SEL-311C-2, -3 Transmission Protection System

Instruction Manual

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SCHWEITZER ENGINEERING LABORATORIES

PM311C-03

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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 and 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, breaker failure, 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–IN216, local control switches (local bit outputs LB1–LB16), remote control switches (remote bit outputs RB1–RB32), 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 U.S. and 5 IEC curves)
- Settings Sheets for a 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 10.62* 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.

Appendices

- *Appendix A: Firmware, ICD, and Manual Versions*
- *Appendix B: Firmware Upgrade Instructions for SEL-311C Relays With Ethernet*
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- ➤ *Appendix Q: Cybersecurity Features*
- ➤ *Appendix R: Fault Location and Supplemental Fault Location and Impedance Data*

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

Safety Information

Dangers, Warnings, and Cautions

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

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

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

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

Safety Symbols

The following symbols are often marked on SEL products.

	**CAUTION** Refer to accompanying documents.	**ATTENTION** Se reporter à la documentation.
	Earth (ground)	Terre
	Protective earth (ground)	Terre de protection
	Direct current	Courant continu
	Alternating current	Courant alternatif
	Both direct and alternating current	Courant continu et alternatif
	Instruction manual	Manuel d’instructions

Safety Marks

The following statements apply to this device.

General Safety Marks

⚠WARNING	⚠AVERTISSEMENT
More than one live circuit. See diagram.	Plus d'un circuit est sous tension. Voir schema.

B300 Relay Code			
Maximum Current [A] Courant Maximal [A]			
120 V		240 V	
Make	Break	Make	Break
30	3	15	1.5

⚠CAUTION There is danger of explosion if the battery is incorrectly replaced. Replace only with Rayovac no. BR2335 or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.	⚠ATTENTION Une pile remplacée incorrectement pose des risques d'explosion. Remplacez seulement avec un Rayovac no BR2335 ou un produit équivalent recommandé par le fabricant. Voir le guide d'utilisateur pour les instructions de sécurité. La pile utilisée dans cet appareil peut présenter un risque d'incendie ou de brûlure chimique si vous en faites mauvais usage. Ne pas recharger, démonter, chauffer à plus de 100°C ou incinérer. Éliminez les vieilles piles suivant les instructions du fabricant. Gardez la pile hors de la portée des enfants.
⚠CAUTION To ensure proper safety and operation, the equipment ratings, installation instructions, and operating instructions must be checked before commissioning or maintenance of the equipment. The integrity of any protective conductor connection must be checked before carrying out any other actions. It is the responsibility of the user to ensure that the equipment is installed, operated, and used for its intended function in the manner specified in this manual. If misused, any safety protection provided by the equipment may be impaired.	⚠ATTENTION Pour assurer la sécurité et le bon fonctionnement, il faut vérifier les classements d'équipement ainsi que les instructions d'installation et d'opération avant la mise en service ou l'entretien de l'équipement. Il faut vérifier l'intégrité de toute connexion de conducteur de protection avant de réaliser d'autres actions. L'utilisateur est responsable d'assurer l'installation, l'opération et l'utilisation de l'équipement pour la fonction prévue et de la manière indiquée dans ce manuel. Une mauvaise utilisation pourrait diminuer toute protection de sécurité fournie par l'équipement.
Connectors for input and supply must have overcurrent protection of 15 A maximum. Provide a 14 AWG copper ground conductor.	Les connecteurs d'entrée et d'alimentation doivent avoir la protection de surintensité de 15 A maximal. Utilisez un conducteur de mise à la terre en cuivre de calibre 14 AWG.
For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.
For use on a flat surface of a Type 1 enclosure.	Destiné à l'utilisation sur une surface plane d'un boîtier de Type 1.
Terminal Ratings Wire Material Use copper supply wires suitable for 75°C (167°F). Tightening Torque Serial Port 1: 0.6–0.8 Nm (5–7 in-lb) A Terminal Blocks: 1.1–1.3 Nm (9–12 in-lb) B Terminal Blocks: 1.1–1.3 Nm (9–12 in-lb) Z Terminal Blocks: 1.1–1.3 Nm (9–12 in-lb)	Spécifications des bornes Type de filage Utilisez des fils d'alimentation en cuivre appropriés pour 75°C (167°F). Couple de serrage Port Série 1 : 0,6–0,8 Nm (5–7 livres-pouce) Borniers A : 1,1–1,3 Nm (9–12 livres-pouce) Borniers B : 1,1–1,3 Nm (9–12 livres-pouce) Borniers Z : 1,1–1,3 Nm (9–12 livres-pouce)
AC Voltage Inputs: 250 Vac rms continuous (UL).	Entrées de tension CA : 250 Vca rms continus (UL).

Other Safety Marks

⚠DANGER Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.	⚠DANGER Débrancher tous les raccordements externes avant d'ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠DANGER Contact with instrument terminals can cause electrical shock that can result in injury or death.	⚠DANGER Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠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.
⚠WARNING Before working on a CT circuit, first apply a short to the secondary winding of the CT.	⚠AVERTISSEMENT Avant de travailler sur un circuit TC, placez d'abord un court-circuit sur l'enroulement secondaire du TC.
⚠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 Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.	⚠ATTENTION Regarder vers les connecteurs optiques, les extrémités des fibres oules connecteurs de cloison peut entraîner une exposition à des rayonnements dangereux.
⚠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).

LED Safety Warnings and Precautions:

- Do not look into the end of an optical cable connected to an optical output.
- Do not look into the fiber ports/connectors.
- Do not perform any procedures or adjustments that are not described in this manual.
- During installation, maintenance, or testing of the optical ports only use test equipment classified as Class 1 laser products.
- Incorporated components such as transceivers and laser/LED emitters are not user serviceable. Units must be returned to SEL for repair or replacement.

General Information

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.

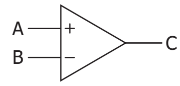
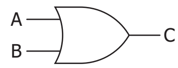
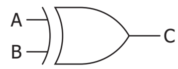
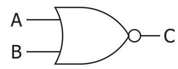
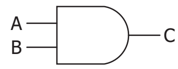
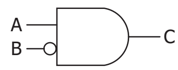
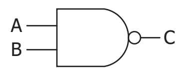
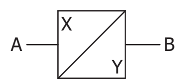
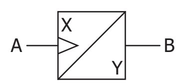
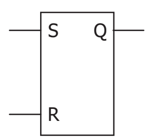
Wire Sizes and Insulation

Wire sizes for grounding (earthing), current, voltage, and contact connections are dictated by the terminal blocks and expected load currents. You can use the following table as a guide in selecting wire sizes.

Connection Type	Wire Size		Insulation Voltage
	Minimum	Maximum	
Grounding (Earthing)	18 AWG (0.80 mm^2)	14 AWG (2.10 mm^2)	300 V min
Current	16 AWG (1.30 mm^2)	12 AWG (3.30 mm^2)	300 V min
Potential (Voltage)	18 AWG (0.80 mm^2)	14 AWG (2.10 mm^2)	300 V min
Contact I/O	18 AWG (0.80 mm^2)	14 AWG (2.10 mm^2)	300 V min
Other	18 AWG (0.80 mm^2)	14 AWG (2.10 mm^2)	300 V min

Logic Diagrams

Logic diagrams in this manual follow the conventions and definitions shown below.

NAME	SYMBOL	FUNCTION
Comparator		Input A is compared to Input B. Output C asserts if Input A is greater than Input B.
Input Flag		Input A comes from other logic.
OR		If either Input A or Input B asserts, Output C asserts.
Exclusive OR		If either Input A or Input B asserts, Output C asserts. If Input A and Input B are of the same state, Output C deasserts.
NOR		If neither Input A nor Input B asserts, Output C asserts.
AND		If Input A and Input B assert, Output C asserts.
AND w/ Inverted Input		If Input A asserts and Input B deasserts, Output C asserts. Inverter "O" inverts any input or output on any gate.
NAND		If Input A and/or Input B deassert, Output C asserts.
Time-Delayed Pick Up and/or Time-Delayed Drop Out		X is a time-delay-pickup value; Y is a time-delay-dropout value. Output B asserts Time X after Input A asserts; Output B does not assert if Input A does not remain asserted for Time X. If Time X is zero, Output B asserts when Input A asserts. If Time Y is zero, Input B deasserts when Input A deasserts.
Edge Trigger Timer		Rising edge of Input A starts timers. Output B asserts Time X after the rising edge of Input A. Output B remains asserted for Time Y. If Time Y is zero, Output B asserts for a single processing interval. Input A is ignored while the timers are running.
Set-Reset/Flip-Flop		Input S asserts Output Q until Input R asserts. Output Q deasserts or resets when Input R asserts.
Falling Edge		Output B asserts at the falling edge of Input A.
Rising Edge		Output B asserts at the rising edge of Input A.

Trademarks

All brand or product names appearing in this document are the trademark or registered trademark of their respective holders. No SEL trademarks may be used without written permission.

SEL trademarks appearing in this manual are shown in the following table.

ACSELERATOR Analytic Assistant®	MIRRORED BITS®
ACSELERATOR Architect®	SafeLock®
ACSELERATOR QuickSet®	SEL-2407®
ACSELERATOR TEAM®	SELOGIC®
Best Choice Ground Directional Element®	SYNCHROWAVE®
Compass®	

Technical Support

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

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Section 1
Introduction and Specifications

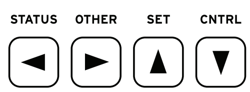
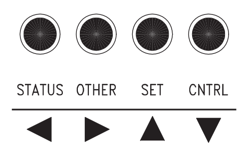
This section includes the following overviews of the SEL-311C Relay:

- *SEL-311C Models*
- *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 the 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]	0311C2 and 0311C3	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-2 provides single-pole tripping with four zones of phase mho, ground mho, and ground quadrilateral distance elements. The SEL-311C-3 adds three zones of high-speed-cycle phase mho and ground mho distance elements. See *Distance Element Operating Time Curves at Nominal Frequency on page 3.14* for the operating speed of the distance elements.

The SEL-311C Transmission Protection System is also available with three-pole trip as model number 0311C1. 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 information to order an SEL-311C. Refer to the actual ordering information sheets.

Compliance

Designed and manufactured under an ISO 9001 certified quality management system
UL Listed to US and Canadian safety standards (File E212775; NRGU, NRGU7)
CE Mark
UKCA Mark
RCM Mark

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

General

Terminal Connections

Note: Terminals or stranded copper wire. Ring terminals are recommended. Minimum temperature rating of 75°C (167°F).

Tightening Torque

Terminals A01–A28 Terminals B01–B40 (if present):	1.1–1.3 Nm (9–12 in-lb)
Terminals Z01–Z27:	1.1–1.3 Nm (9–12 in-lb)
Serial Port 1 (EIA-485, if present):	0.6–0.8 Nm (5–7 in-lb)

AC Voltage Inputs

Nominal Range	
Line to Neutral:	67–120 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 (20 A continuous at 55°C), 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 (4 A continuous at 55°C), 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

High-Voltage Supply

Rated:	125–250 Vdc nominal or 120–230 Vac nominal
Range:	85–350 Vdc or 85–264 Vac
Burden:	<25 W

Medium-Voltage Supply

Rated:	48–125 Vdc nominal or 120 Vac nominal
Range:	38–200 Vdc or 85–140 Vac
Burden:	<25 W

Low-Voltage Supply

Rated:	24–48 Vdc nominal
Range:	18–60 Vdc polarity dependent
Burden:	<25 W

Fuse Ratings

High-Voltage Power Supply Fuse

Rating:	2.5 A
Maximum Rated Voltage:	125 Vdc, 250 Vac
Breaking Capacity:	200 A at 277 Vac/100 A at 125 Vdc
Type:	Time-lag T

Medium-Voltage Power Supply Fuse

Rating:	2.5 A
Maximum Rated Voltage:	125 Vdc, 250 Vac
Breaking Capacity:	200 A at 277 Vac/100 A at 125 Vdc
Type:	Time-lag T

Low-Voltage Power Supply Fuse

Rating:	7 A
Maximum Rated Voltage:	60 Vdc, 250 Vac
Breaking Capacity:	50 A at 250 Vac, p.f. / 50 A at 60 Vdc
Type:	Fast-Acting

Note: Power supply fuses are non-user-replaceable.

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

DC Output Ratings	
Make:	30 A
Carry	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s 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 (10,000 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.

AC Output Ratings

Maximum Operational Voltage (U_e) Rating:	240 Vac
Insulation Voltage (U_i) Rating (Excluding EN 61010-1):	300 Vac
Utilization Category:	AC-15 (control of electromagnetic loads > 72 VA)
Contact Rating Designation:	B300 (B = 5 A, 300 = rated insulation voltage)
Voltage Protection Across Open Contacts:	270 Vac, 40 J
Rated Operational Current (I_e):	3 A @ 120 Vac 1.5 A @ 240 Vac
Conventional Enclosed Thermal Current (I_{the}) Rating:	5 A
Rated Frequency:	50/60 ±5 Hz
Electrical Durability Make VA Rating:	3600 VA, cos ϕ = 0.3
Electrical Durability Break VA Rating:	360 VA, cos ϕ = 0.3

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
1 s Rating:	50 A
MOV Protection:	330 Vdc/145 J
Pickup Time:	Less than 5 ms
Dropout Time:	Less than 8 ms, typical

Breaking Capacity (10,000 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 (10,000 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: 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
1 s 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
1 s 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 and IN201D–IN216D. 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, at the rear-panel BNC input, or through the optional SEL-2812-compatible fiber-optic serial port.

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)
BNC Input Voltage:	2.2 V minimum
BNC Nominal Input Impedance:	≥1 kΩ

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
Fiber-Optic Serial Port:	SEL-2812-compatible port, optional
Wavelength:	820 nm
Optical Connector Type:	ST
Fiber Type:	Multimode
Typical TX Power:	–16 dBm
RX Min. Sensitivity:	–24 dBm
Fiber Size:	62.5/125 µm
Per Port Data Rate Selections:	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600
USB:	1 front (Type-B connector, CDC class device)
Ethernet:	2 standard 10/100BASE-T rear ports (RJ45 connector) 1 or 2 100BASE-FX rear ports optional (LC connectors) Wavelength: 1300 nm Optical Connector Type: LC connector Fiber Type: Multimode fiber Typical TX Power: –15.7 dBm RX Min. Sensitivity: –30 dBm Fiber Size: 62.5 µm Internal Ethernet switch included with second Ethernet port.

Dimensions

Refer to *Figure 2.1*.

Weight

11 lb (5.0 kg)—2U rack unit height relay

15 lb (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.)

Note: Temperature range is not applicable to UL-compliant installations.

Operating Environment

Insulation Class:	2
Pollution Degree:	2
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude Without Derating (Consult the Factory for Higher Altitude Derating):	2000 m

Type Tests

Electromagnetic Compatibility Emissions

Emissions:	IEC 60255-26:2013, Class A Canada ICES-001 (A) / NMB-001 (A)

Electromagnetic Compatibility Immunity

Electromagnetic Compatibility:	IEC 60255-26:2013
Safety Standards:	IEC 60255-27:2013
Magnetic Field Immunity:	IEC 60255-26: 2013, Section 7.2.10 Severity Level: 1000 A/m for 3 seconds 100 A/m for 1 minute; 50/60 Hz
Conducted RF Immunity:	IEC 61000-4-6:2014 Severity Level: 10 Vrms IEC 60255-26:2013, Section 7.2.8 10 Vrms
Digital Radio Telephone RF Immunity:	ENV 50204:1995 Severity Level: 10 V/m at 900 MHz and 1.89 GHz
Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 Severity Level: 2, 4, 6, 8 kV contact; 2, 4, 8, and 15 kV air IEC 60255-26:2013, Section 7.2.3 IEEE C37.90.3-2001 Severity Level: 2, 4, and 8 kV contact; 4, 8, and 15 kV air
Fast Transient/Burst Immunity:	IEC 61000-4-4:2012 Severity Level: 4 kV, 5 kHz IEC 60255-26:2013, Section 7.2.5
Power Supply Immunity:	IEC 61000-4-11:2004/A1:2017 IEC 61000-4-29:2000 IEC 60255-26:2013, Section 7.2.11 IEC 60255-26:2013, Section 7.2.12 IEC 60255-26:2013, Section 7.2.13
Radiated Radio Frequency Immunity:	IEC 61000-4-3:2008 Severity Level: 10 V/m IEC 60255-26:2013, Section 7.2.4 10 V/m IEEE C37.90.2-2004 Severity Level: 35 V/m
Surge Withstand Capability Immunity:	IEC 61004-18:2010 Severity Level: 2.5 kV peak common mode, 1.0 kV peak differential mode IEC 60255-26:2013, Section 7.2.7 2 kV line-to-line 4 kV line-to-earth IEEE C37.90.1-2012 Severity Level: 2.5 kV oscillatory; 4.0 kV fast transient
Surge Immunity:	IEC 60255-26:2013, Section 7.2.7 2 kV line-to-line 4 kV line-to-earth

Environmental

Cold:	IEC 60068-2-1:2007 Severity Level: 16 hours at –40°C IEC 60255-27:2013, Section 10.6.1.2 IEC 60255-27:2013, Section 10.6.1.4 –40°C, 16 hours
Cyclic Temperature With Humidity:	IEC 60068-2-30:2005 Severity Level: +25°C to +55°C, 6 cycles, Relative Humidity: 90% IEC 60255-27:2013, Section 10.6.1.6 25° to 55°C, 95% relative humidity, 6 cycles

Damp Heat, Steady State:	IEC 60068-2-78:2001 Severity Level: +40°C Relative Humidity: 90% IEC 60255-27:2013, Section 10.6.1.5 40°C, 93% relative humidity, 10 days
Dry Heat:	IEC 60068-2-2:2007 Severity Level: 16 hours at +85°C IEC 60255-27:2013, Section 10.6.1.1 IEC 60255-27:2013, Section 10.6.1.3 85°C, 16 hours
Change of Temperature:	IEC 60068-2-14:2009 Severity Level: –40°C to +85°C
Vibration:	IEC 60255-21-1:1988 Severity Level: Class 1 Endurance, Class 2 Response IEC 60255-21-2:1988 Severity Level: Class 1—Shock withstand, Bump, and Class 2—Shock Response IEC 60255-21-3:1993 Severity Level: Class 2 (Quake Response)
Vibration Resistance:	IEC 60255-27:2013, Section 10.6.2.1 Endurance: Class 2 Response: Class 2
Shock Resistance:	IEC 60255-27:2013, Section 10.6.2.2 IEC 60255-27:2013, Section 10.6.2.3 Withstand: Class 1 Response: Class 2 Bump: Class 1
Seismic (Quake Response):	IEC 60255-27:2013, Section 10.6.2.4 Response: Class 2

Safety

Protective Bonding Resistance:	IEC 60255-27:2013
Dielectric:	IEC 60255-27:2013 Severity Level: 2500 Vac on contact inputs, contact outputs, and analog inputs. 3100 Vdc on power supply. Type Tested for 1 minute. IEEE C37.90-2005 Severity Level: 2500 Vac on contact inputs, contact outputs, and analog inputs. 3100 Vdc on power supply. Type Tested for 1 minute.
Dielectric (Hi-Pot):	IEC 60255-27:2013, Section 10.6.4.3
Impulse:	IEC 60255-27:2013 Severity Level: 0.5 Joule, 5 kV IEEE C37.90:2005 Severity Level: 0.5 Joule, 5 kV
IP Code:	IEC 60529:1989+AMD1:1999 +AMD2:2013 Severity Level: IP30
Product Safety:	C22.2 No. 14 - 95 Canadian Standards Association, Industrial control equipment, industrial products UL 508 Underwriters Laboratories inc., Standard for safety: Industrial control equipment

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 (Processing Interval)

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 Binary COMTRADE (128 samples per cycle unfiltered)
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
Max. Operating Time:	See *Figure 3.11–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–Figure 3.17*.

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 *Section 3: Distance, Out-of-Step, Overcurrent, Voltage, Synchronism-Check, and Frequency Elements*.

Breaker Failure Current Detectors and Logic

Pickup Range:	0.5–100.00 A, 0.01 A steps (5 A nominal) 0.1–20.00 A, 0.01 A steps (1 A nominal)
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
Reset Time:	≤1 cycle
Pickup Time:	≤1 cycle for current greater than 2 multiples of pickup
Time Delay:	0.00–6000.00 cycles, 0.25-cycle steps
Timer Accuracy:	±0.25 cycle and ±0.1% of setting

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 (U.S.) 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 ±1.50 cycles and ±4% of curve time for current less than 1 multiple 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:	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)
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

Pickup/Dropout Time: Maximum instantaneous element response time to a step change in frequency (dF)

	NFREQ = 50 Hz	NFREQ = 60 Hz
|81DnP–Initial Freq| ≤ 0.5 |dF|	80 ms	67 ms
|81DnP–Initial Freq| > 0.5 |dF|	120 ms	100 ms

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}

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.

V_A, V_B, V_C: ±0.2% (67.0–250 V)
±0.4% typical (250–300 V)

V_{AB}, V_{BC}, V_{CA}: ±0.4% (67.0–250 V)
±0.8% typical (250–300 V)

V_S: ±0.2% (67.0–250 V)
±0.4% typical (250–300 V)

$3V_0$, V_1, V_2: ±0.6% (67.0–250 V)
±1.2% typical (250–300 V)

I_A, I_B, I_C: ±4 mA and ±0.1% (1.0–100 A) (5 A nominal)
±6 mA and ±0.1% (0.25–1.0 A) (5 A nominal)
±1 mA and ±0.1% (0.2–20 A) (1 A nominal)
±2 mA and ±0.1% (0.05–0.2 A) (1 A nominal)
Temperature coefficient: $[(0.0002\%)/(°C)^2] \bullet (\_\_°C - 20°C)^2$

I_N: ±4 mA and ±0.1% (1.0–100 A) (5 A nominal)
±6 mA and ±0.1% (0.25–1.0 A) (5 A nominal)
±1 mA and ±0.1% (0.2–20 A) (1 A nominal)
±2 mA and ±0.1% (0.05–0.2 A) (1 A nominal)
Temperature coefficient: $[(0.0002\%)/(°C)^2] \bullet (\_\_°C - 20°C)^2$

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

5 A Nominal: ±0.5° (1.0–100 A)
±3° (0.25–1.0 A)

1 A Nominal: ±0.5° (0.2–20 A)
±5° (0.05–0.2 A)

V_A, V_B, V_C, V_S: ±0.5°

V_{AB}, V_{BC}, V_{CA}: ±1.0°

MW/MVAR (A, B, C, and three-phase))	
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 once every two seconds, transferred to nonvolatile storage once per day.

ASCII Report Resolution: 0.01 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 A-phase voltage, frequency-based phasor compensation is enabled (PHCOMP = Y), and the narrow bandwidth filter is selected (PMAPP = N).
Out-of-band interfering frequency (Fs) test, 10 Hz ≤ Fs ≤ (2 • NFREQ).

Current Range: (0.1–2) • I_{NOM} (I_{NOM} = 1 A or 5 A)

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

Voltage Range: 30 V–250 Vs

Phase Angle Range: –179.99° to 180°

Section 2
Installation

Overview

Design your rack or panel installation by 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

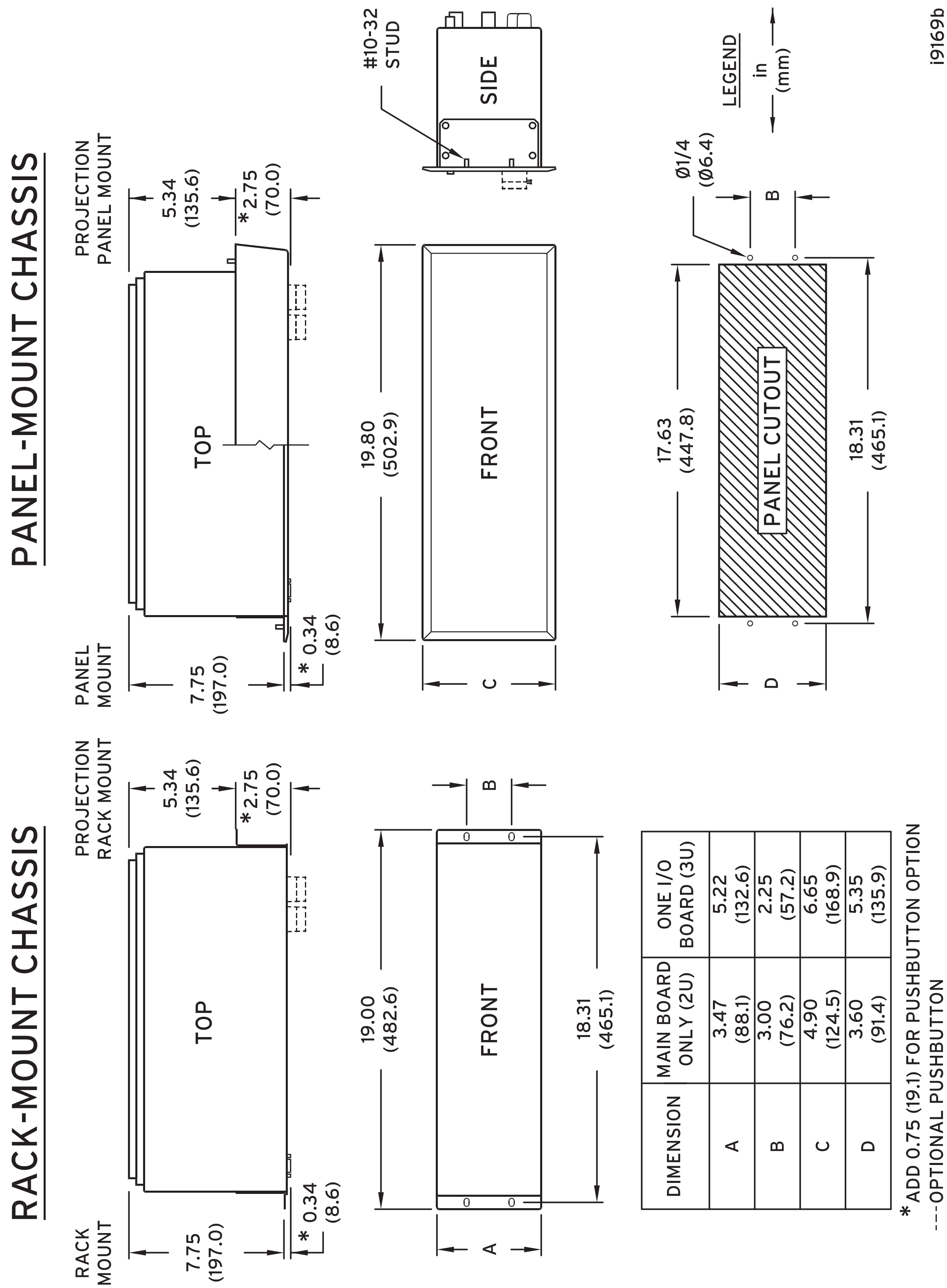
The SEL-311C rack-mount relay bolts easily into a standard 19-inch rack. See *Figure 2.1*. From the front of the relay, insert four rack screws (two on each side) through the holes on the relay mounting flanges.

Reverse the relay mounting flanges to cause the relay to project an additional 2.75 in (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 2.7 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.

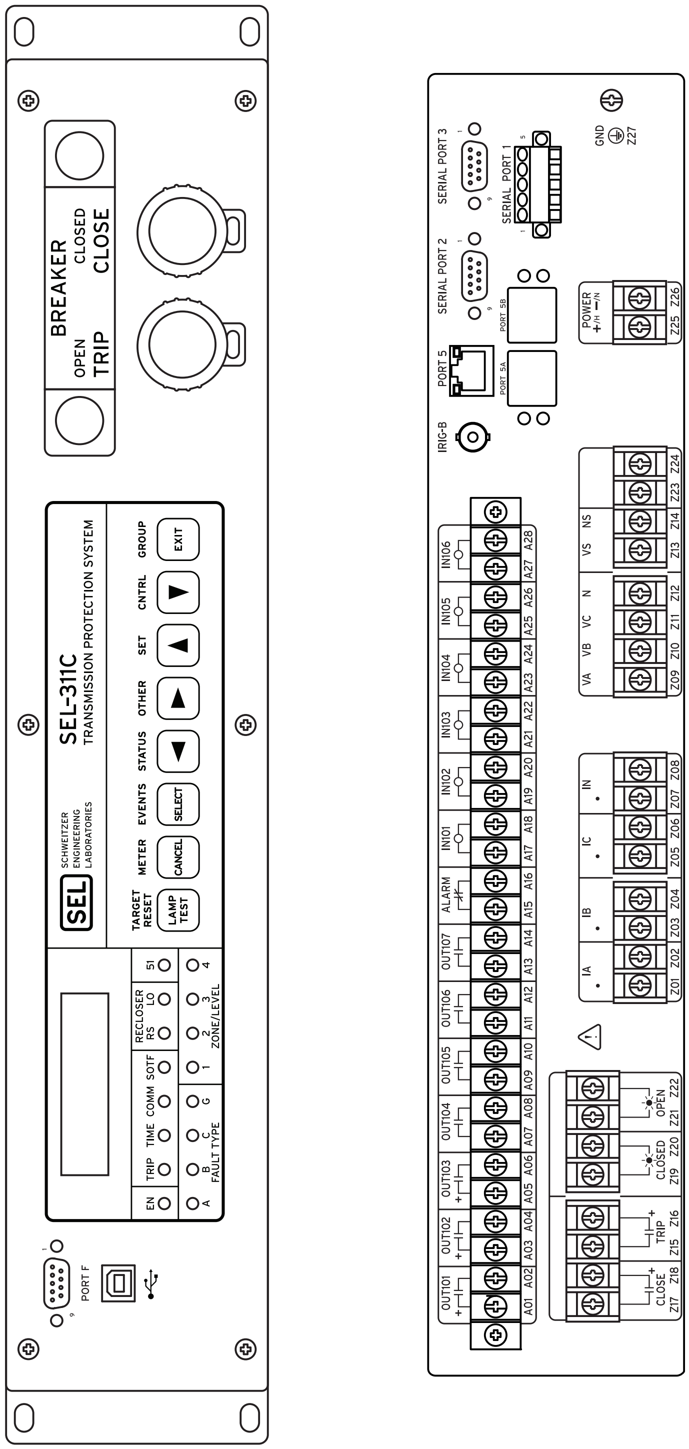


Figure 2.2 SEL-311C Front- and Rear-Panel Drawings; 2U Horizontal Rack-Mount With Optional EIA-485 and USB Ports and Optional SafeLock Trip and Close Pushbuttons

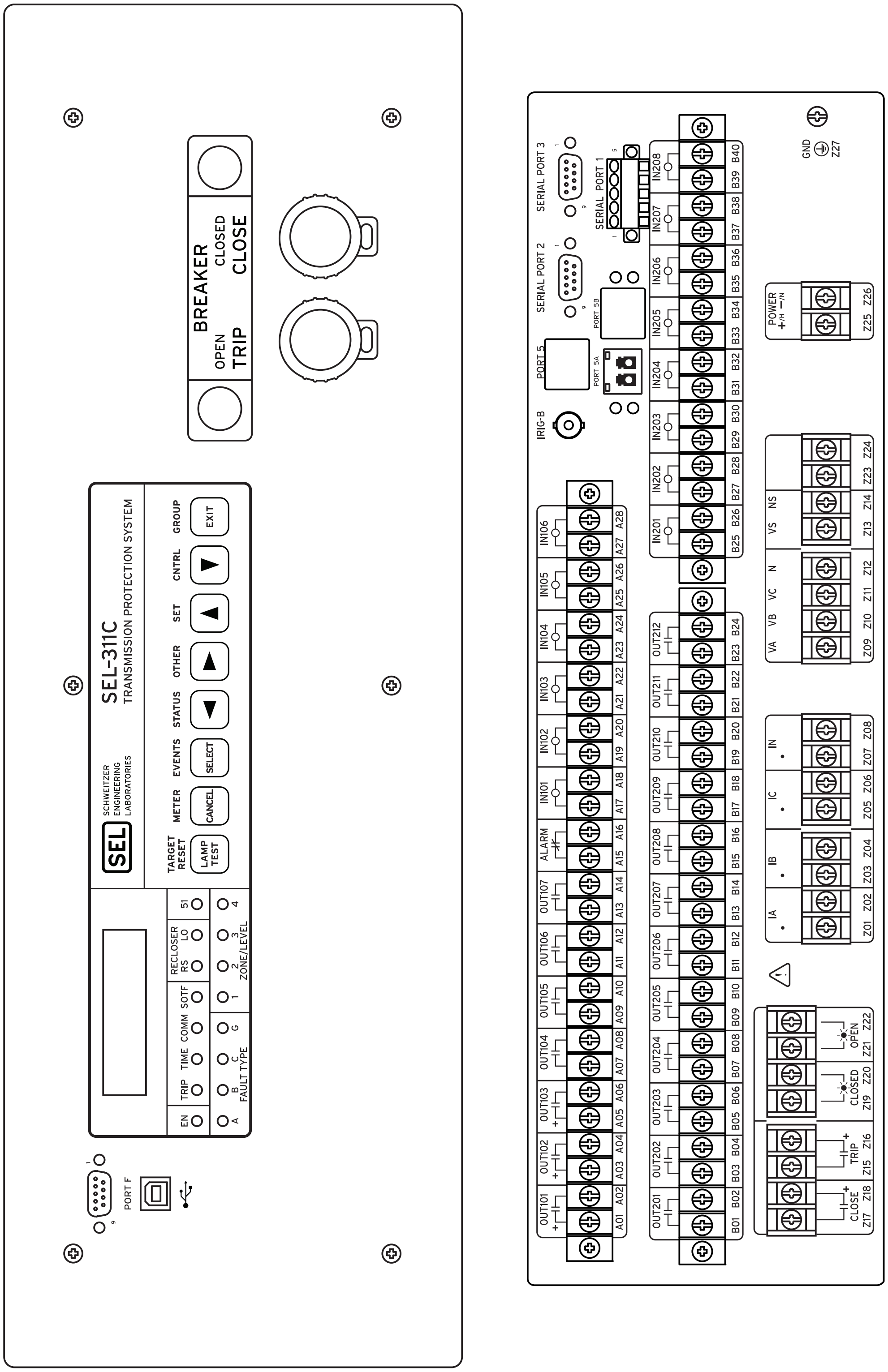


Figure 2.3 SEL-311C Front- and Rear-Panel Drawings; 3U Horizontal Panel Mount With Optional EIA-485 and USB Ports, Optional SafeLock Trip/Close Pushbuttons, Optional Extra I/O Board With 12 Standard Outputs and 8 Inputs, and Optional Single Fiber-Optic Ethernet Port.

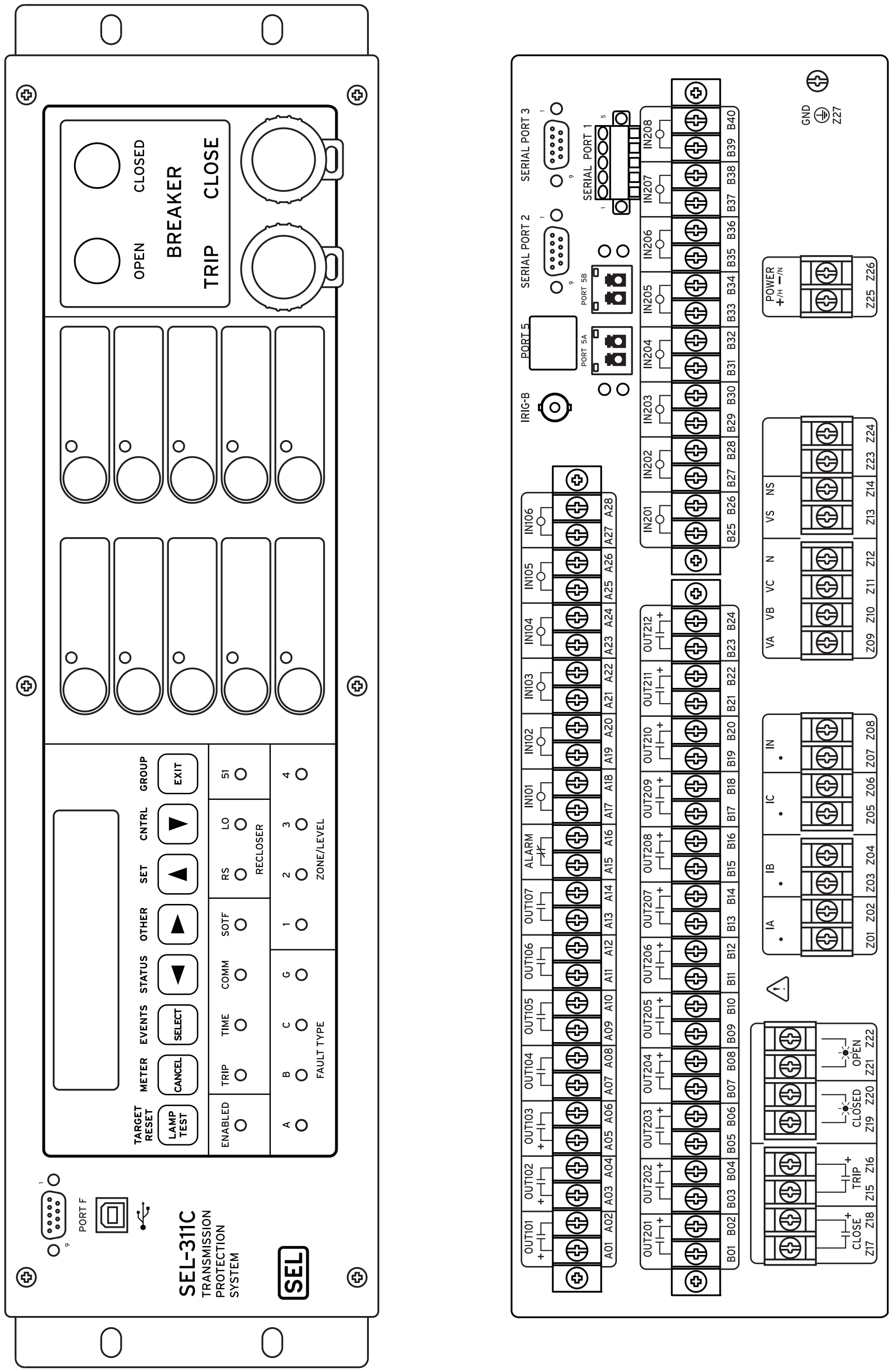


Figure 2.4 SEL-311C Front- and Rear-Panel Drawings; 3U Horizontal Rack-Mount With Optional Programmable Operator Controls and Target LEDs, Optional USB Port and SafeLock Trip/Close Pushbuttons, Optional Extra I/O Board With 12 High-Current Interrupting Outputs and 8 Inputs, Optional EIA-485 Port, and Optional Dual Fiber Ethernet Port

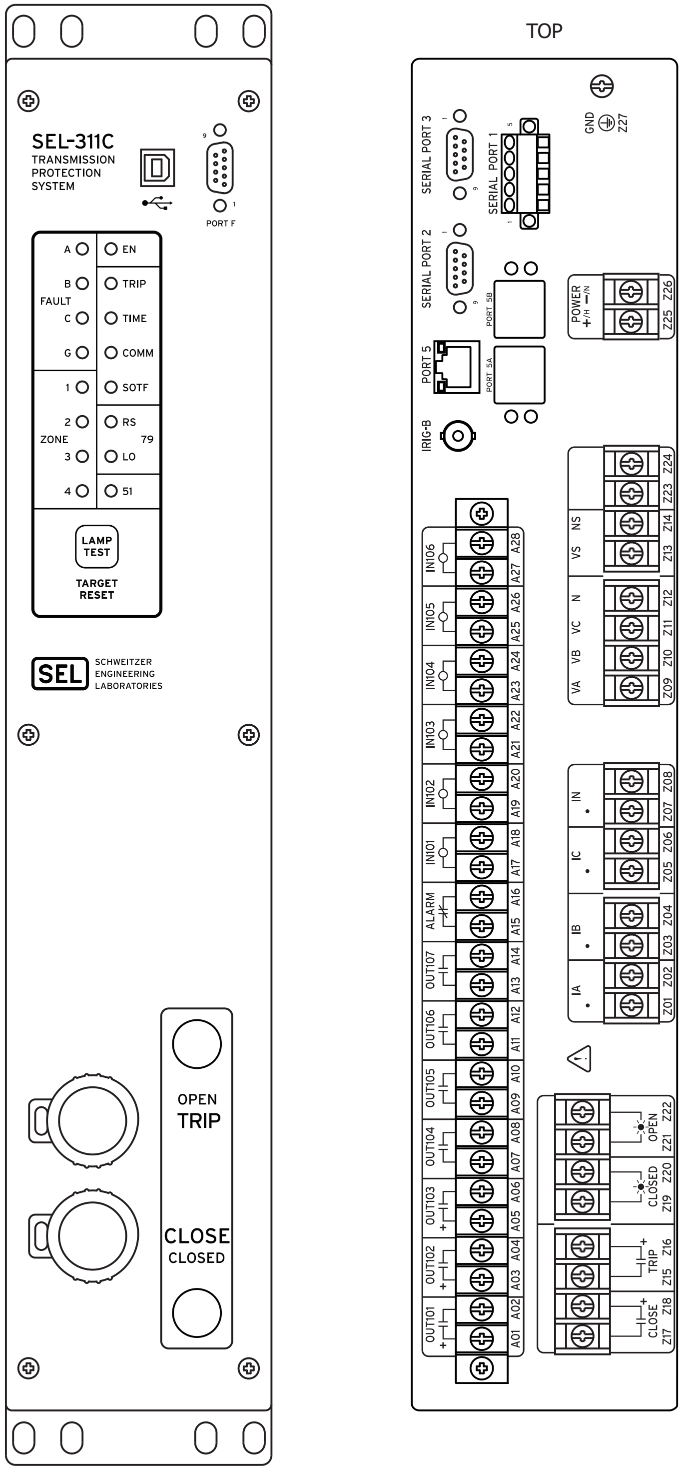


Figure 2.5 SEL-311C Front- and Rear-Panel Drawings; 2U Vertical Rack Mount With Optional USB Port, Optional SafeLock Trip/Close Pushbuttons, and Optional EIA-485 Port

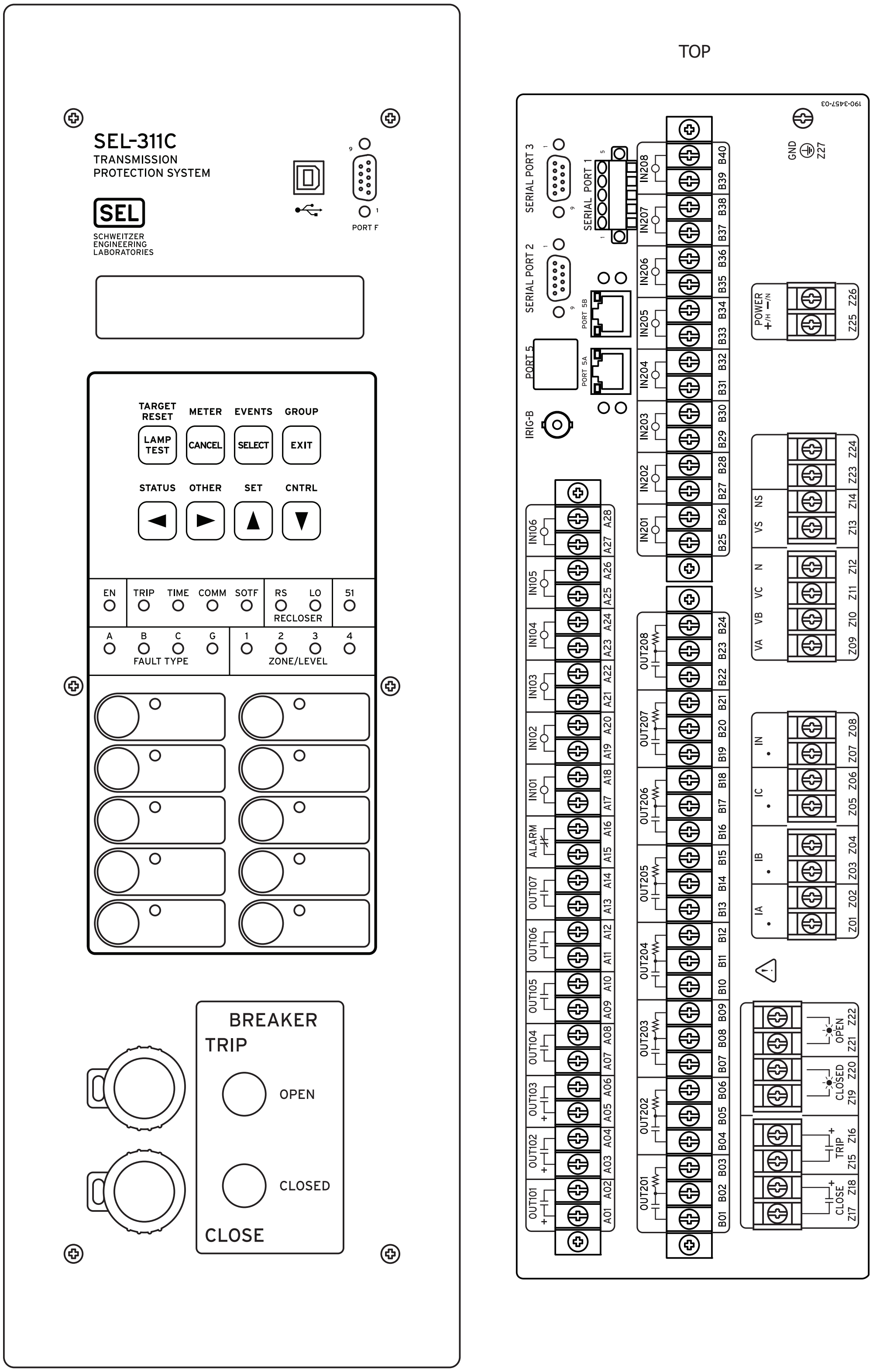


Figure 2.6 SEL-311C Front- and Rear-Panel Drawings; 3U Vertical Panel-Mount With Optional Programmable Operator Controls and Target LEDs, Optional Front-Panel USB Port and SafeLock Trip/Close Pushbuttons, Optional Extra I/O Board With Eight High-Speed, High-Current Interrupting Outputs and Eight Inputs,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

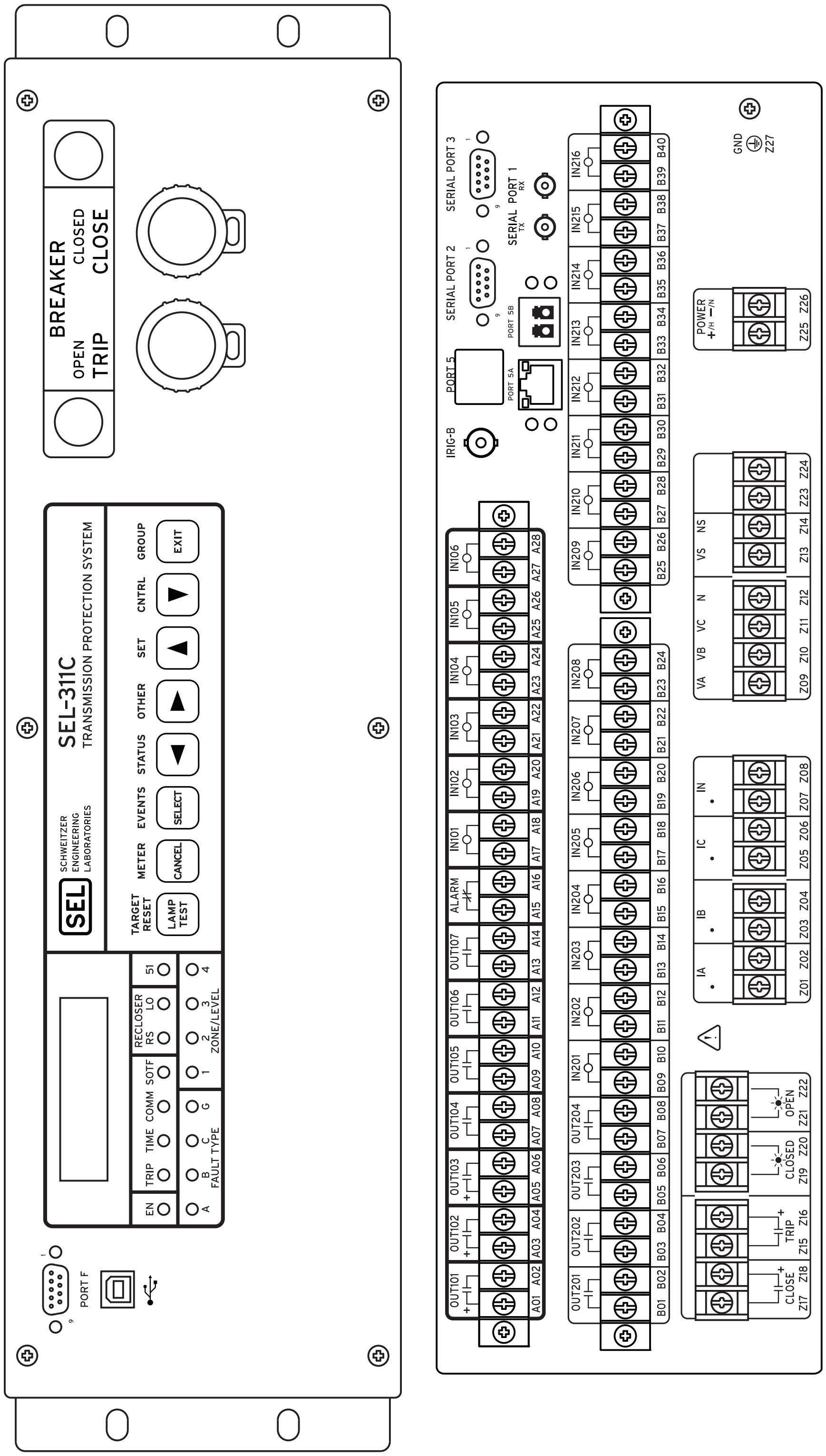


Figure 2.7 SEL-311C Front- and Rear-Panel Drawings; 3U Horizontal Rack-Mount With Optional USB Port, Optional SafeLock Trip/Close Pushbuttons, Optional Extra I/O Board With 4 Standard Outputs and 16 Inputs, and Optional Dual Copper/Fiber-Optic Ethernet With Fiber-Optic Serial Port

Making Rear-Panel Connections

Refer to *Figure 2.14–Figure 2.18* 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 in).

Chassis Ground

Ground the relay chassis at terminal **Z27** by 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 compliance with IEC 60947-1 and IEC 60947-3, place a suitable external switch or circuit breaker in the power leads for the SEL-311C; this device should interrupt both the hot (**+/H**) and neutral (**−/N**) power leads. The maximum current rating for the power disconnect circuit breaker or optional overcurrent device (fuse) should be 15 A.

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 2.10*.

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, as is an extra I/O board with four standard output contacts.

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 number and 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 12 standard output contacts on the extra I/O board (OUT201–OUT212):

0311C21HA3A54**2**1

Standard output contacts are not polarity-dependent.

Model 0311 part numbers with a numeral “4” in the field in bold below (sample part number) indicate four standard output contacts on the extra I/O board (OUT201–OUT204):

0311C21HA3A54**4**1

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 12 high-current interrupting output contacts on the extra I/O board (OUT201–OUT212):

0311C21HA3A54**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 2.4*. 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 eight fast hybrid high-current interrupting output contacts on the extra I/O board (OUT201–OUT208):

0311C21HA3A54**5**1

Fast hybrid high-current interrupting output contacts are not polarity-dependent. 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 2.8 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.

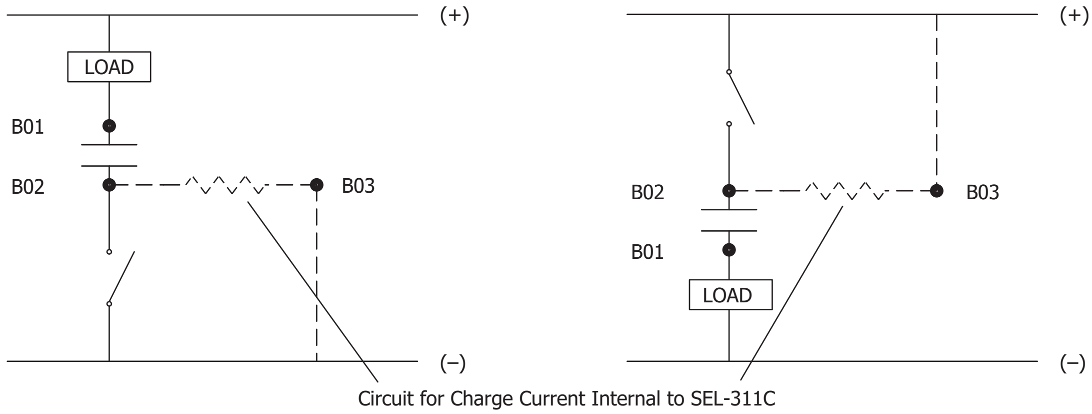


Figure 2.8 Possible Connections for Fast High-Current Interrupting Output Contacts (Third Terminal Connection Is Optional)

Optoisolated Inputs

The optoisolated inputs in the SEL-311C (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, IN201D–IN208D (extra I/O board Option 2, 5, or 6), or IN201D–IN216D (extra I/O board Option 4).

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 by 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 12.28.

Trip and close your circuit breaker or control other devices by 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 by using the integral breaker status LEDs. These features are electrically isolated and function independently of the rest of the relay. *Figure 2.19* 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 2.24* 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 2.24*.

See *Circuit Board Connections and Jumpers on page 2.23* 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 2.9*). 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.

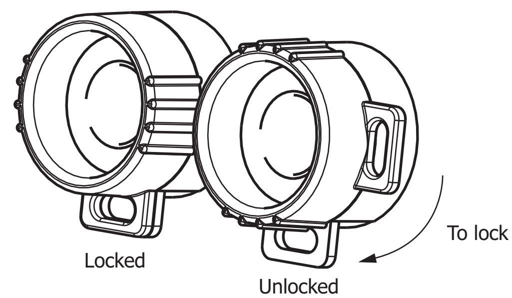


Figure 2.9 SafeLock Trip and Close Pushbuttons

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 2.10* 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.

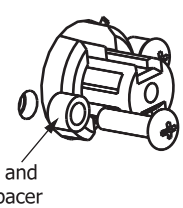


Figure 2.10 Remove Spacer and Reseat Screw to Disable Locking Mechanism

Current Transformer Inputs

Note the polarity dots above terminals **Z01**, **Z03**, **Z05**, and **Z07**. Refer to *Figure 2.14–Figure 2.18* for typical CT wiring examples.

⚠**WARNING**
Before working on a CT circuit, first apply a short to the secondary winding of the CT.

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 2.11* shows the internal connection for terminals **VA**, **VB**, **VC**, and **N**. Note also that **VS-NS** is a separate single-phase voltage input.

NOTE: Three-phase voltages are required for many relay functions including distance elements, directional elements, fault locating, and establishing fault type for front-panel targets and event reports.

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.

Wye-Connected Voltages

Any voltage input (i.e., **VA-N**, **VB-N**, **VC-N**, or **VS-NS**) can be connected to voltages as high as 300 V continuous. *Figure 2.11* 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 3.70*.

Synchronism-Check VS Connection

Voltage input VS is the voltage input for the synchronism-check elements. *Figure 2.14–Figure 2.18* show examples of synchronism-check voltage inputs applied to relay terminals **VS-NS**. See *Synchronism-Check Elements on page 3.53*.

Wye-Connected PT Example

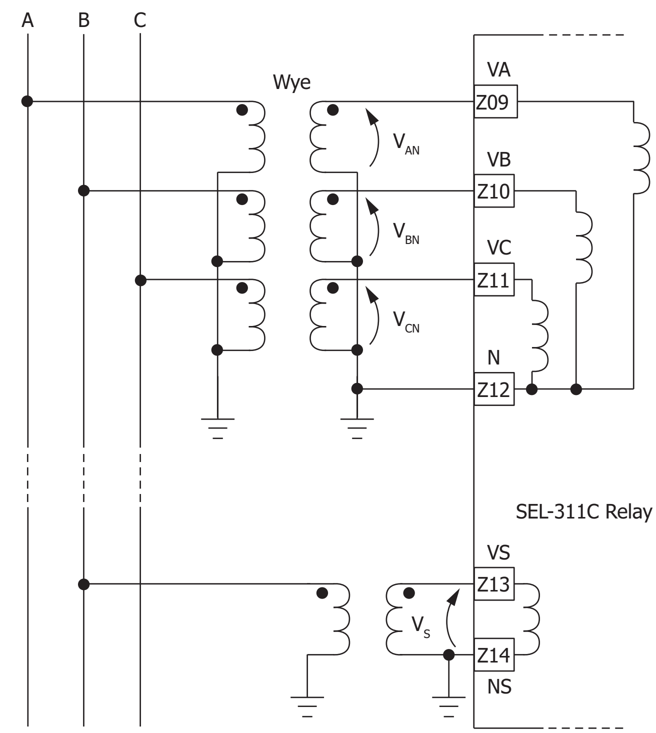


Figure 2.11 Wye-Connected PTs With Phase-to-Ground Connected Synchronism-Check Input

Making Communications Connections

USB Port

The optional front-panel USB port is intended for fast local access to the relay. Use SEL-C664 cable 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 by using SEL-C807 fiber-optic cable with LC connectors, or SEL-C627 Cat 5 cable with RJ45 connectors. Many computers support automatic crossover, so SEL-C627 cable can also be used to connect the relay directly to these computers. For computers that do not support automatic crossover, use crossover SEL-C628 cable. See *Establishing Communications Using an Ethernet Port and Telnet or the 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 either a 4-wire EIA-485 port or an SEL-2812 compatible fiber-optic port. Either option can be configured for SEL ASCII, SEL LMD, Modbus, DNP 3.0, PMU, or MIRRORED BITS protocols. The EIA-485 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.

The optional 820 nm fiber-optic serial port is designed for multimode fiber with ST connectors.

Table 2.1 shows the link budget when the SEL-311C is connected to various SEL devices.

NOTE: The fiber-optic serial port transmitter has a metal barrel. The receiver has a plastic barrel.

Table 2.1 Link Budget

Remote Device	Link Budget (db)
SEL-751A	8
SEL-2812	11
SEL-2505	11
Other SEL-311C or SEL-351	8

See the *Fiber-Optic Products and Applications* data sheet on the SEL website for instructions on how to calculate fiber system losses. When paired with an SEL-2812MT or SEL-2812FT fiber-optic transceiver and SEL communications processor or automation controller, the fiber-optic serial port operates as an IRIG-B input in addition to providing serial communications.

All EIA-232 ports accept 9-pin D-subminiature male connectors. PORT 2 and PORT 3 can be configured for SEL ASCII, SEL LMD, Modbus, DNP 3.0, PMU, or MIRRORED BITS protocols. PORT F can be configured for SEL ASCII, SEL LMD, DNP 3.0, PMU, or MIRRORED BITS protocols. PORT 2 on all SEL-311C models include the IRIG-B time-code signal input (see *Table 10.4*; see the following discussion on IRIG-B time code input).

The pin definitions for all the ports are detailed in *Table 10.4–Table 10.6*.

Refer to *Table 2.2* for a list of cables available from SEL for various communication applications. Refer to *Communications Cables on page 10.12* for detailed cable diagrams for selected cables.

NOTE: Listing of devices not manufactured by SEL in Table 2.2 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 2.2 Communication Cables to Connect the SEL-311C to Other Devices (Sheet 1 of 2)

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

Table 2.2 Communication Cables to Connect the SEL-311C to Other Devices (Sheet 2 of 2)

SEL-311C EIA-232 Serial Ports	Connect to Device (gender refers to the device)	SEL Cable No.
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 2.20.

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 2.2*, 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, to **PORT 2**, or to the optional fiber-optic serial port.

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.

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 by using SEL-C273A Cable.

Optional fiber-optic serial **Port 1** can be used to bring IRIG-B Input to the relay, as shown in *Figure 2.12* and *Figure 2.13*, or directly from the fiber-optic port of an SEL-2407.

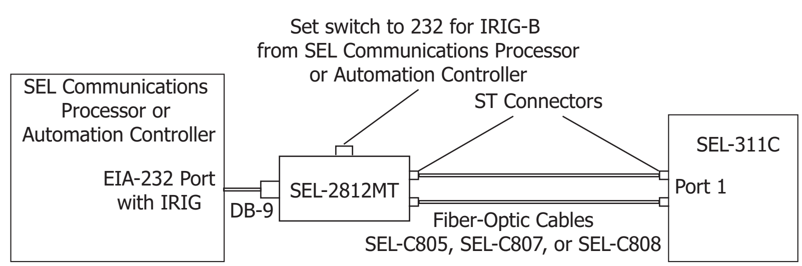


Figure 2.12 IRIG-B Input VIA Fiber-Optic Port 1 (SEL Communications Processor or Automation Controller Source)

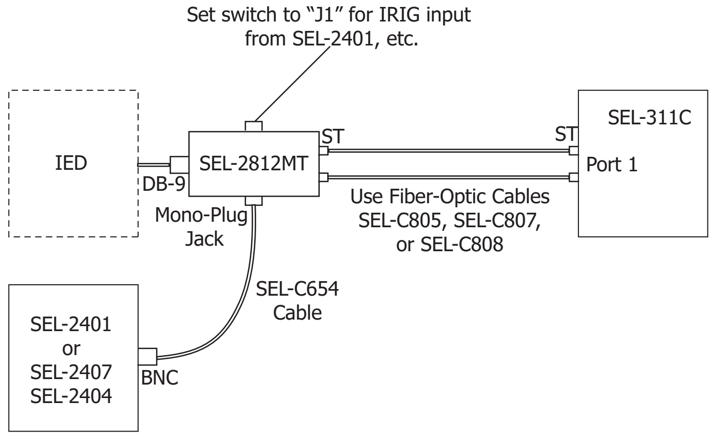


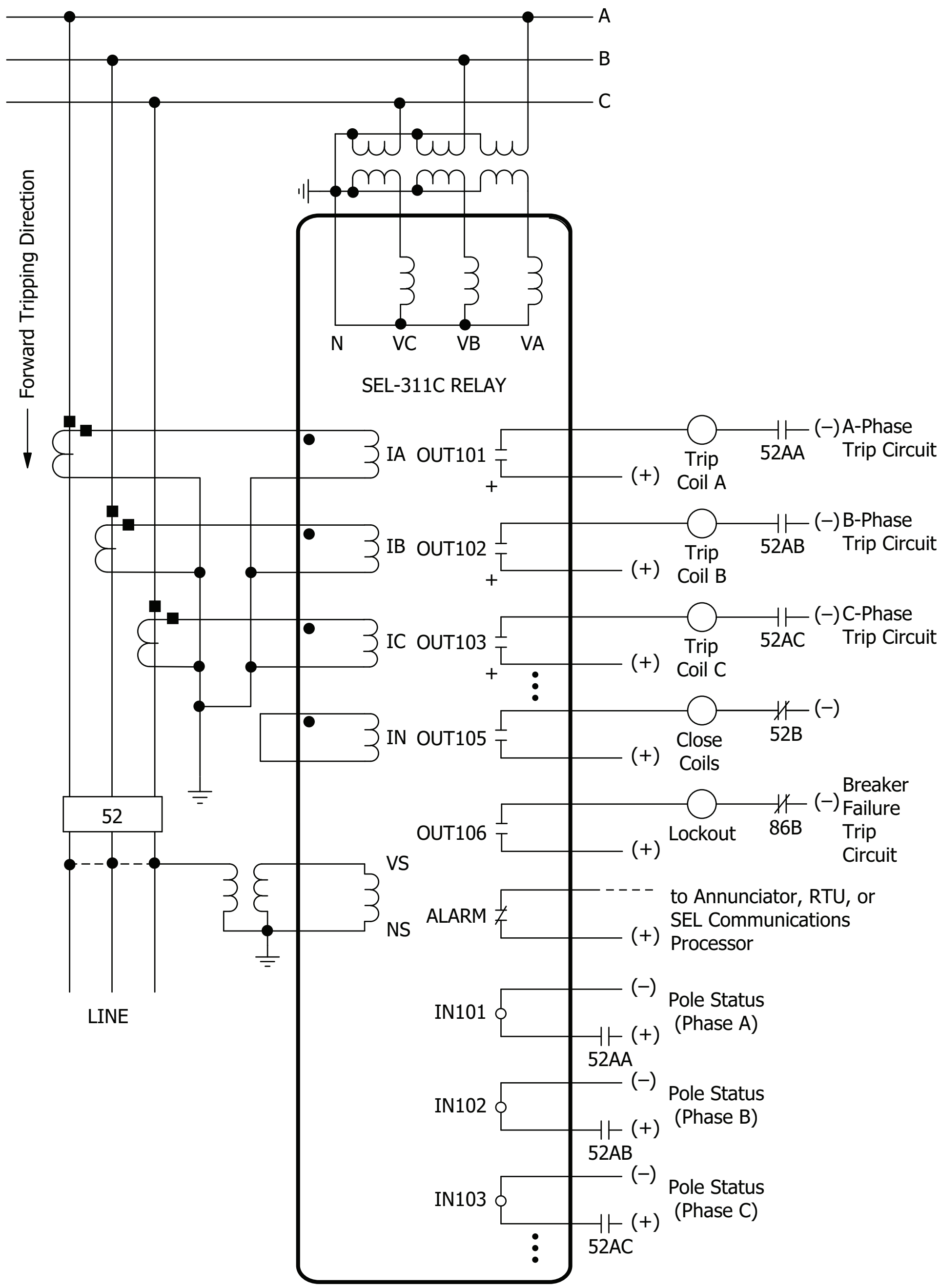
Figure 2.13 IRIG-B Input VIA Fiber-Optic Port 1 (SEL-2401/2404/2407 Time Source)

The IRIG-B signal from the fiber-optic serial port is not suitable for synchrophasor applications.

If IRIG-B signals are connected to multiple inputs, the relay selects the source for time synchronization in the following order:

1. BNC connector
2. Port 2
3. Optional Port 1 fiber-optic port

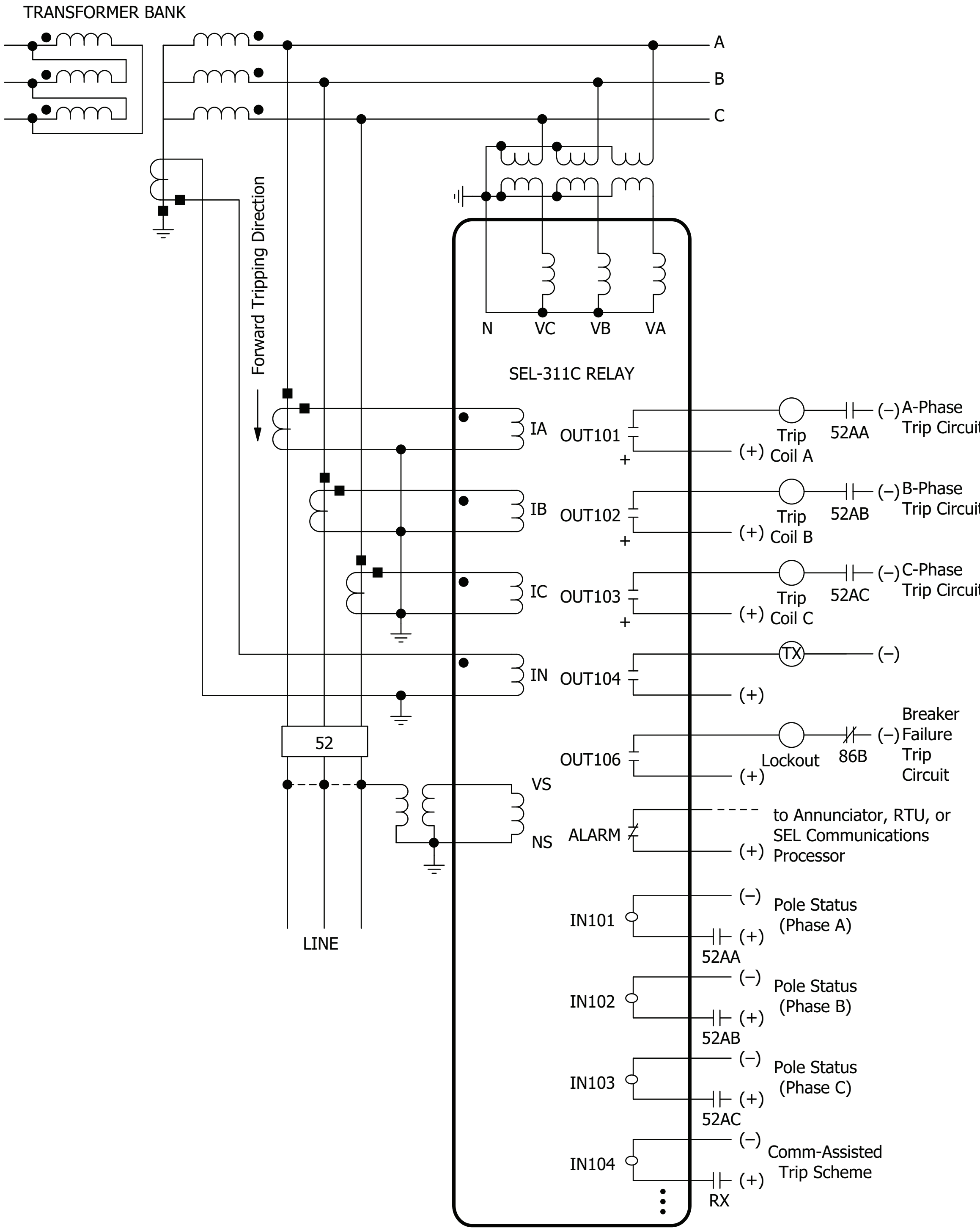
SEL-311C AC/DC Connection Diagrams for Various Applications



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.

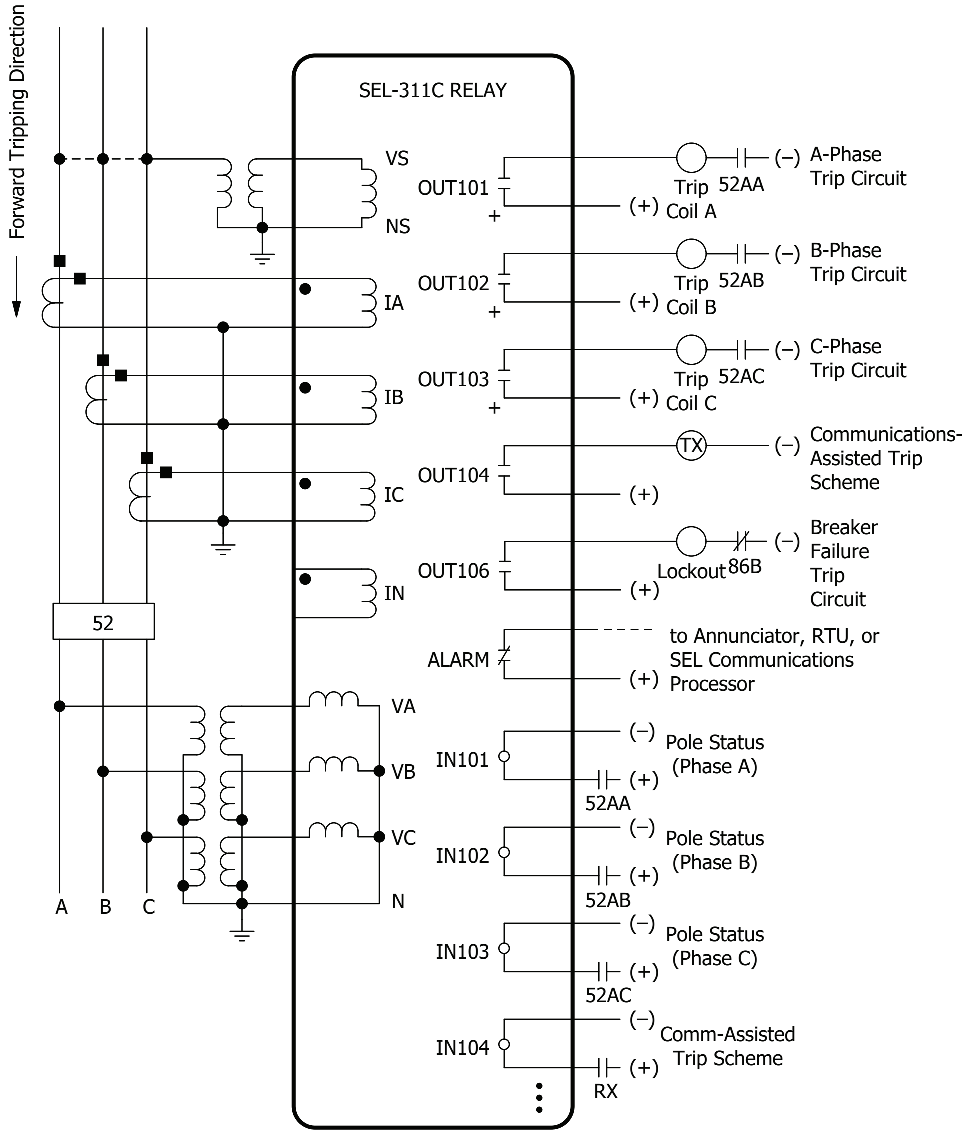
Figure 2.14 SEL-311C Provides Distance and Overcurrent Protection, Reclosing, and Synchronism Check for a Transmission Line



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

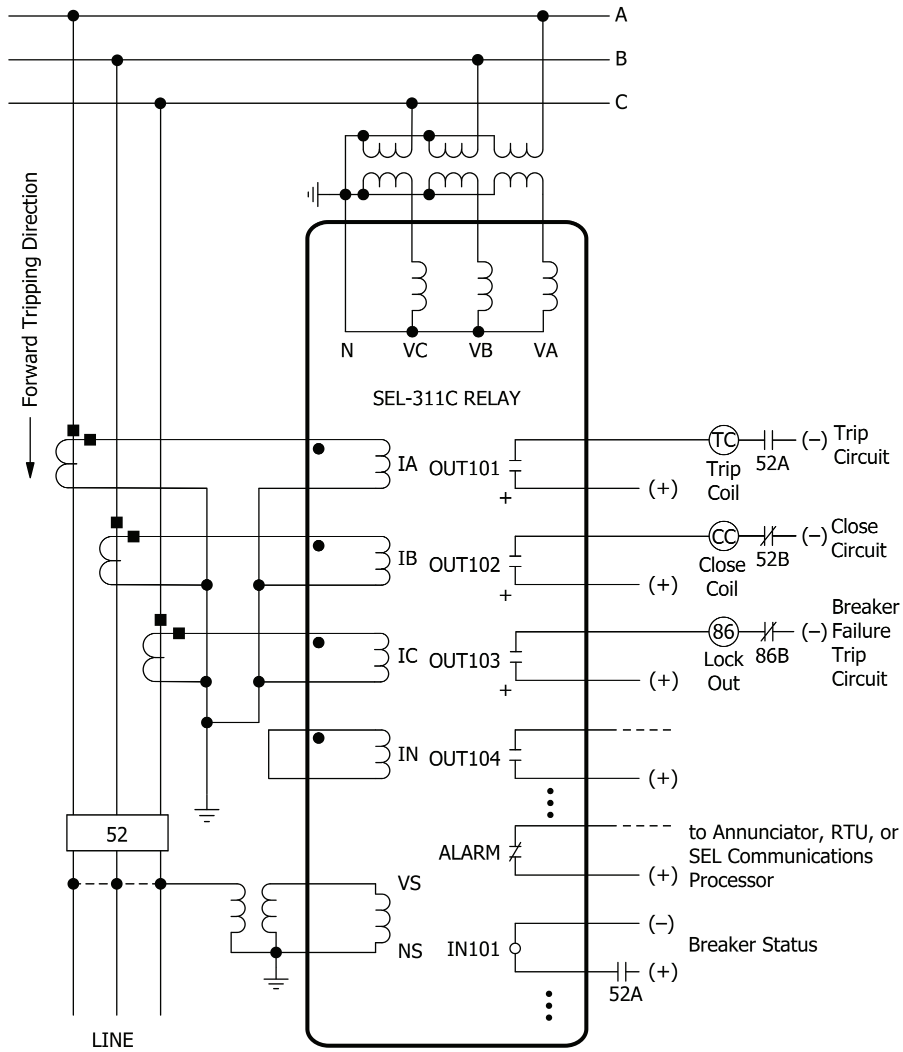
In this example, current Channel IN provides current polarization for a directional element used to control ground elements.

Figure 2.15 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.

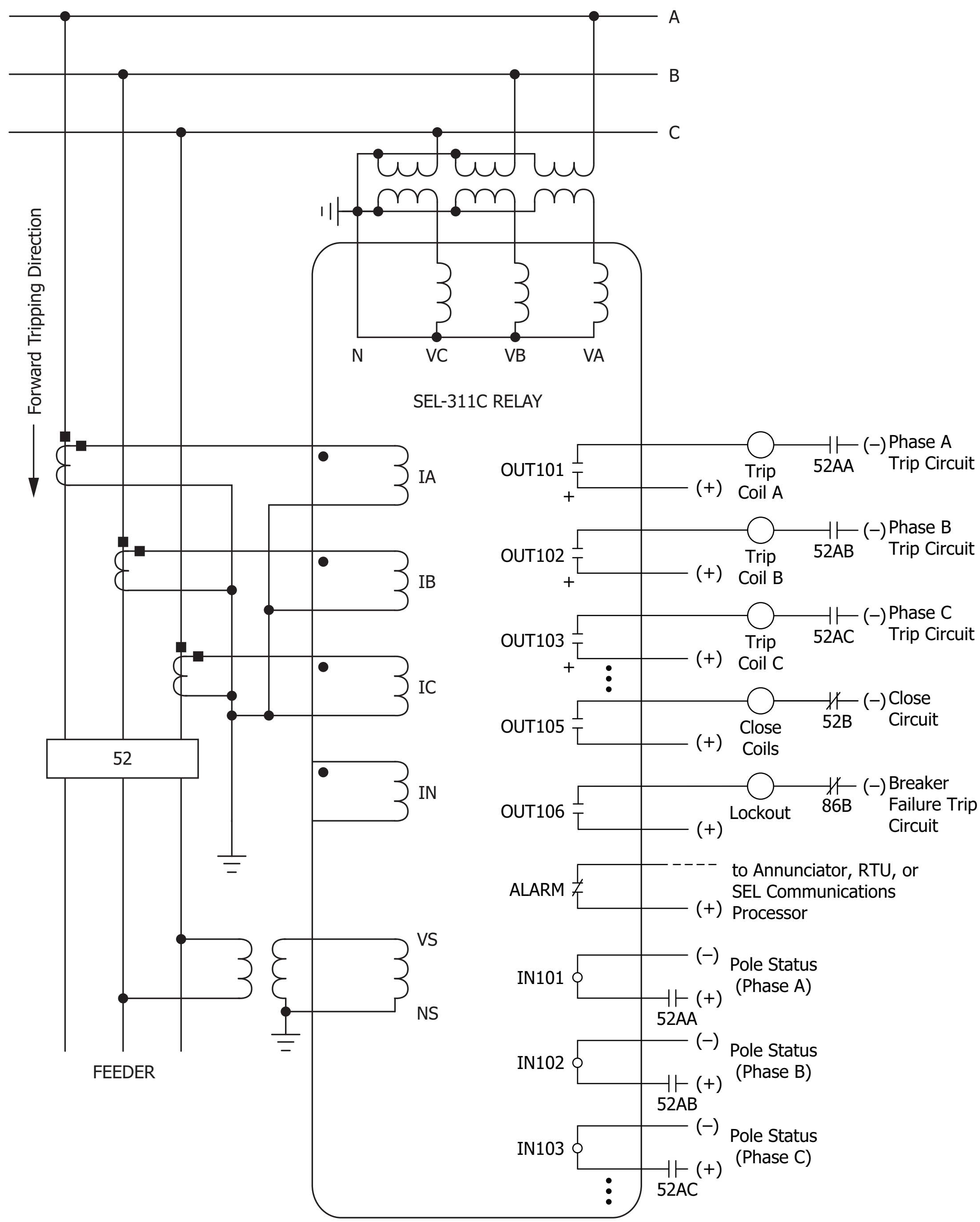
Figure 2.16 SEL-311C Provides Distance and Overcurrent Protection and Reclosing for a Transmission Line With Line-Connected Potential Transformers



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 2.17 SEL-311C Configured for Three-Pole Tripping Provides Distance and Overcurrent Protection, Reclosing, and Synchronism Check for a Transmission Line



Voltage Channel VS is shown connected for use in voltage and synchronism-check elements and voltage metering. See Synchronism-Check VS Connection on page 2.13. 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 2.18 SEL-311C Provides Distance and Overcurrent Protection and Reclosing for a Transmission Line (Wye Connected PTs and Line-to-Line Synchronism-Check Connection)

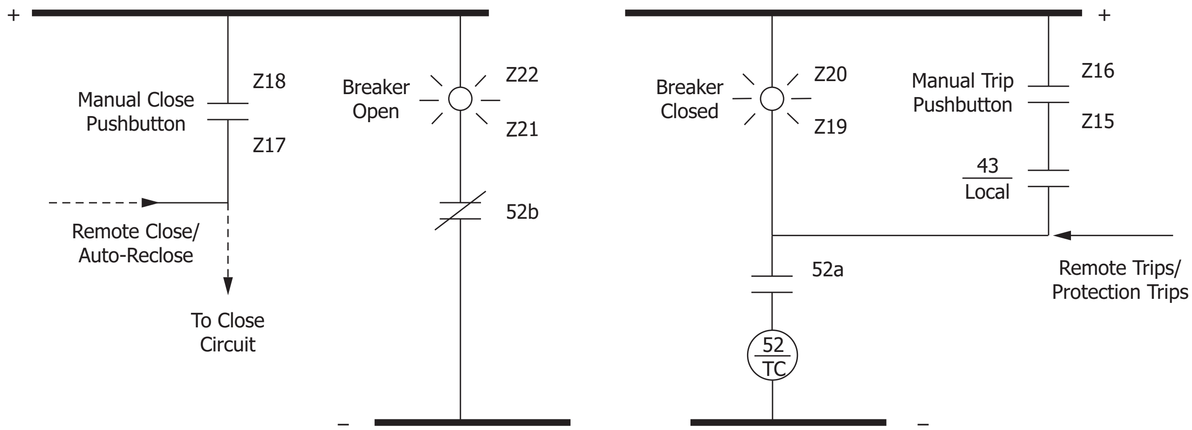


Figure 2.19 SEL-311C Example Wiring Diagram That Uses the SafeLock Trip/Close Pushbuttons

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 main board. Be careful not to damage these daughter cards when handling the main board.

To change circuit board jumpers or replace the clock battery, refer to *Figure 2.20–Figure 2.24* 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 main board only. The main board 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 main board, then remove the extra I/O board below the main board.

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 main board, then remove the extra I/O board below the main board, 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 2.20–Figure 2.24*).

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.

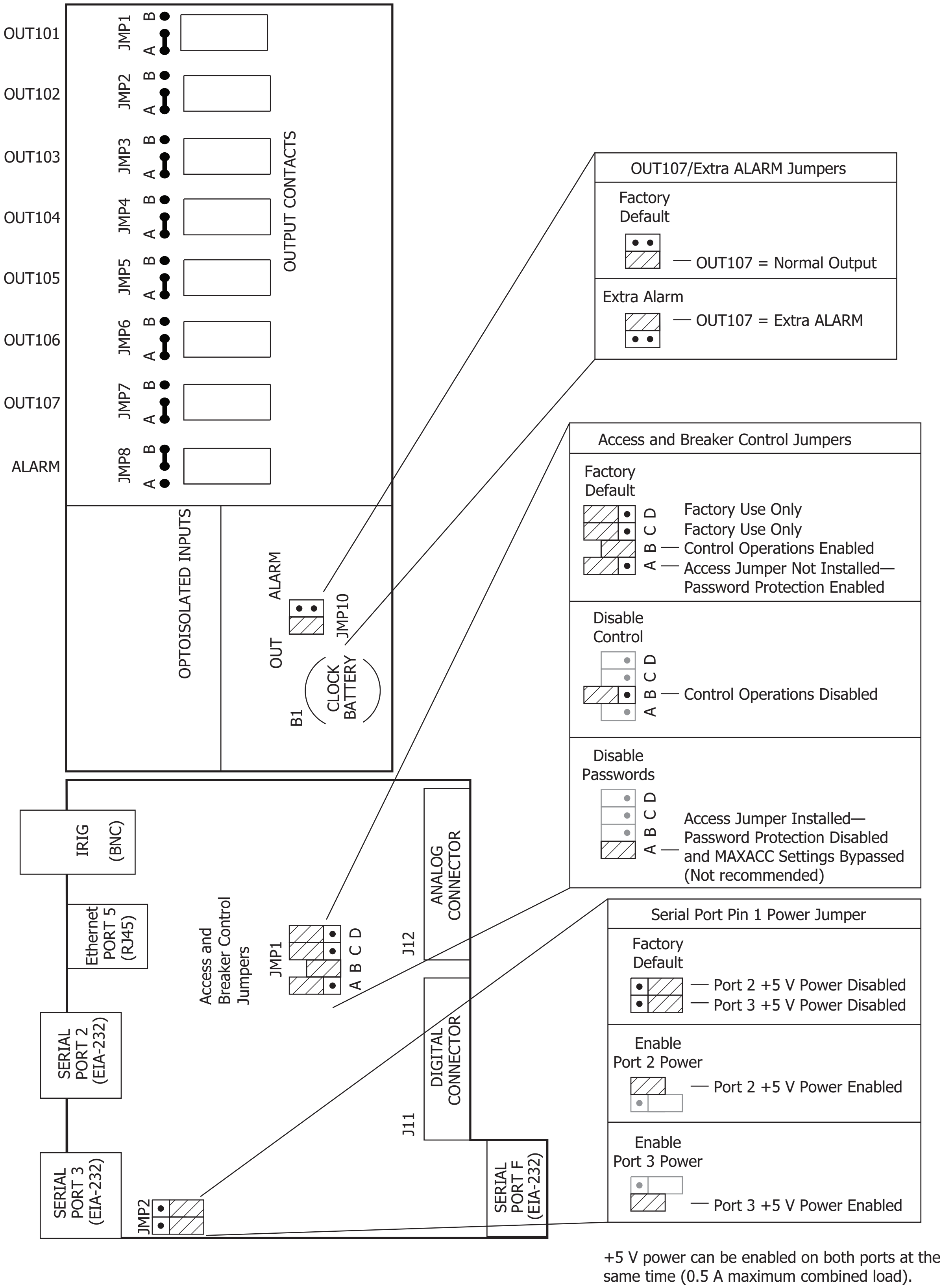


Figure 2.20 Jumper, Connector, and Major Component Locations on the SEL-311C Main Board

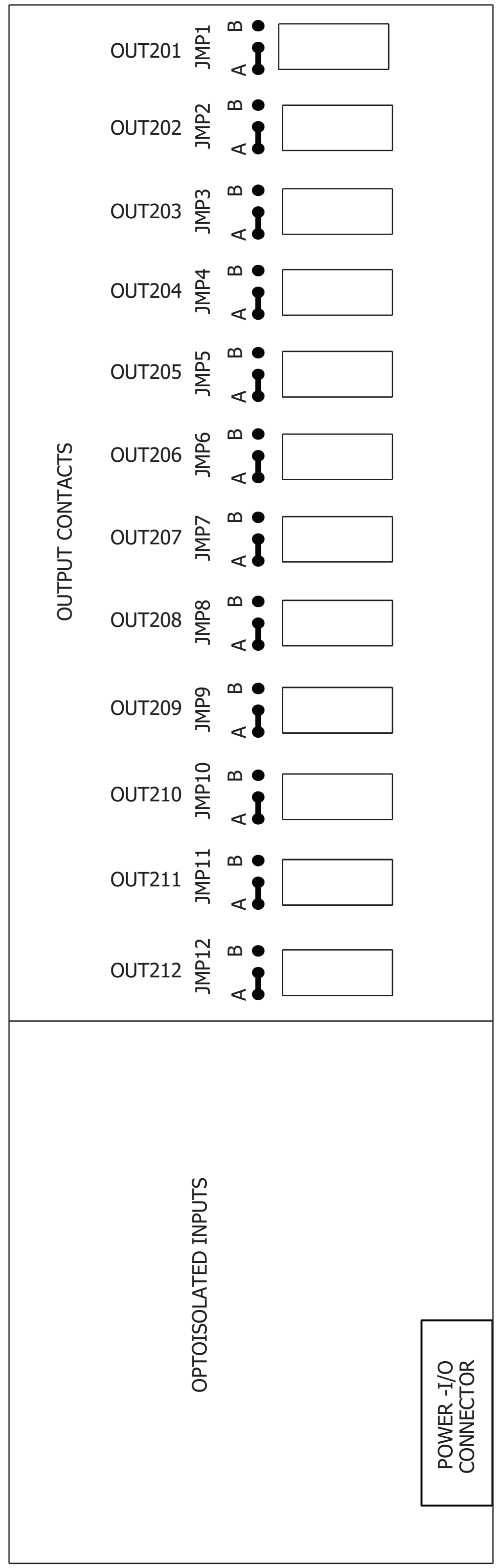


Figure 2.21 Jumper, Connector, and Major Component Locations on the SEL-311C Extra I/O Board With 12 Standard or High-Current Interrupting Outputs (Extra I/O Board Options 2 or 6)

Figure 2.22 Jumper, Connector, and Major Component Locations on the SEL-311C Extra I/O Board With Four Standard Outputs (Extra I/O Board Option 4)

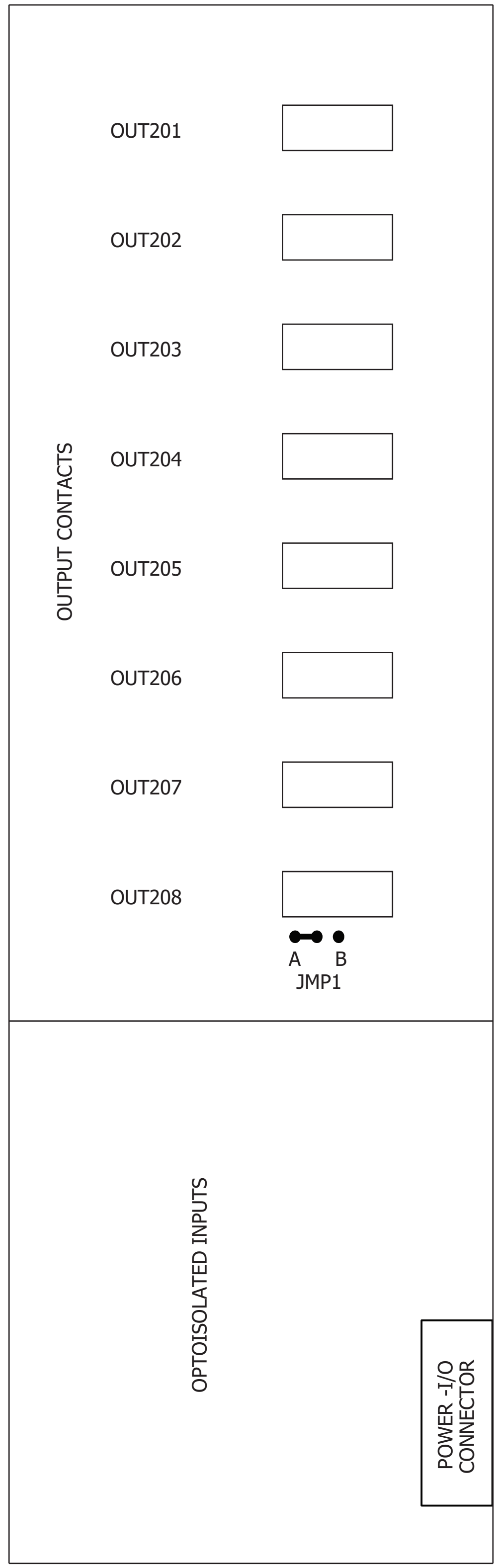


Figure 2.23 Jumper, Connector, and Major Component Locations on the SEL-311C Extra I/O Board With Eight Fast, High-Current Interrupting Outputs (Extra I/O Board Option 5)

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 2.20, *Figure 2.21*, *Figure 2.22*, and *Figure 2.23* 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. OUT201–OUT207 are fixed Form A contacts.

"Extra Alarm" Output Contact Control Jumper

The SEL-311C has one output contact designated as the alarm output and labeled ALARM on the relay rear panel. This output can be programmed to accommodate custom alarm schemes by using SELOGIC control equation ALRMOUT. See *Output Contacts on page 7.32*. Often more than one alarm output contact is necessary for applications such as local annunciation, remote annunciation, or backup schemes. An extra alarm output contact can be programmed 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 2.20 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 ALARM output contact.

If OUT107 is operating as an "extra alarm," it is driven by the same signal that operates the ALARM output contact. In a standard relay shipment, OUT107 will be in the state opposite that of the ALARM output contact because the 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 main board can be changed (see *Output Contact Jumpers*). Therefore, the 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).

See *Output Contacts on page 7.32* and *Relay Self-Tests on page 13.6* for details on the operation and settings for the ALARM and "extra alarm" outputs.

Access and Breaker Jumpers

Figure 2.20 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 when the relay turns on 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 2.20 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 10.6* 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

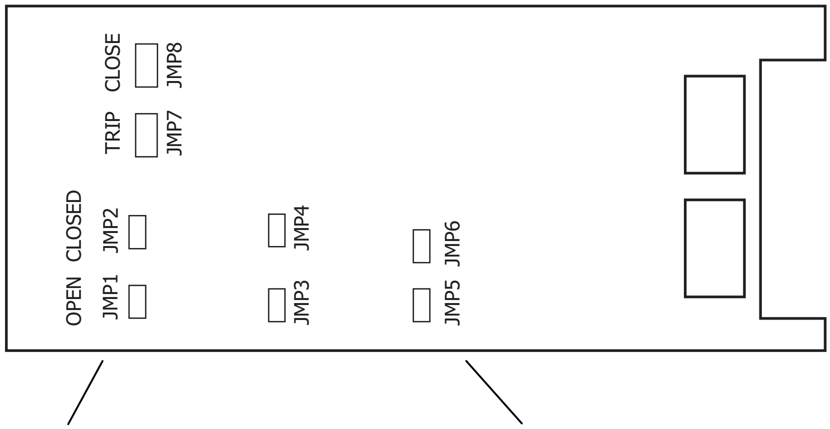
Jumpers on the pushbutton board are used to select the proper control voltage for breaker open/closed indicating LEDs on the relay front panel. *Figure 2.24* shows the jumper locations and their functions. The jumpers come preset from the factory with the voltage range set the same as the control input 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 2.23*.

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

Jumpers on the pushbutton board in *Figure 2.24* 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.

TRIP	CLOSE	ARC SUPPRESS ON, DC ONLY	ARC SUPPRESS OFF, AC OR DC
JMP7	JMP8		



OPEN LED	CLOSED LED	24 V	48 V	110/ 125 V	220/ 250 V
JMP1	JMP2				
JMP3	JMP4				
JMP5	JMP6				

Figure 2.24 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 Rayovac no. BR2335 or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.

Refer to *Figure 2.20* for clock battery location (front of the 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 2.23* 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 2.23*.

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 section 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:

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

Distance Elements

Phase-Distance Elements

NOTE: The SEL-311C described in this manual does not feature Compensator-Distance Elements, as found in some other SEL-311C Relays.

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

Enable as many as four zones of phase-distance elements by using the Group setting E21P:

- Select Positive-Sequence Memory Polarized Elements (Phase Pairs) with E21P = 1, 2, 3, or 4.
- 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.

See *Directional Control Settings on page 4.28* for details on specifying the Zone 3 and Zone 4 direction by using Group settings DIR3 and DIR4.

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.

NOTE: The SEL-311C-2 provides fast and secure tripping but does not have high-speed distance elements. See Distance Element Operating Time Curves at Nominal Frequency on page 3.14 for the operating speed of the distance elements.

In SEL-311C-3 models, Zones 1–3 have subcycle distance elements based on incremental quantities as described in the paper "Experience With Subcycle Operating Time Distance Elements in Transmission Line Digital Relays" (Benmouyal and Zimmerman) available on the SEL web site. The subcycle elements operate in addition to the standard speed elements. No additional settings are required.

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 by 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 12.8* and *Figure 12.9* 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 $\mathrm{Im}(V_1 \bullet V_2^*)$.
- 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 $\mathrm{Re}(V_1 \bullet V_2^*)$.

Table 3.1 shows the calculations used for the positive-sequence polarized 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.

$$0 = \mathrm{Re}[(Z \bullet I - V) \bullet Vmem^*] \qquad \textbf{Equation 3.1}$$

Table 3.1 Phase-Distance Calculations

Positive-Sequence Polarized Mho Element	
A-B-phase	$$\lvert Z\rvert = \frac{\mathrm{Re}(V_{AB} \bullet V_{AB}\mathrm{mem}^*)}{\mathrm{Re}(1\angle Z \bullet I_{AB} \bullet V_{AB}\mathrm{mem}^*)}$$
B-C-phase	$$\lvert Z\rvert = \frac{\mathrm{Re}(V_{BC} \bullet V_{BC}\mathrm{mem}^*)}{\mathrm{Re}(1\angle Z \bullet I_{BC} \bullet V_{BC}\mathrm{mem}^*)}$$
C-A-phase	$$\lvert Z\rvert = \frac{\mathrm{Re}(V_{CA} \bullet V_{CA}\mathrm{mem}^*)}{\mathrm{Re}(1\angle Z \bullet I_{CA} \bullet V_{CA}\mathrm{mem}^*)}$$
	Z = Impedance measurement at the line angle

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* shows the operating voltages “inside” positive-sequence polarized 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.

The SEL-311C does not include logic to address voltage inversion and other conditions that may occur on series-compensated lines. For these applications, consider an SEL-400 series relay with series-compensation logic. For more information on setting relays to protect series- compensated lines see *SEL Application Guide 2000-11: Applying the SEL-321 Relay on Series-Compensated Systems*.

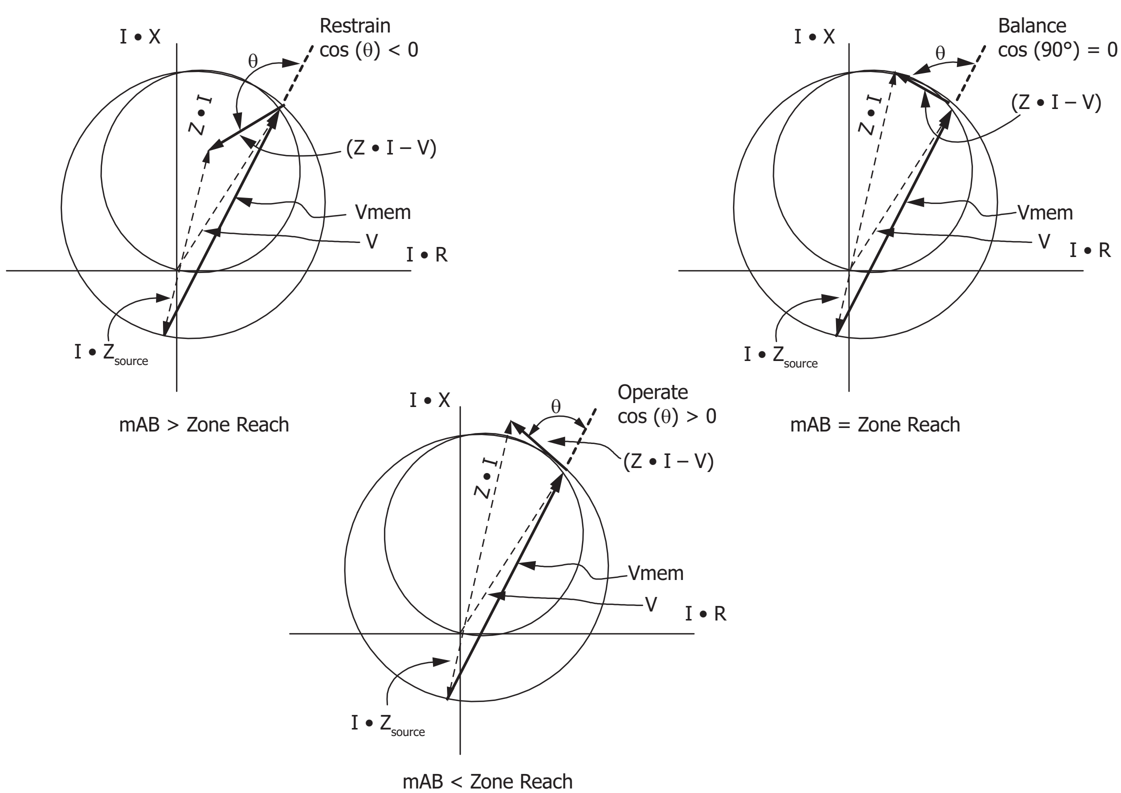


Figure 3.1 Positive-Sequence Polarized Mho Element With Reach Equal to Line Impedance

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. 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.

Elements that have not been enabled or have reach setting Z*n*P = OFF are not processed, and the outputs are forced to logical 0.

Table 3.2 Distance Elements Settings

Mho Phase-Distance Elements (Zones 1–4)	
Enable Setting for Mho Phase Distance Elements (E21P):	N, 1–4, N = Disabled 1–4 Selects number of Positive-Sequence Memory Polarized Elements (Phase Pairs)
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)[a]:	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 3.28* and *Figure 3.29*.

[a] If setting EADVS = N, settings 50PP2–50PP4 are at minimum values and are hidden.

Some of the settings in *Table 3.2* are hidden under the control of the Enable Advanced Settings (EADVS = N) group setting, as described in *Enable Settings on page 9.19*.

The mho phase-distance element logic is shown in *Figure 3.4* through *Figure 3.6*. Only the logic for AB pair is shown in detail. 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.

For faults involving ground, the SEL-311C fault identification logic determines the fault type, and blocks two phase pair elements, as shown at the bottom of *Figure 3.2* through *Figure 3.4*. For example, if the Fault Identification Selection (FIDS) logic output FSB asserts, phase pairs AB and BC are blocked, and phase pair CA is allowed to operate. This functionality is only available when all three breaker poles are closed; otherwise, Relay Word bits FSA, FSB, and FSC cannot assert.

The SEL-311C phase and negative-sequence directional elements supervise the phase-pair distance elements, as shown at the top of *Figure 3.2* through *Figure 3.4* (forward supervision), and in the middle of *Figure 3.4* (reverse supervision). Because these directional elements are defeated when Relay Word bit SPO is asserted, open-pole directional logic is provided for directional control during single-pole open conditions. Relay Word bits 32SPOF and 32SPOR provide this supervision.

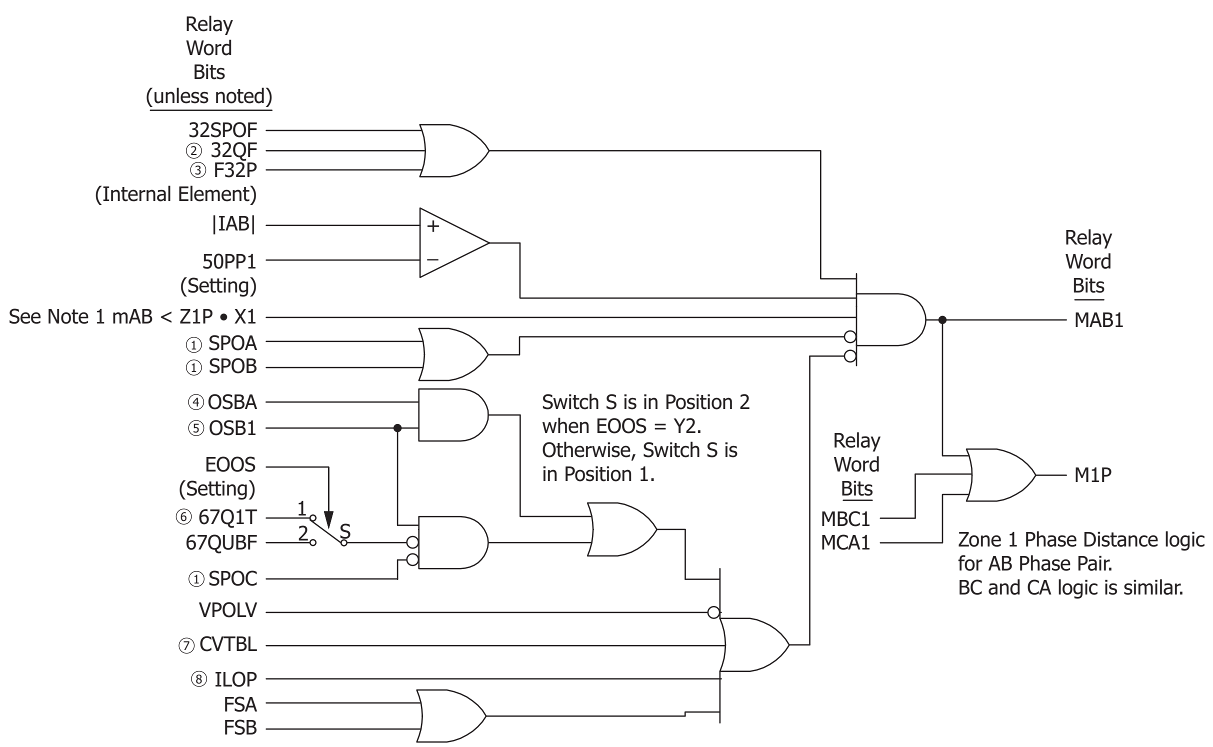
If a single-pole open condition is detected (SPO = logical 1), the fault identification logic is disabled and Relay Word bits FSA, FSB, and FSC can no longer assert. In this situation, the phase pairs are disabled based on the phase of the open pole (Relay Word bit SPOA, SPOB, or SPOC will be asserted), as shown in the middle of *Figure 3.2* through *Figure 3.4*. For example, when SPOB is asserted, the MAB and MBC phase pairs are automatically disabled. See *Figure 5.6* for details on the pole open logic.

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

When EOOS = Y, the out-of-step blocking input to the mho phase pair elements in this model of the SEL-311C differs from that found in some other relay models. The main difference is that the Zone 1 logic in *Figure 3.2* 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 still used for Zones 2, 3, and 4 unblocking, along with the negative-sequence instantaneous overcurrent element 50Q*n*P and the directional control 32QF or 32QR, depending on the element. When EOOS = Y2, the Zone 1 elements are not treated any differently than the remaining zones and use the negative-sequence directional element 67QUBF to perform unblocking.

Phase selection signals OSBA, OSBB, and OSBC may also be active during single pole open (SPO) conditions. See *Out-of-Step Blocking of Distance Elements on page 3.29* for additional details.

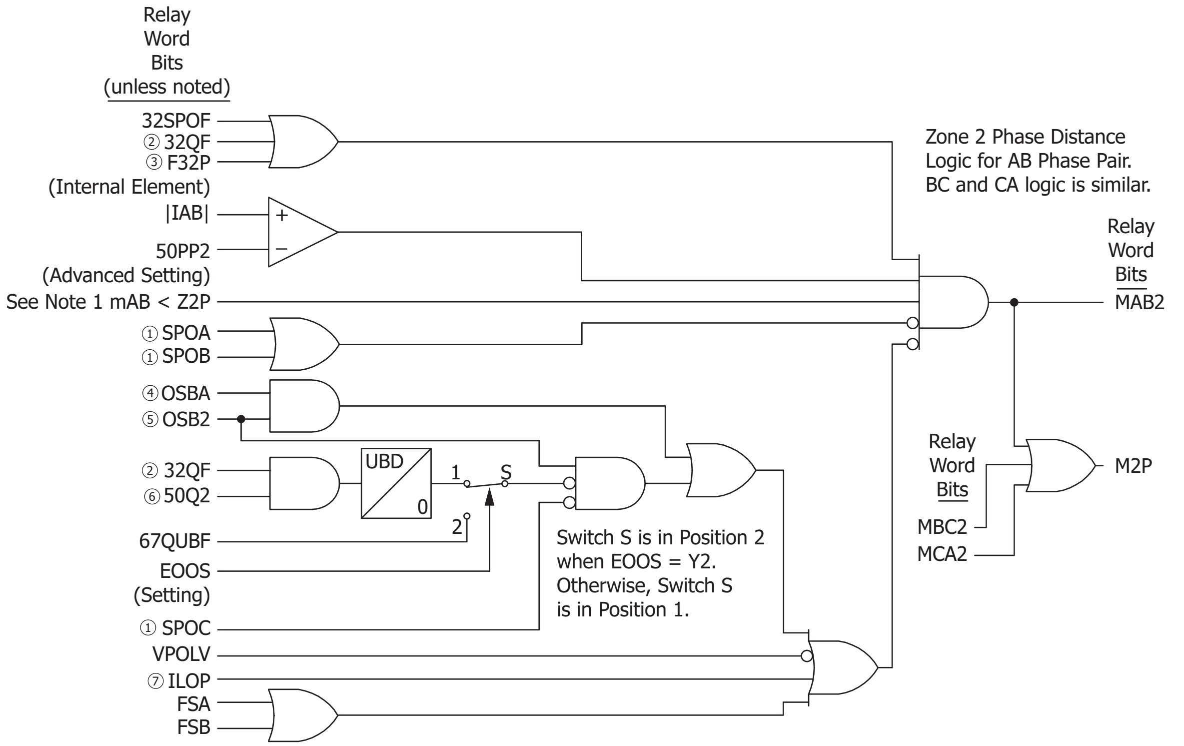
See *SEL-311C Models on page 1.1* for a list of differences between relay models.



Note 1: mAB = A-Phase to B-Phase Distance Calculation, Z1P = Zone 1 Distance Setting, X1 = Zone 1 Extension ⑨.

① From Figure 5.6; ② from Figure 4.20; ③ from Figure 4.21; ④ from Figure 3.24; ⑤ from Figure 3.23; ⑥ from Figure 3.31; ⑦ from Figure 4.9; ⑧ from Figure 4.1; ⑨ from Table 3.4 and Table 3.6.

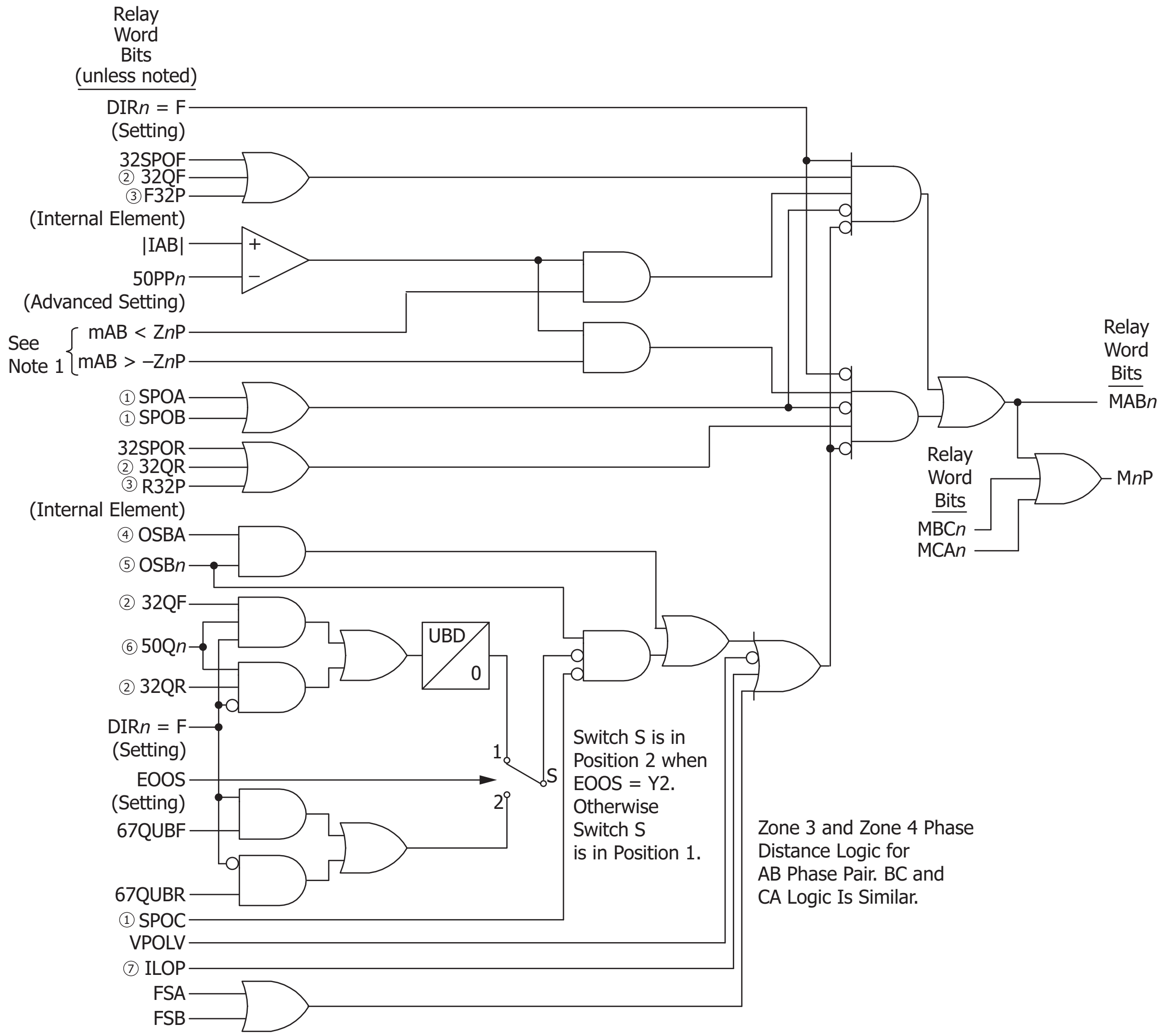
Figure 3.2 Zone 1 Phase-Distance Logic



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

① From Figure 5.6; ② from Figure 4.20; ③ from Figure 4.21; ④ from Figure 3.24; ⑤ from Figure 3.23; ⑥ from Figure 3.31; ⑦ from Figure 4.1.

Figure 3.3 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.

① From Figure 5.6; ② from Figure 4.20; ③ from Figure 4.21; ④ from Figure 3.24; ⑤ from Figure 3.23; ⑥ from Figure 3.31; ⑦ from Figure 4.1.

Figure 3.4 Zone 3 and Zone 4 Phase-Distance Logic

Ground-Distance Elements

The SEL-311C has four independent zones of mho and quadrilateral ground-distance protection. All zones are independently set. Zone 1 and Zone 2 are forward direction only, and Zone 3 and Zone 4 can be set in either the forward or reverse direction.

In SEL-311C-3 models, Zones 1–3 have high-speed distance elements based on incremental quantities as described in the paper "Experience With Subcycle Operating Time Distance Elements in Transmission Line Digital Relays" (Benmouyal and Zimmerman), available on the SEL web site. The high-speed elements operate in addition to the standard speed elements. No additional settings are required.

NOTE: The SEL-311C-2 provides fast and secure tripping but does not have high-speed distance elements. See Distance Element Operating Time Curves at Nominal Frequency on page 3.14 for the operating speed of the distance elements.

Ground-Distance Element Settings and Logic Diagrams

Table 3.3 lists the settings for the ground-distance elements. *Figure 3.5* through *Figure 3.7* contain the logic for the mho ground-distance elements, and *Figure 3.8* through *Figure 3.10* 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.

NOTE: The quadrilateral ground-distance elements are disabled during single pole open (SPO)

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 quadrilateral ground-distance elements by making Group setting E21XG = N.

As shown in *Figure 3.5* through *Figure 3.7*, the mho and quadrilateral ground-distance element outputs are combined as Z1G, Z2G, Z3G, and Z4G for Zone 1 through Zone 4.

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

See *Directional Control Settings on page 4.28* for details on specifying the Zone 3 and Zone 4 direction by using Group settings DIR3 and DIR4.

Out-of-Step Block Applies to Certain Ground Elements

The SEL-311C out-of-step blocking function affects the mho ground elements for Zones 1–4, and the Zone 1 quadrilateral ground element. Out-of-step blocking of the ground-distance elements was not found in the original SEL-311C products.

Additionally, when EOOS = Y, the Zone 1 logic in *Figure 3.5* and *Figure 3.8* uses the directional negative-sequence definite-time overcurrent element 67Q1T to defeat the OSB1 input. When EOOS = Y2, the Zone 1 ground-distance elements use the negative-sequence directional element 67QUBF to perform unblocking.

For the mho ground directional elements, the phase selective out-of-step blocking signals OSBA, OSBB, and OSBC may also be active during single-pole open (SPO) conditions.

See *Out-of-Step Blocking of Distance Elements on page 3.29* for additional details.

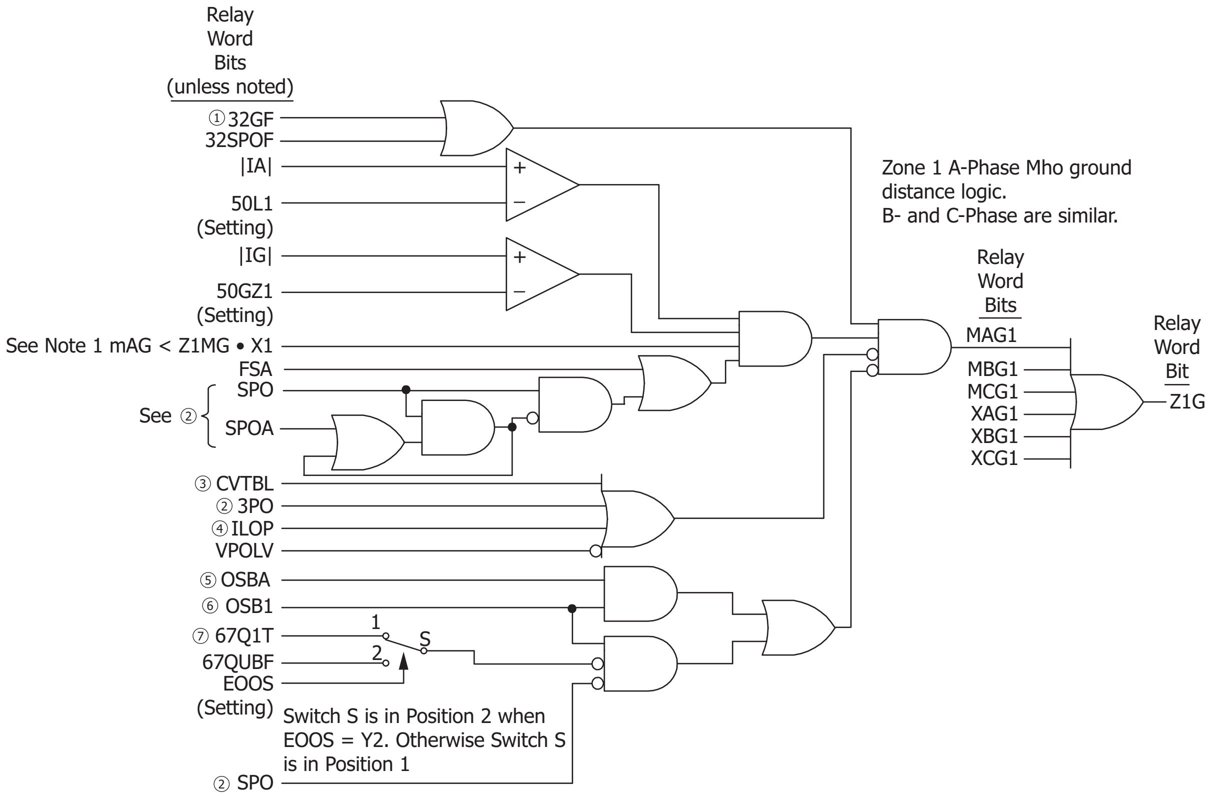
See *SEL-311C Models on page 1.1* for a list of differences between relay models.

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]: 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,c]: k0M[b,c]:	 AUTO, 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,c]: k0A[b,c]:	 –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 = N, zero-sequence compensation settings k0M and k0A are set equal to k0M1 and k0A1, respectively.
[c] When AUTO is entered into the k0M1 setting, the relay calculates the value for k0M1, k0A1, k0M, and k0A according to Equation 3.2. The relay then replaces the AUTO selection with the calculated k0M1 value before the settings are saved. The k0A1, k0M, and k0A setting entries may still be modified after k0M1 is set to AUTO.

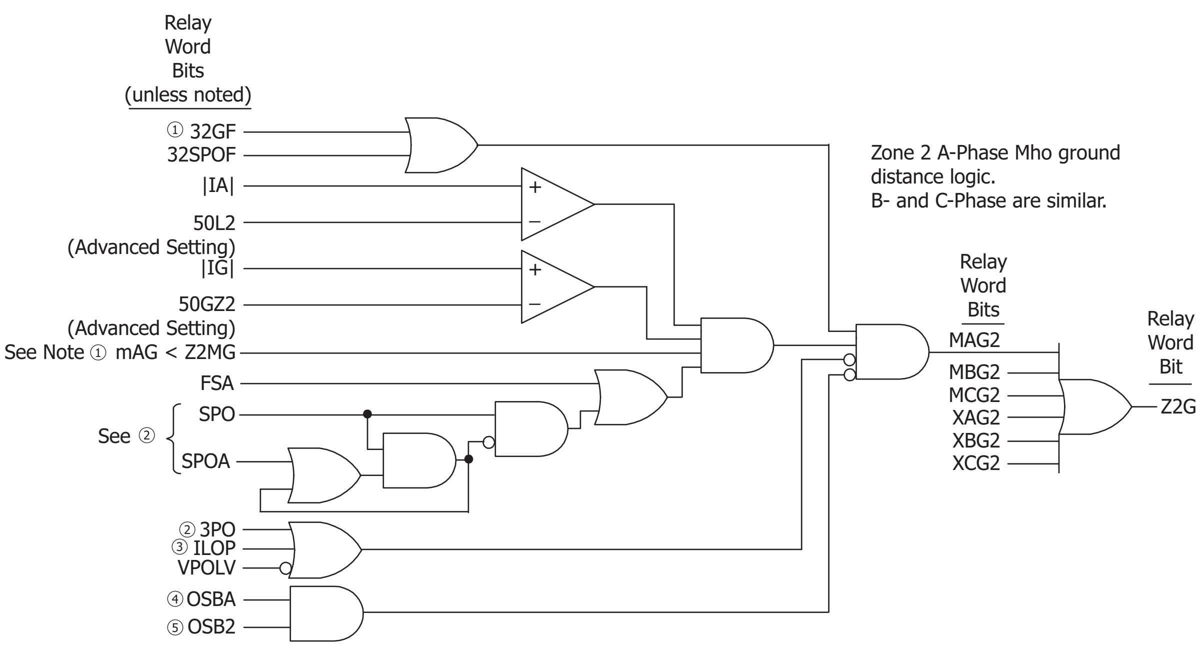
$$k0M1\angle k0A1 = \frac{(\text{Z0MAG } \angle Z0ANG) - (\text{Z1MAG } \angle Z1ANG)}{3 \bullet (\text{Z1MAG } \angle Z1ANG)} \quad \textbf{Equation 3.2}$$



Note 1: mAG = A-Phase-to-Ground Distance Calculation, Z1MG = Zone 1 Distance Setting, X1 = Zone 1 Extension ⑧.

① From Figure 4.18; ② from Figure 5.6; ③ from Figure 4.9; ④ from Figure 4.1; ⑤ from Figure 3.24; ⑥ from Figure 3.23; ⑦ from Figure 3.31; ⑧ from Table 3.4 or Table 3.7.

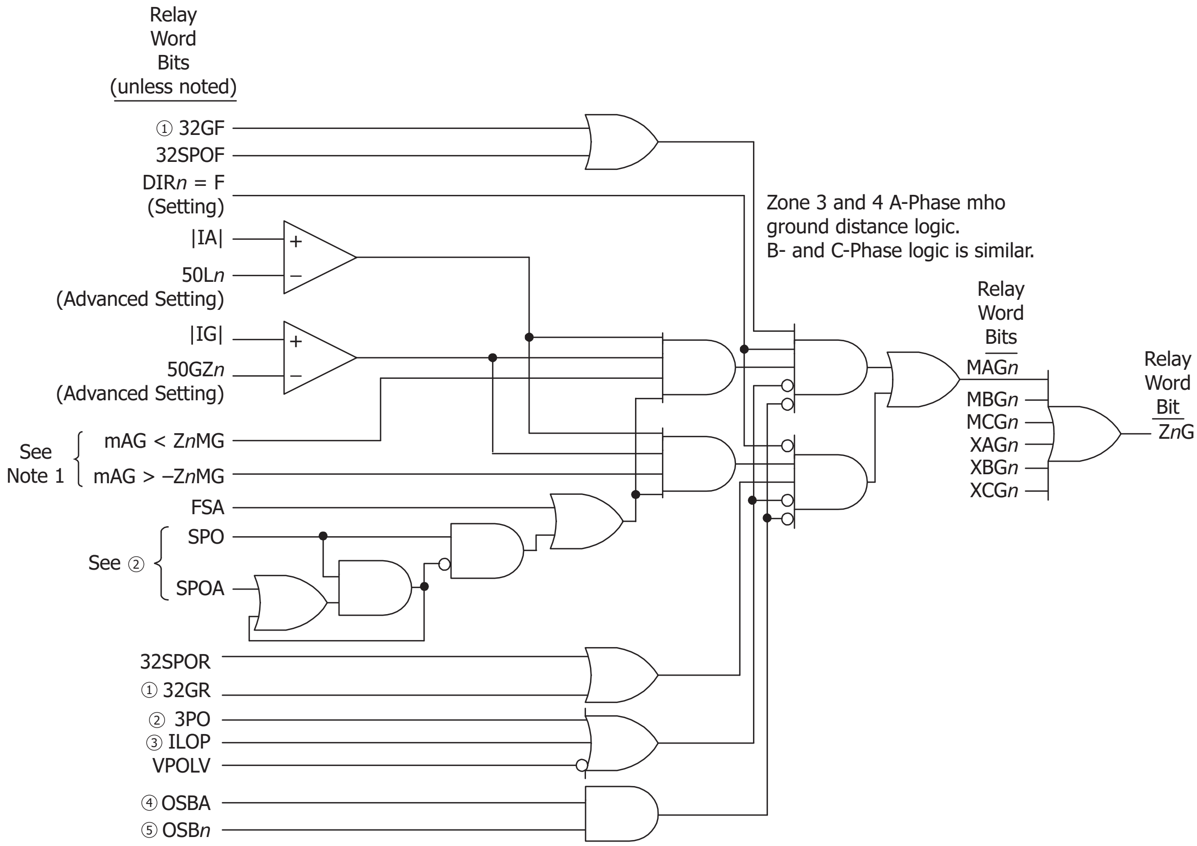
Figure 3.5 Zone 1 Mho Ground-Distance Logic



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

① From Figure 4.18; ② from Figure 5.6; ③ from Figure 4.1; ④ from Figure 3.24; ⑤ from Figure 3.23.

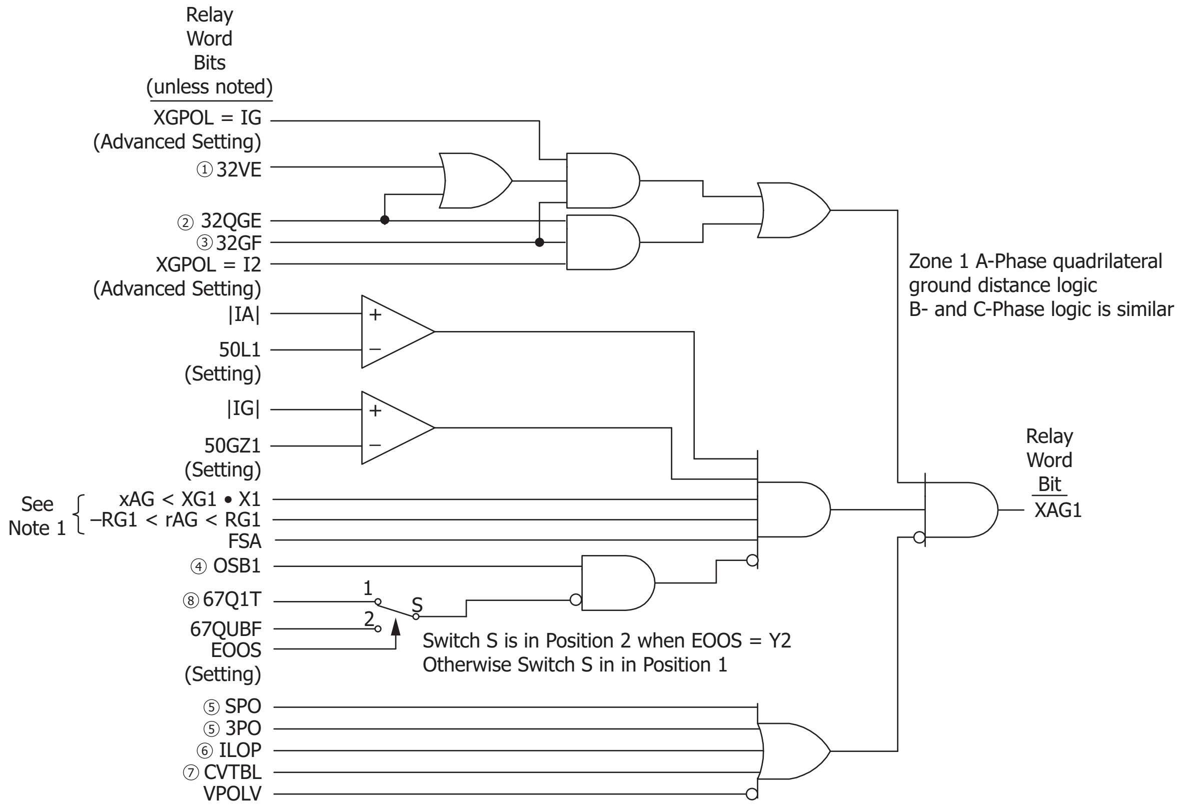
Figure 3.6 Zone 2 Mho Ground-Distance Logic



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 5.6; ③ from Figure 4.1; ④ from Figure 3.24; ⑤ from Figure 3.23.

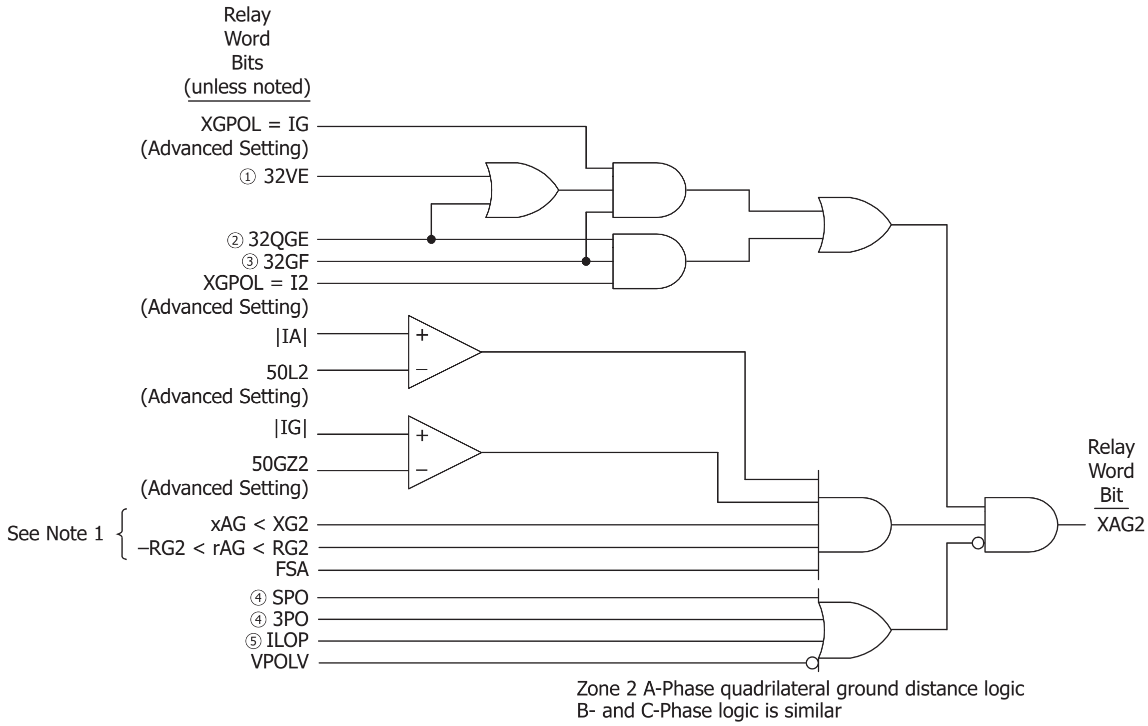
Figure 3.7 Zones 3 and 4 Mho Ground-Distance Logic



Note 1: xAG = A-Phase-to-Ground Reactance Calculation, XG1 = Zone 1 Reactance Setting, X1 = Zone 1 Extension ⑨, 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 5.6; ⑥ from Figure 4.1; ⑦ from Figure 4.9 ⑧ from Figure 3.31; ⑨ from Table 3.4 or Table 3.7.

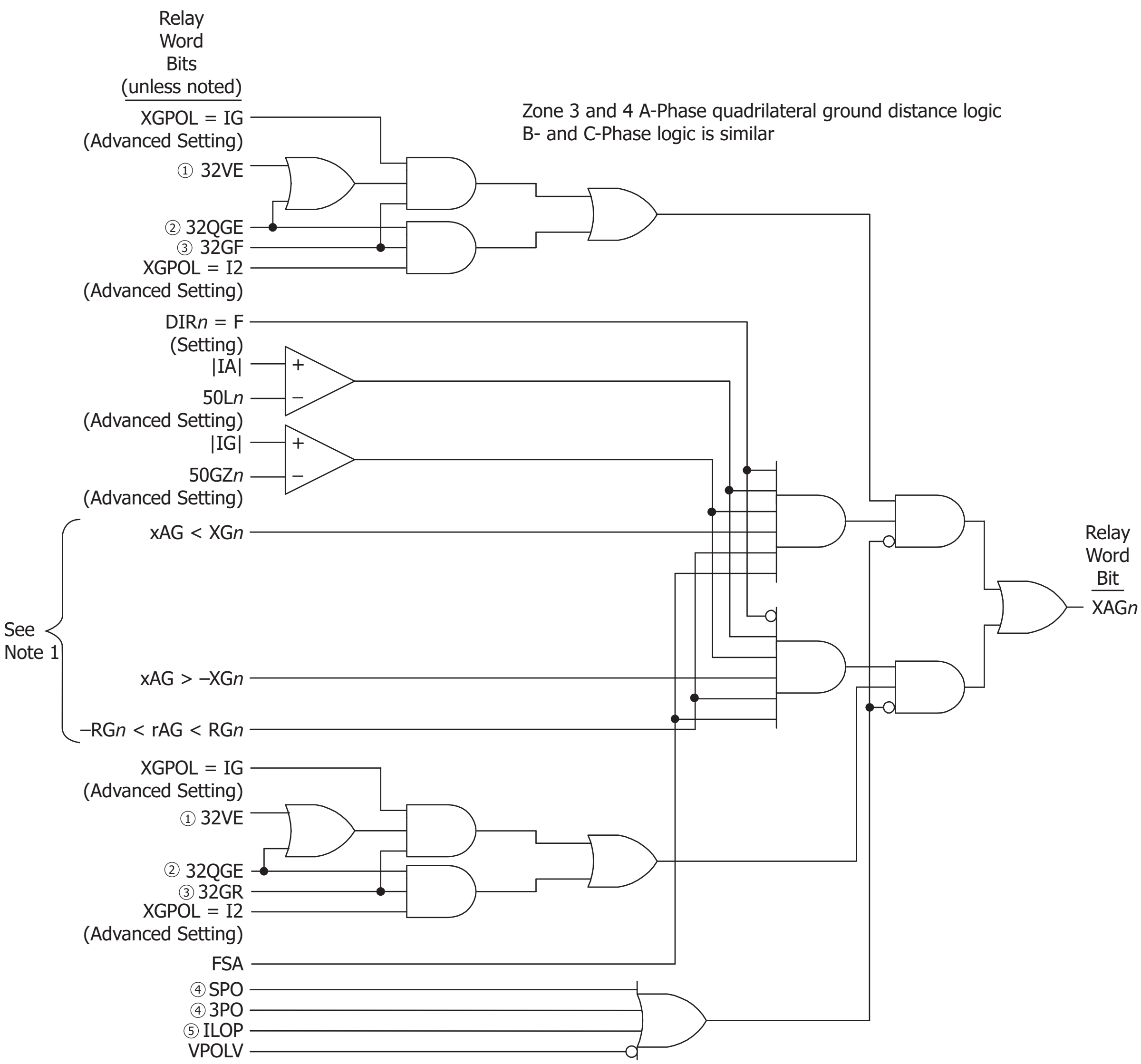
Figure 3.8 Zone 1 Quadrilateral Ground-Distance Logic



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 5.6; ⑤ from Figure 4.1.

Figure 3.9 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 5.6; ⑤ from Figure 4.1.

Figure 3.10 Zones 3 and 4 Quadrilateral Ground-Distance Logic

Distance Element Operating Time Curves at Nominal Frequency

Figure 3.11 through *Figure 3.17* show typical operating times for the SEL-311C distance elements. The diagrams show operating times at each test point. Operating times are shown for Fast Hybrid (High-Speed, High-Current Interrupting) outputs and include output contact pickup time. For applications that use standard or high-current interrupting outputs for tripping, add output contact pickup time from *Specifications on page 1.2*.

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

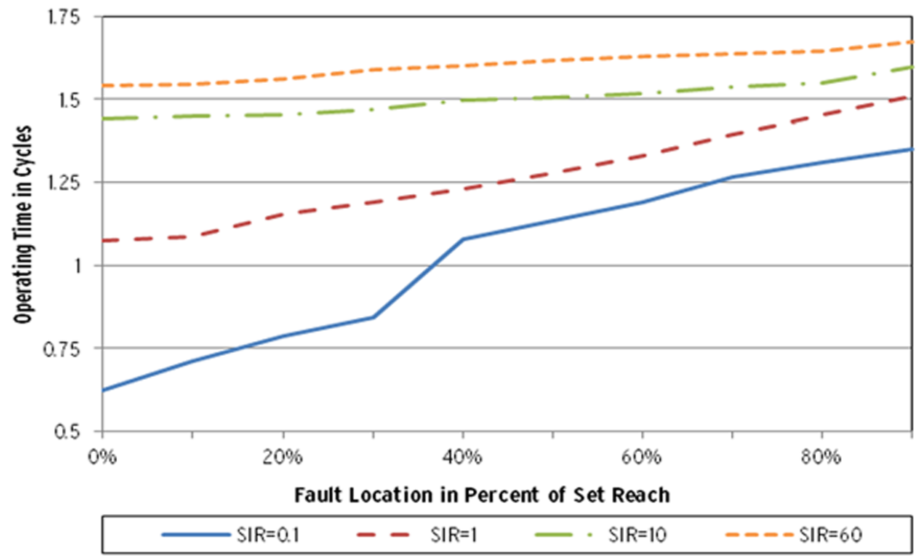


Figure 3.11 SEL-311C Phase Mho Element Operating Times, Standard-Speed Elements, Hybrid Outputs (Three-Phase Faults)

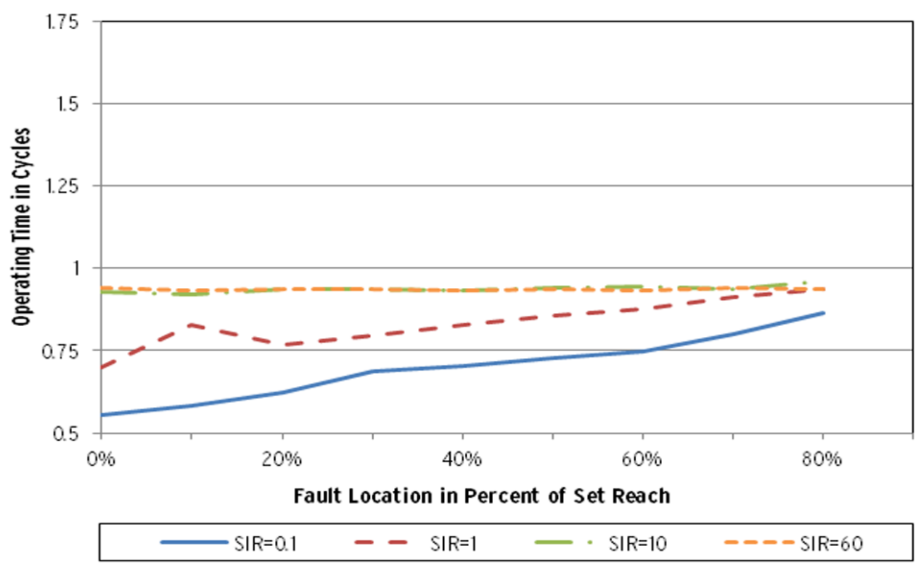


Figure 3.12 SEL-311C Phase Mho Element Operating Times, High-Speed Elements, Hybrid Outputs (Three-Phase Faults)

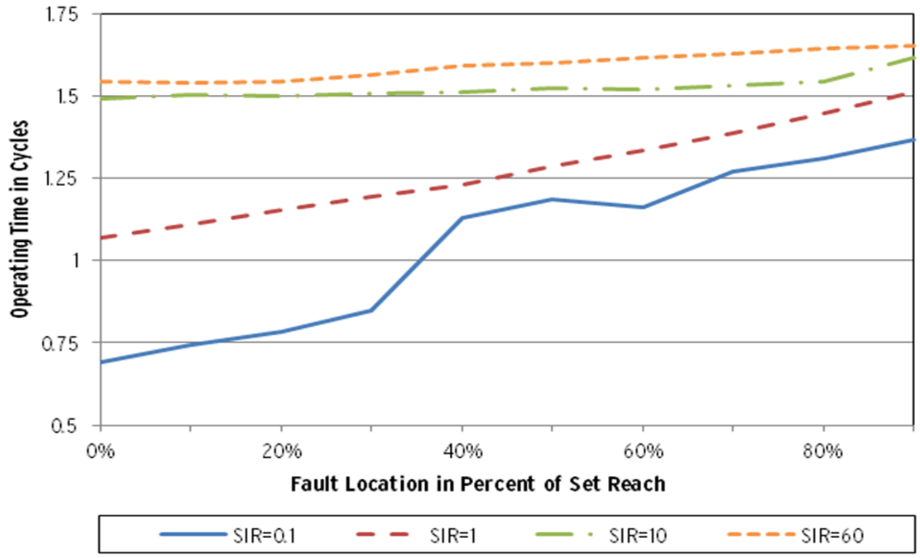


Figure 3.13 SEL-311C Phase Mho Element Operating Times, Standard-Speed Elements, Hybrid Outputs (Phase-to-Phase Faults)

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

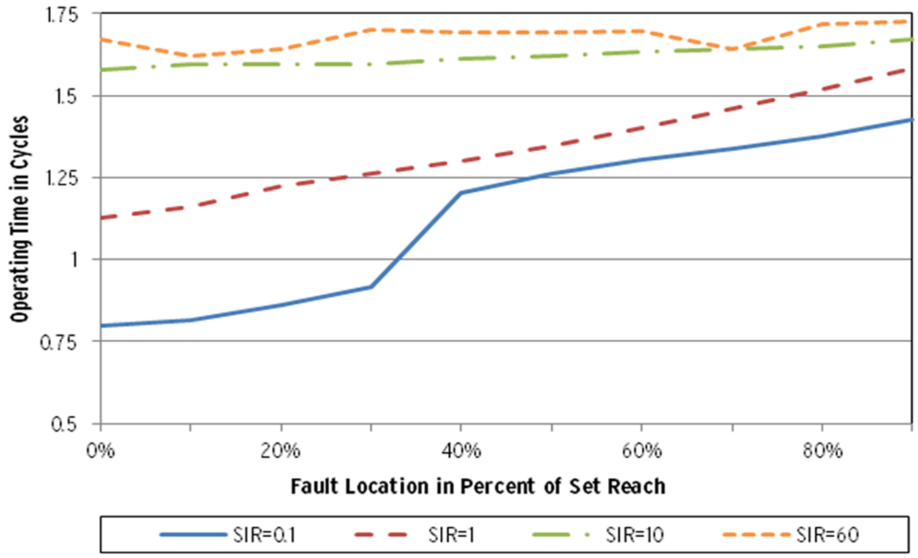


Figure 3.15 SEL-311C Ground Mho Element Operating Times, Standard-Speed Elements, Hybrid Outputs (Single-Phase-to-Ground Faults)

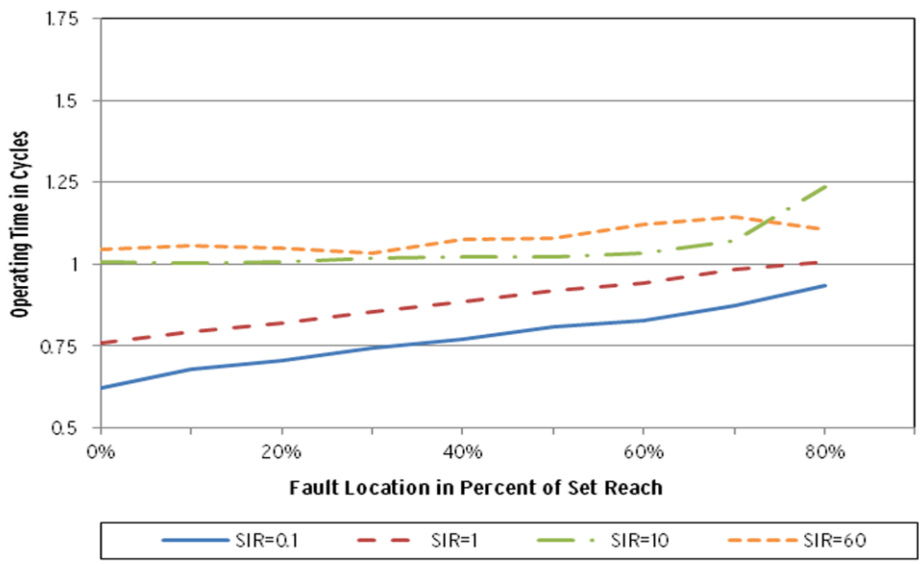


Figure 3.16 SEL-311C Ground Mho Element Operating Times, High-Speed Elements, Hybrid Outputs (Single-Phase-to-Ground Faults)

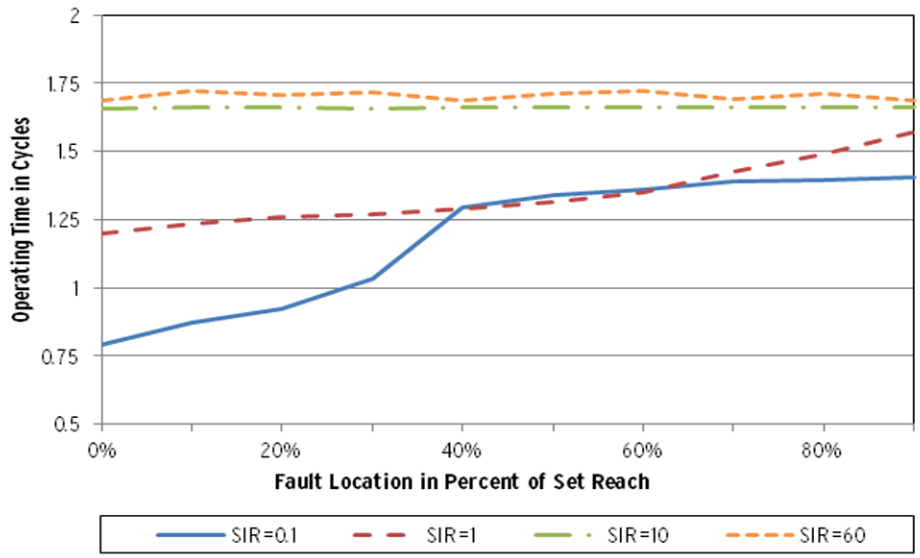


Figure 3.17 SEL-311C Ground Quadrilateral Element Operating Times, Hybrid Outputs (Single-Phase-to-Ground Faults)

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. The SEL-311C-3 includes a similar Relay Word bit VPOLVH that is used in the high-speed distance elements.

