SEL-311L-1, -7 Relay

Protection and Automation System

Instruction Manual

20250127

SCHWEITZER ENGINEERING LABORATORIES

PM311L-02

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SEL-311L-1 Relay vs. SEL-311L-7 Relay

The SEL-311L-7 provides single-pole tripping via the Application Setting 87LSP.

All references to single-pole tripping only apply when you have an SEL-311L-7 with APP = 87LSP.

The following listed Relay Word elements are only functional when APP = 87LSP:

- SPO
- SPOA
- SPOB
- SPOC
- E3PT
- 52AA
- 52AB
- 52AC
- TRPA21
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Manual Overview

The SEL-311L-1/SEL-311L-7 Relay Instruction Manual describes common aspects of line differential 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. Introduces SEL-311L features, options, and accessories. In addition, this section summarizes relay functions and applications, and it lists relay specifications, type tests, and ratings.

Section 2: Installation. Describes mounting and wiring the SEL-311L, application and communications connections, and the operation of circuit board jumpers. *Figure 2.2–Figure 2.8* show the SEL-311L front and rear panels.

Section 3: Line Current Differential Protection. Describes the operation of line current differential elements (phase, negative-sequence, and zero-sequence).

Section 4: Protection Functions. Describes the function of various relay protection elements, describes how the relay processes these elements, and gives detailed specifics on protection scheme logic.

Section 5: Trip and Target Logic. Describes the operation of the following:

- Line current differential high-speed trip logic
- Backup protection trip logic
- Switch-Onto-Fault trip logic
- Communications-assisted trip logic
- Front-panel target LEDs

Section 6: Close and Reclose Logic. Describes the close logic operation for the following:

- Automatic reclosing
- Other close conditions (e.g., manual close initiation via serial port or optoisolated inputs)

Section 7: SELogic Control Equation Programming. Explains the operation of the following:

- Optoisolated inputs **IN101–IN106**, and optional optoisolated inputs **IN301–IN308**
- Output contacts **OUT101–OUT107**, **ALARM**, **OUT201–OUT206,** and optional output contacts **OUT301–OUT312**
- Local control switches (local bit outputs LB1–LB16)
- Remote control switches (remote bit outputs RB1–RB16)
- Latch control switches (latch bit outputs LT1–LT16)
- Multiple setting groups (six available)
- Programmable timers (timer outputs SV1T–SV16T)
- Rotating default displays and display points

Section 8: Metering and Monitoring. Describes the operation of the following:

- Line current differential and local (backup) metering
- Demand and maximum/minimum metering
- Energy metering
- Breaker monitor
- Station dc monitor

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

- Time-overcurrent curves (5 U.S. and 5 IEC curves)
- Relay Word bit table and definitions (Relay Word bits are used in SELOGIC control equation settings)
- *SEL-311L Settings Sheets (APP = 311L)* for general relay, SELOGIC control equation, global, SER, text label, and serial port settings
  - The Settings Sheets can be photocopied and filled out to set the SEL-311L.
  - Note that these sheets correspond to the serial port **SET** commands listed in *Table 9.1*.
- Two-terminal with tapped load settings example

NOTE: See Section 14: Application Settings for SEL-311L Relays for a description of Application Settings APP = 87L, 87L21, 87L21P, and 87LSP.

Section 10: Communications. Describes the following:

- 87L communications
- Dual Ethernet communications
- Serial port communications
- Communications protocols
- SEL ASCII protocol details

NOTE: See SHO Command (Show/View Settings) on page 10.43 for a list of the SEL-311L factory-default relay settings.

Section 11: Front-Panel Operations. Describes the following:

- Pushbuttons and correspondence to serial port commands
- Local control switches (local bit outputs LB1–LB16)
- Rotating default displays and display points

Section 12: Analyzing Events. Describes the following:

- Standard 15-, 30-, and 60-cycle event reports for line current differential and backup protection
- Event summaries
- Sequential events recorder (SER) report

Section 13: Testing and Troubleshooting. Describes the following:

- General testing philosophy, methods, and tools
- Alpha plane 87L element test procedures
- Relay self-tests and troubleshooting
- 87L channel troubleshooting
- Commissioning

Section 14: Application Settings for SEL-311L Relays.

- Settings Sheets for the 87L, 87L21, 87L21P, and 87LSP applications

Appendix A: Firmware and Manual Versions. Lists the current relay firmware version and details differences between the current and previous versions. Provides a record of changes made to the manual since the initial release.

Appendix B: Firmware Upgrade Instructions. Describes the procedure to update the firmware stored in flash memory.

Appendix C: SEL Distributed Port Switch Protocol. Describes how to use the SEL distributed port switch data-link protocol for multi-drop applications.

Appendix D: SEL Communications Processors. Describes how SEL communications processors and PC software use SEL protocols optimized for performance and reliability.

Appendix E: MIRRORED BITS Communications. Describes how SEL protective relays and other devices can directly exchange information quickly, securely, and with minimal cost.

Appendix F: DNP3 Communications. Describes the DNP3 communications protocol and how to apply this protocol to substation integration and automation.

Appendix G: IEC 61850 Communications. Describes IEC 61850 implementation in the SEL-311L.

Appendix H: SEL Synchrophasors. Describes the SEL Fast Message Synchrophasor Protocol and how to apply and interpret this protocol.

Appendix I: Setting SELOGIC Control Equations. Describes SELOGIC control equations and how to apply these equations, discusses SELOGIC control equation features such as operators and processing intervals, and provides examples.

Appendix J: Example Calculations for 87L Settings. Uses examples to show how to calculate 87L settings.

Appendix K: PC Software. Provides an overview of common SEL PC software.

Command Summary. Briefly describes the serial port commands that are fully described in *Section 10*.

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

⚠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.
For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.

Other Safety Marks (Sheet 1 of 2)

⚠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 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.
⚠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 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 accès non-autorisé á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accès non-autorisé.

Other Safety Marks (Sheet 2 of 2)

⚠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.
⚠CAUTION Because the current from the local relay will be looped back into the relay, it is important to remove the relay from trip circuits prior to putting it into the TST mode.	⚠ATTENTION Parce que le courant du relais local est rebouclé sur le relais, il est important de débrancher le relais des circuits de déclenchement avant de le mettre en mode TST.
⚠CAUTION Carefully note the relay terminal polarity designations before wiring high-current interrupting output contacts.	⚠ATTENTION Prenez soigneusement note de l'identification de la polarité sur le bornier du relais avant de raccorder les contacts de sortie à haut pouvoir de coupure.
⚠CAUTION Do not use high-current interrupting output contacts to switch ac control signals.	⚠ATTENTION Ne pas utiliser les contacts de sortie à haut pouvoir de coupure pour commuter des signaux de commande de type CA.
⚠CAUTION Longer channel delays result in slower tripping times. The operate speeds shown in Figure 3.6 and Figure 3.7 were measured using a back-to-back connection. One-way channel delay times that exceed the automatic compensation capability of the SEL-311L (35 milliseconds) can result in misoperation.	⚠ATTENTION Des délais de transmission plus longs sur le canal de communication pourraient entraîner un ralentissement des temps de déclenchement. Les temps d'opération indiqués sur les Figure 3.6 et Figure 3.7 ont été mesurés en utilisant un raccordement dos-à-dos. Les délais pour un aller simple sur le canal qui dépassent la limite de compensation automatique du SEL-311L (35 millisecondes) pourraient entraîner un déclenchement intempestif.
⚠CAUTION The Direct Transparent mode (D parameter) typically should not be used when transparently connecting to SEL devices. SEL interleaved binary messages (binary 20METER, 20TARGET, etc.) are not supported during Direct Transparent mode connections.	⚠ATTENTION Le mode Transparent Direct (paramètre D) ne devrait pas, typiquement, être utilisé quand on se raccorde de façon transparente aux équipements SEL. Les messages binaires intercalés (20METER, 20TARGET, etc...) ne sont pas supportés avec des raccordements en mode Transparent Direct.
⚠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.

General Information

Typographic Conventions

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

➤ 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, command options, and command variables 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.
ENABLE	Relay front- or rear-panel labels and pushbuttons.
MAIN > METER	Relay front-panel LCD menus and relay responses visible on the PC screen. The > character indicates submenus.

Examples

This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-311L. 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-311L.

Trademarks

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

ACSELERATOR Architect®	Best Choice Ground Directional Element®
ACSELERATOR QuickSet®	ACSELERATOR TEAM®
MIRRORED BITS®	SEL Compass®
SELOGIC®	SYNCHROWAVE®

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Section 1
Introduction and Specifications

Overview

This instruction manual covers the SEL-311L, a digital line current differential relay with integrated communications interfaces. In addition to line current differential protection, the SEL-311L contains all the protection, control, and communication features available in the SEL-311C Relay including distance, directional, and nondirectional overcurrent protection; under- and overvoltage and frequency protection; and multishot reclosing.

The SEL-311L implements line current differential protection by using communications interfaces, a processor, and contact outputs separate from those used for backup protection and control. A failure in the line current differential hardware does not impact backup protection.

This section includes the following overviews of the SEL-311L:

- SEL-311L Relay Models
- Applications
- Connections
- Communications Ports
- Communications Connections
- Relay Specifications

SEL-311L Relay Models

The SEL-311L has the following standard features:

- Screw-terminal blocks
- Wye-connected voltage inputs
- Eight standard output contacts and six fast, high-current interrupting output contacts
- Six optoisolated contact inputs
- One EIA-485 port
- Three EIA-232 ports
- IRIG-B time synchronization

Select among the following ordering options:

- ➤ Single-pole tripping for line current differential function
- ➤ Horizontal rack mount, horizontal panel mount, horizontal projection panel mount, or vertical panel mount (3U)
- ➤ Horizontal rack mount, horizontal panel mount, horizontal projection panel mount (4U), or vertical panel mount (4U)
- ➤ 1 A or 5 A current transformers
- ➤ 125/250 V, 48/125 V, or 24/48 V power supply
- ➤ Five control input voltage selections
- ➤ Single-pole tripping for Zone 1 distance backup
- ➤ Enhanced current differential protection
- ➤ Faster distance elements
- ➤ Optional I/O board with as many as 12 output contacts and eight optoisolated contact inputs
- ➤ IEC 61850 communications
- ➤ Dual Ethernet connectivity
- ➤ DNP3 Level 2 Slave

Purchase the SEL-311L with one or a combination of two of the following line current differential channel interfaces:

- ➤ Isolated EIA-422
- ➤ Isolated G.703 codirectional
- ➤ 850 nm Multimode Fiber (IEEE C37.94-compatible)
- ➤ 1300 nm Single-Mode Fiber (IEEE C37.94-compatible modulation)
- ➤ 1300 nm Direct Fiber
- ➤ 1550 nm Direct Fiber

See the SEL-311L Relay Model Option table (MOT) for available combinations.

When the relay is purchased with two channel interfaces, the second channel can be used as a hot standby channel or to protect a three-terminal line.

Applications

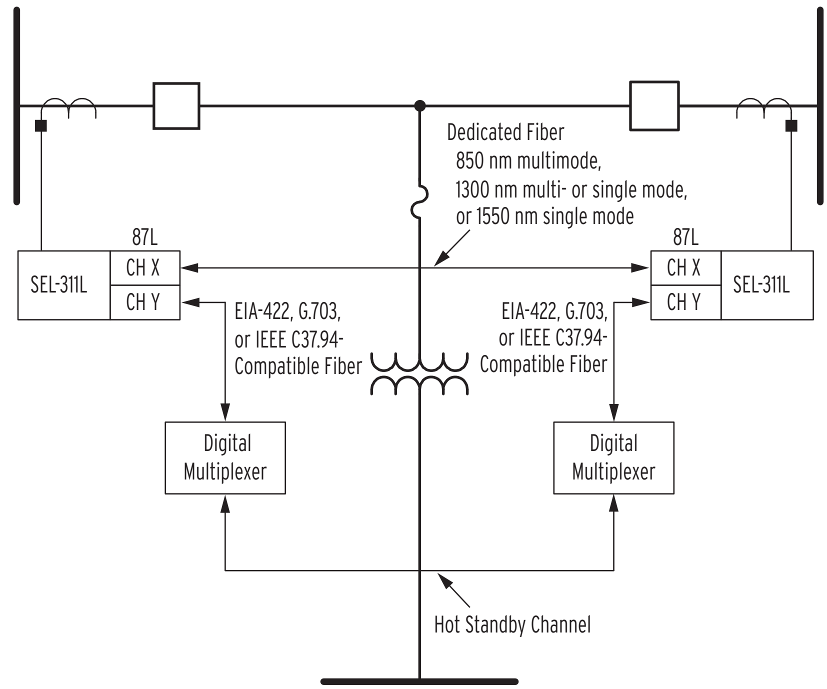

Figure 1.1 Typical Two-Terminal Application With Hot Standby Channel and Tapped Load

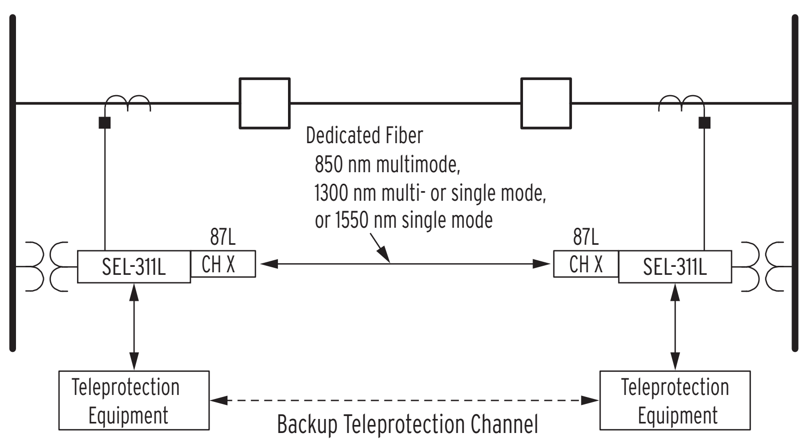

Figure 1.2 Typical Two-Terminal Application With Voltage Inputs

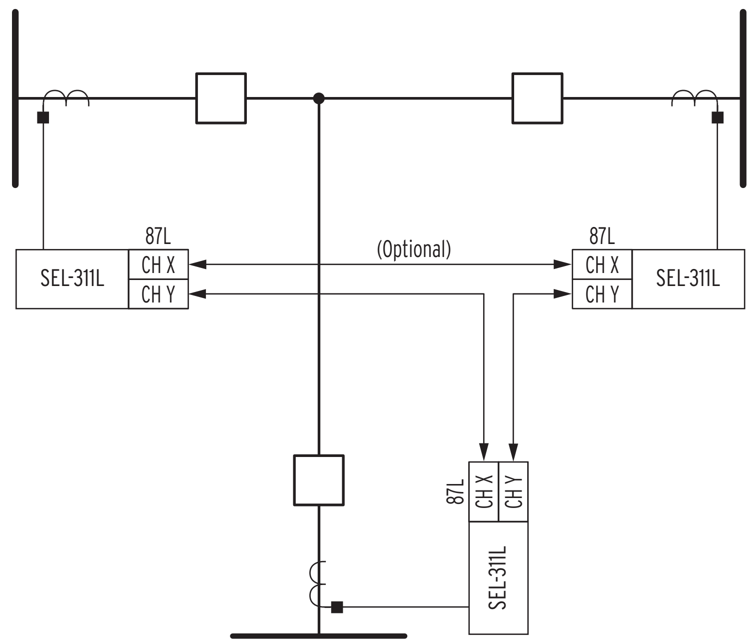

Figure 1.3 Typical Three-Terminal Application With Optional Third Communications Channel

Connections

Figure 1.4 shows general connection points. See *Specifications on page 1.7* and *Section 2: Installation* for more information on hardware and connections.

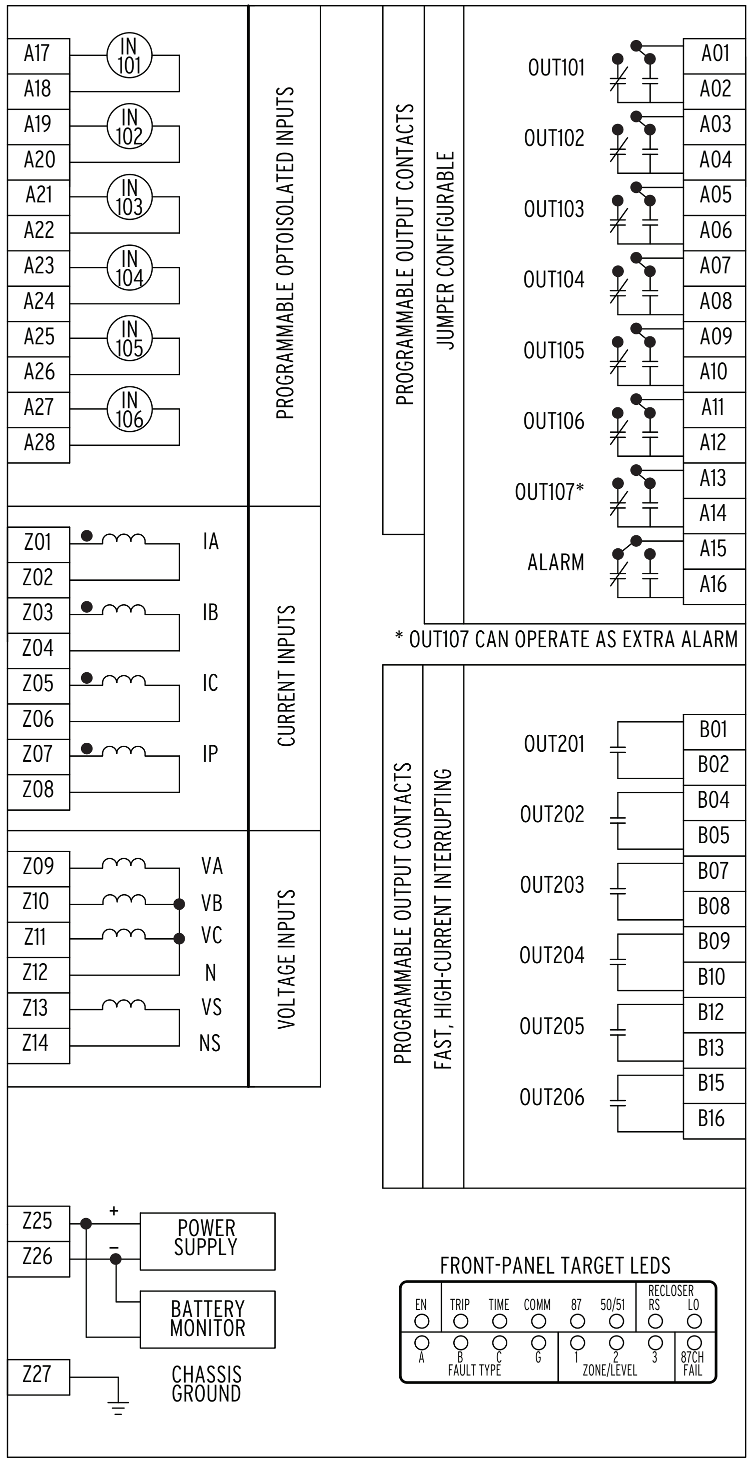

Figure 1.4 SEL-311L Relay Inputs and Outputs

See *Cables on page 10.14* for more communications connection information.

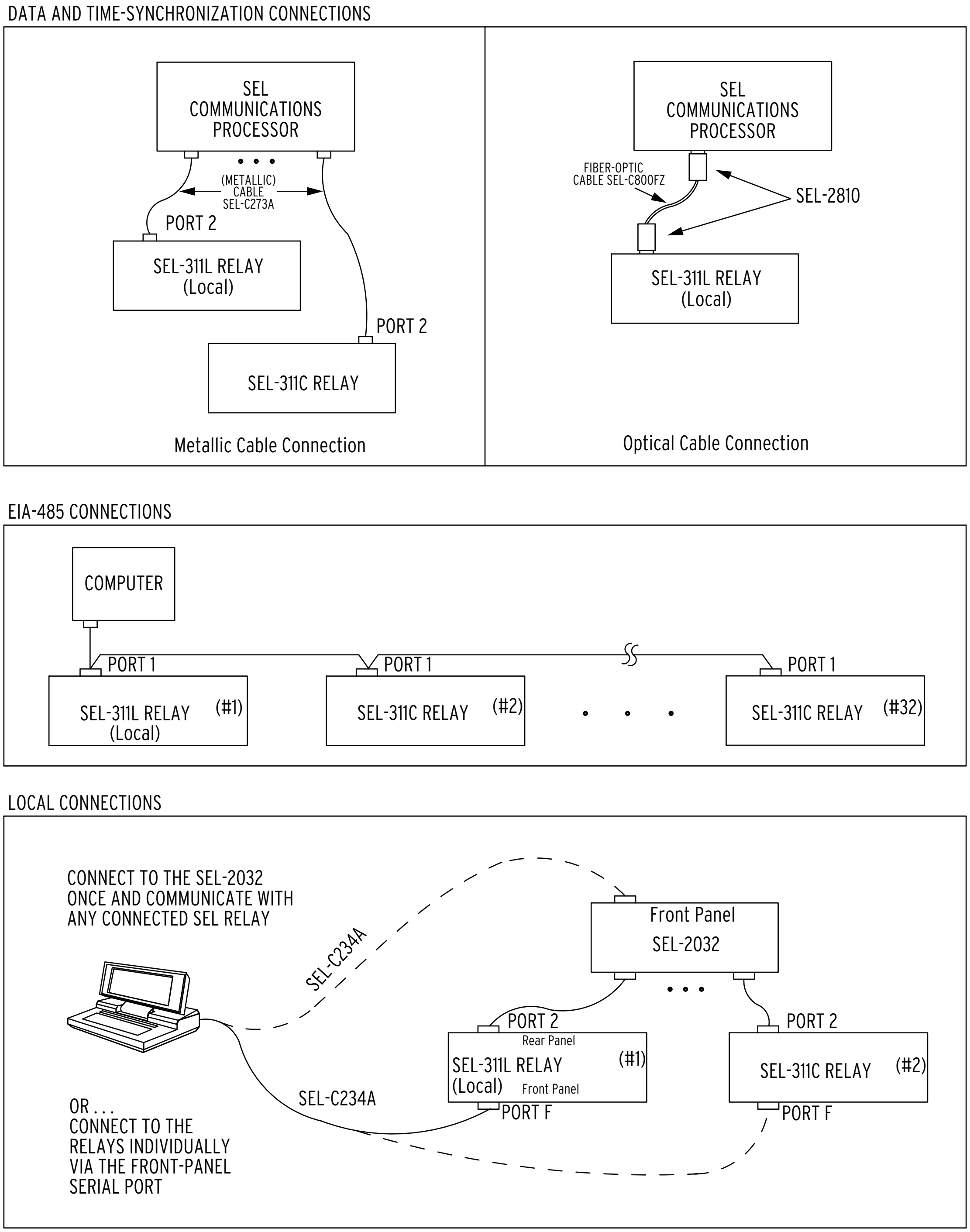

Figure 1.5 SEL-311L Relay Communications Connections Examples

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system
UL Listed to U.S. and Canadian safety standards (File E212775; NRGU, NRGU7)
CE Mark
UKCA Mark
RCM Mark
Class 1 Laser Product
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

Rear Screw-Terminal Tightening Torque:

Minimum:	9 in-lb (1.1 Nm)
Maximum:	12 in-lb (1.3 Nm)

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

AC Current Input

Nominal:	5 A
Continuous:	15 A, linear to 100 A symmetrical.
Thermal Rating:	500 A for 1 second. 1250 A for 1 cycle.
Measurement Range:	0.5–96 A (DC offset for 1.5 cycles @ X/R = 10)
Burden:	0.27 VA at 5 A 2.51 VA at 15 A
Nominal:	1 A
Continuous:	3 A, linear to 20 A symmetrical.
Thermal Rating:	100 A for 1 second. 250 A for 1 cycle.
Measurement Range:	0.1–19.2 A (DC offset for 1.5 cycles @ X/R = 10)
Burden:	0.13 VA at 1 A 1.31 VA at 3 A

AC Voltage Inputs

Nominal:	67 V_{L-N} three-phase four-wire connection.
Continuous:	150 V_{L-N} (connect any voltage up to 150 Vac).
Measurement Range:	365 Vac for 10 seconds.
Burden:	0.13 VA at 67 V 0.45 VA at 120 V

Power Supply

Input Voltage

Rated:	125/250 Vdc or Vac
Range:	85–350 Vdc or 85–264 Vac
Rated:	48/125 Vdc or 125 Vac
Range:	38–200 Vdc or 85–140 Vac
Rated:	24/48 Vdc
Range:	18–60 Vdc polarity-dependent
Power Consumption:	< 25 W

Control Outputs

Standard

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1s Rating:	50 A
MOV Protection (maximum voltage):	270 Vac, 360 Vdc, 40 J
Pickup/Dropout Time:	< 5 ms

Breaking Capacity (10,000 operations):

48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Cyclic Capacity (2.5 cycle/second):

48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Hybrid (High Current Interrupting)

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1s Rating:	50 A
MOV Protection (maximum voltage):	330 Vdc, 130 J
Pickup/Dropout Time:	< 5 ms

Breaking Capacity (10,000 operations):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Cyclic Capacity (4 interruptions/second, followed by 2 minutes idle for thermal dissipation):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Note: Make per IEEE C37.90-1989; Breaking and Cyclic Capacity per IEC 60255-23:1994.

Fast Hybrid (High Current Interrupting)

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1s Rating:	50 A
MOV Protection (maximum voltage):	330 Vdc, 130 J
Pickup/Dropout Time:	< 10 µs; < 8 ms, typical

Breaking Capacity (10,000 operations):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Cyclic Capacity (4 interruptions/second, followed by 2 minutes idle for thermal dissipation):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Note: Make per IEEE C37.90-1989; Breaking and Cyclic Capacity per IEC 60255-23:1994.

Optoisolated Inputs

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

Note: 24, 48, 125, 220, and 250 Vdc optoisolated inputs draw approximately 5 mA of current; 110 Vdc inputs draw approximately 8 mA of current. All current ratings are at nominal input voltages.

Frequency and Rotation

System Frequency:	50 or 60 Hz
Phase Rotation:	ABC or ACB
Frequency Tracking:	40.1–65 Hz

Serial Communications Ports

EIA-232:	1 Front, 2 Rear
EIA-485:	1 Rear, 2100 Vdc isolation
Baud Rate:	300–38400 (Port 1 Baud Rate 300–19200)

Ethernet Communications Ports (SEL-311L-1 and SEL-311L-7)

Application Protocols

FTP to Card:	1 server session (supports IEC 61850 CID files)
Telnet to Card:	1 server session (supports SEL ASCII)
Telnet to Host:	1 server session (supports SEL ASCII, SEL Compressed ASCII, Fast Meter and Fast Operate)
IEC 61850:	6 MMS sessions 16 incoming GOOSE messages 8 outgoing GOOSE messages
Web Server:	3 simultaneous read-only server sessions to host

Protocol Stacks

TCP/IP

OSI

Physical Layer Options (PORT 5 and PORT 6)

10/100BASE-T:	10/100 Mbps, RJ45 connector
100BASE-FX:	100 Mbps, LC connector

Indicators (PORT 5 and PORT 6)

Link:	Green LED is on when the link is operational.
Activity:	Red LED blinks when there is transmit or receive activity.

Differential Communications Ports

Fiber Optics—ST Connector

1550 nm single mode:

Tx Power:	–18 dBm
Rx Min. Sensitivity:	–58 dBm
Rx Max. Sensitivity:	0 dBm
System Gain:	40 dB
Distance Limitations:	120 km

1300 nm multimode or single mode:

Tx Power:	–18 dBm
Rx Min. Sensitivity:	–58 dBm
Rx Max. Sensitivity:	0 dBm
System Gain:	40 dB
Distance Limitations:	*x* km
where:	*x* = 30 for multimode *x* = 80 for single mode

1300 nm Single Mode (IEEE C37.94-Compatible Modulated):

Tx Power:	–24 dBm
Rx Min. Sensitivity:	–37.8 dBm
Rx Max. Sensitivity:	0 dBm
System Gain:	13.8 dB
Distance Limitations:	15 km

850 nm Multimode, IEEE C37.94-Compatible:

Tx Power:	50 µm: –23 dBm; 62.5 µm: –19 dBm
Rx Min. Sensitivity:	50 µm: –32 dBm; 62.5 µm: –32 dBm
Rx Max. Sensitivity:	50 µm: –11 dBm; 62.5 µm: –11 dBm
System Gain:	50 µm: 9 dB; 62.5 µm: 13 dB
Distance Limitations:	2 km

Electrical

EIA-422:	56 or 64 Kbps synchronous; Isolated to 1500 Vac
CCITT G.703:	64 Kbps synchronous, codirectional

Time-Code Input

Relay accepts demodulated IRIG-B time-code input at Port 1 or 2. Relay time is synchronized to within ±5 ms of time-source input.

Synchronization (specification is with respect to the accuracy of the time source)

Synchrophasor:	± 10 µs
Other:	± 5 ms

Current differential protection does not require an external time source.

Dimensions

Refer to *Figure 2.1 on page 2.3* for relay dimensions.

Operating Temperature

–40° to +85°C (–40° to +185°F)

Note: LCD contrast impaired for temperatures below –20°C

Weight

3U Rack Unit: 6.9 kilograms (15.2 pounds)

4U Rack Unit: 8.3 kilograms (18.3 pounds)

Type Tests

Electromagnetic Compatibility Emissions

EN 55011: 1998 + A1:1999 + A2:2002
Canada ICES-001 (A) / NMB-001 (A)

Product Specific Emissions:	IEC 60255-25:2000

Electromagnetic Compatibility Immunity

Conducted RF Immunity:	IEC 60255-22-6:2001 Severity Level: 10 Vrms
Radiated Radio Frequency Immunity:	IEC 60255-22-3:2007 Severity Level: 10 V/m IEC 61000-4-3:2010 Severity Level: 10 V/m
Radiated Digital Radio Telephone RF Immunity:	ENV 50204:1995 Severity Level: 10 V/m at 900 MHz and 1.89 GHz
Electrostatic Discharge Immunity:	IEC 60255-22-2:2008 Severity Level: 2, 4, 6, 8 kV contact; 2, 4, 8, 15 kV air IEEE C37.90.3-2001 Severity Level: 2, 4, and 8 kV contact; 4, 8, and 15 kV air
Fast Transient/Burst Immunity:	IEC 60255-22-4:2008 Severity Level: 4 kV, 5 kHz on power supply, 2 kV, 5 kHz on I/O, signal, data, and control lines IEC 61000-4-4:2011 Severity Level: 4 (4 kV on power supply), 3 (2 kV on inputs and outputs)
Power Supply Immunity:	IEC 60255-11:2008
Radiated Radio Frequency Immunity:	IEEE C37.90.2-2004 Severity Level: 35 V/m
Surge Withstand Capability Immunity:	IEC 60255-22-1:2007 Severity Level: 2.5 kV peak common mode, 1.0 kV peak differential mode IEEE C37.90.1-2002 Severity Level: 2.5 kV oscillatory, 4 kV fast transient waveform

Environmental

Cold:	IEC 60068-2-1:2007 Severity Level: 16 hours at –40°C
Dry Heat:	IEC 60068-2-2:2007 Severity Level: 16 hours at +85°C
Damp Heat, Cyclic:	IEC 60068-2-30:2005 Severity Level: 25°C to 55°C, 6 cycles, Relative Humidity: 95%
Vibration:	IEC 60255-21-3:1993 Severity Level: Class 2 (Quake Response) 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

Safety

Product Safety:	EN 50263:1999
IP Code:	IEC 60529:2001 + CRGD:2003 Severity Level: IP30 for Category 2 equipment
Insulation Coordination:	IEC 60255-5:2000 Severity Level: 5 kV Impulse on DI, DO, AI, and Power Supply; 2.2 kV on IRIG-B, EIA-485 and Ethernet. 2.5 kVac Dielectric on DI, DO, and AI; 3.1 kVdc on Power Supply; 2.2 kVdc on EIA-485; 1.5 kVac on Ethernet. Type tested for 1 minute.
Laser Safety:	IEC 60825-1:2007 Product Class: Class 1 21 CFR 1040.10 Product Class: Class 1 ANSI Z136.1-2007 Product Class: Class 1
Product Safety:	IEC 60255-6:1988

Processing Specifications

AC Voltage and Current Inputs

16 samples per power system cycle, 3 dB low-pass filter cut-off frequency of 560 Hz.

Digital Filtering

One-cycle full cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.

Current Differential Processing

16 times per power system cycle for line current differential protection and tripping logic.

Backup Protection and Control Processing

4 times per power system cycle.

Relay Elements

Line Current Differential (87L) Elements

87L Enable Levels (Difference or Total Current)

Phase Setting Range:	OFF, 1.00 to 10.00 A, 0.01 A steps
Negative-Sequence Setting Range:	OFF, 0.50 to 5.00 A, 0.01 A steps
Zero-Sequence Setting Range:	OFF, 0.50 to 5.00 A, 0.01 A steps
Accuracy:	±3% ±0.01 I_{nom}

Restraint Characteristics

Outer Radius

Radius Range:	2 to 8 in steps of 0.1 (unitless).
Angle Range:	90–270° in steps of 1°
Accuracy:	±5% of radius setting ±3° of angle setting
Operate Time (for bolted fault):	See operate time curves in *Section 3*.

Note: Refer to *Current Differential Elements on page 3.1* for the definition of terms and terminology listed above.

Difference Current Alarm Setting

Setting Range:	OFF, 0.5 to 10.0 A, 0.1 A steps
Accuracy:	± 3% of ±0.01 I_{nom}

Substation Battery Voltage Monitor Specifications

Pickup Range:	20–300 Vdc, 1 Vdc steps
Pickup Accuracy:	±2% ± 2 Vdc of setting

Timer Specifications

Reclosing Relay Pickup:	0.00–999,999.00 cycles, 0.25-cycle steps (reclosing relay and some programmable timers)

Other Timers:	0.00–16,000.00 cycles, 0.25-cycle steps (some programmable and other various timers)
Pickup/Dropout Accuracy for All Timers:	±0.25 cycle and ±0.1% of setting

Mho Phase Distance Elements

Zones 1–4 Impedance Reach

Setting Range:	OFF, 0.05 to 64.00 Ω secondary, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320.00 Ω secondary, 0.01 Ω steps (1 A nominal)

Note: Minimum sensitivity is controlled by the pickup of the supervising phase-to-phase overcurrent elements for each zone, load encroachment, OSB, and supervisory directional logic.

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:	0.5–170.0 A_{P-P} secondary, 0.01 A steps (5 A nominal) 0.1–34.0 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 pickup and reset time curves in *Section 4*.

Mho and Quadrilateral Ground Distance Elements

Zones 1–4 Impedance Reach

Mho Element Reach:	OFF, 0.05 to 64.00 Ω secondary, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320.00 Ω secondary, 0.01 Ω steps (1 A nominal)
Quadrilateral Reactance Reach:	OFF, 0.05 to 64.00 Ω secondary, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320.00 Ω secondary, 0.01 Ω steps (1 A nominal)
Quadrilateral Resistance Reach:	OFF, 0.05 to 50.00 Ω secondary, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 250.00 Ω secondary, 0.01 Ω steps (1 A nominal)

Note: Minimum sensitivity is controlled by the pickup of the supervising phase and residual overcurrent elements for each zone, and supervisory directional logic.

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 and Residual Current Fault Detectors (FD)

Setting Range:	0.5–100.0 A secondary, 0.01 A steps (5 A nominal) 0.1–20.0 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 pickup and reset time curves in *Section 4*.

Undervoltage and Overvoltage Elements

Pickup Range:	OFF, 0.00–150.00 V, 0.01 V steps (various elements) OFF, 0.00–260.00 V, 0.01 V steps (phase-to-phase elements)
Steady-State Pickup Accuracy:	±1 V and ±5% of setting
Transient Overreach	<5% of pickup

Instantaneous/Definite-Time Overcurrent Elements

Pickup Range:	OFF, 0.25–100.00 A, 0.01 A steps (5 A nominal) OFF, 0.05–20.00 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
Time Delay:	0.00–16,000.00 cycles, 0.25-cycle steps
Timer Accuracy:	±0.25 cycle and ±0.1% of setting
Max. Operating Time:	See pickup and reset time curves in *Section 4*.

Time-Overcurrent Elements

Pickup Range:	OFF, 0.25–16.00 A, 0.01 A steps (5 A nominal) OFF, 0.05–3.20 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)
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.

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°

Definite-Time Overfrequency or Underfrequency (81) Elements

Pickup Range:	41.00–65.00 Hz, 0.01 Hz steps
Pickup Time:	32 ms at 60 Hz (max)
Time Delays:	2.00–16,000.00 cycles, 0.25-cycle steps
Maximum Definite-Time Delay Accuracy:	±0.25 cycles, ±1% of setting at 60 Hz
Steady-State plus Transient Overshoot:	±0.01 Hz
Supervisory 27:	20.0–150.0 V, ±5%, ±0.1 V

Metering Accuracy

Voltages

V_A, V_B, V_C, V_S, V_1, V_2, $3V_0$:	± 2% (33.5–150 V)

Currents

I_A, I_B, I_C, I_P (Local):	± 1% (0.5 to 100.0 A) (5 A nominal) ± 1% (0.1 to 20.0 A) (1 A nominal)
I_1, $3I_0$, $3I_2$ (Local):	± 3% (0.25 to 100.0 A) (5 A nominal) ± 3% (0.05 to 20.0 A) (1 A nominal)
I_A, I_B, I_C, $3I_2$, $3I_0$, I_1 (Remote):	± 3% (0.25 to 100.0 A) (5 A nominal) ± 3% (0.05 to 20.0 A) (1 A nominal)
I_A, I_B, I_C, $3I_2$, $3I_0$, I_1 (Total):	± 3% (0.25 to 100.0 A) (5 A nominal) ± 3% (0.05 to 20.0 A) (1 A nominal)
Phase Angle Accuracy:	±1°
MW/MVAR:	± 3%

Synchrophasor Accuracy

Note: Specification is with respect to **MET PM** command and SEL Fast Message Synchrophasor Protocol.

Voltages:	33.5–150 V; 45–65 Hz
Magnitudes:	± 2%
Angles:	±1.0°
Currents:	0.50–1.25 A; 45–65 Hz (5 A nominal) 0.10–0.25 A; 45–65 Hz (1 A nominal)
Magnitudes:	± 4%
Angles:	±1.5° @ 25°C ± 2.0° over the full temperature range
Currents:	1.25–7.50 A; 45–65 Hz (5 A nominal) 0.25–2.50 A; 45–65 Hz (1 A nominal)
Magnitudes:	± 2%
Angles:	± 1.0° @ 25°C ±1.5° over the full temperature range

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Section 2
Installation

Overview

The first steps in applying the SEL-311L Relay are installing and connecting the relay. This section describes common installation features and particular installation requirements for the physical configurations of the SEL-311L. You can order the relay in a 3U or 4U rack-mount, 3U or 4U horizontal panel-mount, 3U or 4U horizontal projections panel-mount, or a 3U or 4U vertical panel-mount version. The SEL-311L comes standard with 6 inputs and 14 outputs, 6 of which are high-speed, high-current outputs. An additional I/O board is available with one of three configurations.

- Interface 2 board: 12 standard output contacts, 8 optoisolated contact inputs
- Interface 5 board: 8 high-speed, high-current interrupting output contacts, 8 optoisolated contact inputs
- Interface 6 board: 12 high-current interrupting output contacts, 8 optoisolated contact inputs

To install and connect the relay safely and effectively, you must be familiar with relay configuration features, options, and relay jumper configuration. You should plan relay placement, cable connection, and relay communication carefully.

Consider the following when installing the SEL-311L:

- General configuration attributes
  - Relay size
  - Front-panel templates
  - Rear panels
  - Connector types
  - Current and voltage inputs
  - Control inputs
  - Control outputs
  - Time inputs
  - Communications interfaces
  - Battery-backed clock
  - Main, password, circuit breaker, and contact output jumpers

- Relay placement
  - Physical location
  - Rack mounting
  - Panel mounting–horizontal or vertical
- Connection
  - Rear-panel layout
  - Rear-panel symbols
  - Screw terminal connectors
  - Grounding
  - Power connections
  - Monitor connections (dc battery)
  - Current and voltage connections
  - Input/output connections
  - Time input connections
  - Communications ports connections
  - Replacing the lithium battery
  - AC/DC connection diagrams

    This section contains drawings of typical ac and dc connections to the SEL-311L (*SEL-311L AC/DC Connection Diagrams for Various Applications on page 2.20*. Use these drawings as a starting point for planning your particular relay application.

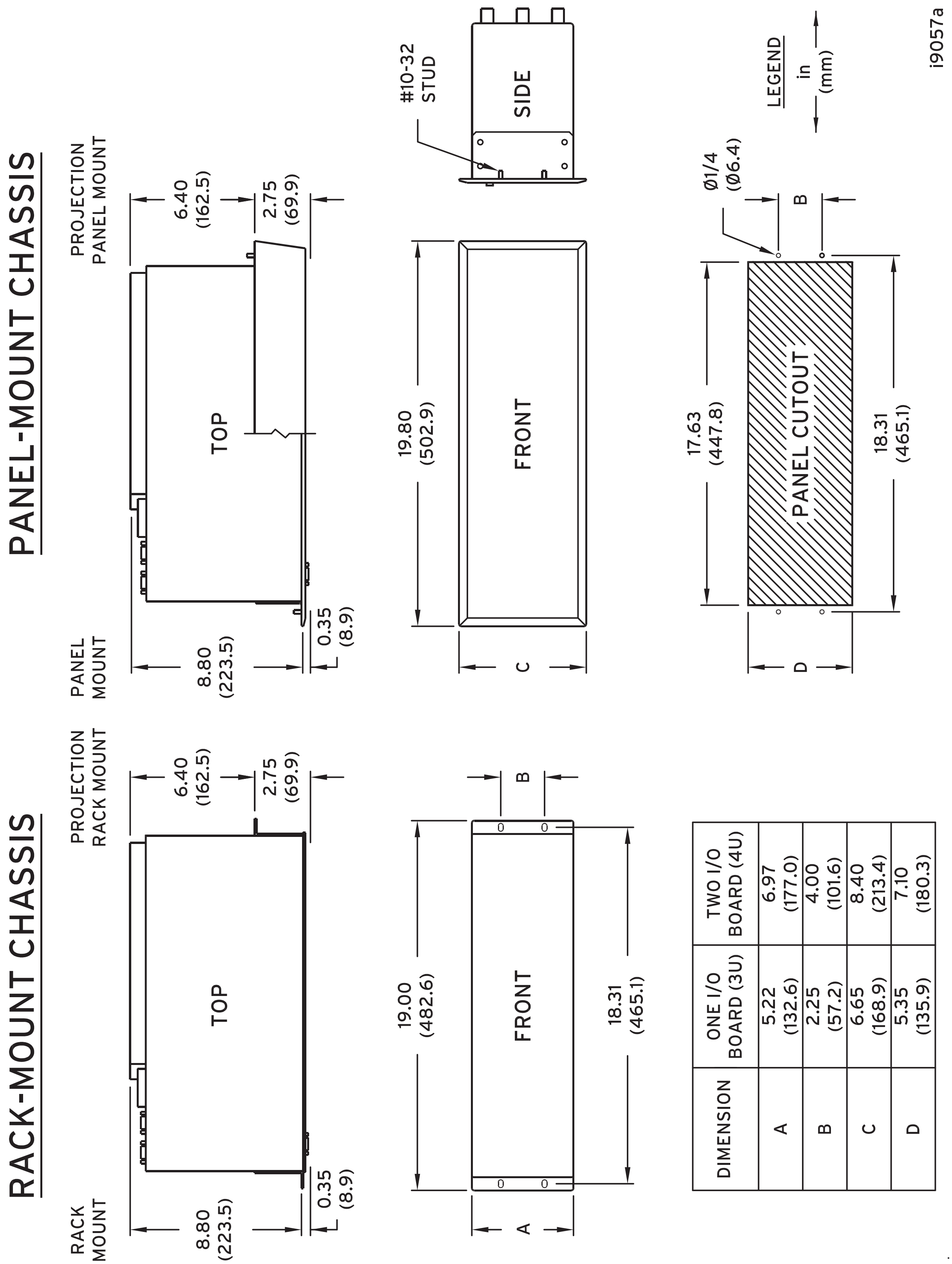
It is very important to limit access to the SEL-311L settings and control functions by using passwords. For information on relay access levels and passwords, see *Section 10: Communications*.

