overvoltage
PH3PTOV1	Str.general	3P59	Three-phase overvoltage
QPTOV1	Str.general	59Q	Negative-sequence overvoltage
NPTOV1	Str.general	59N1	Residual overvoltage, level 1
NPTOV2	Str.general	59N2	Residual overvoltage, level 2
SPTOV1	Str.general	59S	VS overvoltage
VPTOV1	Str.general	59V1	Positive-sequence overvoltage
TRIPPTRC1	Tr.general	TRIP	Trip indication
DPTOF1	Str.general	81D1	Overfrequency pickup, level 1
DPTOF1	Op.general	81D1T	Overfrequency operate, level 1
DPTOF2	Str.general	81D2	Overfrequency pickup, level 2

Table P.16 Logical Device: PRO (Protection) (Sheet 4 of 7)

Logical Node	Attribute	Relay Word Bit	Comment
DPTOF2	Op.general	81D2T	Overfrequency operate, level 2
DPTOF3	Str.general	81D3	Overfrequency pickup, level 3
DPTOF3	Op.general	81D3T	Overfrequency operate, level 3
DPTOF4	Str.general	81D4	Overfrequency pickup, level 4
DPTOF4	Op.general	81D4T	Overfrequency operate, level 4
DPTOF5	Str.general	81D5	Overfrequency pickup, level 5
DPTOF5	Op.general	81D5T	Overfrequency operate, level 5
DPTOF6	Str.general	81D6	Overfrequency pickup, level 6
DPTOF6	Op.general	81D6T	Overfrequency operate, level 6
DPTUF1	Str.general	81D1	Overfrequency pickup, level 1
DPTUF1	Op.general	81D1T	Overfrequency operate, level 1
DPTUF2	Str.general	81D2	Overfrequency pickup, level 2
DPTUF2	Op.general	81D2T	Overfrequency operate, level 2
DPTUF3	Str.general	81D3	Overfrequency pickup, level 3
DPTUF3	Op.general	81D3T	Overfrequency operate, level 3
DPTUF4	Str.general	81D4	Overfrequency pickup, level 4
DPTUF4	Op.general	81D4T	Overfrequency operate, level 4
DPTUF5	Str.general	81D5	Overfrequency pickup, level 5
DPTUF5	Op.general	81D5T	Overfrequency operate, level 5
DPTUF6	Str.general	81D6	Overfrequency pickup, level 6
DPTUF6	Op.general	81D6T	Overfrequency operate, level 6
M1PPDIS1	Str.general	M1P	Mho phase distance, zone 1
M1PPDIS1	Op.general	M1PT	Mho phase distance, zone 1
Z1GPDIS1	Str.general	Z1G	Mho and/or quad. ground distance, zone 1
Z1GPDIS1	Op.general	Z1GT	Mho and/or quad. ground distance, zone 1
M2PPDIS2	Str.general	M2P	Mho phase distance, zone 2
M2PPDIS2	Op.general	M2PT	Mho phase distance, zone 2
Z2GPDIS2	Str.general	Z2G	Mho and/or quad. ground distance, zone 2
Z2GPDIS2	Op.general	Z2GT	Mho and/or quad. ground distance, zone 2
M3PPDIS3	Str.general	M3P	Mho phase distance, zone 3
M3PPDIS3	Op.general	M3PT	Mho phase distance, zone 3
Z3GPDIS3	Str.general	Z3G	Mho and/or quad. ground distance, zone 3
Z3GPDIS3	Op.general	Z3GT	Mho and/or quad. ground distance, zone 3
M4PPDIS4	Str.general	M4P	Mho phase distance, zone 4
M4PPDIS4	Op.general	M4PT	Mho phase distance, zone 4
Z4GPDIS4	Str.general	Z4G	Mho and/or quad. ground distance, zone 4
Z4GPDIS4	Op.general	Z4GT	Mho and/or quad. ground distance, zone 4
MAGPDIS1	Str.general	MAG1	Phase A mho ground distance, zone 1
MAGPDIS1	Op.general	MAG1	Phase A mho ground distance, zone 1
MBGPDIS1	Str.general	MBG1	Phase B mho ground distance, zone 1
MBGPDIS1	Op.general	MBG1	Phase B mho ground distance, zone 1

Table P.16 Logical Device: PRO (Protection) (Sheet 5 of 7)

Logical Node	Attribute	Relay Word Bit	Comment
MCGPDIS1	Str.general	MCG1	Phase C mho ground distance, zone 1
MCGPDIS1	Op.general	MCG1	Phase C mho ground distance, zone 1
MAGPDIS2	Str.general	MAG2	Phase A mho ground distance, zone 2
MAGPDIS2	Op.general	MAG2	Phase A mho ground distance, zone 2
MBGPDIS2	Str.general	MBG2	Phase B mho ground distance, zone 2
MBGPDIS2	Op.general	MBG2	Phase B mho ground distance, zone 2
MCGPDIS2	Str.general	MCG2	Phase C mho ground distance, zone 2
MCGPDIS2	Op.general	MCG2	Phase C mho ground distance, zone 2
MAGPDIS3	Str.general	MAG3	Phase A mho ground distance, zone 3
MAGPDIS3	Op.general	MAG3	Phase A mho ground distance, zone 3
MBGPDIS3	Str.general	MBG3	Phase B mho ground distance, zone 3
MBGPDIS3	Op.general	MBG3	Phase B mho ground distance, zone 3
MCGPDIS3	Str.general	MCG3	Phase C mho ground distance, zone 3
MCGPDIS3	Op.general	MCG3	Phase C mho ground distance, zone 3
MAGPDIS4	Str.general	MAG4	Phase A mho ground distance, zone 4
MAGPDIS4	Op.general	MAG4	Phase A mho ground distance, zone 4
MBGPDIS4	Str.general	MBG4	Phase B mho ground distance, zone 4
MBGPDIS4	Op.general	MBG4	Phase B mho ground distance, zone 4
MCGPDIS4	Str.general	MCG4	Phase C mho ground distance, zone 4
MCGPDIS4	Op.general	MCG4	Phase C mho ground distance, zone 4
XAGPDIS1	Str.general	XAG1	Phase A quad. ground distance, zone 1
XAGPDIS1	Op.general	XAG1	Phase A quad. ground distance, zone 1
XBGPDIS1	Str.general	XBG1	Phase B quad. ground distance, zone 1
XBGPDIS1	Op.general	XBG1	Phase B quad. ground distance, zone 1
XCGPDIS1	Str.general	XCG1	Phase C quad. ground distance, zone 1
XCGPDIS1	Op.general	XCG1	Phase C quad. ground distance, zone 1
XAGPDIS2	Str.general	XAG2	Phase A quad. ground distance, zone 2
XAGPDIS2	Op.general	XAG2	Phase A quad. ground distance, zone 2
XBGPDIS2	Str.general	XBG2	Phase B quad. ground distance, zone 2
XBGPDIS2	Op.general	XBG2	Phase B quad. ground distance, zone 2
XCGPDIS2	Str.general	XCG2	Phase C quad. ground distance, zone 2
XCGPDIS2	Op.general	XCG2	Phase C quad. ground distance, zone 2
XAGPDIS3	Str.general	XAG3	Phase A quad. ground distance, zone 3
XAGPDIS3	Op.general	XAG3	Phase A quad. ground distance, zone 3
XBGPDIS3	Str.general	XBG3	Phase B quad. ground distance, zone 3
XBGPDIS3	Op.general	XBG3	Phase B quad. ground distance, zone 3
XCGPDIS3	Str.general	XCG3	Phase C quad. ground distance, zone 3
XCGPDIS3	Op.general	XCG3	Phase C quad. ground distance, zone 3
XAGPDIS4	Str.general	XAG4	Phase A quad. ground distance, zone 4
XAGPDIS4	Op.general	XAG4	Phase A quad. ground distance, zone 4
XBGPDIS4	Str.general	XBG4	Phase B quad. ground distance, zone 4