The energy stored in the capacitance and reactance of a long transmission line or a line with shunt reactors takes time to dissipate when the line conductors are de-energized. Line-side potential transformers measure a voltage during this time that can affect the positive-sequence memory voltage and other calculations. The SEL-311C contains logic to detect this condition when all three phases are open (3PO = logical 1) and for single-pole open situations (SPO = logical 1).

In the SEL-311C 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).

When all three breaker poles are closed (SPO = logical 0 and 3PO = logical 0), the FIDS logic identifies the faulted phase 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 one breaker pole is open (SPO = logical 1, and one of SPOA, SPOB, or SPOC = logical 1) the FIDS logic is disabled. In this situation, the positive-sequence, negative-sequence, and zero-sequence voltage-polarized and Channel IN current-polarized directional elements are also disabled and distance elements are affected as follows.

- Two mho phase pairs are disabled, and the remaining pair runs with supervision by the open-pole directional logic.
- One mho ground phase is disabled, and the remaining two elements run with supervision by the open-pole directional logic.
- All quadrilateral ground elements are disabled.

See *Pole-Open Logic on page 5.18* for more information on Relay Word bits SPO and 3PO.

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 3.18* 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 equations, as shown in *Figure 3.19*, and uses the settings shown in *Table 3.8*.

Zone 1 Extension is used to allow fast clearing of faults over the entire length of a protected line when communications-assisted tripping is not possible. When communications-assisted tripping is used, set EZ1EXT = N.

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 (or SPO) deasserts. All Zone 1 reaches retreat to their set reach when the breaker opens and 3PO or SPO asserts.

The required settings are shown in *Table 3.5* and the logic diagram is shown in *Figure 3.18*.

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.

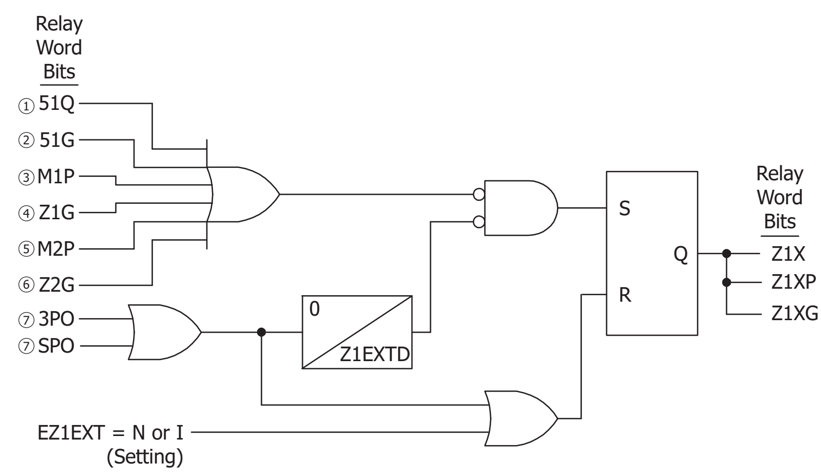
As shown in *Table 3.4*, when the Relay Word bit Z1X is asserted, the relay internally multiplies the Zone 1 phase and ground reach settings by the Z1EXTM value, and uses the resulting extended reach settings in the enabled Zone 1 distance elements (see *Figure 3.2*, *Figure 3.5*, and *Figure 3.8*). 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 3.2):	Effective Zone 1 Mho Ground-Distance Element reach (Figure 3.5):	Effective Zone 1 Quadrilateral Ground-Distance Element Reach (Figure 3.8):
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 3.34; ② from Figure 3.33; ③ from Figure 3.2; ④ from Figure 3.5; ⑤ from Figure 3.3; ⑥ from Figure 3.6; ⑦ from Figure 5.6

Figure 3.18 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 3.19*.

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 3.2*). 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 3.2)
Asserted	Z1P • Z1EXTMP
Deasserted	Z1P

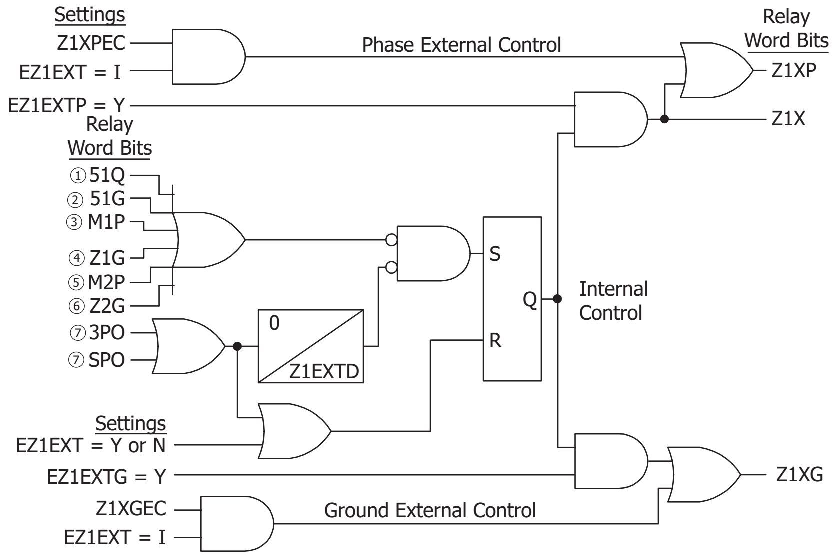
As shown in *Table 3.7*, when the Relay Word bit Z1XG is asserted, the relay internally multiplies the Zone 1 ground reach settings by the Z1EXTMG value, and uses the resulting extended reach settings in the enabled Zone 1 ground-distance elements (see *Figure 3.5* and *Figure 3.8*). When the Relay Word 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 3.5)	Effective Zone 1 Quadrilateral Ground-Distance Element Reach (Figure 3.8)
Asserted	Z1MG • Z1EXTMG	XG1 • Z1EXTMG
Deasserted	Z1MG	XG1

Table 3.8 Independent Phase and Ground Zone 1 Extension Settings

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



① From Figure 3.34; ② from Figure 3.33; ③ from Figure 3.2; ④ from Figure 3.5;
⑤ from Figure 3.3; ⑥ from Figure 3.6; ⑦ from Figure 5.6

Figure 3.19 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 (or SPO) deasserts. The Zone 1 reach retreats to its original value when the breaker opens and 3PO or SPO 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 (or SPO) deasserts. The Zone 1 reach retreats to its original value when the breaker opens and 3PO or SPO 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 by using SELOGIC control equations.

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

At the top of *Figure 3.19*, 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 control 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 control equation Z1XPEC, and the Phase Internal Control logic in *Figure 3.19*.

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

At the bottom of *Figure 3.19*, 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 control 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 control equation Z1XGEC and the Ground Internal Control logic in *Figure 3.19*.

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 control equation 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), single-pole open status (SPO), 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 3.20*). 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 3.20*.

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 4.28*.

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 control equation as required for your application.

Example settings that use a sequential common timer.

Group 1:

E21P = **4**

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-to-phase to three-phase, phase-to-ground to phase-to-phase-to-ground). If the timer expires, the suspension logic is blocked.

Availability Determined by Number of Distance Elements Enabled

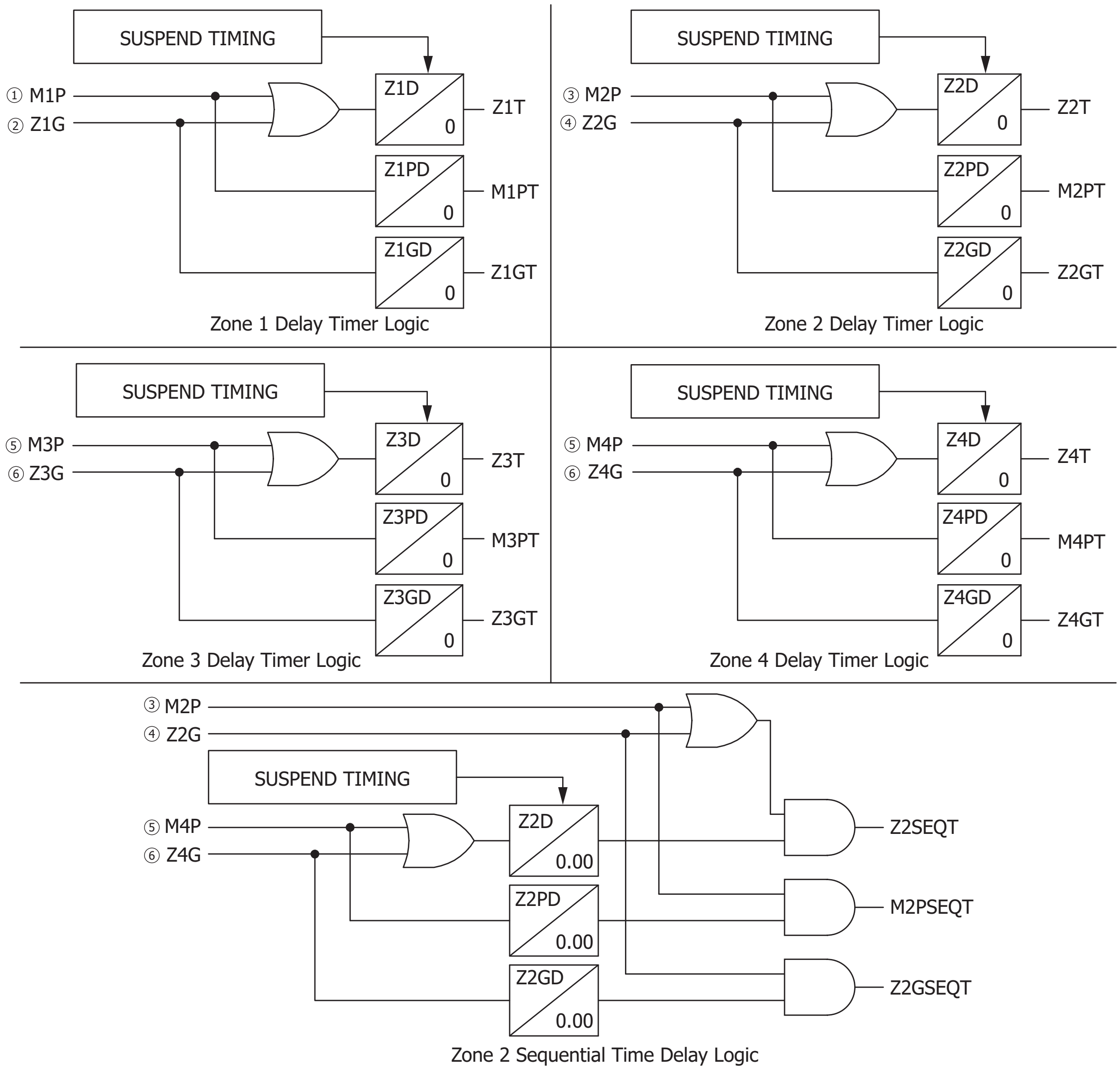
If E21P, E21MG, and/or E21XG are set to anything but N, the common timers are enabled according to the lower of the two enables. For example, if E21P = 3 and E21MG = 2, enable Z1D and Z2D (two Zones as defined by the E21MG setting).

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.

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

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



① From Figure 3.2; ② from Figure 3.5; ③ from Figure 3.3; ④ from Figure 3.6; ⑤ from Figure 3.4; ⑥ from Figure 3.7.

Figure 3.20 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*, *Figure 3.23*, and *Figure 3.24*. The Relay Word bit outputs are listed in *Table 3.14*.

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. This logic allows the distance elements to operate should a three-phase fault occur during a swing condition.

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 (Sheet 1 of 2)

Enable Setting:	EOOS = Y, Y2, N
Block Zone Settings (Zone 1–Zone 4):	OOSB*n* = Y, N (*n* = 1–4)
Out-of-Step Block Time Delay: Pickup Ranges:	OSBD 0.50–8,000.00 cycles, 0.25-cycle steps
Enable Out-of-Step Tripping:	EOOST = N, I, O
Out-of-Step Trip Time Delay: 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.

Table 3.10 Out-of-Step Settings (Sheet 2 of 2)

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:[a] Setting Range:	UBD (see *Figure 3.3* and *Figure 3.4*) 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] UBD time only affects unblocking of Zone 2—Zone 4 phase pair elements when EOOS = Y. The UBD setting is not used when EOOS = Y2.

Out-of-Step Blocking of Distance Elements

The SEL-311C OSB functions are similar to the conventional Out-of-Step Logic of the SEL-421 relay. The four OSB control levels are individually enabled by settings OOSB1 = Y, N through OOSB4 = Y, N.

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

- *Figure 3.2–Figure 3.4* (Phase-distance elements Zone 1 through Zone 4)
- *Figure 3.5* (Mho ground element Zone 1)
- *Figure 3.8* (Quadrilateral ground element Zone 1)

Single-Pole Open Conditions

During single-pole open conditions (SPO = logical 1), two of the Relay Word bits OSBA, OSBB, and OSBC from *Figure 3.24* may assert. These phase selection bits do not by themselves indicate that an out-of-step condition is happening; rather, they are used in the distance element logic to steer the OSB1–OSB4 signals to the appropriate phase elements.

If a power swing occurs during an open-pole condition, the power swing, as seen by the relay, is no longer balanced. The open-pole OOS unblocking logic determines which phase is open so that the relay can correctly identify faults that may occur on the closed phases during the power swing. To identify the open phase, the relay calculates the angle of the ratio of the zero-sequence current and the negative-sequence currents.

For example, if the A-phase is open, the angle of the ratio normally lies between –60 and +60 degrees. and OSBB and OSBC assert, as shown in Figure 3.23. If a fault now occurs on B-phase or C-phase (or both), this angular relationship is no longer true. OSBB and OSBC deassert, removing the out-of-step block and allowing the distance elements to operate.

The OSBA, OSBB, and OSBC Relay Word bits cannot assert when SPO = logical 0.

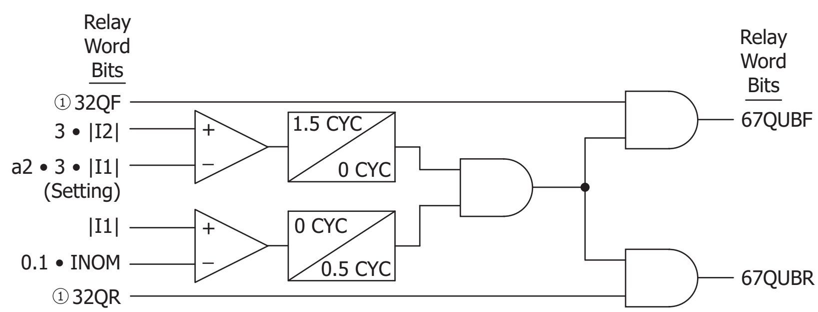
Nonsingle-Pole Open Conditions

The relay offers two mutually exclusive ways to override the OOS blocking logic, should an unbalanced fault occur during an OOS condition, depending on whether EOOS is set to Y or Y2.

When EOOS = Y, negative-sequence overcurrent elements (67Q1T, 50Q2, 50Q3, and 50Q4) are used to defeat out-of-step blocking and allow phase-distance and Zone 1 ground-distance elements to operate should an unbalanced fault occur during a swing condition (see *Figure 3.2– Figure 3.5* and *Figure 3.8*). For each zone with out-of-step blocking enabled via the OOSB1, OOSB2, OOSB3, and OOSB4 settings, set E50Q to enable the corresponding negative-sequence overcurrent element. Select negative-sequence overcurrent pickup settings 50Q1P–50Q4P so that the overcurrent element asserts for unbalanced faults within the reach of the corresponding distance elements, but does not assert for load conditions. Set Level 1 negative-sequence overcurrent element torque-control equation 67Q1TC = 1.

When EOOS=Y, out-of-step blocking for distance Zone 1 is defeated when Relay Word bit 67Q1T asserts after a time delay defined by setting 67Q1D. Additionally, out-of-step blocking for distance Zones 2, 3, and 4 is defeated after the corresponding negative-sequence overcurrent element asserts for a time delay defined by setting UBD.

When EOOS = Y2, the relay does not use the negative-sequence overcurrent elements to defeat out-of-step blocking and allow phase-distance and Zone 1 ground-distance elements to operate should an unbalanced fault occur during a swing condition. Instead, the relay uses the positive-sequence current restraint factor, a2, multiplied by three times the positive-sequence current magnitude to supervise the 67QUBF and 67QUBR elements (see *Figure 3.21* for more detail). If three times the negative-sequence current magnitude exceeds this factor and if the relay has made a valid directional decision (32 elements), the relay asserts either the 67QUBF or the 67QUBR directional element after a fixed time delay of 1.5 cycles. In this manner, the relay removes out-of-step blocking for phase-distance elements and Zone 1 ground-distance elements during unbalanced faults (see *Figure 3.2*–*Figure 3.5* and *Figure 3.8*).



① From Figure 4.20.

Figure 3.21 Directional Element Signals 67QUBF and 67QUBR

Table 3.11 summarizes the differences between settings EOOS = Y and EOOS = Y2.

Table 3.11 Differences Between EOOS = Y and EOOS = Y2 Settings and Unblocking

	EOOS = Y	EOOS = Y2
Unblock Zone 1	67Q1T	67QUBF
Unblock Zone 2	50Q2	67QUBF
Unblock Zone 3	50Q3	67QUBF or 67QUBR
Unblock Zone 4	50Q4	67QUBF or 67QUBR
Settings	E50Q, 50Q1P, 50Q2P, 50Q3P, 50Q4P, 67Q1D, 67Q1TC, UBD[a], UBOSBF	a2

[a] When setting EOOS = Y2, the unblock delay time is fixed at 1.5 cycles.

Unblocking for three-phase faults is provided by Relay Word bit UBOSB (see *Figure 3.22*).

Table 3.12, *Table 3.13*, and *Table 3.14* summarize how the OSB signals are supervised by different means depending on the distance element and the breaker pole status (single-pole open = SPO condition).

Table 3.12 OSB Blocking and Unblocking of Distance Elements (EOOS = Y, non-SPO Conditions)

Element Setting	Phase-Pairs (E21P = 1, 2, etc.)	Ground Mho (E21MG = 1, 2, etc.)	Ground Quad. (E21XG = 1, 2, etc.)
OOSB1 = Y	OSB1, unblocked by 67Q1T[a]	OSB1, unblocked by 67Q1T[a]	OSB1, unblocked by 67Q1T[a]
OOSB2 = Y	OSB2, unblocked by [50Q2 AND 32QF][b] asserted longer than UBD timer setting	Note[c]	Note[c]
OOSB3 = Y (DIR3 = F/R)	OSB3, unblocked by [50Q3 AND (32QF/32QR)][b] asserted longer than UBD timer setting	Note[c]	Note[c]
OOSB4 = Y (DIR4 = F/R)	OSB4, unblocked by [50Q4 AND (32QF/32QR)][b] asserted longer than UBD timer setting	Note[c]	Note[c]

[a] Differs from earlier SEL-311C models. 67Q1T comes from Figure 3.31.
[b] Differs from earlier SEL-311C models. 32QF/32QR come from Figure 4.20.
[c] Element unaffected by OSB logic.

Table 3.13 OSB Blocking and Unblocking of Distance Elements (EOOS = Y2, non-SPO Conditions)

Element Setting	Phase-Pairs (E21P = 1, 2, etc.)	Ground Mho (E21MG = 1, 2, etc.)	Ground Quad. (E21XG = 1, 2, etc.)
OOSB1 = Y	OSB1, unblocked by 67QUBF	OSB1, unblocked by 67QUBF	OSB1, unblocked by 67QUBF
OOSB2 = Y	OSB2, unblocked by 67QUBF	Note[a]	Note[a]
OOSB3 = Y (DIR3 = F/R)	OSB3, unblocked by 67QUBF/67QUBR	Note[a]	Note[a]
OOSB4 = Y (DIR4 = F/R)	OSB4, unblocked by 67QUBF/67QUBR	Note[a]	Note[a]

[a] Element unaffected by OSB logic.

Table 3.14 OSB Blocking and Unblocking of Distance Elements (SPO Conditions)

Element Setting	Phase-Pairs (E21P = 1, 2, etc.)	Ground Mho (E21MG = 1, 2, etc.)	Ground Quad. (E21XG = 1, 2, etc.)
OOSB1 = Y	OSB1, unblocked by open-pole OSB unblock logic	OSB1, unblocked by open-pole OSB unblock logic	Element disabled by SPO
OOSB2 = Y	OSB2, unblocked by open-pole OSB unblock logic	OSB2, unblocked by open-pole OSB unblock logic	Element disabled by SPO
OOSB3 = Y (DIR3 = F/R)	OSB3, unblocked by open-pole OSB unblock logic	OSB3, unblocked by open-pole OSB unblock logic	Element disabled by SPO
OOSB4 = Y (DIR4 = F/R)	OSB4, unblocked by open-pole OSB unblock logic	OSB4, unblocked by open-pole OSB unblock logic	Element disabled by SPO

Table 3.15 OOS Relay Word Bits

Relay Word Bits	Description	Relay Word Bits	Description
50ABC	Positive-sequence current above threshold	OSB2	Block Zone 2 during an out-of-step condition
X6ABC	Impedance inside Zone 6	OSB3	Block Zone 3 during an out-of-step condition
X5ABC	Impedance inside Zone 5	OSB4	Block Zone 4 during an out-of-step condition
UBOSB	Unblock out-of-step blocking	OSBA	A-phase elements selected for out-of-step blocking during single-pole open conditions[a]
OSB	Out-of-step block	OSBB	B-phase elements selected for out-of-step blocking during single-pole open conditions[a]
OSTI	Incoming out-of-step trip	OSBC	C-phase elements selected for out-of-step blocking during single-pole open conditions[a]
OSTO	Outgoing out-of-step trip	67QUBF	Negative-sequence forward directional element
OST	Out-of-step trip	67QUBR	Negative-sequence reverse directional element
OSB1	Block Zone 1 during an out-of-step condition		

[a] Does not indicate an out-of-step condition by itself.

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 control equation. Use them in the TR equation, instead. See TRQUAL Qualified Trip Conditions on page 5.4 for more information.

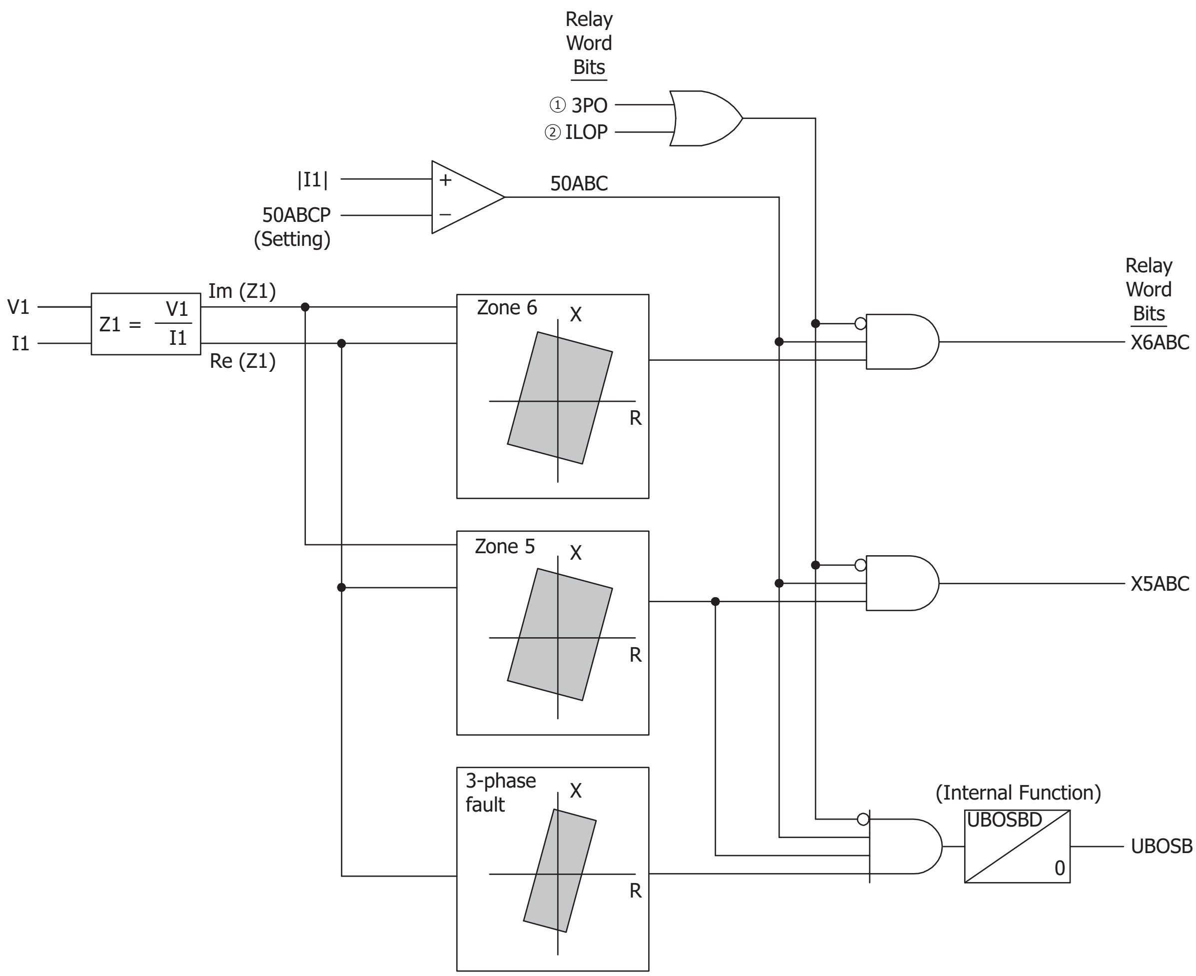
The out-of-step trip application is similar to the SEL-421 relay, and there is no built-in connection to the trip logic of the SEL-311C. For out-of-step tripping applications, the OST Relay Word bit must be included in the relay TR equation. For example, to force a three-phase trip on out-of-step, with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

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

E3PT = **... + OST** (add OST to the three-phase trip enable conditions)

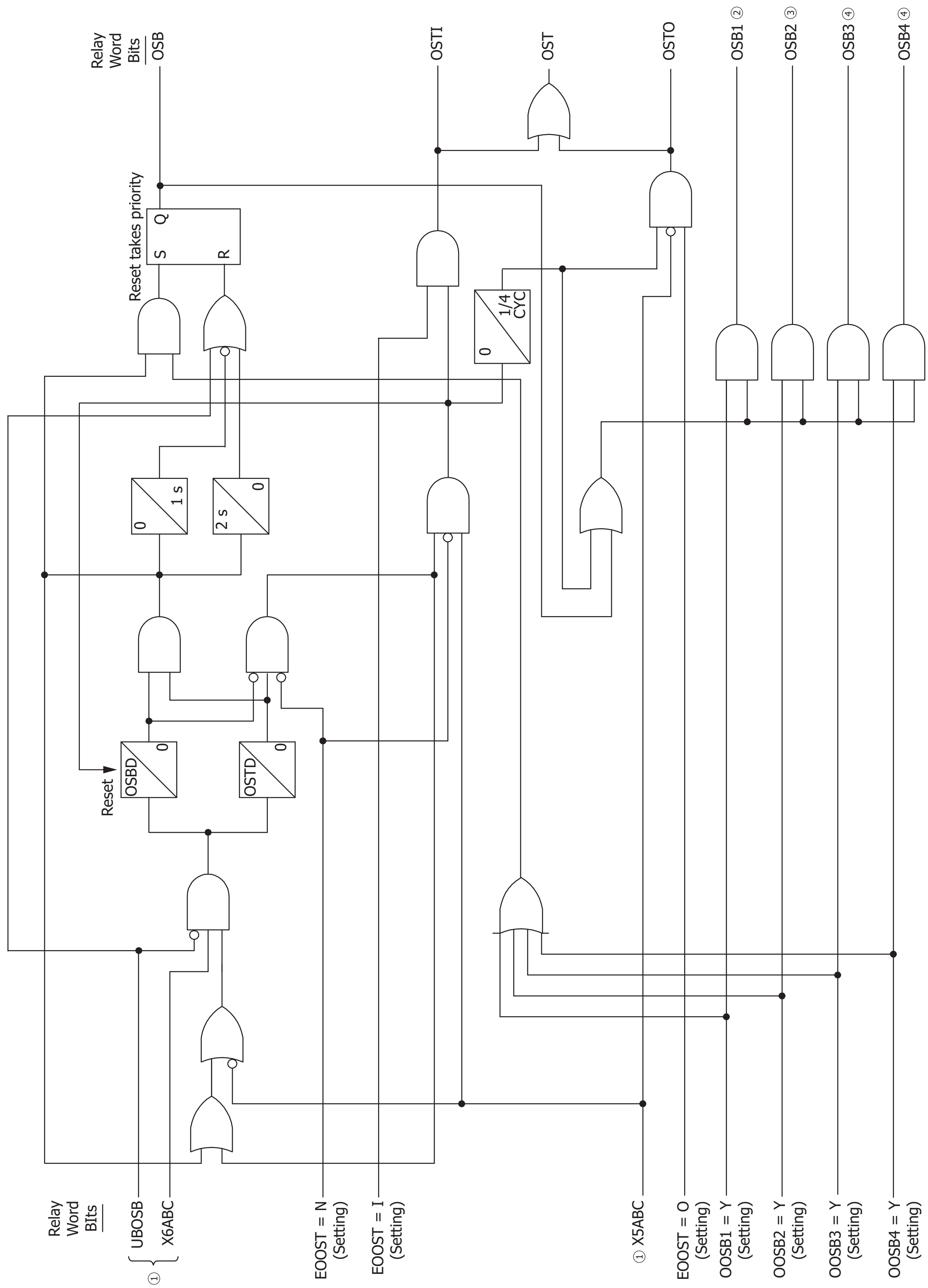
79DTL = **... + OST** (add OST to the drive-to-lockout conditions)

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



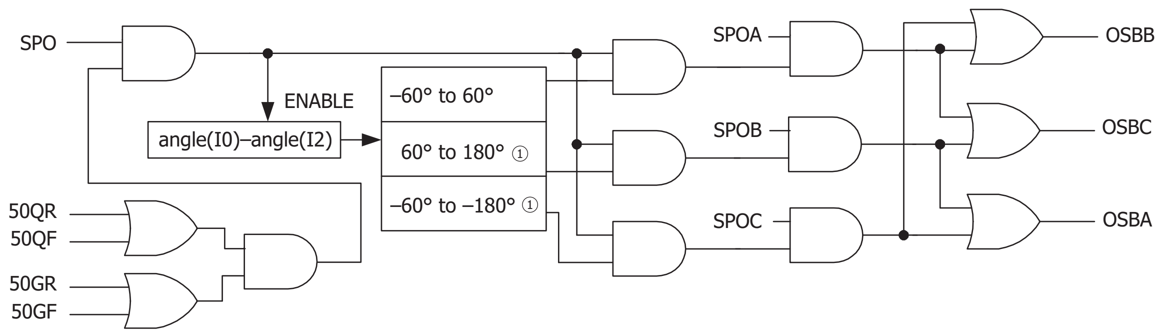
① From Figure 5.6; ② from Figure 4.1.

Figure 3.22 Out-of-Step Zone Detection Logic



① From Figure 3.22; ② to Figure 3.2, Figure 3.5, and Figure 3.8; ③ to Figure 3.3; ④ to Figure 3.4.

Figure 3.23 Out-of-Step Logic



① Angles shown are for ABC phase rotation. For ACB systems, B and C-phase test angles are swapped.

Figure 3.24 Open-Pole OSB Unblock 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 3.25* and *Figure 3.26*.

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 3.25*. 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)

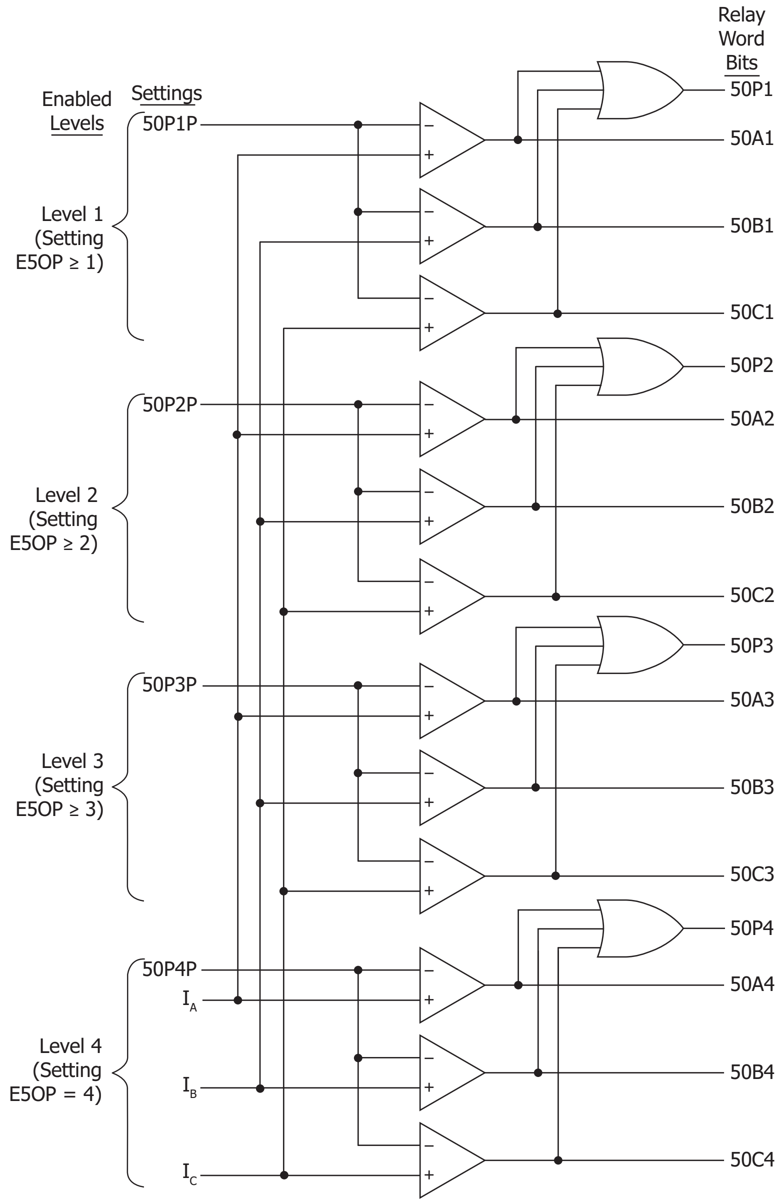
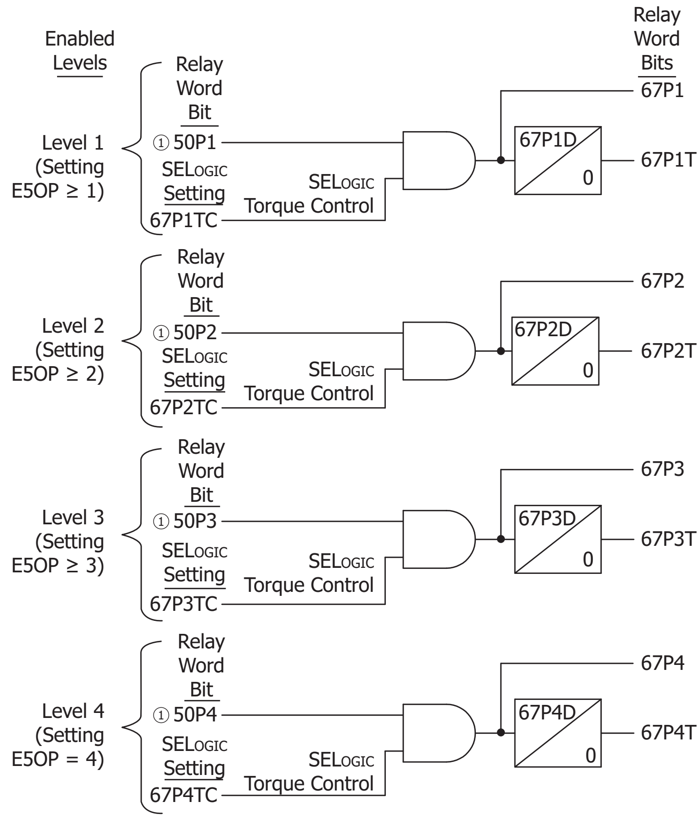


Figure 3.25 Levels 1 Through 4 Phase Instantaneous Overcurrent Elements

These Relay Word bit outputs then become inputs to *Figure 3.26*. 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 12.7* and *Table 12.4*).



① From Figure 3.25

Figure 3.26 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 10.62 for a list of the factory-default settings.

Levels 1 through 4 in *Figure 3.26* 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 3.25*, 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):

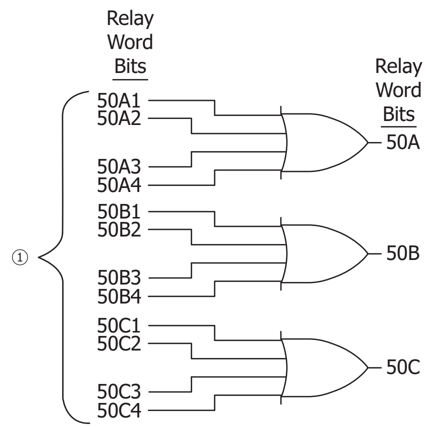
Then phase instantaneous/definite-time overcurrent element 67P1 directly follows the state of 50P1 from *Figure 3.25*, and definite-time element 67P1T has an intentional time-delayed pickup defined by setting 67P1D.

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 3.25* are combined together in *Figure 3.27*, 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 3.25.

Figure 3.27 Combined Single-Phase Instantaneous Overcurrent Elements

Pickup and Reset Time Curves

NOTE: The pickup time curve in Figure 3.28 is not valid for conditions with a saturated CT, where the resultant current to the relay is nonsinusoidal.

Figure 3.28 and *Figure 3.29* 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 3.28* and *Figure 3.29* 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 3.28* is adjusted as follows:

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

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

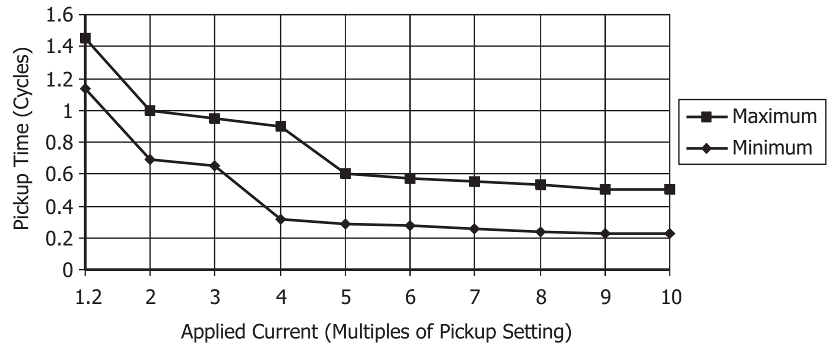


Figure 3.28 Nondirectional Instantaneous Overcurrent Element Pickup Time Curve

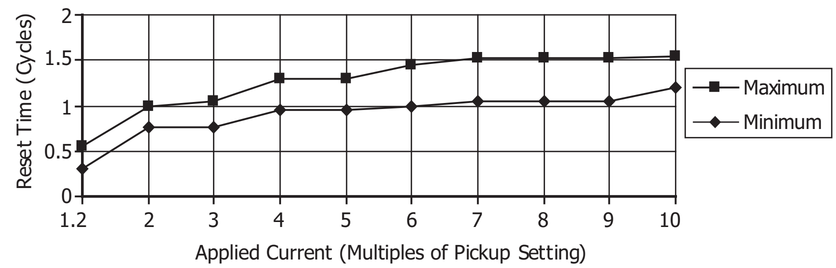


Figure 3.29 Nondirectional Instantaneous Overcurrent Element Reset Time Curve

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 3.30*.

In *Figure 3.30* 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 4.28* for details on specifying the Zone 3 and Zone 4 direction by using Group settings DIR3 and DIR4.

The Level 2 residual-ground directional overcurrent element 67G2 is used in the trip logic, as shown in *Figure 5.1*.

During most single-pole open (SPO) conditions, the open-pole directional element remains operational, as do directional control signals 32GF and 32GR (see *Figure 4.18*).

The single-pole open situation creates an unbalanced load that may cause the residual current (3I0) magnitude to be approximately equal to the remaining (closed breaker pole) phase magnitudes. Depending on the load conditions of the system, and the sensitivity of settings 50G1P–50G4P, elements 50G1–50G4, 67G1–67G4, or 67G1T–67G4T may assert during a single-pole open condition when no fault is present on the closed phases. These elements may also assert during a breaker close operation after a three-pole open situation, because the breaker poles may not close at exactly the same time.

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 5.9*, and Directional Comparison Blocking logic, shown in *Figure 5.17*.

To understand the operation of *Figure 3.30*, follow the explanation given for *Figure 3.25* and *Figure 3.26*, 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 12.7* and *Table 12.4*).

Settings Ranges

NOTE: For pickup settings less than:

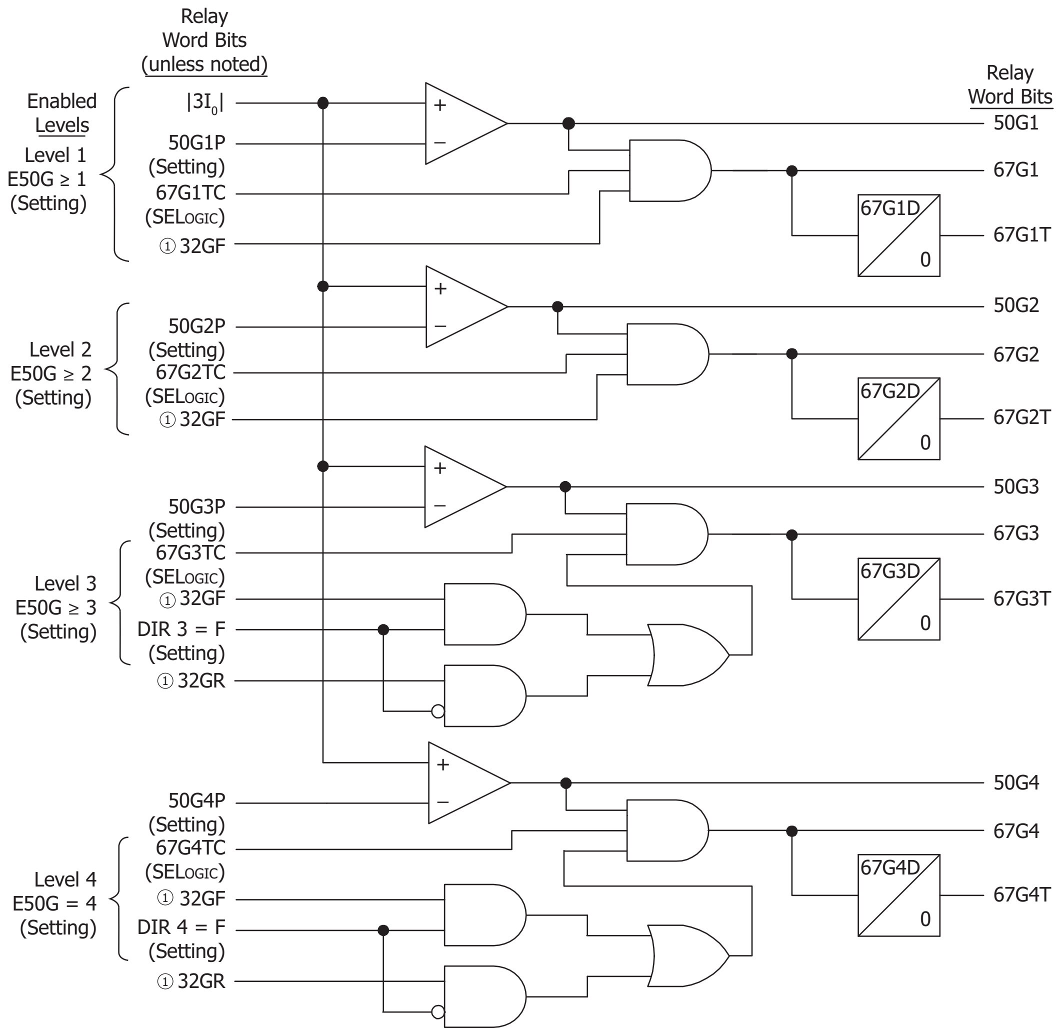
0.25 A secondary (5 A nominal)
0.05 A secondary (1 A nominal)

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 3.28* and *Figure 3.29*.



① From Figure 4.18.

Figure 3.30 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 3.31*.

In *Figure 3.31* 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 4.28* for details on specifying the Zone 3 and Zone 4 direction by using Group settings DIR3 and DIR4.

The Level 2 negative-sequence directional overcurrent element 67Q2 is used in the trip logic, as shown in *Figure 5.1*.

During most single-pole open (SPO) conditions, the directional control signals 32QF and 32QR (shown as inputs to *Figure 3.31*) are nonoperational, effectively disabling the 67Q1–67Q4, and 67Q1T–67Q4T outputs. See

Figure 4.20 for details on Relay Word bits 32QF and 32QR. By contrast, the negative-sequence instantaneous overcurrent elements 50Q1–50Q4 are unaffected by single-pole open conditions.

The single-pole open situation induces an unbalanced load that may cause the negative-sequence current (3I2) magnitude to be approximately equal to the remaining (closed breaker pole) phase magnitudes. Depending on the load conditions of the system, and the sensitivity of settings 50Q1P–50Q4P, the instantaneous elements 50Q1–50Q4 may assert during a single pole open condition when no fault is present on the closed phases. These elements may also assert during a breaker close operation after a three-pole open situation, because the breaker poles may not close at exactly the same time. For these reasons, avoid the unsupervised use of instantaneous elements 50Q1–50Q4 in trip equations.

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 5.9*, and Directional Comparison Blocking logic, shown in *Figure 5.17*.

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

To understand the operation of *Figure 3.31*, follow the explanation given for *Figure 3.25* and *Figure 3.26*, 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.

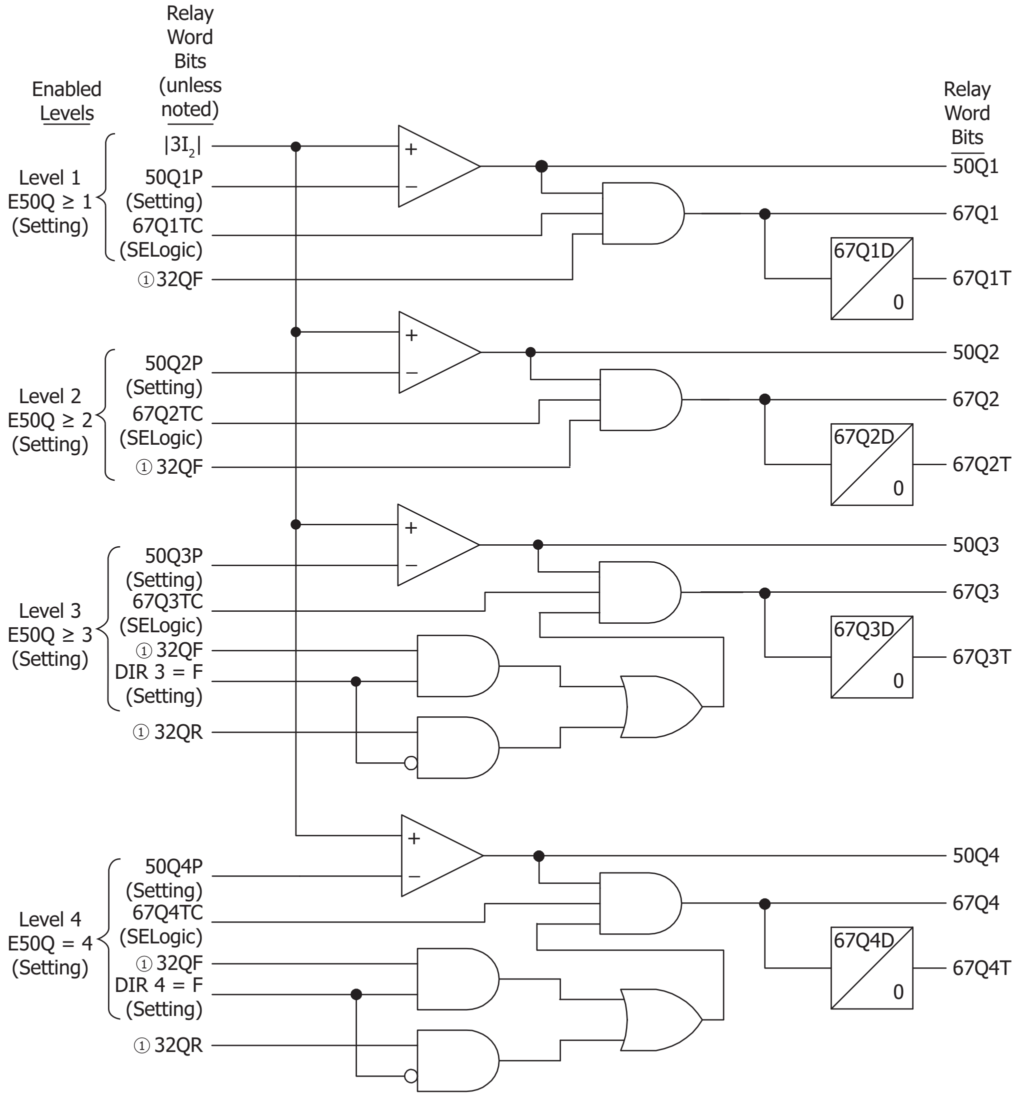
Ideally, set 50Q1P > 50Q2P > 50Q3P > 50Q4P so that instantaneous/definite-time overcurrent elements 50Q1–50Q4 and 67Q1–67Q4 will display in an organized fashion in event reports (see *Figure 12.7* and *Table 12.4*).

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 3.28* and *Figure 3.29*.



① From Figure 4.20.

Figure 3.31 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 3.16 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 3.32*

Settings Ranges

Besides the settings involved with the Torque-Control Switch operation in *Figure 3.32*, the 51PT phase time-overcurrent element has the following settings:

Table 3.17 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 (U.S. curves) see *Figure 9.1–Figure 9.10* C1–C5 (IEC curves)
51PTD	time dial	0.50–15.00 (U.S. 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 9.5* for additional time-overcurrent element setting information.

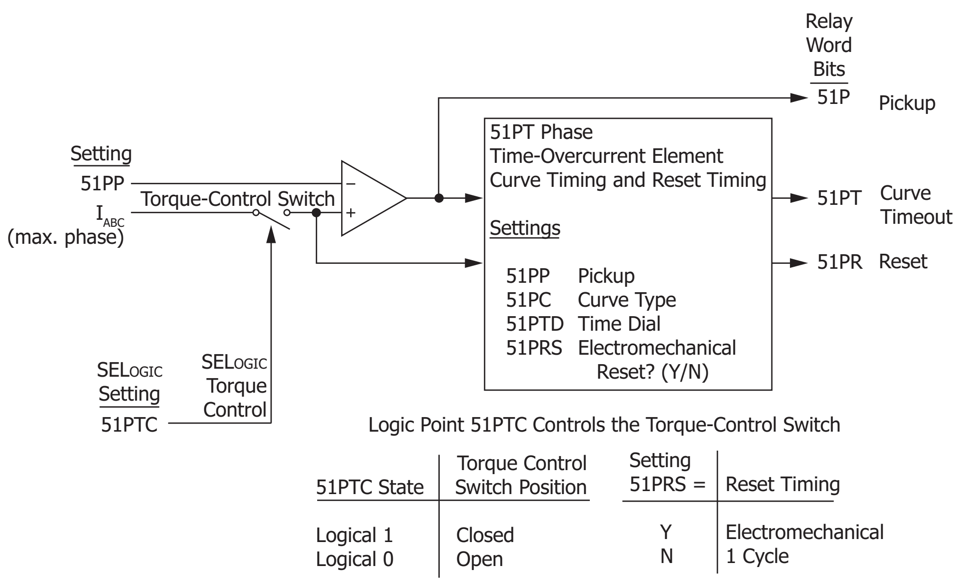


Figure 3.32 Phase Time-Overcurrent Element 51PT

51PT Element Logic Outputs

The logic outputs in *Figure 3.32* are the Relay Word bits shown in *Table 3.18*

Table 3.18 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 3.32* 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 3.32* 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 3.32*.

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 10.62 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 3.32*.

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 9.5* 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 3.33*, follow the explanation given for *Figure 3.32* 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.

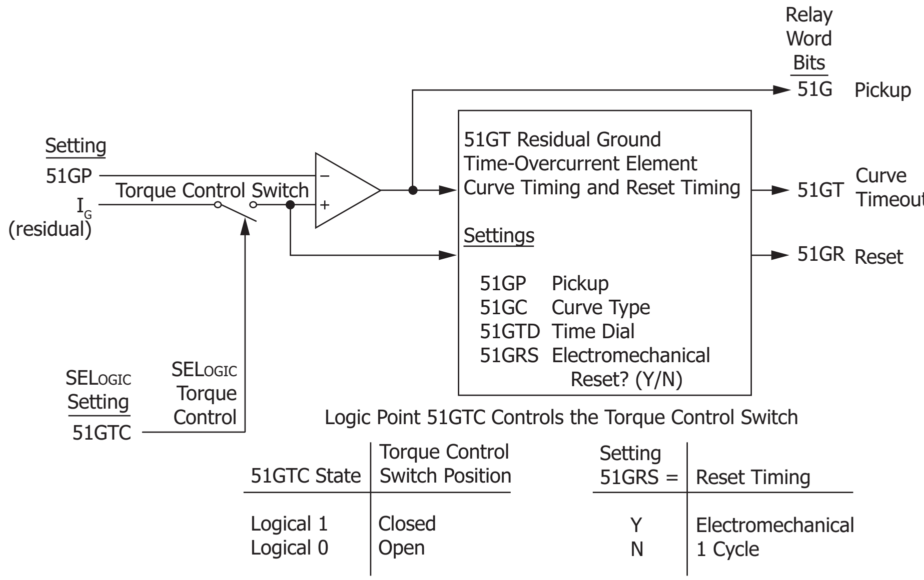


Figure 3.33 Residual-Ground Time-Overcurrent Element 51GT

Settings Ranges

Table 3.19 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 (U.S. curves) see *Figure 9.1–Figure 9.10* C1–C5 (IEC curves)
51GTD	time dial	0.50–15.00 (U.S. 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.

Single-Pole Open Considerations for 51GT

The single-pole open operating state (indicated by Relay Word bit SPO = logical 1) can present some difficulties for applying the residual-ground time-overcurrent element. The SPO condition creates an unbalanced load that may cause the residual current (3I0) magnitude to be approximately equal to the remaining (closed breaker pole) phase magnitudes. Depending on the load conditions of the system, and the sensitivity of the 51G settings, the 51G element may pick up and begin to time during a single-pole open condition. Even when no fault is present on the closed phases, if the single-pole open condition is present for long enough, the 51GT element may time out.

It is possible to use the torque-control setting to disable the 51G element during single-pole open conditions. An example logic setting follows:

51GTC = **!SPO** * other torque control conditions

If the application requires the residual-ground time overcurrent element to remain active during SPO conditions, and if the autoreclose feature is being used, the open interval time settings (79OI1, 79OI2, etc.) that may follow a single-pole trip should be coordinated with the 51G element settings. For example, increasing the time-dial setting (51GTD) or changing the curve setting (51GC) can make the 51GT element less likely to assert for brief SPO conditions. See *Reclosing Relay on page 6.16* for details on the SEL-311C autoreclose functions.

Directional Control Method

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 9.5* for additional time-overcurrent element setting information.

Negative-Sequence Time-Overcurrent Element

To understand the operation of *Figure 3.34*, follow the explanation given for *Figure 3.32* in *Phase Time-Overcurrent Elements on page 3.43*, substituting negative-sequence current $3I_2$

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

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

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.

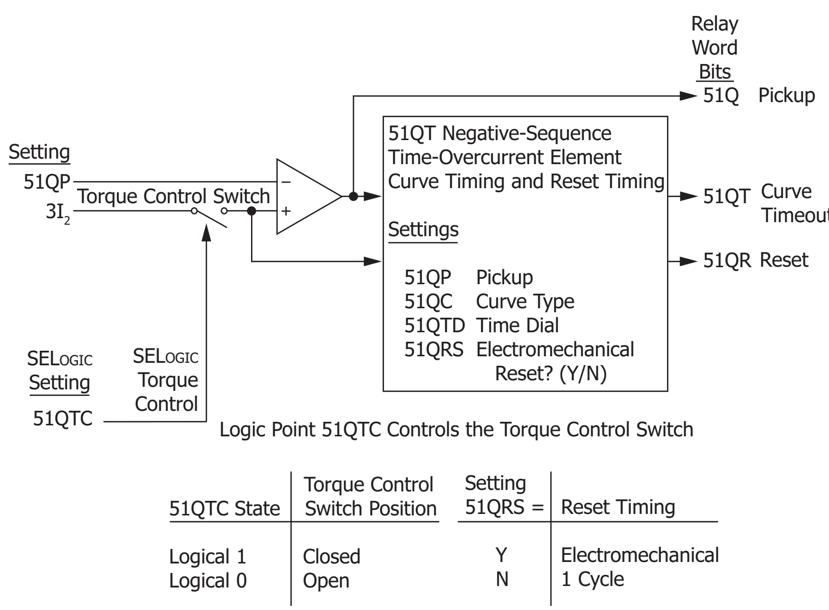


Figure 3.34 Negative-Sequence Time-Overcurrent Element 51QT

Settings Ranges

Table 3.20 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 (U.S. curves) see *Figure 9.1–Figure 9.10* C1–C5 (IEC curves)
51QTD	time dial	0.50–15.00 (U.S. 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.

Single-Pole Open Considerations for 51QT

The single-pole open operating state (indicated by Relay Word bit SPO = logical 1) can present some difficulties for applying the negative-sequence time-overcurrent element. The SPO condition creates an unbalanced load that may cause the negative-sequence current (3I2) magnitude to be approximately equal to the remaining (closed breaker pole) phase magnitudes. Depending on the load conditions of the system, and the sensitivity of the 51Q settings, the 51Q element may pick up and begin to time during a single-pole open condition. Even when no fault is present on the closed phases, if the single-pole open condition is present for long enough, the 51QT element may time out.

It is possible to use the torque-control setting to disable the 51Q element during single-pole open conditions. An example logic setting follows:

51QTC = !**SPO** * other torque control conditions

If the application requires the negative-sequence time overcurrent element to remain active during SPO conditions, and if the autoreclose feature is being used, the open interval time settings (79OI1, 79OI2, etc.) that may follow a single-pole trip should be coordinated with the 51Q element settings. For example, increasing the time-dial setting (51QTD) or changing the curve setting (51QC) can make the 51QT element less likely to assert for brief SPO conditions. See *Reclosing Relay on page 6.16* for details on the SEL-311C autoreclose functions.

Directional Control Method

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 9.5* 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 3.21*.

Table 3.21 Voltage Values Used by Voltage Elements

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

[a] Voltage V_S is used in the synchronism-check elements described in Synchronism-Check Elements on page 3.53. Voltage V_S is also used in the two voltage elements described at the end of Table 3.22. These voltage elements are **independent** of the synchronism-check elements, even though voltage V_S is used in both.

Voltage Element Settings

Table 3.22 lists available voltage elements and the corresponding voltage inputs and settings ranges for the SEL-311C.

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

Table 3.22 Voltage Elements Settings and Settings Ranges (Sheet 1 of 2)

Voltage Element (Relay Word Bits)	Operating Voltage	Pickup Setting/Range	See Figure
27A 27B 27C 3P27	V_A V_B V_C 27A * 27B * 27C	27P OFF, 0.00–300.00 V secondary	*Figure 3.35*
59A 59B 59C 3P59	V_A V_B V_C 59A * 59B * 59C	59P OFF, 0.00–300.00 V secondary	
27AB 27BC 27CA	V_{AB} V_{BC} V_{CA}	27PP OFF, 0.00–520.00 V secondary	*Figure 3.36*
59AB 59BC 59CA	V_{AB} V_{BC} V_{CA}	59PP OFF, 0.00–520.00 V secondary	
59N1	$3V_0$	59N1P OFF, 0.00–300.00 V secondary	
59N2	$3V_0$	59N2P OFF, 0.00–300.00 V secondary	
59Q	V_2	59QP OFF, 0.00–200.00 V secondary	

NOTE: During single-pole open conditions, the voltage measured on the open phase is not included in the positive-sequence voltage (V1) calculation. This should be considered when setting 59V1P for both line-side and bus potential transformers.

Table 3.22 Voltage Elements Settings and Settings Ranges (Sheet 2 of 2)

Voltage Element (Relay Word Bits)	Operating Voltage	Pickup Setting/Range	See Figure
59V1	V_1	59V1P OFF, 0.00–300.00 V secondary	
27S	V_S	27SP OFF, 0.00–300.00 V secondary	*Figure 3.37*
59S	V_S	59SP OFF, 0.00–300.00 V secondary	

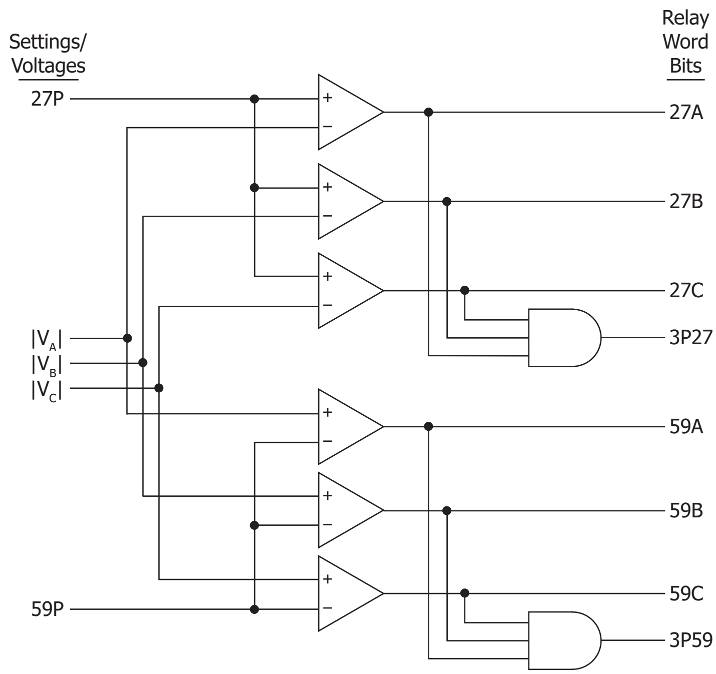


Figure 3.35 Single-Phase and Three-Phase Voltage Elements

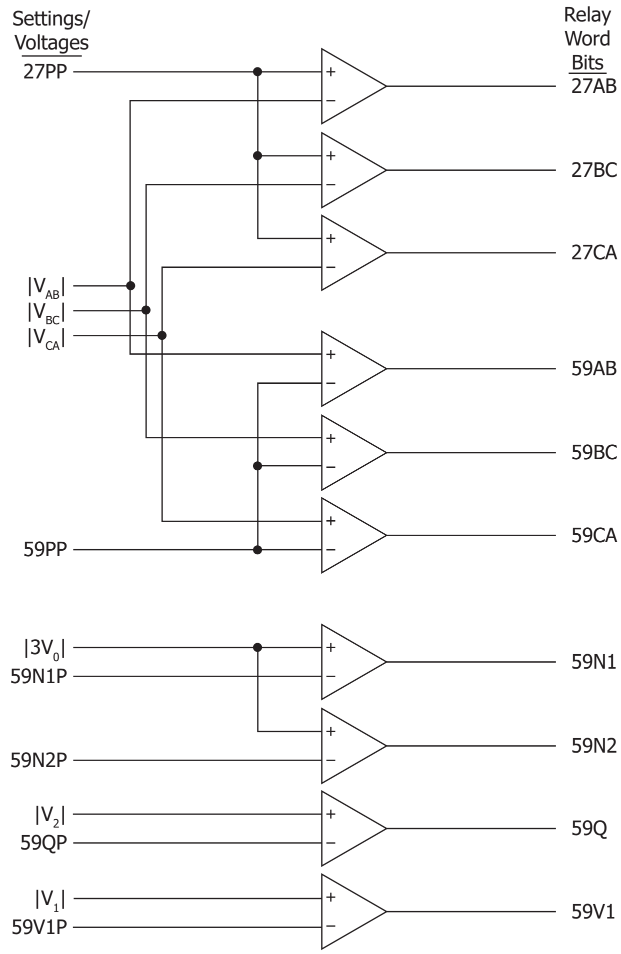


Figure 3.36 Phase-to-Phase and Sequence Voltage Elements

NOTE: During single-pole open conditions, the voltage measured on the open phase is not included in the positive-sequence voltage (V1) calculation. This should be considered when setting 59V1P for both line-side and bus potential transformers.

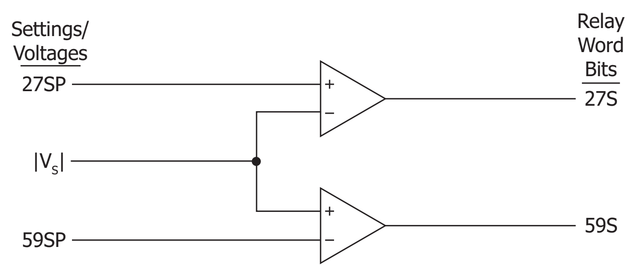


Figure 3.37 Channel VS Voltage Elements

Voltage Element Operation

Note that the voltage elements in *Table 3.22*, and *Figure 3.35* through *Figure 3.37* 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 3.35* (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 3.35* 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 3.35* (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 3.35* 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**

Figure 2.14–Figure 2.16 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 ensure healthy voltage) and slip frequency settings (see *Figure 3.38*). They have separate angle settings (see *Figure 3.39*). 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 3.39*. 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 3.39*. 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

NOTE: Setting 25ANG1 = 0 or 25ANG2 = 0 disables the respective synchronism-check element.

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

Table 3.23 Synchronism-Check Elements Settings and Settings Ranges

Setting	Definition	Range
25VLO	low-voltage threshold for "healthy voltage" window	20.00–300.00 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 the number of degrees that synchronism-check voltage V_S constantly lags voltage V_A	VA, VB, or VC 0°–330°, in 30° steps
TCLOSD	breaker close time for angle compensation	0.00–60.00 cycles, 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 in this relay model. Use an equivalent numeric setting instead.

Setting SYNCP

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 3.38*). 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.

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

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

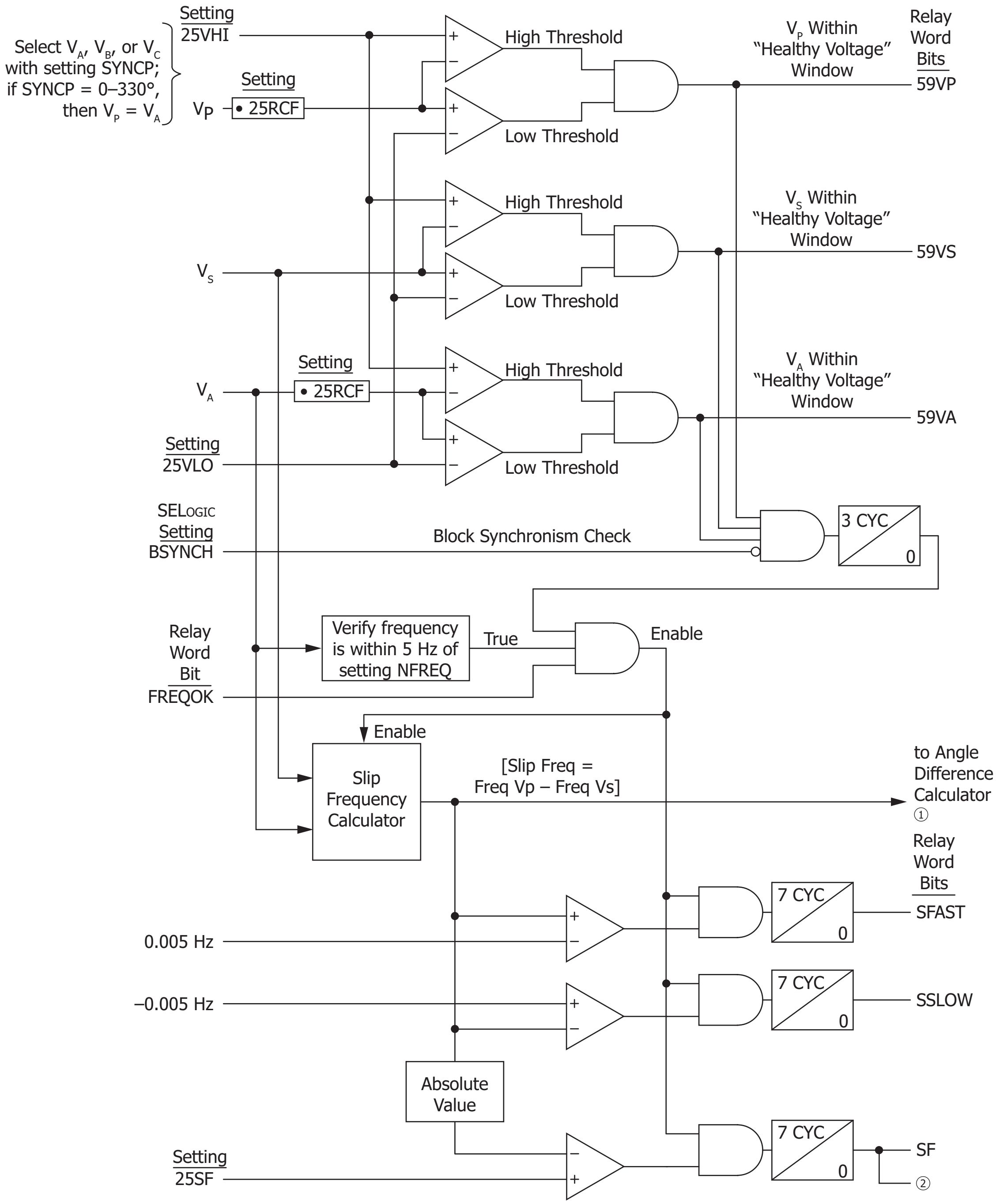
- Phase-to-phase
- Beyond a delta-wye transformer

For such applications, make a numerical angle selection with the SYNCP setting (see *Table 3.23* and *Setting SYNCP*).

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

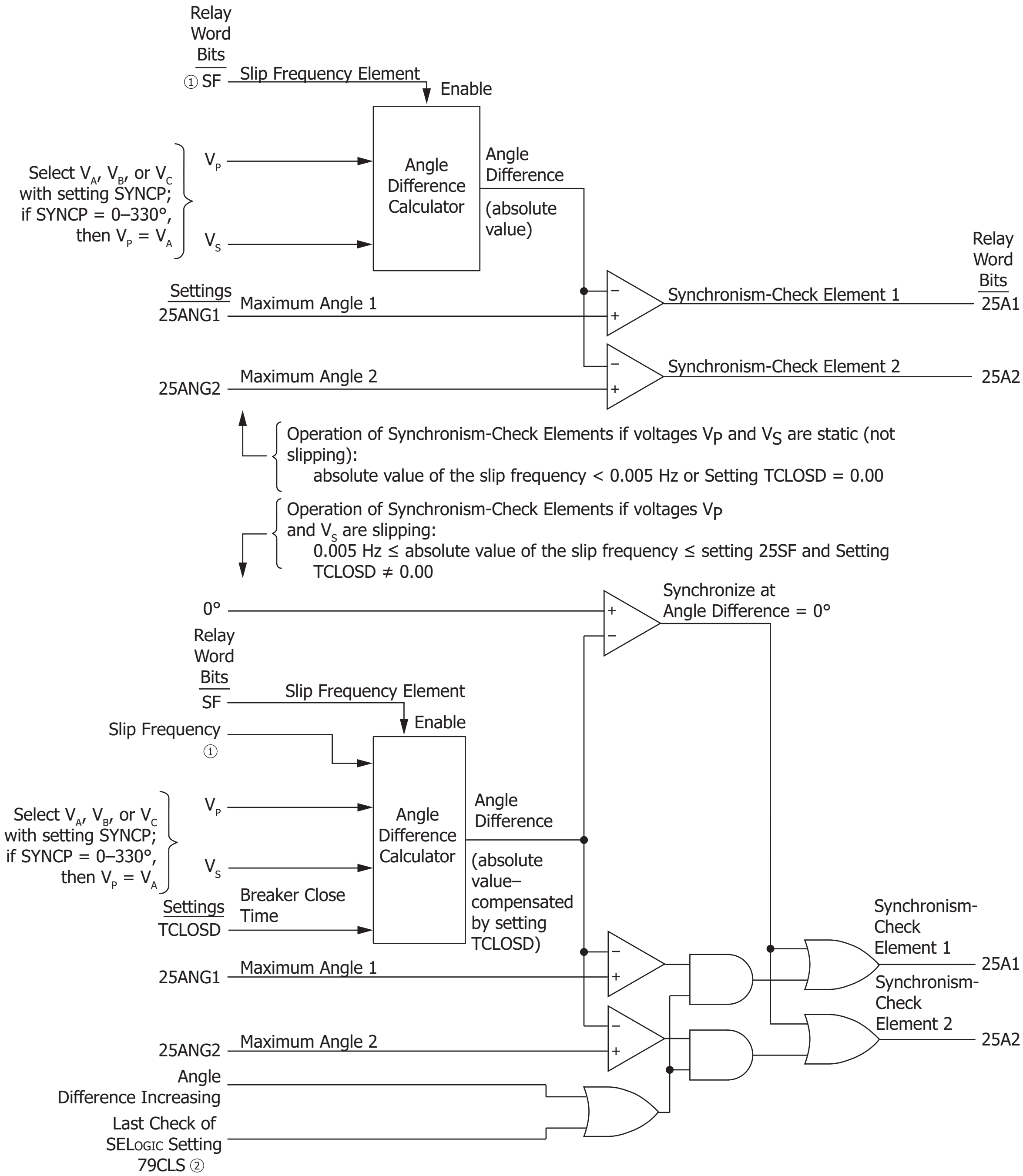
Synchronism-Check Logic Diagrams

The synchronism-check logic is shown in *Figure 3.38* and *Figure 3.39*. Make Group setting E25 = Y to access the settings and to enable this logic.



① See bottom of Figure 3.39; ② Figure 3.39.

Figure 3.38 Synchronism-Check Voltage Window and Slip Frequency Elements



① From Figure 3.38; ② See Figure 6.5.

Figure 3.39 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

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

or

- V_A

when designated by a numeric setting SYNCP (e.g., if SYNCP = 210 degrees, then $V_P = V_A$

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), then rear-panel voltage input **VS-NS** is connected to B-phase on the other side of the circuit breaker. The voltage across terminals **VB-N** is synchronism-checked with the voltage across terminals **VS-NS** (see *Figure 2.14–Figure 2.16*).

System Frequencies Determined from Voltages V_A 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 determines the frequency on the other side. Thus, voltage terminals **VA-N** have to be connected, even if another voltage (e.g., voltage V_B) is to be synchronized with voltage V_S.

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

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

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

System Rotation Can Affect Setting SYNCP

The solution in the preceding paragraph 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 A-phase
- Voltage input **VS** connected to B-phase
- Setting SYNCP = 120 degrees (V_S constantly lags V_A by 120°)

Synchronism-Check Elements Operation

Refer to *Figure 3.38* and *Figure 3.39*.

Voltage Window and SYNCP Settings Example

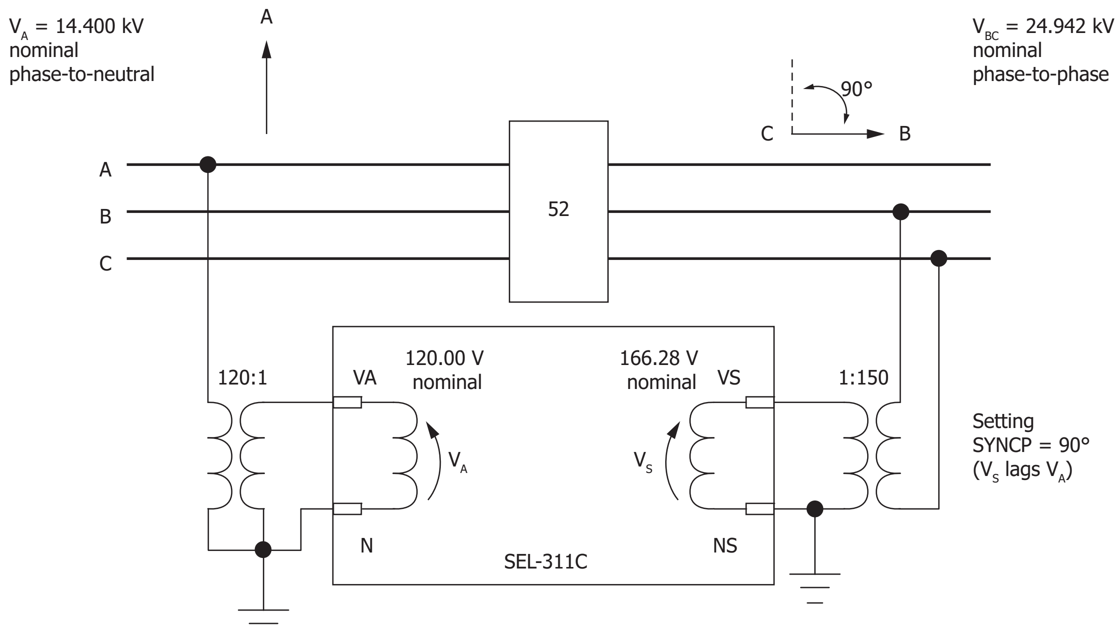


Figure 3.40 Example System With Synchronism-Check Voltage Connected Phase-To-Phase

The example system in *Figure 3.40* 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 3.40* 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 3.40* 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:

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

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

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:

NOTE: In applications where SYNCP is set to VA, VB, or VC, the selected signal is routed to V_P, and V_P is also scaled by the 25RCF setting.

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

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 percent. The settings 25VHI and 25VLO must be entered for the VS-NS terminal voltage.

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

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

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

As shown in *Figure 3.41*, the VA signal is automatically scaled to be compared against the same 25VHI and 25VLO settings.

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

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

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, 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 a numeric setting 0–330 degrees (as in the *Figure 3.40* example), VA is scaled by 25RCF and is used for both the 59VA and 59VP logic.

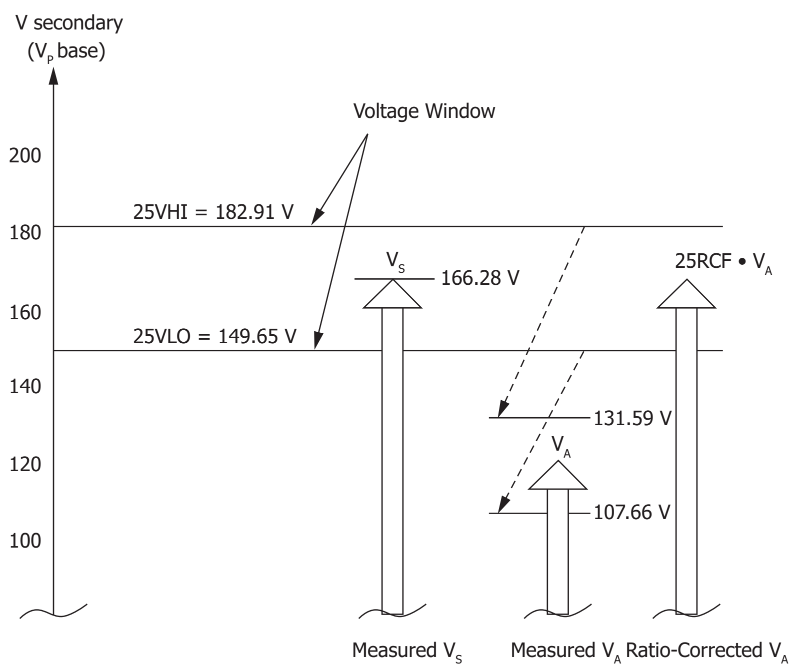


Figure 3.41 25RCF Settings Example Showing V_A Adjustment

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.

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 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 ensure "healthy voltage" for frequency determination, with corresponding Relay Word bit output 59VA.

Other Uses for Voltage Window Elements

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

If synchronism check is not being used, Relay Word bits 59VP, 59VS, and 59VA can still be used in other logic, with voltage limit settings 25VLO and 25VHI set as desired. Enable the synchronism-check logic (setting E25 = Y) and make settings 25VLO, 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 3.38*.

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 = **52AA + 52AB + 52AC** (see *Figure 6.2*)

or

BSYNCH = **!3PO** (see *Figure 5.6*)

These example settings allow the synchronism-check elements to operate only when all three breaker poles are open. Synchronism check during single-pole open conditions (SPO = logical 1) is not possible if voltage VA or VP loses potential.

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

BSYNCH = **... + TRIP**

Slip Frequency Calculator

Refer to *Figure 3.38*.

The synchronism-check element Slip Frequency Calculator in *Figure 3.38* runs if voltages V_P, V_S, and V_A are healthy (59VP, 59VS, and 59VA asserted to logical 1) *and* the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). The Slip Frequency Calculator output is 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]

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 3.38*, 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.

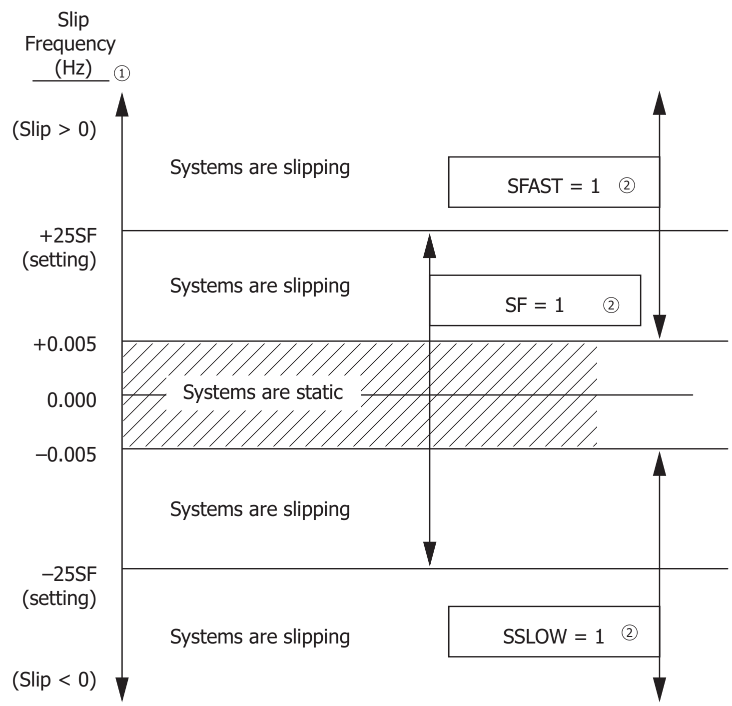
Generator Application for SSLOW and SFAST

Relay Word bits SSLOW and SFAST in *Figure 3.38* 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 3.24* and *Figure 3.42*.

Table 3.24 SSLOW and SFAST Relay Word Bit Operating Range

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



① Slip Frequency = Frequency of **VA-N** signal—Frequency of **VS-NS** signal ② From Figure 3.38.

Figure 3.42 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 3.38* 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 3.39* 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 3.39*.

If the absolute value of the slip frequency is less than 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 the bottom of *Figure 3.39*.

If the absolute value of the slip frequency is greater than or equal to 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 3.43*). 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.

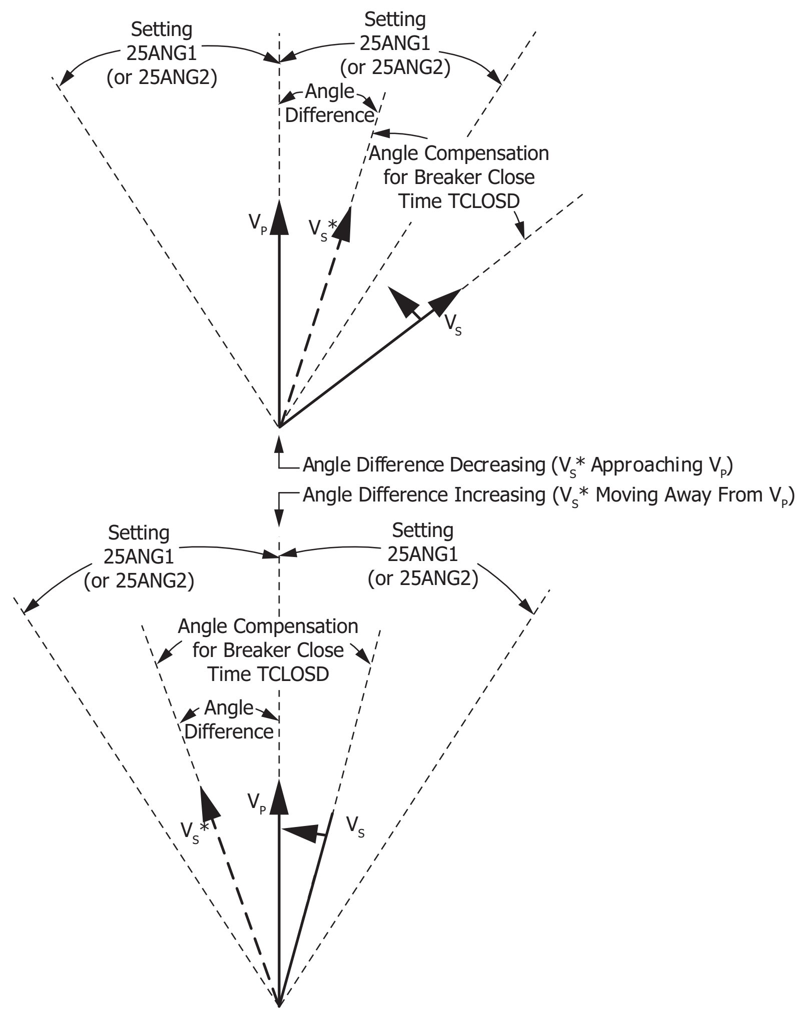


Figure 3.43 Angle Difference Between V_P and V_S Compensated by Breaker Close Time ($f_P < f_S$ and V_P Shown as Reference in this Example)

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

Refer to the bottom of *Figure 3.39*.

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.

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

Resulting in:

Angle Difference

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

NOTE: The angle compensation in Figure 3.43 appears much greater than 6 degrees. Figure 3.43 is for general illustrative purposes only.

NOTE: For the synchronism check algorithm to work as designed, the frequency of both of the voltages used, V_P and V_S, must be tracked. The frequency tracking algorithm requires a qualifications period of V_P and V_S, which can cause an initial delay in the assertion of synchronism check Relay Word bits.

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

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 3.43*.

The top of *Figure 3.43* 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 3.43* 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. 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 3.39*) 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 3.39*.

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 the bottom of *Figure 3.39*. 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 3.43* 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 3.43* 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 6.8*.

Refer to the bottom of *Figure 6.6*. 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 6.7*).

Refer to the top of *Figure 6.6*. 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 3.43*. 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 3.39* 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 6.5*. Element 25A2 operates similarly.

Synchronism-Check Applications for Automatic Reclosing and Manual Closing

Refer to *Close Logic on page 6.5* and *Reclose Supervision Logic on page 6.8*.

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

79CLS = **25A1 + SPO + ...** (see *Figure 6.6* and *Figure 5.6*)

The synchronism-check elements may not be available during a single-pole open condition (SPO = logical 1). The SPO term allows an automatic reclose during SPO conditions.

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 + SV1 * SPO + ...)** (see *Figure 6.5* and *Figure 5.6*)

The SPO term allows a manual close during SPO conditions, when 25A2 may be unavailable.

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 synchronism-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 6.5* logic output).

Testing Synchronism-Check Elements

The energy stored in the capacitance and reactance of a long transmission line takes time to dissipate, or ringdown, when the line conductors are de-energized. The SEL-311C contains logic to detect this condition, block frequency measurement, and cause Relay Word bit FREQOK to deassert. This prevents operation of the synchronism-check elements. When testing these elements, prevent operation of the ringdown detection by using one of the following methods.

1. Apply balanced three-phase voltages with magnitude close to Group setting VNOM.
2. Apply current greater than Group setting 50LP to at least one phase.

   This prevents Relay Word bit 3PO from asserting, which blocks the ringdown detection logic.

3. Temporarily set Group settings E21P, E21XG, and E21MG to N to disable all distance elements.
4. Change Group setting EBBPT to Y temporarily.

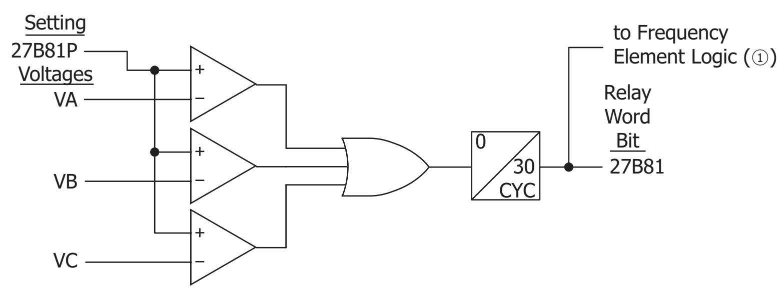
   This prevents the ringdown logic from blocking frequency measurement.

Frequency Elements

Six frequency elements are available. The desired number of frequency elements are enabled with the E81 enable setting as shown in *Figure 3.45*.

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

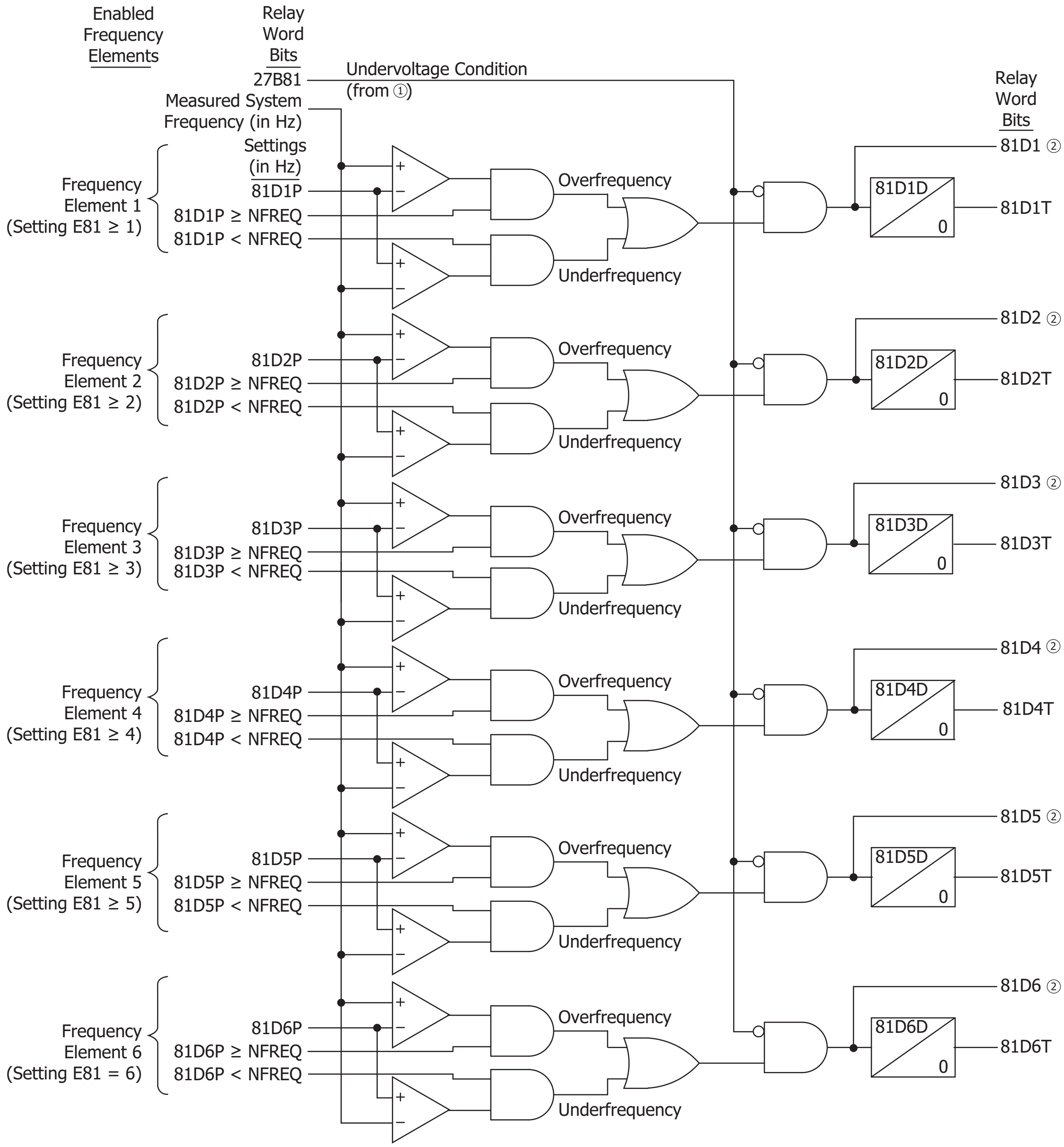
Frequency is determined from the voltage connected to voltage terminals **VA-N**. Frequency elements are blocked by Relay Word bit 27B81. This control prevents improper frequency element operation during faults. Relay Word bit 27B81 deasserts when all phase voltages have been greater than setting 27B81P for at least 30 cycles and the relay is using voltage for frequency measurement. When the relay is using current for frequency measurement, internal logic forces Relay Word bit 27B81 to assert, regardless of voltage conditions.



① Figure 3.45.

Figure 3.44 Undervoltage Block for Frequency Elements

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



① From Figure 3.44; ② 81D1–81D6 are for testing purposes only.

Figure 3.45 Levels 1 Through 6 Frequency Elements

NOTE: 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.

Table 3.25 Frequency Elements Settings and Settings Ranges

Setting	Definition	Range
27B81P	undervoltage frequency element block (responds to V_{LN}	20.00–300.00 V secondary
81D1P	frequency element 1 pickup	40.10–65.00 Hz
81D1D	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	frequency element 2 time delay	2.00–16000.00 cycles, in 0.25-cycle steps
81D3P	frequency element 3 pickup	40.10–65.00 Hz
81D3D	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	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	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	frequency element 6 time delay	2.00–16000.00 cycles, in 0.25-cycle steps

Create Over- and Underfrequency Elements

Refer to *Figure 3.45*.

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 3.45.

With the previous overfrequency element example settings, if the 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 3.25*. 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 by using the pickup setting.

$$\begin{aligned} \text{Delay} &= 30 \text{ s} \bullet 60.60 \text{ Hz} \\ &= 30 \text{ s} \bullet 60.60 \text{ cycles/s} \\ &= 1818 \text{ cycles} \end{aligned}$$

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 3.44* and *Figure 3.45*.

Note that all six frequency elements are controlled by the same undervoltage element (Relay Word bit 27B81). For example, when 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 by 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.

Section 4

Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic

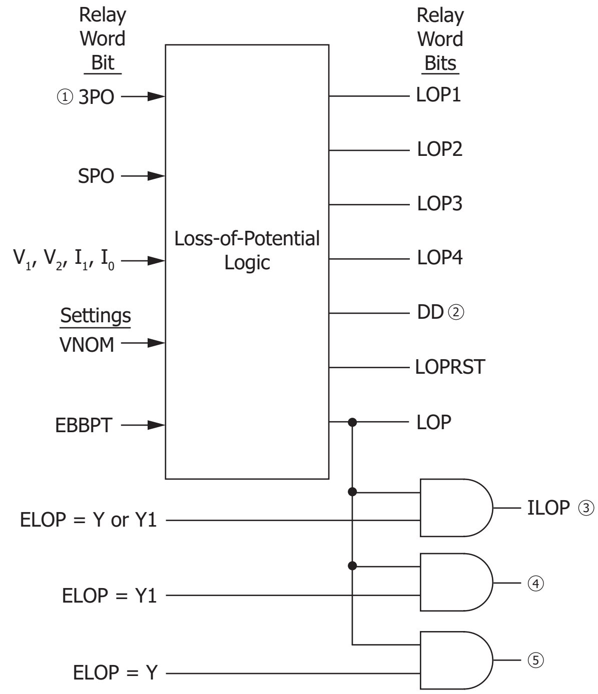
Overview

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 5.6; ② to Figure 5.1; ③ to Figure 3.2–Figure 3.10, Figure 4.13, Figure 4.14, and Figure 4.21; ④ to Figure 5.9; 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 5.6*)
SPO	Single-pole open condition (see *Figure 5.6*)
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 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.

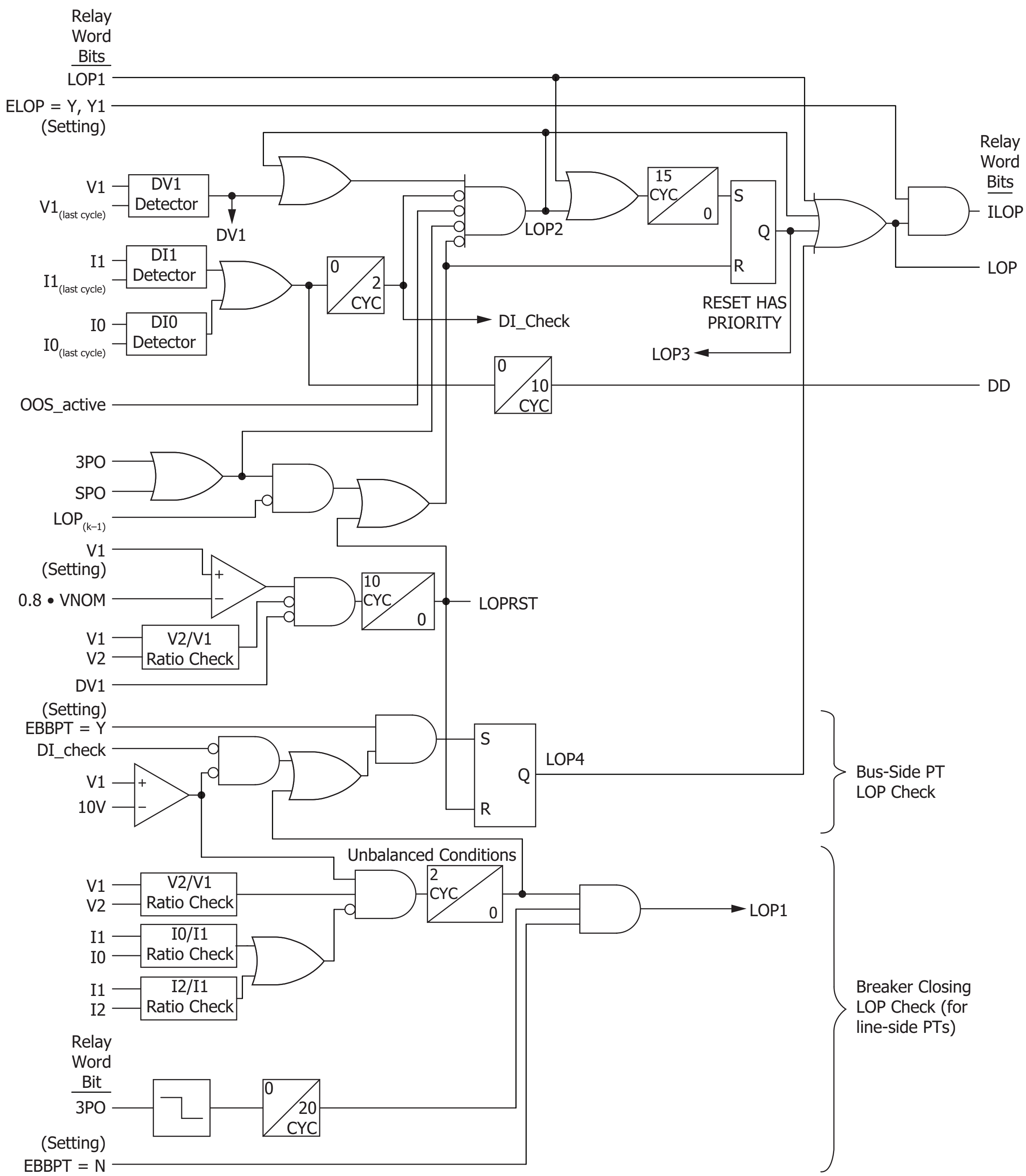


Figure 4.2 Overall LOP Logic Diagram

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 5.1*.
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).

To better understand the logic, the following sections 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 2.16*, 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 5.17* for methods of covering this case.

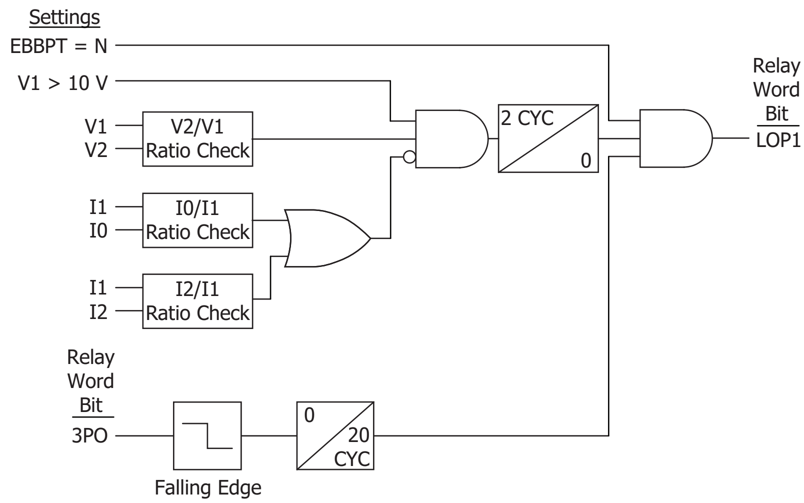


Figure 4.3 Breaker Closing LOP Logic (Relay Word Bit LOP1)

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.

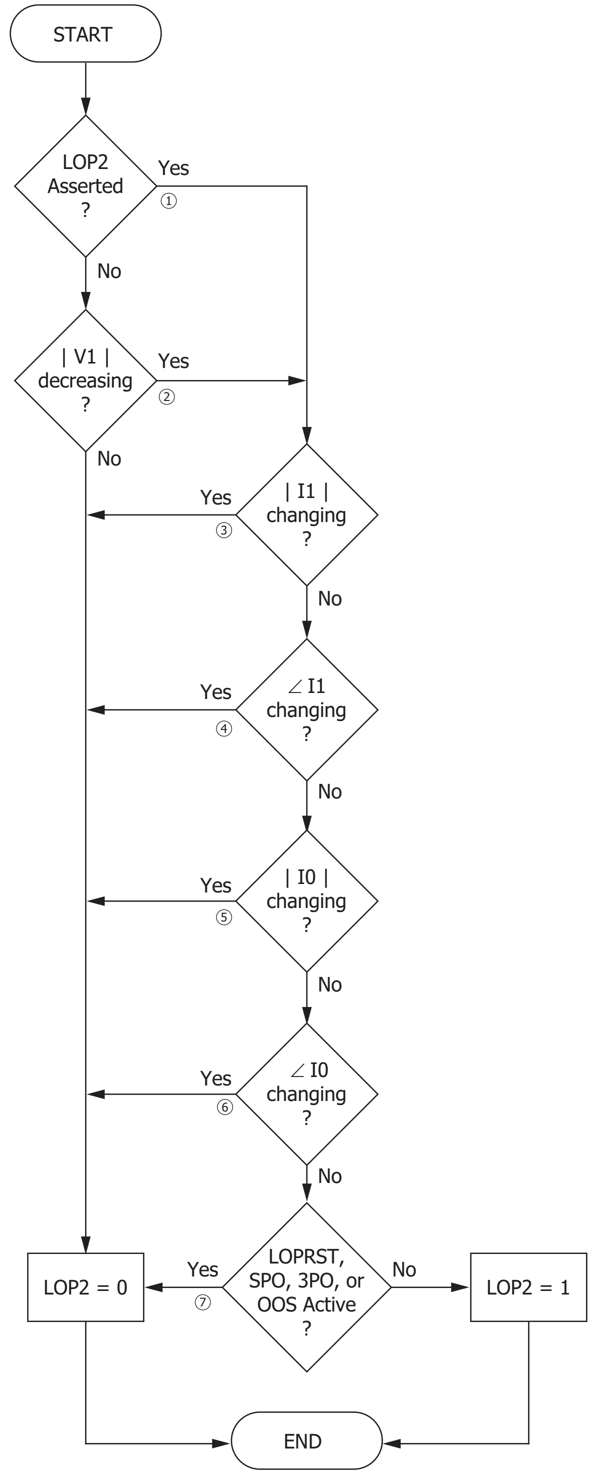


Figure 4.4 LOP2 Logic Processing Overview (Relay Word Bit LOP2)

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 percent 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 percent 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 percent of INOM to override the LOP2 declaration.

Step 7. Is LOPRST, SPO, 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.

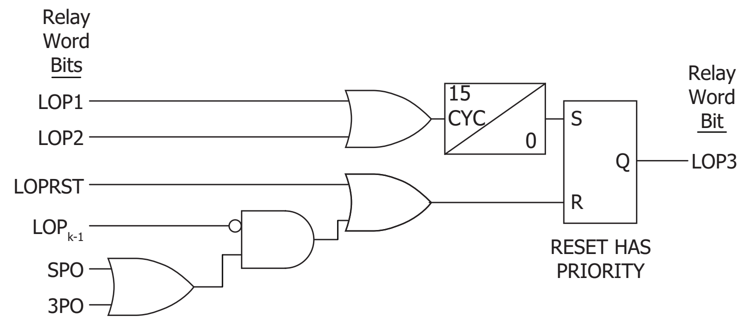


Figure 4.5 LOP Latch Logic (Relay Word Bit LOP3)

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.

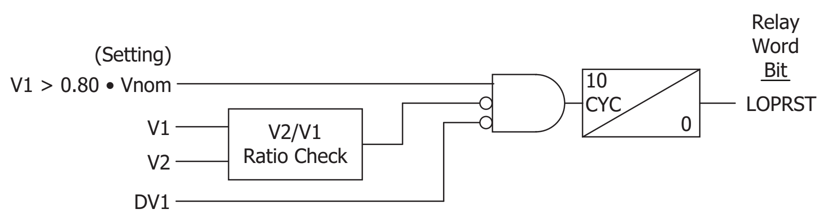


Figure 4.6 LOP Reset Logic (Relay Word Bit LOPRST)

Relay Word Bit LOP4: LOP Logic for PT Transfer Scheme Applications

Only set EBBPT = Y when a PT transfer scheme, such as that shown in *Figure 4.7*, is used; otherwise, the primary system configuration can result in the bus PT being isolated while load is applied to the relay. When set to Y, the relay enables the logic in *Figure 4.8*. 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 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*.

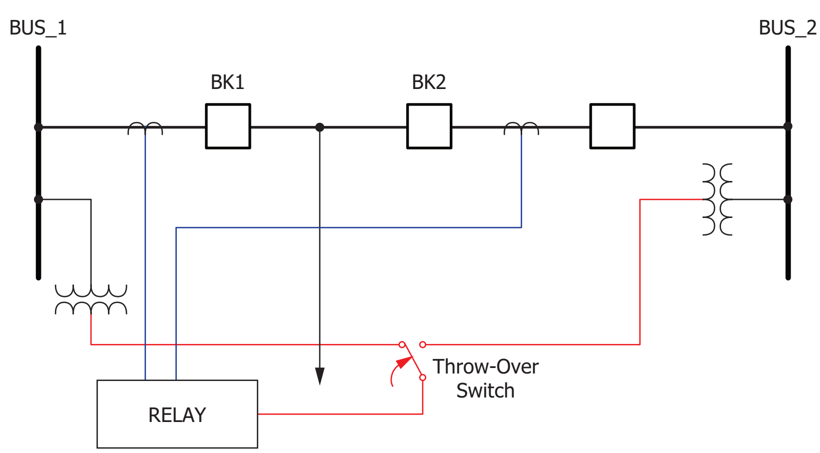


Figure 4.7 Breaker-and-a-Half Scheme with PT Throw-Over Switch

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).

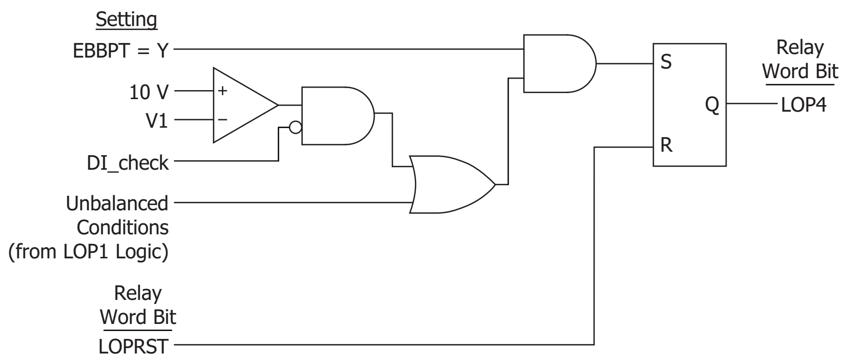


Figure 4.8 Busbar PT Logic (Relay Word Bit LOP4)

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 (see *Figure 4.13*, *Figure 4.14*, *Figure 4.21*, and *Figure 3.2–Figure 3.10*). 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 5.9*, if setting ELOP = Y1 and LOP asserts, keying and echo keying in the permissive overreaching transfer trip (POTT) logic are blocked.

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. 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.

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 A, 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 a source-to-line impedance ratio (SIR) greater than five during a Zone 1 fault, the relay delays Zone 1 distance element operation for as long as 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.

For close-in faults on systems with high SIRs, the SEL-311C uses distance-calculation smoothness detection to override the tripping delay caused by low voltage and low current. Distance elements operate without significant delay for close-in faults.

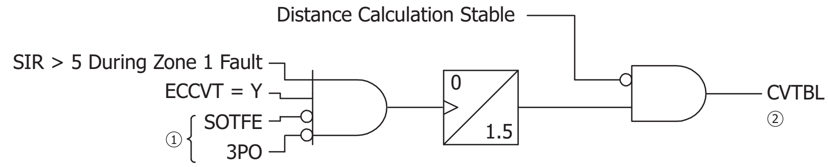
Consider using CCVT transient detection logic when you have both of the following conditions:

- SIR greater than or equal to five
- CCVTs with AFSC (active ferrorresonance-suppression circuits)

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 selinc.com: *Capacitive Voltage Transformer: Transient Overreach Concerns and Solutions for Distance Relaying*.



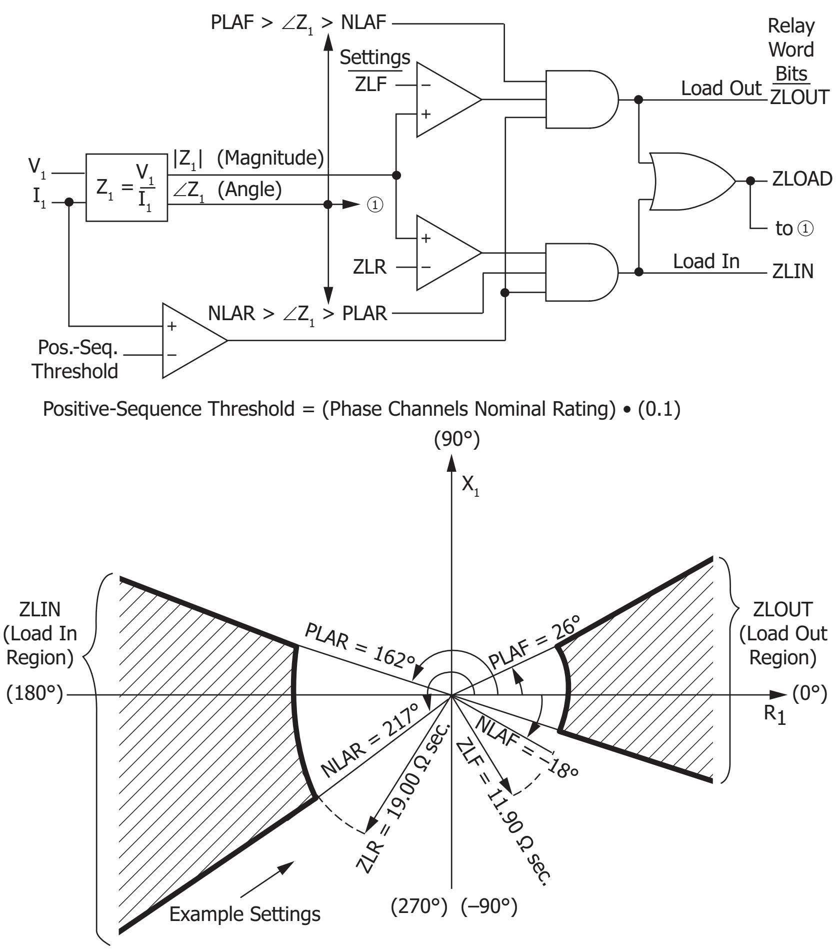
① From Figure 5.5 and Figure 5.6; ② To Figure 3.2, Figure 3.5, and Figure 3.8

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 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**

Load Encroachment During Single-Pole Open Conditions

During single-pole open conditions, the voltage measured on the open phase is not included in the positive-sequence voltage (V1) calculation. However, the SEL-311C load-encroachment logic does not directly consider the circuit breaker status, and can operate as long as sufficient positive-sequence current is available. Thus, ZLOAD, ZLIN, or ZLOUT may still operate during single-pole open (SPO) conditions, although the meaning may be unclear.

This poses no problem for the SEL-311C internal logic, because the only place that ZLOAD is used is in the positive-sequence directional element, shown in *Figure 4.21*. The positive-sequence directional element is already blocked by SPO, and the status of the ZLOAD element will have no effect during SPO conditions.

Load Encroachment Reporting During SPO

During an SPO condition, the standard event report load-encroachment digital element column Zld (see *Table 12.4*) may report element activity that is not representative of the power system load flow. This can be safely ignored.

If any of the ZLOAD, ZLIN, or ZLOUT elements are present in the Sequential Events Recorder (SER) settings, the report may contain several lines of unimportant activity during SPO conditions. To improve this situation, the Relay Word bit(s) may be supervised by SPO, as shown in this example:

LV10 = **ZLIN • !SPO**

LV11 = **ZLOUT • !SPO**

LV10 will assert for incoming load conditions AND NOT[single pole open]

LV11 will assert for outgoing load conditions AND NOT[single pole open]

Place LV10 and LV11 in the SER settings (SET R) instead of ZLIN and ZLOUT, to minimize the number of load encroachment-related SER entries during an SPO condition. See *Sequential Events Recorder (SER) Report on page 12.28*.

Settings Ranges

Refer to *Figure 4.10*.

Table 4.3 Load-Encroachment Settings Ranges (Sheet 1 of 2)

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

Table 4.3 Load-Encroachment Settings Ranges (Sheet 2 of 2)

Setting	Description and Range
	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:

$$\frac{230^2 \bullet 400}{800 \bullet 2000} = 13.2\ \Omega\text{ secondary}$$

To provide a margin for setting ZLF, multiply by a factor of 0.9:

$$\begin{aligned} ZLF &= 13.2\ \Omega \text{ secondary} \bullet 0.9 \\ &= 11.90\ \Omega \text{ secondary} \end{aligned}$$

For the maximum reverse load:

$$\frac{230^2 \bullet 400}{500 \bullet 2000} = 21.1\ \Omega \text{ secondary}$$

Again, to provide a margin for setting ZLR:

$$\begin{aligned} ZLR &= 21.1 \text{ secondary} \bullet 0.9 \\ &= 19.00\ \Omega \text{ secondary} \end{aligned}$$

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**

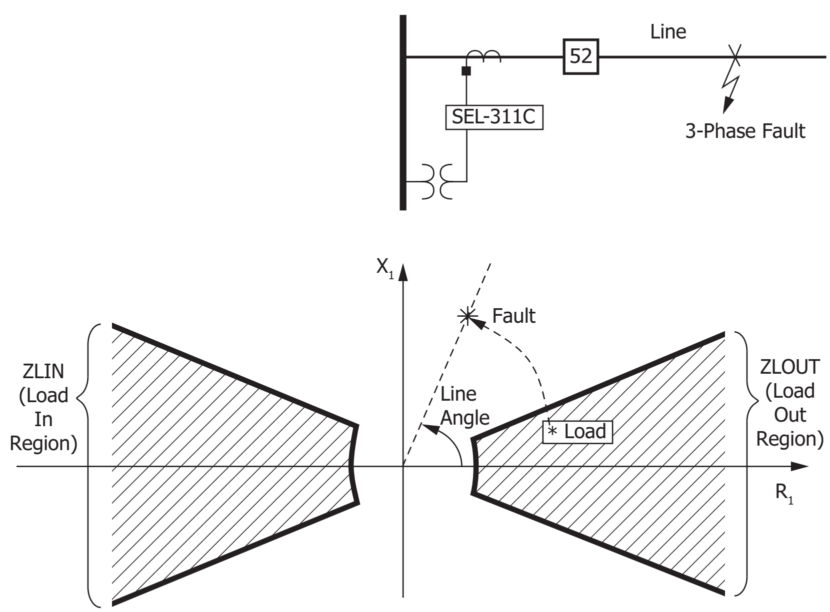


Figure 4.11 Migration of Apparent Positive-Sequence Impedance for a Fault Condition

Refer to *Figure 4.11*. In a load condition, the apparent positive-sequence impedance is *within* the ZLOUT area, resulting in the following.

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 the following.

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-to-ground faults. Similarly, negative-sequence overcurrent elements must be used to detect phase-to-phase faults (see *Appendix G: Setting Negative-Sequence Overcurrent Elements*). These phase-to-ground and phase-to-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 3.32* 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

Example 2

If it is *not* acceptable for the phase-overcurrent element to operate for any unbalanced fault current less than 50P4P or for load conditions, enable load encroachment (refer to *Figure 3.32*) and make the following SELOGIC control equation torque-control setting.

51PTC = **M3P * !R32Q + M4P * !F32Q + 50P4**

Also, make the following Group settings.

DIR3 = **R**

DIR4 = **F**

This uses distance elements M3P (for balanced reverse faults) and M4P (for balanced forward faults) to cause the phase-overcurrent element to be sensitive only to three-phase fault conditions. This example also requires appropriate Zone 3 and Zone 4 phase reach settings Z3P and Z4P, set with enough reach to cover the protected line (or bus) during low-current conditions (below the 50P4P overcurrent element setting).

Residual or neutral ground-overcurrent elements must be used to detect phase-to-ground faults, and negative-sequence overcurrent elements must be used to detect phase-to-phase faults (see *Appendix G: Setting Negative-Sequence Overcurrent Elements*). These phase-to-ground and phase-to-phase elements must be at least as sensitive as the phase-overcurrent elements.

Because the directional control logic is defeated when a loss-of-potential (LOP) occurs, phase instantaneous overcurrent element 50P4 is set above any maximum load current level—if 50P4 picks up, there is assuredly a fault. 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.

See SEL Application Guide *AG2005-07, Guidelines for Applying Load-Encroachment Element for Overcurrent Supervision*, available on the SEL website, for more information.

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 4.28*.

Three directional elements are available to control the ground-distance and residual-ground overcurrent elements. These three directional elements are:

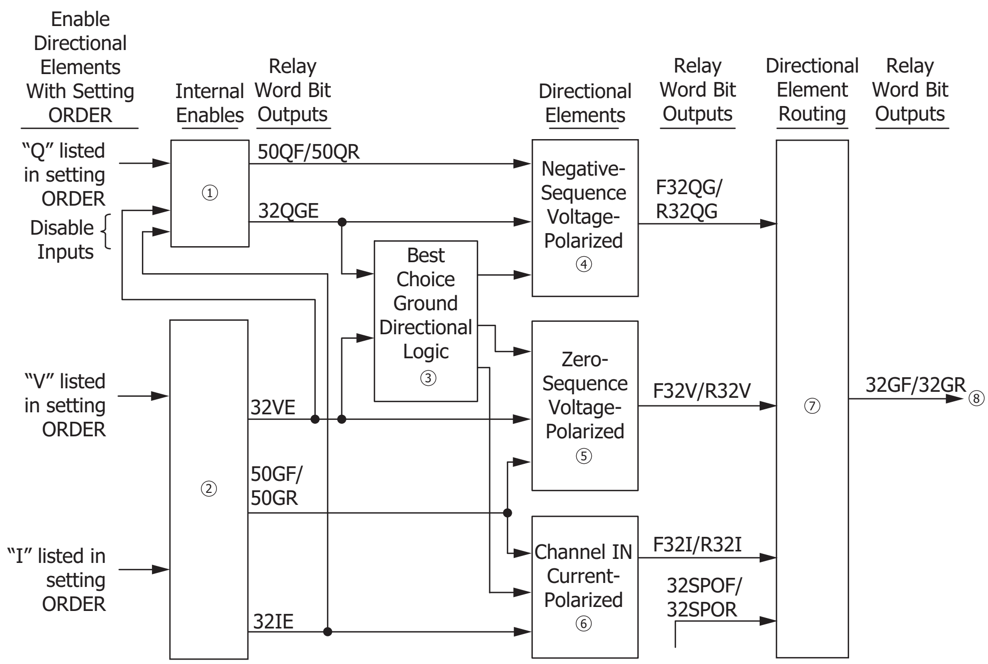
- Negative-sequence voltage-polarized directional element
- Zero-sequence voltage-polarized directional element
- Channel IN current-polarized directional element

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*.

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 4.28*.



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 3.5—Figure 3.10 and Figure 3.30.

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		

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
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
QVI	32QGE	32VE	32IE
VI	32VE	32IE	
VIQ	32VE	32IE	32QGE
VQI	32VE	32QGE	32IE

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*). 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 4.28*.

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 4.28*.

Single-Pole Open

During single-pole open conditions (indicated by Relay Word bit SPO = logical 1), the negative-sequence voltage-polarized, zero-sequence voltage-polarized, and Channel IN current-polarized directional elements are disabled. This SPO control influence can be seen in *Figure 4.13–Figure 4.17*. The 32GF and 32GR signals are supervised by the open-pole directional logic under these conditions, as shown in *Figure 4.18*.

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 3.5* through *Figure 3.10* and the residual-ground directional overcurrent elements in *Figure 3.30*.

Loss of Potential

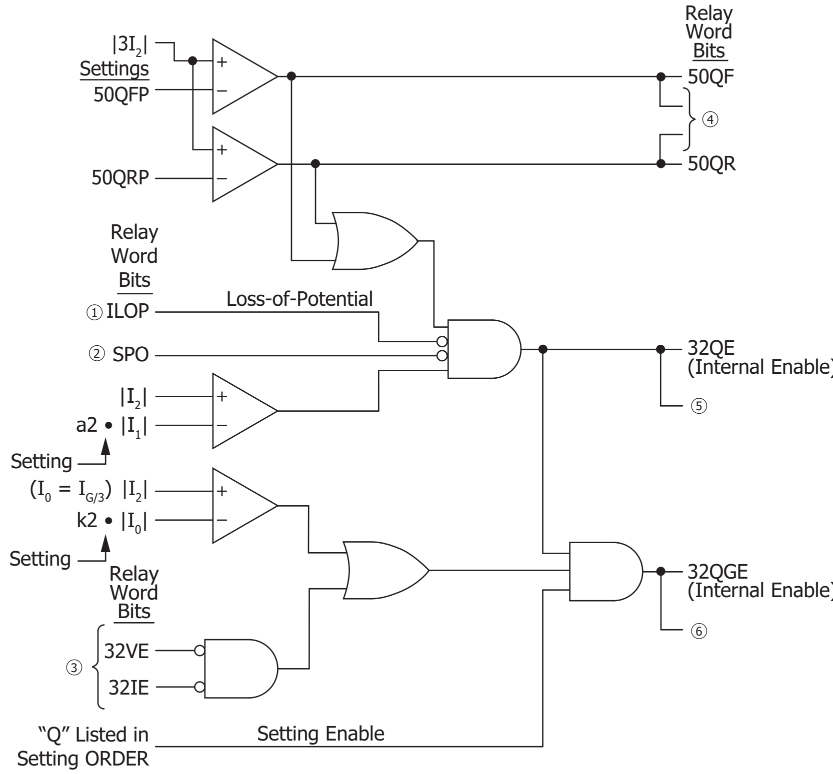
Note in *Figure 4.18* that if *all* the following are true,

- Enable setting ELOP = Y,
- A loss-of-potential condition occurs (Relay Word bit LOP asserts),
- 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, 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.

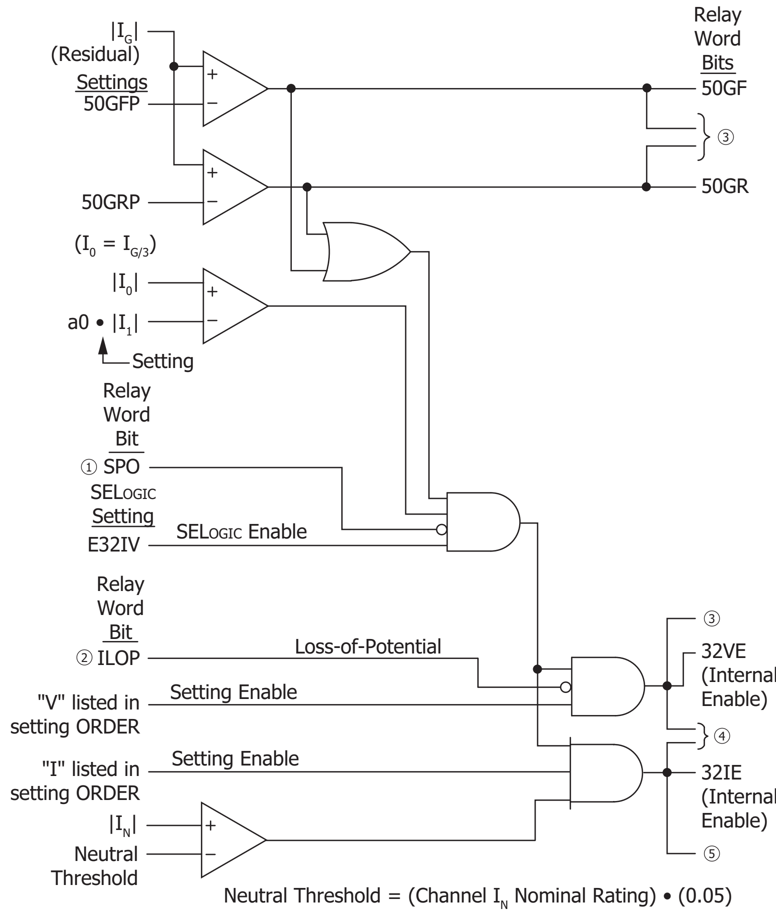
Refer to *Figure 4.1* and accompanying text for more information on loss-of-potential.

As shown in *Figure 3.2* through *Figure 3.10*, ILOP also disables all distance elements.



① From Figure 4.1; ② from Figure 5.6; ③ from Figure 4.14; ④ to Figure 4.15 and Figure 4.20; ⑤ to Figure 4.20; ⑥ to Figure 4.15, Table 4.4, and Table 4.5.

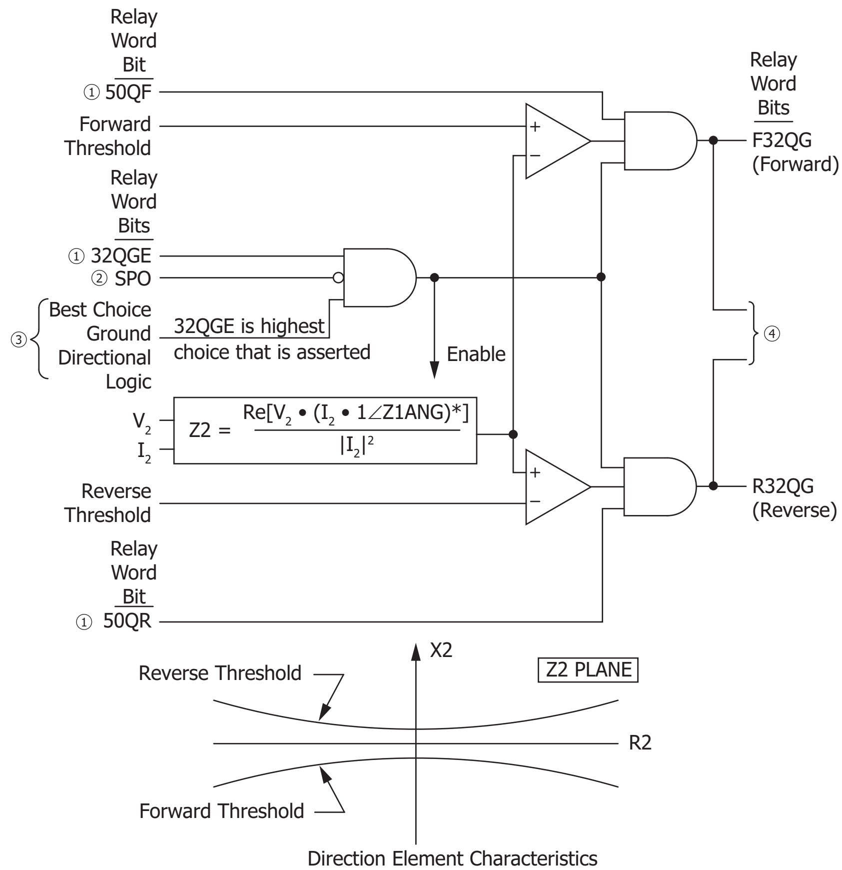
Figure 4.13 Internal Enables (32QE and 32QGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements



① From Figure 5.6; ② From Figure 4.1; 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 control equation setting E32IV.



Forward Threshold:

If Z2F Setting ≤ 0, Forward Threshold = $0.75 \bullet Z2F - 0.25 \bullet \left|\frac{V_2}{I_2}\right|$

If Z2F Setting > 0, Forward Threshold = $1.25 \bullet Z2F - 0.25 \bullet \left|\frac{V_2}{I_2}\right|$

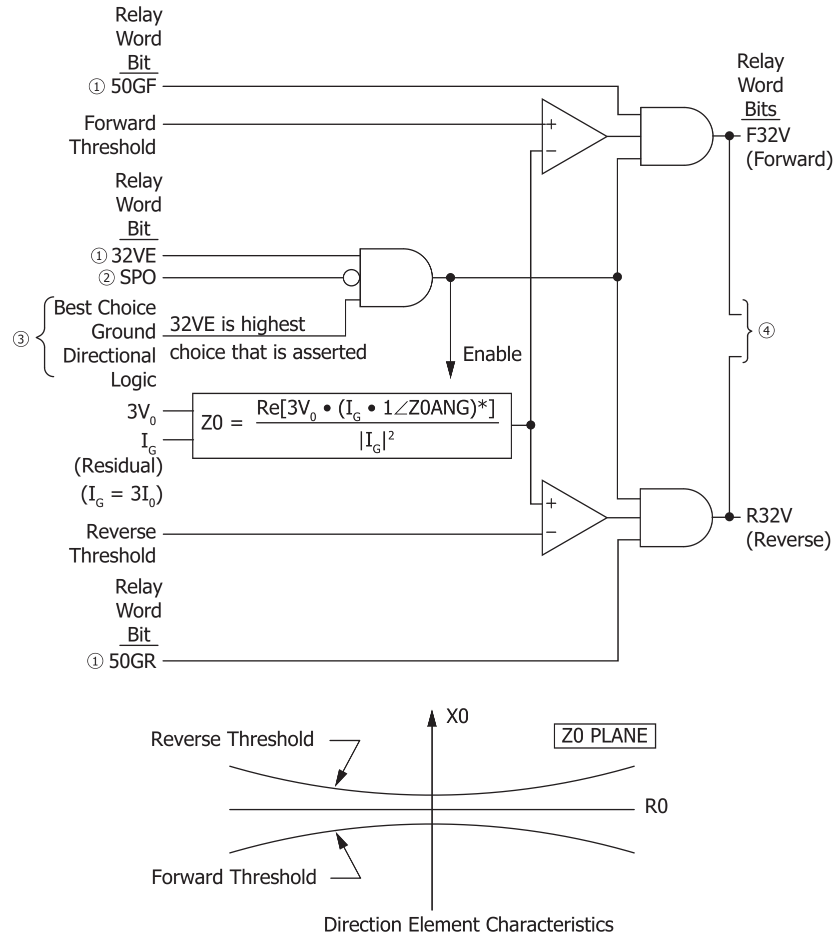
Reverse Threshold:

If Z2R Setting ≥ 0, Reverse Threshold = $0.75 \bullet Z2R + 0.25 \bullet \left|\frac{V_2}{I_2}\right|$

If Z2R Setting < 0, Reverse Threshold = $1.25 \bullet Z2R + 0.25 \bullet \left|\frac{V_2}{I_2}\right|$

① from Figure 4.13; ② From Figure 5.6; ③ From Table 4.5; ④ 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 • Z0F – 0.25 • $\left|\frac{V_0}{I_0}\right|$

If Z0F Setting > 0, Forward Threshold = 1.25 • Z0F – 0.25 • $\left|\frac{V_0}{I_0}\right|$

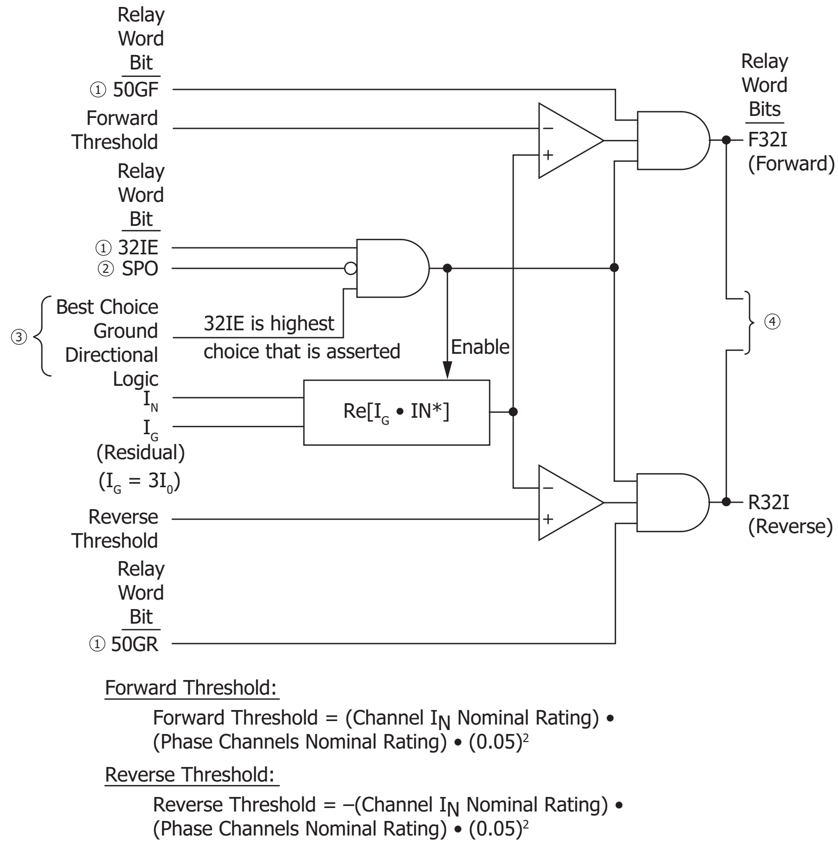
Reverse Threshold:

If Z0R Setting ≥ 0, Reverse Threshold = 0.75 • Z0R + 0.25 • $\left|\frac{V_0}{I_0}\right|$

If Z0R Setting < 0, Reverse Threshold = 1.25 • Z0R + 0.25 • $\left|\frac{V_0}{I_0}\right|$

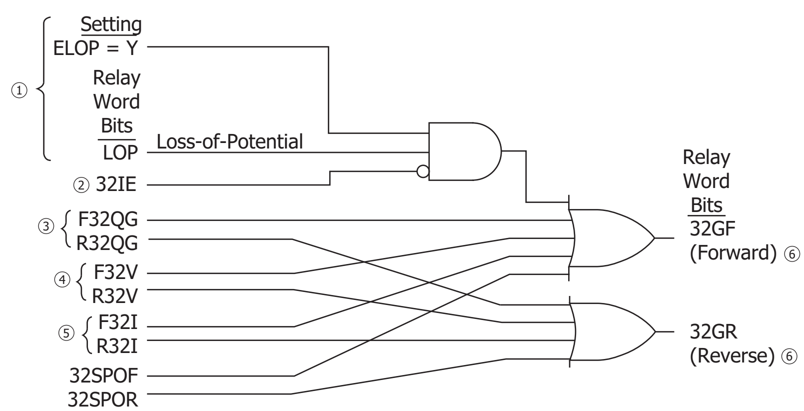
① From Figure 4.14; ② from Figure 5.6; ③ from Table 4.5; ④ to Figure 4.18.

Figure 4.16 Zero-Sequence Voltage-Polarized Directional Element for Ground-Distance and Residual Ground Overcurrent Elements



① From Figure 4.14; ② from Figure 5.6; ③ from Table 4.5; ④ to Figure 4.18.

Figure 4.17 Channel IN Current-Polarized Directional Element for Ground-Distance and Residual-Ground Overcurrent Elements



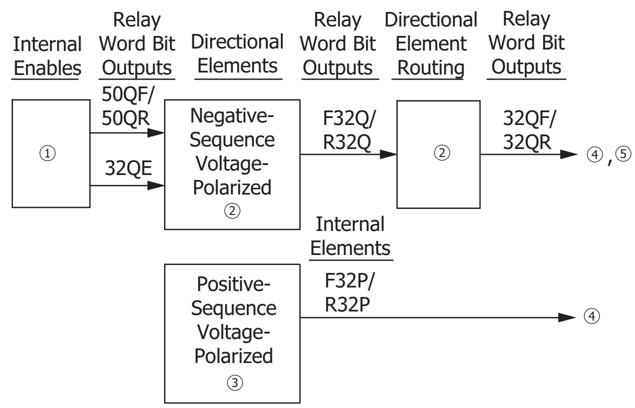
① From Figure 4.1; ② from Figure 4.14; ③ from Figure 4.15; ④ from Figure 4.16; ⑤ from Figure 4.17; ⑥ To Figure 3.5 through Figure 3.10 and Figure 3.30.

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 4.28*.

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 3.2—Figure 3.4; ⑤ Figure 3.31.

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 4.28*.

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*).

Single-Pole Open

During single-pole open conditions (indicated by Relay Word bit SPO = logical 1), both the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements are disabled. This SPO control influence can be seen in *Figure 4.13*, *Figure 4.20*, and *Figure 4.21*.

Because this SPO condition defeats the 32QF and 32QR signals, the negative-sequence overcurrent elements 67Q1–67Q4 and 67Q1T–67Q4T are also defeated.

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.

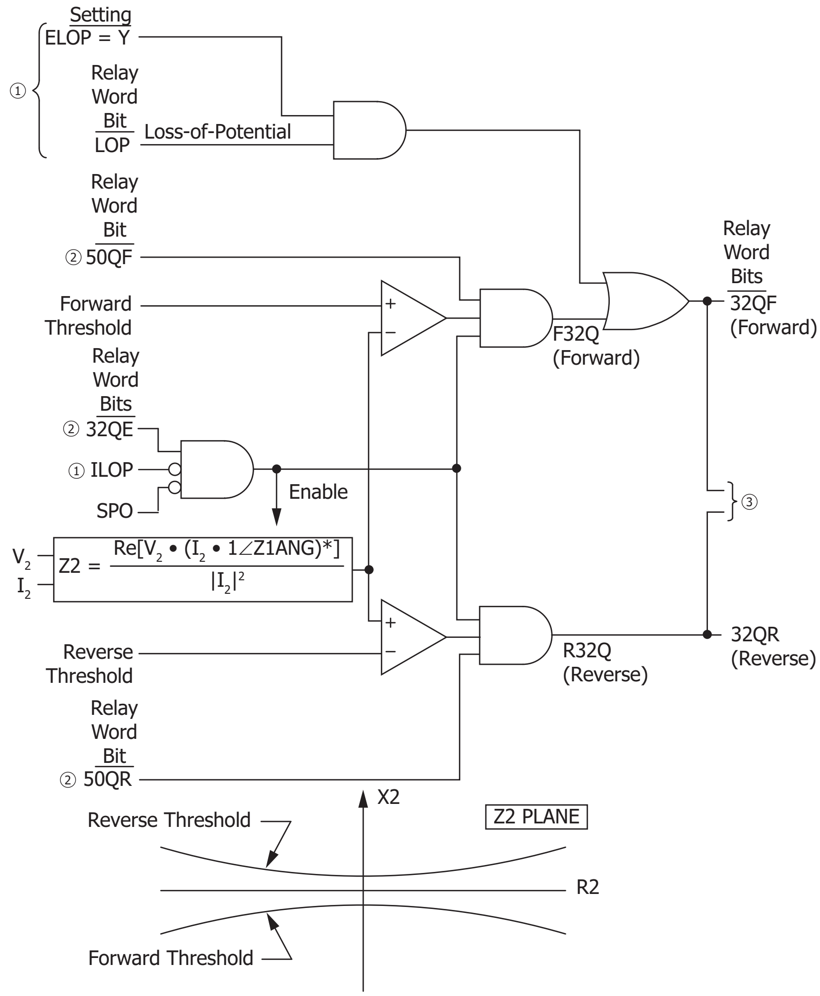
Loss-of-Potential

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, 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.



Direction Element Characteristics

Forward Threshold:

If Z2F Setting ≤ 0, Forward Threshold = 0.75 • Z2F – 0.25 • $\left|\frac{V_2}{I_2}\right|$

If Z2F Setting > 0, Forward Threshold = 1.25 • Z2F – 0.25 • $\left|\frac{V_2}{I_2}\right|$

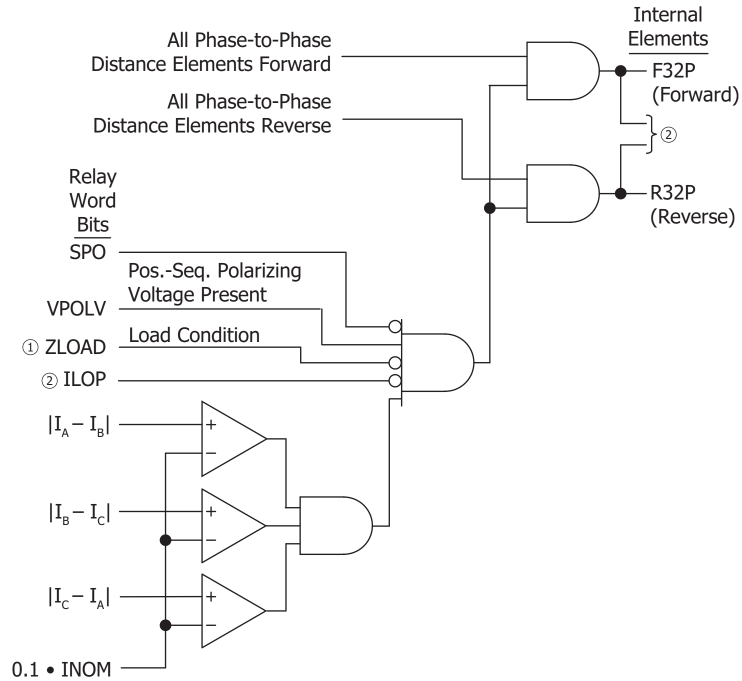
Reverse Threshold:

If Z2R Setting ≥ 0, Reverse Threshold = 0.75 • Z2R + 0.25 • $\left|\frac{V_2}{I_2}\right|$

If Z2R Setting < 0, Reverse Threshold = 1.25 • Z2R + 0.25 • $\left|\frac{V_2}{I_2}\right|$

① from Figure 4.1; ② from Figure 4.13; ③ to Figure 3.2–Figure 3.4 and Figure 3.31.