Relay Mounting

The relay can be ordered with the following mounting options:

- Horizontal Rack Mount (3U or 4U)
- Horizontal Panel Mount (3U or 4U)
- Horizontal Projection Panel Mount (3U or 4U)
- Vertical Panel Mount (3U or 4U)

Figure 2.1 provides the relay dimensions and the panel-mount cutout. Refer to *Figure 2.2–Figure 2.8* for example front- and rear-panel drawings.



DIMENSION	ONE I/O BOARD (3U)	TWO I/O BOARD (4U)
A	5.22 (132.6)	6.97 (177.0)
B	2.25 (57.2)	4.00 (101.6)
C	6.65 (168.9)	8.40 (213.4)
D	5.35 (135.9)	7.10 (180.3)

For projection rack mounting, brackets must be reversed.

Figure 2.1 SEL-311L Relay Dimensions and Panel-Mount Cutout

Front- and Rear-Panel Diagrams

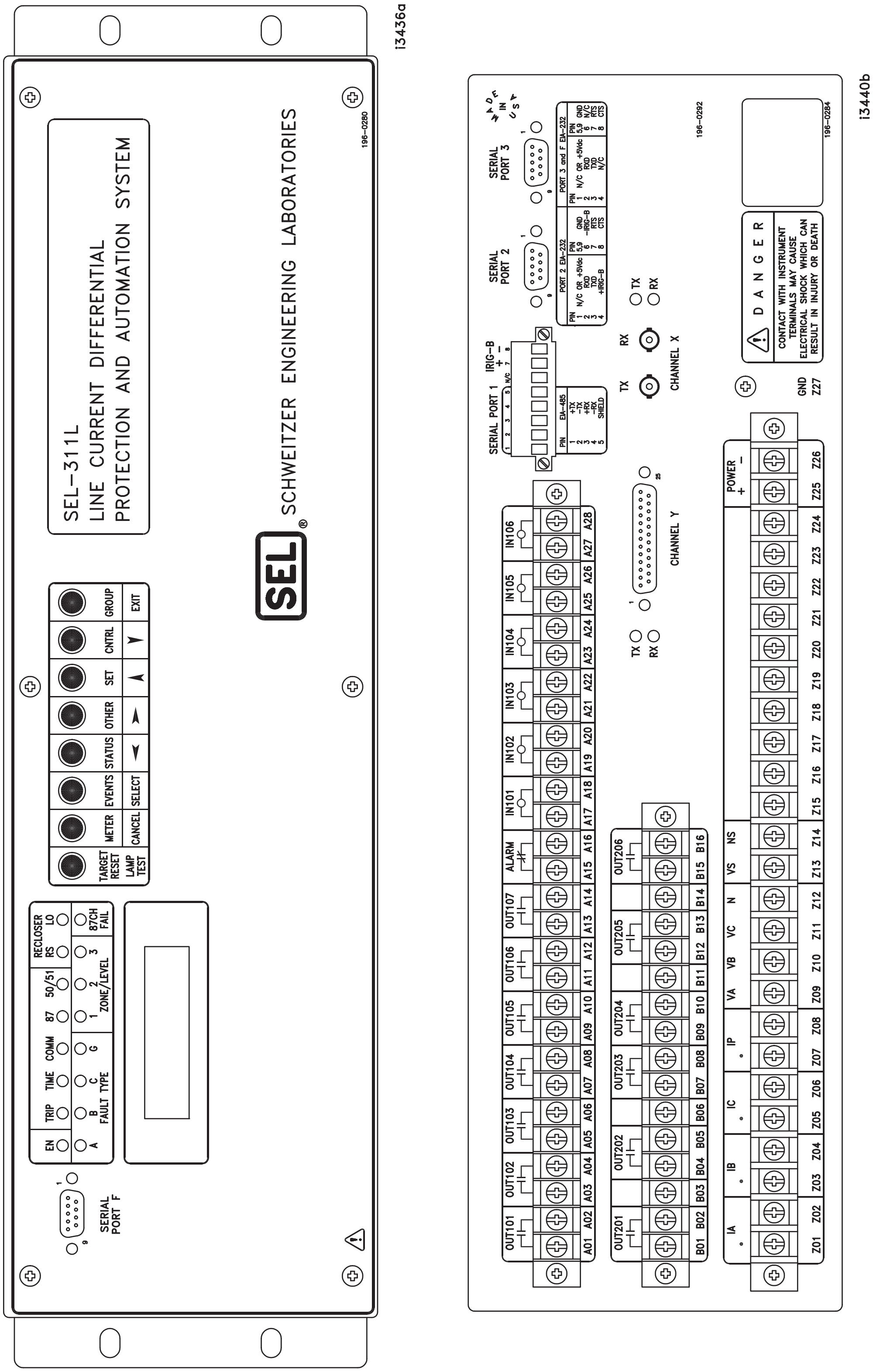


Figure 2.2 SEL-311L Relay 3U Horizontal Rack-Mount Front-Panel and Typical Rear-Panel Drawings

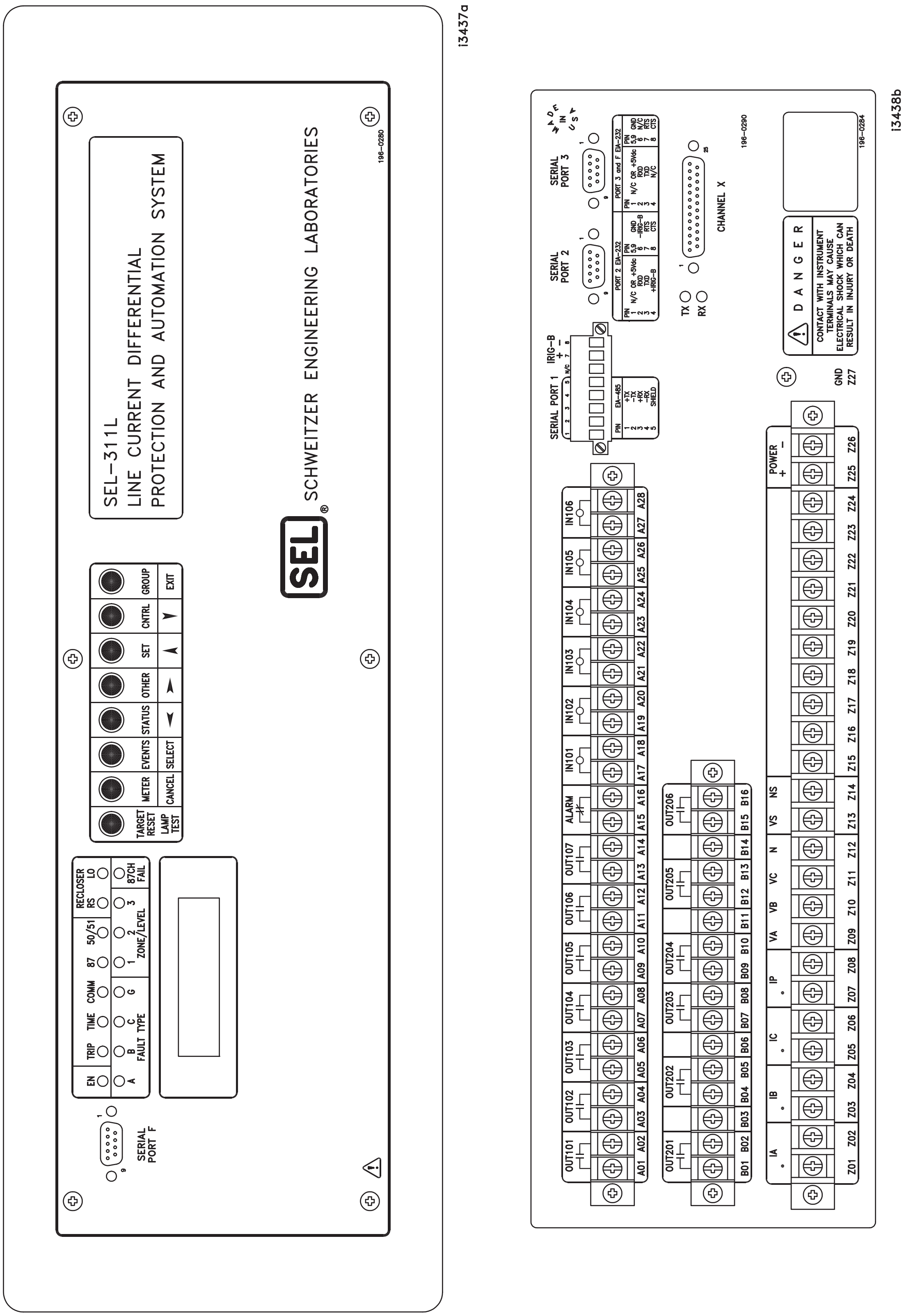
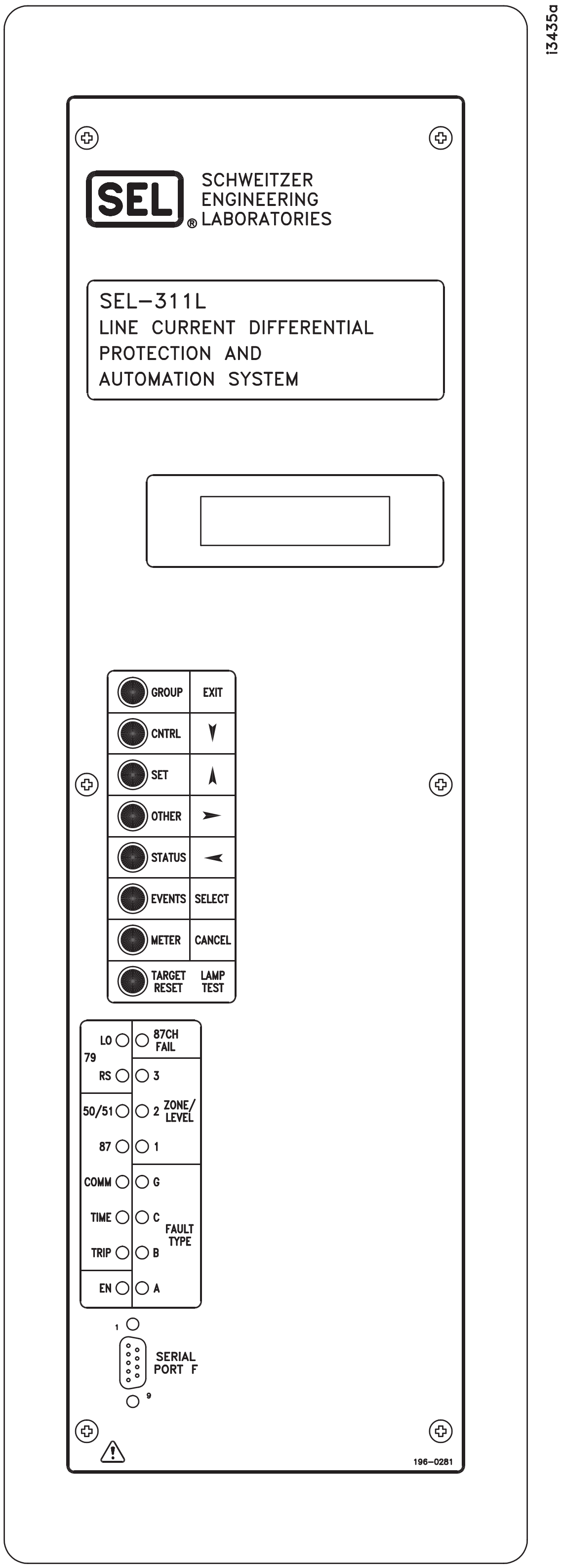


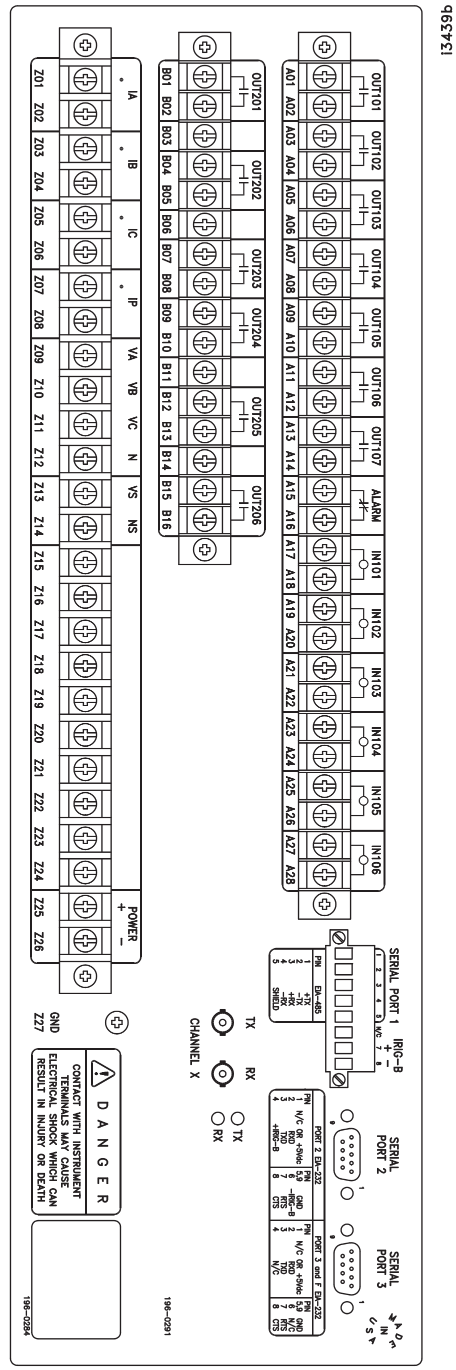
Figure 2.3 SEL-311L Relay 3U Horizontal Panel-Mount Front-Panel and Typical Rear-Panel Drawings

Top



Bottom

Top



Bottom

Figure 2.4 SEL-311L Relay 3U Vertical Panel-Mount Front-Panel and Typical Rear-Panel Drawings

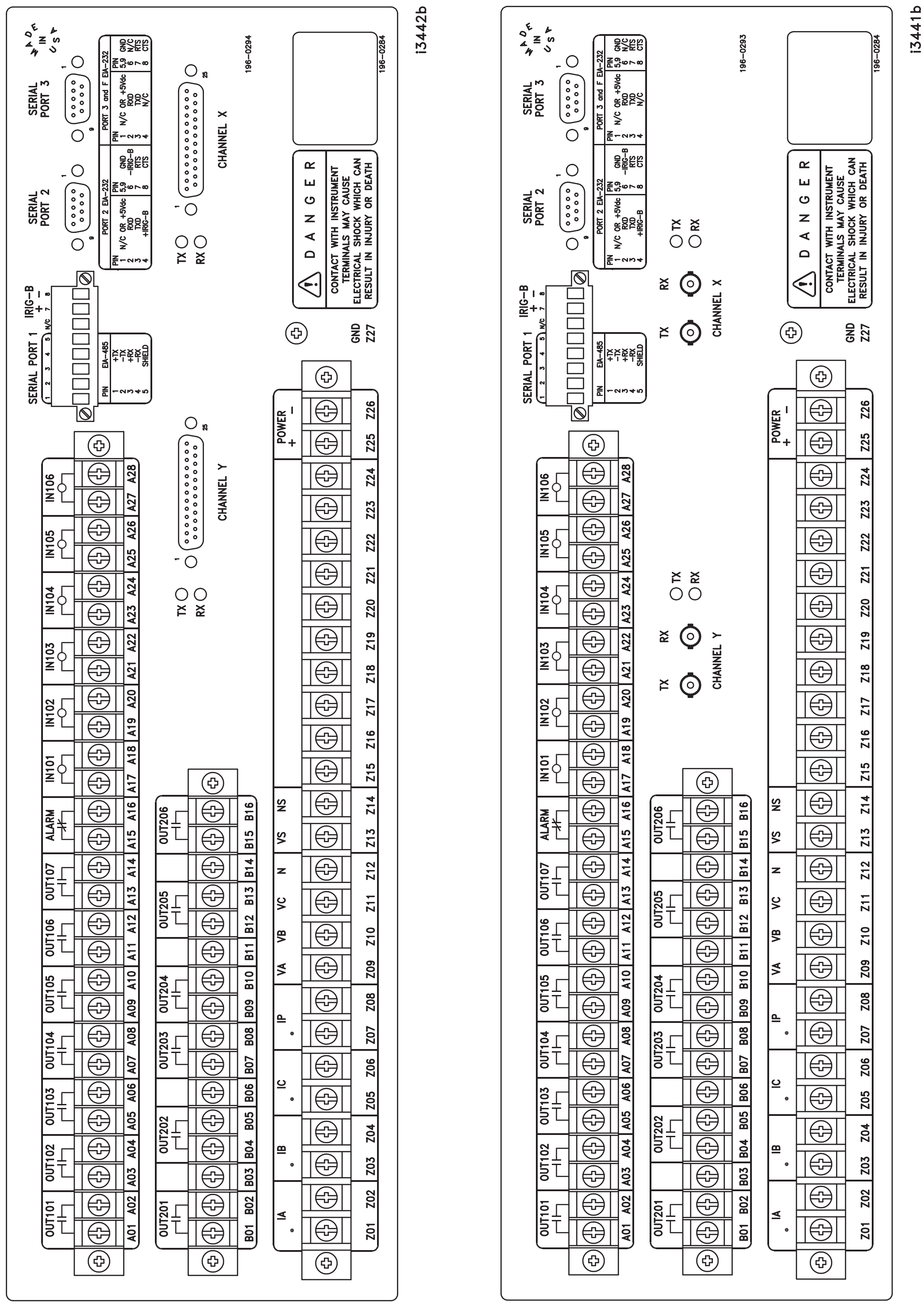


Figure 2.5 SEL-311L Relay 3U Rear-Panel Drawings—DB-25 Connectors at Channel X and Channel Y (Left) and Fiber-Optic Interfaces at Channel X and Channel Y (Right)

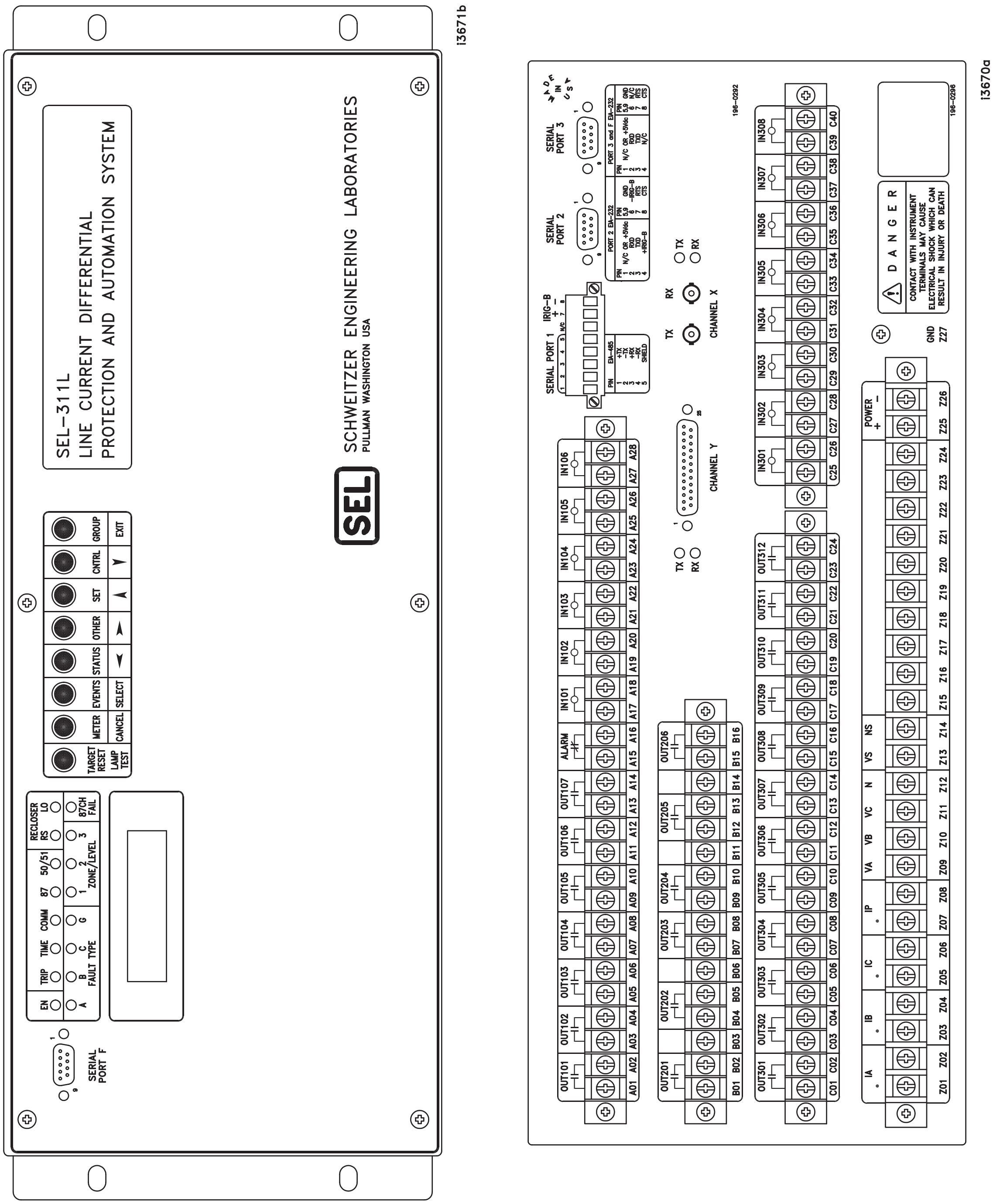


Figure 2.6 SEL-311L Relay 4U Horizontal Rack-Mount Front-Panel and Typical Rear-Panel Drawings

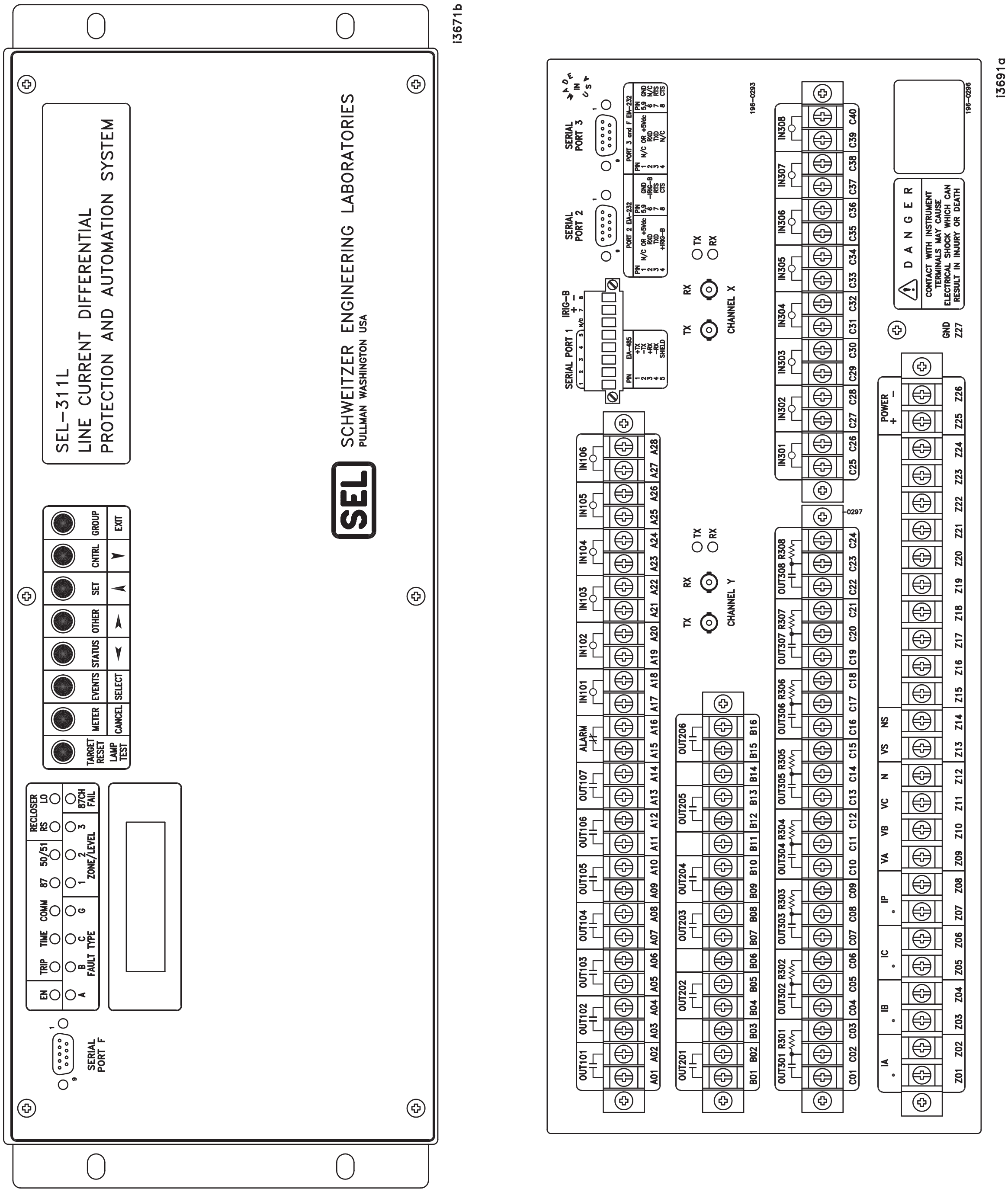


Figure 2.7 SEL-311L Relay 4U Horizontal Rack-Mount Front-Panel and Typical Rear-Panel Drawings

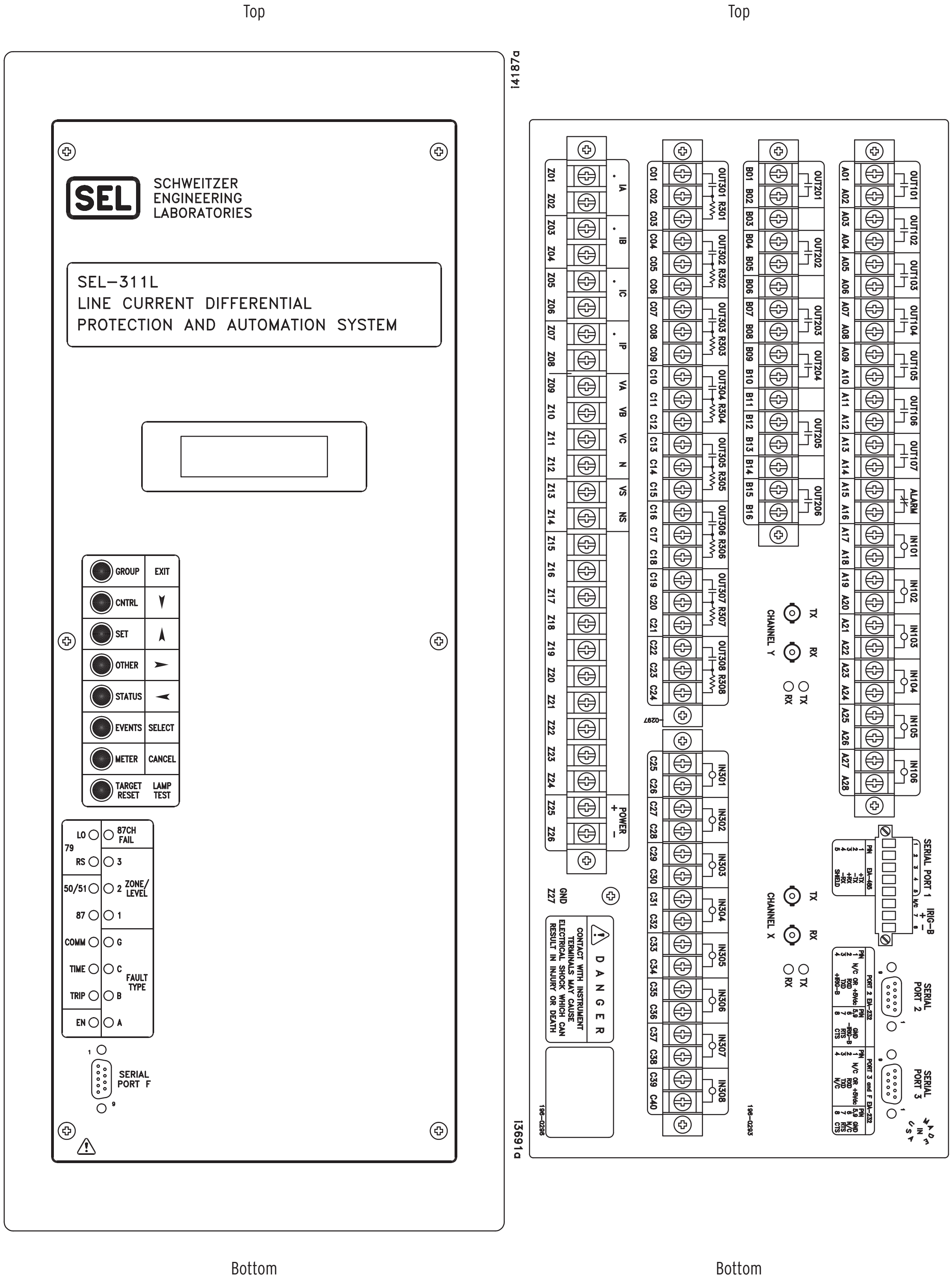


Figure 2.8 SEL-311L Relay 4U Vertical Panel-Mount Front-Panel and Typical Rear-Panel Drawings

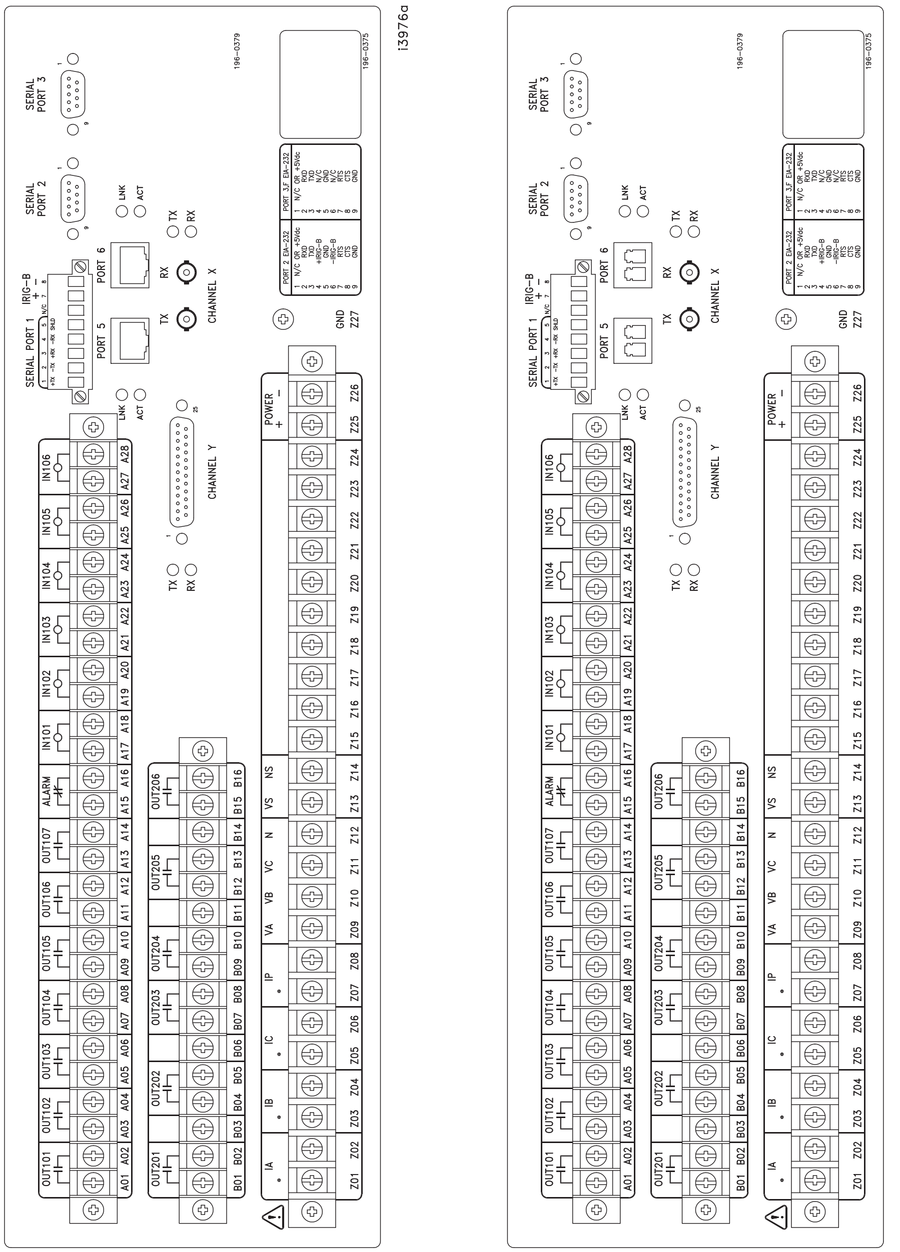


Figure 2.9 SEL-311L Relay 3U Typical Rear-Panel Drawings Showing 10/100BASE-T and 100BASE-FX Ethernet

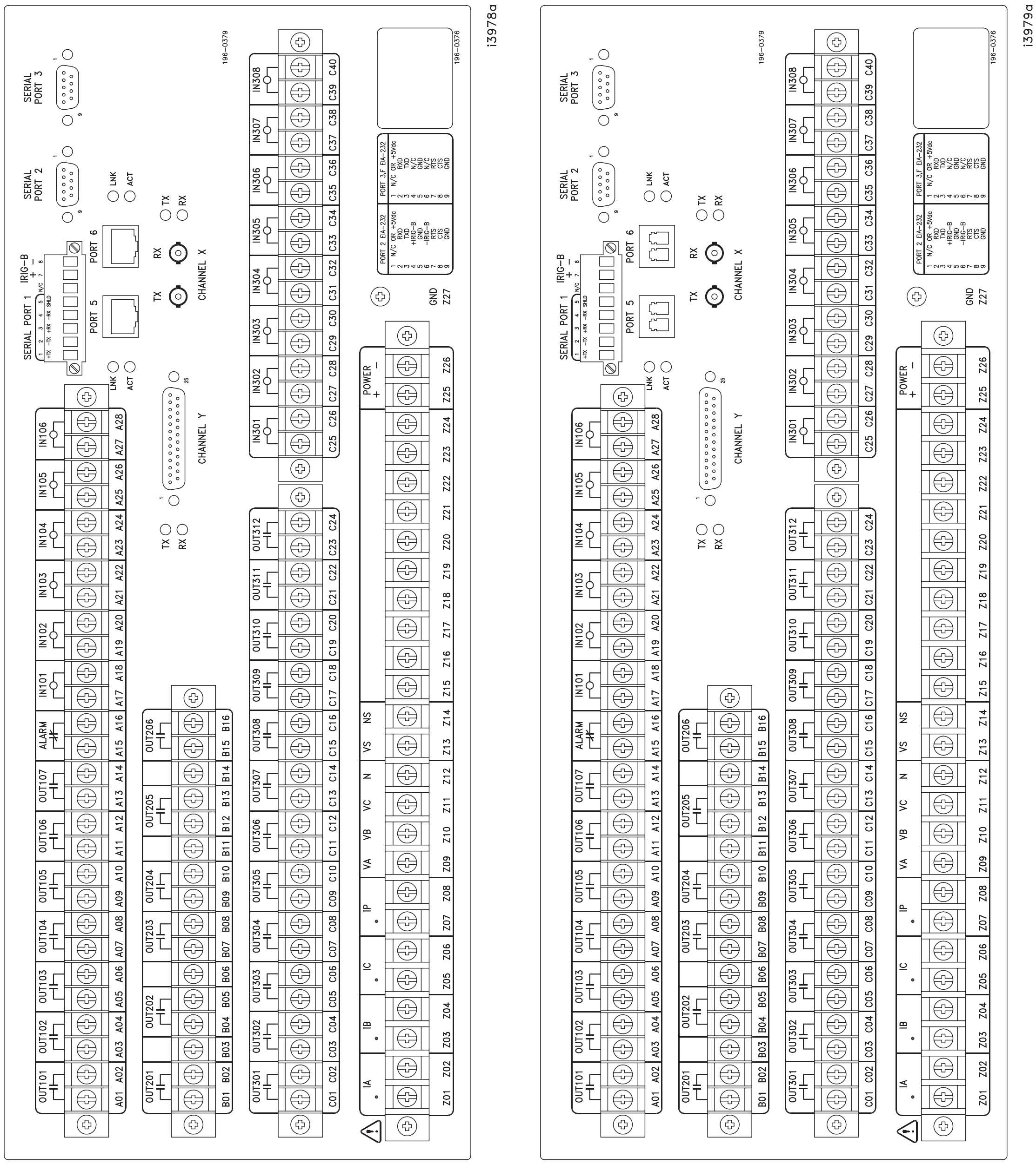


Figure 2.10 SEL-311L Relay 4U Typical Rear-Panel Drawings Showing 10/100BASE-T and 100BASE-FX Ethernet

Making Rear-Panel Connections

Refer to *Figure 2.18–Figure 2.21* for wiring examples of typical applications.

Tools: Phillips or slotted-tip screwdriver

Parts: All screw terminals are size #6-32. Locking screws can be requested from the factory.

Ground the relay chassis at terminal Z27.

Screw Terminal Connections

All screw/washer styles on SEL relays are recognized by UL for field wiring using terminals or bare wire. However, as stated below, SEL strongly recommends the use of ring or fork terminals.

Two types of screw terminal are provided on the SEL relays, one with a washer (Phillips screw head—standard) and one without (slotted screw head—optional). SEL recommends using ring or fork terminals with both types of screw terminals fitted to the relays. There are two main reasons for this recommendation:

- Stray strands and inconsistent wire stripping may compromise HiPot clearances and give rise to the potential for shorting the adjacent terminals.
- Wire/terminal secureness with ring terminals has been tested at SEL to 20 lb. minimum. Bare wire has not been tested at SEL.

NOTE: #6 ring and fork terminals will accommodate wire sizes from 22 AWG to 10 AWG.

NOTE: There is no limit to the number of terminals that can be clamped under one screw; however, there is a maximum total thickness of 0.120" (3 mm). Ring terminals typically range in thickness 0.030" to 0.060".

Both the terminal block manufacturer and UL requirements have qualified the standard terminal blocks for use with bare stranded wire; however, the qualification requirements of SEL are more stringent as required by the utility and industrial applications of protective relays.

The SEL terminal retention and HiPot test voltage requirements are both twice that required by the UL standard.

⚠WARNING
A too-long screw will damage the inside part of the terminal. This is true for both styles of terminal block, but especially for the I/O connections.

All SEL qualification testing of terminal blocks and relays is performed with ring or fork terminals.

Power Supply

Connect control voltage to the **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.

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

All SEL-311L relays have six fast, high-current interrupting output contacts (**OUT201**–**OUT206**) and eight standard output contacts (**OUT101**–**OUT107**, **ALARM**). These 14 output contacts are not polarity-dependent and may be used to switch either ac or dc loads. An additional I/O board with as many as 12 outputs (**OUT301**–**OUT312**) is available. Refer to *Specifications* in *Section 1: Introduction and Specifications* for output contact ratings. Refer to *Figure 2.2 –Figure 2.8* for output contact locations.

Standard Output Contacts

Model 0311L part numbers with a numeral 2 in the field underlined below (sample part numbers) indicate 12 standard output contacts on the extra I/O board (**OUT301–OUT312**):

0311L0JDD42542x

Standard output contacts are not polarity-dependent.

Hybrid (High-Current Interrupting) Output Contacts

⚠CAUTION
Do not use high-current interrupting output contacts to switch ac control signals.

⚠CAUTION
Carefully note the relay terminal polarity designations before wiring high-current interrupting output contacts.

Model 0311L part numbers with a numeral 6 in the field underlined below (sample part numbers) indicate 12 high-current interrupting output contacts on the extra I/O board (**OUT301–OUT312**):

0311L0JDD42546x

High-current interrupting output contacts are polarity-dependent. The extra I/O board of the Model 0311L relay in *Figure 2.6* does not show **+** 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 C01 and C02 (high-current interrupting output contact **OUT301**) in a circuit. Terminal C02 (**+**) has to be at a higher dc voltage potential than terminal C01 (**–**) in the circuit.

Fast Hybrid (High-Current Interrupting) Output Contacts

Model 0311L part numbers with a numeral 5 in the field underlined below (sample part numbers) indicate 8 fast hybrid high-current interrupting output contacts on the extra I/O board (**OUT301–OUT308**):

0311L0JDD42545x

Fast hybrid high-current interrupting output contacts are not polarity-dependent and may be used to switch either ac or dc loads.

Short transient inrush current may flow when a switch that is in series with the contact is closed, and 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 may pick up for this condition. The transient occurs when the capacitance of the output contact circuitry charges. A third terminal provides a path for charging the capacitance when the circuit is open.

Figure 2.11 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.

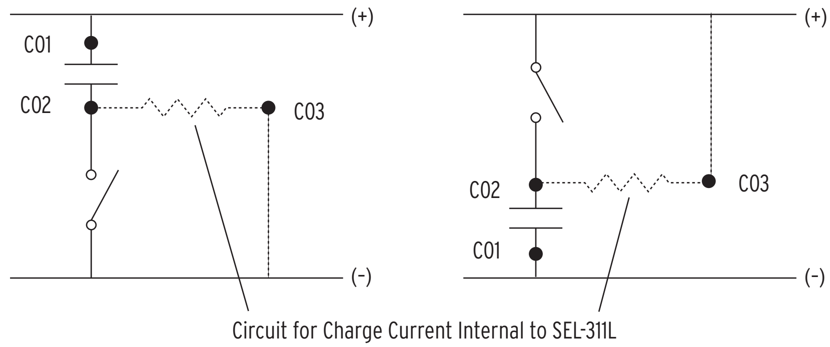


Figure 2.11 Possible Connections for Fast High-Current Interrupting Output Contacts (Circuit Load Not Shown, Third Terminal Connection Is Optional)

Optoisolated Inputs

The optoisolated inputs in the SEL-311L (IN101–IN106 or optional IN301–IN308) are not polarity-dependent. Refer to *Specifications* in *Section 1: Introduction and Specifications* for optoisolated input ratings.

Refer to the serial number sticker on the relay rear panel for the optoisolated input voltage rating.

Current Transformer Inputs

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

Note the polarity dots above terminals Z01, Z03, Z05, and Z07. Refer to *Figure 2.17* through *Figure 2.20* for typical CT wiring examples.

Refer to the serial number sticker on the relay rear panel for the nominal current ratings (5 A or 1 A) for the phase (IA, IB, IC) and polarizing (IP) current inputs.

Potential Transformer Inputs (Optional Connections)

Note the signal labels (VA, VB, VC, N, VS, NS) on terminals Z09–Z14. *Figure 1.4* shows the internal connection for terminals VA, VB, VC, and N. Note also that VS/NS is a separate single-phase voltage input.

Wye-Connected Voltages

Any of the voltage inputs (i.e., VA-N, VB-N, VC-N, or VS-NS) can be connected to voltages as high as 150 V rms continuous. *Figure 2.18* and *Figure 2.19* show examples of wye-connected voltages. System frequency for under- and overfrequency elements is determined from the voltage connected to terminals VA-N if voltage is present on the relay. Otherwise, system frequency is determined from filtered positive-sequence current (I1).

Serial Ports (1, 2, 3, and F)

The SEL-311L contains the following multifunction communications ports.

Serial Port 1 on all the SEL-311L models is an EIA-485 port (4-wire). The Serial Port 1 plug-in connector accepts wire size AWG 24 to 12. Strip the wires 8 mm (0.31 in) and install with a small slotted-tip screwdriver. The Serial Port 1 connector has extra positions for IRIG-B time-code signal input (see *Table 10.5*; also see the following discussion on IRIG-B time-code input).

Serial Ports F, 2, and 3 are EIA-232 ports and accept 9-pin D-subminiature male connectors. Port 2 on all the SEL-311L models includes the IRIG-B time-code signal input (see *Table 10.5*; also see the following discussion on IRIG-B time-code input).

All serial ports are independent—you can communicate to any combination simultaneously.

The pin definitions for all the ports are given on the relay rear panel and are detailed in *Table 10.5–Table 10.7*.

NOTE: Devices not manufactured by SEL are listed in Table 2.1 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.

Refer to *Table 2.1* for a list of cables available from SEL for various EIA-232 communications applications. Refer to *Section 10: Communications* for detailed cable diagrams for selected cables.

For example, to connect any EIA-232 port to the 9-pin male connector on a laptop computer, order cable number SEL-C234A and specify the length needed (standard length is eight feet). To connect the SEL-311L Port 2 to an SEL communications processor (SEL-2032, SEL-2030, or SEL-2020) that supplies the communication link and the IRIG-B time-synchronization signal, order cable number SEL-C273A. For connecting devices at distances longer than 30.48 m (100 ft), 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. See *Application Guide AG2001-06: Communication Cable Application Guideline*, or contact SEL for further information on these products.