Table P.16 Logical Device: PRO (Protection) (Sheet 6 of 7)

Logical Node	Attribute	Relay Word Bit	Comment
XBGPDIS4	Op.general	XBG4	Phase B quad. ground distance, zone 4
XCGPDIS4	Str.general	XCG4	Phase C quad. ground distance, zone 4
XCGPDIS4	Op.general	XCG4	Phase C quad. ground distance, zone 4
ABPDIS1	Str.general	MAB1	Phase-phase AB mho distance, zone 1
ABPDIS1	Op.general	MAB1	Phase-phase AB mho distance, zone 1
BCPDIS1	Str.general	MBC1	Phase-phase BC mho distance, zone 1
BCPDIS1	Op.general	MBC1	Phase-phase BC mho distance, zone 1
CAPDIS1	Str.general	MCA1	Phase-phase CA mho distance, zone 1
CAPDIS1	Op.general	MCA1	Phase-phase CA mho distance, zone 1
ABPDIS2	Str.general	MAB2	Phase-phase AB mho distance, zone 2
ABPDIS2	Op.general	MAB2	Phase-phase AB mho distance, zone 2
BCPDIS2	Str.general	MBC2	Phase-phase BC mho distance, zone 2
BCPDIS2	Op.general	MBC2	Phase-phase BC mho distance, zone 2
CAPDIS2	Str.general	MCA2	Phase-phase CA mho distance, zone 2
CAPDIS2	Op.general	MCA2	Phase-phase CA mho distance, zone 2
ABPDIS3	Str.general	MAB3	Phase-phase AB mho distance, zone 3
ABPDIS3	Op.general	MAB3	Phase-phase AB mho distance, zone 3
BCPDIS3	Str.general	MBC3	Phase-phase BC mho distance, zone 3
BCPDIS3	Op.general	MBC3	Phase-phase BC mho distance, zone 3
CAPDIS3	Str.general	MCA3	Phase-phase CA mho distance, zone 3
CAPDIS3	Op.general	MCA3	Phase-phase CA mho distance, zone 3
ABPDIS4	Str.general	MAB4	Phase-phase AB mho distance, zone 4
ABPDIS4	Op.general	MAB4	Phase-phase AB mho distance, zone 4
BCPDIS4	Str.general	MBC4	Phase-phase BC mho distance, zone 4
BCPDIS4	Op.general	MBC4	Phase-phase BC mho distance, zone 4
CAPDIS4	Str.general	MCA4	Phase-phase CA mho distance, zone 4
CAPDIS4	Op.general	MCA4	Phase-phase CA mho distance, zone 4
MPP1PDIS1	Str.general	MPP1	Phase-phase compensator distance, zone 1
MPP1PDIS1	Op.general	MPP1	Phase-phase compensator distance, zone 1
MPP2PDIS1	Str.general	MPP2	Phase-phase compensator distance, zone 2
MPP2PDIS1	Op.general	MPP2	Phase-phase compensator distance, zone 2
MPP3PDIS1	Str.general	MPP3	Phase-phase compensator distance, zone 3
MPP3PDIS1	Op.general	MPP3	Phase-phase compensator distance, zone 3
MPP4PDIS1	Str.general	MPP4	Phase-phase compensator distance, zone 4
MPP4PDIS1	Op.general	MPP4	Phase-phase compensator distance, zone 4
MABC1PDIS1	Str.general	MABC1	Three-phase compensator distance, zone 1
MABC1PDIS1	Op.general	MABC1	Three-phase compensator distance, zone 1
MABC2PDIS1	Str.general	MABC2	Three-phase compensator distance, zone 2
MABC2PDIS1	Op.general	MABC2	Three-phase compensator distance, zone 2
MABC3PDIS1	Str.general	MABC3	Three-phase compensator distance, zone 3
MABC3PDIS1	Op.general	MABC3	Three-phase compensator distance, zone 3

Table P.16 Logical Device: PRO (Protection) (Sheet 7 of 7)

Logical Node	Attribute	Relay Word Bit	Comment
MABC4PDIS1	Str.general	MABC4	Three-phase compensator distance, zone 4
MABC4PDIS1	Op.general	MABC4	Three-phase compensator distance, zone 4
POTTPSCH1	Str.general	KEY	Key permissive trip
POTTPSCH1	Op.general	PTRX	Permissive trip received
POTTPSCH1	ProTx.stval	KEY	Key permissive trip
POTTPSCH1	ProRx.stval	PTRX	Permissive trip received
POTTPSCH1	Echo.general	EKEY	Echo permissive trip received
POTTPSCH1	WeiOp.general	ECTT	Echo conversion to trip
POTTPSCH1	RvABlk.general	Z3RB	Current reversal guard
DCUBPSCH1	Str.general	KEY	Key permissive trip
DCUBPSCH1	Op.general	PTRX	Permissive trip received
DCUBPSCH1	ProTx.stval	KEY	Key permissive trip
DCUBPSCH1	ProRx.stval	PTRX	Permissive trip received
DCUBPSCH1	Echo.general	EKEY	Echo permissive trip received
DCUBPSCH1	WeiOp.general	ECTT	Echo conversion to trip
DCUBPSCH1	RvABlk.general	Z3RB	Current reversal guard
QFRDIR1	Dir.general	32QF	Forward directional control for phase distance elements
QRRDIR1	Dir.general	32QR	Reverse directional control for phase distance elements
GFRDIR1	Dir.general	32GF	Forward directional control for ground distance elements
GRRDIR1	Dir.general	32GR	Reverse directional control for ground distance elements
BCCSWI1	Pos.ctlVal	CC:OC	Circuit Breaker close/open command
BCCSWI1	Pos.stVal	3PO?2:1	Circuit Breaker position
BCCSWI1	OpOpn.general	OC	Circuit breaker open control
BCCSWI1	OpCls.general	CC	Circuit breaker close control
BSXCBR1	OpCnt.StVal	INTTR	Internal breaker counter
BSXCBR1	Pos.stVal	3PO	Breaker open status. ON when 3PO = 0, OFF when 3PO = 1

NOTE: Not all quantities are available in all settings configurations.

Table P.17 shows the LNs associated with measuring elements, defined as Logical Device MET.

Table P.17 Logical Device: MET (Metering) (Sheet 1 of 3)

Logical Node	Attribute	Analog Quantity	Comment
METMMXU1	TotW.instMag.f	KW3	Three-phase real power
METMMXU1	TotVAr.instMag.f	KVAR3	Three-phase reactive power
METMMXU1	TotPF.instMag.f	PF3	Three-phase power factor
METMMXU1	Hz.instMag.f	FREQ	Measured frequency
METMMXU1	PhV.phsA.instCVal.mag.f	VA	A-phase voltage magnitude
METMMXU1	PhV.phsA.instCVal.ang.f	VAFA	A-phase voltage angle
METMMXU1	PhV.phsB.instCVal.mag.f	VB	B-phase voltage magnitude
METMMXU1	PhV.phsB.instCVal.ang.f	VBFA	B-phase voltage angle
METMMXU1	PhV.phsC.instCVal.mag.f	VC	C-phase voltage magnitude
METMMXU1	PhV.phsC.instCVal.ang.f	VCFA	C-phase voltage angle

Table P.17 Logical Device: MET (Metering) (Sheet 2 of 3)