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 3.2–Figure 3.4.

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.

Use caution when you set E32 = AUTO. It is not appropriate for all applications. Systems with a strong negative-sequence source (e.g., equivalent negative-sequence impedance of less than $2.5/I_{NOM}$ in ohms) can use E32 = AUTO. It is best to use the settings in *Table 4.6* if any of the following apply:

- ➤ The negative-sequence impedance of the source is greater than $2.5/I_{NOM}$ in ohms
- ➤ The line impedance is unknown
- ➤ A non-fault condition occurs, such as a switching transformer energization causing the negative-sequence voltage to be approximately zero

Table 4.6 Ground Directional Element Preferred Settings

Name	5 A nominal	1 A nominal
E32	Y	Y
Z2F	–0.30	–1.5
Z2R	0.30	1.5
Z0F	–0.30	–1.5
Z0R	0.30	1.5
50QFP /50GFP	0. 50 A	0.10 A
50QRP /50GRP	0. 25 A	0.05 A
a2	0.10	0.10
k2	0.20	0.20
a0	0.10	0.10

The preferred settings in *Table 4.6* will provide equal or better protection than E32 = AUTO for most systems.

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 listed below.

> DIR3, DIR4, ORDER, and E32IV (E32IV is a SELOGIC control equation setting)

All these settings are explained in detail in the remainder of this section.

Not all of 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 5.23*.

Setting Range:

F = Direction Forward

R = Direction Reverse

Table 4.7 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 3.2*) M1PT (*Figure 3.20*)	Z1G (*Figure 3.5*, *Figure 3.8*) Z1GT (*Figure 3.20*)	67G1 (*Figure 3.30*) 67G1T (*Figure 3.30*)	67Q1 (*Figure 3.31*) 67Q1T (*Figure 3.31*)
Forward	M2P (*Figure 3.3*) M2PT (*Figure 3.20*)	Z2G (*Figure 3.6*, *Figure 3.9*) Z2GT (*Figure 3.20*)	67G2 (*Figure 3.30*) 67G2T (*Figure 3.30*)	67Q2 (*Figure 3.31*) 67Q2T (*Figure 3.31*)
DIR3 = F or R	M3P (*Figure 3.4*) M3PT (*Figure 3.20*)	Z3G (*Figure 3.7*, *Figure 3.10*) Z3GT (*Figure 3.20*)	67G3 (*Figure 3.30*) 67G3T (*Figure 3.30*)	67Q3 (*Figure 3.31*) 67Q3T (*Figure 3.31*)
DIR4 = F or R	M4P (*Figure 3.4*) M4PT (*Figure 3.20*)	Z4G (*Figure 3.7*, *Figure 3.10*) Z4GT (*Figure 3.20*)	67G4 (*Figure 3.30*) 67G4T (*Figure 3.30*)	67Q4 (*Figure 3.31*) 67Q4T (*Figure 3.31*)

In communications-assisted trip schemes, the levels are defined as follows (see *Figure 5.7*).

- 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*. See *Setting Guidelines for ORDER on page 4.31* for considerations for the ORDER setting.

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.

In 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).

Setting Guidelines for ORDER

For most systems, select ORDER = Q. This enables only the 32QGE negative-sequence directional element for ground faults.

If single contingency (loss-of-line or generator) can cause the loss of the negative-sequence source and no zero-sequence mutual coupling is present, set ORDER = QV to use the Best Choice Ground Directional logic to automatically switch to the zero-sequence voltage-polarized directional element. Avoid selecting an ORDER setting with “V” on lines with zero-sequence mutual coupling, because this creates the risk of false declaration of the 32VE element.

When using “I” in the ORDER setting to apply current polarizing (e.g., “QVI” or “QI”), analyze system faults to verify that the current polarizing source is reliable for all fault types and locations.

If the relay is applied in a communications-assisted trip scheme (e.g., POTT or DCB), use the same ORDER setting at both ends of the line.

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 the following table)

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.

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 because of line asymmetries, CT saturation during three-phase faults, etc.

a2 Set Automatically

If enable setting E32 = AUTO, setting a2 is set automatically as follows.

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 ($|I_2| > 0.1 \bullet |I_1|$).

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:

$$|I_2| > k2 \bullet |I_0|$$

Equation 4.1

This check ensures 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.

$$I_0 = \frac{I_G}{3}$$

$$3I_0 = I_G = I_A + I_B + I_C$$

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 as follows.

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 ($|I_2| > 0.2 \bullet |I_0|$). 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 as follows.

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.

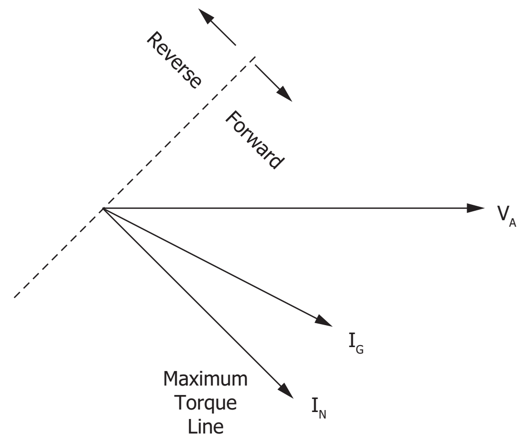


Figure 4.22 Traditional Channel IN Current-Polarized Directional Element

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 because of 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 as follows.

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 ($|I_0| > 0.1 \bullet |I_1|$).

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 shown below.

$Z_M = V_0/(–I_0) = –(V_0/I_0)$

$V_0/I_0 = –Z_M$ (what the relay sees for a forward fault)

For a reverse fault, the SEL-311C effectively sees the sequence impedance in front of it as shown below.

$Z_N = V_0/I_0$

$V_0/I_0 = Z_N$ (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.

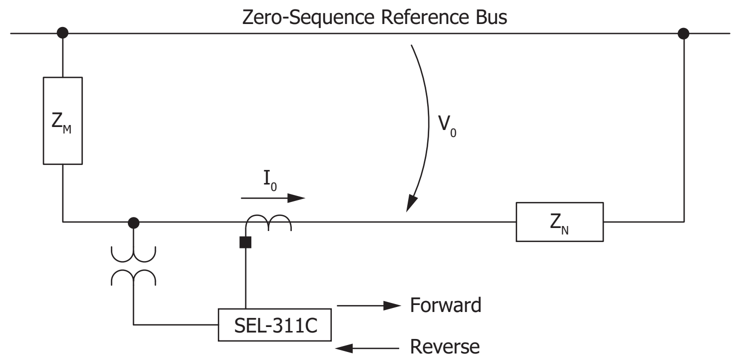


Figure 4.23 Zero-Sequence Impedance Network and Relay Polarity

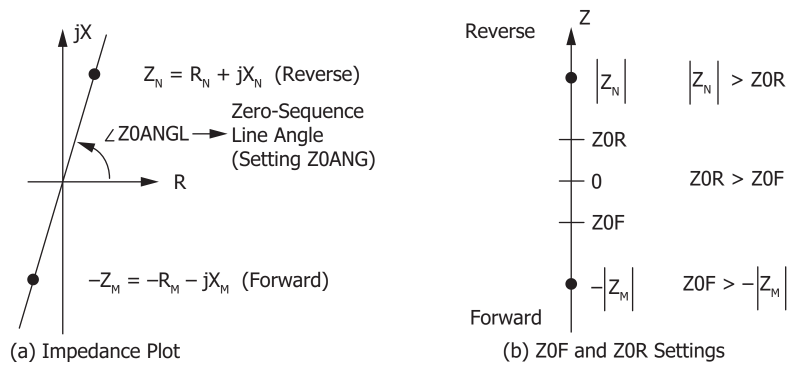


Figure 4.24 Zero-Sequence Impedance Plot for Solidly Grounded, Mostly Inductive System

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." The torque-control equation 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 3.26*
67P2TC	67P2/67P2T	Torque Control	
67P3TC	67P3/67P3T	Torque Control	
67P4TC	67P4/67P4T	Torque Control	
67G1TC	67G1/67G1T	Forward and Torque Control	*Figure 3.30*
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 3.31*
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 3.32*
51GTC	51G/51GT	Torque Control	*Figure 3.33*
51QTC	51Q/51QT	Torque Control	*Figure 3.34*

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 section 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 section explains both the traditional fixed target behavior and the optional programmable target and status LED functionality.

The logic is described in the following sections:

Trip Logic

Use the trip logic to apply the SEL-311C in three-pole tripping applications, or mixed single-pole tripping and three-pole tripping applications. Set the SEL-311C to trip unconditionally (as with step distance) or with the aid of a communications channel (as with the POTT, DCUB, DCB, and DTT schemes).

Three-Pole Tripping

The relay uses three-pole tripping logic if SELOGIC control equation E3PT (three-pole trip enable) evaluates to logical 1. You can permanently set E3PT to logical 1 or assign a control input so that an external condition changes the state of this SELOGIC control equation, or you can assign an internal condition to control the state of E3PT.

Additionally, the relay uses three-pole tripping for the following conditions, regardless of the E3PT equation.

- ➤ Tripping initiated by the Switch-Onto-Fault logic
- ➤ Zone 2 phase-distance protection asserts for a phase-to-phase or three-phase fault and is permitted to trip via the communications-assisted tripping logic
- ➤ Tripping initiated by the manual trip equation BKMTR

The relay uses three-pole tripping for the following conditions when the E3PT equation evaluates to logical 0.

- ➤ A single-pole trip is in progress and another pole trips (for example, a fault is initially B-phase to ground and evolves to an A-phase to B-phase to ground fault before the B-phase breaker pole can open and the trip logic can unlatch)
- ➤ Single-pole tripping conditions are not satisfied (see below)

Three-pole trip conditions are identified by the 3PT Relay Word bit. Individual phase trip bits TPA, TPB, and TPC will also assert for a three-pole trip condition.

The TRIP Relay Word bit asserts for any trip condition (single-pole or three-pole).

Single-Pole Tripping

The relay single-pole tripping logic is enabled if SELOGIC control equation E3PT evaluates to logical 0.

The SEL-311C automatically single-pole trips for the following conditions when the single-pole tripping logic is active.

- ➤ Zone 1 ground-distance protection asserts for a single phase-to-ground fault.
- ➤ Zone 2 ground-distance protection asserts for a single phase-to-ground fault and is permitted to trip via the communications-assisted tripping logic.
- ➤ Any one of three SELOGIC control equations, DTA, DTB, or DTC, is assigned to an input and asserts (per-phase direct transfer trip).

You can also set the SEL-311C to single-pole trip through the following three options.

Table 5.1 Additional Settings for Single-Pole Tripping (SPT)

Setting	Description	Selection
Z2GTSP	Zone 2 Ground-Distance Time Delay Single-Pole Trip	Y
67QGSP	Zone 2 Directional Negative-Sequence/Residual-Ground Overcurrent Single-Pole Trip	Y
EWFC[a]	Weak-Infeed Trip	SP[b]

[a] In POTT and DCUB settings.
[b] SP = Single Pole

Single-pole trip conditions are identified by the SPT Relay Word bit, and the tripping phase is identified by Relay Word bits TPA, TPB, or TPC.

The TRIP Relay Word bit asserts for any trip condition (single-pole or three-pole).

Setting Z2GTSP = Y

You can program the SEL-311C to single-pole trip for Zone 2 ground-distance operations. With typical distance relay settings, employ the Z2GTSP = Y method if you want single-pole tripping during ground faults within the last 20 percent of the protected line when the communications channel is not available. This setting disables one path to the three-phase selection logic (3PS) in the first panel of *Figure 5.1*.

Only tripping initiated via the TR and TRQUAL equations are affected by the Z2GTSP = Y selection.

Setting 67QGSP = Y

The SEL-311C can assert a single-pole trip during high-resistance ground faults so the fault impedance lies outside of the ground-distance protection characteristics; the FIDS logic selects the faulted phase when residual directional overcurrent elements provide communications-assisted tripping. Employ the 67QGSP = Y method to enable phase selection logic when no distance elements are asserted. This setting enables the APS, BPS, and CPS logic in the first panel of *Figure 5.1*.

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 5.23* for more information on communications-assisted tripping.

DTA, DTB, DTC A, B, and C-Phase Direct Transfer Trip Conditions—Note in *Figure 5.1* that setting DTA, DTB, and DTC are supervised by the pole status signals SPOA, SPOB, and SPOC. Any element that asserts in SELOGIC control equations DTA, DTB, or DTC on a closed breaker phase will cause the DTR Relay Word bit to assert (near the top of the diagram).

When DTR asserts, COMPRM and TRPPRM also assert through the OR gate combination, and the corresponding phase trip output TPA, TPB, or TPC will assert, provided that breaker pole was not already open (as indicated by SPOA, SPOB, or SPOC near the bottom of *Figure 5.1*).

NOTE: For breaker control applications such as open commands from SCADA systems, use the BKMTR equation instead of DTA, DTB, and DTC (see below).

Settings DTA, DTB, and DTC are provided separately from setting TR and TRQUAL for direct phase tripping and for target LED purposes (the default **COMM** target LED on the front panel illuminates when DTR asserts to logical 1; see *COMM Target LED on page 5.49*).

Setting DTA, DTB, and DTC are also used for Direct Underreaching Transfer Trip (DUTT) schemes.

If a three-phase direct transfer trip is desired, place the same element in all three equations

DTA = **IN106**

DTB = **IN106**

DTC = **IN106**

where input IN106 is connected to the output of direct transfer trip communications equipment. When IN106 asserts, all three phases will trip (if not already open), and the relay will illuminate the default **COMM** target LED.

If separate phase direct transfer trip is required, program the unique conditions into each setting

DTA = **RMB3B**

DTB = **RMB4B**

DTC = **RMB5B**

where RMB3B–RMB5B are received MIRRORED BITS elements, transmitted by the relay at the remote end of the transmission line. When any one of these elements assert and cause DTR to assert, the relay outputs a trip signal to the corresponding breaker pole (if it was not already open), and the relay will illuminate the default **COMM** target LED.

NOTE: When a trip is required on all three phases for line clearances, use the BKMTR equation instead of DTA, DTB, and DTC (see below).

If the three-phase trip enable SELOGIC control equation E3PT is asserted when DTR asserts, the SEL-311C generates a three-phase trip (TPA, TPB, TPC, and 3PT all assert).

TRSOTF Switch-Onto-Fault Trip Conditions—Setting TRSOTF is supervised by the switch-onto-fault logic enable SOTFE, and optionally, the disturbance detector when EDDSOTF = Y. A switch-onto-fault trip (indicated by Relay Word bit SOTFT) is always a three-pole trip. See *Switch-Onto-Fault (SOTF) Trip Logic on page 5.17* 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, DTA, DTB, DTC) 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 as long as 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 following 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 as long as 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.

BKMTR Breaker Manual Trip Conditions—Setting BKMTR provides unconditional trip capability, suitable for manual trip conditions. A manual trip (indicated by Relay Word bit BKMTR) is always a three-pole trip. When BKMTR initiates a trip, only the factory-default TRIP target LED illuminates.

The BKMTR equation differs from the TR equation by the direct connection from BKMTR to the 3PS (3-Phases Selected) OR-gate in *Figure 5.1* and that the internal target logic does not consider any target condition when BKMTR causes the trip.

More than one trip setting (or all six trip settings TRCOMM, DTT, TRSOTF, TR, TRQUAL, and BKMTR) 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.

Trip Unlatch Options

Unlatch the trip contact output after the trip to remove dc voltage from the trip coil. The SEL-311C provides two settings to unlatch trip contact outputs after a protection trip has occurred:

- TULO—following a protection trip, phase selective
- ULTR—following a protection trip, all three poles

These settings are discussed further in *Unlatch Trip on page 5.12*.

TULO

Table 5.2 shows the four trip unlatch options for setting TULO.

Table 5.2 Setting TULO Unlatch Trip Option

Option	Description
1	Unlatch the trip when the load detector element(s) 50LA, 50LB, or 50LC indicate that the corresponding breaker pole is open. During three pole trip (3PT) operations the TULO = 1 option waits for all three poles to open.[a]
2	Unlatch the trip when the relay detects that the 52A contact(s) from the circuit breaker (e.g., 52AA) are deasserted.
3	Unlatch the trip when the relay detects that the conditions for both Option 1 and Option 2 are satisfied.
4	Do not run this logic.

[a] The load detector element pickup levels are controlled by group setting 50LP. These elements are also used in Pole-Open Logic on page 5.18.

ULTR

Use ULTR, the unlatch trip SELOGIC control equation, to define the conditions that unlatch the trip contact outputs. This method always unlatches all three poles.

Timers

The SEL-311C provides dedicated timers for the trip logic.

Minimum Trip Duration

The minimum trip duration timer settings, TDUR1D and TDUR3D, determine the minimum length of time that Relay Word bits TPA, TPB, TPC, and 3PT assert. Use these timers for the designated trip control outputs. The three timers that use the TDUR1D and TRUR3D settings are shown in the second sheet of *Figure 5.1*. The trip output occurs for the TDURD time or the duration of the trip condition, whichever is greater.

- TDUR1D is the minimum trip duration time following a single-pole trip.
- TDUR3D is the minimum trip duration time following a three-pole trip. If another trip occurs while a single-pole trip is occurring, TDUR3D replaces TDUR1D.

Trip During Open-Pole Time Delay

If another fault occurs, it is common to trip the two remaining phases for the following periods.

- During the interval where the breaker is in the process of opening (single pole) or has just opened but the trip unlatch logic has not yet deasserted.
- During the single-pole open interval following the original single-pole trip.
- During the reclosing relay reset state following a reclose.

Coverage for the first situation is built into the trip logic in *Figure 5.1* and works with the factory-default trip output contact assignments that include single-pole and three-pole terms.

Use the TOP (Trip During Open Pole) Relay Word bit to select a three-pole trip after a single-pole trip in the SEL-311C. Set TOPD (Trip During Open-Pole Time Delay) and include the TOP Relay Word bit in the E3PT setting. The Trip during Open-Pole logic is shown in *Figure 5.3*.

Timer setting TOPD (Trip During Open-Pole Time Delay) determines the period during which any subsequent trips are converted to a three-pole trip following a single-pole trip. The TOP Relay Word bit may also be used in other SELOGIC equations, such as the Reclosing Relay drive-to-lockout setting (79DTL).

To use the reclosing relay in the SEL-311C, see *Reclosing Application for Mixed Single-Pole and Three-Pole Tripping Scheme on page 6.31*. This section describes the settings necessary for autoreclose logic control of the single-pole and three-pole tripping sequence. The TOPD (Trip During Open-Pole Time Delay) timer is used in this example.

If an external reclosing relay is used, control signals from the reclosing relay may be used to control the SEL-311C single- and three-pole tripping sequence.

Trip Logic Diagram and Relay Word Bits

The SEL-311C trip logic is shown in *Figure 5.1* (this diagram spans two pages), *Figure 5.2*, and *Figure 5.3*. The trip logic Relay Word bits are described in *Table 5.3*.

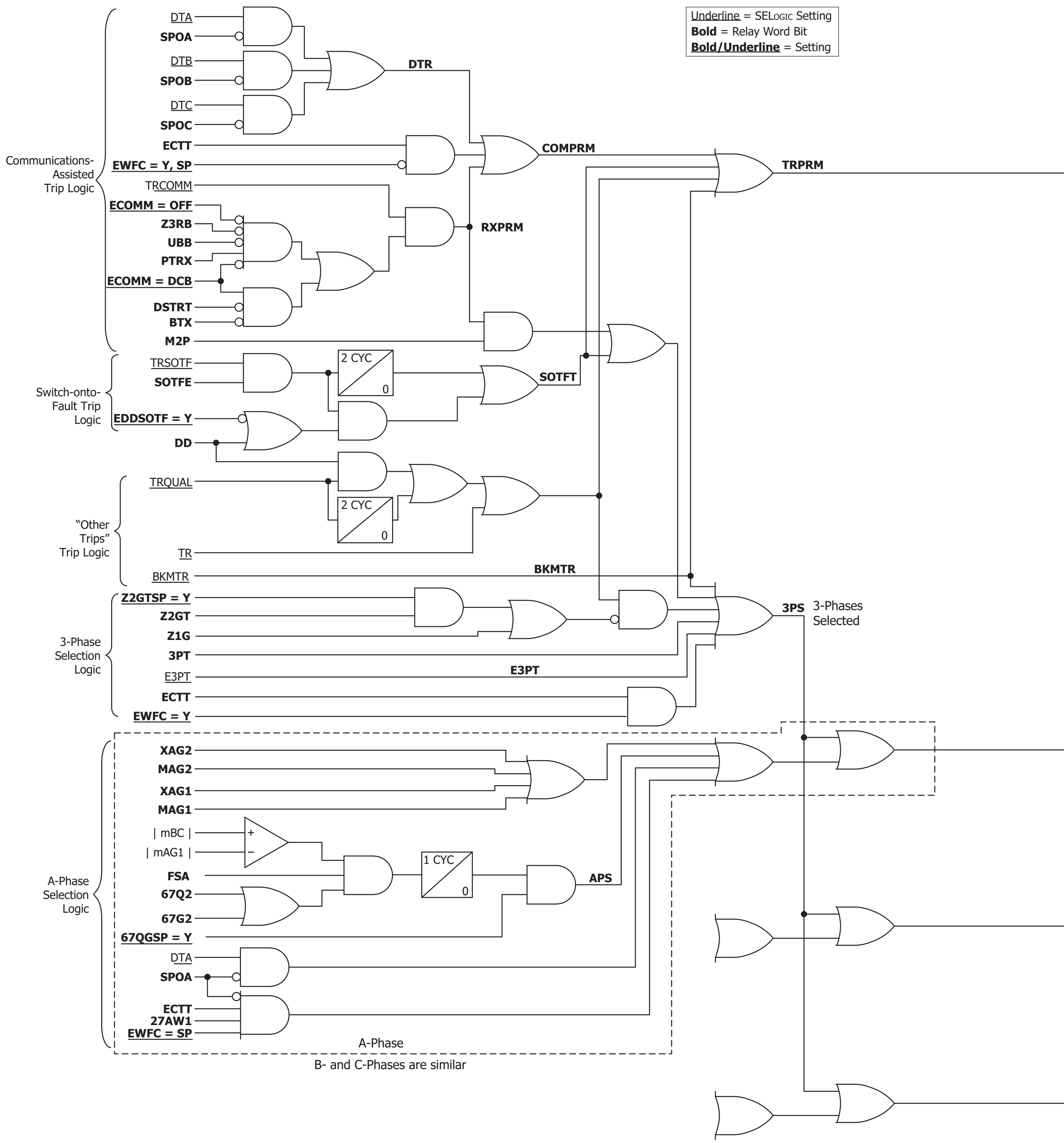
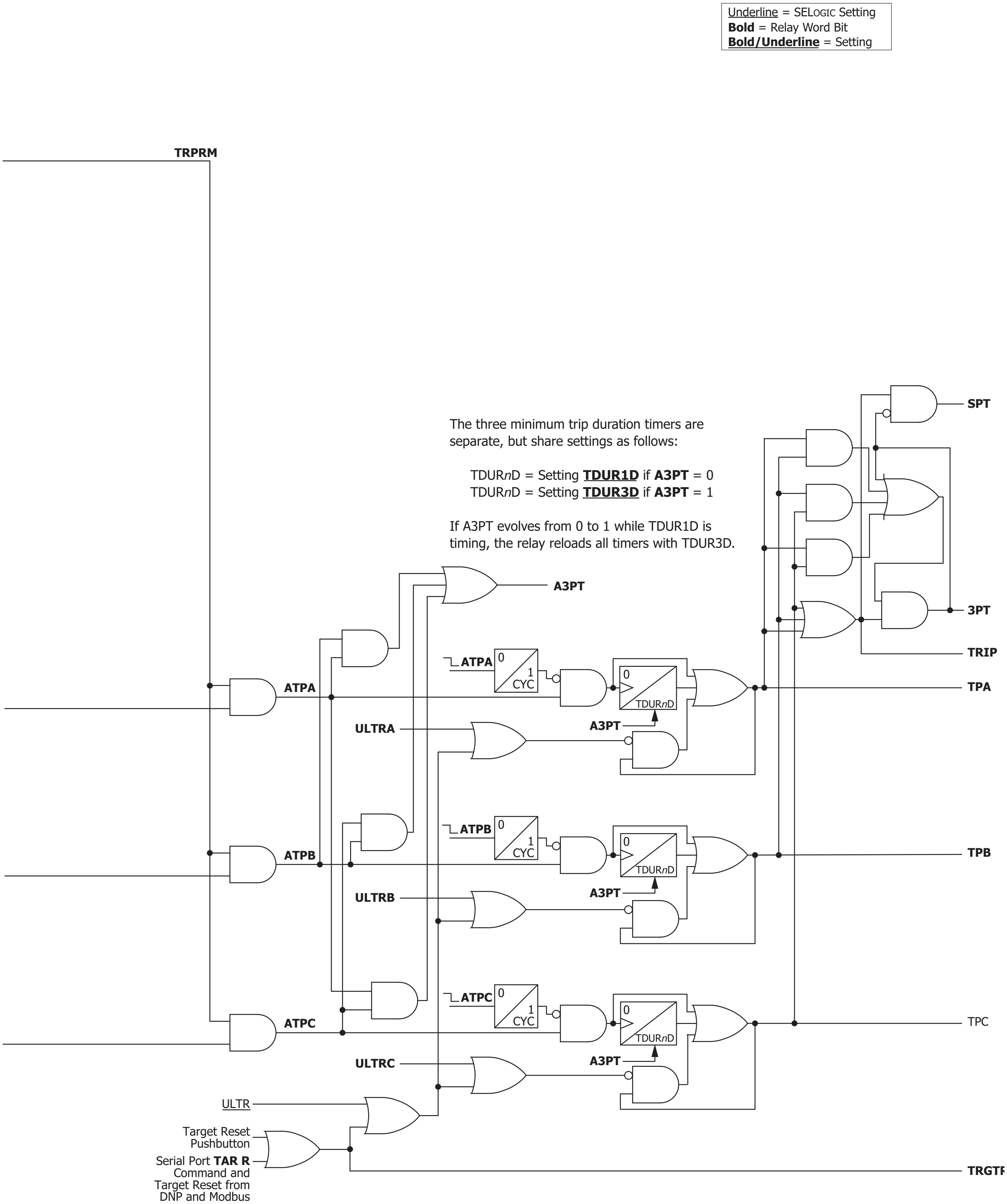


Figure 5.1 Trip Logic


Underline = SELOGIC Setting
Bold = Relay Word Bit
Bold/Underline = Setting
TRPRM
The three minimum trip duration timers are separate, but share settings as follows:
TDURnD = Setting TDUR1D if A3PT = 0
TDURnD = Setting TDUR3D if A3PT = 1
If A3PT evolves from 0 to 1 while TDUR1D is timing, the relay reloads all timers with TDUR3D.
A3PT
SPT
3PT
TRIP
TPA
TPB
TPC
ATPA
ATPB
ATPC
ULTRA
ULTRB
ULTRC
0
1
CYC
TDURnD
ULTR
Target Reset Pushbutton
Serial Port TAR R Command and Target Reset from DNP and Modbus
TRGTR

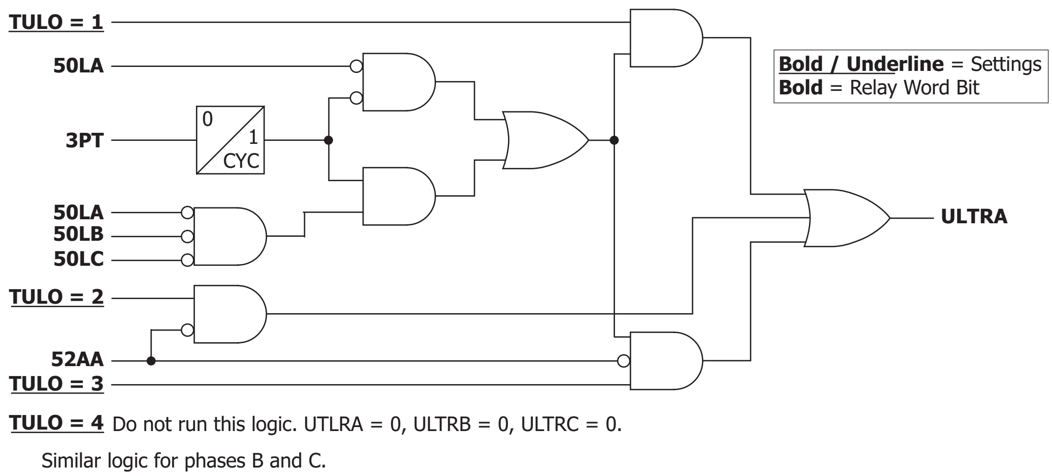


Figure 5.2 Single-Pole Trip Unlatch Logic

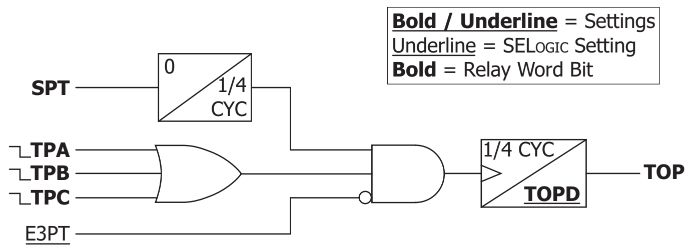


Figure 5.3 Trip During Open Pole Logic

Table 5.3 Trip Logic Relay Word Bits (Sheet 1 of 2)

Relay Word Bit	Description	Usage
Main Outputs		
TRIP	Trip logic output asserted	Indicates any type of trip is in progress
3PT	Three-pole trip (includes minimum trip duration timer and trip latching logic)	Indicates a three-pole trip is in progress (also used in output contact control equations for 3-phase trip)
TPA	Trip A-phase (includes minimum trip duration timer and trip latching logic)	Output contact control equation for A-phase trip
TPB	Trip B-phase (includes minimum trip duration timer and trip latching logic)	Output contact control equation for B-phase trip
TPC	Trip C-phase (includes minimum trip duration timer and trip latching logic)	Output contact control equation for C-phase trip
SPT	Single-pole trip	Indicates a single-pole trip is in progress
TOP	Trip during open-pole timer is asserted	Normally used in E3PT equation
Input Indication (Relay Word bits follow the SELOGIC equation with the same name)		
BKMTR	Breaker manual trip	Indication
E3PT	Three-pole trip enable	Indication
DTA	A-phase direct trip	Indication

Table 5.3 Trip Logic Relay Word Bits (Sheet 2 of 2)

Relay Word Bit	Description	Usage
DTB	B-phase direct trip	Indication
DTC	C-phase direct trip	Indication
Intermediate Logic		
DTR	Direct Trip Received	Testing and Indication
SOTFT	Switch-Onto-Fault Trip	Testing and Indication
RXPRM	Trip Permission Received	Testing and Indication
COMPRM	Communications-Assisted Trip Permission	Testing and Indication
TRPRM	Trip permission	Testing
3PS	Trip logic 3-phase selection	Testing
APS	Trip logic A-phase selection	Testing
BPS	Trip logic B-phase selection	Testing
CPS	Trip logic C-phase selection	Testing
ATPA	Assert A-phase Trip	Testing only[a]
ATPB	Assert B-phase Trip	Testing only[a]
ATPC	Assert C-phase Trip	Testing only[a]
A3PT	Assert 3-phase Trip	Testing only[a]
ULTRA	Unlatch trip A-phase	Testing and Indication
ULTRB	Unlatch trip B-phase	Testing and Indication
ULTRC	Unlatch trip C-phase	Testing and Indication

[a] Do not use these Relay Word bits (ATPA, ATPB, ATPC, A3PT) for breaker control because they do not contain any latching logic.

Set Trip

Refer to *Figure 5.1*. All trip conditions, listed below,

- ➤ Communications-Assisted Trip
- ➤ Direct Transfer Trip
- ➤ Switch-Onto-Fault Trip
- ➤ Breaker Manual Trip
- ➤ Other Trips

are combined into the TRPRM (Trip Permission) Relay Word bit. This signifies that the trip logic has qualified the trip condition (if applicable) but does not indicate which phase(s) to trip.

The phase selection logic in *Figure 5.1* uses various signals to determine whether to trip one phase (the A-phase detail is shown) or all three phases. The TRPRM signal is combined with the phase selection logic to create Relay Word bits ATPA, ATPB, and ATPC. Certain trip conditions always cause a three-phase trip, for example, the breaker manual trip SELOGIC control equation BKMTR is routed to the 3PS Relay Word bit.

In addition, when the E3PT SELOGIC control equation evaluates to logical 1, the 3PS Relay Word bit is forced to assert.

In the absence of the 3PS Relay Word bit, the relay processes the individual phase selection logic.

For single-pole trips, once a single-phase assert output (ATPA, ATPB, or ATPC) is asserted, the single-pole trip duration time-delay setting TDUR1D is loaded into the appropriate timer, and the corresponding final trip output asserts (TPA, TPB, or TPC, respectively). Relay Word bits SPT and TRIP will also assert. With the factory-default settings, relay output contacts OUT101, OUT102, and OUT103 are to be wired to the single-pole trip dc circuitry.

For three-pole trips, the relay asserts all three phase trip signals ATPA, ATPB, and ATPC. The three-pole trip duration time-delay setting TDUR3D is loaded into all three of the phase trip duration timers, and the relay asserts the three final trip outputs TPA, TPB, and TPC. Relay Word bits 3PT and TRIP also assert.

As shown in the time line example in *Figure 5.4*, the Minimum Trip Duration Timer (with setting TDUR1D for single pole trips, and TDUR3D for 3-pole trips) outputs a logical 1 for a time duration of “TDUR_D” 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). Using the A-phase trip logic as an example, the TDUR_D timer ensures that the TPA Relay Word bit remains asserted at logical 1 for a *minimum* of “TDUR_D” cycles. If the output of ATPA gate is logical 1 beyond the TDUR_D time, Relay Word bit TPA remains asserted at logical 1 for as long as the output of TPA gate remains at logical 1, regardless of other trip logic conditions.

The Minimum Trip Duration Timer settings can be set no less than 2 cycles.

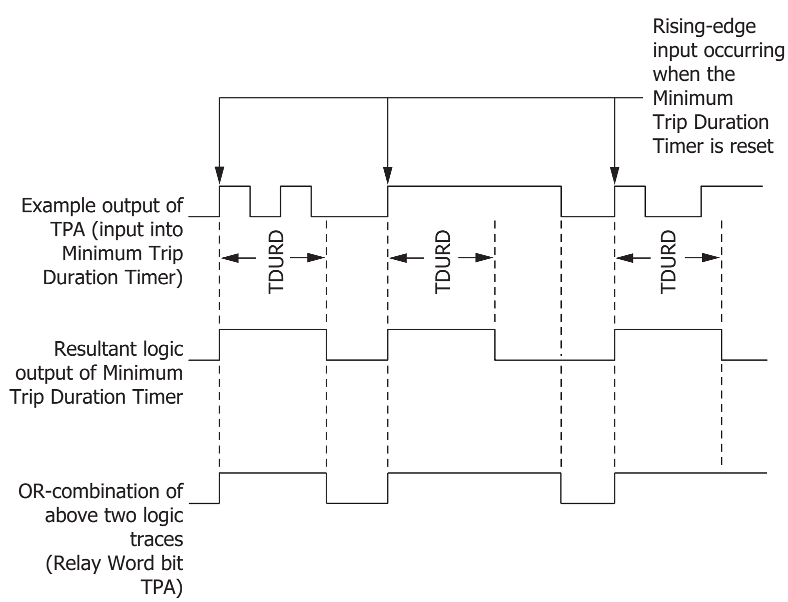


Figure 5.4 Minimum Trip Duration Timer Operation A-Phase Example (See Second Panel of Figure 5.1)

Unlatch Trip

Once the SEL-311C asserts a trip Relay Word bit (TPA, TPB, or TPC), the bit remains asserted until all of the following conditions come true.

- ➤ Minimum Trip Duration Timer stops timing (logic output of the TDUR_D timer goes to logical 0)
- ➤ Output of the driving trip condition (ATPA, ATPB, or ATPC) deasserts to logical 0
- ➤ One of the following occurs.
  - ➢ SELOGIC control equation setting ULTR asserts to logical 1

- ➢ The per-phase unlatch trip logic ULTRA, ULTRB, or ULTRC 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

Per-Phase Unlatch Trip Logic

The SEL-311C features built-in logic to create unlatch trip Relay Word bits ULTRA, ULTRB, and ULTRC for single-pole tripping applications. See *Trip Unlatch Options on page 5.5* for details on the TULO setting and *Figure 5.2* for the ULTRA, ULTRB, and ULTRC logic diagram.

The per-phase unlatch trip logic is shown in the second panel of *Figure 5.1*.

Separate phase unlatch logic is beneficial for single-pole tripping. The TULO setting allows the relay to create unlatch signals based on load detectors (50LA, 50LB, 50LC), breaker status signals (52AA, 52AB, 52AC), or both.

Without special unlatch trip logic, attempting to set the ULTR SELOGIC control equation would be difficult. For example, a typical setting for three-pole tripping relays is shown below.

ULTR = **!(50L + 51G)**

The difficulty is that during single-pole open conditions, the 50L element (which is the logical OR of 50LA, 50LB, 50LC) will not deassert because two phases are still supplying load, while the 51G element may assert because of the imbalance caused by a single-pole open condition.

A better solution is to set ULTR = 0 (logical 0), and set TULO = 1, 2, or 3 depending on your substation design and company practices.

Target Reset Logic

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 asserted trip Relay Word bit (TPA, TPB, or TPC) to logical 0 if setting ULTR or Relay Word bits ULTRA, ULTRB, or ULTRC do not assert to unlatch the trip. This might occur during testing or when ULTR has been set to logical 0 or TULO is set to 4 (which defeats the ULTRA, ULTRB, and ULTRC logic).

Setting ULTR = 0 and TULO = 4 allows a trip condition 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 5.57*) does not unlatch TRIP. See *Optional Logic to Clear Trip Seal-In and Reset Targets on page 5.57* for more information.

Target Reset Logic Output

The front-panel **TARGET RESET** pushbutton, the **TAR R** (Target Reset) serial port command, and the DNP or Modbus target reset commands are combined into Relay Word bit TRGTR as shown in the second panel of *Figure 5.1*. See Other Applications for the *Other Applications for the Target Reset Function on page 5.56* for application ideas for this Relay Word bit.

Factory Settings Example (Using Settings TR, TRQUAL, and BKMTR)

In this example the "communications-assisted" and "switch-onto-fault" trip logic in the first panel of *Figure 5.1* are not used. The SELOGIC control equation trip settings TR, TRQUAL, and BKMTR are the only inputs that need to be discussed. These inputs feed into the trip permission TRPRM Relay Word bit.

The factory settings for the trip logic SELOGIC control equation settings are listed below.

TR = **M2PT + Z2GT + 51GT + 51QT** (time-delayed trip conditions)

TRQUAL = **M1P + Z1G** (instantaneous trip conditions)

E3PT = **1** (enable three-pole trip)

BKMTR = **OC** (manual trip conditions)

ULTR = **!(50L + 51G)** (unlatch trip conditions)

The factory settings for the Minimum Trip Duration Timers are listed below.

TDUR1D = **9.00 cycles** (single-pole duration—not used when E3PT = 1)

TDUR3D = **9.00 cycles** (three-pole duration)

The factory setting for the Trip During Open-Pole Delay is listed below.

TOPD = **2.00 cycles**

The factory setting for the Trip Unlatch Option is listed below.

TULO = **3** (both methods enabled)

See the *SEL-311C Settings Sheets* in *Section 9: Setting the Relay* for setting ranges.

Set Trip

In SELOGIC control equation setting TR = **M2PT + Z2GT + 51GT + 51QT**

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.

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 by using the TRQUAL equation in some situations. Use these types of Relay Word bits in the TR or BKMTR 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 *Trip Logic Settings on page 5.3*.

In SELOGIC control equation setting E3PT = **1**

The three-pole trip mode is permanently selected. For every trip condition, the relay will assert the TPA, TPB, TPC, 3PT, and TRIP Relay Word bits.

In SELOGIC control equation setting BKMTR = **OC**

Relay Word bit OC asserts for execution of the **OPEN** Command. This manual trip equation always causes a three-pole trip, regardless of the state of equation E3PT. See *OPE Command (Open Breaker) on page 10.58* for more information on the **OPEN** Command.

NOTE: In the factory settings, because E3PT = 1, the relay always trips three-pole, and the single-pole minimum trip duration setting TDUR1D is not used.

With setting TDUR3D = 9.00 cycles, once the TPA, TPB, TPC, 3PT, and TRIP Relay Word bits assert via the trip logic, they remain asserted at logical 1 for a minimum of 9 cycles.

Unlatch Trip

NOTE: If single-pole tripping is enabled (by removing the factory setting E3PT = 1), the ULTR setting will also require changing. See Unlatch Trip on page 5.12 for details.

In SELOGIC control equation setting ULTR =!(50L + 51G)

Both elements must be deasserted before the trip logic unlatches and the TPA, TPB, TPC, 3PT, and TRIP Relay Word bits deassert to logical 0.

Additional Settings Examples

The factory setting for SELOGIC control equation setting ULTR is a current-based trip unlatch condition, suitable for three-pole tripping. The built-in unlatch logic, enabled by the TULO setting, should be used for single-pole tripping applications.

Single-Pole Unlatch Trip With 52a Circuit Breaker Auxiliary Contacts

The factory settings require the A-phase 52a circuit breaker auxiliary contact to be wired to optoisolated input IN101, the B-phase wired to IN102, and C-phase wired to IN103. See *Optoisolated Inputs on page 7.1* for contact debounce timer settings details on IN101–IN103. See *Section 2: Installation* for wiring details. For single-pole trip applications, the trip unlatch option can be configured to operate from the 52AA, 52AB, and 52AC Relay Word bits.

Logic Settings

52A = **52AA * 52AB * 52AC** (Derived breaker status. Do not use for external indication that equipment is de-energized.)

52AA = **IN101** (SELOGIC control equation A-phase circuit breaker status)

52AB = **IN102**

52AC = **IN103**

ULTR = **0** (not used)

Group Settings

TULO = **2** (Select unlatching from 52A status bits. See *Table 5.2*)

Global Settings

IN101D = **0.50 cycles** (recommended contact debounce setting)

IN102D = **0.50 cycles**

IN103D = **0.50 cycles**

These example settings will generate unlatch trip Relay Word bits ULTRA, ULTRB, and ULTRC for each trip output (TPA, TPB, and TPC) based on the breaker status signals. The single-phase unlatch trip logic is shown in *Figure 5.2*.

Single-Pole Unlatch Trip With 52b Circuit Breaker Auxiliary Contacts

The factory settings require the A-phase 52b circuit breaker auxiliary contact to be wired to optoisolated input IN101, the B-phase wired to IN102, and C-phase wired to IN103.

Logic settings

52A = **52AA * 52AB * 52AC** (Derived breaker status. Do not use for external indication that equipment is de-energized.)

52AA = **!IN101 [= NOT (IN101)]** (Inverted A-phase circuit breaker status)

52AB = **!IN102**

52AC =**!IN103**

ULTR = **0** (not used)

The remaining settings are the same as for the previous Single-Pole Unlatch Trip With 52a Circuit Breaker Auxiliary Contacts example.

Single-Pole Unlatch Trip With Load Detectors

The SEL-311C load detector pickup setting, 50LP, creates separate overcurrent elements 50LA, 50L, and 50LC, as explained in *Pole-Open Logic on page 5.18*. For single-pole trip applications, the trip unlatch option can be configured to operate from these load detector Relay Word bits.

Logic settings

ULTR = **0** (not used)

Group settings

50LP = **0.25 A secondary** (minimum setting value)

TULO = **1** (Select unlatching from load detectors. See *Table 5.2*)

These example settings will generate unlatch trip Relay Word bits ULTRA, ULTRB, and ULTRC for each trip output (TPA, TPB, and TPC) based on the load detector signal(s) deasserting when the open-phase current falls below the 50LP setting threshold. For three-pole trips (3PT = logical 1), the relay waits until all three load detectors have deasserted before asserting the unlatch bits. The single-phase unlatch trip logic is shown in *Figure 5.2*.

Single-Pole Unlatch Trip With Load Detectors and 52a Circuit Breaker Auxiliary Contacts

This method uses both the breaker auxiliary contact status and the load detector status from the previous two examples.

Logic settings

52A = **52AA * 52AB * 52AC** (Derived breaker status. Do not use for external indication that equipment is de-energized.)

52AA = **IN101** (SELOGIC control equation A-phase circuit breaker status)

52AB = **IN102**

52AC = **IN103**

ULTR = **0** (not used)

Group settings

50LP = **0.25 A secondary** (minimum setting value)

TULO = **3** (Select unlatching from 52A status bits and load detectors. See *Table 5.2*.)

These example settings will generate unlatch trip Relay Word bits ULTRA, ULTRB, and ULTRC for each trip output (TPA, TPB, and TPC) based on the load detector signal(s) deasserting AND the same phase breaker status signal deasserting. The single-phase unlatch trip logic is shown in *Figure 5.2*.

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, OUT102, and OUT103 with the following SELOGIC control equation settings:

OUT101 = **3PT + TPA**

OUT102 = **3PT + TPB**

OUT103 = **3PT + TPC**

These settings are appropriate for both single-pole tripping and three-pole tripping. If an additional three-pole only trip output is required, program the additional output using only 3PT.

If more than one set of trip output contacts are needed, program other output contacts with the same set of equations. Below are 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 7.32* for more information on programming output contacts.

TRIP Results Used in Other Settings

Besides operating a trip output contact (e.g., OUT101 = 3PT + TPA), the various trip output Relay Word bits are used in some other factory-default SELOGIC control equation settings.

ULCL = **TRIP** unlatch close (see *Figure 6.1*)

BKMONA = **TPA + 3PT** A-phase breaker monitor initiation (see *Breaker Monitor on page 8.1*)

BKMONB = **TPB + 3PT** B-phase breaker monitor initiation

BKMONC = **TPC + 3PT** C-phase breaker monitor initiation

Switch-Onto-Fault (SOTF) Trip Logic

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.

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 the first panel). 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 5.5* and the following discussion describe the SOTF logic.

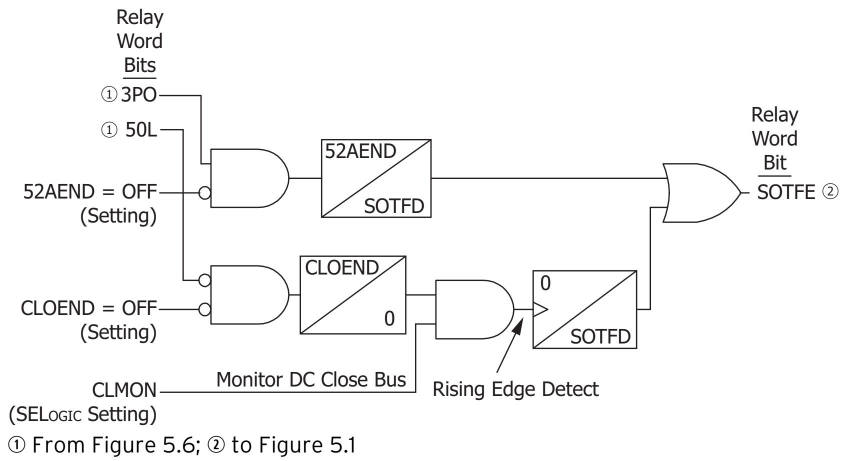


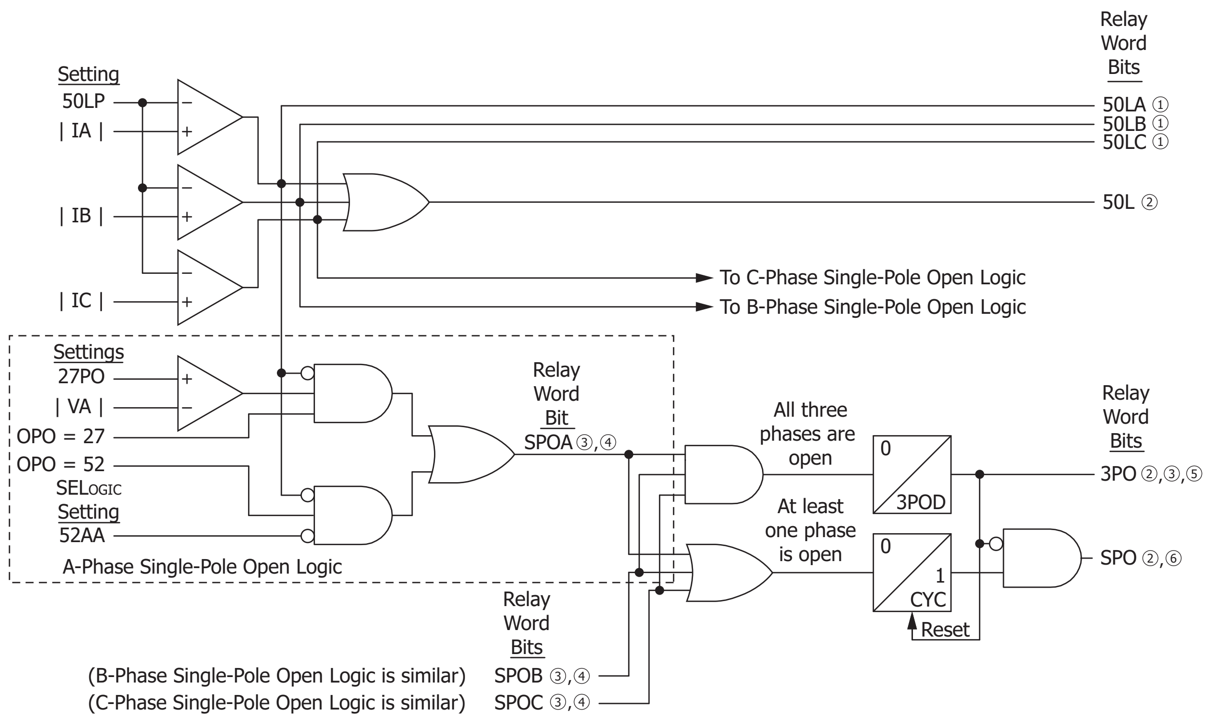
Figure 5.5 Switch-Onto-Fault Logic

Pole-Open Logic

The pole-open logic is shown in *Figure 5.6*. The outputs of the pole-open logic are the single-phase pole-open indications (SPOA, SPOB, and SPOC), the single-pole open indication (SPO), and the three-pole open indication (3PO).

The SEL-311C always generates the phase-specific pole status Relay Word bits SPOA, SPOB, and SPOC. The relay asserts the SPO Relay Word bit when one or two of the phase-specific Relay Word bits are asserted.

When all three of SPOA, SPOB, and SPOC are asserted, the SEL-311C asserts the three-pole open (3PO) Relay Word bit, and deasserts the single-pole open (SPO) Relay Word bit.



① To Figure 5.2; ② to Figure 5.5; ③ to Distance Elements on page 3.1; ④ to Figure 5.1; ⑤ to Figure 4.1, Figure 4.9, Figure 5.5; ⑥ to Loss-of-Potential Logic on page 4.1.

Figure 5.6 Pole Open Logic

The open circuit breaker condition is determined by the individual phase-load current and either one of the following.

- ➤ Circuit breaker phase status (52AA or 52AB or 52AC = logical 0), recommended
- ➤ Phase voltage (|VA| or |VB| or |VC| < 27PO, for special applications

Select OPO = 52 if SPOA, SPOB, and SPOC are to be determined by circuit breaker status. Select OPO = 27 if SPOA, SPOB, and SPOC are to be determined by phase voltage. This selection requires the potential transformers to be connected to the line-side of the circuit breaker.

If OPO = 52, *and* the circuit breaker is open (52AA or 52AB or 52AC = logical 0) *and* the phase current is below phase pickup 50LP, then the single-pole open (SPOA, SPOB, or SPOC) condition is true.

SPOA or SPOB or SPOC = **logical 1** (circuit breaker open)

If OPO = 27, *and* |VA|, |VB|, or |VC| is less than setting 27PO, *and* the phase current is below phase pickup 50LP, then the single-pole open (SPOA, SPOB, or SPOC) condition is true.

SPOA or SPOB or SPOC = **logical 1** (circuit breaker open)

When OPO = 27, 3PO deasserts when the line is energized from any terminal.

The OPO = 27 selection can inhibit some SEL-311C logic functions that expect 3PO, SPOA, SPOB, or SPOC to be asserted when the breaker is open.

For example, do not select OPO = 27 if shunt reactors are applied. In such applications, the voltage decays slowly after the circuit breaker opens, which could delay the declaration of an open pole.

If the breaker status signal is available, the recommended setting is OPO = 52.

The 3POD dropout time qualifies circuit breaker closure, whether detected by circuit breaker status (52AA, 52AB, 52AC), phase voltage, or load current level (50LA, 50LB, 50LC). When all three poles of the circuit breaker are closed,

SPO = 3PO = **logical 0** (circuit breaker closed)

after the three-pole open dropout qualifying timer 3POD expires.

There is a fixed one-cycle dropout timer in the SPO Relay Word bit logic. If a single pole opens, (e.g., SPOB transitions from logical 0 to logical 1) the SPO Relay Word bit will assert at the same time. If the breaker is then closed (SPOB deasserts), the SPO Relay Word bit will deassert one cycle later.

The SEL-311C pole-open logic contains an interlock that prevents both SPO and 3PO from being asserted at the same time.

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 Group setting OPO = 52, SELOGIC control equation setting 52A may be set.

52A = **0** (numeral 0)

52AA = **0**

52AB = **0**

52AC = **0**

NOTE: This configuration is not recommended for single-pole trip schemes. Light load conditions may be misinterpreted as an open pole condition.

With SELOGIC control equation settings 52A, 52AA, 52AB, 52AC continually at logical 0, the 3PO logic is controlled solely by load detection elements 50LA, 50LB, and 50LC. Phase pickup 50LP should be set below load current levels.

When all three poles of the circuit breaker are opened, Relay Word bits 50LA, 50LB, 50LC, and 50L deassert (= logical 0) and 3PO asserts.

3PO = **logical 1** (circuit breaker is open, three-pole)

SPO = **logical 0** (circuit breaker is not in a single-pole open state)

Per phase results.

SPOA = **logical 1**

SPOB = **logical 1**

SPOC = **logical 1**

When all three poles of the circuit breaker are closed, Relay Word bits 50LA, 50LB, 50LC, and 50L assert (= logical 1; currents above phase pickup 50LP) and 3PO deasserts after the 3POD dropout time.

3PO = **logical 0** (circuit breaker is not open, 3-pole)

SPO = **logical 0** (circuit breaker is not in a single-pole open state)

Per phase results.

SPOA = **logical 0**

SPOB = **logical 0**

SPOC = **logical 0**

When one pole (for example, B-phase) of the circuit breaker is opened, Relay Word bits 50LB and 50L are asserted (= logical 1), 50LA and 50LC are deasserted (= logical 0), and SPO asserts.

3PO = **logical 0** (circuit breaker is not open, three-pole)

SPO = **logical 1** (circuit breaker is in a single-pole open state)

Per phase results.

SPOA = **logical 0**

SPOB = **logical 1**

SPOC = **logical 0**

Note that the 3PO, SPO, and per-phase results are routed to several other subsystems of the SEL-311C, as shown in the footnotes of *Figure 5.6*.

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.

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 * 3PO**

Starting from a three-pole open condition (3PO = logical 1), 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.

Starting from a single-pole open condition (SPO = logical 1, 3PO = logical 0), when optoisolated input **IN105** is energized, CLMON is prevented from asserting and remains at logical 0. This prevents a Switch-Onto-Fault Enable condition (SOFTE) from being initiated if the line was lightly loaded (i.e., 50L is not asserted, but 3PO is not asserted).

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 first panel). 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 as many as 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 5.4*.

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.

Use the TRSOTF setting with instantaneous elements, such as in the factory-default setting.

TRSOTF = **M2P+Z2G+50P1**

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.

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.

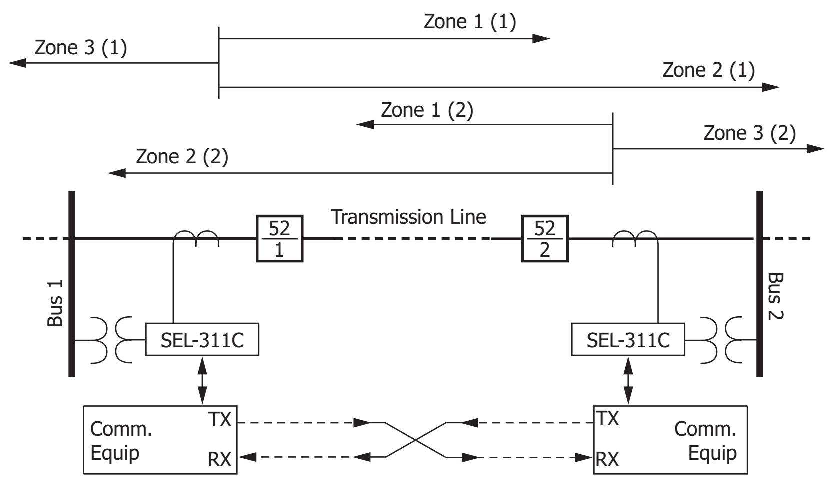


Figure 5.7 Communications-Assisted Tripping Scheme

Refer to *Figure 5.7* and the left panel 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 include the following.

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 4.28* for more information on Zone/Level direction settings DIR3 and DIR4.

POTT, PUTT, DCUB, and DCB communications-assisted tripping schemes are explained in sections 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 left panel 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 5.17*), 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 5.17*.

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 5.4* for full details.

Trip Settings DTA, DTB, DTC

The DTT and DUTT tripping schemes are realized with SELOGIC control equation trip settings DTA, DTB, DTC, discussed at the beginning of this section.

MIRRORED BITS protocol default settings provide adequate security for POTT, DCB, and DCUB applications. Set the receive bit security counter RMB1PU – RMB8PU = 2 when using MIRRORED BITS protocol for DTT applications or any other tripping scheme that is unsupervised by a local fault detector. For example, if Direct Transfer Tripping SELOGIC control equation DTT is set to

DTA = RMB3A

make the receive bit security counter setting

RMB3PU = 2

on MIRRORED BITS Port A.

When RMB3PU = 2 on MIRRORED BITS Port A, the MIRRORED BITS protocol requires reception of two sequential MIRRORED BITS messages with RMB3 asserted (deasserted) before allowing Relay Word Bit RMB3A to assert (deassert).

Trip Settings E3PT, EWFC, Z2GTSP, 67QGSP

Single-pole trip conditions are controlled by the enable settings EWFC, Z2GTSP, 67QGSP, and SELOGIC control equation E3PT.

E3PT

SELOGIC control equation E3PT can be used to select when a three-phase trip is appropriate. Setting E3PT does not trip the circuit breaker by itself, but enables the three-phase trip logic.

- When E3PT is asserted to logical 1, any new TRIP condition will operate all three circuit breaker poles.
- When E3PT = logical 0, a new TRIP condition will be processed as either a single-pole trip or a three-pole trip, depending on the elements asserted, or the other settings EWFC, Z2GTSP, and 67QGSP.

Because E3PT is a SELOGIC control equation, it can be set dynamically. For example, some applications may require it to evaluate to logical 0 for the first trip in an autoreclose sequence and logical 1 for any subsequent trips.

EWFC

Weak-Infeed setting EWFC = SP enables single-pole tripping for Echo Conversion to Trip (ECTT) conditions. The SEL-311C uses phase undervoltage to trip only the pole(s) that are experiencing the weak infeed condition when ECTT asserts. The undervoltage elements 27AWI, 27BWI, and 27CWI are controlled by setting 27PWI. However, if SELOGIC equation E3PT = logical 1 when ECTT asserts, the EWFC = SP selection is overridden and all three poles are tripped.

Weak-Infeed setting EWFC = Y enables three-pole tripping for Echo Conversion to Trip (ECTT) conditions. In this configuration, SELOGIC control equation E3PT has no effect on ECTT trips because the ECTT trips will always be three-pole.

Weak-Infeed setting EWFC = N disables tripping for Echo Conversion to Trip (ECTT) conditions.

The EWFC setting is available when ECOMM = POTT, DCUB1, or DCUB2.

The 27PWI setting is available when EWFC = Y or SP.

Z2GTSP

The Zone 2 Ground-Distance Time Delay Single-Pole (Z2GTSP) trip enable setting controls the SEL-311C trip characteristics for ground-distance element operation. When Z2GTSP = Y, any TRIP condition that occurs when the Zone 2 ground-distance time-delayed element Z2GT is asserted will cause a single-pole trip. This single-pole trip condition is overridden if SELOGIC equation E3PT = logical 1 at the time of TRIP.

When Z2GTSP = N, any TRIP condition that occurs when only the Zone 2 ground-distance time-delayed element Z2GT is asserted will cause a three-pole trip.

Trips that occur when the Zone 1 ground element (Z1G) is asserted are always single-pole trip, regardless of the Z2GTSP setting (again, provided that E3PT is not asserted).

67QGSP

The Zone 2 directional overcurrent negative-sequence/residual-overcurrent single-pole trip enable setting controls the SEL-311C trip characteristics for COMPRM TRIP conditions that do not include a distance element.

When 67QGSP = Y, the SEL-311C can assert a single-pole trip during high resistance ground faults such that the fault impedance lies outside of the ground-distance protection characteristics; the FIDS logic selects the faulted phase when residual directional overcurrent elements provide communications-assisted tripping. This single-pole trip condition is overridden if SELOGIC control equation E3PT = logical 1 at the time of TRIP.

When 67QGSP = N, communications-assisted tripping will only be successful if a ground-distance element asserts to select the appropriate phase to trip.

If the application includes the possibility of communications-assisted tripping without the ground-distance elements, consider using the E3PT SELOGIC control equation to select three-phase tripping when no phase decision can be made. Other approaches include using direct trip SELOGIC control equations DTA, DTB, and DTC.

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 7.1* 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 listed below.

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)
	BKMTR	(Manual Trip conditions)

Certain models of the SEL-321 and the SEL-311C described in this manual use trip unlatch option setting TULO. The SEL-311C TULO details are shown in *Figure 5.2* and described in *Unlatch Trip on page 5.12*.

Certain models of the SEL-321 and the SEL-311C described in this manual feature 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 the following 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 sections 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 (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 5.9* 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.
- Allows the Zone 1 distance elements to reset the current reversal detection timer. This allows the local relay to immediately send permission to trip to the remote relay if a fault is detected in Zone 1.

Single-Pole Trip Considerations

The SEL-311C uses a single-communications-channel implementation of the POTT scheme, and this design is suitable for many applications.

For certain simultaneous faults in parallel line applications, this single-channel design lacks phase selectivity because the remote phase information is not available. For advanced parallel line applications, multichannel POTT schemes (POTT2 and POTT3) are available in the SEL-421 Protection, Automation, and Control System.

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 5.27* for more setting comparison information on the SEL-321/SEL-311C relays).

External Inputs

See *Optoisolated Inputs on page 7.1* for more information on optoisolated inputs.

PT1—Received Permissive Trip Signal(s)

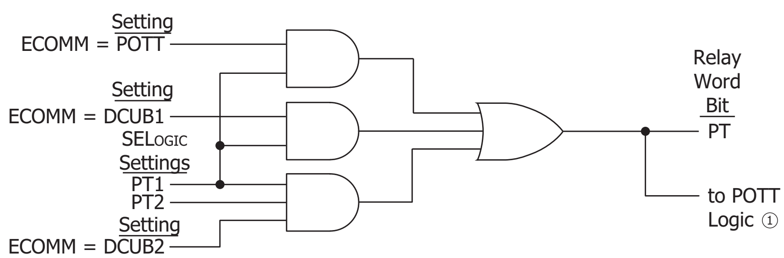
In two-terminal line POTT applications, a permissive trip signal is received from one remote terminal. One optoisolated input on the SEL-311C (e.g., input IN104) is driven by a communications equipment receiver output (see *Figure 5.11*). Make SELOGIC control equation setting PT1 as shown below.

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 5.12*). Make SELOGIC control equation setting PT1 as follows.

PT1 = **IN104 * IN106** (three-terminal line application)

SELOGIC control equation setting PT1 in *Figure 5.8* 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 5.9* (for echo keying).



① Figure 5.9.

Figure 5.8 Permissive Input Logic Routing to POTT Logic

Also note that SELOGIC control equation setting PT1 in *Figure 5.10* 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 7.32* 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 5.13*).

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 as follows.

OUT105 = **KEY**

Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.11*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.12*).

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 for three-phase weak-infeed tripping or SP for single-phase weak-infeed tripping. Making one of these settings choices exposes additional settings 27PPW, 27PWI, and 59NW.

Disable the weak-infeed logic by setting EWFC = N.

The SEL-311C provides additional logic (see *Figure 5.9*) 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 picked up.
- No reverse-looking elements are picked up.
- All three poles of the circuit breaker are closed.
- No loss-of-potential (LOP) condition is present when ELOP = Y1.

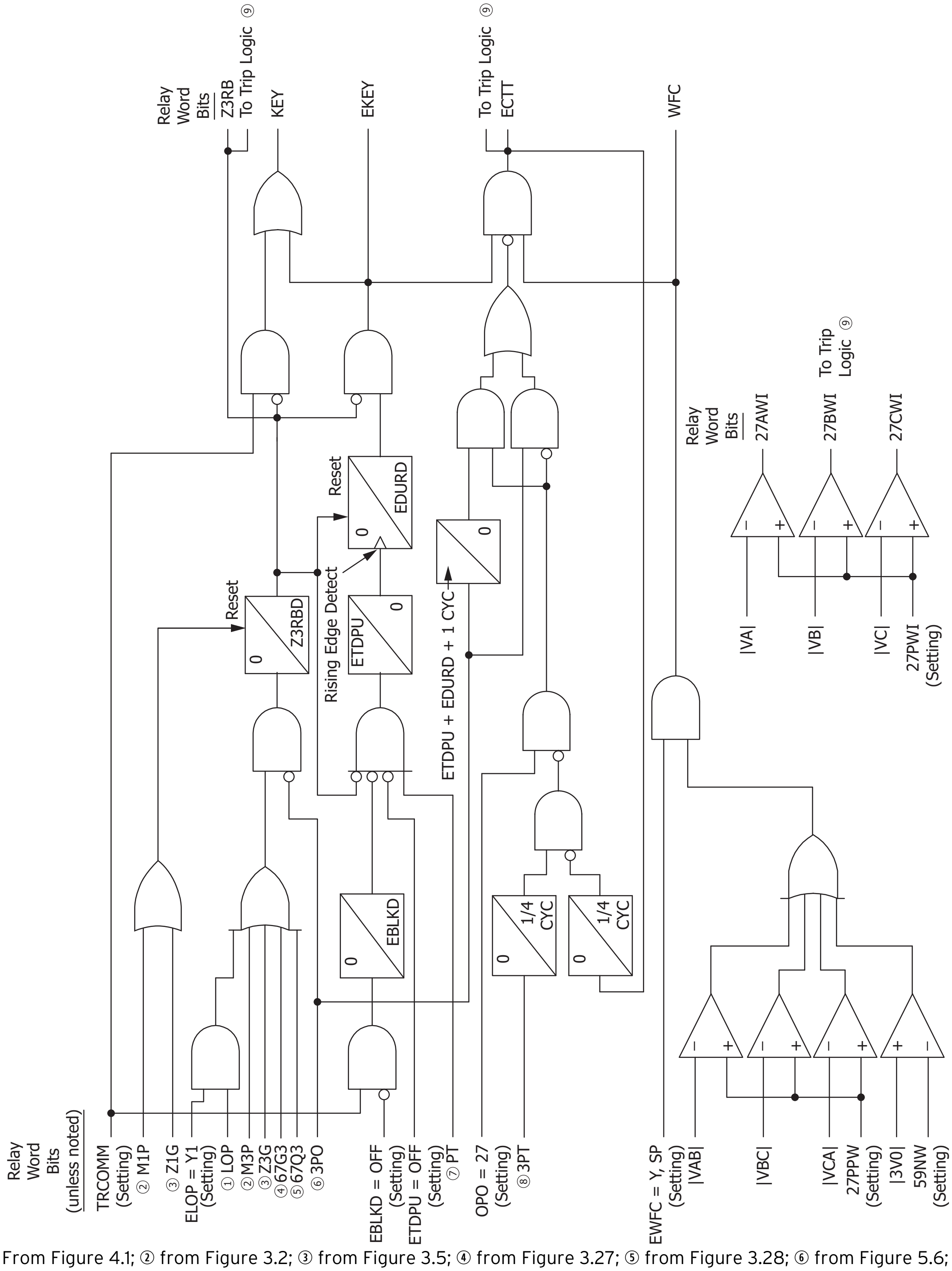
After these conditions are met, the weak-infeed logic sets the Echo-Conversion-To-Trip (ECTT) bit in the Relay Word. The ECTT bit is included in the trip logic (see *Figure 5.1*) and a trip signal is issued to the local breaker when the conditions described above are true.

Typical phase-to-phase undervoltage setting (27PPW) is 70–80 percent of the lowest expected system operating voltage, on a phase-to-phase basis.

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.

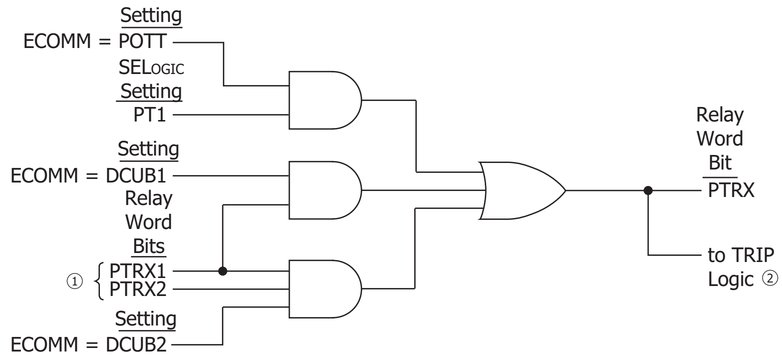
When EWFC = Y, all three phases are tripped during ECTT conditions.

When EWFC = SP, the phase undervoltage setting (27PWI) is used to detect which phase voltages are depressed, as shown at the bottom of *Figure 5.9*. A typical setting is 70–80 percent of the lowest expected system operating voltage on a phase-to-neutral basis. The resulting undervoltage Relay Word bits 27AWI, 27BWI, and 27CWI are used in *Figure 5.1* to select which phase(s) to trip during ECTT conditions.



① From Figure 4.1; ② from Figure 3.2; ③ from Figure 3.5; ④ from Figure 3.27; ⑤ from Figure 3.28; ⑥ from Figure 5.6; ⑦ from Figure 5.8; ⑧ from Figure 5.1; ⑨ Figure 5.1.

Figure 5.9 POTT Logic



① Figure 5.13; ② Figure 5.1.

Figure 5.10 Permissive Input Logic Routing to Trip Logic

Variations for Permissive Underreaching Transfer Trip (PUTT) Scheme

Refer to *Figure 5.7* and *Figure 5.9*. 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 5.11*).

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 5.12*).

Installation Variations

Figure 5.12 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 5.12*. Then output contact **OUT107** can be used for another function.

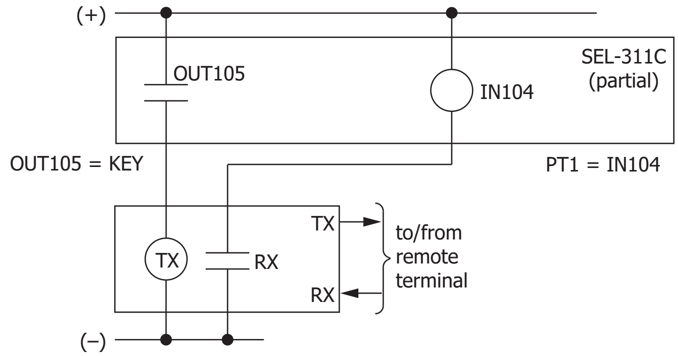


Figure 5.11 SEL-311C Connections to Communications Equipment for a Two-Terminal Line POTT Scheme

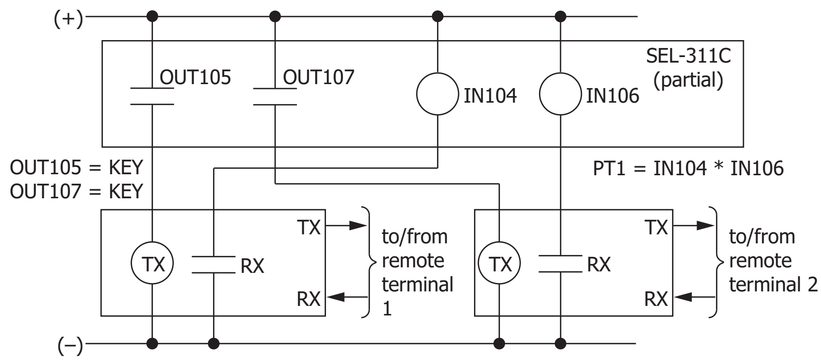


Figure 5.12 SEL-311C Connections to Communications Equipment for a Three-Terminal Line POTT Scheme

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 because of 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 5.13* is an extension of the POTT logic in *Figure 5.9*. 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 listed below.

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 5.13* takes in the loss-of-guard and permissive trip outputs from the communication receivers (see *Figure 5.15* and *Figure 5.16*) 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 5.27* for more setting comparison information on the SEL-321/SEL-311C relays).

External Inputs

See *Optoisolated Inputs on page 7.1* 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 5.15*). Make SELOGIC control equation setting PT1 as shown below.

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 5.16*). 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 5.13* for “unblocking block” and “permissive trip receive” logic decisions.

As explained in *Permissive Overreaching Transfer Trip (POTT) Logic on page 5.28*, the SELOGIC control equation settings PT1 and PT2 in *Figure 5.8* 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 5.9* (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 5.15*). Make SELOGIC control equation setting LOG1 as follows.

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 5.16*). 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 5.13* 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

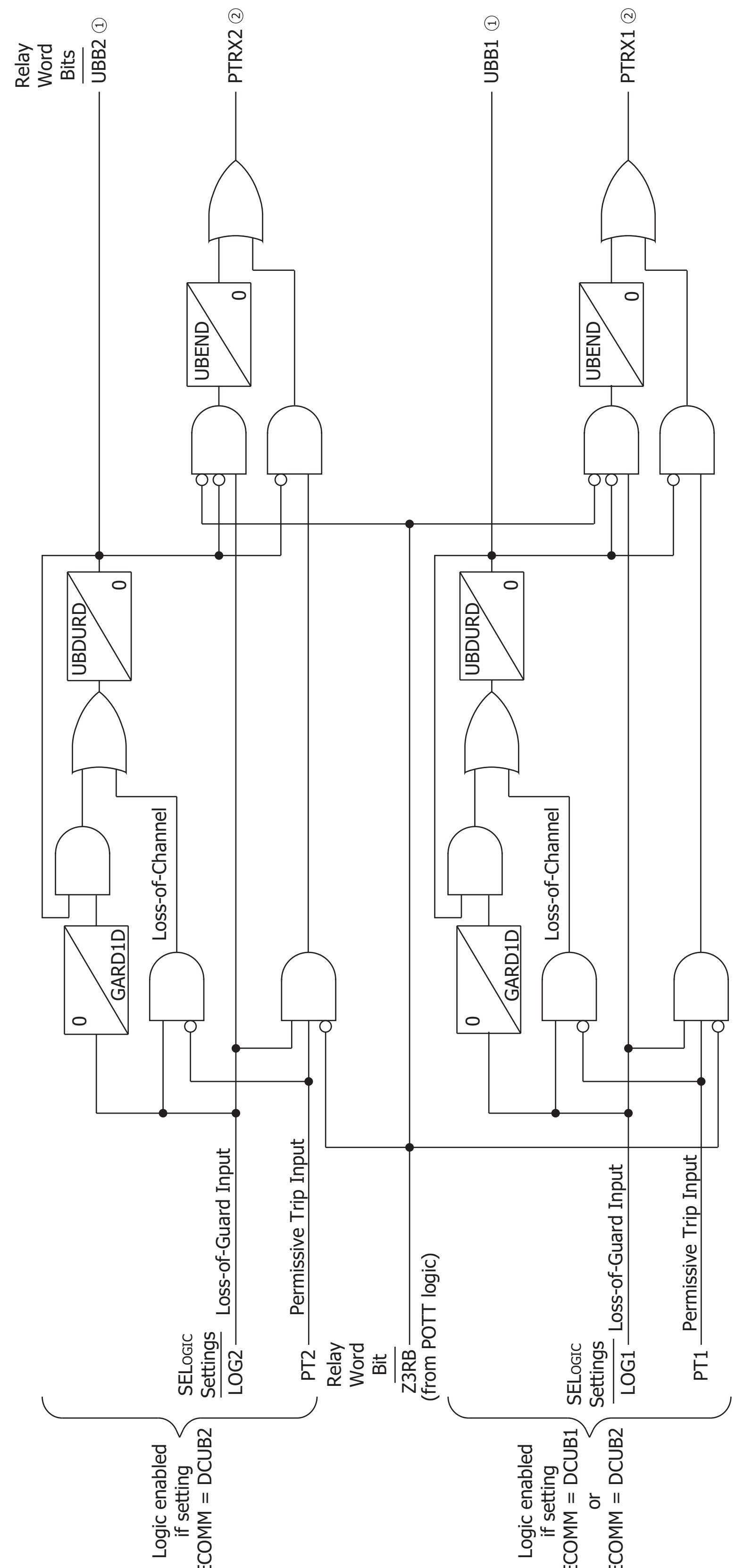
The following logic outputs can be tested by assigning them to output contacts. See *Output Contacts on page 7.32* for more information on output contacts.

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.

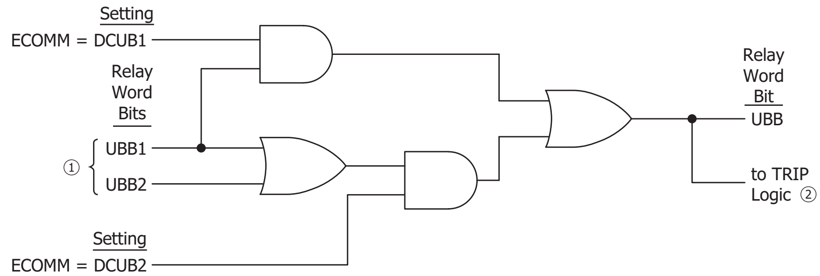
In three-terminal line DCUB applications (setting ECOMM = DCUB2), UBB1 or UBB2 disable tripping if the loss-of-channel condition (for the respective Channel 1 or 2) continues for longer than time UBDURD.

The UBB1 and UBB2 are routed in various combinations in *Figure 5.14* 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 5.14; ② to Figure 5.10.

Figure 5.13 DCUB Logic



① From Figure 5.13; ② Figure 5.1.

Figure 5.14 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 5.10* 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 5.16 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 5.16*. Then output contact OUT107 can be used for another function.

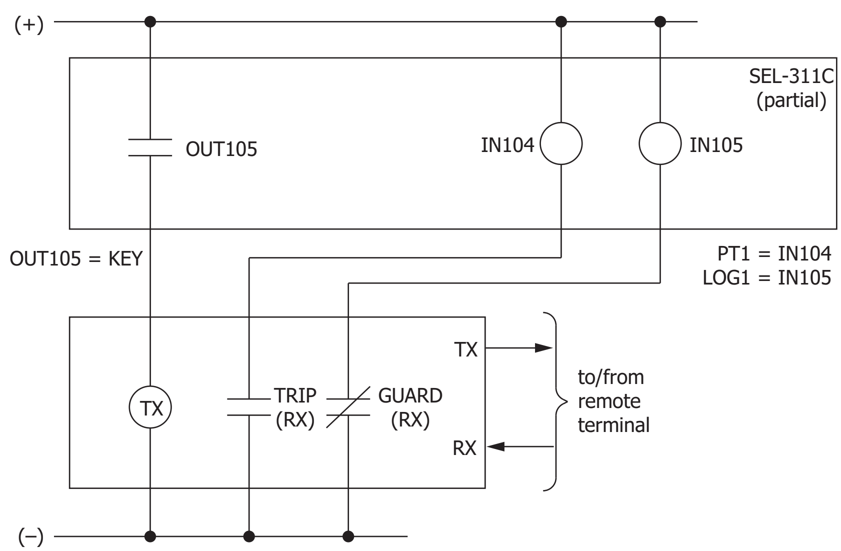


Figure 5.15 Connections to Communications Equipment for a Two-Terminal Line DCUB Scheme (Setting ECOMM = DCUB1)

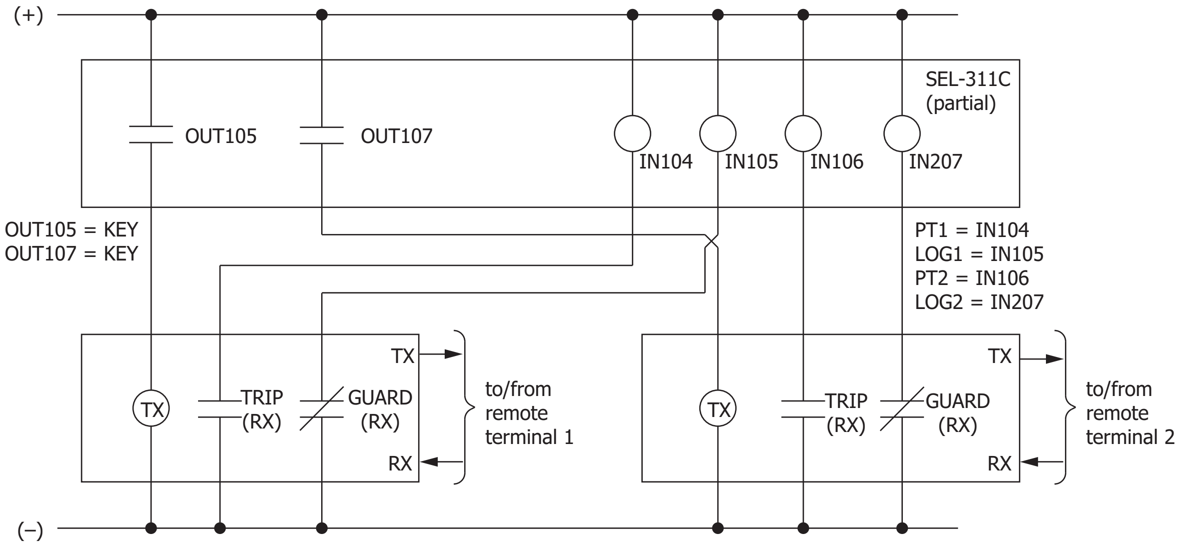


Figure 5.16 Connections to Communications Equipment for a Three-Terminal Line DCUB Scheme (Setting ECOMM = DCUB2)

Directional Comparison Blocking (DCB) Logic

Enable the DCB logic by setting ECOMM = DCB. The DCB logic in *Figure 5.17* 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 5.27* for more setting comparison information on the SEL-321/SEL-311C relays).

External Inputs

See *Optoisolated Inputs on page 7.1* 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 5.18*). Make SELOGIC control equation setting BT as follows.

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 5.19*). 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 5.17*. 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 7.32* 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 as follows.

OUT105 = **DSTRT**

Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.18*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.19*).

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 as follows.

OUT105 = **DSTRT + NSTRT**

Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.18*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.19*).

OUT107 = **DSTRT + NSTRT**

STOP—Stop Carrier

Program to an output contact to stop carrier. For example, SELOGIC control equation setting OUT106 is set as follows.

OUT106 = **STOP**

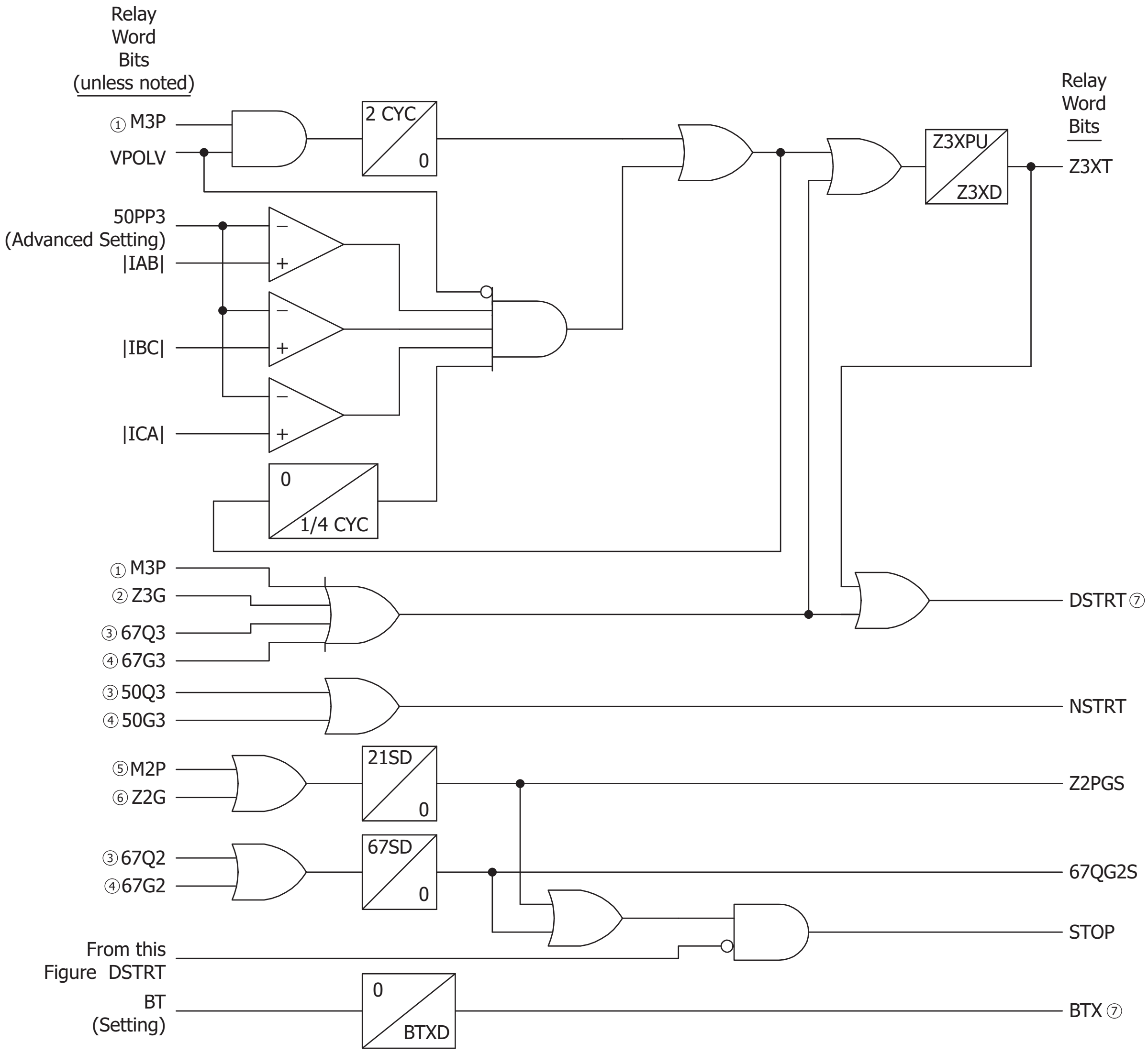
Output contact **OUT106** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.18*).

In a three-terminal line scheme, output contact **OUT208** is set the same as **OUT106** (see *Figure 5.19*).

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 5.17*. The timer output (BTX) is routed to the trip logic in *Figure 5.1*.



① From Figure 3.4; ② from Figure 3.7; ③ from Figure 3.27; ④ from Figure 3.26; ⑤ from Figure 3.3; ⑥ from Figure 3.6; ⑦ to Figure 5.1.

Figure 5.17 DCB Logic

Installation Variations

Figure 5.19 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 5.19*. 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 5.19*. Then output contact **OUT208** can be used for another function.

Figure 5.19 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 5.19*. Then setting BT would be programmed as follows,

BT = **IN104**

and input **IN106** can be used for another function.

In *Figure 5.18* and *Figure 5.19*, 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.

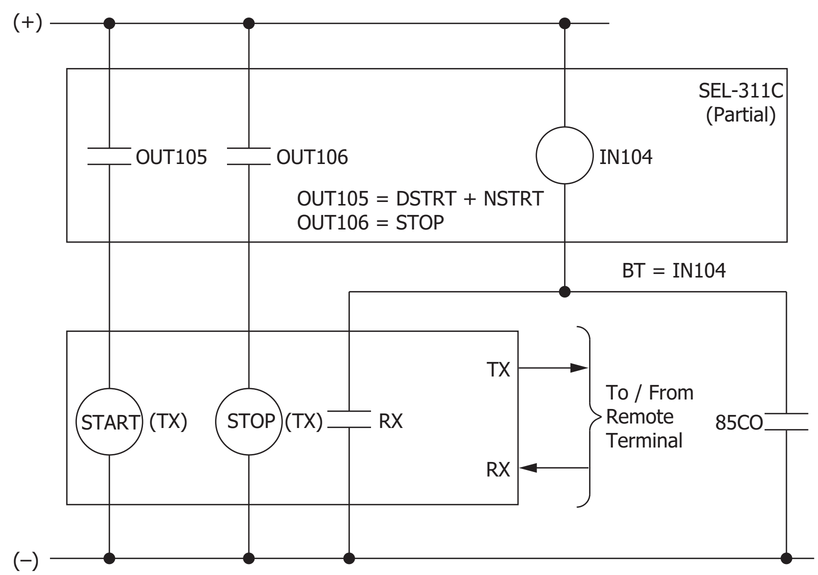


Figure 5.18 Connections to Communications Equipment for a Two-Terminal Line DCB Scheme

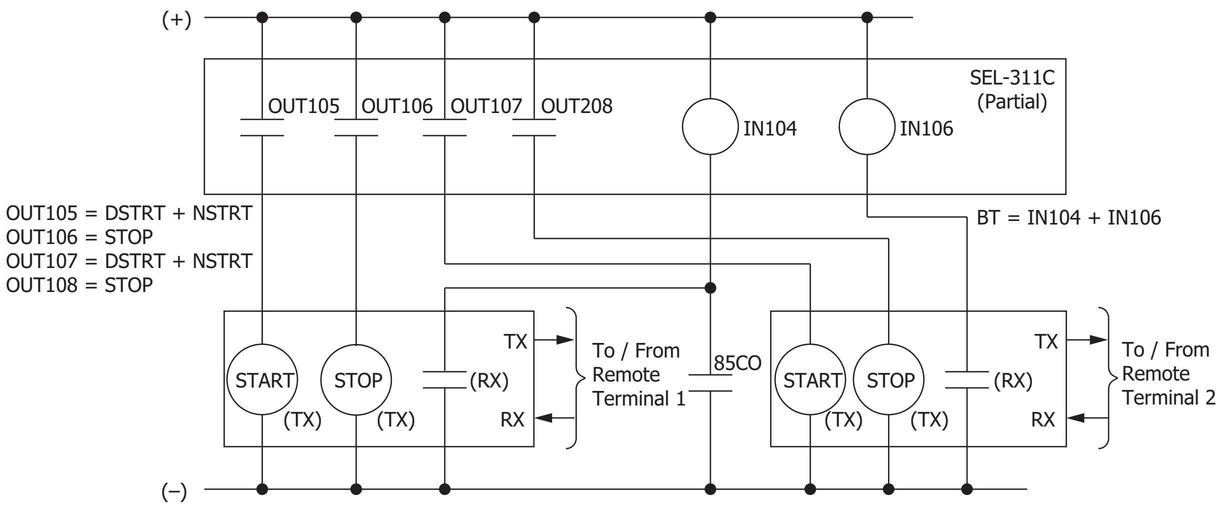


Figure 5.19 Connections to Communications Equipment for a Three-Terminal Line DCB Scheme

Breaker Failure Protection

Breaker failure protection provides local backup protection when a circuit breaker fails to trip during a fault. In breaker failure schemes, it is important to quickly detect the dropout of fault-detecting overcurrent elements. Fault detector dropout can be delayed by the presence of subsidence current, which results from the energy trapped in the CT magnetizing branch after the circuit breaker opens to clear a fault or interrupt load. Subsidence current decays exponentially and delays the dropout of filtered instantaneous overcurrent elements. The open-pole detection logic of the SEL-311C uses unfiltered data to identify a breaker open pole and reset the breaker failure logic in less than one cycle, even when subsidence current is present.

Breaker Failure Current Detectors

Figure 5.20 shows how the A-phase open-pole detection logic controls the breaker failure current detector. The logic for B-phase and C-phase is similar. When a breaker fails to trip during a fault, the A-phase open-pole detection logic remains deasserted. If the phase current, IA, is greater than breaker failure current pickup threshold, 50BFP, Relay Word bits 50BFA and 50BFT assert. If the breaker trips, phase current IA may remain above the breaker failure current pickup threshold 50BFP for some time because of subsidence. The open-pole detection logic detects this and asserts, causing 50BFA and 50BFT to deassert.

The breaker failure current pickup is usually set above maximum load.

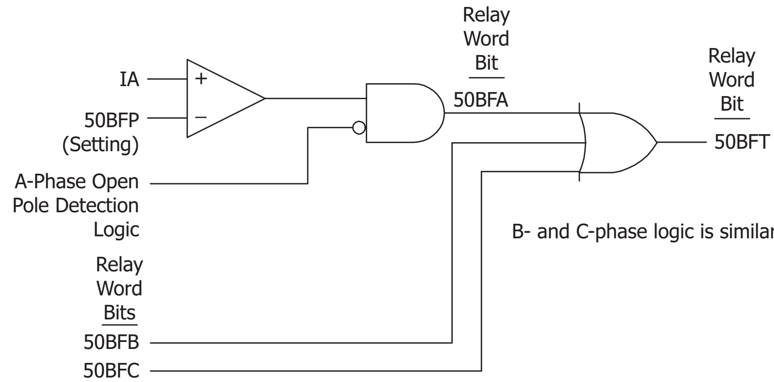


Figure 5.20 Breaker Failure Current Detector Logic for A-Phase

Breaker Failure Logic

Figure 5.21 shows the breaker failure logic for A-phase. B and C-phase are similar. Fault current causes 50BFA to assert immediately following fault inception and just prior to the assertion of SELogic control equation BFIA (Breaker Failure Initiate). Program BFIA with internal breaker failure initiate conditions, such as the Relay Word bit TRIP, or breaker failure initiate signals from external devices communicated to the relay through contact inputs or Mirrored Bits communications. When BFIA asserts, timer BFPU (Breaker Failure Trip Timer) starts timing. If 50BFA remains asserted when the BFPU timer expires, Relay Word bit BFTA asserts. Use this Relay Word bit in the circuit breaker failure tripping logic to cause a circuit breaker failure trip (see *Breaker Failure Trip Logic on page 5.46*). If the protected circuit breaker opens successfully, 50BFA deasserts before the BFPU timer expires and BFTA and BFT do not assert.

If the breaker failure logic of *Figure 5.21* does not match your preferred breaker failure scheme, Relay Word bits 50BFA, 50BFB, 50BFC, and 50BFT may be used along with SELogic control equation variables to create custom schemes. Use the breaker failure trip logic (*Figure 5.22*) to ensure that breaker failure trip signals are properly latched.

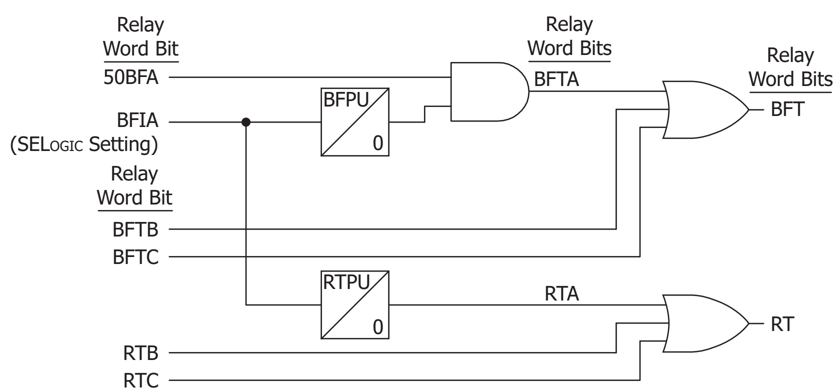


Figure 5.21 Breaker Failure Logic, A-Phase. B-Phase and C-Phase Are Similar

Retrip Logic

Some three-pole circuit breakers have two separate trip coils. If one trip coil fails, the local protection can energize the second trip coil to attempt to trip the breaker again. Configure your protection system to attempt a local retrip using the second trip coil before the circuit breaker failure pickup timer expires.

RTPU (Breaker Failure Retrip Timer) begins timing when BFIA asserts. Relay Word bit RTA asserts when RTPU times out. Program a contact output to energize the second circuit breaker trip coil when Relay Word bit RTA asserts.

Breaker Failure Trip Logic

Usually, SELOGIC control equation BFTR (Breaker Failure Trip Equation) includes Relay Word bit BFT. When BFTR evaluates to logical 1, Relay Word bit BFTRIP asserts and seals in. Include BFTRIP in an output contact equation to transmit breaker failure status to remote relays for backup protection. For example,

OUT106 = **BFTRIP**

Relay Word bit TRGTR and SELOGIC control equation BFULTR reset BFTRIP. The minimum trip duration of BFTRIP is controlled by Group setting TDURD. See *Trip Logic on page 5.1* for a description of minimum trip duration timers, trip unlatch conditions, and operation of Relay Word bit TRGTR.

The breaker failure logic does not automatically trigger an event report. Modify the SELOGIC event report trigger equation ER to trigger an event when a breaker failure trip occurs. For example:

ER = **/51P + /51G + /BFTRIP + ...**

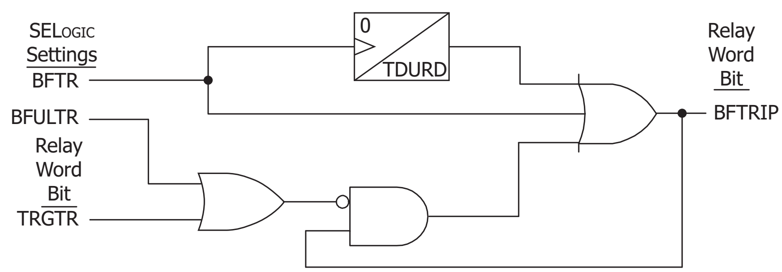


Figure 5.22 Breaker Failure Trip Logic

Table 5.4 Breaker Failure Protection Settings

Setting	Definition	Range
E50BF	Enable Breaker Failure	Y, N
50BFP	Breaker Failure Current Pickup Threshold	OFF, 0.25–100 A, secondary {5 A nominal phase current inputs, IA, IB, IC} OFF, 0.05–20 A, secondary {1 A nominal phase current inputs, IA, IB, IC}
BFI	Breaker Failure Initiate	SELOGIC control equation
BFPU	Breaker Failure Trip Timer Pickup	0–16,000 cycles
RTPU	Breaker Failure Retrip Timer Pickup	0–16,000 cycles
BFTR	Breaker Failure Trip Equation	SELOGIC control equation
BFULTR	Breaker Failure Unlatch Trip Equation	SELOGIC control equation
TDURD	Minimum Trip Duration Time	4–16,000 cycles

Table 5.5 Breaker Failure Protection Logic Outputs (Sheet 1 of 2)

Relay Word Bit	Definition	Application
50BFA	A-phase current threshold exceeded	A-phase breaker failure detection
50BFB	B-phase current threshold exceeded	B-phase breaker failure detection

Table 5.5 Breaker Failure Protection Logic Outputs (Sheet 2 of 2)

Relay Word Bit	Definition	Application
50BFC	C-phase current threshold exceeded	C-phase breaker failure detection
50BFT	Any phase current threshold exceeded	Breaker failure detection
BFTA	A-phase circuit breaker failure	
BFTB	B-phase circuit breaker failure	
BFTC	C-phase circuit breaker failure	
BFT	Any phase circuit breaker failure	
RTA	A-phase retrip	
RTB	B-phase retrip	
RTC	C-phase retrip	
RT	Retrip	
BFTRIP	Circuit breaker failure trip	

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. 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 that 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 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 5.6*. See *Figure 2.2, Figure 2.3*, and *Figure 2.5* for example front panels with fixed target logic.

Table 5.6 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 13.6*	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**	A-phase involved in the fault	Target
TLED20	**B**	B-phase involved in the fault	Target
TLED21	**C**	C-phase 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 5.7* for a cross reference, and *TAR Command (Display Relay Element Status) on page 10.74* for more command options.

Table 5.7 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 5.6* 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 a 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 5.6* 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.

Trips initiated by the manual trip SELOGIC control equation BKMTR illuminate the **TRIP** target LED only.

TIME Target LED

The **TIME** target LED illuminates at the rising edge of a 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 5.58*.

COMM Target LED

The **COMM** target LED illuminates at the rising edge of a trip if the trip is the sole and direct result of the communications-assisted trip logic, indicated by the COMPRM Relay Word bit in *Figure 5.1* (first panel of the diagram). Elements that affect COMPRM include the TRCOMM, DTA, DTB, and DTC SELOGIC control equations and the ECTT Relay Word bit.

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 settings DTA, DTB, and DTC (Direct Transfer Trip, A, B, and C-phase) to accomplish this.

For example, if Remote Bit 1 is used to command a three-phase trip from a remote master, and the **COMM** target LED should be illuminated, make these settings.

DTA = **RB1**

DTB = **RB1**

DTC = **RB1**

E3PT = **... + RB1**

Including RB1 in the enable three-pole trip setting E3PT is not strictly necessary because RB1 appears in all three direct-trip equations. However, the E3PT = … + RB1 setting ensures that a trip output is generated even for breaker poles already reported as open. This is recommended for taking lines out of service, in case the pole status signals are misreported. For example, without the E3PT setting modification, if the A-phase and B-phase poles were reported open when RB1 is received (SPOA = SPOB = logical 1), only DTC would propagate through the logic and issue a trip output (TPC), as shown in the first panel of *Figure 5.1*.

NOTE: Using the manual trip setting BKMTR (alone) to issue a three-phase trip does not illuminate the COMM LED.

Another method is to use the manual trip setting BKMTR in place of E3PT to guarantee a three-phase trip.

BKMTR = **RB1 + other manual trip conditions**

Using the methods shown in this example, any Relay Word bits set in SELOGIC control equation settings DT*p* (*p* = A, B or C) do not have to be repeated in SELOGIC control equation setting TR, because both types of settings directly activate the trip logic. The only difference between settings DT*p* and the trip setting (TR) is that DT*p* causes the **COMM** target LED to illuminate, and the DT*p* settings can be used to manually trip a single phase of the breaker.

Many other variations of the above DT*p* 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 (see *Figure 5.5*).

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 a 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

NOTE: The SEL-311C phase targeting logic requires 3-phase voltage signals for proper operation.

A (A-phase) target LED is illuminated one cycle after the rising edge of TRIP if a protection element causes the trip, and A-phase is involved in the fault (likewise for **B** [B-phase] and **C** [C-phase] 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 a 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 a 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 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 5.8*. 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. As many as 11 of the 16 LED definitions can be changed. There are no settings associated with the five permanent function LEDs, which have an internal logic.

Table 5.8 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 13.6)*	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**	A-phase involved in the fault	None
Internal[a]	Yes	TLED20	**B**	B-phase involved in the fault	None
Internal[a]	Yes	TLED21	**C**	C-phase 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 5.7* for a cross reference for relays with factory-default LED settings, and *TAR Command (Display Relay Element Status) on page 10.74* for more command options.

If the LED definitions are changed from the default settings, a copy of *Table 5.9* can filled-in to be used in your documentation and training materials.

Table 5.9 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
	( )	( )	( )	( )	( )	( )	( )	( )

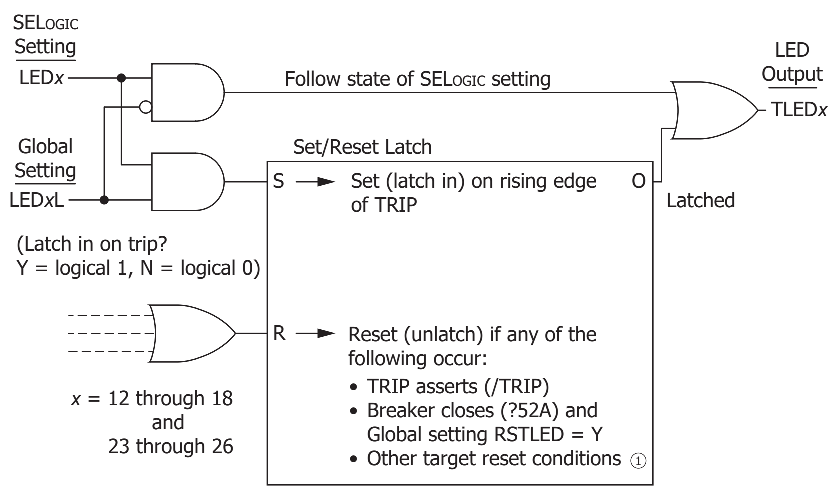
NOTE: The Global settings for Target LED Alias names (for example, LED12A = TRIP) do not affect the **TAR** command response. These alias settings are used in the event summary target reporting.

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 5.9*.

Programmable Target/Status Logic Details

Refer to *Table 5.8* and *Figure 5.23*.

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 5.8*. They either latch-in on the rising-edge of a 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 5.55

Figure 5.23 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 5.48*.

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 as many as 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 5.10, 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 5.11.

Table 5.10 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 5.11 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.

Global Settings (SET G or via ACSELERATOR QuickSet SEL-5030 Software)

LED17L = **N** {no change, LED17 is still a status LED}

LED18L = **N** {the LO LED is a status LED, and is not included in event summary Target fields}

LED26L = **Y** {no change, LED26 is still 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 is used in event summary Target fields}

[1] As described in the footnotes of Table 5.8, 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.

In all six settings groups (SET L n, [n = 1 to 6] or via 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.

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 5.8*. 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 control 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 control 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 Control 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 control 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 5.6 or Table 5.8) 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 second panel 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)

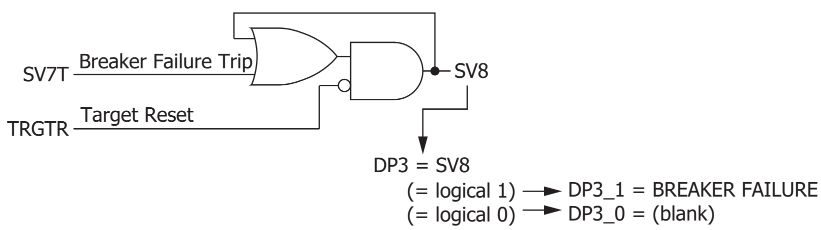
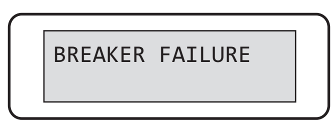


Figure 5.24 Seal-in of Breaker Failure Occurrence for Message Display

If a breaker failure trip has occurred, the momentary assertion of SV7T (breaker failure trip) will cause SV8 in *Figure 5.24* to seal-in. Asserted SV8 in turn asserts DP3, causing the following 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 control 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 as follows.

RSTTRGT = **IN106**

The built-in rising edge requirement ensures that leaving IN106 asserted does not continually reset the targets.

However, if RSTTRGT is asserted when the relay turns on, 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 as shown below.

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 12.28*.

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 control 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 shown below.

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 Autoreclose 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 by 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 5.47*.
- Demand Metering—FAULT is used to suspend demand metering peak recording. See *Demand Metering on page 8.19*.
- Maximum/Minimum Metering—FAULT is used to block Maximum/Minimum metering updating. See *Maximum/Minimum Metering on page 8.28*.

Section 6
Close and Reclose Logic

Overview

This section is made up of the following topics:

- *Breaker Status Logic*
- *Close Logic on page 6.5*
- *Reclose Supervision Logic on page 6.8*
- *Reclosing Relay on page 6.16*

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

The components of *Figure 6.1* are discussed below. 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 sections. Note particularly the description of SELOGIC control equation setting CL in the Close Logic section.

Breaker Status Logic—Breaker Status Logic shows how the breaker status (Relay Word bits 52AA, 52AB, 52AC, and 52A) is derived.

Close Logic—This section describes the final logic that controls the close output contact (e.g., OUT105 = 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 section (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 section 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.

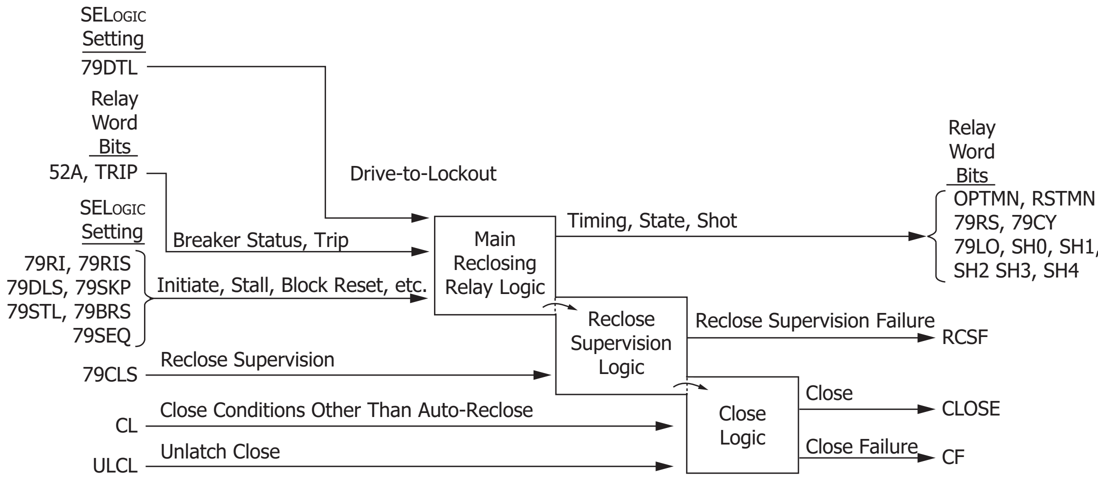


Figure 6.1 Close Logic and Reclosing Relay Logic Overview

Breaker Status Logic

The SEL-311C breaker status logic consists of four SELOGIC control equation settings: 52AA, 52AB, 52AC, and 52A, and the corresponding Relay Word bits, as shown in *Figure 6.2*.

52AA = **Breaker Pole A status** (typically driven by a relay input)

52AB = **Breaker Pole B status** (typically driven by a relay input)

52AC = **Breaker Pole C status** (typically driven by a relay input)

52A = **Combined breaker status** (typically a SELOGIC control equation)

NOTE: The available SafeLock CLOSE pushbutton is electrically separate from the rest of the relay and not part of the close logic in Figure 6.5. It provides separate closing capability as shown in Figure 2.19.

The SEL-311C only considers the combined 52A Relay Word bit in the close and reclose logic described in the following sections. In order for automatic reclosing to function, the 52A logic must deassert when one or more circuit breaker poles are open.

If 52A is set with numeral 0, all internal close logic is inoperable and the reclosing relay is defeated.

The SEL-311C may use the individual phase breaker status signals 52AA, 52AB, and 52AC as part of other relay functions, as described in *Pole-Open Logic on page 5.18*.

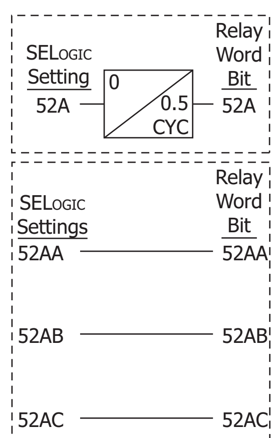


Figure 6.2 Breaker Status Logic

Conventional Breaker Connections—Individually Wired Pole Status

When applying the relay to a single-pole trip (SPT) capable breaker, individual, normally open (52a) breaker-pole status signals are recommended for the SELOGIC breaker status settings. See *Figure 2.14* for a wiring diagram of this connection. This connection method provides the relay with full information on the status of the individual poles of the circuit breaker.

The factory-default settings are listed below.

Logic settings (**SHO L *n***, where *n* = group 1 through 6)

52A = **52AA * 52AB * 52AC** [= 52AA AND 52AB AND 52AC]

52AA = **IN101**

52AB = **IN102**

52AC = **IN103**

The pickup and dropout operation of Relay Word bit 52AA, 52AB, and 52AC are affected by the Global debounce timer settings IN101D–IN103D. See *Optoisolated Inputs on page 7.1* for information on the debounce timers. The 52A element dropout operation is affected by the 0.5 cycle timer (shown in *Figure 6.2*) plus any delays from the individual phase elements 52AA, 52AB, and 52AC.

⚠WARNING
The logic status of the factory default 52A Relay Word bit cannot be used to determine whether a line or other equipment is de-energized.

Relay Word bit 52A provides a necessary status signal to the reclosing relay but normally cannot indicate when a breaker is completely open. Positive pole-open indication can be generated by using an alternative logic expression such as this example using a logic variable.

LV1 = **!(52AA + 52AB + 52AC)** [=NOT(52AA OR 52AB OR 52AC)]

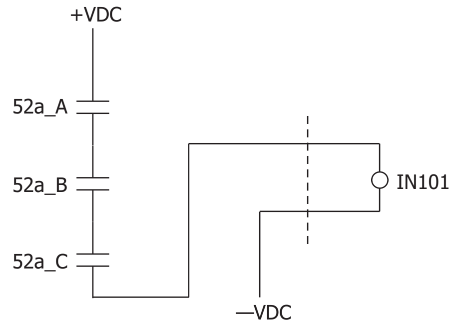
In this example, LV1 will be asserted only when all three circuit breaker pole status signals are reporting an open condition. Relay Word bit LV1 could then be used for breaker or line status indication, independent of the 52A setting.

If automatic reclosing is not required or if only thee-pole tripping is used in an SEL-311C relay application, the 52A setting can be changed from the factory default.

Other breaker and line status indication methods could involve the Thee-Pole Open (3PO) and Single-Pole Open (SPO) Relay Word bits, described in *Pole-Open Logic on page 5.18*.

Alternative Breaker Connections—Series Connected Pole (Form A) Status

For maximum operational benefit, SEL recommends wiring three separate 52A breaker pole status signals, as shown in *Conventional Breaker Connections—Individually Wired Pole Status on page 6.3*. However, in some installations individual pole status lines may not be wired between a breaker and the control house. Instead, only a single series-connected circuit may be available, as depicted in *Figure 6.4*.



All poles closed: IN101 = logical 1
At least one pole open: IN101 = logical 0

Figure 6.3 Series 52a Breaker Status Connection

If the SEL-311C is to be installed in this type of system, consider using the following settings.

Logic settings (**SET L *n***, where *n* = group 1 through 6):

52A = **IN101** (external series combination)

52AA = **52A + !52A * 52AA * (!TPA*SPT+ !TRIP*SPO) * !CF * !SV1T**

52AB = **52A + !52A * 52AB * (!TPB*SPT + !TRIP*SPO) * !CF * !SV1T**

52AC = **52A + !52A * 52AC * (!TPC*SPT + !TRIP*SPO) * !CF * !SV1T**

SV1 = **!52A**

Group settings (**SET *n***):

ESV = **1**

SV1PU = **120.00 cyc**

SV1DO = **0.00 cyc**

These settings operate to set or clear the individual phase breaker status settings based on information determined from the 52A input (IN101), along with knowledge of which phase is being tripped or has recently been tripped. Group setting SV1PU is normally set greater than the longest duration recloser open interval time (setting 79OI1, 79OI2, etc.).

With all three breaker poles closed, 52A = IN101 will be asserted, and the logic settings will cause all three equations 52AA, 52AB, and 52AC to assert.

When the relay issues a B-phase single-pole trip command, the settings cause the corresponding equation 52AB to be deasserted and the remaining two equations 52AA and 52AC to stay asserted.

If the relay issues a three-pole trip, the settings cause all three equations 52AA, 52AB, and 52AC to deassert.

If a single-pole open condition lasts for more than 120 cycles or a close failure condition is detected, these settings will cause all three equations 52AA, 52AB, and 52AC to be deasserted

Alternative Breaker Connections—Parallel Connected Pole (Form b) Status

In some installations, individual pole-status lines may not be wired between a breaker and the control house. Instead, only a single parallel-connected circuit may be available, as depicted in *Figure 6.4*.

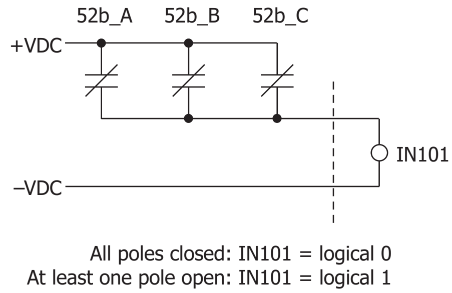


Figure 6.4 Parallel 52b Breaker Status Connection

If the SEL-311C is to be installed in this type of system, only the 52A logic setting needs to be changed. All of the other settings from the series connected pole example will apply.

The 52A Relay Word bit will operate in the same manner in this system:

- ➤ 52A will be asserted when all three poles are closed:
  52A = !IN101 = NOT(0) = logical 1
- ➤ 52A will be deasserted when any pole is open:
  52A = !IN101 = NOT(1) = logical 0.

Refer to the operating description from the series connection, above.

Close Logic

The close logic in *Figure 6.5* provides flexible circuit breaker closing/automatic reclosing with SELOGIC control equation settings,

`52A` (breaker status)

`CL` (close conditions, other than automatic reclosing)

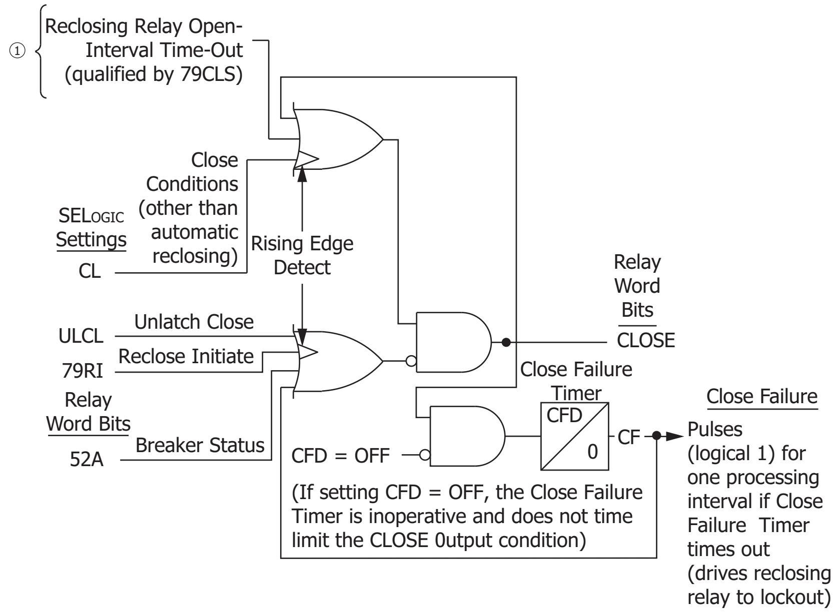
`ULCL` (unlatch close conditions, other than circuit breaker status, close failure, or reclose initiation)

and setting.

`CFD` (Close Failure Time)

See the *SEL-311C Settings Sheets* for setting ranges.

⚠WARNING
Setting CFD = OFF can create an indefinite "standing close" condition. This is usually not desirable in practice.



① From Figure 6.6.

Figure 6.5 Close Logic

Set Close

NOTE: See Breaker Status Logic on page 6.2 for details on setting 52A for various circuit breaker wiring schemes.

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 6.6*).
- ➤ SELOGIC control equation setting CL goes from logical 0 to logical 1 (rising-edge transition).

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 6.5. It provides separate closing capability as shown in Figure 2.19.

Relay Word bit CC asserts for execution of the **CLOSE** command. See *CON Command (Control Remote Bit) on page 10.41* 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.

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 listed below.

52A = **52AA * 52AB * 52AC**

52AA = **IN101**

52AB = **IN102**

52AC = **IN103**

CL = **CC**

ULCL = **TRIP**

The factory setting for the Close Failure Timer setting is listed below.

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 6.5* is ignored (reclosing is discussed in detail in a following section), 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 10.39* 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.

For applications that require single-pole tripping with reclosing, the 52A setting must be properly configured to allow automatic reclosing. The reclosing relay logic does not directly use Relay Word bits 52AA, 52AB, and 52AC.

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 6.16*) if any of the following are true.

- SELOGIC control equation setting 52A is set with numeral 0 (52A = 0)
- Unlatch close logic SELOGIC control equation setting ULCL is set with numeral 1 (ULCL = 1)
- SELOGIC control equation 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 = **52AA * 52AB * 52AC**

then if breaker status is used in other SELOGIC control equations, it can be entered as 52A, rather than 52AA * 52AB * 52AC.

Program an Output Contact for Closing

In the factory settings, the result of the close logic in *Figure 6.5* is routed to output contact **OUT105** with the following SELOGIC control equation.

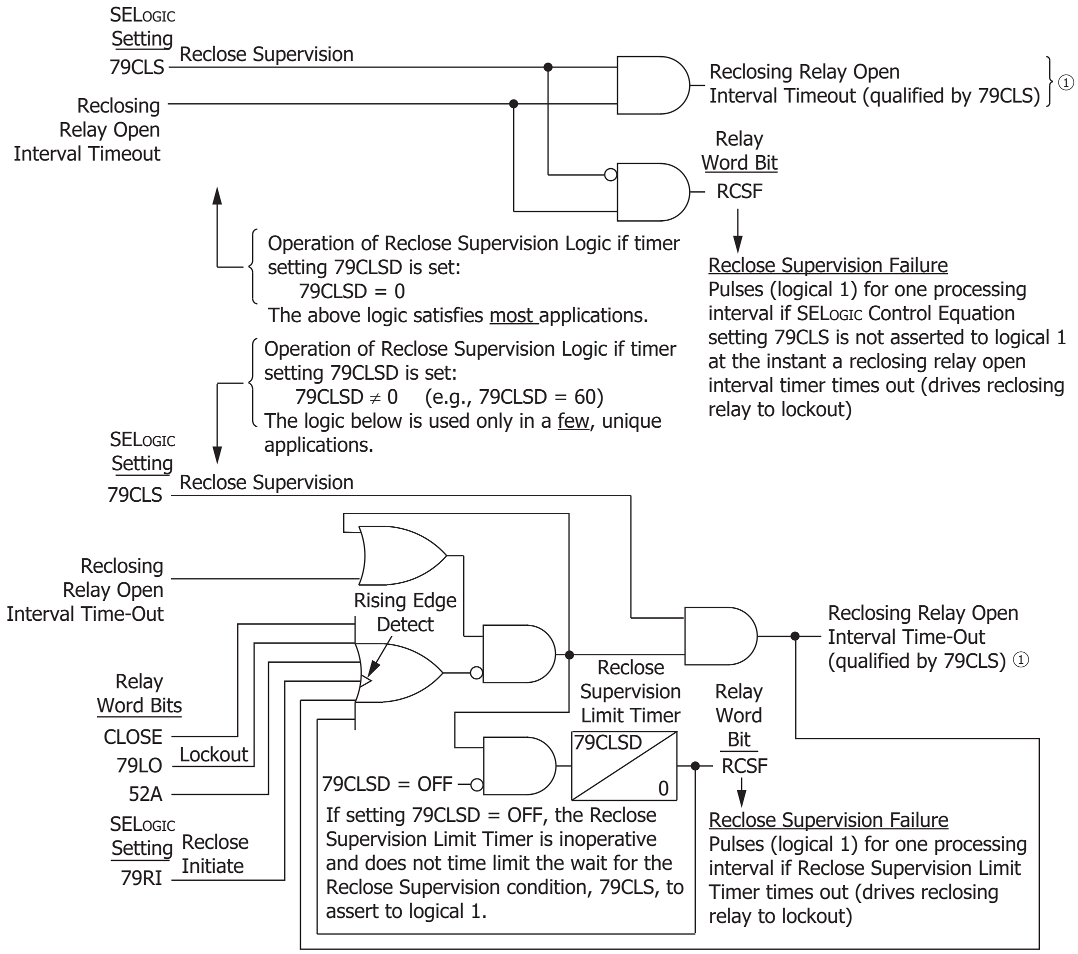
OUT105 = **CLOSE**

See *Output Contacts on page 7.32* for more information on programming output contacts.

Reclose Supervision Logic

Note that one of the inputs into the close logic in *Figure 6.5* is Reclosing Relay Open Interval Time-Out (qualified by 79CLS).

This input into the close logic in *Figure 6.5* is the indication that a reclosing relay open interval has timed out (see *Figure 6.10*), 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 6.5* is an output of the reclose supervision logic in the following *Figure 6.6*.



① To Figure 6.5.

Figure 6.6 Reclose Supervision Logic (Following Open Interval Time-Out)

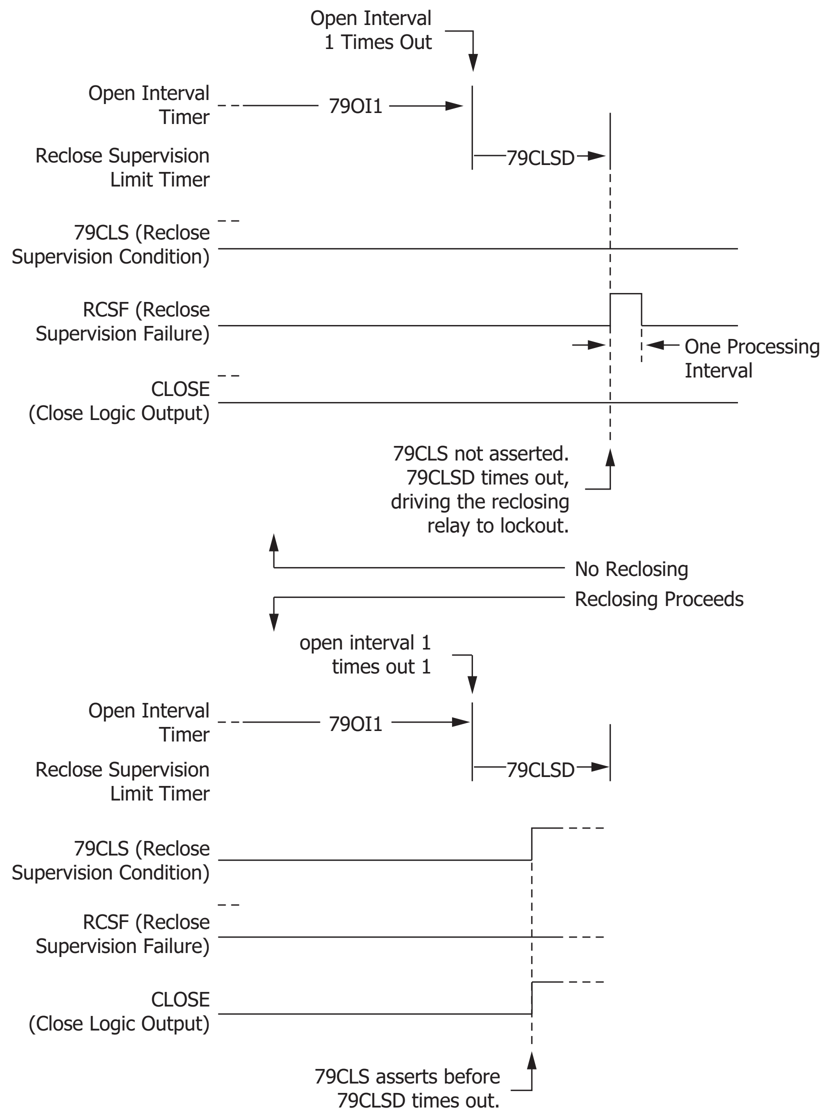


Figure 6.7 Reclose Supervision Limit Timer Operation (Refer to Bottom of Figure 6.6)

Settings and General Operation

Figure 6.6 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 6.6)

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 6.6* 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 6.5* 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 6.12* and *Additional Settings Example 1 on page 6.12*.

For a Few, Unique Applications (Bottom of Figure 6.6 and Figure 6.7)

For a few unique applications, the Reclose Supervision Limit Time setting is *not* set equal to zero cycles.

79CLSD = **60.00**

With this setting, the logic in the bottom of *Figure 6.6* 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 6.5* 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 6.6* is explained in more detail in the following text.

Set Reclose Supervision Logic (Bottom of Figure 6.6)

Refer to the bottom of *Figure 6.6*. If *all* the following are true,

- The close logic output CLOSE (also see *Figure 6.5*) 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 6.6*. Then, when 79CLS asserts to logical 1, the sealed-in reclosing relay open interval time-out condition will propagate through *Figure 6.6* and on to the close logic in *Figure 6.5*.

Unlatch Reclose Supervision Logic (bottom of Figure 6.6)

Refer to the bottom of *Figure 6.6*. 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 6.6*) 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 6.5*.

See *Additional Settings Example 2 on page 6.15*.

Factory Settings Example

Refer to the top of *Figure 6.6*.

The factory setting for the SELOGIC control equation reclose supervision setting is as follows.

79CLS = **1** (numeral 1)

The factory setting for the Reclose Supervision Limit Timer setting is as follows.

79CLSD = **0.00 cycles**

Any time a reclosing relay open interval times out, it propagates immediately through *Figure 6.6* and then on to *Figure 6.5*, 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 6.6* and *Figure 6.8*.

SEL-311C relays are installed at both ends of a transmission line in a high-speed reclose scheme. For three-phase and phase-to-phase faults, after both circuit breakers trip three-pole (3PT)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. After any trip, only one reclose is attempted by the SEL-311C(1) relay. Supervision settings in the SEL-311C(2) prevent an autoreclose attempt if breaker 52/1 does not successfully reclose.

Any trip after a reclose attempt is a three-pole trip, locking-out the reclosing relay.

Both relays have phase discordance timers that will limit the duration of a single-pole open condition. If the SPO condition persists for longer than

10 seconds in either relay, the relay issues a three-pole trip (3PT) and drives the reclosing relay to lockout.

The logic settings use timer pickup setting SV3PU to determine if a single-pole open condition has lasted longer than the open interval time, plus a margin.

Logic settings in each relay are listed below.

SV3 = **SPO**

TR = **... + SV3T**

E3PT = **... + SV3T**

79DTL = **... + SV3T**

Group settings in each relay are listed below.

SV3PU = **600.00 cycles** (= 10 s at 60 Hz)

SV3DO = **0.00 cycles**

When single-phase faults cause both relays to trip single pole (SPT), the reclosing at each terminal is coordinated by using voltage and/or line current supervision.

This example does not use any communications. A more sophisticated installation would feature communications between the two terminals.

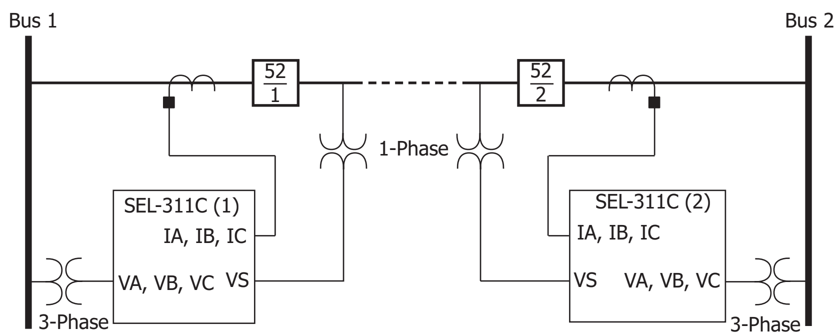


Figure 6.8 SEL-311C Relays Installed at Both Ends of a Transmission Line in a High-Speed Reclose Scheme

SEL-311C(1) Relay

For three-pole open conditions (3PO = logical 1), 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. For single-pole open conditions (SPO = logical 1), no line-side voltage checks are made because relay SEL-311C(1) is the first to perform an automatic reclose in this example. This requires reclose supervision settings:

79CLSD = **0.00 cycles** (only one check)

79CLS = **3P59 * (27S * 3PO + SPO)**

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

3PO = Three-Pole Open

SPO = Single-Pole Open

See *Pole-Open Logic on page 5.18* for more information on Relay Word bits 3PO and SPO.

SEL-311C(2) Relay

For three-phase tripping, 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.

For single-phase tripping, the SEL-311C(2) performs some voltage and current checks. If the relay senses voltage on Bus 2, voltage on the monitored line phase, and load current on at least one phase of the line, a reclose is attempted. This method requires the reclosing relay open interval times (not shown) to be set longer on the SEL-311C(2) to allow the SEL-311C(1) terminal to reclose first.

If SEL-311C(1) recloses and remains closed, SEL-311C(2) will also close, provided there is some power being transferred over the two closed phases, indicating that Bus 1 and Bus 2 are synchronized.

If SEL-311C(1) recloses and then trips to lockout or does not attempt a reclose because of a supervising condition, SEL-311C(2) will not reclose because either 27S will be asserted, indicating a dead line, or 50L will be deasserted, indicating no line current is present. After 10 seconds in SPO, the pole discordance logic will issue a three-pole trip (3PT) to breaker 52/2 and drive the reclosing relay to lockout.

This functionality requires the following reclose supervision settings:

79CLSD = **0.00 cycles** (only one check)

79CLS = **(25A1 * 3PO) + (3P59 * !27S * 50L * SPO)**

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.

3PO = Three-Pole Open

3P59 = all three Bus 2 phase voltages (VA, VB, and VC) are hot

!27S = NOT(27S). 27S is an undervoltage element monitoring a single-phase of the transmission line using channel VS. When voltage is detected, the term !27S asserts.

50L = Load detector. Asserts when any phase exceeds the 50LP setting.

SPO = Single-Pole Open

See *Block Synchronism-Check Conditions on page 3.62* for information on how to configure SELOGIC control equation setting BSYNCH for use with single-pole tripping.

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 6.27.*

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 re-energized the line. For three-phase tripping, 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 * 3PO** [=NOT(25A1) AND (3PO)]

The 79STL example setting for the SEL-311C(2) only includes a term that operates for three-pole open conditions. For single-phase tripping applications, the SEL-311C(2) in the example wiring configuration of *Figure 6.8* cannot reliably stall the open interval timing because only one of the three phases are covered by the single-phase VS connection.

If there is a reliable communications channel between SEL-311C(1) and SEL-311C(2), the state of the reclosing relay in SEL-311C(1) could be shared with the other terminal, and a proper decision could be made regarding stall timing, and reclose supervision.

Coordinate Time-Delay Settings

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 3.38*.

Additional Settings Example 2

Refer to *Synchronism-Check Elements on page 3.53*. Also, refer to *Figure 6.7* and *Figure 6.8*.

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. An example is provided below.

79CLSD = **60.00 cycles**

79CLS = **25A1 + SPO**

For three-pole breaker operations, 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.

For single-pole open conditions, no synchronism check is needed because the remaining closed phases bind the systems so they cannot drift out of synchronism. The **+ SPO** term ensures the 79CLS equation is satisfied for these conditions.

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 3.67*, 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

The SEL-311C reclosing relay can be configured to suit many applications. This section details the various settings, inputs, and outputs for the reclosing function, including some application examples. The SEL-311C relay described in this manual is not preconfigured with default settings for autoreclose functionality.

It is important to study all of the *Section 6* material to design, test, and apply the reclosing relay to the power system.

Note that input

Reclosing Relay Open Interval Time-Out

in *Figure 6.6* is the logic input that is qualified by SELOGIC control equation setting 79CLS, and then propagated on to the close logic in *Figure 6.5* to automatically reclose a circuit breaker. The explanation that follows in this reclosing relay section describes all the reclosing relay settings and logic that eventually result in this open interval time-out logic input into *Figure 6.6*. 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 6.20*).

Reclosing Relay States and General Operation

The SEL-311C reclosing relay is a state machine, as depicted in *Figure 6.9*. When running in the reclose cycle state (79CY) it can provide as many as four reclose attempts or “shots.”

For applications that use single-pole (SPT) and three-pole tripping (3PT), the number of automatic reclosure attempts is the total of the number of attempts, regardless of which type of trip occurred. See *Reclosing Application for Mixed Single-Pole and Three-Pole Tripping Scheme on page 6.31* for application details.

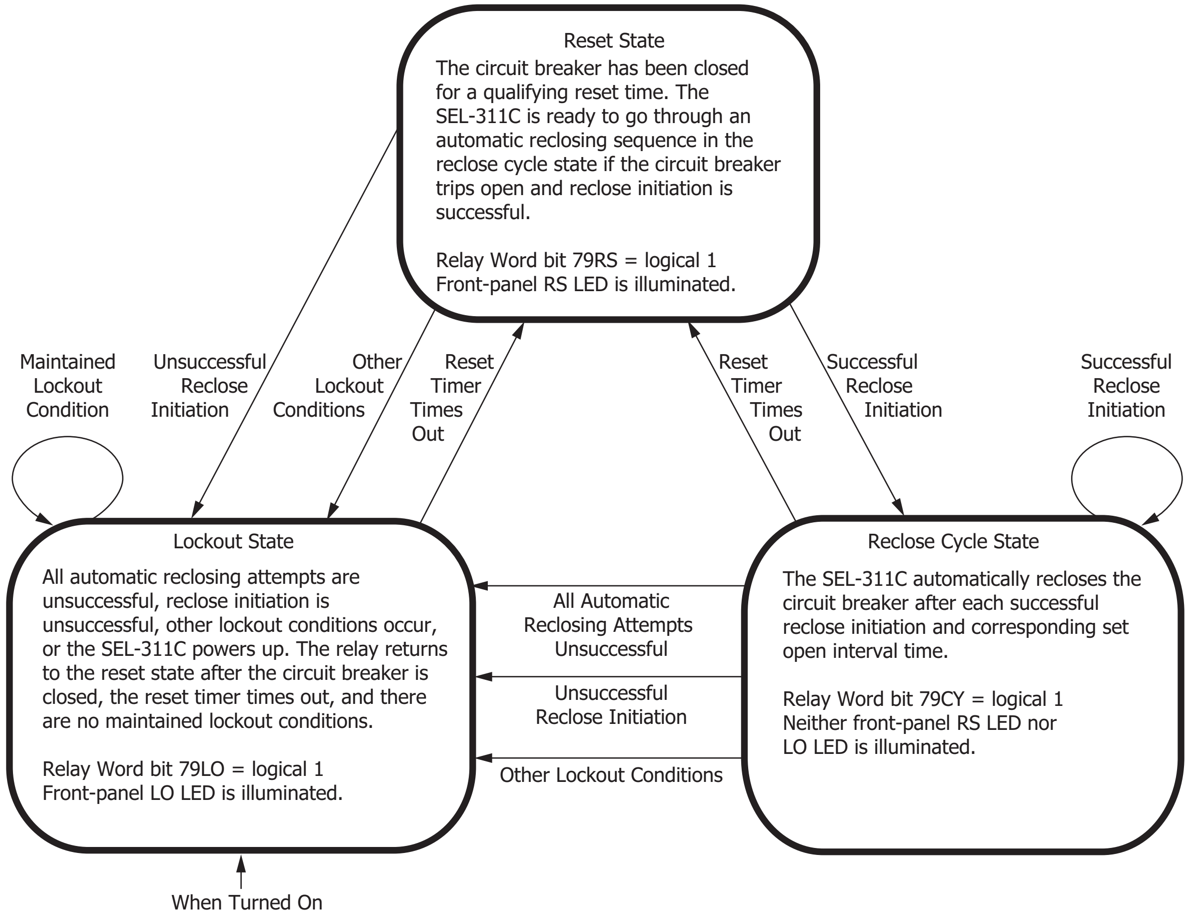


Figure 6.9 Reclosing Relay States and General Operation

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 6.10*).
- 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 6.23*).

NOTE: The SEL-311C reclosing relay uses Relay Word bit 52A to indicate breaker status. See Breaker Status Logic on page 6.2 for SELOGIC setting configuration details for single-pole circuit breaker applications.

- 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 2.19*, 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 6.25*).
- The close failure timer (setting CFD) times out (see *Figure 6.5*).
- 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 6.6* and top of *Figure 6.7*) and the reclose enable setting, E79, is set to 1, 2, 3, or 4.
- A normal reclose initiation (e.g., SELOGIC control equation 79RI = TRIP) occurs and properly loads up an open-interval time (e.g., 79OI2 = 600 cycles; see *Figure 6.9*). Then, before the open-interval time has timed out completely (or even started timing), a subsequent unexpected reclose initiation occurs (e.g., flashover inside the circuit breaker tank while it is open or during single-pole open conditions, a fault occurs on another phase and causes a trip).
- This lockout condition occurs when the open interval timer expires and CLOSE is asserted. If the SELOGIC control equation setting ULCL deasserts CLOSE before the breaker status indication, 52A, Relay Word bit asserts, then the relay will consider the close operation unsuccessful and go to lockout.

In most applications, the **OPEN** command should drive the reclosing relay to lockout. To include this functionality, make the 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 10.58* for more information on the **OPEN** command. Also, see *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 6.25*.

If the **OPEN** command is set to manually trip the breaker (BKMTR = … + OC), then the following reclosing relay SELOGIC control equation settings should also be made (presuming an **OPEN** command trip should not 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 6.5*) 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 = 52AA * 52AB * 52AC, and the related settings are made as shown in *Breaker Status Logic on page 6.2*, even 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 6.5* for more discussion on SELOGIC control equation settings 52A and CL. Also see *Optoisolated Inputs on page 7.1* 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**

Therefore, 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 6.10*. 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 control equation 79STL is asserted (logical 1).

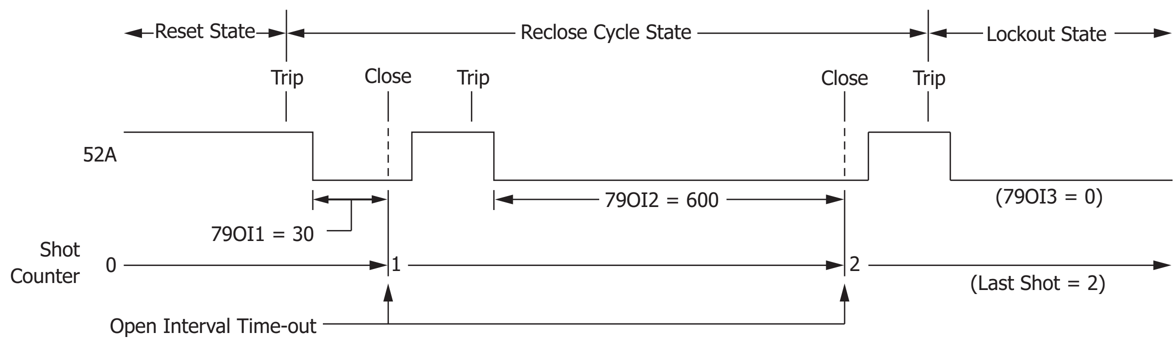


Figure 6.10 Reclosing Sequence From Reset to Lockout With Example Settings

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 6.27*).

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 example settings above, two set open interval times precede open interval three 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 6.31*).

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 6.5*).

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 6.19*).

See *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 6.25* for the description of a scenario where there is no reset timing via setting 79RSLD to get from the Lockout State to the Reset State. In this scenario, the breaker remains closed continuously as the relay transitions (Reset State > Lockout State > Reset State) because of drive-to-lockout setting 79DTL.

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 6.29*).

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 6.27*).

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 6.29*.

Reclosing Relay Shot Counter

Refer to *Figure 6.10*.

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 6.21*). 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 6.31*).

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 section.

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* set as follows,

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. See *Breaker Status Logic on page 6.2* for details on configuring SELOGIC setting 52A for various circuit breaker connections.

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 example 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) or, if during single-pole open conditions, a fault occurs on another phase and causes a separate 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.

With SELOGIC control equation setting 52A configured as described in *Breaker Status Logic on page 6.2*, Relay Word bit 52A indicates the circuit breaker status for the reclosing relay.

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 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 5.4*).

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 2.19*.

If circuit breaker status indication (52A) is slow, the TRIP Relay Word bit should be removed from unlatch close setting ULCL (*Figure 6.5*) when setting 79RI = !52A. This keeps the SEL-311C from going to lockout prematurely for an instantaneous trip after an autoreclose. 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 6.26*).
- ➤ Reclose initiation is by the breaker contact opening (e.g., 79RI = !52A—refer to *Additional Settings Example on page 6.24*).

Then the drive-to-lockout condition overlaps reclose initiation and the SEL-311C stays in lockout after the breaker trips open.