Table 2.1 EIA-232 Communications Cables to Connect the SEL-311L to Other Devices

SEL-311LEIA-232 Serial Ports	Connect to Device (gender refers to the device)	SEL Cable No.
all EIA-232 ports	PC, 25-Pin Male (DTE)	SEL-C227A
all EIA-232 ports	Laptop PC, 9-Pin Male (DTE)	SEL-C234A
all EIA-232 ports	SEL-2032, SEL-2030, or SEL-2020 without IRIG-B	SEL-C272A
2	SEL-2032, SEL-2030, or SEL-2020 with IRIG-B	SEL-C273A
all EIA-232 ports	SEL-DTA2	SEL-C272A
2[a] 3[a]	Dial-up modem, 5 Vdc Powered	SEL-C220[a]
all EIA-232 ports	Standard dial-up modem, 25-Pin Female (DCE)	SEL-C222
all EIA-232 ports	SEL-2100	SEL-C272A
2	SEL-2100 with IRIG	SEL-C273A
2 3	SEL-2505	SEL-2800

[a] A corresponding main board jumper must be installed to power the dial-up modem with +5 Vdc (0.5 A limit) from the SEL-311L. See Figure 2.21 and Table 2.7.

IRIG-B Time-Code Input

The SEL-311L accepts a demodulated IRIG-B time signal to synchronize the relay internal clock with some external source. The IRIG-B time signal does not update the relay internal year. The line current differential protection does NOT rely upon IRIG-B time synchronization.

A demodulated IRIG-B time code can be input into Serial Port 2 on any of the SEL-311L models (see *Table 10.5*) by connecting Serial Port 2 of the SEL-311L to an SEL communications processor (SEL-2032, SEL-2030, or SEL-2020 with an SEL-C273A cable, or by using an SEL-2810 Fiber-Optic Transceiver.

A demodulated IRIG-B time code can also be input into the connector for Serial Port 1 (see *Table 10.6*). If demodulated IRIG-B time code is input into this connector, it should not be input into Serial Port 2 and vice versa.

Line Current Differential Communications Channel Interfaces

Order the SEL-311L with as many as two line current differential interfaces. Each interface is factory configured as one of the options listed in *Table 2.2*. When the SEL-311L arrives, the channels are configured per your ordering options.

Table 2.2 Current Differential Communication Interface Options

Data Interface	Medium	Data Rate	Relay Connection	Maximum Point-to-Point Range
EIA-422	Electrical	56 k or 64 k	DB-25 Male	100 ft
CCITT G.703	Electrical	64 k	DB-25 Male	100 ft
IEEE C37.94 Compatible	850 nm Multimode Fiber	64 k	ST	2 km
IEEE C37.94 Compatible Modulation	1300 nm Single-Mode Fiber	64 k	ST	15 km
Direct Fiber	1300 nm Multi- or Single-Mode Fiber	64 k	ST	30 km; 80 km
Direct Fiber	1550 nm Single-Mode Fiber	64 k	ST	120 km

Table 2.3 shows the appropriate SEL cable to connect the SEL-311L to some popular multiplexers for the electrical interfaces. *Figure 2.12* and *Figure 2.13* depict the signal names, pinout, and direction at the SEL-311L. All of the electrical 87L channel interface options on the SEL-311L are isolated from the chassis to at least 1500 V rms. To maintain that isolation, and to avoid ground loops, ground all cable shields only at the communications equipment.

See *Section 10: Communications* for channel interface configuration settings, and for channel monitor settings.

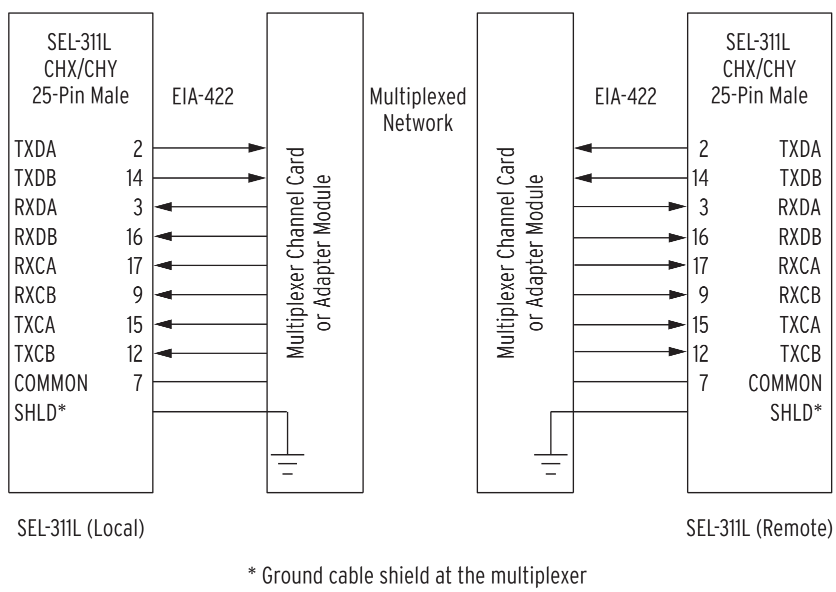


Figure 2.12 Typical EIA-422 Interconnection

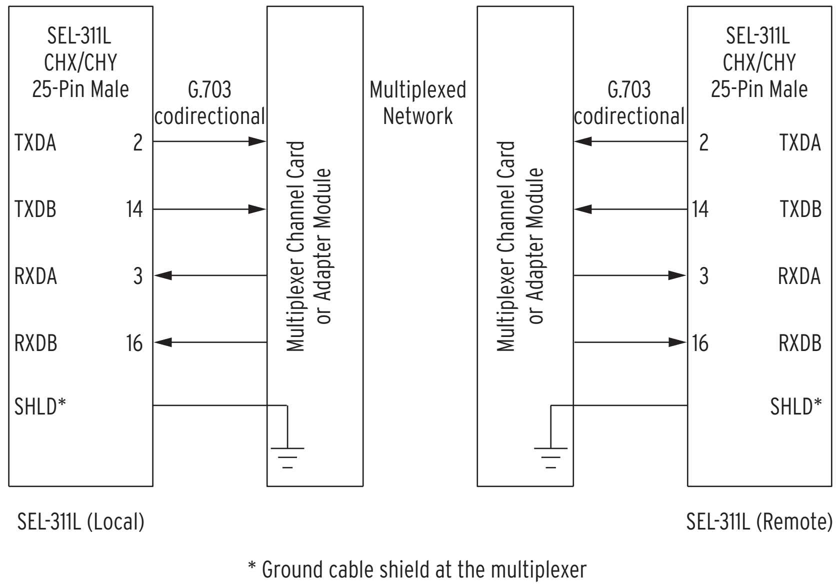


Figure 2.13 Typical G.703 Codirectional Interconnection

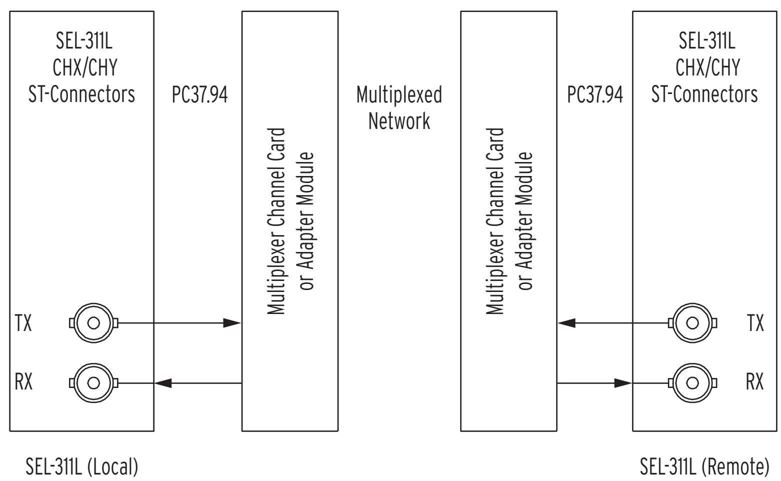


Figure 2.14 IEEE C37.94-Compatible Fiber-to-Multiplexer Interface

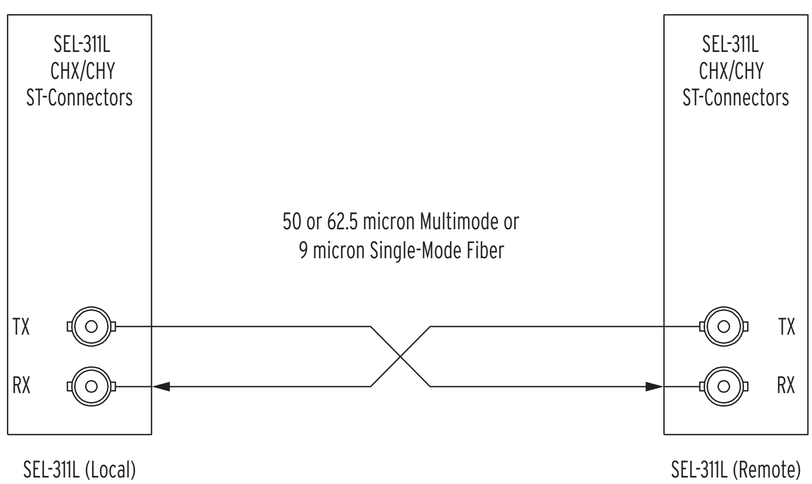


Figure 2.15 1300 nm Direct-Fiber Connection

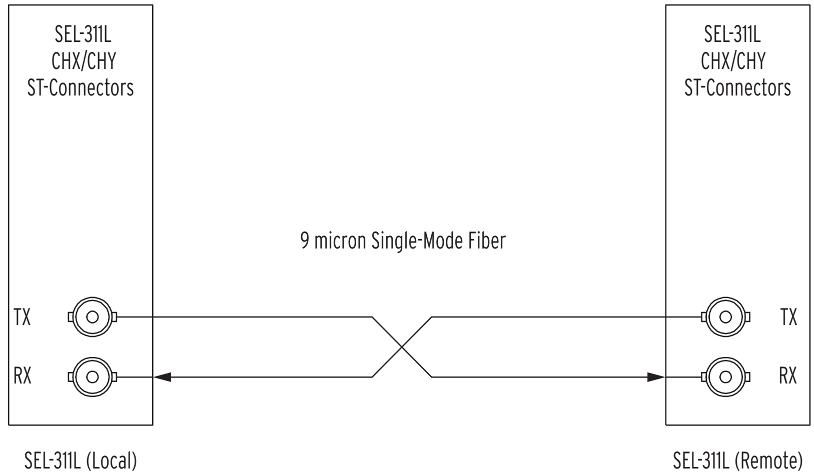
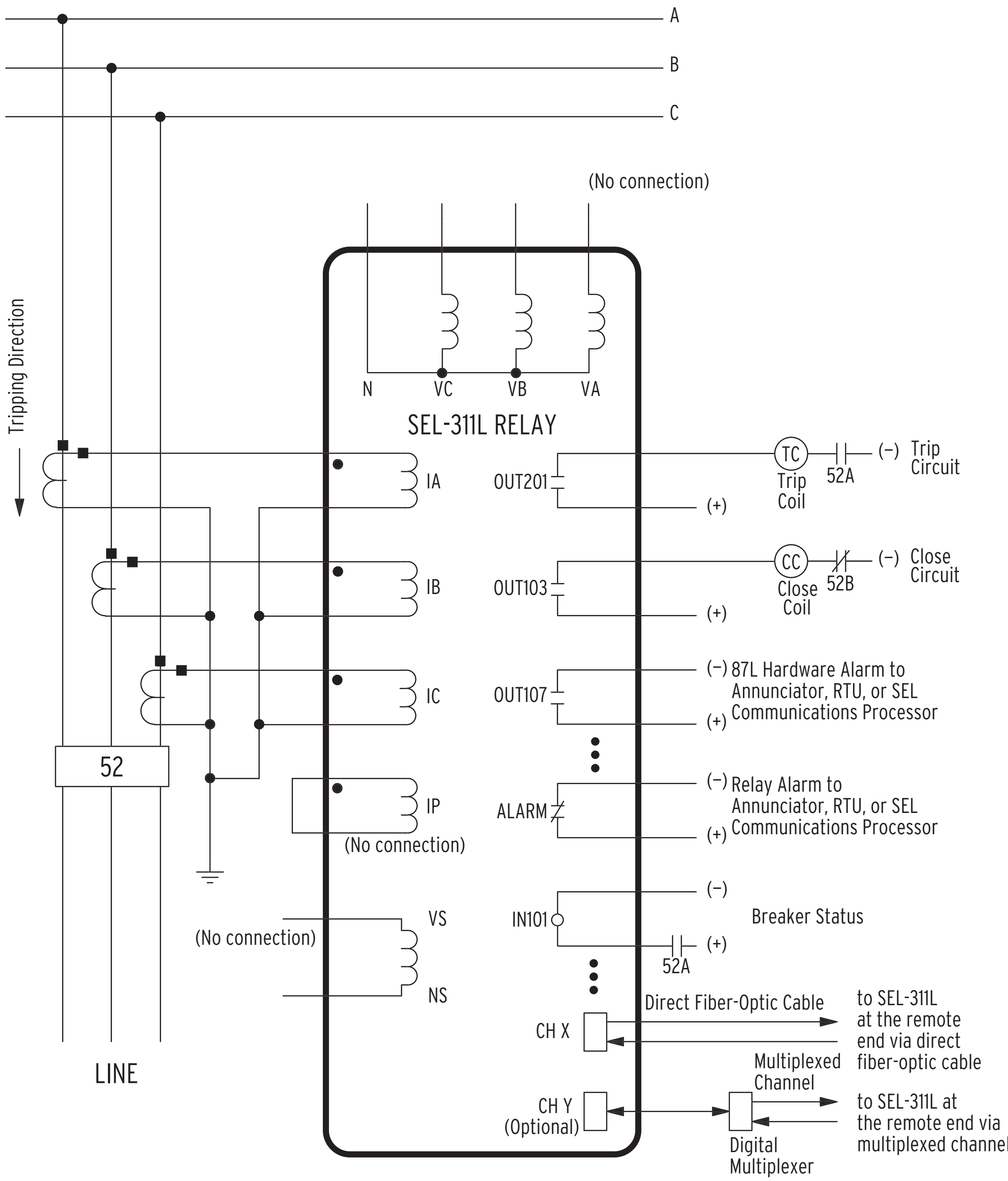


Figure 2.16 1550 nm Direct-Fiber Connection

Table 2.3 SEL-311L Line Current Differential Electrical Interface Cable Application

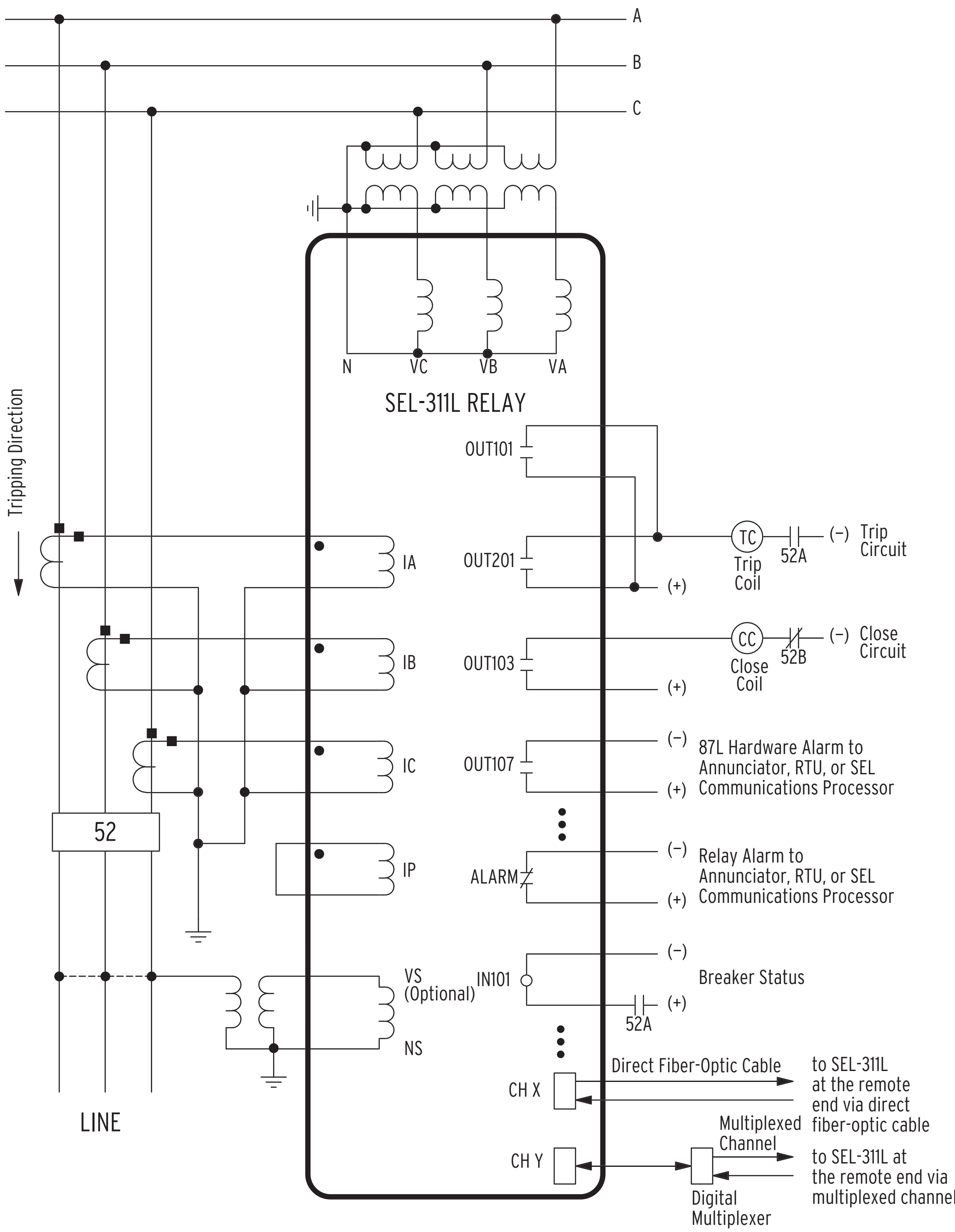
MFG	Product	Channel Card	Interface Adapter	SEL Cable	Interface Type
RFL	IMUX	DS562I	MA406IA	C453	EIA-422; RS-449
RFL	IMUX	DS562I	MA408IA	C452	G.703
Pulsar	FOCUS	64K	N/A	C451	EIA-422; RS-530
Nortel	JMUX	Nx64 Unit 86464-01	86447-90	C450	EIA-422; Terminals

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



Voltage Channels (VA, VB, VC, and VS) and current Channel IP are not used in this application.

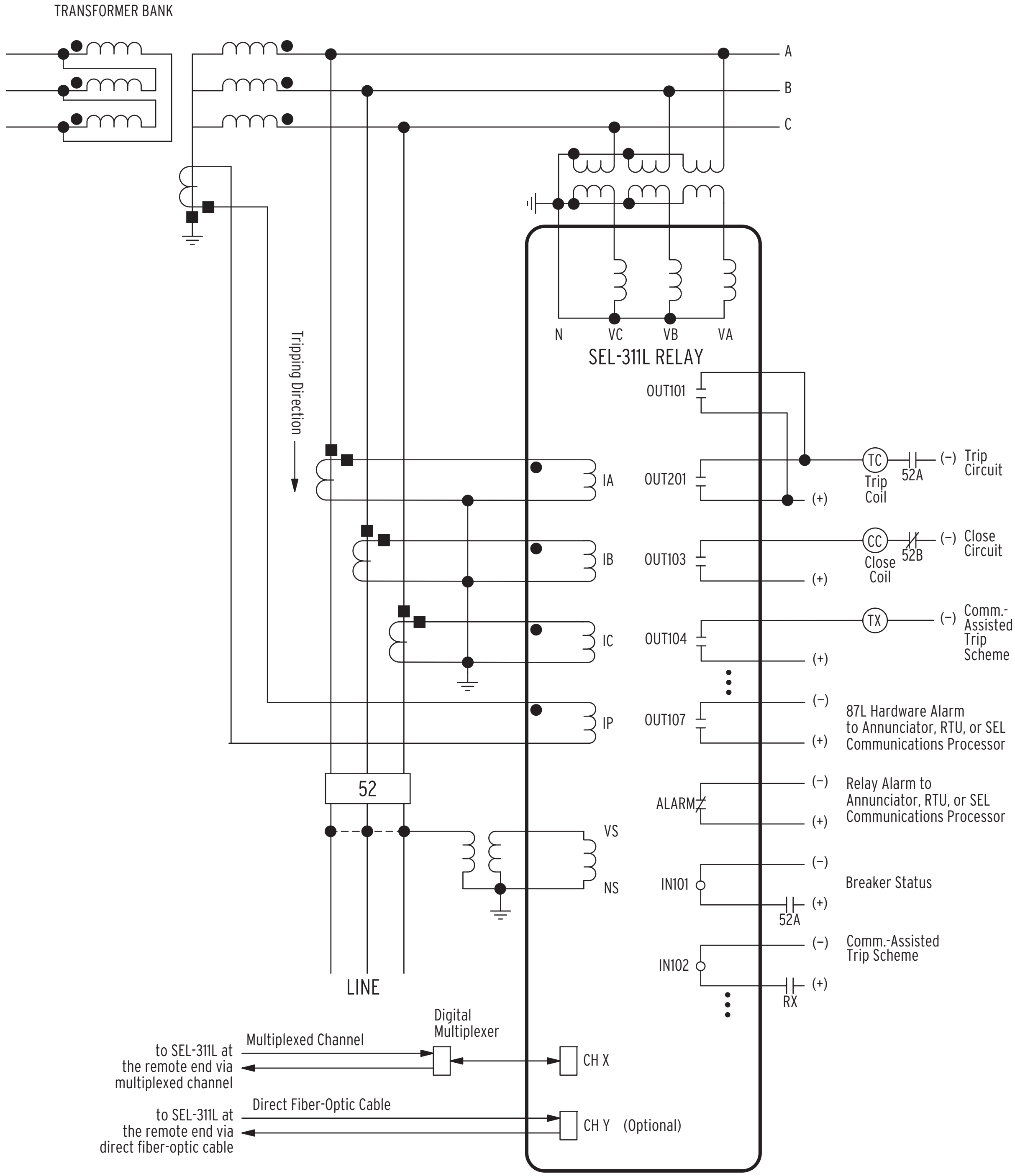
Figure 2.17 SEL-311L Provides Line Current Differential Protection (Setting APP = 87L)



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

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

Figure 2.18 SEL-311L Provides Line Current Differential, Backup Distance and Overcurrent Protection, Reclosing, and Synchronism Check for a Transmission Line (Setting APP = 87L21 or 87L21P)



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 IP provides current polarization for a directional element used to control ground elements.

Figure 2.19 SEL-311L Provides Line Current Differential, Backup Distance and Overcurrent Protection, and Reclosing for a Transmission Line (Current-Polarization Source Connected to Channel IP; Setting APP = 311L)

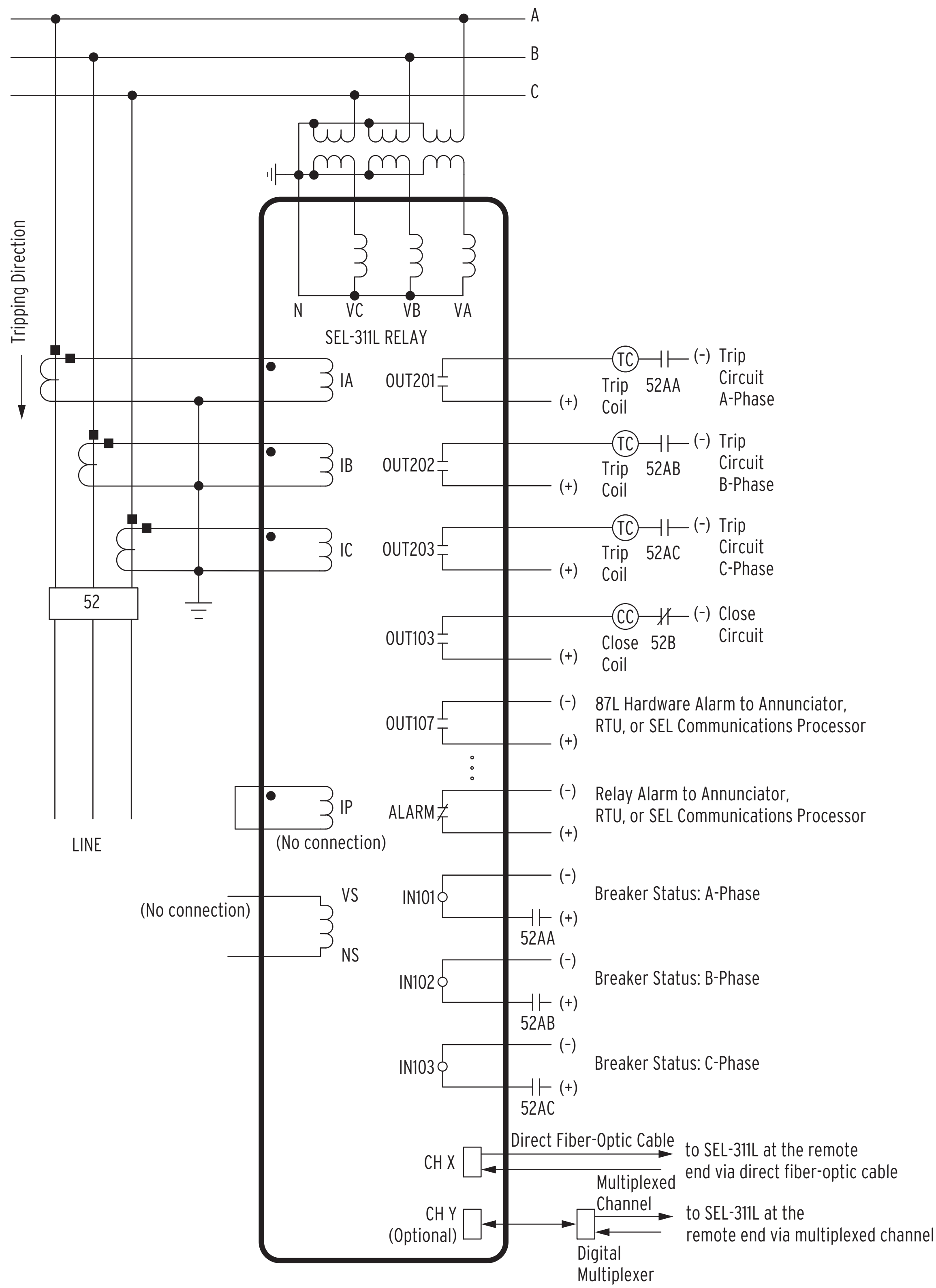


Figure 2.20 SEL-311L Provides Single-Pole Tripping Line Current Differential and Single-Pole Tripping Zone 1 Distance Protection (Setting APP = 87LSP—SEL-311L-7 Only)

Circuit Board Connections

Accessing the Relay Circuit Boards

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

⚠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.

To change circuit board jumpers or replace the clock battery, refer to *Figure 2.21* and take the following steps:

Step 1. De-energize the relay.

Step 2. Remove any cables connected to serial ports or line current differential communications on the front and rear panels.

Step 3. Remove the EIA-485 connector.

Step 4. Loosen the six front-panel screws (they remain attached to the front panel), and remove the relay front panel.

Step 5. Each circuit board corresponds to a row of rear-panel terminal blocks or connectors and is affixed to a drawout tray.

Step 6. Disconnect circuit board cables as necessary.

Removal of the differential board requires removal of the main board first.

a. Ribbon cables can be removed by pushing the extraction ears away from the connector.

b. The 6-conductor power cable can be removed by grasping the power connector wires and pulling away from the circuit board.

Step 7. Grasp the drawout assembly of the board and pull the assembly from the relay chassis.

Step 8. Locate the jumper(s) or battery to be changed (refer to *Figure 2.21*).

Step 9. Make the desired changes.

NOTE: 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 removed in *Step 6*.

Step 12. Replace the relay front-panel cover.

Step 13. Replace any cables previously connected to serial ports or line current differential communications.

Step 14. Re-energize the relay.

Step 15. Verify that the **ENABLE** LED illuminates.

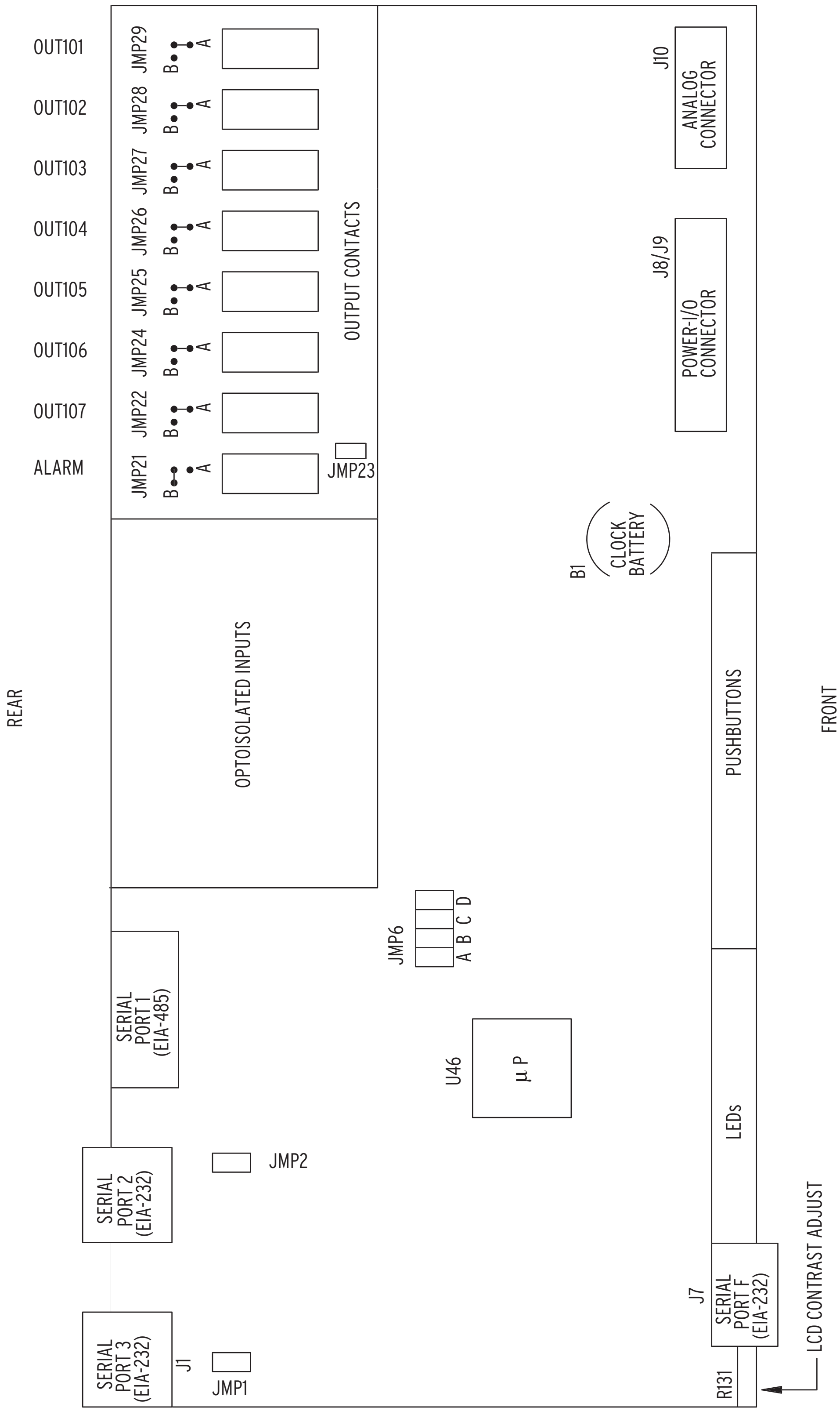


Figure 2.21 Jumper, Connector, and Major Component Locations on the SEL-311L Main Board

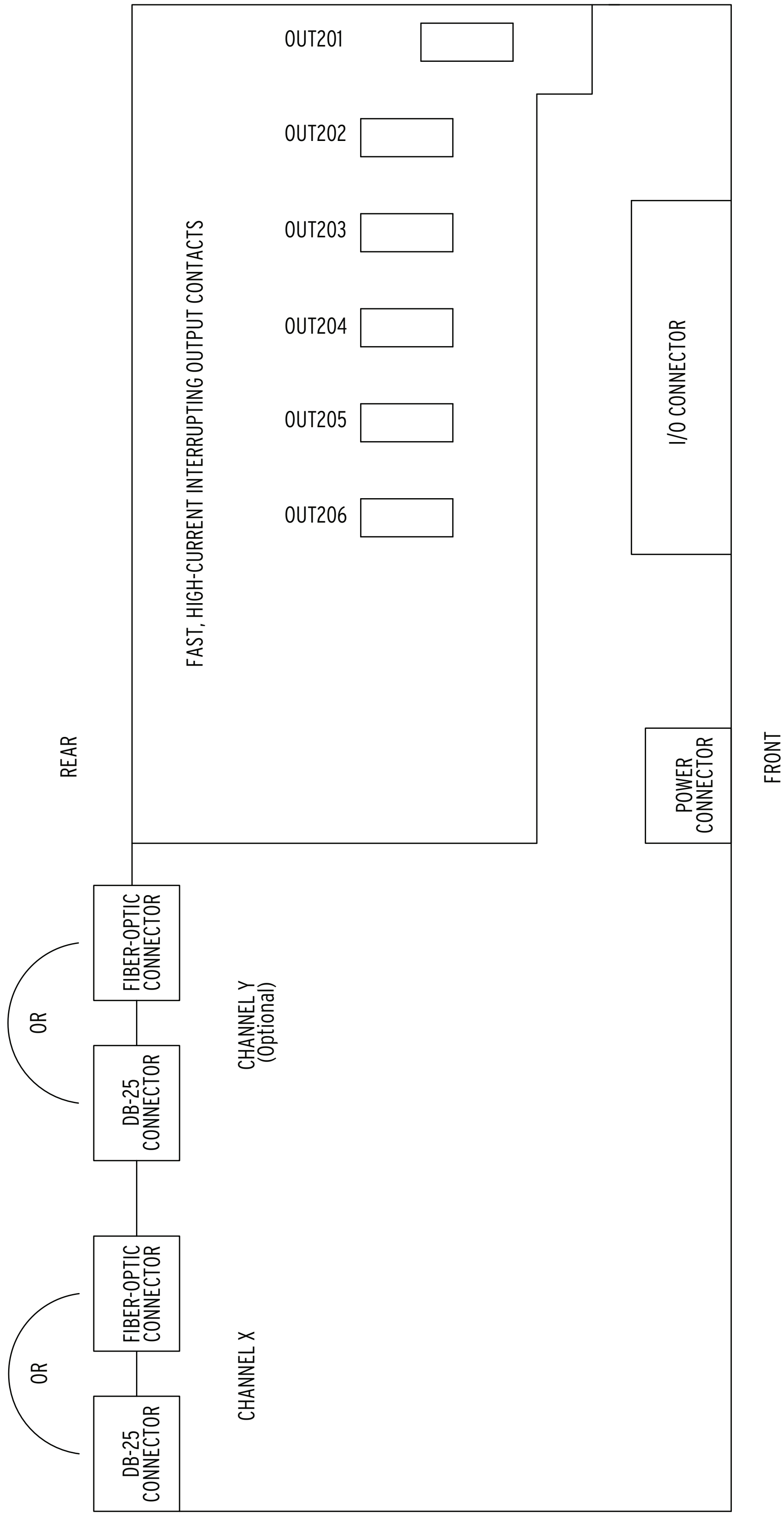


Figure 2.22 Connector and Major Component Locations on the SEL-311L Differential I/O Board

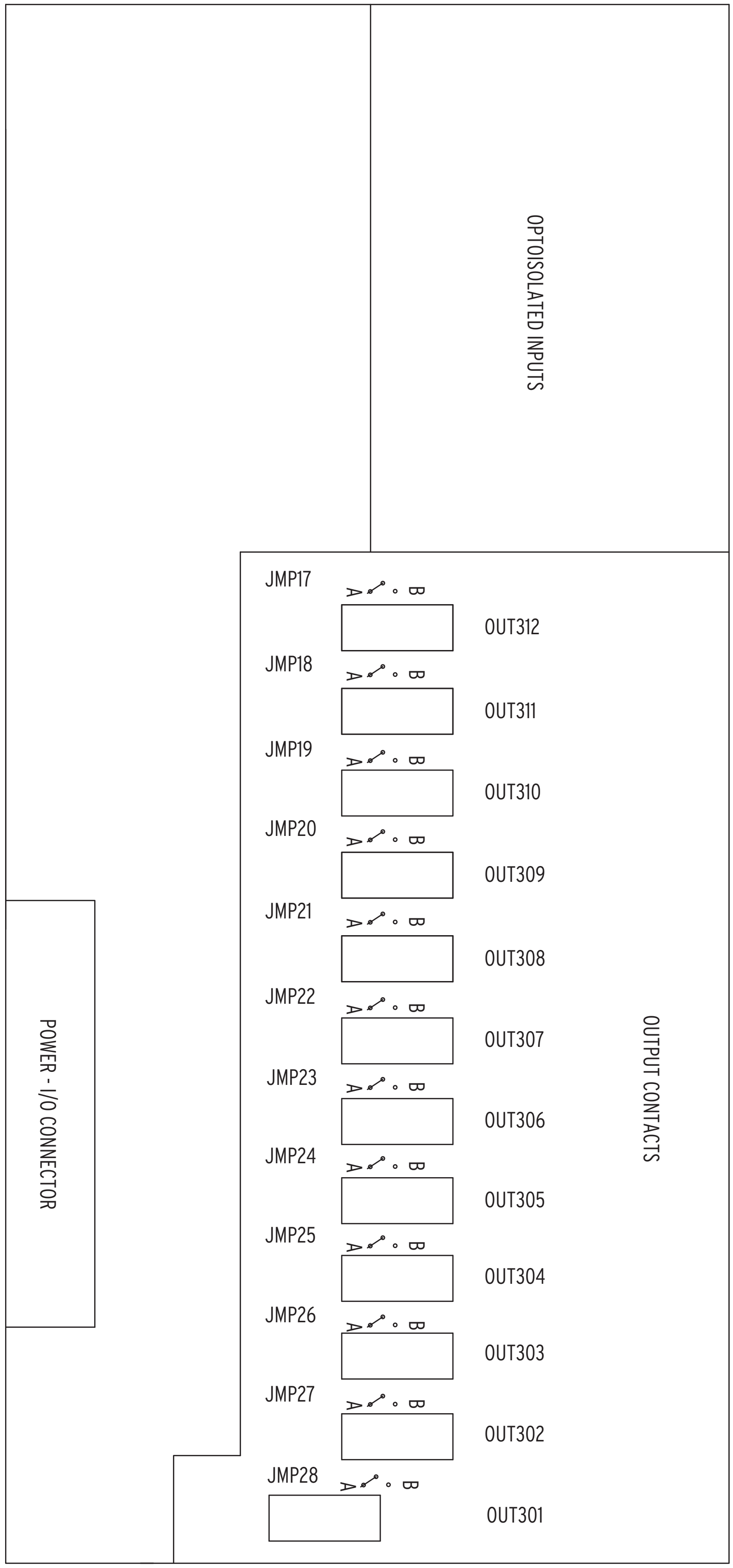


Figure 2.23 Jumper, Connector, and Major Component Locations on the SEL-311L Relay Interface 2 (INT2) and Interface 6 (INT6) I/O Boards

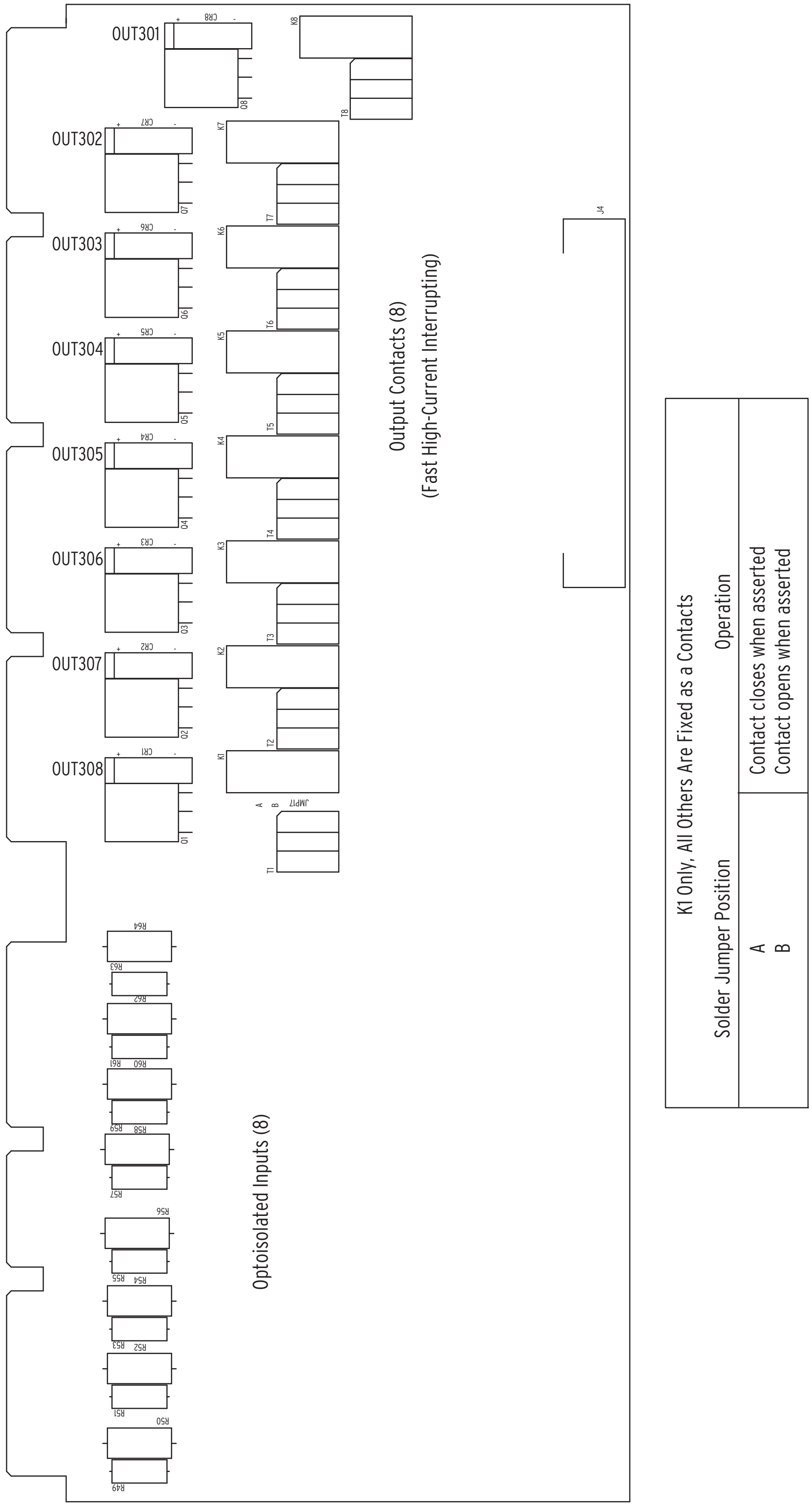


Figure 2.24 Jumper, Connector, and Major Component Locations on the SEL-311L Relay Interface 5 (INT5) I/O Board

Output Contact Jumpers

Table 2.4 shows the correspondence between output contact jumpers and the output contacts they control. The referenced figures show the exact location and correspondence. With a jumper in the A position, the corresponding output contact is an "a" type output contact. An "a" type output contact is closed when the associated SELOGIC control equation is asserted, and open when the associated SELOGIC control equation is deasserted. With a jumper in the B position, the corresponding output contact is a "b" type output contact. A "b" type output contact is closed when the associated SELOGIC control equation is deasserted, and open when the associated SELOGIC control equation is asserted. These jumpers are soldered in place.

NOTE: The output contact jumpers are soldered in place.

In *Figure 2.21*, note that the **ALARM** output contact is a "b" type output contact and the other output contacts are all "a" type output contacts. This is how these jumpers are configured in a standard relay shipment. Refer to *Output Contacts on page 7.28* for examples of output contact operation for different output contact types.