Logical Node	Attribute	Analog Quantity	Comment
METMMXU1	PPV.phsAB.instCVal.mag.f	VAB	AB phase-phase voltage magnitude
METMMXU1	PPV.phsAB.instCVal.ang.f	VABFA	AB phase-phase voltage angle
METMMXU1	PPV.phsBC.instCVal.mag.f	VBC	BC phase-phase voltage magnitude
METMMXU1	PPV.phsBC.instCVal.ang.f	VBCFA	BC phase-phase voltage angle
METMMXU1	PPV.phsCA.instCVal.mag.f	VCA	CA phase-phase voltage magnitude
METMMXU1	PPV.phsCA.instCVal.ang.f	VCAFA	CA phase-phase voltage angle
METMMXU1	Vsyn.instCVal.mag.f	VS	VS input magnitude
METMMXU1	Vsyn.instCVal.ang.f	VS	VS input angle
METMMXU1	A.phsA.instCVal.mag.f	IA	A-phase current magnitude
METMMXU1	A.phsA.instCVal.ang.f	IAFA	A-phase current angle
METMMXU1	A.phsB.instCVal.mag.f	IB	B-phase current magnitude
METMMXU1	A.phsB.instCVal.ang.f	IBFA	B-phase current angle
METMMXU1	A.phsC.instCVal.mag.f	IC	C-phase current magnitude
METMMXU1	A.phsC.instCVal.ang.f	ICFA	C-phase current angle
METMMXU1	A.neut.instCVal.mag.f	IN	Neutral current magnitude
METMMXU1	A.neut.instCVal.ang.f	INFA	Neutral current angle
METMMXU1	A.res.instCVal.mag.f	IG	Residual current magnitude
METMMXU1	A.res.instCVal.ang.f	IGFA	Residual current angle
METMMXU1	W.phsA.instMag.f	KWA	A-phase real power
METMMXU1	W.phsB.instMag.f	KWB	B-phase real power
METMMXU1	W.phsC.instMag.f	KWC	C-phase real power
METMMXU1	VAr.phsA.instMag.f	KVARA	A-phase reactive power
METMMXU1	VAr.phsB.instMag.f	KVARB	B-phase reactive power
METMMXU1	VAr.phsC.instMag.f	KVARC	C-phase reactive power
METMMXU1	PF.phsA.instMag.f	PFA	A-phase power factor
METMMXU1	PF.phsB.instMag.f	PFB	B-phase power factor
METMMXU1	PF.phsC.instMag.f	PFC	C-phase power factor
METMSQI1	SeqA.c1.instCVal.mag.f	I1	Positive-sequence current magnitude
METMSQI1	SeqA.c1.instCVal.ang.f	I1FA	Positive-sequence current angle
METMSQI1	SeqA.c2.instCVal.mag.f	3I2	Negative-sequence current magnitude
METMSQI1	SeqA.c2.instCVal.ang.f	3I2FA	Negative-sequence current angle
METMSQI1	SeqA.c3.instCVal.mag.f	3I0	Zero-sequence current magnitude
METMSQI1	SeqA.c3.instCVal.ang.f	3I0FA	Zero-sequence current angle
METMSQI1	SeqV.c1.instCVal.mag.f	V1	Positive-sequence voltage magnitude
METMSQI1	SeqV.c1.instCVal.ang.f	V1FA	Positive-sequence voltage angle
METMSQI1	SeqV.c2.instCVal.mag.f	V2	Negative-sequence voltage magnitude
METMSQI1	SeqV.c2.instCVal.ang.f	V2FA	Negative-sequence voltage angle
METMSQI1	SeqV.c3.instCVal.mag.f	3V0_MAG	Zero-sequence voltage magnitude
METMSQI1	SeqV.c3.instCVal.ang.f	3V0FA	Zero-sequence voltage angle
METMDST1	DmdA.phsA.instMag.f	IADEM	Demand, phase A current
METMDST1	DmdA.phsB.instMag.f	IBDEM	Demand, phase B current

Table P.17 Logical Device: MET (Metering) (Sheet 3 of 3)

Logical Node	Attribute	Analog Quantity	Comment
METMDST1	DmdA.phsC.instMag.f	ICDEM	Demand, phase C current
METMDST1	DmdA.res.instMag.f	IGDEM	Demand, residual current
METMDST1	DmdA.neut.instMag.f	INDEM	Demand, neutral current
METMDST1	DmdA.nseq.instMag.f	3I2DEM	Demand, negative-sequence current
METMDST1	PkDmdA.phsA.instMag.f	IAPK	Peak demand, phase A current
METMDST1	PkDmdA.phsB.instMag.f	IBPK	Peak demand, phase B current
METMDST1	PkDmdA.phsC.instMag.f	ICPK	Peak demand, phase C current
METMDST1	PkDmdA.res.instMag.f	IGPK	Peak demand, residual current
METMDST1	PkDmdA.neut.instMag.f	INPK	Peak demand, neutral current
METMDST1	PkDmdA.nseq.instMag.f	3I2PK	Peak demand, negative-sequence current
METMDST1	SupWh.instMag.f	MWH3I	Energy, real (MWh), supply direction toward busbar
METMDST1	SupVArh.instMag.f	MVRH3I	Energy, reactive (MVARh), supply direction toward busbar
METMDST1	DmdWh.instMag.f	MWH3O	Energy, real (MWh), supply direction away from busbar
METMDST1	DmdVArh.instMag.f	MVRH3O	Energy, reactive (MVARh), supply direction away from busbar
DCZBAT1	Vol.instMag.f	VDC	DC supply voltage
DCZBAT1	DCZBAT1.ST.BatHi.stVal	DCHI	DC supply overvoltage (Boolean)
DCZBAT1	DCZBAT1.ST.BatLo.stVal	DCLO	DC supply undervoltage (Boolean)

Table P.18 shows the LNs associated with control elements, defined as Logical Device CON.

Table P.18 Logical Device: CON (Remote Control)

Logical Node	Status	Control	Relay Word Bit	Comment
RBGGIO1	SPCSO01.stVal–SPCSO08.stVal	SPCSO01.Oper.ctlVal–SPCSO08.Oper.ctlVal	RB1–RB8	Remote Bits (RB1–RB8)
RBGGIO2	SPCSO09.stVal–SPCSO16.stVal	SPCSO09.Oper.ctlVal–SPCSO16.Oper.ctlVal	RB9–RB16	Remote Bits (RB9–RB16)

Table P.19 shows the LNs associated with the annunciation element, defined as Logical Device ANN. See *Appendix D: Relay Word Bits* for descriptions.

Table P.19 Logical Device: ANN (Annunciation) (Sheet 1 of 2)

Logical Node	Attribute	Relay Word Bit	Comment
IN1GGIO1	Ind01.stVal–Ind06.stVal	IN101–IN106	Digital Inputs
IN2GGIO2	Ind01.stVal–Ind08.stVal	IN201–IN208	Digital Inputs
OUT1GGIO3	Ind01.stVal–Ind07.stVal	OUT101–OUT107	Digital Output
OUT1GGIO3	Ind08.stVal	ALARM	Digital Output
OUT2GGIO4	Ind01.stVal–Ind12.stVal	OUT201–OUT212	Digital Outputs
SVGGIO5	Ind01.stVal–Ind16.stVal	SV1–SV16	SELOGIC variables
SVTGGIO6	Ind01.stVal–Ind16.stVal	SV1T–SV16T	SELOGIC variables timers
LTGGIO7	Ind01.stVal–Ind16.stVal	LT1–LT16	Latch bits
LVGGIO8	Ind01.stVal–Ind32.stVal	LV1–LV32	Logic variables
RMBAGGIO9	Ind01.stVal–Ind08.stVal	RMB1A–RMB8A	Receive MIRRORED BITS®, Channel A
TMBAGGIO10	Ind01.stVal–Ind08.stVal	TMB1A–TMB8A	Transmit MIRRORED BITS, Channel A