If the relay had previously been in the Reset State (Relay Word bit 79RS = logical 1) with the breaker closed and then a drive-to-lockout condition comes true (via setting 79DTL), the relay immediately goes to the Lockout State (Relay Word bit 79LO = logical 1). If the breaker continues to remain closed and then the drive-to-lockout condition (via setting 79DTL) goes away (after the 60-cycle dropout time), the relay then reverts immediately back to the Reset State. No reset timing via setting 79RSLD is needed to return to the Reset State in this scenario because the breaker remains closed the entire time. The relay had previously timed on a reset time (setting 79RSD or 79RSLD) when it first went to the Reset State, before the drive-to-lockout logic (via setting 79DTL) started activating. Thus, there is no need to again reset time qualify a breaker that remained closed throughout such a transition (Reset State > Lockout State > Reset State), because of drive-to-lockout setting 79DTL.

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 6.22*).

Settings Example

The drive-to-lockout *Table 6.4* example setting is as follows.

79DTL = **OC + !IN105 + LB3**

Optoisolated input **IN105** is set to operate as a reclose enable switch (see *Optoisolated Inputs on page 7.1*). 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 7.5* 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 6.17*.

The drive-to-last shot *Table 6.4* example setting is shown below.

79DLS = **79LO**

If there is one open interval time delay (e.g., setting 79OI1 = 300.00 cycles), the 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 6.17*).

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 6.17*).

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 6.22*).

Factory Settings Example

The skip shot function is not enabled in the factory settings.

79SKP = **0** (numeral 0)

The stall open interval timing function is not enabled in the factory settings.

79STL = **0** (numeral 0)

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 6.11*.

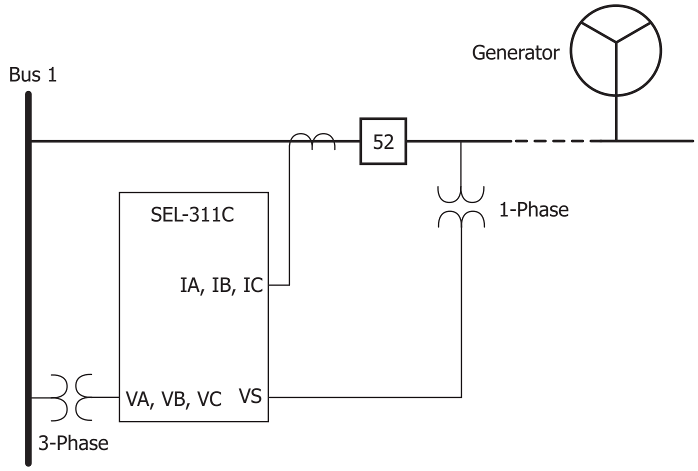


Figure 6.11 Reclose Blocking for Islanded Generator

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).

The example connection in *Figure 6.11* may only sense voltage on one phase of the line. An alternative connection would place the three-phase potential transformers on the line side of the breaker (connected to VA, VB, VC) and the single-phase potential transformer on the bus side of the breaker (connected to VS). With this alternative connection, the stall open interval timing condition would include all three phases (e.g., 79STL = 59A + 59B + 59C).

Additional Settings Example 3

Refer to *Figure 6.8* 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 6.22*).

Settings Example

The block reset timing example setting is as follows.

79BRS = **TRIP**

The block reset timing example 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 5.4*)—long enough to encompass this brief time period (waiting for the circuit breaker to open after the trip coil is energized). Thus, setting 79BRS = TRIP is used in most applications.

Additional Settings Example 1

The block reset timing setting is as follows.

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 6.9* 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 as follows.

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 6.8*.

Reclosing Application for Mixed Single-Pole and Three-Pole Tripping Scheme

The SEL-311C can be used in a variety of applications, including protection schemes with single-pole tripping (SPT) for ground faults and three-pole tripping (3PT) for other types of faults, with reclosing.

This section provides details on how to configure the reclosing relay to operate for a combined SPT and 3PT reclosing scheme. The preceding pages described each of the settings related to the reclosing relay but did not bring them together for this application. Some of this information is repeated to make the example easier to follow, and some details are not repeated to make the text easier to read.

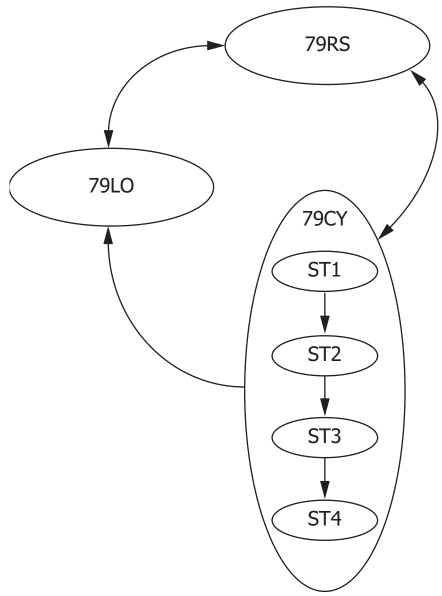
To help understand this example, refer to *Section 5: Trip and Target Logic* for details on the single-pole and three-pole trip logic capabilities of the SEL-311C. As with many examples, this is provided as a starting point, and not all required settings have been specified.

Shot Counter Operation

Relay Word bits SH0, SH1, SH2, SH3, and SH4 are important for the operation of the reclosing scheme in the SEL-311C. These signals, together with the “reclose initiate” (79RI) and “skip” (79SKP) SELOGIC control equation settings, are used to create the SPT and 3PT reclosing logic.

Once the 79RI (reclose initiate) setting is active, the reclosing relay logic jumps from 79RS (reset state) to 79CY (cycle state). Within 79CY, there are conceptually four other substates, shown in *Figure 6.12*.

NOTE: The "Substates" shown in Figure 6.12 are introduced here for discussion purposes only. There are no Relay Word bits called ST1, ST2, etc.



Initiate State

	SH0	SH1	SH2	SH3	SH4
ST1	1	0	0	0	0
ST2	0	1	0	0	0
ST3	0	0	1	0	0
ST4	0	0	0	1	0

After Successful Reclose Issued

	SH0	SH1	SH2	SH3	SH4
ST1	0	1	0	0	0
ST2	0	0	1	0	0
ST3	0	0	0	1	0
ST4	0	0	0	0	1

Figure 6.12 Shot Counter and Substates

Regardless of the state, there is always a path to the lockout state (79LO), which can be reached because of a failure to close, last shot, or the 79DTL (Drive-to-Lockout setting).

The 79RI setting starts the reclosing cycle. The open interval will start when the 52A signal (Breaker Status) deasserts.

The 79SKP setting is used to transit, incrementing the shot counters, from substate to substate (ST1 to ST2, for example). The SH*x* counter bits, and their corresponding values before entering the substate and after issuing the successful reclose operation are shown in *Figure 6.12*. These shot counter Relay Word bits are used in the SPT and 3PT reclosing logic example that follows.

Settings Example

Figure 6.13 shows a typical transmission line bay. The line breaker will be controlled by the reclosing relay (79) in the SEL-311C. The synchronism-check function (25) in the SEL-311C will also be used for reclosing during three-pole open conditions.

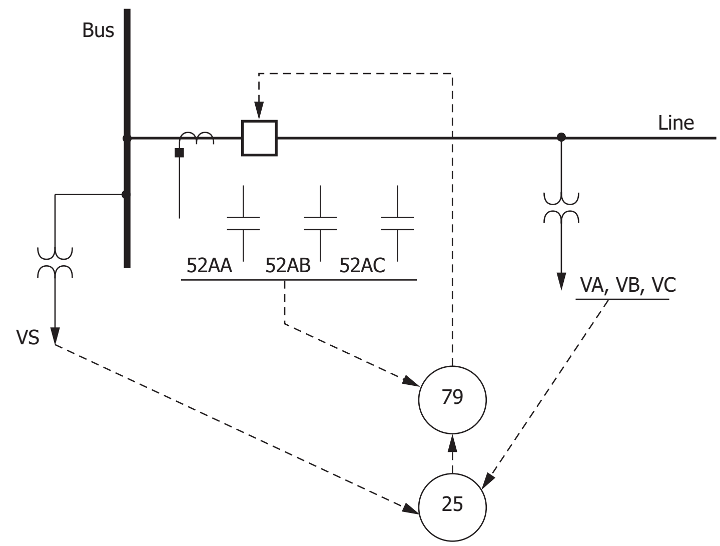


Figure 6.13 Typical Transmission Line Bay

The system is designed to operate as follows:

- For phase-to-ground faults, there will be a single-phase trip (SPT) followed by a reclosure after one second. If the fault is still present when the open pole recloses, there will be a three-phase trip (3PT) and the reclosing relay will be driven to lockout.
- If a fault develops in the healthy phases during the single-pole open (SPO) condition, the reclosing relay will be forced to lockout and the other two phases tripped permanently.
- For phase-to-phase and three-phase faults, there will be a three-phase trip (3PT) followed by a reclosure after 0.5 seconds. This reclose will be supervised by synchronism check across the open breaker. If the fault is still present when the breaker recloses, there will be a three-phase trip (3PT) and the reclosing relay will be driven to lockout.
- The reset time for manual close and reclose cycle completion is the same and equal to two minutes.
- During the reset time, the trip is three-phase (3PT) regardless of the fault type.

The example does not cover the settings for the relay at the remote end of the transmission line (not shown). The remote relay would be set to operate in a similar fashion, with shorter open interval times, and a dead-line check instead of a synchronism check during three-pole open conditions. If the remote relay was not the first to reclose after a three-pole trip, the synchronism-check function in the local relay would never be successful because the line would still be dead. See *Synchronism-Check Elements on page 3.53* for additional information.

Breaker Status Assignment

The breaker status inputs should be assigned and the settings should correspond to the wiring into the relay. For this example, the factory-default settings are used.

52A = **52AA * 52AB * 52AC**

52AA = **IN101**

52AB = **IN102**

52AC = **IN103**

Number of Shots

Two reclosing shots are required: one is used after a single-pole trip and the other is used after a three-pole trip. Only one auto-reclosing shot will be observed when the relay is in operation.

E79 = **2**

Open Interval Assignment

Referring to *Figure 6.12*, defining the conceptual substates (ST1, ST2, etc.) requires assigning the open interval times (for a 60 Hz nominal power system).

79OI1 = **60 cycles** [= 1.0 second at 60 Hz]

79OI2 = **30 cycles** [= 0.5 seconds at 60 Hz]

Reset Time Assignments

The reset times from the reclose cycle and from lockout are the same.

79RSD = **7200 cycles** [= 2 minutes at 60 Hz]

79RSLD = **7200 cycles** [= 2 minutes at 60 Hz]

Define the Close Failure Time

Assume that the breaker requires three cycles to close, then add a margin to the expected closing time. An example is shown below.

CFD = **5 cycles**

Define the Trip During Open Pole Time Delay

The Trip During Open-Pole Delay setting TOPD is shown in *Figure 5.3*. When the TOP Relay Word bit is included in the E3PT setting, this timer provides a window after a single-pole trip (SPT) during which any new trip is converted into a three-pole trip (3PT). In this example, make the TOPD setting the same as the reclose open interval for SPT conditions.

This example also uses TOP in the 79DTL setting.

Group settings

TOPD = **60 cycles** [same as 79OI1]

Define the Phase Discordance Time Delay

The phase discordance timer limits the amount of time the breaker remains in a single-pole open condition. This timer must be set to a longer time delay than the greatest open interval time, plus a margin. In this example, if the SPO condition persists for longer than 2 seconds, the relay issues a three-pole trip (3PT) and drives the reclosing relay to lockout.

These settings use SELOGIC timer SV3T with pickup setting SV3PU.

Logic settings

SV3 = **SPO**

TR = **... + SV3T**

E3PT = **... + SV3T**

79DTL = **... + SV3T**

Group settings

SV3PU = **120.00 cycles** (= 2 s at 60 Hz)

SV3DO = **0.00 cycles**

Define the Reclose Supervision Failure Time

For the 3PT reclosing cycle, the synchronism-check function (25) will supervise the reclosing relay as shown in *Figure 6.13*. In this example, if the open interval times out and the synchronism-check (25) condition has not asserted within 2 cycles, the reclosing relay will go to lockout.

79CLSD = **2 cycles**

Reclose Initiate Conditions

The reclose initiate cycle will be started when the relay trips. The reclose initiate logic responds to the rising edge of the 79RI equation. This example requires no reclose initiate supervision.

79RI = **TRIP**

79RIS = **1**

Drive-to-Lockout Conditions

There are several conditions that are typically used to send the reclosing relay to lockout. In this application, they are as follows.

1. Manual trip issued via SELOGIC control equation setting BKMTR.
2. Trip of any time delayed protective function.
3. A TRIP occurs while in Substate 1, after a single-pole trip (SPT) operation. In this settings example, the relay asserts TOP for 60 cycles, matching the 79OI1 setting. This condition sends the reclosing relay to lockout for any new trip after a single-pole trip.
4. Any trip occurs during an automatic reclose attempt following a single-pole trip.
5. Failure to close.
6. Reclose enable condition not asserted (for example, LT2 = logical 0) and the breaker is open.
7. A single-pole open condition (SPO) exceeds the phase discordance timer setting.
8. Failure in the reclose supervision check.

NOTE: The failure in reclose supervision case is built into the reclosing relay and does not need to be included in the 79DTL setting. See the bottom of Figure 6.6.

Example drive-to lockout-setting.

79DTL = **BKMTR + (M2PT + Z2GT + 51PT + ...) + (TRIP * TOP) + (TRIP*LT10) + CF + (!LT2 * !52A) + SV3T**

For drive-to-lockout condition #4, above, a latching relay (LT10) is programmed to assert when a CLOSE operation occurs in the reclose cycle state (79CY) after a single-pole trip (SH0 to SH1 transition). SH1 must be used in this expression because of the processing order of the equations. The 79RS state clears the latch.

SET10 = **CLOSE * 79CY * SH1**

RST10 = **79RS**

Reclosing Relay State Transition

From the 79RS (reset) state, the reclosing relay enters the 79CY (cycle) state and is initially in substate ST1. The first substate is assigned to the single-pole trip (SPT) cycle. The second substate is assigned to the three-pole trip (3PT) cycle. If there is a SPT, then the substate is correct and the reclose initiation will cause the 79OI1 open interval time setting to be used. When the open interval timer times out, the relay will issue a CLOSE because 79CLS will be asserted (see *Reclose Supervision on page 6.36*) and will move to Shot 1 (SH1 = logical 1).

However, if there is a 3PT, there is a need to jump to the next substate. The “skip shot” equation is used for this purpose.

79SKP = **3PT * SH0**

As shown in *Figure 6.10*, from the 79RS state the shot counter will be at SH0 when the first reclose initiate condition occurs. If a 3PT is present, the 79SKP expression will assert, the reclosing relay will immediately advance the shot counter to SH1, and the 79OI2 open interval time setting will be used. When the open interval timer times-out, the relay will issue the CLOSE if 79CLS is asserted and will move to shot 2 (SH2 = logical 1).

For phase-to-ground faults, the relay asserts SPT and the 79SKP equation will not assert for the first trip. The SH0 term in the 79SKP expression deasserts as soon as the shot counter is changed, preventing any further shots from being skipped.

The skip-shot setting is only used in this example for moving from SH0 to SH1 (for a three-phase trip). The drive-to-lockout setting 79DTL prevents any subsequent autoreclose attempts from occurring.

Reclose Supervision

The 3PT reclose will use the synchronism-check function to allow the reclosing relay to send the **CLOSE** command. The SPT reclose cycle does not need supervision. Including SH0 in the 79CLS supervision equation allows the reclose from SPT to occur.

79CLS = **SH0 + 25A1 * SH1**

Nonapplicable Setting Equations

The reclosing relay has a few other settings that are not used in this example.

1. Drive to Last Shot (79DLS).

   79DLS = **0**

2. Stall Open Interval Timing freezes the open interval timer.

   79STL = **0**

3. Block Reset Timing freezes the reset interval timer. This can be useful if an input coming from the breaker indicates that the breaker is not yet ready, for example.

   79BRS = **0**

4. Sequence coordination is used mainly in distribution networks to coordinate reclosing counts of upstream devices.

   79SEQ = **0**

Required E3PT Setting

The operation of the reclosing relay in the SEL-311C and the single-pole trip logic need to be coordinated. When enabled by the trip-related settings (see *Single-Pole Tripping on page 5.2*), the trip logic in the SEL-311C will send the single-pole trip (SPT) signal for ground faults, unless forced to perform a three-phase trip by the E3PT setting.

It is necessary to force the 3PT under certain conditions, for example,

- When the reclosing relay is in the lockout state.
- When the breaker is open (after a single-pole trip) and the reclosing relay open interval timer is timing. Relay Word bit TOP remains asserted for TOPD cycles. In this example, TOPD is set the same as the first open interval time setting 79OI1.
- When the reclosing relay is in Shot 2.
- When the reclose enable latch LT2 is deasserted. This causes any trip to be a three-pole trip when reclosing is defeated.
- When the phase discordance timer has timed-out.

Other conditions may be needed. The conditions above will be used as an example.

E3PT = **79LO + TOP + SH2 + !LT2 + SV3T**

In cases where the fault is a permanent single line-to-ground fault, the 79LO term asserts and causes the resulting trip after reclosure to be three-pole (3PT). This ensures the breaker three-pole open (3PO) condition whenever the reclosing relay enters the lockout state.

External Signals

Most likely the reclosing scheme will require information from other protective relays in the bay. For example, backup protection, breaker failure relays, or transfer trip schemes could send initiation and/or blocking signals to the reclosing relay.

When incorporating external devices in the reclosing scheme, care should be taken to provide the SEL-311C similar inputs (via optoisolated inputs, MIRRORED BITS, or IEC 61850 GOOSE messages) with the same meaning as the internal ones described in the discussion above.

For example, if IN105 is an external reclose initiation signal, it should have the same meaning as the TRIP bit used in the example.

79RI = **TRIP + IN105**

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 main board inputs IN101–IN106, is used for the following discussion and examples. The optoisolated inputs on the extra I/O board operate similarly. *Figure 7.2* shows the eight inputs IN201–IN208 available with extra I/O board Options 2, 5, and 6. Extra I/O board Option 4 provides 16 inputs IN201–IN216.

NOTE: Optoisolated inputs are not polarity sensitive.

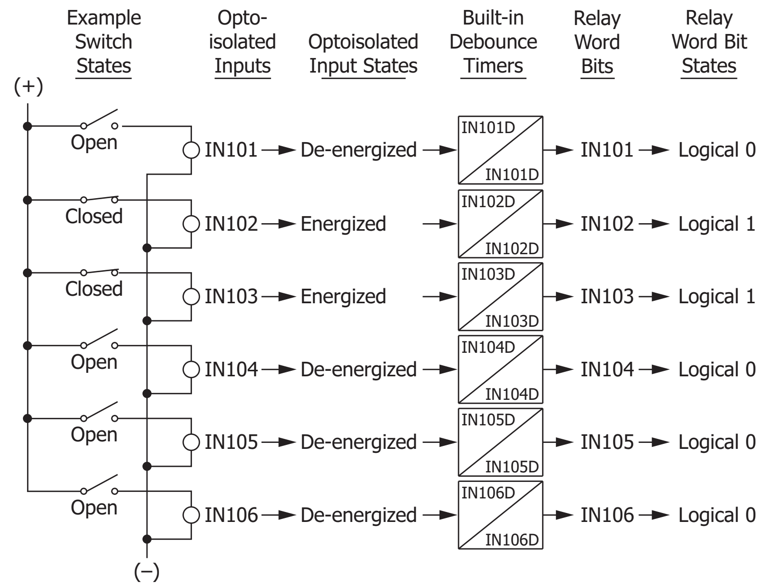


Figure 7.1 Example Operation of Optoisolated Inputs IN101–IN106 (All Models)

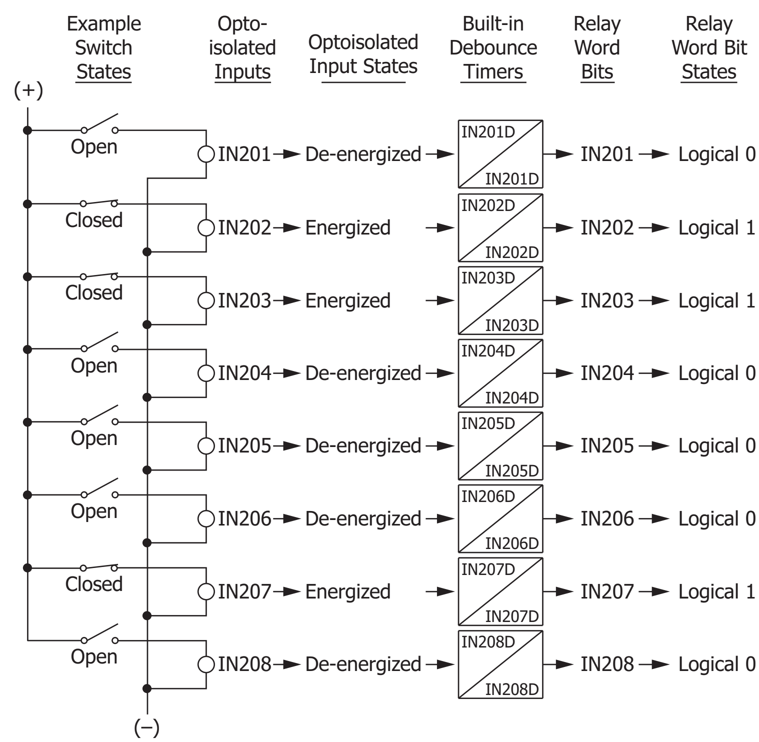


Figure 7.2 Example Operation of Optoisolated Inputs IN201–IN208

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*) for the main board, IN201D–IN208D for extra I/O board Options 2, 5, and 6, and IN201D–IN216D for extra I/O board Option 4. The setting 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).

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)].

Relay Word bits IN101–IN106 and IN201–IN216 are updated on the next 1/4-cycle processing interval after the debounce timer expires.

If more than two cycles of debounce are 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*).

The AC setting allows the input to sense ac control signals. When you use the AC setting, 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 16 successive 1/16 cycle samples are lower than the optoisolated input voltage threshold.

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.

View Raw Input Status

For system testing and analysis, the status of the IN101–IN106 and IN201–IN216 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 12.17* 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

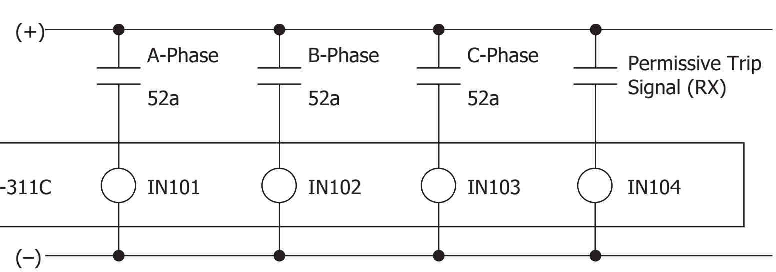


Figure 7.3 Circuit Breaker Auxiliary Contacts and Received Permissive Trip Contact Connected to Optoisolated Inputs IN101–IN104

The functions for inputs IN101–IN104 are described in the following discussions.

Inputs IN101–IN103

Relay Word bits IN101–IN103 are used in the factory settings for the SELOGIC control equation circuit breaker status settings.

52AA = **IN101**

52AB = **IN102**

52AC = **IN103**

Connect inputs IN101–IN103 to the 52a circuit breaker auxiliary contacts, as shown in *Figure 7.3*.

If 52b circuit breaker auxiliary contacts are connected instead of 52a auxiliary contacts, the settings must be changed to the following.

52AA = **!IN101** [!IN101 = NOT(IN101)]

52AB = **!IN102** [!IN102 = NOT(IN102)]

52AC = **!IN103** [!IN103 = NOT(IN103)]

See *Breaker Status Logic on page 6.2* for more information on SELOGIC control equation settings 52AA, 52AB, and 52AC.

It is recommended that the pickup/dropout timers for inputs IN101–IN103 be set as follows.

IN101D = **0.50 cycles**

IN102D = **0.50 cycles**

IN103D = **0.50 cycles**

These settings provide input energization/de-energization debounce, and may be adjusted to suit the application.

Inputs IN101–IN103 are indirectly used via the 52AA, 52AB, and 52AC Relay Word bits for other purposes. For example, the SEL-311C pole open logic may use the breaker status inputs as part of the single-pole open (SPO) or three-pole open (3PO) determination (see *Pole-Open Logic on page 5.18*).

The relay also requires a three-phase status Relay Word bit called 52A, that is programmable via SELOGIC control equation 52A. The factory-default setting includes the 52AA, 52AB, and 52AC Relay Word bits, as described in *Breaker Status Logic on page 6.2*.

Relay Word bit 52A appears in factory SELOGIC control equation settings BSYNCH (see *Synchronism-Check Elements on page 3.53*) and 79RIS (see *Reclosing Relay on page 6.16*).

Using Relay Word bits IN101–IN103 for the circuit breaker status settings 52AA, 52AB, and 52AC does *not* prevent using Relay Word bits IN101–IN103 in other SELOGIC control equation settings.

Input IN104

Relay Word bit IN104 is used in the factory settings for the SELOGIC control equation received permissive trip setting.

PT1 = **IN104**

Connect input IN104 to the communications receiver permissive trip output.

When the permissive trip (RX) output contact is open, input IN104 is de-energized and the permissive trip input is deasserted.

PT1 = **IN104** = logical 0

When the permissive trip (RX) output contact is closed, input **IN104** is energized and the permissive trip input is asserted.

PT1 = **IN104** = 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 **IN104** (IN104D) could be set as follows.

IN104D = **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 16 local control switches by using the **CNTRL** pushbutton on the front-panel keyboard/display (see *Section 11: Front-Panel Interface*).

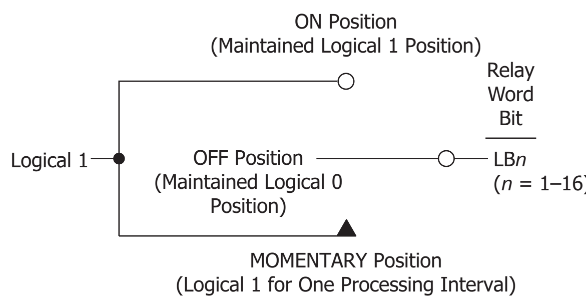


Figure 7.4 Local Control Switches Drive Local Bits LB1 Through LB16

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 by using the command **SET T**. View these settings by 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.

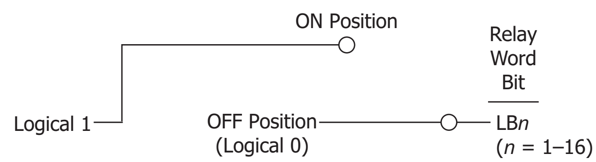


Figure 7.5 Local Control Switch Configured as an ON/OFF Switch

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).

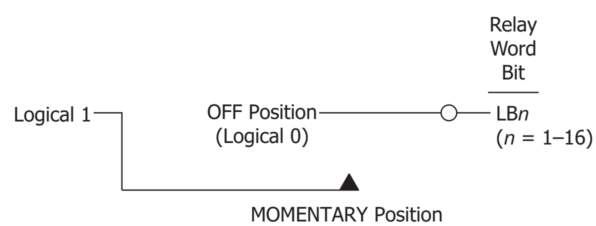


Figure 7.6 Local Control Switch Configured as an OFF/MOMENTARY Switch

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).

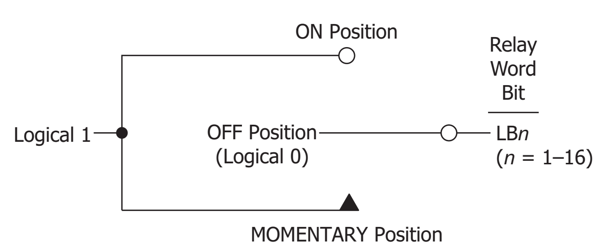


Figure 7.7 Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

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.

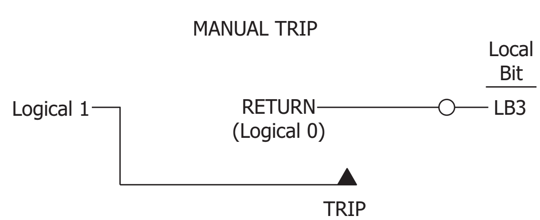


Figure 7.8 Configured Manual Trip Switch Drives Local Bit LB3

Local bit LB3 is set to trip in the following SELOGIC control equation manual trip setting (see *Figure 5.1*).

BKMTR = **... + 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**

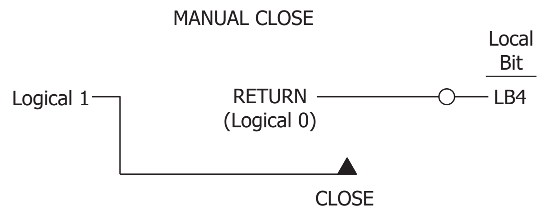


Figure 7.9 Configured Manual Close Switch Drives Local Bit LB4

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 6.5*).

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 applications such as those listed below.

- 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 7.8* 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 10.41*), *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*).

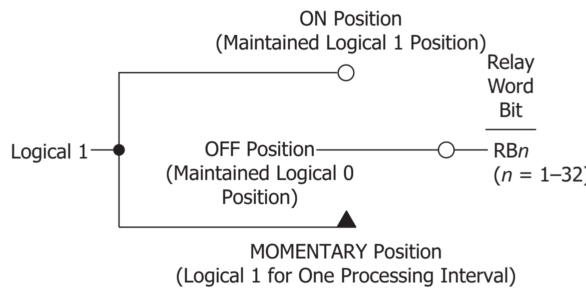


Figure 7.10 Remote Control Switches Drive Remote Bits RB1–RB32

The outputs of the remote control switches in *Figure 7.10* are Relay Word bits RB*n* (*n* = 1 to 32), 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 in which local bits are used (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–RB32) 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 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 section describes remote control switch 3, which is also called remote bit 3 (RB3). All of the remote bits, RB1–RB32, operate in the same way.

See *CON Command (Control Remote Bit) on page 10.41*.

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).

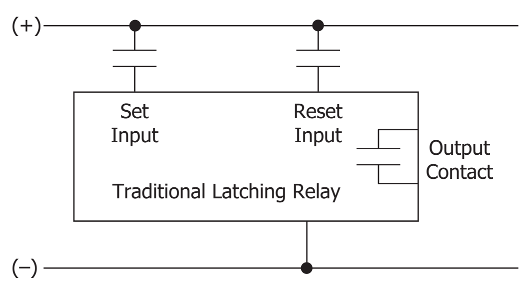


Figure 7.11 Traditional Latching Relay

The 16 latch control switches in the SEL-311C provide latching relay type functions.

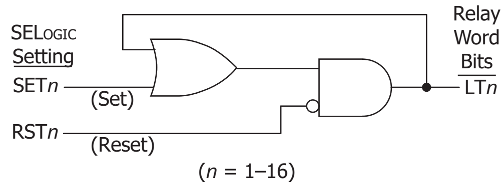


Figure 7.12 Latch Control Switches Drive Latch Bits LT1–LT16

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 the following.

- 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.

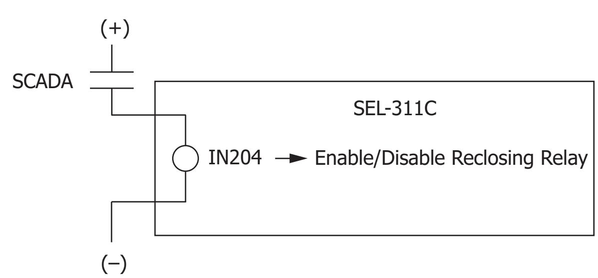


Figure 7.13 SCADA Contact Pulses Input IN204 to Enable/Disable Reclosing Relay

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 as shown below.

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]

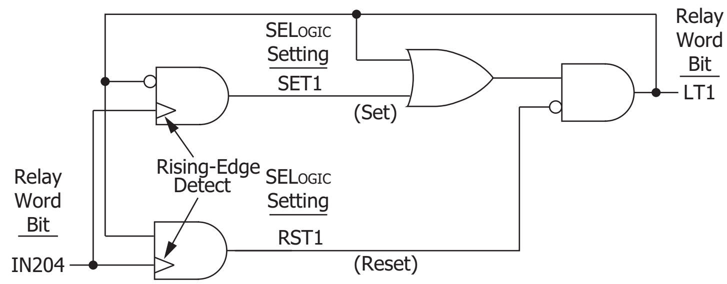


Figure 7.14 Latch Control Switch Controlled by a Single Input to Enable/Disable Reclosing

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 in the next processing interval.

LT1 = logical 1

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 7.1 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.

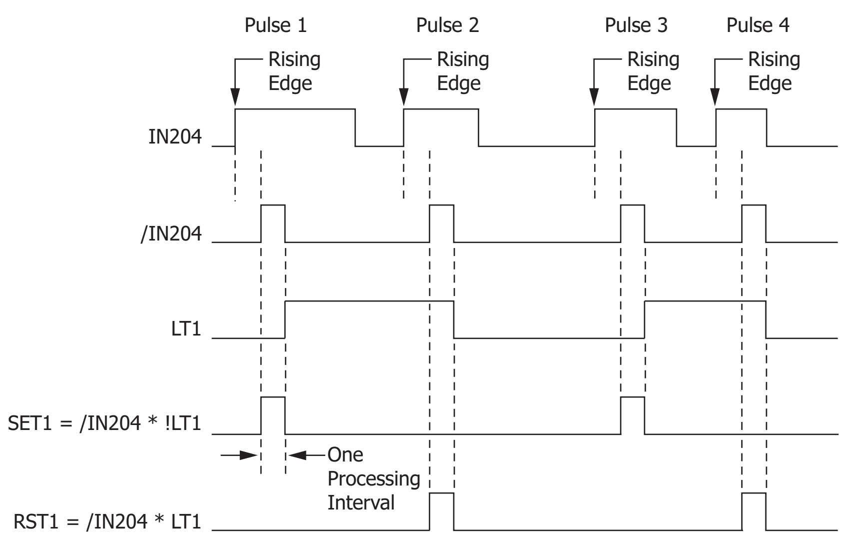


Figure 7.15 Latch Control Switch Operation Time Line

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–RB32) are operated through the serial port. See *Remote Control Switches on page 7.9* 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 7.14* 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]

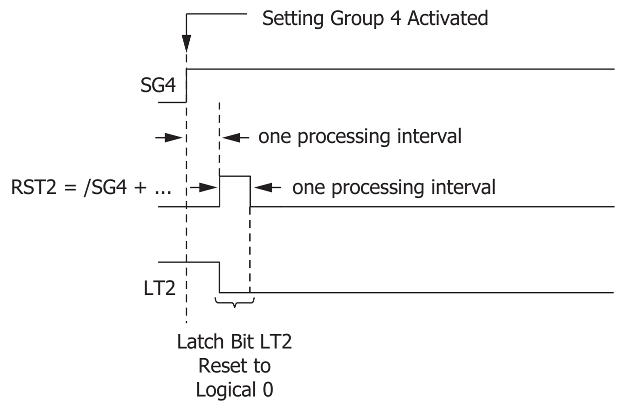


Figure 7.16 Time Line for Reset of Latch Bit LT2 After Active Setting Group Change

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 turned on 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–IN216 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).

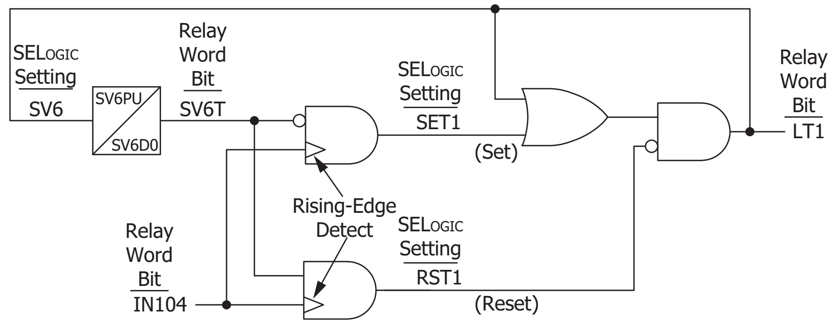


Figure 7.17 Latch Control Switch (With Time Delay Feedback) Controlled by a Single Input to Enable/Disable Reclosing

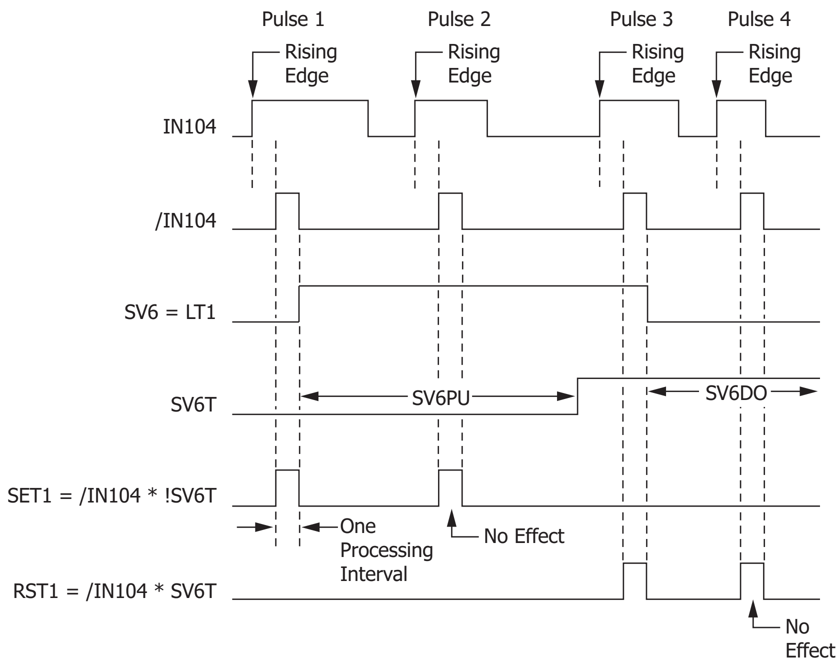


Figure 7.18 Latch Control Switch (With Time Delay Feedback) Operation Time Line

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 (Sheet 1 of 2)

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

Table 7.3 Definitions for Active Setting Group Indication Relay Word Bits SG1 Through SG6 (Sheet 2 of 2)

Relay Word Bit	Definition
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 one of the following.

- 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, the front-panel **GROUP** pushbutton, DNP, and Modbus 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, the other group switch controls cannot be used to switch the active setting group. But if SS1–SS6 *all* deassert to logical 0, the other controls 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–RB32), 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.

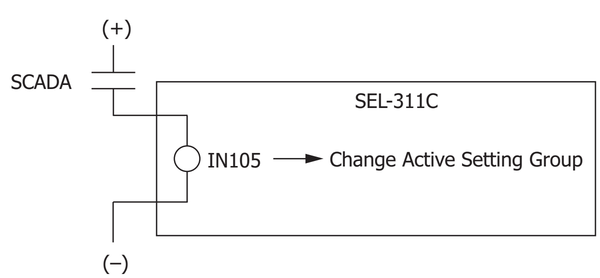


Figure 7.19 SCADA Contact Pulses Input IN105 to Switch Active Setting Group Between Setting Groups 1 and 4

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 Group 1 and Group 4.

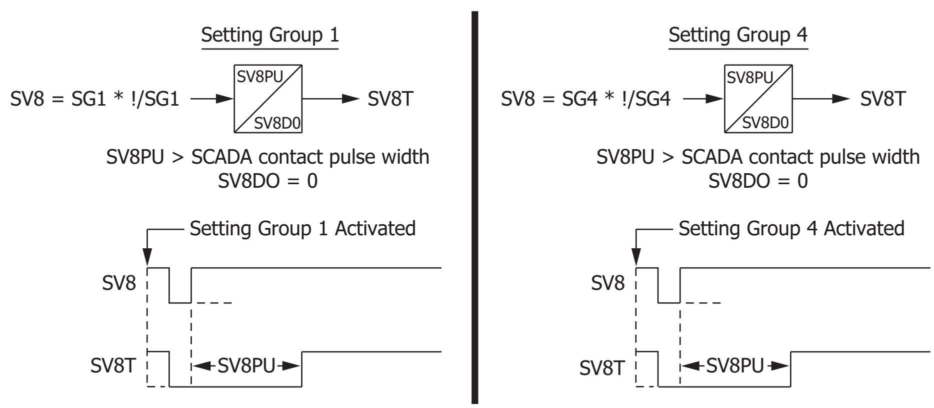


Figure 7.20 SELOGIC Control Equation Variable Timer SV8T Used in Setting Group Switching

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 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.

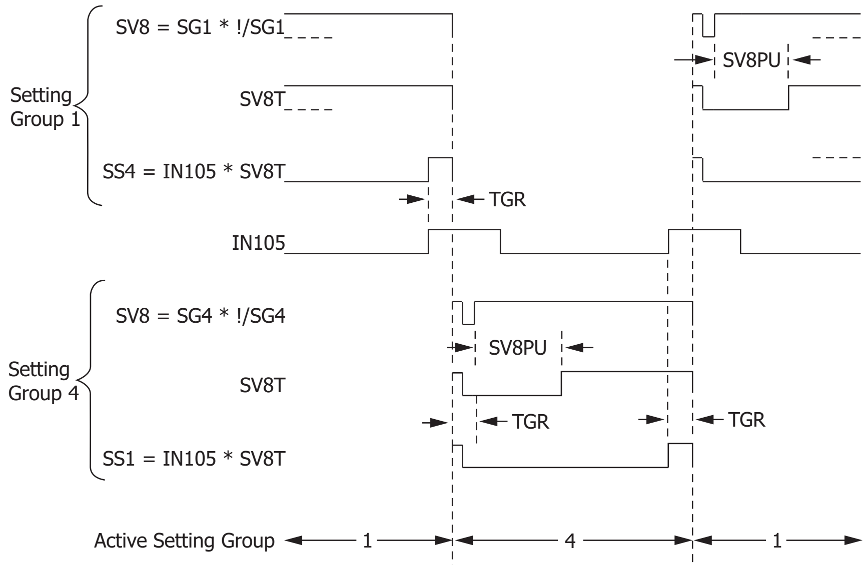


Figure 7.21 Active Setting Group Switching (With Single Input) Time Line

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*.

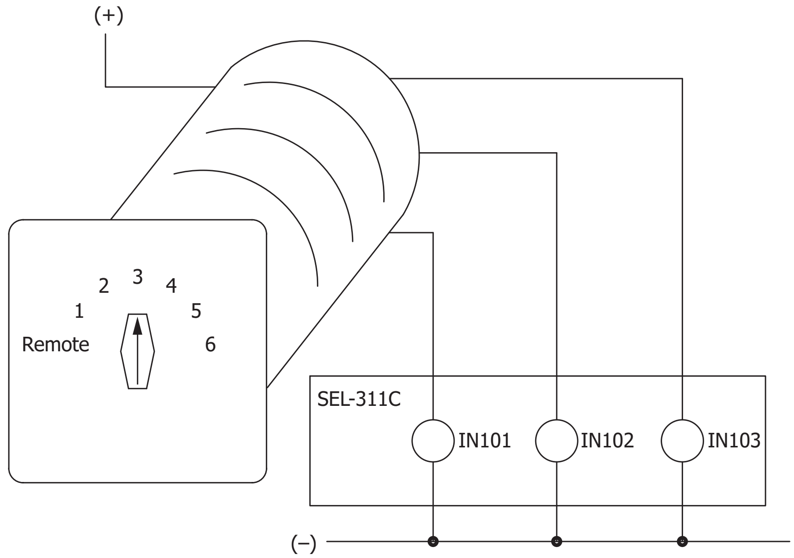


Figure 7.22 Rotating Selector Switch Connected to Inputs IN101, IN102, and IN103 for Active Setting Group Switching

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 Group 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 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 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.

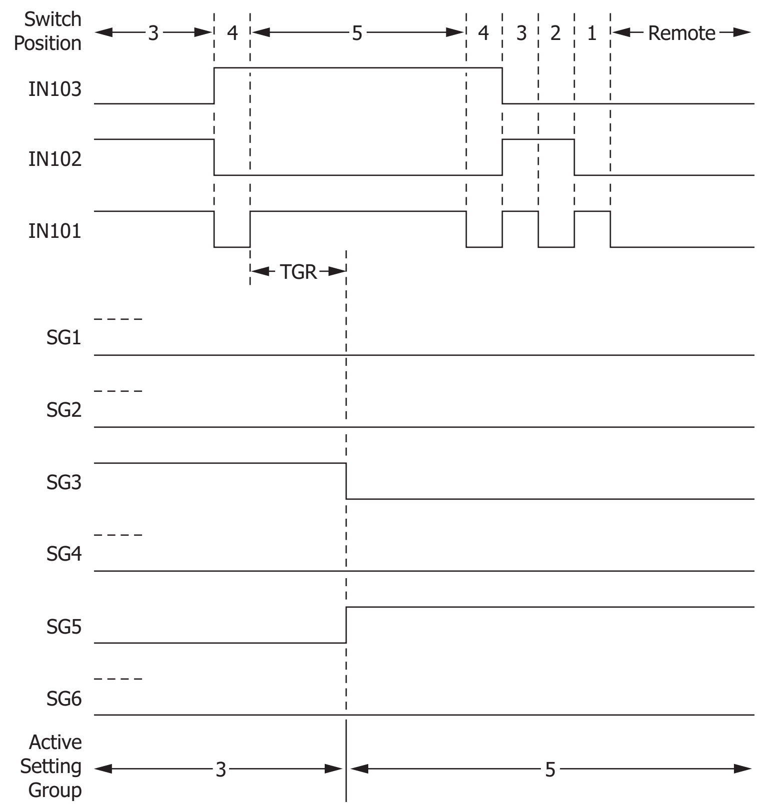


Figure 7.23 Active Setting Group Switching (With Rotating Selector Switch) Time Line

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 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 1 to 16 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).

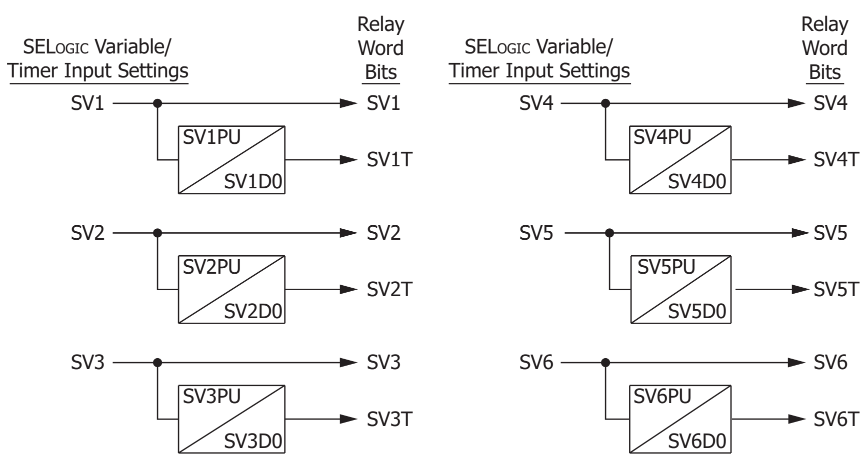


Figure 7.24 SELOGIC Control Equation Variables/Timers SV1/SV1T Through SV6/SV6T

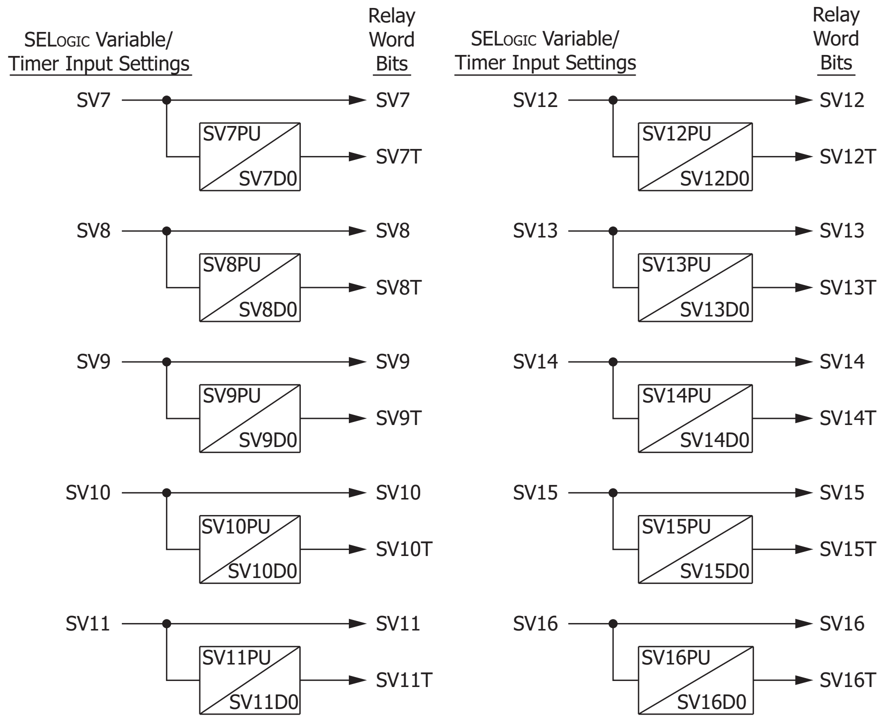


Figure 7.25 SELOGIC Control Equation Variables/Timers SV7/SV7T Through SV16/SV16T

Settings Example

In the SELOGIC control equation settings, a SELOGIC control equation timer is used for a simple breaker failure scheme.

SV1 = **SPT + 3PT * !\SPT**

The single-phase and three-phase trip states are 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 both the single-phase TDUR1D and three-phase TDUR3D trip duration settings. 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 OUT105.

OUT105 = **SV1T**

In situations where a single-phase trip condition (SPT = logical 1, 3PT = logical 0) evolves into a three-phase trip condition (SPT = logical 0, 3PT = logical 1), the trip duration timer TDUR1D may have partially timed before the TDUR3D setting takes over. If SV1PU is set close in value to TDUR1D or TDUR3D, a simple OR equation of SPT + 3PT might allow a false breaker failure pickup. To prevent this from happening, the * !\SPT term is included in the SV1 equation to momentarily deassert SV1 and restart the pickup timing.

!\SPT = **NOT** (falling edge of SPT) (= logical 0 for one processing interval after SPT deasserts)

Additional Settings Example 1

Another application idea is dedicated breaker failure protection with breaker failure initiate seal-in (see *Figure 7.26*).

SV6 = **IN106** (breaker failure initiate)

SV7 = **(SV7 + IN106) * 50BFT**

OUT106 = **SV6T** (retrip)

OUT107 = **SV7T** (breaker failure trip)

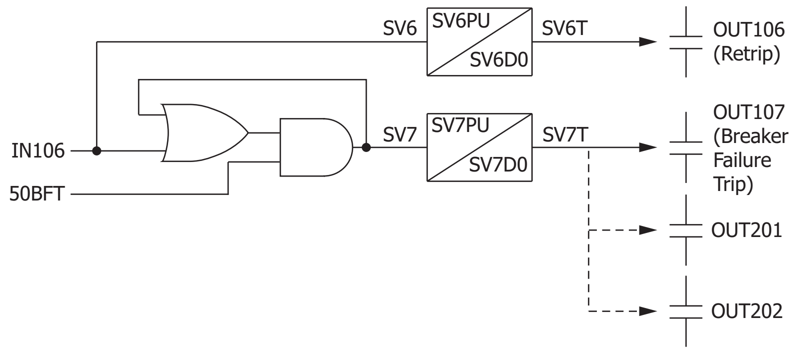


Figure 7.26 Dedicated Breaker Failure Scheme Created With SELOGIC Control Equation Variables/Timers

Relay Word bit 50BFT is the output of the three-phase breaker failure current detector logic (see *Breaker Failure Protection on page 5.44*).

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) * 50BFT**

Optoisolated input **IN106** functions as a breaker failure initiate input. Relay Word bit 50BFT functions as a fault detector.

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 50BFT 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 the greater of Group settings TDUR1D or TDUR3D.

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) * 50BFT**

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 current detector 50BFT, or turning off 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) * 50BFT * !/SG6**

   In Group 5

   SV7 = **(SV7 + IN106) * 50BFT * !/SG5**

   •
   •
   •

   In Group 1

   SV7 = **(SV7 + IN106) * 50BFT * !/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) * 50BFT * !/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) * 50BFT * !/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 control equation 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*.

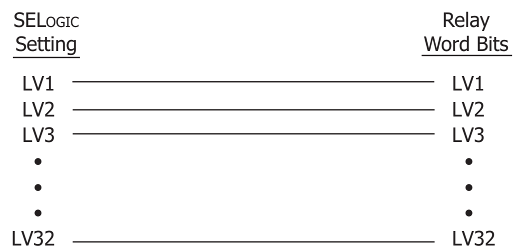


Figure 7.27 Logic Variables

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 control 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

NOTE: If Logic Variables are used in mission-critical SELOGIC control equations, such as in the trip equation, care should be taken to consider the power loss condition and the processing order of Logic Variables (refer to *Table F.4*). See *Processing Order Considerations on page F.12* for more information.

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, 52AA, 52AB, 52AC, 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.

Virtual bits are volatile and are reset to zero when a new CID file is loaded, the device is restarted, or they are overwritten by another GOOSE message.

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 2.9 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, the equations of six output contacts are used.

OUT101 = **3PT + TPA** (automatic tripping three-phase or A-phase/manual tripping three-phase; see *Section 5: Trip and Target Logic*)

OUT102 = **3PT + TPB** (automatic tripping three-phase or B-phase/manual tripping three-phase)

OUT103 = **3PT + TPC** (automatic tripping three-phase or C-phase/manual tripping three-phase)

OUT104 = **KEY** (POTT scheme key permissive trip; see *Section 5: Trip and Target Logic*)

OUT105 = **CLOSE** (automatic reclosing/manual closing; see *Section 6: Close and Reclose Logic*)

OUT106 = **0** (output contact **OUT106** not used—set equal to zero)

OUT107 = **0** (output contact **OUT107** not used—set equal to zero)

ALRMOUT = **!(SALARM + HALARM)**

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 2.29* for output contact type options.

ALARM Output Contact

NOTE: Firmware versions R502 and earlier have fixed alarm logic. Refer to the documentation provided with earlier firmware for details on the operation of the ALARM output.

Refer to *Figure 7.28* and *Relay Self-Tests on page 13.6*.

With factory-default logic settings, when the relay is operational and there are no alarm conditions, the **ALARM** output contact coil is energized and the Relay Word bit ALARM is deasserted. When an alarm occurs, the **ALARM** output contact closes or opens, depending on the **ALARM** output contact type (a or b), as demonstrated in *Figure 7.28*, and Relay Word bit ALARM asserts.

The alarm outputs are controlled by SELOGIC control equation ALRMOUT. The default setting for this equation is shown below.

ALRMOUT = **!(SALARM + HALARM)**

NOTE: The default setting of SELOGIC control equation ALRMOUT mimics the alarm behavior of firmware versions R502 and earlier.

With this setting, SELOGIC control equation and Relay Word bit ALRMOUT are asserted and the **ALARM** output relay coil is energized when the relay has power and there are no alarm conditions. OUT107, if it is configured as an alarm output by using main board jumper **JMP10**, is also energized. As shown in *Figure 7.28*, Relay Word bit ALARM is deasserted, because it is the opposite of ALRMOUT.

When a software or hardware alarm condition occurs, SELOGIC control equation and Relay Word bit ALRMOUT are deasserted, Relay Word bit ALARM is asserted, and the **ALARM** output relay coil is de-energized. OUT107, if it is configured as an alarm output by using main board jumper **JMP10**, is also de-energized.

The **ALARM** and **OUT107** output relay coils are also de-energized if the relay restarts, there is a loss of power, or a failure prevents the relay from operating.

The alarm output contacts can be programmed to change state for the following reasons.

1. Software alarm conditions programmed in SELOGIC control equation SALARM.
2. Hardware warning or failure conditions from relay self-test logic.

Software alarm conditions are programmed in SELOGIC control equation SALARM and may be modified as necessary for the application. The following Relay Word bits are available to monitor software alarm conditions.

ACCESS—Asserts while any user is logged in at Access Level B or higher.

ACCESSP—Pulses for approximately one second when any user increases to Access Level B or higher.

SETCHG—Pulses for approximately one second when settings are changed or saved.

SETCHG does not pulse when settings are reset to defaults or when the active settings group switches.

CHGPASS—Pulses for approximately one second whenever a password changes.

PASNVAL—Pulses for approximately one second when an incorrect password is entered when attempting to enter Access Level B or higher, or when an incorrect password is entered when attempting to change passwords.

BADPASS—Pulses for approximately one second whenever a user enters three successive incorrect passwords in an SEL ASCII terminal session or web session.

GRPSW—Pulses for approximately one second when the relay switches active settings group.

These Relay Word bits are intended for indication only and should not be used in protection logic.

NOTE: The SALARM setting makes the software alarm behavior similar to that of firmware version R502 and earlier. SETCHG now pulses when Port, DNP, and Modbus settings are saved and when settings are copied into a settings group that is not the active settings group. The alarm output does not pulse for these settings save operations in R502 and earlier.

In default settings, SELOGIC control equation SALARM is set as follows.

SALARM = **BADPASS + CHGPASS + SETCHG + GRPSW + ACCESSP + PASNVAL**

Hardware alarm conditions are generated by the relay self-test logic (see *Table 13.3*) and are classified as warnings or failures, depending upon severity. Relay Word bit HALARM pulses for approximately five seconds to indicate that a hardware warning has occurred and asserts continuously when there is a hardware failure. Additional hardware alarm Relay Word bits HALARMP, HALARML, and HALARMA are available to support custom alarm schemes. See *Relay Self-Tests on page 13.6*.

In a standard shipment, the ALARM output is a Form B contact. This contact closes to alarm with the factory-default logic. If a Form A contact is necessary (open to alarm), do not change the ALRMOUT SELOGIC control equation so that the ALARM output must energize to alarm, as this will cause incorrect alarm operation during hardware and power failures. Instead, use OUT107 as an extra alarm output or change the ALARM output to a Form A contact. See *Output Contact Jumpers on page 2.29* and *“Extra Alarm” Output Contact Control Jumper on page 2.29*.

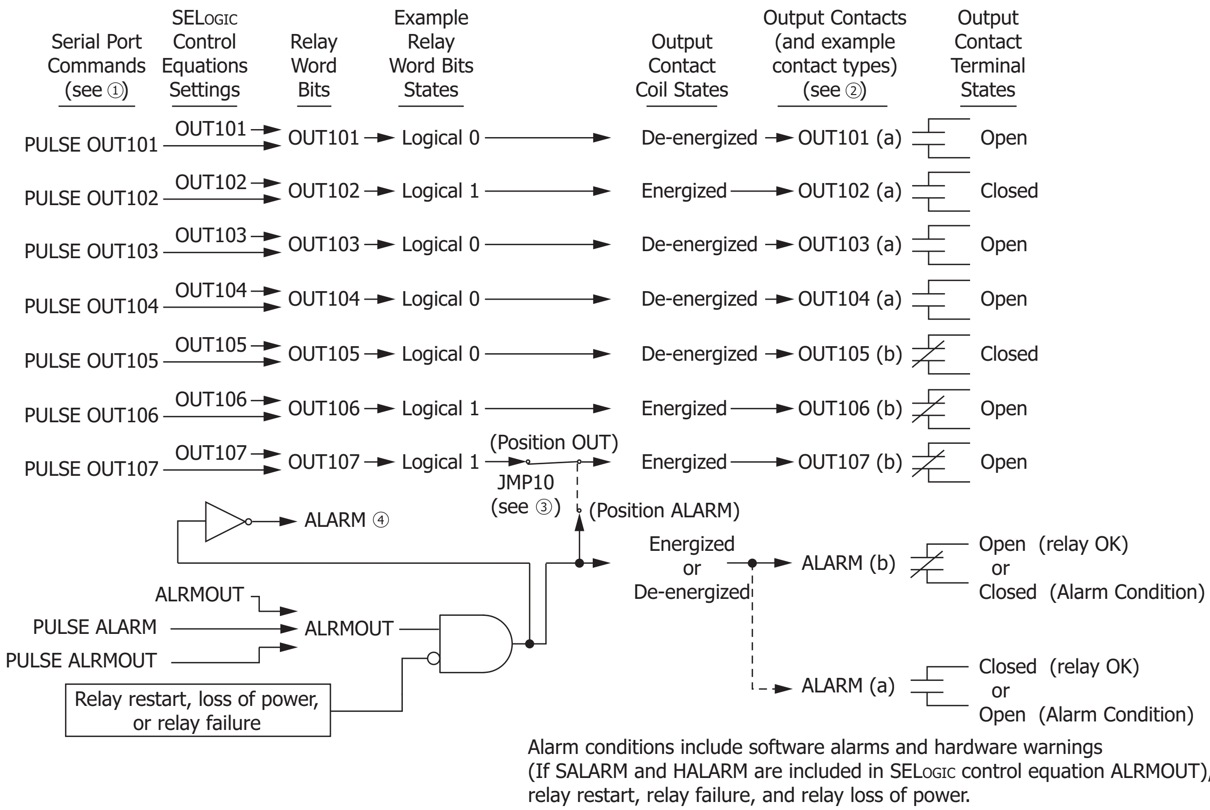
To verify ALARM output contact mechanical integrity, execute the serial port command **PULSE ALARM**. Execution of this command momentarily de-energizes the ALARM output contact coil.

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 2.29* for output contact type options.

Output Contacts OUT201–OUT2xx (On Relays With Optional Extra I/O Board)

Refer to *Figure 7.29* and *Figure 7.30*.

The various I/O board choices have 4, 8, or 12 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 2.29* for full information.



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).

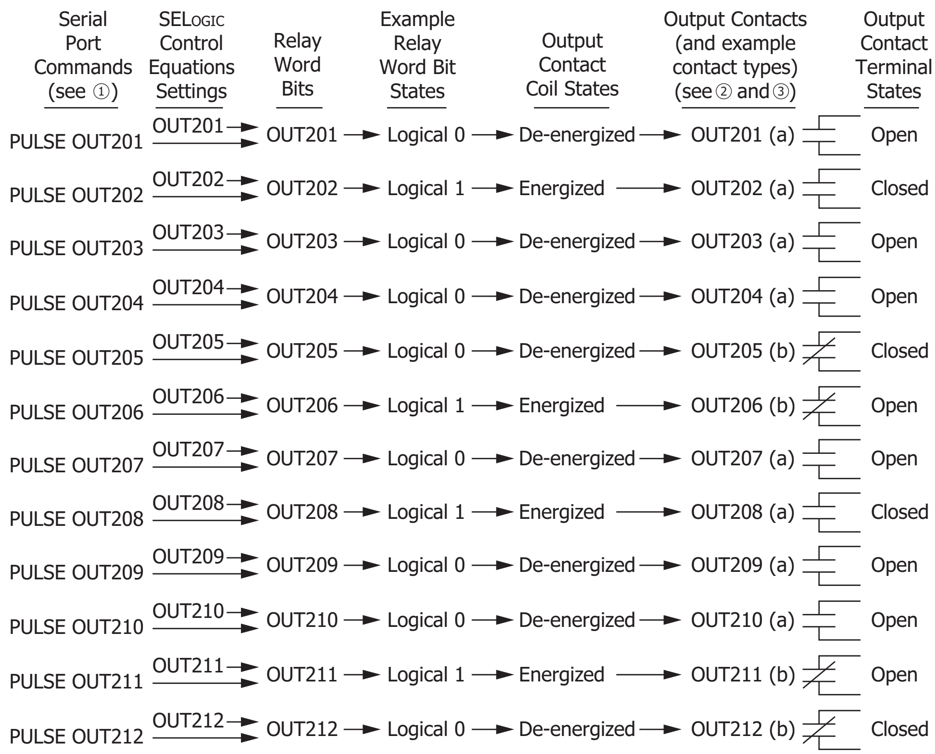
② Output contacts **OUT101–ALARM** are configurable as Form A or Form B output contacts. See Figure 2.20 and Output Contact Jumpers on page 2.29 for more information on selecting output contact type. **OUT101–OUT107** are shipped as Form A contacts, and **ALARM** is shipped as a Form B contact in the standard relay configuration.

③ Main I/O board jumper **JMP10** allows output contact **OUT107** to operate as a regular output contact **OUT107** or as an extra Alarm output contact.

④ Although the **ALARM** output changes state, Relay Word bit ALARM does not assert during a loss of power, relay restart, or a relay failure. Relay Word bit ALARM asserts briefly after a restart and upon recovery from loss of power.

See Figure 2.20 and Output Contact Jumpers on page 2.29 for more information on jumper **JMP10**.

Figure 7.28 Logic Flow for Example Output Contact Operation (All Models)

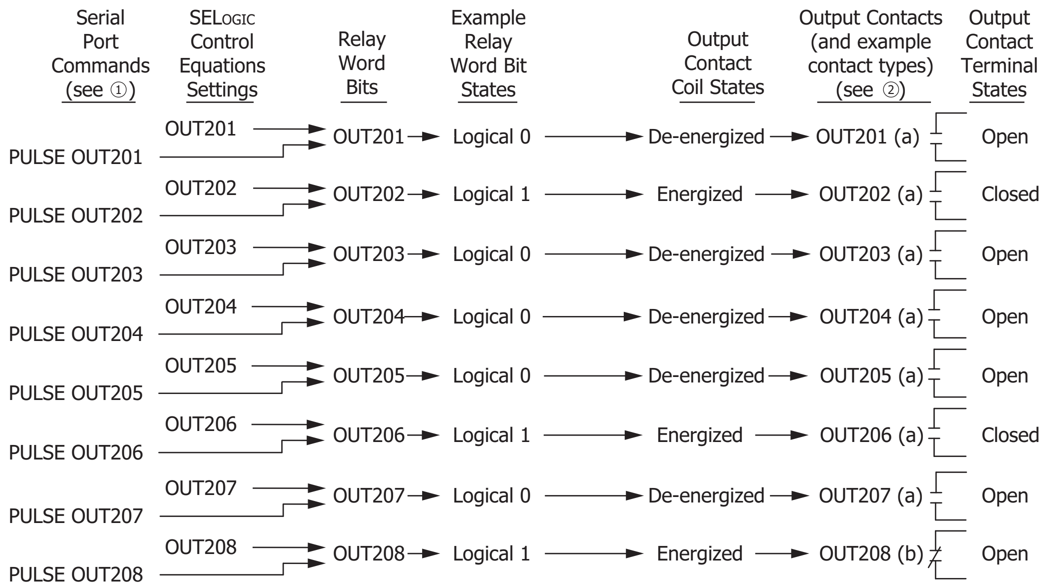


① **PULSE** command is also available via the front panel (**CNTRL** pushbutton, `Output Contact Testing` option). Execution of the **PULSE** command results in a logical 1 input into the above logic (one-second default pulse width).

② All output contacts are configurable as Form A or Form B output contacts. See Output Contact Jumpers on page 2.29 for more information on selecting output contact type. **OUT201–OUT212** are shipped as Form A contacts in the standard relay configuration for extra I/O board Options 2 or 6. **OUT201–OUT204** are shipped as Form A contacts in the standard relay configuration for extra I/O board Option 4.

③ I/O board Option 4 has output contacts **OUT201—OUT204** only.

Figure 7.29 Logic Flow for Example Output Contact Operation—Extra I/O Board (Models 0311Cxxxxxxxx2x, 0311Cxxxxxxxx4x, 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 2.29 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 follows.

- circuit breaker open/closed
- reclosing relay enabled/disabled

Traditional Indicating Panel Lights

NOTE: The examples shown for replacing traditional indicating panel lights are provided for tutorial purposes only. Using the 52A Relay Word bit to drive a display point on the SEL-311C-2 may provide misleading breaker status reporting. See Factory Display Point Settings on page 7.40 for a detailed explanation.

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]

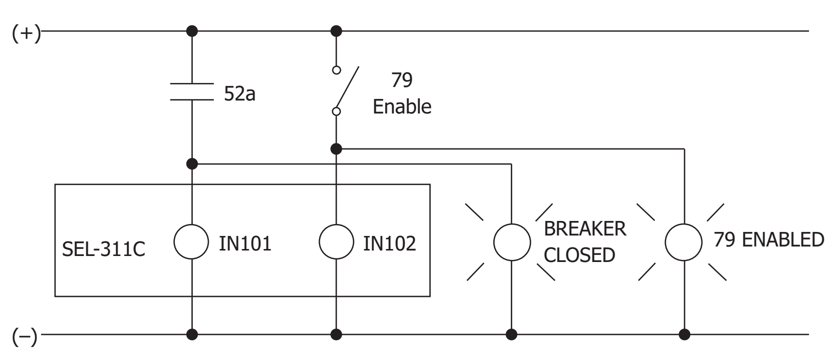


Figure 7.31 Traditional Panel Light Installations

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.

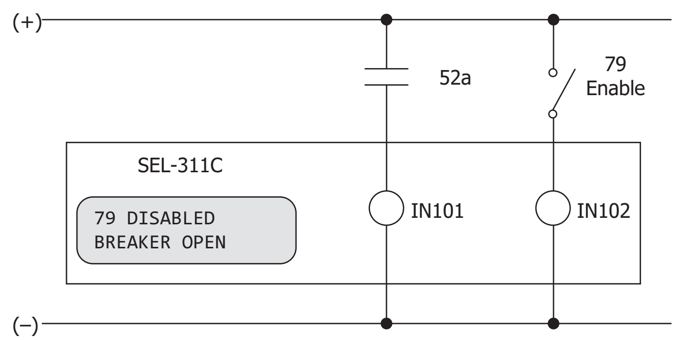


Figure 7.32 Rotating Default Display Replaces Traditional Panel Light Installations

There are 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 by using the command **SET T** or the Text settings in QuickSet. View these text settings by using the serial port command **SHO T** (see *Section 9: Setting the Relay* and *Section 10: Communications*) or the Text settings in QuickSet. These text settings are displayed on the SEL-311C front-panel display on a time-variable rotation by 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–RB32), 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 the following.

DP1 = **IN102** = logical 1

This results in the display of corresponding text setting DP1_1 on the front-panel display as shown below.

```
79 ENABLED
```

Reclosing Relay Disabled

In *Figure 7.32*, optoisolated input IN102 is de-energized to disable the reclosing relay, resulting in the following.

DP1 = **IN102** = logical 0

This results in the display of corresponding text setting DP1_0 on the front-panel display as shown below.

```
79 DISABLED
```

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.

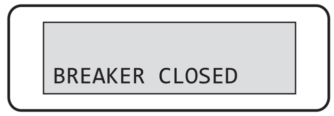
Circuit Breaker Closed

In *Figure 7.32*, optoisolated input IN101 is energized when the 52a circuit breaker auxiliary contact is closed, resulting in the following.

52A = **IN101** = logical 1

DP2 = **52A** = logical 1

This results in the display of corresponding text setting DP2_1 on the front-panel display as shown below.



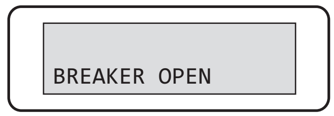
Circuit Breaker Open

In *Figure 7.32*, optoisolated input **IN101** is de-energized when the 52a circuit breaker auxiliary contact is open, resulting in the following.

52A = **IN101** = logical 0

DP2 = **52A** = logical 0

This results in the display of corresponding text setting DP2_0 on the front-panel display as shown below.



Factory Display Point Settings

Three display points are used in the SEL-311C-2 relay factory-default settings, as follows.

In the logic settings class

DP1 = **!(3PO + SPO**)

DP2 = **SPO**

DP3 = **3PO**

DP4 = **0**

•

•

•

DP16 = **0**

In the text settings class

DP1_1 = **BREAKER CLOSED**

DP1_0 = **NA**

DP2_1 = **SINGLE POLE OPEN**

DP2_0 = **NA**

DP3_1 = **THREE POLE OPEN**

DP3_0 = **NA**

(Remaining display point settings = NA)

The operation of the relay with default settings will be similar to the previous Settings Examples, except only one of the `BREAKER CLOSED`/`SINGLE POLE OPEN`/`THREE POLE OPEN` messages will appear at a time.

For example, when both 3PO and SPO are deasserted (= logical 0), the expression

DP1 = **!(3PO + SPO) = NOT(3PO OR SPO) = NOT** (logical 0) = logical 1

SELOGIC control equation DP1 evaluates to logical 1 and causes the message `DP1_1 = BREAKER CLOSED` to appear on the front-panel display.

At the same time, the following expressions select the corresponding DP2_0 and DP3_0 messages, but because they are both set to NA, no additional message displays.

DP2 = **SPO** (= logical 0)

DP3 = **3PO** (= logical 0)

See *Pole-Open Logic on page 5.18* for details on the 3PO and SPO Relay Word bits.

Notice that the factory-default display point settings do not include 52A. The reason is that the factory-default setting for 52A = 52AA * 52AB * 52AC, and this will deassert (= logical 0) when any one-phase breaker is open. There may be a dangerous situation if 52A = logical 0 was being used to drive a display point that indicates the breaker is open, when in fact, one or two phases are still closed. See *Breaker Status Logic on page 6.2* for details on the 52AA, 52AB, 52AC, and 52A functions.

Additional Settings Examples

Continually Display a Message

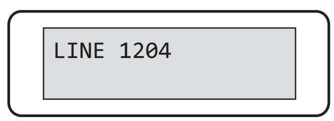
To permanently include a message in the rotation, set the SELOGIC control equation display point setting directly to 0 (logical 0) or 1 (logical 1) and the corresponding text setting. For example, if an SEL-311C is protecting a 230 kV transmission line, labeled "Line 1204," the line name can be permanently 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.



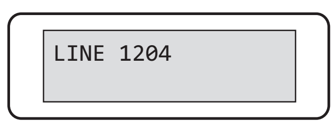
This can also be realized with the following settings.

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)

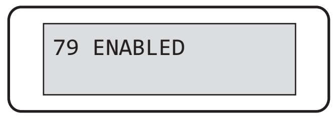
DP1_0 = **79 DISABLED** (displayed when DP1 = logical 0)

Reclosing Relay Enabled

In *Figure 7.32*, optoisolated input IN102 is energized to enable the reclosing relay, resulting in the following.

DP1 = **IN102** = logical 1

This results in the display of corresponding text setting DP1_1 on the front-panel display as shown below.

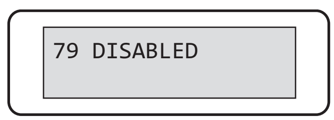


Reclosing Relay Disabled

In *Figure 7.32*, optoisolated input IN102 is de-energized to disable the reclosing relay, resulting in the following.

DP1 = **IN102** = logical 0

This results in the display of corresponding text setting DP1_0 on the front-panel display as shown below.



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 5.24* 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 by 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
```

```
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.

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 as many as 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°
```

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 the use of the rotating display to show breaker wear monitor quantities automatically on the rotating display. This example will set the EXTTRA, INTTRA, INTIA, EXTIA, and WEARA quantities to display in the rotating display.

Set the following settings.

NOTE: Some of the labels for breaker monitor quantities differ between relays. For example, the SEL-311C uses the label ::INTIA, where legacy SEL-311 relays have used ::CTRLIA for the same quantity. See the notes after Table E.1 for details.

SET T	SET L
DP1_0 = ::EXTTRA	DP1 = 0
DP2_0 = ::INTTRA	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 display first,

```
EXTA TRIPS=    4
INTA 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 was 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 settings.

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 display first,

```
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.

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.

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.

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 uppercase 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 the following.

```

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 sections.

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 on page SET.3*). Also, refer to *BRE Command (Breaker Monitor Data) on page 10.36*.

Breaker Wear Monitor

The breaker wear 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*.

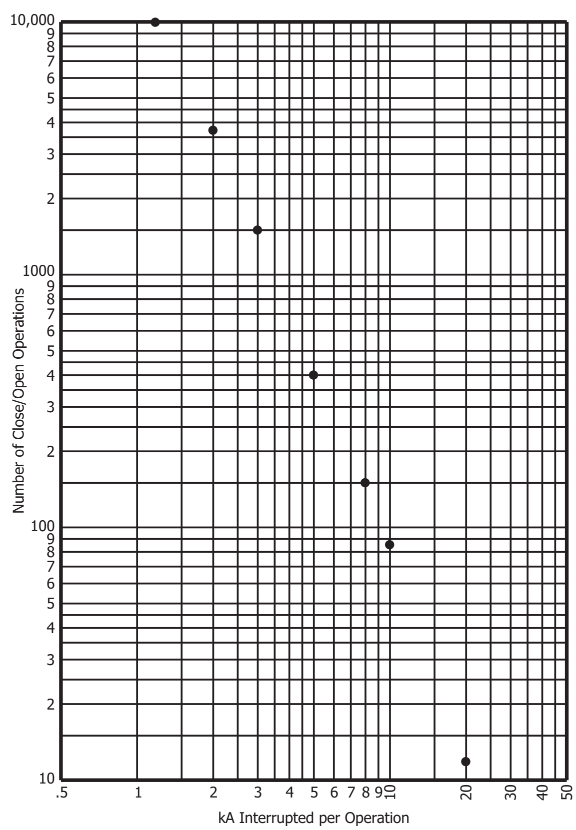


Figure 8.1 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

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
BKMONA	SELOGIC control equation, A-phase breaker monitor initiation setting	Relay Word bits referenced in *Table D.1*
BKMONB	SELOGIC control equation, B-phase breaker monitor initiation setting	Relay Word bits referenced in *Table D.1*
BKMONC	SELOGIC control equation, C-phase 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 A-phase, B-phase, and C-phase do not necessarily interrupt the same magnitude current (depending on fault type and loading).

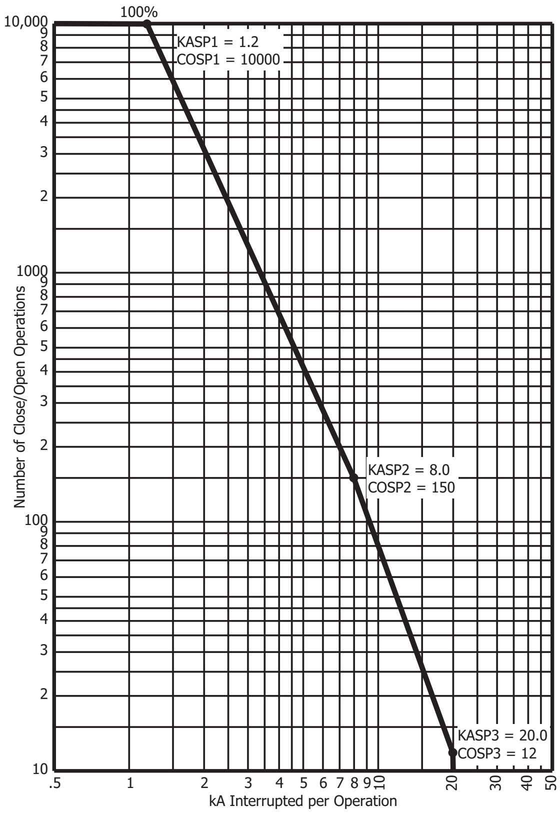


Figure 8.2 Breaker Maintenance Curve for a 25 kV Circuit Breaker

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 relay sets contact wear at 100 percent.

Operation of SELogic Control Equation Breaker Monitor Initiation Setting BKMON

The SELogic control equation breaker monitor initiation setting BKMON*n* in *Table 8.2* determines when the breaker monitor reads in the corresponding phase current value (Phases A, B, and/or 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 10.36*).

NOTE: In the following discussion three elements are specified, one for each phase (n = A, B, and C). The relay only reads and records phase values when the corresponding BKMONn bit is asserted.

The BKMON*n* setting looks for a rising edge (logical 0 to logical 1 transition) as the indication to read in the corresponding phase current value. The acquired current value is 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 settings are listed below:

BKMONA = **TPA + 3PT** (TPA and 3PT are logical outputs of *Figure 5.1*)

BKMONB = **TPB + 3PT** (TPB and 3PT are logical outputs of *Figure 5.1*)

BKMONC = **TPC + 3PT** (TPC and 3PT are logical outputs of *Figure 5.1*)

Refer to *Figure 8.3*. When BKMON*n* asserts (Relay Word bit TP*n* or 3PT goes from logical 0 to logical 1), the breaker monitor reads in the corresponding phase current values and applies it 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*n*. 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.

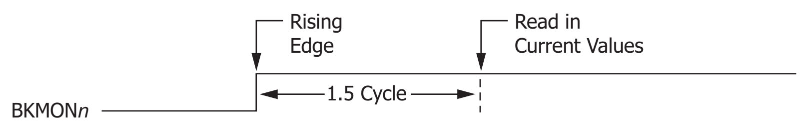


Figure 8.3 Operation of SELogic Control Equation Breaker Monitor Initiation Setting

See *Figure 8.10* and accompanying text for more information on setting BKMON*n*. 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 8.10*). 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.

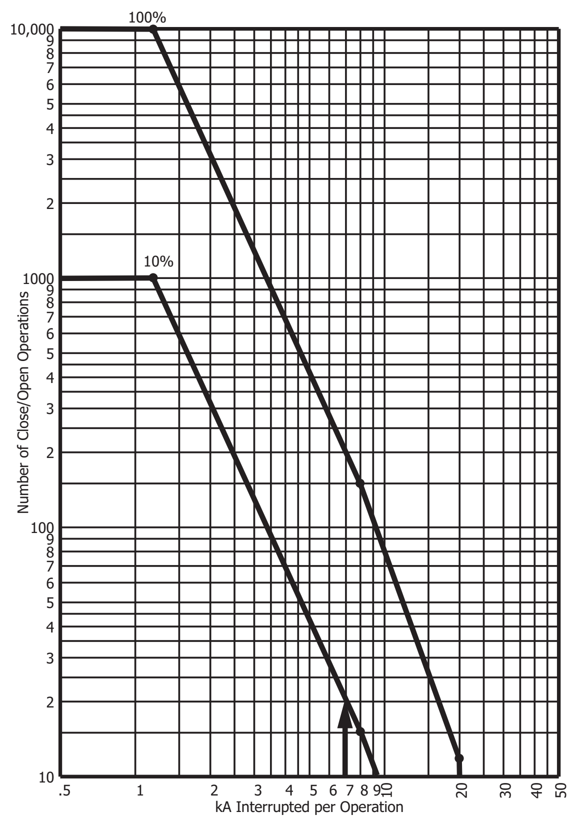


Figure 8.4 Breaker Monitor Accumulates 10 Percent Wear

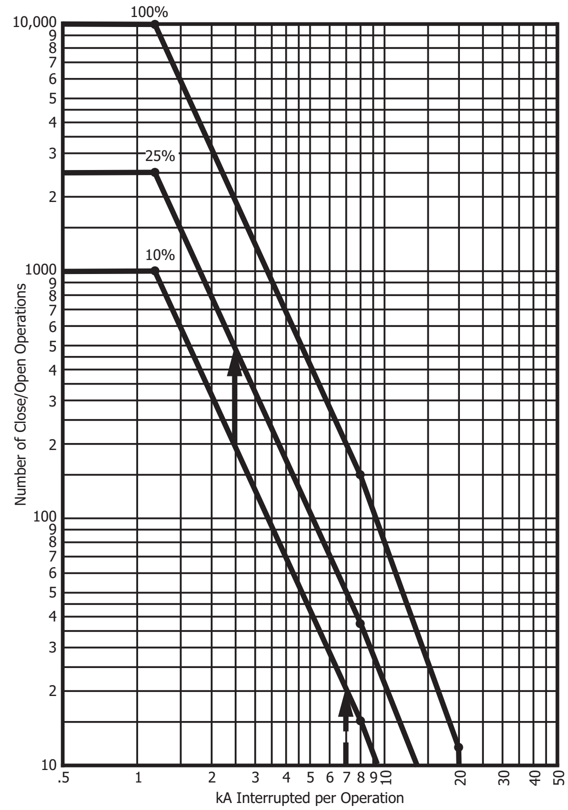


Figure 8.5 Breaker Monitor Accumulates 25 Percent Wear

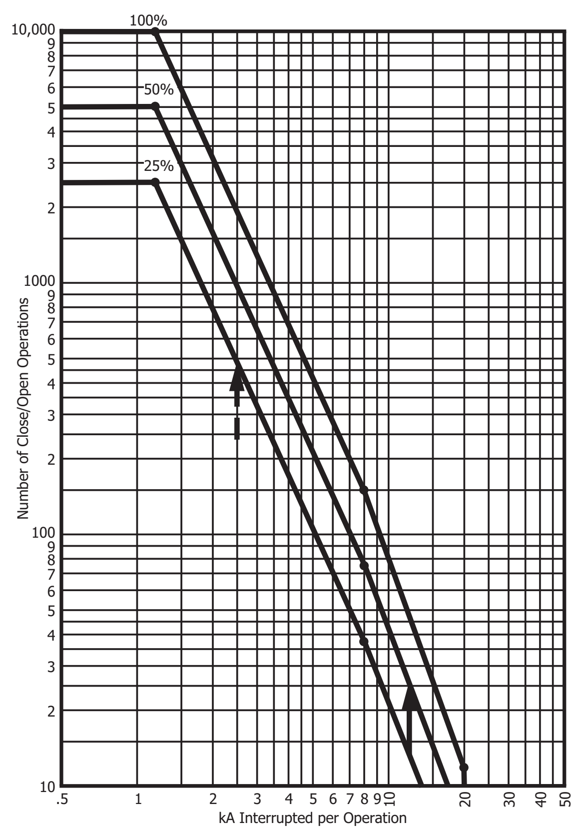


Figure 8.6 Breaker Monitor Accumulates 50 Percent Wear

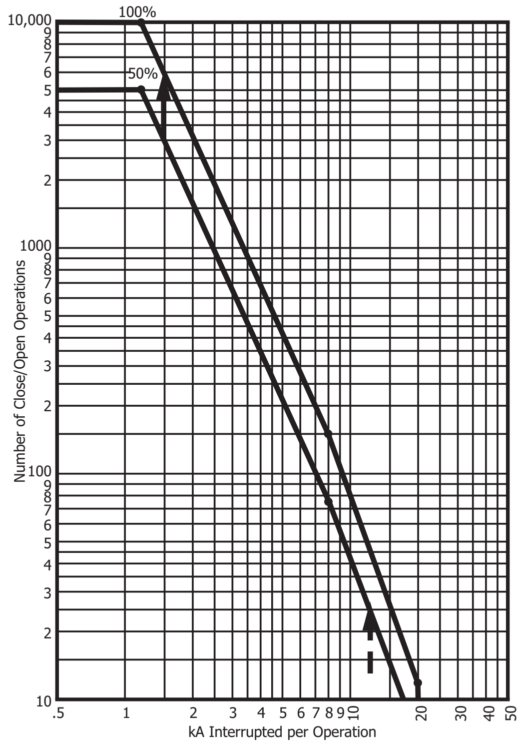


Figure 8.7 Breaker Monitor Accumulates 100 Percent Wear

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	A-phase breaker contact wear has reached the 100 percent wear level
BCWB	B-phase breaker contact wear has reached the 100 percent wear level
BCWC	C-phase 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**

Mechanical and Electrical Operate Timers and Alarms

Mechanical Operate Time

The mechanical operating time is the time between trip or close initiation and the change of status of the circuit breaker status contact. The relay determines the mechanical trip time for the breaker by measuring the time elapsed between the assertion of SELOGIC control equation BKMONA, BKMONB, or BKMONC and the deassertion of the corresponding breaker pole position Relay Word bit 52AA, 52AB, or 52AC. The relay determines the mechanical close time for the breaker by measuring the time elapsed from the assertion of SELOGIC control equation BKCLSA, BKCLSB, or BKCLSC to the assertion of the corresponding breaker pole position Relay Word bit 52AA, 52AB, or 52AC. The relay compares the trip and close time to the mechanical slow operation time thresholds for tripping and closing, Global settings MSTRT and MSCLT, respectively. If the trip or close time exceeds the threshold for a particular phase, the corresponding Relay Word bit MSTRA, MSTRB, or MSTRC for trip or MSCLA, MSCLB, or MSCLC for close pulses for 1/4 cycle, which asserts the electrical slow operation alarm Relay Word bit, MSOAL, for five seconds. The mechanical operation time alarm counter also increments.

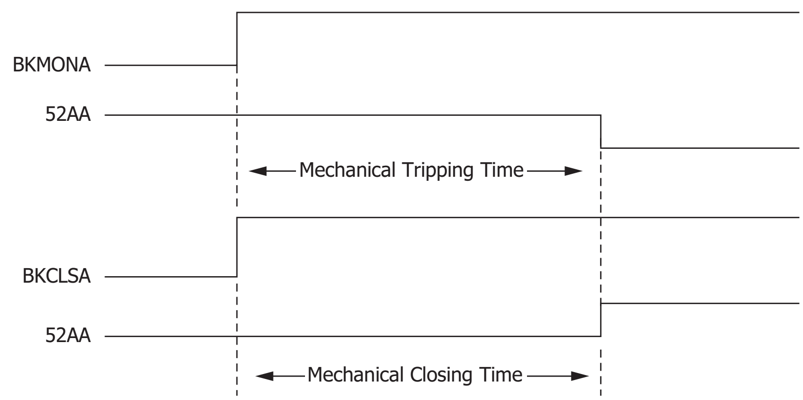


Figure 8.8 Mechanical Operating Time, A-Phase. B-Phase and C-Phase Are Similar

Electrical Operate Time

NOTE: Open-pole detection logic in the SEL-311C relay differs from that used in other products, such as the SEL-451. As a result, electrical operating times calculated by these relays may differ slightly.

The electrical operating time is the time between trip or close initiation and the change of status of the open-pole detection logic. The relay determines the electrical trip time for each breaker pole by measuring the time elapsed between the assertion of SELOGIC control equation BKMONA, BKMONB, or BKMONC and the assertion of the open-pole detection logic. The relay determines the electrical close time for each breaker pole by measuring the time elapsed from the assertion of SELOGIC control equation BKCLSA, BKCLSB, or BKCLSC to the de-assertion of the open-pole detection logic. The relay compares the trip and close time to the electrical slow operation time thresholds for tripping and closing, Global settings ESTRT and ESCLT, respectively. If the trip or close time exceeds the threshold for a particular phase, the corresponding Relay Word bit ESTRA, ESTRB, or ESTRC for trip or ESCLA, ESCLB, or ESCLC for close pulses for 1/4 cycle, which asserts the electrical slow operation alarm Relay Word bit, ESOAL, for five seconds. The electrical operation time alarm counter also increments.

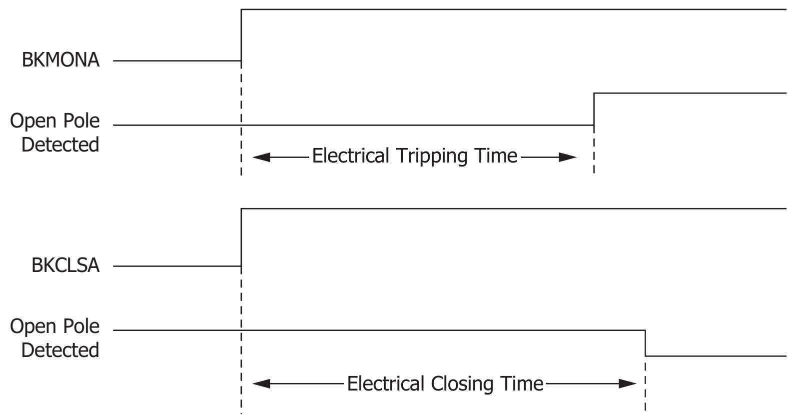


Figure 8.9 Electrical Operating Time, A-Phase. B-Phase and C-Phase Are Similar

Breaker Operation Reporting

After each trip or close operation, the relay stores the mechanical and electrical operate time. If this time does not exceed the slow operating time threshold, the new operate time is combined with previous data to calculate the average operating time. If the time exceeds the threshold, a plus (+) sign is appended to indicate the slow operation. If the time exceeds the threshold by more than 100 milliseconds, timing is stopped. This information can be viewed with the **BRE** command. See *BRE Command (Breaker Monitor Data) on page 10.36*.

NOTE: Trip and close initiations are independent of one another, so back-to-back events only occur when the relay receives two trip or two close initiations.

If the relay detects back-to-back breaker operations and the first event has not finished before the second event starts, the relay displays all incomplete information as 0.00. The relay excludes operate times displayed as 0.00 from the average.

When Global setting DCLOP is set to a numerical value, the relay stores the minimum voltage measured by the DC Voltage monitor function (see *Station DC Battery Monitor on page 8.13* for details) during a 20-cycle period after BKMON asserts or during a 30-cycle period after BKCLS asserts.

View or Reset Breaker Monitor Information

Accumulated breaker wear/operations data are retained if the relay loses power or the breaker monitor is disabled (setting EBMON = N).

Via Serial Port

See *BRE Command (Breaker Monitor Data) on page 10.36*. 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
- Mechanical operate time data
- Electrical operate time data
- Date when the preceding items were last reset

See *BRE n Command (Preload/Reset Breaker Wear) on page 10.37*. The **BRE W** command allows the trip counters, accumulated values, and percent breaker wear to be preloaded for each individual phase.

The **BRE H** command displays the following information for as many as 128 operations.

- ➤ Date and time of relay operation
- ➤ Type of operation (trip/close)
- ➤ Mechanical operate time
- ➤ Electrical operate time
- ➤ Interrupted current for trip operations (measured 1.5 cycles after BKMON asserts)
- ➤ Minimum dc voltage

The **BRE R** command resets the accumulated values and the percent wear for all three phases and clears the events in the **BRE H** command. 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 available via the **BRE** command is also available via the front-panel OTHER pushbutton, with the exception of the electrical and mechanical operate times and the minimum dc voltage. All breaker monitor data can be reset via the front-panel OTHER pushbutton. See *Figure 11.3*.

Via DNP or Modbus

The internal and external trip counters, breaker wear data, electrical and mechanical alarm counters, and the average electrical and mechanical trip and close times 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

Selected breaker monitor data are available via IEC 61850. See the Breaker Monitor section of *Table E.1*.

Reset Via SELOGIC Control 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 8.27*.

Determination of Relay Initiated Trips and Externally Initiated Trips

See *BRE Command (Breaker Monitor Data) on page 10.36*. 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 information is determined by the status of the TRIP Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON*n* operates.

Refer to *Figure 8.3* and accompanying explanation. If BKMON*n* newly asserts (logical 0 to logical 1 transition), the relay reads in the corresponding phase current value (Phases A, B, and/or 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*n* newly asserts (TRIP is the logic output of *Figure 5.1*). If TRIP is asserted (TRIP = logical 1), the corresponding phase 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 corresponding phase 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 settings are shown below.

BKMONA = **TPA + 3PT**

BKMONB = **TPB + 3PT**

BKMONC = **TPC + 3PT**

Thus, any new assertion of BKMON*n* 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 8.10*. 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.

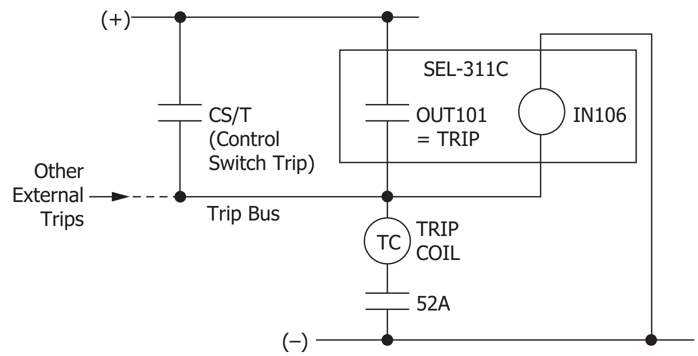


Figure 8.10 Input IN106 Connected to Trip Bus for Breaker Monitor Initiation

If the SELOGIC control equation breaker monitor initiation setting is set,

BKMONn = **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*n* is newly asserted (input IN106 energized), the TRIP Relay Word bit is asserted. Thus, the corresponding phase 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*n* is newly asserted (input IN106 energized), the TRIP Relay Word bit is deasserted. Thus, the corresponding phase 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 on page SET.3*).

DC Under- and Overvoltage Elements

Refer to *Figure 8.11*. 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 *General Specifications 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.

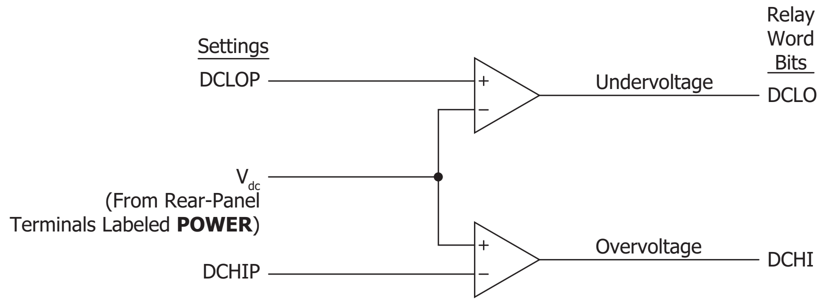


Figure 8.11 DC Under- and Overvoltage Elements

Logic outputs DCLO and DCHI in *Figure 8.11* 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 as follows.

DCLOP < DCHIP or DCLOP > DCHIP

Figure 8.12 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.

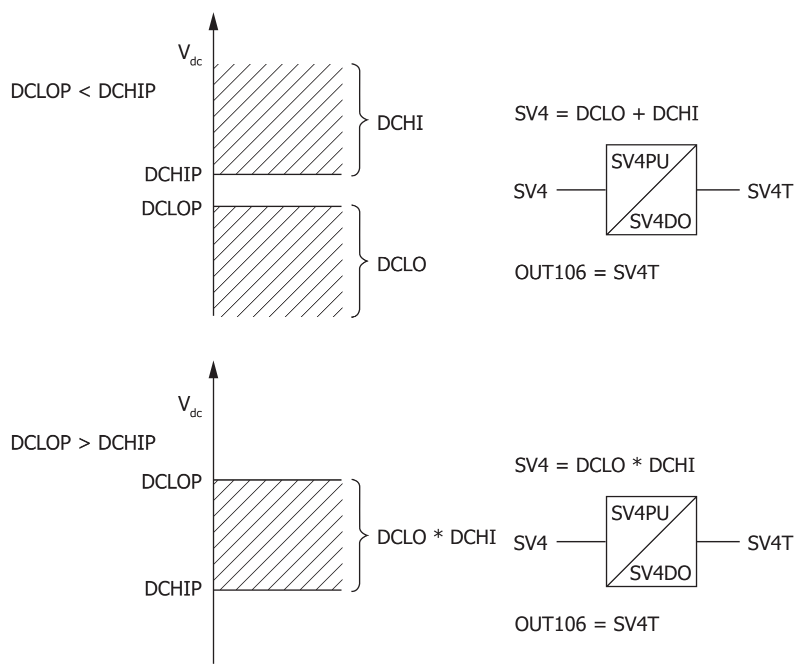


Figure 8.12 Create DC Voltage Elements With SELOGIC Control Equations

DCLO < DCHI (Top of Figure 8.12)

Output contact **OUT106** asserts when either of the following conditions are true.

$V_{dc} \leq$ DCLOP or $V_{dc} \geq$ 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 8.12*), 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 8.12* would probably be a better choice—see the following discussion.

DCLO > DCHI (Bottom of Figure 8.12)

Output contact **OUT106** asserts when the following condition is true.

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 8.12*), 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 7.32* (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 8.12* (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 as listed below.

- 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 as listed below.

- 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 as listed below.

- 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 8.12*. 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 10.52*. 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 Fast Meter, DNP, Modbus, or IEC 61850

The station dc battery voltage reading VDC is available via Fast Meter, 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 12.7*. 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 8.10* and program optoisolated input IN106 (monitoring the trip bus) in the SELOGIC control equation event report generation setting.

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 6.5*)

NOTE: The **BRE** and **BRE H** commands display the minimum dc voltage recorded by the breaker monitor when the breaker trips or closes.

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 8.12*. 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 12.28*).

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 8.11* 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 by 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 by 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 10.52*
- 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.

The relay applies a small-signal cutoff threshold to the voltage and current signals, and this can affect subsequent uses of the measurement. See *Small Signal Cutoff for Metering on page 8.31* for more details.

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.

Voltage Connections for Metering

Description

The SEL-311C supports metering from a three-phase voltage connection from wye-connected Potential Transformers (PTs).

See *Potential Transformer Inputs on page 2.13* for terminal designations and wiring details.

The SEL-311C metering output values are available as analog quantities, and a full listing appears in *Table E.1*.

Table 8.3 identifies the metering outputs that are available in the SEL-311C. 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

Currents[a] MET	Voltages[a] MET	Power MET	Demand and Peak Demand IN and OUT[b] MET D	Energy IN and OUT[b] MET E	Maximum/Minimum MET M
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

[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 on page SET.23*). Also, refer to *MET Command (Metering Data) on page 10.52*).

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
$MVAR_{A,\,B,\,C}$	Single-phase megaVARs
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 8.13* 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”).

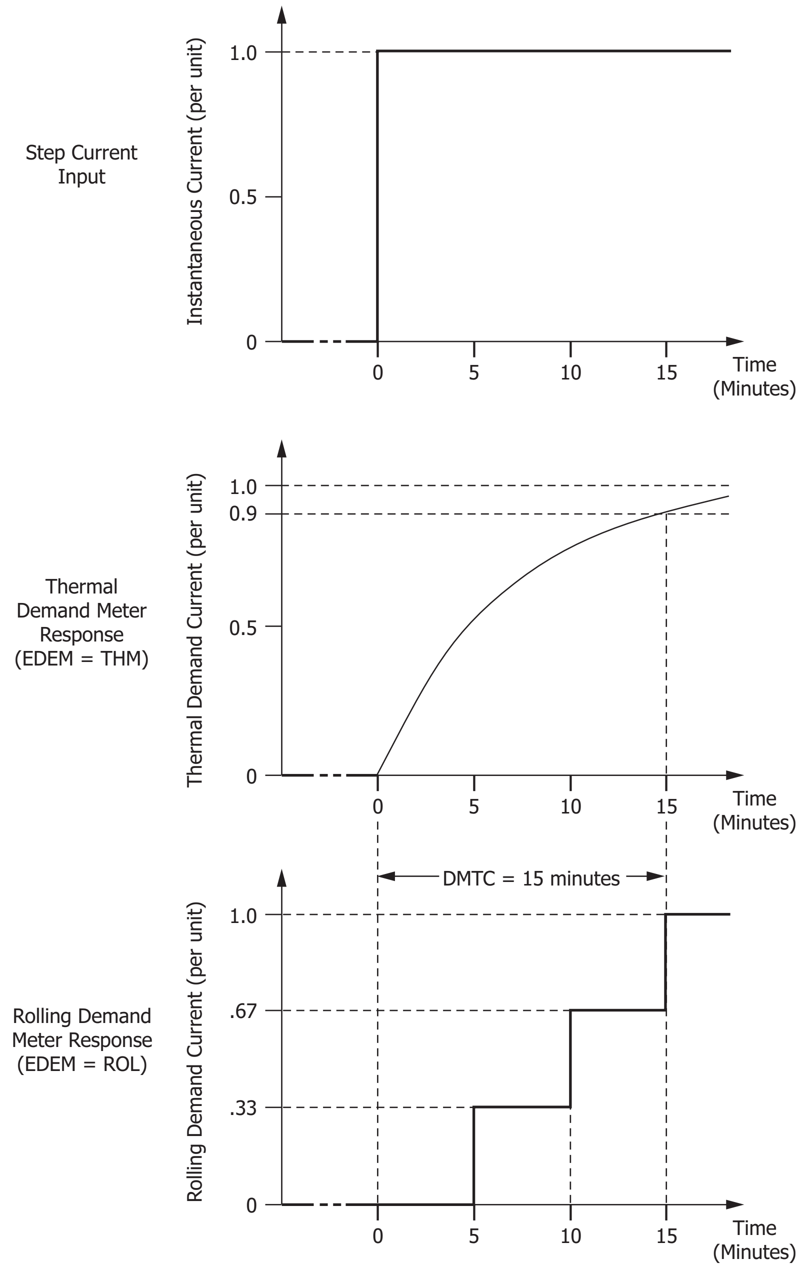


Figure 8.13 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 Minutes)

Thermal Demand Meter Response (EDEM = THM)

The response of the thermal demand meter in *Figure 8.13* (middle) to the step current input (top) is analogous to the series RC circuit in *Figure 8.14*.

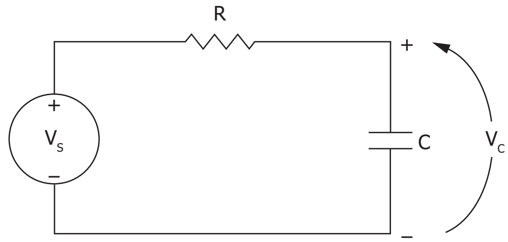


Figure 8.14 Voltage V_S Applied to Series RC Circuit

In the analogy

> Voltage V_S in *Figure 8.14* corresponds to the step current input in *Figure 8.13* (top).
>
> Voltage V_C across the capacitor in *Figure 8.14* corresponds to the response of the thermal demand meter in *Figure 8.13* (middle).

If voltage V_S in *Figure 8.14* has been at zero (V_S = 0.0 per unit) for some time, voltage V_C across the capacitor in *Figure 8.14* 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 8.13* (middle) to the step current input (top).

In general, as voltage V_C across the capacitor in *Figure 8.14* 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 8.13*, 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 8.13* (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 8.13*, 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 8.13* 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 8.13* (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 8.19.

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 8.15*. 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.

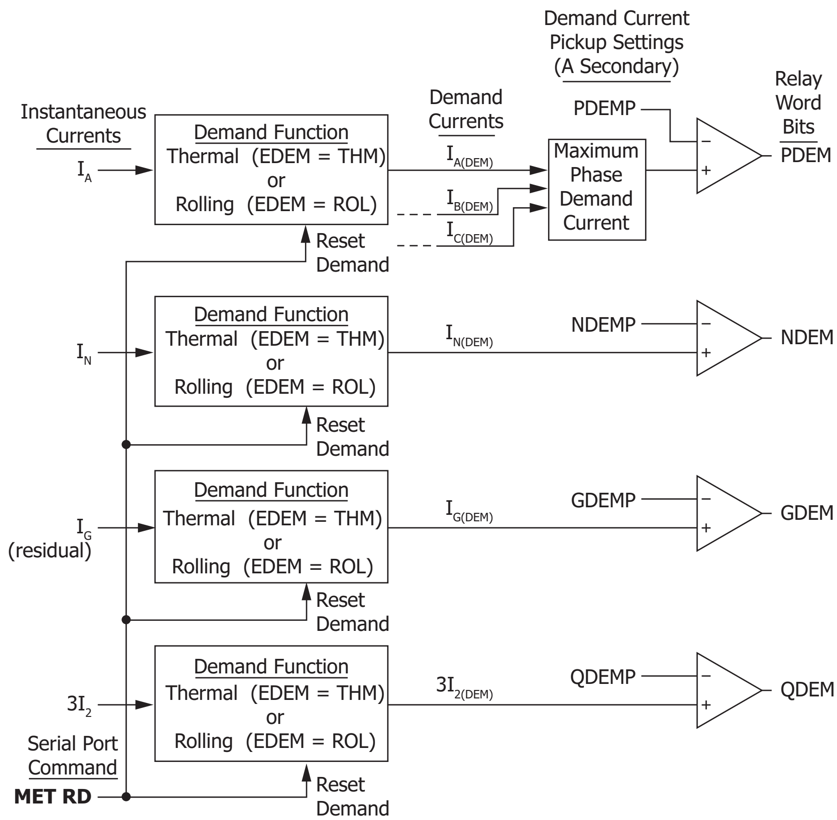


Figure 8.15 Demand Current Logic Outputs

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 8.15*, *Figure 8.16*, and *Figure 3.33*.

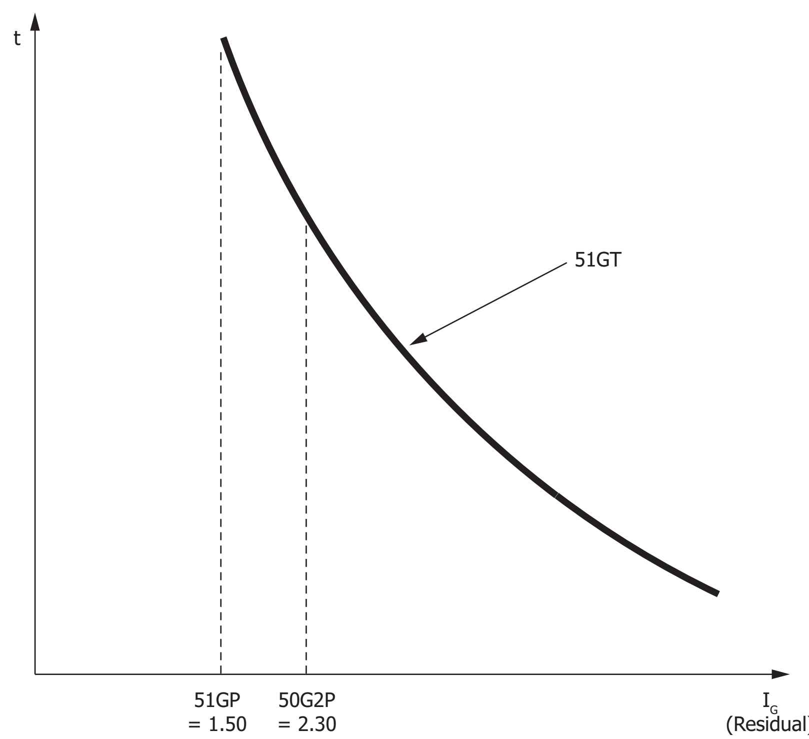


Figure 8.16 Raise Pickup of Residual-Ground Time-Overcurrent Element for Unbalance Current

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 following 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 following 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 IG decreases again, unbalance demand current IG(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 following 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 10.52*. 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 Single-phase megaVARs
$MVAR_{A, B, C}$	Three-phase megawatts
MW_{3P}	Three-phase megaVARs
$MVAR_{3P}$	

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 as long as 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 Meter or IEC 61850

Selected 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 the following.

- ➤ 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 control equations should be tested to ensure they do not assert after a group change or after the relay turns on.

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 8.28*.

Energy Metering

The SEL-311C provides energy metering for the following values where IN and OUT correspond to the standard relay convention of OUT for positive power, and IN for negative power.

$MWH_{A, B, C, 3P}$ 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

See *Table E.1* for a listing of the Analog Quantities for energy metering.

View or Reset Energy Metering Information

Via Serial Port

See *MET Command (Metering Data) on page 10.52*. 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

Three-phase energy metering values are available via IEC 61850. See the Energy Metering section of *Table E.1*.

Reset Via SELOGIC Control 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 control equation should be tested to ensure it does not assert after a group change or after the relay turns on.

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)
V_S	Input voltage (kV primary)

Power

MW_{3P}	Three-phase megawatts
$MVAR_{3P}$	Three-phase megaVARs

See *Table E.1* for a listing of the Analog Quantities for Maximum/Minimum metering.

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 10.56*. 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 Control 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 control equation should be tested to ensure it does not assert after a group change or after the relay turns on.

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 5.58.

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 voltage values (V_A, V_B, V_C, 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 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 previously 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

NOTE: The factory-default setting of 52A is the logical AND of 52AA, 52AB, and 52AC.

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.

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.

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 10.52*. The **MET PM** command displays the synchrophasor measurements. For more information, see *View Synchrophasors by Using the MET PM Command on page N.17*.

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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 sections.

- *Introduction*
- *Time-Overcurrent Curves on page 9.5*
- *Settings Explanations on page 9.16*
- *Settings Sheets on page 9.21*

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	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 by 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 10.62* for examples of the **SHO** command, including the SEL-311C factory-default settings.

The **SET** command is described in a later section. *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.6*
SET *n*	Group	Overcurrent and voltage elements, reclosing relay, timers, etc., for settings Group *n* (*n* = 1, 2, 3, 4, 5, 6).	*SET.7–SET.25*
SET L *n*	Logic	SELOGIC control equations for settings Group *n* (*n* = 1, 2, 3, 4, 5, 6).	*SET.26–SET.35*
SET R	Report	Sequential Events Recorder (SER) trigger conditions.	*SET.36*
SET T	Text	Front-panel default display and local control text.	*SET.37–SET.40*
SET P *n*	Port	Port *n* settings *n* = 1: optional EIA-485 or fiber-optic serial port *n* = 2, 3, or F: EIA-232 serial ports *n* = 5: single or optional dual Ethernet	*SET.41–SET.53*
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 9.20.

See *Using the Embedded Web Server (HTTP) on page 10.22* for information on reading settings by 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.

Settings Changes Via PC Software

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 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 following 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.
\<Enter>	Allows text entry to be continued on next line. The \ symbol must appear at the end of a line, just before pressing **<Enter>**.

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.

Settings Change Confirmation

If changes are made to Global, Report, or Text settings, or to the Group or Logic settings for the active settings group (see *Table 9.2*), the relay is disabled for less than two seconds while it saves the new settings. The **EN** LED extinguishes (see *Table 5.6*) while the relay is disabled. Relay Word bit SETCHG pulses for approximately one second to indicate that the settings have changed.

If changes are made to the Group or Logic settings for a settings group other than the active settings group, or to Port, DNP maps, or Modbus map settings (see *Table 9.2*), the relay is not disabled while it saves the new settings. Relay Word bit SETCHG pulses for approximately one second, but the **EN** LED remains on (see *Table 5.6*) 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 3.32–Figure 3.34*). The U.S. and IEC time-overcurrent relay curves are shown in *Figure 9.1 –Figure 9.10*

Definitions:

T_p = Operating time in seconds

T_R = Electromechanical induction-disk emulation reset time in seconds (if you select electromechanical reset setting)

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*

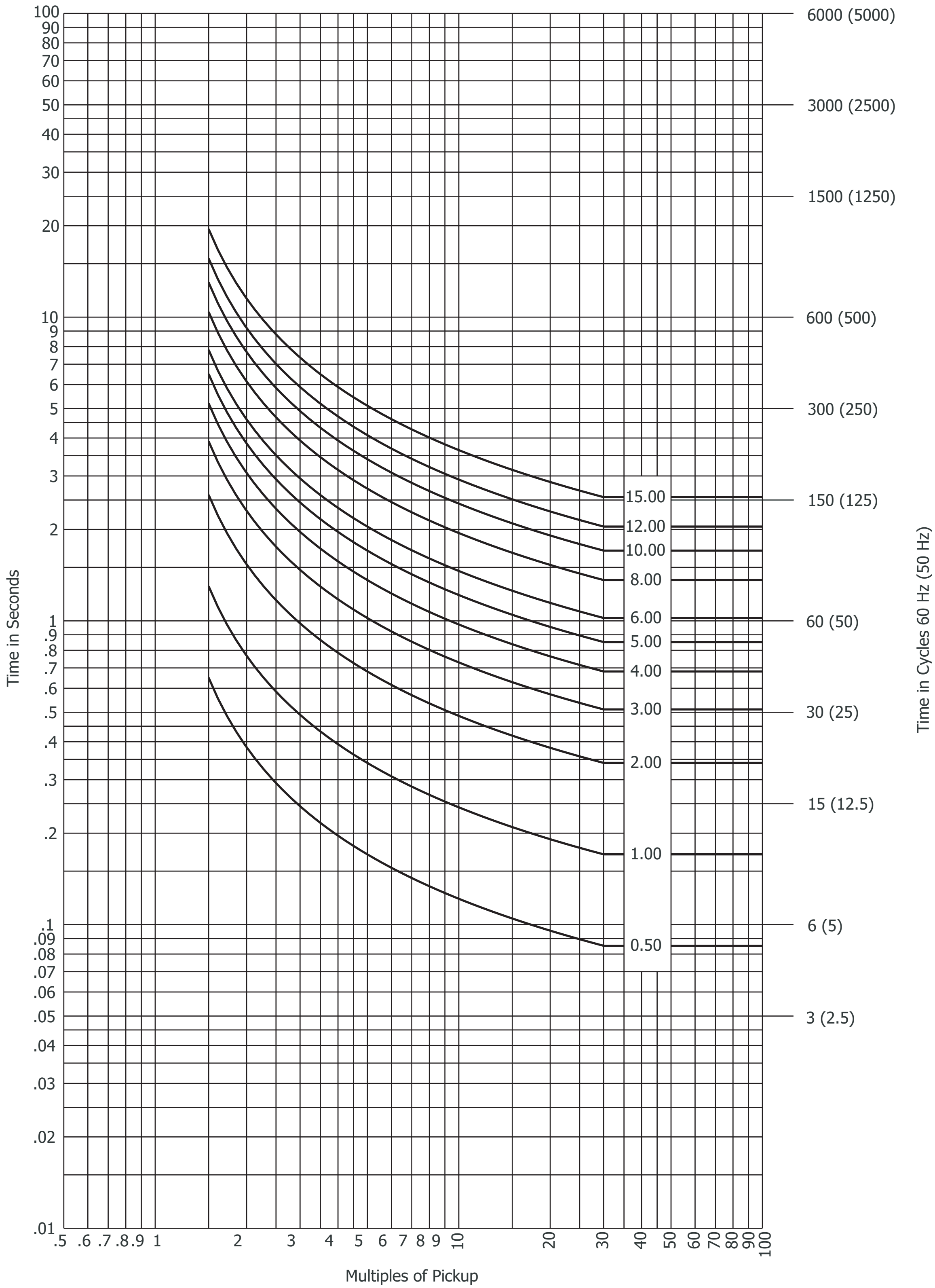

Figure 9.1 U.S. Moderately Inverse Curve: U1

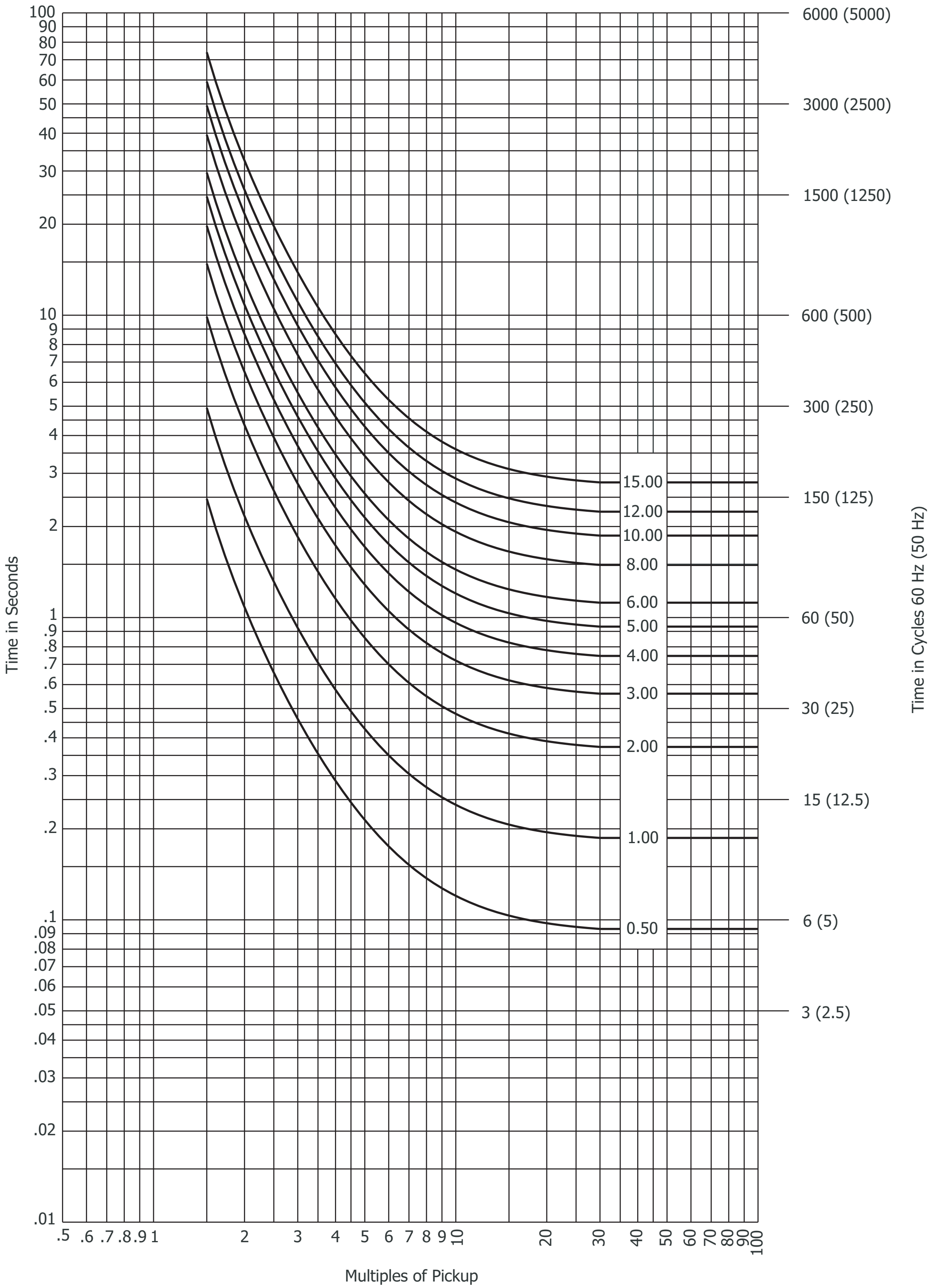

Figure 9.2 U.S. Inverse Curve: U2

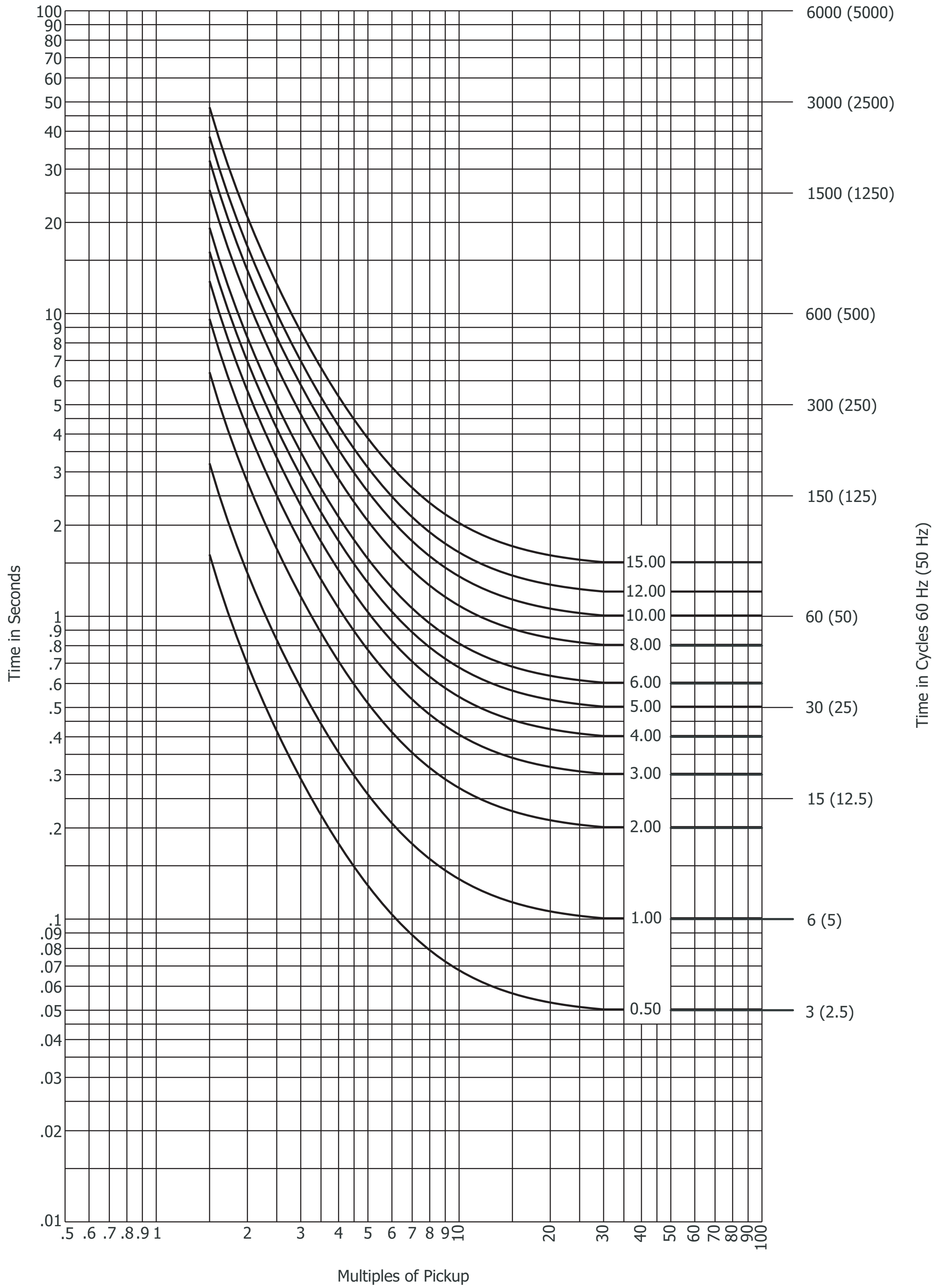

Figure 9.3 U.S. Very Inverse Curve: U3

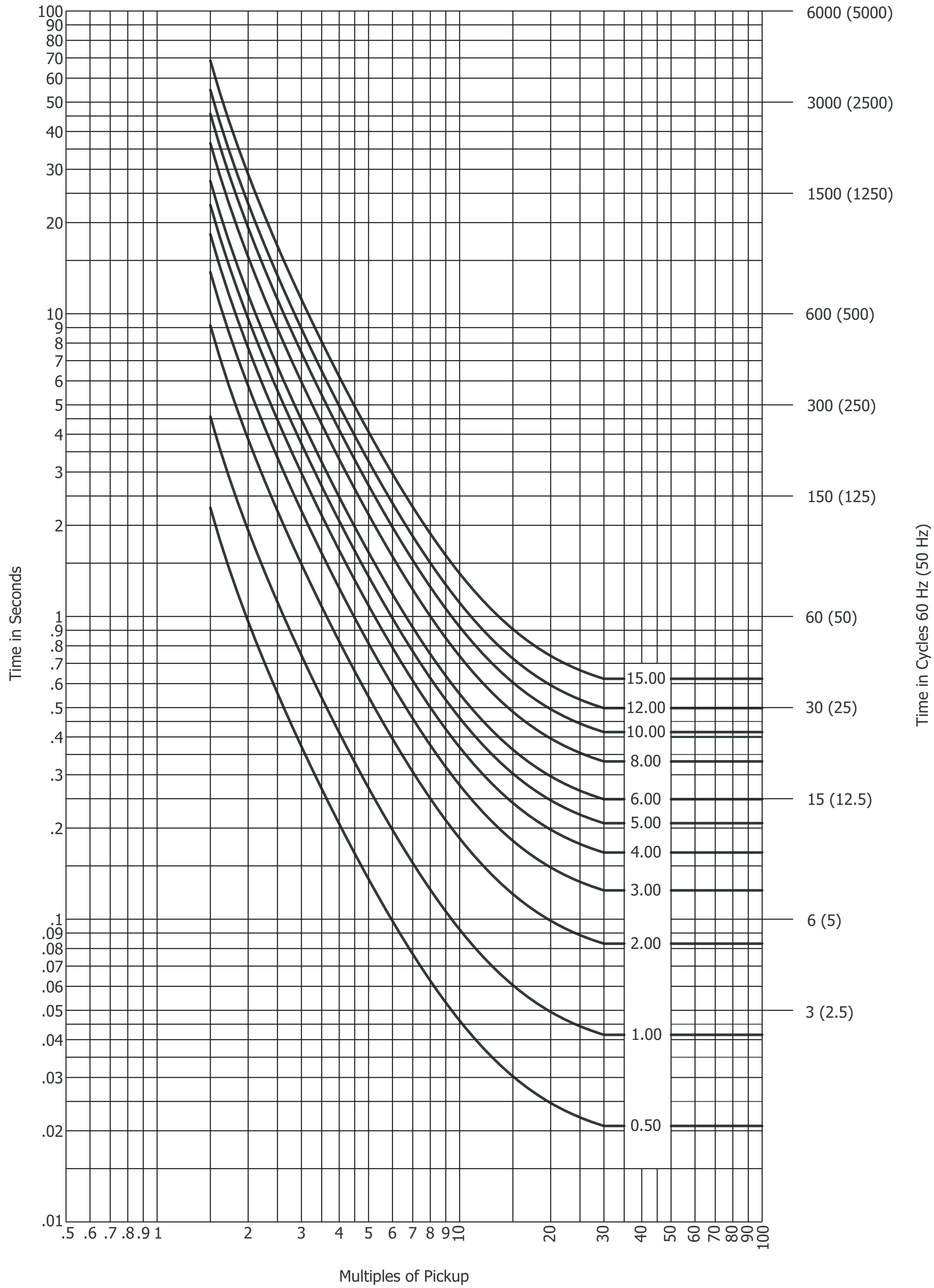

Figure 9.4 U.S. Extremely Inverse Curve: U4

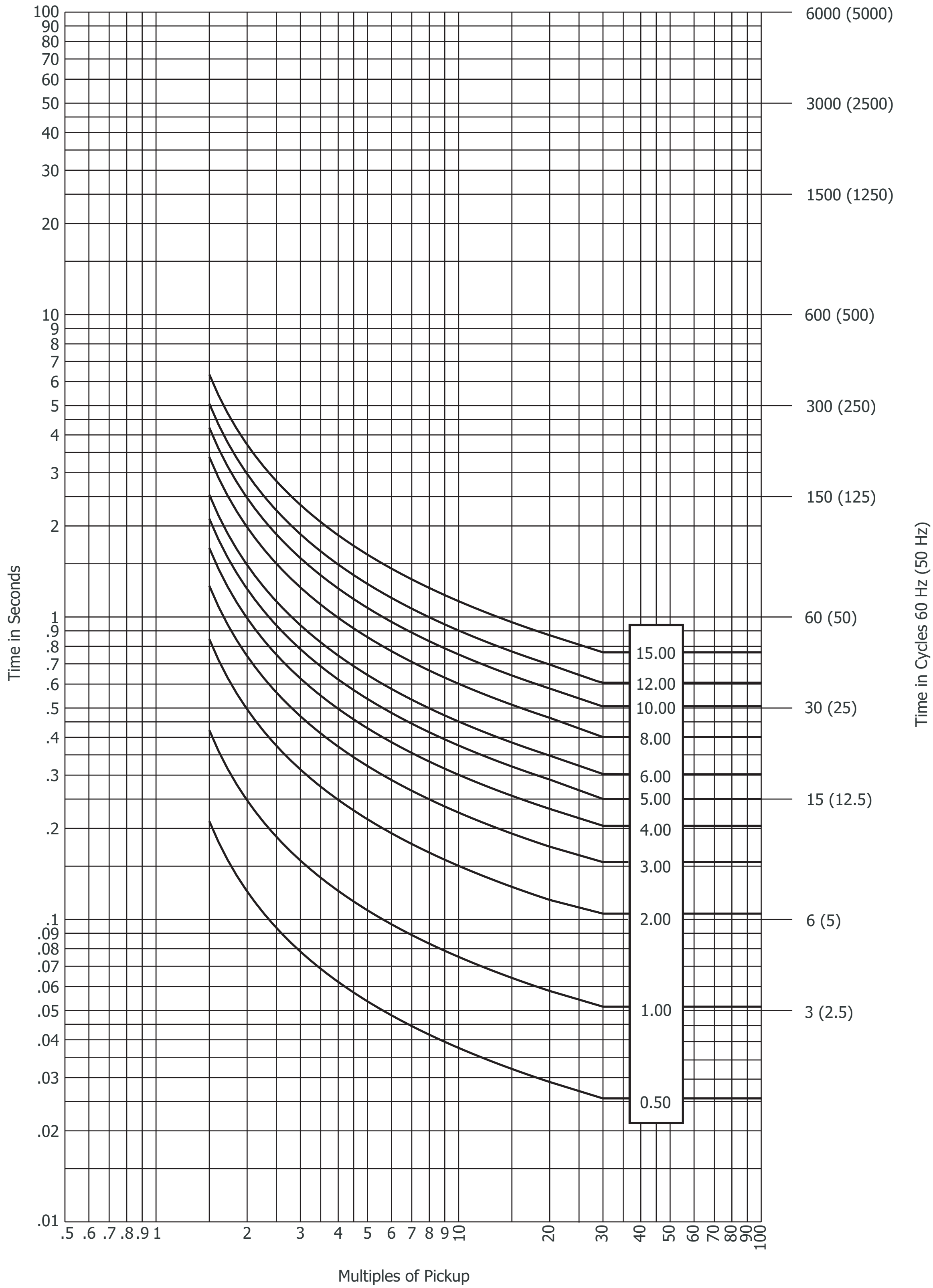

Figure 9.5 U.S. Short-Time Inverse Curve: U5

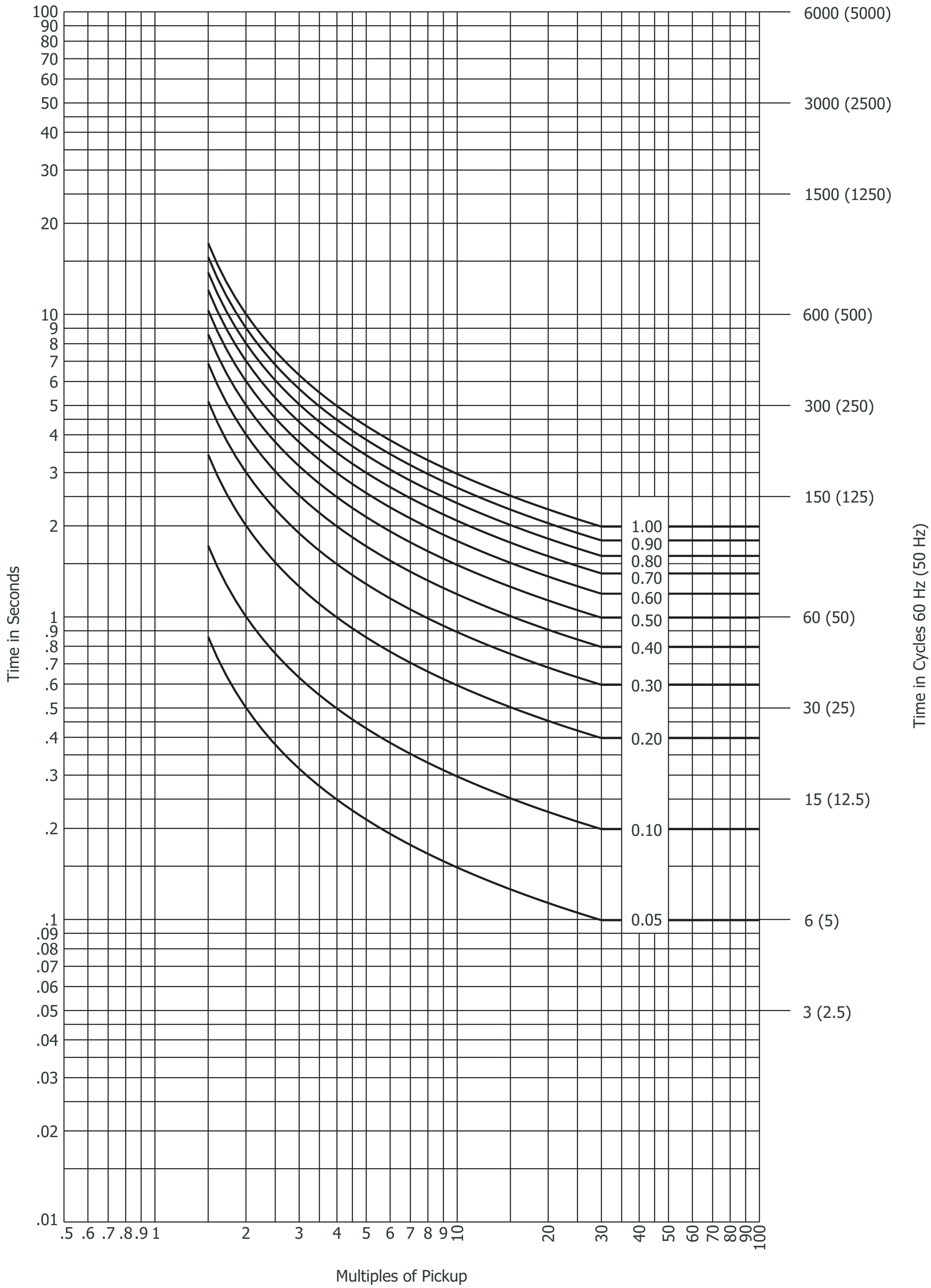

Figure 9.6 IEC Standard Inverse (Class A) Curve (C1)

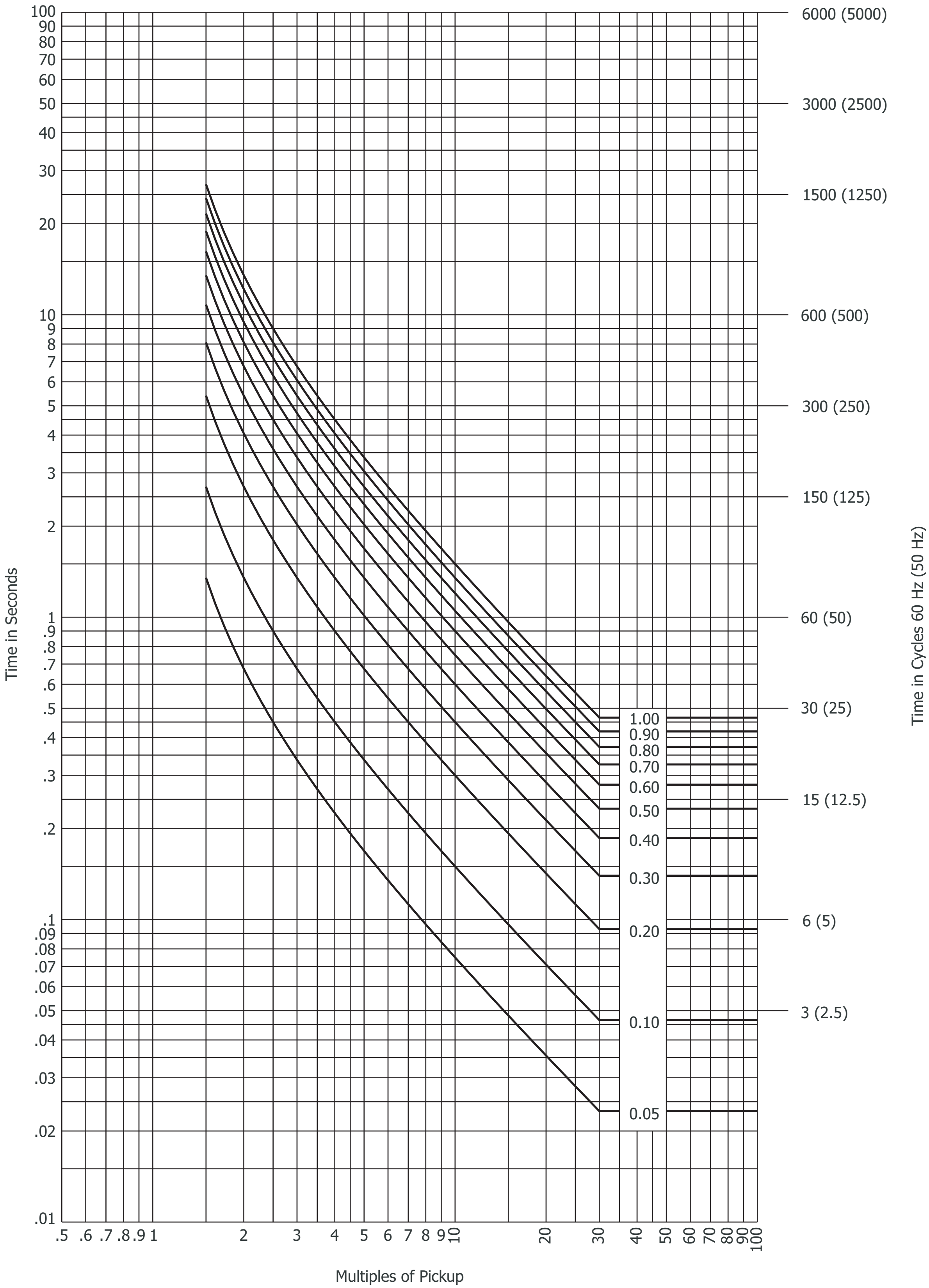

Figure 9.7 IEC Very Inverse (Class B) Curve (C2)

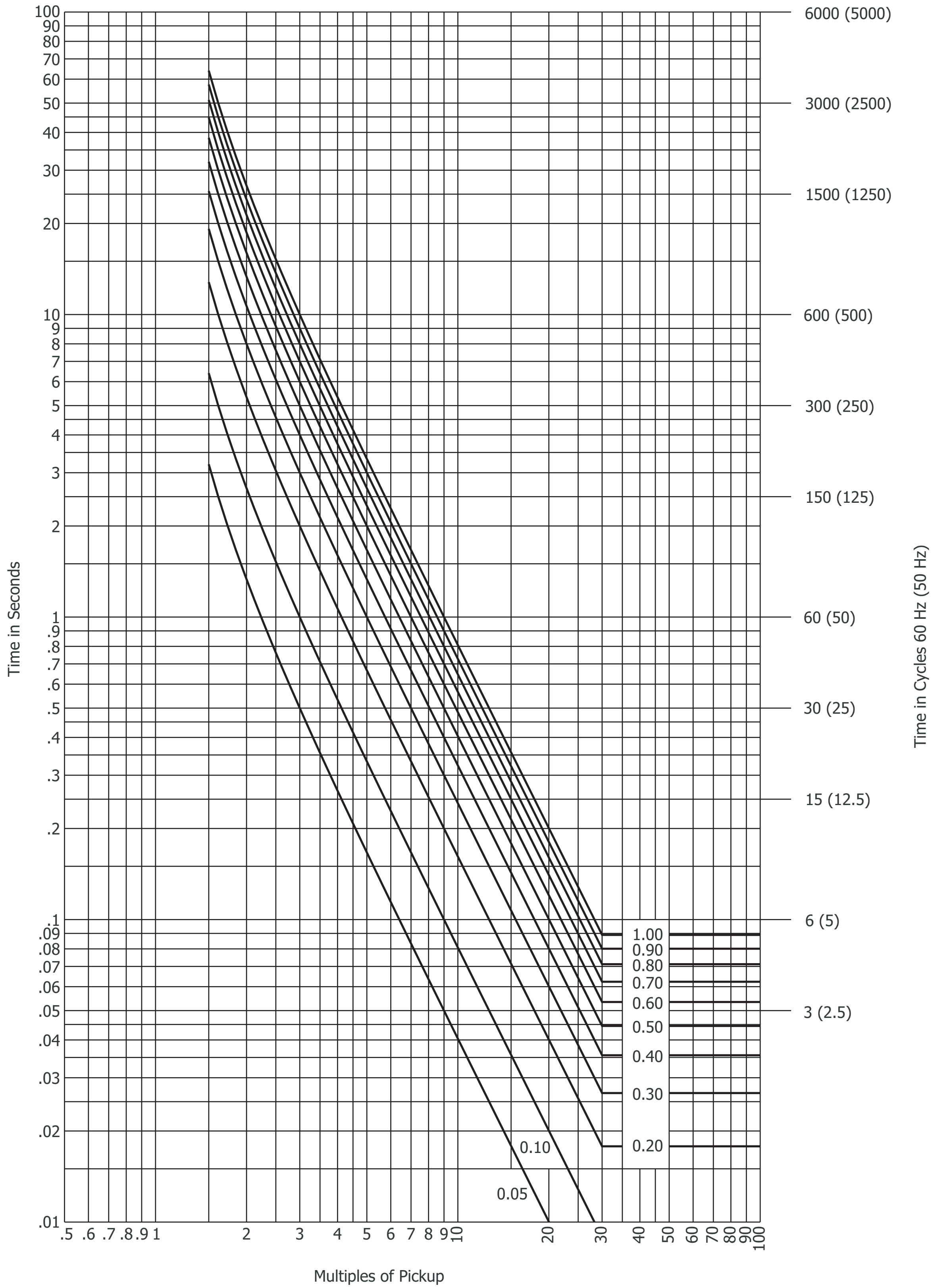

Figure 9.8 IEC Extremely Inverse (Class C) Curve (C3)

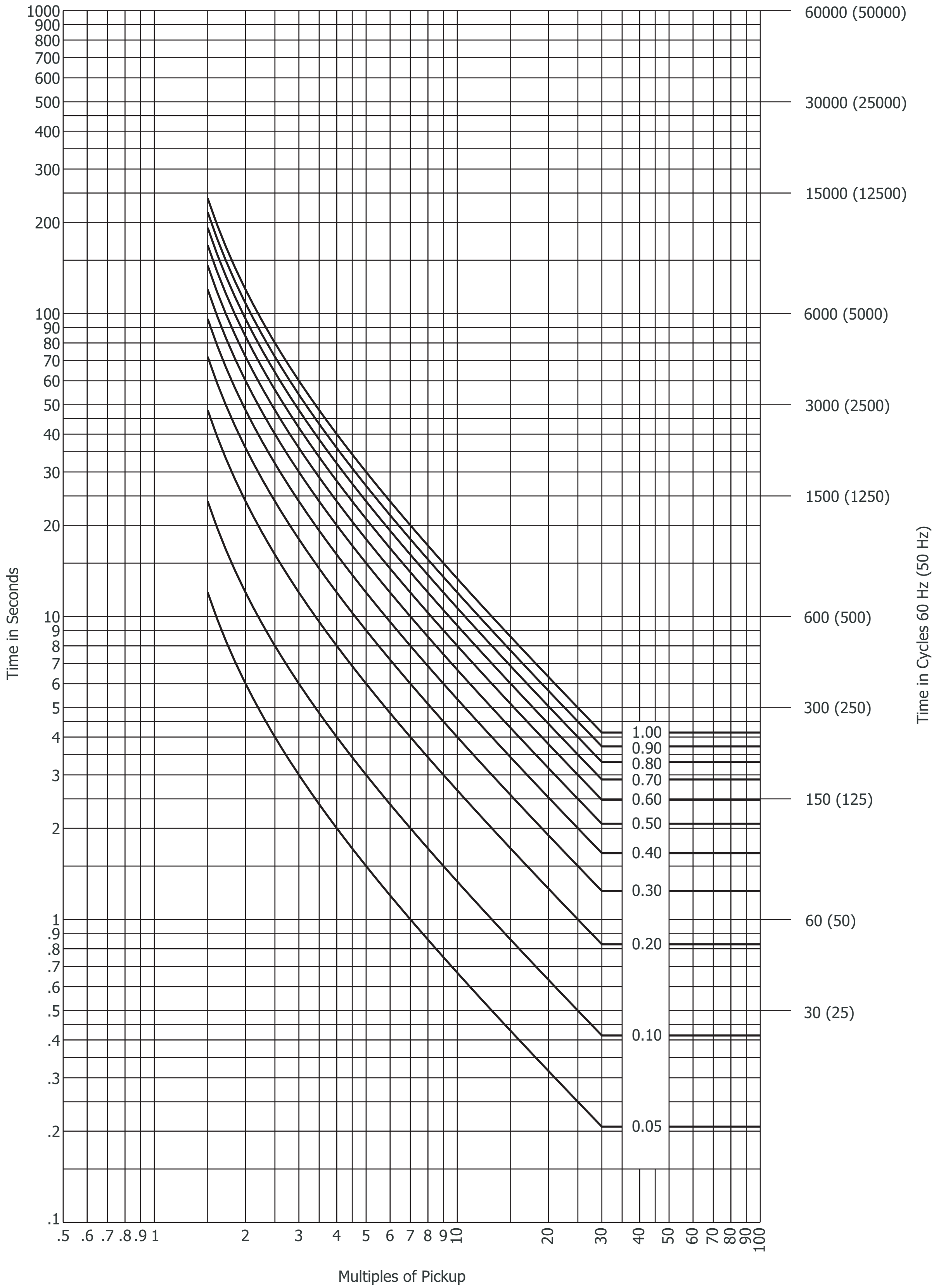

Figure 9.9 IEC Long-Time Inverse Curve (C4)

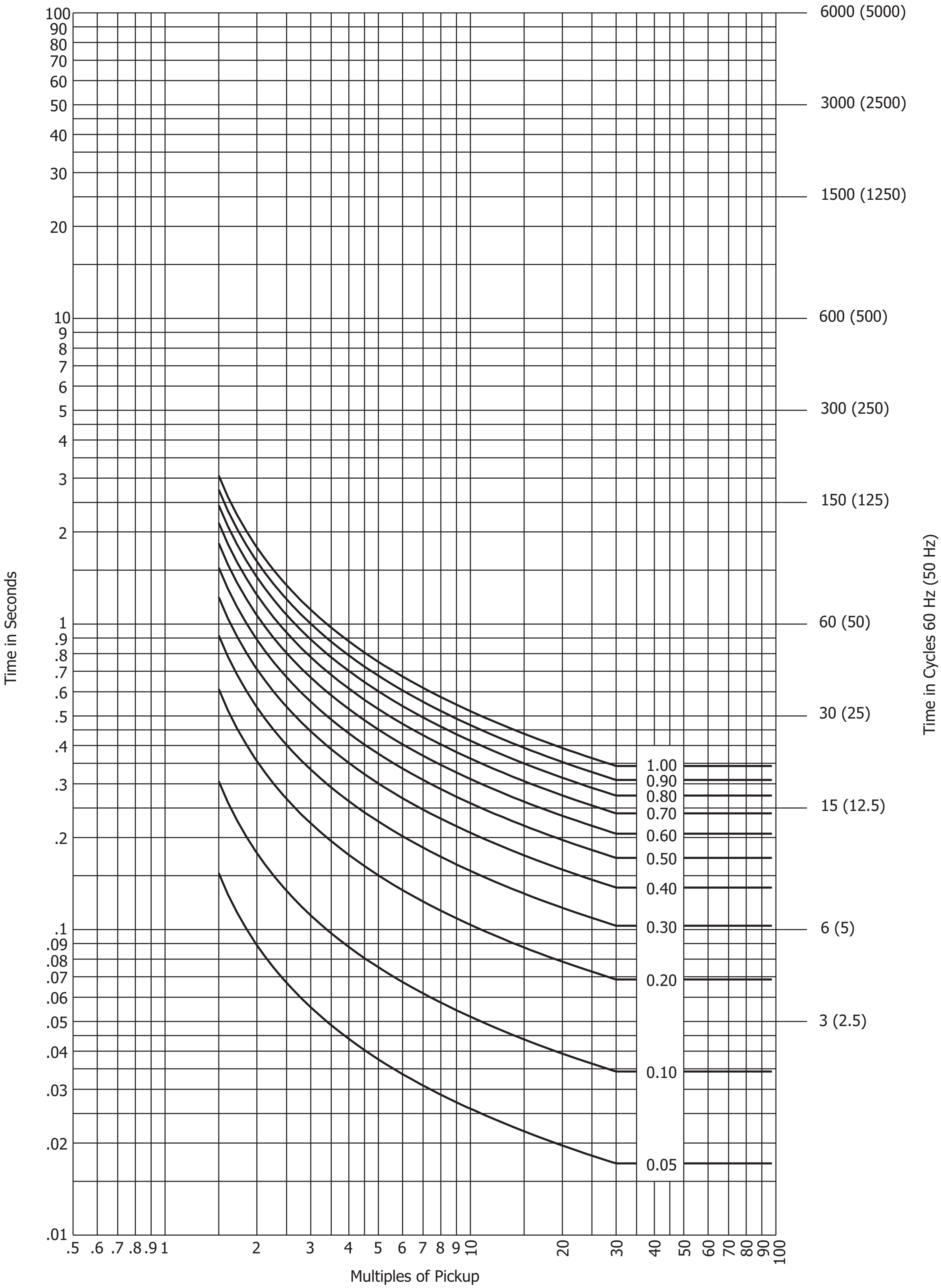

Figure 9.10 IEC Short-Time Inverse Curve (C5)

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 on page SET.7*.