The fast, high-current interrupting contacts **OUT201–OUT206** are all "a" type contacts and cannot be configured as "b" type contacts.

Three different options are available for the additional I/O board: INT2, INT5, and INT6. Both the INT2 and INT6 boards have 12 output contacts that can be jumper configured as either "a" or "b" type contacts. The INT5 has eight output contacts; however, only one contact, OUT308, can be configured as either an "a" or "b" type contact. The other seven output contacts are "a" type contacts and cannot be configured as "b" type contacts.

Table 2.4 Output Contact Jumpers and Corresponding Output Contacts

SEL-311L Model Number	Output Contact Jumpers	Corresponding Output Contacts	Reference Figure
All Models	JMP21–JMP29 (but not JMP23)	**ALARM–OUT101**	*Figure 2.21*
0311L w/INT2/ INT6	JMP17–JMP28	**OUT312–OUT301**	*Figure 2.23*
0311L w/INT5	JMP17	**OUT308**	*Figure 2.24*

"Extra Alarm" Output Contact Control Jumper

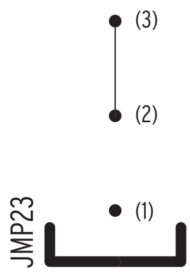
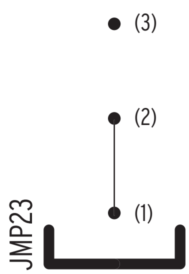
All the SEL-311L relays have a dedicated alarm output contact labeled **ALARM** (see *Figure 2.2–Figure 2.8*). Often more than one alarm output contact is needed for such applications as local or remote annunciation, backup schemes, etc.

Convert the output contact adjacent to the dedicated **ALARM** output contact to operate as an "extra alarm" output contact by moving jumper JMP23 on the main board (see *Table 2.5*).

With the jumper in one position, the output contact operates regularly. With the jumper in the other position, the output contact is driven by the same signal that operates the dedicated **ALARM** output contact (see *Table 2.5*).

Do not convert **OUT107** to an "extra alarm" if it is used as a line current differential hardware alarm. When configured as an "extra alarm," **OUT107** no longer responds to SELOGIC control equation OUT107 = 87HWAL.

Table 2.5 Move Jumper JMP23 to Select Extra Alarm

Position	Output Contact OUT107 Operation
	Output contact **OUT107** is operated by Relay Word bit OUT107. Jumper JMP23 comes in this position in a standard relay shipment (see *Figure 7.27*). Place jumper JMP23 as shown and set SELOGIC control equation OUT107 = 87HWAL to obtain an alarm upon loss of the 87L Hardware.
	"Extra Alarm" output contact is operated by alarm logic/circuitry. Relay Word bit OUT107 does not have any effect on output contact **OUT107** when jumper JMP23 is in this position (see *Figure 7.27*). If you place jumper JMP23 in position 1–2, loss of the 87L board will not result in an alarm via OUT107 = 87HWAL.

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

The output contact type for output contacts **OUT101**–**OUT107** can be changed (see *Output Contact Jumpers on page 2.29*). Thus, the dedicated **ALARM** output contact and the "extra alarm" output contact can be configured as the same output contact type if desired (e.g., both can be configured as "b" type output contacts).

Password and Breaker Jumpers

Table 2.6 Password and Breaker Jumper Operation

Jumper	Jumper Position	Function
Password JMP6-A	ON (in place)	Disable password protection[a] for serial ports and front panel.
	OFF (removed/not in place)	Enable password protection[a] for serial ports and front panel. Passwords are enabled in a standard relay shipment.
Breaker JMP6-B	ON (in place)	Enable serial port commands **OPEN**, **CLOSE**, and **PULSE**[b]. These commands are disabled in a standard relay shipment.
	OFF (removed/not in place)	Disable serial port commands **OPEN**, **CLOSE**, and **PULSE**[b]. These commands are disabled in a standard relay shipment.

[a] View or set the passwords with the **PASSWORD** command (see Section 10: Communications).
[b] The **OPEN**, **CLOSE**, and **PULSE** commands are used primarily to assert output contacts for circuit breaker control or testing purposes (see Section 10: Communications).

Note that JMP6 in *Figure 2.21* has multiple jumpers A–D. Jumpers A and B are used (see *Table 2.6*). Because jumpers C and D are not used, the positions (ON or OFF) of jumpers C and D are of no consequence.

EIA-232 Multifunction Serial Port Voltage Jumpers

The jumpers listed in *Table 2.7* 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 for each port. See *Table 10.5* for EIA-232 serial port pin functions.

In a standard relay shipment, the jumpers are “OFF” (removed/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 the +5 Vdc is connected to Pin 1 on the corresponding EIA-232 serial ports.

Table 2.7 EIA-232 Serial Port Voltage Jumper Positions for Standard Relay Shipments

SEL-311L Model Number	EIA-232 Serial Port 2 (rear panel)	EIA-232 Serial Port 3 (rear panel)	Reference Figure
All Models	JMP2 = OFF	JMP1 = OFF	*Figure 2.21*

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.

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 2.21* for clock battery B1 location. This lithium battery powers the relay clock (date and time) if the external power source is lost or removed. The battery is a 3 V lithium coin cell, Rayovac No. BR2335 or equivalent. At room temperature (25°C), the battery will nominally operate for 10 years with power removed from the relay.

If external power 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.

Step 1. Follow the instructions in *Accessing the Relay Circuit Boards on page 2.24* to remove the relay main board.

Step 2. Remove the battery from beneath the clip.

Step 3. Install a new one.

The positive side (+) of the battery faces up.

Step 4. Reassemble the relay as described in *Accessing the Relay Circuit Boards*.

Step 5. Set the relay date and time via serial communications port or front panel (see *Section 10: Communications* or *Section 11: Front-Panel Operations*).

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Section 3

Line Current Differential Protection

Overview

The SEL-311L Line Current Differential Protection and Automation System includes both current-based and voltage-based protection elements. Loss or absence of potential does not affect current-based elements such as line current differential, overcurrent and tapped-load protection. This section describes operational theory and settings guidelines for the current differential protection.

Current Differential Elements

The SEL-311L Relay contains five line current differential elements:

- one for each phase
- one each for negative-sequence and ground current

The phase elements provide high-speed protection for high-current faults. Negative-sequence and ground elements provide sensitive protection for unbalanced faults without compromising security. This section familiarizes you with the operating principles of the line current differential elements in the SEL-311L and introduces a setting philosophy that gives secure, fast, sensitive, and dependable operation. For most two-terminal and three-terminal applications, the 87L settings need not be changed from the factory defaults.

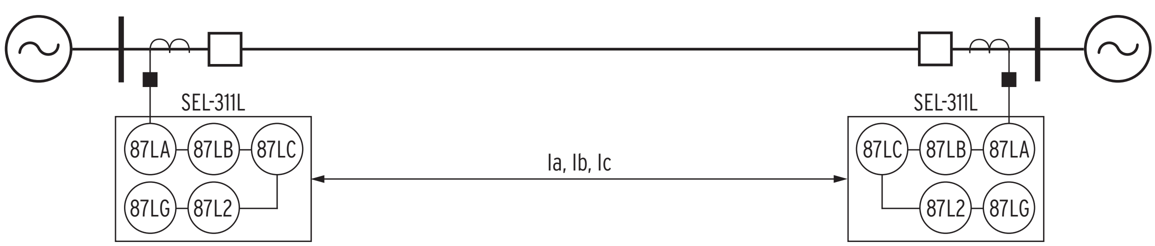


Figure 3.1 SEL-311L Line Current Differential Elements

The SEL-311L exchanges time-synchronized Ia, Ib, and Ic samples between two or three line terminals. Each relay calculates 3I2 and 3I0 for all line terminals. Current differential elements 87LA, 87LB, 87LC, 87L2, and 87LG in each relay compare Ia, Ib, Ic, 3I2, and 3I0 (IG) from each line terminal. All relays perform identical line current differential calculations in a peer-to-peer architecture to avoid transfer trip delays.

This section describes settings considerations for the differential elements. Phase differential elements 87LA, 87LB, and 87LC reliably detect three-phase faults. The negative-sequence element 87L2 detects internal unbalanced faults and is restrained when all three of the phase currents from any terminal exceed 3 • Inom. *Settings Example: 230 kV Transmission Line With Tapped Load on page 9.37* shows how to use the zero-sequence element for high-speed tripping with delta-wye grounded tapped loads.

Theory of Operation (patented)

Figure 3.2 helps understand how the phase and negative-sequence differential elements operate for a two-terminal line. Three-terminal cases are described later, but all of the two-terminal discussion applies to three-terminal cases. *Figure 3.2* shows the alpha plane, which represents the phasor or complex ratio of remote (IR) to local (IL) currents. There is a separate alpha plane for every current (phase, negative-sequence, zero-sequence, etc).

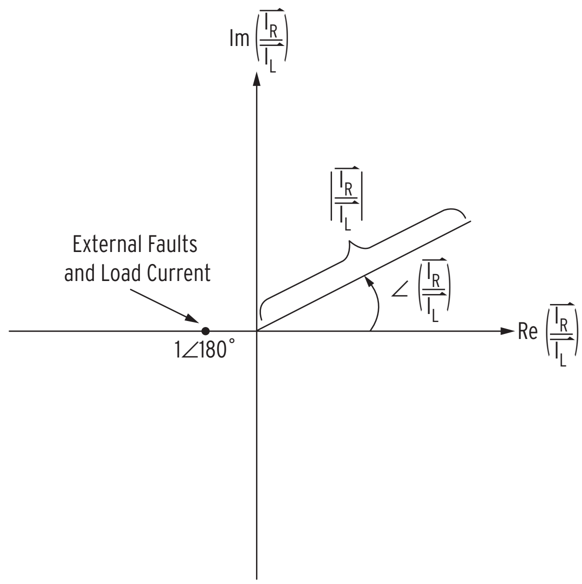


Figure 3.2 Alpha Plane Represents Complex Ratio of Remote-to-Local Currents

Arbitrarily assign current flowing into the protected line to have zero angle, and current flowing out of the protected line to have angle 180 degrees. 5 A of load current flowing from the local to the remote relay produces an A-phase current of $5\angle0°$ at the local relay and $5\angle180°$ at the remote relay. The ratio of remote to local current is:

$$\frac{\overrightarrow{I_{AR}}}{\overrightarrow{I_{AL}}} = \frac{5\angle180°}{5\angle0°} = 1\angle180°$$
$$\frac{\overrightarrow{I_{BR}}}{\overrightarrow{I_{BL}}} = \frac{5\angle60°}{5\angle-120°} = 1\angle180°$$
$$\frac{\overrightarrow{I_{CR}}}{\overrightarrow{I_{CL}}} = \frac{5\angle-60°}{5\angle120°} = 1\angle180°$$

Equation 3.1

On the A-phase alpha plane, this plots one unit to the left of the origin, as shown in *Figure 3.2*. The other two phases also reside at $1\angle180°$ on their respective alpha planes.

In fact, all through-load current plots at 1∠180° regardless of magnitude and regardless of angle with respect to the system voltages. Likewise, an external fault has equal and opposite current at the two line ends, and so external faults also plot at 1∠180°.

The SEL-311L surrounds the point 1∠180°on the alpha plane with a restraint region, as shown in *Figure 3.3*. The relay trips when the alpha plane ratio travels outside the restraint region, and the difference current is above a settable threshold. The relay restrains when the alpha plane ratio remains inside the restraint region, or when there is insufficient difference current.

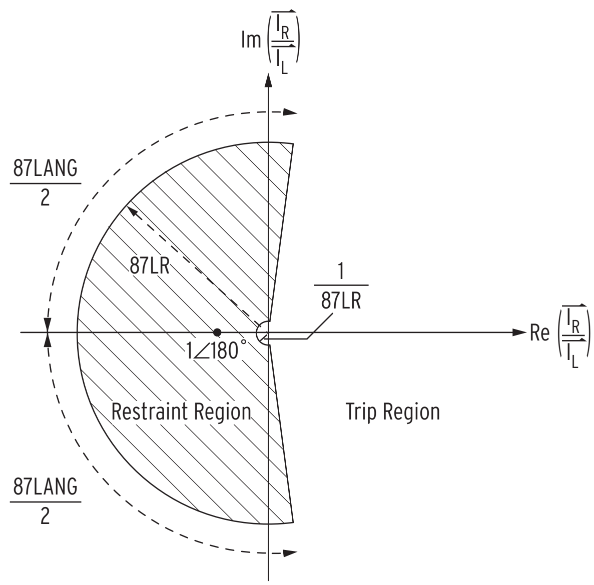


Figure 3.3 SEL-311L Restraint Region Surrounds External Faults

The shape of the restraint region is described by two settings, as shown in *Figure 3.3*. Setting 87LANG determines the angular extent of the restraint region. Setting 87LR determines the outer radius of the restraint region. The inner radius is the reciprocal of 87LR. All three types of elements (phase, negative-sequence, and zero-sequence) further qualify trips with a differential pickup setting. For example, setting 87LPP qualifies trips generated by the phase current differential elements 87LA, 87LB, and 87LC. If the A-phase current ratio travels outside the restraint characteristic, and the A-phase difference current exceeds setting 87LPP, then element 87LA asserts, indicating an internal fault. Differential pickup settings 87LGP and 87L2P provide similar supervision for the ground current differential element 87LG and the negative-sequence current differential element 87L2, respectively.

Traditional line current differential relays, phase comparison relays, and charge comparison relays can also be represented as a restraint region on the alpha plane. See the technical paper "The Effect of Multiprinciple Line Protection on Dependability and Security" by Jeff Roberts, Demetrios Tziouvaras, et al. to see how other alpha plane restraint regions compare to the restraint region of the SEL-311L. In every case, the SEL-311L gives significant improvement in security, sensitivity, speed, dependability, or all four.

Current Transformer Requirements

The SEL-311L is very tolerant of CT saturation. The equation below relates the maximum permissible CT burden that avoids CT saturation.

$$Z_B < \frac{V_S}{I_F\left(\frac{X}{R} + 1\right)}$$

Equation 3.2

where:

Z_B = the burden impedance in Ω
V_s = the voltage class of the CT
I_F = the fault current in secondary A
X/R = the power system reactance to resistance ratio for the fault of interest

If the CT burden is exactly Z_B as expressed above, then a fully offset fault current of magnitude I_F that decays as indicated by the system X/R ratio will bring the CT to the brink of saturation.

In two-terminal applications, the SEL-311L requires current transformers that meet both of the following criteria.

1. The CT cannot saturate at less than $I_F = 15$ A secondary for a relay with 5 A current transformers, or $I_F = 3$ A secondary for a relay with 1 A current transformers.
2. The CT burden cannot exceed:

$$\frac{7.5V_S}{I_F\left(\frac{X}{R} + 1\right)}$$

Equation 3.3

In other words, when set per the recommendations set forth in the following sections, the SEL-311L will operate and restrain properly if the CT does not saturate at less than 3 per-unit nominal current, and the CT burden is less than 7.5 times the burden that just causes the CT to saturate.

The requirements for three-terminal applications are as follows.

1. The CT cannot saturate at less than $I_F = 15$ A secondary for a relay with 5 A current transformers, or $I_F = 3$ A secondary for a relay with 1 A current transformers.
2. The CT burden cannot exceed

$$\frac{2.5V_S}{I_F\left(\frac{X}{R} + 1\right)}$$

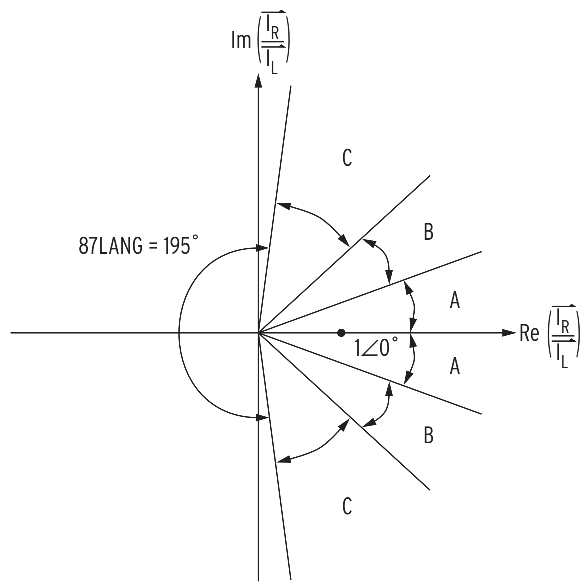
Equation 3.4

Setting the Restraint Region and Supervision Elements

This section discusses setting the restraint region and differential overcurrent supervision elements to protect a two-terminal line. Three-terminal settings are similar and are discussed later. Set the phase differential elements 87LA, 87LB, and 87LC to reliably detect internal three-phase faults. Set the negative-sequence differential element 87L2 to reliably detect internal unbalanced faults (87L2 is restrained when all three of the phase currents from any line terminal exceed 15 A in a 5 A nominal relay or 3 A in a 1 A nominal relay. Element 87LG is restrained when two or more phase currents from any line terminal exceed 3 • Inom).

Set Phase Differential Elements 87LA, 87LB, and 87LC to Detect Internal Three-Phase Faults

Refer to *Figure 3.4*. Consider a three-phase fault at midline on a homogeneous system with no load flow. For this example, the remote and local currents are equal in magnitude and phase. The vector ratio of remote to local currents is 1∠0°. This plots one unit to the right of the origin, as shown in *Figure 3.4*. If the system is nonhomogeneous, then the line-end current angles differ, and hence the angle of the current ratio is not zero. If the source impedance angles differ by 10 degrees, and there is an angular difference of 10 degrees between the sources, then the angle between remote and local currents can approach 20 degrees. *Appendix J: Example Calculations for 87L Settings* gives a more thorough discussion of the effects of source angle and source impedance angle.



A: 20° shift caused by source angle and source impedance angle.
B: 21.6° shift caused by 2 ms channel asymmetry.
C: 40° shift caused by CT saturation.

Figure 3.4 Alpha Plane Angle Setting 87LANG Is Based on Maximum Alpha Plane Angle for an External Fault

If the internal fault is not at midline, or if the sources do not have equal strength, the alpha plane ratio moves away from 1∠0° to the right or left. In the limit, either the remote or the local current approaches zero during weak infeed.

If the remote current approaches zero, the ratio moves toward the origin from the right half-plane. If the local current approaches zero, the ratio moves toward the far right end of the right half-plane.

Therefore, for an internal three-phase fault the phase current ratio lies in the right hand plane within ±20 degrees of the positive real axis as shown in *Figure 3.4* for the source and impedance angles assumed above.

Now consider a data alignment error caused by unequal delays in transmit and receive channels. In a unidirectional SONET ring with 20 nodes, the transmit and receive times might be different by 2 ms, assuming adjacent nodes in one direction and 19 intervening nodes in the other direction (an extreme case).

The SEL-311L estimates the one-way channel delay as half the round trip delay. In this situation, the round trip delay is about 2 ms (100 µs one way, 2 ms the other way, for a total round trip of about 2 ms).

In this extreme case both SEL-311L relays estimate a one-way channel delay of 1 ms, and each relay uses local currents measured 1 ms earlier to align the local data with the received remote data. Thus, both relays have a 1 ms data alignment error (one relay leading, the other lagging). This causes the angle of the alpha plane ratio to be in error by about 22 degrees on a 60 Hz system. In one relay, the error is positive (counterclockwise on the alpha plane); in the other relay the error is negative (clockwise on the alpha plane).

Depending on the angular shift at a particular relay, this error could add to or subtract from the angles caused by the system nonhomogeneity and load angle discussed above. Assume the angles add, as a worst case. For an internal fault, the alpha plane angle could be as much as ±(20 + 22) = ±42 degrees.

Next consider CT saturation. As shown in *Figure 3.5*, a severely saturated CT might temporarily cause the fundamental component of the secondary current to lead the primary current by as much as 40 degrees. Considering CT saturation, system nonhomogeneity, load angle, and asymmetrical channel delay, the alpha plane angle for phase currents could be as much as ±(40 + 22 + 20) = ±82 degrees for an internal three-phase fault.

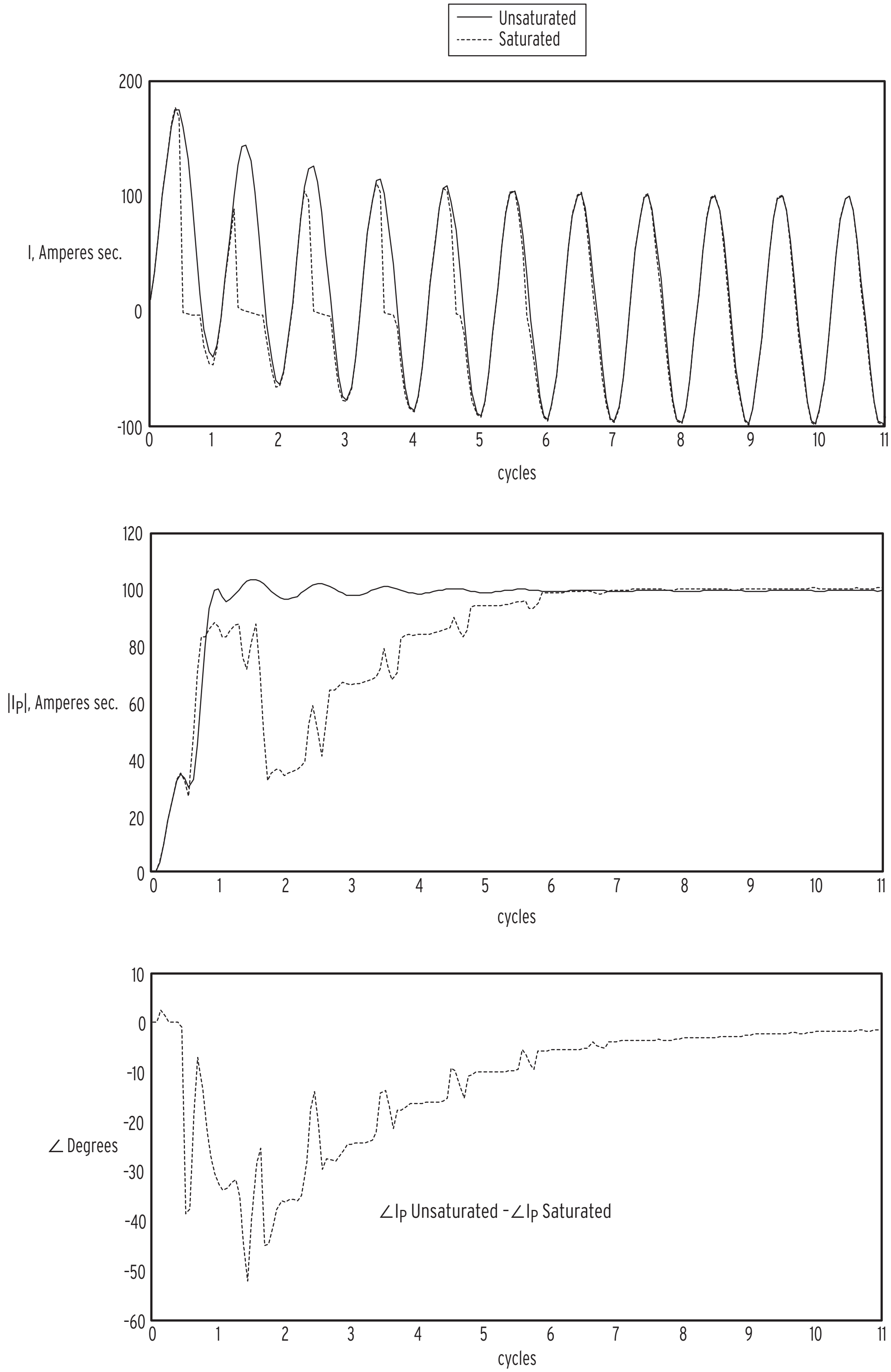


Figure 3.5 CT Saturation Causes Angle Lead and Reduction in Magnitude

Another possible source of phase angle error might be line charging current. However, because we are discussing internal three-phase faults, line charging current is not a source of significant error. See *Appendix J: Example Calculations for 87L Settings* for a more thorough discussion of line charging current.

From this discussion, it is apparent that given combinations of asymmetrical channel delay, system nonhomogeneity and load angle, and CT saturation, an internal three-phase fault should lie within about 82 degrees of the positive real axis. For the example power system considered, conditions that cause points to lie outside that region can safely be considered non-internal faults (external faults, load current, etc.). We shall see that the SEL-311L handles all of these conditions easily, even if all conditions exist simultaneously.

Phase 87L Settings and Alpha Plane Settings

Three settings control operation of the phase 87L elements. Refer to *Figure 3.3*.

- 87LANG (the angular extent of the restraint region)
- 87LR [the outer radius of the restraint region (the inner radius is the reciprocal of 87LR)]
- 87LPP (the difference current that qualifies tripping when the alpha plane ratio lies outside the restraint region)

Settings 87LANG and 87LR are common for all differential elements. There are not separate restraint region settings for each type of element.

Three-phase fault protection places the highest constraints on setting 87LANG, because of source angle considerations. Set 87LANG as described above, considering maximum load angle, system nonhomogeneity, asymmetrical channel delay, and CT saturation. For this example, set 87LANG to 360 – (82 • 2) = 196 degrees. The factory-default setting is 195 degrees. Even if your installation cannot experience these conditions, consider leaving 87LANG = 195 degrees. Extensive testing at SEL demonstrates that this setting provides a good balance of security and dependability.

Setting 87LR defines the outer radius of the restraint region, and the reciprocal of 87LR defines the inner radius of the restraint region. Set 87LR to exclude from the restraint region all internal three-phase faults, including those with zero-infeed. An 87LR setting of 6 gives an outside radius of 6 and an inside radius of 1/6. This comfortably excludes zero-infeed conditions from the restraint region.

Set 87LPP to reliably detect all internal three-phase faults. Setting 87LPP must be set above line charging current. Set 87LPP above maximum expected load current to prevent misoperation when a ganged set of CT test switches is left shorted at one line end. The factory-default setting for 87LPP is 1.2 times nominal secondary current (6 A for a 5 A relay or 1.2 A for a 1 A relay) and probably does not need to be changed except for special conditions.

The settings defined above are factory-default. They are also the settings used to produce the operate speed curves shown in *Figure 3.6* (using high-speed output contacts).

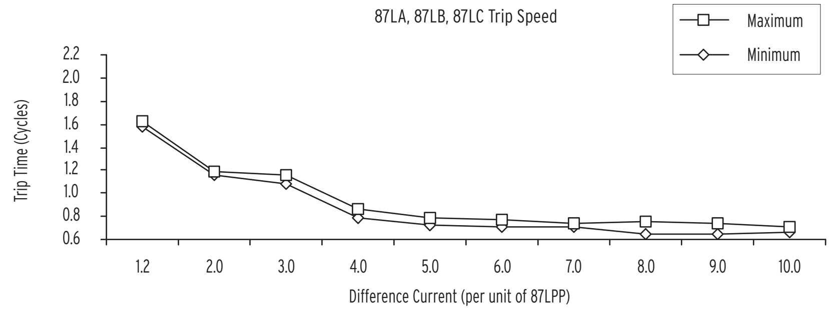


Figure 3.6 Phase 87L Element Trip Speeds for Symmetrical Fault Currents With 87LANG = 195 and 87LR = 6 Using a Direct Fiber Connection

Set Negative-Sequence Differential Element 87L2 to Detect Internal Unbalanced Faults

Refer again to *Figure 3.4*. Consider a midline bolted ground fault on a homogeneous system with no load flow. For this example, the remote and local negative-sequence currents are equal in magnitude and phase. The vector ratio of remote to local currents is $1\angle 0°$ on the negative-sequence alpha plane, as shown in *Figure 3.4*. If the system is nonhomogeneous, the angle between the line-end currents is not zero. With 10 degrees of system nonhomogeneity, there are 10 degrees of difference between the negative-sequence currents from the two line ends. *Appendix J: Example Calculations for 87L Settings* gives a more thorough discussion on the effects of source impedance angle.

If the internal fault is not at midline, or if the sources are of unequal strength, the alpha plane ratio moves away from $1\angle 0°$ to the right or left. At the limit, either the remote or the local current could approach zero for a weak-infeed situation.

If the remote current approaches zero, the ratio moves toward the origin from the right half-plane. If the local current approaches zero, the ratio moves toward the far right end of the right half-plane.

Therefore, for an internal ground fault the negative-sequence alpha plane current ratio lies in the right half-plane with ±10 degrees of the positive real axis, as shown in *Figure 3.4*, for the source and impedance angles considered above.

CT saturation and channel delay asymmetry produce the same effects in the negative-sequence alpha plane during an internal unbalanced fault as for the phase alpha plane during a three-phase fault. As discussed previously, severe CT saturation and a large channel delay asymmetry can add 62 degrees of angle error on the alpha plane.

Negative-Sequence 87L Settings and Alpha Plane Settings

Three settings control operation of the negative-sequence 87L element. Refer to *Figure 3.3*.

- ➤ 87LANG (the angular extent of the restraint region)
- ➤ 87LR [the outer radius of the restraint region (the inner radius is the reciprocal of 87LR)]
- ➤ 87L2P (the 3I2 difference current that qualifies tripping when the alpha plane ratio lies outside the restraint region)

Settings 87LANG and 87LR are common for all line current differential elements. There are not separate restraint region settings for each type of element.

Set 87LANG as described previously in the phase 87L discussion.

Set 87LR as described previously in the phase 87L discussion.

Set 87L2P to reliably detect all internal unbalanced faults, but above expected maximum line charging current unbalance. Line charging current unbalance is dependent upon voltage unbalance, i.e., the greater a system voltage unbalance, the greater the charging current unbalance. In extreme cases, such as during a pole-open condition or during an external bolted ground fault that completely collapses the voltage on one phase, the charging current unbalance can equal the phase charging current. For more typical installations, consider setting 87L2P at 10 percent of nominal current, or 0.5 A for a 5 A relay.

The settings defined above are factory-default. They are also the settings used to produce the operate speed curves shown in *Figure 3.7* (using high-speed output contacts).

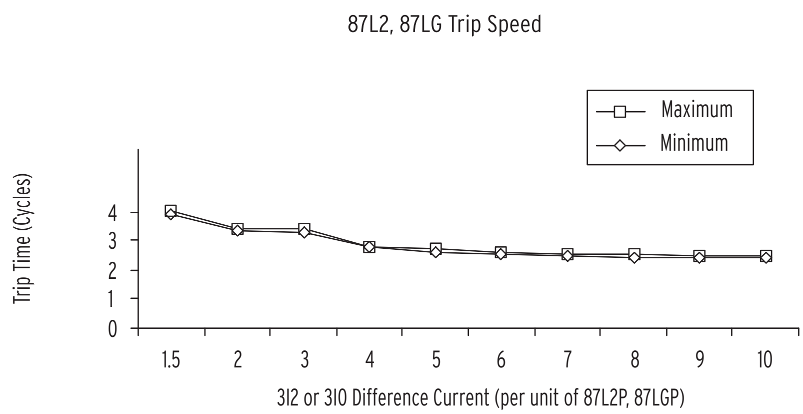


Figure 3.7 87LG and 87L2 Element Trip Speeds for Symmetrical Fault Currents With 87LANG = 195 and 87LR = 6 Using a Direct Fiber Connection

These settings give excellent sensitivity for internal unbalanced faults, as shown in *Figure 3.8*. For load currents less than 1/3 Inom, the ground fault sensitivity is determined by the minimum 87L2P and 87LGP pickup settings of 0.5 A, and is 132.8 Ω secondary referenced to Vnom = 66.4 V. Above 1/3 Inom, ground fault sensitivity is determined by the ratio |I2| / |I1| for 87L2, and |I0| / |I1| for 87LG. The 87L2 element enables when |I2| / |I1| > 0.05 from at least one terminal. Likewise, 87LG is enabled when |I0| / |I1| > 0.05 from at least one terminal. This linearly decreases the fault resistance coverage from 132.8 Ω secondary worst case at 1/3 of nominal load current to 45 Ω worst case at nominal load current, as shown in *Figure 3.8*. This sensitivity is in secondary Ω referenced to the highest CTR.

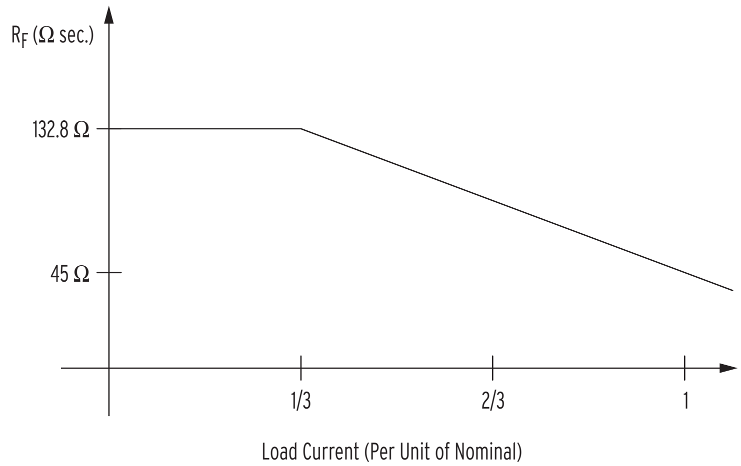


Figure 3.8 Ground Fault Sensitivity of 87L2 and 87LG Elements With 87L2P = 0.5 or 87LGP = 0.5

Other Unbalanced Fault Types

Identical considerations for other internal unbalanced fault types (phase-to-phase, and phase-to-phase-to-ground), give identical settings for the negative-sequence 87L element.

Factory Settings Give Excellent Security During External Faults

In summary, the 87L element settings derived above give excellent speed, sensitivity, and dependability for internal faults of all types on the example power system considered. Recall that the alpha plane ratio ideally lies at $1\angle 180°$ for external faults. The restraint regions defined by the settings derived above surround $1\angle 180°$ and must include possible sources of error. To check these settings for security during external faults, consider all possible sources of ratio and angle error on the alpha plane during an external fault.

External Three-Phase Faults Larger Than 3 • Inom

First, consider negative-sequence element 87L2. During an external three-phase fault, the CTs at one terminal could saturate, while the CTs at the other terminal do not. This can produce false negative-sequence current at one terminal, and essentially zero negative-sequence current at the other terminal. Because all of the measured negative-sequence current is errant, the angle and ratio on the negative-sequence alpha plane are not easy to predict. To prevent the 87L2 element from misoperating during an external three-phase fault that produces CT saturation at one line terminal, the 87L2 element is blocked if all three-phase currents from any line terminal exceed 300 percent of nominal current (15 A for a 5 A relay).

A similar argument holds for the zero-sequence or ground differential element. To prevent the 87LG element from misoperating for an external three-phase or phase-to-phase fault that causes CT saturation at one line terminal, the ground differential element is blocked if two or three of the phase currents from any line terminal exceed 300 percent of nominal current (15 A for a 5 A relay). If the negative-sequence element is not used, set the phase elements to detect internal phase faults AND internal phase-to-phase-to-ground faults, and set the ground element to detect internal phase-to-ground faults.

External Three-Phase Faults Smaller Than 3 • Inom

The logic described above makes the negative-sequence and zero-sequence elements secure to faults that produce more than 3 • Inom secondary fault current. During external faults that produce less than 3 • Inom current, the negative-sequence and zero-sequence current differential elements receive additional supervision by Relay Word bits 87L2T and 87LGT, respectively, as shown in *Figure 3.16* and *Figure 3.17*. These bits are the result of 2nd harmonic and dc restraint algorithms exclusive to the zero-sequence and negative-sequence current differential elements.

External Unbalanced Faults

During an external unbalanced fault, both terminals see nearly identical negative-sequence fault current. If CTs at one line terminal saturate, the effect on the alpha plane ratio can be predicted, because relays at both line terminals measure negative-sequence fault current. For a severely saturated CT, the measured current magnitude might decrease to as little as 1/3 the unsaturated current. This moves the alpha plane ratio from 1 to as low as 1/3 or as high as 3. Setting 87LR = 6 as recommended above enables the restraint region to contain even severe CT saturation.

Severe CT saturation can also cause an angle error as large as 40 degrees, as shown in *Figure 3.5*. A large 2 ms asymmetrical channel delay produces 22 degrees of data alignment error, which might add to the CT saturation induced angle error. In that case, the alpha plane angle can be in error by as much as 62 degrees. The default 87LANG setting of 195 degrees allows 35 degrees of margin for other sources of error.

Similar considerations for the phase elements produce similar results. An external fault with simultaneous CT saturation and a large 2 ms channel delay asymmetry can produce as much as 300 percent error in phase current ratio magnitude, and 62 degrees of phase current ratio angle error. The default restraint region easily contains these cases, even if they occur simultaneously.

SYNCHROWAVE Event Produces Alpha Plane Plots

Use SEL-5601-2 SYNCHROWAVE Event Software to visualize SEL-311L event reports on the alpha plane. Use the **CEV L** or **EVE C** commands to retrieve differential event reports. SYNCHROWAVE Event reads compressed SEL-311L event reports and produces alpha plane plots for phase current, negative-sequence current, or zero-sequence current.

Settings Related to 87L Elements

The remainder of this section discusses all settings related to the 87L elements. Most settings need not be calculated, only selected to match system topology and protection practices. Use the **SET** command to access these settings.

CTR (1–6000)

Select CTR to match the local CT ratio. For example, for a local CT ratio of 600:5, set CTR = 120. Settings CTR_X and CTR_Y allow you to enter different CT ratios for the remote line terminals. Differential current in each relay is referenced to the highest CTR setting (the maximum of settings CTR, CTR_X, and CTR_Y). For example, consider a two-terminal application with different CT ratios at the two line terminals, as shown in *Figure 3.9*. At Relay S, CTR = 120 and CTR_X = 240. At Relay R, CTR = 240 and CTR_X = 120. The differential current used by 87L elements in both relays is secondary current referenced to the relay with the maximum CTR setting, or relay R in this case. If setting 87LPP = 6 in both relays, the phase differential elements assert for internal faults that produce more than 6 • 240 = 1440 A phase difference current. Event reports and meter displays report primary values (current, voltage, power, and energy).

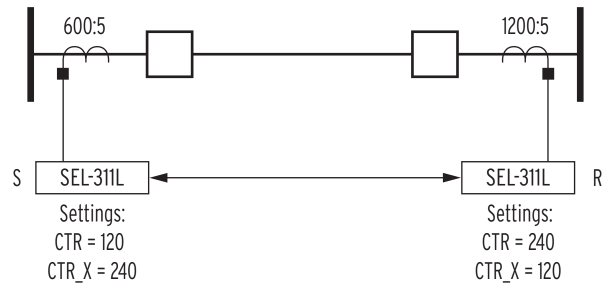


Figure 3.9 SEL-311L Relays Applied With Different CT Ratios

APP (87L, 87L21, 87L21P, 87LSP, 311L)

Select setting APP to match your application of the SEL-311L.

- Setting APP = 87L enables all line current differential-based protection, plus tapped-load coordination elements and nondirectional overcurrent backup elements.

  Settings for all other protective elements are hidden from view.
- Setting APP = 87L21 adds step-distance and directional overcurrent backup elements.
- APP = 87L21P adds capability for pilot protection such as DCB, POTT, DCUB, etc.
- Setting APP = 87LSP enables single-pole tripping via the line current differential function.

  SEL-311L-7: Directional overcurrent elements can be set to provide three-pole tripping backup. Zone 1 distance elements can be set to provide single-pole tripping backup. All other distance zones can be set for three-pole tripping backup.
- Setting APP = 311L enables all line current differential-based protection, plus tapped-load coordination, nondirectional and directional overcurrent backup elements, step-distance, and pilot protection.

See *Section 14: Application Settings for SEL-311L Relays* for more information about setting APP.

E87L (2, 3, 3R, N)

This setting selects the number of terminals in the 87L protection zone (2 or 3), and also allows you to configure the relay to protect three terminals with just two communications channels (3R). For example, in a configuration such as shown in *Figure 3.13*, set E87L = 3 in Relay L and E87L = 3R in Relays R and S. Three-terminal protection with setting E87L = 3 or E87L = 3R is discussed later. Set E87L = N to disable line current differential protection. Setting E87L = N also disables all 87L communications circuits and the tapped-load coordination elements.

EHST (N, 1–6) or (N, SP1, SP2) When APP = 87LSP

Use setting EHST to enable high-speed tripping logic and achieve the operate speeds shown in *Figure 3.6* and *Figure 3.7*. This setting enables high-speed tripping via outputs OUT201–OUT206. For example, if EHST = 3, the relay controls output contacts OUT201–OUT203 directly with Relay Word bit TRIP87. This speeds tripping by over 1/2 cycle compared to using SELOGIC control equations with Relay Word bit TRIP87.

When APP = 87LSP, EHST can be set to N, SP1, or SP2. Setting EHST = SP1 enables high-speed, single-pole tripping via outputs OUT201, OUT202, and OUT203. Setting EHST = SP2 enables all high-speed output contacts for single-pole tripping. A-phase tripping is via OUT201 and OUT204, B-phase tripping is via OUT202 and OUT205, and C-phase tripping is via OUT203 and OUT206.

If 87L protection is only desired during certain conditions (e.g., only during shot two of a reclosing sequence), then do not use setting EHST. Instead, combine Relay Word bit TRIP87 and the shot counter bits in the tripping SELOGIC control equation TR. See *Section 7: SELOGIC Control Equation Programming* for more information regarding setting EHST and outputs OUT201–OUT206. See *Section 5: Trip and Target Logic* for more information regarding the latching logic for Relay Words TRIP and TRIP87. See *Section 6: Close and Reclose Logic* for more information regarding automatic reclosing.

EHSDTT (Y, N)

EHSDTT enables tripping via the direct transfer trip signal on the 87L communications channel. When EHSDTT = Y, the relay asserts Relay Word bit TRIP87 if it receives a direct transfer trip signal on any 87L communications channel. Reception of the DTT bit results in a trip if high-speed tripping is also enabled or if Relay Word bit TRIP87 is used in SELOGIC control tripping equation TR. The relay enables high-speed direct transfer tripping if setting E87L = 3 and an 87L communications channel fails, or if setting E87L = 3R, even if setting EHSDTT = N. The relay always transmits a direct transfer trip signal when any 87L element detects an internal fault, even if setting EHSDTT = N.

Note that when App = 87LSP, the direct transfer trip bits result in a three-pole trip. In addition, the DTT received bits must be programmed via the TR logic equation. For example, set TR = RDTX + … . When the direct transfer trip bit RDTX is asserted, the relay will output a trip via the TRIP Relay Word bit. Set TRIP in all three output contact equations to trip three-pole.

EDD (Y, N)

Setting EDD enables local supervision of the 87L elements with a local current disturbance detector. When EDD = Y, the relay supervises 87L elements with the disturbance detector Relay Word bit DD. Disturbance detector supervision ensures the relay detects some change in the local currents before allowing a trip because of 87L element assertion. Relay Word bit DD does not supervise received direct trip signals.

Disturbance detector supervision is also enabled when Relay Word bits CHXAL or CHYAL indicate that a communications channel is impaired, even if setting EDD = N.

Disturbance detector supervision is intended to prevent misoperation resulting from undetected errors in 87L communications. Undetected errors are transient in nature; to increase dependability, disturbance detection supervision has a maximum duration of two cycles. If the relay detects an internal fault (87L Relay Word bit) continuously for two cycles, disturbance detector supervision is defeated, and the relay trips even if a local disturbance has not been detected. See *Section 5: Trip and Target Logic* for more information about the disturbance detector.

ETAP (Y, N)

Set ETAP = Y to enable the tapped-load coordination elements. *Settings Example: 230 kV Transmission Line With Tapped Load on page 9.37* describes how to use these elements to coordinate with tapped-load protection.

EOCTL (Y, N)

Set EOCTL to enable the open-CT detection logic. Use this logic to disable sensitive negative and zero-sequence differential elements in the event of current transformer malfunction or disconnect. If difference current is measured to be greater than the CTALRM setting, and neither the local or remote breaker are open, the open-CT logic will block the operation of the negative and zero-sequence differential elements. This logic is only available for two-terminal applications (E87L = 2).

PCHAN (X, Y)

This setting selects the primary 87L protection channel when the relay is equipped with two 87L channels. In two-terminal mode (E87L = 2), the channel selected by PCHAN is used for 87L protection. The channel not selected by the PCHAN setting can be used as a hot-standby channel. When setting E87L = 3R, the channel selected by PCHAN is used for protection and the other channel is unused.

EHSC (Y, N)

If the relay is equipped with two 87L channels and is set for two-terminal protection (E87L = 2), setting EHSC = Y enables the channel not selected by PCHAN as a hot-standby 87L protection channel. The relay executes all 87L protection algorithms continuously, using aligned data from both the primary and hot-standby channel. When the primary channel is healthy, the relay uses trip decisions based on the 87L elements processed with currents from that channel. If the primary channel fails, the relay uses trip decisions based on 87L elements processed with currents from the hot-standby channel. There is no delay encountered when switching from primary to hot-standby channels.