Table P.19 Logical Device: ANN (Annunciation) (Sheet 2 of 2)

Logical Node	Attribute	Relay Word Bit	Comment
RMBBGGIO11	Ind01.stVal–Ind08.stVal	RMB1B–RMB8B	Receive MIRRORED BITS, Channel B
TMBBGGIO12	Ind01.stVal–Ind08.stVal	TMB1B–TMB8B	Transmit MIRRORED BITS, Channel B
TLEDGGIO13	Ind01.stVal–Ind10.stVal	LED1–LED10	Programmable pushbutton LEDs
TLEDGGIO13	Ind11.stVal–Ind26.stVal	TLED11–TLED26	Target LEDs
BRGGIO14	Ind01.stVal	52A	Breaker status
BRGGIO14	Ind02.stVal	3PO	Three pole open
VBGGIO15	Ind001.stVal–Ind128.stVal	VB001–VB128	Virtual bits
SGGGIO16	Ind01.stVal–Ind06.stVal	SG1–SG6	Setting group selected
LBGGIO17	Ind01.stVal–Ind16.stVal	LB1–LB16	Local bits
MBOKGGIO18	Ind01.stVal	ROKA	MIRRORED BITS receive OK, Channel A
MBOKGGIO18	Ind02.stVal	RBADA	MIRRORED BITS receive bad Channel A
MBOKGGIO18	Ind03.stVal	CBADA	MIRRORED BITS channel bad Channel A
MBOKGGIO18	Ind04.stVal	LBOKA	MIRRORED BITS loopback ok Channel A
MBOKGGIO18	Ind05.stVal	ROKB	MIRRORED BITS receive OK, Channel B
MBOKGGIO18	Ind06.stVal	RBADB	MIRRORED BITS receive bad Channel B
MBOKGGIO18	Ind07.stVal	CBADB	MIRRORED BITS channel bad Channel B
MBOKGGIO18	Ind08.stVal	LBOKB	MIRRORED BITS loopback ok Channel B
RCGGIO19	Ind01.stVal	79RS	Recloser reset
RCGGIO19	Ind02.stVal	79CY	Recloser cycling
RCGGIO19	Ind03.stVal	79LO	Recloser lockout
RCGGIO19	Ind04.stVal	SH0	Recloser shot 0
RCGGIO19	Ind05.stVal	SH1	Recloser shot 1
RCGGIO19	Ind06.stVal	SH2	Recloser shot 2
RCGGIO19	Ind07.stVal	SH3	Recloser shot 3
RCGGIO19	Ind08.stVal	SH4	Recloser shot 4
ETHGGIO20	Ind01.stVal	P5ASEL	Port 5 A selected
ETHGGIO20	Ind02.stVal	LINK5A	Link healthy on port 5 A
ETHGGIO20	Ind03.stVal	P5BSEL	Port 5 B selected
ETHGGIO20	Ind04.stVal	LINK5B	Link healthy on port 5 B
ETHGGIO20	Ind05.stVal	LNKFAIL	No healthy link on active port

Protocol Implementation Conformance Statement: SEL-311C

The tables below are as shown in the IEC 61850 standard, Part 8-1, Section 24. Note that since the standard explicitly dictates which services and functions must be implemented to achieve conformance, only the optional services and functions are listed.

Table P.20 PICS for A-Profile Support

Profile		Client	Server	Value/Comment
A1	Client/Server	N	Y	
A2	GOOSE/GSE management	Y	Y	Only GOOSE, not GSSE management
A3	GSSE	N	N	
A4	Time Sync	N	N	

Table P.21 PICS for T-Profile Support

Profile		Client	Server	Value/Comment
T1	TCP/IP	N	Y	
T2	OSI	N	N	
T3	GOOSE/GSE	Y	Y	Only GOOSE, not GSSE
T4	GSSE	N	N	
T5	Time Sync	N	N	

Refer to the *ACSI Conformance Statements on page P.36* for information on the supported services.

MMS Conformance

The Manufacturing Message Specification (MMS) stack provides the basis for many IEC 61850 protocol services. *Table P.22* defines the service support requirement and restrictions of the MMS services in SEL-311C devices. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table P.22 MMS Service Supported Conformance (Sheet 1 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
status		Y
getNameList		Y
identify		Y
rename		
read		Y
write		Y
getVariableAccessAttributes		Y
defineNamedVariable		
defineScatteredAccess		
getScatteredAccessAttributes		
deleteVariableAccess		
defineNamedVariableList		

Table P.22 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
getNamedVariableListAttributes		Y
deleteNamedVariableList		
defineNamedType		
getNamedTypeAttributes		
deleteNamedType		
input		
output		
takeControl		
relinquishControl		
defineSemaphore		
deleteSemaphore		
reportPoolSemaphoreStatus		
reportSemaphoreStatus		
initiateDownloadSequence		
downloadSegment		
terminateDownloadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
requestDomainDownload		
requestDomainUpload		
loadDomainContent		
storeDomainContent		
deleteDomain		
getDomainAttributes		Y
createProgramInvocation		
deleteProgramInvocation		
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		

Table P.22 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
defineEventAction		
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		
getAlarmEnrollmentSummary		
readJournal		
writeJournal		
initializeJournal		
reportJournalStatus		
createJournal		
deleteJournal		
fileOpen		
fileRead		
fileClose		
fileRename		
fileDelete		
fileDirectory		
unsolicitedStatus		
informationReport		Y
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		Y
cancel		Y
getDataExchangeAttributes		
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
reconfigureProgramInvocation		

Table P.23 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table P.23 MMS Parameter CBB

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
STR1		Y
STR2		Y
VNAM		Y
VADR		Y
VALT		Y
TPY		Y
VLIS		Y
CEI		

The following variable access conformance statements are listed in the order specified in the IEC 61850 standard, Part 8-1. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table P.24 AlternateAccessSelection Conformance Statement

AlternateAccessSelection	Client-CR Supported	Server-CR Supported
accessSelection		Y
component		Y
index		
indexRange		
allElements		
alternateAccess		Y
selectAccess		Y
component		Y
index		
indexRange		
allElements		

Table P.25 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y
variableListName		Y

Table P.26 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		Y
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table P.27 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		Y
listOfAccessResult		Y

Table P.28 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		
address		
typeSpecification		

Table P.29 DefineNamedVariableList Conformance Statement

DefineVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table P.30 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		Y
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y

Table P.31 DeleteNamedVariableList Conformance Statement

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table P.32 GOOSE Conformance

	Subscriber	Publisher	Value/Comment
GOOSE Services	Y	Y	
SendGOOSEMessage		Y	
GetGoReference			
GetGOOSEElementNumber			
GetGoCBValues		Y	
SetGoCBValues			
GSENotSupported			
GOOSE Control Block (GoCB)		Y	

ACSI Conformance Statements

Table P.33 ACSI Basic Conformance Statement

Services		Client/Subscriber	Server/Publisher	SEL-311C Support
Client-Server Roles				
B11	Server side (of Two-Party Application-Association)	–	c1[a]	YES
B12	Client side (of Two-Party Application-Association)	c1[a]	–	
SCMS Supported				
B21	SCSM: IEC 61850-8-1 used			YES
B22	SCSM: IEC 61850-9-1 used			
B23	SCSM: IEC 61850-9-2 used			
B24	SCSM: other			
Generic Substation Event Model (GSE)				
B31	Publisher side	–	O[b]	YES
B32	Subscriber side	O[b]	–	YES
Transmission of Sampled Value Model (SVC)				
B41	Publisher side	–	O[b]	
B42	Subscriber side	O[b]	–	

[a] c1 shall be mandatory if support for LOGICAL-DEVICE model has been declared.
[b] O = optional.