The SEL-311C Relay has two identifier labels.

- ➤ Relay Identifier (RID)
- ➤ 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 on page SET.7*.

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

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. The default value is 67.00 V.

Potential Transformer Ratios and PT Nominal Secondary Voltage Settings

Refer to *Current and Potential Transformer Ratios on page SET.7*.

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.

Relay setting PTRS is the overall potential ratio from the synchronizing voltage source to the relay **VS-NS** voltage inputs. For example, 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.

Settings PTR and PTRS are used in event report and **METER** commands so that power system values can be reported in primary units.

Relay setting VNOM is the nominal secondary voltage connected to voltage inputs **VA-VB–VC-N**.

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 as follows.

$$10000\ \text{V}/(\sqrt{3} \bullet 60) = 96.22\ \text{V}$$

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.26*.

For Simple Network Time Protocol (SNTP) applications, refer to *Simple Network Time Protocol (SNTP) on page 10.20*.

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 0.01-hour increments.

The relay HTTP (Web) Server uses the UTC_OFF setting to calculate UTC time stamps 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 commences, while the last four settings control the month, week, day, and time that daylight-saving time ceases.

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-saving times properly even if you expect some other time source, such as IRIG-B, to correct for daylight-saving 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. Use the **TIME DST** command to confirm the daylight-saving time settings and status.

Line Settings

Refer to *Line Settings on page SET.7*.

Line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG are used in the fault locator (see *Fault Location on page 12.7* and *Fault Location on page R.1*) and in automatically making directional element settings Z2F, Z2R, Z0F, and Z0R (see *Settings Made Automatically on page 4.28*). 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)

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.7*.

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 three enable settings. These settings control other Global settings as follows.

- EBMON: Breaker Monitor (Y, N). Hides six settings when set to N.
- EPMU: Synchronized Phasor Measurement (Y, N). Hides as many as 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.7* 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
- E50BF: Breaker Failure
- 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 as many as 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 (0, 1, B, 2, C). Selects highest access level allowed on port by limiting the availability of commands **ACC**, **BAC**, **2AC**, or **CAL**. The MAXACC for Port F (only) can be set to 1, B, 2, or C 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 (0, 1, B, 2, C). Selects highest access level allowed on a Telnet session by limiting the availability of commands **ACC**, **BAC**, **2AC**, or **CAL**.
- EFTPSERV: Enable FTP (Y, N). Hides three settings when set to N.
- EHTTP: Enable HTTP Server (Y, N). Hides five settings when set to N. When EHTTP is set to Y, another enable setting appears:

  HTTPACC: HTTP Maximum Access Level (1, 2). Selects highest access level allowed over the Web Server interface.
- 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 (as many as 31 settings per session).
- EPMIP: Enable PMU Processing (Y,N). Controls availability of as many as six subsequent settings.

- EMODBUS: Enable Modbus (0–3). Controls availability of as many as seven subsequent settings.
- ESNTP: Enable SNTP client (OFF, UNICAST, MANYCAST, BROADCAST). Controls availability of as many as five subsequent settings.

PC Software

These enable settings are also present in the SEL-311C driver for QuickSet. The effect of changing an enable setting is easy to see, because the associated setting field turns gray when it is unavailable. See *Appendix C: PC Software* for more information on 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 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)

Settings Group Change Delay

See Multiple Setting Groups on page 7.16.

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 9.21.

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 the 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 pre-fault in event report (1 to LER-1 cycles in 1-cycle steps)	**PRE**	=________

Station DC Battery Monitor

See Figure 8.11 and Figure 8.12.

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**	=________

Date____________

Optoisolated Input Timers

See Figure 7.1.

Input IN101 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN101D**	= ________
Input IN102 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN102D**	= ________
Input IN103 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN103D**	= ________
Input IN104 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN104D**	= ________
Input IN105 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN105D**	= ________
Input IN106 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN106D**	= ________

Optoisolated Input Timers—Extra I/O Board Options 2, 4, 5, or 6

See Figure 7.2.

Input IN201 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN201D**	= ________
Input IN202 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN202D**	= ________
Input IN203 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN203D**	= ________
Input IN204 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN204D**	= ________
Input IN205 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN205D**	= ________
Input IN206 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN206D**	= ________
Input IN207 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN207D**	= ________
Input IN208 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN208D**	= ________

Optoisolated Input Times—Extra I/O Board Option 4

Input IN209 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN209D**	= ________
Input IN210 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN210D**	= ________
Input IN211 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN211D**	= ________
Input IN212 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN212D**	= ________

Input IN213 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN213D**	=_________
Input IN214 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN214D**	=_________
Input IN215 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN215D**	=_________
Input IN216 debounce time (AC, 0.00–2.00 cycles in 0.25-cycle steps)	**IN216D**	=_________

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**	=_________
Electrical Slow Trip Alarm Threshold (1–999 ms in 1 ms steps)	**ESTRT**	=_________
Electrical Slow Close Alarm Threshold (1–999 ms in 1 ms steps)	**ESCLT**	=_________
Mechanical Slow Trip Alarm Threshold (1–999 ms in 1 ms steps)	**MSTRT**	=_________
Mechanical Slow Close Alarm Threshold (1–999 ms in 1 ms steps)	**MSCLT**	=_________

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 5.8.

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 as many as 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) 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).	**RSTLED**	=________

Synchronized Phasor Settings

See Appendix N.

Synchronized Phasor Measurement (Y, N)	**EPMU**	=________

NOTE: Make the following setting if EPMU = Y.

Message Format (C37.118, FM)	**MFRMT**	=________

NOTE: C37.118 is an IEEE Standard. “FM” is SEL Fast Message.

C37.118 Settings

Make the following settings when EPMU = Y and MFRMT = C37.118.

Message Rate (messages per second) (1, 2, 4, 5, 10, 12, 15, 20, 30, 60 when NFREQ = 60) (1, 2, 5, 10, 25, 50 when NFREQ = 50)	**MRATE**	=________

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, mixed case) **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** = __________

Date ___________
Group___________

DNP

See Appendix L.

Event Summary Lock Period (0 to 1000 seconds)	**EVELOCK**	= _______
DNP Session Time Base (LOCAL, UTC)	**DNPSRC**	= _______
DNP BO Close/Trip Behavior (SET, PULSE)	**BOOPTCC**	= _______
DNP BO Pulse On Behavior (SET, PULSE)	**BOOPPUL**	= _______

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 in 0.01-hour increments)	**UTC_OFF**	= _______

Daylight-Saving Time Settings

See Automatic Daylight-Saving Time Settings on page 9.17.

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; 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) (25.00–300.00 V secondary in 0.013 V steps)	**VNOM**	=________

Line Settings

See Line Settings on page 9.18.

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**	=________
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) (see *Figure 3.2*)	**E21P**	= ________
Mho ground-distance element zones (N, 1–4) (see *Figure 3.5–Figure 3.7*)	**E21MG**	= ________
Quadrilateral ground-distance element zones (N, 1–4) (see *Figure 3.8–Figure 3.10*)	**E21XG**	= ________

Instantaneous/Definite-Time Overcurrent Enable Settings

Phase element levels (N, 1–4) (see *Figure 3.25* and *Figure 3.26*)	**E50P**	= ________
Residual-ground element levels (N, 1–4) (see *Figure 3.30*)	**E50G**	= ________
Negative-sequence element levels (N, 1–4) (see *Figure 3.31*)	**E50Q**	= ________

Time-Overcurrent Enable Settings

Phase elements (Y, N) (see *Figure 3.32*)	**E51P**	= ________
Residual-ground elements (Y, N) (see *Figure 3.33*)	**E51G**	= ________
Negative-sequence elements (Y, N) (see *Figure 3.34*)	**E51Q**	= ________

Other Enable Settings

Breaker Failure (Y, N)	**E50BF**	= ________
Directional control (Y, AUTO) (see *Directional Control Settings on page 4.28*)	**E32**	= ________
Out-of-Step (Y, Y2, 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 5.5*)	**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 3.35–Figure 3.37*)	**EVOLT**	= ________
Synchronism check (Y, N) (see *Figure 3.38* and *Figure 3.39*)	**E25**	= ________
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 5.23*)	**ECOMM**	= ________

NOTE: If ECOMM is enabled, then at least three distance zones must be enabled.

Frequency elements (N, 1–6) (see *Figure 3.45*)	**E81**	= ________
Reclosures (N, 1– 4) (see *Reclosing Relay on page 6.16*)	**E79**	= ________

Make setting EZ1EXT if ECOMM = N or DCB.

Zone 1 extension (Y, I, N) (see *Figure 3.18* and *Figure 3.19*)	**EZ1EXT**	= ________

Make settings EZ1EXTP and EZ1EXTG if EZ1EXT = I.

Zone 1 phase element extension (Y, N) (see *Figure 3.19*)	**EZ1EXTP**	= ________
Zone 1 ground element extension (Y, N) (see *Figure 3.19*)	**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 8.13*)	**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 3.2*)	**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 3.3*)	**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 3.4*)	**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 3.4*)	**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 3.2*)	**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 3.3*)	**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 3.4*)	**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 3.4*)	**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 3.5*)	**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 3.6*)	**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 3.7*)	**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 3.7*)	**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 3.8*)	**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 3.9*)	**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 3.10*)	**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 3.10*)	**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 3.8*)	**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 3.9*)	**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 3.10*)	**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 3.10*)	**RG4**	=________
Quadrilateral ground polarizing quantity (I2, IG) *Setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.* (See *Figure 3.8–Figure 3.10*)	**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 3.5* and *Figure 3.8*)	**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 3.6* and *Figure 3.9*)	**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 3.7* and *Figure 3.10*)	**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 3.7* and *Figure 3.10*)	**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 3.5* and *Figure 3.8*)	**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 3.6* and *Figure 3.9*)	**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 3.7* and *Figure 3.10*)	**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 3.7* and *Figure 3.10*)	**50GZ4**	=__________

Zero-Sequence Compensation (ZSC) Settings

See Ground-Distance Elements on page 3.7.

Zone 1 ZSC factor magnitude *Selecting AUTO causes the relay to calculate k0M1, k0A1, k0M, and k0A values according to Equation 3.2.* (AUTO, 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 3.20.

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 3.20.

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 3.20.

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 3.25.

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 3.26.

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**	=_________

Date ____________
Group____________

Residual-Ground Instantaneous/Definite-Time Overcurrent Elements

See Figure 3.30.

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 3.30.

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 3.31.

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 3.31.

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 3.32.

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 3.33.

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 3.34.

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**	=________

Breaker Failure Settings

Make the following settings if E50BF = Y.

Phase Fault Current Pickup (OFF, 0.5–100 A, secondary in 0.01 A steps)	**50BFP**	=________
Breaker Failure Time Delay (0.00–16000 cycles in 0.25 cycle steps)	**BFPU**	=________
Retrip Time Delay (0.00–16000 cycles in 0.25 cycle steps)	**RTPU**	=________

Out-of-Step Settings

See Figure 3.22 and Figure 3.23.

Make the following settings if preceding enable setting EOOS = Y or Y2.

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 *Only make this setting when EOOS = Y.* (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 DIR3 must be set to reverse.

Zone/Level 4 direction: Forward, Reverse (F, R) **DIR4** =________

Directional Elements

See Directional Control Settings on page 4.28.

Ground directional element priority (combination of Q, V, I) **ORDER** =________

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 3.35—Figure 3.37.

Make the following settings if EVOLT = Y.

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**	= ________

Make the following settings if EVOLT = Y.

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**	= ________
Negative-sequence (V2) overvoltage pickup (OFF, 0.00–200.00 V secondary in 0.01 V steps)	**59QP**	= ________
Positive-sequence (V1) overvoltage pickup (OFF, 0.00–300.00 V secondary in 0.013 V steps)	**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)	**27PP**	= ________
Phase-to-phase overvoltage pickup (OFF, 0.00–520.00 V secondary in 0.02 V steps)	**59PP**	= ________

Synchronism-Check Elements

See Figure 3.38 and Figure 3.39.

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 (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)	**SYNCP**	=________
Breaker close time for angle compensation (0.00–60.00 cycles in 0.25-cycle steps)	**TCLOSD**	=________

Frequency Elements

See Figure 3.44–Figure 3.45.

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 6.6*)	**79CLSD**	=________

Switch-Onto-Fault

See Figure 5.5.

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 5.9.

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, SP, N)	**EWFC**	=________

Make settings 27PWI, 27PPW and 59NW if EWFC = Y or SP.

WIF phase undervoltage (0.00–300.00 V secondary in 0.01 V steps)	**27PWI**	=________
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**	=________

Additional DCUB Trip Scheme Settings

See Figure 5.13.

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 5.17.

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 3.18.

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**	= ________
Zone 1 ground-distance multiplier (1.00–4.00 in steps of 0.01)	**Z1EXTMG**	= ________

Demand Metering Settings

See Figure 8.13 and Figure 8.15.

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

Single-Pole Min. Trip Duration (2.00–16000.00 cycles in 0.25-cycle steps; see *Figure 5.1*)	**TDUR1D**	= ________
Three-Pole Min. Trip Duration (2.00–16000.00 cycles in 0.25-cycle steps; see *Figure 5.1*)	**TDUR3D**	= ________
Close failure time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) (see *Figure 6.5*)	**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 5.6*)	**3POD**	= ________
Open pole option (52, 27)	**OPO**	= ________

Three-pole open undervoltage (0.0–150 V secondary in 0.01 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 5.6*)	**50LP**	= ________
Trip During Open Pole Delay (2.00–16000.00 cycles in 0.25-cycle steps; see *Figure 5.3*)	**TOPD**	= ________
Trip Unlatch Option (1,2,3,4; see *Figure 5.2*)	**TULO**	= ________
Zone 2 Ground-Distance Single Pole Trip (Y,N; see *Figure 5.1*)	**Z2GTSP**	= ________
Zone 2 Overcurrent Single Pole Trip (Y,N; see *Figure 5.1*)	**67QGSP**	= ________

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**	=_________

Date ___________
Group___________

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, A-phase	**DTA**	= ________
Direct transfer trip conditions, B-phase	**DTB**	= ________
Direct transfer trip conditions, C-phase	**DTC**	= ________
Enable Three-pole trip	**E3PT**	= ________
Breaker Manual trip	**BKMTR**	= ________
Unlatch trip conditions	**ULTR**	= ________

Communications-Assisted Trip Scheme Input Equations

Permissive trip 1 (used for ECOMM = POTT, DCUB1, or DCUB2; see *Figure 5.8*, *Figure 5.10*, and *Figure 5.13*)	**PT1**	= ________
Loss-of-guard 1 (used for ECOMM = DCUB1 or DCUB2; see *Figure 5.13*)	**LOG1**	= ________
Permissive trip 2 (used for ECOMM = DCUB2; see *Figure 5.8* and *Figure 5.13*)	**PT2**	= ________
Loss of guard 2 (used for ECOMM = DCUB2; see *Figure 5.13*)	**LOG2**	= ________
Block trip (used for ECOMM = DCB; see *Figure 5.17*)	**BT**	= ________

Close Logic Equations

See Figure 6.5.

Circuit breaker status (see *Figure 6.2*)	**52A**	= ________
A-phase circuit breaker status (see *Figure 6.2*)	**52AA**	= ________
B-phase circuit breaker status (see *Figure 6.2*)	**52AB**	= ________

C-phase circuit breaker status (see *Figure 6.2*)	**52AC**	= ______________________
Close conditions (other than automatic reclosing)	**CL**	= ______________________
Unlatch close conditions	**ULCL**	= ______________________

Reclosing Relay Equations

See Reclosing Relay on page 6.16.

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 6.6*)	**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**	= ______________________

Date ____________
Group ____________

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 3.26*)	**67P1TC**	=
Level 2 phase (see *Figure 3.26*)	**67P2TC**	=
Level 3 phase (see *Figure 3.26*)	**67P3TC**	=
Level 4 phase (see *Figure 3.26*)	**67P4TC**	=
Level 1 residual ground (see *Figure 3.30*)	**67G1TC**	=
Level 2 residual ground (see *Figure 3.30*)	**67G2TC**	=
Level 3 residual ground (see *Figure 3.30*)	**67G3TC**	=
Level 4 residual ground (see *Figure 3.30*)	**67G4TC**	=
Level 1 negative-sequence (see *Figure 3.31*)	**67Q1TC**	=
Level 2 negative-sequence (see *Figure 3.31*)	**67Q2TC**	=
Level 3 negative-sequence (see *Figure 3.31*)	**67Q3TC**	=
Level 4 negative-sequence (see *Figure 3.31*)	**67Q4TC**	=

Torque-Control Equations for Time-Overcurrent Elements

NOTE: Torque-control equation settings cannot be set directly to logical 0.

Phase (see *Figure 3.32*)	**51PTC**	= ____________
Residual Ground (see *Figure 3.33*)	**51GTC**	= ____________
Negative-Sequence (see *Figure 3.34*)	**51QTC**	= ____________

Breaker Failure Equations

Breaker Failure Trip	**BFTR**	= ____________
Breaker Failure Initiate, A-phase	**BFIA**	= ____________
Breaker Failure Initiate, B-phase	**BFIB**	= ____________
Breaker Failure Initiate, C-phase	**BFIC**	= ____________
Breaker Failure Unlatch Trip	**BFULTR**	= ____________

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**	=

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

Se 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 ALARM	**ALRMOUT**	= ______________________

Output Contact Equations—Extra I/O Board Options 2, 4, 5, and 6

See Figure 7.29.

Output Contact OUT201	**OUT201**	= ______________________
Output Contact OUT202	**OUT202**	= ______________________
Output Contact OUT203	**OUT203**	= ______________________
Output Contact OUT204	**OUT204**	= ______________________

Output Contact Equations—Extra I/O Board Options 2, 5, and 6

See Figure 7.29.

Output Contact OUT205	**OUT205**	= ______________________
Output Contact OUT206	**OUT206**	= ______________________
Output Contact OUT207	**OUT207**	= ______________________
Output Contact OUT208	**OUT208**	= ______________________

Output Contact Equations—Extra I/O Board Options 2 and 6

See Figure 7.29.

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 5.8.

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**	= ______________
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 5.58*)	**FAULT**	=
Block synchronism-check elements (see *Figure 3.38*)	**BSYNCH**	=
Close bus monitor (see *Figure 5.5*)	**CLMON**	=
A-Phase breaker monitor initiation (see *Figure 8.3*)	**BKMONA**	=
B-Phase breaker monitor initiation (see *Figure 8.3*)	**BKMONB**	=
C-Phase breaker monitor initiation (see *Figure 8.3*)	**BKMONC**	=
Breaker monitor close initiation, A-phase (see *Mechanical and Electrical Operate Timers and Alarms on page 8.8*)	**BKCLSA**	=
Breaker monitor close initiation, B-phase	**BKCLSB**	=
Breaker monitor close initiation, C-phase	**BKCLSC**	=

Date____________

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**	= ____________
Software alarm conditions	**SALARM**	= ____________

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**	= ____________
Reset Hardware Alarm	**RST_HAL**	= ____________
Reset DNP Event Queue	**RSTDNPE**	= ____________

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 consist of three trigger lists. Each trigger list can include as many as 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**	=

Date ____________
Port___________

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 or SEL-2812 compatible fiber-optic 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 Access 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 Access 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). As many as 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. As many as 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 (0, 1, B, 2, C)	**MAXACC**	= ________

NOTE: The MAXACC setting controls the availability of **ACC**, **BAC**, **2AC**, and **CAL** commands on this port.

NOTE: MAXACC for Port F (only) can be set to 1, B, 2, or C and affects both serial port F and the optional USB port.

Date ____________
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 10.17.

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 10.17.

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.

Amperes 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-synchronization requests and ignores syncs from master.

NOTE: TIMERQ = M: Disables time-synchronization 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**	= ________
Event Min Fault Loc (OFF, –10000.0 to 10000.0 in steps of 0.1)	**MINDIST**	= ________
Event Max Fault Loc (OFF, –10000.0 to 10000.0 in steps of 0.1)	**MAXDIST**	= ________

NOTE: MAXDIST must be greater than MINDIST.

Event Mode (SINGLE, MULTI)	**EVEMODE**	=_________
Event Report (TRIP, ALL)	**RPEVTYP**	=_________

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

IP addresses are entered by using zzz = 1–126, 128–223; yyy = 0–255; xxx = 0–255; www = 0–255.

Device IP Address (zzz.yyy.xxx.www) **IPADDR** = ____________________

Subnet Mask (yyy.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** = ________

TCP Keep-Alive is enabled with default KAIDLE, KAINTV, and KACNT settings for PMU sessions even when ETCPKA = N.

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, PRP) **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 when NETMODE = PRP.

PRP Entry Time-Out (400–10000 ms) **PRPTOUT** = ________

PRP Destination Address LSB (0–255) **PRPADDR** = ________

PRP Supervision TX Interval (1–10 s) **PRPINTV** = ________

Make the following settings for each enabled port when the relay has dual 10/100BASE-T (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 10/100BASE-T (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 (0, 1, B, 2, C) **MAXACC** = ________

NOTE: The MAXACC setting controls the availability of the **ACC**, **BAC**, **2AC**, and **CAL** commands in the Telnet session.

Telnet Port (23, 1025–65534) **TPORT** = ________

Telnet Connect Banner (254 characters maximum, NA to NULL, mixed case. Use "\n" to create a new line.)

TCBAN = ____

____

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 10.17).

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 Username (20 characters maximum) **FTPUSER** = ________________

FTP Connect Banner (254 characters maximum. Use "\n" to create a new line.)

FTPCBAN = ____

____

FTP Idle Time-Out (5–255 minutes) **FTPIDLE** = ________

Hypertext Transfer Protocol (HTTP) Web Server Settings

Enable HTTP Server (Y, N) **EHTTP** = ________

Make the following settings when EHTTP = Y.

HTTP Maximum Access Level (1, 2) **HTTPACC** = ________

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 Connect Banner (254 characters maximum, NA to NULL, mixed case. Use "\n" to create a new line.)

HTTPBAN = ____________________

HTTP Web Server Time-Out (1–30 min) **HTTPIDLE** = ______

Firmware Upgrade Front-Panel Confirmation (Y, N) **FWFPC** = ______

IEC 61850 Protocol Settings (Ordering Option)

Enable IEC 61850 Protocol (Y, N) **E61850** = ______

Make the following settings when E61850 = Y.

Enable IEC 61850 GSE (Y, N) **EGSE** = ______

Enable MMS File Services (Y, N) **EMMSFS** = ______

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.

Amperes 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: The relay requests 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.

Event Min Fault Loc (OFF, –10000.0 to 10000.0 in steps of 0.1)	**MINDIST*n***	=_________
Event Max Fault Loc (OFF, –10000.0 to 10000.0 in steps of 0.1)	**MAXDIST*n***	=_________

NOTE: MAXDISTn must be greater than MINDISTn.

Event Mode (SINGLE, MULTI)	**EVEMODE*n***	=_________
Event Report Type (TRIP, ALL)	**RPEVTYP*n***	=_________

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. IP addresses from 224.0.0.1 through 239.255.255.255 are also valid when PMOTS1 = UDP_S. IP address 255.255.255.255 is also valid when PMOTS1 = UDP_S or TCP.

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. IP addresses from 224.0.0.1 through 239.255.255.255 are also valid when PMOTS2 = UDP_S. IP address 255.255.255.255 is also valid when PMOTS2 = UDP_S or TCP.

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: MODIP1, 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: MODIP1, 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: MODIP1, 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. Only IP addresses in the range 224.0.0.1 through 239.255.255.255 are valid when ESNTP = MANYCAST.

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 the same value as DNPNUM when EDNP > 0.

SNTP Update Rate (15–3600 seconds) **SNTPRATE** = ________

Make the following setting when ESNTP = UNICAST or MANYCAST.

SNTP Time-Out (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

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Section 10
Communications

Introduction

The SEL-311C relay has as many as seven communications ports as shown in *Table 10.1*. Use the communications ports to establish local and remote communications with the relay by using numerous communications protocols.

Table 10.1 SEL-311C Communications Ports

Port Number	Type	Location	Standard/ Optional
1	EIA-485 Serial or SEL-2812 Compatible Fiber Optic	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 by using serial, USB, Ethernet ports and the SEL ASCII communications protocol, or the built-in 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-C234A cable between the relay and a personal computer. The serial port default communications parameters are listed below:

- 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 by 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 select **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 by 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 10.7* 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 by using the PC application software, or disconnect and then reconnect the USB connector at either the PC or the relay.

QuickSet is more tolerant to unexpected USB device disconnections than most other PC applications. While using 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

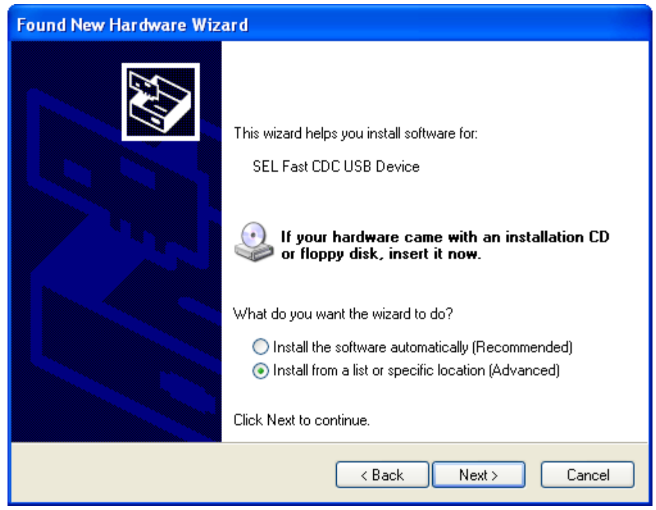
The following detailed instructions for USB driver installation are specifically for the Windows XP operating system. Some steps may be different and some screens may be changed for other Windows operating systems.

Step 1. Retrieve the USB driver file "SEL Fast CDC USB Device.INF" from the SEL-311C product page on the SEL website (selinc.com). Place the INF file in any convenient directory, such as C:\SEL\Drivers\Relay_USB.

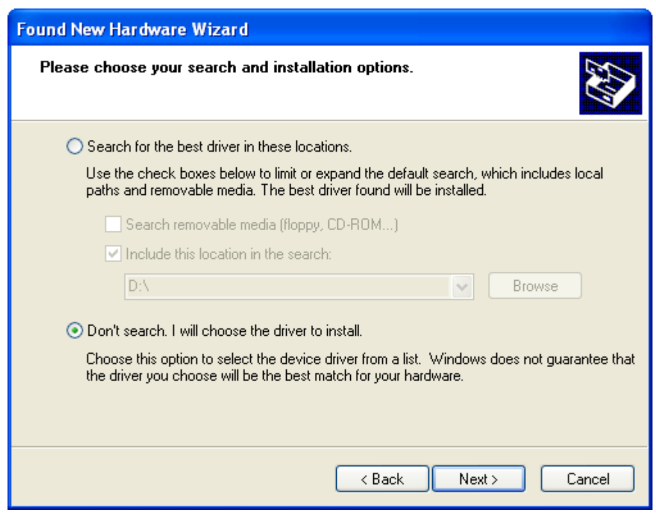
NOTE: The SEL-311 USB driver is different than the driver used for SEL EIA-232 serial to USB converter SEL-C662 cable, and is different from the driver used for the SEL-2440 Discrete Programmable Automation Controller.

Step 2. Connect the relay to your PC with SEL-C664 Cable, 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 select **Next**. Some Windows XP systems will skip this screen and go to the screen shown in *Step 3*.

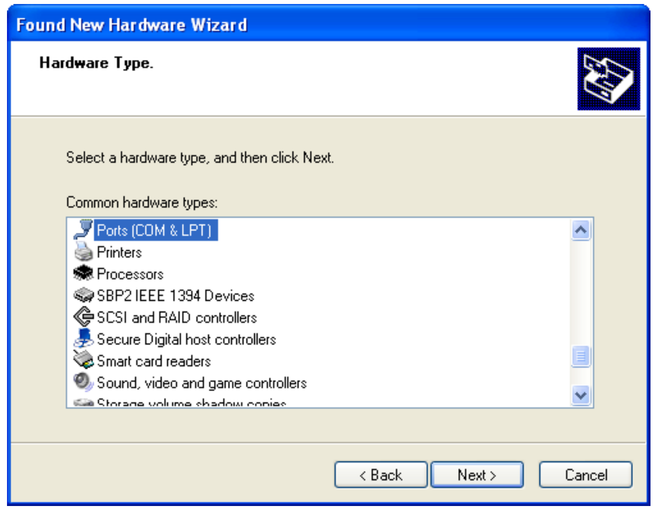
Step 3. Select **Install from a list or specific location (Advanced)**. Select **Next**.



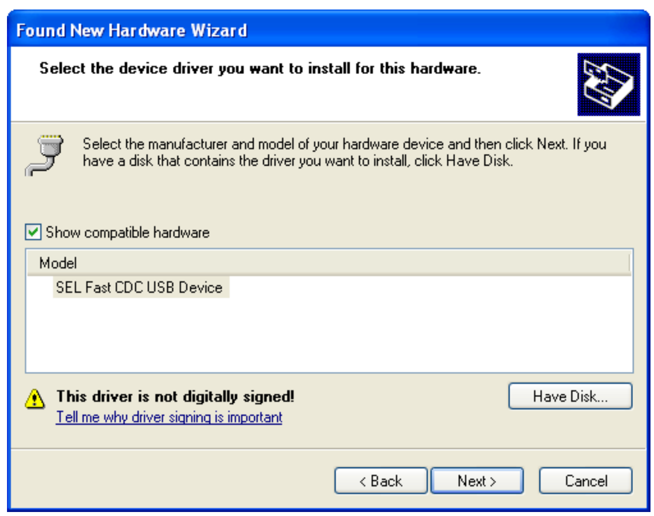
Step 4. Select **Don't search. I will choose the driver to install**. Select **Next**.



Step 5. If prompted for a hardware type select **Ports (COM & LPT)** and select **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**. Select **Next**.

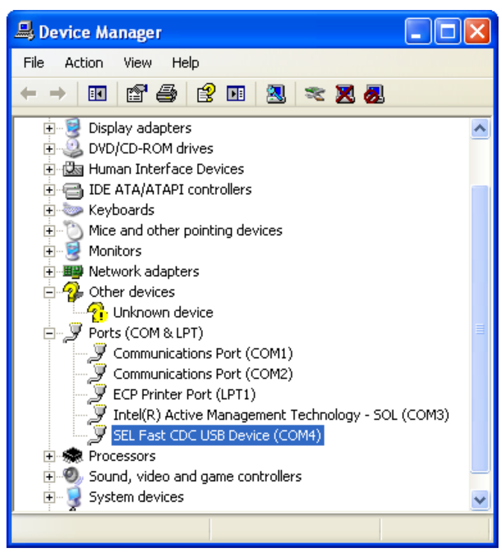


Step 7. If Windows warns that the driver has not passed Windows Logo testing, verify that the name **SEL Fast CDC USB Device** matches the Model selected in *Step 6*, and then select **Continue Anyway**.

Step 8. Wait while the wizard installs the driver software.

Step 9. Select **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 the steps below.

Step 1. Launch QuickSet, and select **Communications > Parameters** from the menu, or select the **Communications Parameters** icon from the opening screen. See *Appendix C: PC Software* for more information on 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 select the terminal icon on the tool bar. Log in to the relay normally. The USB port should work similarly to an EIA-232 port, only much faster. See *Table 10.7* for a list of features available from the USB port.

Establishing Communications Using an Ethernet Port and Telnet or the Web Server

NOTE: The host portion of the IP address cannot be set to all 0s or 1s.

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 by 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 10.62* 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.47* for the Port 5 settings sheets.

Make the following settings by 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

NOTE: Telnet and the 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.

- NETMODE = SWITCHED (available with dual Ethernet ports)
- ETELNET = Y
- EHTTP = Y

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 automatic crossover, so nearly any Cat 5 Ethernet cable with RJ45 connectors, such as SEL-C627 cable will work. When the computer does not support automatic crossover, use a crossover cable, such as SEL-C628 cable. For fiber-optic Ethernet ports use SEL-C807 cable62.5 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 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.

Ethernet Port Speed

Change the speed of 10/100BASE-T copper Ethernet ports by using Port setting NET5SPD for relays equipped with one 10/100BASE-T Ethernet port and settings NET5ASPD and NET5BSPD for relays equipped with two 10/100BASE-T Ethernet ports. Port speed is fixed at 100 Mbps for all copper and fiber-optic ports in relays with one or more 100BASE-FX Ethernet ports.

Using Redundant Ethernet Ports

The SEL-311C is optionally equipped with two 10/100BASE-T copper Ethernet ports, two 100BASE-FX fiber-optic Ethernet ports, or one 10/100BASE-T and one 100BASE-FX port. 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*.

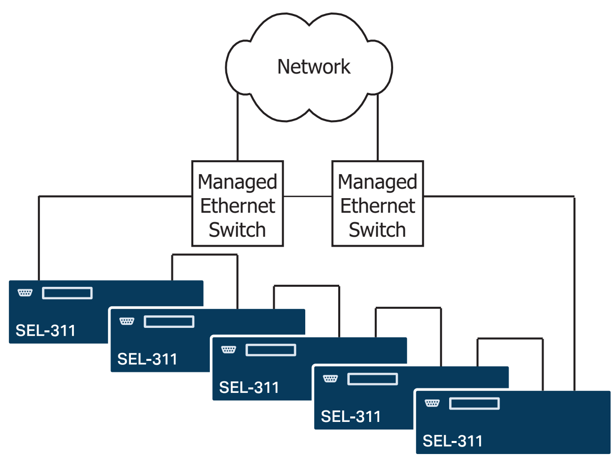


Figure 10.1 Self-Healing Ring Using Internal Ethernet Switch

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 time-out 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*.

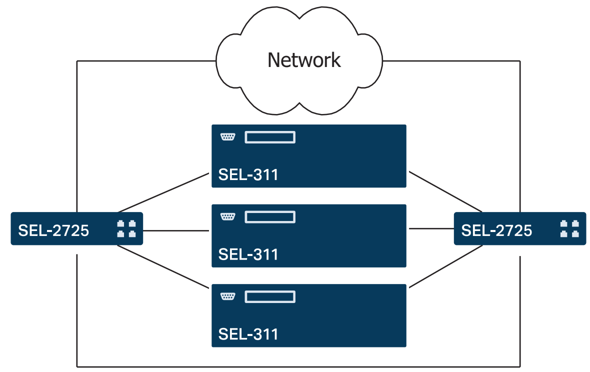


Figure 10.2 Failover Network Topology

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.

Network Connection Using PRP Connection Mode

Parallel Redundancy Protocol (PRP) is part of an IEC standard for high availability automation networks (IEC 62439-3). The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure.

The basic concept is that the Ethernet network and all traffic are fully duplicated with the two copies operating in parallel.

Make the following settings in Port 5 to configure the relay for PRP mode.

- ➤ NETMODE := PRP
- ➤ PRPTOUT := desired time-out for PRP frame entry
- ➤ PRPADDR := PRP destination MAC address LSB 01-15-4E-00-01-XX
- ➤ PRPINTV := desired supervision frame transmit interval

When NETMODE is not set to PRP, the following settings are hidden.

Table 10.2 PRP Settings

Setting Name	Range	Units	Default Value	Setting Description
PRPTOUT	400–10000	ms	500	PRP Entry Time-out
PRPADDR	0–255		00	The multicast MAC address of PRP supervision frames is 01-15-4E-00-01-XX where XX is specified by this setting.
PRPINTV	1–10	seconds	2	PRP Supervision TX Interval

Ethernet Status Relay Word Bits

The SEL-311C Ethernet status is available through the Relay Word bits shown in *Table 10.3*.

Table 10.3 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 optional 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 10.4* through *Table 10.6* show the functions of the pins and terminals of the serial ports.

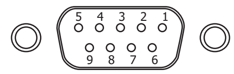


Figure 10.3 DB-9 Connector Pinout for EIA-232 Serial Ports

Table 10.4 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 2.30.

Table 10.5 Terminal Functions for EIA-485 Serial Port 1

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

Table 10.6 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 at the rear of 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 10.4*). This is handled adeptly by connecting Serial Port 2 of the SEL-311C to an SEL-2032 with SEL-C273A Cable (see cable diagrams that follow in this section).

When paired with an SEL-2812MT or SEL-2812FT fiber-optic transceiver and SEL communications processor, automation controller, or satellite-synchronized clock, the fiber-optic serial port also operates as an IRIG-B input.

The relay uses IRIG-B signals from the three sources with the following priority.

- BNC input
- Serial Port 2 IRIG-B pins
- SEL-2812 compatible fiber-optic Port 1 (if present)

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.26* for more details on TIRIG.

Relay Word Bit TSOK

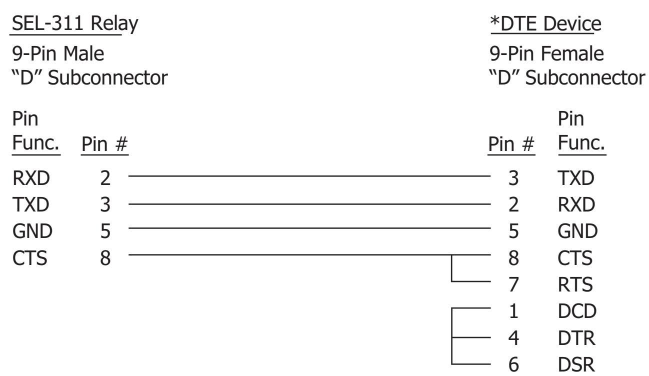
TSOK asserts to indicate that the IRIG-B time source is of a sufficient accuracy for synchrophasor measurement. See *Configuring High-Accuracy Timekeeping on page N.26*.

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.

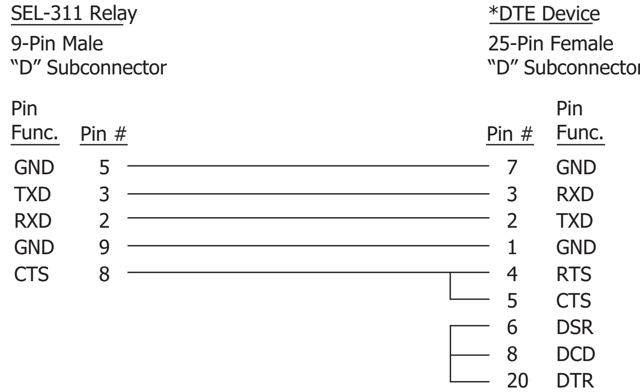
SEL-311C to Computer

SEL-C234A Cable



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

SEL-C227A Cable

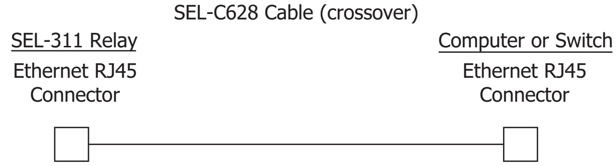


*DTE = Data Terminal Equipment (Computer, Terminal, Printer, etc.)

SEL-C664 Cable

SEL-311C to Network

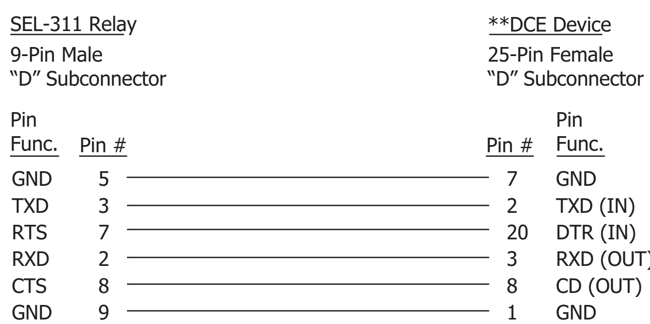
SEL-C627 Cable (straight-through)
SEL-C628 Cable (crossover)



SEL-C807 Cable

SEL-311C to Modem

SEL-C222 Cable



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

SEL-311C to SEL-PRTU

SEL-C231 Cable

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

SEL-C273A Cable

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

SEL-C272A Cable

SEL-DTA2
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
GND	5	5	GND
RTS	7	7	RTS
CTS	8	8	CTS

For long-distance communications as far as 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 10.7*.

Table 10.7 Supported SEL-311C Communications Protocols

	Port 1 EIA-485 or Fiber Optic	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*
C37.118 Synchrophasors	X	X	X	X		X	*Appendix N*
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*
SNTP						X	*Section 10*
FTP						X	*Section 10*
Telnet						X	*Section 10*
Ping						X	*Section 10*
Web Server (HTTP)						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 10.7*. The number of allowed protocol sessions depends on what other protocols are enabled, as shown in *Table 10.8*.

Table 10.8 Protocol Session Limits (Sheet 1 of 2)

Protocol	Sessions Supported[a]
DNP3	The relay supports seven total DNP sessions (combined serial and Ethernet sessions).
IEC 61850	The relay supports seven 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.

Table 10.8 Protocol Session Limits (Sheet 2 of 2)

Protocol	Sessions Supported[a]
Telnet	The number of available simultaneous Telnet sessions depends on Port 5 relay settings E61850, EHTTP (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.)

Distributed Network Protocol (DNP3)

The relay provides Distributed Network Protocol (DNP3) slave support. DNP is described in *Appendix L: DNP3 Communications*.

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.

Modbus Protocol

The relay provides Modbus protocol as described in *Appendix O: Modbus RTU and TCP Communications*.

IEEE C37.118 Synchrophasor Protocol

The relay supports the C37.118 protocol at as many as 60 messages per second as described in *Appendix N: Synchrophasors*.

Ping Server

Use a Ping client with the relay Ping server to verify that your network configuration is correct. Ping is an application based on ICMP over an IP network. A free Ping application is included with most computer operating systems.

SEL ASCII Protocol

SEL ASCII protocol is designed for manual and automatic communications.

All commands received by the relay must be of the following 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*. The optional USB port does not support automatic messages.

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

Condition	Description
Turn On	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*.
Group Switch	The relay displays the active settings group after a group switch occurs. See *GRO Command (Display Active Setting Group Number) on page 10.48*.
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 10.71*.

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 10.19*. The commands can be accessed only from the corresponding access level as shown in *Table 10.19*. The access levels are listed below.

- ➤ 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

Limit the maximum allowable access level on any enabled port configured for Telnet, SEL ASCII, or LMD protocols by 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 as high as 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 time-out, any new access level attempts on the USB port are only granted as high as the Port F MAXACC allowed level.

When MAXACC = 0, the port is available for SEL Fast Messaging, Fast Operate, and Fast Synchrophasors only.

Disable any port by using the EPORT setting. For example, if EPORT = N on **Port 5**, then **Port 5**, **5A**, and **5B** will be nonresponsive.

See *Port Enable Settings on page 9.20* 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 10.35* 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 10.19*. 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 10.19*. 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 10.19*. 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 Access Level C 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 Access Level C 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 10.35* for more detail). Enter the **CAL** command at the Access Level 2 prompt.

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

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 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*.

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 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*.

MIRRORED BITS Communications

The SEL-311C supports MIRRORED BITS relay-to-relay communications on two ports simultaneously (see *Appendix H: MIRRORED BITS Communications*).

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.

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.26). 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 IRIG-B 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 both TSOK and 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 website 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*
- AN2009-38: *Using SEL Satellite-Synchronized Clocks With the SEL-3332 or SEL-3351 to Output NTP*
- AN2010-03: *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 10.10* shows each setting associated with SNTP.

Table 10.10 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 the 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 within 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. The relay maintains synchronism to either the primary or backup NTP server until the connection to that server is lost.

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 TSNTPP deasserts if the relay does not receive a valid broadcast within 5 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 webpages 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. As many as three users can access the embedded web server simultaneously.

Access Level 1 provides a read-only display of settings, reports, and meter values. Access Level 2 allows the user to upgrade firmware over the Web Server interface (see *Method Three: Using a Web Browser on page B.21*). Port 5 setting HTTPACC determines the maximum access level available to the web server, and its default is level 2.

To begin using the embedded 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*.

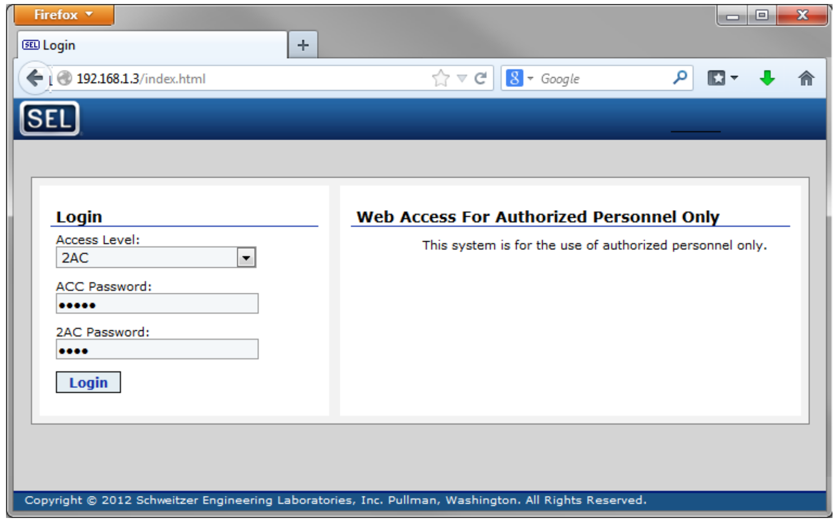


Figure 10.4 Web Server Login Screen

If HTTPACC is set to 2, Access Level 1 (ACC) or Access Level 2 (2AC) can be chosen from the Access Level drop-down box. Enter the appropriate password(s) in the text box(es) below the Access Level drop-down box. If 2AC is chosen, both the ACC and 2AC passwords must be entered to log in, as shown in *Figure 10.4*. Note that access level passwords are not encrypted in any way by the web server when logging in.

Once you have entered the correct password(s), the relay responds with the meter display homepage. While you remain logged into the relay, the webpage displays the approximate time as determined by the relay time-of-day clock, and increments the displayed time every few seconds based on the clock contained in your PC. *Figure 10.5* shows an example of the Device Features screen, equivalent to the relay version (**VER**) command.

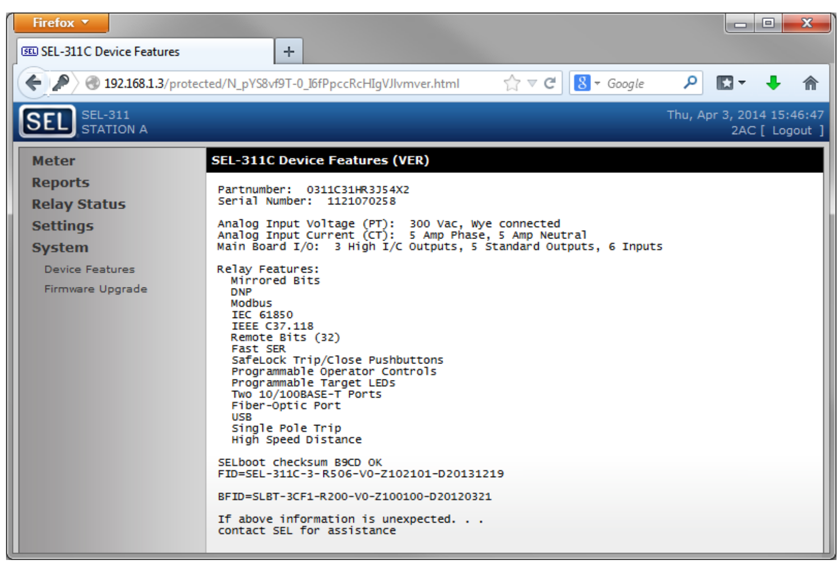


Figure 10.5 Web Server Response to System, Device Features Selection

Select 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*.

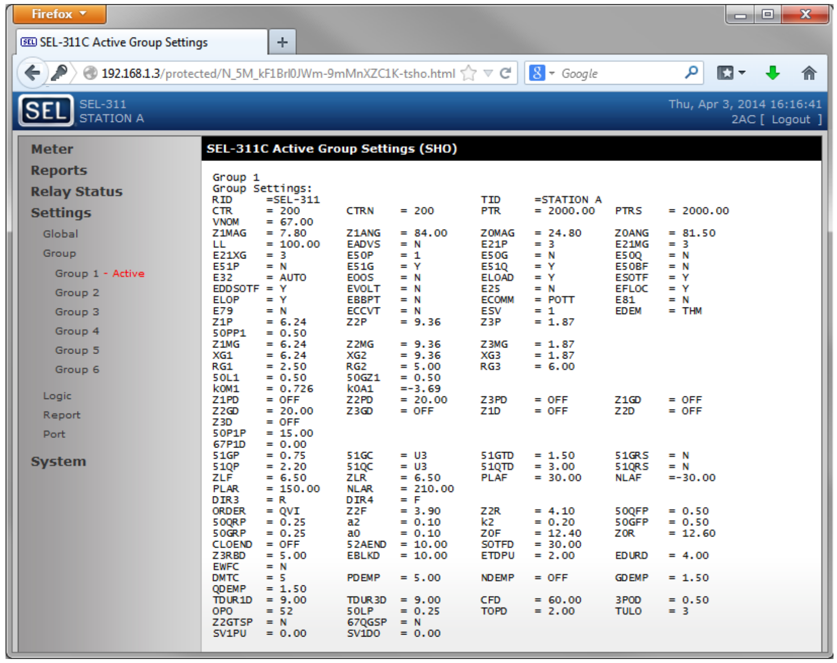


Figure 10.6 Web Server Show Settings Screen

The Meter Reports screens update automatically about every 5 seconds.

To log out, either close the web browser window or select **[Logout]** in the banner bar near the top of the webpage.

File Transfer Protocol (FTP) and MMS File Transfer

File Transfer Protocol (FTP) is a standard protocol for exchanging files between computers over a TCP/IP network. The SEL-311C operates as an FTP server, presenting files to FTP clients. The relay supports one FTP session at a time. Requests to establish additional FTP sessions are denied.

Manufacturing Messaging Specification (MMS) is used in IEC 61850 applications and provides services for the transfer of real-time data, including files, within a substation LAN.

File Structure

The file structure is organized as a directory and subdirectory tree similar to that used by Windows and other common operating systems. See *Virtual File Interface on page 10.25* for information on available files.

File dates within the last 12 months are displayed with month, day, hour, and minutes. Dates older than 12 months have the year, month, and day. The times are UTC.

Access Control

To log into the FTP server, enter the value of the Port 5 setting FTPUSER as the user name in your FTP application. Enter the Level 2 password as the password in your FTP application. Note that FTP does not encrypt passwords before sending them to the server.

MMS is enabled when Port 5 setting E61850 is set to Y. MMS File Transfer is enabled when setting EMMSFS is set to Y. If MMS Authentication is enabled via the CID file, then an authenticated connection must be established via MMS for MMS file transfer to take place.

Using FTP and MMS

A free FTP application is included with most web browser software and PC operating systems. You can also obtain free or inexpensive FTP applications from the internet. Once you have retrieved the necessary files, be sure to close the FTP connection by using the disconnect function of your FTP application or by completely closing the application. Failure to do so can cause the FTP connection to remain open, which blocks subsequent connection attempts until FTPIDLE time expires.

See *Appendix P: IEC 61850* for information about using MMS.

Virtual File Interface

You can retrieve and send data as files through the relay virtual file interface. Devices with embedded computers can also use the virtual file interface. When using serial ports or virtual terminal links, use the **FILE DIR** command to access the file interface.

Send and receive files by using the following three protocols:

1. File Transfer Protocol (FTP)
2. MMS File Transfer
3. Ymodem

FTP and MMS File Structure

FTP and MMS have a two-level file structure. Files are available at the root level and subdirectories. *Table 10.11* shows the directories and their contents.

Table 10.11 FTP and MMS Virtual File Structure

Directory	Contents
Root (/)	CFG.TXT[a] file, CFG.XML file, ERR.TXT file and SET_61850.CID and the SETTINGS, REPORTS, DIAGNOSTICS, EVENTS, and COMTRADE[b] directories
/SETTINGS[a]	Relay settings
/REPORTS	SER, target, metering, circuit breaker, and history reports
/DIAGNOSTICS	Relay status and vector reports
/EVENTS	CEV, COMTRADE, and history reports
/COMTRADE[b]	COMTRADE events

[a] Only available in FTP file structure
[b] Only available in MMS file structure.

Root Directory

The root directory (/) contains files and subdirectories as shown in *Table 10.11*.

CFG.TXT File (Read-Only)

The CFG.TXT file contains general configuration information about the relay and each settings class. External support software retrieves the CFG.TXT file to interact automatically with the relay. The relay calculates a checksum, or hash code, for each settings class and lists the codes in the CFG.TXT file (see *Figure 10.7*). Improve system security by periodically reading the CFG.TXT file and comparing the current hash codes to those in a secured copy of the file. See *Appendix Q: Cybersecurity Features* for more information.

```
[INFO]
RELAYTYPE=0311C
FID=SEL-311C-3-R507-V0-Z103101-Dyyyymmdd
BFID=SLBT-3CF1-R200-V0-Z100100-D20120321
PARTNO=0311C30HH3J54X1
[CLASSES]
"1","Group 1","SET_1.TXT","88FE63CB"
"2","Group 2","SET_2.TXT","88FE63CB"
"3","Group 3","SET_3.TXT","88FE63CB"
"4","Group 4","SET_4.TXT","88FE63CB"
"5","Group 5","SET_5.TXT","88FE63CB"
"6","Group 6","SET_6.TXT","88FE63CB"
"D1","DNP Map 1","SET_D1.TXT","761C0BCD"
"D2","DNP Map 2","SET_D2.TXT","761C0BCD"
"D3","DNP Map 3","SET_D3.TXT","761C0BCD"
"G","Global","SET_G.TXT","99901E1D"
"L1","Logic 1","SET_L1.TXT","C0E7C556"
"L2","Logic 2","SET_L2.TXT","C0E7C556"
"L3","Logic 3","SET_L3.TXT","C0E7C556"
"L4","Logic 4","SET_L4.TXT","C0E7C556"
"L5","Logic 5","SET_L5.TXT","C0E7C556"
"L6","Logic 6","SET_L6.TXT","C0E7C556"
"M","Modbus","SET_M.TXT","FCC01D5C"
"P1","Port 1","SET_P1.TXT","939DC3DD"
"P2","Port 2","SET_P2.TXT","55D70365"
"P3","Port 3","SET_P3.TXT","C47944EC"
"PF","Port F","SET_PF.TXT","8A4F4858"
"P5","Port 5","SET_P5.TXT","FBA33731"
"R","Report","SET_R.TXT","165EA02E"
"T","Text","SET_T.TXT","ABACF931"
[STORAGE]
```

Figure 10.7 CFG.TXT File

CFG.XML File (Read-Only)

Present only in units with the optional Ethernet card installed, the CFG.XML file is supplementary to the CFG.TXT file. The CFG.XML file describes the IED configuration, any options such as the Ethernet port, and includes firmware identification, settings class names, and configuration file information.

ERR.TXT (Read-Only) and SET_61850.CID File

Present if ordered with the IEC 61850 protocol option. The ERR.TXT file contents are based on the most recent SET_61850.CID file written to the relay. If there were no errors, the file is empty. If errors occurred, the relay logs these errors in the ERR.TXT file. The SET_61850.CID file contains the IEC 61850 configured IED description in XML. ACSELERATOR Architect SEL-5032 Software generates and then downloads this file to the relay. See *Appendix P: IEC 61850* for more information.

Settings Directory (Available only for FTP)

You can access the relay settings through files in the SETTINGS directory. We recommend that you use support software to access the settings files, rather than directly accessing them via other means. External settings support software reads settings from all of these files to perform its functions. The relay only allows you to write to the individual SET_cn files, where c is the settings class code and n is the settings instance. Except for the SET_61850

CID file, changing settings with external support software involves the following steps:

Step 1. The PC software reads the CFG.TXT and SET_ALL.TXT files from the relay.

Step 2. You modify the settings at the PC. For each settings class that you modify, the software sends a SET_cn.TXT file to the relay.

Step 3. The PC software reads the ERR.TXT file. If it is not empty, the relay detects errors in the SET_cn.TXT file.

Step 4. For any detected errors, modify the settings and send the settings until the relay accepts your settings.

Step 5. Repeat *Step 2–Step 4* for each settings class that you want to modify.

Step 6. Test and commission the relay.

SET_ALL.TXT File (Read-Only)

The SET_ALL.TXT file contains the settings for all of the settings classes in the relay.

SET_cn.TXT Files (Read and Write)

There is a file for each instance of each setting class. *Table 10.12* summarizes the settings files. The settings class is designated by *c*, and the settings instance number is designated by *n*.

ERR.TXT (Read-Only)

The ERR.TXT file contents are based on the most recent SET_*cn*.TXT file written to the relay. If there were no errors, the file is empty. If errors occurred, the relay logs these errors in the ERR.TXT file.

Table 10.12 Settings Directory Files

Filename	Settings Description
SET_*n*.TXT	Group; *n* in range 1–6
SET_D*n*.TXT	DNP3 remapping; *n* in range 1–3
SET_G.TXT	Global
SET_L*n*.TXT	Logic; *n* in range 1–6
SET_M.TXT	Modbus remapping
SET_P*n*.TXT	Port; *n* in range 1, 2, 3, 5, F
SET_R.TXT	Report
SET_T.TXT	Text
SET_ALL.TXT	All instances of all settings classes
ERR.TXT	Error log for most recently written settings file

Reports Directory (Read-Only)

Use the REPORTS directory to retrieve files that contain the reports shown in *Table 10.13*. Note that the relay provides a report file that contains the latest information each time you request the file. Each time you request a report, the relay stores its corresponding command response in the designated text file.

Table 10.13 Reports Directory Files

Filename	Description	Equivalent Command Response
BRE.TXT	Breaker Report	**BRE**
BRE_H.TXT	Breaker History Report	**BRE H**
CHISTORY.TXT	Compressed ASCII History Report	**CHI**
HISTORY.TXT	History Report	**HIS**
MET.TXT	Instantaneous Metering	**MET**
MET_D.TXT	Demand Metering	**MET D**
MET_E.TXT	Energy Metering	**MET E**
MET_M.TXT	Max-Min Metering	**MET M**
MET_PM.TXT	Synchrophasor Metering	**MET PM**
SER. TXT	Sequence of Events	**SER**
TAR.TXT	Status of all Relay Word bits	**TAR ROW LIST**

Events Directory (Read-Only)

The relay provides history, event reports, and oscillography files in the EVENTS directory as shown in *Table 10.14*.

Event reports are available in the following formats:

- Compressed SEL ASCII
- Binary COMTRADE format (IEEE C37.111-1999)

The size of each event report file is determined by the LER setting in effect at the time the event is triggered.

Compressed SEL ASCII event report files are generated, when requested, by storing the appropriate command response shown in table *Table 10.14*. Oscillography files are generated at the time the event is triggered (see *Standard Event Report Triggering on page 12.3*). Higher resolution oscillography is available with SEL Compressed ASCII 128 sample/cycle raw event reports and binary COMTRADE files.

COMTRADE event files are available to read as a batch. See *Batch File Access on page 10.31*.

Table 10.14 Event Directory Files (Sheet 1 of 2)

Filename	Description	Equivalent Command Response
CHISTORY.TXT[a]	Compressed ASCII History Report	**CHI**
HISTORY. TXT[a]	History Report	**HIS**
C4_*nnnnn*.CEV	Compressed 4-samples/cycle ASCII filtered event report; event ID number = *nnnnn*	**CEV *nnnnn***
CR_*nnnnn*.CEV	Compressed 128-samples/cycle ASCII raw event report; event ID number = *nnnnn*	**CEV R S128 *nnnnn***

Table 10.14 Event Directory Files (Sheet 2 of 2)

Filename	Description	Equivalent Command Response
HR_*nnnnn*.CFG[b]	COMTRADE configuration file; event ID number = *nnnnn*	N/A
HR_*nnnnn*.DAT[b]	COMTRADE binary data file; event ID number = *nnnnn*	N/A
HR_*nnnnn*.HDR[b]	COMTRADE header file; event ID number = *nnnnn*	N/A

[a] Also available in the Reports directory for convenience.
[b] Also available in the COMTRADE directory for MMS only.

HR_nnnnn.* (Read-Only)

The three files HR_*nnnnn*.CFG, HR_*nnnnn*.DAT, and HR_*nnnnn*.HDR shown in *Table 10.14* are used to create an event report that conforms to the COMTRADE standard. The event is an unfiltered (raw) 128 samples/cycle event. The field, *nnnnn*, corresponds to the unique event identification number displayed by the **HIS E** command. For details on event reports see *Section 12: Standard Event Reports and SER*.

Diagnostics Directory (Read-Only)

Use the DIAGNOSTICS directory to retrieve files that contain the reports shown in *Table 10.15*. Each time a diagnostic report is requested the relay stores the following command response in the designated text file.

Table 10.15 Diagnostic Directory Files

Filename	Description	Equivalent Command Response
STATUS.TXT	Status report	**STA**
VEC_D.TXT	Standard vector report	**VEC D**
VEC_E.TXT	Extended vector report	**VEC E**

COMTRADE Directory (Available Only for MMS)

When using MMS file transfer, conveniently retrieve all of the COMTRADE files from the COMTRADE directory. Note that the COMTRADE files are also available in the Events directory. Refer to *Table 10.14* for all the files available in the COMTRADE directory.

Ymodem File Structure

All the files available (see *Table 10.16*) for Ymodem protocol are in the root directory. See *FIL Command on page 10.44* for a response of the **FIL DIR** command.

Table 10.16 Files Available for Ymodem Protocol (Sheet 1 of 3)

Filename	Description	Read Access Level	Write Access Level
CFG.TXT	See *Root Directory on page 10.25*	1, B, 2, C	N/A
ERR.TXT	See *Settings Directory (Available only for FTP) on page 10.26*	1, B, 2, C	N/A

Table 10.16 Files Available for Ymodem Protocol (Sheet 2 of 3)

Filename	Description	Read Access Level	Write Access Level
SET_ALL.TXT[a]	See *Settings Directory (Available only for FTP) on page 10.26*	1, B, 2, C	N/A
SET_*n*.TXT	See *Settings Directory (Available only for FTP) on page 10.26*	1, B, 2, C	2, C
SET_C.TXT[a]	See *Settings Directory (Available only for FTP) on page 10.26*	C	C
SET_D*n*.TXT	See *Settings Directory (Available only for FTP) on page 10.26*	1, B, 2, C	2, C
SET_G.TXT	See *Settings Directory (Available only for FTP) on page 10.26*	1, B, 2, C	2, C
SET_L*n*.TXT	See *Settings Directory (Available only for FTP) on page 10.26*	1, B, 2, C	2, C
SET_M.TXT	See *Settings Directory (Available only for FTP) on page 10.26*	1, B, 2, C	2, C
SET_P*n*.TXT	See *Settings Directory (Available only for FTP) on page 10.26*	1, B, 2, C	2, C
SET_R.TXT	See *Settings Directory (Available only for FTP) on page 10.26*	1, B, 2, C	2, C
SET_T.TXT	See *Settings Directory (Available only for FTP) on page 10.26*	1, B, 2, C	2, C
SWCFG.ZIP	The SWCFG.ZIP file is a compressed file used to store external support for software settings.	1, B, 2, C	2, C
C4_nnnnn.CEV	See *Events Directory (Read-Only) on page 10.28*	1, B, 2, C	N/A
CR_nnnnn.CEV	See *Events Directory (Read-Only) on page 10.28*	1, B, 2, C	N/A
HR_nnnnn.CFG	See *Events Directory (Read-Only) on page 10.28*	1, B, 2, C	N/A
HR_nnnnn.DAT	See *Events Directory (Read-Only) on page 10.28*	1, B, 2, C	N/A
HR_nnnnn.HDR	See *Events Directory (Read-Only) on page 10.28*	1, B, 2, C	N/A
STATUS.TXT	See *Diagnostics Directory (Read-Only) on page 10.29*	1, B, 2, C	N/A
VEC_D.TXT	See *Diagnostics Directory (Read-Only) on page 10.29*	2, C	N/A
VEC_E.TXT	See *Diagnostics Directory (Read-Only) on page 10.29*	2, C	N/A
BRE.TXT	See *Reports Directory (Read-Only) on page 10.27*	1, B, 2, C	N/A
BRE_H.TXT	See *Reports Directory (Read-Only) on page 10.27*	1, B, 2, C	N/A
CHIS-TORY.TXT	See *Reports Directory (Read-Only) on page 10.27*	1, B, 2, C	N/A
HISTORY.TXT	See *Reports Directory (Read-Only) on page 10.27*	1, B, 2, C	N/A
MET.TXT	See *Reports Directory (Read-Only) on page 10.27*	1, B, 2, C	N/A

Table 10.16 Files Available for Ymodem Protocol (Sheet 3 of 3)

Filename	Description	Read Access Level	Write Access Level
MET_D.TXT	See *Reports Directory (Read-Only) on page 10.27*	1, B, 2, C	N/A
MET_E.TXT	See *Reports Directory (Read-Only) on page 10.27*	1, B, 2, C	N/A
MET_M.TXT	See *Reports Directory (Read-Only) on page 10.27*	1, B, 2, C	N/A
MET_PM.TXT	See *Reports Directory (Read-Only) on page 10.27*	1, B, 2, C	N/A
SER.TXT	See *Reports Directory (Read-Only) on page 10.27*	1, B, 2, C	N/A
TAR.TXT	See *Reports Directory (Read-Only) on page 10.27*	1, B, 2, C	N/A

[a] Calibration settings are included only when accessed at Level C.

SWCFG.ZIP

SWCFG.ZIP file is only available for Ymodem protocol and is not available in the FTP and MMS file structure. The SWCFG.ZIP file is a fixed name, general purpose file that can be as large as 2 MB in length. Users may store any type of data or information file they choose in this file, even if it is not a zipped file, as long as it is named SWCFG.ZIP. QuickSet uses the SWCFG.ZIP file to store template files created by the licensed version of QuickSet. The SWCFG.ZIP file is only visible in the **FIL DIR** command when a user has loaded it onto the relay.

Batch File Access

FTP and MMS Wildcard Usage

Table 10.17 shows some examples using supported wildcards. Note that these wildcards may be appended to a directory path (e.g., /specified_directory/*.txt).

Table 10.17 FTP and MMS Wildcard Usage Examples

Usage	Description	Example	Note
Null String	Lists all files and/or subdirectories in a specified directory.	/SETTINGS/	Lists all files and/or subdirectories within the SETTINGS directory.
*	Lists all files and/or subdirectories in a specified directory.	/EVENTS/*	Lists all files and/or subdirectories within the EVENTS directory.
**xyz*	Lists all files and/or subdirectories in a specified directory whose name (including extension) ends with *xyz*.	/*.TXT	Lists all files with the *.TXT extension.
*abc**	Lists all files and/or subdirectories in a specified directory whose name begins with *abc*.	/SETTINGS/SET*	List all settings files that start with SET.
mno	Lists all files and/or subdirectories in a specified directory whose name contains *mno*.	/EVENTS/*_100*	List all events that contain _100 in the ID number.
filename	Lists only *filename* if it is a file and not a directory (i.e. it does not end with /).	/cfg.xml	

Ymodem Wildcard Usage

NOTE: Ymodem protocol does not support wildcards for settings files.

Event, report, and diagnostic files can also be accessed as batch by using wildcards.

Table 10.18 Ymodem Wildcard Usage Examples

Usage	Description	Example	Note
**xyz*	Lists all files that end with *xyz*.	FILE DIR MET*.TXT	Lists all of the metering files (MET.TXT, MET_D.TXT, etc.)
*abc**	Lists all files a whose name begins with *abc*.	FILE READ HR_10007*	Retrieves all of the three files for the COMTRADE event 10007 (HR_10007.CFG, HR_10007.DAT, and HR_10007.HDR)
mno	Lists all files a whose name begins with *mno*.	FILE READ *10007*	Retrieves all event files pertaining to the unique event number 10007 (including both the filtered and raw compressed event reports and all three COMTRADE files).
abc?.*xyz*	Lists all files whose name begins with *abc* and whose name (including extension) ends with *xyz* and has any one single character following the letter *c*.	FILE READ C?_10007.CEV	Retrieves both the filtered and raw compressed event reports pertaining to the unique event number 10007.

Command Summary

Table 10.19 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 10.19 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-311C Relays With Ethernet*, *Appendix J: Configuration, Fast Meter, and Fast Operate Commands*, and *Appendix K: Compressed ASCII Commands*.

Table 10.19 ASCII Command Summary (Sheet 1 of 2)

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	
0	=	**BNA**	Displays information useful for autoconfiguration of data gathering equipment	
1	=>	**BRE**	Breaker monitor data	OTHER
1	=>	**BRE H**	View breaker history	
B	==>	**BRE R**	Reset breaker wear	OTHER
B	==>	**BRE W**	Preload breaker wear	
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
0	=	**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	=>	**ETH C**	Clears Ethernet port statistics	
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	

Table 10.19 ASCII Command Summary (Sheet 2 of 2)

Access Level	Prompt	ASCII Command	Command Description	Corresponding Front-Panel Pushbutton
1	=>	**GRO**	Display active setting group number	GROUP
B	==>	**GRO *n***	Change active setting group	GROUP
1	=>	**HIS**	Event summaries/histories	EVENTS
1	=>	**HIS E**	Event history with unique event number	
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	
1	=>	**PIN**	Ping command	
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
0	=	**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	
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 listed below:

`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 10.19*. 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 2.20* for Access jumper information. See *PAS Command (Change Passwords) on page 10.58* 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 10.58*. At the prompt above, enter the default password and press the **<Enter>** key. The relay responds as follows.

```
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: ?`). If the requested password is incorrectly entered for levels above Access Level 1, the relay asserts Relay Word bit PASNVAL for approximately one second. After three attempts, the relay displays an invalid access message, asserts Relay Word bit BADPASS for approximately 1 second 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 as follows.

```
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.

Access Level Indication

The relay asserts Relay Word bit ACCESSP for approximately one second after a successful Level B, Level 2, or Level C access. Relay Word bit ACCESS also asserts and remains asserted when an access level above Access Level 1 has been achieved on any port or on the front panel. These Relay Word bits can be used to create custom alarm schemes. See *Output Contacts on page 7.32*. Refer to *Port Access Levels on page 10.18* 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 H	Display the 128 most recent breaker operations	1
BRE W	Preload breaker/recloser contact wear monitor data.	B
BRE R	Reset breaker/recloser contact wear monitor.	B

```
=>>BRE <Enter>
SEL-311C                        Date: 08/17/11    Time: 04:45:23.181
STATION A

                                A-phase     B-phase     C-phase
Accum Contact Wear (%)                4           4           6

Rly Accum Pri Current (kA)         40.7        41.4        53.8
Ext Accum Pri Current (kA)          0.8         0.9         1.1

Rly Trip Count                        9
Ext Trip Count                        3

                               Trip A  Trip B  Trip C   Cls A   Cls B   Cls C
Avg. Elect Op Time (ms)          35.4    35.2    33.8    50.5    51.2    51.3
Last Elect Op Time (ms)          75.5    75.1    75.9    51.8    51.6    52.1

Avg. Mech Op Time (ms)           43.7    44.5    44.0    50.6    51.4    50.9
Last Mech Op Time (ms)          109.0+   44.1    43.5    52.3    52.5    51.9

Last Op Minimum VDC (V)         124.4   124.3   124.4   123.8   123.8   123.8

                                Alarm  Total Count
Mechanical Operating Time       MSOAL         3
Electrical Operating Time       ESOAL         1

LAST RESET 08/17/11 04:42:29
=>>
```

See *BRE n Command (Preload/Reset Breaker Wear)* and *Breaker Monitor on page 8.1* for further details on the breaker monitor.

The **BRE** and **BRE H** command responses are also available via File Transfer Protocol (FTP) and MMS. See *File Transfer Protocol (FTP) and MMS File Transfer on page 10.24*.

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) A-phase = 0          ? 14 <ENTER>
Relay/Internal Trip Counter (0-65535) B-phase = 0          ? 14 <ENTER>
Relay/Internal Trip Counter (0-65535) C-phase = 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)       A-phase = 0          ? 2 <ENTER>
External Trip Counter (0-65535)       B-phase = 0          ? 2 <ENTER>
External Trip Counter (0-65535)       C-phase = 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    = 10:30:00   ? 00:39:58 <ENTER>
Save Changes(Y/N)? Y <Enter>

SEL-311                         Date: 01/04/11    Time: 08:37:56.690
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          14          14
Ext Trip Count                        2           2           2

                               Trip A  Trip B  Trip C   Cls A   Cls B   Cls C
Avg. Elect Op Time (ms)           0.0     0.0     0.0     0.0     0.0     0.0
Last Elect Op Time (ms)           0.0     0.0     0.0     0.0     0.0     0.0
```

```
Avg. Mech Op Time (ms)            0.0     0.0     0.0     0.0     0.0     0.0
Last Mech Op Time (ms)            0.0     0.0     0.0     0.0     0.0     0.0

Last Op Minimum VDC (V)           0.0     0.0     0.0     0.0     0.0     0.0

                                Alarm  Total Count
Mechanical Operating Time       MSOAL         0
Electrical Operating Time       ESOAL         0

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           0           0
Ext Trip Count                        0           0           0

                               Trip A  Trip B  Trip C   Cls A   Cls B   Cls C
Avg. Elect Op Time (ms)          35.4    35.2    33.8    50.5    51.2    51.3
Last Elect Op Time (ms)          75.5    75.1    75.9    51.8    51.6    52.1

Avg. Mech Op Time (ms)           43.7    44.5    44.0    50.6    51.4    50.9
Last Mech Op Time (ms)          109.0+   44.1    43.5    52.3    52.5    51.9

Last Op Minimum VDC (V)         124.4   124.3   124.4   123.8   123.8   123.8

                                Alarm  Total Count
Mechanical Operating Time       MSOAL         3
Electrical Operating Time       ESOAL         1


LAST RESET 01/03/11 00:39:58
==>
```

Use the **BRE H** command to view the most recent 128 breaker operations:

```
=>BRE H <Enter>
FEEDER 1                           Date: 08/17/12    Time: 05:38:47.063
STATION A
                                   Op Time(ms)   Current   VDC
No.    Date      Time       Bkr Op  Elec    Mech     (A)      (V)
1    08/17/12 05:38:42.741  TRIP A  75.5  109.0+    6649  124.4
2    08/17/12 05:38:42.741  TRIP C  75.9   43.5     7002  124.4
3    08/17/12 05:38:42.699  TRIP B  75.1   44.1     6500  123.3
4    08/16/12 10:21:35.005  CLS A   51.8   52.3           123.8
5    08/16/12 10:21:35.005  CLS B   51.6   52.5           123.8
6    08/16/12 10:21:35.005  CLS C   52.1   51.9           123.8
   •
   •
   •
128  07/07/12 11:16:32.000  CLS B   51.4   52.7           122.5
```

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           0           0
Ext Trip Count                         0           0           0

                                Trip A  Trip B  Trip C   Cls A   Cls B   Cls C
Avg. Elect Op Time (ms)            0.0     0.0     0.0     0.0     0.0     0.0
Last Elect Op Time (ms)            0.0     0.0     0.0     0.0     0.0     0.0

Avg. Mech Op Time (ms)             0.0     0.0     0.0     0.0     0.0     0.0
Last Mech Op Time (ms)             0.0     0.0     0.0     0.0     0.0     0.0

Last Op Minimum VDC (V)            0.0     0.0     0.0     0.0     0.0     0.0

                                 Alarm  Total Count
Mechanical Operating Time        MSOAL        0
Electrical Operating Time        ESOAL        0

LAST RESET 01/03/11 00:39:58
```

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 6.5*.

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 2.20*). If the Breaker jumper is not in place (Breaker jumper = OFF), the relay does not execute the **CLO** command and responds as follows.

```
Aborted: No Breaker Jumper
```

COM Command (Communications 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-2-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-2-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 as many as 255 records in the extended report.

If an error occurs before a previous error has cleared, the error counts in Summary and the communication history events in the Long report are not updated. Last error always displays the most recent error. If communication with the other MIRRORED BITS device does not begin when the relay starts, such as when power is applied, the Last error is `Relay Disabled`.

CON Command (Control Remote Bit)

The **CON** command is a two-step command that allows you to control Relay Word bits RB1–RB32 (see Rows 7, 8, 102, and 103 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 32 representing RB1–RB32.

Step 1. At the Access Level B prompt, type the following.

a. **CON**

b. A space

c. The number of the remote bit you wish to control (1–32)

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 10.20*).

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 as follows.

```
Invalid Command
```

Table 10.20 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 7.9* 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 Relay Word bit SETCHG pulses for approximately one second.

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 turning off the relay or the new setting may be lost.

To set the date follow the steps below.

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 the following.

```
=>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.26* 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 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 C	Clears Ethernet port sent and received packets, bytes, and error statistics	1

```
=>ETH <Enter>

SEL-311                          Date: 10/25/11    Time: 05:40:00.603
STATION A

NETMODE: FAILOVER

PRIMARY PORT:  5A
ACTIVE PORT:   5A

             LINK   SPEED  DUPLEX MEDIA
PORT 5A      Up     100M   Full   TX
PORT 5B      Down   --     --     TX

IP Port:

MAC: 00-30-A7-01-09-2E
IP ADDRESS: 192.168.1.2
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 192.168.1.1

      PACKETS          BYTES          ERRORS
    SENT  RCVD      SENT    RCVD    SENT  RCVD
       2     2       128     172       0     0

GOOSE Port:

MAC: 00-30-A7-01-09-2F

      PACKETS          BYTES          ERRORS
    SENT  RCVD      SENT    RCVD    SENT  RCVD
      34     2      6932     184       0     0
=>
```

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 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 and to retrieve event files (see *Retrieving COMTRADE Event Files on page 12.14*). Reports, event, and diagnostic files are available to read via Ymodem as a batch. See the *Ymodem Wildcard Usage on page 10.32* for more information on using wildcards.

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

The following response shows the available reports, events, and settings available with the **FILE** command. For more information on these files, see *Virtual File Interface on page 10.25*.

```
=>>FILE DIR <ENTER>
CFG.TXT          R    14/03/04    07:14:06
ERR.TXT          R    14/03/04    07:14:06
SET_ALL.TXT      R    14/03/04    07:14:06
SET_1.TXT        RW   14/03/03    08:02:56
SET_2.TXT        RW   14/03/03    08:02:56
SET_3.TXT        RW   14/03/03    08:02:56    Group Settings
SET_4.TXT        RW   14/03/03    08:02:56
SET_5.TXT        RW   14/03/03    08:02:56
SET_6.TXT        RW   14/03/03    08:02:56
SET_D1.TXT       RW   14/03/03    08:02:56
SET_D2.TXT       RW   14/03/03    08:02:56    DNP Settings
SET_D3.TXT       RW   14/03/03    08:02:56
SET_G.TXT        RW   14/03/03    08:02:56    Global Settings
SET_L1.TXT       RW   14/03/03    08:02:56
SET_L2.TXT       RW   14/03/03    08:02:56
SET_L3.TXT       RW   14/03/03    08:02:56
SET_L4.TXT       RW   14/03/03    08:02:56    Logic Settings
SET_L5.TXT       RW   14/03/03    08:02:56
SET_L6.TXT       RW   14/03/03    08:02:56
SET_M.TXT        RW   14/03/03    08:02:56    Modbus Settings
SET_P1.TXT       RW   14/03/03    08:02:56
SET_P2.TXT       RW   14/03/03    08:02:56
SET_P3.TXT       RW   14/03/03    08:02:56    Port Settings
SET_PF.TXT       RW   14/03/03    08:02:56
SET_P5.TXT       RW   14/03/03    08:02:56
SET_R.TXT        RW   14/03/03    08:02:56    SER Settings
SET_T.TXT        RW   14/03/03    08:02:56    Text Settings
SWCFG.TXT        RW   14/03/03    08:02:56
C4_10000.CEV     R    14/03/03    07:14:01    Compressed ASCII Filtered Event Report
CR_10000.CEV     R    14/03/03    07:14:01    Compressed ASCII Raw Event Report
HR_10000.CFG     R    14/03/03    07:14:01
HR_10000.DAT     R    14/03/03    07:14:01    COMTRADE Raw Event Report
HR_10000.HDR     R    14/03/03    07:14:01
STATUS.TXT       R    14/03/03    07:14:01
VEC_D.TXT        R    14/03/03    07:14:01    Diagnostic Reports
VEC_E.TXT        R    14/03/03    07:14:01
BRE.TXT          R    14/03/03    07:14:01    Breaker Monitor Reports
BRE_H.TXT        R    14/03/03    07:14:01
CHISTORY.TXT     R    14/03/03    07:14:01    History Reports
HISTORY.TXT      R    14/03/03    07:14:01
MET.TXT          R    14/03/03    07:14:01
MET_D.TXT        R    14/03/03    07:14:01
MET_E.TXT        R    14/03/03    07:14:01    Metering Reports
MET_M.TXT        R    14/03/03    07:14:01
MET_PM.TXT       R    14/03/03    07:14:01
SER.TX           R    14/03/03    07:14:01    SER Report
TAR.TXT          R    14/03/03    07:14:01    Relay Word Bits Status
```

The date and time values are defined as follows:

- ➤ Settings files: when settings last modified
- ➤ Event report files: event trigger time
- ➤ Report files: DIR read request time

Dates are displayed in yy/mm/dd format and are not affected by the Global setting DATE_F. Times are UTC.

GOO Command

Use the **GOOSE** command to display transmit and receive GOOSE messaging and statistics information, which can be used for troubleshooting. The **GOOSE** command variants and options are shown in the following table.

Command Variant	Description	Access Level
GOO	Display GOOSE information.	1
GOO *k*	Display GOOSE information *k* times.	1
GOO S	Display a list of GOOSE subscriptions with their ID.	1
GOO S *n*	Display GOOSE statistics for subscription ID *n*.	1
GOO S ALL	Display GOOSE statistics for all subscriptions.	1
GOO S *n* L	Display GOOSE statistics for subscription ID *n* including error history.	1
GOO S ALL L	Display GOOSE statistics for all subscriptions including error history.	1
GOO S *n* C	Clear GOOSE statistics for subscription ID *n*.	1
GOO S ALL C	Clear GOOSE statistics for all subscriptions.	1

The information displayed for each GOOSE IED is described in the following table.

Information Field	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_311CCFG/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_311CCFG/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 retransmitted 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
`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).

Information Field	Description
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).
Ctrl Ref/ ControlBlockReference	This is the GOOSE control block reference. It is a concatenation of the logical device name, LLN0 (logical node containing the control block), GO (functional constraint), and the GSEControl name. (e.g. SEL_311C_1CFG/LLN0GOGooseDSet13)
AppID	This is the application identifier as a decimal number.
From	This is the date and time the current statistics collection started.
To	This is the date and time the GOOSE statistics command was executed.
Accumulated downtime duration	This represents the total amount of time a subscription was in an error state. The duration is displayed in the format: hhhh:mm:ss.zzz.
Maximum downtime duration	This represents the maximum amount of time a subscription was continuously in error state. The duration is displayed in the format: hhhh:mm:ss.zzz.
Date & time maximum downtime began	This is the date and time the recorded maximum downtime started.
Number of messages received out-of-sequence (OOS)	This represents the total number of messages received with either the state number and/or sequence number out-of-sequence. This includes cases where more than one instance of a message is received within a single relay processing interval. In this case, the most recent message is processed and the others are discarded.
Number of time-to-live (TTL) violations detected	This represents the total number of times a message was not received within the expected period/interval.
Number of messages incorrectly encoded or corrupted	This represents the total number of messages that were identified with this subscription but were either incorrectly encoded or encoded with a wrong data set.
Number of messages lost due to receive overflow	This represents the total number of messages that were not processed because memory resources were exhausted. This includes cases where more than one instance of a message is received within a single relay processing interval. In this case, the most recent message is processed and the others are discarded.
Calculated max. sequential messages lost due to OOS	This represents the maximum estimated number of messages that were missed after receiving a message with a higher state or sequence number than expected.
Calculated number of messages lost due to OOS	This represents the total of all estimated number of messages lost as a result of state or sequence number skip in received messages.

An example response to the **GOOSE** commands is shown in *Figure 10.8*.

```
#>GOOSE <Enter>

GOOSE Transmit Status

 MultiCastAddr   Ptag:Vlan AppID  StNum      SqNum      TTL    Code
----------------------------------------------------------------------------
SEL_311C_1CFG/LLN0$GO$GooseDSet13
 01-0C-CD-01-00-12 4:1     4114   1          11175      638
 Data Set: SEL_311C_1CFG/LLN0$DSet13

GOOSE Receive Status

 MultiCastAddr   Ptag:Vlan AppID  StNum      SqNum      TTL    Code
----------------------------------------------------------------------------
SEL_487E_1CFG/LLN0$GO$GOOSEMessage1
 01-0C-CD-01-00-10 4:1     4112   2          18248      2000
 Data Set: SEL_487E_1CFG/LLN0$DSet13

SEL_487E_1CFG/LLN0$GO$GOOSEMessage2
 01-0C-CD-01-00-05 4:3     5      3          18249      2000
 Data Set: SEL_487E_1CFG/LLN0$DSet03

SEL_487E_1CFG/LLN0$GO$GOOSEMessage3
 01-0C-CD-01-00-06 4:3     6      2          18250      2000
 Data Set: SEL_487E_1CFG/LLN0$DSet04

SEL_487E_1CFG/LLN0$GO$GOOSEMessage4
 01-0C-CD-01-00-07 4:3     7      2          18250      2000
 Data Set: SEL_487E_1CFG/LLN0$DSet10

=>GOOSE S 1 L <Enter>

 SubsID 1
----------------------------------------------------------------------------
 Ctrl Ref: SEL_487E_1CFG/LLN0$GO$GOOSEMessage1
 AppID   : 4112
 From    : 03/14/2012 12:21:04.694  To: 03/14/2012 15:28:08.734

 Accumulated downtime duration                      : 0000:00:00.029
 Maximum downtime duration                          : 0000:00:00.029
 Date & time maximum downtime began                 : 03/14/2012 12:21:04.719
 Number of messages received out-of-sequence(OOS)   : 0
 Number of time-to-live(TTL) violations detected    : 1
 Number of messages incorrectly encoded or corrupted: 0
 Number of messages lost due to receive overflow    : 0
 Calculated max. sequential messages lost due to OOS: 0
 Calculated number of messages lost due to OOS      : 0

 #    Date        Time          Duration        Failure
 1    03/14/2012  12:21:04.719  0000:00:00.029  TTL EXPIRED

=>
```

Figure 10.8 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 7.16* 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 Relay Word bit GRPSW for approximately one second. 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 7.16*.

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 by 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 (Loopback)

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
LOO *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
LOO *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
LOO *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 time-out 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 are 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)

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.

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 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	$V_{A, B, C, S}$	Input voltages (kV primary)
	$V_{AB, BC, CA, S}$	Delta-connected voltage inputs (kV primary)
Power	$MW_{A, B, C}$	Single-phase megawatts
	MW_{3P}	Three-phase megawatts
	$MVAR_{A, B, C}$	Single-phase megaVARs
	$MVAR_{3P}$	Three-phase megaVARs
Power Factor	$PF_{A, B, C}$	Single-phase power factor; leading or lagging
	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 if VA 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 **MET *k*** 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)
	$V_{AB, BC, CA}$	Calculated phase-to-phase voltages (kV primary)
Power	$MW_{A, B, C}$	Single-phase megawatts
	MW_{3P}	Three-phase megawatts
	$MVAR_{A, B, C}$	Single-phase megaVARs
	$MVAR_{3P}$	Three-phase megaVARs
Power Factor	$PF_{A, B, C}$	Single-phase power factor; leading or lagging
	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)
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 if VA 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 **MET X *k*** 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
	MW_{3P}	Three-phase megawatts
	$MVAR_{A,B,C}$	Single-phase megaVARs
	$MVAR_{3P}$	Three-phase megaVARs
Reset Time	Demand, Peak	Last time the demands and peak demands were reset

To view demand metering values, enter the **MET D** 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 8.31 for metering behavior with small signals.

Reset the accumulated demand values by using the **MET RD** command. Reset the peak demand values by using the **MET RP** command. For more information on demand metering, see *Demand Metering on page 8.19*.

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
	MWh_{3P}	Three-phase megawatt-hours (in and out)
	$MVARh_{A,B,C}$	Single-phase megaVAR hours (in and out
	$MVARh_{3P}$	Three-phase megaVAR hours (in and out)
Reset Time		Last time the energy meter was reset

To view energy metering values, enter the **MET E** command.

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

The output from an SEL-311C with wye-connected voltage inputs is shown.

```
=>MET E <Enter>

SEL-311                          Date: 10/15/12    Time: 15:11:24.056
STATION A
        MWhA     MWhB     MWhC    MWh3P   MVARhA   MVARhB   MVARhC  MVARh3P
IN      0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
OUT    36.05    36.62    36.71   109.28     5.13     5.26     5.39    15.68
LAST RESET 10/14/12 23:31:28.864

=>
```

NOTE: See Small Signal Cutoff for Metering on page 8.31 for metering behavior with small signals.

Reset the energy values by using the **MET RE** command. For more information on energy metering, see *Energy Metering on page 8.27*.

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	$V_{A,B,C,S}$	Input voltages (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 **MET M** command.

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

The output from an SEL-311C is shown below.

```
=>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 by 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 8.28*.

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.17*.

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.

```
=>MET PM time <Enter>
```

The command 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.

```
=>MET PM HIS <Enter>
```

To help facilitate comparing meter reports between several relays, the command recalls the most recently triggered synchrophasor meter report.

NOTE: The values reported by the **MET PM HIS** command are only valid if settings are not changed after the trigger.

```
=>MET PM k <Enter>
```

For exploratory testing, the command 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 below.

```
=>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 BKMTR 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 control equation 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 6.25*.

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 2.20*). 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)

⚠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.

The relay is shipped with factory-default passwords for Access Levels 1, B, 2, and C. These passwords are shown in *Table 10.21*.

Command	Description	Access Level
PAS *level*	Set a password for Access Level *level*.	2

Table 10.21 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 2.20* 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 as many as 12 characters. See *Table 10.22* 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 are shown below.

➤ Ot3579A24.68
➤ Ih2d&s4u-Iwg
➤ .311c.Nt9g-t

Table 10.22 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.

=>>
```

PIN Command

The **PIN** command allows you to determine if a host is reachable across an IP network and/or if the Ethernet port is functioning or configured correctly. When you are setting up or testing substation networks, it is helpful to determine if the network is connected properly and if the other devices are turned on and configured properly.

Command	Description	Access Level
PIN *addr*	Use **PIN *addr*** without parameters to ping the specified address every 1 second until the command is canceled or 30 minutes elapse.	1
PIN *addr* [I*i*]	Ping the specified address at the specified interval until the command is canceled or 30 minutes elapse.	1
PIN *addr* [T*t*]	Ping the specified address every 1 second until the specified time-out elapses.	1
PIN *addr* [I*i*] [T*t*]	Ping the specified address at the specified interval until the specified time-out elapses.	1

After valid **PIN** command is issued, the relay sends out an ICMP echo request message at a 1-second interval (unless overridden by the I*i* parameter) until receiving a carriage return <CR>, the letter Q is typed, or the 30-minute duration elapses (unless overridden by the T*t* parameter). Use the optional I*i* parameter to specify the time in seconds (1–30) between successive ping commands. If I*i* is not specified, the interval between successive ping commands is 1 second. Use the optional T*t* parameter to specify the duration in minutes (1–60) of the **PIN** command. If T*t* is not specified, the ping duration is 30 minutes.

Command **PIN 10.201.7.52 I1** is executed in the following example.

```
=>PIN 10.201.7.52 I1 <Enter>
Pinging 10.201.7.52
Press <Enter> or Q to Terminate Ping Test
Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
No response from host 10.201.7.52
Ping test stopped.

Ping Statistics for 10.201.7.52
Packets: Sent = 7, Received = 6, Lost = 1
Elapsed Time:    13 seconds

=>
```

Figure 10.9 PIN Command Response

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 7.32*.

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 2.20*). If the Breaker is not in place (Breaker jumper = OFF), the relay does not execute the **PUL** command and responds as follows.

```
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 as follows.

```
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 (as many as 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         E50BF   = N
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
TDUR1D  = 9.00      TDUR3D  = 9.00      CFD     = 60.00     3POD    = 0.50
OPO     = 52        50LP    = 0.25      TOPD    = 2.00      TULO = 3
Z2GTSP  = N         67QGSP  = N
SV1PU   = 0.00      SV1DO   = 0.00

=>>
```

```
=>>SHO L <Enter>

SELOGIC group 1

SELOGIC Control Equations:
TR      = M2PT + Z2GT + 51GT + 51QT
TRQUAL  = M1P + Z1G
TRCOMM  = M2P + Z2G
TRSOTF  = M2P + Z2G + 50P1
DTA     = 0
DTB     = 0
DTC     = 0
E3PT    = 1
BKMTR   = OC
ULTR    = !(50L + 51G)
PT1     = IN104
LOG1    = 0
PT2     = 0
LOG2    = 0
BT      = 0
52A     = 52AA * 52AB * 52AC
52AA    = IN101
52AB    = IN102
52AC    = IN103
CL      = CC
ULCL    = TRIP
79RI    = 0
79RIS   = 1
79DTL   = 0
79DLS   = 0
79SKP   = 0
79STL   = 0
79BRS   = 0
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
BFIA    = 0
BFIB    = 0
BFIC    = 0
BFTR    = 0
BFULTR  = 0
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  = 3PT + TPA
OUT102  = 3PT + TPB
OUT103  = 3PT + TPC
OUT104  = KEY
OUT105  = CLOSE
OUT106  = 0
OUT107  = 0
ALRMOUT = !(SALARM + HALARM)
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     = !(3PO + SPO)
DP2     = SPO
DP3     = 3PO
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
BKMONA  = TPA + 3PT
BKMONB  = TPB + 3PT
BKMONC  = TPC + 3PT
BKCLSA  = CLOSE
BKCLSB  = CLOSE
BKCLSC  = CLOSE
E32IV   = 1
Z1XPEC  = 0
Z1XGEC  = 0
SALARM  = BADPASS + CHGPASS + SETCHG + GRPSW + ACCESSP + PASNVAL
RSTTRGT = 0
RST_DEM = 0
RST_PDM = 0
RST_BK  = 0
RST_HIS = 0
RST_ENE = 0
RST_MML = 0
RST_HAL = 0
RSTDNPE = 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:
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
EBMON   = Y         COSP1   = 10000     COSP2   = 150       COSP3   = 12
KASP1   = 1.20      KASP2   = 8.00      KASP3   = 20.00     ESTRT   = 50
ESCLT   = 120       MSTRT   = 50        MSCLT   = 120
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       BOOPTCC = PULSE
BOOPPUL = PULSE     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
NETMODE = FAILOVER  FTIME   = 1.00      NETPORT = A
NET5ASPD= AUTO      NET5BSPD= AUTO
ETELNET = N
EFTPSERV= N         EHTTP   = N
E61850  = 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   =
DP2_1   = SINGLE POLE OPEN DP2_0   =
DP3_1   = THREE POLE OPEN  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
```

```
BO_033 = NA                BO_034 = NA                BO_035 = NA
---
BO_069 = NA                BO_070 = NA

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  = INTTRA         CO_002  = INTTRB
CO_003  = INTTRC         CO_004  = EXTTRA         CO_005  = EXTTRB
CO_006  = EXTTRC         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 STA ***n*** command where *n* is an optional parameter to specify the number of times (1–32767) to repeat the status display.

```
=>STA n <Enter>
```

If *n* is not specified, the status report is displayed once.

A sample output of an SEL-311C is shown below.

```
=>STA <Enter>
SEL-311                          Date: 10/15/10    Time: 23:19:50.339
STATION A

FID=SEL-311C-2-Rxxx-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 to capture transient out-of-tolerance conditions. To reset the self-test statuses, use the **STA C** command from Access Level 2.

```
=>>STA C <Enter>
```

The relay responds as follows.

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

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

```
Canceled
```

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

```
Rebooting the relay
```

The relay then restarts (just like turning off, then turning on 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 the following message.

```
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

Fault Location and Fault Impedance
Fault Location Impedance:      5.06 Ohm,sec
Fault Location Angle:         84.00 deg
Per-Unit of Line Length:       0.65
Fault Resistance:              2.17 Ohm,sec

Mirrored Bits Channel Status:                       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 (2–110) 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 listed below.

TAR *n k* or **TAR ROW *n k***	Shows Relay Word row number *n* (0–110). *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 because 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

Row    SALARM   ACCESS   ALRMOUT  *        HALARMA  HALARMP  HALARML  HALARM
100    0        0        1        0        0        0        0        0

Row    *        *        PASNVAL  ACCESSP  GRPSW    SETCHG   CHGPASS  BADPASS
101    0        0        0        0        0        0        0        0

Row    RB17     RB18     RB19     RB20     RB21     RB22     RB23     RB24
102    0        0        1        0        0        0        0        0

Row    RB25     RB26     RB27     RB28     RB29     RB30     RB31     RB32
103    0        0        0        0        0        0        0        0

Row    *        *        *        BFTA     BFTB     BFTC     BFT      BFTRIP
104    0        0        0        0        0        0        0        0

Row    50BFA    50BFB    50BFC    50BFT    RTA      RTB      RTC      RT
105    0        0        0        0        0        0        0        0

Row    *        *        *        *        *        *        *        *
106    0        0        0        0        0        0        0        0

Row    *        *        *        *        *        *        *        *
107    0        0        0        0        0        0        0        0

Row    *        *        *        *        *        *        *        *
108    0        0        0        0        0        0        0        0
```

```
Row    ESTRA    ESTRB    ESTRC    ESCLA    ESCLB    ESCLC    ESOAL    MSOAL
109    0        0        0        0        0        0        0        0

Row    *        MSTRA    MSTRB    MSTRC    *        MSCLA    MSCLB    MSCLC
110    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* (PSF-1841 and DE-490) (Modbus and SEL Fast Message only).	B
TEST DB D *name value*	Force protocol digital element *name* to override *value* (PSF-1841 and DE-490) (DNP and IEC 61850 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 A-phase current magnitude transmitted to a remote device to 100 A.

```
=>>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 as follows.

```
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 as follows.

```
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.26* 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
TIME Q	Display time statistics	1
TIME DST	Display daylight-saving time information	1

NOTE: After setting the date, allow at least 60 seconds before turning off 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 the following.

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

If **TIM** is entered with the Q parameter, time statistics are displayed.

```
FEEDER 1                    Date: 08/07/2011    Time: 07:13:01.005
STATION A

FID=SEL-311C-x-R5xx-V0-Z100100-Dxxxxxxxx   CID=83ED

UTC: 12:13:01
UTC Offset: -5.00 hrs

Time Source: HIRIG
Last Update Source: HIRIG
Active Irig Port: BNC

Last Update Time: 07:13:01  08/07/11

IRIG Time Quality: 0.0 ms

Internal Clock Period: 20.000156 ns
```

Time Source is HIRIG when Relay Word bit TSOK is asserted. Otherwise, Time Source is OTHER. Last Update Source indicates the source of the last time or date update. Valid update sources are HIRIG, IRIG, DNP, MODBUS, SNTP, ASCII DATE, ASCII TIME, FRONT PANEL DATE, and FRONT PANEL TIME. If the relay time was last updated from the battery-backed clock, such as after a loss of power, Last Update Source is NONV CLK.

When at least one source of IRIG-B time signal is connected, Active IRIG Port displays which source is in use (BNC, Port 2, or Fiber).

If setting IRIGC = C37.118 and TIRIG or TSOK is asserted, IRIG Time Quality displays the time error calculated based on information contained in the control fields of the IRIG-B signal (see *Configuring High-Accuracy Timekeeping on page N.26*).

The internal clock period shows the time associated with the processor clock. This time may change slightly when an IRIG signal is connected.

If **TIM** is entered with the DST parameter and daylight-saving time is enabled (see *Automatic Daylight-Saving Time Settings on page 9.17*), daylight-saving time information is displayed.

```
=>TIME DST <Enter>

07:50:16

Daylight Saving Time Begin Rule: 2nd Sunday of March at 02:00
Daylight Saving Time End Rule:   1st Sunday of November at 02:00

Daylight Saving Time Active

Next Daylight Saving Time Beginning: 03/11/2012 02:00
Next Daylight Saving Time Ending:    11/06/2011 02:00
```

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 canceled and the new request will be pending. **TRI** commands entered without the time parameter will not affect 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: 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

Fault Location and Fault Impedance
Fault Location Impedance:      5.06 Ohm,sec
Fault Location Angle:         84.00 deg
Per-Unit of Line Length:       0.65
Fault Resistance:              2.17 Ohm,sec

Mirrored Bits Channel Status:                        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


Partnumber:  0311C20HR3E54X2
Serial Number:  2009240223

Analog Input Voltage (PT):  300 Vac, Wye 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
  IEC61850
  IEEE C37.118
  Remote Bits (16)
  Fast SER
  SafeLock Trip/Close Pushbuttons
  Programmable Operator Controls
  Programmable Target LEDs
  Two 10/100BASE-T Ports
  EIA-485
  USB
  Single Pole Trip

SELboot checksum B0AB OK
FID=SEL-311C-2-X006-V0-Z100100-D20100628

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 H	Display breaker history.
BRE R	Reset breaker monitor.
BRE W	Preload breaker wear.
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 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* = 1–32). 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.

Command	Description
ETH	Displays the Ethernet port configuration and status.
ETH C	Clear Ethernet port statistics.
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 information.
GOO *k*	Display GOOSE information *k* times.
GOO S	Display a list of GOOSE subscriptions with their ID.
GOO S *n*	Display GOOSE statistics for subscription ID *n*.
GOO S ALL	Display GOOSE statistics for all subscriptions.
GOO S *n* L	Display GOOSE statistics for subscription ID *n* including error history.
GOO S ALL L	Display GOOSE statistics for all subscriptions including error history.
GOO S *n* C	Clear GOOSE statistics for subscription ID *n*.
GOO S ALL C	Clear GOOSE statistics for all subscriptions.
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 *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.
LOO *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.
LOO *c* R	Cease loopback on MIRRORED BITS communications channel *c*. Reset the channel to normal use.
MAC	Display Ethernet MAC address.

Command	Description
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 *k*	Display synchrophasor measurements (available when TSOK = logical 1). Enter *k* for repeat count.
MET PM *time*	Display synchrophasor measurements (available when TSOK = logical 1). Enter *time* to display the synchrophasor for an exact specified time, in 24-hour format.
MET PM HIS	Display the most recent **MET PM** synchrophasor report.
OPE	Assert the open command Relay Word bit OC.
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.
PIN *addr* [I*i*] [T*t*]	Determines if the network is properly connected. Enter ***i*** to specify the time, in seconds, between successive ping commands (i = 1–30, if not specified, default is 1 second). Enter ***t*** to specify the duration, in minutes, of the ping command (t = 1–60, if not specified, default is 30 minutes). Command is terminated by typing **Q** or by issuing a carriage return <CR>.
PUL *n k*	Pulse output contact *n* (where *n* is one of ALARM, ALRMOUT, 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 a 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).

Command	Description
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 a 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.
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**).
TIM DST	Display daylight-saving time information.
TIM Q	Display time statistics.
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 the 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 2.11 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*
- ➤ *Functions Unique to the Front-Panel Interface on page 11.5*
- ➤ *Rotating Display on page 11.11*
- ➤ *Programmable Operator Controls on page 11.14*

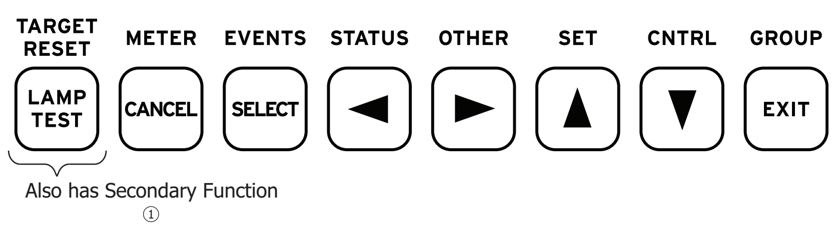
Front-Panel Pushbutton Operation

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) on page SET.1*). The relay is shipped with FP_TO = 15 minutes.



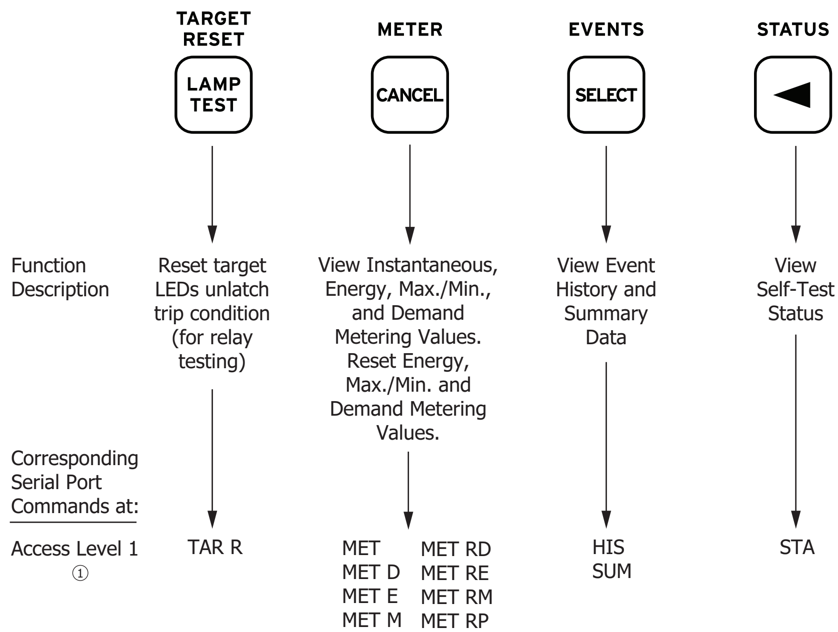
① See Figure 11.4.

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 10.19*. 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 10.52*.

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*.



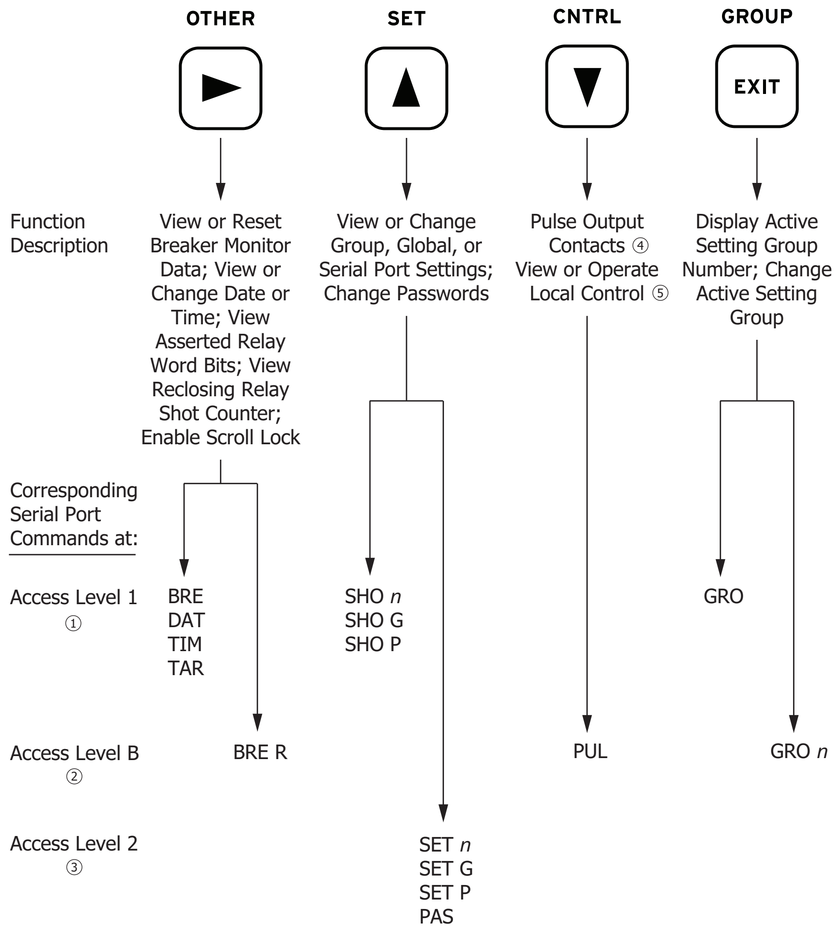
① Front-panel pushbutton functions that correspond to Access Level 1 serial port commands do **not** require the entry of the Access Level 1 password through the front panel.

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 10.58* 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 by 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 2.29).

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 2.29).

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*).

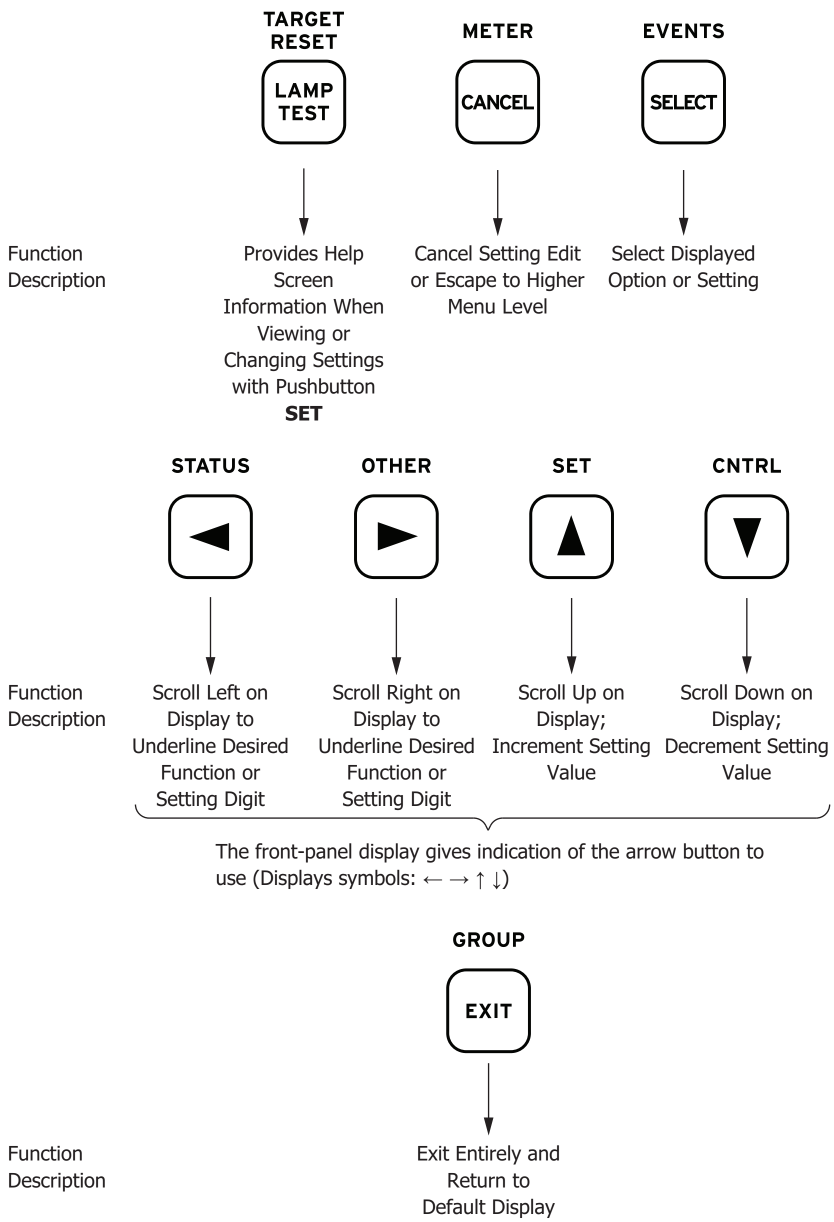


Figure 11.4 Front-Panel Pushbuttons—Secondary Functions

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` by 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 6.16*), 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 10.62*).

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*.

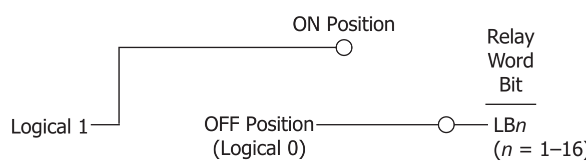


Figure 11.5 Local Control Switch Configured as an ON/OFF Switch

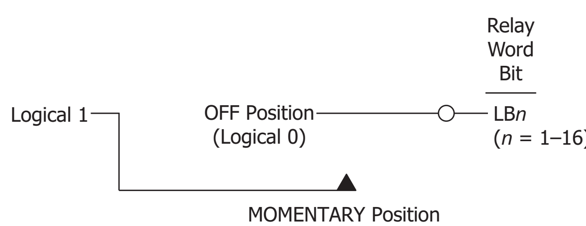


Figure 11.6 Local Control Switch Configured as an OFF/MOMENTARY Switch

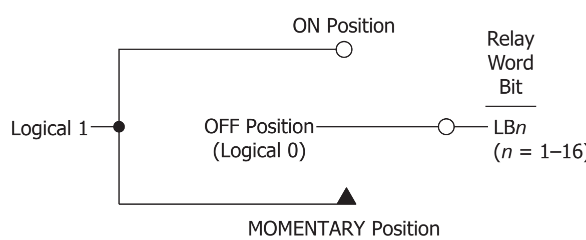


Figure 11.7 Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

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 10.62*). See *Local Control Switches on page 7.5* 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:

BKMTR = **...+LB3 +...** (Trip setting includes LB3)

CL = **...+ LB4 +...** (Close setting includes LB4)

NLB3 = **MANUAL TRIP**

CLB3 = **RETURN**

PLB3 = **TRIP**

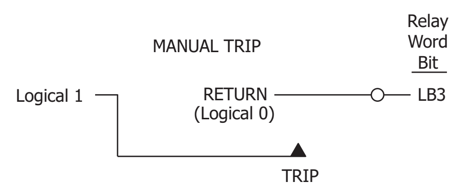
NLB4 = **MANUAL CLOSE**

CLB4 = **RETURN**

PLB4 = **CLOSE**

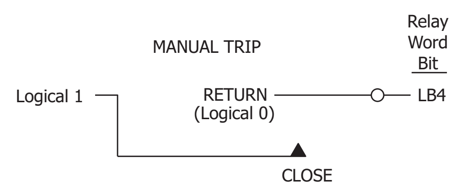
Press the **CNTRL** pushbutton, and the first set local control switch displays (shown here with example settings):

```
MANUAL TRIP  ←→
Position: RETURN
```



Press the right arrow pushbutton, and scroll to the next example local control switch:

```
MANUAL TRIP  ←→
Position: RETURN
```



The `MANUAL TRIP: RETURN/TRIP` and `MANUAL CLOSE: RETURN/CLOSE` switches are both OFF/MOMENTARY switches (see *Figure 11.6*).

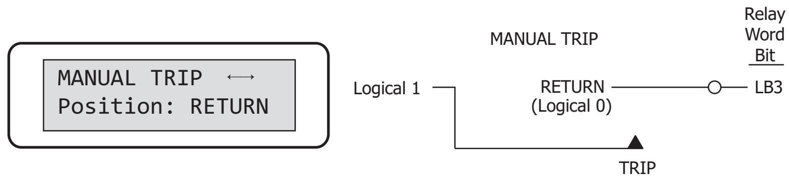
There are no more local control switches in the example settings. Press the right arrow pushbutton, and scroll to the `Output Contact Testing` function:

```
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)

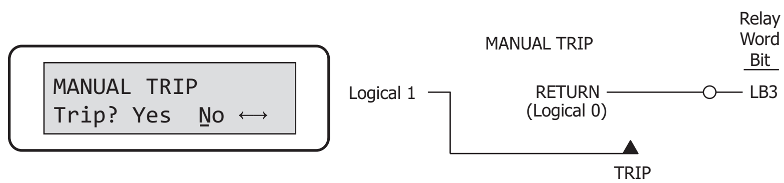
Press the right arrow pushbutton, and scroll back to the first set local control switch in the example settings:



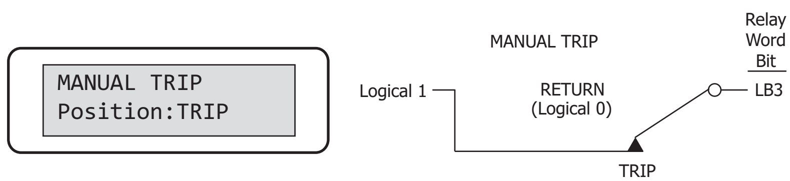
NOTE: See Local Control Availability on page 11.10 for conditions where local control switch operations are not allowed.

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:



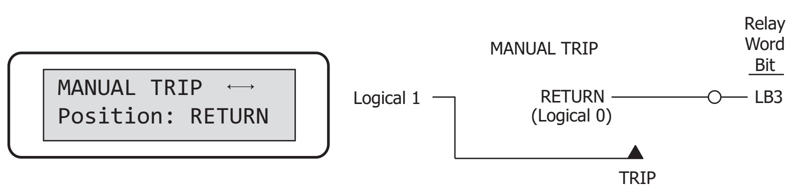
Because this is an OFF/MOMENTARY type switch, the `MANUAL TRIP` switch returns to the `RETURN` position after momentarily being in the `TRIP` position. Technically, the `MANUAL TRIP` switch (being an OFF/MOMENTARY type switch) is in the:

> `TRIP` position for one processing interval (1/4 cycle) that 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 7.5* 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

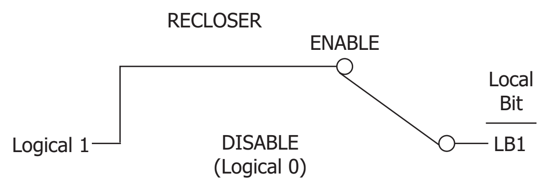
It is not possible to operate a local control switch while a settings change session is in progress, for example, while another technician is using a **SET** command or a PC software application to send settings to the relay over a communications port. In this situation, if the front-panel **SELECT** 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:

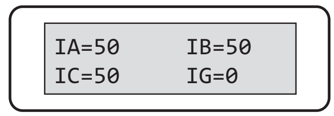
79DTL = **OC + !LB1 + LB3** [=OC + NOT(LB1) + LB3]

Notice that local bit 1 is inverted [!LB1 = NOT(LB1)] in the SELOGIC control 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 6.25* for more information on setting 79DTL.

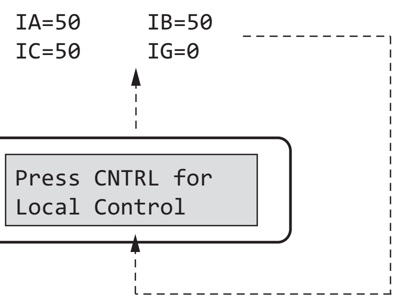
Rotating Display

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 7.5* 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.

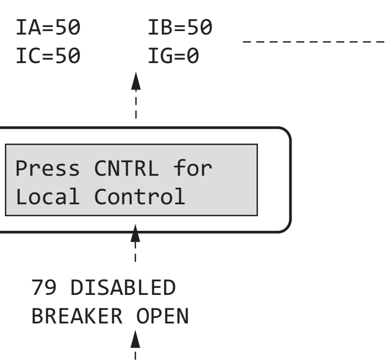


Figure 11.8 illustrates the correspondence between display point logic equations (e.g., DP1 and DP2) and enabled display point labels (DP1_1/DP1_0 and DP2_1/DP2_0, respectively).

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 7.1*.

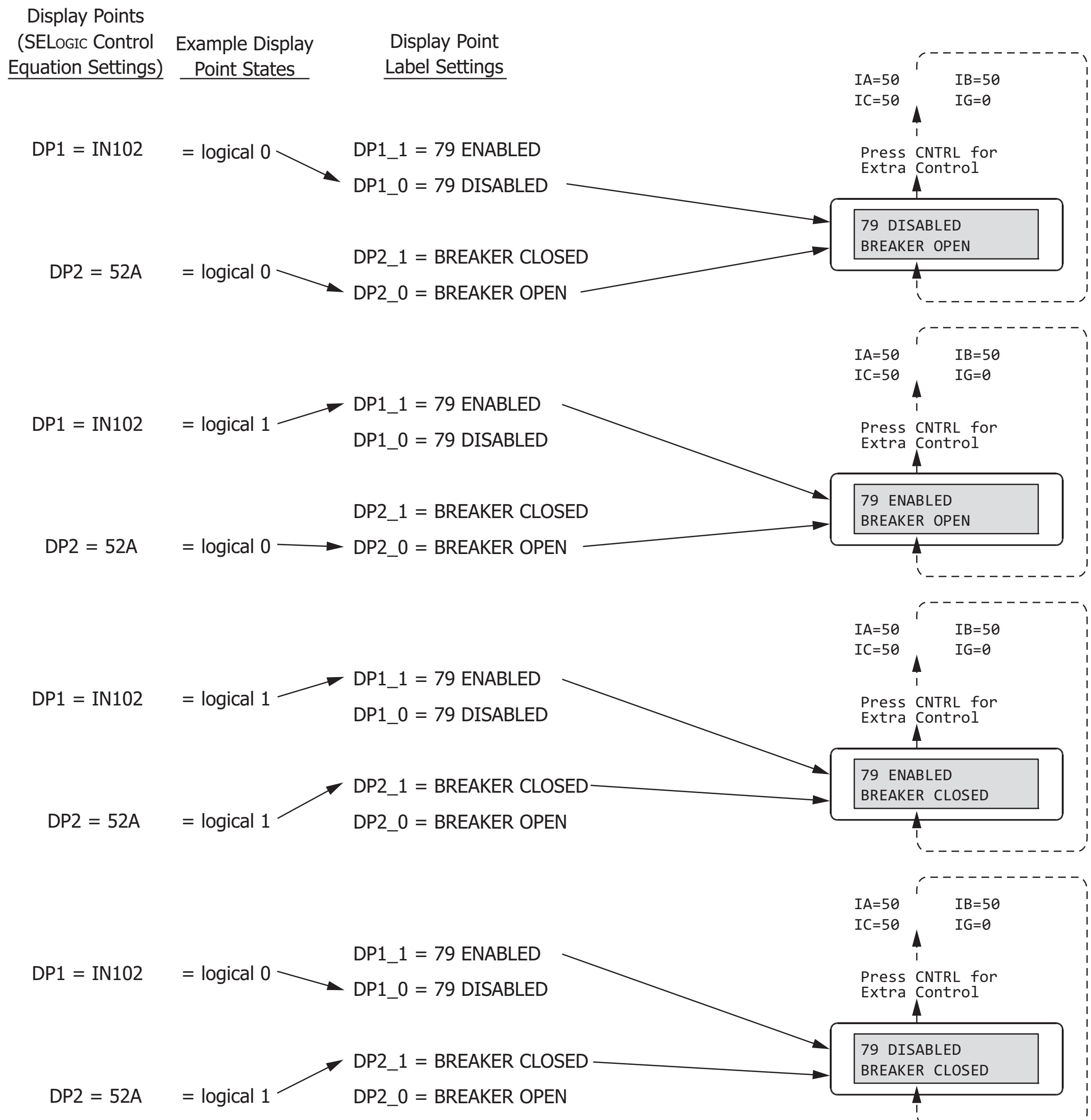


Figure 11.8 Correspondence Between Changing Display Point States and Enabled Display Point Labels

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 5.24* 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*.

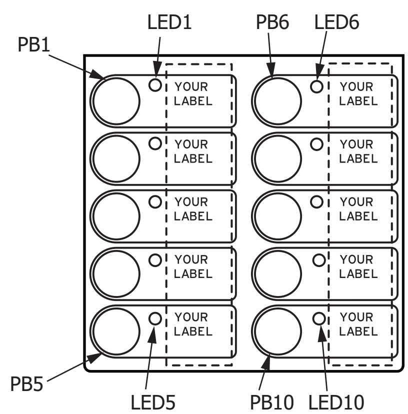


Figure 11.9 Programmable Operator Controls Optional on Three-Rack Unit SEL-311C Relays

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 control equation 79DTL by using pushbutton **PB2** to activate latch LT2. *Figure 11.10* shows the latch-bit control logic.

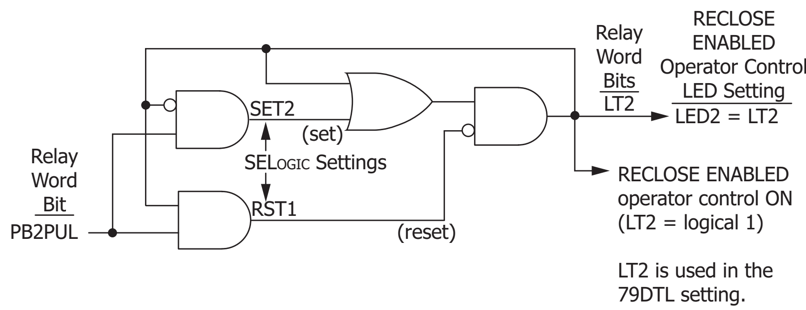


Figure 11.10 GROUND ENABLED Operator Control LED and Logic

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 7.10* for more information on latch bits.

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 sections.

Introduction

The SEL-311C Relay offers four styles of event reports: Standard ASCII (EVE) reports, Compressed ASCII (CEV) reports, Binary COMTRADE event reports, and Sequential Event Recorder (SER) 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-5601-2 SYNCHROWAVE Event Software 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 are stored to nonvolatile memory just after they are 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.

- EVE: Event summary, including the front-panel target states at the time of tripping, fault current, fault location, and fault type.
- CEV: Event summary, including the front-panel target states at the time of tripping, fault current, fault location, fault type, impedance to the fault location in secondary ohms, line angle to the fault location, distance to the fault in per-unit of line length, and fault resistance in secondary ohms.
- 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 pre-fault recording period allows system conditions to be captured prior to the actual event report trigger.

Use SYNCHROWAVE Event and QuickSet to analyze Compressed ASCII and COMTRADE file format versions 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 pre-fault, 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 as many as 72 Relay Word bits to be monitored, in addition to the automatically generated triggers when the relay turns on, a settings changes, and an active setting group changes. State changes are time-tagged to the nearest millisecond.

SER report data are 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 12.7 is on multiple pages.

See *Figure 12.7* for an example event report.

Event Report Length (Settings LER and PRE)

The SEL-311C provides user-programmable event report length and pre-fault length. Event report length is either 15, 30, 60, or 180 cycles. Pre-fault length ranges from 1 to 179 cycles. Pre-fault 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 pre-fault length with the PRE setting. See the **SET G** command in *Table 9.2* and corresponding *Event Report Parameters on page SET.1* 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.

The factory settings for trip settings TR, TRQUAL, and BKMTR are as follows:

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

TRQUAL = **M1P + Z1G**

BKMTR = **OC**

If any of the individual conditions in the TR equation (M2PT, Z2GT, 51GT, or 51QT), or the BKMTR equation (OC) assert, Relay Word bit TRIP asserts immediately. If any of the elements in the TRQUAL equation (M1P or Z1GT) assert, the TRIP bit asserts within 2 cycles, depending on the state of the disturbance detector logic. In either case an event report is automatically generated once TRIP asserts. Thus, these conditions do not have to be entered in SELOGIC control equation setting ER.

The SEL-311C asserts Relay Word bit TRIP for any single-pole trip or three-pole trip condition. See *Trip Logic on page 5.1* for full details.

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 3.33*).
51Q	Maximum phase current above pickup setting 51QP for phase time-overcurrent element 51QT (see *Figure 3.34*).
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 as many as 360 cycles. When back-to-back events are triggered, the relay shortens the pre-fault 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 contains less than 4-cycles of pretrigger data, and the second event report analog data are 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 contains the usual 4 cycles of PRE data, and there will be an unrecorded period between the event reports.

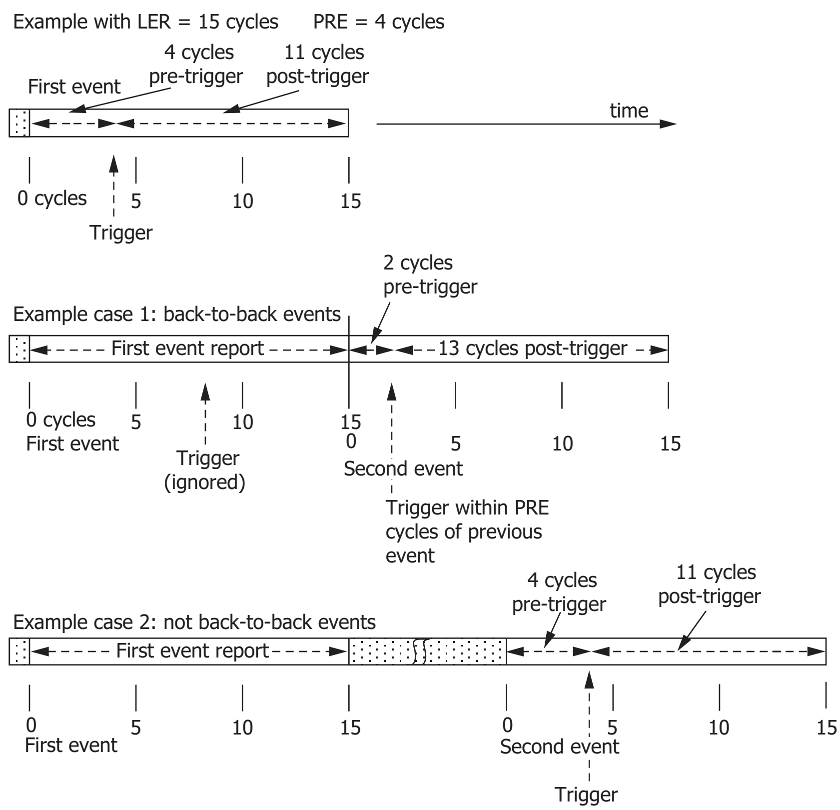


Figure 12.1 Example Behavior for Back-to-Back Event Reports

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 A 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 12.7 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 12.7*.

Event 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). 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 10.49* for details).

The example event summary in *Figure 12.2* corresponds to the full-length standard 15-cycle event report in *Figure 12.7*.

```
SEL-311                              Date: 10/14/10 Time: 08:53:34.926
STATION A
FID=SEL-311C-2-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 10.73*.

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.

Table 12.2 Event Types (Sheet 2 of 2)

Event Type	Description
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.
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 5.47* 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.

NOTE: The fault locator will not operate if Relay Word bit SPO is asserted.

NOTE: See SEL application guide "Impedance-Based Fault Location Using Custom Calculations in SYNCHROWAVE Event" (AG2020-25) on the SEL website for more information about calculating the fault location manually.

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; and corresponding line length setting LL. See the **SET** command in *Table 9.2* and corresponding *Line Settings on page SET.7* 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. The relay calculates fault location by using a number of event report rows from the 15-cycle subset. When the fault evolves, the fault location is calculated using rows that represent the predominant fault type.

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 5.47* 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 5.47*.

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 10.49* 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 12.8*.

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 10.49* 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 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 pre-fault and fault quantities.
  - Fault location and fault impedance data
  - 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) is displayed (see *Targets on page 12.8* 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 pre-fault A-phase voltage if it is greater than 13V secondary. Otherwise, angles are referenced to the pre-fault A-phase current.

Fault Location and Fault Impedance Data

The relay calculates and displays fault location and fault impedance data, including distance to the fault in the units of group setting LL, impedance to the fault location in secondary ohms, line angle to the fault location, and distance to the fault in per-unit of line length.

In addition, the relay also calculates fault resistance in secondary ohms. The fault resistance is associated with the fault type; phase-to-ground fault impedance for a single-phase-to-ground fault, phase-to-phase fault impedance for a fault involving two or more phases, including phase-to-phase-to-ground and three-phase faults.

If the relay does not calculate a valid fault location, then these fields will display dollar signs ($$$$$$).

See *Appendix R: Fault Location and Supplemental Fault Location and Impedance Data* for additional details on fault location.

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.

COMTRADE File Format Event Reports

The SEL-311C stores high-resolution raw data oscillography in binary format and uses COMTRADE file types to output these data:

- .HDR—header file
- .CFG—configuration file
- .DAT—high-resolution raw data file

The .HDR file contains summary information about the event in ASCII format. The .CFG file is an ASCII configuration file that describes the layout of the .DAT file. The .DAT file is in binary format and contains the values for each input channel for each sample in the record. These data conform to the IEEE C37.111-1999 COMTRADE standard.

.HDR File

The .HDR file contains the event summary and relay settings information that appears in the event report for the data capture. The settings portion is in a comma-delimited format as illustrated in *Figure 12.4*.

```
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

Fault Location and Fault Impedance
Fault Location Impedance:      5.06 Ohm,sec
Fault Location Angle:         84.00 deg
Per-Unit of Line Length:       0.65
Fault Resistance:              2.17 Ohm,sec

[1]
RID,"SEL-311"
TID,"STATION A"
CTR,"200"
CTRN,"200"
PTR,"2000.00"
PTRS,"2000.00"
 •
 •
 •
SAM/CYC_A = 128
SAM/CYC_D = 4
SAM/CYC_INPUTS = 16
```

Event Summary Information

Relay Settings

Analog, Digital, and Input samples per cycle data

Figure 12.4 Sample COMTRADE .HDR Header File

.CFG File

The .CFG file contains data that are used to reconstruct the input signals to the relay and status of Relay Word bits during the event report (see *Figure 12.5*). A <CR><LF> follows each line. If control inputs or control outputs are not available because of board loading and configuration, the relay does not report these inputs and outputs in the analog and digital sections of the .CFG file.