The primary and hot-standby channels need not be the same type of interface, and it is not necessary to match the delays from primary to hot-standby channels. This enables diverse routing of primary and hot-standby 87L channels. The two channels can even be of different data rates (64 kbps for one, 56 kbps for the other).

If the primary channel is restored, protection resumes using the primary channel. If both primary and hot-standby channels fail, 87L protection is safely disabled.

CTR_X and CTR_Y (1–6000)

Set CTR_X to match setting CTR in the remote SEL-311L connected to Channel X. Set CTR_Y to match setting CTR in the remote SEL-311L connected to Channel Y. Settings CTR_X and CTR_Y may be different from each other and different from the local CTR setting. This setting flexibility accommodates different CT ratios at all line terminals. All 87L line current differential settings are in secondary A, referenced to the highest CTR setting (the maximum of CTR, CTR_X, and CTR_Y).

87LPP (OFF, 1–10 A Secondary)

The phase line current differential elements 87LA, 87LB, and 87LC restrain when the phase difference current is less than 87LPP. Set 87LPP to detect three-phase faults as described above. The setting is in secondary A, referenced to the relay with the highest CTR setting. For example, assume E87L = 2, PCHAN = X, CTR = 200, and CTR_X = 400. If setting 87LPP = 6 A in both relays, the phase 87L elements assert for all internal faults that produce more than 6 • 400 = 2400 A of phase difference current.

87L2P (OFF, 0.5–5 A Secondary)

The negative-sequence differential element 87L2 restrains when |3I2| is less than 87L2P. Set 87L2P above expected line charging current unbalance. As with setting 87LPP, setting 87L2 is in A secondary referenced to the relay with the highest CTR setting.

87LGP (OFF, 0.5–5 A Secondary)

The zero-sequence differential element 87LG restrains when the |3I0| is less than 87LGP. Set 87LGP above expected line charging current unbalance. As with setting 87LPP, setting 87LG is in A secondary referenced to the relay with the highest CTR setting.

CTALRM (0.5–10 A Secondary)

Relay Word bit CTAA asserts when A-phase difference current exceeds setting CTALRM. Similarly, CTAB and CTAC assert when B-phase or C-phase difference current exceeds setting CTARLM. Use these bits to detect and alarm for excessive steady-state phase difference current, such as might be caused when the CTs at one terminal are shorted. This setting is in secondary A, referenced to the relay with the highest CTR setting.

87LR (2.0–8, Unitless)

This setting controls the outside radius and the inner radius of the restraint region, as shown in *Figure 3.3*. Unless special circumstances warrant, set 87LR = 6 (the factory default).

87LANG (90–270 Degrees)

This setting controls the angular extension of the restraint region, as shown in *Figure 3.3*. Unless special circumstances warrant, set 87LANG = 195 (the factory default).

OPO Open Pole Option (52, 27)

Do not use OPO = 27 in an application that requires 87L elements for tripping. OPO = 27 can compromise logic that manages charging current inrush when a power line is energized.

87LTC 87L Torque Control (SELOGIC Setting)

SELOGIC torque-control equation 87LTC blocks 87L tripping but does not affect 87L communications. See *Figure 3.15*. Use 87LTC to temporarily block 87L tripping. Block 87L tripping in the local and remote relay from a local contact input or other local control by using 87L channel transmit/receive bits T1X–T4X and T1Y–T4Y.

Three-Terminal Protection With the SEL-311L

Three-Terminal Protection Logic

Use the 87L elements and other elements in the SEL-311L for three-terminal line protection. The SEL-311L applies the alpha plane concept introduced earlier to three-terminal lines by combining (vectorly adding) currents from two of the terminals to produce the remote current. The remaining (uncombined) current becomes the local current in the calculation of the alpha plane ratio of remote to local current. In other words, the SEL-311L converts the three-terminal line to an electrically equivalent two-terminal line and then applies two-terminal protection algorithms. All of the considerations described above in the two-terminal discussion apply to three-terminal protection also.

For internal faults with no outfeed and for external faults with no CT saturation, there is no wrong way to choose which two currents to combine into the remote current; all three possibilities result in the correct trip/restrain decision.

For internal faults with outflow, external faults with CT saturation, and terminal(s) with open breaker or low current, all three alpha calculations do not make the same trip/restrain decision. During such events, the relay executes special CT Saturation Security Logic to provide both security and dependability to the differential elements. This logic differentiates between an internal and an external fault. If the traditional restraint region is not enabled (R87LA, R87LB, R87LC, R87L2 or R87LG are deasserted), the CT Saturation Security Logic sets the restraint region angle at 180 degrees. The CT Saturation Security Logic is only enabled when the relay is used in a three-terminal application. See the technical paper “The Effect of Multiprinciple Line Protection on Dependability and Security” by Jeff Roberts, Demetrios Tziouvaras, Gabriel Benmouyal, and Hector Altuve for details.

The SEL-311L uses all three possible combinations of remote current to process all 87L elements. *Table 3.1* shows the three possibilities. The relay uses the trip/restrain decision from the 87L elements, which use the maximum terminal current as the “local” current.

Table 3.1 Three Possible Combinations of Remote and Local Currents at Relay R. Relays S and L Use the Same Three Combinations.

	1	2	3
I_{Remote}	$I_L + I_S$	$I_R + I_S$	$I_L + I_R$
I_{Local}	I_R	I_L	I_S

For example, consider the fault depicted in *Figure 3.10*. For this internal fault, the relay at R experiences outfeed. Fault current flows from Terminal L, through Terminal R, through the parallel line, and to the fault through Terminal S. Assume the fault involves ground. All three relays process the 87LG elements, using three possible combinations of remote ground current. The relay at R produces three trip/restrain decisions for the 87LG element. One trip/restrain decision uses the ground current from Terminal R as the local current and vectorly adds the ground currents from Terminals L and S to produce the remote ground current (Column 1 in *Table 3.1*). The relay at R produces another trip/restrain decision, using the ground current from Terminal L as the local ground current and combining the ground currents from Terminals R and S as the remote ground current (Column 2 in *Table 3.1*). The relay at R produces the third trip/restrain decision, using the ground current from Terminal S as the local current and combining the ground currents from Terminals L and R as the remote ground current (Column 3 in *Table 3.1*). The relay then selects the trip/restrain decision produced by the processing method that used the largest ground current as the local current.

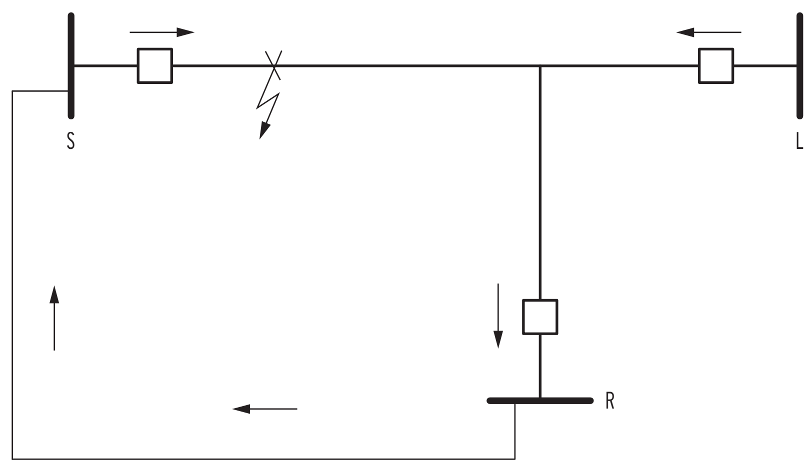


Figure 3.10 Internal Fault on Three-Terminal Line May Produce Outfeed at One Terminal

The relay processes the 87L2, 87LA, 87LB, and 87LC elements in the same manner. It produces three trip/restrain decisions for each element and then selects the decision that resulted from use of the largest current as the local current.

In effect, the relay with the largest local current makes the proper trip/restrain decision, and the other two relays make the same trip/restrain decision as the relay with the largest local current.

The same processing occurs in all three relays. This method works in all cases where the outfeed current is the smallest terminal current.

CT Saturation Considerations for Three-Terminal Protection

In the example shown in *Figure 3.11* an external fault behind Source S on the three-terminal line causes Terminals L and R to source equal fault current. The current flowing out of Terminal L and out of Terminal R is half the magnitude of the current flowing into Terminal S. The three-terminal logic selects the Terminal S current as the local current when forming the alpha plane ratio, because Terminal S has the current with the largest magnitude. The same selection occurs in all three relays. If a CT at Terminal S saturates, and the resulting current magnitude drops to less than half of the perspective value, then the current from Terminal S will no longer be the largest of the three-terminal currents. In that case, the relays select the largest of the other terminal currents. Assume the relays select Terminal L as the largest current magnitude and use that current as the local current. The remote current is then $I_R + I_S$. The current magnitude at S has decreased to less than half of the non-saturated value. The inflow current from Terminal R dominates the combination of $I_R + I_S$, producing a net inflow for the external fault.

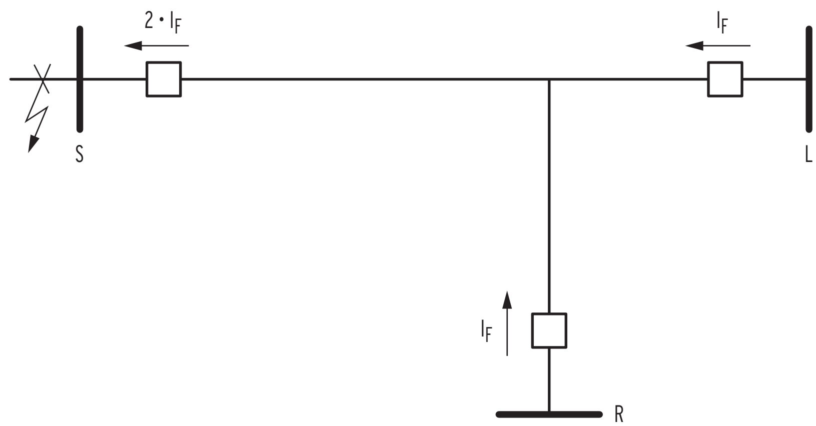


Figure 3.11 External Fault on Three-Terminal Line With Equal Infeed From Two Terminals

To prevent the relay from misoperating on a three-terminal line, the CTs must be selected and applied such that the fundamental magnitude does not drop to less than half the unsaturated case for an external fault. This selection criterion is quantified by the following equation:

$$Z_B < \frac{2.5\ V_S}{I_F\left(\frac{X}{R} + 1\right)} \qquad \textbf{Equation 3.5}$$

where:

I_F = secondary fault current (A secondary)
Z_B = secondary burden (Ω)
X/R = maximum and minimum system X/R ratio

Three-Terminal Protection During 87L Channel Loss or With Setting E87L = 3R

Figure 3.12 shows a typical three-terminal communications channel arrangement. Notice that if any of the three communications channels is lost, the relay connected to two healthy communications channels still has all of the information necessary to perform three-terminal protection. In the case of a lost communications channel, the other two relays automatically disable 87L protection and enable direct-transfer tripping, **even if setting EHSDTT = N**.

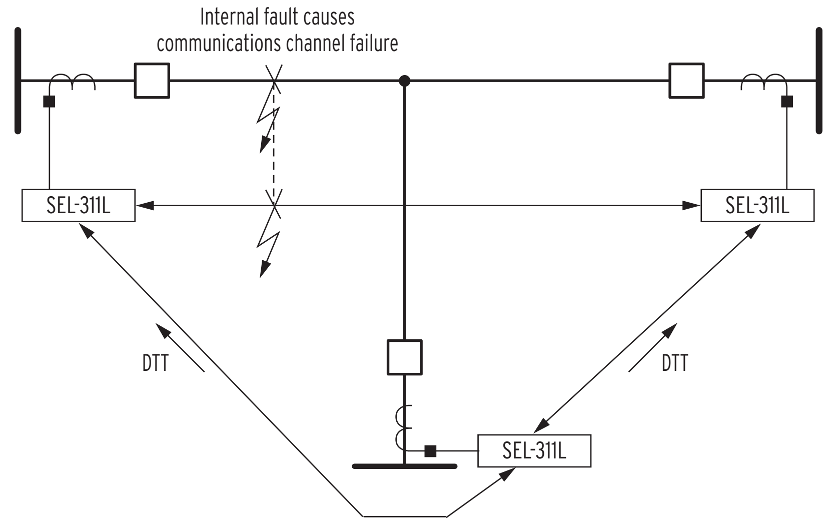


Figure 3.12 Three-Terminal Line With Internal Fault and Channel Failure

Alternatively, install only two communications channels, as shown in *Figure 3.13*. Set E87L = 3R in the relays connected to a single communications channel. Set E87L = 3 in the relay connected to two communications channels. The relays with setting E87L = 3R enable direct-transfer tripping, and setting EHSDTT is hidden.

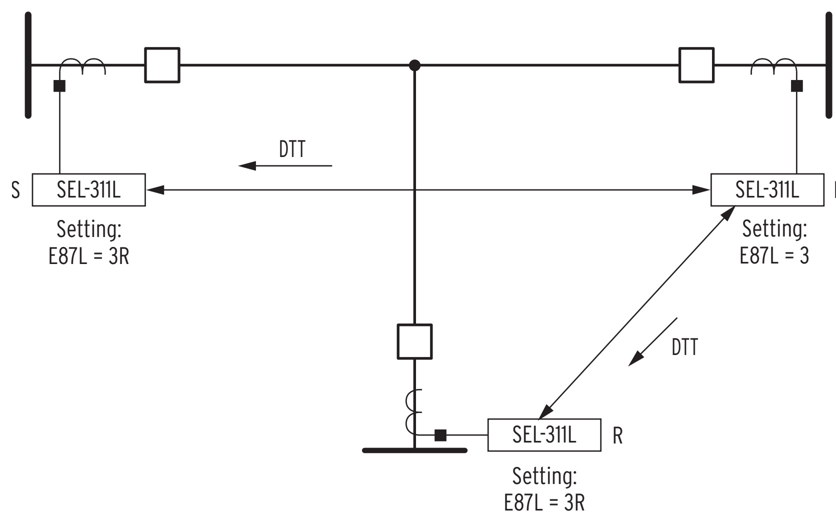


Figure 3.13 SEL-311L Protects Three-Terminal Line, Using Only Two Communications Channels

87L Relay Word Bits Represent Local Three-Terminal Processing Only

As explained above, all three SEL-311L relays process all 87L protection elements, using each of the three-terminal currents as the local current. The Relay Word bits shown in *Table 3.2* are the result of using the local terminal currents as the local currents when processing the 87L elements.

Table 3.2 Relay Word Bits Representing Local Current Processing Only When E87L = 3

87L Element	Relay Word Bits Representing Local Processing Only							
A-phase	50RA	50LA	87LOPA	87LAE	CTAA	R87LA		PQ87LA
B-phase	50RB	50LB	87LOPB	87LBE	CTAB	R87LB		PQ87LB
C-phase	50RC	50LC	87LOPC	87LCE	CTAC	R87LC		PQ87LC
Ground	50RG	50LG	87LOPG	87LGE		R87LG	B87LG	PQ87LG
Neg.-Seq.	50R2	50L2	87LOP2	87L2E		R87L2	B87L2	PQ87L2

Relay Word bits shown in *Table 3.3* represent the actual relay trip/restrain decision, regardless of which current is selected as the local current.

Table 3.3 Relay Word Bits Representing Actual Trip/Restrain Decision of Three-Terminal Protection Logic

87L Element	Relay Word Bits Representing Actual Trip/Restrain Decision	
A-phase	87LA	BXYZA
B-phase	87LB	BXYZB
C-phase	87LC	BXYZC
Ground	87LG	BXYZG
Neg.-Seq.	87L2	BXYZ2

Relay Word bits BXYZ2 and BXYZG assert if any of the three processing methods asserts the corresponding block bit B87LG or B87L2.

Table 3.4 Differential Element Settings and Specifications (Sheet 1 of 3)

Setting Description	Setting	Setting Range
Minimum Difference Current Enable Level Settings		
Phase 87L:	87LPP	OFF, 1.0–10.0 A, sec. (5 A nominal) OFF, 0.2–2.0 A, sec. (1 A nominal)
3I2 Neg.-Seq. 87L:	87L2P	OFF, 0.5–5.0 A, sec. (5 A nominal) OFF, 0.1–1.0 A, sec. (1 A nominal)
Ground 87L:	87LGP	OFF, 0.5–5.0 A, sec. (5 A nominal) OFF, 0.1–1.0 A, sec. (1 A nominal)
Accuracy:		±3% ±0.01 Inom
Ph. Diff. Current Alarm Pickup:	CTALRM	0.5–10, A, sec. (5 A nominal) 0.1–2 A, sec. (1 A nominal)
Accuracy:		±3% ±0.01 Inom
Restraint Region Characteristic Settings		
Outer Radius:	87LR	2.0–8.0
Angle:	87LANG	90–270, degrees
Accuracy:		±5% of radius setting ±3° of angle setting
Tapped-Load Coordination Enabling Functions		
Tapped-Load Coordination:	ETAP	Y, N
Enable Setting (Phase)	ETP	Y, N
Enable Setting (Residual Ground)	ETG	Y, N
Enable Setting (Negative-Sequence)	ETQ	Y, N

Table 3.4 Differential Element Settings and Specifications (Sheet 2 of 3)

Setting Description	Setting	Setting Range
Tapped-Load Phase Time-Overcurrent Element Settings		
Pickup:	T51PP	OFF, 0.50–16 A, sec. (5 A nominal)
		OFF, 0.10–3.2 A sec. (1 A nominal)
Steady-State Pickup Accuracy:		±0.05 A and ±4% of setting (5 A nominal) ±0.01 A and ±4% of setting (1 A nominal)
Curve:	T51PC	U1–U5, C1–C5
Time Dial:	T51PTD	0.50–15.00[a]
EM Reset Delay:	T51PRS	Y, N
Curve Timing Accuracy:		±1.50 cycles and ±5% of curve time for current between 2 and 30 multiples of pickup
Tapped-Load Phase Instantaneous Overcurrent Element Settings		
Pickup:	T50PP	OFF, 0.5–100.0 A, sec. (5 A nominal) OFF, 0.1–20.0 A, sec. (1 A nominal)
Steady-State Pickup Accuracy:		±0.05 A and ±4% of setting (5 A nominal) ±0.01 A and ±4% of setting (1 A nominal)
Transient Overreach:		<5% of pickup
Time Delay:	T50PD	0.0–16000 cycles
Timer Accuracy:		±0.25 cycle and ±0.1% of setting
Tapped-Load Residual-Ground Time-Overcurrent Element Settings		
Pickup:	T51GP	OFF, 0.50–16 A, sec. (5 A nominal) OFF, 0.1–3.2 A, sec. (1 A nominal)
Steady-State Pickup Accuracy:		±0.05 A and ±4% of setting (5 A nominal) ±0.01 A and ±4% of setting (1 A nominal)
Curve:	T51GC	U1–U5, C1–C5
Time Dial:	T51GTD	0.50–15.00[b]
EM Reset Delay:	T51GRS	Y, N
Curve Timing Accuracy:		±1.50 cycles and ±5% of curve time for current between 2 and 30 multiples of pickup
Tapped-Load Residual-Ground Inst. Overcurrent Element Settings		
Pickup:	T50GP	OFF, 0.5–100.0 A, sec. (5 A nominal) OFF, 0.1–20.0 A, sec. (1 A nominal)
Steady-State Pickup Accuracy:		±0.05 A and ±4% of setting (5 A nominal) ±0.01 A and ±4% of setting (1 A nominal)
Transient Overreach:		<5% of pickup
Time Delay:	T50GD	0.0–16000 cycles
Timer Accuracy:		±0.25 cycle and ±0.1% of setting

Table 3.4 Differential Element Settings and Specifications (Sheet 3 of 3)

Setting Description	Setting	Setting Range
Tapped-Load Negative-Sequence Time-Overcurrent Element Settings		
Pickup:	T51QP	OFF, 0.50–16 A, sec. (5 A nominal) OFF, 0.1–3.2 A, sec. (1 A nominal)
Steady-State Pickup Accuracy:		±0.05 A and ±4% of setting (5 A nominal) ±0.01 A and ±4% of setting (1 A nominal)
Curve:	T51QC	U1–U5, C1–C5
Time Dial:	T51QTD	0.50–15.00[c]
EM Reset Delay:	T51QRS	Y, N
Curve Timing Accuracy:		±1.50 cycles and ±5% of curve time for current between 2 and 30 multiples of pickup
Tapped-Load Negative-Sequence Inst. Overcurrent Element Settings		
Pickup:	T50QP	OFF, 0.5–100.0 A, sec. (5 A nominal) OFF, 0.1–20.0 A, sec. (1 A nominal)
Steady-State Pickup Accuracy:		±0.05 A and ±4% of setting (5 A nominal) ±0.01 A and ±4% of setting (1 A nominal)
Transient Overreach:		<5% of pickup
Time Delay:	T50QD	0.0–16000 cycles
Timer Accuracy:		±0.25 cycle and ±0.1% of setting

[a] If 51PC is a C curve, this range is 0.05–1.0.
[b] If 51GC is a C curve, this range is 0.05–1.0.
[c] If 51QC is a C curve, this range is 0.05–1.0.

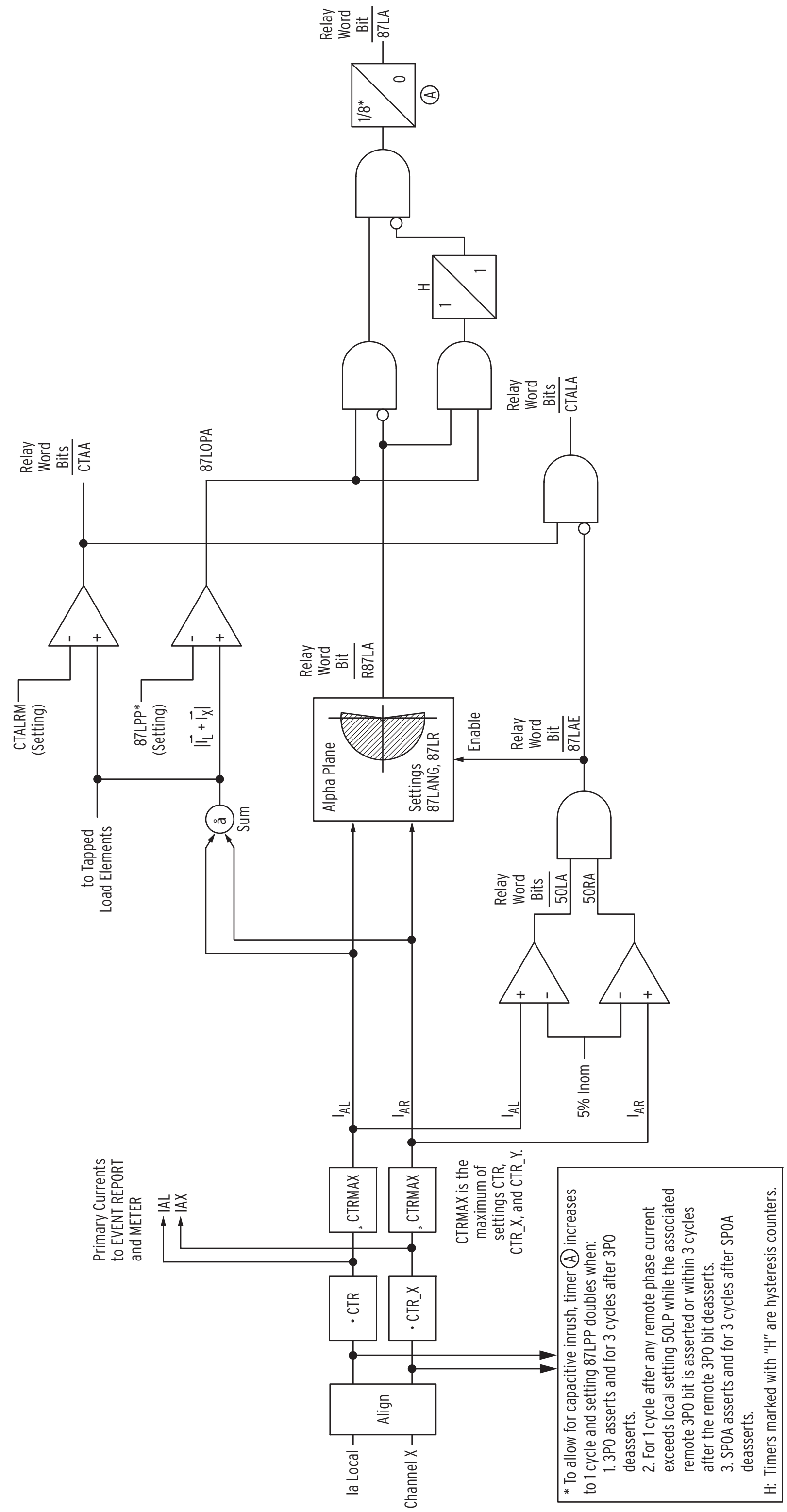


Figure 3.14 Differential Element 87L Processing for A-Phase Channel X; B-Phase, C-Phase, and Channel Y Are Similarly Processed

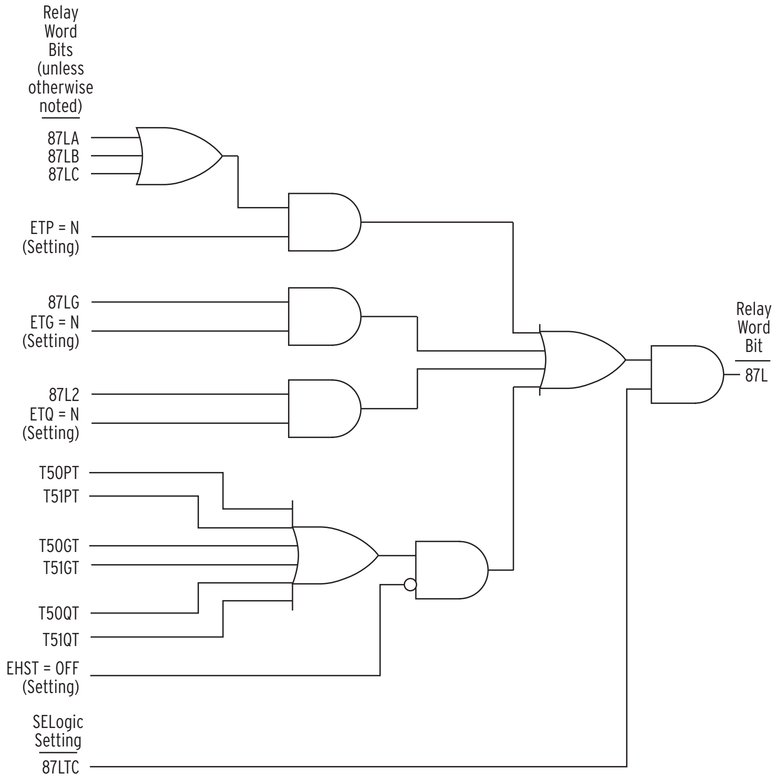


Figure 3.15 Differential Element 87L Processing

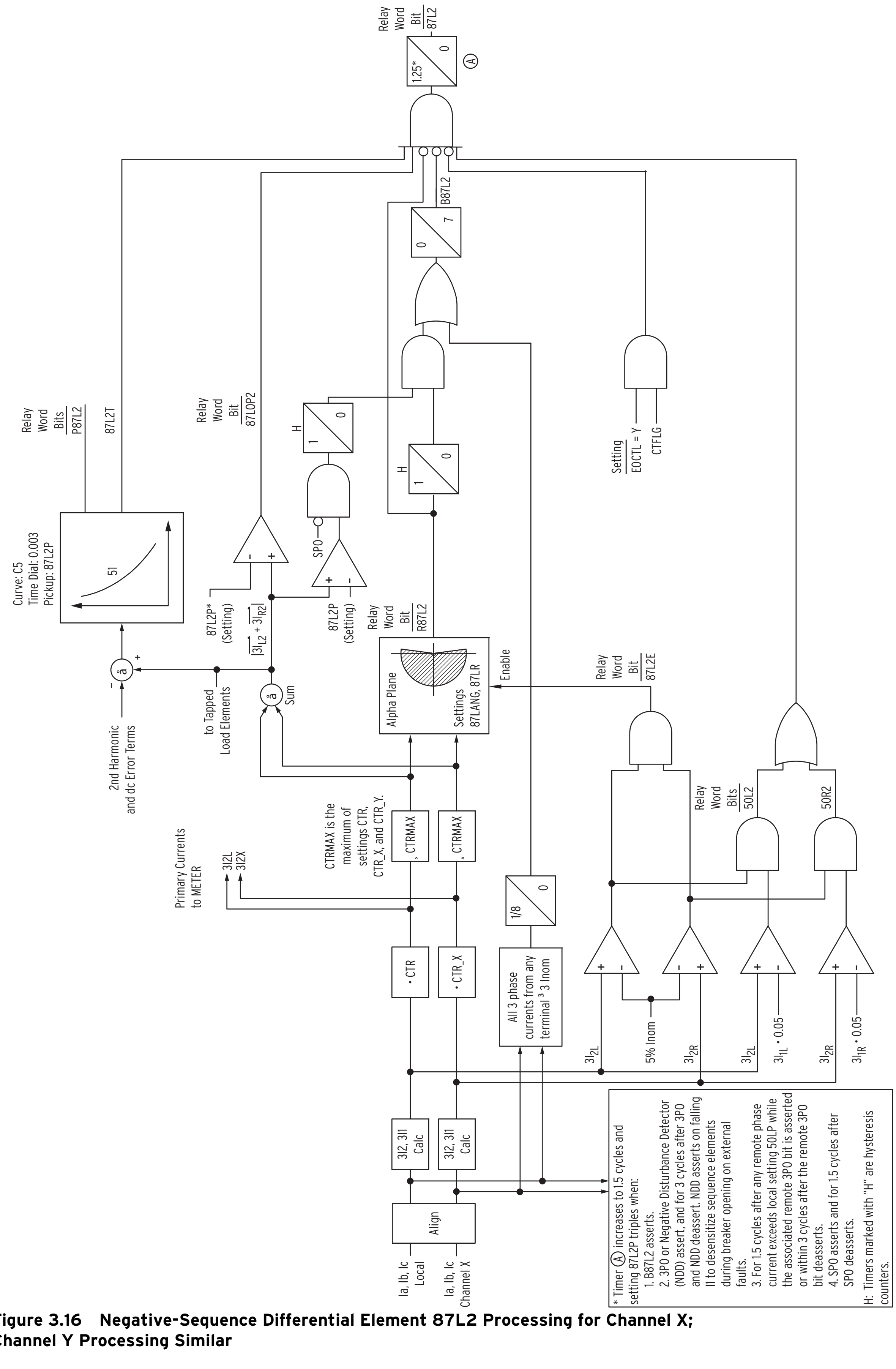


Figure 3.16 Negative-Sequence Differential Element 87L2 Processing for Channel X; Channel Y Processing Similar

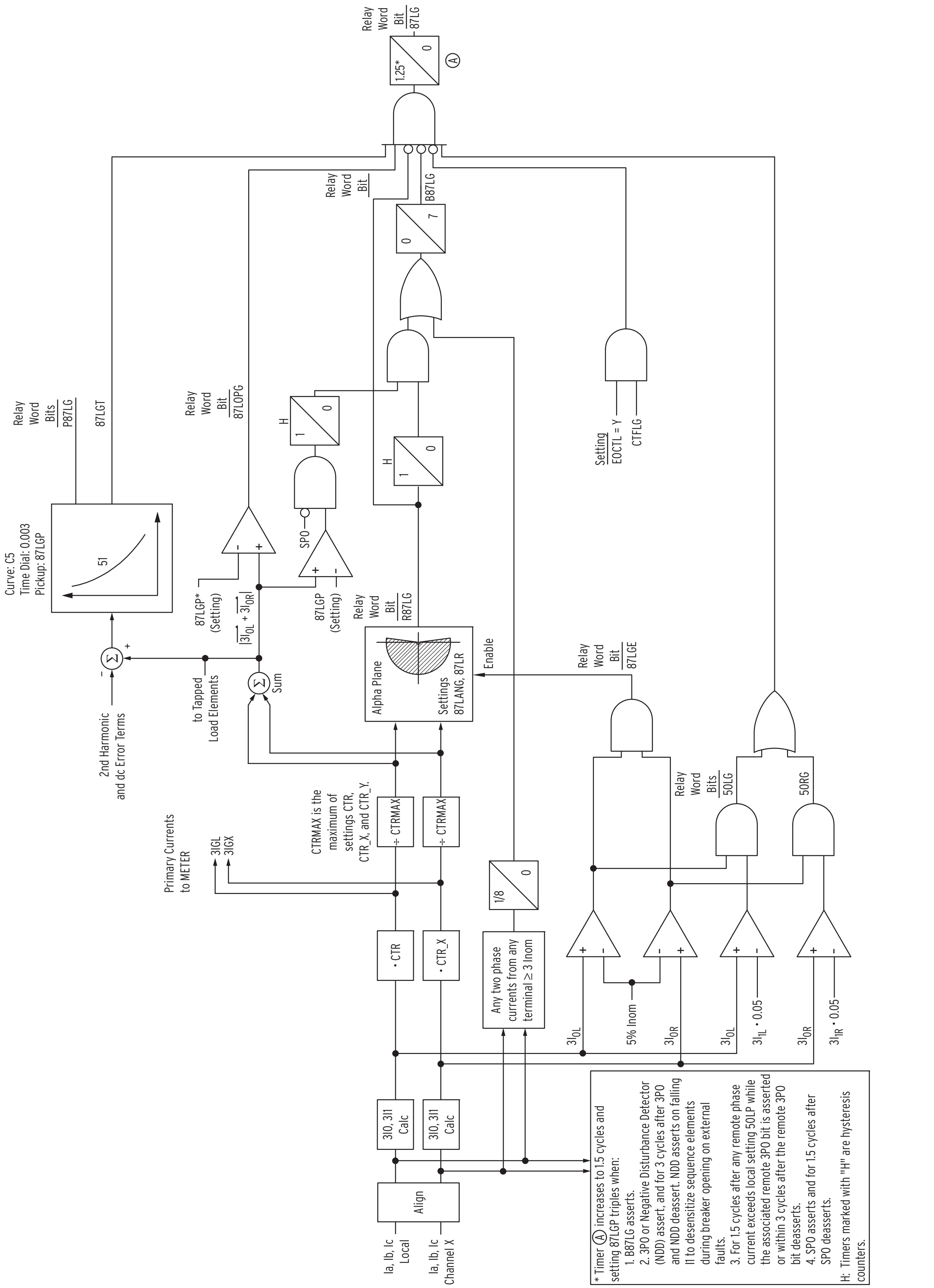


Figure 3.17 Ground Differential Element 87LG Processing for Channel X; Channel Y Processing Similar

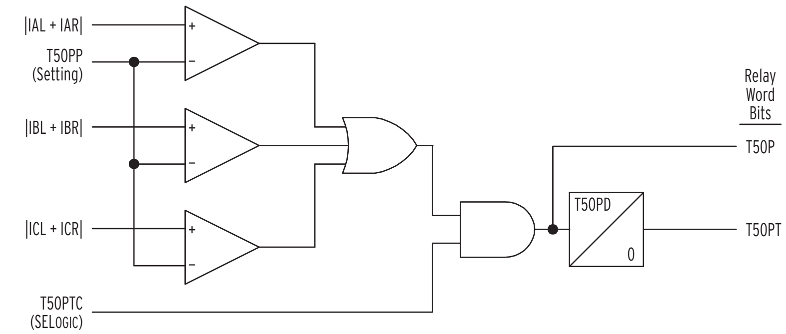


Figure 3.18 Phase Instantaneous and Definite-Time Overcurrent Elements

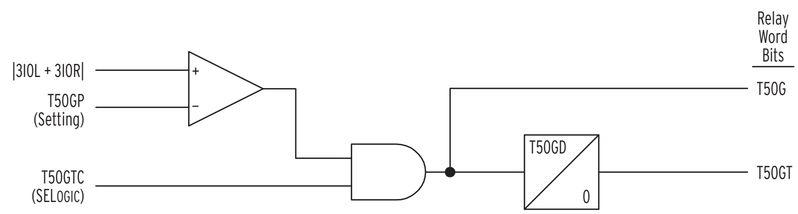


Figure 3.19 Residual Instantaneous and Definite-Time Overcurrent Elements

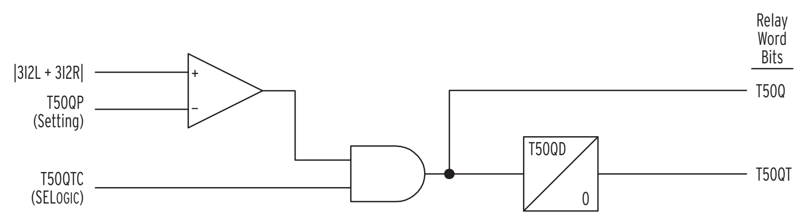


Figure 3.20 Negative-Sequence Instantaneous and Definite-Time Overcurrent Elements

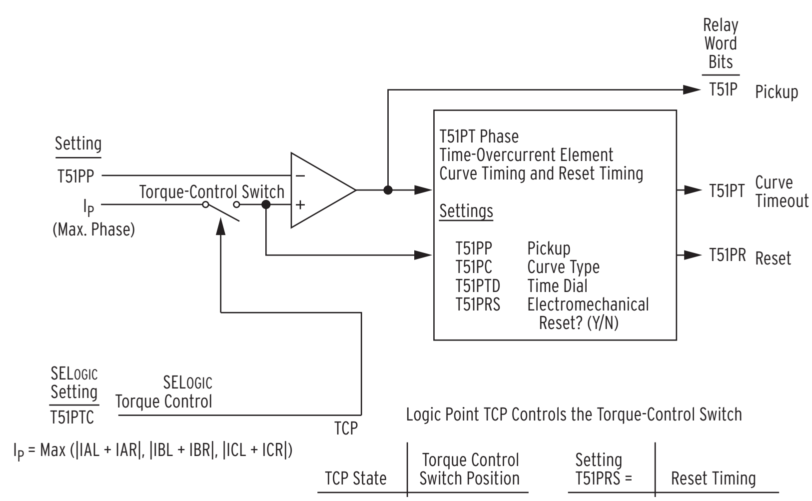


Figure 3.21 Phase Time-Overcurrent Elements

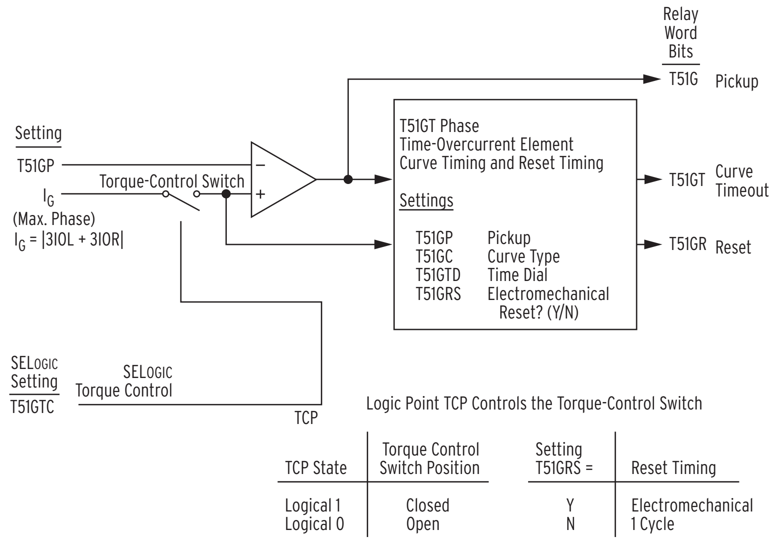


Figure 3.22 Residual-Ground Time-Overcurrent Elements

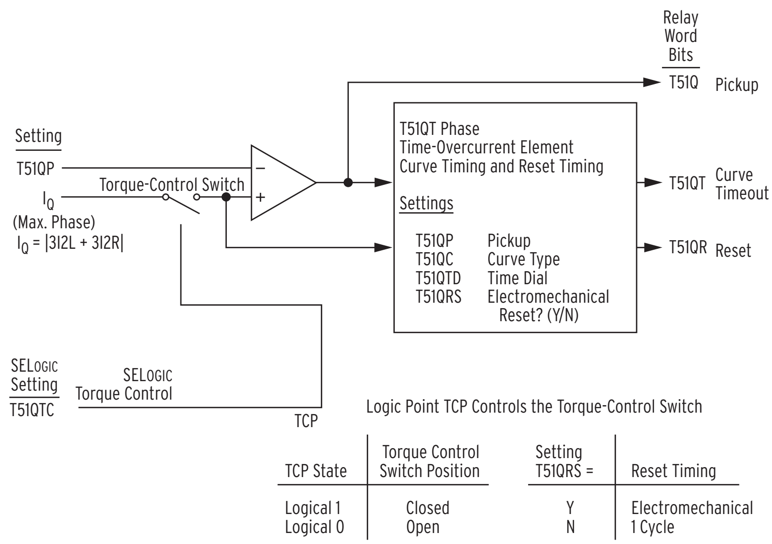


Figure 3.23 Negative-Sequence Time-Overcurrent Elements

Open-CT Detection Logic

The open-CT detection logic operates when a current input at one terminal fails to provide the expected current. The failure could be caused by internal or external conditions. This logic can be used to block the negative-sequence (87L2) and zero-sequence (87LG) differential elements when enabled by setting EOCTL = Y. When the abnormal condition is removed and the current circuit is restored to normal, the logic automatically resets after 120 cycles.

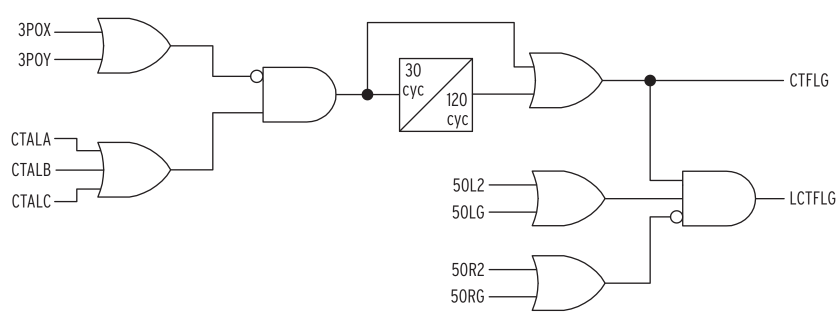


Figure 3.24 Open-CT Detection

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Section 4
Protection Functions

Overview

This section provides detailed information on the operation of SEL-311L Relay protection functions (logic and elements), other than line current differential protection.

Protection functions available without voltages connected to the relay include:

- Instantaneous and Definite-Time Overcurrent Elements
- Inverse-Time Overcurrent Elements
- Current-Polarized Directional Elements
- Best Choice Ground Directional Element Logic and Automatic Settings

Additional protection functions that are available when voltages are connected include:

- Distance Elements
- Out-of-Step Elements
- Voltage Elements
- Voltage-Polarized Directional and Distance Elements
- Synchronism-Check Elements
- Frequency Elements
- Loss-of-Potential Detection Logic
- CCVT Transient Detection Logic
- Load-Encroachment Detection Logic

Distance Elements

Mho Phase Distance Elements

The SEL-311L has four independent zones of mho phase distance protection. All zones are independently set. Zones 1 and 2 are fixed to operate in the forward direction only. Zones 3 and 4 can be set to operate in either the forward or reverse direction. The phase distance elements use positive-sequence voltage polarization for security and to create an expanded mho characteristic. The phase distance elements operate on phase-to-phase, phase-to-phase-to-ground, and three-phase faults.

Compensator distance elements are included for distance relaying through wye-delta transformer banks and for users who desire a different operating principle for backup relaying. Compensator distance phase elements implemented in the SEL-311L detect phase-to-phase, phase-to-phase-to-ground and three-phase faults.

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 12.5* and *Figure 12.6* 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 $\text{Im}(V_1 \bullet V_2^*)$.
- 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 $\text{Re}(V_1 \bullet V_2^*)$.