Table P.34 ACSI Models Conformance Statement (Sheet 1 of 2)

Models		Client/Subscriber	Server/Publisher	SEL-311C Support
If Server Side (B11) Supported				
M1	Logical device	c2[a]	c2[a]	YES
M2	Logical node	c3[b]	c3[b]	YES
M3	Data	c4[c]	c4[c]	YES
M4	Dataset	c5[d]	c5[d]	YES
M5	Substitution	O[e]	O[e]	
M6	Setting group control	O[e]	O[e]	
Reporting				
M7	Buffered report control	O[e]	O[e]	YES
M7-1	sequence-number			YES
M7-2	report-time-stamp			YES
M7-3	reason-for-inclusion			YES
M7-4	data-set-name			YES
M7-5	data-reference			YES
M7-6	buffer-overflow			YES
M7-7	entryID			YES
M7-8	BufTm			YES
M7-9	IntgPd			YES
M7-10	GI			YES

Table P.34 ACSI Models Conformance Statement (Sheet 2 of 2)

Models		Client/Subscriber	Server/Publisher	SEL-311C Support
M8	Unbuffered report control	O[e]	O[e]	YES
M8-1	sequence-number			YES
M8-2	report-time-stamp			YES
M8-3	reason-for-inclusion			YES
M8-4	data-set-name			YES
M8-5	data-reference			YES
M8-6	BufTm			YES
M8-7	IntgPd			YES
M8-8	GI			
	Logging	O[e]	O[e]	
M9	Log control	O[e]	O[e]	
M9-1	IntgPd			
M10	Log	O[e]	O[e]	
M11	Control	M[f]	M[f]	YES
If GSE (B31/32) Is Supported				
M12	GOOSE	O[e]	O[e]	YES
M12-1	entryID			YES
M12-2	DataReflnc			YES
M13	GSSE	O[e]	O[e]	
If GSE (B41/42) Is Supported				
M14	Multicast SVC	O[e]	O[e]	
M15	Unicast SVC	O[e]	O[e]	
M16	Time	M[f]	M[f]	
M17	File Transfer	O[e]	O[e]	

[a] c2 shall be "M" if support for LOGICAL-NODE model has been declared.
[b] c3 shall be "M" if support for DATA model has been declared.
[c] c4 shall be "M" if support for DATA-SET, Substitution, Report, Log Control, or Time model has been declared.
[d] c5 shall be "M" if support for Report, GSE, or SV models has been declared.
[e] O = optional.
[f] M = mandatory.

Table P.35 ACSI Services Conformance Statement (Sheet 1 of 4)

Services		AA: TP/MC	Client/ Subscriber	Server/Publisher	SEL-311C Support
Server (Clause 6)					
S1	ServerDirectory	TP		M[a]	YES
Application Association (Clause 7)					
S2	Associate		M[a]	M[a]	YES
S3	Abort		M[a]	M[a]	YES
S4	Release		M[a]	M[a]	YES
Logical Device (Clause 8)					
S5	LogicalDeviceDirectory	TP	M[a]	M[a]	YES

Table P.35 ACSI Services Conformance Statement (Sheet 2 of 4)

Services		AA: TP/MC	Client/ Subscriber	Server/Publisher	SEL-311C Support
Logical Node (Clause 9)					
S6	LogicalNodeDirectory	TP	M[a]	M[a]	YES
S7	GetAllDataValues	TP	O[b]	M[a]	YES
Data (Clause 10)					
S8	GetDataValues	TP	M[a]	M[a]	YES
S9	SetDataValues	TP	O[b]	O[b]	YES
S10	GetDataDirectory	TP	O[b]	M[a]	YES
S11	GetDataDefinition	TP	O[b]	M[a]	YES
Dataset (Clause 11)					
S12	GetDataSetValues	TP	O[b]	M[a]	YES
S13	SetDataSetValues	TP	O[b]	O[b]	YES
S14	CreateDataSet	TP	O[b]	O[b]	
S15	DeleteDataSet	TP	O[b]	O[b]	
S16	GetDataSetDirectory	TP	O[b]	O[b]	YES
Substitution (Clause 12)					
S17	SetDataValues	TP	M[a]	M[a]	
Setting Group Control (Clause 13)					
S18	SelectActiveSG	TP	O[b]	O[b]	
S19	SelectEditSG	TP	O[b]	O[b]	
S20	SetSGvalues	TP	O[b]	O[b]	
S21	ConfirmEditSGVal	TP	O[b]	O[b]	
S22	GetSGValues	TP	O[b]	O[b]	
S23	GetSGCBValues	TP	O[b]	O[b]	
Reporting (Clause 14)					
Buffered Report Control Block (BRCB)					
S24	Report	TP	c6[c]	c6[c]	YES
S24-1	data-change (dchg)				YES
S24-2	qchg-change (qchg)				YES
S24-3	data-update (dupd)				
S25	GetBRCBValues	TP	c6[c]	c6[c]	YES
S26	SetBRCBValues	TP	c6[c]	c6[c]	YES
Unbuffered Report Control Block (URCB)					
S27	Report	TP	c6[c]	c6[c]	YES
S27-1	data-change (dchg)				YES
S27-2	qchg-change (qchg)				YES
S27-3	data-update (dupd)				
S28	GetURCBValues	TP	c6[c]	c6[c]	YES
S29	SetURCBValues	TP	c6[c]	c6[c]	YES

Table P.35 ACSI Services Conformance Statement (Sheet 3 of 4)

Services		AA: TP/MC	Client/ Subscriber	Server/Publisher	SEL-311C Support
Logging (Clause 14)					
Log Control Block					
S30	GetLCBValues	TP	M[a]	M[a]	
S31	SetLCBValues	TP	O[b]	M[a]	
LOG					
S32	QueryLogByTime	TP	c7[d]	M[a]	
S33	QueryLogByEntry	TP	c7[d]	M[a]	
S34	GetLogStatusValues	TP	M[a]	M[a]	
Generic Substation Event Model (GSE) (Clause 14.3.5.3.4.)					
GOOSE-Control-Block					
S35	SendGOOSEMessage	MC	c8[e]	c8[e]	YES
S36	GetReference	TP	O[b]	c9[f]	
S37	GetGOOSEElementNumber	TP	O[b]	c9[f]	
S38	GetGoCBValues	TP	O[b]	O[b]	YES
S39	SetGoCBValues	TP	O[b]	O[b]	Client/Sub ONLY
GSSE-Control-Block					
S40	SendGSSEMessage	MC	c8[e]	c8[e]	
S41	GetReference	TP	O[b]	c9[f]	
S42	GetGSSEElementNumber	TP	O[b]	c9[f]	
S43	GetGsCBValues	TP	O[b]	O[b]	
S44	SetGsCBValues	TP	O[b]	O[b]	
Transmission of Sample Value Model (SVC) (Clause 16)					
Multicast SVC					
S45	SendMSVMessage	MC	c10[g]	c10[g]	
S46	GetMSVCBValues	TP	O[b]	O[b]	
S47	SetMSVCBValues	TP	O[b]	O[b]	
Unicast SVC					
S48	SendUSVMessage	MC	c10[g]	c10[g]	
S49	GetUSVCBValues	TP	O[b]	O[b]	
S50	SetUSVCBValues	TP	O[b]	O[b]	
Control (Clause 16.4.8)					
S51	Select		M[a]	O[b]	YES
S52	SelectWithValue	TP	M[a]	O[b]	YES
S53	Cancel	TP	O[b]	M[a]	YES
S54	Operate	TP	M[a]	M[a]	YES
S55	Commmand-Termination	TP	M[a]	M[a]	YES
S56	TimeActivated-Operate	TP	O[b]	O[b]	