```
<RID setting>,FID=SEL-311C-3-Rxxx-V0-Zxxxxxx-Dyyyymmdd,1999      COMTRADE Standard
#T,#A,#D                                                          Total Channels, Analog, Digital
1,IA,A,,A,scale_factor[a],0.0,0,-32767,32767,[CTR],1.0,P
2,IB,B,,A,scale_factor[a],0.0,0,-32767,32767,[CTR],1.0,P
3,IC,C,,A,scale_factor[a],0.0,0,-32767,32767,[CTR],1.0,P
4,IN,,,A,scale_factor[a],0.0,0,-32767,32767,[CTRN],1.0,P
5,IG,,,A,scale_factor[a],0.0,0,-32767,32767,[CTR],1.0,P
6,VA,A,,kV,scale_factor[a],0.0,0,-32767,32767,[PTR],1.0,P
7,VB,B,,kV,scale_factor[a],0.0,0,-32767,32767,[PTR],1.0,P        Analog Channel Data
8,VC,C,,kV,scale_factor[a],0.0,0,-32767,32767,[PTR],1.0,P
9,VS,C,,kV,scale_factor[a],0.0,0,-32767,32767,[PTRS],1.0,P
10,V1MEM,C,,kV,scale_factor[a],0.0,0,-32767,32767,[PTR],1.0,P
11,FREQ,,,Hz,0.01,0.0,0,0,12000,1.0,1.0,P
12,VDC,C,,V,scale_factor[a],0.0,0,-32767,32767,-0.0,1.0,P
1,rwb_label[b,c],,,0
2,rwb_label[b,c],,,0
 •
 •                                                                 Digital (Status) Channel Data
 •
nnnn[d],rwb_label[b,c],,,0
<NFREQ>
0
0,<# of samples>
dd/mm/yyyy,hh:mm:ss.ssssss                                         First Data Point
dd/mm/yyyy,hh:mm:ss.ssssss                                         Trigger Point
BINARY
<time stamp multiplication factor>
```

[a] Scale_factor is the value used to convert the equivalent channel analog data in the DAT file to primary units (A or kV peak-to-peak)

[b] rwb_label will be replaced with Relay Word bit labels as seen in Table D.1

[c] Place holders denoted by asterisk (*), will be labeled as UNUSEDxxx (where xxx is the number of the associated label)

[d] nnnn = number of the last Relay Word bit

Figure 12.5 Sample COMTRADE .CFG Configuration File Data

The configuration file has the following format:

- Station name, device identification, COMTRADE standard year
- Number and type of channels
- Channel name units and conversion factors
- Digital Relay Word bit names
- System frequency
- Sample rate and number of samples
- Date and time of first data point
- Date and time of trigger point
- Data file type
- Time stamp multiplication factor

.DAT File

The .DAT file follows the COMTRADE binary standard. The format of the binary data files is sample number, time stamp, data value for each analog channel, and digital channel status data for each sample in the file. There are no data separators in the binary file, and the file contains no carriage return/line feed characters. The sequential position of the data in the binary file determines the data translation. Refer to the *IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111–1999* for more information. Many programs read the binary COMTRADE files. These programs include SYNCHROWAVE Event and QuickSet.

Retrieving COMTRADE Event Files

COMTRADE files are available as read-only files that can be retrieved using QuickSet, the **FILE** command and Ymodem file transfer, Ethernet File Transfer Protocol (FTP), or Manufacturing Messaging Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 is enabled (E61850 = Y). See *FIL Command on page 10.44*, *File Transfer Protocol (FTP) and MMS File Transfer on page 10.24*, and *FTP and MMS File Structure on page 10.25* for additional information.

Retrieving Full-Length Standard 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. See Compressed ASCII Event Reports on page 12.16.

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

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 are available with this accuracy. When M or D are specified with P, then the P option is ignored because 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 S*x* 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 L*y* parameter is entered and *y* = 0 or *y* > LER, the relay 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 has 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 12.6 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-2-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 12.6 Example Synchrophasor-Level Precise Event Report 1/16-Cycle Resolution

Compressed ASCII Event Reports

The SEL-311C provides Compressed ASCII event reports to facilitate event report storage and display. The SEL-2020 Communications Processor, QuickSet, and SYNCHROWAVE Event take advantage of the Compressed ASCII format. Use the **EVE C** command or **CEVENT** command to display

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.

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 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 are 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, the unfiltered event report data for that input have an asserting/deasserting pattern at twice the applied signal frequency. See Input Debounce Timers on page 7.3. The status of extra I/O board optoisolated inputs is available only in Compressed ASCII event reports.

- ➤ 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 updated at 16 samples/cycle
- ➤ 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).

Retrieving Event Reports Via Ethernet File Transfer

Selected event reports are available as read-only files that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Messaging Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 is enabled (E61850 = Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 10.24* and *MMS on page P.4* for additional information.

The Ethernet file server EVENTS folder contains two types of files for each event stored in the relay.

- ➤ Compressed, 4 sample/cycle, filtered event, equivalent to issuing a **CEV** command. These files are named C4.*nnnnn*.cev, where *nnnnn* is the unique event identifier.
- ➤ Compressed, 128 sample/cycle, unfiltered event, equivalent to issuing a **CEV R S128** command. These files are named CR.*nnnnn*.cev, where *nnnnn* is the unique event identifier.

The date and time displayed for events are from the time of event trigger. The times are UTC.

The EVENTS folder also contains the event history with unique event identification number (equivalent to the **HIS E** command) and the compressed event history (equivalent to the **CHIS** command). See *Event History (HIS) on page 12.8* and *CHISTORY Command on page K.4*.

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 Control 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 12.7* 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 12.7 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 (Sheet 1 of 2)

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)
VB	Voltage measured by channel VB (primary kV)
VC	Voltage measured by channel VC (primary kV)
VS	Voltage measured by channel VS (primary kV)
V1MEM	Positive-sequence memory voltage

Table 12.3 Standard Event Report Current, Voltage, and Frequency Columns (Sheet 2 of 2)

Column Heading	Definition
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)

[c] Not available with P parameter.
[d] Only available with P parameter. See Synchrophasor-Level Accuracy in Event Reports on page 12.15.

Note that the ac values change from plus to minus (–) values in *Figure 12.7*, indicating the sinusoidal nature of the waveforms.

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

Figure 12.8: shows how event report current column data relates to the actual sampled current waveform and RMS current values.

Figure 12.9: 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**):

```
=>>EVE <Enter>
SEL-311                          Date: 05/16/10    Time: 13:13:14.233
STATION A
FID=SEL-311C-2-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**):

```
=>>EVE V <Enter>

SEL-311                           Date: 05/16/05    Time: 13:13:14.233
STATION A

FID=SEL-311C-2-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*.

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, remote bits RB17–RB32, optoisolated inputs IN209–IN216 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 12.16* 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-to-phase distance element (MAB1) set
	MAB2	2	If Zone 2 AB phase-to-phase distance element (MAB2) set, not MAB1
	MAB3	3	If Zone 3 AB phase-to-phase distance element (MAB3) set, not MAB1 or MAB2
	MAB4	4	If Zone 4 AB phase-to-phase distance element (MAB4) set, not MAB1 or MAB2 or MAB3
21 ZBC[a]	MBC1	1	If Zone 1 BC phase-to-phase distance element (MBC1) set
	MBC2	2	If Zone 2 BC phase-to-phase distance element (MBC2) set, not MBC1
	MBC3	3	If Zone 3 BC phase-to-phase distance element (MBC3) set, not MBC1 or MBC2
	MBC4	4	If Zone 4 BC phase-to-phase distance element (MBC4) set, not MBC1 or MBC2 or MBC3
21 ZCA[a]	MCA1	1	If Zone 1 CA phase-to-phase distance element (MCA1) set
	MCA2	2	If Zone 2 CA phase-to-phase distance element (MCA2) set, not MCA1
	MCA3	3	If Zone 3 CA phase-to-phase distance element (MCA3) set, not MCA1 or MCA2
	MCA4	4	If Zone 4 CA phase-to-phase distance element (MCA4) set, not MCA1 or MCA2 or MCA3

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 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
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.

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
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
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 N G	NDEM, GDEM	N	Neutral-demand ammeter element NDEM picked up.
		G	Residual-ground demand ammeter element GDEM picked up.
		b	Both NDEM and GDEM picked up.
27 P	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.

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 P	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.
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	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).
Time	OPTMN, RSTMN	o	Recloser open interval timer is timing.
		r	Recloser reset interval timer is timing.

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
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, OUT102	1	Output contact OUT101 asserted.
		2	Output contact OUT102 asserted.
		b	Both OUT101 and OUT102 asserted.
Out1 3 4[b]	OUT103, OUT104	3	Output contact OUT103 asserted.
		4	Output contact OUT104 asserted.
		b	Both OUT103 and OUT104 asserted.
Out1 5 6[b]	OUT105, OUT106	5	Output contact OUT105 asserted.
		6	Output contact OUT106 asserted.
		b	Both OUT105 and OUT106 asserted.
Out1 7 A[b]	OUT107, ALARM	7	Output contact OUT107 asserted.
		A	Output contact ALARM asserted.
		b	Both OUT107 and ALARM asserted.
Out2 1 2[b]	OUT201[d], OUT-202[c]	1	Output contact OUT201 asserted.
		2	Output contact OUT202 asserted.
		b	Both OUT201 and OUT202 asserted.
Out2 3 4[b]	OUT203[c], OUT-204[c]	3	Output contact OUT203 asserted.
		4	Output contact OUT204 asserted.
		b	Both OUT203 and OUT204 asserted.
Out2 5 6[b]	OUT205[c], OUT-206[c]	5	Output contact OUT205 asserted.
		6	Output contact OUT206 asserted.
		b	Both OUT205 and OUT206 asserted.
Out2 7 8[b]	OUT207[c], OUT-208[c]	7	Output contact OUT207 asserted.
		8	Output contact OUT208 asserted.
		b	Both OUT207 and OUT208 asserted.
Out2 9 0[b]	OUT209[c], OUT-210[c]	9	Output contact OUT209 asserted.
		0	Output contact OUT210 asserted.
		b	Both OUT209 and OUT210 asserted.
Out2 1 2[b]	OUT211[c], OUT-212[c]	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, IN102	1 2 b	Optoisolated input IN101 asserted. Optoisolated input IN102 asserted. Both IN101 and IN102 asserted.
In1 3 4	IN103, IN104	3 4 b	Optoisolated input IN103 asserted. Optoisolated input IN104 asserted. Both IN103 and IN104 asserted.
In1 5 6	IN105, IN106	5 6 b	Optoisolated input IN105 asserted. Optoisolated input IN106 asserted. Both IN105 and IN106 asserted.
In2 1 2	IN201[c], IN202[c]	1 2 b	Optoisolated input IN201 asserted. Optoisolated input IN202 asserted. Both IN201 and IN202 asserted.
In2 3 4	IN203[c], IN204[c]	3 4 b	Optoisolated input IN203 asserted. Optoisolated input IN204 asserted. Both IN203 and IN204 asserted.
In2 5 6	IN205[c], IN206[c]	5 6 b	Optoisolated input IN205 asserted. Optoisolated input IN206 asserted. Both IN205 and IN206 asserted.
In2 7 8	IN207[c], IN208[c]	7 8 b	Optoisolated input IN207 asserted. Optoisolated input IN208 asserted. Both IN207 and IN208 asserted.
PO	3PO, SPOA, SPOB, SPOC	3 A B C a b c	Three pole open condition 3PO asserted. A-phase pole open condition, SPOA asserted. B-phase pole open condition, SPOB asserted. C-phase pole open condition, SPOC asserted. A- and B-phase pole open condition, SPOA and SPOB asserted. B- and C-phase pole open condition, SPOB and SPOC asserted. C- and A-phase pole open condition, SPOC and SPOA 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.

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
BTX	BTX	*	Block trip input extension BTX asserted.
TMB A 1 2	TMB1A, TMB2A	1 2 b	MIRRORED BITS channel A transmit bit 1 TMB1A asserted. MIRRORED BITS channel A transmit bit 2 TMB2A asserted. Both TMB1A and TMB2A asserted.
TMB A 3 4	TMB3A, TMB4A	3 4 b	MIRRORED BITS channel A transmit bit 3 TMB3A asserted. MIRRORED BITS channel A transmit bit 4 TMB4A asserted. Both TMB3A and TMB4A asserted.
TMB A 5 6	TMB5A, TMB6A	5 6 b	MIRRORED BITS channel A transmit bit 5 TMB5A asserted. MIRRORED BITS channel A transmit bit 6 TMB6A asserted. Both TMB5A and TMB6A asserted.
TMB A 7 8	TMB7A, TMB8A	7 8 b	MIRRORED BITS channel A transmit bit 7 TMB7A asserted. MIRRORED BITS channel A transmit bit 8 TMB8A asserted. Both TMB7A and TMB8A asserted.
RMB A 1 2	RMB1A, RMB2A	1 2 b	MIRRORED BITS channel A receive bit 1 RMB1A asserted. MIRRORED BITS channel A receive bit 2 RMB2A asserted. Both RMB1A and RMB2A asserted.
RMB A 3 4	RMB3A, RMB4A	3 4 b	MIRRORED BITS channel A receive bit 3 RMB3A asserted. MIRRORED BITS channel A receive bit 4 RMB4A asserted. Both RMB3A and RMB4A asserted.
RMB A 5 6	RMB5A, RMB6A	5 6 b	MIRRORED BITS channel A receive bit 5 RMB5A asserted. MIRRORED BITS channel A receive bit 6 RMB6A asserted. Both RMB5A and RMB6A asserted.
RMB A 7 8	RMB7A, RMB8A	7 8 b	MIRRORED BITS channel A receive bit 7 RMB7A asserted. MIRRORED BITS channel A receive bit 8 RMB8A asserted. Both RMB7A and RMB8A asserted.
TMB B 1 2	TMB1B, TMB2B	1 2 b	MIRRORED BITS channel B transmit bit 1 TMB1B asserted. MIRRORED BITS channel B transmit bit 2 bit TMB2B asserted. Both TMB1B and TMB2B asserted.
TMB B 3 4	TMB3B, TMB4B	3 4 b	MIRRORED BITS channel B transmit bit 3 TMB3B asserted. MIRRORED BITS channel B transmit bit 4 TMB4B asserted. Both TMB3B and TMB4B asserted.
TMB B 5 6	TMB5B, TMB6B	5 6 b	MIRRORED BITS channel B transmit bit 5 TMB5B asserted. MIRRORED BITS channel B transmit bit 6 TMB6B asserted. Both TMB5B and TMB6B asserted.
TMB B 7 8	TMB7B, TMB8B	7 8 b	MIRRORED BITS channel B transmit bit 7 TMB7B asserted. MIRRORED BITS channel B transmit bit 8 TMB8B asserted. Both TMB7B and TMB8B asserted.
RMB B 1 2	RMB1B, RMB2B	1 2 b	MIRRORED BITS channel B receive bit 1 RMB1B asserted. MIRRORED BITS channel B receive bit 2 RMB2B asserted. Both RMB1B and RMB2B asserted.
RMB B 3 4	RMB3B, RMB4B	3 4 b	MIRRORED BITS channel B receive bit 3 RMB3B asserted. MIRRORED BITS channel B receive bit 4 RMB4B asserted. Both RMB3B and RMB4B asserted.
RMB B 5 6	RMB5B, RMB6B	5 6 b	MIRRORED BITS channel B receive bit 5 RMB5B asserted. MIRRORED BITS channel B receive bit 6 RMB6B asserted. Both RMB5B and RMB6B 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 7 8	RMB7B, RMB8B	7 8 b	MIRRORED BITS channel B receive bit 7 RMB7B asserted. MIRRORED BITS channel B receive bit 8 RMB8B asserted. Both RMB7B and RMB8B asserted.
ROK	ROKA, ROKB	A B b	MIRRORED BITS channel A receive OK ROKA asserted. MIRRORED BITS channel B receive OK ROKB asserted. Both ROKA and ROKB asserted.
RBAD	RBADA, RBADB	A B b	MIRRORED BITS channel A extended outage RBADA asserted. MIRRORED BITS channel B extended outage RBADB asserted. Both RBADA and RBADB asserted.
CBAD	CBADA, CBADB	A B b	MIRRORED BITS channel A unavailability CBADA asserted. MIRRORED BITS channel B unavailability CBADB asserted. Both CBADA and CBADB asserted.
LBOK	LBOKA, LBOKB	A B b	MIRRORED BITS channel A loopback OK LBOKA asserted. MIRRORED BITS channel B loopback OK LBOKB asserted. Both LBOKA and LBOKB asserted.
OC	OC, CC	o c	**OPE** (Open) command executed. **CLO** (Close) command executed.
Lcl RW 5	LB1–LB8	00–FF Hex[e]	Hex value of Relay Word Row 5, LB1–LB8, Local Bits
Lcl RW 6	LB9–LB16	00–FF Hex[d]	Hex value of Relay Word Row 6, LB9–LB16, Local Bits
Rem RW 7	RB1–RB8	00–FF Hex[d]	Hex value of Relay Word Row 7, RB1–RB8, Remote Bits
Rem RW 8	RB9–RB16	00–FF Hex[d]	Hex value of Relay Word Row 8, RB9–RB16, Remote Bits
Ltch RW 9	LT1–LT8	00–FF Hex[d]	Hex value of Relay Word Row 9, LT1–LT8, Latch Bits
Ltch RW 10	LT9–LT16	00–FF Hex[d]	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.
[c] Output contacts can be A or B type contacts (see Figure 7.28 through Figure 7.30).
[d] Model with extra I/O board only.
[e] 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 12.10* 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.

The SER stops recording all Relay Word bits except ALARM, HALARM, HALARML, SETCHG, and GRPSW when the relay is disabled.

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*
Active settings group changed	`Relay group changed`	*Section 7: Inputs, Outputs, Timers, and Other Control Logic*
SER C command issued	`SER archive cleared`	*Clearing SER Report on page 12.31*
Start of SER data loss	`SER data loss begin`	*SER Memory Operation on page 12.31*
End of SER data loss	`SER data loss end`	
Invalid SER data	`Invalid Data`	
Data overwritten while relay is responding to **SER** command	`Command aborted, data overwrite occurred`	
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 as many as 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.36*. 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 as many as 72 elements in the SER (24 in each of SER1, SER2, and SER3).

Make 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 (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

NOTE: If any elements change state during the clearing process, the SER entries for these elements may be reported with time stamps that are prior to the `SER archive cleared` message.

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 are generated. During some conditions, such as during event report capture, the update of SER data are 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 are 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 turned on.

Example Standard 15-Cycle Event Report

The following example standard 15-cycle event report in *Figure 12.7* also corresponds to the example sequential events recorder (SER) report in *Figure 12.10*. The circled numbers in *Figure 12.7* correspond to the SER row numbers in *Figure 12.10*. The row explanations follow *Figure 12.10*.

In *Figure 12.7*, 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 12.8* and *Figure 12.9*). 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.

Because 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-2-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
      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 identification number

one cycle of data

see Figure 12.8 and Figure 12.9 for details on this one cycle of B-phase (Channel IB) current.

```
[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

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 PN  P   P 1  9S 71357mo 1Od 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]                                                                                  ⑬
...... . V ... ...... .. ...... .. ... ..... .......... o.. .... ...... 1.. ....
...... . V ... ...... .. ...... .. ... ..... .......... ... .... ...... 1.. ....
...... . V ..p ...... QQ ...... .. ... ..... .......... ... .... ...... 1.. ....
...... . V .pp ...... QQ ...... .. ... ..... ...*...... ... .... ...... 1.. ....>
[5]                                                                                  ⑪, ⑩
.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, ⑧
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
[6]                                                                                  ⑫
.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.. ....
[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]                                                                                 ⑥
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....     ⑤
.1.... . V .pp 1..... QQ 1..... .. ... ..... ...*...... ... b4.. ...... 1.. ....
.2.... . V .rp ...... QQ ...... .. ... ..... ...*...... ... b4.. ...... 1.. ....
[11]                                                                                 ③
...... . V .rp ...... QQ ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .rp ...... QQ ...... .. ... ..... ...*...... o.. b... ...... ... ....
...... . V .rp ...... QQ ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .rr ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
[12]                                                                                 ⑦
...... . V .rr ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .rr ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .rr ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
[13]                                                                                 ④
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... b... ...... ... ....
[14]                                                                                 ①, ②
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... .... ...... ... ....
...... . V .r. ...... .. ...... .. ... ..... ...*...... ... .... ...... ... ....
...... . 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]
A. ........ ..... .... .... .... .... .... . 00 00 00 00 40 00 ................
A. ........ ..... .... .... .... .... .... . 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

=>>
```

see Figure 12.2

Settings follow but are not shown in this example.

Figure 12.7 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution

Figure 12.8 and *Figure 12.9* look in detail at one cycle of B-phase current (channel IB) identified in *Figure 12.7*. *Figure 12.8* shows how the event report ac current column data relates to the actual sampled waveform and rms values. *Figure 12.9* shows how the event report current column data can be converted to phasor rms values. Voltages are processed similarly.

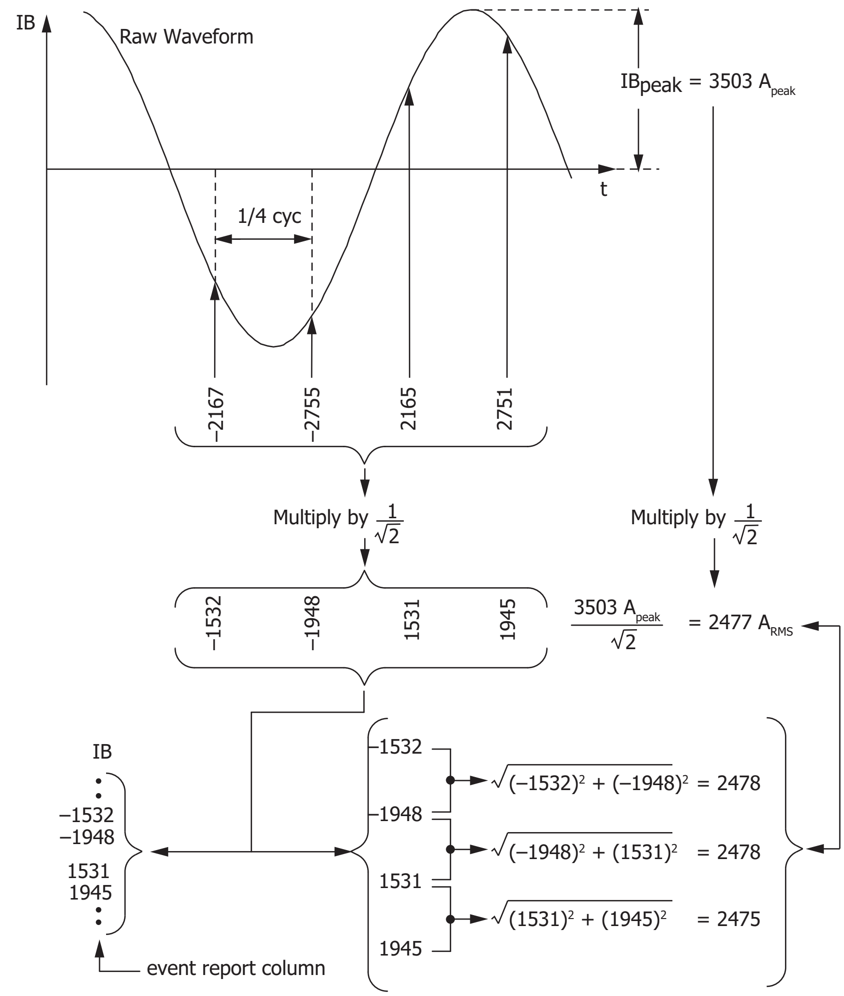
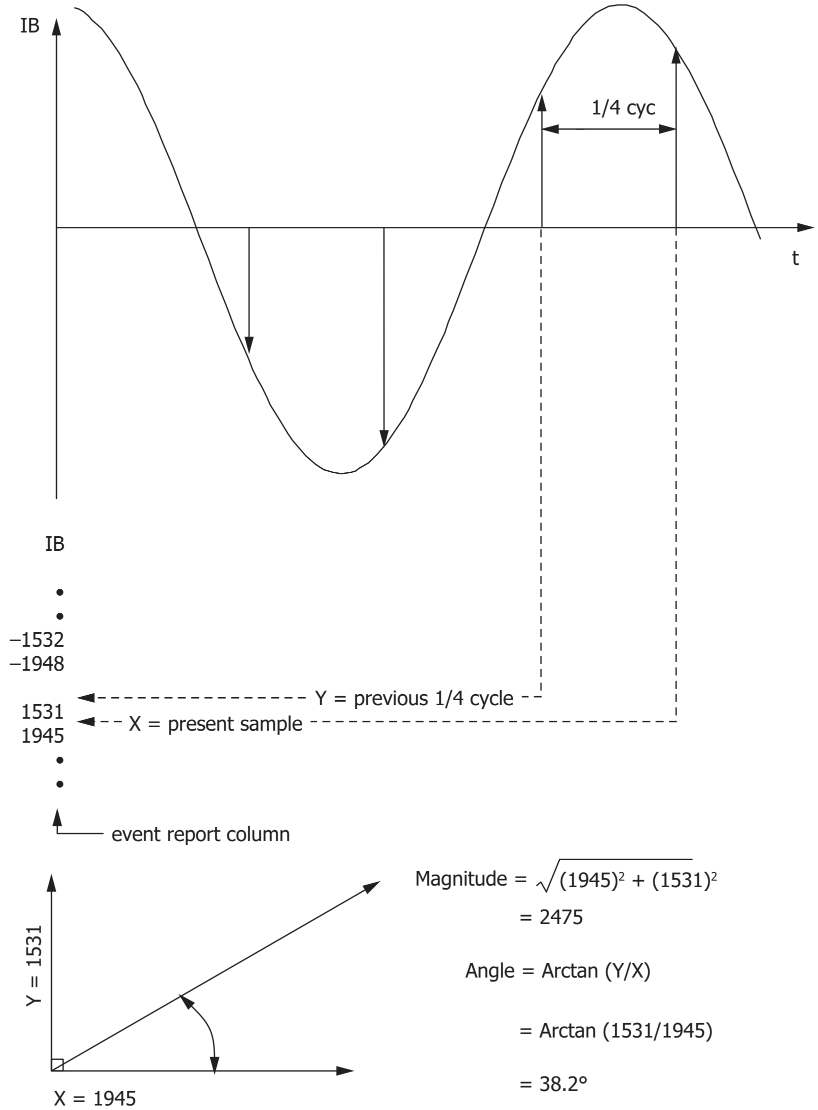


Figure 12.8 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 12.8*, note that any two rows of current data from the event report in *Figure 12.7*, 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 12.9 Derivation of Phasor RMS Current Values From Event Report Current Values

In *Figure 12.9*, note that two rows of current data from the event report in *Figure 12.7*, 1/4 cycle apart, can be used to calculate phasor rms current values. In *Figure 12.9*, at the present sample, the phasor rms current value is:

$$IB = 2475\ A \angle 38.2°$$

The present sample (IB = 1945 A) is a real rms current value that relates to the phasor rms current value:

$$2475\ A * \cos(38.2°) = 1945\ A$$

Example Sequential Recorder (SER) Report

The following example sequential events recorder (SER) report in *Figure 12.10* also corresponds to the example standard 15-cycle event report in *Figure 12.7*.

```
=>>SER <Enter>

SEL-311C POTT                    Date: 10/14/99    Time: 08:56:47.400
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311C-2-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 12.10 Example Sequential Events Recorder (SER) Event Report

The SER event report rows in *Figure 12.10* are explained in the following text, numbered in correspondence to the # column. The boxed, numbered comments in *Figure 12.7* also correspond to the # column numbers in *Figure 12.10*. The SER event report in *Figure 12.10* contains records of events that occurred before and after the standard event report in *Figure 12.7*.

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 two categories: 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.

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.

⚠WARNING
Before working on a CT circuit, first apply a short to the secondary winding of the CT.

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.

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.

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 *Using the Embedded Web Server (HTTP) on page 10.22*.
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 I/O 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 QuickSet.
SER	The relay provides a Sequential Events Recorder (SER) event report that time tags changes in relay element and I/O 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 QuickSet or the web server. See *Using the Embedded Web Server (HTTP) on page 10.22*.
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 QuickSet HMI or the web server. See *Using the Embedded Web Server (HTTP) on page 10.22*.
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 QuickSet HMI.

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.

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 2.20 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).

⚠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.

You can test the relay-processing module (via input J12) by using signals from the SEL-4000 Relay Test System. The power supply for the relay main board is provided through the ribbon cable between J2 and J12. SEL-C724 cable 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.

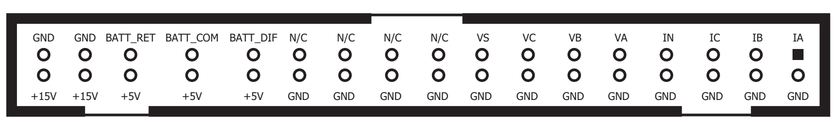

Figure 13.1 Low-Level Test Interface (J2 or J12) Connector

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 (I/O)
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:

$$\frac{67\text{ V}}{0.2911\text{ V}} = 223.97\left(\frac{\text{V}}{\text{V}}\right)$$

$$\frac{5\text{ A}}{0.045\text{ V}} = 110.60\left(\frac{\text{A}}{\text{V}}\right)$$

Logic and Protection Element Test Methods

Test the pickup and dropout of relay elements by 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 by 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 QuickSet HMI or on the web server. See *Using the Embedded Web Server (HTTP) on page 10.22*.

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 10.76*.

Relay Self-Tests

The relay runs a variety of self-tests. Hardware alarm conditions are generated by the self-test logic and are classified as warnings or failures, depending on severity. The relay may take the following actions for out-of-tolerance conditions (see *Table 13.3*):

➤ Relay Word bits HALARMP and HALARM assert for five seconds to indicate that a hardware warning has occurred. Relay Word bits HALARML and HALARM assert and remain asserted to indicate most hardware failures. *Table 13.3* lists the various hardware warning and failure conditions. Some hardware failures prevent the relay from operating. In such cases, Relay Word bits HALARML and HALARM do not assert.

Once HALARMP pulses, Relay Word bit HALARMA continues to assert for approximately five seconds once per minute to indicate that a hardware warning has occurred. HALARMA continues to pulse until it is reset by pulsing SELOGIC control equation RST_HAL, DNP binary output DRST_HAL, or the Modbus Reset Hardware Alarm coil. Restarting the relay also resets HALARMA. HALARMP does not assert again for the same alarm condition, unless the condition is cleared and returns.

Depending on SELOGIC control equation settings, the ALARM output contact may signal an alarm condition for hardware warnings. The ALARM output is always de-energized for hardware failures, regardless of settings. See *Output Contacts on page 7.32* for an explanation of ALARM contact operation for various SELOGIC settings and hardware configurations.

NOTE: The SEL-311C is shipped from the factory with the ALARM output configured as a B contact.

- ➤ 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.
- ➤ 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 automatically restarts as many as three times within 24 hours. In many instances, this will correct the failure. A “diagnostic restart” entry is recorded in the Sequential Events Recorder (SER), but the automatic restart may occur before Relay Word bits ALARM, HALARM, and HALARML are recorded in the SER and before front-panel failure messages are displayed.

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 Relay Word Bits	Protection Disabled on Failure[a]	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		HALARML	Yes	Yes	STATUS FAIL IO_BRD FAIL	**STA C**
I/O Board Warning	Actual and expected board IDs do not match.		HALARMP, HALARMA	No	Yes	STATUS WARNING IO_BRD WARNING	**STA C**
Temperature		–40°C to 100°C	HALARMP, HALARMA	No	Yes		
Communications Board Warning	Installed communications card does not match relay Part Number			No	Yes		**STA C**

Table 13.3 Relay Self-Tests (Sheet 2 of 3)

Self-Test	Description	Normal Range	Alarm Relay Word Bits	Protection Disabled on Failure[a]	Port Auto Message on Failure	Front-Panel Message on Failure	Corrective Action
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		HALARML	Yes	Yes		
FPGA	FPGA failure		HALARML	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		HALARMP, HALARMA	No	No		
HMI	Invalid HMI board ID		HALARMP, HALARMA	No	Yes	STATUS WARNING HMI WARNING	
HMI	HMI time-out		HALARMP, HALARMA	No	Yes	STATUS WARNING HMI WARNING	
External Ram	Failure of read/write test on system RAM			Yes	No		
Internal/External RAM	Failure of internal or external RAM		HALARML	Yes	Yes	STATUS FAIL RAM FAILURE	Automatic restart. Contact SEL if failure returns.
Code Flash Failure	Failure of checksum test on firmware code			Yes	No		
Code Flash Failure	Firmware relay type code does not match part number		HALARML	Yes	Yes	STATUS FAIL ROM FAILURE	Verify correct version of firmware installed
Operating System	Operating System check fails			Yes	Yes	CPU ERROR/RELAY DISABLED	Automatic restart. Contact SEL if failure returns.

Table 13.3 Relay Self-Tests (Sheet 3 of 3)

Self-Test	Description	Normal Range	Alarm Relay Word Bits	Protection Disabled on Failure[a]	Port Auto Message on Failure	Front-Panel Message on Failure	Corrective Action
Data Flash Failure	Failure of checksum test on relay settings		HALARML	Yes	Yes	STATUS FAIL FLASH FAILURE	
EEPROM Failure	Failure to determine latch bit status on power-up		HALARML	Yes	Yes	STATUS FAIL EEPROM FAILURE	
EEPROM Warning	Failure of read/write to EEPROM		HALARMP, HALARMA	No	Yes		
Exception Failure	CPU Error			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	HALARMP, HALARMA	No	Yes		
Master Offset	DC offset in A/D ground channel outside of normal range	<10 mV	HALARMP, HALARMA	No	Yes		
A/D Failure	Analog to digital converter failure		HALARML	Yes	Yes	STATUS FAIL A/D FAILURE	
+15 V Warning	+15 V Power supply outside of warning range	14.25 V to 15.75 V	HALARMP, HALARMA	No	Yes		
+15 V Failure	+15 V Power supply outside of failure range	14.00 V to 16.00 V	HALARML	Yes	Yes	STATUS FAIL +15V FAILURE	
+5 V Warning	+5 V Power supply outside of warning range	4.76 V to 5.23 V	HALARMP, HALARMA	No	Yes		
+3.3 V Warning	+3.3 V Power supply outside of warning range	3.16 V to 3.46 V	HALARMP, HALARMA	No	Yes		

[a] ALARM output de-energizes when protection is disabled.

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 is loose or damaged.

Relay Does Not Respond to Commands From Device Connected to Communications Port

NOTE: The SEL-311C default baud rate (SPEED setting) is 9600 on all serial ports. This is different than legacy SEL-311C relays.

1. Communications device not connected to relay.
2. Relay or communications device at incorrect baud rate or other communication parameter incompatibility, including cabling error.
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 by using the **SET P *n*** command from another communications interface (serial port, USB, or Telnet session) or by 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 9.20*.

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 by using the **SET P F** command from another communications interface (serial port or Telnet session) or by using the front-panel interface. See *Port Enable Settings on page 9.20*.
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 by using the **STATUS** command by 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 appear*s* 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. Connect a communications device to the relay. See *Section 10: Communications* for details on connecting and configuring communications.
2. The relay Ethernet port is disabled (setting EPORT = N). Change the setting by using the **SET P 5** command from another communications interface (serial port or USB session) or by using the front-panel interface. See *Port Enable Settings on page 9.20*.
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*.
5. Firmware upgrade option is not available on the web server. Check HTTPACC setting.

Relay Does Not Respond to Faults

NOTE: Improper phase fault targeting may occur if fault tests are performed without proper phase voltages applied during testing.

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 NFREQ or PHROT not set correctly.
2. Group Settings CTR, CTRN, PTR or PTRN not set correctly.
3. Relay analog inputs not connected correctly.

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 2.11*.

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 is 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 2.10*.
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.

Technical Support

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

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Appendix A
Firmware, ICD, and Manual Versions

Firmware

Determining the Firmware Version

To determine the firmware version, view the status report by using the serial port **STATUS** command or the front-panel **STATUS** pushbutton. The status report displays the Firmware Identification (FID) number.

The firmware version will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device FID number.

Existing firmware:
FID=SEL-311C-2-**R500**-V0-Z001001-Dxxxxxxxx

Standard release firmware:
FID=SEL-311C-2-**R501**-V0-Z001001-Dxxxxxxxx

A point release is identified by a change in the V-number of the device FID number.

Existing firmware:
FID=SEL-311C-2-R500-**V0**-Z001001-Dxxxxxxxx

Point release firmware:
FID=SEL-311C-2-R500-**V1**-Z001001-Dxxxxxxxx

The date code is after the D. For example, the following is firmware version number R500, date code December 10, 2003.

FID=SEL-311C-2-R500-V0-Z001001-**D20031210**

Revision History

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 (Sheet 1 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-311C-2-R509-V0-Z104101-D20240709 SEL-311C-3-R509-V0-Z104101-D20240709	➤ [Cybersecurity] Improved web server security against session hijacking. ➤ [Cybersecurity] Improved web server security against intentionally large files causing denial of service.	20240709

Table A.1 Firmware Revision History (Sheet 2 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ [Cybersecurity] Improved web server security against cross-site scripting and misuse of session tokens. ➤ [Cybersecurity] Removed advanced diagnostic commands from Access Level C. ➤ [Cybersecurity] Resolved an issue where a user logged into the web server at ACC access level can restart the relay. ➤ [Cybersecurity] Resolved an issue where third party could make use of the account session to access information from the relay web server. ➤ [Cybersecurity] Resolved an issue where logging into the relay web server at the same time as a relay settings change would cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Resolved an issue where MMS authentication did not limit incorrect password attempts. ➤ Improved fault location for short duration faults. ➤ Resolved an issue where certain relay settings no longer accept incorrect ASCII characters.	
SEL-311C-2-R508-V5-Z104101-D20240709 SEL-311C-3-R508-V5-Z104101-D20240709	Includes all the functions of SEL-311C-2-R508-V4-Z104101-D20210917 and SEL-311C-3-R508-V4-Z104101-D20210917 with the following additions: ➤ [Cybersecurity] Improved web server security against session hijacking. ➤ [Cybersecurity] Improved web server security against intentionally large files causing denial of service. ➤ [Cybersecurity] Improved web server security against cross-site scripting and misuse of session tokens. ➤ [Cybersecurity] Removed advanced diagnostic commands from Access Level C. ➤ [Cybersecurity] Resolved an issue where a user logged into the web server at ACC access level can restart the relay. ➤ [Cybersecurity] Resolved an issue where third party could make use of the account session to access information from the relay web server. ➤ [Cybersecurity] Resolved an issue where logging into the relay web server at the same time as a relay settings change would cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Resolved an issue where MMS authentication did not limit incorrect password attempts. ➤ Resolved an issue where certain relay settings no longer accept incorrect ASCII characters.	20240709
SEL-311C-2-R508-V4-Z104101-D20210917 SEL-311C-3-R508-V4-Z104101-D20210917	Includes all the functions of SEL-311C-2-R508-V3-Z104101-D20201008 and SEL-311C-3-R508-V3-Z104101-D20211008 with the following addition: ➤ Resolved an issue where deliberately crafted Ethernet traffic or a misconfigured network could cause the relay to perform a diagnostic restart. By design, three diagnostic restarts in 24 hours causes the relay to disable.	20210917

Table A.1 Firmware Revision History (Sheet 3 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-311C-2-R508-V3-Z104101-D20201008 SEL-311C-3-R508-V3-Z104101-D20201008	Includes all the functions of SEL-311C-2-R508-V2-Z104101-D20190111 and SEL-311C-3-R508-V2-Z104101-D20190111 with the following addition: ➤ Resolved an extremely rare issue that could cause the relay to perform a diagnostic restart when configured for Parallel Redundancy Protocol (NETMODE = PRP) and the relay received abnormal Ethernet traffic.	20201008
SEL-311C-2-R508-V2-Z104101-D20190111 SEL-311C-3-R508-V2-Z104101-D20190111	Includes all the functions of SEL-311C-2-R508-V1-Z104101-D20170818 and SEL-311C-3-R508-V1-Z104101-D20170818 with the following additions: ➤ Modified Ethernet communications to automatically correct a loss of synchronization between the communications subsystem and the other relay subsystems. ➤ Resolved an issue where certain Ethernet traffic could cause the relay to safely restart.	20190111
SEL-311C-2-R508-V1-Z104101-D20170818 SEL-311C-3-R508-V1-Z104101-D20170818	Includes all the functions of SEL-311C-2-R508-V0-Z104101-D20150219 and SEL-311C-3-R508-V0-Z104101-D20150219 with the following addition: ➤ Resolved an issue where certain Ethernet traffic could cause diagnostic restarts.	20170818
SEL-311C-2-R508-V0-Z104101-D20150219 SEL-311C-3-R508-V0-Z104101-D20150219	➤ Added Modbus Map labels to set, clear, or pulse remote bits using Modbus Function Code 06h or 10h.	20150219
SEL-311C-2-R507-V5-Z103101-D20240709 SEL-311C-3-R507-V5-Z103101-D20240709	Includes all the functions of SEL-311C-2-R507-V4-Z103101-D20210917 and SEL-311C-3-R507-V4-Z103101-D20210917 with the following additions: ➤ [Cybersecurity] Improved web server security against session hijacking. ➤ [Cybersecurity] Improved web server security against intentionally large files causing denial of service. ➤ [Cybersecurity] Improved web server security against cross-site scripting and misuse of session tokens. ➤ [Cybersecurity] Removed advanced diagnostic commands from Access Level C. ➤ [Cybersecurity] Resolved an issue where a user logged into the web server at ACC access level can restart the relay. ➤ [Cybersecurity] Resolved an issue where third party could make use of the account session to access information from the relay web server. ➤ [Cybersecurity] Resolved an issue where logging into the relay web server at the same time as a relay settings change would cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Resolved an issue where MMS authentication did not limit incorrect password attempts. ➤ Resolved an issue where certain relay settings no longer accept incorrect ASCII characters.	20240709
SEL-311C-2-R507-V4-Z103101-D20210917 SEL-311C-3-R507-V4-Z103101-D20210917	Includes all the functions of SEL-311C-2-R507-V3-Z103101-D20201008 and SEL-311C-3-R507-V4-Z134101-D20210917 with the following addition: ➤ Resolved an issue where deliberately crafted Ethernet traffic or a misconfigured network could cause the relay to perform a diagnostic restart. By design, three diagnostic restarts in 24 hours causes the relay to disable.	20210917

Table A.1 Firmware Revision History (Sheet 4 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-311C-2-R507-V3-Z103101-D20201008 SEL-311C-3-R507-V3-Z103101-D20201008	Includes all the functions of SEL-311C-2-R507-V2-Z103101-D20190111 and SEL-311C-3-R507-V2-Z103101-D20190111 with the following addition: ➤ Resolved an extremely rare issue that could cause the relay to perform a diagnostic restart when configured for Parallel Redundancy Protocol (NETMODE = PRP) and the relay received abnormal Ethernet traffic.	20201008
SEL-311C-2-R507-V2-Z103101-D20190111 SEL-311C-3-R507-V2-Z103101-D20190111	Includes all the functions of SEL-311C-2-R507-V1-Z103101-D20170818 and SEL-311C-3-R507-V1-Z103101-D20170818 with the following additions: ➤ Modified Ethernet communications to automatically correct a loss of synchronization between the communications subsystem and the other relay subsystems. ➤ Resolved an issue where certain Ethernet traffic could cause the relay to safely restart.	20190111
SEL-311C-2-R507-V1-Z103101-D20170818 SEL-311C-3-R507-V1-Z103101-D20170818	Includes all the functions of SEL-311C-2-R507-V0-Z103101-D20140730 and SEL-311C-3-R507-V0-Z103101-D20140730 with the following addition: ➤ Resolved an issue where certain Ethernet traffic could cause diagnostic restarts.	20170818
SEL-311C-2-R507-V0-Z103101-D20140730 SEL-311C-3-R507-V0-Z103101-D20140730	➤ Added IEEE C37.111-1999 COMTRADE standard event reports. ➤ Added fault resistance calculation to the Compressed ASCII event report, event summary command, Compressed ASCII event summary command, and to the front-panel event data. ➤ Added the ability to remotely upgrade relay firmware over an Ethernet network. ➤ Added support for **PING** command. ➤ Added Parallel Redundancy Protocol (PRP). ➤ Added the ability to automatically calculate the value of group settings k0M1, k0A1, k0M, and k0A. ➤ Improved fault location accuracy. ➤ Increased DNP binary outputs from 33 to 71. ➤ Added support for "*" and "?" wildcards with Ymodem, FTP, and MMS file transfers. ➤ Made events (COMTRADE file format and Compressed ASCII) and reports (Metering, History, diagnostics, etc.) available for Ymodem, FTP, and MMS file transfer. ➤ Made fault impedance magnitude and angle available over DNP3 and Modbus. ➤ Made fault resistance, and per-unit of line length fault location available over DNP3, Modbus, and IEC 61850. ➤ Added MAXWEAR analog quantity; made MAXWEAR available for display points, DNP, Modbus, and IEC 61850. ➤ Modified IEC 61850 GOOSE virtual bit behavior to be reset when CID file is loaded. ➤ Modified DNP binary outputs so that they are no longer reported as offline when the binary output is present in the binary input map and the Sequential Events Recorder (SER).	20140730

Table A.1 Firmware Revision History (Sheet 5 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Corrected issue where relay rejects settings file because of hidden settings. In previous firmware revisions when NETMODE := FIXED and NETPORT := A, hidden setting NET5BSPD was transmitted in the settings file and caused the settings file to be rejected. Similarly, when NETMODE := FIXED and NETPORT := B, hidden setting NET5ASPD was transmitted in the settings file and caused the settings file to be rejected. ➤ Added support for MMS Authentication. ➤ Added support for CID file transfer through MMS, and added EMMSFS setting to enable/disable MMS file services. ➤ Added feature to retain the existing valid CID file when an invalid CID file is sent. ➤ Added COMTRADE events directory for MMS file transfer. ➤ Added FLRNUM and FLREP analog quantities and made available for IEC61850.	
SEL-311C-2-R506-V0-Z102101-D20131219 SEL-311C-3-R506-V0-Z102101-D20131219	➤ Reduced the normal time constant of the distance element polarizing voltage memory to more closely follow changes in power system frequency; the time constant automatically adapts to provide security for zero-voltage three-phase faults. ➤ Added option Y2 to setting EOOS to use the positive-sequence current restraint factor a2 as part of the OOS unblocking logic.	20131219
SEL-311C-2-R505-V0-Z101101-D20130620 SEL-311C-3-R505-V0-Z101101-D20130620	➤ Corrected handling of unrecognized Ethertype frames that can cause Ethernet to stop responding. ➤ Improved fault location accuracy for certain phase-to-ground faults. ➤ UDP port is no longer reported as open by a port scanner when 61850 is enabled.	20130620
SEL-311C-2-R504-V0-Z101101-D20130304 SEL-311C-3-R504-V0-Z101101-D20130304	➤ Made changes for manufacturing process improvements.	20130304
SEL-311C-2-R503-V0-Z101101-D20121203 SEL-311C-3-R503-V0-Z101101-D20121203	➤ Added high-speed dropout breaker failure logic with CT subsidence detection. ➤ The status of Relay Word bit NDEM is now included in standard event reports. ➤ Added logic to reset POTT Relay Word bit Z3RB if a Zone 1 fault is detected. ➤ Added directional control logic for single-pole open conditions. ➤ First release of SEL-311C-3 with high-speed distance elements. ➤ Single-pole open conditions now block Loss-of-Potential logic. ➤ Positive-sequence voltage for protection is now calculated without contribution from open phases under single-pole open conditions. Metering calculations are unaffected by single-pole open conditions. ➤ Added support for Ethernet communications option with 10/100BASE-T and 100BASE-FX ports. ➤ Added support for fiber-optic serial port option. ➤ Added support for extra I/O board option with 16 inputs and 4 outputs. ➤ Relay now checks for proper parity in IRIG-B signals with either even or odd parity. ➤ Improved metering accuracy when current is low. ➤ Global setting PMSTN now accepts upper- and lower-case characters.	20121203

Table A.1 Firmware Revision History (Sheet 6 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Reformatted relay web server. ➤ Revised fault locator logic to ensure proper operation for three-phase faults under test conditions. ➤ Corrected checksum in the settings section of compressed event reports. ➤ Added breaker open and close time reporting and alarms. ➤ Corrected breaker monitor function to properly handle test settings that prevented the relay from enabling. ➤ Added SELogic control equations for ALARM output and Relay Word bits for various self-test alarms. ➤ FTP and MMS can now transfer event files and selected ASCII commands. ➤ Enhanced front-panel events display to show fractional seconds. ➤ Added **TIME Q** and **TIME DST** commands. ➤ Added more statistics in **ETH** command response and ability to clear **ETH** command statistics. ➤ Settings group switch messages are now automatically included in SER records. ➤ Relay can now store acSELerator QuickSet design templates. ➤ Revised CFG.txt file to include settings checksum. ➤ Added MAXACC = 0 setting to restrict access to ports while allowing SEL Fast protocols to function and allow **SNS**, **BNA**, and **DNA** commands at Access Level 0. ➤ Relay now allows Calibration Level access on any port. ➤ Added settings for the user policy banners for the web server and TCP. ➤ Increased size of user-defined FTP banner. ➤ Added Remote Bits RB17–RB32. ➤ Revised IP addressing to use Classless addressing scheme and restricted addresses so that the first octet cannot be zero and the host portion of the IP address cannot be all ones or all zeros. ➤ Web Server now always displays the settings from the active settings group by default. ➤ Serial ports can no longer time out during **FILE SHO** command responses. ➤ Corrected issue that could occasionally cause the USB port to become unresponsive when a connected PC goes into hibernation or when the port is left connected to a powered USB hub with no PC connected. ➤ Added EVEMODE setting to force the relay to start in single or multiple event mode. ➤ Added DNP binary output SINGEVE to allow the DNP master to place the outstation in single-event mode. ➤ Added RSTDNPE SELogic control equation and DRSTDNPE DNP binary output to reset relay event queue. ➤ Added MINDIST and MAXDIST fault location settings to limit event reports made available via DNP. ➤ Added RPEVTYP setting to control which event types are made available via DNP.	

Table A.1 Firmware Revision History (Sheet 7 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Added BOOPTCC and BOOPPUL settings to allow customized DNP binary output behavior. ➤ Relay serial number and firmware revision are now available as DNP and Modbus quantities. ➤ Added support for DNP Function Code 22 (Assign Class). ➤ DNP sessions on Ethernet ports now include a keep-alive signal and close the session if communication with the DNP master is lost. This ensures that the DNP master can reconnect to the session. ➤ RTS is now forced high and CTS is ignored when PREDLY setting is OFF to power certain fiber-optic transceivers. ➤ Fault location, fault currents, and fault impedance are now available as IEC 61850 quantities. ➤ Relay serial number is now available as an IEC 61850 quantity. ➤ Changed dead band for IEC 61850 ZBAT logical node from 500 to 5. ➤ Increased energy metering resolution in front-panel display and **MET E** command. ➤ Added support for zipped and digitally signed (.ZDS) firmware files. Firmware files with the .s19 extension cannot be sent to relays with this firmware. ➤ Relay Word bit PMDOK now asserts when the measured frequency is between 40 Hz and 65 Hz. It is not necessary for the relay to be tracking the frequency. ➤ Relay Word bit 27B81 now deasserts only when voltage is used for frequency measurement. ➤ The relay now enables TCP keep-alive for PMU sessions regardless of ETCPKA setting. ➤ Modified retransmit intervals for outgoing GOOSE messages. ➤ Minimum GOOSE retransmit time is now configurable. ➤ Changed logical node METMMXU1 per-phase power factor (PF.), real power (W.), and reactive power (VAr.) objects to use CMV cdc instead of MV cdc. ➤ Data references within the OptFlds attribute are no longer included in the default report control blocks of the ICD file. ➤ MMS inactivity timeout is now user configurable. ➤ CID files with APPID or VLAN-ID strings shorter than the maximum length are now accepted. ➤ Smallest maximum MMS PDU size changed to 512 bytes. ➤ Maximum number of MMS variables that can be read or written reduced to 256. ➤ Improved synchrophasor frequency accuracy when PHCOMP = Y. ➤ appID in a GOOSE control block and rptID in a Report control block may be left empty, and if so, will be automatically replaced with the control block reference. ➤ GOOSE mAddr attribute may now contain nonmulticast addresses. ➤ The messages provided when no GOOSE subscriptions or publications are configured have been changed to `No GOOSE subscriptions configured` and `No GOOSE publications configured`, respectively.	

Table A.1 Firmware Revision History (Sheet 8 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Change report is now sent if integrity or GI report is sent before BufTM expires. ➤ Different segments of segmented reports now have different sequence numbers. ➤ The buffer overflow flag is now set in the first report to be transmitted after a buffered report control block (BRCB) re-enable. ➤ Corrected Str.dirGeneral datasource for ICD file logical nodes DCUBPSCH1 and POTTPSCH1.	
SEL-311C-2-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-2-R501-V0-Z100100-D20110420	➤ Changes for manufacturing process improvements.	20110420
SEL-311C-2-R500-V0-Z100100-D20110224	➤ Initial version. Note: This firmware revision was not released. See R501 above.	20110224

ICD File

Determining the ICD File Version in Your Relay

To find the ICD revision number in your relay, view the configVersion by using the serial port **ID** command. The configVersion is the last item displayed in the information returned from the **ID** command.

configVersion=ICD-311C3-R503-V0-Z507005-D20140813

The ICD revision number is after the R (e.g., 503) and the release date is after the D. This revision number is not related to the relay firmware revision number. The configVersion revision displays the ICD file version used to create the CID file that is loaded in the relay.

NOTE: The Z-number representation is implemented with ClassFileVersion 005. Previous ClassFileVersions do not provide an informative Z-number.

The configVersion contains other useful information. The Z-number consists of six digits. The first three digits following the Z represent the minimum IED firmware required to be used with the ICD (e.g., 507). The second three digits represent the ICD ClassFileVersion (e.g., 005). The ClassFileVersion increments when there is a major addition or change to the IEC 61850 implementation of the relay.

Table A.2 and *Table A.3* list the ICD file versions, a description of modifications, and the instruction manual date code that corresponds to the versions. The most recent version is listed first.

Table A.2 SEL-311C-2 ICD File Revision History (Sheet 1 of 3)

configVersion	Summary of Revisions	Min. Relay Firmware	ClassFile Version	Manual Date Code
ICD-311C2-R505-V0-Z507005-D20150205	➤ Corrected ldNs and lnNs values. ➤ Increased default MMS inactivity time-out from 120 to 900 seconds.	507	005	20150205

Table A.2 SEL-311C-2 ICD File Revision History (Sheet 2 of 3)

configVersion	Summary of Revisions	Min. Relay Firmware	ClassFile Version	Manual Date Code
ICD-311C2-R504-V0-Z101101-D20140730	➤ Made MMS inactivity timeout user-configurable. ➤ Added file-handling service. ➤ Removed maxEntries and maxMappedItems. ➤ Updated orCat control instances to proprietary node.	503	004	20140730
ICD-311C2-R503-V0-Z507005-D20140730	➤ Corrected SCBR logical nodes logical device to PRO. ➤ Corrected ReportControl rptID attributes to display report name instead of dataset name. ➤ Made corrections per KEMA recommendations. ➤ Increased number of MMS reports to 14. ➤ Modified all MMS report and dataset names. ➤ Updated ClassFileVersion to 005. ➤ Updated all ReportControls. ➤ Made MMS inactivity timeout user-configurable. ➤ Added new MMS Authentication Support. ➤ Updated configVersion for new format. ➤ Added new RDRE logical node and attributes. ➤ Added new FLTRFLO1 FltRis and FltDis attributes to RFLO LN. ➤ Added new SCBR MaxAbrPrt (MAXWEAR) attributes. ➤ Added file-handling service. ➤ Removed maxEntries and maxMappedItems. ➤ Removed extra space from BRDSet03 and URDSet03 dataset descriptions. ➤ Updated orCat control instances to proprietary node.	507	005	20140730
ICD-311C2-R502-V0-Z101101-D20121203	➤ Corrected DCZBAT Vol deadband. ➤ Corrected DCUB and POTT Str.dirGeneral. ➤ Corrected multiplier enum Giga scale factor. ➤ Corrected PDIS NamPlt.d and Str.dirGeneral attributes. ➤ Corrected M3PPDIS3, M4PPDIS4, MABC3PDIS1, MABC4PDIS1, MPP3PDIS1, MPP4PDIS1 Str.dirGeneral datasource. ➤ Corrected LPHD1 PhyHealth stVal datasource.	503	004	20121203

Table A.2 SEL-311C-2 ICD File Revision History (Sheet 3 of 3)

configVersion	Summary of Revisions	Min. Relay Firmware	ClassFile Version	Manual Date Code
	➤ Corrected datatype for MMXU W, VAr, and PF attributes. ➤ Made corrections for KEMA approval. ➤ Increased remote bits to 32. ➤ Increased number of inputs for IN2GGIO2 logical node. ➤ Set all ReportControl dataRef OptFields to false. ➤ Added new RFLO logical node and attributes. ➤ Added new SCBR logical nodes and attributes datasourse. ➤ Added new MinTime support. ➤ Added new serNum DAI. ➤ Added new LOP attributes to LOPPTUV1 logical node. ➤ Added new XCBR OpCntEx attribute. ➤ Added new RBRF logical nodes and attributes. ➤ New Ind07 attribute for SGGGIO16 logical node. ➤ Added new ALMGGIO21 logical node and attributes.			
ICD-311C2-R501-V0-Z000000-D20110407	➤ Initial ICD file release.	501	004	20110420

Table A.3 SEL-311C-3 ICD File Revision History (Sheet 1 of 2)

configVersion	Summary of Revisions	Min. Relay Firmware	ClassFile Version	Manual Date Code
ICD-311C3-R505-V0-Z507005-D20150205	➤ Corrected ldNs and lnNs values. ➤ Increased default MMS inactivity timeout from 120 to 900 seconds.	507	005	20150205
ICD-311C3-R504-V0-Z101101-D20140730	➤ Made MMS inactivity timeout user-configurable. ➤ Added file-handling service. ➤ Removed maxEntries and maxMappedItems. ➤ Updated orCat control instances to proprietary node.	503	004	20140730
ICD-311C3-R503-V0-Z507005-D20140730	➤ Corrected SCBR logical nodes logical device to PRO. ➤ Corrected ReportControl rptID attributes to display report name instead of dataset name. ➤ Made corrections per KEMA recommendations.	507	005	20140730

Table A.3 SEL-311C-3 ICD File Revision History (Sheet 2 of 2)

configVersion	Summary of Revisions	Min. Relay Firmware	ClassFile Version	Manual Date Code
	➤ Increased number of MMS reports to 14. ➤ Modified all MMS report and dataset names. ➤ Updated ClassFileVersion to 005. ➤ Updated all ReportControls. ➤ Made MMS inactivity timeout user-configurable. ➤ Added new MMS Authentication Support. ➤ Updated configVersion for new format. ➤ Added new RDRE logical node and attributes. ➤ Added new FLTRFLO1 FltRis and FltDis attributes to RFLO LN. ➤ Added new SCBR MaxAbrPrt (MAX-WEAR) attributes. ➤ Added file-handling service. ➤ Removed maxEntries and maxMappedItems. ➤ Removed extra space from BRDSet03 and URDSet03 dataset descriptions. ➤ Updated orCat control instances to proprietary node.			
ICD-311C3-R502-V0-Z101101-D20121203	➤ Initial ICD file release.	503	004	20121203

Instruction Manual

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

Table A.4 lists the instruction manual date codes and a description of modifications. The most recent instruction manual revision is listed at the top.

Table A.4 Instruction Manual Revision History (Sheet 1 of 9)

Date Code	Summary of Revisions
20250127	General ➤ Removed references to CDs throughout.
20240709	Appendix A ➤ Updated for firmware versions R509-V0, R508-V5, and R507-V5.
20230831	Section 2 ➤ Updated *Fast Hybrid High-Current Interrupting Output Contacts*. Section 6 ➤ Updated *Lockout State*. Section 7 ➤ Updated *Power Loss*.

Table A.4 Instruction Manual Revision History (Sheet 2 of 9)

Date Code	Summary of Revisions
	Section 13 ➤ Updated *Testing Philosophy*. Appendix F ➤ Updated *Processing Order Considerations*. Appendix Q ➤ Updated entire appendix.
20221103	Section 1 ➤ Added UKCA Mark in *Specifications*.
20211203	Section 1 ➤ Updated *Type Tests* in *Specifications*.
20210917	Settings Sheets ➤ Updated CL setting description. Appendix A ➤ Updated for firmware version R508-V4 and R507-V4.
20201008	Appendix A ➤ Updated for firmware versions R507-V3 and R508-V3.
20200812	Preface ➤ Updated Safety Information. ➤ Added *Wire Sizes and Insulation*. Section 1 ➤ Updated *Specifications*. Section 4 ➤ Updated *CCVT Transient Detection Logic.*
20191107	Section 1 ➤ Updated *Specifications*.
20190809	Section 4 ➤ Updated *Relay Word Bit LOP4: LOP Logic for PT Transfer Scheme Applications*. ➤ Section 10 ➤ Updated *Detailed Instructions for USB Port Driver Installation*. Appendix C ➤ Updated *Table C.1: SEL Software Solutions*.
20190111	Section 1 ➤ Updated *Specifications*. Appendix A ➤ Updated for firmware versions R507-V2 and R508-V2.
20171023	Section 1 ➤ Updated *Specifications*.
20170818	Appendix A ➤ Updated for firmware versions R507-V1 and R508-V1.
20170215	Section 1 ➤ Updated *Specifications*.
20160715	Section 4 ➤ Enhanced the *Directional Control Settings* subsection to include a description of specific applications for the E32 setting.
20150820	Section 2 ➤ Updated power supply rear-panel connection information.

Table A.4 Instruction Manual Revision History (Sheet 3 of 9)

Date Code	Summary of Revisions
20150219	Section 1 ➤ Updated *Specifications*. Appendix A ➤ Updated for firmware version R508. Appendix O ➤ Added Modbus Map labels to set, clear, or pulse remote bits using Modbus Function Code 06h or 10h to Table O.22 Modbus Quantities Table. ➤ Added information on new remote bit set, clear, and pulse labels to Bit Operations Using Function Codes 06h and 10h section. Appendix P ➤ Changed MMS Object Explorer to AX-S4 61850 Explorer and AX-S4 MMS to AX-S4 61850. ➤ Updated MMS client sessions to seven.
20150126	Preface ➤ Added *Safety Information*. Section 1 ➤ Changed *Certifications* to *Compliance* and moved it to the beginning of *Specifications.*
20140730	Section 3 ➤ Added description of k0M1 automatic calculation. Section 7 ➤ Added virtual bit reset behavior to *Virtual Bits* section. Setting Sheets ➤ Updated the setting range for k0M1. ➤ Updated the setting range for NETMODE. ➤ Added new PRPTOUT, PRPADDR, and PRPINTV settings. ➤ Added new HTTPACC and FWFPC settings. ➤ Added new EMMSFS IEC 61850 Protocol Setting. Section 10 ➤ Added description of PRP Connection Mode. ➤ Added description of **PING** command. ➤ Added description of Virtual File Interface. ➤ Updated description of Embedded Web Server. ➤ Updated Access Control description for MMS for new EMMSFS setting and authentication. Section 12 ➤ Added description of fault resistance quantity. ➤ Added description of COMTRADE event report. Appendix A ➤ Updated for firmware version R507. ➤ Added ICD File section. Appendix B ➤ Added description for firmware upgrade over an Ethernet connection. Appendix C ➤ Modified to reference *ACSELERATOR QuickSet SEL-5030 Software Instruction Manual*.

Table A.4 Instruction Manual Revision History (Sheet 4 of 9)

Date Code	Summary of Revisions
	Appendix E ➤ Added *Fault Location* section. ➤ Moved FLOC, FZ, and FZFA to new *Fault Location* section. ➤ Updated FZ and FZFA quantities for DNP and Modbus use. ➤ Added FR and FM quantities. ➤ Corrected FSHO units. ➤ Added MAXWEAR quantity. ➤ Added FLRNUM and FLREP quantities. Appendix H ➤ Added description of Ethernet Synchrophasor settings. Appendix L ➤ Added Obj. Type 34 to all fault Labels (FTYPE through FIQ) and LDPF labels (LDPFA through LDPF3) in *Table L.10: DNP3 Reference Data Map*. ➤ Added FZ, FZFA, FR, and FM quantities to *Table L.10: DNP3 Reference Data Map*. ➤ Added MAXWEAR to *Table L.10: DNP3 Reference Data Map*. ➤ Updated *Table L.11:DNP3 Default Data Map* format ➤ Added BO_033 through BO_70 to *Table L.11:DNP3 Default Data Map*. ➤ Increased number of Binary Outputs to 71. ➤ Corrected *Figure L.7: Sample Custom DNP3 BO Map Settings* for new binary outputs. ➤ Updated *Event Data* section with new fault data. ➤ Added more detail to FTYPE description and numbered FTYPE tables. ➤ Made corrections to *Reading Relay Event Data* section. ➤ Added BO_033 through BO_070 to *DNP Settings Sheets*. Appendix O ➤ Added description of reading event data using Modbus. ➤ Added FZ, FZFA, FR, and FM quantities to *Table O.22: Modbus Quantities Table*. ➤ Added MAXWEAR to *Table O.22: Modbus Quantities Table*. Appendix P ➤ Added description of MMS authentication. ➤ Updated *Datasets* section with new datasets (total of 15 datasets now) and new dataset naming and *Figure P.1: SEL-311C Datasets*. ➤ Updated *Reports* section with new reports (total of 14 now) and new report naming and *Figure P.2: SEL-311C Predefined Reports*. ➤ Updated *Table P.5: Buffered Report Control Block Client Access*. ➤ Updated *Table P.6: Unbuffered Report Control Block Client Access*. ➤ Updated GOOSE Construction Tips section with new figures (*Figure P.3: Example of a Poorly Constructed GOOSE Dataset* through *Figure P.6: Example Transmit GOOSE Dataset*). ➤ Updated *IEC 61850 Configuration* section for MMS File Services modifications and virtual bit reset behavior. ➤ Added information to *SEL ICD File Versions* section. ➤ Added MaxAbrPrt (MAXWEAR) attribute to *Table P.17: Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition*. ➤ Removed TotVA from *Table P.20: Measurement Logical Node Class Definition*. ➤ Added FltRis (FR) and FltDis (FM) to *Table P.22: Fault Locator Logical Node Class Definition*. ➤ Added FltRis and FltDis to *Table P.24: Logical Device: PRO (Protection)*. ➤ Moved SCBR logical node items from *Table P.27: Logical Device: ANN (Annunciation)* to *Table P.24: Logical Device: PRO (Protection)*. ➤ Updated virtual bit reset behavior for footnote b in *Table P.27: Logical Device: ANN (Annunciation)*. ➤ Added RcdMade (FLREP) and FltNum (FLRNUM) attributes to *Table P.24: Logical Device: PRO (Protection)*. ➤ Corrected MAXWEAR Logical Node value in *Table P.24: Logical Device: PRO (Protection)* and *Table P.27: Logical Device: ANN (Annunciation)* for BSASCBR1 logical node. Appendix R ➤ Added new *Appendix R: Fault Location and Supplemental Fault Location and Impedance Data*.

Table A.4 Instruction Manual Revision History (Sheet 5 of 9)

Date Code	Summary of Revisions
20131219	Section 3 ➤ Revised *Figure 3.2: Zone 1 Phase Distance Logic*, *Figure 3.3: Zone 2 Phase Distance Logic*, *Figure 3.4: Zone 3 and Zone 4 Phase Distance Logic*, *Figure 3.5: Zone 1 Mho Ground Distance Logic*, and *Figure 3.8: Zone 1 Quadrilateral Ground Distance Logic* for changes to OOS unblocking logic. ➤ Revised discussion of OOS unblocking logic to include EOOS=Y2 unblocking method. ➤ Added *Figure 3.21: Directional Element Signals 67QUBF and 67QUBR*. ➤ Added *Table 3.11: Differences Between EOOS = Y and EOOS = Y2 Settings and Unblocking*. ➤ Added *Table 3.13: OOS Blocking and Unblocking of Distance Elements (EOOS=Y2)*. Section 9, Settings Sheets ➤ Updated Settings Sheets for Group settings classes. Appendix A ➤ Updated for firmware version R506. Appendix D ➤ Updated for Relay Word bits 67QUBF and 67QUBR. Appendix N ➤ Added *Table N.24: Time Quality Decoding*.
20130620	Appendix A ➤ Updated for firmware version R505.
20130403	Section 13 ➤ Removed A/D Failure corrective action note in *Table 13.3: Relay Self-Tests*. Appendix A ➤ Updated firmware version R503 summary of revisions (see *Table A.1*). Appendix P ➤ Corrected DmdA.nseq and PkDmdA.nseq Attribute Type to be MV in *Table P.16: Demand Metering Logical Node Class Definition*. ➤ Modified *Table P.16: Demand Metering Logical Node Class Definition–Table P.18: Circuit Breaker Supervision Logical Node Class Definition* and *Table P.20: Measurement Logical Node Class Definition–Table P.23: Circuit Breaker Logical Node Class Definition* formats to match IEC 61850 standard.
20130304	Appendix A ➤ Updated for firmware version R504.
20121203	Preface ➤ Updated descriptions of *Section 5: Trip and Target Logic* and *Section 7: Inputs, Outputs, and Other Control Logic*. Section 1 ➤ Added discussion of new models. ➤ Revised *Time-Code Inputs* for new fiber-optic serial port option. ➤ Added current metering accuracy specifications for low currents. ➤ Added specifications for fiber-optic serial port option. ➤ Added specifications for breaker failure element. ➤ Added frequency element operating time specification. ➤ Revised synchrophasor accuracy criteria. ➤ Increased energy metering resolution.

Table A.4 Instruction Manual Revision History (Sheet 6 of 9)

Date Code	Summary of Revisions
	Section 2 ➤ Revised rear-panel views in *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* and *Figure 2.7: SEL-311C Front and Rear-Panel Drawings; 3U Horizontal Rack-Mount With Optional USB Port, Optional SafeLock Trip/Close Pushbuttons, Optional Extra I/O Board With 4 Standard Outputs and 16 Inputs, and Optional Dual Copper/Fiber-Optic Ethernet With Fiber-Optic Serial Port* for new communications and extra I/O board options. ➤ Revised *Making Rear-Panel Connections* for new extra I/O board option. ➤ Revised *Making Communications Connections* for new fiber-optic serial port option. ➤ Revised *Figure 2.22: Jumper, Connector, and Major Component Locations on the SEL-311C Main Board* to show factory use for JMP1C and JMP1D. ➤ Revised F*igure 2.21: Jumper, Connector, and Major Component Locations on the SEL-311C Extra I/O Board With 12 Standard or High-Current Interrupting Outputs (Extra I/O Board Options 2 or 6)* through *Figure 2.23: Jumper, Connector, and Major Component Locations on the SEL-311C Extra I/O Board With Eight Fast, High-Current Interrupting Outputs (Extra I/O Board Option 5)* for new extra I/O board option. ➤ Revised *"Extra Alarm" Output Contact Control Jumper* for programmable ALARM functionality. Section 3 ➤ Revised *Phase Distance Elements* and *Ground Distance Elements* to add discussion of subcycle distance elements. ➤ Added discussion and revised distance element logic diagrams for single-pole open directional logic. ➤ Updated *Figure 3.11: SEL-311C Phase Mho Element Operating Times, Standard Outputs (Three-Phase Faults)* through *Figure 3.17: SEL-311C Ground Quadrilateral Element Operating Times, Standard Outputs (Single-Phase-to-Ground Faults)*. ➤ Added *Testing Synchronism-Check Elements*. ➤ Added sidebar note to *Table 3.21: Synchronism-Check Elements Settings and Settings Ranges*. ➤ Added description of purpose and operation of Relay Word bit 27B81. ➤ Changed *Table 3.23: Frequency Elements Settings and Settings Ranges* footnote to a margin note. ➤ Revised *Additional Distance Element Supervision* for ringdown detection. ➤ Revised discussion in *Zone 1 Extension* to explain the purpose of Zone 1 extension. ➤ Corrected typographical error in *Figure 3.19: Independent Phase and Ground Zone 1 Extension Logic*. ➤ Added discussion of settings to defeat out-of-step blocking during faults in *OSB Settings Descriptions and Logic Diagrams* and *Out-of-Step Blocking of Distance Elements*. ➤ Revised *Voltage Element Settings* to explain the impact of single-pole open conditions on positive-sequence voltage for 59V1 element. Section 4 ➤ Revised *Figure 4.2: Overall LOP Logic Diagram*, *Figure 4.4: LOP2 Logic Processing Overview (Relay Word Bit LOP2)*, and *Figure 4.5: LOP Latch Logic (Relay Word Bit LOP3)* to show SPO influence on loss-of-potential logic. ➤ Added *Setting Guidelines for ORDER and Negative-Sequence Impedance Directional Thresholds*. Section 5 ➤ Added discussion of MIRRORRED BITS protocol security counter settings in Trip Setting DTA, DTB, DTC. ➤ Revised *Permissive Overreaching Transfer Trip (POTT) Logic* for new Z3RB reset logic. ➤ Added *Breaker Failure Protection*. Section 7 ➤ Updated *Optoisolated Inputs* and *Output Contacts* for new extra I/O board option. ➤ Added remote bits RB17–RB32. ➤ Added programmable ALARM functionality, including new Relay Word bits and the SALARM and ALRMOUT SELOGIC control equations. Section 8 ➤ Added *Mechanical and Electrical Operate Timers and Alarms* and revised **BRE** commands. ➤ Added references to IEC 61850 for various analog quantities.

Table A.4 Instruction Manual Revision History (Sheet 7 of 9)

Date Code	Summary of Revisions
	Section 9 ➤ Added Relay Word bit SETCHG to *Settings Change Confirmation.* ➤ Added **\<ENTER** keystrokes to *Table 9.3: SET Command Editing Keystrokes*. ➤ Updated *Coordinated Universal Time (UTC) Offset Setting* and *Automatic Daylight-Saving Time Settings* in *Settings Explanations*. Section 9, Settings Sheets ➤ Updated Settings Sheets for Global, Group, Logic, and Port settings classes. Section 10 ➤ Revised for new communications and I/O board options and additional Relay Word bits. ➤ Added *Ethernet Port Speed*. ➤ Updated *Limit Maximum Access Level or Disable Any Rear Port* to include new MAXACC = 0 setting. ➤ Revised *Figure 10.4: Web Server Login Screen*, *Figure 10.5: Web Server Home Page and Response to System, Device Features Selection*, and *Figure 10.6: Web Server Show Settings Screen* for revised Web server format. ➤ Clarified **GOO** command syntax and response data fields. ➤ Added *File Transfer Protocol (FTP) and MMS File Transfer*. ➤ Revised **BRE** and **BRE W** commands to include mechanical and electrical operate timers and station battery voltage. ➤ Revised **COM** command to clarify treatment of errors. ➤ Revised **CON** command for addition of RB17–RB32. ➤ Added **BRE H** command. ➤ Added **ETH C** command and additional **ETH** command data. ➤ Updated **GOO S** command. ➤ Revised **MET E** command for increased resolution. ➤ Updated **FILE** command description to include explanations of file types CFG.TXT, ERR.TXT, and SWCFG.ZIP. ➤ Added **TIME Q** and **TIME DST** commands. ➤ Updated **SHO** command for new default settings ➤ Updated *Command Summary*. Section 12 ➤ Added *Retrieving Event Reports Via Ethernet File Transfer*. ➤ Added NDEM in *Table 12.4: Output, Input, Protection, and Control Element Event Report Columns* and *Figure 12.5: Example Standard 15-Cycle Event Report 1/4-Cycle Resolution*. ➤ Revised *Output, Input, Protection and Control, and Communication Columns* for new extra I/O board option. ➤ Updated *Sequential Events Recorder (SER) Report* to include discussion of ALARM, HALARM, HALARML, SETCHG, and GRPSW under *SER Triggering*. ➤ Added Relay Group Changed message to *Table 12.5: Automatic SER Triggers*. Section 13 ➤ Updated *Relay Self-Tests* to include Relay Word bits for programmable alarm operation. Appendix A ➤ Updated for firmware version R503. Appendix B ➤ Added *Upgrading to Digitally Signed Firmware Files*. Appendix C ➤ Updated *Table C.1: SEL Software Solutions* and *Table C.3 ACSELERATOR QuickSet Submenu Options*. ➤ Updated ACSELERATOR QuickSet settings to include design templates. Appendix D ➤ Updated *Table D.1: Relay Word Bit Mapping* and *Table D.2: Alphabetical List of Relay Word Bits* for new firmware features.

Table A.4 Instruction Manual Revision History (Sheet 8 of 9)

Date Code	Summary of Revisions
	Appendix E ➤ Added new analog quantities for mechanical and electrical operate timers and alarms in *Table E.1: SEL-311C Analog Quantities*. ➤ Added relay information analog quantities for DNP3, Modbus, and IEC 61850. ➤ Added a footnote to *Table E.1: SEL-311C Analog Quantities* to clarify how various quantities are reported when fault location is undefined. Appendix F ➤ Updated *Maximum Total Number of Elements, Rising-Edge, and Falling-Edge Operators*. ➤ Updated *Table F.5: Processing Order of Relay Elements and Logic (Top to Bottom)* and *Table F.6: Asynchronous Processing Order of Relay Elements*. Appendix H ➤ Clarified relationship between security counters and IEC 60834-1. Appendix J ➤ Updated for additional Relay Word rows and Remote Bits. Appendix L ➤ Revised Qualifier Codes for Object 21 in *Table L.9: SEL-311C DNP Object List*. ➤ Revised notes in *Table L:10 DNP3 Reference Data Map*. ➤ Added SINGEVE and clarified scaling for various quantities in *Table L.10: DNP3 Reference Data Map*. ➤ Corrected DNP Device Profile points lists to eliminate unused points. ➤ Updated *Binary Outputs* to reflect new behavior. ➤ Added *Counter Inputs*. ➤ Updated *Reading Relay Event Data* subsection, including operation of new Global setting EVEMODE and Port settings RPEVTYP, MAXDIST, and MINDIST. Appendix N ➤ Revised PMSTN setting to allow mixed case. ➤ Added Channel Name column in *Table N.3: Synchrophasor Order in Data Stream (Voltages and Currents)*. ➤ Added *Table N.6: C37.118 Data Frame*. ➤ Added description of holdover mode and **TIME Q** command to *Configuring High-Accuracy Timekeeping*. ➤ Revised *Configuring High-Accuracy Timekeeping* for new fiber-optic serial port option and for change in parity checking. Appendix O ➤ Added output coils for new Remote Bits RB17–RB32. ➤ Added a footnote to *Table O.14: 01h, 05h SEL-311C Output Coils* and revised accompanying text. ➤ Added function codes and scaling for various quantities in *Table O.22: Modbus Quantities Table*. Appendix P ➤ Added more IEC 61850 detail to *Datasets* and *Reports* sections. ➤ Removed 'Quality Bit Strings' Data Type from *Table P.11: Score For Data Types Contained in Published Messages* because transmit quality counting as 0 points. ➤ Corrected score example in *Message Point Value Calculation Example* section. ➤ Added more IEC 61850 detail to the *Settings* subsection under *IEC 61850 Configuration*. ➤ Added new SCBR logical node and other logical node extensions (*Table P.15: New Logical Node Extensions, Table P.17: Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition* through *Table P.23: Circuit Breaker Logical Node Class Definition*). ➤ Updated logical node tables and notes (*Table P.25:Logical Device: MET (Metering)* through *Table P.28: Logical Device: CFG (Configuration)*).
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.

Table A.4 Instruction Manual Revision History (Sheet 9 of 9)

Date Code	Summary of Revisions
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.

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Appendix B

Firmware Upgrade Instructions for SEL-311C Relays With Ethernet

Overview

⚠CAUTION
Do not install firmware with a lower revision number than the current version. Changing the firmware from R503 or higher to R502 or lower will cause the relay to lose calibration.

From time to time, SEL issues firmware upgrades for this relay. The instructions that follow explain how you can install new firmware in your SEL-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-311C-1 to an SEL-311C-2), contact SEL for assistance.

This appendix contains the following sections:

Upgrading to Digitally Signed Firmware Files

NOTE: These instructions are for upgrading a relay with digitally signed firmware files (.zds file name extension). Proceed to Relay Firmware Upgrade Methods on page B.3 if upgrading to firmware with .s19 file name extension.

This device supports digitally signed firmware upgrades for firmware version R503 and higher. These firmware upgrade files are compressed to reduce file transfer times and digitally signed by SEL using a secure hash algorithm. The signature ensures that the file has been provided by SEL and that its contents have not been altered. Once uploaded to the relay, the signature of the firmware is verified with a public key number that is stored on the relay. If the relay cannot verify the signature, it rejects the file.

The name of the digitally signed firmware file is of the form R*xxx*311C.zds, where R*xxx* is the firmware revision number, 311C indicates the relay type, and .zds is the file extension reserved for digitally-signed files. Firmware files with the .s19 extension are not available for firmware version R503 and higher.

NOTE: Relays with SELBOOT (BFID) version R200 or later only support firmware versions with .zds extensions. Firmware versions with .s19 extensions are not supported.

If you are upgrading a relay from relay firmware version R502 or earlier, follow the *Special Instructions for Upgrading from Firmware Version R502 or Earlier on page B.2*. Otherwise, continue with *Relay Firmware Upgrade Methods on page B.3*.

Special Instructions for Upgrading from Firmware Version R502 or Earlier

The SELBOOT firmware loader in relays shipped with firmware R502 and earlier must be upgraded before digitally signed firmware files can be used. The process for upgrading SELBOOT is similar to Firmware Upgrade Method Two.

To determine if SELBOOT must be updated, do the following:

Step 1. Establish communication between the relay and a personal computer, as described in *C. Establish Communications With the Relay on page B.10*.

Step 2. From the computer, type **ID <Enter>**.

The relay responds with the following:

```
"FID=SEL-311C-1-Rxxx-V0-Zxxxxxx-Dxxxxxxxx","xxxx"
"BFID=SLBT-3CF1-R102-V0-Zxxxxxx-Dxxxxxxx","xxxxx"
"CID=xxx","xxxx"
"DEVID=xxxxxxx","xxxx"
"DEVCODE=xx","xxxx"
"PARTNO=xxxxxxxxxxxxxxx","xxxx"
"SERIALNO=xxxxxxxxxx","xxxx"
"CONFIG=xxxxxxxx","xxxx"
"SPECIAL=xxxxx","xxxx"
```

Step 3. Locate the Boot Firmware Identification String (BFID).

Step 4. Find the SELBOOT revision number in the BFID (R*xxx*). If the revision number is R102 or earlier, the SELBOOT must be upgraded. If the revision number is R200 or later, follow the instructions under *Relay Firmware Upgrade Methods on page B.3*.

Step 5. To upgrade SELBOOT, contact SEL customer service for the SELBOOT file (R*xxx*3cfl.s19). Follow the instructions under *Method Two: Using a Terminal Emulator on page B.9*. At *G. Upload New Firmware on page B.17*, *Step 1*, replace the **REC** command with **REC BOOT** and follow the prompts.

Step 6. When the relay prompts:

```
Press any key to begin transfer and then start transfer at the terminal.
```

press **<Enter>** and use *Step 4 on page B.16* to select the SELBOOT file.

Step 7. When the SELBOOT upgrade is successful, the relay prompts:

```
Erasing SELboot.
Writing SELboot.
SELboot upload completed successfully.
Restarting SELboot.
!>
```

Step 8. Type **EXI <Enter>** at the SELBOOT !> prompt to exit SELBOOT. The relay should display the = prompt.

Step 9. If the relay does not return to the SELBOOT !> prompt within two minutes after displaying `Restarting SELboot`, cycle the relay power. The relay should restart and display the = prompt.

Once the SELBOOT upgrade is complete, select a firmware upgrade method as discussed in *Relay Firmware Upgrade Methods*. To use Method One, go to *D. Prepare the Relay (Save Relay Settings and Other Data) on page B.5*. To use Method Two, go to *E. Start SELBOOT on page B.16*. It is not necessary to save the relay settings and other data again if you did this before upgrading SELBOOT.

Relay Firmware Upgrade Methods

Introduction

These firmware upgrade instructions apply to SEL-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 three 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 by using the steps documented in *Method Two: Using a Terminal Emulator on page B.9*.
- ➤ Method Three: Establish an Ethernet connection and use a web browser to access the embedded web server. Upgrade the firmware by using the steps documented in *Method Three: Using a Web Browser on page B.21*. This is the fastest method to complete an upgrade.

The same basic actions are required when using any of these methods:

A. Obtain Firmware File

B. Remove Relay From Service

C. Establish Communications With the Relay

D. Prepare the Relay (Save Relay 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 Relay to Service

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- ➤ Personal computer
- ➤ To use Method One, QuickSet

- ➤ To use Method Two, terminal emulation software that supports 1K Xmodem or Xmodem (these instructions use HyperTerminal from a Microsoft Windows operating system)
- ➤ To use Method Three, a CAT5 Ethernet cable with RJ45 connectors, such as SEL cable SEL-C627, can be used. See *Section 10: Communications* for detailed instructions.
- ➤ Serial communications cable (SEL Cable SEL-C234A, SEL-C662 USB-to-232 converter, or equivalent) or USB cable (SEL-C664 or equivalent)
- ➤ Firmware Upgrade Instructions (these instructions)
- ➤ Your relay instruction manual

Method One: Using QuickSet Firmware Loader

To use the QuickSet Firmware Loader, you must have 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

NOTE: Firmware versions R502 and earlier have the .s19 file name extension.

Contact SEL customer service for the firmware file. The file name will be of the form R*xxx*311C.zds, where R*xxx* is the firmware revision number, 311C indicates the relay type, and .zds 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.

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.

C. Establish Communications With the Relay

Use the **Communications > Parameters** menu of QuickSet to establish a connection using the communications settings determined in *Step 3* of *B. Remove Relay From Service*. For the USB port, the baud rate does not matter. 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, select the ellipsis button and browse to the location of the firmware file. Select the file and click **Open**. See *Figure B.1*.

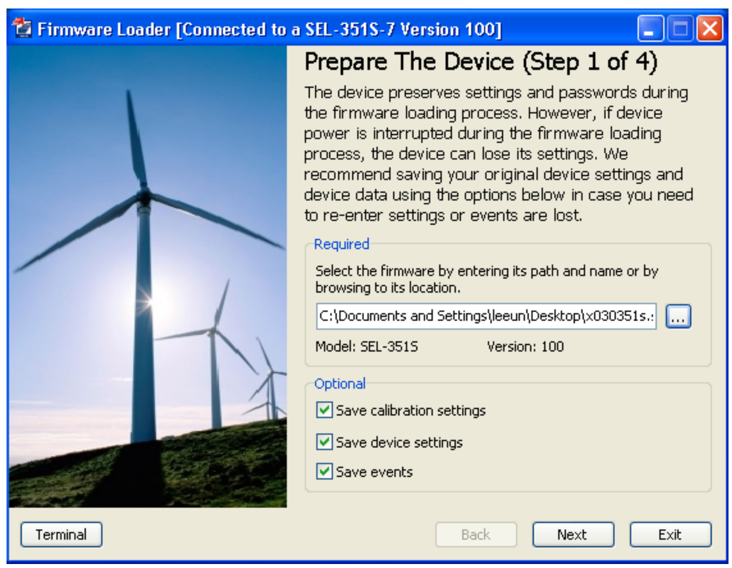


Figure B.1 Prepare the Device (Step 1 of 4)

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.

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.

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 and issue the following commands to save stored data. It is possible for these 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*.

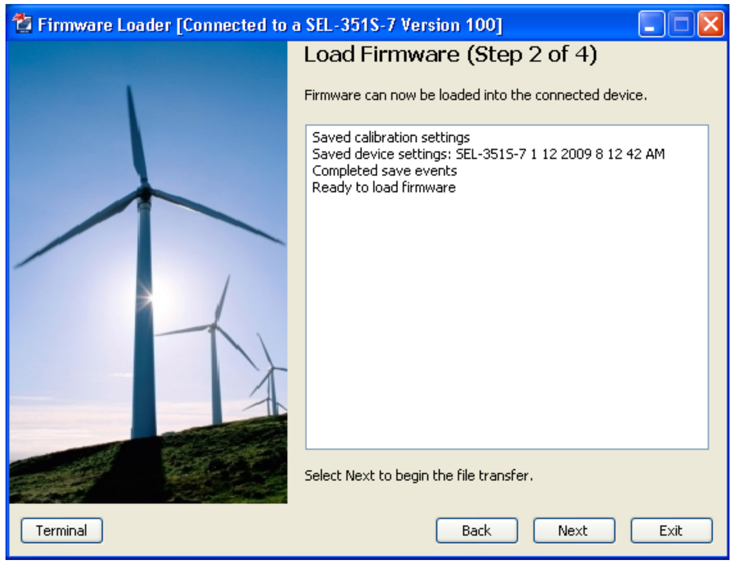


Figure B.2 Load Firmware (Step 2 of 4)

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 an **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 by 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.24*.

Click **Next** to go to the completion step.

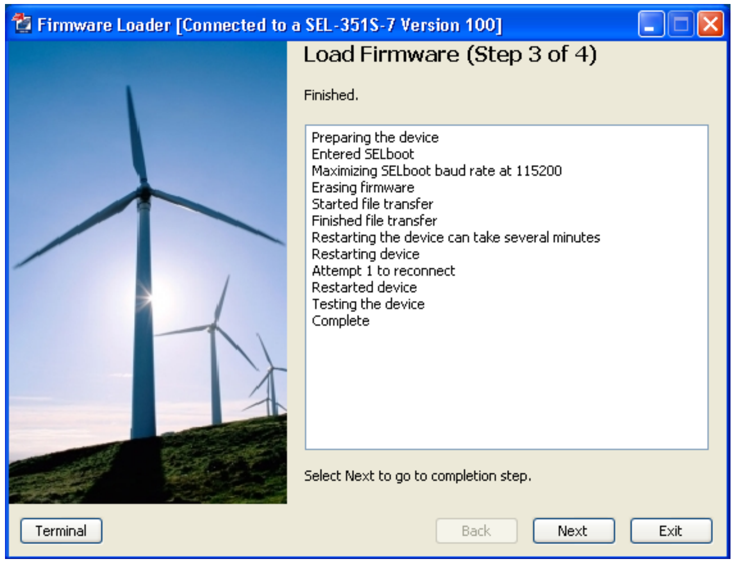


Figure B.3 Load Firmware (Step 3 of 4)

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 by 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 (R*xxx*) 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 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.5*.

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

Step 7. Type **MET <Enter>** or use the 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 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

The instructions for this section use HyperTerminal as a terminal emulator. If HyperTerminal is not used, certain instructions may have to be modified (different menu names used) to execute the step.

A. Obtain Firmware File

NOTE: Firmware versions R502 and earlier have the .s19 file name extension.

NOTE: These instructions can also be used to upgrade the SELBOOT firmware loader. See Upgrading to Digitally Signed Firmware Files on page B.1 to determine if this is necessary.

Contact SEL customer service for the firmware file. The file name will be of the form, for example, R*xxx*311C.zds, where R*xxx* is the firmware revision number, 311C indicates the relay type, and .zds is the standard firmware file name 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.

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.

NOTE: The terminal window of QuickSet can be used to upgrade firmware.

Step 1. From the computer, open HyperTerminal or other terminal emulation software.

On a personal computer running Windows, you would typically click **Start > Programs > Accessories > Communications**.

Step 2. Enter a name, select any icon, and click **OK** (*Figure B.5*).

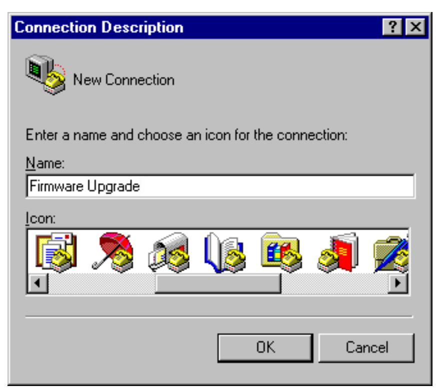


Figure B.5 Establishing a Connection

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.

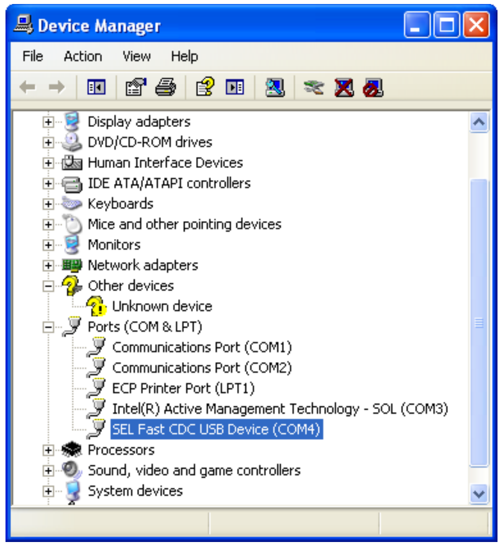


Figure B.6 Inspect Available COM Ports

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.9*.

b. Click **OK**.

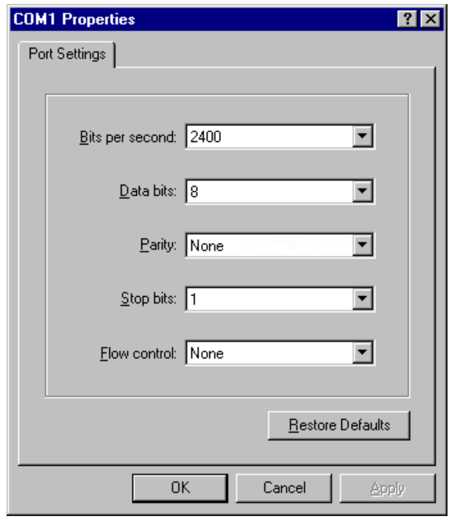


Figure B.8 Determining Communications Parameters for the Computer

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**.

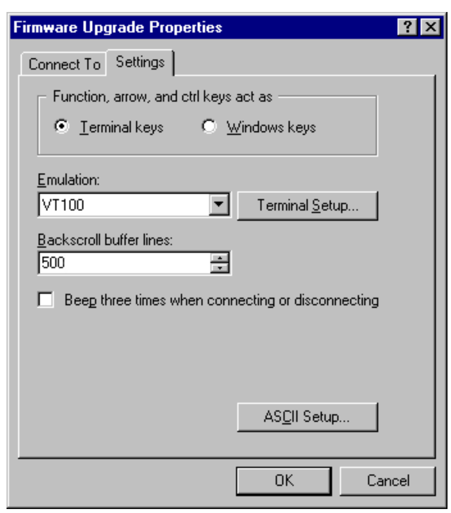


Figure B.9 Setting Terminal Emulation

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.14*.

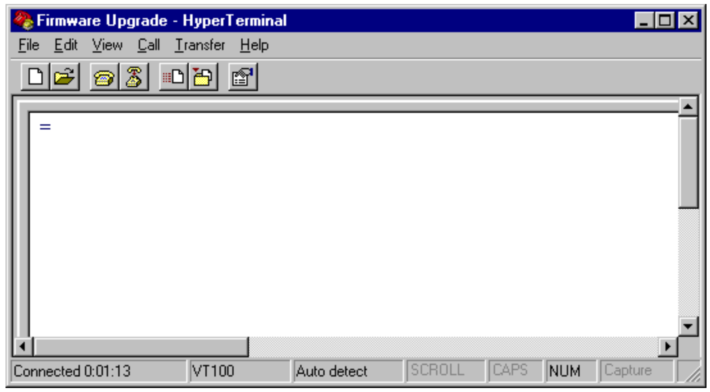


Figure B.10 Terminal Emulation Startup Prompt

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.

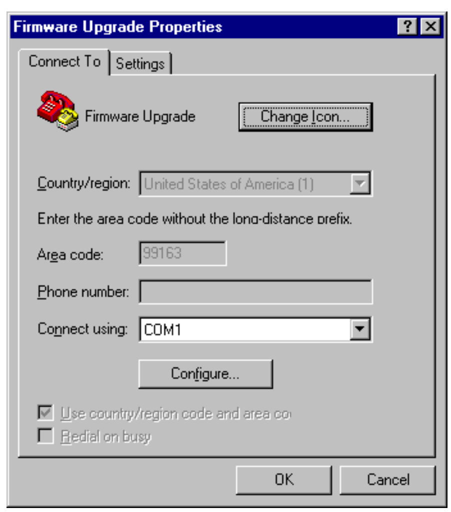


Figure B.11 Correcting the Port Setting

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.9* and click **OK** twice to return to the terminal emulation window.

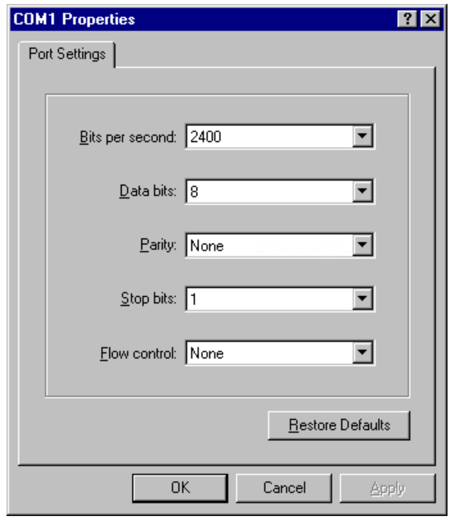


Figure B.12 Correcting the Communications Parameters

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 QuickSet to record the existing relay settings and proceed to *E. Start SELBOOT on page B.16*. 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 these 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**.

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.9*.

E. Start SELBOOT

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 `SELboot`. 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.17.

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.

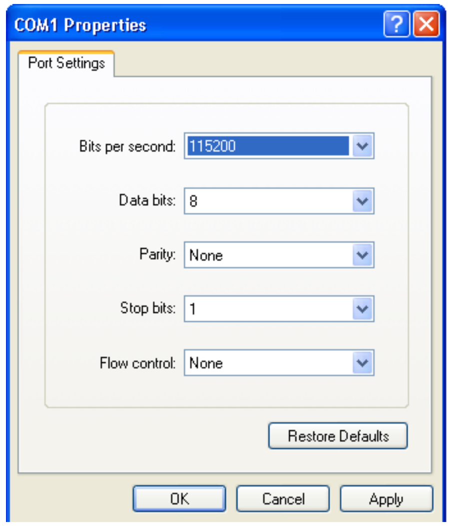


Figure B.14 Matching Computer to Relay Parameters

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 firmware.

If you erase the firmware then new firmware
must be loaded before returning the IED to service
Are you sure you want to erase the existing firmware (Y/N)?
```

NOTE: When upgrading SELBOOT, type **REC BOOT <Enter>** at the SELBOOT prompt !>in Step 1 to command the relay to receive new SELBOOT firmware.

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.

The relay responds with the following:

```
Erasing firmware.

Erase successful
Press any key to begin transfer then start transfer at the terminal <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*).

NOTE: If you are using the QuickSet terminal window to upgrade firmware, right-click in the terminal window, select **Send File, Xmodem**, and browse to select the new firmware file.

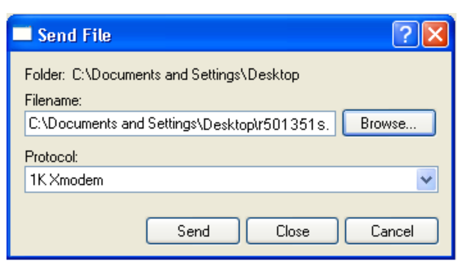


Figure B.15 Selecting New Firmware to Send to the Relay

NOTE: When upgrading SELBOOT, select the SELBOOT filename in Step b.

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. Once turned on, 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.10 to increase the serial connection data speed. Then resume the firmware upgrade process at G. Upload New Firmware on page B.17.

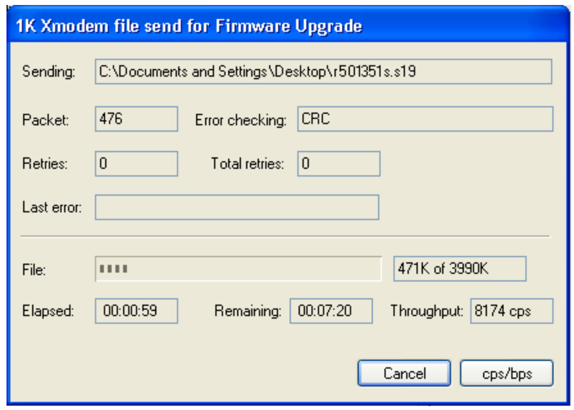


Figure B.16 Transferring New Firmware to the Relay

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.17.

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. In this situation, refer to *Solving Firmware Upgrade Issues on page B.24*

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.20*.

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.9*).	Change the computer terminal speed to match the relay data transmission rate you recorded in *B. Remove Relay From Service on page B.9*. 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.9*. 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.16*). 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.17*) 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.10*. 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.20*.

If failures are displayed in the status message, proceed to *Solving Firmware Upgrade Issues on page B.24*.

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.15*).

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 (R*xxx*) 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.5*.

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.

Method Three: Using a Web Browser

A. Set Port 5 Setting HTTPACC to 2

To upgrade firmware by using the Web Browser, the Port 5 setting HTTPACC must be set to 2. If this setting is set to 2, the FWFPC setting becomes available. FWFPC determines whether front-panel confirmation is required for firmware upgrades and defaults to Y. If FWFPC is set to N, the firmware upgrade process takes place without the need for front-panel confirmation. See *F. Upload New Firmware on page B.22* for details on the front-panel confirmation process.

B. Obtain Firmware File

Follow instructions under *A. Obtain Firmware File on page B.4*.

C. 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. Establish an Ethernet connection to the device. See *Section 10: Communications* for more detailed instructions.

D. Establish Communications With the Relay

Establish communication between your personal computer and the relay by using a web browser. See *Section 10: Communications* for more information. Establish a Telnet session with HyperTerminal (or an equivalent) using the TCP/IP connection, with the Host address and Port number set to match the Port 5 settings IPADDR (e.g., 192.168.1.2) and TPORT (e.g. 23), respectively.

E. Prepare the Relay (Save Relay Settings and Other Data)

Using the Telnet session, follow *D. Prepare the Relay (Save Relay Settings and Other Data) on page B.14*.

F. Upload New Firmware

NOTE: Access Level passwords are not encrypted in any way by the Web Server when logging in.

Step 1. To upload new firmware, log in to Access Level 2 of the web server. Select **2AC** from the Access Level drop-down box. Enter the respective **ACC** and **2AC** passwords and click the **Login** button.

Step 2. Once logged in, verify communication with the correct relay by checking the Relay Identifier (RID setting) and Terminal Identifier (TID setting). Choose **System > Firmware Upgrade** from the left pane, which brings up the page shown in *Figure B.17*. This page also displays feedback from the previous firmware upgrades. If the prior firmware upgrade was successful, the page displays `Previous firmware upgrade successful. Date: mm/dd/yy Time: hh:mm:ss`. If the prior firmware upgrade failed, the page displays `Previous firmware upgrade failed. Date: mm/dd/yy Time: hh:mm:ss`, with an error message below. See *Solving Firmware Upgrade Issues on page B.24* for possible error messages and their descriptions. If no prior firmware upgrade has occurred (which is the case for a new unit from the factory), the page displays the message shown in *Figure B.17*.

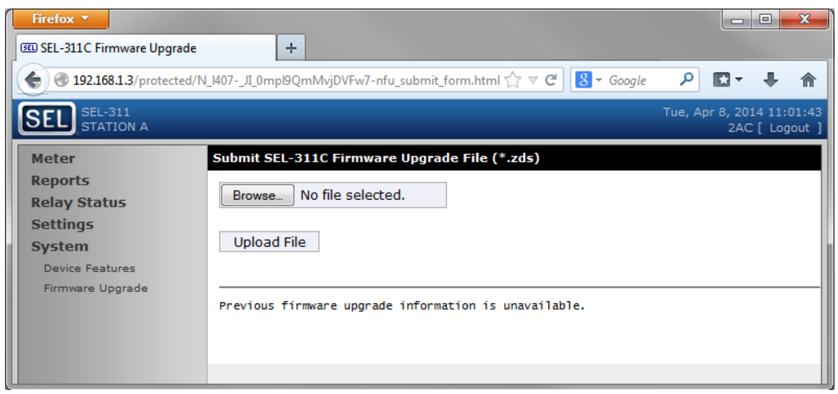


Figure B.17 Firmware Upload File Selection Page

Step 3. To search for your firmware file, click on the **Browse** button. The format of this file must be .zds.

Step 4. To submit, click **Upload File**. Once the upload has started, it cannot be canceled. During the upload process the relay remains enabled and continues normal operation.

Step 5. Once the firmware file is transferred to the device, the relay attempts to restart using the new firmware. This process completes in as few as 45 seconds.

Step 6. If front-panel confirmation is enabled (setting FWFPC = Y) and the file upload is complete, the Web Server displays the message shown in *Figure B.18* and the following message is displayed on the relay's LCD:

```
CONFIRM UPGRADE?
SELECT=Y; EXIT=N
```

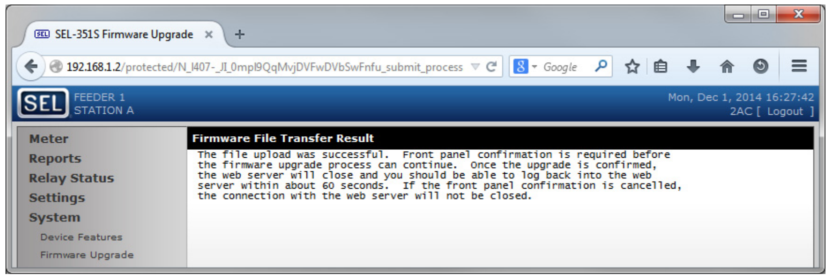


Figure B.18 Firmware Upgrade With Front-Panel Confirmation Required

a. Press the **SELECT** button to confirm the firmware upgrade. Once front-panel confirmation is given, the HTTP session closes and the firmware upgrade takes place.

b. If front-panel confirmation is not given within 60 seconds, the message shown in *Figure B.19* is displayed by the Web Server at the Firmware Upgrade page. The HTTP session remains open and the firmware upgrade does not take place.

c. The relay remains enabled and in normal operation until the upgrade is confirmed via the front panel. If confirmation times out, the relay stays enabled and continues normal operation.

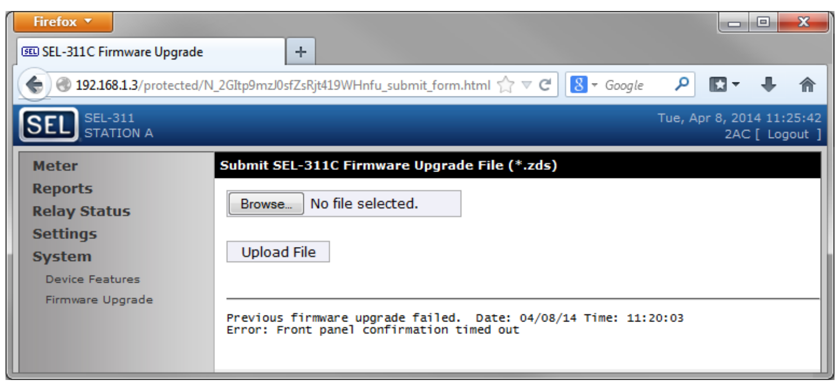


Figure B.19 Front-Panel Confirmation Time Out Message

Step 7. If front-panel confirmation is not enabled (FWFPC = N), the message shown in *Figure B.20* is displayed by the Web Server. The HTTP session closes after the upload is complete and the firmware upgrade takes place.

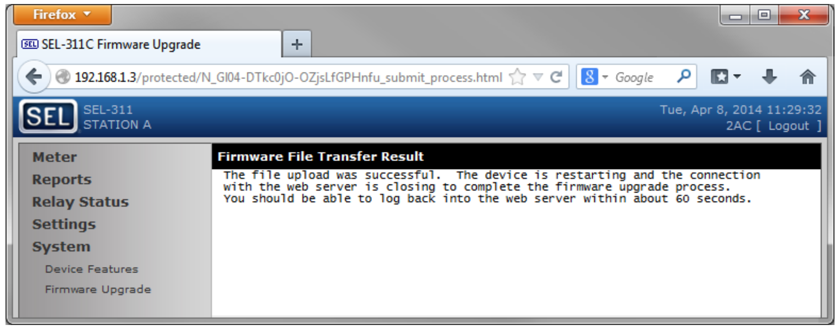


Figure B.20 Firmware Upgrade Without Front-Panel Confirmation Required

G. Check Relay Self-Tests

After the firmware upgrade is completed and once you have logged back into Access Level 1 of the Web Server, you can check the relay self-tests by clicking on **Relay Status > Self-Test** in the left pane. If the relay displays no fail status message, proceed to *I. Verify Relay Settings on page B.20*. If failures are displayed in the status message, proceed to *Solving Firmware Upgrade Issues on page B.24*.

H. Verify Relay Settings

To verify the settings are correct for your relay, choose **Show Settings** in the left pane. Verify that these match the settings saved earlier (see *Backup Relay Settings and Other Data on page B.15*). Note that Calibration settings are not viewable via the Web Server, a terminal connection is needed to verify these settings. If the settings do not match, reenter the settings saved earlier.

I. Return Relay to Service

Step 1. Begin a Telnet session by opening the terminal window. Type **telnet IPADDR**, where IPADDR is the Port 5 setting IPADDR (e.g., 192.168.1.2).

Step 2. Follow *Step 2 on page B.20–Step 10 on page B.21* under *J. Return the Relay to Service on page B.20*.

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.8*.

If there are no fail messages and you are using Method Two, go to *I. Verify Relay Settings on page B.20*.

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.5*, 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.14*, 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 the SEL-5010 or QuickSet, restore the original settings by following the instructions for the respective software.

b. If you do not have the SEL-5010 or 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.

If the firmware upgrade process fails, the firmware upgrade page of the web server displays one of the error messages in *Table B.2*.

Table B.2 Error Messages

Error Message	Description
Invalid digital signature	The digital signature verification failed.
Invalid firmware file	The firmware file failed one of many possible integrity checks.
Front-panel confirmation canceled	The user canceled the front-panel confirmation process.
Front-panel confirmation timed out	The user did not confirm or cancel the firmware upgrade process before the time-out period expired.

Appendix C
PC Software

Overview

NOTE: PC software is updated more frequently than relay firmware. As a result, the descriptions in this section may differ slightly from the software. Select **Help** in the PC software for information.

SEL provides many PC software solutions (applications) that support SEL devices. These software solutions are listed in *Table C.1*.

Visit selinc.com to obtain the latest versions of the software 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	QuickSet is a powerful setting, event analysis, and measurement tool that aids in applying and using the relay. See *ACSELERATOR QuickSet SEL-5030 Software Instruction Manual* for information about the various QuickSet applications.[a]
ACSELERATOR Architect SEL-5032 Software	Use this application to design and commission SEL IEDs in IEC 61850 substations, create and map GOOSE messages, use predefined reports, create and edit data sets, 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. See *ACSELERATOR Team SEL-5045 Software Instruction Manual* for information about the various TEAM applications.
SEL-5601-2 SYNCHROWAVE Event Software	Converts SEL Compressed ASCII and COMTRADE event report files to oscillography.
Cable Selector SEL-5801 Software	Selects the proper SEL cables for your application.

[a] The SEL-311C does not support the freeform logic described in the QuickSet instruction manual.

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 10.74*).

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) and Single-Pole Open Directional Logic (see Section 3)								
23	32SPOF	32SPOR	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	*	*	*	*	*
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	67QUBF	67QUBR	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)								
44[b,c,d]	OUT201	OUT202	OUT203	OUT204	OUT205	OUT206	OUT207	OUT208
45[b,c]	OUT209	OUT210	OUT211	OUT212	*	*	*	*
Extra I/O Board Optoisolated Inputs (see Section 7)								
46[c,d]	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 *Table D.3*)								
56	*	*	*	*	*	*	*	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[e]	LINK5A[f]	LINK5B[f]	LNKFAIL	P5ASEL[f]	P5BSEL[f]	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	RST_HAL	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	*	*	*	*
Extra I/O Board Optoisolated Inputs (see Section 7)								
66[d]	IN216	IN215	IN214	IN213	IN212	IN211	IN210	IN209
67	*	*	*	*	*	*	*	*
Single- and Three-Pole Tripping Elements (see Section 5)								
68	3PS	APS	BPS	CPS	SPO	SPOA	SPOB	SPOC
69	27AWI	27BWI	27CWI	*	*	*	TRPRM	COMPRM
70	DTA	DTB	DTC	ATPA	ATPB	ATPC	A3PT	RXPRM
71	ULTRA	ULTRB	ULTRC	TPA	TPB	TPC	SPT	3PT
Breaker Status (see Section 5)								
72	52AA	52AB	52AC	E3PT	50LA	50LB	50LC	TOP
Trip/Target Logic (see Section 5) and Out-of-Step (see Section 3)								
73	DTR	*	OSBC	OSBB	OSBA	*	*	BKMTR
Operator Control Pushbuttons and LEDs (see Section 11)								
74[g]	PB1PUL	PB2PUL	PB3PUL	PB4PUL	PB5PUL	PB6PUL	PB7PUL	PB8PUL
75[g]	LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
76[g]	LED9	*	LED10	*	*	*	PB10PUL	PB9PUL
DNP Event Register Reset Equation (see Appendix L)								
77	*	*	*	*	*	*	*	RSTDNPE
Target Logic Outputs (see Section 5)								
78[h]	LTRIP	LTIME	LCOMM	LSOTF	LZONE1	LZONE2	LZONE3	LZONE4
79[h]	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[i]	VB001	VB002	VB003	VB004	VB005	VB006	VB007	VB008
85[i]	VB009	VB010	VB011	VB012	VB013	VB014	VB015	VB016
86[i]	VB017	VB018	VB019	VB020	VB021	VB022	VB023	VB024
87[i]	VB025	VB026	VB027	VB028	VB029	VB030	VB031	VB032
88[i]	VB033	VB034	VB035	VB036	VB037	VB038	VB039	VB040
89[i]	VB041	VB042	VB043	VB044	VB045	VB046	VB047	VB048
90[i]	VB049	VB050	VB051	VB052	VB053	VB054	VB055	VB056
91[i]	VB057	VB058	VB059	VB060	VB061	VB062	VB063	VB064
92[i]	VB065	VB066	VB067	VB068	VB069	VB070	VB071	VB072
93[i]	VB073	VB074	VB075	VB076	VB077	VB078	VB079	VB080
94[i]	VB081	VB082	VB083	VB084	VB085	VB086	VB087	VB088
95[i]	VB089	VB090	VB091	VB092	VB093	VB094	VB095	VB096
96[i]	VB097	VB098	VB099	VB100	VB101	VB102	VB103	VB104
97[i]	VB105	VB106	VB107	VB108	VB109	VB110	VB111	VB112
98[i]	VB113	VB114	VB115	VB116	VB117	VB118	VB119	VB120
99[i]	VB121	VB122	VB123	VB124	VB125	VB126	VB127	VB128
Alarm and Security Bits (see Section 7, Section 13, and Appendix Q)								
100	SALARM	ACCESS	ALRMOUT	*	HALARMA	HALARMP	HALARML	HALARM
101	*	*	PASNVAL	ACCESSP	GRPSW	SETCHG	CHGPASS	BADPASS
Remote Bits (see Section 7)								
102	RB17	RB18	RB19	RB20	RB21	RB22	RB23	RB24
103	RB25	RB26	RB27	RB28	RB29	RB30	RB31	RB32
Breaker Failure Elements (see Section 5)								
104	*	*	*	BFTA	BFTB	BFTC	BFT	BFTRIP
105	50BFA	50BFB	50BFC	50BFT	RTA	RTB	RTC	RT
High-Speed Distance Elements (see Section 3)								
106[j]	CVTBLH	VPOLVH	MAB1H	MBC1H	MCA1H	MAG1H	MBG1H	MCG1H
107[j]	*	*	MAB2H	MBC2H	MCA2H	MAG2H	MBG2H	MCG2H
108[j]	*	*	MAB3H	MBC3H	MCA3H	MAG3H	MBG3H	MCG3H
Mechanical and Electrical Breaker Operate Timer Alarms (see Section 8)								
109	ESTRA	ESTRB	ESTRC	ESCLA	ESCLB	ESCLC	ESOAL	MSOAL
110	*	MSTRA	MSTRB	MSTRC	*	MSCLA	MSCLB	MSCLC

[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 7.33 for details.
[c] OUT201–OUT212 and IN201–IN208 are available when extra I/O board Option 2 or 6 is present. OUT201–OUT208 and IN201–IN208 are available when extra I/O board Option 5 is present.
[d] OUT201–OUT204 and IN201–IN216 are available when extra I/O board Option 4 is present.
[e] LINK5 is replaced by "*" when dual Ethernet connectors are present.
[f] Relay Word bits (for Ethernet ports) are replaced by "*" when a single Ethernet connector is present.
[g] Relay Word bits for Operator Control pushbuttons and LEDs are replaced by "*" when not supported by the relay.
[h] Relay Word Bits For Programmable Targets are replaced by "*" when not supported by the relay.
[i] Virtual bits VB001–VB128 are only present in relays ordered with IEC 61850 protocol.
[j] SEL-311C-3 only. High-speed distance Relay Word bits are for indication only. Do not use in trip logic.

Table D.2 Alphabetic List of Relay Word Bits (Sheet 1 of 12)

Name	Description	Usage	Row (Table D.1)
25A1, 25A2	Synchronism-check elements 1 and 2 (see *Figure 3.39*)	Control	30
27A	A-phase instantaneous undervoltage element (A-phase voltage below pickup setting 27P; see *Figure 3.35*)	Control	42
27AB	AB-phase-to-phase instantaneous undervoltage element (AB-phase-to-phase voltage below pickup setting 27PP; see *Figure 3.36*)	Control	43
27AWI	Weak infeed A-phase undervoltage condition (see *Figure 5.9*)	Testing	69
27B	B-phase instantaneous undervoltage element (B-phase voltage below pickup setting 27P; see *Figure 3.35*)	Control	42
27B81	Undervoltage element for frequency element blocking (voltage below pickup setting 27B81P; see *Figure 3.44*)	Testing	52
27BC	BC-phase-to-phase instantaneous undervoltage element (BC-phase-to-phase voltage below pickup setting 27PP; see *Figure 3.36*)	Control	43
27BWI	Weak infeed B-phase undervoltage condition (see *Figure 5.9*)	Testing	69
27C	C-phase instantaneous undervoltage element (C-phase voltage below pickup setting 27P; see *Figure 3.35*)	Control	42
27CA	CA-phase-to-phase instantaneous undervoltage element (CA-phase-to-phase voltage below pickup setting 27PP; see *Figure 3.36*)	Control	43
27CWI	Weak infeed C-phase undervoltage condition (see *Figure 5.9*)	Testing	69
27S	Channel VS instantaneous undervoltage element (channel VS voltage below pickup setting 27SP; see *Figure 3.39*)	Control	29
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
32SPOF	Forward open-pole directional declaration (see *Section 3*)	Indication	23
32SPOR	Reverse open-pole directional declaration (see *Section 3*)	Indication	23
32VE	Internal enable for zero-sequence voltage-polarized directional element (see *Figure 4.14*)	Testing	21
3P27	= 27A1 * 27B1 * 27C1 (see *Figure 3.35*)	Control	42
3P59	= 59A1 * 59B1 * 59C1 (see *Figure 3.35*)	Control	42
3PO	Three pole open condition (see *Figure 5.5*)	Testing	19
3PS	Trip logic three phase selected (see *Figure 5.1*)	Indication	68
3PT	Three-pole trip condition (see *Figure 5.1*)	Trip output contact assignment	71
50A	= 50A1 + 50A2 + 50A3 + 50A4 (see *Figure 3.27*)	Tripping, Control	55

Table D.2 Alphabetic List of Relay Word Bits (Sheet 2 of 12)

Name	Description	Usage	Row (Table D.1)
50A1–50A4	Level 1 through Level 4 A-phase instantaneous overcurrent elements (see *Figure 3.25*)	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 3.27*)	Tripping, Control	55
50B1–50B4	Level 1 through Level 4 B-phase instantaneous overcurrent elements (see *Figure 3.25*)	Tripping, Control	54, 55
50BFA	A-phase breaker failure current threshold exceeded (see *Figure 5.20*)	Indication	105
50BFB	B-phase breaker failure current threshold exceeded (see *Figure 5.20*)	Indication	105
50BFC	C-phase breaker failure current threshold exceeded (see *Figure 5.20*)	Indication	105
50BFT	Any phase breaker failure current threshold exceeded (see *Figure 5.20*)	Tripping, Control	105
50C	= 50C1 + 50C2 + 50C3 + 50C4 (see *Figure 3.27*)	Tripping, Control	55
50C1–50C4	Level 1 through Level 4 C-phase instantaneous overcurrent elements (see *Figure 3.25*)	Tripping, Control	54, 55
50G1–50G4	Level 1 through Level 4 residual-ground instantaneous overcurrent elements (see *Figure 3.30*)	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 5.5*)	Testing	19
50LA	Phase instantaneous overcurrent element for closed breaker detection (A-phase current above pickup setting 50LP; see *Figure 5.5*)	Testing	72
50LB	Phase instantaneous overcurrent element for closed breaker detection (B-phase current above pickup setting 50LP; see *Figure 5.5*)	Testing	72
50LC	Phase instantaneous overcurrent element for closed breaker detection (C-phase current above pickup setting 50LP; see *Figure 5.5*)	Testing	72
50P1–50P4	Level 1 through Level 4 phase instantaneous overcurrent elements (see *Figure 3.25*)	Tripping, Testing, Control	3, 26, 57
50Q1–50Q4	Level 1 through Level 4 negative-sequence instantaneous overcurrent elements (see *Figure 3.31*)	Testing Control	37, 38
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 3.33*)	Testing, Control	4
51GR	Residual-ground time-overcurrent element 51GT reset (see *Figure 3.33*)	Testing	4
51GT	Residual-ground time-overcurrent element 51GT timed out (see *Figure 3.33*)	Tripping	4
51P	Maximum phase current above pickup setting 51PP for phase time-overcurrent element 51PT (see *Figure 3.32*)	Testing, Control	28
51PR	Phase time-overcurrent element 51PT reset (see *Figure 3.32*)	Testing	28
51PT	Phase time-overcurrent element 51PT timed out (see *Figure 3.32*)	Tripping	28
51Q	Negative-sequence current above pickup setting 51QP for negative-sequence time-overcurrent element 51QT (see *Figure 3.34*)	Testing, Control	39
51QR	Negative-sequence time-overcurrent element 51QT reset (see *Figure 3.34*)	Testing	39
51QT	Negative-sequence time-overcurrent element 51QT timed out (see *Figure 3.34*)	Tripping	39

Table D.2 Alphabetic List of Relay Word Bits (Sheet 3 of 12)

Name	Description	Usage	Row (Table D.1)
52A	Circuit breaker status (asserts to logical 1 when circuit breaker is closed; see *Breaker Status Logic on page 6.2*)	Indication	19
52AA	A-phase circuit breaker status (asserts to logical 1 when A-phase circuit breaker is closed; see *Breaker Status Logic on page 6.2*)	Indication	72
52AB	B-phase circuit breaker status (asserts to logical 1 when B-phase circuit breaker is closed; see *Breaker Status Logic on page 6.2*)	Indication	72
52AC	C-phase circuit breaker status (asserts to logical 1 when C-phase circuit breaker is closed; see *Breaker Status Logic on page 6.2*)	Indication	72
59A	A-phase instantaneous overvoltage element (A-phase voltage above pickup setting 59P; see *Figure 3.35*)	Control	42
59AB	AB-phase-to-phase instantaneous overvoltage element (AB-phase-to-phase voltage above pickup setting 59PP; see *Figure 3.36*)	Control	43
59B	B-phase instantaneous overvoltage element (B-phase voltage above pickup setting 59P; see *Figure 3.35*)	Control	42
59BC	BC-phase-to-phase instantaneous overvoltage element (BC-phase-to-phase voltage above pickup setting 59PP; see *Figure 3.36*)	Control	43
59C	C-phase instantaneous overvoltage element (C-phase voltage above pickup setting 59P; see *Figure 3.35*)	Control	42
59CA	CA-phase-to-phase instantaneous overvoltage element (CA-phase-to-phase voltage above pickup setting 59PP; see *Figure 3.36*)	Control	43
59N1	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N1P; see *Figure 3.36*)	Control	37
59N2	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N2P; see *Figure 3.36*)	Control	37
59Q	Negative-sequence instantaneous overvoltage element (negative-sequence voltage above pickup setting 59QP; see *Figure 3.36*)	Control	38
59S	Channel VS instantaneous overvoltage element (channel VS voltage above pickup setting 59SP; see *Figure 3.37*)	Control	29
59V1	Positive-sequence instantaneous overvoltage element (positive-sequence voltage above pickup setting 59V1P; see *Figure 3.36*)	Control	38
59VA	Channel VA voltage window element (channel VA voltage between threshold settings 25VLO and 25VHI; see *Figure 3.38*)	Testing	28
59VP	Phase voltage window element (selected phase voltage [VP] between threshold settings 25VLO and 25VHI; see *Figure 3.38*)	Testing	29
59VS	Channel VS voltage window element (channel VS voltage between threshold settings 25VLO and 25VHI; see *Figure 3.38*)	Testing	29
67G1–67G4	Level 1 through Level 4 residual-ground instantaneous overcurrent elements with directional control option (derived from 50G1–50G4; see *Figure 3.30*)	Tripping, Testing, Control	3, 27, 36
67G1T–67G4T	Level 1 through Level 4 residual-ground definite-time overcurrent elements (derived from 67G1–67G4; see *Figure 3.30*)	Tripping	3, 27, 36
67P1–67P4	Level 1 through Level 4 phase instantaneous overcurrent elements with torque control (derived from 50P1–50P4; see *Figure 3.26*)	Tripping, Testing, Control	3, 26, 57
67P1T–67P4T	Level 1 through Level 4 phase definite-time overcurrent elements (derived from 67P1–67P4; see *Figure 3.26*)	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 3.31*)	Testing, Control	37, 38
67Q1T–67Q4T	Level 1 through Level 4 negative-sequence definite-time overcurrent elements (derived from 67Q1–67Q4; see *Figure 3.31*)	Tripping	37, 38

Table D.2 Alphabetic List of Relay Word Bits (Sheet 4 of 12)

Name	Description	Usage	Row (Table D.1)
67QG2S	Negative-sequence and residual directional overcurrent short delay element (see *Figure 5.17*)	Tripping in DCB logic	39
67QUBF	Negative-sequence forward directional element	Indication	39
67QUBR	Negative-sequence reverse directional element	Indication	39
79CY	Reclosing relay in the Reclose Cycle State (see *Figure 6.9*)	Control	31
79LO	Reclosing relay in the Lockout State (see *Figure 6.9*)	Control	31
79RS	Reclosing relay in the Reset State (see *Figure 6.9*)	Control	31
81D1–81D6	Level 1 through Level 6 instantaneous frequency elements (see *Figure 3.45*)	Testing	52
81D1T–81D6T	Level 1 through Level 6 definite-time frequency elements (derived from 81D1–81D6; see *Figure 3.45*)	Tripping, Control	53
A3PT	Assert three-phase trip (see *Figure 5.1*)	Testing	70
ACCESS	Asserted while any user is logged in at Access Level B or higher	Indication	100
ACCESSP	Pulses for approximately one second when any user increases to Access Level B or higher	Indication	101
ALARM	ALARM condition (ALRMOUT deasserted, **PULSE ALARM**, or **PULSE ALRMOUT** command executed; see *Figure 7.28*)	Indication	24
APS	Trip logic A-phase selected (see *Figure 5.1*)	Testing	68
ATPA	Assert A-phase trip (see *Figure 5.1*)	Testing	70
ATPB	Assert B-phase trip (see *Figure 5.1*)	Testing	70
ATPC	Assert C-phase trip (see *Figure 5.1*)	Testing	70
ALRMOUT	ALARM output contact coil energized (see *Figure 7.28*)	Indication	100
BADPASS	Pulses for approximately one second whenever a user enters three successive bad passwords in an SEL ASCII terminal session or web session (see *Access Level Attempt (Password Required) on page 10.35*)	Indication	101
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
BKMTR	Breaker manual trip (see *Figure 5.1*)	Indication	73
BPS	Trip logic B-phase selected (see *Figure 5.1*)	Testing	68
BFT	Circuit breaker failure (see *Figure 5.21*)	Tripping, Control	104
BFTA	Circuit breaker failure. A-phase	Tripping, Control	104
BFTB	Circuit breaker failure. B-phase	Tripping, Control	104
BFTC	Circuit breaker failure. C-phase	Tripping, Control	104
BFTRIP	Circuit breaker failure trip (see *Figure 5.22*)	Tripping, Control	104
BTX	Block trip input extension (see *Figure 5.17*)	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 6.6*)	Testing, Control	18
CF	Close Failure condition (asserts for 1/4 cycle; see *Figure 6.5*)	Indication	19

Table D.2 Alphabetic List of Relay Word Bits (Sheet 5 of 12)

Name	Description	Usage	Row (Table D.1)
CLOSE	Close logic output asserted (see *Figure 6.5*)	Output contact assignment	19
COMPRM	Communications-assisted trip permission (see *Figure 5.1*)	Testing, Indication	69
CPS	Trip logic C-phase selected (see *Figure 5.1*)	Testing	68
CVTBL	CCVT transient blocking logic active (see *Figure 4.9*)	Indication	15
CVTBLH[a]	Half-cycle CCVT transient blocking logic active	Indication	106
DCHI	Station dc battery instantaneous overvoltage element (see *Figure 8.11*)	Indication	16
DCLO	Station dc battery instantaneous undervoltage element (see *Figure 8.11*)	Indication	16
DD	Disturbance Detector (see *Figure 4.2*)	Indication	59
DST	Daylight-saving time active (see *Configuring High-Accuracy Timekeeping on page N.26*).	Indication	61
DSTP	Daylight-saving time change pending. Asserts approximately one minute before daylight-saving time change (see *Configuring High-Accuracy Timekeeping on page N.26*).	Indication	61
DSTRT	Directional carrier start (see *Figure 5.17*)	Testing	40
DTA	A-phase direct trip asserted (see *Figure 5.1*)	Indication	70
DTB	B-phase direct trip asserted (see *Figure 5.1*)	Indication	70
DTC	C-phase direct trip asserted (see *Figure 5.1*)	Indication	70
DTR	Direct trip received (see *Figure 5.1*)	Testing, Indication	73
E3PT	Three-pole trip enabled (see *Figure 5.1*)	Indication	72
ECTT	Echo conversion to trip condition (see *Figure 5.9*)	Testing	40
EKEY	Echo key (see *Figure 5.9*)	Testing	40
ESCLA	Circuit breaker electrical close operating time alarm, A-phase (see *Electrical Operate Time on page 8.9*)	Indication	109
ESCLB	Circuit breaker electrical close operating time alarm, B-phase (see *Electrical Operate Time on page 8.9*)	Indication	109
ESCLC	Circuit breaker electrical close operating time alarm, C-phase (see *Electrical Operate Time on page 8.9*)	Indication	109
ESOAL	Circuit breaker electrical operating time alarm (see *Electrical Operate Time on page 8.9*)	Indication	109
ESTRA	Circuit breaker electrical trip operating time alarm, A-phase (see *Electrical Operate Time on page 8.9*)	Indication	109
ESTRB	Circuit breaker electrical trip operating time alarm, B-phase (see *Electrical Operate Time on page 8.9*)	Indication	109
ESTRC	Circuit breaker electrical trip operating time alarm, C-phase (see *Electrical Operate Time on page 8.9*)	Indication	109
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

Table D.2 Alphabetic List of Relay Word Bits (Sheet 6 of 12)

Name	Description	Usage	Row (Table D.1)
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.18*.	Indication, Testing	57
FSA, FSB, FSC	Fault identification logic outputs used in targeting (see *Additional Distance Element Supervision on page 3.18*)	Control	17
GDEM	Residual-ground demand current above pickup setting GDEMP (see *Figure 8.15*)	Indication	20
GRPSW	Pulses for approximately one second whenever groups are switched	Indication	101
HALARM	Indicates a hardware diagnostic failure or warning (see *Relay Self-Tests on page 13.6*)	Indication	100
HALARMA	Pulses for five seconds per minute until reset when a hardware diagnostic warning occurs (see *Relay Self-Tests on page 13.6*)	Indication	100
HALARML	Latches for relay hardware diagnostic failures (see *Relay Self-Tests on page 13.6*)	Indication	100
HALARMP	Pulses for five seconds when a hardware warning diagnostic condition occurs (see *Relay Self-Tests on page 13.6*)	Indication	100
IAMET	Channel IA high-gain mode active. See *Analog Scaling and Frequency Indicators on page D.18*.	Event Report	62
IBMET	Channel IB high-gain mode active. See *Analog Scaling and Frequency Indicators on page D.18*.	Event Report	62
ICMET	Channel IC high-gain mode active. See *Analog Scaling and Frequency Indicators on page D.18*.	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
IN209–IN216	Optoisolated inputs IN209 through IN216, asserted (see *Figure 7.2*)	Status sensing or control via optoisolated inputs (only operable if extra I/O board Option 4 installed)	66
INMET	Channel IN high-gain mode active. See *Analog Scaling and Frequency Indicators on page D.18*.	Event Report	62
KEY	Key permissive trip signal start (see *Figure 5.9*)	Testing	40
L51	Time-overcurrent trip target bit (see *Table 5.8*)	Event Targeting	79
LB1–LB16	Local Bits 1 through 16 asserted (see *Figure 7.4*)	Control via front panel—replacing traditional panel-mounted control switches	5, 6

Table D.2 Alphabetic List of Relay Word Bits (Sheet 7 of 12)

Name	Description	Usage	Row (Table D.1)
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 5.8*)	Event Targeting	78
LED1–LED10	Operator control pushbutton LEDs 1 through 10. Driven by associated SELOGIC control equation 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.26*).	Indication	61
LPSECP	Leap Second Pending. Asserts approximately one minute prior to leap second insertion (see *Configuring High-Accuracy Timekeeping on page N.26*).	Indication	61
LSOTF	Switch-onto-fault trip target bit (see *Table 5.8*)	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 5.8*)	Event Targeting	78
LTRIP	Trip target bit (see *Table 5.8*)	Event Targeting	78
LV1–LV32	Logic Variables 1 through 32. Logic variables follow the states of SELOGIC control equation 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 5.8*)	Event Targeting	78
LZONE2	Fault in Zone 2 / Level 2 target bit (see *Table 5.8*)	Event Targeting	78
LZONE3	Fault in Zone 3 / Level 3 target bit (see *Table 5.8*)	Event Targeting	78
LZONE4	Fault in Zone 4 / Level 4 target bit (see *Table 5.8*)	Event Targeting	78
M1P–M4P	Zone 1 through Zone 4 phase-distance instantaneous elements (see *Figure 3.2–Figure 3.4*)	Tripping, Control	2, 25
M1PT–M4PT	Zone 1 through Zone 4 phase-distance time delayed elements (see *Figure 3.20*)	Tripping, Control	2, 25
M2PSEQT	Zone 2 phase-distance, sequential trip, time delayed element (see *Figure 3.20*)	Tripping, Control	58
MAB1–MAB4	Zone 1 through Zone 4 mho AB phase-distance instantaneous elements (see *Figure 3.2–Figure 3.4*)	Testing	15, 28, 32

Table D.2 Alphabetic List of Relay Word Bits (Sheet 8 of 12)

Name	Description	Usage	Row (Table D.1)
MAB1H–MAB3H[a,b]	Zone 1 through Zone 3 high-speed mho AB-phase distance elements (see *Figure 3.4–Figure 3.6*)	Testing, Indication	106, 107, 108
MAG1–MAG4	Zone 1 through Zone 4 mho ground-distance A-phase instantaneous elements (see *Figure 3.5–Figure 3.7*)	Testing	16, 29, 32
MAG1H–MAG3H[a,b]	Zone 1 through Zone 3 high-speed mho ground A-phase instantaneous elements (see *Figure 3.7–Figure 3.9*)	Testing, Indication	106, 107, 108
MBC1–MBC4	Zone 1 through Zone 4 mho BC-phase distance instantaneous elements (see *Figure 3.2–Figure 3.4*)	Testing	15, 28, 32
MBC1H–MBC3H[a,b]	Zone 1 through Zone 3 high-speed mho BC-phase distance elements (see *Figure 3.4–Figure 3.6*)	Testing, Indication	106, 107, 108
MBG1–MBG4	Zone 1 through Zone 4 mho ground-distance B-phase instantaneous elements (see *Figure 3.5–Figure 3.7*)	Testing	16, 29, 32
MBG1H–MBG3H[a,b]	Zone 1 through Zone 3 high-speed mho ground B-phase distance instantaneous (see *Figure 3.7–Figure 3.9*)	Testing, Indication	106, 107, 108
MCA1–MCA4	Zone 1 through Zone 4 mho CA-phase distance instantaneous elements (see *Figure 3.2–Figure 3.4*)	Testing	15, 28, 32
MCA1H–MCA3H[a,b]	Zone 1 through Zone 3 high-speed mho CA-phase distance elements (see *Figure 3.4–Figure 3.6*)	Testing, Indication	106, 107, 108
MCG1–MCG4	Zone 1 through Zone 4 mho ground-distance C-phase instantaneous elements (see *Figure 3.5–Figure 3.7*)	Testing	16, 29, 32
MCG1H–MCG3H[a,b]	Zone 1 through Zone 3 high-speed mho ground C-phase distance instantaneous (see *Figure 3.7–Figure 3.9*)	Testing, Indication	106, 107, 108
MSCL	Circuit breaker mechanical close operating time alarm (see *Mechanical Operate Time on page 8.8*)	Indication	110
MSOAL	Circuit breaker mechanical operating time alarm (see *Mechanical Operate Time on page 8.8*)	Indication	109
MSTR	Circuit breaker mechanical trip operating time alarm (see *Mechanical Operate Time on page 8.8*)	Indication	110
NDEM	Neutral ground demand current above pickup setting NDEMP (see *Figure 8.15*)	Indication	62
NSTRT	Nondirectional carrier start (see *Figure 5.17*)	Testing	40
OC	Asserts 1/4 cycle for OPEN command execution (see *Factory Settings Example (Using Settings TR, TRQUAL, and BKMTR) on page 5.14*)	Testing, Control	18
OPTMN	Open interval timer is timing (see *Reclosing Relay on page 6.16*)	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
OSBA	A-phase elements selected for out-of-step blocking during single-pole open conditions (see *Figure 3.24*)	Testing	73
OSBB	B-phase elements selected for out-of-step blocking during single-pole open conditions (see *Figure 3.24*)	Testing	73
OSBC	C-phase elements selected for out-of-step blocking during single-pole open conditions (see *Figure 3.24*)	Testing	73
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

Table D.2 Alphabetic List of Relay Word Bits (Sheet 9 of 12)

Name	Description	Usage	Row (Table D.1)
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 8.15*)	Indication	20
PMDOK	Phasor measurement data OK (see *Synchrophasor Relay Word Bits on page N.17*)	Synchrophasors	30
PMTRIG	Phasor Measurement Unit SELOGIC control equation trigger (see *Synchrophasor Relay Word Bits on page N.17*). Sent with C37.118 synchrophasor message.	Indication, Synchrophasors	64
PT	Permissive trip signal to POTT logic (see *Figure 5.8*)	Testing	41
PTRX	Permissive trip signal to Trip logic (see *Figure 5.10*)	Testing	41
PTRX1, PTRX2	Permissive trip signals 1 or 2 from DCUB logic (see *Figure 5.13*)	Testing	41
QDEM	Negative-sequence demand current above pickup setting QDEMP (see *Figure 8.15*)	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–RB32	Remote Bits 1 through 32, asserted (see *Figure 7.10*)	Control via serial port	7, 8, 102, 103
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 6.6*)	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

Table D.2 Alphabetic List of Relay Word Bits (Sheet 10 of 12)

Name	Description	Usage	Row (Table D.1)
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_HAL	Reset hardware alarm SELOGIC control equation asserted.	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 6.16*).	Testing	30
RSTDNPE	Reset DNP relay event registers (see *Reading Relay Event Data on page L.35*).	Indication, Control	77
RSTTRGT	Reset Target SELOGIC control equation (see *SELOGIC Control Equation Setting RSTTRGT on page 5.57*). The relay resets the front-panel target LEDs when a rising edge is detected on RSTTRGT.	Indication, Control	63
RXPRM	Trip permission received (see *Figure 5.1*)	Testing, Indication	70
RT	Breaker failure retrip (see *Figure 5.21*).	Tripping, Control	105
RTA	Breaker failure retrip, A-phase	Tripping, Control	105
RTB	Breaker failure retrip, B-phase	Tripping, Control	105
RTC	Breaker failure retrip, C-phase	Tripping, Control	105
SALARM	Indicates software or user activity (see *ALARM Output Contact on page 7.33*).	Indication	100
SETCHG	Pulses for approximately one second when settings are changed (see *ALARM Output Contact on page 7.33*).	Indication	101
SF	Synchronism-check element, slip frequency less than setting 25SF (see *Figure 3.38*)	Testing	30
SFAST	Synchronism-check element, frequency VP > frequency VS (see *Figure 3.38*)	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 5.5*)	Testing	19
SOTFT	Switch-onto-fault trip condition (see *Figure 5.1*)	Testing, Indication	15
SPO	Single-pole open condition (see *Figure 5.6*)	Indication	68
SPOA	A-phase open condition (see *Figure 5.6*)	Indication	68
SPOB	B-phase open condition (see *Figure 5.6*)	Indication	68
SPOC	C-phase open condition (see *Figure 5.6*)	Indication	68
SPT	Single-pole trip asserted (see *Figure 5.1*)	Tripping	71
SSLOW	Synchronism-check element, frequency VP < frequency VS (see *Figure 3.38*)	Special control schemes	64
STOP	Carrier stop (see *Figure 5.17*)	Testing	40

Table D.2 Alphabetic List of Relay Word Bits (Sheet 11 of 12)

Name	Description	Usage	Row (Table D.1)
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.17*)	Synchrophasors	32
TLED11–TLED26	Front-panel target LEDs 11–26 (see *Front-Panel Target LEDs on page 5.47*)	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
TOP	Trip during open pole timer asserted (see *Figure 5.3*)	Indication	72
TPA	A-phase trip (see *Figure 5.1*)	Trip output contact assignment	71
TPB	B-phase trip (see *Figure 5.1*)	Trip output contact assignment	71
TPC	C-phase trip (see *Figure 5.1*)	Trip output contact assignment	71
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 5.56*)	Control	19
TRIP	Trip logic output asserted (see *Figure 5.1*)	Output contact assignment	20
TRPRM	Permission to trip asserted (see *Figure 5.1*)	Indication	69
TSNTPB	Asserted when relay time is based on Simple Network Time Protocol (SNTP) backup server (see *Simple Network Time Protocol (SNTP) on page 10.20*).	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 10.20*).	Indication	60
TSOK	Time synchronization OK (see *Synchrophasor Relay Word Bits on page N.17*)	Synchrophasors	32
UBB	Unblocking block to Trip logic (see *Figure 5.14*)	Testing	41
UBB1, UBB2	Unblocking block 1 and 2 from DCUB logic (see *Figure 5.13*)	Testing	41
UBOSB	Unblock out-of-step blocking (see *Figure 3.22*)	Testing	35
ULTRA	Unlatch A-phase trip (see *Figure 5.2*)	Control	71
ULTRB	Unlatch B-phase trip (see *Figure 5.2*)	Control	71

Table D.2 Alphabetic List of Relay Word Bits (Sheet 12 of 12)

Name	Description	Usage	Row (Table D.1)
ULTRC	Unlatch C-phase trip (see *Figure 5.2*)	Control	71
V0GAIN	3V0 high-gain mode active (see *Analog Scaling and Frequency Indicators on page D.18*)	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
VPOLVH[a]	Half-cycle positive-sequence polarization voltage valid	Testing	106
WFC	Weak-infeed condition (see *Figure 5.9*)	Testing	41
WYE	Wye-connected configuration element (Always asserted)	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 3.8–Figure 3.10*)	Testing	33, 34
XBG1–XBG4	Zone 1 through Zone 4 quadrilateral ground-distance instantaneous B-phase elements (see *Figure 3.8–Figure 3.10*)	Testing	33, 34
XCG1–XCG4	Zone 1 through Zone 4 quadrilateral ground-distance instantaneous C-phase elements (see *Figure 3.8–Figure 3.10*)	Testing	33, 34
Z1GT–Z4GT	Zone 1 through Zone 4 ground-distance time delayed elements (see *Figure 3.20*)	Tripping, Control	2, 25
Z1G–Z4G	Zone 1 through Zone 4 mho and/or quadrilateral, instantaneous ground-distance elements (see *Figure 3.5–Figure 3.7*)	Tripping, Control	2, 25
Z1T–Z4T	Zone 1 through Zone 4 phase- and/or ground-distance elements timed out (see *Figure 3.20*)	Tripping, Control	3, 26
Z1X	Zone 1 extension element picked up (see *Figure 3.18* and *Figure 3.19*)	Indication	28
Z1XG	Zone 1 ground extension element picked up (see *Figure 3.18* and *Figure 3.19*)	Indication	59
Z1XP	Zone 1 phase extension element picked up (see *Figure 3.18* and *Figure 3.19*)	Indication	59
Z2GSEQT	Zone 2 phase- or ground-distance, sequential trip, time delayed element (see *Figure 3.20*)	Tripping, Control	58
Z2PGS	Zone 2 phase and ground short delay element (see *Figure 5.17*)	Testing	39
Z2SEQT	Zone 2 ground-distance, sequential trip, time delayed element (see *Figure 3.20*)	Tripping, Control	58
Z3RB	Zone/level 3 reverse block (see *Figure 5.9*)	Testing	40
Z3XT	Logic output from zone/level 3 extension timer (see *Figure 5.17*)	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

[a] SEL-311C-3 only.
[b] High-speed distance Relay Word bits are for testing and indication only. Do not use in trip logic.

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, ringdown detection logic is not asserted, and the rate-of-change of frequency is small.

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 7)

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	x			x
VA, VB, VC	Phase (A, B, C) Voltage Magnitudes	V pri			x	x	
VAFA, VBFA, VCFA	Phase (A, B, C) Voltage Angles	degrees	[b]	x	x	x	x
VS	Channel VS Voltage Magnitude	kV pri	x	x			x
VS	Channel VS Voltage Magnitude	V pri			x	x	
VSFA	Channel VS Voltage Angle	degrees	[b]	x	x	x	x
VAB, VBC, VCA	Phase-to-Phase (AB, BC, CA) Voltage Magnitudes	kV pri	x	x			x
VAB, VBC, VCA	Phase-to-Phase (AB, BC, CA) Voltage Magnitudes	V pri			x		
VABFA, VBCFA, VCAFA	Phase-to-Phase (AB, BC, CA) Voltage Angles	degrees	[b]	x	x		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	Zero-Sequence ($3V_0$) Voltage Magnitude	kV pri	x				
3V0_MAG	Zero-Sequence ($3V_0$) Voltage Magnitude	kV pri		x			x
3V0_MAG	Zero-Sequence ($3V_0$) Voltage Magnitude	V pri			x	[c]	
3V0FA	Zero-Sequence ($3V_0$) Voltage Angle	degrees	[b]	x	x	[c]	x
MWA, MWB, MWC	Phase (A, B, C) Real Power	MW	x	x		[c]	
KWA, KWB, KWC	Phase (A, B, C) Real Power	kW			x		x
MW3	3-phase Real Power	MW	x	x		[c]	
KW3	3-phase Real Power	kW			x		x

Table E.1 SEL-311C Analog Quantities (Sheet 2 of 7)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
MVARA, MVARB, MVARC	Phase (A, B, C) Reactive Power	MVAr	x	x		[c]	
KVARA, KVARB, KVARC	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	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	Phase (A, B, C) Power Factor Leading (1 indicates leading PF)	0 or 1	[d]	x	x		
LDPF3	3-Phase Power Factor Leading (1 indicates leading PF)	0 or 1	[d]	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	Phase (A, B, C) Real Power Demand—IN	MW	x	x		x	
KWADI, KWBDI, KWCDI	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	Phase (A, B, C) Real Power Demand—OUT	MW	x	x		x	
KWADO, KWBDO, KWCDO	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	Phase (A, B, C) Reactive Power Demand—IN	MVAr	x	x		x	
KVRADI, KVRBDI, KVRCDI	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		
MVRADO, MVRBDO, MVRCDO	Phase (A, B, C) Reactive Power Demand—OUT	MVAr	x	x		x	
KVRADO, KVRBDO, KVRCDO	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		

Table E.1 SEL-311C Analog Quantities (Sheet 3 of 7)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
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	Phase (A, B, C) Real Power Peak Demand—IN	MW	x	x		x	
KWAPI, KWBPI, KWCPI	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	Phase (A, B, C) Real Power Peak Demand—OUT	MW	x	x		x	
KWAPO, KWBPO, KWCPO	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	Phase (A, B, C) Reactive Power Peak Demand—IN	MVAr	x	x		x	
KVRAPI, KVRBPI, KVRCPI	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	Phase (A, B, C) Reactive Power Peak Demand—OUT	MVAr	x	x		x	
KVRAPO, KVRBPO, KVRCPO	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		
Energy Metering							
MWHAI, MWHBI, MWHCI	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	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	Phase (A, B, C) Reactive Energy—IN	MVArh	x	x	x		
MVRH3I	3-Phase Reactive Energy—IN	MVArh	x	x	x		x

Table E.1 SEL-311C Analog Quantities (Sheet 4 of 7)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
MVRHAO, MVRHBO, MVRHCO	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				
INTTRA	Internal A-Phase Trip Counter	count	x	x[e]	x		x
INTTRB	Internal B-Phase Trip Counter	count	x	x[e]	x		x
INTTRC	Internal C-Phase Trip Counter	count	x	x[e]	x		x
EXTTRA	External A-Phase Trip Counter	count	x	x[e]	x		
EXTTRB	External B-Phase Trip Counter	count	x	x[e]	x		
EXTTRC	External C-Phase Trip Counter	count	x	x[e]	x		
OPSCTRA	Combined A-Phase Trip Counter = (INTTRA + EXTTRA)	count	x				
OPSCTRB	Combined B-Phase Trip Counter = (INTTRB + EXTTRB)	count	x				
OPSCTRC	Combined C-Phase Trip Counter = (INTTRC + EXTTRC)	count	x				
INTIA, INTIB, INTIC	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		x
MAXWEAR	Greatest wear of WEARA, WEARB, or WEARC	percent	x	x	x		x
EOTTRAAV	Average electrical trip operating time, A-phase	ms		x	x		x
EOTTRBAV	Average electrical trip operating time, B-phase	ms		x	x		x
EOTTRCAV	Average electrical trip operating time, C-phase	ms		x	x		x
EOTCLAAV	Average electrical close operating time, A-phase	ms		x	x		x
EOTCLBAV	Average electrical close operating time, B-phase	ms		x	x		x
EOTCLCAV	Average electrical close operating time, C-phase	ms		x	x		x
MOTTRAAV	Average mechanical trip operating time, A-phase	ms		x	x		x
MOTTRBAV	Average mechanical trip operating time, B-phase	ms		x	x		x
MOTTRCAV	Average mechanical trip operating time, C-phase	ms		x	x		x
MOTCLAAV	Average mechanical close operating time, A-phase	ms		x	x		x

Table E.1 SEL-311C Analog Quantities (Sheet 5 of 7)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
MOTCLBAV	Average mechanical close operating time, B-phase	ms		x	x		x
MOTCLCAV	Average mechanical close operating time, C-phase	ms		x	x		x
EOSALCNT	Electrical operation alarm counter	count		x	x		x
MSOALCNT	Mechanical operation alarm counter	count		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			
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[f]	Fault Type			x			
FTYPE16[f]	Fault Type formatted as a 16-bit signed value			x			
EVE_TYPE[f]	Event Type				x		
FI	Fault Current Maximum of IA, IB, IC	A pri		x	x		x
FIA, FIB, FIC	Fault Current, A, B, or C-phase	A pri		x	x		x
FIN	Fault Current, IN channel	A pri		x	x		x
FIG	Fault Current, Residual Ground (IG = $3I_0$)	A pri		x	x		x
FIQ	Fault Current, Negative-Sequence ($3I_2$)	A pri		x	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	count		x	x		
FUNR	Number of Unread faults	count		x			
FLRNUM	Unique event ID number	unitless					x
FLREP	Event report present (1 when an event report is present and 0 otherwise)						x

Table E.1 SEL-311C Analog Quantities (Sheet 6 of 7)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
Fault Location							
FLOC[g,h]	Fault Location	LL units		x	x		x
FZ[g]	Fault Impedance Magnitude	ohms, sec		x	x		x
FZFA[g]	Fault Impedance Angle	degrees		x	x		x
FR[g]	Fault Resistance	ohms, sec		x	x		x
FM[g]	Distance to fault in per-unit of line length	per unit		x	x		x
Time-Overcurrent Element (TOC) Pickup Settings							
51PP	Pickup for maximum-phase TOC element 51PT	A pri	x[i]	x			
51GP	Pickup for residual-ground (IG = $3I_0$) TOC element 51GT	A pri	x[i]	x			
51QP	Pickup for negative-sequence ($3I_2$) TOC element 51QT	A pri	x[i]	x			
Setting Group, Date, Time, and Internal Temperature							
ACTGRP	Active Settings Group	count		x[j]	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		
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		
Relay Information							
FWREV	Relay Firmware Revision			x	x		x
SNUMBL	Relay Serial Number, lowest four digits			x	x		x

Table E.1 SEL-311C Analog Quantities (Sheet 7 of 7)

Label	Description	Units	Display Points[a]	DNP3	Modbus	Fast Meter	IEC 61850
SNUMBM	Relay Serial Number, middle four digits			x	x		x
SNUMBH	Relay Serial Number, high four digits			x	x		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] 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.
[e] Available in DNP as a counter input.
[f] Refer to Section 12: Standard Event Reports and SER for definitions of FTYPE and EVE_TYPE values.
[g] When fault location is undefined, for IEC 61850, the relay will report –999.9 for FLOC, FZ, FR, and FM, and 0 for FZFA. For DNP, the relay will report –9999 for FLOC, –99990 for FZ, FM, and FR, and 0 for FZFA after default scaling. For Modbus, the relay will report 32767 for FZ, FR, and FM, 65535 for FZ, and 18000 for FZFA.
[h] Fault location is a unitless quantity and depends upon the units used for the relay group setting for line length (LL). IEC 61850 assumes the units for fault location are km.
[i] See Additional Format for Displaying Time-Overcurrent Elements on the Rotating Display on page 7.46 for full display point formatting options.
[j] Available in DNP as both a counter input and analog output.