Table 4.1 shows the different calculations used for the positive-sequence polarized mho elements and compensator-distance mho elements. Notice that the positive-sequence polarized mho element equation is the solution of *Equation 4.1* 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.

$$0 = \text{Re}[(Z \bullet I - V) \bullet V_1\text{mem}^*]$$ **Equation 4.1**

Table 4.1 Phase Distance Calculations

	Positive-Sequence Polarized Mho Element	Compensator-Distance Mho Element
Distance Calculation in a Digital Relay	A-B-phase $mAB = \frac{Re(V_{AB} \bullet V_{AB1}mem^*)}{Re(1\angle Z \bullet I_{AB} \bullet V_{AB1}mem^*)}$ B-C-phase $mBC = \frac{Re(V_{BC} \bullet V_{BC1}mem^*)}{Re(1\angle Z \bullet I_{BC} \bullet V_{BC1}mem^*)}$ C-A-phase $mCA = \frac{Re(V_{CA} \bullet V_{CA1}mem^*)}{Re(1\angle Z \bullet I_{CA} \bullet V_{CA1}mem^*)}$ Z = Impedance measurement at the line angle.	$mPP = Im[(V_{AB} - Z \bullet I_{AB}) \bullet (V_{BC} - Z \bullet I_{BC})^*]$ Phase-to-Phase Element $mABC$ $= Im[(V_{AB} - Z \bullet I_{AB}) \bullet (-jV_{AB} - 0.25 \bullet V_c mem)^*]$ Three-Phase Element mPP = Phase-to-phase torque calculation. Positive torque restrains, negative torque operates. mABC = Three-phase torque calculation. Positive torque restrains, negative torque operates. Z = Replica line impedance at operating or balance point.

As mentioned previously, a digital relay mho element tests the angle between a line drop-compensated voltage and a polarizing (reference) voltage. *Figure 4.1–Figure 4.3* show the operating voltages “inside” positive-sequence polarized mho elements and compensator-distance mho elements. Note that V1mem is the polarizing voltage for the positive-sequence polarized mho element and (Z • I–V) is the line drop-compensated voltage.

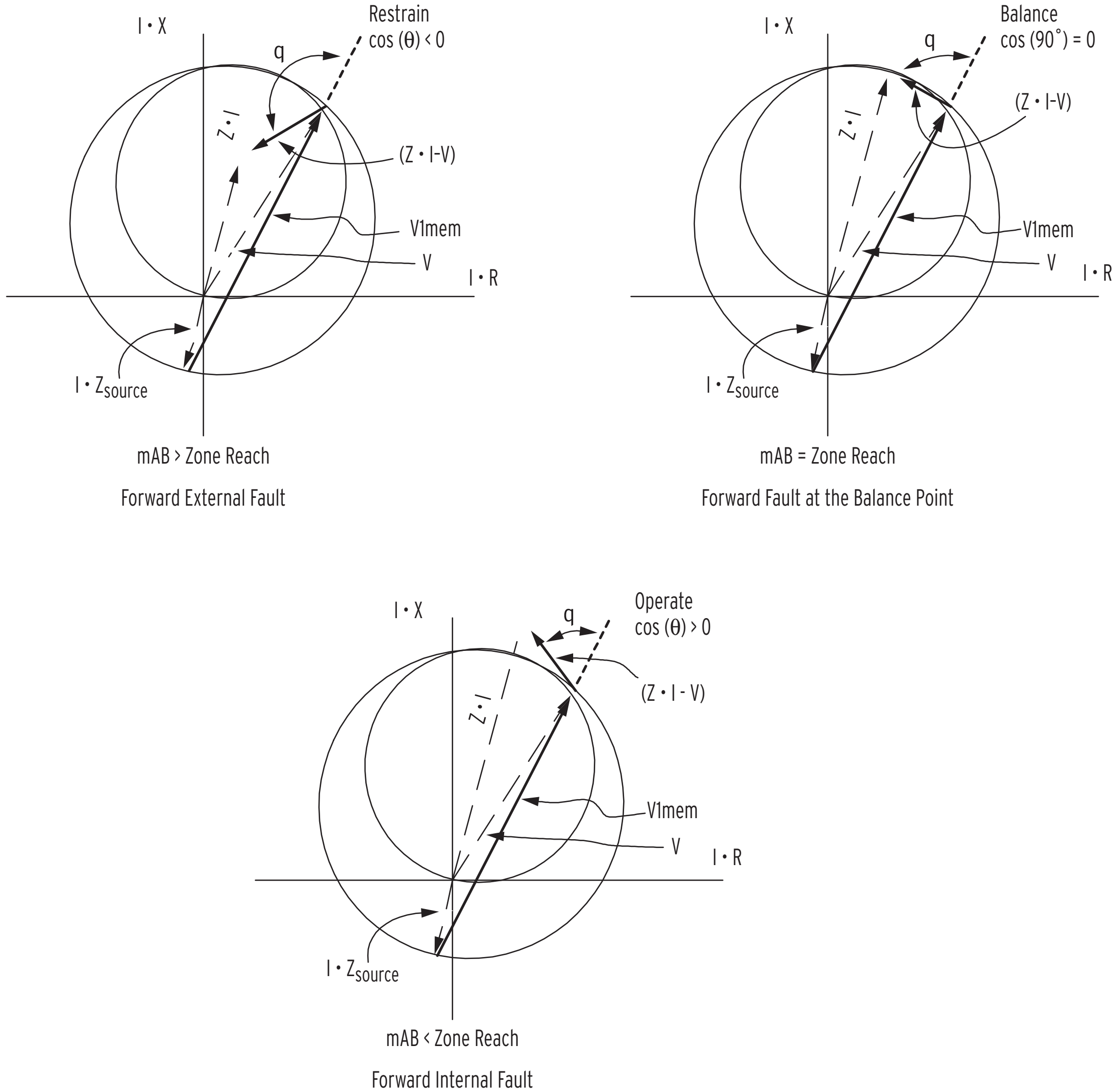
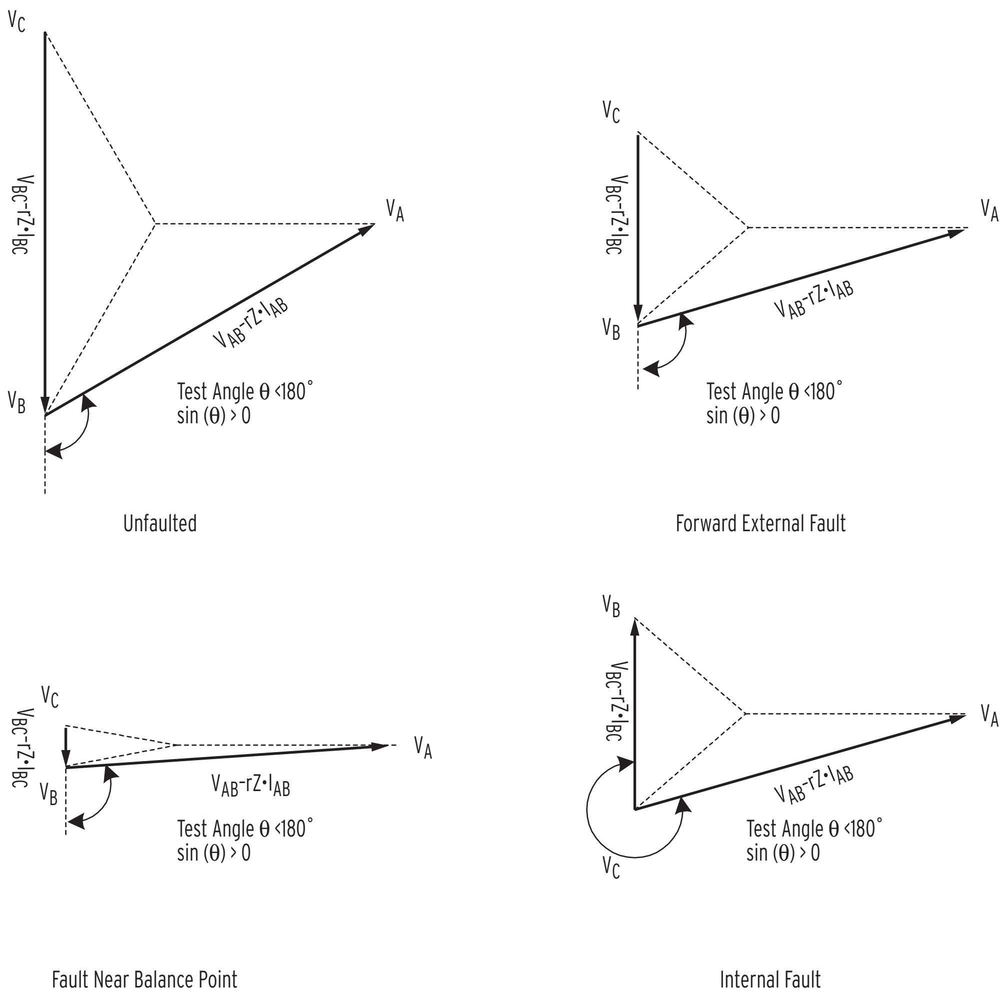
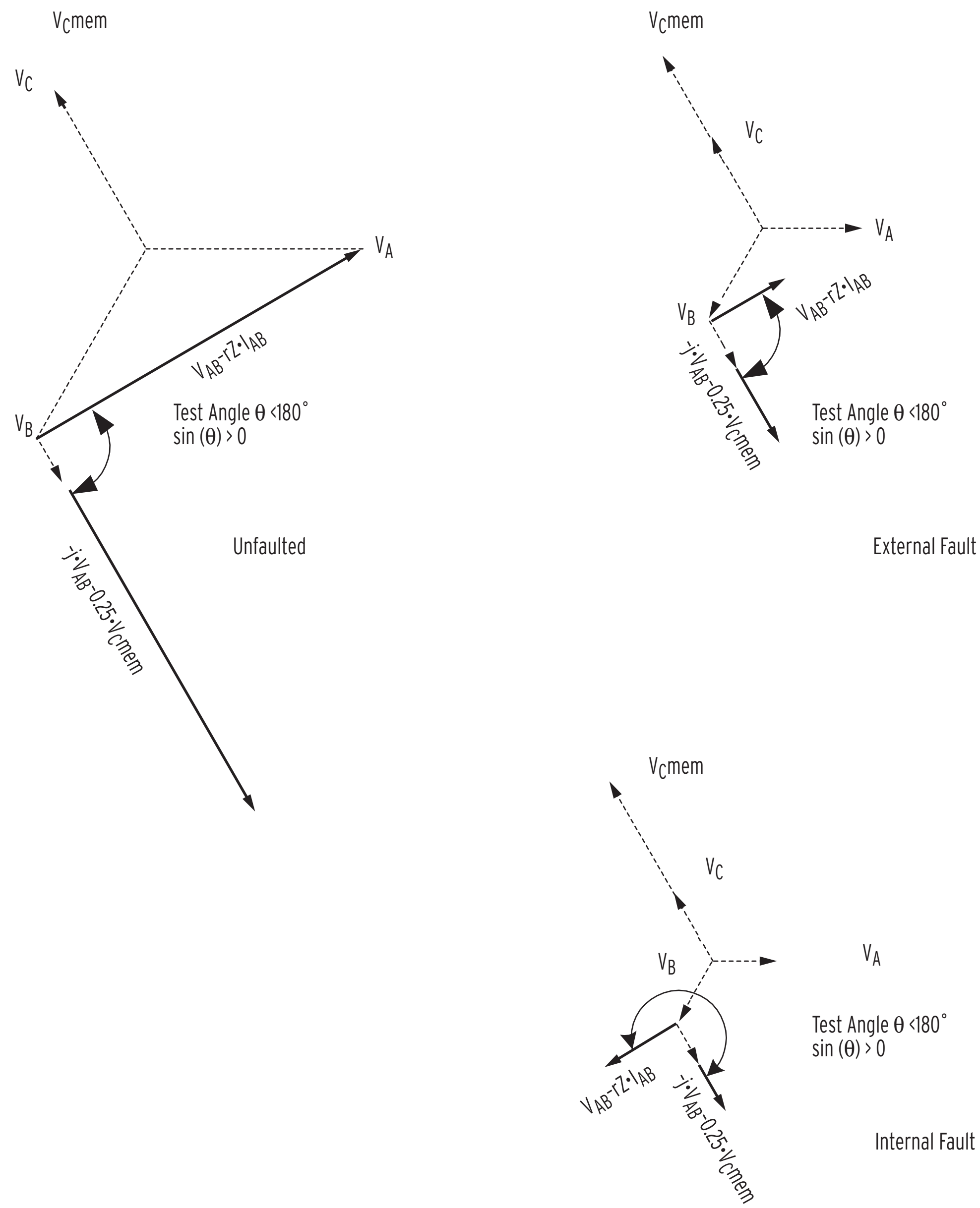


Figure 4.1 Positive-Sequence Polarized Mho Element With Reach Equal to Line Impedance



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

Figure 4.2 Compensator-Distance Phase-to-Phase Element Operation



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

Figure 4.3 Compensator-Distance Three-Phase Element Operation

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

- A different phase-distance operating principle is desired for backup relaying.
- Protecting a transmission line through a delta-wye transformer.

  The compensator distance element reaches through a delta-wye transformer bank for phase-to-phase, phase-to-phase-to-ground, and three-phase faults. Calculate the total primary impedance as the sum of the per-unit transformer and line impedances, then convert from per-unit to actual primary impedance at the protected bus voltage. The compensator distance element measures impedance through the transformer for all phase faults and will not overreach on ground faults. See SEL *Application Guide AG96-16: Applying SEL Distance Relays on Lines with Power Transformers or Open Delta VTs* for more information.

➤ Blocking reclose on three-phase faults.

Relay Word bits MPP*n* (Zone/Level *n* phase-to-phase compensator distance element) and MABC*n* (Zone/Level *n* three-phase compensator distance element) may be used to discriminate between phase-to-phase and three-phase faults in the SELOGIC control equation 79DTL (drive-to-lockout).

79DTL = **MABC2 * !MPP2 ...**

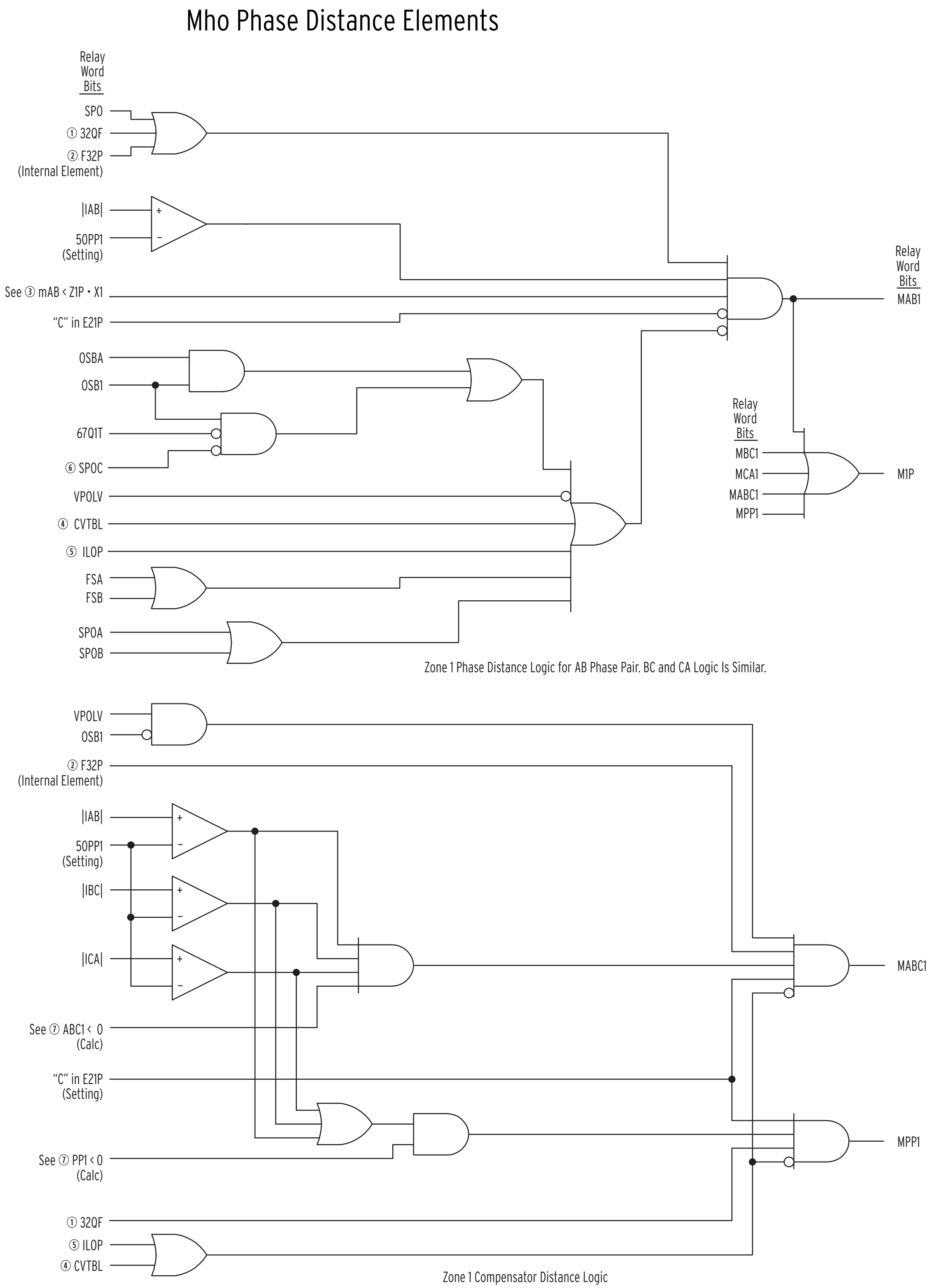
Note that both three-phase and single-phase compensator-distance elements will operate for A-B-phase faults within the protected zone because the three-phase element uses $V_C$mem (V_C memorized voltage) for polarizing.

Compensator distance and positive-sequence polarized distance may not be applied at the same time. Select compensator distance with a "C" suffix to the number of zones in the E21P setting (e.g., 3C is three zones of compensator distance relaying).

Table 4.2 Distance Elements Settings

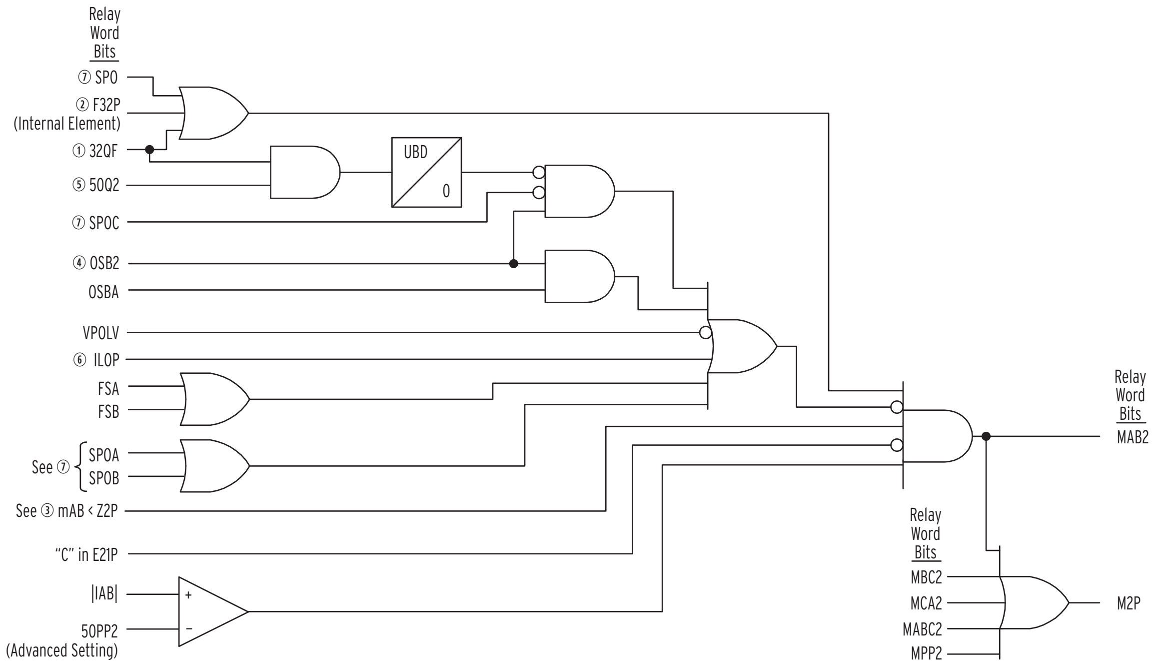
Mho Phase Distance Elements (Zones 1–4)	
Enable Setting:	E21P
Setting range for Mho Phase Distance Elements (Z1P–Z4P):	OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal) Minimum sensitivity is controlled by the pickup of the supervising phase-to-phase overcurrent elements for each zone.
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
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)
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 pickup and reset time curves in *Figure 4.20* and *Figure 4.21*.

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

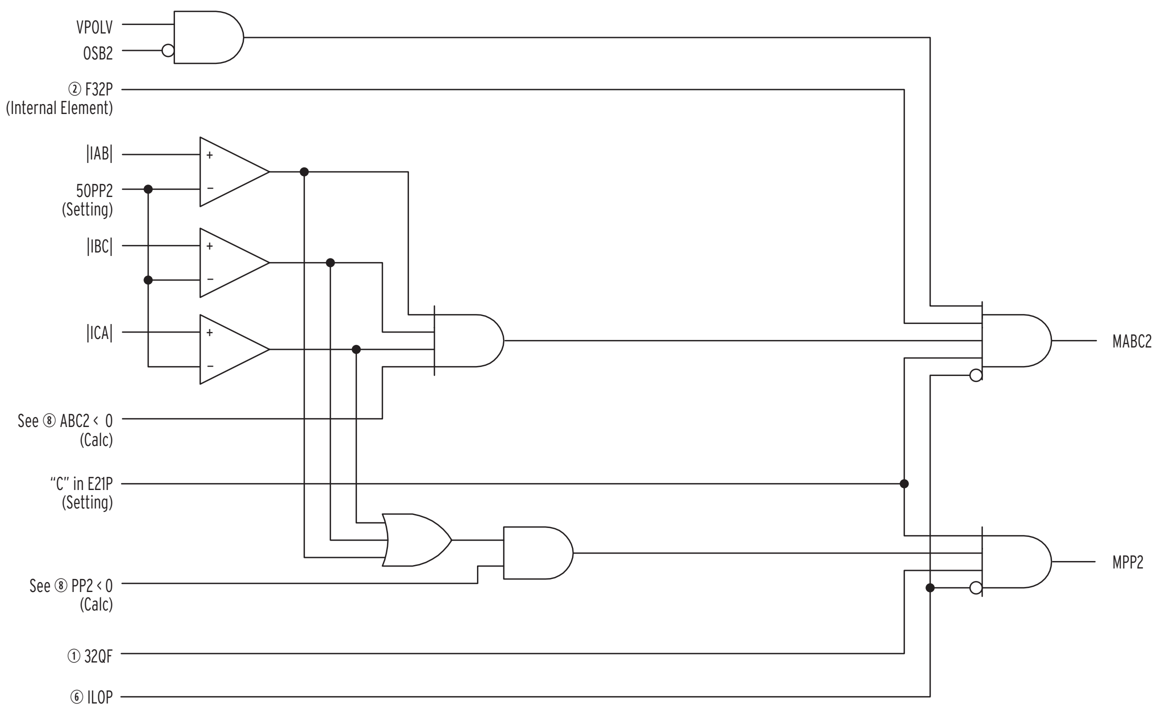


① From Figure 4.49; ② from Figure 4.50; ③ mAB = A-Phase to B-Phase Distance Calculation, Z1P = Zone 1 Distance Setting, X1 = Zone 1 Extension from Figure 4.14; ④ from Figure 4.37; ⑤ from Figure 4.35; ⑥ from Figure 5.8; ⑦ ABC1 and PP1 are compensator distance element calculations, Zone 1 extension, if active, is included in this calculation

Figure 4.4 Zone 1 AB Phase Distance Logic



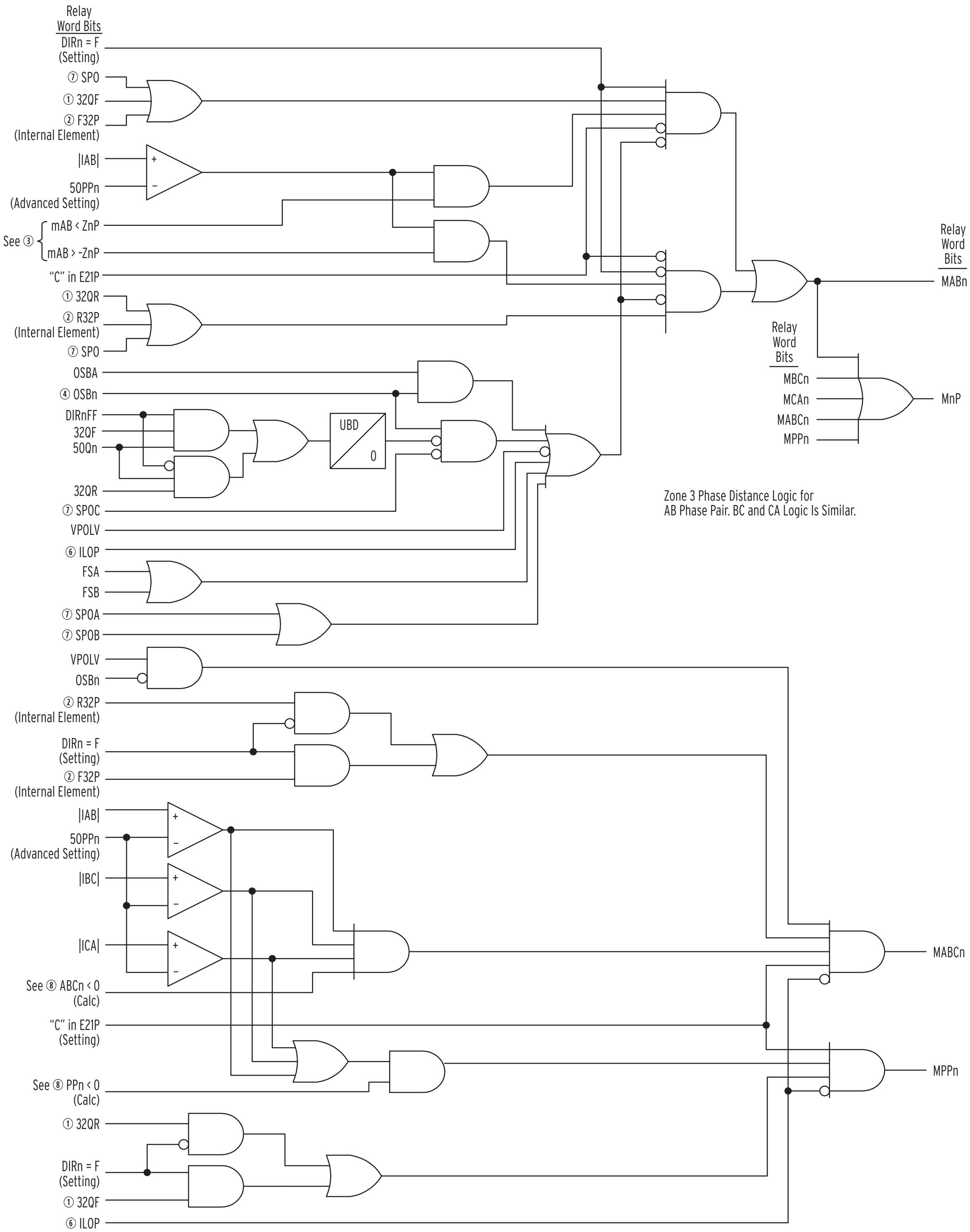
Zone 2 Phase Distance Logic for AB Phase Pair. BC and CA Logic Is Similar.



Zone 2 Compensator Distance Logic

① From Figure 4.49; ② from Figure 4.50; ③ mAB = A-Phase to B-Phase Distance Calculation, Z2P = Zone 2 Distance Setting; ④ from Figure 4.17; ⑤ from Figure 4.23; ⑥ from Figure 4.35; ⑦ from Figure 5.8; ⑧ ABC2 and PP2 are compensator distance element calculations

Figure 4.5 Zone 2 AB Phase Distance Logic



① From Figure 4.49; ② from Figure 4.50; ③ mAB = A-Phase to B-Phase Distance Calculation, ZnP = Zone n Distance Setting, n = 3 for Zone 3, n = 4 for Zone 4; ④ from Figure 4.17; ⑤ from Figure 4.35 ⑥ from Figure 4.35; ⑦ from Figure 5.8; ⑧ ABCn and PPn are compensator distance element calculations

Figure 4.6 Zones 3 and 4 AB Phase Distance Logic

Ground Distance Elements

The SEL-311L has four independent zones of mho and quadrilateral ground distance protection. All zones are independently set. Zones 1 and 2 are forward direction only, and Zones 3 and 4 can be set in either a forward or reverse direction. The mho ground distance elements use positive-sequence voltage polarization for security and to create an expanded mho characteristic. 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).

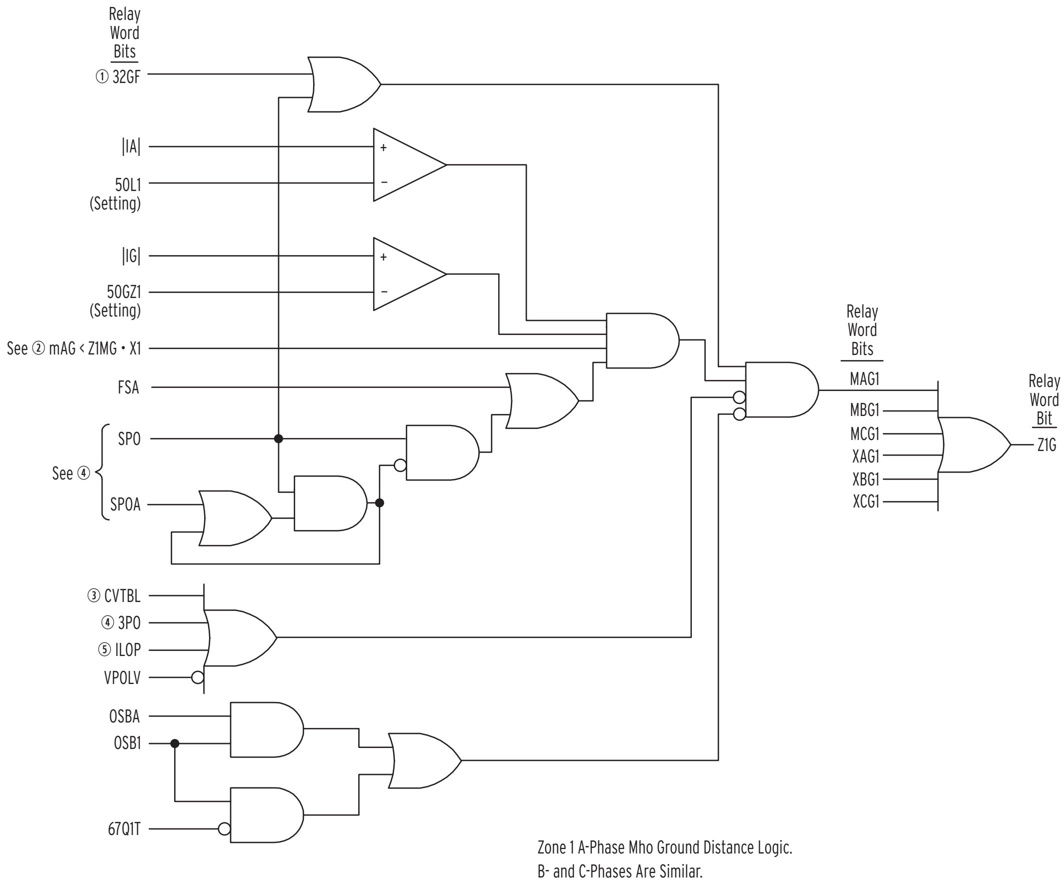
Table 4.3 Ground Distance Elements Settings

Impedance Reach (Zones 1–4)		
Enable Setting:	E21MG E21XG	Mho Ground Quadrilateral Ground
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.	
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	
Phase and Residual Current Fault Detectors (Zones 1–4)		
Setting Range for Phase and Residual Current Fault Detectors (50L1–50L4 and 50GZ1–50GZ4)[a]:	0.50–100.00 A secondary, 0.01 A steps (5 A nominal) 0.10–20.00 A secondary, 0.01 A steps (1 A nominal)	
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 pickup and reset time curves in *Figure 4.20* and *Figure 4.21*.	
Other Settings		
Settings range for zero-sequence compensation (ZSC) factor magnitude:	k0M1 = k0M =	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 = k0A =	–180.0 to +180.0 degrees (Zone 1) –180.0 to +180.0 degrees (Zone 2, 3, 4 advanced setting hidden and set to k0A1 when EADVS = N)

$$\text{where } k0M1 \angle k0A1 = \frac{(Z0MAG \angle Z0ANG) - (Z1MAG \angle Z1ANG)}{3 \bullet (Z1MAG \angle Z1ANG)}$$

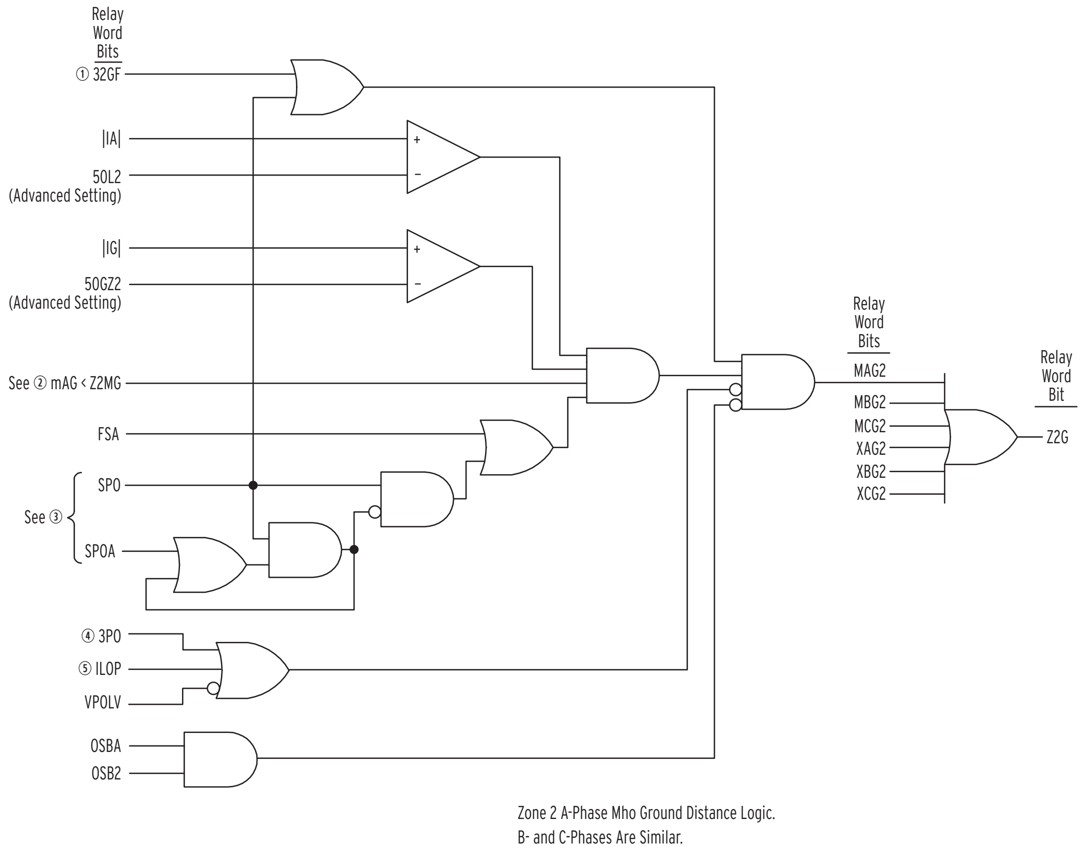
Settings range for quadrilateral ground polarizing quantity (hidden and set to I2 when EADVS = N):	XGPOL =	I2 (negative-sequence current) or I0 (zero-sequence current) (advanced setting)
Settings range for nonhomogeneous correction angle (hidden and set to –3 when EADVS = N):	TANG =	–45 to +45 degrees (advanced setting)

[a] If EADVS = N, levels 2–4 fault detectors are set at their minimum values and are hidden.



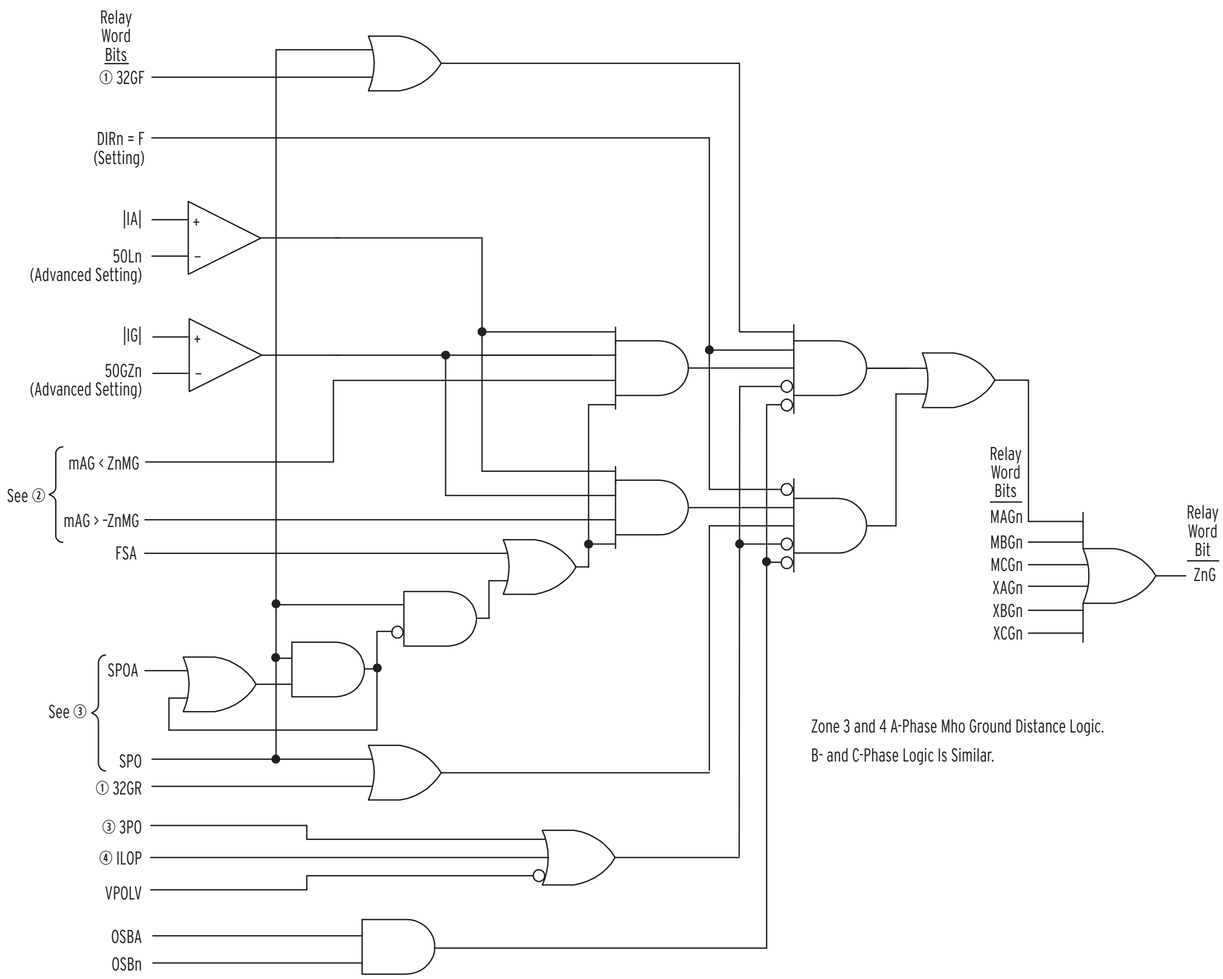
① From Figure 4.47; ② mAG = A-Phase to Ground Distance Calculation, Z1MG = Zone 1 Distance Setting, X1 = Zone 1 Extension from Figure 4.14; ③ from Figure 4.37; ④ from Figure 5.8; ⑤ from Figure 4.35

Figure 4.7 Zone 1 Mho Ground Distance Logic



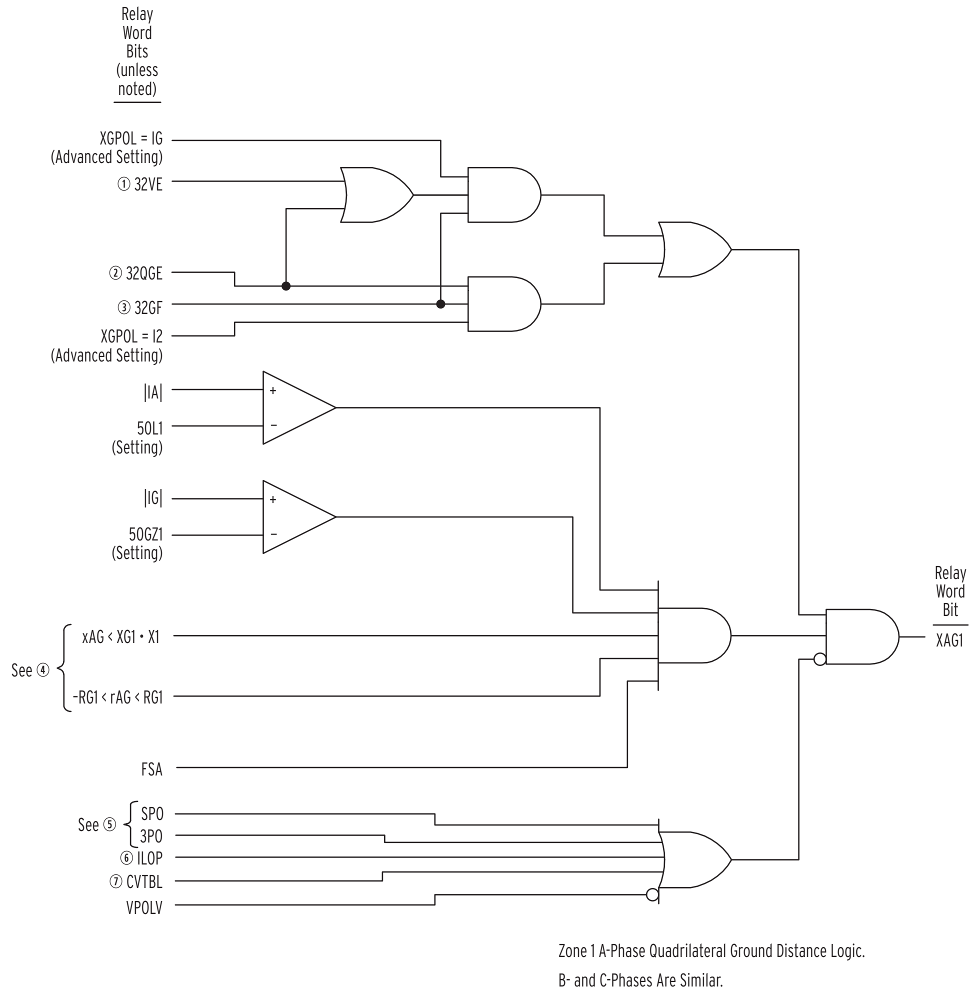
① From Figure 4.47; ② mAG = A-Phase to Ground Distance Calculation, Z2MG = Zone 2 Distance Setting; ③ from Figure 5.8; ④ from Figure 4.35