Table P.35 ACSI Services Conformance Statement (Sheet 4 of 4)

Services		AA: TP/MC	Client/ Subscriber	Server/Publisher	SEL-311C Support
File Transfer (Clause 20)					
S57	GetFile	TP	O[b]	M[a]	
S58	SetFile	TP	O[b]	O[b]	
S59	DeleteFile	TP	O[b]	O[b]	
S60	GetFileAttributeValues	TP	O[b]	M[a]	
Time (Clause 5.5)					
T1	Time resolution of internal clock (nearest negative power of 2 in seconds)			2–10 (1 ms)	T1
T2	Time accuracy of internal clock				10/9
	T1				YES
	T2				YES
	T3				YES
	T4				YES
	T5				YES
T3	Supported TimeStamp resolution (nearest negative power of 2 in seconds)			2–10 (1 ms)	10

[a] M = mandatory.
[b] O = optional.
[c] c6 shall declare support for at least one (BRCB or URCB).
[d] c7 shall declare support for at least one (QueryLogByTime or QueryLogAfter).
[e] c8 shall declare support for at least one (SendGOOSEMessage or SendGSSEMessage).
[f] c9 shall declare support if TP association is available.
[g] c10 shall declare support for at least one (SendMSVMessage or SendUSVMessage).

SEL-311C Command Summary

Command	Description
2AC	Enter Access Level 2. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level 2 password.
ACC	Enter Access Level 1. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level 1 password.
BAC	Enter Breaker Access Level (Access Level B). If the main board Access jumper is not in place, the relay prompts the user for the Access Level B password.
BNA	Display names of status bits in the A5D1 Fast Meter Message.
BRE	Display breaker monitor data (trips, interrupted current, wear).
BRE *n*	Enter **BRE W** to preload breaker wear. Enter **BRE R** to reset breaker monitor data.
CAL	Enter Access Level C. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CAS	Display compressed ASCII configuration message.
CEV *n*	Display event report *n* in compressed ASCII format.
CHI	Display history data in compressed ASCII format.
CLO	Close circuit breaker (assert Relay Word bit CC).
COM *n*	Show communications summary report (COM report) on MIRRORED BITS® channel *n* (where *n* = A or B) using all failure records in the channel calculations.
COM *n row1*	Show a COM report for MIRRORED BITS channel *n* using the latest *row1* failure records (*row1* = 1–255, where 1 is the most recent entry).
COM *n row1 row2*	Show COM report for MIRRORED BITS channel *n* using failure records *row1–row2* (*row1* = 1–255).
COM *n date1*	Show COM report for MIRRORED BITS channel *n* using failures recorded on date *date1* (see **DAT** command for date format).
COM *n date1 date2*	Show COM report for MIRRORED BITS BITS channel *n* using failures recorded between dates *date1* and *date2* inclusive.
COM . . . L	For all **COM** commands, L causes the specified COM report records to be listed after the summary.
COM *n* C	Clears communications records for MIRRORED BITS channel *n* (or both channels if *n* is not specified, **COM C** command).
CON *n*	Control Relay Word bit RB*n* (Remote Bit *n*; *n* = 1–16). Execute **CON *n*** and the relay responds: CONTROL RB*n*. Then reply with one of the following: **SRB *n*** set Remote Bit *n* (assert RB*n*). **CRB *n*** clear Remote Bit *n* (deassert RB*n*). **PRB *n*** pulse Remote Bit *n* (assert RB*n* for 1/4 cycle).
COP *m n*	Copy relay and logic settings from group *m* to group *n* (*m* and *n* are numbers 1–6).
COP D *m n*	Copy DNP Map *m* into Map *n* (*m* and *n* are numbers 1–3).
CST	Display relay status in compressed ASCII format.
CSU	Display summary event report in compressed ASCII format.
DAT	Show date.
DAT mm/dd/yy	Enter date in this manner if Global Date Format setting, DATE_F, is set to MDY.
DAT yy/mm/dd	Enter date in this manner if Global Date Format setting, DATE_F, is set to YMD.
DNA T/X	Display names of Relay Word bits included in the A5D1 Fast Meter message. Either “T” or “X” are mandatory and are identical.
ETH	Displays the Ethernet port configuration and status.

Command	Description
EVE *n*	Show event report *n* with 4 samples per cycle (*n* = 1 to highest numbered event report, where 1 is the most recent report: see **HIS** command). If *n* is omitted (**EVE** command), most recent report is displayed.
EVE *n* A	Show event report *n* with analog section only.
EVE *n* C	Show event report *n* in compressed ASCII format with 16 samples-per-cycle analog resolution and 4 samples-per-cycle digital resolution.
EVE *n* D	Show event report *n* with digital section only.
EVE *n* L	Show event report *n* with 32 samples per cycle (similar to **EVE *n* S32**).
EVE *n* L*y*	Show first *y* cycles of event report *n* (*y* = 1 to Global setting LER).
EVE *n* M	Show event report *n* with communications section only.
EVE *n* P	Show event report *n* with synchrophasor-level accuracy time adjustment.
EVE *n* R	Show event report *n* in raw (unfiltered) format with 32 samples-per-cycle resolution.
EVE *n* S*x*	Show event report *n* with *x* samples per cycle (*x* = 4, 16, 32, or 128). Must append R parameter for S128 (**EVE S128 R**)
EVE *n* V	Show event report *n* with variable scaling for analog values.
EXI	Terminate Telnet session.
FIL DIR	Display a list of available files.
FILE READ *filename*	Transfer settings file *filename* from the relay to the PC.
FILE SHOW *filename*	Display contents of file *filename*.
FILE WRITE *filename*	Transfer settings file *filename* from the PC to the relay.
GOO	Display GOOSE transmit and receive information.
GRO	Display active group number.
GRO *n*	Change active group to group *n* (*n* = 1–6).
HIS *n*	Show brief summary of *n* latest event reports, where 1 is the most recent entry. If *n* is not specified, (**HIS** command) all event summaries are displayed.
HIS C	Clear all event reports from nonvolatile memory.
HIS E	Same as **HIS** command except reports have unique identification numbers in the range 10000 to 65535.
ID	Display relay configuration.
L_D	Prepares the relay to receive new firmware.
LOO *n t*	Set MIRRORED BITS channel *n* to loopback (*n* = A or B). The received MIRRORED BITS elements are forced to default values during the loopback test; *t* specifies the loopback duration in minutes (*t* = 1–5000, default is 5).
LOO *n* DATA	Set MIRRORED BITS channel *n* to loopback. DATA allows the received MIRRORED BITS elements to change during the loopback test.
LOO *n* R	Cease loopback on MIRRORED BITS channel *n* and return the channel to normal operation.
MAC	Display Ethernet MAC address.
MET *k*	Display instantaneous metering data. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
MET X *k*	Display same as **MET** command with phase-to-phase voltages. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
MET D	Display demand and peak demand data. Select **MET RD** or **MET RP** to reset.
MET E	Display energy metering data. Select **MET RE** to reset.
MET M	Display maximum/minimum metering data. Select **MET RM** to reset.
MET PM *time k*	Display synchrophasor measurements (available when TSOK = logical 1). Enter *time* to display the synchrophasor for an exact specified time, in 24-hour format. Enter *k* for repeat count.
MET PM HIS	Display the most recent **MET PM** synchrophasor report.
OPE	Open circuit breaker (assert Relay Word bit OC).