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.26*). See the *SHO Command (Show/View Settings) on page 10.62* 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 3.32*. Read the text that accompanies *Figure 3.32*.

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 section.

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 3.32*)
51G	Residual-ground current above pickup setting 51GP for residual-ground time-overcurrent element 51GT (see *Figure 3.33*)
OUT103	Output contact OUT103 is set as a breaker failure trip output (see *Output Contacts on page 7.32*)

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.

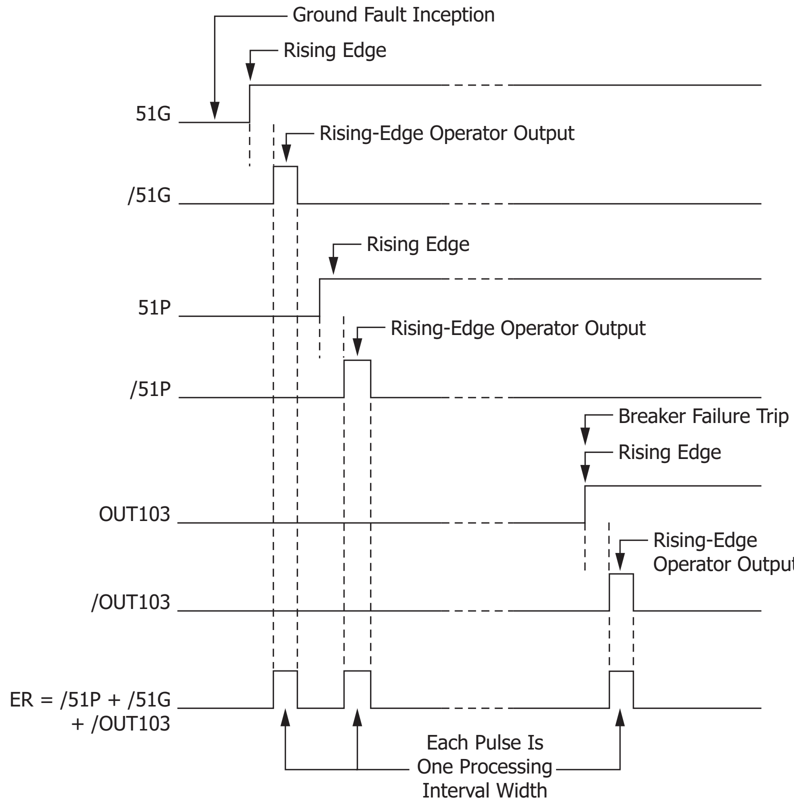


Figure F.1 Result of Rising-Edge Operators on Individual Elements in Setting ER

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 3.45* and *Table 3.25*. *Figure F.2* demonstrates the action of the falling-edge operator \ on the underfrequency element in setting ER.

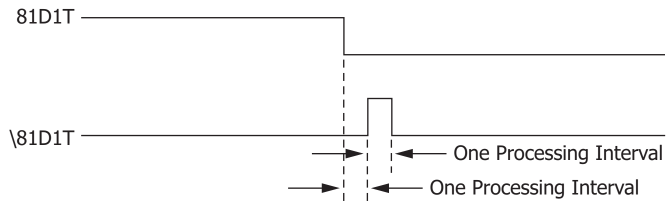


Figure F.2 Result of Falling-Edge Operator on a Deasserting Underfrequency Element

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. There is one SELOGIC control equation circuit breaker status setting for each pole of a single-pole trip breaker. These breaker SELOGIC control equations are 52AA for A-phase, 52AB for B-phase, and 52AC for C-phase. See *Optoisolated Inputs on page 7.1* and *Close Logic on page 6.5* for more information on SELOGIC control equation circuit breaker status settings.

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

The opposite is true for a 52b circuit breaker auxiliary contact. When a circuit breaker pole is closed, the 52b circuit breaker auxiliary contact for that pole is open. When the circuit breaker pole is open, the 52b contact is closed.

If a 52a contact from the A-phase of a single-pole trip breaker is connected to optoisolated input IN101, the SELOGIC control equation circuit breaker status setting for A-phase is set:

52AA = **IN101**

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

52AA = **!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)]:

52AA = **!IN101** = NOT(IN101) = NOT(0) = 1

Thus, the SELOGIC control equation circuit breaker status setting 52AA detects that the A-phase pole of the circuit breaker is closed.

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)]:

52AA = **!IN101** = NOT(IN101) = NOT(1) = 0

Thus, the SELOGIC control equation circuit breaker status setting 52AA detects that the A-phase pole of the circuit breaker is open.

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, TRQUAL, or BKMTR are the only trip settings needed. Refer to *Trip Logic on page 5.1*.

Note that *Figure 5.1* appears quite complex. But because 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 the logical OR gate that generates Relay Word bit TRPRM in *Figure 5.1* are SELOGIC control equation trip settings TR, TRQUAL, and BKMTR. 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 * SH0**

TRQUAL = **0**

TRCOMM = **0** (not used—set directly to logical 0)

TRSOTF = **0** (not used—set directly to logical 0)

BKMTR = **0** (not used in this discussion) ULTR = **!(50L + 51G)** (discussed in preceding section)

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 3.25*), 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 7.32*):

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 10.62*, 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.26*) 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 10.62*.

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 3.30* 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

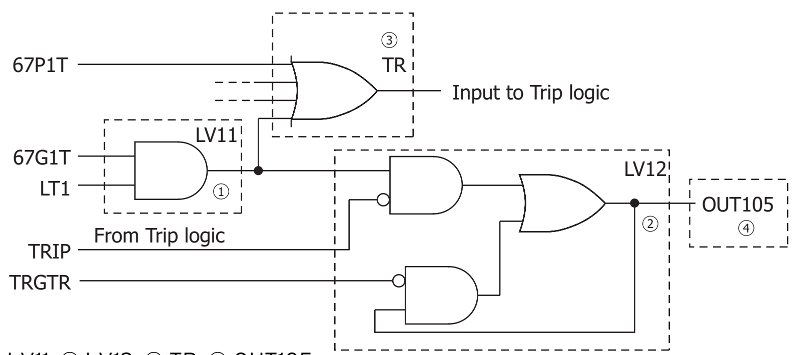
TR = other trip settings + 67P1T + LV11

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 control 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.

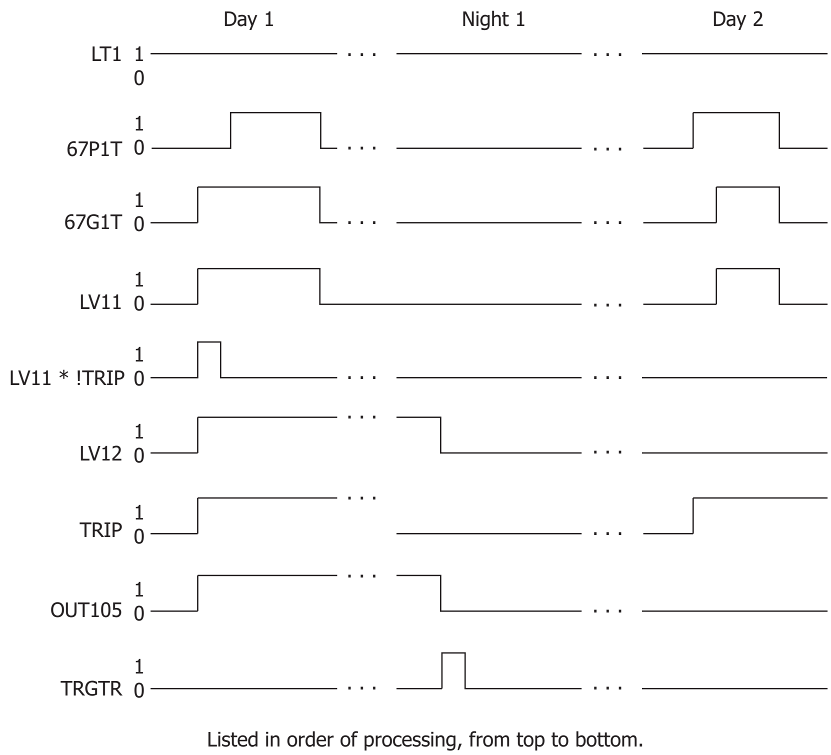


Figure F.4 Timing Diagram of LV12 Seal-In Example

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 turned on, 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.

Time-Line 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 SELOGIC Control 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.

Consider the case where a Relay Word bit listed later 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 control 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 7.27*.

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).

Note in *Table F.4* that the Logic Variables (SELOGIC control equation settings LV1–LV32) are processed prior to the trip equation. When power is lost to the relay, Logic Variables are reset to logical 0 (See *Logic Variable Behavior After Power Loss, Settings Change, or Group Change on page 7.31*). When power is applied to the relay, the Logic Variables will be processed in order from LV1 to LV32. For example, if LV4 is used in a mission critical SELOGIC control equation (TR = LV4 + ...) and LV4 is dependent on a Logic Variable which is processed later (LV4 = !LV6), then the trip equation will evaluate to logical one. A safe method of using Logic Variables in applications like this is to inspect or test any mission-critical SELOGIC settings for desired behavior on power up of the relay.

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 ≤ 537
- 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 3)

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–IN216 (extra I/O board), IAMET, IBMET, ICMET, INMET, V0GAIN	*Section 7*, *Section 8*, *Section 9*
Polarizing Voltage	VPOLV, VPOLVH	*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*
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	(52AA, 52AB, 52AC, 52A) 3PO, SPOA, SPOB, SPOC, SPO	*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, 32SPOF, 32SPOR	*Section 4*
Switch-Onto-Fault Logic	(CLMON)	*Section 5*

Table F.4 Processing Order of Relay Elements and Logic (Top to Bottom) (Sheet 2 of 3)

Relay Elements and Logic	Order of Processing of the SELOGIC Control Equations (Listed in Parentheses) and Relay Word Bits	Reference Instruction Manual Section
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*
Switch-Onto-Fault Logic	SOTFE	*Section 5*
Out-of-Step Logic	50ABC, X5ABC, X6ABC, UBOSB, OSB, OSB1–OSB4, OST, OSTI, OSTO, OSBA, OSBB, OSBC, 67QUBF, 67QUBR, 67QUBF, 67QUBR	*Section 3*
High-Speed Distance Logic	MAB1H–MAB3H, MBC1H–MBC3H, MCA1H–MCA3H, MAG1H–MAG3H, MBG1H–MBG3H, MCG1H–MCG3H, CVTBLH	*Section 3*
Distance Logic	MAB1–MAB4, MBC1–MBC4, MCA1–MCA4, M1P–M4P, MAG1–MAG4, MBG1–MBG4, MCG1–MCG4, Z1G–Z4G, XAG1–XAG4, XBG1–XBG4, XCG1–XCG4, CVTBL	*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, DTA, DTB, DTC, E3PT, BKMTR, 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, SOTFT, RXPRM, COMPRM, TRPRM, DTR, E3PT, 27AWI, 27BWI, 27CWI, APS, BPS, CPS, 3PS, ATPA, ATPB, ATPC, A3PT, TPA, TPB, TPC, 3PT, SPT, TOP, ULTRA, ULTRB, ULTRC, TRIP, RSTTRGT	*Section 5*
Breaker Failure	(BFIA, BFIB, BFIC), 50BFA, 50BFB, 50BFC, 50BFT, RT, RTA, RTB, RTC, BFT, BFTA, BFTB, BFTC	*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	(BKMONA, BKMONB, BKMONC, BKCLSA, BKCLSB, BKCLSC), BCWA, BCWB, BCWC, BCW, ESTRA, ESTRB, ESTRC, ESCLA, ESCLB, ESCLC, ESOAL, MSTRA, MSTRB, MSTRC, MSCLA, MSCLB, MSCLC, MSOAL	*Section 8*
SELOGIC Control Equation Variables/ Timers	(SV1–SV16) SV1–SV16, SV1T–SV16T	*Section 7*
Breaker Failure Trip	(BFTR, BFULTR), BFTRIP	*Section 5*
Software Alarm Equation	(SALARM), SALARM	*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*

Table F.4 Processing Order of Relay Elements and Logic (Top to Bottom) (Sheet 3 of 3)

Relay Elements and Logic	Order of Processing of the SELogic Control Equations (Listed in Parentheses) and Relay Word Bits	Reference Instruction Manual Section
Reset Equations	(RST_DEM, RST_PDM, RST_BK, RST_HIS, RST_ENE, RST_MML, RST_HAL, RSTDNPE), RST_DEM, RST_PDM, RST_BK, RST_HIS, RST_ENE, RST_MML, RST_HAL, RSTDNPE	*Section 8*
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	*Appendix D*
IRIG-B and Synchrophasor status	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*
Local Control Switches	LB1–LB16	*Section 7*
Remote Control Switches	RB1–RB32	*Section 7*
Target Reset	TRGTR	*Section 5*
Alarm processing	ALARM, HALARM, HALARML, HALARMP, HALARMA, BAD-PASS, CHGPASS, GRPSW, SETCHG, ACCESS, ACCESSP, PASNVAL	*Section 7* and *Section 13*

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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 3.31* 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 3.34* 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)

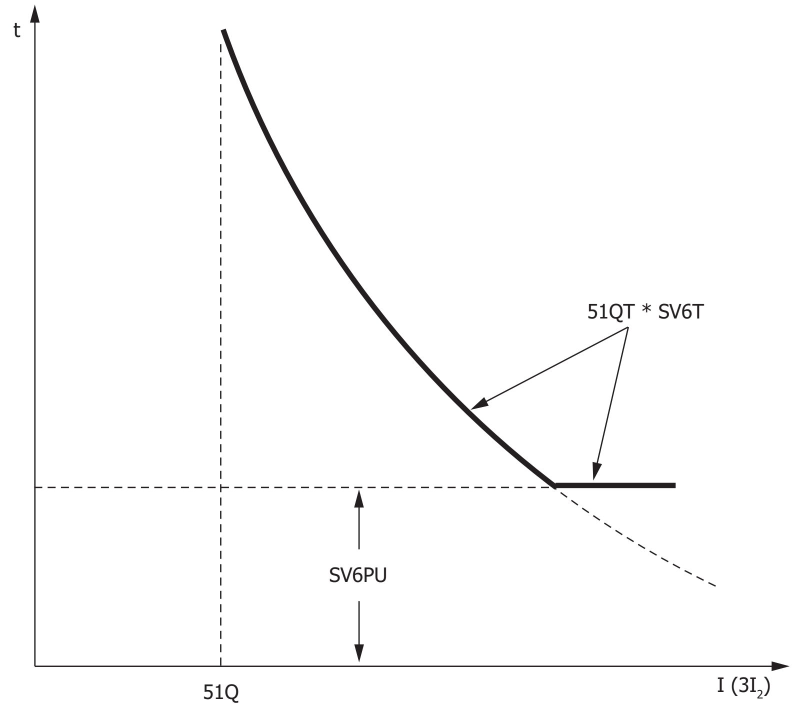

Figure G.1 Minimum Response Time Added to a Negative-Sequence Time-Overcurrent Element 51QT

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*.

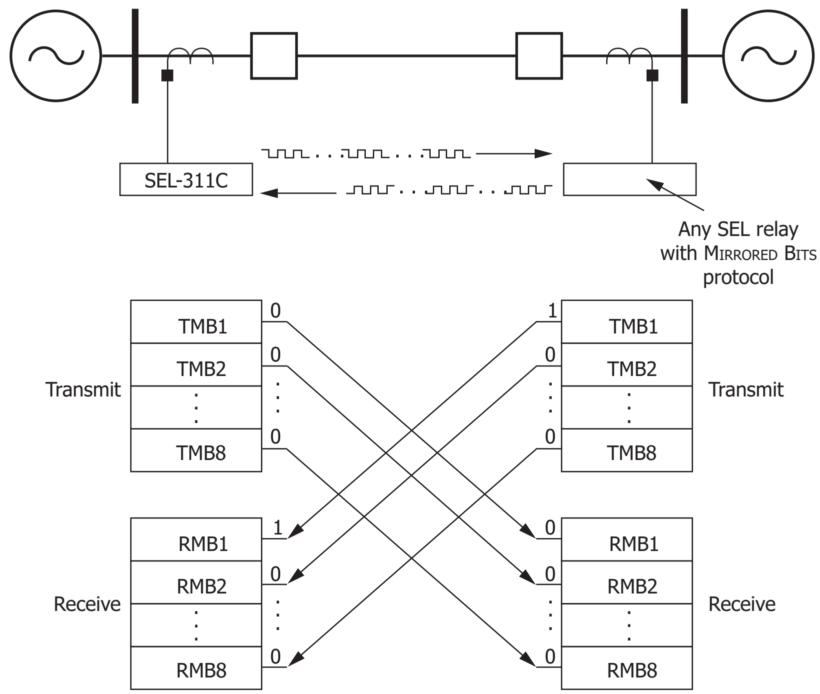

Figure H.1 Relay-to-Relay Logic Communication

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. The bit error rate of the MIRRORED BITS communications channel meets IEC-834-1 recommendations for direct tripping when the security counter (debounce) is set to 2 and can be further improved by increasing the security counter.

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. Because 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. Unfortunately, this method temporarily defeats communications over the entire loop for a receive error at any node in the loop. This decreases availability and 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 (Loopback) on page 10.51* 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 (Communications Data) on page 10.40* 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.

NOTE: The Pulsar MBT modem draws power from the relay serial port. See EIA-232 Serial Port Voltage Jumpers on page 2.30.

- The relay monitors the CTS signal on the EIA-232 connector, which the modem will deassert if the channel has too many errors.

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.41*.

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[b]	1–10000	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.
[b] PPM = Parts per million.

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 downtime 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 (Communications Data) on page 10.40* 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.42* for the full list of settings, including the port time-out setting.

Operation

NOTE: You can use the front-panel SET pushbutton, or another communications port, to change the LMD port settings to return to SEL protocol.

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.
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

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
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	1-byte checksum of all preceding bytes

A5C1 Fast Meter Configuration Block

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

NOTE: Analog channel names are transmitted by the relay as part of the A5C1 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.

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
6F	# 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	Analog channel name [VA] (VA)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564200000000	Analog channel name [VB] (VB)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564300000000	Analog channel name [VC] (VC)
01	Analog channel type
FF	Scale factor type

Table J.4 A5C1 Fast Meter Configuration Block (Sheet 2 of 2)

Data	Description
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, 01-ACB
00	Power Calculations (fixed value)
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
05	VB channel index
06	VC channel index
00	Reserved
xx	1-byte checksum of all preceding bytes

A5D1 Fast Meter Data Block

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

Table J.5 A5D1 Fast Meter Data Block

Data	Description
A5D1	Command
CE	Length
1 byte	1 Status Byte
80 bytes	X and Y components of: IA, IB, IC, IN, VA, VB, VC, VS, FREQ and VDC in 4-byte IEEE FPS
8 bytes	Time stamp
111 bytes	Two target LED rows and 109 digital banks: TAR0–TAR110
2 bytes	Reserved
xx	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 A5C2 and A5C3 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
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

Table J.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 2 of 3)

Data	Description
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
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

Table J.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 3 of 3)

Data	Description
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
xx	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
xx	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 when the relay turns on. 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 3)

Data	Description
A5CE	Command
6C	Length
01	Support 1 circuit breaker
0020	Support 32 remote bit set/clear commands
0100	Allow remote bit pulse commands
31	Operate code, open breaker 1
11	Operate code, close breaker 1
00	Operate code, clear remote bit RB1
20	Operate code, set remote bit RB1
40	Operate code, pulse remote bit RB1
01	Operate code, clear remote bit RB2
21	Operate code, set remote bit RB2
41	Operate code, pulse remote bit RB2
02	Operate code, clear remote bit RB3
22	Operate code, set remote bit RB3
42	Operate code, pulse remote bit RB3
03	Operate code, clear remote bit RB4
23	Operate code, set remote bit RB4
43	Operate code, pulse remote bit RB4
04	Operate code, clear remote bit RB5
24	Operate code, set remote bit RB5
44	Operate code, pulse remote bit RB5
05	Operate code, clear remote bit RB6
25	Operate code, set remote bit RB6
45	Operate code, pulse remote bit RB6
06	Operate code, clear remote bit RB7
26	Operate code, set remote bit RB7
46	Operate code, pulse remote bit RB7
07	Operate code, clear remote bit RB8
27	Operate code, set remote bit RB8
47	Operate code, pulse remote bit RB8
08	Operate code, clear remote bit RB9
28	Operate code, set remote bit RB9

Table J.8 A5CE Fast Operate Configuration Block (Sheet 2 of 3)

Data	Description
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
10	Operate code, clear remote bit RB17
30	Operate code, set remote bit RB17
50	Operate code, pulse remote bit RB17
11	Operate code, clear remote bit RB18
31	Operate code, set remote bit RB18
51	Operate code, pulse remote bit RB18
12	Operate code, clear remote bit RB19
32	Operate code, set remote bit RB19
52	Operate code, pulse remote bit RB19
13	Operate code, clear remote bit RB20
33	Operate code, set remote bit RB20
53	Operate code, pulse remote bit RB20
14	Operate code, clear remote bit RB21
34	Operate code, set remote bit RB21
54	Operate code, pulse remote bit RB21
15	Operate code, clear remote bit RB22
35	Operate code, set remote bit RB22
55	Operate code, pulse remote bit RB22
16	Operate code, clear remote bit RB23

Table J.8 A5CE Fast Operate Configuration Block (Sheet 3 of 3)

Data	Description
36	Operate code, set remote bit RB23
56	Operate code, pulse remote bit RB23
17	Operate code, clear remote bit RB24
37	Operate code, set remote bit RB24
57	Operate code, pulse remote bit RB24
18	Operate code, clear remote bit RB25
38	Operate code, set remote bit RB25
58	Operate code, pulse remote bit RB25
19	Operate code, clear remote bit RB26
39	Operate code, set remote bit RB26
59	Operate code, pulse remote bit RB26
1A	Operate code, clear remote bit RB27
3A	Operate code, set remote bit RB27
5A	Operate code, pulse remote bit RB27
1B	Operate code, clear remote bit RB28
3B	Operate code, set remote bit RB28
5B	Operate code, pulse remote bit RB28
1C	Operate code, clear remote bit RB29
3C	Operate code, set remote bit RB29
5C	Operate code, pulse remote bit RB29
1D	Operate code, clear remote bit RB30
3D	Operate code, set remote bit RB30
5D	Operate code, pulse remote bit RB30
1E	Operate code, clear remote bit RB31
3E	Operate code, set remote bit RB31
5E	Operate code, pulse remote bit RB31
1F	Operate code, clear remote bit RB32
3F	Operate code, set remote bit RB32
5F	Operate code, pulse remote bit RB32
00	Reserved
xx	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: 00–1F clear remote bit RB1–RB32 20–3F set remote bit RB1–RB32 40–5F pulse remote bit for RB1–RB32 for one processing interval
1 byte	Operate validation: 4 • Operate code + 1
xx	1-byte checksum of preceding bytes

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

- The Operate code is valid.
- The Operate validation = 4 • 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–RB32), 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
xx	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	1-byte checksum of preceding bytes

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	1-byte checksum of preceding bytes

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-2-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=0311C21HR3F54C2","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 0 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","yyyy"<CR><LF>
"TLED19","TLED20","TLED21","TLED22","TLED23","TLED24","TLED25","TLED26","yyyy"<CR><LF>
"M1P","M1PT","Z1G","Z1GT","M2P","M2PT","Z2G","Z2GT","yyyy"<CR><LF>
"Z1T","Z2T","50P1","67P1","67P1T","50G1","67G1","67G1T","yyyy"<CR><LF>
"51G","51GT","51GR","LOP","ILOP","ZLOAD","ZLOUT","ZLIN","yyyy"<CR><LF>
"LB1","LB2","LB3","LB4","LB5","LB6","LB7","LB8","yyyy"<CR><LF>
"LB9","LB10","LB11","LB12","LB13","LB14","LB15","LB16","yyyy"<CR><LF>
"RB1","RB2","RB3","RB4","RB5","RB6","RB7","RB8","yyyy"<CR><LF>
"RB9","RB10","RB11","RB12","RB13","RB14","RB15","RB16","yyyy"<CR><LF>
"LT1","LT2","LT3","LT4","LT5","LT6","LT7","LT8","yyyy"<CR><LF>
"LT9","LT10","LT11","LT12","LT13","LT14","LT15","LT16","yyyy"<CR><LF>
"SV1","SV2","SV3","SV4","SV1T","SV2T","SV3T","SV4T","yyyy"<CR><LF>
"SV5","SV6","SV7","SV8","SV5T","SV6T","SV7T","SV8T","yyyy"<CR><LF>
"SV9","SV10","SV11","SV12","SV9T","SV10T","SV11T","SV12T","yyyy"<CR><LF>
"SV13","SV14","SV15","SV16","SV13T","SV14T","SV15T","SV16T","yyyy"<CR><LF>
"MAB1","MBC1","MCA1","MAB2","MBC2","MCA2","CVTBL","SOTFT","yyyy"<CR><LF>
"MAG1","MBG1","MCG1","MAG2","MBG2","MCG2","DCHI","DCLO","yyyy"<CR><LF>
"BCW","BCWA","BCWB","BCWC","FIDEN","FSA","FSB","FSC","yyyy"<CR><LF>
"SG1","SG2","SG3","SG4","SG5","SG6","OC","CC","yyyy"<CR><LF>
"CLOSE","CF","TRGTR","52A","3PO","SOTFE","VPOLV","50L","yyyy"<CR><LF>
"PDEM","GDEM","QDEM","TRIP","50QF","50QR","50GF","50GR","yyyy"<CR><LF>
"32QF","32QR","32GF","32GR","32VE","32QGE","32IE","32QE","yyyy"<CR><LF>
"F32I","R32I","F32Q","R32Q","F32QG","R32QG","F32V","R32V","yyyy"<CR><LF>
"32SPOF","32SPOR","IN106","IN105","IN104","IN103","IN102","IN101","yyyy"<CR><LF>
"ALARM","OUT107","OUT106","OUT105","OUT104","OUT103","OUT102","OUT101","yyyy"<CR><LF>
"M3P","M3PT","Z3G","Z3GT","M4P","M4PT","Z4G","Z4GT","yyyy"<CR><LF>
"Z3T","Z4T","50P2","67P2","67P2T","50P3","67P3","67P3T","yyyy"<CR><LF>
"50G2","67G2","67G2T","50G3","67G3","67G3T","*","*","yyyy"<CR><LF>
"51P","51PT","51PR","Z1X","59VA","MAB3","MBC3","MCA3","yyyy"<CR><LF>
"MAG3","MBG3","MCG3","27S","59S","*","59VP","59VS","yyyy"<CR><LF>
"SF","25A1","25A2","RCSF","OPTMN","RSTMN","*","PMDOK","yyyy"<CR><LF>
"79RS","79CY","79LO","SH0","SH1","SH2","SH3","SH4","yyyy"<CR><LF>
"MAB4","MBC4","MCA4","MAG4","MBG4","MCG4","TSOK","TIRIG","yyyy"<CR><LF>
```

```
"XAG1","XBG1","XCG1","XAG2","XBG2","XCG2","XAG3","XBG3","yyyy"<CR><LF>
"XCG3","XAG4","XBG4","XCG4","OSTI","OSTO","OST","50ABC","yyyy"<CR><LF>
"X5ABC","X6ABC","OSB","OSB1","OSB2","OSB3","OSB4","UBOSB","yyyy"<CR><LF>
"50G4","67G4","67G4T","*","*","*","*","*","yyyy"<CR><LF>
"50Q1","67Q1","67Q1T","50Q2","67Q2","67Q2T","59N1","59N2","yyyy"<CR><LF>
"50Q3","67Q3","67Q3T","50Q4","67Q4","67Q4T","59Q","59V1","yyyy"<CR><LF>
"51Q","51QT","51QR","*","*","Z2PGS","67QG2S","BTX","yyyy"<CR><LF>
"Z3XT","DSTRT","NSTRT","STOP","Z3RB","KEY","EKEY","ECTT","yyyy"<CR><LF>
"PTRX","UBB1","UBB2","UBB","WFC","PT","PTRX1","PTRX2","yyyy"<CR><LF>
"27A","27B","27C","59A","59B","59C","3P27","3P59","yyyy"<CR><LF>
"27AB","27BC","27CA","59AB","59BC","59CA","*","*","yyyy"<CR><LF>
"*","*","*","*","*","*","*","*","yyyy"<CR><LF>
"*","*","*","*","*","*","*","*","yyyy"<CR><LF>
"*","*","*","*","*","*","*","*","yyyy"<CR><LF>
"RMB8A","RMB7A","RMB6A","RMB5A","RMB4A","RMB3A","RMB2A","RMB1A","yyyy"<CR><LF>
"TMB8A","TMB7A","TMB6A","TMB5A","TMB4A","TMB3A","TMB2A","TMB1A","yyyy"<CR><LF>
"RMB8B","RMB7B","RMB6B","RMB5B","RMB4B","RMB3B","RMB2B","RMB1B","yyyy"<CR><LF>
"TMB8B","TMB7B","TMB6B","TMB5B","TMB4B","TMB3B","TMB2B","TMB1B","yyyy"<CR><LF>
"LBOKB","CBADB","RBADB","ROKB","LBOKA","CBADA","RBADA","ROKA","yyyy"<CR><LF>
"81D1","81D2","81D3","81D4","81D5","81D6","27B81","*","yyyy"<CR><LF>
"81D1T","81D2T","81D3T","81D4T","81D5T","81D6T","*","*","yyyy"<CR><LF>
"50A1","50B1","50C1","50A2","50B2","50C2","50A3","50B3","yyyy"<CR><LF>
"50C3","50A4","50B4","50C4","*","50A","50B","50C","yyyy"<CR><LF>
"*","*","*","*","*","*","*","WYE","yyyy"<CR><LF>
"50P4","67P4","67P4T","*","*","*","*","FREQOK","yyyy"<CR><LF>
"*","*","*","*","Z2SEQT","M2PSEQT","Z2GSEQT","*","yyyy"<CR><LF>
"Z1XP","Z1XG","*","*","*","*","*","*","yyyy"<CR><LF>
"*","LINK5A","LINK5B","LNKFAIL","P5ASEL","P5BSEL","TSNTPP","TSNTPB","yyyy"<CR><LF>
"DST","DSTP","LPSEC","LPSECP","TQUAL4","TQUAL3","TQUAL2","TQUAL1","yyyy"<CR><LF>
"*","VOGAIN","INMET","ICMET","IBMET","IAMET","NDEM","TESTDB","yyyy"<CR><LF>
"*","RSTTRGT","RST_MML","RST_ENE","RST_HIS","RST_BK","RST_PDM","RST_DEM","yyyy"<CR><LF>
"SFAST","SSLOW","LOPRST","PMTRIG","TREA1","TREA2","TREA3","TREA4","yyyy"<CR><LF>
"LOP1","LOP2","LOP3","LOP4","*","*","*","*","yyyy"<CR><LF>
"*","*","*","*","*","*","*","*","yyyy"<CR><LF>
"*","*","*","*","*","*","*","*","yyyy"<CR><LF>
"3PS","APS","BPS","CPS","SPO","SPOA","SPOB","SPOC","yyyy"<CR><LF>
"27AWI","27BWI","27CWI","*","*","*","TRPRM","COMPRM","yyyy"<CR><LF>
"DTA","DTB","DTC","ATPA","ATPB","ATPC","A3PT","RXPRM","yyyy"<CR><LF>
"ULTRA","ULTRB","ULTRC","TPA","TPB","TPC","SPT","3PT","yyyy"<CR><LF>
"52AA","52AB","52AC","E3PT","50LA","50LB","50LC","TOP","yyyy"<CR><LF>
"DTR","*","OSBC","OSBB","OSBA","*","*","BKMTR","O9DA","yyyy"<CR><LF>
"PB1PUL","PB2PUL","PB3PUL","PB4PUL","PB5PUL","PB6PUL","PB7PUL","PB8PUL","yyyy"<CR><LF>
"LED1","LED2","LED3","LED4","LED5","LED6","LED7","LED8","yyyy"<CR><LF>
"LED9","*","LED10","*","*","*","PB10PUL","PB9PUL","yyyy"<CR><LF>
"*","*","*","*","*","*","*","*","yyyy"<CR><LF>
"LTRIP","LTIME","LCOMM","LSOTF","LZONE1","LZONE2","LZONE3","LZONE4","yyyy"<CR><LF>
"L51","*","*","*","*","*","*","RSTDNPE","yyyy"<CR><LF>
"LV1","LV2","LV3","LV4","LV5","LV6","LV7","LV8","yyyy"<CR><LF>
"LV9","LV10","LV11","LV12","LV13","LV14","LV15","LV16","yyyy"<CR><LF>
"LV17","LV18","LV19","LV20","LV21","LV22","LV23","LV24","yyyy"<CR><LF>
"LV25","LV26","LV27","LV28","LV29","LV30","LV31","LV32","yyyy"<CR><LF>
"VB001","VB002","VB003","VB004","VB005","VB006","VB007","VB008","yyyy"<CR><LF>
"VB009","VB010","VB011","VB012","VB013","VB014","VB015","VB016","yyyy"<CR><LF>
"VB017","VB018","VB019","VB020","VB021","VB022","VB023","VB024","yyyy"<CR><LF>
"VB025","VB026","VB027","VB028","VB029","VB030","VB031","VB032","yyyy"<CR><LF>
"VB033","VB034","VB035","VB036","VB037","VB038","VB039","VB040","yyyy"<CR><LF>
"VB041","VB042","VB043","VB044","VB045","VB046","VB047","VB048","yyyy"<CR><LF>
"VB049","VB050","VB051","VB052","VB053","VB054","VB055","VB056","yyyy"<CR><LF>
"VB057","VB058","VB059","VB060","VB061","VB062","VB063","VB064","yyyy"<CR><LF>
"VB065","VB066","VB067","VB068","VB069","VB070","VB071","VB072","yyyy"<CR><LF>
"VB073","VB074","VB075","VB076","VB077","VB078","VB079","VB080","yyyy"<CR><LF>
"VB081","VB082","VB083","VB084","VB085","VB086","VB087","VB088","yyyy"<CR><LF>
"VB089","VB090","VB091","VB092","VB093","VB094","VB095","VB096","yyyy"<CR><LF>
"VB097","VB098","VB099","VB100","VB101","VB102","VB103","VB104","yyyy"<CR><LF>
"VB105","VB106","VB107","VB108","VB109","VB110","VB111","VB112","yyyy"<CR><LF>
"VB113","VB114","VB115","VB116","VB117","VB118","VB119","VB120","yyyy"<CR><LF>
"VB121","VB122","VB123","VB124","VB125","VB126","VB127","VB128","yyyy"<CR><LF>
"SALARM","ACCESS", "ALRMOUT","*", "HALARMA", "HALARMP", "HALARML", "HALARM","yyyy"<CR><LF>
"*","*","PASNVAL", "ACCESSP", "GRPSW","SETCHG", "CHGPASS","BADPASS","yyyy"<CR><LF>
"RB17", "RB18", "RB19", "RB20", "RB21",'RB22",'RB23","RB24","yyyy"<CR><LF>
"RB25", "RB26", "RB27", "RB28", "RB29", "RB30", "RB31",'RB32","yyyy"<CR><LF>
" *","*","*", "*","*","*","BFT", "BFTRIP","yyyy"<CR><LF>
"50BFA", "50BFB", "50BFC', "50BFT", "RTA","RTB", "RTC", "RT","yyyy"<CR><LF>'
"*","*","*","*","*","*","*","*","yyyy"<CR><LF>
"*","*","*","*","*","*","*","*","yyyy"<CR><LF>
"*","*","*","*","*","*","*","*","yyyy"<CR><LF>
"ESTRA","ESTRB","ESTRC","ESCLA","ESCLB","ESCLC","ESOAL","MSOAL","yyyy"<CR><LF>
"MSTRA","MSTRB","MSTRC","MSCLA","MSCLB","MSCLC",""*","*","yyyy"<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:

```
"*","*","*","*","*","PWRUP","STSET","*","07AD"
```

where:

"*" indicates an unused bit location

The **BNA** command is available from Access Level 0 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 0 and higher.

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","yyyy",<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 that directly imports into spreadsheet or database programs, and that 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","yyyy"<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>
"19H","REF_NUM","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IN","IG","3I2","FLT_LOC_Z","FLT_LOC_ANG",
    "PER_UNIT_LL","FLT_R","yyyy"<CR>
"1D","I","F","I","I","I","6S","F","I","143S","I","I","I","I","I","I","F","F","F",
    "F""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","F","F","F","F","F","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>
"19H","REF_NUM","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IN","IG","3I2","FLT_LOC_Z","FLT_LOC_ANG",
    "PER_UNIT_LL","FLT_R","yyyy"<CR>
"1D","I","F","I","I","I","6S","F","I","143S","I","I","I","I","I","I","F","F","F",
    "F""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","F","F","F","F","F","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>
"19H","REF_NUM","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IN","IG","3I2","FLT_LOC_Z","FLT_LOC_ANG",
    "PER_UNIT_LL","FLT_R","yyyy"<CR>
"1D","I","F","I","I","I","6S","F","I","143S","I","I","I","I","I","I","F","F","F",
    "F""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","F","F","F","F","F","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>
"22H","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","FLT_LOC_Z","FLT_LOC_ANG",
    "PER_UNIT_LL","FLT_R","yyyy"<CR>
```

```
"1D","I","F","I","F","I","F","I","F","I","F","I","F","F","F","F","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","yyyy"<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","FLT_LOC_Z",
    "FLT_LOC_ANG","PER_UNIT_LL","FLT_R","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"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,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","yyyy"<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 32SPOF 32SPOR
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 SHO 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
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * * * * RSTDNPE 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 SALARM ACCESS ALRMOUT * HALARMA HALARMP HALARML HALARM * * PASNVAL
ACCESSP GRPSW SETCHG CHGPASS BADPASS RB17 RB18 RB19 RB20 RB21 RB22 RB23 RB24 RB25
RB26 RB27 RB28 RB29 RB30 RB31 RB32 * * * * * * BFT BFTRIP 50BFA 50BFB 50BFC 50BFT RTA
RTB RTC RT * * * * * * * * * * * * * * * * * * * * * * * * ESTRA ESTRB ESTRC ESCLA
ESCLB ESCLC ESOAL MSOAL MSTRA MSTRB MSTRC MSCLA MSCLB MSCLC * * ","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:

```
8100000020000000000000000000000000800C00000000000000000000000000000000000020000
000000000000000000000200000001000004C0F7C0000080000000000000000000000000000000000
00000000000000000000000000000000
```

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","yyyy"<CR>
"FID=SEL-311C-2-RXXX-VO-ZXXXXXX-DXXXXXX","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<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","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
"yyyy"<CR><LF>
"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>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
xxxx,xxxx,"yyyyy"<CR><LF>
"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","FLT_LOC_Z","FLT_LOC_ANG",
    "PER_UNIT_LL","FLT_R","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyyy"<CR><LF>
"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>
">","mmmmmmmmmm","yyyy"<CR>
"*","mmmmmmmmmm","yyyy"<CR><ETX>
```

where:

xxxx	are the data values corresponding to the line labels
yyyy	are the 4-byte hex ASCII representation of the checksum
REF_NUM	is the unique identification number
EVENT	is the event type
LOCATION	is the fault location
HOUR_T, MIN_T, SEC_T, and MSEC_T	are the breaker trip time
SHOT	is the recloser shot counter
FREQ	is the power system frequency at the trigger instant
GROUP	is the Active Settings Group
HOUR_C, MIN_C, SEC_C, and MSEC_C	are the breaker close time
TARGETS	are the front-panel tripping targets
BREAKER	is the breaker position at the end of the event
IA_PF	is the A-phase current pre-fault magnitude, IA_DEG_PF is the A-phase current angle. IB, IC, IG, 3I2, VA, VB, and VC are similar
IA	is the A-phase current fault magnitude, IA_DEG is the A-phase current angle. IB, IC, IG, 3I2, VA, VB, and VC are similar
FLT_LOC_Z	is the impedance to the fault location in ohms, secondary
FLT_LOC_ANG	is the angle of the impedance to the fault location in degrees
PER_UNIT_LL	is the per-unit distance to the fault location
FLT_R	is the fault resistance in ohms, secondary
“>”	indicates MIRRORED BIT status at the trigger row
“*”	indicates MIRRORED BIT status at the time of trip
mmmmmmmmmm	is the hexidecimal representation of the five MIRRORED BIT status bytes

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

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

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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*
- *DNP3 in the SEL-311C on page L.6*
- *DNP3 Documentation on page L.13*

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 by 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 deadband. 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. 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 interoperability.

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 because of 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 uses 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 is retained in full
- Link layer confirmations are 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

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.

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 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 when the relay turns on. 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 when the relay turns on is convenient, this can cause problems if your DNP3 master is not prepared to start receiving data immediately when the relay turns on. 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 acknowledgment 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. 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.

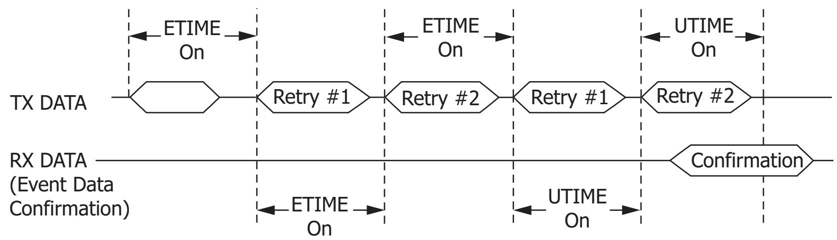

Figure L.1 Application Confirmation Timing With URETRYn = 2

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*).

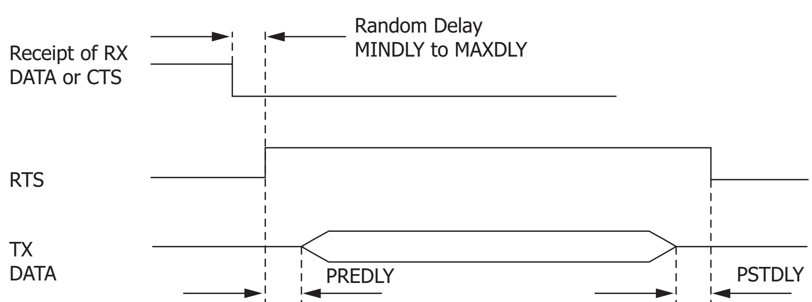

Figure L.2 Message Transmission Timing

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

NOTE: Time stamps reported in the SER are truncated to the nearest millisecond while time stamps reported through DNP are rounded to the nearest millisecond. As a result, the time stamps reported in each interface may occasionally be different by 1 ms.

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 deadband and scaling operation on analog points shown in *Table L.10*. You can either:

- set and use default deadband and scaling according to data type, or
- use a custom data map to select deadbands on a point-by-point basis.

Deadbands for analog inputs can be modified at run-time by writing to Object 34. Deadband changes via Object 34 are stored in volatile memory. Make sure to reissue the Object 34 deadband 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 deadband 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 deadbands occurs after scaling. For example, if you set DECPLA*n* to 2 and ANADBA*n* to 10, a measured current of 10.14 A 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 A) 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 by 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	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").

If the relay time is only synchronized over DNP, the relay time is considered synchronized for a period based on the TIMERQ port setting. When the TIMERQ setting is less than 30 minutes, the relay time is considered synchronized for two times the TIMERQ setting. When the TIMERQ setting is greater than 30 minutes, the relay time is considered synchronized for 30 minutes plus the TIMERQ setting. When TIMERQ is not set to a time (TIMERQ = M) for any port, the time is considered synchronized for 60 minutes. When the device time is considered synchronized, an Object 2, Variation 3 (Binary Input Event with Relative Time) request will result in an Object 51, Variation 1 (Time and Date Common Time-of-Occurrence synchronized) response. When the device time is no longer considered synchronized, an Object 2, Variation 3 (Binary Input Event with Relative Time) request will result in an Object 51, Variation 2 (Time and Date Common Time-of-Occurrence unsynchronized) response.

Global setting DNPSRC controls the time base for DNP time. If the master sends time in UTC, set DNPSRC to UTC. If the master sends local time, set DNPSRC to Local.

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 serial Ports 1, 2, 3, or F or on Ethernet Port 5, as many as a maximum of six concurrent DNP3 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 10.8* 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 deadband for current; hidden if ECLASSA set to 0	0–32767	100
ANADBV	Analog reporting deadband for voltages; hidden if ECLASSA set to 0	0–32767	100
ANADBM	Analog reporting deadband 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	0
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[a]	Enable unsolicited reporting when the relay turns on; 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 time out, 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, seconds; Off disables PSTDLY	OFF, 0.00–30.00	0.00
PSTDLY	Settle time from TX to RTS off, seconds; hidden if PREDLY set to Off	0.00–30.00	0.00

Table L.7 Port DNP3 Protocol Settings (Sheet 2 of 3)

Name	Description	Range	Default
MINDIST	Event minimum fault location	OFF, –10000.0 to 10000.0	OFF
MAXDIST	Event maximum fault location	OFF, –10000.0 to 10000.0	OFF
EVEMODE	Event mode for startup	SINGLE, MULTI	SINGLE
RPEVTYP	Event type to report	TRIP, ALL	ALL
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; hidden if DNPTR1 set to TCP	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
DECPLV1	Decimal places scaling for Voltage data	0–3	1
DECPLM1	Decimal places scaling for Miscellaneous data	0–3	1
ANADBA1	Analog reporting deadband for current; hidden if ECLASSA1 set to 0	0–32767	100
ANADBV1	Analog reporting deadband for voltages; hidden if ECLASSA1 set to 0	0–32767	100
ANADBM1	Analog reporting deadband 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[a]	Enable unsolicited reporting when the relay turns on; hidden 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 time out, seconds	1–5000	60
MINDIST1	Event minimum fault time	OFF, –10000.0 to 10000.0	OFF
MAXDIST1	Event maximum fault time	OFF, –10000.0 to 10000.0	OFF
EVEMODE1	Event mode for startup	SINGLE, MULTI	SINGLE
RPEVTYP1	Event type to report	TRIP, ALL	ALL

Table L.7 Port DNP3 Protocol Settings (Sheet 3 of 3)

Name	Description	Range	Default
Session 2 Settings			
DNPIP2[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR2	Transport protocol	UDP, TCP	TCP
•			
•			
•			
EVEMODE2	Event mode for startup	SINGLE, MULTI	SINGLE
RPEVTYP2	Event type to report	TRIP, ALL	ALL
Session 3 Settings			
DNPIP3[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR3	Transport protocol	UDP, TCP	TCP
•			
•			
•			
EVEMODE3	Event mode for startup	SINGLE, MULTI	SINGLE
RPEVTYP3	Event type to report	TRIP, ALL	ALL
Session 4 Settings			
DNPIP4[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR4	Transport protocol	UDP, TCP	TCP
•			
•			
•			
EVEMODE4	Event mode for startup	SINGLE, MULTI	SINGLE
RPEVTYP4	Event type to report	TRIP, ALL	ALL
Session 5 Settings			
DNPIP5[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR5	Transport protocol	UDP, TCP	TCP
•			
•			
•			
EVEMODE5	Event mode for startup	SINGLE, MULTI	SINGLE
RPEVTYP5	Event type to report	TRIP, ALL	ALL
Session 6 Settings			
DNPIP6[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR6	Transport protocol	UDP, TCP	TCP
•			
•			
•			
EVEMODE6	Event mode for startup	SINGLE, MULTI	SINGLE
RPEVTYP6	Event type to report	TRIP, ALL	ALL

[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 as a download from the SEL website, contains the standard device profile information for the SEL-311C. 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 check boxes in the example Device Profile in the DNP3 Subset Definitions, only the relevant selections are shown.

Table L.8 SEL-311C DNP3 Device Profile

Parameter	Value
Vendor name	Schweitzer Engineering Laboratories
Device name	SEL-311C-2, -3
Highest DNP request level	Level 2
Highest DNP response level	Level 2
Device function	Outstation
Notable objects, functions, and/or qualifiers supported	Analog Deadband 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
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 objects conforms to the format laid out in the DNP specifications and includes supported objects for DNP3 implementation Level 2 and above and nonsupported objects for DNP3 implementation Level 2 only. DNP3 implementation Level 2 functionality that is not supported is noted.

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, 6	129	0, 17
0	212	Device Attributes—Master data set prototypes	1	0, 6	129	0, 17
0	213	Device Attributes—Outstation data set prototypes	1	0, 6	129	0, 17
0	214	Device Attributes—Master data sets	1	0, 6	129	0, 17
0	215	Device Attributes—Outstation data sets	1	0, 6	129	0, 17
0	216	Device Attributes—Max binary outputs per request	1	0, 6	129	0, 17
0	219	Device Attributes—Support for analog output events	1	0, 6	129	0, 17
0	220	Device Attributes—Max analog output index	1	0, 6	129	0, 17
0	221	Device Attributes—Number of analog outputs	1	0, 6	129	0, 17
0	222	Device Attributes—Support for binary output events	1	0, 6	129	0, 17
0	223	Device Attributes—Max binary output index	1	0, 6	129	0, 17
0	224	Device Attributes—Number of binary outputs	1	0, 6	129	0, 17
0	225	Device Attributes—Support for frozen counter events	1	0, 6	129	0, 17
0	226	Device Attributes—Support for frozen counters	1	0, 6	129	0, 17
0	227	Device Attributes—Support for counter events	1	0, 6	129	0, 17
0	228	Device Attributes—Max counter index	1	0, 6	129	0, 17
0	229	Device Attributes—Number of counters	1	0, 6	129	0, 17
0	230	Device Attributes—Support for frozen analog inputs	1	0, 6	129	0, 17
0	231	Device Attributes—Support for analog input events	1	0, 6	129	0, 17
0	232	Device Attributes—Max analog input index	1	0, 6	129	0, 17
0	233	Device Attributes—Number of analog inputs	1	0, 6	129	0, 17
0	234	Device Attributes—Support for double-bit events	1	0, 6	129	0, 17
0	235	Device Attributes—Max double-bit binary index	1	0, 6	129	0, 17
0	236	Device Attributes—Number of double-bit binaries	1	0, 6	129	0, 17
0	237	Device Attributes—Support for binary input events	1	0, 6	129	0, 17
0	238	Device Attributes—Max binary input index	1	0, 6	129	0, 17
0	239	Device Attributes—Number of binary inputs	1	0, 6	129	0, 17
0	240	Device Attributes—Max transmit fragment size	1	0, 6	129	0, 17
0	241	Device Attributes—Max receive fragment size	1	0, 6	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	242	Device Attributes—Device manufacturer's software version (FID string)	1	0, 6	129	0, 17
0	243	Device Attributes—Device manufacturer's hardware version (Part number)	1	0, 6	129	0, 17
0	245	Device Attributes—User-assigned location name (TID setting)	1	0, 6	129	0, 17
0	246	Device Attributes—User-assigned ID code/ number (RID setting)	1	0, 6	129	0, 17
0	247	Device Attributes—User-assigned device name (RID setting)	1	0, 6	129	0, 17
0	248	Device Attributes—Device serial number	1	0, 6	129	0, 17
0	249	Device Attributes—DNP subset and conformance (e.g., "2:2009")	1	0, 6	129	0, 17
0	250	Device Attributes—Device manufacturer's product name and model (e.g., "SEL-311C Relay")	1	0, 6	129	0, 17
0	252	Device Attributes—Device manufacturer's name ("SEL")	1	0, 6	129	0, 17
0	254	Device Attributes—Nonspecific all attributes request	1	0, 6	129	0, 17
0	255	Device Attributes—List of attribute variations	1	0, 6	129	0, 17
1	0	Binary Input—Any Variation	1, 22	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, 17, 28		
10	2[e]	Binary Output Status	1	0, 1, 6, 7, 8	129	0, 1
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	7	129	echo of request
12	3	Pattern Mask	3, 4, 5, 6	0, 1	129	echo of request
20	0	Binary Counter—Any Variation	1, 22	0, 1, 6, 7, 8, 17, 28		
20	0	Binary Counter—Any Variation	7, 8, 9, 10[f]	0, 1, 6, 7, 8		
20	1	32-Bit Binary Counter	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	2	16-Bit Binary Counter	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	5	32-Bit Binary Counter Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	6[e]	16-Bit Binary Counter Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
21[g]	0	Frozen Counter—Any Variation	1, 22	6, 7, 8		
21[g]	1	32-Bit Frozen Counter	1	6, 7, 8	129	0, 1, 17, 28
21[g]	2	16-Bit Frozen Counter	1	6, 7, 8	129	0, 1, 17, 28
21[g]	5	32-Bit Frozen Counter With Time of Freeze	1	6, 7, 8	129	0, 1, 17, 28
21[g]	6	16-Bit Frozen Counter With Time of Freeze	1	6, 7, 8	129	0, 1, 17, 28
21[g]	9	32-Bit Frozen Counter Without Flag	1	6, 7, 8	129	0, 1, 17, 28
21[g]	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

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]
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[h]	0	Analog Input—Any Variation	1, 22	0, 1, 6, 7, 8, 17, 28		
30[h]	1	32-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[h]	2	16-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[h]	3	32-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[h]	4	16-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[h]	5	Short Floating-Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[h]	6	Long Floating-Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
32[h]	0	Analog Change Event—Any Variation	1	6, 7, 8		
32[h]	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130[g]	17, 28
32[h]	2	16-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130	17, 28
32[h]	3	32-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[h]	4	16-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[h]	5	Short Floating-Point Analog Change Event	1	6, 7, 8	129	17, 28
32[h]	6	Long Floating-Point Analog Change Event	1	6, 7, 8	129	17, 28
32[h]	7	Short Floating-Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[h]	8	Long Floating-Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
34	0	Analog Deadband—Any Variation	1, 2	0, 1, 6, 7, 8, 17, 28		
34	1[e]	16-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	2	32-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	3	Short Floating-Point Analog Input Reporting Deadband 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		
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	Long 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	1	Time and Date CTO			129, 130[g]	07, quantity = 1
51	2	Unsynchronized Time and Date CTO			129, 130[g]	07, quantity = 1
52	1	Time Delay, Coarse			129[g]	07, quantity = 1
52	2	Time Delay, Fine			129	07, quantity = 1
60	0	All Classes of Data	1, 20, 21, 22	6, 7, 8		
60	1	Class 0 Data	1, 22	6, 7, 8		

Table L.9 SEL-311C DNP Object List (Sheet 4 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]
60	2	Class 1 Data	1, 20, 21, 22	6, 7, 8		
60	3	Class 2 Data	1, 20, 21, 22	6, 7, 8		
60	4	Class 3 Data	1, 20, 21, 22	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] The relay accepts function codes 7, 8, 9, and 10 and responds without error, but no action is taken, because the frozen counters are not supported.
[g] DNP3 implementation Level 2 functionality, which is not supported by the relay.
[h] Default variation specified by serial port setting DVARAI (or DVARAIn for Ethernet session n [n = 1–6]).

Reference Data Map

NOTE: Deadband changes via Object 34 are stored in volatile memory. Make sure to reissue any Object 34 deadband changes you wish to retain after a change to DNP port settings, after issuing a **STA C** command or after the relay restarts.

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.

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.

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 time stamp when included in the default or custom data map.

The SEL-311C scales analog values by the indicated settings or fixed scaling indicated in the description. Analog deadbands 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 5)

Obj. Type	Label[a b]	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

Table L.10 DNP3 Reference Data Map (Sheet 2 of 5)

Obj. Type	Label[a] [b]	Description	Index (for firmware prior to R500)
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	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	RB17–RB32	Remote bits	–
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
10, 12	RB17:RB18, RB19:RB20, RB21:RB22, RB23:RB24, RB25:RB26, RB27:RB28, RB29:RB30, RB31:RB32	Remote bit pairs	–
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	–
10, 12	DRST_HAL	Reset HALARMA	–
10, 12	DRSTDNPE	DNP Relay Event Registers/Buffers	–
10, 12	SINGEVE	Switch to Single-Event Mode	–
Counter Inputs			
20, 22	ACTGRP	Active settings group.	0
20, 22	INTTRA	Internal A-phase breaker trips.	–
20, 22	INTTRB	Internal B-phase breaker trips.	–
20, 22	INTTRC	Internal C-phase breaker trips.	–
20, 22	ESOALCNT	Electrical operation time alarm counter	–

Table L.10 DNP3 Reference Data Map (Sheet 3 of 5)

Obj. Type	Label[a] [b]	Description	Index (for firmware prior to R500)
20, 22	MSOALCNT	Mechanical operation time alarm counter	–
20, 22	EXTTRA	External A-phase breaker trips.	–
20, 22	EXTTRB	External B-phase breaker trips.	–
20, 22	EXTTRC	External C-phase breaker trips.	–
Analog Inputs			
30, 32, 34	IA[c], IAFA[d]	IA magnitude and angle.	00, 01
30, 32, 34	IB[c], IBFA[d]	IB magnitude and angle.	02, 03
30, 32, 34	IC[c], ICFA[d]	IC magnitude and angle.	04, 05
30, 32, 34	IN[c], INFA[d]	IN magnitude and angle.	06, 07
30, 32, 34	VA[e], VAFA[d]	VA magnitude (kV) and angle.	08, 09
30, 32, 34	VB[e], VBFA[d]	VB magnitude (kV) and angle.	10, 11
30, 32, 34	VC[e], VCFA[d]	VC magnitude (kV) and angle.	12, 13
30, 32, 34	VS[e], VSFA[d]	VS magnitude (kV) and angle.	14, 15
30, 32, 34	VAB[e], VABFA[d]	VAB magnitude (kV) and angle.	–
30, 32, 34	VBC[e], VBCFA[d]	VBC magnitude (kV) and angle.	–
30, 32, 34	VCA[e], VCAFA[d]	VCA magnitude (kV) and angle.	–
30, 32, 34	IG[c], IGFA[d]	IG magnitude and angle.	16, 17
30, 32, 34	3I0[c], 3I0FA[d]	3I0 magnitude (kV) and angle.	–
30, 32, 34	I1[c], I1FA[d]	I1 magnitude and angle.	18, 19
30, 32, 34	3I2[c], 3I2FA[d]	3I2 magnitude and angle.	20, 21
30, 32, 34	3V0_MAG[e], 3V0FA[d]	3V0 magnitude (kV) and angle.	22, 23
30, 32, 34	V1[e], V1FA[d]	V1 magnitude (kV) and angle.	24, 25
30, 32, 34	V2[e], V2FA[d]	V2 magnitude (kV) and angle.	26, 27
30, 32, 34	MWA[f], MWB[f], MWC[f], MW3[f]	MW A, B, C and 3 phase.	28–31
30, 32, 34	MVARA[f], MVARB[f], MVARC[f], MVAR3[f]	MVAR A, B, C and 3 phase.	32–35
30, 32, 34	PFA[d], PFB[d], PFC[d], PF3[d]	Power factor A, B, C and 3 phase.	36–39
30, 32, 34	FREQ[d]	Frequency	40
30, 32, 34	VDC[g]	VDC	41
30, 32, 34	MWHAI[f], MWHAO[f]	A-phase MWhr in and out	42, 43
30, 32, 34	MWHBI[f], MWHBO[f]	B-phase MWhr in and out.	44, 45
30, 32, 34	MWHCI[f], MWHCO[f]	C-phase MWhr in and out.	46, 47
30, 32, 34	MWH3I[f], MWH3O[f]	3-phase MWhr in and out.	48, 49
30, 32, 34	MVRHAI[f], MVRHAO[f]	A-phase MVARhr in and out.	50,51
30, 32, 34	MVRHBI[f], MVRHBO[f]	B-phase MVARhr in and out.	52,53
30, 32, 34	MVRHCI[f], MVRHCO[f]	C-phase MVARhr in and out.	54,55
30, 32, 34	MVRH3I[f], MVRH3O[f]	3-phase MVARhr in and out.	56,57
30, 32, 34	IADEM[c], IBDEM[c], ICDEM[c], IGDEM[c], 3I2DEM[c]	Demand IA, IB, IC, IG, and 3I2 magnitudes.	58–62
30, 32, 34	INDEM[c]	Demand IN magnitude.	–
30, 32, 34	MWADI[f], MWBDI[f], MWCDI[f], MW3DI[f]	A, B, C and 3 phase demand MW in.	63–66
30, 32, 34	MVRADI[f], MVRBDI[f], MVRCDI[f], MVR3DI[f]	A, B, C and 3 phase demand MVAR in.	67–70

Table L.10 DNP3 Reference Data Map (Sheet 4 of 5)

Obj. Type	Label[a b]	Description	Index (for firmware prior to R500)
30, 32, 34	MWADO[f], MWBDO[f], MWCDO[f], MW3DO[f]	A, B, C and 3 phase demand MW out.	71–74
30, 32, 34	MVRADO[f], MVRBDO[f], MVRCDO[f], MVR3DO[f]	A, B, C and 3 phase demand MVAR out.	75–78
30, 32, 34	IAPK[c], IBPK[c], ICPK[c], IGPK[c], 3I2PK[c]	Peak demand IA, IB, IC, IG, and 3I2 magnitudes.	79–83
30, 32, 34	INPK[c]	Peak demand IN magnitude.	–
30, 32, 34	MWAPI[f], MWBPI[f], MWCPI[f], MW3PI[f]	A, B, C and 3 phase peak demand MW in.	84–87
30, 32, 34	MVRAPI[f], MVRBPI[f], MVRCPI[f], MVR3PI[f]	A, B, C and 3 phase peak demand MVAR in.	88–91
30, 32, 34	MWAPO[f], MWBPO[f], MWCPO[f], MW3PO[f]	A, B, C and 3 phase peak demand MW out.	92–95
30, 32, 34	MVRAPO[f], MVRBPO[f], MVRCPO[f], MVR3PO[f]	A, B, C and 3 phase peak demand MVAR out.	96–99
30, 32, 34	WEARA, WEARB, WEARC	Breaker contact wear percentage (A, B, C)	100–102
30, 32, 34	MAXWEAR	Greatest wear of WEARA, WEARB, or WEARC	–
30, 32, 34	EOTTRAAV[f]	Average electrical trip operating time, A-phase	–
30, 32, 34	EOTTRBAV[f]	Average electrical trip operating time, B-phase	–
30, 32, 34	EOTTRCAV[f]	Average electrical trip operating time, C-phase	–
30, 32, 34	EOTCLAAV[f]	Average electrical close operating time, A-phase	–
30, 32, 34	EOTCLBAV[f]	Average electrical close operating time, B-phase	–
30, 32, 34	EOTCLCAV[f]	Average electrical close operating time, C-phase	–
30, 32, 34	MOTTRAAV[f]	Average mechanical trip operating time, A-phase	–
30, 32, 34	MOTTRBAV[f]	Average mechanical trip operating time, B-phase	–
30, 32, 34	MOTTRCAV[f]	Average mechanical trip operating time, C-phase	–
30, 32, 34	MOTCLAAV[f]	Average mechanical close operating time, A-phase	–
30, 32, 34	MOTCLBAV[f]	Average mechanical close operating time, B-phase	–
30, 32, 34	MOTCLCAV[f]	Average mechanical close operating time, C-phase	–
30, 32, 34	FTYPE[h]	Fault type	103
30, 32, 34	FTYPE16[h, i]	Fault type (formatted as a 16-bit signed value)	–
30, 32, 34	FLOC[f, h]	Fault location. If FLOC = $$$$$$, it will be set to –999.9 in DNP.	104
30, 32, 34	FI[c, h]	Maximum-phase fault current	105
30, 32, 34	FFREQ[d, h]	Fault frequency	106
30, 32, 34	FGRP[h]	Fault settings group (1–6)	107
30, 32, 34	FSHO[h]	Fault recloser shot counter	108
30, 32, 34	FTIMEH[h], FTIMEM[h], FTIMEL[h]	Fault time in DNP format (high, middle, and low 16 bits)	109–111
30, 32, 34	FTIMEH16[h, i], FTIMEM16[h, i], FTIMEL16[h, i]	Fault time in DNP format (high, middle, and low 16 bits formatted as a 16-bit signed value)	–
30, 32, 34	FUNR[h]	Number of unread Faults	–
30, 32, 34	FIA[c, h]	A-phase fault current, A primary	–
30, 32, 34	FIB[c, h]	B-phase fault current, A primary	–
30, 32, 34	FIC[c, h]	C-phase fault current, A primary	–
30, 32, 34	FIG[c, h]	Residual-ground fault current, A primary	–
30, 32, 34	FIN[c, h]	IN channel fault current, A primary	–

Table L.10 DNP3 Reference Data Map (Sheet 5 of 5)

Obj. Type	Label[a b]	Description	Index (for firmware prior to R500)
30, 32, 34	FIQ[c, h]	Negative-sequence fault current, A primary	–
30, 32, 34	FZ[d, h]	Fault impedance magnitude in ohms secondary	–
30, 32, 34	FZFA[d, h]	Fault impedance angle in degrees	–
30, 32, 34	FR[d, h]	Fault resistance in ohms secondary	–
30, 32, 34	FM[d, h]	Distance to fault in per-unit of line length	–
30, 32, 34	LDPFA	Power Factor Leading = 1, A-phase	–
30, 32, 34	LDPFB	Power Factor Leading = 1, B-phase	–
30, 32, 34	LDPFC	Power Factor Leading = 1, C-phase	–
30, 32, 34	LDPF3	Power Factor Leading = 1, 3-phase	–
30, 32, 34	TEMP[g]	Relay Internal Temperature	–
30, 32, 34	51PP[c]	51PP setting in primary units	–
30, 32, 34	51GP[c]	51GP setting in primary units	–
30, 32, 34	51QP[c]	51QP setting in primary units	–
30, 32, 34	FWREV	Relay Firmware Revision	–
30, 32, 34	SNUMBL	Relay Serial Number, lowest four digits	–
30, 32, 34	SNUMBM	Relay Serial Number, middle four digits	–
30, 32, 34	SNUMBH	Relay Serial Number, highest four digits	–
Analog Outputs			
40, 41	ACTGRP[j]	Active settings group	0

[a] Any label not shown to be scaled by any other value has a scaling of 1.
[b] Any label not shown to be associated with a deadband setting is associated with the ANADBM setting.
[c] Scaled according to the DECPLA setting, deadband according to ANADBA setting.
[d] Scaled by 100, deadband according to ANADBM setting.
[e] Scaled according to the DECPLV setting, deadband according to ANADBV setting.
[f] Scaled according to the DECPLM setting, deadband according to ANADBM setting.
[g] Scaled by 10, deadband according to ANADBM setting.
[h] See the Event Data on page L.33 for a detailed description of these labels.
[i] 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.
[j] The active settings group can be modified by writing the desired settings group number to ACTGRP. If any of the SELOGIC Group Switch equations SS1–SS6 are asserted, 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)

DNP Setting	Object	Point Label	Index
BI_000	01, 02	52A	0
BI_001	01, 02	79RS	1
BI_002	01, 02	79LO	2
BI_003	01, 02	TLED18	3
BI_004	01, 02	TLED17	4
BI_005	01, 02	TLED16	5
BI_006	01, 02	TLED15	6
BI_007	01, 02	TLED14	7
BI_008	01, 02	TLED13	8

Table L.11 DNP3 Default Data Map (Sheet 2 of 3)

DNP Setting	Object	Point Label	Index
BI_009	01, 02	TLED12	9
BI_010	01, 02	TLED11	10
BI_011	01, 02	TLED26	11
BI_012	01, 02	TLED25	12
BI_013	01, 02	TLED24	13
BI_014	01, 02	TLED23	14
BI_015	01, 02	TLED22	15
BI_016	01, 02	TLED21	16
BI_017	01, 02	TLED20	17
BI_018	01, 02	TLED19	18
BI_019	01, 02	LDPF3	19
BI_020	01, 02	RLYDIS	20
BI_021	01, 02	STFAIL	21
BI_022	01, 02	STWARN	22
BI_023	01, 02	UNRDEV	23
BI_024–BI_199	01, 02	NA	24–199
BO_000–BO_015	10, 12	RB1–RB16	0–15
BO_016	10, 12	OC	16
BO_017	10, 12	CC	17
BO_018	10, 12	DRST_DEM	18
BO_019	10, 12	DRST_PDM	19
BO_020	10, 12	DRST_ENE	20
BO_021	10, 12	DRST_BK	21
BO_022	10, 12	DRST_TAR	22
BO_023	10, 12	NXTEVE	23
BO_024	10, 12	RB1:RB2	24
BO_025	10, 12	RB3:RB4	25
BO_026	10, 12	RB5:RB6	26
BO_027	10, 12	RB7:RB8	27
BO_028	10, 12	RB9:RB10	28
BO_029	10, 12	RB11:RB12	29
BO_030	10, 12	RB13:RB14	30
BO_031	10, 12	RB15:RB16	31
BO_032	10, 12	OC:CC	32
BO_033–BO_070	10, 12	NA	33–70
CO_000	20, 22	ACTGRP	0
CO_001	20, 22	INTTR	1
CO_002	20, 22	EXTTR	2
CO_003–CO_007	20, 22	NA	3–7
AI_000	30, 32, 34	IA	0
AI_001	30, 32, 34	IAFA::500	1
AI_002	30, 32, 34	IB	2
AI_003	30, 32, 34	IBFA::500	3
AI_004	30, 32, 34	IC	4
AI_005	30, 32, 34	ICFA::500	5
AI_006	30, 32, 34	IN	6
AI_007	30, 32, 34	INFA::500	7

Table L.11 DNP3 Default Data Map (Sheet 3 of 3)

DNP Setting	Object	Point Label	Index
AI_008	30, 32, 34	VA	8
AI_009	30, 32, 34	VAFA::500	9
AI_010	30, 32, 34	VB	10
AI_011	30, 32, 34	VBFA::500	11
AI_012	30, 32, 34	VC	12
AI_013	30, 32, 34	VCFA::500	13
AI_014	30, 32, 34	VS	14
AI_015	30, 32, 34	VSFA::500	15
AI_016	30, 32, 34	IG	16
AI_017	30, 32, 34	IGFA::500	17
AI_018	30, 32, 34	MW3	18
AI_019	30, 32, 34	MVAR3	19
AI_020	30, 32, 34	PF3	20
AI_021	30, 32, 34	FREQ	21
AI_022	30, 32, 34	VDC	22
AI_023	30, 32, 34	MWH3I	23
AI_024	30, 32, 34	MWH3O	24
AI_025	30, 32, 34	MVRH3I	25
AI_026	30, 32, 34	MVRH3O	26
AI_027	30, 32, 34	WEARA	27
AI_028	30, 32, 34	WEARB	28
AI_029	30, 32, 34	WEARC	29
AI_030	30, 32, 34	FTYPE	30
AI_031	30, 32, 34	FLOC	31
AI_032	30, 32, 34	FI	32
AI_033	30, 32, 34	FFREQ	33
AI_034	30, 32, 34	FGRP	34
AI_035	30, 32, 34	FSHO	35
AI_036	30, 32, 34	FTIMEH	36
AI_037	30, 32, 34	FTIMEM	37
AI_038	30, 32, 34	FTIMEL	38
AI_039	30, 32, 34	FUNR	39
AI_040–AI_199	30, 32, 34	NA	40–199
AO_000	40, 41	ACTGRP	0
AO_001–AO_007	40, 41	NA	1–7

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 deadbands. 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 as many as six unique DNP3 masters. Each map is initially populated with default data points, as described in *Default Data Map on page L.21*. You may remap the points in a default map to create a custom map with as many as the number of inputs and outputs listed below:

- 200 Binary Inputs
- 71 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
BO_033  = NA                BO_034  = NA                BO_035  = NA
---
BO_069  = NA                BO_070  = NA


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  = INTTRA         CO_002  = INTTRB
CO_003  = INTTRC         CO_004  = EXTTRA         CO_005  = EXTTRB
CO_006  = EXTTRC         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 QuickSet 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.30*), 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.31*), or NA

- Analog Inputs—Any Analog Input Quantity (see *Analog Inputs on page L.33*) with scaling and/or deadband 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 yields 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 deadband settings. Class scaling (DECPLA, DECPLV, and DECPLM) and deadband (ANADBA, ANADBV, and ANADBM) settings are applied to indices that do not have per-point entries. Per-point scaling and deadband settings override class scaling and deadband settings. 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 A to 11 A. 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 A 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 by 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 by 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 those 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 QuickSet 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  = NA
     ? IA <Enter>

DNP Analog Input Label Name
AI_001  = NA
     ? IB::4 <Enter>

DNP Analog Input Label Name
AI_002  = NA
     ? IC <Enter>

DNP Analog Input Label Name
AI_003  = NA
     ? IN <Enter>

DNP Analog Input Label Name
AI_004  = NA
     ? MW3:5 <Enter>

DNP Analog Input Label Name
AI_005  = NA
     ? VA <Enter>

DNP Analog Input Label Name
AI_006  = NA
     ? VAFA:1:15 <Enter>

DNP Analog Input Label Name
AI_007  = NA
     ? FREQ:0.01:1 <Enter>

DNP Analog Input Label Name
AI_008  = NA
     ? END <Enter>

Save Changes(Y/N)? Y <Enter>

Settings saved
=>>
```

Figure L.4 Sample Custom DNP3 AI Map Settings

You can also use QuickSet to enter the above AI map settings as shown in *Figure L.5*. To enter scaling and deadband setting, double-click the AI point and enter the values in the pop-up dialog, as shown in *Figure L.6*.

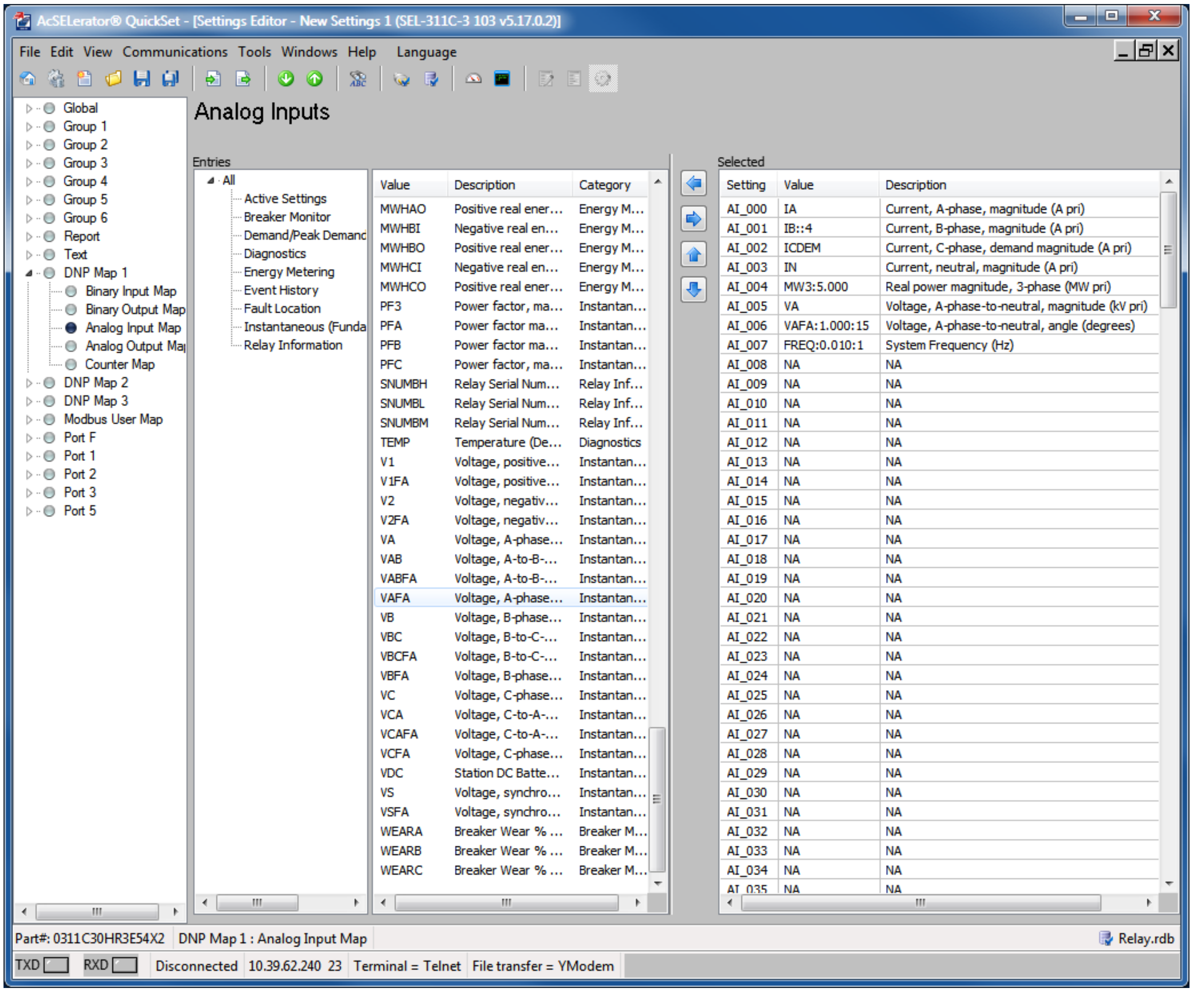

Figure L.5 Analog Input Map Entry in QuickSet Software

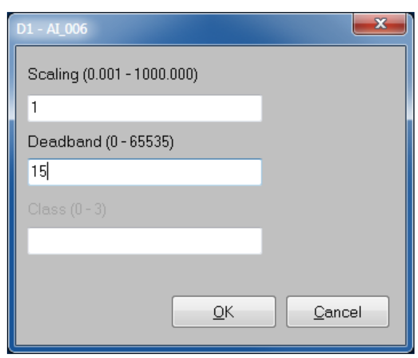

Figure L.6 AI Point Label, Scaling and Deadband in QuickSet Software

The **SET D x CO_000 TERSE <Enter>** command allows you to populate the DNP counter map and adjust the per-point scaling and deadbands 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 32 remote bits (RB1–RB32), breaker bits (OC, CC), data reset bits (DRST_DEM, DRST_PDM, DRST_BK, DRST_HIS, DRST_ENE, DRST_MML, DRST_TAR, DRST_HAL, DRSTDNPE), or the NXTEVE and SINGEVE bits. You can define bit pairs for remote bits or breaker bits in BO maps by including a colon (:) between the bit labels. Paired mode allows the mapping of two remote bits into a single binary output to send trip/close command codes to the same binary output while operating on two separate remote bits in the relay.

```
=>>SET D 1 BO_000 TERSE <Enter>

DNP Map Settings 1

Binary Output Map:
DNP Binary Output Label Name
BO_000  = NA
     ? RB1 <Enter>

DNP Binary Output Label Name
BO_001  = NA
     ? RB2 <Enter>

DNP Binary Output Label Name
BO_002  = NA
     ? RB3:RB4 <Enter>

DNP Binary Output Label Name
BO_003  = NA
     ? RB5:RB6 <Enter>

DNP Binary Output Label Name
BO_004  = NA
     ? END <Enter>

Save Changes(Y/N)? Y <Enter>

Settings saved
=>>
```

Figure L.7 Sample Custom DNP3 BO Map Settings

You can also use QuickSet to enter the BO map settings as shown in *Figure L.8*.

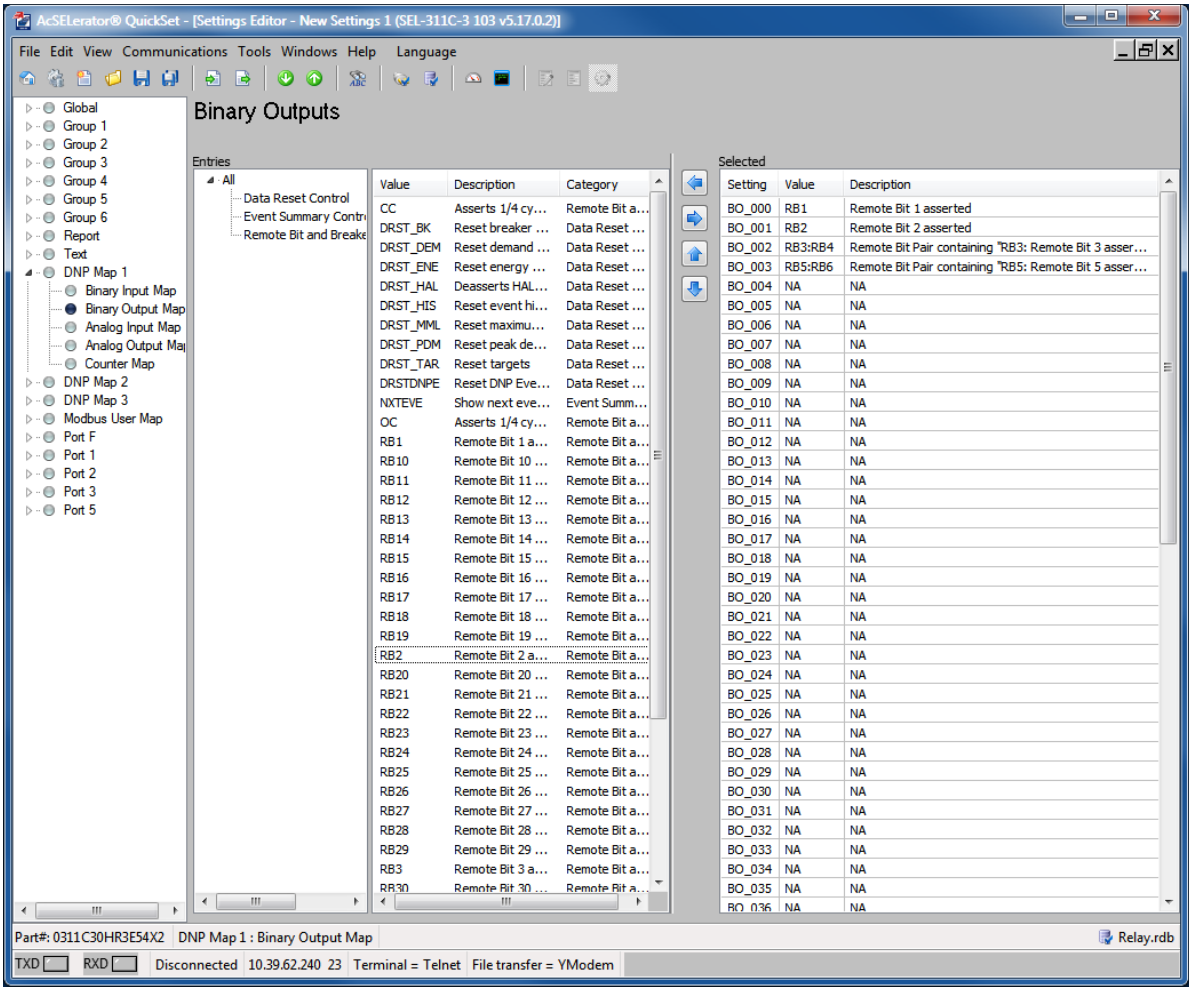

Figure L.8 Binary Output Map Entry in QuickSet Software

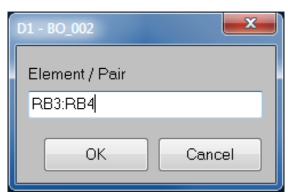

Figure L.9 BO Point Label Entry in QuickSet Software

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.9* and *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.

Binary Outputs

Binary Outputs are supported as defined in *Table L.9* and *Table L.10*. Binary Output status (Object 10 variation 2) is supported. Static reads of points RB1–RB32 respond with the online bit set and the state of the requested bit. Reads of NXTEVE respond with the online bit set and a state of 1 if event summary data are being read in Multiple-Event FIFO mode and a state of 0 otherwise. Reads of SINGEVE respond with the online bit set and a state of 1 when event summary data are being read in Single-Event mode and a state of 0 when Event Summary Data are being read in Multiple-Event mode. Reads from OC, CC, and control-only binary output points (such as the data reset controls DRST_DEM and 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 (CROB) objects (Object 12, Variations 1, 2, and 3) are supported. The control relays correspond to the remote bits and other labels as shown in *Table L.13* through *Table L.16*. The Trip/Close bits take precedence over the control field. CROB operations are not guaranteed to occur during the same processing interval.

Operation of the binary outputs is controlled by the Global settings BOOPTCC and BOOPPUL. BOOPTCC controls how binary outputs respond to Close and Trip operations. BOOPPUL controls how the binary outputs respond to Pulse On operations. Each setting has two choices, SET and PULSE. The response of various outputs for different settings of BOOPTCC and BOOPPUL is shown in *Table L.13* through *Table L.16*. Note that the operation of remote bit and OC:CC pairs is not affected by these settings, nor is the operation of any binary outputs for Latch On and Latch Off operations.

Table L.13 BOOPTCC = PULSE, BOOPPUL = PULSE

Label	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
RBx	Pulse	Pulse	Set	Clear	Pulse	Clear
OC and CC	Pulse	Pulse	Pulse	Do nothing	Pulse	Do Nothing
Resets[a]	Pulse	Pulse	Pulse	Do nothing	Pulse	Do Nothing
NXTEVE	Read Oldest	Read Oldest	Read Oldest	Read Newest	Read Oldest	Read Newest
SINGEVE	Pulse	Pulse	Pulse	Do nothing	Pulse	Do Nothing
RBx:RBy	Pulse RB*y*	Pulse RB*x*	Pulse RB*y*	Pulse RB*x*	Pulse RB*y*	Pulse RB*x*
OC:CC	Pulse CC	Pulse OC	Pulse CC	Pulse OC	Pulse CC	Pulse OC

[a] DRST_DEM, DRST_ENE, DRST_BK, DRST_MML, DRST_HIS, DRST_PDM, DRST_TAR, DRST_HAL, and DRSTDNPE.

Table L.14 BOOPTCC = SET, BOOPPUL = PULSE (Sheet 1 of 2)

Label	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
RBx	Set	Clear	Set	Clear	Pulse	Clear
OC and CC	Pulse	Do Nothing	Pulse	Do nothing	Pulse	Do Nothing
Resets[a]	Pulse	Do Nothing	Pulse	Do nothing	Pulse	Do Nothing
NXTEVE	Read Oldest	Read Newest	Read Oldest	Read Newest	Read Oldest	Read Newest
SINGEVE	Pulse	Do Nothing	Pulse	Do nothing	Pulse	Do Nothing

Table L.14 BOOPTCC = SET, BOOPPUL = PULSE (Sheet 2 of 2)

Label	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
RBx:RBy	Pulse RB*y*	Pulse RB*x*	Pulse RB*y*	Pulse RB*x*	Pulse RB*y*	Pulse RB*x*
OC:CC	Pulse CC	Pulse OC	Pulse CC	Pulse OC	Pulse CC	Pulse OC

[a] DRST_DEM, DRST_ENE, DRST_BK, DRST_MML, DRST_HIS, DRST_PDM, DRST_TAR, DRST_HAL, and DRSTDNPE.

Table L.15 BOOPTCC = PULSE, BOOPPUL = SET

Label	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
RBx	Pulse	Pulse	Set	Clear	Set	Clear
OC and CC	Pulse	Pulse	Pulse	Do nothing	Pulse	Do Nothing
Resets[a]	Pulse	Pulse	Pulse	Do nothing	Pulse	Do Nothing
NXTEVE	Read Oldest	Read Oldest	Read Oldest	Read Newest	Read Oldest	Read Newest
SINGEVE	Pulse	Pulse	Pulse	Do nothing	Pulse	Do Nothing
RBx:RBy	Pulse RB*y*	Pulse RB*x*	Pulse RB*y*	Pulse RB*x*	Pulse RB*y*	Pulse RB*x*
OC:CC	Pulse CC	Pulse OC	Pulse CC	Pulse OC	Pulse CC	Pulse OC

[a] DRST_DEM, DRST_ENE, DRST_BK, DRST_MML, DRST_HIS, DRST_PDM, DRST_TAR, DRST_HAL, and DRSTDNPE.

Table L.16 BOOPTCC = SET, BOOPPUL = SET

Label	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
RBx	Set	Clear	Set	Clear	Set	Clear
OC and CC	Pulse	Do Nothing	Pulse	Do nothing	Pulse	Do Nothing
Resets[a]	Pulse	Do Nothing	Pulse	Do nothing	Pulse	Do Nothing
NXTEVE	Read Oldest	Read Newest	Read Oldest	Read Newest	Read Oldest	Read Newest
SINGEVE	Pulse	Do Nothing	Pulse	Do nothing	Pulse	Do Nothing
RBx:RBy	Pulse RB*y*	Pulse RB*x*	Pulse RB*y*	Pulse RB*x*	Pulse RB*y*	Pulse RB*x*
OC:CC	Pulse CC	Pulse OC	Pulse CC	Pulse OC	Pulse CC	Pulse OC

[a] DRST_DEM, DRST_ENE, DRST_BK, DRST_MML, DRST_HIS, DRST_PDM, DRST_TAR, DRST_HAL, and DRSTDNPE.

The Status field is used exactly as defined. All other fields are ignored. A pulse operation is asserted for a single processing interval. A maximum of ten operations can be performed for a single command. If more than ten operations are attempted, the relay will respond with `Too Many Operations` to each attempt in excess of ten. If the relay is disabled, remote bit operations are not performed. If the relay is disabled or the breaker jumper is not installed, OC and CC operations are not performed.

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 processing interval.

Table L.17 Example Object 12 Trip/Close or Code Selection Operation (BOOPTCC = PULSE and BOOPPUL = PULSE)

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	PULSE RB2	PULSE RB1
RB3	PULSE RB3	PULSE RB3	SET RB3	CLEAR RB3	PULSE RB3	CLEAR RB3
RB4	PULSE RB4	PULSE RB4	SET RB4	CLEAR RB4	PULSE RB4	CLEAR RB4
RB5:RB6	PULSE RB6	PULSE RB5	PULSE RB6	PULSE RB5	PULSE RB6	PULSE RB5
RB7	PULSE RB7	PULSE RB7	SET RB7	CLEAR RB7	PULSE RB7	CLEAR RB7
RB8	PULSE RB8	PULSE RB8	SET RB8	CLEAR RB8	PULSE RB8	CLEAR RB8
RB14:RB15	PULSE RB15	PULSE RB14	PULSE RB15	PULSE RB14	PULSE RB15	PULSE RB14
RB18:RB21	PULSE RB21	PULSE RB18	PULSE RB21	PULSE RB18	PULSE RB21	PULSE RB18

Counter Inputs

Counters (Object 20) and Counter Change Events (Object 22) are supported as defined in *Table L.9* and *Table L.10*. Supported variations are shown in *Table L.9*. Event class messages are generated whenever a counter changes beyond the value given by the appropriate deadband setting. For example, with a deadband of 1 and a starting value of 5, when the counter changes from 5 to 6, no event will be generated. When the value changes from 6 to 7, an event will be generated and the new starting value will be 7. The default counter deadband setting is 0. A per-point deadband can be applied to a counter object by adding the deadband after the object label in the DNP map (i.e., INTTR:2). The per-point deadband overrides the default deadband. Counters are scanned at approximately a one-second rate and are time-stamped with the time the scan was initiated.

Analog Inputs

Analog Inputs (Object 30) and Analog Change Events (Object 32) are supported as defined in *Table L.9* and *Table L.10*, with the default variation based on the Serial Port setting DVARAI and the Ethernet port setting DVARAI*n*, where *n* denotes the Ethernet session being used. 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 deadbands. A deadband 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 deadband setting. 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, FUNR, FZ, FZFA, FR, and FM. These quantities, also referred to as the DNP relay event registers, generate DNP3 analog change events (Object 32). Because these DNP relay event registers refer to the same event summary record, the relay creates analog change events for all of these DNP relay event registers when any one of the registers exceeds its deadband. 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 FTYPE is a 16-bit composite value where the upper byte value indicates an event cause as shown in *Table L.18* and the lower byte indicates a fault type as shown in *Table L.19*. The upper and lower byte will be the sum of the applicable event cause and fault types. For example, a FTYPE value of 3079 decimal would translate to 0C07 hex, and indicate a Trip and an ER element Event Cause (4 + 8 = 12 or 0C hex) on A-phase, B-phase, and C-phase (1 + 2 + 4 = 7 or 07 hex). If input FTYPE is 0, fault information has not yet been read and the fault analog inputs do not contain valid event data.

Table L.18 Fault Type Upper Byte: Event Cause

Value	Event Cause
1	Trigger command
2	Pulse command
4	Trip element
8	ER element

Table L.19 Fault Type Lower Byte: Fault Type

Value	Fault Type
0	Indeterminate
1	A Phase
2	B Phase
4	C Phase
8	Ground

In some instances, the values in the FTIME*x* registers and FTYPE register may contain a value greater than 32767, which can be read correctly using Object 30, Variation 1 or 3 (32-bit value). However, some DNP masters cannot read a 32-bit value, so the 16-bit variations (2 and 4) clamp the value and Variation 2 reports an over-range flag. FTYPE16, FTIMEH16, FTIMEM16, and FTIMEL16 contain a 16-bit signed value that can be read using Variation 2 or 4. The FTIME*x* 16 and FTYPE16 registers contain the FTIME*x* or FTYPE value minus 65536 if the value is greater than 32767. The value is reported as a negative number without an over-range flag.

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. 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. *Event Data on page L.33* describes the analog DNP relay event registers that are updated for the most recently read event from the event history. When in single-event mode, the relay makes event data available in the DNP relay event registers as described in *Single-Event Mode on page L.36*. When in multiple-event mode, the relay makes event data available in the DNP relay event registers as described in *Multiple-Event Mode on page L.36*.

Each DNP session starts up in the mode specified by Port setting EVEMODE when the relay turns on, when there is a DNP port settings change, a DNP map change, or a SER settings change. When EVEMODE = SINGLE, the relay starts up in single-event mode. When EVEMODE = MULTI, the relay starts up in multiple-event mode.

The reporting method can also be changed by asserting a binary output control point. The relay changes to multiple-event mode on a per-session basis if the NXTEVE control point is operated on. The relay changes to single-event mode on a per-session basis if the SINGEVE control point is operated on. A relay turning on, a DNP port settings change, a DNP map change, or an SER settings change returns the reporting method to the mode specified by EVEMODE. When switching from multiple-event mode to single-event mode, the DNP relay event registers are set to zero.

For single-event mode, all registers except FUNR update when a new event occurs. 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 DNP relay 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 because FUNR does not update for single-event mode. If changes are detected in the analog DNP relay event registers, the DNP3 master should latch on or latch off NXTEVE to put the relay into multiple-event mode.

Event summary data are only generated for events that have occurred since the last time the relay turned on, within the limits of the DNP event buffer. Upon an initial switch from single-event mode to multiple-event mode, all existing events since the relay turned on are considered unread. Once an event is read via FIFO, it is no longer available via LIFO and vice-versa. FIFO and LIFO are discussed in *Multiple-Event Mode on page L.36*. The user cannot traverse event summaries forward, then backwards. After the initial switch from single-event mode to multiple-event mode, when switching to single-event mode by operating SINGEVE, the DNP relay event registers are set to zero but the DNP event buffer is not reset. For example, if the relay is in single-event mode, three events occur, and the relay is switched to multiple-event mode by latching on NXTEVE, a read of the analog DNP relay event registers will show data for the oldest event and FUNR will be equal to 2. If the relay is switched to single-event mode by operating SINGEVE, a read of the analog DNP relay event registers will show that they are all zero but the DNP event buffer will still contain two unread events. This can be seen by latching on NXTEVE to switch back to multiple-event mode. Once in multiple-event mode, a read of the analog DNP relay event registers will show data for the oldest event and FUNR will be equal to 1, indicating that there is still one unread event in the DNP event buffer. Note that the switching between modes is not normal behavior for a DNP master and is only discussed here to illustrate the DNP event buffer functionality when switching modes.

Port setting RPEVTYP controls the type of events that are reported to the relay DNP event summary. When Port setting RPEVTYP = TRIP, only TRIP events are reported in the DNP event summary data. When Port setting RPEVTYP = ALL, all events are reported in the DNP event summary data.

The Port settings MINDIST and MAXDIST can be used to limit fault summary data to only data within a certain fault distance. If MINDIST and MAXDIST are set to a numeric value, DNP events will only be generated when the fault location is within these setting values. If MINDIST is set to OFF, there is no lower limit for the fault location distance. If MAXDIST is set to OFF, there is no upper limit for the fault location distance. If the fault location is undetermined, the event is displayed regardless of the MINDIST and MAXDIST settings but is constrained by the RPEVTYP setting.

SELOGIC control equation RSTDNPE is used to clear the DNP relay event registers and the DNP event buffer for both single-event mode and multiple-event mode for all DNP sessions. When RSTDNPE is evaluated to one, the DNP relay event registers are set to zero and the DNP event buffer is cleared. The DNP binary output DRSTDNPE is similar in function to RSTDNPE and can also be used to clear the DNP relay event registers and the DNP event buffer when the relay is in single-event mode or multiple-event mode on a per-session basis.

Single-Event Mode

Single-event mode provides the most recent event report summary data as they occur in the relay. When a new event report is triggered (TRIP, ER assert, TRI, etc.), the new event data are stored in DNP relay event registers as long as the Port settings RPEVTYP, MINDIST, and MAXDIST criteria are satisfied. When the DNP relay event registers are updated, a DNP3 event is generated. The event report summary values are locked into the DNP relay 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 DNP relay event registers to be updated as soon as a new event report is triggered. EVELOCK has no effect 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 are 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 are transferred to the DNP relay event registers. To check for more available unread event summary data, read the UNRDEV binary input. If UNRDEV is asserted, then more event data exist. 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 analog event data registers to zero.

When the session DNP3 master sends a latch-off control to NXTEVE, the newest unread event summary data are transferred to the DNP relay event registers. To check for more available unread event summary data, read the UNRDEV binary input. If UNRDEV is asserted, then more event data exist. 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 newest 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 D n Command)

Use **SET D *n*** command with *n* = 1, 2, or 3 to create as many as three DNP User Maps. Refer to *Default Data Map on page L.21* 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**	=______________
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Binary Output Map

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DNP Binary Output Label Name	**BO_070**	=______________

Analog Input Map

Entry format for Analog Inputs: Analog Label [: optional scaling factor 0.001–1000 : optional deadband 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**	=______________
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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**	=_______________

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 10.7*.

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 when the relay turns on. 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 (as long as 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.

Table M.3 Function Code 18 Message Format (Sheet 2 of 2)

Data	Description
FFFFFFFE	Four-byte end-of-records flag
ssssssss	Packed four-byte element status for as many as 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 is due to the relay turning on. 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 as many as 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:

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.17*.

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 are available on multiple serial ports when the port setting PROTO = SEL. When MFRMT = C37.118, IEEE C37.118 compliant synchrophasor data are 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.17*.

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.6*. 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.

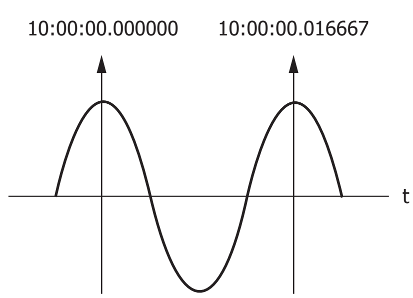

Figure N.1 High-Accuracy Clock Controls Reference Signal (60 Hz System)

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.

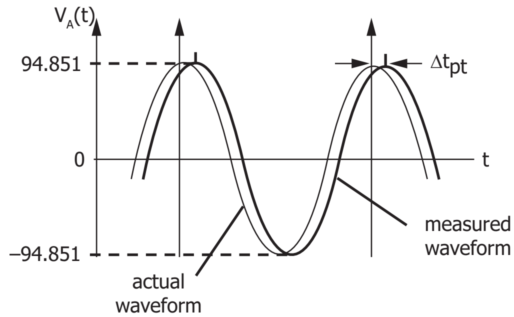

Figure N.2 Waveform at Relay Terminals May Have Phase Shift

$$\text{Compensation Angle} = \frac{\Delta t_{pt}}{\left(\frac{1}{\text{freq}}\right)} \bullet 360° = \Delta t_{pt} \bullet \text{freq} \bullet 360°$$

Equation N.1

If the time shift on the pt measurement path Δt_{pt} = 0.784 ms and the nominal frequency, $\text{freq}_{\text{nominal}}$ = 60Hz, use *Equation N.2* to obtain the correction angle:

$$0.784 \bullet 10^{-3}\text{s} \bullet 60\text{s}^{-1} \bullet 360° = 16.934°$$

Equation N.2

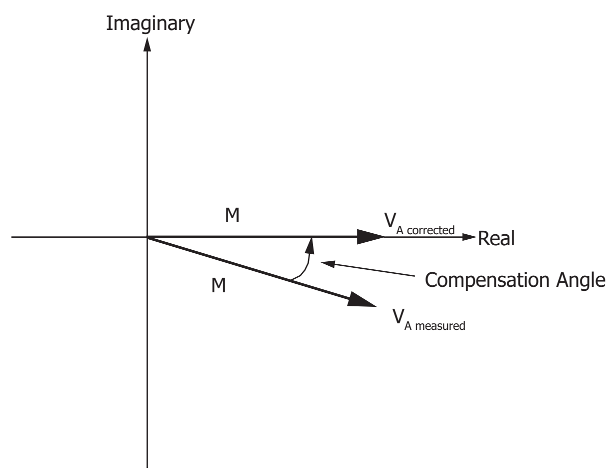

Figure N.3 Correction of Measured Phase Angle

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.

$$\text{Magnitude M} = \frac{V_{pk}}{\sqrt{2}} \bullet \text{PTR}_{\text{setting}}$$

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 by 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*.

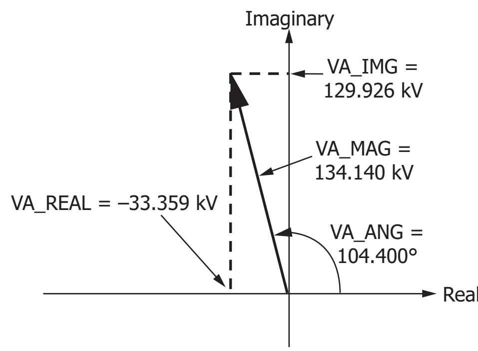

Figure N.4 Example Calculation of Real and Imaginary Components of Synchrophasor

$$\text{Real part} = \text{M} \bullet \cos(\text{angle})$$

Equation N.5

$$\text{Imaginary part} = \text{M} \bullet \sin(\text{angle})$$

Equation N.6

Using the magnitude M from *Equation N.5*, the real part is given in *Equation N.7*.

$$\begin{aligned} \text{VA\_REAL} &= 134.140 \text{ kV} \bullet \cos 104.400° \\ &= -33.359 \text{ kV} \end{aligned}$$

Equation N.7

Similarly, the imaginary part is calculated in *Equation N.8*

$$\begin{aligned} \text{VA\_IMG} &= 134.140 \text{ kV} \bullet \sin 104.400° \\ &= 129.926 \text{ kV} \end{aligned}$$

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.21*).

Table N.1 PMU Settings in the SEL-311C (Global Settings)

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, mixed case)	STATION A
PMID	PMU Hardware ID (1–65534)	1
PHDATAV	Phasor Data Set, Voltages (V1, PH, ALL, NA)	V1
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.20.
[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 control equation)	0
TREA2	Trigger Reason Bit 2 (SELOGIC control equation)	0
TREA3	Trigger Reason Bit 3 (SELOGIC control equation)	0
TREA4	Trigger Reason Bit 4 (SELOGIC control equation)	0
PMTRIG	Trigger (SELOGIC control 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.15* 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.15* for detailed information.

- PHDATAV = V1 will transmit only positive-sequence voltage, V_1
- PHDATAV = PH will transmit VA, VB, and VC
- PHDATAV = ALL will transmit V1, VA, VB, VC, and VS
- 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.15* 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]	Channel Name
A-Phase Current	CTR	IAPM
B-Phase Current	CTR	IBPM
C-Phase Current	CTR	ICPM
Neutral Current	CTRN	INPM
A-Phase Voltage	PTR	VAPM
B-Phase Voltage	PTR	VBPM
C-Phase Voltage	PTR	VCPM
VS Input Voltage	PTRS	VSPM
Positive-Sequence Current	CTR	I1PM
Positive-Sequence Voltage	PTR	V1PM

[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.

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.15* 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 root-mean-square (rms) 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.15* 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:

$$(\text{FREQ}_{\text{measured}} - \text{NFREQ}) \bullet 1000,$$

represented as a signed, two-byte value.

Setting FNR = I also sends the rate-of-change of frequency data with scaling.

$$\text{DFDT}_{\text{measured}} \bullet 100,$$

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.15* 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, because VS channel synchrophasors are IEEE C37.118 Level 1 compliant only when the frequency is the same as the A-phase 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.19* 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 control equations.

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 (0, 1, B, 2, C)	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.30.

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.

Descriptions of Ethernet Synchrophasor Settings

Definitions for some of the settings in *Table N.5* are as follows.

EPMIP

Setting this to Y enables synchrophasor data transmission over Ethernet port. Setting this to N disables the synchrophasor data transmission over Ethernet port.

Ethernet port setting EPMIP 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.

PMOTS1 and PMOTS2

Selects the PMU Output transport scheme for Session 1 and 2, respectively.

➤ PMOTS*n* := TCP establishes a single, persistent TCP socket for transmitting and receiving synchrophasor messages (both commands and data), as illustrated in *Figure N.5*.

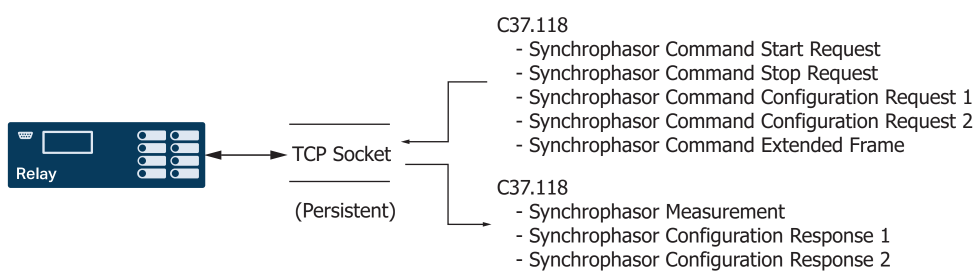

Figure N.5 TCP Connection

➤ PMOTS*n* := UDP_T establishes two socket connections. A nonpersistent TCP connection is used for receiving synchrophasor command messages as well as transmitting synchrophasor configuration messages. A persistent UDP socket is used to transmit synchrophasor data messages. *Figure N.6* depicts the UDP_T connection.

➤ PMOTS*n* := UDP_U uses the same connection scheme as the UDP_T except the synchrophasor configuration messages are sent over the UDP socket, as shown in *Figure N.6*.

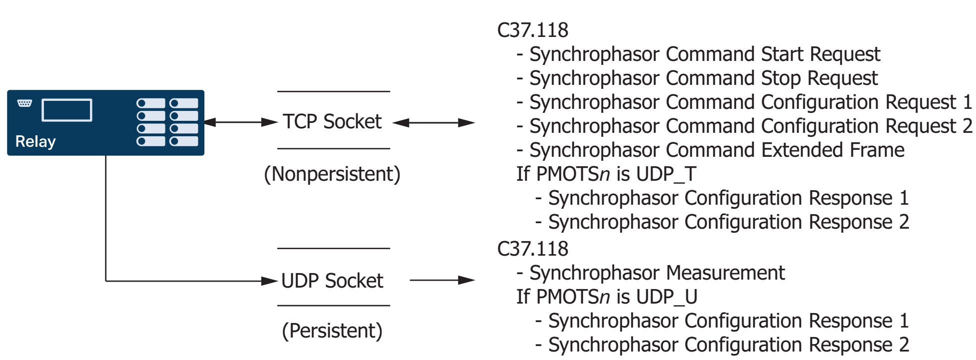

Figure N.6 UDP_T and UDP_U Connections

➤ PMOTS*n* := UDP_S establishes a single persistent UDP socket to transmit synchrophasor messages. Synchrophasor data are transmitted whenever new data are read. With this communication scheme, the relay sends a `Synchrophasor Configuration Response 2` once every minute, as shown in *Figure N.7*.

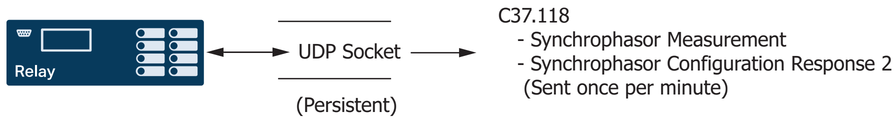

Figure N.7 UDP_S Connection

PMOIPA1 and PMOIPA2

Defines the PMU Output Client IP address for Session 1 and 2, respectively.

PMOTCP1 and PMOTCP2

Defines the TCP/IP (Local) port number for Session 1 and 2, respectively. These port numbers, as well as all servers running on the relay, must have unique local port numbers.

PMOUDP1 and PMOUDP2

Defines the UDP/IP (Remote) port number for Session 1 and 2, respectively.

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 section 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 control equations TREA1, TREA2, TREA3, and TREA4, and the trigger SELOGIC control equation result PMTRIG, in the synchrophasor message.

Table N.6 C37.118 Data Frame (Sheet 1 of 2)

Field	Size (Bytes)	Description
SYNC	2	Bits 15 to 8—0xAA Bit 7—Reserved Always set to 0 Bits 6 to 4—Frame identifier 000 for data frames 001 for header frames 010 for configuration 1 frames 011 for configuration 2 frames 100 for command frames Bits 3 to 0—Version of synchrophasor spec, set to 001
FRAMESIZE	2	Number of bytes in frame, 16-bit unsigned integer
IDCODE	2	PMID setting, 16-bit unsigned integer
SOC	4	Time stamp, 32 bit unsigned second of century from January 1, 1970
FRACSEC	4	Bit 31—Reserved. Always set to 0 Bit 30—Leap second direction, 0 for add, 1 for delete Bit 29—Leap second occurred. Set on the falling edge of leap second pending bit (LPSECP) if TIRIG = 1. Once set, Bit 29 remains set for 24 hours. Bit 28—Leap second pending. Follows LPSECP Bits 27 to 24—Time quality flags. TQUAL1–TQUAL4 Bits 23 to 0—Fractions of a second 16777215 * Message index for current second/ MRATE
STAT	2	Bit 15—Data Valid. Always set to 0 Bit 14—PMU error flag. Follows !PMDOK Bit 13—PMU Sync flag. Follows !TSOK Bit 12—Data sorting flag. Always set to 0. Bit 11—PMU trigger detected flag. Follows PMTRIG Bit 10—Configuration changed flag Bits 9 to 6—Reserved. Always set to 0 Bits 5 and 4—Time error 00 = best quality, synchronized. TSOK = 1 or TSOK = 0 for 10 seconds or less 01 = TSOK = 0 for 10 seconds to not more than 100 seconds 10 = TSOK = 0 for 100 seconds but less than 1000 seconds 11 = TSOK = 0 for 1000 seconds or longer Bits 3 to 0—Trigger reason Bit 3 follows TREA4 Bit 2 follows TREA3 Bit 1 follows TREA2 Bit 0 follows TREA1
PHASORS	See *Table N.3* and *Table N.7*	Phasor data
FREQ	2 or 4	(Measured Frequency – NFREQ) * 100 if FNR = INT, Measured Frequency if FNR = FLOAT
DFREQ	2 or 4	Rate-of-change of frequency * 100 if FNR = INT, Rate-of-change of frequency if FNR = FLOAT
ANALOG	0	No analog data are transmitted

Table N.6 C37.118 Data Frame (Sheet 2 of 2)

Field	Size (Bytes)	Description
DIGITAL	0 or 2	2 * NUMDSW
CHK	2	

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.7* can be used to calculate the number of bytes in a synchrophasor message.

Table N.7 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.8 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.8 Serial Port Bandwidth for Synchrophasors (in Bytes) (Sheet 1 of 2)

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

Table N.8 Serial Port Bandwidth for Synchrophasors (in Bytes) (Sheet 2 of 2)

Global Setting MRATE	Port Setting SPEED							
	300	1200	2400	4800	9600	19200	38400	57600
50 (50 Hz only)						33	66	99
60 (60 Hz only)						27	55	82

Referring to *Table N.7* and *Table N.8*, it is clear that the lower SPEED settings are very restrictive.

The smallest practical synchrophasor message would consist 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, as much as MRATE = 50 or 30 when SPEED = 19200, or MRATE = 25 or 20 when SPEED = 9600.

Another example application has messages consisting 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 as much as MRATE = 25 or 30 when SPEED = 57600, MRATE = 20 or 25 when SPEED = 38400, and 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.9 and *Table N.10* list the SEL-311C Relay Word bits that are related to synchrophasor measurement.

The synchrophasor Trigger Relay Word bits in *Table N.9* 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.9 Synchrophasor Trigger Relay Word Bits

Name	Description
PMTRIG	Trigger (SELOGIC control equation).
TREA4	Trigger Reason Bit 4 (SELOGIC control equation)
TREA3	Trigger Reason Bit 3 (SELOGIC control equation)
TREA2	Trigger Reason Bit 2 (SELOGIC control equation)
TREA1	Trigger Reason Bit 1 (SELOGIC control equation)

The time-synchronization Relay Word bits in *Table N.10* indicate the present status of the high-accuracy timekeeping function of the SEL-311C. See *Configuring High-Accuracy Timekeeping on page N.26*.

Table N.10 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 frequency is 40–65 Hz, 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 10.52* 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, 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.8* shows a sample **MET PM** command response. The synchrophasor data are also available in the QuickSet HMI and have a similar format to *Figure N.8*.

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.8* 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 10.56* for complete command options, and error messages.

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.8*. After 14:14, connect to each relay, issue the **MET PM HIS** command, and capture the results. Because **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.8 Sample MET PM Command Response

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-3373 Station Phasor Data Concentrator (PDC) 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 are being used for system monitoring.

The protection settings will not be shown.

Determining Settings

The protection engineer performs a bandwidth check, using *Table N.7*, and determines the required message size. The system requirements, in order of appearance in *Table N.7*, 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.8*, the engineer verifies that the port baud of 19200 is adequate for the message, at 10 messages per second.

The Protection SELOGIC control equation 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.11*.

Table N.11 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, mixed case)	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.12 Example Synchrophasor Logic Settings

Logic Setting	Description	Value
TREA1	Trigger Reason Bit 1 (SELOGIC control equation)	NA
TREA2	Trigger Reason Bit 2 (SELOGIC control equation)	NA
TREA3	Trigger Reason Bit 3 (SELOGIC control equation)	NA
TREA4	Trigger Reason Bit 4 (SELOGIC control equation)	NA
PMTRIG	Trigger (SELOGIC control equation)	NA

The three Relay Word bits required in this example must be placed in certain SELOGIC control equation variables. Make the settings in *Table N.13* in all six setting groups.

Table N.13 Example Synchrophasor SELOGIC Control Equation Settings

Setting	Value
SV14	52A
SV15	LOP
SV16	FREQOK

Make the *Table N.14* settings for Serial Port 3, using the **SET P 3** command.

Table N.14 Example Synchrophasor Port Settings

Setting	Description	Value
EPORT	Enable Port (Y, N)	Y
MAXACC	Maximum Access Level (0, 1, B, 2, C)	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

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.21* 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.15 lists the Synchrophasor Fast Message Write function codes and the actions the relay takes in response to each command.

Table N.15 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.16–Table N.18 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.16 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.21.
[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.21.

Table N.17 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.19 for permissible data message period values.

Table N.18 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 acknowledgment 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.19* 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.19 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.20*. Many of these settings are identical to the settings for the C37.118 format.

Table N.20 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.
[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.20* 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.21*.

- 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.21 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.21*.

- 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.21 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 14 user-programmable SELOGIC control equation variables SV3–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.21* 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.21* 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.21 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 by using the high-accuracy time stamp (see *Synchrophasor-Level Accuracy in Event Reports on page 12.15*).

IRIG-B

IRIG Standard 200-04 defines many different types of time-code formats. IRIG-B002, or "standard IRIG-B" provides time data once per second. The time data are formatted as second of the minute, minute of the hour, hour of the day, and day of the year. IRIG-B000, or extended IRIG-B, adds control functions that are defined based on the application. In this manual, IRIG-B000 is used to identify a time signal containing the control functions defined by IEEE C37.118 Standard for Synchrophasors for Power Systems. These control functions include the year, leap second, and daylight-saving time information, UTC offset, time quality indicator codes, and a parity bit.

In a standard shipment, the SEL-311C has two input connectors that accept IRIG-B demodulated time-code format: the IRIG-B pins of Serial Port 2, and the IRIG-B BNC connector. The optional SEL-2812 compatible fiber port can also provide an IRIG-B signal if connected to a fiber-optic transceiver that transmits IRIG-B or the fiber-optic port of an SEL-2407 clock.

The BNC and Port 2 connections can be used for high-accuracy timekeeping purposes, with as much as 1 µs accuracy with an appropriate time source. Any of the three inputs can be used for general purpose timekeeping, and the relay will have as much as 5 ms accuracy. The SEL-2812-compatible fiber-optic port is not suitable for high-accuracy timekeeping. See *Table N.22* for SEL-311C timekeeping mode details.

Table N.22 SEL-311C Timekeeping Modes

Item	Internal Clock	Normal Accuracy IRIG	Holdover	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), Serial Port 2, or fiber-optic Serial Port 1		BNC connector (preferred) or Serial Port 2
Relay Word bits	TIRIG = logical 0 TSOK = logical 0	TIRIG = logical 1 TSOK = logical 0	TIRIG = logical 0 TSOK = logical 1	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 a higher priority source degrades in quality, the SEL-311C will not switch over to a lower priority source. The SEL-311C will only switch to Serial Port 2 or fiber-optic Serial Port 1 if the signal on the higher priority source completely fails (e.g., the cable is unplugged). Use the **TIME Q** command to determine which IRIG-B source is in use.

Only one IRIG-B time source can be used by the SEL-311C. The relay uses IRIG-B signals from the three sources with the following priority.

1. BNC input
2. Serial Port 2 IRIG-B pins
3. SEL-2812 compatible fiber-optic Port 1 (if present)

The SEL-311C determines the suitability of the IRIG-B signal for Normal Accuracy IRIG by applying several tests.

- Seconds, minutes, and day field are in range
- Time from two consecutive messages differ by 1 second, except for leap second or daylight-saving time transitions.
- When IRIGC = C37.118, the signal contains the correct parity bit.

The SEL-311C determines the suitability of the IRIG-B signal for high-accuracy timekeeping by applying two additional tests.

- ➤ The jitter between positive-transitions (rising edges) of the clock signal is less than 500 ns.
- ➤ The time-error information contained in the IRIG-B control field indicates time error 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 only the first test is met.

The relay accepts C37.118 (IRIG-B000) signals with either odd or even parity. When an IRIG-B signal is connected, the relay detects whether the signal has odd or even parity and continues to check received IRIG-B messages for that parity. If a message is received with the opposite parity or no parity, the signal fails the parity test.

If your clock has programmable parity and the parity is changed, the relay disqualifies the IRIG-B signal for a few seconds until it detects that the parity change is not because of corrupt messages.

If the relay is in High Accuracy mode and any of the tests fail, the relay enters Holdover mode. When in Holdover, the relay asserts TSOK, deasserts TIRIG, and holds Relay Word bits TQUAL1, TQUAL2, TQUAL3, and TQUAL4 at their last state. The relay remains in Holdover mode for as long as 15 seconds and reverts to High Accuracy IRIG, Normal Accuracy IRIG, or internal clock, depending on conditions.

If you connect two IRIG-B sources, they should be of the same format (IRIG-B000 with C37.118 control extensions or IRIG-B002) and match the IRIGC setting. SEL does not recommend connecting different types of signals to different inputs (for example, an IRIG-B000 signal to the BNC input and an IRIG-B002 signal to Port 1 or Port 2) when IRIGC = C37.118. The IRIG-B002 signal provides neither the year nor the parity bit required for Normal Accuracy mode when IRIGC = C37.118. In this case, if the IRIG-B000 source fails, relay timekeeping reverts to the internal clock, but the relay year changes to 2000 and remains incorrect until the IRIG-B000 signal returns. The relay will update the time from the IRIG-B002 signal about once every 10 seconds if the signal passes the remaining two tests for Normal Accuracy mode. Relay Word bit TIRIG asserts momentarily during the update.

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.23 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.

See *Table N.24* for time quality decoding. 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.

Table N.24 Time Quality Decoding

TQUAL	Time Quality	TQUAL	Time Quality
0000	Locked	1000	10 milliseconds
0001	1 nanosecond	1001	100 milliseconds
0010	10 nanoseconds	1010	1 second
0011	100 nanoseconds	1011	10 seconds
0100	1 microsecond	1100	100 seconds
0101	10 microseconds	1101	1000 seconds
0110	100 microseconds	1110	10,000 seconds
0111	1 millisecond	1111	Fault

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.

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.9*. Only the state of the TIRIG and TSOK Relay Word bits are discussed in the following troubleshooting steps.

```
=>TAR TIRIG <Enter>

MAB4     MBC4     MCA4     MAG4     MBG4     MCG4     TSOK     TIRIG
0        0        0        0        0        0        1        1
=>
```

Figure N.9 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 the 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 control equation 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.

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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 modbus.org.

The SEL-311C allows as many as 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 because 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 by 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 PROTO setting.

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 the 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.

Function Codes

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 toward 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 zeros 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

02h 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 toward 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

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

To build the response, the 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 zeros 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.

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
Address 15 = TLED19
Address 14 = TLED20
Address 13 = TLED21
Address 12 = TLED22
Address 11 = TLED23
Address 10 = TLED24
Address 9 = TLED25
Address 8 = TLED26

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
0–7	0–7	2	Relay Element Status Row 0
8–15	8–F	2	Relay Element Status Row 1

Table O.7 O2h SEL-311C Inputs[a] (Sheet 2 of 4)

Discrete Input Address in Decimal	Discrete Input Address in Hex	Function Code Supported	Discrete Address Description
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
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

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
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
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

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
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
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
800–807	320–327	2	Relay Element Status Row 100
808–815	328–32F	2	Relay Element Status Row 101
816–823	330–337	2	Relay Element Status Row 102
824–831	338–33F	2	Relay Element Status Row 103
832–839	340–347	2	Relay Element Status Row 104
840–847	348–34F	2	Relay Element Status Row 105
848–855	350–357	2	Relay Element Status Row 106
856–863	358–35F	2	Relay Element Status Row 107
864–871	360–367	2	Relay Element Status Row 108
872–879	368–36F	2	Relay Element Status Row 109
880–887	370–377	2	Relay Element Status Row 110

[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 *Configurable Register Mapping on page O.18*) to configure the map by 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.

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 *Configurable Register Mapping on page O.18*) to configure the map by 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.

Table O.11 04h Read Input Register Command (Sheet 1 of 2)

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*)

Table O.11 04h Read Input Register Command (Sheet 2 of 2)

Bytes	Field
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

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

Table O.14 lists the coil numbers supported by the SEL-311C. The physical coils (coils 00–23) are self-resetting. Pulsing a remote bit (decimal address 64 through 79 and 128 through 143), which is already set, 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 6)

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description	Coil Function	Duration
0	0	1, 5	OUT101[a]	Pulse	1 second
1	1	1, 5	OUT102[a]	Pulse	1 second
2	2	1, 5	OUT103[a]	Pulse	1 second
3	3	1, 5	OUT104[a]	Pulse	1 second
4	4	1, 5	OUT105[a]	Pulse	1 second
5	5	1, 5	OUT106[a]	Pulse	1 second
6	6	1, 5	OUT107[a]	Pulse	1 second
7	7	1, 5	ALRMOUT[b]	Pulse	1 second
8	8	1, 5	Reserved		
9	9	1, 5	Reserved		
10	A	1, 5	Reserved		
11	B	1, 5	Reserved		

Table O.14 01h, 05h SEL-311C Output Coils (Sheet 2 of 6)

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description	Coil Function	Duration
12	C	1, 5	OUT201[a, c]	Pulse	1 second
13	D	1, 5	OUT202[a, c]	Pulse	1 second
14	E	1, 5	OUT203[a, c]	Pulse	1 second
15	F	1, 5	OUT204[a, c]	Pulse	1 second
16	10	1, 5	OUT205[a, c]	Pulse	1 second
17	11	1, 5	OUT206[a, c]	Pulse	1 second
18	12	1, 5	OUT207[a, c]	Pulse	1 second
19	13	1, 5	OUT208[a, c]	Pulse	1 second
20	14	1, 5	OUT209[a, c]	Pulse	1 second
21	15	1, 5	OUT210[a, c]	Pulse	1 second
22	16	1, 5	OUT211[a, c]	Pulse	1 second
23	17	1, 5	OUT212[a, c]	Pulse	1 second
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	

Table O.14 01h, 05h SEL-311C Output Coils (Sheet 3 of 6)

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description	Coil Function	Duration
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	
63	3F	1, 5	RB16	Set/Clear	
64	40	1, 5	RB1	Pulse[d]	1 SELOGIC Processing Interval
65	41	1, 5	RB2	Pulse[d]	1 SELOGIC Processing Interval
66	42	1, 5	RB3	Pulse[d]	1 SELOGIC Processing Interval
67	43	1, 5	RB4	Pulse[d]	1 SELOGIC Processing Interval
68	44	1, 5	RB5	Pulse[d]	1 SELOGIC Processing Interval
69	45	1, 5	RB6	Pulse[d]	1 SELOGIC Processing Interval
70	46	1, 5	RB7	Pulse[d]	1 SELOGIC Processing Interval
71	47	1, 5	RB8	Pulse[d]	1 SELOGIC Processing Interval
72	48	1, 5	RB9	Pulse[d]	1 SELOGIC Processing Interval
73	49	1, 5	RB10	Pulse[d]	1 SELOGIC Processing Interval
74	4A	1, 5	RB11	Pulse[d]	1 SELOGIC Processing Interval
75	4B	1, 5	RB12	Pulse[d]	1 SELOGIC Processing Interval

Table O.14 01h, 05h SEL-311C Output Coils (Sheet 4 of 6)

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description	Coil Function	Duration
76	4C	1, 5	RB13	Pulse[d]	1 SELOGIC Processing Interval
77	4D	1, 5	RB14	Pulse[d]	1 SELOGIC Processing Interval
78	4E	1, 5	RB15	Pulse[d]	1 SELOGIC Processing Interval
79	4F	1, 5	RB16	Pulse[d]	1 SELOGIC Processing Interval
80	50	1, 5	Reserved		
81	51	1, 5	Reserved		
82	52	1, 5	Reserved		
83	53	1, 5	Reserved		
84	54	1, 5	Breaker Open (Relay Word bit OC)	Pulse[e]	1 SELOGIC Processing Interval
85	55	1, 5	Breaker Close (Relay Word bit CC)	Pulse[e]	1 SELOGIC Processing Interval
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	Reset Hard-ware Alarm	Pulse	
96	60	1, 5	Reserved		
97	61	1, 5	Reserved		
98	62	1, 5	Reserved		
99	63	1, 5	Reserved		
100	64	1, 5	Reserved		
101	65	1, 5	Reserved		
102	66	1, 5	Reserved		

Table O.14 01h, 05h SEL-311C Output Coils (Sheet 5 of 6)

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description	Coil Function	Duration
103	67	1, 5	Reserved		
104	68	1, 5	Reserved		
105	69	1, 5	Reserved		
106	6A	1, 5	Reserved		
107	6B	1, 5	Reserved		
108	6C	1, 5	Reserved		
109	6D	1, 5	Reserved		
110	6E	1, 5	Reserved		
111	6F	1, 5	Reserved		
112	70	1, 5	RB17	Set/Clear	
113	71	1, 5	RB18	Set/Clear	
114	72	1, 5	RB19	Set/Clear	
115	73	1, 5	RB20	Set/Clear	
116	74	1, 5	RB21	Set/Clear	
117	75	1, 5	RB22	Set/Clear	
118	76	1, 5	RB23	Set/Clear	
119	77	1, 5	RB24	Set/Clear	
120	78	1, 5	RB25	Set/Clear	
121	79	1, 5	RB26	Set/Clear	
122	7A	1, 5	RB27	Set/Clear	
123	7B	1, 5	RB28	Set/Clear	
124	7C	1, 5	RB29	Set/Clear	
125	7D	1, 5	RB30	Set/Clear	
126	7E	1, 5	RB31	Set/Clear	
127	7F	1, 5	RB32	Set/Clear	
128	80	1, 5	RB17	Pulse[d]	1 SELOGIC Processing Interval
129	81	1, 5	RB18	Pulse[d]	1 SELOGIC Processing Interval
130	82	1, 5	RB19	Pulse[d]	1 SELOGIC Processing Interval
131	83	1, 5	RB20	Pulse[d]	1 SELOGIC Processing Interval
132	84	1, 5	RB21	Pulse[d]	1 SELOGIC Processing Interval
133	85	1, 5	RB22	Pulse[d]	1 SELOGIC Processing Interval

Table O.14 01h, 05h SEL-311C Output Coils (Sheet 6 of 6)

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description	Coil Function	Duration
134	86	1, 5	RB23	Pulse[d]	1 SELOGIC Processing Interval
135	87	1, 5	RB24	Pulse[d]	1 SELOGIC Processing Interval
136	88	1, 5	RB25	Pulse[d]	1 SELOGIC Processing Interval)
137	89	1, 5	RB26	Pulse[d]	1 SELOGIC Processing Interval
138	8A	1, 5	RB27	Pulse[d]	1 SELOGIC Processing Interval
139	8B	1, 5	RB28	Pulse[d]	1 SELOGIC Processing Interval
140	8C	1, 5	RB29	Pulse[d]	1 SELOGIC Processing Interval
141	8D	1, 5	RB30	Pulse[d]	1 SELOGIC Processing Interval
142	8E	1, 5	RB31	Pulse[d]	1 SELOGIC Processing Interval
143	8F	1, 5	RB32	Pulse[d]	1 SELOGIC Processing Interval

[a] Coils are also controlled by the SELOGIC control equation of the same name.
[b] ALRMOUT coil is also controlled by SELOGIC control equation ALRMOUT.
[c] Supported in 3U relay with extra I/O board; otherwise Reserved.
[d] Pulsing a remote bit that is already set will cause the remote bit to be cleared at the end of the pulse.
[e] If the relay is disabled or the breaker control jumper is removed, the relay returns an error code 06 (Slave Device Busy).

Coil addresses start at 0000. If the device is disabled, a Function Code 05 to any coil will respond with Error Code 4 (Device Error). In addition to Error Codes 4 and 6, 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.

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, to as many as 100 per operation.

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.

Remote Bit labels RB1_8S, RB1_8C, RB1_8P, RB9_16S, etc., are also bit operations. Only those bit positions containing a 1 will operate when writing to registers containing the Remote Bit labels.

For Set and Clear operations, each single register write operation will be atomic. For Pulse operations, bits pulsed in a single register write are not guaranteed to be atomic.

In the case of function code 10h Multiple Register write, the order of operation will be determined by the order the Remote Bits are received. When multiple registers are written to, the registers with the highest address take priority.

A function code 03h or 04h read of any of the bit operation registers (LOG_CMD, RSTDAT, or Remote Bit Operations) will return a value of 0.

Modbus Documentation

Configurable Register Mapping

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 QuickSet 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 are 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 (as many as 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 QuickSet Modbus User Map to map user registers 001 to 250 (MOD_001 to MOD_250) by 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.

NOTE: If your master uses 5- or 6-digit address references, add the appropriate number to the Modbus Address provided in Table O.23 when configuring your master. For example, if your master uses 5-digit addressing, add 40001 for holding register operations. For input register functions, add 30001.

If your master uses 6-digit addressing, add 400001 for holding register operations or 300001 for input register functions.

The actual address that appears in the address field of the message will be the Modbus Address shown in Table O.23. For example, MOD_001 is address 0000 (see Table O.23 for Modbus register addresses). A master using 6-digit addresses to read a holding register may be configured for address 400001. However, the data address field of the message from the master will contain address 0000.