Figure 4.8 Zone 2 Mho Ground Distance Logic



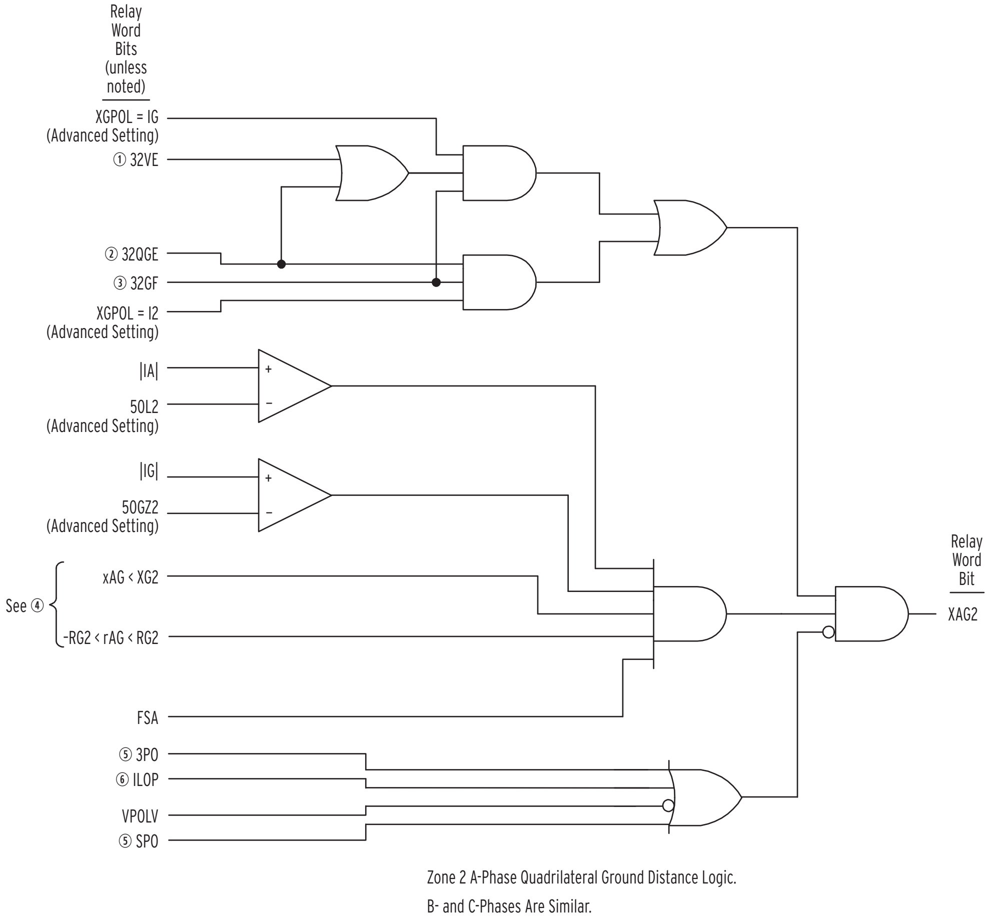
① From Figure 4.47; ② mAG = A-Phase to Ground Distance Calculation, ZnMG = Zone n Distance Setting, n = 3 for Zone 3, n = 4 for Zone 4; ③ from Figure 5.8; ④ from Figure 4.35

Figure 4.9 Zones 3 and 4 Mho Ground Distance Logic



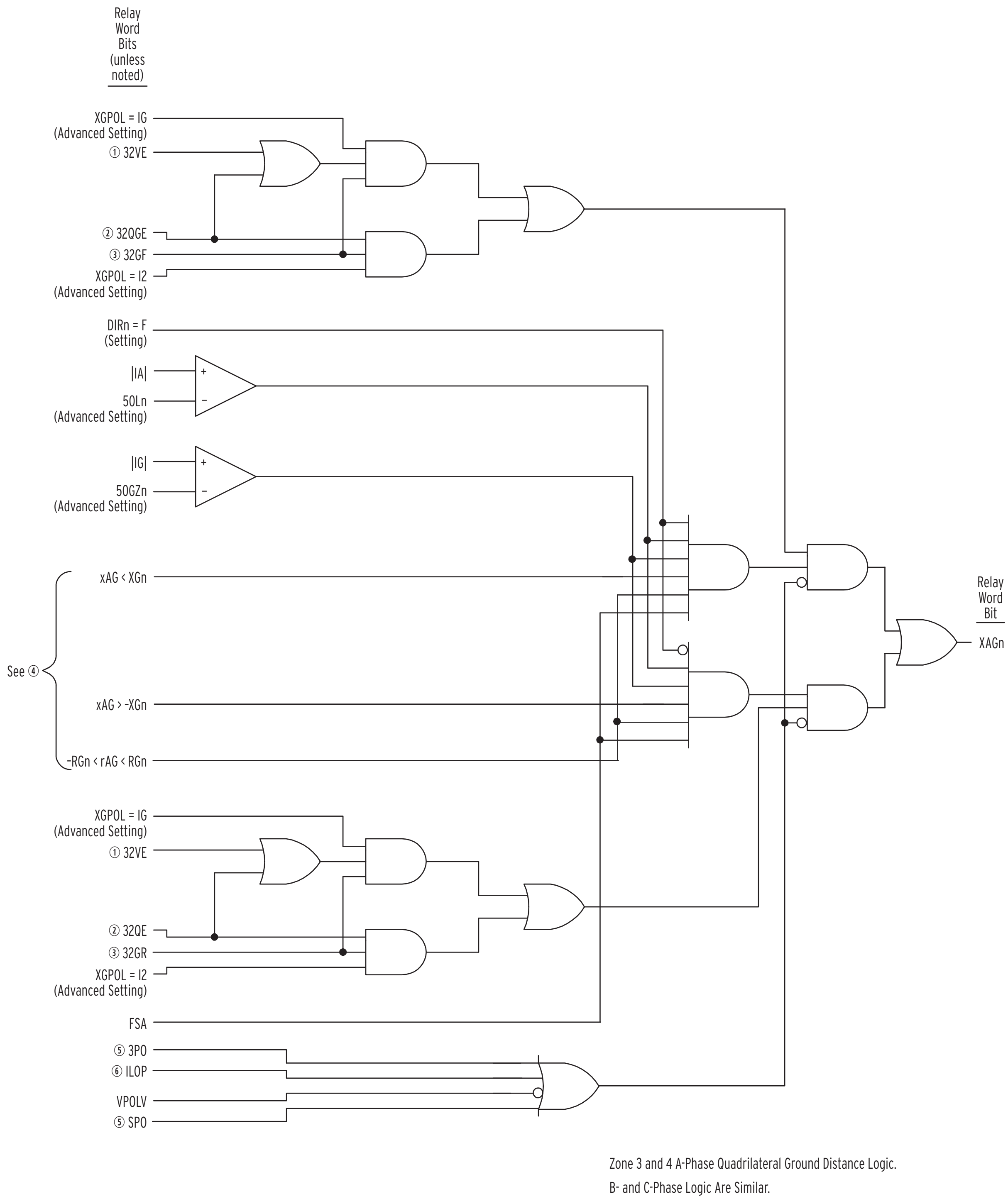
① From Figure 4.42; ② from Figure 4.41; ③ from Figure 4.47; ④ xAG = A-Phase to Ground Reactance Calculation, XG1 = Zone 1 Reactance Setting, X1 = Zone 1 Extension from Figure 4.14, rAG = A-Phase to Ground Resistance Calculation, RG1 = Zone 1 Resistance Setting; ⑤ from Figure 5.8; ⑥ from Figure 4.35; ⑦ from Figure 4.37

Figure 4.10 Zone 1 Quadrilateral Ground Distance Logic



① From Figure 4.42; ② from Figure 4.41; ③ from Figure 4.47; ④ xAG = A-Phase to Ground Reactance Calculation, XG2 = Zone 2 Reactance Setting, rAG = A-Phase to Ground Resistance Calculation, RG2 = Zone 2 Resistance Setting; ⑤ from Figure 5.8; ⑥ from Figure 4.35

Figure 4.11 Zone 2 Quadrilateral Ground Distance Logic



① From Figure 4.42; ② from Figure 4.41; ③ from Figure 4.47; ④ 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; ⑤ from Figure 5.8; ⑥ from Figure 4.35

Figure 4.12 Zones 3 and 4 Quadrilateral Ground Distance Logic

Distance Element Operating Time Curves at Nominal Frequency

Figure 4.13 shows operating times for the SEL-311L distance elements. The diagram shows operating times at each test point. Operating times include output contact closure time.

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

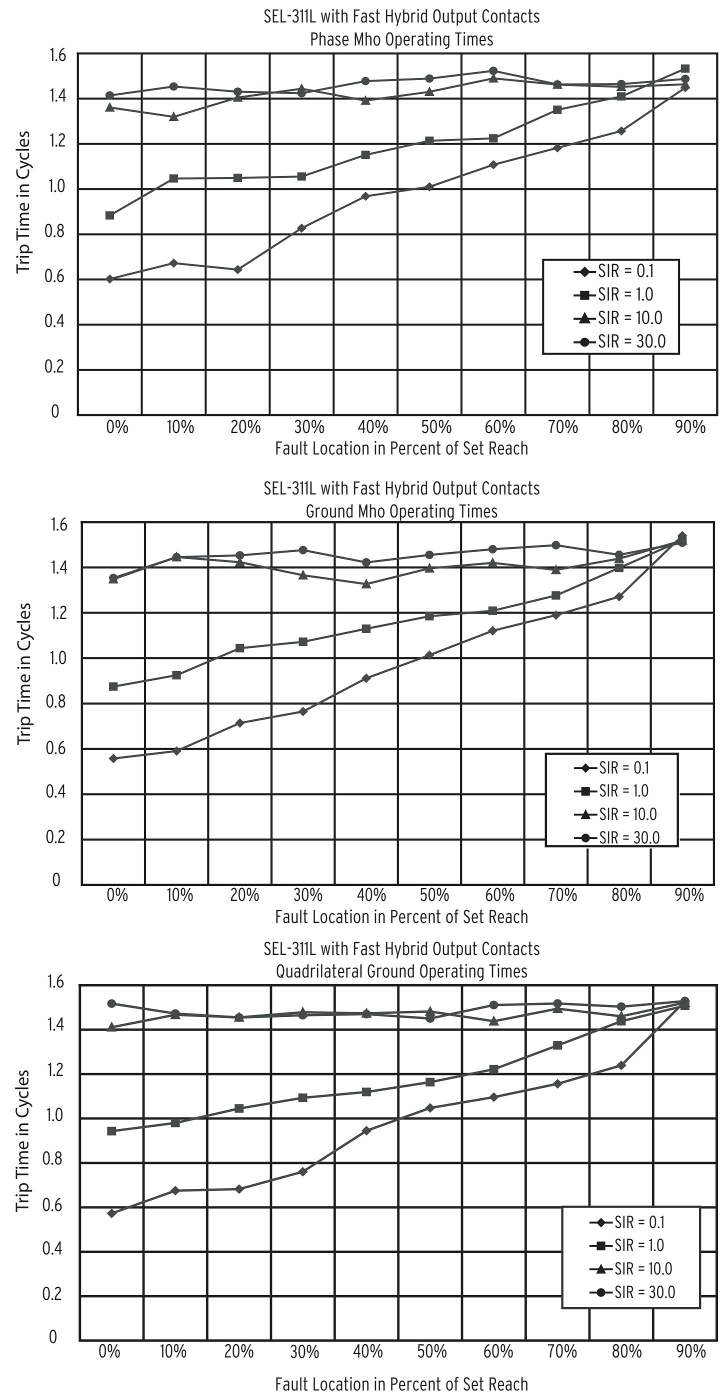


Figure 4.13 Fast Hybrid Output Ground and Phase Distance Speed Curves

Additional Distance Element Supervision

The SEL-311L 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.

Phase and ground distance elements are supervised with Fault Identification Selection (FIDS) or Fault Type Select (FTS) from the 87 logic board. This logic identifies the faulted phase(s) for all faults involving ground by comparing the angle between I0 and I2 (FIDS and FTS) or the operation of an 87L phase element (FTS). 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.

Distance Element Operation When APP = 87LSP (SEL-311L-7 Relay Only)

When the SEL-311L model number supports single-pole tripping with the APP=87LSP setting, the Zone 1 distance element also provides single-pole tripping. All other distance element zones and communications-assisted tripping schemes trip three-pole only. Refer to *Figure 5.3*. Special distance element trip bits, TRPA21, TRPB21, TRPC21, TRP3P21, are used to provide a single-pole trip output. These trip bits are automatically routed to the high-speed output contacts, OUT201–OUT206, based upon your EHST setting. Refer to *Figure 5.4*. These trip outputs can also be manually programmed to other output contacts, if desired.

The trip output can be forced into a three-pole tripping mode by using the E3PT SELOGIC Control Equation. Set E3PT to a logic one for conditions in which the Zone 1 distance element must trip three-pole. For example, during the single-pole open period following a successful single-pole trip.

The Zone 2, Zone 3, and Zone 4 distance elements only trip three-pole. When the relay detects a single-pole open condition, all mho distance elements associated with the open phase are disabled during the pole-open period. For example, when the A-phase pole is open, the AG, AB, and CA distance elements are disabled. All quadrilateral distance elements are disabled during the single-pole open period.

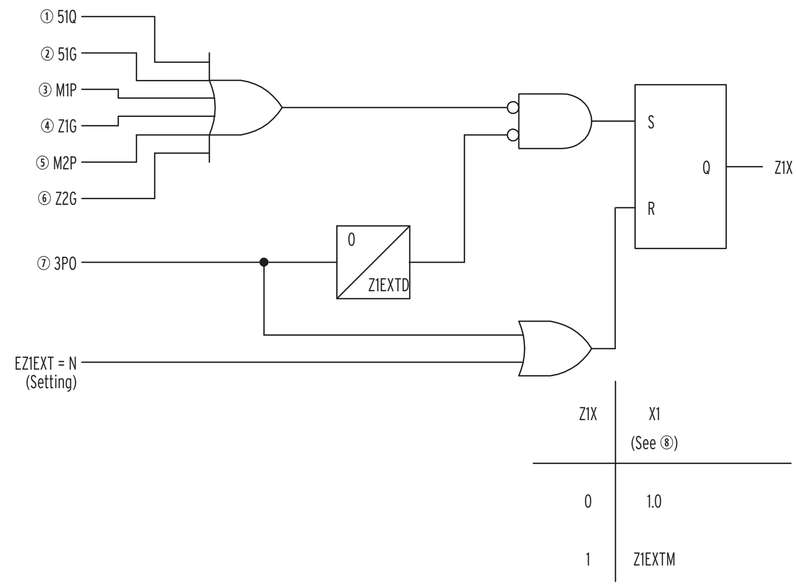
Zone 1 Extension

See *Figure 4.14*. When enabled, this logic modifies the reach of all Zone 1 distance elements by multiplier setting Z1EXTM once all three poles are closed for Z1EXTD time. All Zone 1 reaches retreat to their set reach when 3PO asserts (breaker open).

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

Table 4.4 Zone 1 Settings

Description	Setting	Setting Recommendation
Enable Zone 1 Extension	EZ1EXT	
Zone 1 Extension Delay	Z1EXTD	Sets the minimum time the breaker must be closed before extending the Zone 1 reach.
Zone 1 Extension Multiplier	Z1EXTM	Sets the scalar by which all Zone 1 reaches are multiplied. Z1EXTM times the Zone 1 distance setting is never set less than the Zone 1 distance setting or greater than 90 percent of Zone 2 reach. Z1P < (Z1EXTM • Z1P) < (0.9 • Z2P) and Z1MG < (Z1EXTM • ZMG) < (0.9 • Z2MG) and X1G < (Z1EXTM • X1G) < (0.9 • X2G) must all be true or the SEL-311L will not allow the Z1EXTM setting.



① From Figure 4.26; ② from Figure 4.25; ③ from Figure 4.4; ④ from Figure 4.7; ⑤ from Figure 4.5; ⑥ from Figure 4.8; ⑦ from Figure 5.8; ⑧ from Figure 4.4, Figure 4.7, and Figure 4.10

Figure 4.14 Zone 1 Extension Logic

Zone Time Delay Elements

The SEL-311L supports two philosophies of zone timing:

- independent timing
- common timing

(see *Figure 4.15*). 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 4.5 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
Accuracy	Pickup and dropout accuracy for all timers:	±0.25 cycle and ±0.1% of setting

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

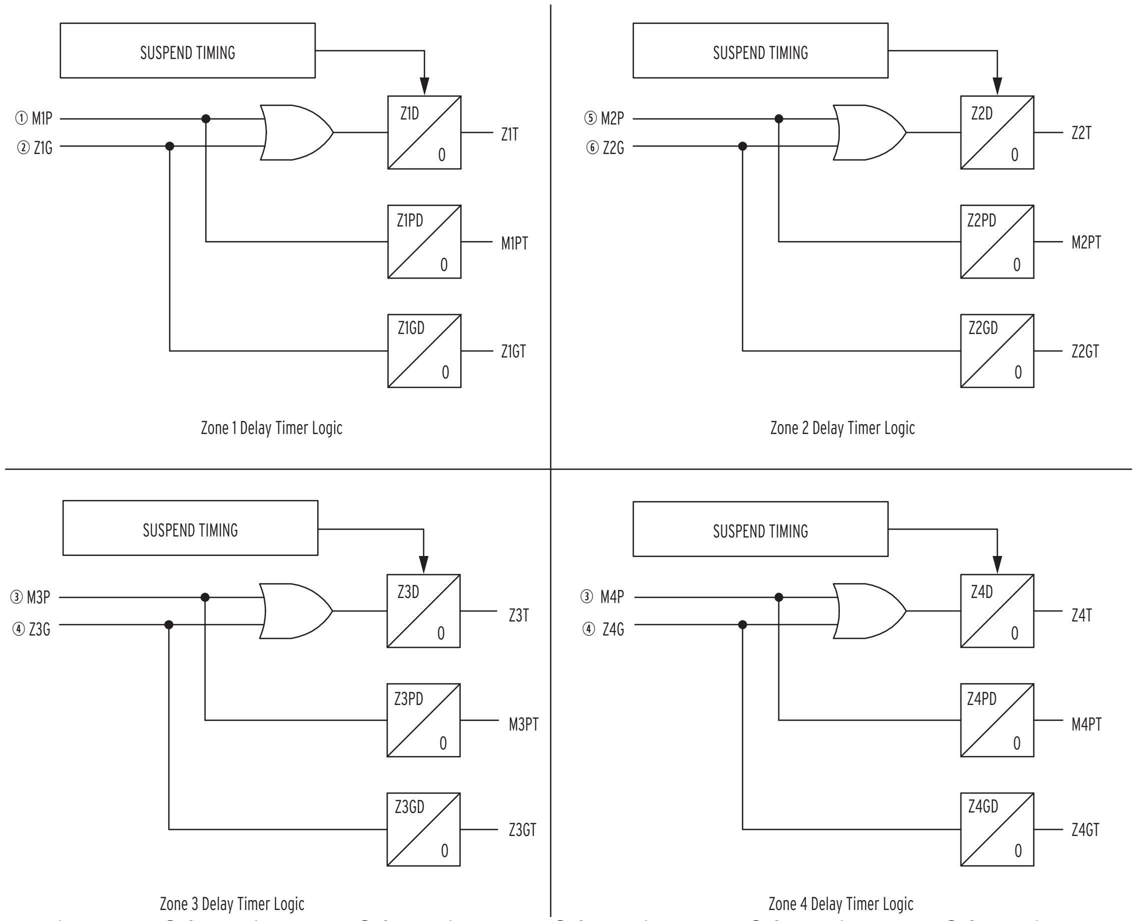
TR = **M1P + Z1G + M2PT + Z2GT + 51GT + 51QT**

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

TR = **M1P + Z1G + Z2T + 51GT + 51QT**

The timing of the 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., ϕϕ to 3ϕ, SLG to ϕϕG). If the timer expires, the suspension logic is blocked.

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, E21P = 3 and E21MG = 2 enable Z1D and Z2D (two zones as defined by the E21MG setting). If an enable is set to OFF, common timing is disabled.



① From Figure 4.4; ② from Figure 4.7; ③ from Figure 4.6; ④ from Figure 4.9; ⑤ from Figure 4.5; ⑥ from Figure 4.8

Figure 4.15 Zone Timing Elements

Out-of-Step Characteristics

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.

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.

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-311L makes these settings automatically. Enable the advanced user settings to set these elements individually (EADVS = Y).

Use SEL-321 Relay Application Guides for the SEL-311L

The out-of-step logic and settings in the SEL-311L are the same as those in the SEL-321-5 Relay. Refer to SEL *Application Guide 97-13: SEL-321-5 Relay Out-of-Step Logic* for applying the out-of-step logic in the SEL-311L.

The timer setting UBOSBD, shown in *Figure 4.16*, is an adaptive setting calculated by the relay. This adaptive setting, which is the expected duration of the swing within the inner blinders, is based on the actual time it takes for the swing to travel between the Zone 6 and Zone 5 blinders prior to moving into inner blinders. If the swing stays between the inner blinders for a period longer than UBOSBD cycles, an unblock signal is asserted.

In the SEL-311L, increase the adaptive setting UBOSBD in multiples of setting UBOSBF. If UBOSBF is set at a multiplier of one, the relay calculates 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 multiplies the adaptive time setting by four.

Table 4.6 Out-of-Step Settings (Sheet 1 of 2)

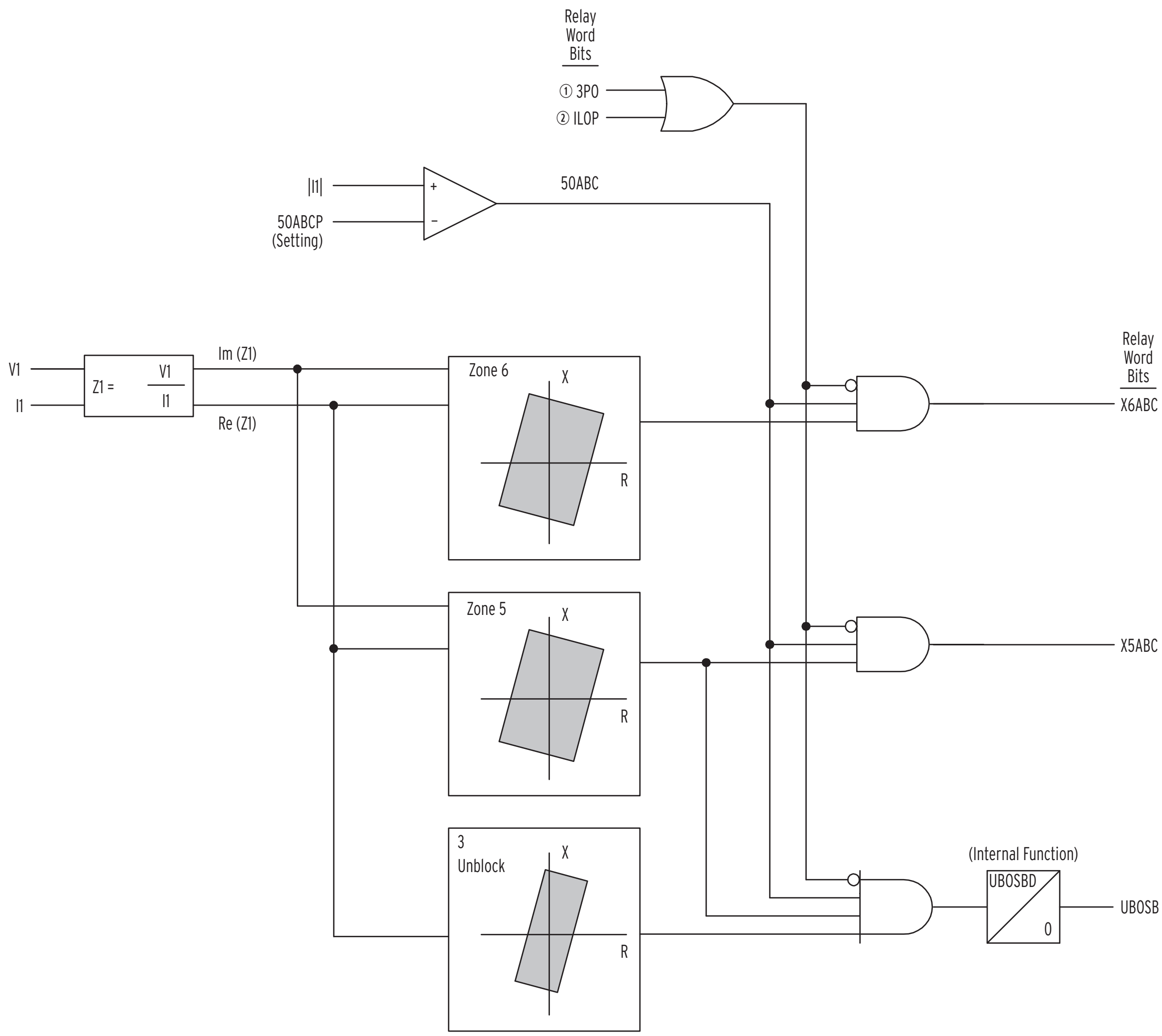
Enable Setting:	EOOS = Y
Block Zone Settings (Zone 1–Zone 4):	OOSB*n* = Y, N (*n* = 1–4)
Out-of-Step Block Time Delay: Pickup Ranges: Pickup and dropout accuracy for all timers:	OSBD 0.5–8,000.0 cycles, 0.25-cycle steps ±0.25 cycle and ±0.1% of setting
Enable Out-of-Step Tripping:	EOOST = N, I, O
Out-of-Step Trip Time Delay: Pickup Ranges:	OSTD 0.5–8,000.0 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.
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

Table 4.6 Out-of-Step Settings (Sheet 2 of 2)

Positive-Sequence Current Supervision Element 50ABC	
Setting Range for Positive-Sequence Current Supervision (50ABCP):	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)
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 pickup and reset time curves in *Figure 4.20* and *Figure 4.21*
Negative-Sequence Current Unblock Time Delay:	UBD (see *Figure 4.4–Figure 4.6*)
Pickup Ranges:	0.5–120.0 cycles, 0.25-cycle steps
Out-of-Step Angle Change Unblock Rate (Advanced Setting: EADVS = Y):	UBOSBF
Pickup Ranges:	1–10 unitless

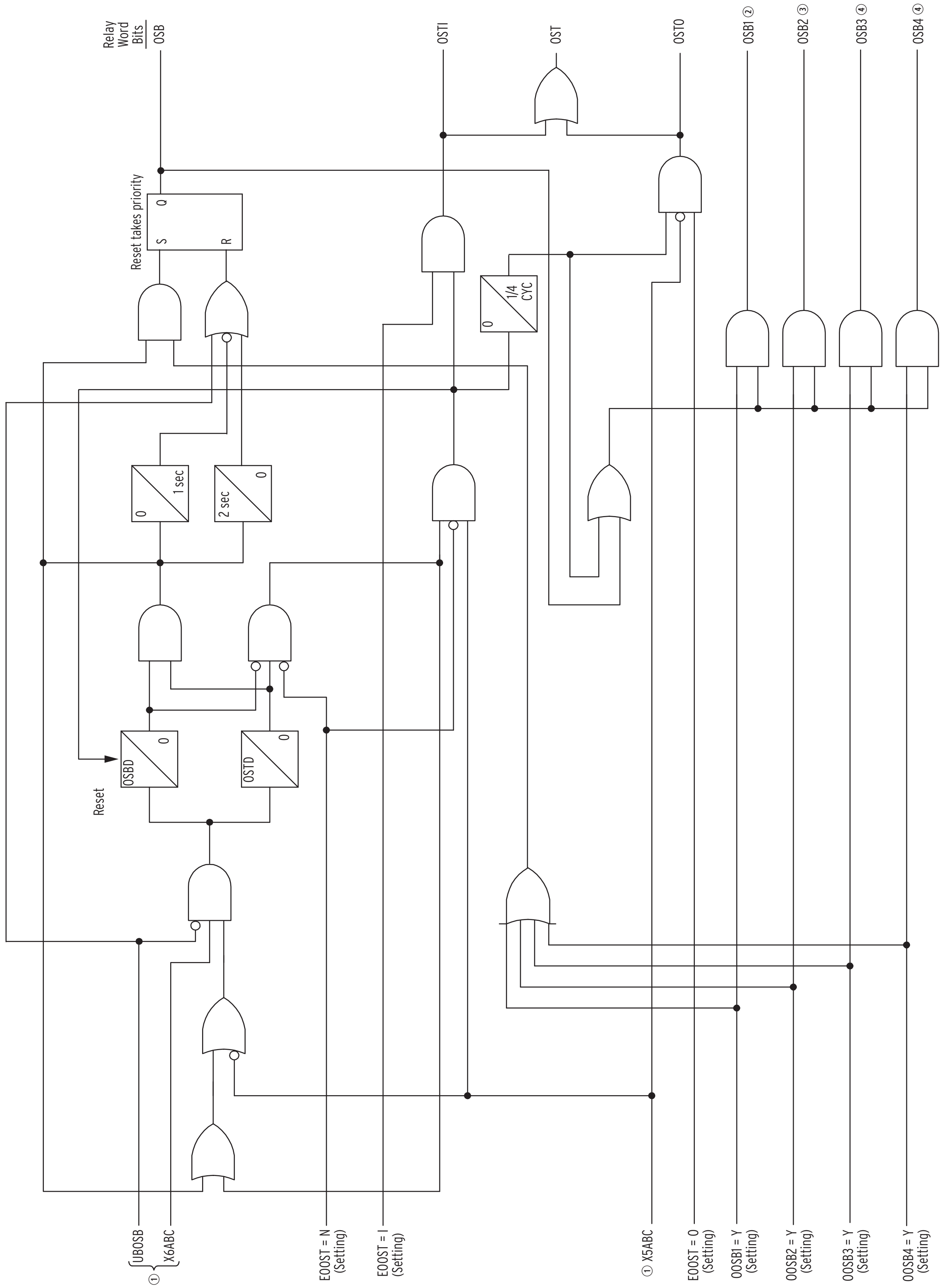
Table 4.7 OOS Relay Word Bits

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



① From Figure 5.8; ② from Figure 4.35

Figure 4.16 Out-of-Step Zone Detection Logic



① From Figure 4.16; ② to Figure 4.4; ③ to Figure 4.5; ④ to Figure 4.6

Figure 4.17 Out-of-Step Logic

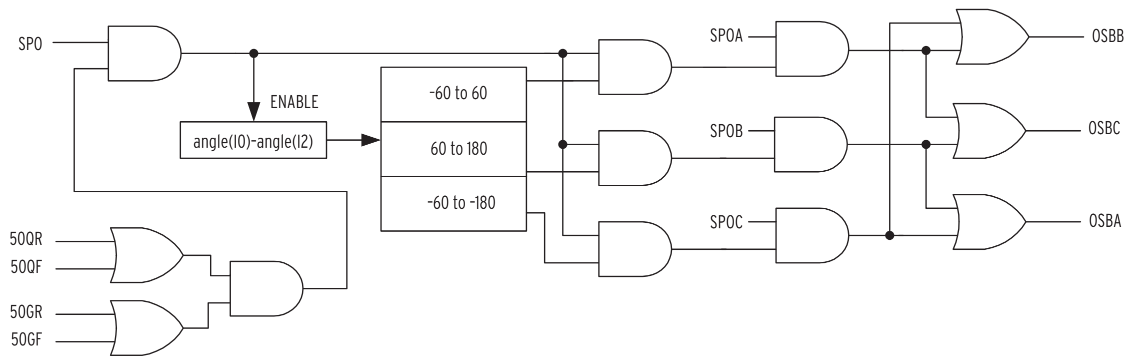


Figure 4.18 Open Pole OSB Unblock Logic

Overcurrent Protection

The SEL-311L provides the following overcurrent protection elements:

- ➤ Phase instantaneous/definite-time overcurrent elements
- ➤ Residual-ground instantaneous/definite-time overcurrent elements
- ➤ Negative-sequence instantaneous/definite-time overcurrent elements
- ➤ Phase inverse-time overcurrent elements
- ➤ Residual-ground inverse-time overcurrent elements
- ➤ Negative-sequence inverse-time overcurrent elements

All of the elements listed above are either directional or nondirectional, if potentials are present at terminals **VA**, **VB**, and **VC**. If you apply the SEL-311L as a line current differential relay with no potentials applied, directional control is available only to residual-ground elements when ORDER = I and polarizing current (IP) is available. Under tapped-load conditions the differential function can also provide directional control for the tapped-load coordination elements.

SELOGIC torque-control equations also control the operation of various levels of overcurrent elements. For example, with application setting 87L, the factory-default torque control 67P1TC is set such that the Level 1 phase instantaneous/definite-time element is enabled only if the line current differential protection is not available (possibly because of channel loss). Configure the torque-control equations for each of the overcurrent elements to suit your application needs. Refer to *Section 14: Application Settings for SEL-311L Relays* for more details.

For more information about SELOGIC control equations refer to *Section 7: SELOGIC Control Equation Programming*.

For directional element logic refer to *Ground Distance and Residual-Ground Overcurrent Directional Logic on page 4.67*.

Instantaneous/Definite-Time Overcurrent Elements

Phase Instantaneous/ Definite-Time Overcurrent Elements

Three levels of phase instantaneous/definite-time overcurrent elements are available. The different levels are enabled with the E50P enable setting, as shown in *Figure 4.19*.

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

Settings Ranges

Settings Range	Description
Pickup Settings 50P1P–50P3P	
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–67P3D	
0.00–16000.00 cycles, in 0.25-cycle steps	

Accuracy

Pickup	±0.05 A secondary and ±3% of setting (5 A nominal phase current inputs, IA, IB, IC) ±0.01 A secondary and ±3% of setting (1 A nominal phase current inputs, IA, IB, IC)
Timer	±0.25 cycles and ±0.1% of setting
Transient Overreach	<5% of setting

Pickup Operation

See the phase instantaneous/definite-time overcurrent element logic in *Figure 4.19*. The pickup settings for each level (50P1P–50P3P) are compared to the magnitudes of the individual phase currents IA, IB, and IC. The logic outputs in *Figure 4.19* are Relay Word bits and operate as follows (Level 1 example shown):

50P1 = **1** (logical 1), if at least one phase current exceeds the 50P1P setting

50P1 = **0** (logical 0), if no phase current exceeds the 50P1P setting

Ideally, set 50P1P > 50P2P > 50P3P so that overcurrent elements display in an organized fashion in event reports (see *Figure 4.19* and *Table 12.3*).

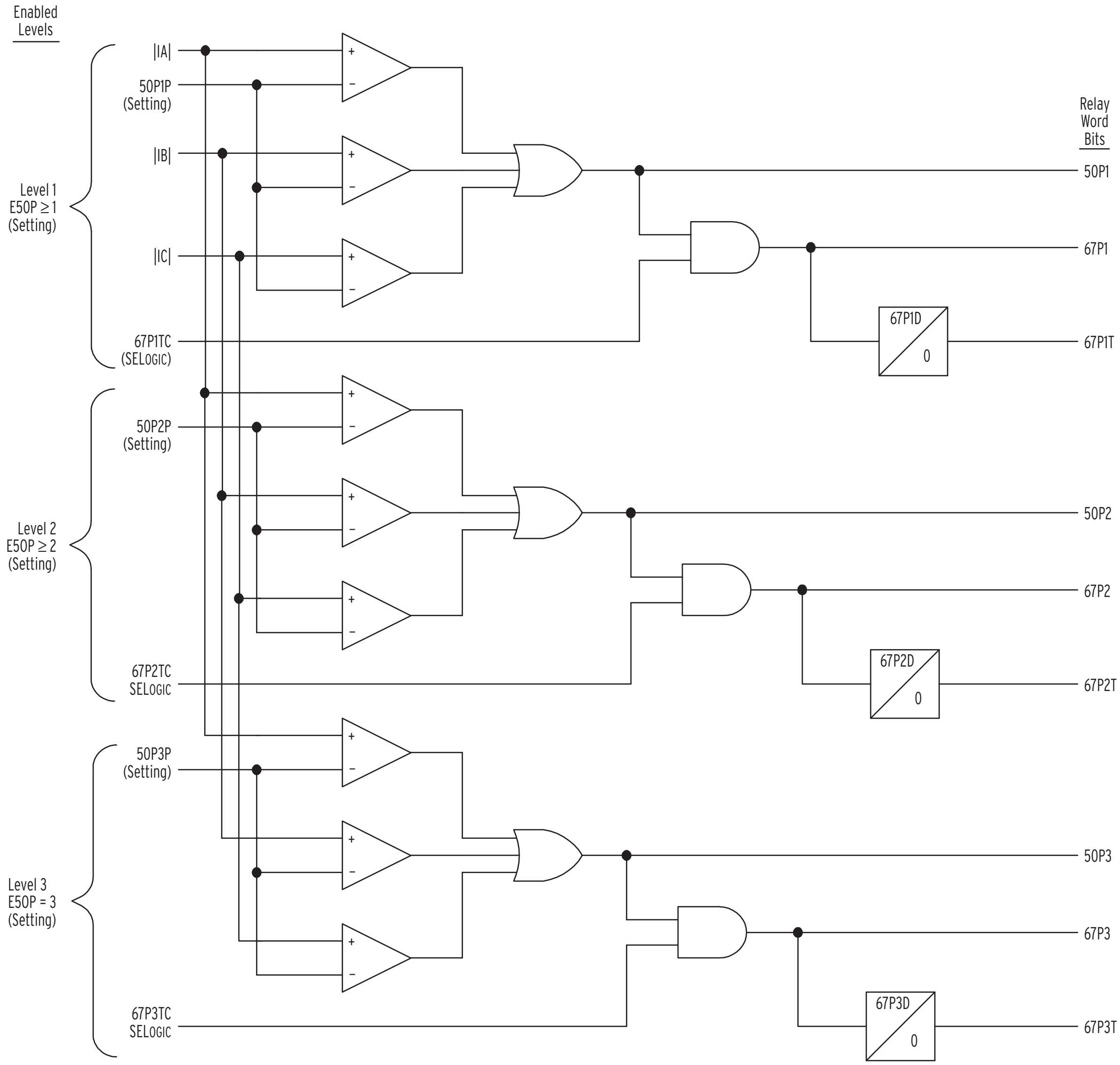


Figure 4.19 Levels 1 through 3 Phase Instantaneous/Definite-Time Overcurrent Elements

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 10.43 for a list of the factory-default settings.

Levels 1 through 3 in *Figure 4.19* have corresponding SELOGIC control equation torque-control settings 67P1TC–67P3TC. 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 to logical 1: Then 67P1/67P1T follows 50P1.

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

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

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

67P1/67P1T follows 50P1.

67P1TC = **M2P** 67P1/67P1T uses the Zone 2 mho phase distance element to provide forward directional control if potentials are present at Terminals VA, VB, and VC. The element will be nondirectional if 67P1TC = 1.

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 4.87*.

Pickup and Reset Time Curves

Figure 4.20 and *Figure 4.21* show pickup and reset time curves applicable to all nondirectional instantaneous overcurrent elements in the SEL-311L (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. See *Section 1: Introduction and Specifications* for output contact operating time specifications.

If instantaneous overcurrent elements are made directional (with standard directional elements such as 32QF), the pickup time curve in *Figure 4.20* is adjusted as follows:

multiples of pickup setting ≤ 4: add 0.25 cycle

multiples of pickup setting > 4: add 0.50 cycle

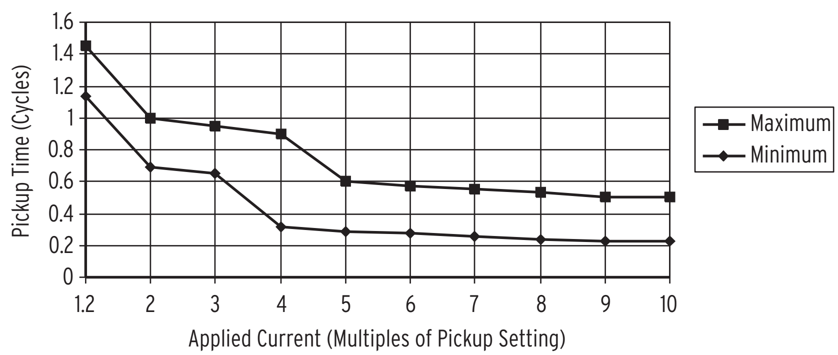


Figure 4.20 SEL-311L Nondirectional Instantaneous Overcurrent Element Pickup Time Curve

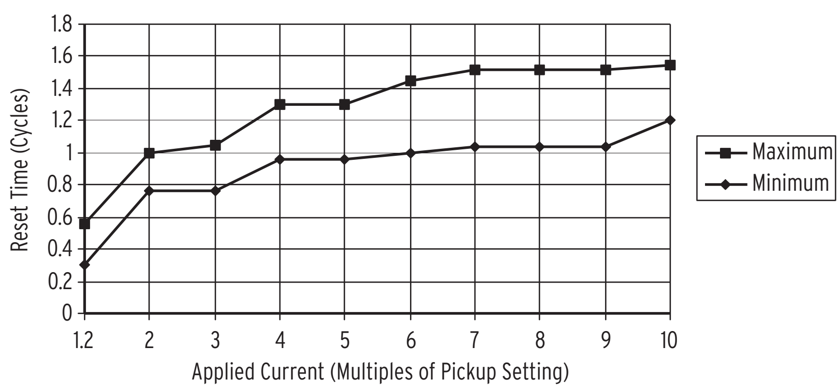


Figure 4.21 SEL-311L Nondirectional Instantaneous Overcurrent Element Reset Time Curve

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 4.22*.

All residual-ground instantaneous/definite-time overcurrent elements are available for use in any user-defined tripping or control scheme.

To understand the operation of *Figure 4.22*, follow the explanation given for *Figure 4.19* in *Phase Instantaneous/Definite-Time Overcurrent Elements on page 4.27*, 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.

In *Figure 4.22* Levels 1 and 2 67G*n* elements have their directional control fixed forward. Levels 3 and 4 have selectable forward and reverse directional controls. See *Figure 4.47* for more information on directional control.

If potentials are not applied to terminals **VA**, **VB**, and **VC**, you have the following options (refer to *Ground Distance and Residual-Ground Overcurrent Directional Logic on page 4.67* for more details on directional control):

- ➤ Use Levels 1 and 2 fixed in the forward direction by setting the ORDER = I. This setting will allow the directional algorithm to use Ip (if available) as a polarizing quantity.
- ➤ Use Levels 3 and 4 in either the forward or reverse direction by setting ORDER = I, and setting DIR3 and DIR4 to either F (forward) or R (reverse) to use Ip (if available) as a polarizing quantity.
- ➤ To make the residual-ground instantaneous/definite-time element operate in a nondirectional mode, set ORDER = OFF. Do not set ORDER = OFF if potentials are applied at Terminals **VA**, **VB**, and **VC** because setting ORDER = OFF disables the ground distance element.

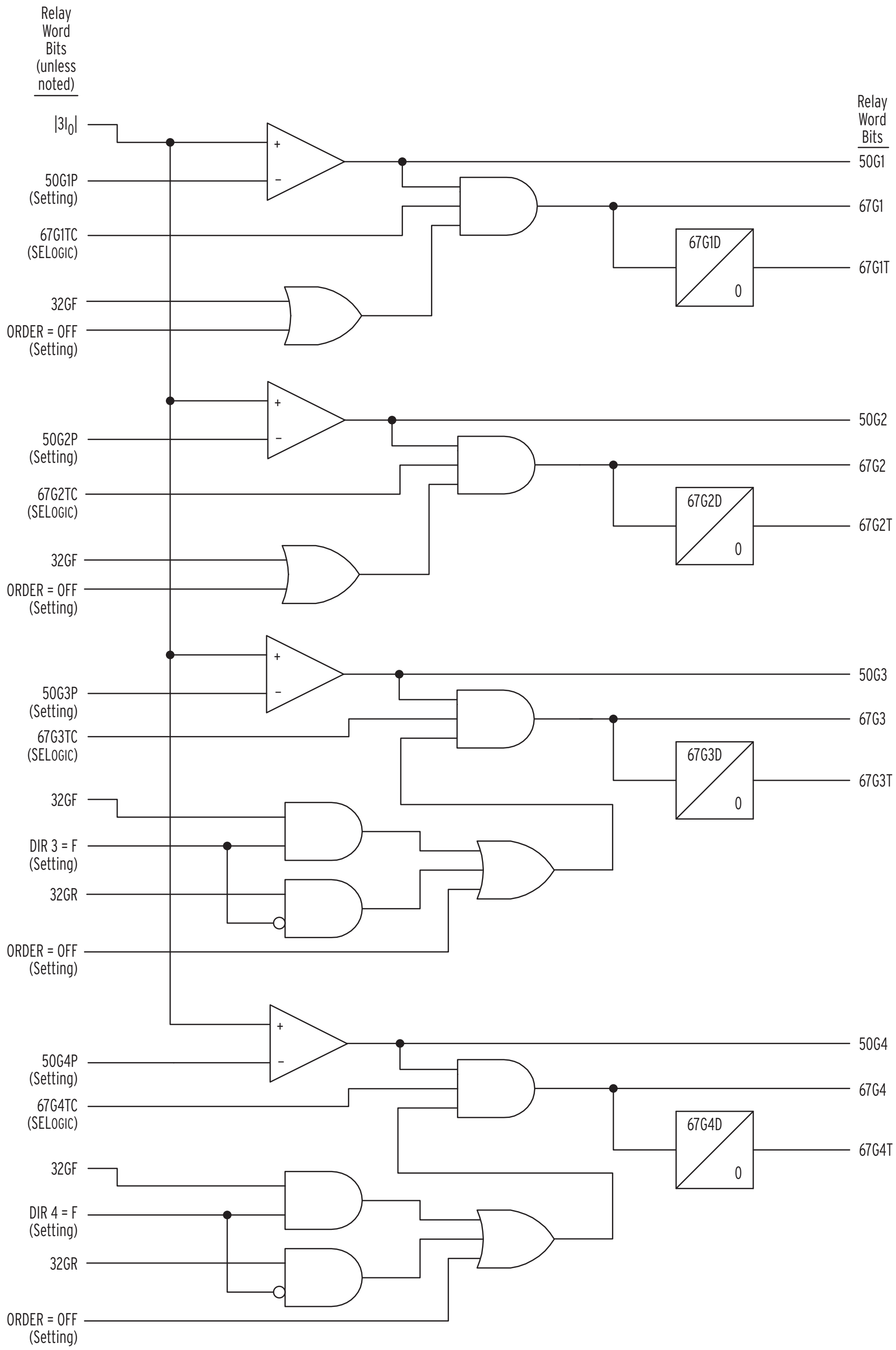


Figure 4.22 Levels 1–4 Residual-Ground Instantaneous/Definite-Time Overcurrent Elements With Directional and Torque Control

Settings Ranges

Settings Range	Description
Pickup Settings 50G1P–50G4P	
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 67G1D–67G4D	
0.00–16000.00 cycles, in 0.25-cycle steps	

Accuracy

Pickup	±0.05 A secondary and ±3% of setting (5 A nominal phase current inputs, IA, IB, IC) ±0.01 A secondary and ±3% of setting (1 A nominal phase current inputs, IA, IB, IC)
Timer	±0.25 cycles and ±0.1% of setting
Transient Overreach	<5% of setting

Pickup and Reset Time Curves

See *Figure 4.20* and *Figure 4.21*.