Command	Description
PAR	Change the device part number. Use only under the direction of SEL.
PAS 1	Change Access Level 1 password.
PAS B	Change Access Level B password.
PAS 2	Change Access Level 2 password.
PAS C	Change the Access Level C password.
PUL *n k*	Pulse output contact *n* (where *n* is one of ALARM, OUT101–OUT107, OUT201–OUT212) for *k* seconds. *k* = 1–30 seconds; if not specified, default is 1.
QUI	Quit. Returns to Access Level 0.
R_S	Restore factory default settings. Use only under the direction of SEL. Only available under certain conditions.
SER	Show entire Sequential Events Recorder (SER) report.
SER *row1*	Show latest *row1* rows in the SER report (*row1* = 1–1024, where 1 is the most recent entry).
SER *row1 row2*	Show rows *row1–row2* in the SER report.
SER *date1*	Show all rows in the SER report recorded on the specified date (see **DAT** command for date format).
SER *date1 date2*	Show all rows in the SER report recorded between dates *date1* and *date2*, inclusive.
SER C	Clears SER report from nonvolatile memory.
SET *n*	Change relay settings (overcurrent, reclosing, timers, etc.) for Group *n* (*n* = 1–6, if not specified, default is active setting group).
SET *n* L	Change SELOGIC® control equation settings for Group *n* (*n* = 1–6, if not specified, default is the SELOGIC control equations for the active setting group).
SET D	Change DNP settings.
SET G	Change Global settings.
SET M	Change Modbus® settings.
SET P *p*	Change serial port *p* settings (*p* = 1, 2, 3, F, or 5; if not specified, default is active port).
SET R	Change SER and LDP Recorder settings.
SET T	Change text label settings.
SET . . . *name*	For all **SET** commands, jump ahead to specific setting by entering setting name.
SET . . . TERSE	For all **SET** commands, TERSE disables the automatic **SHO** command after settings entry.
SHO *n*	Show relay settings (overcurrent, reclosing, timers, etc.) for Group *n* (*n* = 1–6, if not specified, default is active setting group).
SHO *n* L	Show SELOGIC control equation settings for Group *n* (*n* = 1–6, if not specified, default is the SELOGIC control equations for the active setting group).
SHO D	Show DNP settings.
SHO G	Show Global settings.
SHO M	Show Modbus settings.
SHO P *p*	Show serial port *p* settings (*p* = 1, 2, 3, or F; if not specified, default is active port).
SHO R	Show SER and LDP Recorder settings.
SHO T	Show text label settings.
SHO . . . *name*	For all **SHO** commands, jump ahead to specific setting by entering setting name.
SNS	Display the Fast Message name string of the SER settings.
STA	Show relay self-test status.
STA C	Resets self-test warnings/failures and reboots the relay.
SUM *n*	Shows event report summary for event *n*.
SUM ACK	Acknowledge oldest unacknowledged summary event report.

Command	Description
SUM N	Shows event report summary for oldest unacknowledged report.
TAR *n k*	Display Relay Word row. If *n* = 0–67, display row *n*. If *n* is an element name (e.g., 50A1), display row containing element *n*. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
TAR LIST	Shows all the Relay Word bits in all of the rows.
TAR R	Reset front-panel tripping targets.
TAR ROW. . .	Shows the Relay Word row number at the start of each line, with other selected **TARGET** commands as described above, such as *n*, *name*, *k*, and LIST.
TEST DB A *name value*	Override analog label *name* with *value* in communications interface.
TEST DB D *name value*	Override Relay Word bit *name* with *value* in communications interface, where *value* = 0 or 1.
TIM	Show or set time (24-hour time). Show current relay time by entering **TIM**. Set the current time by entering **TIM** followed by the time of day (e.g., set time 22:47:36 by entering **TIM 22:47:36**).
TRI [*time*]	Trigger an event report. Enter *time* to trigger an event at an exact specified time, in 24-hour format.
VEC	Display standard vector troubleshooting report (useful to the factory in troubleshooting).
VER	Show relay configuration and firmware version.

Key Stroke Commands

Key Stroke	Description	Key Stroke When Using SET Command	Description
Ctrl + Q	Send **XON** command to restart communications port output previously halted by XOFF.	**<Enter>**	Retains setting and moves on to next setting.
Ctrl + S	Send **XOFF** command to pause communications port output.	**^<Enter>**	Returns to previous setting.
Ctrl + X	Send **CANCEL** command to abort current command and return to current access level prompt.	**<<Enter>**	Returns to previous setting section.
		><Enter>	Skips to next setting section.
		END <Enter>	Exits setting editing session, then prompts user to save settings.
		Ctrl + X	Aborts setting editing session without saving changes.

SEL-311C Command Summary

Command	Description
2AC	Enter Access Level 2. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level 2 password.
ACC	Enter Access Level 1. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level 1 password.
BAC	Enter Breaker Access Level (Access Level B). If the main board Access jumper is not in place, the relay prompts the user for the Access Level B password.
BNA	Display names of status bits in the A5D1 Fast Meter Message.
BRE	Display breaker monitor data (trips, interrupted current, wear).
BRE *n*	Enter **BRE W** to preload breaker wear. Enter **BRE R** to reset breaker monitor data.
CAL	Enter Access Level C. If the main board Access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CAS	Display compressed ASCII configuration message.
CEV *n*	Display event report *n* in compressed ASCII format.
CHI	Display history data in compressed ASCII format.
CLO	Close circuit breaker (assert Relay Word bit CC).
COM *n*	Show communications summary report (COM report) on MIRRORED BITS® channel *n* (where *n* = A or B) using all failure records in the channel calculations.
COM *n row1*	Show a COM report for MIRRORED BITS channel *n* using the latest *row1* failure records (*row1* = 1–255, where 1 is the most recent entry).
COM *n row1 row2*	Show COM report for MIRRORED BITS channel *n* using failure records *row1–row2* (*row1* = 1–255).
COM *n date1*	Show COM report for MIRRORED BITS channel *n* using failures recorded on date *date1* (see **DAT** command for date format).
COM *n date1 date2*	Show COM report for MIRRORED BITS BITS channel *n* using failures recorded between dates *date1* and *date2* inclusive.
COM . . . L	For all **COM** commands, L causes the specified COM report records to be listed after the summary.
COM *n* C	Clears communications records for MIRRORED BITS channel *n* (or both channels if *n* is not specified, **COM C** command).
CON *n*	Control Relay Word bit RB*n* (Remote Bit *n*; *n* = 1–16). Execute **CON *n*** and the relay responds: CONTROL RB*n*. Then reply with one of the following: **SRB *n*** set Remote Bit *n* (assert RB*n*). **CRB *n*** clear Remote Bit *n* (deassert RB*n*). **PRB *n*** pulse Remote Bit *n* (assert RB*n* for 1/4 cycle).
COP *m n*	Copy relay and logic settings from group *m* to group *n* (*m* and *n* are numbers 1–6).
COP D *m n*	Copy DNP Map *m* into Map *n* (*m* and *n* are numbers 1–3).
CST	Display relay status in compressed ASCII format.
CSU	Display summary event report in compressed ASCII format.
DAT	Show date.
DAT mm/dd/yy	Enter date in this manner if Global Date Format setting, DATE_F, is set to MDY.
DAT yy/mm/dd	Enter date in this manner if Global Date Format setting, DATE_F, is set to YMD.
DNA T/X	Display names of Relay Word bits included in the A5D1 Fast Meter message. Either “T” or “X” are mandatory and are identical.
ETH	Displays the Ethernet port configuration and status.