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. Because 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

=>>
```

Modbus Quantities Table

The available labels for the user-defined Modbus data region are defined in *Table O.22*.

Table O.22 Modbus Quantities Table (Sheet 1 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (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	
Relay Firmware Revision	03, 04	FWREV	1	0	9999	
Relay Serial Number, lowest 4 digits	03, 04	SNUMBL	1	0	9999	
Relay Serial Number, middle 4 digits	03, 04	SNUMBM	1	0	9999	
Relay Serial Number, high 4 digits	03, 04	SNUMBH	1	0	9999	

Table O.22 Modbus Quantities Table (Sheet 2 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
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**				
Reset Hardware Alarm		**Bit 10**				
Reserved		**Bits 11–15**				
Date/Time Set						
Set Seconds	03, 04, 06, 10h	**TIME_S**	1	0	59	
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
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						

Table O.22 Modbus Quantities Table (Sheet 3 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
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[d]	1	–32768	32767	100
Maximum Phase Fault Current	03, 04	FI	1	0	65535	
A-Phase Fault Current	03, 04	FIA	1	0	65535	
B-Phase Fault Current	03, 04	FIB	1	0	65535	
C-Phase 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	
Fault impedance magnitude in ohms secondary	03, 04	FZ	1	0	65535	100
Fault impedance angle in degrees	03, 04	FZFA	1	–18000	18000	100
Fault resistance in ohms secondary	03, 04	FR	1	–32768	32767	100
Distance to fault in per-unit of line length	03, 04	FM	1	–32768	32767	100
Control I/O Commands						
Logic Command[e]	03, 04, 06, 10h	**LOG_CMD**	1			
Breaker Close (Relay Word bit CC)		**Bit 0**				
Breaker Open (Relay Word bit OC)		**Bit 1**				
Remote Bit Operations						
Remote Bits 1–8 Set	03, 04, 06, 10h	**RB1_8S**	1	0	65535	
RB8		**Bit 0**				
RB7		**Bit 1**				
RB6		**Bit 2**				

Table O.22 Modbus Quantities Table (Sheet 4 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
RB5		**Bit 3**				
RB4		**Bit 4**				
RB3		**Bit 5**				
RB2		**Bit 6**				
RB1		**Bit 7**				
Reserved		**Bits 8–15**				
Remote Bits 9–16 Set	03, 04, 06, 10h	**RB9_16S**	1	0	65535	
RB16		**Bit 0**				
RB15		**Bit 1**				
RB14		**Bit 2**				
RB13		**Bit 3**				
RB12		**Bit 4**				
RB11		**Bit 5**				
RB10		**Bit 6**				
RB9		**Bit 7**				
Reserved		**Bits 8–15**				
Remote Bits 17–24 Set	03, 04, 06, 10h	**RB17_24S**	1	0	65535	
RB24		**Bit 0**				
RB23		**Bit 1**				
RB22		**Bit 2**				
RB21		**Bit 3**				
RB20		**Bit 4**				
RB19		**Bit 5**				
RB18		**Bit 6**				
RB17		**Bit 7**				
Reserved		**Bits 8–15**				
Remote Bits 25–32 Set	03, 04, 06, 10h	**RB25_32S**	1	0	65535	
RB32		**Bit 0**				
RB31		**Bit 1**				
RB30		**Bit 2**				
RB29		**Bit 3**				
RB28		**Bit 4**				
RB27		**Bit 5**				
RB26		**Bit 6**				
RB25		**Bit 7**				
Reserved		**Bits 8–15**				
Remote Bits 1–8 Clear	03, 04, 06, 10h	**RB1_8C**	1	0	65535	
RB8		**Bit 0**				
RB7		**Bit 1**				
RB6		**Bit 2**				

Table O.22 Modbus Quantities Table (Sheet 5 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
RB5		**Bit 3**				
RB4		**Bit 4**				
RB3		**Bit 5**				
RB2		**Bit 6**				
RB1		**Bit 7**				
Reserved		**Bits 8–15**				
Remote Bits 9–16 Clear	03, 04, 06, 10h	**RB9_16C**	1	0	65535	
RB16		**Bit 0**				
RB15		**Bit 1**				
RB14		**Bit 2**				
RB13		**Bit 3**				
RB12		**Bit 4**				
RB11		**Bit 5**				
RB10		**Bit 6**				
RB9		**Bit 7**				
Reserved		**Bits 8–15**				
Remote Bits 17–24 Clear	03, 04, 06, 10h	**RB17_24C**	1	0	65535	
RB24		**Bit 0**				
RB23		**Bit 1**				
RB22		**Bit 2**				
RB21		**Bit 3**				
RB20		**Bit 4**				
RB19		**Bit 5**				
RB18		**Bit 6**				
RB17		**Bit 7**				
Reserved		**Bits 8–15**				
Remote Bits 25–32 Clear	03, 04, 06, 10h	**RB25_32C**	1	0	65535	
RB32		**Bit 0**				
RB31		**Bit 1**				
RB30		**Bit 2**				
RB29		**Bit 3**				
RB28		**Bit 4**				
RB27		**Bit 5**				
RB26		**Bit 6**				
RB25		**Bit 7**				
Reserved		**Bits 8–15**				
Remote Bits 1–8 Pulse	03, 04, 06, 10h	**RB1_8P**	1	0	65535	
RB8		**Bit 0**				
RB7		**Bit 1**				
RB6		**Bit 2**				

Table 0.22 Modbus Quantities Table (Sheet 6 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
RB5		**Bit 3**				
RB4		**Bit 4**				
RB3		**Bit 5**				
RB2		**Bit 6**				
RB1		**Bit 7**				
Reserved		**Bits 8–15**				
Remote Bits 9–16 Pulse	03, 04, 06, 10h	**RB9_16P**	1	0	65535	
RB16		**Bit 0**				
RB15		**Bit 1**				
RB14		**Bit 2**				
RB13		**Bit 3**				
RB12		**Bit 4**				
RB11		**Bit 5**				
RB10		**Bit 6**				
RB9		**Bit 7**				
Reserved		**Bits 8–15**				
Remote Bits 17–24 Pulse	03, 04, 06, 10h	**RB17_24P**	1	0	65535	
RB24		**Bit 0**				
RB23		**Bit 1**				
RB22		**Bit 2**				
RB21		**Bit 3**				
RB20		**Bit 4**				
RB19		**Bit 5**				
RB18		**Bit 6**				
RB17		**Bit 7**				
Reserved		**Bits 8–15**				
Remote Bits 25–32 Pulse	03, 04, 06, 10h	**RB25_32P**	1	0	65535	
RB32		**Bit 0**				
RB31		**Bit 1**				
RB30		**Bit 2**				
RB29		**Bit 3**				
RB28		**Bit 4**				
RB27		**Bit 5**				
RB26		**Bit 6**				
RB25		**Bit 7**				
Reserved		**Bits 8–15**				
Current Data						
A-Phase Current Mag.	03, 04	IA	1	0	65535	
A-Phase Angle	03, 04	IAFA	1	–18000	18000	100
B-Phase Current Mag.	03, 04	IB	1	0	65535	

Table O.22 Modbus Quantities Table (Sheet 7 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
B-Phase Angle	03, 04	IBFA	1	–18000	18000	100
C-Phase Current Mag.	03, 04	IC	1	0	65535	
C-Phase 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						
A-Phase Voltage Mag.	03, 04	VA	2	0	4294967295	
A-Phase Voltage Angle	03, 04	VAFA	1	–18000	18000	100
B-Phase Voltage Mag.	03, 04	VB	2	0	4294967295	
B-Phase Voltage Angle	03, 04	VBFA	1	–18000	18000	100
C-Phase Voltage Mag.	03, 04	VC	2	0	4294967295	
C-Phase Voltage Angle	03, 04	VCFA	1	–18000	18000	100
VS Voltage Mag.	03, 04	VS	2	0	4294967295	
VS Voltage Angle	03, 04	VSFA	1	–18000	18000	100
AB-Phase Voltage Mag.	03, 04	VAB	2	0	4294967295	
AB-Phase Voltage Angle	03, 04	VABFA	1	–18000	18000	100
BC-Phase Voltage Mag.	03, 04	VBC	2	0	4294967295	
BC-Phase Voltage Angle	03, 04	VBCFA	1	–18000	18000	100
CA-Phase Voltage Mag.	03, 04	VCA	2	0	4294967295	
CA-Phase Voltage Angle	03, 04	VCAFA	1	–18000	18000	100
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	2	0	4294967295	
3V0 Voltage Angle	03, 04	3V0FA	1	–18000	18000	100
Power Data						
A-Phase Real Power	03, 04	KWA	2	–2147483648	2147483647	
B-Phase Real Power	03, 04	KWB	2	–2147483648	2147483647	
C-Phase Real Power	03, 04	KWC	2	–2147483648	2147483647	

Table O.22 Modbus Quantities Table (Sheet 8 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
3-Phase Real Power	03, 04	KW3	2	–2147483648	2147483647	
A-Phase Reactive Power	03, 04	KVARA	2	–2147483648	2147483647	
B-Phase Reactive Power	03, 04	KVARB	2	–2147483648	2147483647	
C-Phase Reactive Power	03, 04	KVARC	2	–2147483648	2147483647	
3-Phase Reactive Power	03, 04	KVAR3	2	–2147483648	2147483647	
A-Phase Power Factor	03, 04	PFA	1	–100	100	100
B-Phase Power Factor	03, 04	PFB	1	–100	100	100
C-Phase Power Factor	03, 04	PFC	1	–100	100	100
3-Phase Power Factor	03, 04	PF3	1	–100	100	100
A-Phase PF Leading 0 = Lag 1 = Lead	03, 04	LDPFA	1	0	1	
B-Phase PF Leading 0 = Lag 1 = Lead	03, 04	LDPFB	1	0	1	
C-Phase PF Leading 0 = Lag 1 = Lead	03, 04	LDPFC	1	0	1	
3-Phase PF Leading 0 = Lag 1 = Lead	03, 04	LDPF3	1	0	1	
Energy Data						
A-Phase Real Energy IN	03, 04	MWHAI	2	–2147483648	2147483647	
B-Phase Real Energy IN	03, 04	MWHBI	2	–2147483648	2147483647	
C-Phase Real Energy IN	03, 04	MWHCI	2	–2147483648	2147483647	
3-Phase Real Energy IN	03, 04	MWH3I	2	–2147483648	2147483647	
A-Phase Real Energy OUT	03, 04	MWHAO	2	–2147483648	2147483647	
B-Phase Real Energy OUT	03, 04	MWHBO	2	–2147483648	2147483647	
C-Phase Real Energy OUT	03, 04	MWHCO	2	–2147483648	2147483647	
3-Phase Real Energy OUT	03, 04	MWH3O	2	–2147483648	2147483647	
A-Phase Reactive Energy IN	03, 04	MVRHAI	2	–2147483648	2147483647	
B-Phase Reactive Energy IN	03, 04	MVRHBI	2	–2147483648	2147483647	
C-Phase Reactive Energy IN	03, 04	MVRHCI	2	–2147483648	2147483647	
3-Phase Reactive Energy IN	03, 04	MVRH3I	2	–2147483648	2147483647	
A-Phase Reactive Energy OUT	03, 04	MVRHAO	2	–2147483648	2147483647	
B-Phase Reactive Energy OUT	03, 04	MVRHBO	2	–2147483648	2147483647	
C-Phase Reactive Energy OUT	03, 04	MVRHCO	2	–2147483648	2147483647	
3-Phase Reactive Energy OUT	03, 04	MVRH3O	2	–2147483648	2147483647	

Table O.22 Modbus Quantities Table (Sheet 9 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
Demand Data						
A-Phase Demand Current	03, 04	IADEM	1	0	65535	
B-Phase Demand Current	03, 04	IBDEM	1	0	65535	
C-Phase 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	
A-Phase Real Power Demand IN	03, 04	KWADI	2	–2147483648	2147483647	
B-Phase Real Power Demand IN	03, 04	KWBDI	2	–2147483648	2147483647	
C-Phase Real Power Demand IN	03, 04	KWCDI	2	–2147483648	2147483647	
3-Phase Real Power Demand IN	03, 04	KW3DI	2	–2147483648	2147483647	
A-Phase Reactive Power Demand IN	03, 04	KVRADI	2	–2147483648	2147483647	
B-Phase Reactive Power Demand IN	03, 04	KVRBDI	2	–2147483648	2147483647	
C-Phase Reactive Power Demand IN	03, 04	KVRCDI	2	–2147483648	2147483647	
3-Phase Reactive Power Demand IN	03, 04	KVR3DI	2	–2147483648	2147483647	
A-Phase Real Power Demand OUT	03, 04	KWADO	2	–2147483648	2147483647	
B-Phase Real Power Demand OUT	03, 04	KWBDO	2	–2147483648	2147483647	
C-Phase Real Power Demand OUT	03, 04	KWCDO	2	–2147483648	2147483647	
3-Phase Real Power Demand OUT	03, 04	KW3DO	2	–2147483648	2147483647	
A-Phase Reactive Power Demand OUT	03, 04	KVRADO	2	–2147483648	2147483647	
B-Phase Reactive Power Demand OUT	03, 04	KVRBDO	2	–2147483648	2147483647	
C-Phase Reactive Power Demand OUT	03, 04	KVRCDO	2	–2147483648	2147483647	
3-Phase Reactive Power Demand OUT	03, 04	KVR3DO	2	–2147483648	2147483647	
A-Phase Peak Demand Current	03, 04	IAPK	1	0	65535	
B-Phase Peak Demand Current	03, 04	IBPK	1	0	65535	
C-Phase Peak Demand Current	03, 04	ICPK	1	0	65535	

Table O.22 Modbus Quantities Table (Sheet 10 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
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	
A-Phase Real Power Peak Demand IN	03, 04	KWAPI	2	–2147483648	2147483647	
B-Phase Real Power Peak Demand IN	03, 04	KWBPI	2	–2147483648	2147483647	
C-Phase Real Power Peak Demand IN	03, 04	KWCPI	2	–2147483648	2147483647	
3-Phase Real Power Peak Demand IN	03, 04	KW3PI	2	–2147483648	2147483647	
A-Phase Reactive Power Peak Demand IN	03, 04	KVRAPI	2	–2147483648	2147483647	
B-Phase Reactive Power Peak Demand IN	03, 04	KVRBPI	2	–2147483648	2147483647	
C-Phase Reactive Power Peak Demand IN	03, 04	KVRCPI	2	–2147483648	2147483647	
3-Phase Reactive Power Peak Demand IN	03, 04	KVR3PI	2	–2147483648	2147483647	
A-Phase Real Power Peak Demand OUT	03, 04	KWAPO	2	–2147483648	2147483647	
B-Phase Real Power Peak Demand OUT	03, 04	KWBPO	2	–2147483648	2147483647	
C-Phase Real Power Peak Demand OUT	03, 04	KWCPO	2	–2147483648	2147483647	
3-Phase Real Power Peak Demand OUT	03, 04	KW3PO	2	–2147483648	2147483647	
A-Phase Reactive Power Peak Demand OUT	03, 04	KVRAPO	2	–2147483648	2147483647	
B-Phase Reactive Power Peak Demand OUT	03, 04	KVRBPO	2	–2147483648	2147483647	
C-Phase Reactive Power Peak Demand OUT	03, 04	KVRCPO	2	–2147483648	2147483647	
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

Table O.22 Modbus Quantities Table (Sheet 11 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
Breaker Monitor						
Internal A-Phase Trip Counter	03, 04	INTTRA	1	0	65535	
Internal B-Phase Trip Counter	03, 04	INTTRB	1	0	65535	
Internal C-Phase Trip Counter	03, 04	INTTRC	1	0	65535	
External A-Phase Trip Counter	03, 04	EXTTRA	1	0	65535	
External B-Phase Trip Counter	03, 04	EXTTRB	1	0	65535	
External C-Phase Trip Counter	03, 04	EXTTRC	1	0	65535	
Average Electrical Trip Operating Time, A-Phase	03, 04	EOTTRAAV	1	0	65535	10
Average Electrical Trip Operating Time, B-Phase	03, 04	EOTTRBAV	1	0	65535	10
Average Electrical Trip Operating Time, C-Phase	03, 04	EOTTRCAV	1	0	65535	10
Average Electrical Close Operating Time, A-Phase	03, 04	EOTCLAAV	1	0	65535	10
Average Electrical Close Operating Time, B-Phase	03, 04	EOTCLBAV	1	0	65535	10
Average Electrical Close Operating Time, C-Phase	03, 04	EOTCLCAV	1	0	65535	10
Electrical Operating Time Alarm Counter	03, 04	ESOALCNT	1	0	65535	
Average mechanical trip operating time, A-phase	03, 04	MOTTRAAV	1	0	65535	10
Average mechanical trip operating time, B-phase	03, 04	MOTTRBAV	1	0	65535	10
Average mechanical trip operating time, C-phase	03, 04	MOTTRCAV	1	0	65535	10
Average mechanical close operating time, A-phase	03, 04	MOTCLAAV	1	0	65535	10
Average mechanical close operating time, B-phase	03, 04	MOTCLBAV	1	0	65535	10
Average mechanical close operating time, C-phase	03, 04	MOTCLCAV	1	0	65535	10
Mechanical Operating Time Alarm Counter	03, 04	MSOALCNT	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	
Max Breaker Wear	03, 04	MAXWEAR	1	0	65535	

Table O.22 Modbus Quantities Table (Sheet 12 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
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	
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	

Table O.22 Modbus Quantities Table (Sheet 13 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
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	
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	

Table O.22 Modbus Quantities Table (Sheet 14 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
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	
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	
ROW 100	03, 04	ROW_100	1	0	255	
ROW 101	03, 04	ROW_101	1	0	255	
ROW 102	03, 04	ROW_102	1	0	255	
ROW 103	03, 04	ROW_103	1	0	255	
ROW 104	03, 04	ROW_104	1	0	255	

Table O.22 Modbus Quantities Table (Sheet 15 of 15)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Number of 16-Bit Registers[b]	Min Value	Max Value	Scaling[c] (X1 unless specified)
ROW 105	03, 04	ROW_105	1	0	255	
ROW 106	03, 04	ROW_106	1	0	255	
ROW 107	03, 04	ROW_107	1	0	255	
ROW 108	03, 04	ROW_108	1	0	255	
ROW 109	03, 04	ROW_109	1	0	255	
ROW 110	03, 04	ROW_110	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] Scaling occurs prior to Min/Max value check.
[d] If the fault location is undefined, Modbus will report the value as 32767.
[e] 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.
[f] The active settings group can be modified by writing the desired settings group number to ACTGRP. If any of the SELOGIC Group Switch equations SS1—SS6 are asserted, the write will be accepted but the active group will not change.

Default Modbus Map and Modbus Addresses

The default user map entries and correlation to Modbus address fields are defined in *Table O.23*. Use the **SET M** and **SHO M** commands to modify or view these map settings, or QuickSet to manage the Modbus mapping.

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**	
012	MOD_013	VAFA	
013	MOD_014	**VB**	
015	MOD_016	VBFA	
016	MOD_017	**VC**	
018	MOD_019	VCFA	
019	MOD_020	**VS**	
021	MOD_022	VSFA	
022	MOD_023	**KW3**	
024	MOD_025	**KVAR3**	
026	MOD_027	PF3	
027	MOD_028	LDPF3	

Table O.23 Default Modbus Map (Sheet 2 of 2)

Modbus Address	User Map Register	Mapped Register Label[a]	Notes
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.

Reading Event Data Using Modbus

The SEL-311C provides a feature that allows relay event history data to be retrieved via Modbus. The Event History registers are listed in *Table O.22* under the Historical Data description heading. To read the history data, set the Modbus Map to contain the EVESEL label, along with the other Fault History related labels. The following example shows some of the available history data labels in the Modbus Map:

```
=>>SHO M <Enter>

MOD_001 = NUMEVE
MOD_002 = EVESEL
MOD_003 = FTIME_S
MOD_004 = FTIME_M
MOD_005 = FTIME_H
MOD_006 = FDATE_D
MOD_007 = FDATE_M
MOD_008 = FDATE_Y
MOD_009 = FLOC
MOD_010 = FI
MOD_011 = FIA
MOD_012 = FIB
MOD_013 = FIC
MOD_014 = FIG
MOD_015 = FIN
MOD_016 = FFREQ
MOD_017 = FGRP
MOD_018 = FSHO
MOD_019 = EVE_TYPE
```

Use Modbus function code 03 or 04 to read the Modbus registers. The NUMEVE label will contain the number of events listed in the event history, **HIS** command, and response. To read relay event history data by using

Modbus, use function code 06 to write the event number to the Modbus register containing the EVESEL label. The SEL-311C will populate the other event-related registers with the data related to the event number specified in the EVESEL label address. Issue a Modbus function code 03 or 04 command to read the registers containing the history data.

For example, use the following relay response to the **HIS** command:

```
=>>HIS <Enter>
SEL-311                          Date: 06/05/01    Time: 13:32:54.127
STATION A

# DATE     TIME         EVENT    LOCAT    CURR   FREQ  GRP SHOT   TARGETS
1 06/05/13 04:14:19.950 ABC T    64.93    2144  60.00   1         ZONE 1
2 12/06/13 08:31:50.978 ABG T    94.95    9983  60.00   1         INST SOTF 50 51 81
3 02/13/14 12:25:44.449 PULSE    26.92    1830  60.00   2         TRIP SOTF
4 06/22/14 07:18:19.088 AG T      9.65    2279  60.00   3         TIME 51
```

Retrieve the history data in this example for event number 4, using the map shown above, by setting register address 0001 to the value of 4 using a function code 06 command. (Note: The Modbus Map is indexed beginning with 1, which corresponds to register address 0 in Modbus). If a value is written to the EVESEL register for an event that does not currently exist in the history data, the SEL-311C will respond with an exception code 03.

Following the function code 06 command, issue a function code 03 or 04 command to read registers 0–18. The data returned in registers 2–18 would contain the event time, event date, fault location, maximum fault current, fault current per phase, ground fault current, neutral fault current, the frequency, settings group, number of shots, and event type associated with event number 4.

The **HIS E** command returns the same history data but uses a unique event number in the range 10000 to 65535. The relay will also return the history data if the unique event number is written to the EVESEL register as long as that event is currently in the history data.

```
=>>HIS E <Enter>
SEL-311                          Date: 06/05/01    Time: 13:36:29.192
STATION A

#     DATE     TIME          EVENT  LOCAT  CURR   FREQ   GRP SHOT  TARGETS
10007 06/05/13 04:14:19.950  ABC T  64.93  2144  60.00    1        ZONE 1
10006 12/06/13 08:31:50.978  ABG T  94.95  9983  60.00    1        INST SOTF 50 51 81
10005 02/13/14 12:25:44.449  PULSE  26.92  1830  60.00    2        TRIP SOTF
10004 06/22/14 07:18:19.088  AG T    9.65  2279  60.00    3        TIME 51
```

When the history data are cleared in the relay, either from the **HIS C** command or from a remote control point, the NUMEVE register will contain the value of 0, indicating there are no events that can be read using Modbus. The Modbus fault data registers may contain data from a past event, until a new valid event number is written to the EVESEL register.

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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**	= ______________
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Date____________

User Map Register Label Name	**MOD_029**	=
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Appendix P
IEC 61850

Features

The SEL-311C Relay supports the following features using Ethernet and IEC 61850:

NOTE: The SEL-311C supports one CID file, which should be transferred only if a change in the relay configuration is required.

- **SCADA**—Connect as many as seven simultaneous IEC 61850 MMS client sessions. The SEL-311C also supports as many as seven buffered and seven 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, an MMS file transfer utility, 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 the SEL Real Time Automation Controller (RTAC) as an MMS client to poll data sets in the relay or use IEC 61850 MMS client software to browse the relay logical nodes and verify functionality.
- **IEC 61850 Standard**—IEC 61850 Standard, Edition 1 is supported unless otherwise noted.

This section presents the information you need to use the IEC 61850 features of the SEL-311C:

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 seven 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 METMMXU1AphsA$cVal is broken down into its component parts. The Data Attribute is characterized (filtered) by a functional constraint (FC) property. The supported FCs are listed in *Table P.3*. The FC for the given example above is MX.

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	A-phase
cVal	Data Attribute	Complex value

Table P.3 Functional Constraints

FC	Description
ST	Status information
MX	Measurements (analog values)
CO	Control
CF	Configuration
DC	Description
EX	Extended definition

Data Mapping

Device data are 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.4* for descriptions of the Logical Devices in an SEL-311C. See *Logical Nodes on page P.29* for a description of the LNs that make up these Logical Devices.

Table P.4 SEL-311C Logical Devices

Logical Device	Description
ANN	Annunciator elements—alarms, status values
CFG	Configuration elements—data sets 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.

Event files and reports are also available through MMS. See *File Transfer Protocol (FTP) and MMS File Transfer on page 10.24*, *Retrieving COMTRADE Event Files on page 12.14* and *Retrieving Event Reports Via Ethernet File Transfer on page 12.17*.

If MMS authentication is enabled, the device authenticates each MMS association by requiring the client to provide the password authentication parameter with a value that is equal to the 2AC password of the SEL-311C.

- ➤ If the correct password authentication parameter is not received, the device returns a not authenticated error code.
- ➤ If the correct password authentication parameter value is received, the device gives a successful association response.

Once an authenticated association is established, the device allows access to all supported MMS services for that association.

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 Architect. Also, configure outgoing GOOSE messages for SEL devices in Architect. See the 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 by using the Architect software. If you intend to use any SEL-311C virtual bits for controls, you must create SELOGIC control equations to define these operations.

File Services

The Ethernet File System allows reading or writing data as files. The File System supports FTP and MMS File Transfer. The File System provides:

- ➤ A means for the device to transfer data as files.
- ➤ A hierarchical file structure for the device data.

The SEL-311C supports MMS File transfer with or without authentication. The service is intended to support the following:

- ➤ CID file download and upload
- ➤ Retrieval of events, reports, and relay diagnostics

MMS File Services are enabled or disabled via Port 5 settings. See *Virtual File Interface on page 10.25* for details on the files available for MMS File Services.

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.

Data Sets

Data sets are configured using Architect and contain data attributes that represent real data values within the SEL-311C device. See the Logical Nodes section in this appendix for the logical node tables that list the available data attributes for each logical node and the Relay Word bit mapping for these data attributes. The list of data sets in *Figure P.1* are the defaults for am SEL-311C device. Data sets BRDSet01 through BRDSet07 and URDSet01 through URDSet07 are preconfigured with common FCDAs to be used for reporting. These data sets can be configured to represent the desired data to be monitored. Data set GPDSet01 is a preconfigured example data set used for the example GOOSE publication GPub01.

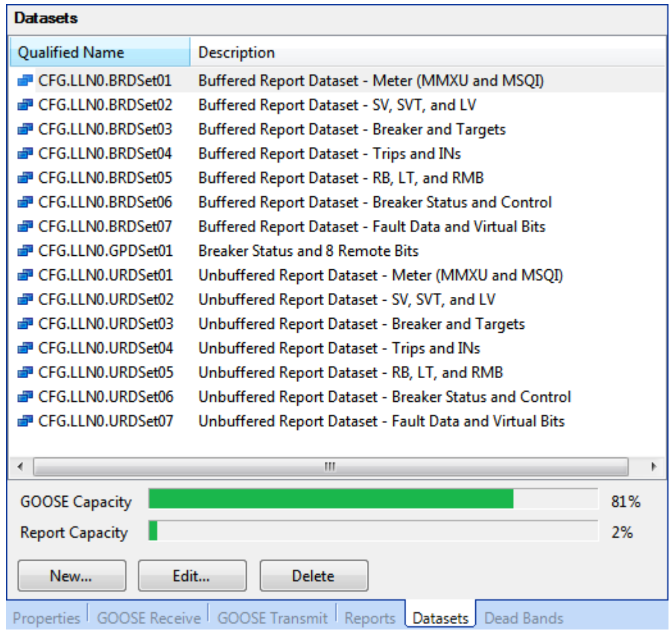


Figure P.1 SEL-311C Data Sets

Within Architect, IEC 61850 data sets have the following purposes:

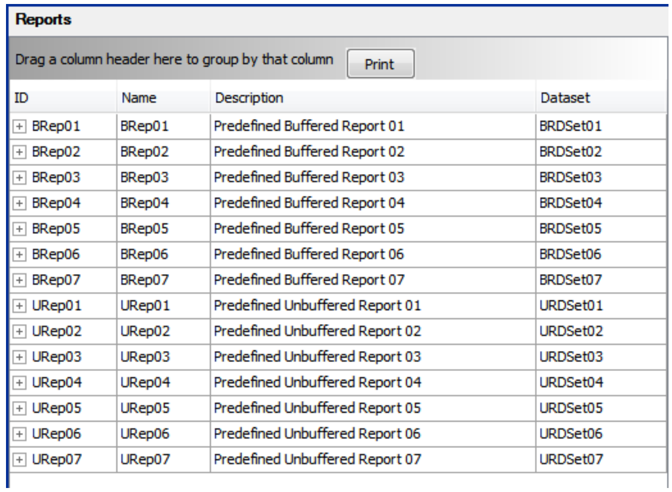
- GOOSE: You can use predefined or edited data sets, or create new data sets for outgoing GOOSE transmission.
- Reports: Fourteen predefined data sets (BRDSet01 through BRDSet07 and URDSet01 through URDSet07) correspond to the default seven buffered and seven unbuffered reports. Note that you cannot change the number (14) or type of reports (buffered or unbuffered) within Architect. However, you can alter the data attributes that a data set contains and so define what data an IEC 61850 client receives with a report.
- MMS: You can use predefined or edited data sets, or you can create new data sets to be monitored by MMS clients.

NOTE: Do not edit the data set names used in reports. Changing or deleting any of those data set names will cause a failure in generating the corresponding report.

Reports

The SEL-311C implements the IEC 61850 reporting service as part of its server functionality. The reporting service includes the functionality necessary to configure, manage, and send IEC 61850 buffered and unbuffered reports as unsolicited reports, periodic integrity reports, or as the result of a general interrogation. See the IEC 61850 Standard, Part 7-1, Section 6.4.3.3, Part 7-2, Section 14, and Part 8-1, Section 17 for more details on the IEC 61850 reporting service.

A total of 14 predefined reports (7 buffered and 7 unbuffered) are supported. The predefined reports and the data sets assigned to each report are shown in *Figure P.2* and are available by default via IEC 61850. The number of reports (14), the data set assigned to each report, and the type of reports (buffered or unbuffered) cannot be changed. However, by using Architect software, you can reallocate data within each report data set to present different data attributes for each report beyond the predefined data sets.



Reports

Drag a column header here to group by that column   Print

ID	Name	Description	Dataset
BRep01	BRep01	Predefined Buffered Report 01	BRDSet01
BRep02	BRep02	Predefined Buffered Report 02	BRDSet02
BRep03	BRep03	Predefined Buffered Report 03	BRDSet03
BRep04	BRep04	Predefined Buffered Report 04	BRDSet04
BRep05	BRep05	Predefined Buffered Report 05	BRDSet05
BRep06	BRep06	Predefined Buffered Report 06	BRDSet06
BRep07	BRep07	Predefined Buffered Report 07	BRDSet07
URep01	URep01	Predefined Unbuffered Report 01	URDSet01
URep02	URep02	Predefined Unbuffered Report 02	URDSet02
URep03	URep03	Predefined Unbuffered Report 03	URDSet03
URep04	URep04	Predefined Unbuffered Report 04	URDSet04
URep05	URep05	Predefined Unbuffered Report 05	URDSet05
URep06	URep06	Predefined Unbuffered Report 06	URDSet06
URep07	URep07	Predefined Unbuffered Report 07	URDSet07

Figure P.2 SEL-311C Predefined Reports

For each buffered report control block (BRCB), there can be just one client association (i.e., only one client can be associated to a BRCB at any given time). The client association occurs when the client enables the RptEna attribute of the 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 and the associated client will be the only client that receives buffered report data. The BRCB parameters are shown in *Table P.5*.

Table P.5 Buffered Report Control Block Client Access (Sheet 1 of 2)

RCB Attribute	User Changeable (Report Disabled)	User Changeable (Report Enabled)	Default Values
RptId	YES		BRep01–BRep07
RptEna	YES	YES	FALSE
DatSet	YES		BRDSet01–BRDSet07
ConfRev			1
OptFlds	YES		0111100100
reserved			
sequence-number			TRUE
report-time-stamp			TRUE
reason-for-inclusion			TRUE
data-set-name			TRUE
data-reference			FALSE
buffer-overflow			FALSE
entryID			TRUE
conf-revision			FALSE
segmentation			
BufTm	YES		500
SqNum			0
TrgOps	YES		011011
reserved			
dchg			TRUE

Table P.5 Buffered Report Control Block Client Access (Sheet 2 of 2)

RCB Attribute	User Changeable (Report Disabled)	User Changeable (Report Enabled)	Default Values
qchg			TRUE
dupd[a]			
integrity			TRUE
gi			TRUE
IntgPd	YES		0
GI	YES[b,c]	YES[b]	FALSE
PurgeBuf	YES[b]		FALSE
EntryId	YES		00 00 00 00 00 00 00 00

[a] TrgOps data update (dupd) is not supported.
[b] Exhibits a pulse behavior. Write a one to issue the command. Once the command is accepted, the value will return to zero. Always read as zero.
[c] 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.

Once a BRCB has been enabled, a report buffer is established. The buffer is sized to contain 10 complete reports with a size hard coded in the SEL-311C ICD file. However, in cases where the report data set is smaller than the allowed maximum size, or when the encoded report does not include the entire data set, as many as 200 reports may appear in the buffer. Reports are maintained in the buffer regardless of having been sent. This allows the client to retrieve reports that have already been sent by writing an EntryID prior to the current EntryID.

When a client sets the RptEna attribute of a BRCB to true, all new reports contained in the report buffer, starting from the buffer entry following the EntryID attribute specified in the BRCB until the most current buffered report, are sent. At this time, new reports will be sent as required by normal report processing. This behavior allows the client to write the last received EntryID to the BRCB before enabling the report in an attempt to retrieve all report entries that were lost during a lapse in the client association.

When insertion of a new report into a report buffer would cause the buffer size to be exceeded, the oldest entries in the buffer are discarded until the buffer size has been reduced sufficiently to allow the new report to be added to the buffer. If the reports removed from the buffer have not yet been sent to the client, a buffer overflow indication is set in the next report queued for transmission to indicate that reports have been lost. The buffer overflow indication is reported in the BufOvfl field of the report if the buffer overflow OptFld has been enabled in the BRCB.

The contents of a report buffer are deleted when a PurgeBuf is commanded by a client. As noted in the requirements for the BRCB, the PurgeBuf can only be commanded when the report is disabled. The buffer overflow indication is cleared when the client commands a PurgeBuf. Additionally, the buffered reports will be purged if any of the BRCB attributes RptID, DatSet, BufTm, TrgOps, or IntgPd are modified by the client while the report is disabled.

For each unbuffered control block (URCB), there can be as many as six client associations. The client association occurs when the client enables the RptEna attribute of the URCB. Once enabled, each client has independent access to its instance of the URCB and all associated clients receive unbuffered report data. The URCB parameters are shown in *Table P.6*.

The URCB 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 instance of the URCB—in essence, acquiring a reservation.

Table P.6 Unbuffered Report Control Block Client Access

RCB Attribute	User Changeable (Report Disabled)	User Changeable (Report Enabled)	Default Values
RptId	YES		URep01–URep07
RptEna	YES	YES	FALSE
Resv	YES		FALSE
DatSet	YES		URDSet01–URDSet07
ConfRev			1
OptFlds	YES		0111100000
reserved			
sequence-number			TRUE
report-time-stamp			TRUE
reason-for-inclusion			TRUE
data-set-name			TRUE
data-reference			FALSE
conf-revision			FALSE
segmentation			
BufTm	YES		250
SqNum			0
TrgOps	YES		011011
reserved			
dchg			TRUE
qchg			TRUE
dupd[a]			
integrity			TRUE
gi			TRUE
IntgPd	YES		0
GI		YES[b]	TRUE

[a] TrgOps data update (dupd) is not supported.
[b] Exhibits a pulse behavior. Write a one to issue the command. Once the command is accepted, the value will return to zero. Always read as zero.

NOTE: The TrgOp data update is not supported by the SEL-311C device.

The IEC 61850 standard defines the trigger options (TrgOps) of data change, quality change, and data update. These TrgOps allow reports to be filtered to report only changes associated with the selected TrgOps. Additionally, each of these TrgOps is only associated with or valid for certain data attributes. The valid TrgOps for any given data attribute is described in the Common Data Class (CDC) Descriptions contained within the IEC standard, Part 7-3.

When a client has enabled the RptEna attribute of a BRCB or an URCB, and any of the data change or quality change TrgOps are enabled within the same BRCB or URCB, the SEL-311C sends an unsolicited report to that client upon detecting a change on an FCDA with a reason corresponding to one of the enabled TrgOps. The unsolicited report contains only those FCDAs that have been detected to have changed for a reason corresponding to one of the enabled TrgOps.

When a client has enabled the RptEna attribute of a BRCB or an URCB, and that same client writes a non-zero value to the GI attribute of the BRCB or URCB, a report is sent to that client containing the current data for all FCDA within the report data set.

When a client has enabled the RptEna attribute and the IntgPd TrgOp of a BRCB or an URCB, and the IntgPd attribute of the BRCB or URCB is set to a non-zero value, a report is sent to that client containing the current data for all FCDAs within the report data set upon detecting an expiration of the IntgPd.

FCDA updates are serviced every 500 ms. The client can set the report control block (BRCB or URCB) IntgPd to any value greater than 500 ms with a resolution of 1 ms. However, the integrity report is only sent when the period has been detected as having expired. The new IntgPd will begin at the time that the current report is serviced.

BufTm timers are part of the report control block (BRCB and URCB). Each client that enables an unbuffered report may have a BufTm value independent of other clients that enable the same unbuffered report. This does not apply to buffered reports because only one client can enable a buffered report.

Setting BufTm less than 500 ms does not result in data changes from multiple scans being buffered into a single report. For a BRCB with a non-zero BufTm attribute, a BufTm timer is started upon receiving notification of the change of a member of a data set, and all changes received during BufTm are combined into a single report to be buffered and sent at the expiration of BufTm. If a second internal notification of the same member of a data set has occurred prior to the expiration of BufTm, a report is immediately buffered and sent.

Reports are formatted as specified in the IEC 61850 standard, Part 7-2, Table 24. The report EntryID attribute is incremented each time a report is built.

Supplemental Software

Examine the data structure and values of the supported IEC 61850 LNs with an MMS browser such as AX-S4 61850 Explorer and AX-S4 61850 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 (q) and time stamp (t) are available at any time. The time stamp 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 time stamp 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 (FCDA) mapped to points assigned to the SER report have SER-accuracy time stamps for data change events. To ensure that you will get SER-quality time stamps 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 time stamp accuracy. See *SET Command (Change Settings) on page 10.62* 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.

➤ The relay supports no more than 128 unique Boolean elements mapped between all GOOSE publications.

GOOSE Construction Example

The data set 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 data set 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 data set 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.

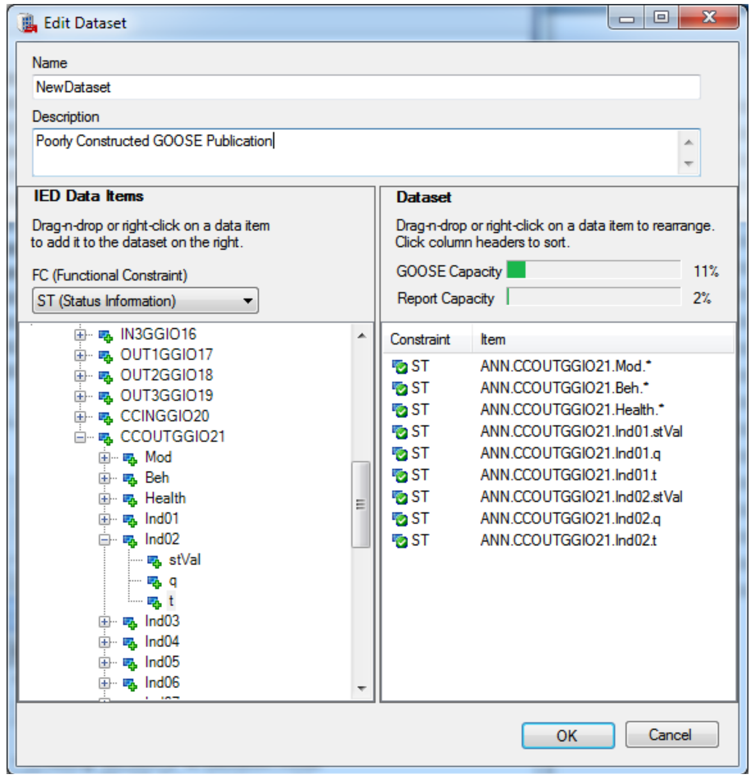


Figure P.3 Example of a Poorly Constructed GOOSE Data Set

Figure P.4 shows an example of a GOOSE publication from an SEL-311C with better construction. This data set contains only the information required by the subscribing relay(s) to decode the CCOUT status from the publishing SEL-311C (.CCOUTGGIO21.Ind01.stVal and CCOUTGGIO21.Ind02.stVal) and does not include quality bit strings or time stamps.

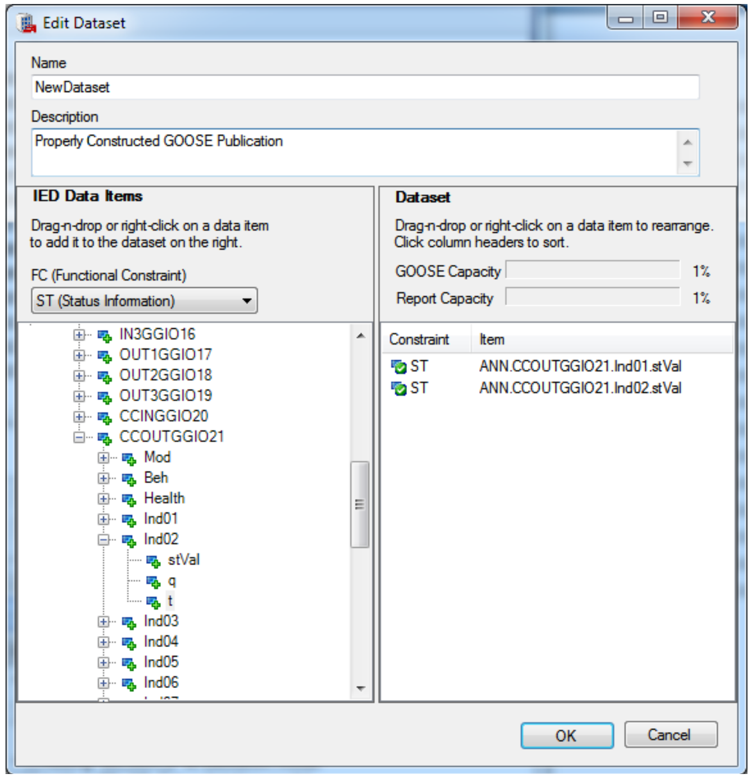


Figure P.4 Example of a Properly Constructed GOOSE Data Set

GOOSE Receive and Transmit Capacity

Each processing interval, the relay processes received and transmitted GOOSE messages. The relay assigns each received and transmitted message a point value at configuration time (when the relay receives and parses the CID file). The point values for various messages are calculated as described in *GOOSE Subscription (Receive) Processing on page P.14* and *GOOSE Publication (Transmit) Processing on page P.19*. The number of points that can be received per processing interval is 80 and that can be transmitted per processing interval is 40.

GOOSE Subscription (Receive) Processing

The relay supports as many as 24 GOOSE subscriptions. GOOSE messages that arrive at the relay are subjected to the following processing steps when port setting EGSE is set to Y.

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 24 possible 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 as many as 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 the total point value of the messages in the receive buffers at the beginning of the processing interval exceeds the capacity given in the *GOOSE Receive and Transmit Capacity on page P.14*, 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 that 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.7* shows the cost of each type of data in the message body, and also shows the cost of decoding the message header.

Table P.7 Point Cost of Decoding GOOSE Messages (Sheet 1 of 2)

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 are 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.

Table P.7 Point Cost of Decoding GOOSE Messages (Sheet 2 of 2)

Data Type	Description	Point Value	Comments
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 are 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 data set for such a message is shown in *Figure P.5*. As described above not all items from the data set are mapped to local resources within the receive SEL-311C. Similar to the example GOOSE shown in *Figure P.3*, the GOOSE message shown in *Figure P.5* is poorly constructed and is shown only as an example of a GOOSE message containing several types of data.

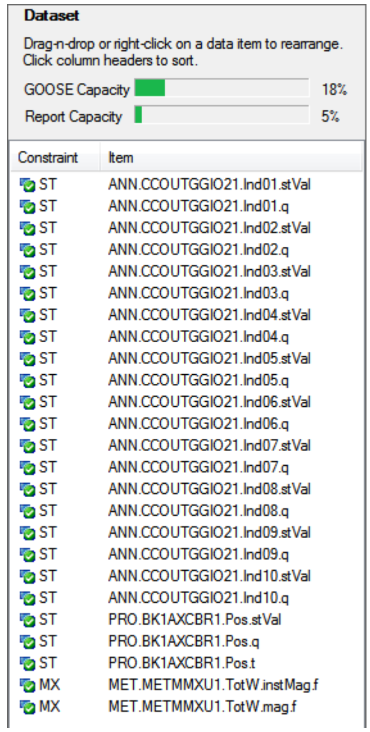


Figure P.5 Example Receive GOOSE Data Set

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.8*.

Table P.8 Scores for Subscribed Messages Used in Example (Sheet 1 of 2)

Subscription Number	Message Score
1	16
2	20
3	10

Table P.8 Scores for Subscribed Messages Used in Example (Sheet 2 of 2)

Subscription Number	Message Score
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.8* 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.9*.

Table P.9 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.10*.

Table P.10 Scores for Subscribed Messages Used in Example (Sheet 1 of 2)

Subscription Number	Message Score
1	16
2	20
3	10
4	16
5	16
6	10
7	12

Table P.10 Scores for Subscribed Messages Used in Example (Sheet 2 of 2)

Subscription Number	Message Score
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 totaling 80 or fewer points arrive each processing interval, the relay will process all received messages every processing interval. If messages totaling more than 80 points arrive in any processing interval, then the relay will process messages totaling 80 or fewer points and will continue processing during the next quarter-cycle processing interval.

GOOSE Publication (Transmit) Processing

The relay supports as many as eight GOOSE publications. Each publication can contain data from any logical node in the relay. The relay supports no more than 128 unique Boolean elements mapped between all GOOSE publications.

The relay transmits a message from each publication soon after initialization (e.g., after the relay turns on). 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. Transmission of GOOSE messages does not occur if the relay is disabled, port setting EGSE is set to NO, or after a permanent self-test failure.

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, as 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 first transmission occurs immediately upon the trigger occurring. The second transmission occurs approximately MinTime later. The third transmission occurs approximately MinTime after the second. The fourth transmission occurs twice MinTime after the third. All subsequent transmissions occur at the MaxTime interval. For example, MinTime is 4 ms and MaxTime is 100 ms; the intervals between transmissions will be 4 ms, 4 ms, 8 ms, and then 100 ms. If MaxTime is not greater than twice MinTime, the third and all subsequent transmissions will occur at the MaxTime interval. The MinTime and MaxTime intervals can be configured for each GOOSE transmit message by using Architect software. The time-to-live reported in the first two messages is three times MinTime. The time-to-live in all subsequent messages is two times MaxTime.

The total number of message transmissions possible during each processing interval because of either state number changes or transmit interval time-out 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 with total point values as great as the capacity given in the *GOOSE Receive and Transmit Capacity on page P.14*. If messages totaling more than the value given in the *GOOSE Receive and Transmit Capacity on page P.14* 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.11* shows the point value for different parts of the GOOSE message.

Table P.11 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.
Quality Bit String	A quality field associated with a data item.	0	Transmit quality is always zero.
Boolean, Time, Bit Strings (other than Quality), Integer, Floating-Point, Enumerations		1	Each of these data types costs 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 two floating-point numbers, each with an associated time stamp.

The data set 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.

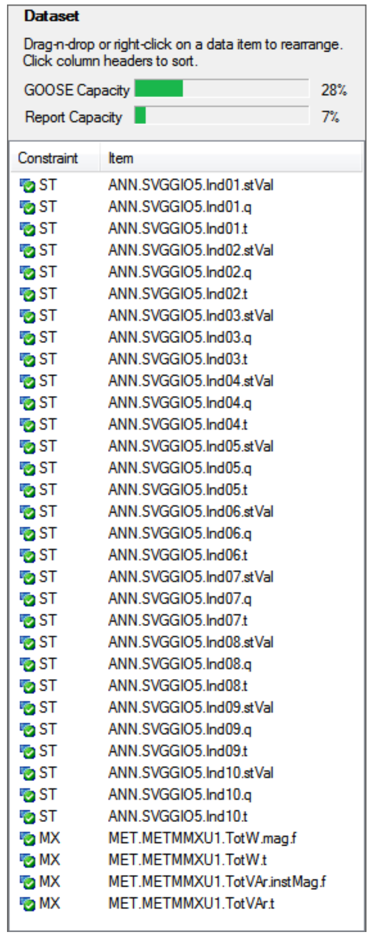


Figure P.6 Example Transmit GOOSE Data Set

The score for this message is as follows:

8 points for the message

10 points for 10 Boolean values

0 points for 10 quality bit strings associated with the Boolean values

10 points for 10 time stamps associated with the Boolean values

2 points for 2 floating-point values

2 points for the time stamps associated with the floating-point values

32 total points in this message

Message Transmission Example

Assume the relay publishes GOOSE messages as shown in *Table P.12*.

Table P.12 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.13*.

Table P.13 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.14 lists IEC 61850 settings. These settings are only available if your device includes the optional IEC 61850 protocol.

Table P.14 IEC 61850 Settings

Label	Description	Range	Default
E61850	IEC 61850 interface enable	Y, N	N
EGSE[a]	IEC 61850 GSE message enable	Y[b], N	N
EMMSFS[a]	MMS file services enable	Y[b], N	N[c]

[a] Settings EGSE and EMMSFS are hidden when E61850 is set to N.
[b] Requires E61850 set to Y.
[c] For firmware versions prior to R507, if E61850 = Y during firmware upgrade to R507, EMMSFS will be set to Y.

NOTE: Virtual bits retain state until overwritten, a new CID file is loaded, or the device is restarted. To reset the virtual bits by restarting the device, issue a **STA C** command or cycle power on the device.

Devices ordered with the optional IEC 61850 protocol are delivered with a default CID file loaded on the device. The file is named "SET_61850.CID." To make the device communicate with other devices over IEC 61850, the device must be configured. Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with Architect software.

When IEC 61850 is enabled (E61850 = Y), the device parses the CID file to determine the device IEC 61850 configuration. When EGSE = Y, the device begins transmitting GOOSE messages and receiving GOOSE subscriptions configured in the CID file. Issuing the ASCII **GOO** command provides GOOSE status information. See *GOO Command on page 10.46* for a detailed description of the **GOO** command.

NOTE: Firmware versions previous to R507 will display PARSE FAILURE in the iedName, type, and configVersion fields of the **ID** Command if the CID file is invalid. No GOOSE messages will be transmitted and MMS will be unavailable if PARSE FAILURE is displayed in these fields.

If the device does not have a valid IEC 61850 configuration, it will not send or receive any IEC 61850 communications. Issuing the ASCII **ID** command provides information on the status of the CID file. If there is a problem with the CID file, the iedName, type, and configVersion fields of the **ID** command response will display PARSE FAILURE as shown below.

```
=>>ID <Enter>

"FID=SEL-311C-2-R502-V0-Z100100-D20120111","0933"
"BFID=SLBT-3CF1-R102-V0-Z100100-D20091207","0985"
"CID=268B","025F"
"DEVID=STATION A","049C"
"DEVCODE=48","0313"
"PARTNO=0311C21HR3E5422","05CB"
"SERIALNO=0000000000","04EA"
"CONFIG=11112200","03EB"
"SPECIAL=10000","039F"
"iedName=PARSE FAILURE","0703"
"type=PARSE FAILURE","0612"
"configVersion=PARSE FAILURE","09AC"

=>>
```

NOTE: MMS File Services can be used to load a new CID file if EMMSFS := Y.

You will need to load a valid CID file into the device by using FTP, Architect, or MMS File Services. When loading a new CID file, Architect returns an error message if the file is not accepted. If using FTP or MMS File Services to load a new CID file, follow the write operation with a read of the ERR.TXT file from the device to verify successful transmission and configuration of the new CID file. If the file transfer fails or the device detects an invalid CID file, the ERR.TXT file will contain an error message. If the ERR.TXT file is blank (length is zero), then the new CID file was accepted by the device. If a failure occurs, the CID file that you previously loaded in the device will be retained. The new CID file will replace the current CID file only if the transfer and configuration of the new CID file is successful.

Once a valid CID file is loaded into the device, the **ID** command response should look like that shown below with the iedName, type, and configVersion fields revealing the proper configured information. The iedName displays the configured IED name, which can be modified by using Architect. The type and configVersion fields cannot be modified and represent the relay type and the ICD file version used for the configured CID file.

```
=>>ID <Enter>

"FID=SEL-311C-2-R502-V0-Z100100-D20120111","0933"
"BFID=SLBT-3CF1-R102-V0-Z100100-D20091207","0985"
"CID=268B","025F"
"DEVID=STATION A","049C"
"DEVCODE=48","0313"
"PARTNO=0311C21HR3E5422","05CB"
"SERIALNO=0000000000","04EA"
"CONFIG=11112200","03EB"
"SPECIAL=10000","039F"
"iedName=SEL_311C_2","060C"
"type=SEL_311C_2","051B"
"configVersion=ICD-311C2-R501-V0-Z000000-D20110407","0D7F"

=>>
```

Architect

The Architect software enables users to design and commission IEC 61850 substations containing SEL IEDs.

Users can use Architect to do the following:

- Organize and configure all SEL IEDs in a substation project.
- Configure incoming and outgoing GOOSE messages.
- Edit and create GOOSE data sets.
- 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 data sets for reports.
- Enable/disable MMS authentication.
- Configure MMS inactivity time-out.
- Load IEC 61850 CID files into SEL IEDs.
- Generate ICD and CID files that will provide SEL IED descriptions to other manufacturers' tools so they can use SEL GOOSE messages and reporting features.
- Edit deadband settings for measured values.

Architect provides a Graphical User Interface (GUI) for users 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 user can also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain.

Some measured values are reported to IEC 61850 only when the value changes beyond a defined deadband value. Architect allows a deadband to be changed during the CID file configuration. Check and set the deadband values for your particular application when configuring the CID file for a device.

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 Architect online help for more information.

SEL ICD File Versions

Architect version R.1.1.69.0 and later supports multiple ICD file versions for each type of IED in a project. Because relays with different firmware versions may require different CID file versions, users can manage the CID files of all IEDs within a single project.

Ensure that you work with the appropriate version of Architect relative to your current configuration, existing project files, and ultimate goals. If you want the best available IEC 61850 functionality for your SEL relay, obtain the latest version of Architect and select the appropriate ICD version(s) for your needs.

Architect generates CID files from ICD files so the ICD file version Architect uses also determines the CID file version generated. Details about the different SEL-311C ICD files can be found in *Table A.2* and *Table A.3*.

Logical Node Extensions

The following Logical Nodes and Data Classes were created in this device as extensions to the IEC 61850 standard, in accordance with IEC 61850 guidelines.

Table P.15 New Logical Node Extensions

Logical Node	IEC 61850	Description or Comments
Demand Metering	MDST	Demand and peak demand values for current and energy.
Circuit Breaker Supervision	SCBR	Circuit breaker supervision abrasion and operation values.

Table P.16 Demand Metering Logical Node Class Definition (Sheet 1 of 2)

IEC 61850 Logical Node Class: MDST					
Attribute Name	**Attribute Type**	**Data Source**	**Explanation**	**T**[a]	**M/O/C/E**[b]
LNName			The name is composed of the class name, LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Data					
Common Logical Node Information					
			LN inherits all mandatory data from Common Logical Node Class		M
Measured Values					
DmdA.nseq	MV	3I2DEM	Demand, negative-sequence current		O
PkDmdA.nseq	MV	3I2PK	Peak demand, negative-sequence current		O
DmdA.phsA	MV	IADEM	Demand, A-phase current		O
PkDmdA.phsA	MV	IAPK	Peak demand, A-phase current		O
DmdA.phsB	MV	IBDEM	Demand, B-phase current		O
PkDmdA.phsB	MV	IBPK	Peak demand, B-phase 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

Table P.16 Demand Metering Logical Node Class Definition (Sheet 2 of 2)

IEC 61850 Logical Node Class: MDST					
Attribute Name	**Attribute Type**	**Data Source**	**Explanation**	**T[a]**	**M/O/C/E[b]**
SupWh	MV	MWH3I	Energy, real (MWh), supply direction toward busbar		O
DmdWh	MV	MWH3O	Energy, real (MWh), supply direction away from busbar		O

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table P.17 Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition

IEC 61850 Logical Node Class: SCBR				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name is composed of the class name, LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Data				
Common Logical Node Information				
		LN inherits all mandatory data from Common Logical Node Class		M
Status Information				
ColOpn	SPS	Open command of trip coil		M
OpTmAlm1	SPS	Switch operating time exceeded—electrical close time	T	O
OpTmAlm2	SPS	Switch operating time exceeded—electrical open time	T	O
OpCnt	INS	Switch operating time exceeded counter		E
Measured Values				
OpTmCls	MV	Operation time close		O
OpTmOpn	MV	Operation time open		O
AbrPrt	MV	Calculated or measured wear (e.g., of main contact), expressed in % where 0% corresponds to new condition		E
MaxAbrPrt	MV	Maximum breaker wear (greatest wear of WEARA, WEARB, or WEARC), expressed in %		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table P.18 Circuit Breaker Supervision Logical Node Class Definition

IEC 61850 Logical Node Class: SCBR				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name is composed of the class name, LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Data				
Common Logical Node Information				
		LN inherits all mandatory data from Common Logical Node Class		M
Status Information				
ColOpn	SPS	Open command of trip coil		M
OpTmAlm1	SPS	Switch operating time exceeded—mechanical close time	T	O

Table P.18 Circuit Breaker Supervision Logical Node Class Definition

IEC 61850 Logical Node Class: SCBR				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
OpTmAlm2	SPS	Switch operating time exceeded—mechanical open time	T	O
OpCnt	INS	Switch operating time exceeded counter		E
Measured Values				
OpTmCls	MV	Operation time close		O
OpTmOpn	MV	Operation time open		O

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table P.19 Compatible Logical Nodes With Extensions

Logical Node	IEC 61850	Description or Comments
Measurement	MMXU	This LN is used for power system measurement data.
Under Voltage	PTUV	This LN is used for loss-of-potential status.
Fault Locator	RFLO	This LN is used for fault locator measurement data.
Circuit Breaker	XCBR	This LN is used for circuit breaker status and measurement data.

Table P.20 Measurement Logical Node Class Definition

IEC 61850 Logical Node Class: MMXU				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name is composed of the class name, LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Data				
Common Logical Node Information				
		LN inherits all mandatory data from Common Logical Node Class		M
Measured Values				
TotW	MV	Total active power		O
TotVAr	MV	Total reactive power		O
TotPF	MV	Average power factor		O
Hz	MV	Frequency		O
PPV	DEL	Phase-to-phase voltages		O
PhV	WYE	Phase-to-ground voltages		O
A	WYE	Phase currents		O
W	WYE	Phase active power		O
Var	WYE	Phase reactive power		O
PF	WYE	Phase power factor		O
VSyn	CMV	Synchronous voltage		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table P.21 Undervoltage Logical Node Class Definition

IEC 61850 Logical Node Class: PTUV				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name is composed of the class name, LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Data				
Common Logical Node Information				
		LN inherits all mandatory data from Common Logical Node Class		M
Status Information				
Str	ACD	Start (pickup)	T	M
Op	ACT	Operate	T	M
LOP4	SPS	Breaker VT LOP logic asserted	T	E
LOP3	SPS	LOP—latched		E
LOP2	SPS	Drop-in voltage without change in current LOP logic asserted	T	E
LOP1	SPS	Breaker closing LOP logic asserted	T	E
LOPRST	SPS	LOP reset condition based on healthy voltages	T	E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table P.22 Fault Locator Logical Node Class Definition

IEC 61850 Logical Node Class: RFLO				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name is composed of the class name, LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Data				
Common Logical Node Information				
		LN inherits all mandatory data from Common Logical Node Class		M
Measured Values				
FltZ	CMV	Fault impedance		M
FltDiskm	MV	Fault distance		O
A	WYE	Fault currents		E
FltRis	MV	Fault resistance in ohms, secondary		E
FltDis	MV	Distance to fault in per-unit of line length		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table P.23 Circuit Breaker Logical Node Class Definition

IEC 61850 Logical Node Class: XCBR				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name is composed of the class name, LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Data				
Common Logical Node Information				
		LN inherits all mandatory data from Common Logical Node Class		M
Status Information				
Loc	SPS	Local control behavior		M
OpCnt	INS	Operation counter		M
OpCntEx	INS	Operation counter—external		E
CBOpCap	INS	Circuit breaker operating capability		M
Controls				
Pos	DPC	Switch position		M
BlkOpn	SPC	Block opening		M
BlkCls	SPC	Block closing		M

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Logical Nodes

NOTE: Not all quantities are available in all settings configurations.

Table P.24 through *Table P.28* show the logical nodes (LNs) supported in the SEL-311C and the Relay Word bits or Measured Values mapped to those LNs.

Table P.24 shows the LNs associated with protection elements, defined as Logical Device PRO. See *Appendix D: Relay Word Bits* and *Appendix E: Analog Quantities* for descriptions.

Table P.24 Logical Device: PRO (Protection) (Sheet 1 of 14)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
BCCSWI1	Pos.Oper.ctlVal	CC:OC[a]	Circuit Breaker close/open command
Functional Constraint = MX[b]			
FLTRFLO1	A.phsMax.instMag.f	FI[c]	Fault current, maximum phase current in primary amperes
FLTRFLO1	A.phsA.instMag.f	FIA[c]	A-phase fault current in primary amperes
FLTRFLO1	A.phsB.instMag.f	FIB[c]	B-phase fault current in primary amperes
FLTRFLO1	A.phsC.instMag.f	FIC[c]	C-phase fault current in primary amperes
FLTRFLO1	A.res.instMag.f	FIG[c]	Ground fault current in primary amperes
FLTRFLO1	A.neut.instMag.f	FIN[c]	Neutral fault current in primary amperes
FLTRFLO1	A.nseq.instMag.f	FIQ[c]	Negative-sequence fault current in primary amperes
FLTRFLO1	FltDiskm.instMag.f	FLOC[d,e]	Fault location
FLTRFLO1	FltZ.instCVal.mag.f	FZ[d]	Fault impedance magnitude in ohms, secondary
FLTRFLO1	FltZ.instCVal.ang.f	FZFA[d]	Fault impedance angle in degrees

Table P.24 Logical Device: PRO (Protection) (Sheet 2 of 14)

Logical Node	Attribute	Data Source	Comment
FLTRFLO1	FltRis.instMag.f	FR[d]	Fault resistance in ohms, secondary
FLTRFLO1	FltDis.instMag.f	FM[d]	Distance to fault in per-unit of line length
BSASCBR1	AbrPrt.instMag.f	WEARA	Breaker wear %, A-phase
BSASCBR1	MaxAbrPrt.instMag.f	MAXWEAR	Greatest wear of WEARA, WEARB, or WEARC
BSASCBR1	OpTmCls.instMag.f	EOTCLAAV	Average electrical close operating time, A-phase
BSASCBR1	OpTmOpn.instMag.f	EOTTRAAV	Average electrical trip operating time, A-phase
BSBSCBR2	AbrPrt.instMag.f	WEARB	Breaker wear %, B-phase
BSBSCBR2	MaxAbrPrt.instMag.f	MAXWEAR	Greatest wear of WEARA, WEARB, or WEARC
BSBSCBR2	OpTmCls.instMag.f	EOTCLBAV	Average electrical close operating time, B-phase
BSBSCBR2	OpTmOpn.instMag.f	EOTTRBAV	Average electrical trip operating time, B-phase
BSCSCBR3	AbrPrt.instMag.f	WEARC	Breaker wear %, C-phase
BSCSCBR3	MaxAbrPrt.instMag.f	MAXWEAR	Greatest wear of WEARA, WEARB, or WEARC
BSCSCBR3	OpTmCls.instMag.f	EOTCLCAV	Average electrical close operating time, C-phase
BSCSCBR3	OpTmOpn.instMag.f	EOTTRCAV	Average electrical trip operating time, C-phase
BSMASCBR1	OpTmCls.instMag.f	MOTCLAAV	Average mechanical close operating time, A-phase
BSMASCBR1	OpTmOpn.instMag.f	MOTTRAAV	Average mechanical trip operating time, A-phase
BSMBSCBR2	OpTmCls.instMag.f	MOTCLBAV	Average mechanical close operating time, B-phase
BSMBSCBR2	OpTmOpn.instMag.f	MOTTRBAV	Average mechanical trip operating time, B-phase
BSMCSCBR3	OpTmCls.instMag.f	MOTCLCAV	Average mechanical close operating time, C-phase
BSMCSCBR3	OpTmOpn.instMag.f	MOTTRCAV	Average mechanical trip operating time, C-phase
Functional Constraint = ST			
ABPDIS1	Op.general	MAB1	Phase-to-phase AB mho distance, Zone 1
ABPDIS1	Str.dirGeneral	forward	Direction always forward
ABPDIS1	Str.general	MAB1	Phase-to-phase AB mho distance, Zone 1
ABPDIS2	Op.general	MAB2	Phase-to-phase AB mho distance, Zone 2
ABPDIS2	Str.dirGeneral	forward	Direction always forward
ABPDIS2	Str.general	MAB2	Phase-to-phase AB mho distance, Zone 2
ABPDIS3	Op.general	MAB3	Phase-to-phase AB mho distance, Zone 3
ABPDIS3	Str.general	MAB3	Phase-to-phase AB mho distance, Zone 3
ABPDIS3	Str.dirGeneral	unknown	Direction unknown because of settings
ABPDIS4	Op.general	MAB4	Phase-to-phase AB mho distance, Zone 4
ABPDIS4	Str.general	MAB4	Phase-to-phase AB mho distance, Zone 4
ABPDIS4	Str.dirGeneral	unknown	Direction unknown because of settings
ABPTOV1	Str.general	59AB	Phase-to-phase AB overvoltage
ABPTOV1	Str.dirGeneral	unknown	Direction unknown because of settings
ABPTUV1	Op.general	27AB	Phase-to-phase AB undervoltage
ABPTUV1	Str.general	27AB	Phase-to-phase AB undervoltage
ABPTUV1	Str.dirGeneral	unknown	Direction unknown because of settings
APIOC1	Op.general	50A1	Instantaneous A-phase overcurrent, Level 1
APIOC2	Op.general	50A2	Instantaneous A-phase overcurrent, Level 2
APIOC3	Op.general	50A3	Instantaneous A-phase overcurrent, Level 3

Table P.24 Logical Device: PRO (Protection) (Sheet 3 of 14)

Logical Node	Attribute	Data Source	Comment
APIOC4	Op.general	50A4	Instantaneous A-phase overcurrent, Level 4
APIOC5	Op.general	50A	Instantaneous A-phase combined overcurrent, Levels 1-4
APTOV1	Str.general	59A	A-phase overvoltage
APTOV1	Str.dirGeneral	unknown	Direction unknown because of settings
APTUV1	Op.general	27A	A-phase undervoltage
APTUV1	Str.general	27A	A-phase undervoltage
APTUV1	Str.dirGeneral	unknown	Direction unknown because of settings
BARBRF1	OpEx.general	BFTRIP	Circuit breaker failure trip
BARBRF1	OpIn.general	RTA	A-phase retrip
BARBRF1	Str.general	BFTA	A-phase circuit breaker failure
BARBRF1	Str.dirGeneral	unknown	Direction unknown because of settings
BBRBRF2	OpEx.general	BFTRIP	Circuit breaker failure trip
BBRBRF2	OpIn.general	RTB	B-phase retrip
BBRBRF2	Str.general	BFTB	B-phase circuit breaker failure
BBRBRF2	Str.dirGeneral	unknown	Direction unknown because of settings
BCCSWI1	OpCls.general	CC	Circuit breaker close control
BCCSWI1	OpOpn.general	OC	Circuit breaker open control
BCCSWI1	Pos.stVal	3PO?2:1[f]	Breaker position (3PO = false, breaker closed; 3PO = true, breaker opened)
BCPDIS1	Op.general	MBC1	Phase-to-phase BC mho distance, Zone 1
BCPDIS1	Str.dirGeneral	forward	Direction always forward
BCPDIS1	Str.general	MBC1	Phase-to-phase BC mho distance, Zone 1
BCPDIS2	Op.general	MBC2	Phase-to-phase BC mho distance, Zone 2
BCPDIS2	Str.dirGeneral	forward	Direction always forward
BCPDIS2	Str.general	MBC2	Phase-to-phase BC mho distance, Zone 2
BCPDIS3	Op.general	MBC3	Phase-to-phase BC mho distance, Zone 3
BCPDIS3	Str.general	MBC3	Phase-to-phase BC mho distance, Zone 3
BCPDIS3	Str.dirGeneral	unknown	Direction unknown because of settings
BCPDIS4	Op.general	MBC4	Phase-to-phase BC mho distance, Zone 4
BCPDIS4	Str.general	MBC4	Phase-to-phase BC mho distance, Zone 4
BCPDIS4	Str.dirGeneral	unknown	Direction unknown because of settings
BCPTOV1	Str.general	59BC	Phase-to-phase BC overvoltage
BCPTOV1	Str.dirGeneral	unknown	Direction unknown because of settings
BCPTUV1	Op.general	27BC	Phase-to-phase BC undervoltage
BCPTUV1	Str.general	27BC	Phase-to-phase BC undervoltage
BCPTUV1	Str.dirGeneral	unknown	Direction unknown because of settings
BCRBRF3	OpEx.general	BFTRIP	Circuit breaker failure trip
BCRBRF3	OpIn.general	RTC	C-phase retrip
BCRBRF3	Str.general	BFTC	C-phase circuit breaker failure
BCRBRF3	Str.dirGeneral	unknown	Direction unknown because of settings
BPIOC1	Op.general	50B1	Instantaneous B-phase overcurrent, Level 1

Table P.24 Logical Device: PRO (Protection) (Sheet 4 of 14)

Logical Node	Attribute	Data Source	Comment
BPIOC2	Op.general	50B2	Instantaneous B-phase overcurrent, Level 2
BPIOC3	Op.general	50B3	Instantaneous B-phase overcurrent, Level 3
BPIOC4	Op.general	50B4	Instantaneous B-phase overcurrent, Level 4
BPIOC5	Op.general	50B	Instantaneous B-phase combined overcurrent, Levels 1-4
BPTOV1	Str.general	59B	B-phase overvoltage
BPTOV1	Str.dirGeneral	unknown	Direction unknown because of settings
BPTUV1	Op.general	27B	B-phase undervoltage
BPTUV1	Str.general	27B	B-phase undervoltage
BPTUV1	Str.dirGeneral	unknown	Direction unknown because of settings
BSASCBR1	ColOpn.stVal	OC	Circuit breaker open control
BSASCBR1	OpCnt.stVal	ESOALCNT	Electrical operation alarm counter
BSASCBR1	OpTmAlm1.stVal	ESCLA	Electrical close operating time alarm, A-phase
BSASCBR1	OpTmAlm2.stVal	ESTRA	Electrical trip operating time alarm, A-phase
BSBSCBR2	ColOpn.stVal	OC	Circuit breaker open control
BSBSCBR2	OpCnt.stVal	ESOALCNT	Electrical operation alarm counter
BSBSCBR2	OpTmAlm1.stVal	ESCLB	Electrical close operating time alarm, B-phase
BSBSCBR2	OpTmAlm2.stVal	ESTRB	Electrical trip operating time alarm, B-phase
BSCSCBR3	ColOpn.stVal	OC	Circuit breaker open control
BSCSCBR3	OpCnt.stVal	ESOALCNT	Electrical operation alarm counter
BSCSCBR3	OpTmAlm1.stVal	ESCLC	Electrical close operating time alarm, C-phase
BSCSCBR3	OpTmAlm2.stVal	ESTRC	Electrical trip operating time alarm, C-phase
BSMASCBR1	ColOpn.stVal	OC	Circuit breaker open control
BSMASCBR1	OpCnt.stVal	MSOALCNT	Mechanical operation alarm counter
BSMASCBR1	OpTmAlm1.stVal	MSCLA	Mechanical close operating time alarm, A-phase
BSMASCBR1	OpTmAlm2.stVal	MSTRA	Mechanical trip operating time alarm, A-phase
BSMBSCBR2	ColOpn.stVal	OC	Circuit breaker open control
BSMBSCBR2	OpCnt.stVal	MSOALCNT	Mechanical operation alarm counter
BSMBSCBR2	OpTmAlm1.stVal	MSCLB	Mechanical close operating time alarm, B-phase
BSMBSCBR2	OpTmAlm2.stVal	MSTRB	Mechanical trip operating time alarm, B-phase
BSMCSCBR3	ColOpn.stVal	OC	Circuit breaker open control
BSMCSCBR3	OpCnt.stVal	MSOALCNT	Mechanical operation alarm counter
BSMCSCBR3	OpTmAlm1.stVal	MSCLC	Mechanical close operating time alarm, C-phase
BSMCSCBR3	OpTmAlm2.stVal	MSTRC	Mechanical trip operating time alarm, C-phase
BSAXCBR1	BlkCls.stVal	0	Breaker close blocking not configured by default
BSAXCBR1	BlkOpn.stVal	0	Breaker open blocking not configured by default
BSAXCBR1	CBOpCap.stVal	None	Breaker physical operation capabilities not known to relay
BSAXCBR1	Loc.stVal	0	Breaker local control status not configured by default
BSAXCBR1	OpCnt.stVal	INTTRA	Internal A-phase breaker trip counter
BSAXCBR1	OpCntEx.stVal	EXTTRA	External A-phase breaker trip counter
BSAXCBR1	Pos.stVal	SPOA?2:1[f]	Breaker A-phase position (SPOA = false, A-phase closed; SPOA = true, A-phase opened)

Table P.24 Logical Device: PRO (Protection) (Sheet 5 of 14)

Logical Node	Attribute	Data Source	Comment
BSBXCBR2	BlkCls.stVal	0	Breaker close blocking not configured by default
BSBXCBR2	BlkOpn.stVal	0	Breaker open blocking not configured by default
BSBXCBR2	CBOpCap.stVal	None	Breaker physical operation capabilities not known to relay
BSBXCBR2	Loc.stVal	0	Breaker local control status not configured by default
BSBXCBR2	OpCnt.stVal	INTTRB	Internal B-phase breaker trip counter
BSBXCBR2	OpCntEx.stVal	EXTTRB	External B-phase breaker trip counter
BSBXCBR2	Pos.stVal	SPOB?2:1[f]	Breaker B-phase position (SPOB = false, B-phase closed; SPOB = true, B-phase opened)
BSCXCBR3	BlkCls.stVal	0	Breaker close blocking not configured by default
BSCXCBR3	BlkOpn.stVal	0	Breaker open blocking not configured by default
BSCXCBR3	CBOpCap.stVal	None	Breaker physical operation capabilities not known to relay
BSCXCBR3	Loc.stVal	0	Breaker local control status not configured by default
BSCXCBR3	OpCnt.stVal	INTTRC	Internal C-phase breaker trip counter
BSCXCBR3	OpCntEx.stVal	EXTTRC	External C-phase breaker trip counter
BSCXCBR3	Pos.stVal	SPOC?2:1[f]	Breaker C-phase position (SPOC = false, C-phase closed; SPOC = true, C-phase opened)
CAPDIS1	Op.general	MCA1	Phase-to-phase CA mho distance, Zone 1
CAPDIS1	Str.dirGeneral	forward	Direction always forward
CAPDIS1	Str.general	MCA1	Phase-to-phase CA mho distance, Zone 1
CAPDIS2	Op.general	MCA2	Phase-to-phase CA mho distance, Zone 2
CAPDIS2	Str.dirGeneral	forward	Direction always forward
CAPDIS2	Str.general	MCA2	Phase-to-phase CA mho distance, Zone 2
CAPDIS3	Op.general	MCA3	Phase-to-phase CA mho distance, Zone 3
CAPDIS3	Str.general	MCA3	Phase-to-phase CA mho distance, Zone 3
CAPDIS3	Str.dirGeneral	unknown	Direction unknown because of settings
CAPDIS4	Op.general	MCA4	Phase-to-phase CA mho distance, Zone 4
CAPDIS4	Str.general	MCA4	Phase-to-phase CA mho distance, Zone 4
CAPDIS4	Str.dirGeneral	unknown	Direction unknown because of settings
CAPTOV1	Str.general	59CA	Phase-to-phase BC overvoltage
CAPTOV1	Str.dirGeneral	unknown	Direction unknown because of settings
CAPTUV1	Op.general	27CA	Phase-to-phase CA undervoltage
CAPTUV1	Str.general	27CA	Phase-to-phase CA undervoltage
CAPTUV1	Str.dirGeneral	unknown	Direction unknown because of settings
CPIOC1	Op.general	50C1	Instantaneous C-phase overcurrent, Level 1
CPIOC2	Op.general	50C2	Instantaneous C-phase overcurrent, Level 2
CPIOC3	Op.general	50C3	Instantaneous C-phase overcurrent, Level 3
CPIOC4	Op.general	50C4	Instantaneous C-phase overcurrent, Level 4
CPIOC5	Op.general	50C	Instantaneous C-phase combined overcurrent, Levels 1-4
CPTOV1	Str.general	59C	C-phase overvoltage
CPTOV1	Str.dirGeneral	unknown	Direction unknown because of settings
CPTUV1	Op.general	27C	C-phase undervoltage
CPTUV1	Str.general	27C	C-phase undervoltage

Table P.24 Logical Device: PRO (Protection) (Sheet 6 of 14)

Logical Node	Attribute	Data Source	Comment
CPTUV1	Str.dirGeneral	unknown	Direction unknown because of settings
DCUBPSCH1	Echo.general	EKEY	Echo permissive trip received
DCUBPSCH1	Op.general	PTRX	Permissive trip received
DCUBPSCH1	ProRx.stVal	PTRX	Permissive trip received
DCUBPSCH1	ProTx.stVal	KEY	Key permissive trip
DCUBPSCH1	RvABlk.general	Z3RB	Current reversal guard
DCUBPSCH1	Str.general	KEY	Key permissive trip
DCUBPSCH1	Str.dirGeneral	KEY?0:1	Key permissive, direction (KEY = false, direction unknown; KEY = true, direction forward)
DCUBPSCH1	WeiOp.general	ECTT	Echo conversion to trip
DPTOF1	BlkV.stVal	27B81	Overfrequency pickup, Frequency blocking, Level 1
DPTOF1	Op.general	81D1T[g]	Overfrequency operate, Frequency operate, Level 1
DPTOF1	Str.general	81D1[g]	Overfrequency pickup, Frequency pickup, Level 1
DPTOF1	Str.dirGeneral	unknown	Direction unknown because of settings
DPTOF2	BlkV.stVal	27B81	Overfrequency pickup, Frequency blocking, Level 2
DPTOF2	Op.general	81D2T[g]	Overfrequency operate, Frequency operate, Level 2
DPTOF2	Str.general	81D2[g]	Overfrequency pickup, Frequency pickup, Level 2
DPTOF2	Str.dirGeneral	unknown	Direction unknown because of settings
DPTOF3	BlkV.stVal	27B81	Overfrequency pickup, Frequency blocking, Level 3
DPTOF3	Op.general	81D3T[g]	Overfrequency operate, Frequency operate, Level 3
DPTOF3	Str.general	81D3[g]	Overfrequency pickup, Frequency pickup, Level 3
DPTOF3	Str.dirGeneral	unknown	Direction unknown because of settings
DPTOF4	BlkV.stVal	27B81	Overfrequency pickup, Frequency blocking, Level 4
DPTOF4	Op.general	81D4T[g]	Overfrequency operate, Frequency operate, Level 4
DPTOF4	Str.general	81D4[g]	Overfrequency pickup, Frequency pickup, Level 4
DPTOF4	Str.dirGeneral	unknown	Direction unknown because of settings
DPTOF5	BlkV.stVal	27B81	Overfrequency pickup, Frequency blocking, Level 5
DPTOF5	Op.general	81D5T[g]	Overfrequency operate, Frequency operate, Level 5
DPTOF5	Str.general	81D5[g]	Overfrequency pickup, Frequency pickup, Level 5
DPTOF5	Str.dirGeneral	unknown	Direction unknown because of settings
DPTOF6	BlkV.stVal	27B81	Overfrequency pickup, Frequency blocking, Level 6
DPTOF6	Op.general	81D6T[g]	Overfrequency operate, Frequency operate, Level 6
DPTOF6	Str.general	81D6[g]	Overfrequency pickup, Frequency pickup, Level 6
DPTOF6	Str.dirGeneral	unknown	Direction unknown because of settings
DPTUF1	BlkV.stVal	27B81	Underfrequency pickup, Frequency blocking, Level 1
DPTUF1	Op.general	81D1T[g]	Underfrequency operate, Frequency operate, Level 1
DPTUF1	Str.general	81D1[g]	Underfrequency pickup, Frequency pickup, Level 1
DPTUF1	Str.dirGeneral	unknown	Direction unknown because of settings
DPTUF2	BlkV.stVal	27B81	Underfrequency pickup, Frequency blocking, Level 2
DPTUF2	Op.general	81D2T[g]	Underfrequency operate, Frequency operate, Level 2
DPTUF2	Str.general	81D2[g]	Underfrequency pickup, Frequency pickup, Level 2

Table P.24 Logical Device: PRO (Protection) (Sheet 7 of 14)

Logical Node	Attribute	Data Source	Comment
DPTUF2	Str.dirGeneral	unknown	Direction unknown because of settings
DPTUF3	BlkV.stVal	27B81	Underfrequency pickup, Frequency blocking, Level 3
DPTUF3	Op.general	81D3T[g]	Underfrequency operate, Frequency operate, Level 3
DPTUF3	Str.general	81D3[g]	Underfrequency pickup, Frequency pickup, Level 3
DPTUF3	Str.dirGeneral	unknown	Direction unknown because of settings
DPTUF4	BlkV.stVal	27B81	Underfrequency pickup, Frequency blocking, Level 4
DPTUF4	Op.general	81D4T[g]	Underfrequency operate, Frequency operate, Level 4
DPTUF4	Str.general	81D4[g]	Underfrequency pickup, Frequency pickup, Level 4
DPTUF4	Str.dirGeneral	unknown	Direction unknown because of settings
DPTUF5	BlkV.stVal	27B81	Underfrequency pickup, Frequency blocking, Level 5
DPTUF5	Op.general	81D5T[g]	Underfrequency operate, Frequency operate, Level 5
DPTUF5	Str.general	81D5[g]	Underfrequency pickup, Frequency pickup, Level 5
DPTUF5	Str.dirGeneral	unknown	Direction unknown because of settings
DPTUF6	BlkV.stVal	27B81	Underfrequency pickup, Frequency blocking, Level 6
DPTUF6	Op.general	81D6T[g]	Underfrequency operate, Frequency operate, Level 6
DPTUF6	Str.general	81D6[g]	Underfrequency pickup, Frequency pickup, Level 6
DPTUF6	Str.dirGeneral	unknown	Direction unknown because of settings
FLTRDRE1	RcdMade.stVal	FLREP	Event report present
FLTRDRE1	FltNum.stVal	FLRNUM	Unique event ID number
G51PTOC1	Op.general	51GT	Residual time-overcurrent operate
G51PTOC1	Str.general	51G	Residual time-overcurrent pickup
G51PTOC1	Str.dirGeneral	unknown	Direction unknown because of settings
G67PTOC1	Op.general	67G1T	Definite time, torque-controlled 50G1
G67PTOC1	Str.general	67G1	Torque-controlled 50G1
G67PTOC1	Str.dirGeneral	unknown	Direction unknown because of settings
G67PTOC2	Op.general	67G2T	Definite time, torque-controlled 50G2
G67PTOC2	Str.general	67G2	Torque-controlled 50G2
G67PTOC2	Str.dirGeneral	unknown	Direction unknown because of settings
G67PTOC3	Op.general	67G3T	Definite time, torque-controlled 50G3
G67PTOC3	Str.general	67G3	Torque-controlled 50G3
G67PTOC3	Str.dirGeneral	unknown	Direction unknown because of settings
G67PTOC4	Op.general	67G4T	Definite time, torque-controlled 50G4
G67PTOC4	Str.general	67G4	Torque-controlled 50G4
G67PTOC4	Str.dirGeneral	unknown	Direction unknown because of settings
GFPIOC1	Op.general	50GF	Residual forward direction decision supervision
GFRDIR1	Dir.general	32GF	Forward directional control for ground-distance elements
GFRDIR1	Dir.dirGeneral	32GF?0:1	Forward directional control for ground-distance elements, direction (32GF = false, direction unknown; 32GF = true, direction forward)
GPIOC1	Op.general	50G1	Instantaneous residual overcurrent, Level 1
GPIOC2	Op.general	50G2	Instantaneous residual overcurrent, Level 2
GPIOC3	Op.general	50G3	Instantaneous residual overcurrent, Level 3

Table P.24 Logical Device: PRO (Protection) (Sheet 8 of 14)

Logical Node	Attribute	Data Source	Comment
GPIOC4	Op.general	50G4	Instantaneous residual overcurrent, Level 4
GRPIOC1	Op.general	50GR	Residual reverse direction decision supervision
GRRDIR1	Dir.general	32GR	Reverse directional control for ground-distance elements
GRRDIR1	Dir.dirGeneral	32GR?0:2	Reverse directional control for ground-distance elements, direction (32GR = false, direction unknown; 32GR = true, direction reverse)
LAPIOC1	Op.general	50LA	Instantaneous A-phase overcurrent, closed breaker detection
LBPIOC1	Op.general	50LB	Instantaneous B-phase overcurrent, closed breaker detection
LCPIOC1	Op.general	50LC	Instantaneous C-phase overcurrent, closed breaker detection
LOPPTUV1	LOP1.stVal	LOP1	Breaker closing LOP logic asserted
LOPPTUV1	LOP2.stVal	LOP2	Drop in voltage without change in current LOP logic asserted
LOPPTUV1	LOP3.stVal	LOP3	LOP latched
LOPPTUV1	LOP4.stVal	LOP4	Busbar VT LOP logic asserted
LOPPTUV1	LOPRST.stVal	LOPRST	LOP Reset condition based on detection of healthy voltages
LOPPTUV1	Op.general	LOP	Loss of potential
LOPPTUV1	Str.general	LOP	Loss of potential
LOPPTUV1	Str.dirGeneral	unknown	Direction unknown because of settings
LPIOC1	Op.general	50L	Instantaneous phase overcurrent, closed breaker detection
M1PPDIS1	Op.general	M1PT	mho phase distance, Zone 1, operate
M1PPDIS1	Str.dirGeneral	forward	Direction always forward
M1PPDIS1	Str.general	M1P	mho phase distance, Zone 1, pickup
M2PPDIS2	Op.general	M2PT	mho phase distance, Zone 2, operate
M2PPDIS2	Str.dirGeneral	forward	Direction always forward
M2PPDIS2	Str.general	M2P	mho phase distance, Zone 2, pickup
M3PPDIS3	Op.general	M3PT	mho phase distance, Zone 3, operate
M3PPDIS3	Str.general	M3P	mho phase distance, Zone 3, pickup
M3PPDIS3	Str.dirGeneral	unknown	Direction unknown because of settings
M4PPDIS4	Op.general	M4PT	mho phase distance, Zone 4, operate
M4PPDIS4	Str.general	M4P	mho phase distance, Zone 4, pickup
M4PPDIS4	Str.dirGeneral	unknown	Direction unknown because of settings
MABHPDIS1	Op.general	MAB1H[h]	High-speed Zone 1 mho A-B phase element
MABHPDIS1	Str.dirGeneral	forward[h]	Direction always forward
MABHPDIS1	Str.general	MAB1H[h]	High-speed Zone 1 mho A-B phase element
MABHPDIS2	Op.general	MAB2H[h]	High-speed Zone 2 mho A-B phase element
MABHPDIS2	Str.dirGeneral	forward[h]	Direction always forward
MABHPDIS2	Str.general	MAB2H[h]	High-speed Zone 2 mho A-B phase element
MABHPDIS3	Op.general	MAB3H[h]	High-speed Zone 3 mho A-B phase element
MABHPDIS3	Str.general	MAB3H[h]	High-speed Zone 3 mho A-B phase element
MABHPDIS3	Str.dirGeneral	unknown[h]	Direction unknown because of settings
MAGHPDIS1	Op.general	MAG1H[h]	High-speed Zone 1 mho A-phase ground element
MAGHPDIS1	Str.dirGeneral	forward[h]	Direction always forward
MAGHPDIS1	Str.general	MAG1H[h]	High-speed Zone 1 mho A-phase ground element

Table P.24 Logical Device: PRO (Protection) (Sheet 9 of 14)

Logical Node	Attribute	Data Source	Comment
MAGHPDIS2	Op.general	MAG2H[h]	High-speed Zone 2 mho A-phase ground element
MAGHPDIS2	Str.dirGeneral	forward[h]	Direction always forward
MAGHPDIS2	Str.general	MAG2H[h]	High-speed Zone 2 mho A-phase ground element
MAGHPDIS3	Op.general	MAG3H[h]	High-speed Zone 3 mho A-phase ground element
MAGHPDIS3	Str.general	MAG3H[h]	High-speed Zone 3 mho A-phase ground element
MAGHPDIS3	Str.dirGeneral	unknown[h]	Direction unknown because of settings
MAGPDIS1	Op.general	MAG1	A-phase mho ground distance, Zone 1
MAGPDIS1	Str.dirGeneral	forward	Direction always forward
MAGPDIS1	Str.general	MAG1	A-phase mho ground distance, Zone 1
MAGPDIS2	Op.general	MAG2	A-phase mho ground distance, Zone 2
MAGPDIS2	Str.dirGeneral	forward	Direction always forward
MAGPDIS2	Str.general	MAG2	A-phase mho ground distance, Zone 2
MAGPDIS3	Op.general	MAG3	A-phase mho ground distance, Zone 3
MAGPDIS3	Str.general	MAG3	A-phase mho ground distance, Zone 3
MAGPDIS3	Str.dirGeneral	unknown	Direction unknown because of settings
MAGPDIS4	Op.general	MAG4	A-phase mho ground distance, Zone 4
MAGPDIS4	Str.general	MAG4	A-phase mho ground distance, Zone 4
MAGPDIS4	Str.dirGeneral	unknown	Direction unknown because of settings
MBCHPDIS1	Op.general	MBC1H[h]	High-speed Zone 1 mho B-C phase element
MBCHPDIS1	Str.dirGeneral	forward[h]	Direction always forward
MBCHPDIS1	Str.general	MBC1H[h]	High-speed Zone 1 mho B-C phase element
MBCHPDIS2	Op.general	MBC2H[h]	High-speed Zone 2 mho B-C phase element
MBCHPDIS2	Str.dirGeneral	forward[h]	Direction always forward
MBCHPDIS2	Str.general	MBC2H[h]	High-speed Zone 2 mho B-C phase element
MBCHPDIS3	Op.general	MBC3H[h]	High-speed Zone 3 mho B-C phase element
MBCHPDIS3	Str.general	MBC3H[h]	High-speed Zone 3 mho B-C phase element
MBCHPDIS3	Str.dirGeneral	unknown[h]	Direction unknown because of settings
MBGHPDIS1	Op.general	MBG1H[h]	High-speed Zone 1 mho B-phase ground element
MBGHPDIS1	Str.dirGeneral	forward[h]	Direction always forward
MBGHPDIS1	Str.general	MBG1H[h]	High-speed Zone 1 mho B-phase ground element
MBGHPDIS2	Op.general	MBG2H[h]	High-speed Zone 2 mho B-phase ground element
MBGHPDIS2	Str.dirGeneral	forward[h]	Direction always forward
MBGHPDIS2	Str.general	MBG2H[h]	High-speed Zone 2 mho B-phase ground element
MBGHPDIS3	Op.general	MBG3H[h]	High-speed Zone 3 mho B-phase ground element
MBGHPDIS3	Str.general	MBG3H[h]	High-speed Zone 3 mho B-phase ground element
MBGHPDIS3	Str.dirGeneral	unknown[h]	Direction unknown because of settings
MBGPDIS1	Op.general	MBG1	B-phase mho ground distance, Zone 1
MBGPDIS1	Str.dirGeneral	forward	Direction always forward
MBGPDIS1	Str.general	MBG1	B-phase mho ground distance, Zone 1
MBGPDIS2	Op.general	MBG2	B-phase mho ground distance, Zone 2
MBGPDIS2	Str.dirGeneral	forward	Direction always forward

Table P.24 Logical Device: PRO (Protection) (Sheet 10 of 14)

Logical Node	Attribute	Data Source	Comment
MBGPDIS2	Str.general	MBG2	B-phase mho ground distance, Zone 2
MBGPDIS3	Op.general	MBG3	B-phase mho ground distance, Zone 3
MBGPDIS3	Str.general	MBG3	B-phase mho ground distance, Zone 3
MBGPDIS3	Str.dirGeneral	unknown	Direction unknown because of settings
MBGPDIS4	Op.general	MBG4	B-phase mho ground distance, Zone 4
MBGPDIS4	Str.general	MBG4	B-phase mho ground distance, Zone 4
MBGPDIS4	Str.dirGeneral	unknown	Direction unknown because of settings
MCAHPDIS1	Op.general	MCA1H[h]	High-speed Zone 1 mho C-A phase element
MCAHPDIS1	Str.dirGeneral	forward[h]	Direction always forward
MCAHPDIS1	Str.general	MCA1H[h]	High-speed Zone 1 mho C-A phase element
MCAHPDIS2	Op.general	MCA2H[h]	High-speed Zone 2 mho C-A phase element
MCAHPDIS2	Str.dirGeneral	forward[h]	Direction always forward
MCAHPDIS2	Str.general	MCA2H[h]	High-speed Zone 2 mho C-A phase element
MCAHPDIS3	Op.general	MCA3H[h]	High-speed Zone 3 mho C-A phase element
MCAHPDIS3	Str.general	MCA3H[h]	High-speed Zone 3 mho C-A phase element
MCAHPDIS3	Str.dirGeneral	unknown[h]	Direction unknown because of settings
MCGHPDIS1	Op.general	MCG1H[h]	High-speed Zone 1 mho C-phase ground element
MCGHPDIS1	Str.dirGeneral	forward[h]	Direction always forward
MCGHPDIS1	Str.general	MCG1H[h]	High-speed Zone 1 mho C-phase ground element
MCGHPDIS2	Op.general	MCG2H[h]	High-speed Zone 2 mho C-phase ground element
MCGHPDIS2	Str.dirGeneral	forward[h]	Direction always forward
MCGHPDIS2	Str.general	MCG2H[h]	High-speed Zone 2 mho C-phase ground element
MCGHPDIS3	Op.general	MCG3H[h]	High-speed Zone 3 mho C-phase ground element
MCGHPDIS3	Str.general	MCG3H[h]	High-speed Zone 3 mho C-phase ground element
MCGHPDIS3	Str.dirGeneral	unknown[h]	Direction unknown because of settings
MCGPDIS1	Op.general	MCG1	C-phase mho ground distance, Zone 1
MCGPDIS1	Str.dirGeneral	forward	Direction always forward
MCGPDIS1	Str.general	MCG1	C-phase mho ground distance, Zone 1
MCGPDIS2	Op.general	MCG2	C-phase mho ground distance, Zone 2
MCGPDIS2	Str.dirGeneral	forward	Direction always forward
MCGPDIS2	Str.general	MCG2	C-phase mho ground distance, Zone 2
MCGPDIS3	Op.general	MCG3	C-phase mho ground distance, Zone 3
MCGPDIS3	Str.general	MCG3	C-phase mho ground distance, Zone 3
MCGPDIS3	Str.dirGeneral	unknown	Direction unknown because of settings
MCGPDIS4	Op.general	MCG4	C-phase mho ground distance, Zone 4
MCGPDIS4	Str.general	MCG4	C-phase mho ground distance, Zone 4
MCGPDIS4	Str.dirGeneral	unknown	Direction unknown because of settings
NPTOV1	Str.general	59N1	Zero-sequence instantaneous overvoltage, Level 1
NPTOV1	Str.dirGeneral	unknown	Direction unknown because of settings
NPTOV2	Str.general	59N2	Zero-sequence instantaneous overvoltage, Level 2
NPTOV2	Str.dirGeneral	unknown	Direction unknown because of settings

Table P.24 Logical Device: PRO (Protection) (Sheet 11 of 14)

Logical Node	Attribute	Data Source	Comment
P51PTOC1	Op.general	51PT	Phase time-overcurrent operate
P51PTOC1	Str.general	51P	Phase time-overcurrent pickup
P51PTOC1	Str.dirGeneral	unknown	Direction unknown because of settings
P67PTOC1	Op.general	67P1T	Definite time, torque-controlled 50P1
P67PTOC1	Str.general	67P1	Torque-controlled 50P1
P67PTOC1	Str.dirGeneral	unknown	Direction unknown because of settings
P67PTOC2	Op.general	67P2T	Definite time, torque-controlled 50P2
P67PTOC2	Str.general	67P2	Torque-controlled 50P2
P67PTOC2	Str.dirGeneral	unknown	Direction unknown because of settings
P67PTOC3	Op.general	67P3T	Definite time, torque-controlled 50P3
P67PTOC3	Str.general	67P3	Torque-controlled 50P3
P67PTOC3	Str.dirGeneral	unknown	Direction unknown because of settings
P67PTOC4	Op.general	67P4T	Definite time, torque-controlled 50P4
P67PTOC4	Str.general	67P4	Torque-controlled 50P4
P67PTOC4	Str.dirGeneral	unknown	Direction unknown because of settings
PH3PTOV1	Str.general	3P59	Three-phase overvoltage
PH3PTOV1	Str.dirGeneral	unknown	Direction unknown because of settings
PH3PTUV1	Op.general	3P27	Three-phase undervoltage
PH3PTUV1	Str.general	3P27	Three-phase undervoltage
PH3PTUV1	Str.dirGeneral	unknown	Direction unknown because of settings
POTTPSCH1	Echo.general	EKEY	Echo permissive trip received
POTTPSCH1	Op.general	PTRX	Permissive trip received
POTTPSCH1	ProRx.stVal	PTRX	Permissive trip received
POTTPSCH1	ProTx.stVal	KEY	Key permissive trip
POTTPSCH1	RvABlk.general	Z3RB	Current reversal guard
POTTPSCH1	Str.general	KEY	Key permissive trip
POTTPSCH1	Str.dirGeneral	KEY?0:1	Key permissive, direction (KEY = false, direction unknown; KEY = true, direction forward)
POTTPSCH1	WeiOp.general	ECTT	Echo conversion to trip
PPIOC1	Op.general	50P1	Instantaneous phase overcurrent, Level 1
PPIOC2	Op.general	50P2	Instantaneous phase overcurrent, Level 2
PPIOC3	Op.general	50P3	Instantaneous phase overcurrent, Level 3
PPIOC4	Op.general	50P4	Instantaneous phase overcurrent, Level 4
Q51PTOC1	Op.general	51QT	Negative-sequence time-overcurrent operate
Q51PTOC1	Str.general	51Q	Negative-sequence time-overcurrent pickup
Q51PTOC1	Str.dirGeneral	unknown	Direction unknown because of settings
Q67PTOC1	Op.general	67Q1T	Definite time, torque-controlled 50Q1
Q67PTOC1	Str.general	67Q1	Torque-controlled 50Q1
Q67PTOC1	Str.dirGeneral	unknown	Direction unknown because of settings
Q67PTOC2	Op.general	67Q2T	Definite time, torque-controlled 50Q2
Q67PTOC2	Str.general	67Q2	Torque-controlled 50Q2

Table P.24 Logical Device: PRO (Protection) (Sheet 12 of 14)

Logical Node	Attribute	Data Source	Comment
Q67PTOC2	Str.dirGeneral	unknown	Direction unknown because of settings
Q67PTOC3	Op.general	67Q3T	Definite time, torque-controlled 50Q3
Q67PTOC3	Str.general	67Q3	Torque-controlled 50Q3
Q67PTOC3	Str.dirGeneral	unknown	Direction unknown because of settings
Q67PTOC4	Op.general	67Q4T	Definite time, torque-controlled 50Q4
Q67PTOC4	Str.general	67Q4	Torque-controlled 50Q4
Q67PTOC4	Str.dirGeneral	unknown	Direction unknown because of settings
QFPIOC1	Op.general	50QF	Negative-sequence forward direction decision supervision
QFRDIR1	Dir.general	32QF	Forward directional control routed to phase-distance elements
QFRDIR1	Dir.dirGeneral	32QF?0:1	Forward directional control routed to phase-distance elements, direction (32QF = false, direction unknown; 32QF = true, direction forward)
QPIOC1	Op.general	50Q1	Instantaneous negative-sequence overcurrent, Level 1
QPIOC2	Op.general	50Q2	Instantaneous negative-sequence overcurrent, Level 2
QPIOC3	Op.general	50Q3	Instantaneous negative-sequence overcurrent, Level 3
QPIOC4	Op.general	50Q4	Instantaneous negative-sequence overcurrent, Level 4
QPTOV1	Str.general	59Q	Negative-sequence overvoltage
QPTOV1	Str.dirGeneral	unknown	Direction unknown because of settings
QRPIOC1	Op.general	50QR	Negative-sequence reverse direction decision supervision
QRRDIR1	Dir.general	32QR	Reverse directional control for phase-distance elements
QRRDIR1	Dir.dirGeneral	32QR?0:2	Reverse directional control for phase-distance elements, direction (32QR = false, direction unknown; 32QR = true, direction reverse)
SPTOV1	Str.general	59S	VS overvoltage
SPTOV1	Str.dirGeneral	unknown	Direction unknown because of settings
SPTUV1	Op.general	27S	VS undervoltage
SPTUV1	Str.general	27S	VS undervoltage
SPTUV1	Str.dirGeneral	unknown	Direction unknown because of settings
TPAPTRC2	Tr.general	TPA	A-phase trip
TPBPTRC3	Tr.general	TPB	B-phase trip
TPCPTRC4	Tr.general	TPC	C-phase trip
TRIPPTRC1	Tr.general	TRIP	Trip indication
VPTOV1	Str.general	59V1	Positive-sequence overvoltage
VPTOV1	Str.dirGeneral	unknown	Direction unknown because of settings
XAGPDIS1	Op.general	XAG1	A-phase quad. ground distance, Zone 1
XAGPDIS1	Str.dirGeneral	forward	Direction always forward
XAGPDIS1	Str.general	XAG1	A-phase quad. ground distance, Zone 1
XAGPDIS2	Op.general	XAG2	A-phase quad. ground distance, Zone 2
XAGPDIS2	Str.dirGeneral	forward	Direction always forward
XAGPDIS2	Str.general	XAG2	A-phase quad. ground distance, Zone 2
XAGPDIS3	Op.general	XAG3	A-phase quad. ground distance, Zone 3
XAGPDIS3	Str.dirGeneral	unknown	Direction unknown because of settings
XAGPDIS3	Str.general	XAG3	A-phase quad. ground distance, Zone 3
XAGPDIS4	Op.general	XAG4	A-phase quad. ground distance, Zone 4

Table P.24 Logical Device: PRO (Protection) (Sheet 13 of 14)

Logical Node	Attribute	Data Source	Comment
XAGPDIS4	Str.dirGeneral	unknown	Direction unknown because of settings
XAGPDIS4	Str.general	XAG4	A-phase quad. ground distance, Zone 4
XBGPDIS1	Op.general	XBG1	B-phase quad. ground distance, Zone 1
XBGPDIS1	Str.dirGeneral	forward	Direction always forward
XBGPDIS1	Str.general	XBG1	B-phase quad. ground distance, Zone 1
XBGPDIS2	Op.general	XBG2	B-phase quad. ground distance, Zone 2
XBGPDIS2	Str.dirGeneral	forward	Direction always forward
XBGPDIS2	Str.general	XBG2	B-phase quad. ground distance, Zone 2
XBGPDIS3	Op.general	XBG3	B-phase quad. ground distance, Zone 3
XBGPDIS3	Str.dirGeneral	unknown	Direction unknown because of settings
XBGPDIS3	Str.general	XBG3	B-phase quad. ground distance, Zone 3
XBGPDIS4	Op.general	XBG4	B-phase quad. ground distance, Zone 4
XBGPDIS4	Str.dirGeneral	unknown	Direction unknown because of settings
XBGPDIS4	Str.general	XBG4	B-phase quad. ground distance, Zone 4
XCGPDIS1	Op.general	XCG1	C-phase quad. ground distance, Zone 1
XCGPDIS1	Str.dirGeneral	forward	Direction always forward
XCGPDIS1	Str.general	XCG1	C-phase quad. ground distance, Zone 1
XCGPDIS2	Op.general	XCG2	C-phase quad. ground distance, Zone 2
XCGPDIS2	Str.dirGeneral	forward	Direction always forward
XCGPDIS2	Str.general	XCG2	C-phase quad. ground distance, Zone 2
XCGPDIS3	Op.general	XCG3	C-phase quad. ground distance, Zone 3
XCGPDIS3	Str.dirGeneral	unknown	Direction unknown because of settings
XCGPDIS3	Str.general	XCG3	C-phase quad. ground distance, Zone 3
XCGPDIS4	Op.general	XCG4	C-phase quad. ground distance, Zone 4
XCGPDIS4	Str.dirGeneral	unknown	Direction unknown because of settings
XCGPDIS4	Str.general	XCG4	C-phase quad. ground distance, Zone 4
Z1GPDIS1	Op.general	Z1GT	Mho and/or quad. ground distance, Zone 1, operate
Z1GPDIS1	Str.dirGeneral	forward	Direction always forward
Z1GPDIS1	Str.general	Z1G	Mho and/or quad. ground distance, Zone 1, pickup
Z2GPDIS2	Op.general	Z2GT	Mho and/or quad. ground distance, Zone 2, operate
Z2GPDIS2	Str.dirGeneral	forward	Direction always forward
Z2GPDIS2	Str.general	Z2G	Mho and/or quad. ground distance, Zone 2, pickup
Z3GPDIS3	Op.general	Z3GT	Mho and/or quad. ground distance, Zone 3, operate
Z3GPDIS3	Str.dirGeneral	unknown	Direction unknown because of settings
Z3GPDIS3	Str.general	Z3G	Mho and/or quad. ground distance, Zone 3, pickup
Z4GPDIS4	Op.general	Z4GT	Mho and/or quad. ground distance, Zone 4, operate

Table P.24 Logical Device: PRO (Protection) (Sheet 14 of 14)

Logical Node	Attribute	Data Source	Comment
Z4GPDIS4	Str.dirGeneral	unknown	Direction unknown because of settings
Z4GPDIS4	Str.general	Z4G	Mho and/or quad. ground distance, Zone 4, pickup

[a] Writing a 0 to BCCSWI1.CO.Pos.Oper.ctlVal will cause OC to assert and writing any other value will cause CC to assert.
[b] MX values contain instantaneous attributes (instMag and instCVal) that are updated whenever the source updates and attributes that are only updated when the source goes outside the points deadband (mag and cVal). Only the instantaneous values are shown in the table.
[c] Current is controlled by Global Setting FLTDISP. When FLTDISP = MAX, registers are populated with currents from the maximum fault row. When FLTDISP = FL, registers are populated with fault locator currents. See Standard Event Report Summary on page 12.5.
[d] When fault location is undefined, the relay will report –999.9 for FLOC, FZ, FR, and FM, 0 for FZFA. FZ and FZFA are calculated by the fault locator and represent the portion of the line impedance between the relay and the fault.
[e] Fault location is a unitless quantity and depends on the units used when entering group setting LL. IEC61850 assumes the location is in km.
[f] If breaker is closed, value = 10 (2). If breaker is opened, value = 01 (1).
[g] There is only one set of frequency settings. Over- and underfrequency determined by the 81DxP setting. See Create Over- and Underfrequency Elements on page R.3.72.
[h] Available in the SEL-311C-3 only. High-speed distance Relay Word bits are for testing and indication only. Do not use in trip logic.

NOTE: Not all quantities are available in all settings configurations.

Table P.25 shows the LNs associated with measuring elements, defined as Logical Device MET. See *Appendix D: Relay Word Bits* and *Appendix E: Analog Quantities* for descriptions.

Table P.25 Logical Device: MET (Metering) (Sheet 1 of 3)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = MX[a]			
DCZBAT1	Vol.instMag.f	VDC	DC supply voltage
METMDST1	DmdA.nseq.instMag.f	3I2DEM	Demand, negative-sequence current
METMDST1	DmdA.phsA.instMag.f	IADEM	Demand, A-phase current
METMDST1	DmdA.phsB.instMag.f	IBDEM	Demand, B-phase current
METMDST1	DmdA.phsC.instMag.f	ICDEM	Demand, C-phase current
METMDST1	DmdA.res.instMag.f	IGDEM	Demand, residual current
METMDST1	DmdA.neut.instMag.f	INDEM	Demand, neutral current
METMDST1	DmdVArh.instMag.f	MVRH3O	Energy, reactive (MVARh), supply direction away from busbar
METMDST1	DmdWh.instMag.f	MWH3O	Energy, real (MWh), supply direction away from busbar
METMDST1	PkDmdA.nseq.instMag.f	3I2PK	Peak demand, negative-sequence current
METMDST1	PkDmdA.phsA.instMag.f	IAPK	Peak demand, A-phase current
METMDST1	PkDmdA.phsB.instMag.f	IBPK	Peak demand, B-phase current
METMDST1	PkDmdA.phsC.instMag.f	ICPK	Peak demand, C-phase current
METMDST1	PkDmdA.res.instMag.f	IGPK	Peak demand, residual current
METMDST1	PkDmdA.neut.instMag.f	INPK	Peak demand, neutral current
METMDST1	SupVArh.instMag.f	MVRH3I	Energy, reactive (MVARh), supply direction toward busbar
METMDST1	SupWh.instMag.f	MWH3I	Energy, real (MWh), supply direction toward busbar
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.res.instCVal.mag.f	IG	Residual current magnitude
METMMXU1	A.res.instCVal.ang.f	IGFA	Residual current angle

Table P.25 Logical Device: MET (Metering) (Sheet 2 of 3)

Logical Node	Attribute	Data Source	Comment
METMMXU1	A.neut.instCVal.mag.f	IN	Neutral current magnitude
METMMXU1	A.neut.instCVal.ang.f	INFA	Neutral current angle
METMMXU1	Hz.instMag.f	FREQ	Measured frequency
METMMXU1	PF.phsA.instCVal.mag.f	PFA	A-phase power factor
METMMXU1	PF.phsB.instCVal.mag.f	PFB	B-phase power factor
METMMXU1	PF.phsC.instCVal.mag.f	PFC	C-phase power factor
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
METMMXU1	PPV.phsAB.instCVal.mag.f	VAB	AB phase-to-phase voltage magnitude
METMMXU1	PPV.phsAB.instCVal.ang.f	VABFA	AB phase-to-phase voltage angle
METMMXU1	PPV.phsBC.instCVal.mag.f	VBC	BC phase-to-phase voltage magnitude
METMMXU1	PPV.phsBC.instCVal.ang.f	VBCFA	BC phase-to-phase voltage angle
METMMXU1	PPV.phsCA.instCVal.mag.f	VCA	CA phase-to-phase voltage magnitude
METMMXU1	PPV.phsCA.instCVal.ang.f	VCAFA	CA phase-to-phase voltage angle
METMMXU1	TotPF.instMag.f	PF3	Three-phase power factor
METMMXU1	TotVAr.instMag.f	KVAR3	Three-phase reactive power
METMMXU1	TotW.instMag.f	KW3	Three-phase real power
METMMXU1	VAr.phsA.instCVal.mag.f	KVARA	A-phase reactive power
METMMXU1	VAr.phsB.instCVal.mag.f	KVARB	B-phase reactive power
METMMXU1	VAr.phsC.instCVal.mag.f	KVARC	C-phase reactive power
METMMXU1	VSyn.instCVal.mag.f	VS	VS input magnitude
METMMXU1	VSyn.instCVal.ang.f	VSFA	VS input angle
METMMXU1	W.phsA.instCVal.mag.f	KWA	A-phase real power
METMMXU1	W.phsB.instCVal.mag.f	KWB	B-phase real power
METMMXU1	W.phsC.instCVal.mag.f	KWC	C-phase real power
METMSQI1	SeqA.c3.instCVal.mag.f	3I0	Zero-sequence current magnitude
METMSQI1	SeqA.c3.instCVal.ang.f	3I0FA	Zero-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.c1.instCVal.mag.f	I1	Positive-sequence current magnitude
METMSQI1	SeqA.c1.instCVal.ang.f	I1FA	Positive-sequence current angle
METMSQI1	SeqA.seqT	0	Sequence type (0 = pos–neg–zero [I1–3I2–3I0])
METMSQI1	SeqV.c3.instCVal.mag.f	3V0_MAG	Zero-sequence voltage magnitude
METMSQI1	SeqV.c3.instCVal.ang.f	3V0FA	Zero-sequence voltage 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

Table P.25 Logical Device: MET (Metering) (Sheet 3 of 3)

Logical Node	Attribute	Data Source	Comment
METMSQI1	SeqV.c2.instCVal.ang.f	V2FA	Negative-sequence voltage angle
METMSQI1	SeqV.seqT	0	Sequence type (0 = pos–neg–zero [V1–V2–3V0])
Functional Constraint = ST			
DCZBAT1	BatHi.stVal	DCHI	DC supply overvoltage (Boolean)
DCZBAT1	BatLo.stVal	DCLO	DC supply undervoltage (Boolean)

[a] MX values contain instantaneous attributes (instMag and instCVal) that are updated whenever the source updates and attributes that are only updated when the source goes outside the points deadband (mag and cVal). Only the instantaneous values are shown in the table.

Table P.26 shows the LNs associated with control elements, defined as Logical Device CON. See *Appendix D: Relay Word Bits* for descriptions.

Table P.26 Logical Device: CON (Remote Control)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
RBGGIO1	SPCSO01.Oper.ctlVal–SPCSO08.Oper.ctlVal	RB1–RB8	Remote Bits (RB1–RB8)
RBGGIO2	SPCSO09.Oper.ctlVal–SPCSO16.Oper.ctlVal	RB9–RB16	Remote Bits (RB9–RB16)
RBGGIO3	SPCSO17.Oper.ctlVal–SPCSO24.Oper.ctlVal	RB17–RB24	Remote Bits (RB17–RB24)
RBGGIO4	SPCSO25.Oper.ctlVal–SPCSO32.Oper.ctlVal	RB25–RB32	Remote Bits (RB25–RB32)
Functional Constraint = ST			
RBGGIO1	SPCSO01.stVal–SPCSO08.stVal	RB1–RB8	Remote Bits (RB1–RB8)
RBGGIO2	SPCSO09.stVal–SPCSO16.stVal	RB9–RB16	Remote Bits (RB9–RB16)
RBGGIO3	SPCSO17.stVal–SPCSO24.stVal	RB17–RB24	Remote Bits (RB17–RB24)
RBGGIO4	SPCSO25.stVal–SPCSO32.stVal	RB25–RB32	Remote Bits (RB25–RB32)

Table P.27 shows the LNs associated with the annunciation element, defined as Logical Device ANN. See *Appendix D: Relay Word Bits* and *Appendix E: Analog Quantities* for descriptions.

Table P.27 Logical Device: ANN (Annunciation) (Sheet 1 of 3)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = ST			
ALMGGIO21	Ind01.stVal	HALARM	Indication of a diagnostic failure or warning that warrants an ALARM
ALMGGIO21	Ind02.stVal	HALARML	Latches in for relay diagnostic failures
ALMGGIO21	Ind03.stVal	HALARMP	Pulses for five seconds when a warning diagnostic condition occurs
ALMGGIO21	Ind04.stVal	HALARMA	Pulses for five seconds every minute until reset when a hardware diagnostic warning occurs
ALMGGIO21	Ind05.stVal	0	Reserved for future use
ALMGGIO21	Ind06.stVal	ALRMOUT	Output contact ALARM asserted
ALMGGIO21	Ind07.stVal	ACCESS	Asserted while any user is logged in at access level B or higher
ALMGGIO21	Ind08.stVal	SALARM	Indication of software or user activity that warrants an ALARM
ALMGGIO21	Ind09.stVal	BADPASS	Pulses for one second whenever a user enters three successive bad passwords in an SEL ASCII terminal session or web session
ALMGGIO21	Ind10.stVal	CHGPASS	Pulses for one second whenever a password changes
ALMGGIO21	Ind11.stVal	SETCHG	Pulses for one second whenever settings are changed

Table P.27 Logical Device: ANN (Annunciation) (Sheet 2 of 3)

Logical Node	Attribute	Data Source	Comment
ALMGGIO21	Ind12.stVal	0	Reserved for future use
ALMGGIO21	Ind13.stVal	ACCESSP	Pulses for one second when any user increases their access level to B or higher
ALMGGIO21	Ind14.stVal	PASNVAL	Pulses for one second when an incorrect password is entered when attempting to access Level B or higher, or when changing passwords
ALMGGIO21	Ind15.stVal–Ind32.stVal	0	Reserved for future use
BRGGIO14	Ind01.stVal	52A	Breaker status, closed
BRGGIO14	Ind02.stVal	52AA	Breaker status, A-phase closed
BRGGIO14	Ind03.stVal	52AB	Breaker status, B-phase closed
BRGGIO14	Ind04.stVal	52AC	Breaker status, C-phase closed
BRGGIO14	Ind05.stVal	3PO	Three pole open condition
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
IN1GGIO1	Ind01.stVal–Ind06.stVal	IN101–IN106	Digital Inputs
IN2GGIO2	Ind01.stVal–Ind16.stVal	IN201–IN216	Digital Inputs
LBGGIO17	Ind01.stVal–Ind16.stVal	LB1–LB16	Local bits
LTGGIO7	Ind01.stVal–Ind16.stVal	LT1–LT16	Latch bits
LVGGIO8	Ind01.stVal–Ind32.stVal	LV1–LV32	Logic variables
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
OUT1GGIO3	Ind01.stVal–Ind07.stVal	OUT101–OUT107	Digital Outputs
OUT1GGIO3	Ind08.stVal	ALARM	Digital output—Inverse of ALRMOUT
OUT2GGIO4	Ind01.stVal–Ind12.stVal	OUT201–OUT212	Digital Outputs
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
RMBAGGIO9	Ind01.stVal–Ind08.stVal	RMB1A–RMB8A	Receive MIRRORED BITS, channel A
RMBBGGIO11	Ind01.stVal–Ind08.stVal	RMB1B–RMB8B	Receive MIRRORED BITS, channel B

Table P.27 Logical Device: ANN (Annunciation) (Sheet 3 of 3)

Logical Node	Attribute	Data Source	Comment
SGGGIO16	Ind01.stVal–Ind06.stVal	SG1–SG6	Setting group selected
SGGGIO16	Ind07.stVal	GRPSW	Group switch indication
SVGGIO5	Ind01.stVal–Ind16.stVal	SV1–SV16	SELOGIC variables
SVTGGIO6	Ind01.stVal–Ind16.stVal	SV1T–SV16T	SELOGIC variable timers
TLEDGGIO13	Ind01.stVal–Ind10.stVal	LED1–LED10	Programmable pushbutton LEDs
TLEDGGIO13	Ind11.stVal	TLED11	Status LED11 state (ENABLED)
TLEDGGIO13	Ind12.stVal–Ind18.stVal	TLED12–TLED18[a]	Programmable target/status LEDs
TLEDGGIO13	Ind19.stVal	TLED19	A-phase involved in the fault target
TLEDGGIO13	Ind20.stVal	TLED20	B-phase involved in the fault target
TLEDGGIO13	Ind21.stVal	TLED21	C-phase involved in the fault target
TLEDGGIO13	Ind22.stVal	TLED22	Ground-distance or residual-ground element picked up at time of trip
TLEDGGIO13	Ind23.stVal–Ind26.stVal	TLED23–TLED26[b]	Programmable target/status LEDs
TMBAGGIO10	Ind01.stVal–Ind08.stVal	TMB1A–TMB8A	Transmit MIRRORED BITS, channel A
TMBBGGIO12	Ind01.stVal–Ind08.stVal	TMB1B–TMB8B	Transmit MIRRORED BITS, channel B
VBGGIO15	Ind001.stVal–Ind128.stVal	VB001–VB128[b]	Virtual bits

[a] See the Front-Panel Target LEDs on page 5.47 section for details on the target/status LEDs.
[b] Virtual bits retain state until overwritten or device is restarted.

Table P.28 shows the LNs associated with the configuration element, defined as Logical Device CFG.

Table P.28 Logical Device: CFG (Configuration)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.serNum	SERNUM	Relay serial number (string format)
LLN0	NamPlt.swRev	FID	Firmware revision

Protocol Implementation Conformance Statement: SEL-311C

Table P.29 and *Table P.30* below are as shown in the IEC 61850 standard, Part 8-1, Section 24. Note that because the standard explicitly dictates which services and functions must be implemented to achieve conformance, only the optional services and functions are listed.

Table P.29 PICS for A-Profile Support

Profile		Client	Server	Value/Comment
A1	Client/Server	N	Y	
A2	GOOSE/GSE management	Y	Y	Only GOOSE, not GSE management
A3	GSSE	N	N	
A4	Time Sync	N	Y	

Table P.30 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 GSE
T4	GSSE	N	N	
T5	Time Sync	N	Y	

Refer to the *ACSI Conformance Statements on page P.52* 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.31* 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.31 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		
getNamedVariableListAttributes		Y
deleteNamedVariableList		
defineNamedType		
getNamedTypeAttributes		
deleteNamedType		
input		
output		
takeControl		
relinquishControl		
defineSemaphore		
deleteSemaphore		
reportPoolSemaphoreStatus		
reportSemaphoreStatus		
initiateDownloadSequence		

Table P.31 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
downloadSegment		
terminateDownloadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
requestDomainDownload		
requestDomainUpload		
loadDomainContent		
storeDomainContent		
deleteDomain		
getDomainAttributes		Y
createProgramInvocation		
deleteProgramInvocation		
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		Y
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		
getAlarmEnrollmentSummary		
readJournal		
writeJournal		
initializeJournal		
reportJournalStatus		
createJournal		
deleteJournal		

Table P.31 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
fileOpen		Y
fileRead		Y
fileClose		Y
fileRename		
fileDirectory		Y
unsolicitedStatus		
informationReport		Y
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		Y
cancel		Y
getDataExchangeAttributes		
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
reconfigureProgramInvocation		

Table P.32 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table P.32 MMS Parameter CBB

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
STR1		Y
STR2		Y
VNAM		Y
VADR		
VALT		Y
TPY		
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.33 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.34 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y
variableListName		Y

Table P.35 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		Y
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table P.36 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		Y
listOfAccessResult		Y

Table P.37 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		
address		
typeSpecification		

Table P.38 DefineNamedVariableList Conformance Statement

DefineVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table P.39 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		Y
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y

Table P.40 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.41 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.42 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 is mandatory if support for LOGICAL-DEVICE model has been declared.
[b] O = optional.

Table P.43 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	Data set	c5[d]	c5[d]	YES
M5	Substitution	O[e]	O[e]	
M6	Setting group control	O[e]	O[e]	

Table P.43 ACSI Models Conformance Statement (Sheet 2 of 2)

Models		Client/Subscriber	Server/Publisher	SEL-311C Support
		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
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			YES
	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]	YES
M17	File Transfer	O[e]	O[e]	YES

[a] c2 is "M" if support for LOGICAL-NODE model has been declared.
[b] c3 is "M" if support for DATA model has been declared.
[c] c4 is "M" if support for DATA-SET, Substitution, Report, Log Control, or Time model has been declared.
[d] c5 is "M" if support for Report, GSE, or SV models has been declared.
[e] O = optional.
[f] M = mandatory.

Table P.44 ACSI Services Conformance Statement (Sheet 1 of 3)

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
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]	
S10	GetDataDirectory	TP	O[b]	M[a]	YES
S11	GetDataDefinition	TP	O[b]	M[a]	YES
Data Set (Clause 11)					
S12	GetDataSetValues	TP	O[b]	M[a]	YES
S13	SetDataSetValues	TP	O[b]	O[b]	
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

Table P.44 ACSI Services Conformance Statement (Sheet 2 of 3)

Services		AA: TP/MC	Client/ Subscriber	Server/Publisher	SEL-311C Support
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
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]	
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]	

Table P.44 ACSI Services Conformance Statement (Sheet 3 of 3)

Services		AA: TP/MC	Client/ Subscriber	Server/Publisher	SEL-311C Support
Control (Clause 16.4.8)					
S51	Select		M[a]	O[b]	
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	Command-Termination	TP	M[a]	M[a]	YES
S56	TimeActivated-Operate	TP	O[b]	O[b]	
File Transfer (Clause 20)					
S57	GetFile	TP	O[b]	M[a]	YES
S58	SetFile	TP	O[b]	O[b]	
S59	DeleteFile	TP	O[b]	O[b]	
S60	GetFileAttributeValues	TP	O[b]	M[a]	YES
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 declares support for at least one (BRCB or URCB).
[d] c7 declares support for at least one (QueryLogByTime or QueryLogAfter).
[e] c8 declares support for at least one (SendGOOSEMessage or SendGSSEMessage).
[f] c9 declares support if TP association is available.
[g] c10 declares support for at least one (SendMSVMessage or SendUSVMessage).

Appendix Q
Cybersecurity Features

Introduction and Security Environment

Product Function

The SEL-311C is a protective relay which can be configured to have up to seven communications ports. The serial ports allow users to access five access levels for the device. The communications protocols available on the SEL-311C allow the device to periodically communicate information like relay status or metering quantities to other devices such as a SCADA client. The available communications protocols also allow for local engineering access via a terminal connection.

Security Requirements

The SEL-311C was designed to be applied in secure environments like substation control houses, switchyards, or similar control facilities. Only permit authorized personnel physical or remote access to the relay. Restrict communications to the SEL-311C to trusted network segments that are isolated from the internet.

Version Information

Obtaining Version Information

To determine the firmware version in your relay, view the status report by using the serial port **STATUS** command or the front panel **STATUS** pushbutton. The status report displays the Firmware Identification (FID) number. An example FID is shown here.

FID=SEL-311C-x-R500-V0-Z001001-Dxxxxxxxx

The date code is after the D. The single x after the "SEL-311C" is the firmware version number and will be a 1, 2, or 3, depending on the firmware features ordered with the relay.

x = 1	Three-Pole Trip and Reclosing
x = 2	Single-Pole Trip with Three-Pole Reclosing
x = 3	Single-Pole Trip with Three-Pole Reclosing and High-Speed Mho Distance Elements

Appendix A: Firmware, ICD, and Manual Versions includes the release notes for every firmware version. More firmware version information, including identification of the current version and identification of compatible SELBOOTversion, is available at selinc.com/products/firmware/.

Integrity Indicators

The **STATUS** command displays the firmware checksum identifier (CID) specific for each version of SEL-311C firmware. SEL also provides firmware hashes as an additional tool to verify the integrity of firmware files. Visit selinc.com/products/firmware to verify firmware CID and hash values.

Commissioning and Decommissioning

Commissioning

All communications ports of the SEL-311C are enabled by default. Serial Port (Port 1, 2, 3, or F) and Ethernet Port (Port 5) setting EPORT allows users to enable or disable communications for each individual port.

Secure Operation Recommendations

The SEL-311C provides a physical ALARM output contact that you can use to monitor relay diagnostic failures or access to the relay. If a diagnostic self-test results in the relay disabling protection, then the ALARM output contact asserts and provides users an external indication of the relay failure. 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.

Good operating practice is to always monitor the physical state of the ALARM output contact for assertions.

Decommissioning

It is often desirable to erase settings and data from a relay when it is removed from service. You can completely erase all the settings and data from the SEL-311C by using the following procedure:

Step 1. Log in at Access Level 2, and use the **CAL** command to log into Access Level C.

Step 2. Execute the **R_S** command.

Step 3. Allow the relay to restart.

Once this procedure is complete, all settings, passwords, and other data are erased; and you can return the relay to inventory, redeploy it, or dispose of it.

Returning Protective Relays for Service

When returning protective relays to SEL for service, preserve the data stored in the relay because it is needed to diagnose many problems.

One option is to leave data in the relay but specify special handling to protect the data. The online return merchandise authorization (RMA) form contains an option for special BES Cyber Asset handling. Ensure that the RMA number generated during the return process appears on the exterior of the shipping container. The shipping method you choose should provide tracking information and delivery confirmation.

If your processes do not permit the relay to be shipped with the settings intact, the other option is to export settings and data from the relay, and then erase the data from the relay as described in Decommissioning. You can send the data to SEL separately from the relay by coordinating with an SEL application engineer or customer service representative to use SEL's secure file transfer service (securefile.selinc.com). Include the RMA number for the associated product in the file name.

Prior to return shipping of your BES Cyber Asset, SEL follows NIST Special Publication 800-88 Revision 1 guidelines to ensure secure handling and destruction of all customer data before returning the unit. The returned unit will also be packaged by using tamper-evident tape or a similar device. The shipping service will provide tracking information and delivery confirmation.

External Interfaces

Ports and Services

SEL-311C Relay has as many as seven communications ports, as shown in the table below.

Port Number	Type	Location	Standard/ Optional
1	EIA-485 Serial or SEL-2812 Compatible Fiber Optic	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 SEL-311C provides the following software communications protocols.

	Port 1 EIA-485 or Fiber-Optic	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*
C37.118 Synchro-phasors	X	X	X	X		X	*Appendix N*
SEL ASCII and Compressed ASCII	X	X	X	X	X	Telnet	*Section 10*, *Appendix K*
SEL Fast Synchro-phasors	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*
SNTP						X	*Section 10*
FTP						X	*Section 10*
Telnet						X	*Section 10*
Ping						X	*Section 10*
Web Server (HTTP)						X	*Section 10*

[a] Not available with single copper Ethernet port.

Firmware Upgrade Interface

The SEL-311C firmware upgrade interface includes a firmware loader program called SELBOOT. To upgrade firmware, use the SELBOOT program to download an SEL-supplied firmware file from a PC to the relay through one of the serial ports. Refer to *Appendix B: Firmware Upgrade Instructions for SEL-311C Relays With Ethernet* for more information.

Access Controls

Privilege Levels

The SEL-311C has five access levels. Four access levels require separate passwords that allow administrators to restrict access to users authorized for the capabilities those levels provide.

Access Levels

The SEL-311C supports five access levels which are described here. These access levels cannot be edited.

Access Level 0: The lowest access level that provides limited read-only function for unauthenticated users.

Access Level 1: Allows you to look at more information such as settings and metering, but still read only.

Access Level B: Allows you to operate output contacts or change the active setting group.

Access Level 2: Allows you to change relay settings.

Access Level C: Restricted access level for specific maintenance functions, some of which should be used under direction of SEL only.

Passwords

The SEL-311C ships with default passwords in place for each access level that you should change at installation. The factory-default passwords for Access Levels 1, B, 2, and C are:

Access Level	Factory-Default Password
1	OTTER
B	EDITH
2	TAIL
C[a]	CLARKE

[a] Use only under the direction of SEL.

Change the default passwords at installation. Failure to set non-default passwords for all access levels may allow unauthorized access. SEL is not responsible for any damage resulting from unauthorized access.

Passwords may include up to 12 characters. Upper- and lowercase letters are treated as different characters.

<table>
<tr><td>Alpha</td><td>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z</td></tr>
<tr><td>Numeric</td><td>0 1 2 3 4 5 6 7 8 9</td></tr>
<tr><td>Special</td><td>! " # $ % & ' ( ) * , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~</td></tr>
</table>

X.509 Certificates

The SEL-311C does not support X.509 Certificates.

Physical Access Controls

The SEL-311C has no physical access controls. However, you can monitor physical ingress by wiring a door sensor to one of the SEL-311C contact inputs. This input can then be mapped for SCADA monitoring or added to the Sequential Events Recorder (SER) log so that you can monitor when physical access to the relay occurs. You also can wire an electronic latch to an SEL-311C contact output and then map this output for SCADA control.

Logging Features

Security Events

When you log in to the SEL-311C at Access Level 2, the ALARM Relay Word bit asserts to logical 1 for 1 second and the ALARM output contact coil is de-energized for 1 second.

The ALARM Relay Word bit can be mapped for SCADA monitoring or added to the SER report for later analysis. The ALARM output contact can be physically monitored to provide a notification of when Access Level 2 is reached.

Internal Log Storage

The SEL-311C does not provide security logs to notify users of the storage capacity of the relay or indications that the storage capacity is full. The SEL-311C self-manages its memory storage capacity for each of the event recording features by overwriting older entries first when storage is full.

The SEL-311C provides user-programable 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. The relay stores the most recent event report data in nonvolatile memory. Forty-three 15-cycle events, twenty-five 30 cycle events, thirteen 60 cycle events, or four 180 cycle event reports are maintained; if more reports are triggered, the latest event report overwrites the oldest event report.

The relay adds lines in the SER report for a change of state of a programmable condition. The SER lists date and time stamped lines of information each time a programmed condition changes state. The relay stores the latest 1024 lines of the SER report in nonvolatile memory. If the report fills up, newer rows overwrite the oldest rows in the report.

Syslog

The SEL-311C does not support Syslog functionality.

Alarm Contact

The alarm output contact is controlled by SELOGIC control equation ALRMOUT. The default setting for this equation is:

ALRMOUT = !(SALARM + HALARM)

With factory default settings, when the relay is operational and there are no alarm conditions, the ALARM output contact coil is energized. The alarm logic and circuitry keep the ALARM output contact coil energized. Depending on the ALARM output contact type (a or b) the ALARM output contact closes or opens. 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.

Backup and Restore

The SEL-311C supports the backup and restoration of settings. ‘Read’ and 'Send' functions are available in the ACSELERATOR QuickSet software. Connect the SEL-311C to a personal computer which has the latest version of ACSELERATOR QuickSet installed. Once communications are established, settings can be read from the SEL-311C relay and saved as a .rdb file. Settings files with the .rdb extension can be opened and sent back to SEL-311C relays with the same part number and firmware configuration.

Malware Protection Features

The SEL-311C is an embedded product which does not provide for installation of additional software and has continuous health monitoring. For a full description of how this protects against malware, see selinc.com/mitigating_malware/.

Product Updates

The most recent instruction manual release is available on selinc.com for download. *Appendix A* contains the latest product updates.

The *Appendix A* entries for firmware versions released after March 1, 2022 adds the [Cybersecurity] tag to each firmware change which is related to a security vulnerability, and [Cybsecurity Enhancement] to other cybersecurity improvements.

Information for security vulnerabilities can be obtained at selinc.com/security_vulnerabilities/.

Obtaining Updates

Contact your local SEL customer service representative for firmware updates for the SEL-311C.

Update Verification

A terminal **STATUS** command gives users a firmware checksum identifier (CID) for the firmware installed in a relay. Additionally, SEL provides firmware hashes as a tool to verify the integrity of firmware files. Visit selinc.com/products/firmware to verify firmware CID and hash values.

Contact SEL

For further questions or concerns about SEL product security, please contact SEL:

Email: security@selinc.com or phone +1-509-332-1890.

Appendix R

Fault Location and Supplemental Fault Location and Impedance Data

Fault Location

The SEL-311C relay calculates and reports a line-distance-to-fault location by using event report voltage and current data samples to determine the impedance to the fault. See *Standard 15/30/60/180-Cycle Event Reports on page 12.2* for additional information on event recording, event summaries, and fault location.

The relay scales the calculated impedance against the known line impedance and line length values entered in the Line Parameter Settings (line length setting, LL, and line impedance settings, Z1MAG, Z1ANG, Z0MAG, and Z0ANG) to determine the distance to the fault.

The fault location calculated from single-ended fault data using an impedance-based method is a best estimate. On lines with two or more active sources the following factors can affect fault location calculations:

- Fault contribution from remote sources
- Nonhomogeneous source impedances
- Load flow
- Fault resistance

The fault location calculation performed by the SEL-311C is designed to minimize the influence of these power system complexities. For further information on fault location calculations, refer to SEL technical papers listed at the end of this section.

The fault location appears in a variety of relay reports, including the following:

- Formatted and compressed event reports generated from **EVE** and **CEV** commands, respectively.
- Formatted and compressed long summary event reports generated from **SUM** and **CSU** commands, respectively,
- The Event Summaries/History report generated from the **HIS** command.
- In the *.HDR file provided with COMTRADE event reporting

The fault location is also available in the front-panel HMI events data and as a data point for communication through various protocols to master and peer devices.

Fault Location Requirements

Selected criteria must be met to provide a valid fault location (e.g., the fault location function is enabled by setting EFLOC = Y, sufficient fault data are available, appropriate protection elements are asserted, and a valid fault-type is determined). If these criteria are not met, the distance-to-fault location appears as all dollar signs ($$$$$$$) in the relay reports. For more information on fault location requirements, see *Fault Location on page 12.7*.

Supplemental Fault Location Data

The SEL-311C also calculates the following supplemental fault location and fault impedance data that appear in selected reports:

- Impedance to the fault location (magnitude and angle) in secondary ohms and degrees, respectively.
- Distance to the fault in per-unit of line length.

The front-panel HMI events data and long summary event reports (formatted and compressed) include this supplemental fault location and impedance data. The impedance to the fault location is provided for comparison with the respective positive-sequence zone distance element reach settings. The distance to the fault in per-unit of line length is provided for comparison with the desired per-unit reach of each zone with respect to the overall line length. The basic fault location and supplemental fault impedance data are shown graphically on an R-X impedance plane in *Figure R.1* below:

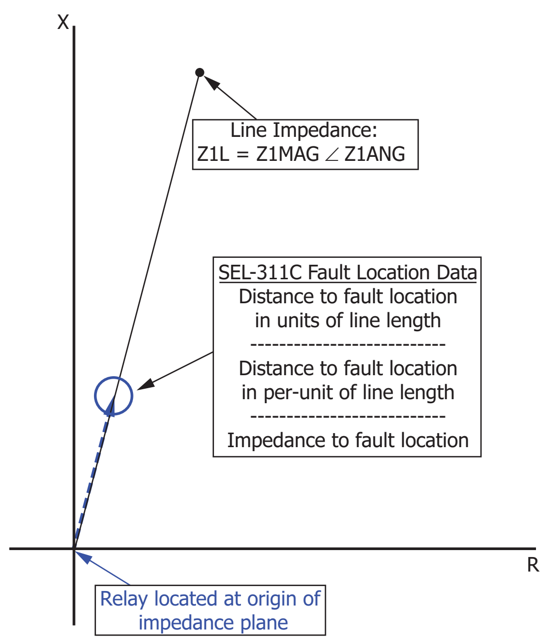


Figure R.1 Graphical Representation of SEL-311C Fault Location Data

Fault Resistance

Fault resistance includes the resistance of the arc created during the fault, and may also include other fault path current limiters (e.g., tower footing resistance for faults involving ground, tree limbs) that are either not known or not typically included in the fault study impedance model. The effect of fault resistance is to increase the apparent fault impedance, thereby decreasing the fault current from its calculated maximum available fault current for a fault at that location on the system.

The SEL-311C reports the calculated fault resistance as FAULT R in the front-panel HMI events data, as Fault Resistance in the formatted Long Summary Event Report (SUM), and as FLT_R in the compressed Long Event Summary Report (CSU) and COMTRADE *.HDR files.

Phase-to-Ground Faults

The fault resistance, R_{fault}, for a phase-to-ground fault is represented schematically in *Figure R.2(a)*, below. *Figure R.2(b)* shows the fault resistance represented vectorially on a positive-sequence R-X impedance plane. The fault resistance vector is shown as $R_{fault}/(1 + k0L)$, adjusted by the zero-sequence compensation factor, $(1 + k0L)$, for display in the positive-sequence domain. The compensation factor is actually $I_A/I_R + k0L$ for a A-phase-to-ground fault. In a radial circuit, $I_A = I_R$, resulting in $1 + k0L$. However, in a network with more than one source, the phase current and residual-ground current may be, and are most likely, different because of fault contribution from remote sources.

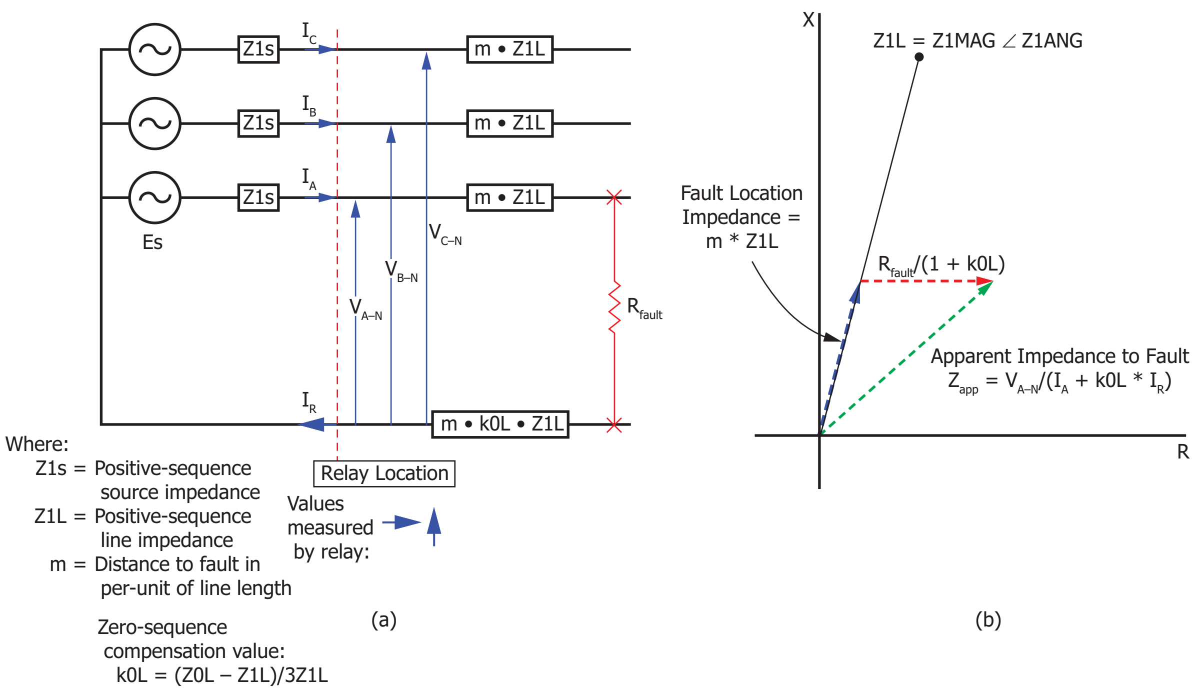


Figure R.2 Schematic (a) and Vectoral (b) Representation of Fault Resistance, R_{fault}, for a Phase-to-Ground Fault

Phase-to-Phase Faults

Figure R.3(a) shows the schematic representation of the fault resistance for a phase-to-phase fault. And *Figure R.3(b)* shows the phase-to-phase fault resistance represented vectorially on a positive-sequence R-X impedance plane, where $R_{fault}/2$ adjusts the fault resistance to the fault location impedance, m • Z1L, that is one-half the fault loop impedance without fault resistance.

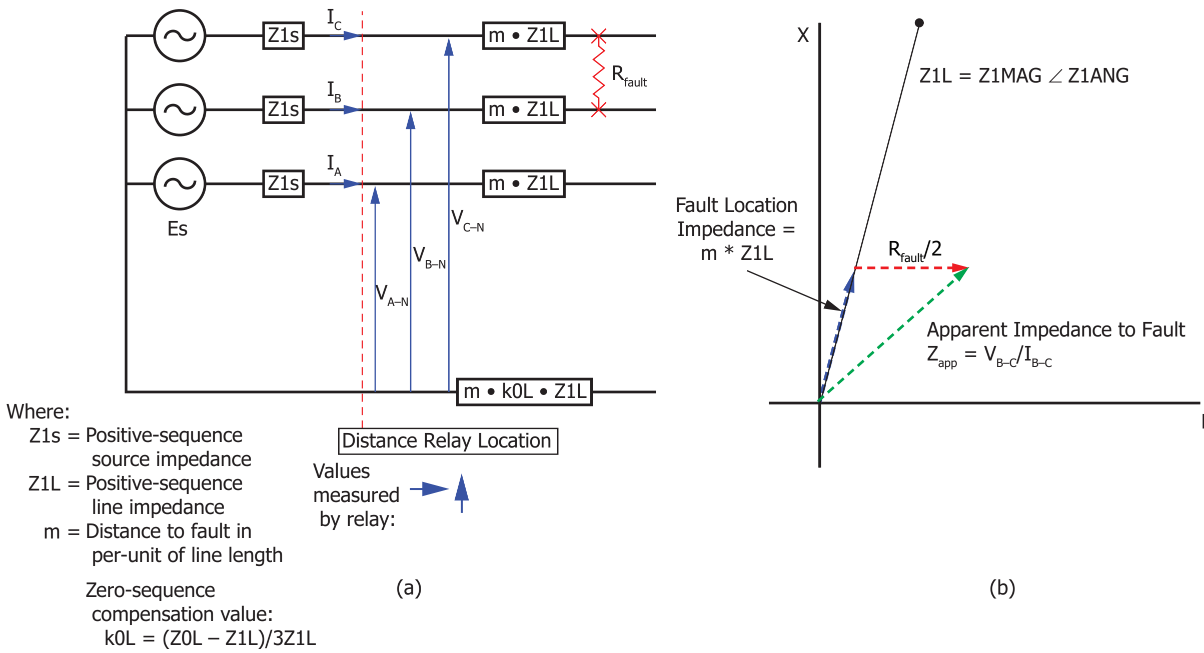


Figure R.3 Schematic (a) and Vectoral (b) Representation of Fault Resistance, R_{fault}, for a Phase-to-Phase Fault

Calculation Method

The SEL-311C calculates the resistance of the fault by taking the real part of the difference between the fault location impedance and the apparent fault impedance, Z_{app}, as shown graphically in *Figure R.2(b)* and *Figure R.3(b)*.

The calculated fault resistance determined through this technique is valid for a radial line application. As shown in *Figure R.4*, the voltage, V_S, measured by the relay at Bus S, is the sum of the line voltage drop to the fault, V', and the voltage drop, V", across the fault resistance, R_F. The voltage V" across the fault resistance is a function of the fault current times the fault resistance. On a radial system, where the fault current through the fault resistance is the same as the current, I_S, measured by the relay at Terminal S, the fault resistance calculated from the Terminal S single-ended fault data are relatively accurate.

On a multiterminal line, the current, I_S, measured by the relay at Bus S is a fraction of the total fault current ($I_F = I_S + I_R$). The fault resistance, R_{FS}, calculated from the single-ended fault data are therefore greater than the actual fault resistance by a factor of I_F/I_S.

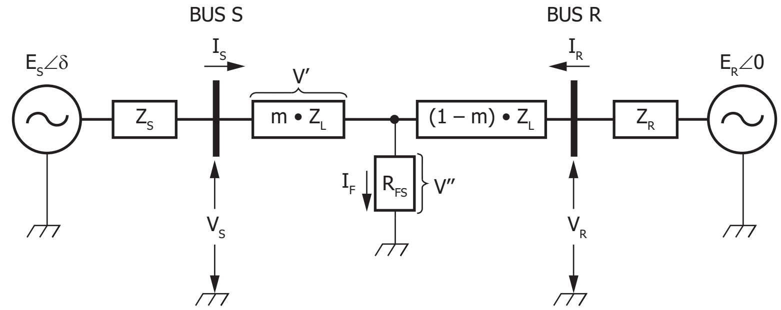


Figure R.4 Currents and Voltages in a Two-Terminal Line Fault With Fault Resistance, R_F

Figure R.5 shows a representation of two parallel fault resistance values, each calculated independently from single-ended fault data at Bus S and Bus R. R_{FS} is the fault resistance value calculated from the Bus S terminal by using fault voltage V_S and fault current I_S. R_{FR} is the fault resistance value calculated from the Bus R terminal by using fault voltage V_R and fault current I_R.

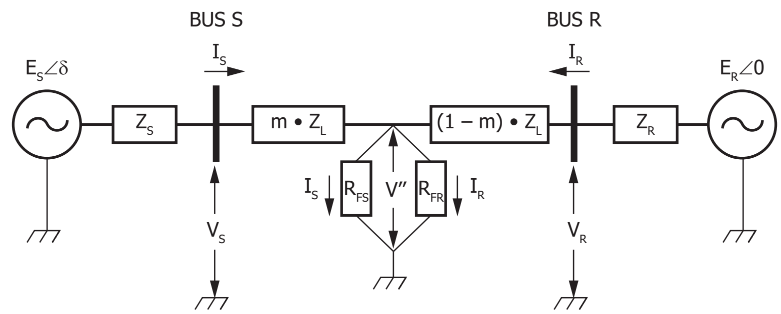


Figure R.5 Currents and Voltages in a Two-Terminal Line Fault With Parallel Fault Resistance Values, R_{FS} and R_{FR}

There is value in knowing the amplified fault resistance calculated at each terminal because it represents the fault resistance seen by the relay at each terminal. Therefore, the relay resistive reach needs to exceed this value to reliably detect the fault.

A two-ended fault location analysis is required to obtain a more accurate measure of actual fault resistance. The two-ended fault location analysis has the advantage of knowing the total fault current, I_F, which can then be used to accurately calculate the fault resistance. Likewise, knowing the total fault current also makes the two-ended fault location analysis more accurate.

As an alternative, the fault resistance, R_F, can be calculated with relatively good accuracy from the two fault resistances, R_{FS} and R_{FR} that are available individually from SEL-311C relay event report data at each line terminal so long as the event reports were triggered at the same time. The calculation simply uses the classic paralleling equation:

$$R_F = \left[\left(\frac{1}{R_{FS}}\right) + \left(\frac{1}{R_{FR}}\right)\right]^{-1}$$

Equation R.1

This technique works for both phase-to-ground and phase-to-phase faults, and can be expanded to include more than two sources by simply adding $(1/R_N)$ terms inside the [ ] brackets. When sequential tripping occurs on multi-terminal systems, the fault resistance from the relay that tripped last should be used because the system was effectively radial when that relay operated.

Reported Fault Resistance

The reported fault resistance quantity depends on the fault type information.

- The reported fault resistance value for a three-phase fault will be the phase-to-phase fault resistance that is the minimum of the three possible phase-to-phase quantities.
- The reported fault resistance value for a phase-to-phase-to-ground fault will be the phase-to-phase fault resistance.
- The reported fault resistance value for a phase-to-phase fault will be the phase-to-phase fault resistance.
- The reported fault resistance value for a phase-to-ground fault will be the phase-to-ground fault resistance.

SEL Technical Papers for Further Reading

E.O. Schweitzer, III and Jeff Roberts, “Distance Relay Element Design,” 19th Annual Western Protective Relay Conference, Spokane, Washington, October 19–22, 1992.

S.E. Zocholl, “Three-Phase Circuit Analysis and the Mysterious k0 Factor,” 48th Annual Conference for Protective Relay Engineers at Texas A&M University, College Station, Texas, April 3–5, 1995.

Joe Mooney, Jackie Peer, “Application Guidelines for Ground Fault Protection,” 24th Annual Western Protective Relay Conference, Spokane, Washington, October, 1997.

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 H	Display breaker history.
BRE R	Reset breaker monitor.
BRE W	Preload breaker wear.
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 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* = 1–32). 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.

Command	Description
ETH	Displays the Ethernet port configuration and status.
ETH C	Clear Ethernet port statistics.
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 information.
GOO *k*	Display GOOSE information *k* times.
GOO S	Display a list of GOOSE subscriptions with their ID.
GOO S *n*	Display GOOSE statistics for subscription ID *n*.
GOO S ALL	Display GOOSE statistics for all subscriptions.
GOO S *n* L	Display GOOSE statistics for subscription ID *n* including error history.
GOO S ALL L	Display GOOSE statistics for all subscriptions including error history.
GOO S *n* C	Clear GOOSE statistics for subscription ID *n*.
GOO S ALL C	Clear GOOSE statistics for all subscriptions.
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.

Command	Description
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 *k*	Display synchrophasor measurements (available when TSOK = logical 1). Enter *k* for repeat count.
MET PM *time*	Display synchrophasor measurements (available when TSOK = logical 1). Enter *time* to display the synchrophasor for an exact specified time, in 24-hour format.
MET PM HIS	Display the most recent **MET PM** synchrophasor report.
OPE	Open circuit breaker (assert Relay Word bit OC).
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.
PIN *addr* [I*i*] [T*t*]	Determines if the network is properly connected. Enter ***i*** to specify the time, in seconds, between successive ping commands (i = 1–30, if not specified, default is 1 second). Enter ***t*** to specify the duration, in minutes, of the ping command (t = 1–60, if not specified, default is 30 minutes). Command is terminated by typing **Q** or by issuing a carriage return <CR>.
PUL *n k*	Pulse output contact *n* (where *n* is one of ALARM, ALRMOUT, 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 a 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).

Command	Description
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 a 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.
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**).
TIM DST	Display daylight-saving time information.
TIM Q	Display time statistics.
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 the 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 H	Display breaker history.
BRE R	Reset breaker monitor.
BRE W	Preload breaker wear.
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 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* = 1–32). 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.

Command	Description
ETH	Displays the Ethernet port configuration and status.
ETH C	Clear Ethernet port statistics.
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 information.
GOO *k*	Display GOOSE information *k* times.
GOO S	Display a list of GOOSE subscriptions with their ID.
GOO S *n*	Display GOOSE statistics for subscription ID *n*.
GOO S ALL	Display GOOSE statistics for all subscriptions.
GOO S *n* L	Display GOOSE statistics for subscription ID *n* including error history.
GOO S ALL L	Display GOOSE statistics for all subscriptions including error history.
GOO S *n* C	Clear GOOSE statistics for subscription ID *n*.
GOO S ALL C	Clear GOOSE statistics for all subscriptions.
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.

Command	Description
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 *k*	Display synchrophasor measurements (available when TSOK = logical 1). Enter *k* for repeat count.
MET PM *time*	Display synchrophasor measurements (available when TSOK = logical 1). Enter *time* to display the synchrophasor for an exact specified time, in 24-hour format.
MET PM HIS	Display the most recent **MET PM** synchrophasor report.
OPE	Open circuit breaker (assert Relay Word bit OC).
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.
PIN *addr* [I*i*] [T*t*]	Determines if the network is properly connected. Enter ***i*** to specify the time, in seconds, between successive ping commands (i = 1–30, if not specified, default is 1 second). Enter ***t*** to specify the duration, in minutes, of the ping command (t = 1–60, if not specified, default is 30 minutes). Command is terminated by typing **Q** or by issuing a carriage return <CR>.
PUL *n k*	Pulse output contact *n* (where *n* is one of ALARM, ALRMOUT, 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 a 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).

Command	Description
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 a 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.
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**).
TIM DST	Display daylight-saving time information.
TIM Q	Display time statistics.
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 the user to save settings.
		Ctrl + X	Aborts setting editing session without saving changes.