Command	Description
EVE *n*	Show event report *n* with 4 samples per cycle (*n* = 1 to highest numbered event report, where 1 is the most recent report: see **HIS** command). If *n* is omitted (**EVE** command), most recent report is displayed.
EVE *n* A	Show event report *n* with analog section only.
EVE *n* C	Show event report *n* in compressed ASCII format with 16 samples-per-cycle analog resolution and 4 samples-per-cycle digital resolution.
EVE *n* D	Show event report *n* with digital section only.
EVE *n* L	Show event report *n* with 32 samples per cycle (similar to **EVE *n* S32**).
EVE *n* L*y*	Show first *y* cycles of event report *n* (*y* = 1 to Global setting LER).
EVE *n* M	Show event report *n* with communications section only.
EVE *n* P	Show event report *n* with synchrophasor-level accuracy time adjustment.
EVE *n* R	Show event report *n* in raw (unfiltered) format with 32 samples-per-cycle resolution.
EVE *n* S*x*	Show event report *n* with *x* samples per cycle (*x* = 4, 16, 32, or 128). Must append R parameter for S128 (**EVE S128 R**)
EVE *n* V	Show event report *n* with variable scaling for analog values.
EXI	Terminate Telnet session.
FIL DIR	Display a list of available files.
FILE READ *filename*	Transfer settings file *filename* from the relay to the PC.
FILE SHOW *filename*	Display contents of file *filename*.
FILE WRITE *filename*	Transfer settings file *filename* from the PC to the relay.
GOO	Display GOOSE transmit and receive information.
GRO	Display active group number.
GRO *n*	Change active group to group *n* (*n* = 1–6).
HIS *n*	Show brief summary of *n* latest event reports, where 1 is the most recent entry. If *n* is not specified, (**HIS** command) all event summaries are displayed.
HIS C	Clear all event reports from nonvolatile memory.
HIS E	Same as **HIS** command except reports have unique identification numbers in the range 10000 to 65535.
ID	Display relay configuration.
L_D	Prepares the relay to receive new firmware.
LOO *n t*	Set MIRRORED BITS channel *n* to loopback (*n* = A or B). The received MIRRORED BITS elements are forced to default values during the loopback test; *t* specifies the loopback duration in minutes (*t* = 1–5000, default is 5).
LOO *n* DATA	Set MIRRORED BITS channel *n* to loopback. DATA allows the received MIRRORED BITS elements to change during the loopback test.
LOO *n* R	Cease loopback on MIRRORED BITS channel *n* and return the channel to normal operation.
MAC	Display Ethernet MAC address.
MET *k*	Display instantaneous metering data. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
MET X *k*	Display same as **MET** command with phase-to-phase voltages. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
MET D	Display demand and peak demand data. Select **MET RD** or **MET RP** to reset.
MET E	Display energy metering data. Select **MET RE** to reset.
MET M	Display maximum/minimum metering data. Select **MET RM** to reset.
MET PM *time k*	Display synchrophasor measurements (available when TSOK = logical 1). Enter *time* to display the synchrophasor for an exact specified time, in 24-hour format. Enter *k* for repeat count.
MET PM HIS	Display the most recent **MET PM** synchrophasor report.
OPE	Open circuit breaker (assert Relay Word bit OC).

Command	Description
PAR	Change the device part number. Use only under the direction of SEL.
PAS 1	Change Access Level 1 password.
PAS B	Change Access Level B password.
PAS 2	Change Access Level 2 password.
PAS C	Change the Access Level C password.
PUL *n k*	Pulse output contact *n* (where *n* is one of ALARM, OUT101–OUT107, OUT201–OUT212) for *k* seconds. *k* = 1–30 seconds; if not specified, default is 1.
QUI	Quit. Returns to Access Level 0.
R_S	Restore factory default settings. Use only under the direction of SEL. Only available under certain conditions.
SER	Show entire Sequential Events Recorder (SER) report.
SER *row1*	Show latest *row1* rows in the SER report (*row1* = 1–1024, where 1 is the most recent entry).
SER *row1 row2*	Show rows *row1*–*row2* in the SER report.
SER *date1*	Show all rows in the SER report recorded on the specified date (see **DAT** command for date format).
SER *date1 date2*	Show all rows in the SER report recorded between dates *date1* and *date2*, inclusive.
SER C	Clears SER report from nonvolatile memory.
SET *n*	Change relay settings (overcurrent, reclosing, timers, etc.) for Group *n* (*n* = 1–6, if not specified, default is active setting group).
SET *n* L	Change SELOGIC® control equation settings for Group *n* (*n* = 1–6, if not specified, default is the SELOGIC control equations for the active setting group).
SET D	Change DNP settings.
SET G	Change Global settings.
SET M	Change Modbus® settings.
SET P *p*	Change serial port *p* settings (*p* = 1, 2, 3, F, or 5; if not specified, default is active port).
SET R	Change SER and LDP Recorder settings.
SET T	Change text label settings.
SET . . . *name*	For all **SET** commands, jump ahead to specific setting by entering setting name.
SET . . . TERSE	For all **SET** commands, TERSE disables the automatic **SHO** command after settings entry.
SHO *n*	Show relay settings (overcurrent, reclosing, timers, etc.) for Group *n* (*n* = 1–6, if not specified, default is active setting group).
SHO *n* L	Show SELOGIC control equation settings for Group *n* (*n* = 1–6, if not specified, default is the SELOGIC control equations for the active setting group).
SHO D	Show DNP settings.
SHO G	Show Global settings.
SHO M	Show Modbus settings.
SHO P *p*	Show serial port *p* settings (*p* = 1, 2, 3, or F; if not specified, default is active port).
SHO R	Show SER and LDP Recorder settings.
SHO T	Show text label settings.
SHO . . . *name*	For all **SHO** commands, jump ahead to specific setting by entering setting name.
SNS	Display the Fast Message name string of the SER settings.
STA	Show relay self-test status.
STA C	Resets self-test warnings/failures and reboots the relay.
SUM *n*	Shows event report summary for event *n*.
SUM ACK	Acknowledge oldest unacknowledged summary event report.

Command	Description
SUM N	Shows event report summary for oldest unacknowledged report.
TAR *n k*	Display Relay Word row. If *n* = 0–67, display row *n*. If *n* is an element name (e.g., 50A1), display row containing element *n*. Enter *k* for repeat count (*k* = 1–32767, if not specified, default is 1).
TAR LIST	Shows all the Relay Word bits in all of the rows.
TAR R	Reset front-panel tripping targets.
TAR ROW. . .	Shows the Relay Word row number at the start of each line, with other selected **TARGET** commands as described above, such as *n*, *name*, *k*, and LIST.
TEST DB A *name value*	Override analog label *name* with *value* in communications interface.
TEST DB D *name value*	Override Relay Word bit *name* with *value* in communications interface, where *value* = 0 or 1.
TIM	Show or set time (24-hour time). Show current relay time by entering **TIM**. Set the current time by entering **TIM** followed by the time of day (e.g., set time 22:47:36 by entering **TIM 22:47:36**).
TRI [*time*]	Trigger an event report. Enter *time* to trigger an event at an exact specified time, in 24-hour format.
VEC	Display standard vector troubleshooting report (useful to the factory in troubleshooting).
VER	Show relay configuration and firmware version.

Key Stroke Commands

Key Stroke	Description	Key Stroke When Using SET Command	Description
Ctrl + Q	Send **XON** command to restart communications port output previously halted by XOFF.	**<Enter>**	Retains setting and moves on to next setting.
Ctrl + S	Send **XOFF** command to pause communications port output.	**^<Enter>**	Returns to previous setting.
Ctrl + X	Send **CANCEL** command to abort current command and return to current access level prompt.	**<<Enter>**	Returns to previous setting section.
		><Enter>	Skips to next setting section.
		END <Enter>	Exits setting editing session, then prompts user to save settings.
		Ctrl + X	Aborts setting editing session without saving changes.