Negative-Sequence Instantaneous/ Definite-Time Overcurrent Elements

IMPORTANT: See Setting Negative-Sequence Elements on page 4.88 for information on setting negative-sequence 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 4.23*.

To understand the operation of *Figure 4.23*, follow the explanation given for *Figure 4.19* in *Phase Instantaneous/Definite-Time Overcurrent Elements on page 4.27*, substituting negative-sequence current $3I_2$ [$3I_2 = I_A + a^2 \bullet I_B + a \bullet I_C$ (ABC rotation), $3I_2 = I_A + a^2 \bullet I_C + a \bullet I_B$ (ACB rotation), where $a = 1 \angle 120°$ and $a^2 = 1 \angle -120°$] for phase currents and substituting like settings and Relay Word bits.

In *Figure 4.23*, Levels 1 and 2 67Q*n* elements have directional controls fixed forward. Levels 3 and 4 have selectable forward and reverse directional controls. See *Figure 4.49* for more information on this optional directional control.

In cases where the SEL-311L is applied without potentials VA, VB, and VC, use the negative-sequence instantaneous/definite-time overcurrent elements in nondirectional mode by setting ORDER = OFF. For more details, refer to *Figure 4.23*.

Settings Ranges

Settings Range	Description
Pickup Settings 50Q1P–50Q4P	
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 67Q1D–67Q4D	
0.00–16000.00 cycles, in 0.25-cycle steps	

Accuracy

Pickup	±0.05 A secondary and ±3% of setting (5 A nominal phase current inputs, IA, IB, IC) ±0.01 A secondary and ±3% of setting (1 A nominal phase current inputs, IA, IB, IC)
Timer	±0.25 cycles and ±0.1% of setting
Transient Overreach	<5% of setting

Pickup and Reset Time Curves

See *Figure 4.20* and *Figure 4.21*.

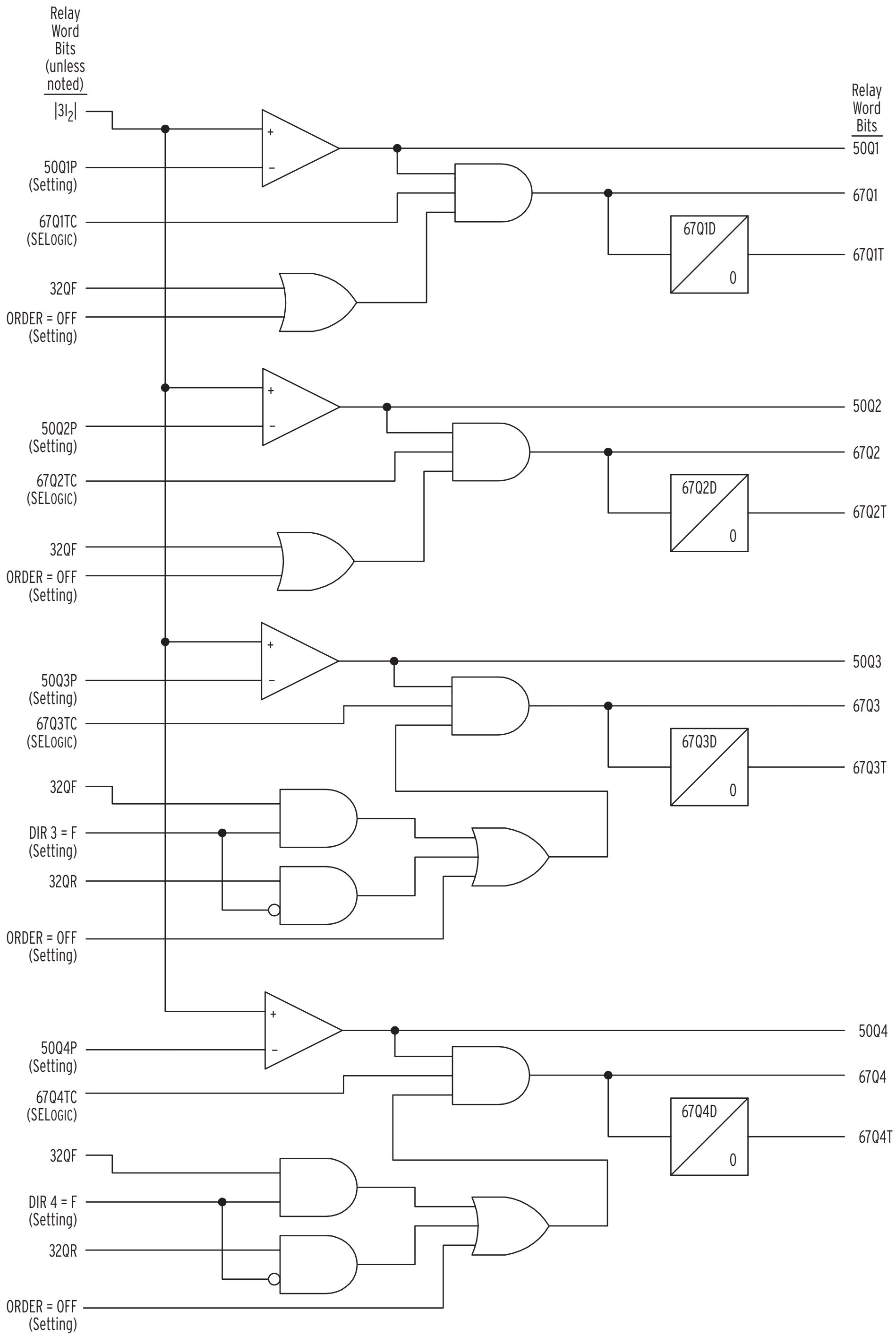


Figure 4.23 Levels 1–4 Negative-Sequence Instantaneous/Definite-Time Overcurrent Elements With Directional and Torque Control

Time-Overcurrent Elements

Phase Time-Overcurrent Elements

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

Table 4.8 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 4.24*

51PT Element Settings Ranges

The 51PT phase time-overcurrent element has the following settings:

Table 4.9 Phase Time-Overcurrent Element (Maximum Phase) Settings

Setting	Definition	Range
51PP	pickup	OFF, 0.25–16.00 A secondary (5 A nominal phase current inputs, IA, IB, IC) OFF, 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 = Enable electromechanical reset timing N = 1 cycle reset delay
51PTC	SELOGIC control equation torque-control setting	Relay Word bits referenced in *Table 9.5* and *Table 9.6* or set directly to logical 1[a]

[a] SELOGIC control equation torque-control settings (e.g., 51PTC) cannot be set directly to logical 0.

See *Section 9: Settings* for additional time-overcurrent element setting information.

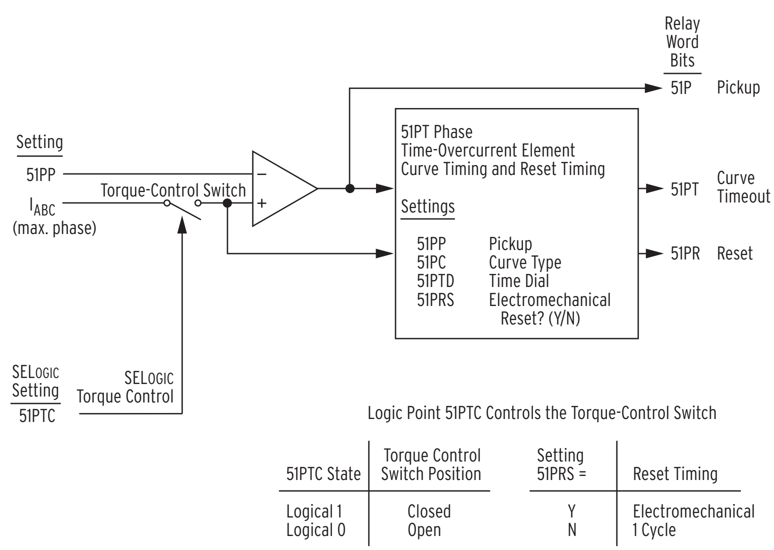


Figure 4.24 Phase Time-Overcurrent Element 51PT

Accuracy

Pickup	±0.05 A secondary and ±3% of setting (5 A nominal phase current inputs, IA, IB, IC) ±0.01 A secondary and ±3% of setting (1 A nominal phase current inputs, IA, IB, IC)
Curve Timing	±1.50 cycles and ±4% of curve time for currents between (and including) 2 and 30 multiples of pickup

51PT Element Logic Outputs

The logic outputs in *Figure 4.24* are the Relay Word bits shown in *Table 4.10*.

Table 4.10 Phase Time-Overcurrent Element (Maximum Phase) Logic Outputs

Relay Word Bit	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. See *Section 5: Trip and Target Logic*.
51PT	Phase time-overcurrent element is timed out on its curve.	Tripping and other control applications. See *Section 5: Trip and Target Logic*.
51PR	Phase time-overcurrent element is fully reset.	Element reset testing or other control applications.

51PT Element Torque-Control Switch Operation

Torque-Control Switch Closed

The pickup comparator in *Figure 4.24* 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 4.24* 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:

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

resulting 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 4.24*.

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 10.43 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. Where potentials are absent at Terminals VA, VB, VC, set 51PTC = 1 to use this element in a nondirectional mode. See *Overcurrent Directional Control Provided by Torque-Control Settings on page 4.87*.

Reset Timing Details (51PT Element Example)

Refer to *Figure 4.24*.

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

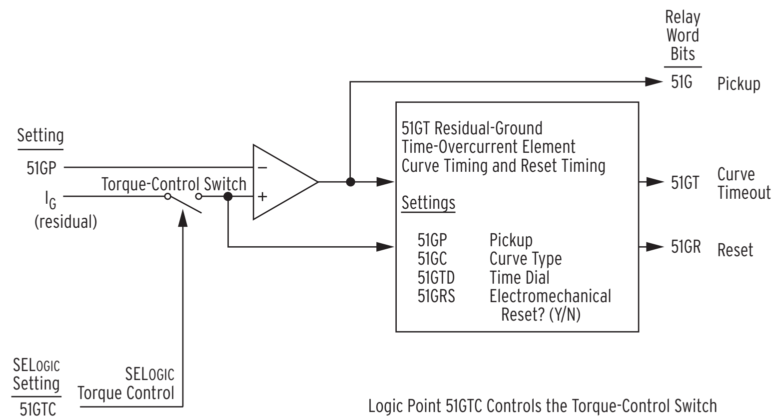
If electromechanical reset timing setting 51PRS = Y, the phase time-overcurrent element reset timing emulates electromechanical reset timing. If maximum phase current, I_{ABC}, goes above pickup setting 51PP (element is timing or already timed out) and then current I_{ABC} goes below 51PP, the element 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 9.3* 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 4.25*, follow the explanation given for *Figure 4.24* in *Phase Time-Overcurrent Elements on page 4.35*, substituting residual-ground current I_G ($I_G = 3I_0 = I_A + I_B + I_C$) for maximum phase current IABC and substituting like settings and Relay Word bits.



51GTC State	Torque Control Switch Position
Logical 1	Closed
Logical 0	Open

Setting 51GRS =	Reset Timing
Y	Electromechanical
N	1 Cycle

Figure 4.25 Residual-Ground Time-Overcurrent Element 51GT

Settings Ranges

Table 4.11 Residual-Ground Time-Overcurrent Element Settings

Setting	Definition	Range
51GP	pickup	OFF, 0.25–16.00 A secondary (5 A nominal phase current inputs, IA, IB, IC) OFF, 0.05–3.20 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 = Enable electromechanical reset timing N = 1-cycle reset delay
51GTC	SELOGIC control equation torque-control setting	Relay Word bits referenced in *Table 9.5* and *Table 9.6* or set directly to logical 1[a]

[a] SELOGIC control equation torque-control settings (e.g., 51GTC) cannot be set directly to logical 0.

If potentials are not applied at Terminals VA, VB, and VC, you can use this element in a directional or nondirectional mode by performing the following:

- To use this element in a directional mode, if polarizing current (Ip) is available, set the torque-control equation to 51GTC = 32GF (for forward direction) or 51GTC = 32GR (reverse direction) and set the ORDER = I.
- To use this element in a nondirectional mode set the ORDER = OFF.

See *Section 9: Settings* for additional time-overcurrent element settings information.

Accuracy

Pickup	±0.05 A secondary and ±3% of setting (5 A nominal phase current inputs, IA, IB, IC) ±0.01 A secondary and ±3% of setting (1 A nominal phase current inputs, IA, IB, IC)
Curve Timing	±1.50 cycles and ±4% of curve time for currents between (and including) 2 and 30 multiples of pickup

Negative-Sequence Time-Overcurrent Element

To understand the operation of *Figure 4.26*, follow the explanation given for *Figure 4.24* in *Phase Time-Overcurrent Elements on page 4.35*, substituting negative-sequence current $3I_2$ [$3I_2 = I_A + a^2 \bullet I_B + a \bullet I_C$ (ABC rotation), $3I_2 = I_A + a^2 \bullet I_C + a \bullet I_B$ (ACB rotation), where $a = 1 \angle 120°$ and $a^2 = 1 \angle -120°$] for maximum phase current I_{ABC} and like settings and Relay Word bits.

IMPORTANT: See Setting Negative-Sequence Elements on page 4.88 for information on setting negative-sequence overcurrent elements.

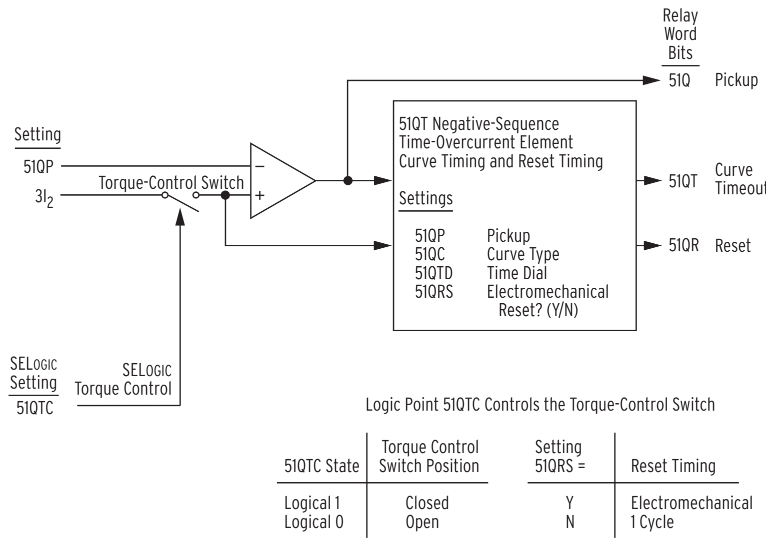


Figure 4.26 Negative-Sequence Time-Overcurrent Element 51QT

Settings Ranges

Table 4.12 Negative-Sequence Time-Overcurrent Element Settings

Setting	Definition	Range
51QP	pickup	OFF, 0.25–16.00 A secondary (5 A nominal phase current inputs, IA, IB, IC) OFF, 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 = Enable electromechanical reset timing N = 1-cycle reset delay
51QTC	SELOGIC control equation torque-control setting	Relay Word bits referenced in *Table 9.5* and *Table 9.6* or set directly to logical 1[a]

[a] SELOGIC control equation torque-control settings (e.g., 51QTC) cannot be set directly to logical 0.

Where potentials are absent at Terminals VA, VB, VC, set 51QTC = 1 to use this element in a nondirectional mode. See *Section 9: Settings* for additional time-overcurrent element setting information.

Accuracy

Pickup	±0.05 A secondary and ±3% of setting (5 A nominal phase current inputs, IA, IB, IC) ±0.01 A secondary and ±3% of setting (1 A nominal phase current inputs, IA, IB, IC)
Curve Timing	±1.50 cycles and ±4% of curve time for currents between (and including) 2 and 30 multiples of pickup

Voltage Elements

Enable SEL-311L voltage elements by making the Enable setting:

EVOLT = **Y**

Voltage Values

Voltage elements operate from the voltage values shown in *Table 4.13*.

Table 4.13 Voltage Values Used by Voltage Elements

Voltage	Description
V_A	A-phase voltage, from SEL-311L rear-panel voltage input **VA**
V_B	B-phase voltage, from SEL-311L rear-panel voltage input **VB**
V_C	C-phase voltage, from SEL-311L 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
$3V_0$	Residual voltage (**VA** + **VB** + **VC**)
V_2	Negative-sequence voltage
V_1	Positive-sequence voltage
V_S	Synchronism-check voltage, from SEL-311L rear-panel voltage input **VS**[a]

[a] Voltage V_S is used in the synchronism-check elements described in the following section Synchronism-Check Elements on page 4.44. Voltage V_S is also used in the three voltage elements described at the end of Table 4.14 and in Figure 4.29. These voltage elements are **independent** of the synchronism-check elements, even though voltage V_S is used in both.

Voltage Element Settings

Table 4.14 lists available voltage elements and the corresponding voltage inputs and settings ranges for the SEL-311L (see *Figure 4.1* for voltage input connection).

Table 4.14 Voltage Elements Settings and Settings Ranges (Sheet 1 of 2)

Voltage Element (Relay Word Bits)	Operating Voltage	Pickup Setting/Range	See Figure
27A	V_A	27P	*Figure 4.27*
27B	V_B	OFF, 0.00–150.00 V secondary	
27C	V_C		
3P27	27A * 27B * 27C		
59A	V_A	59P	
59B	V_B	OFF, 0.00–150.00 V secondary	
59C	V_C		
3P59	59A * 59B * 59C		
27AB	V_{AB}	27PP	*Figure 4.28*
27BC	V_{BC}	OFF, 0.00–260.00 V secondary	
27CA	V_{CA}		

Table 4.14 Voltage Elements Settings and Settings Ranges (Sheet 2 of 2)

Voltage Element (Relay Word Bits)	Operating Voltage	Pickup Setting/Range	See Figure
59AB	V_{AB}	59PP	
59BC	V_{BC}	OFF, 0.00–260.00 V secondary	
59CA	V_{CA}		
59N1	$3V_0$ ($V_A + V_B + V_C$)	59N1P OFF, 0.00–150.00 V secondary	
59N2	$3V_0$ ($V_A + V_B + V_C$)	59N2P OFF, 0.00–150.00 V secondary	
59Q	V_2 1/3 ($V_A + a^2V_B + aV_C$)	59QP OFF, 0.00–100.00 V secondary	
59V1	V_1 1/3 ($V_A + aV_B + a^2V_C$)	59V1P OFF, 0.00–150.00 V secondary	
27S	V_S	27SP OFF, 0.00–150.00 V secondary	*Figure 4.29*
59S	V_S	59SP OFF, 0.00–150.00 V secondary	

Accuracy

Pickup	±1 V and ±5% of setting
Transient Overreach	<5% of setting

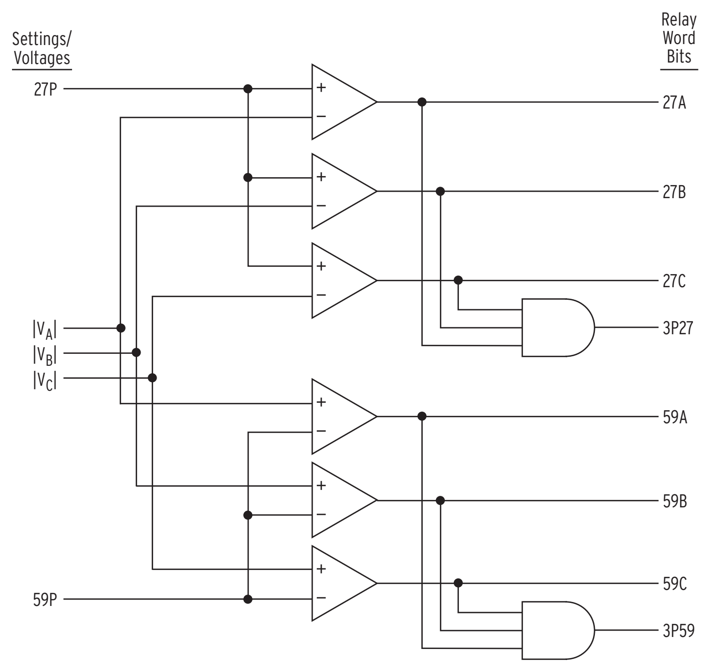


Figure 4.27 Single-Phase and Three-Phase Voltage Elements

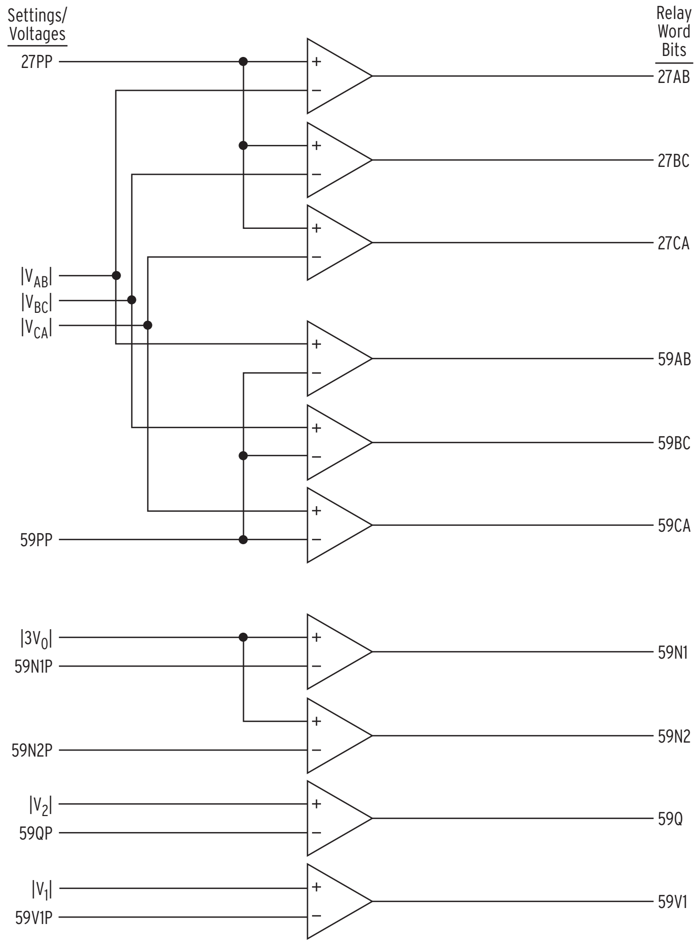


Figure 4.28 Phase-to-Phase and Sequence Voltage Elements

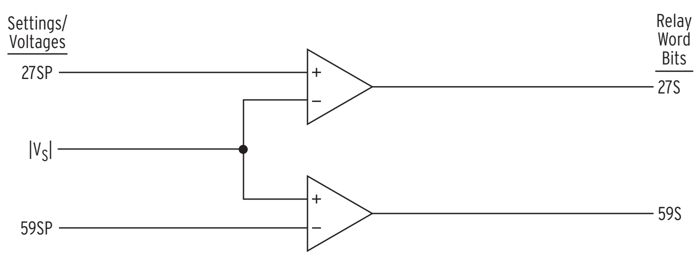


Figure 4.29 Channel V_S Voltage Elements

Voltage Element Operation

Note that the voltage elements in *Table 4.14* and *Figure 4.27–Figure 4.29* 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.

EXAMPLE 4.1 Undervoltage Element Operation

Refer to Figure 4.27 (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 4.27 are the following Relay Word bits:

27A = 1 (logical 1), if V_A < pickup setting 27P

27A = 0 (logical 0), if $V_A \geq$ pickup setting 27P

27B = 1 (logical 1), if V_B < pickup setting 27P

27B = 0 (logical 0), if VB ≥ pickup setting 27P

27C = 1 (logical 1), if VC < pickup setting 27P

27C = 0 (logical 0), if VC ≥ 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)

3P27 = 0 (logical 0), if at least one of the Relay Word bits 27A, 27B, or 27C is deasserted (e.g., 27A = 0)

EXAMPLE 4.2 Overvoltage Element Operation

Refer to Figure 4.27 (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 4.27 are the following Relay Word bits:

59A = 1 (logical 1), if V_A > pickup setting 59P

59A = 0 (logical 0), if VA ≤ pickup setting 59P

59B = 1 (logical 1), if VB > pickup setting 59P

59B =0 (logical 0), if VB ≤ pickup setting 59P

59C =1 (logical 1), if VC > pickup setting 59

59C =0 (logical 0), if VC ≤ 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)

3P59 =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 2.18 and *Figure 2.19* show examples where synchronism check can be applied. Synchronism-check voltage input **VS** is connected to a potential transformer secondary on one side of the circuit breaker, on any desired phase or between any two phases. The other synchronizing phase (**VA**, **VB**, **VC**, **VAB**, **VBC**, or **VCA**) taken from a potential transformer secondary on the other side of the circuit breaker is selected by setting SYNCP.

The two synchronism-check elements use the same voltage magnitude window (to ensure healthy voltage) and slip frequency settings (see *Figure 4.30*). They have separate angle settings (see *Figure 4.31*).

If the voltages are static (voltages not slipping with respect to one another) or setting TCLOSD = OFF, the two synchronism-check elements operate as shown in the top of *Figure 4.31* 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 4.31*. The angle difference is compensated by the 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

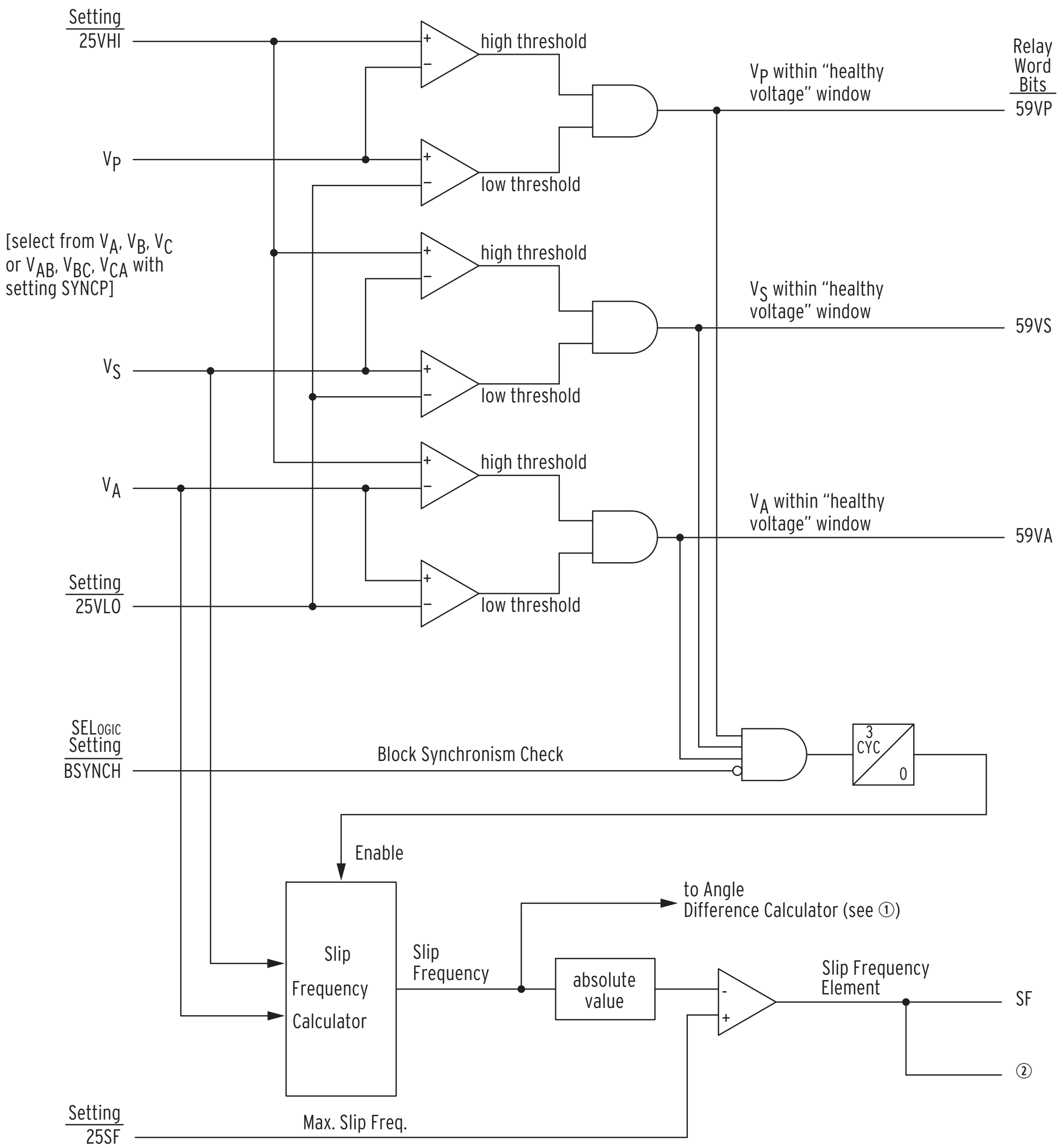
NOTE: Setting 25ANG1 = 0 or 25ANG2 = 0 disables the respective synchronism-check element.

Table 4.15 Synchronism-Check Elements Settings and Settings Ranges

Setting	Definition	Range
25VLO	low voltage threshold for "healthy voltage" window	0.00–150.00 V secondary
25VHI	high voltage threshold for "healthy voltage" window	0.00–150.00 V secondary
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	synchronizing phase	VA, VB, VC, VAB, VBC, or VCA
TCLOSD	breaker close time for angle compensation	OFF, 1.00–60.00 cycles
BSYNCH	SELOGIC control equation that blocks synchronism check	Relay Word bits referenced in *Table 9.5* and *Table 9.6*

Accuracy

Voltage Pickup	±1 V and ±5% of setting
Voltage Transient Overreach	<5% of setting
Slip Pickup	±0.003 Hz
Angle Pickup	±4°



① Bottom of Figure 4.31; ② to Figure 4.31

Figure 4.30 Synchronism-Check Voltage Window and Slip Frequency Elements

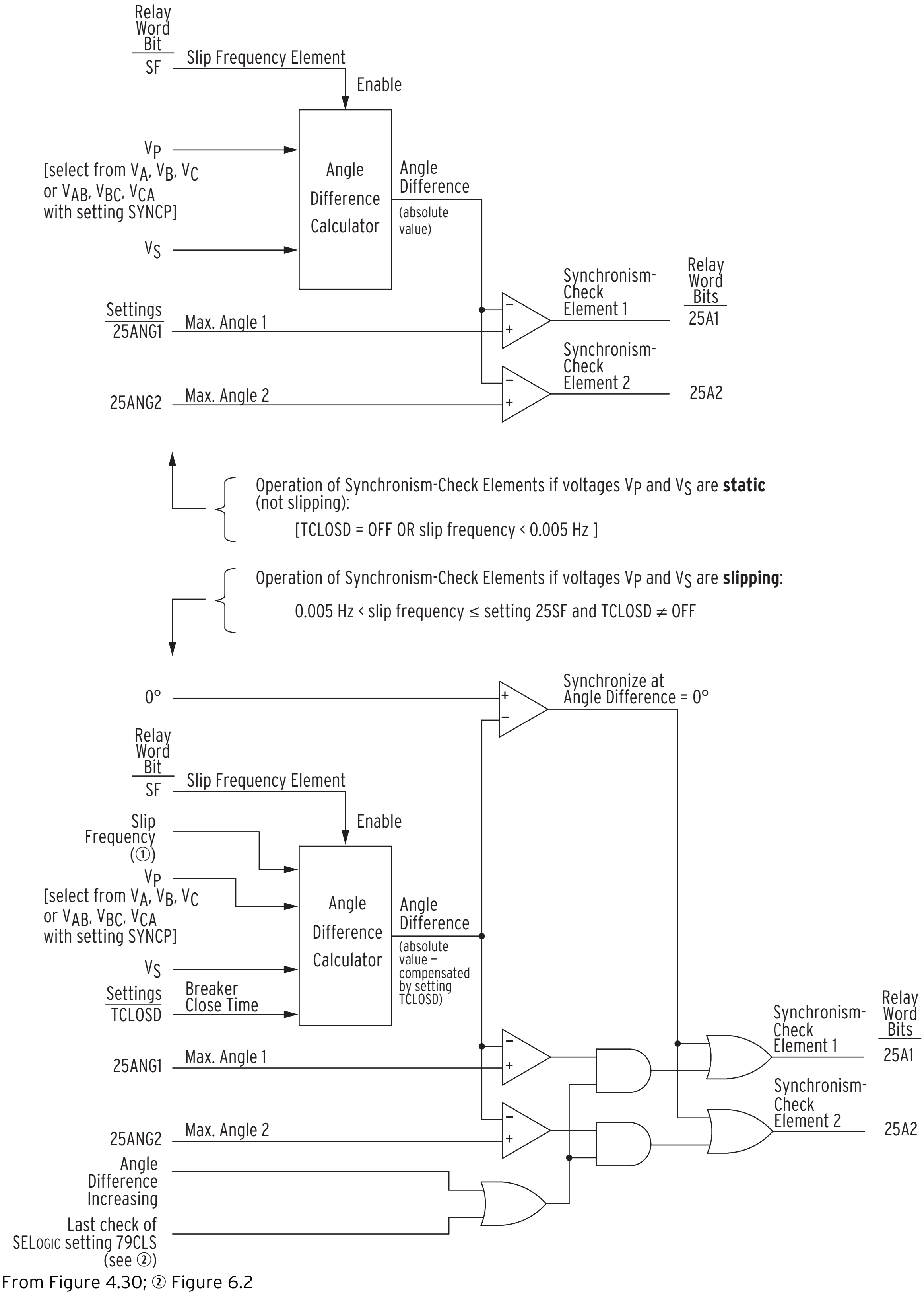


Figure 4.31 Synchronism-Check Elements

Synchronism-Check Elements Voltage Inputs

The two synchronism-check elements use voltage inputs V_P and V_S for both elements:

V_P

Phase input voltage (V_A, V_B, V_C, V_{AB}, V_{BC}, or V_{CA}), designated by setting SYNCP (e.g., if SYNCP = VB, then $V_P = V_B$)

V_S

Synchronism-check voltage, from SEL-311L 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** 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 1.4*, *Figure 2.18*, and *Figure 2.19*).

System Frequencies Determined from Voltages V_A and V_S

To determine slip frequency, you need to determine the system frequencies on both sides of the circuit breaker. Voltage V_S determines the frequency on one side. Voltage V_A determines the frequency on the other side.

Synchronism-Check Elements Operation

Refer to *Figure 4.30* and *Figure 4.31*.

Voltage Window

Refer to *Figure 4.30*.

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

59VP

indicates that voltage V_P is within voltage window setting limits 25VLO and 25VHI

59VS

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

As discussed previously, voltage V_A determines the frequency on the voltage V_P side of the circuit breaker. Voltage V_A is also compared against voltage limits 25VLO and 25VHI to ensure "healthy voltage" for frequency determination, with corresponding Relay Word bit output 59VA. If V_P is a phase-to-phase voltage, V_A is multiplied internally by √ 3 for the 25VLO and 25VHI checks.

Other Uses for Voltage Window Elements

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

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

Block Synchronism-check Conditions

Refer to *Figure 4.30*.

The synchronism-check element slip frequency calculator runs if voltages V_A, V_P, and V_S are "healthy" (59VA, 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 = **IN101** (input **IN101** connected to a breaker auxiliary 52a contact)

BSYNCH = **!IN101** (input **IN101** connected to a breaker auxiliary 52b contact)

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

BSYNCH = **... + TRIP**

Slip Frequency Calculator

Refer to *Figure 4.30*.

The synchronism-check element Slip Frequency Calculator in *Figure 4.30* 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:

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

f_P = frequency of voltage V_P [determined from VA]
(in units of Hz = cycles/second)

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 4.30*, 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.

Angle Difference Calculator

The synchronism-check element Angle Difference Calculator in *Figure 4.31* 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 4.31*.

If the slip frequency is less than or equal to 0.005 Hz or TCLOSD = OFF, 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:

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

Voltages V_P and V_S Are "Slipping"

Refer to bottom of *Figure 4.31*.

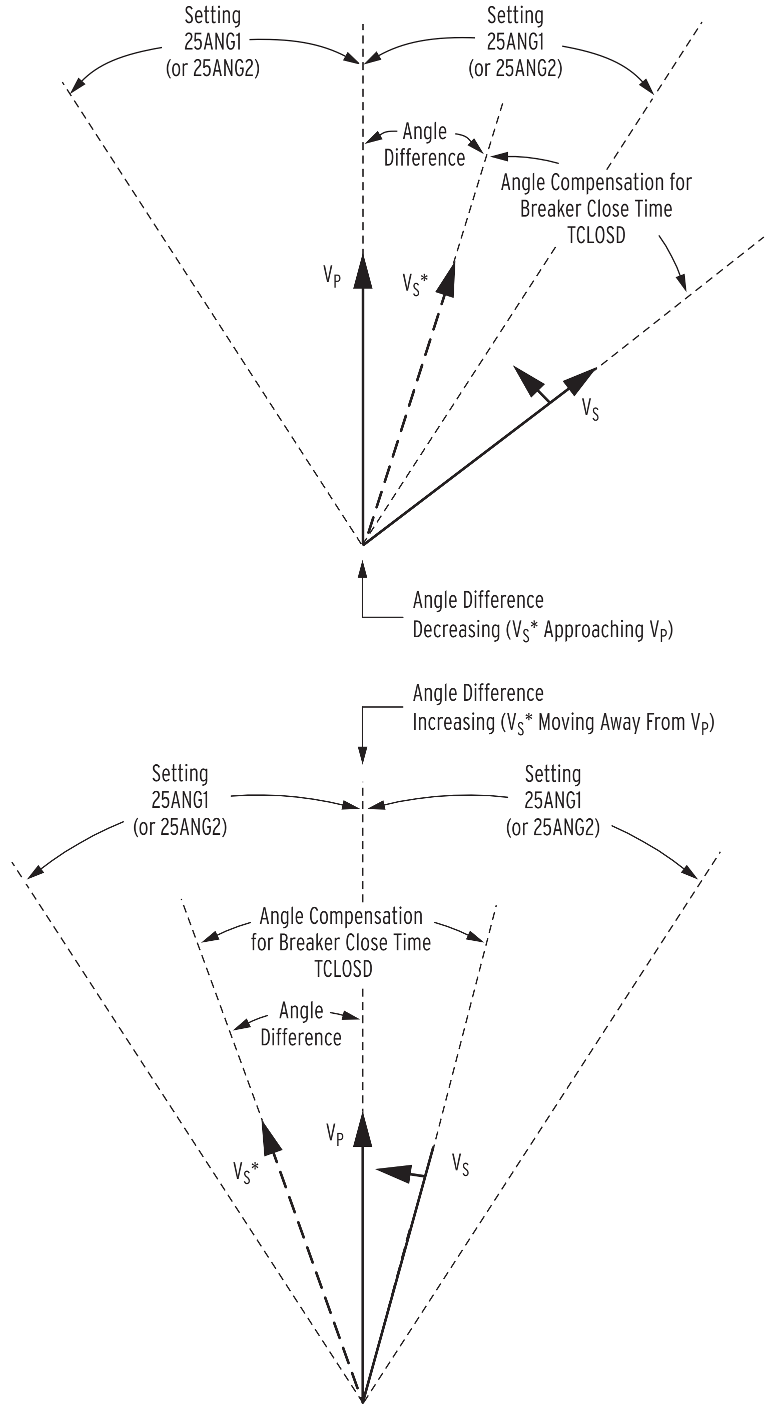


Figure 4.32 Angle Difference Between V_P and V_S Compensated by Breaker Close Time ($f_P < f_S$ and V_P Shown as Reference in This Example)

If the slip frequency is greater than 0.005 Hz, the Angle Difference Calculator takes the breaker close time into account with breaker close time setting TCLOSD (set in cycles; see *Figure 4.32*). The Angle Difference Calculator calculates the Angle Difference between voltages V_P and V_S, compensated with the breaker close time:

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

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

Refer to bottom of *Figure 4.31* and *Figure 4.32*.

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

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

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:

$$\begin{aligned}\text{Angle Difference} &= |(\angle V_P - \angle V_S) + [(f_P - f_S) \bullet \text{TCLOSD} \bullet (1\ \text{second}/60\ \text{cycles}) \bullet (360°/\text{slip cycle})]| \\ &= |(\angle V_P - \angle V_S) + [-0.10 \bullet 0.167 \bullet 360°]| \\ &= |(\angle V_P - \angle V_S) - 6°|\end{aligned}$$

NOTE: The angle compensation in Figure 4.32 appears much greater than six degrees. Figure 4.32 is for general illustrative purposes only.

During the breaker close time (TCLOSD), the voltage angle difference between voltages V_P and V_S changes by 6 degrees. This six-degree angle compensation is applied to voltage V_S, resulting in derived voltage V_S*, as shown in *Figure 4.32*.

The top of *Figure 4.32* 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). When the circuit breaker main contacts finally close, V_S is in phase with V_P, minimizing system shock.

The bottom of *Figure 4.32* 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). 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 4.31*) assert to logical 1 for the conditions explained in the following text.

Voltages V_P and V_S Are "Static"

Refer to top of *Figure 4.31*.

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

Voltages V_P and V_S Are "Slipping"

Refer to bottom of *Figure 4.31*. If V_P and V_S are "slipping" with respect to one another, 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 4.32* 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 4.32* shows the Angle Difference increasing–V_S* is moving away from V_P. V_S* was in phase with V_P (Angle Difference = 0 degrees), but has now moved past V_P. If the Angle Difference is increasing, but the Angle Difference is still less than maximum angle settings 25ANG1 or 25ANG2, then corresponding synchronism-check elements 25A1 or 25A2 assert to logical 1.

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

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

   Refer to the bottom of *Figure 6.2*. 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 6.3*).

   Refer to the top of *Figure 6.2*. 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 4.32*. 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 4.31* becomes less restrictive at the "instant" timer 79CLSD is going to time out (or making 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 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 6.1*. Element 25A2 operates similarly.

Synchronism-Check Applications for Automatic Reclosing and Manual Closing

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

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

79CLS = **25A1 + ...** (see *Figure 6.2*)

Set 25ANG2 = 25° and use the resultant synchronism-check element in manual close logic to supervise manual closing (for example, assert IN106 to initiate manual close).

CL = **IN106 * (25A2 + ...)** (see *Figure 6.1*)

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).

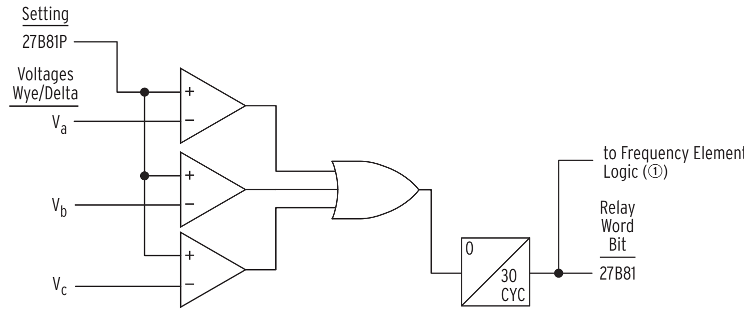
A single output contact (e.g., OUT102 = CLOSE) can provide the close function for both automatic reclosing and manual closing (see *Figure 6.1* logic output).

Frequency Elements

Six frequency elements are available. The desired number of frequency elements are enabled with the E81 enable setting:

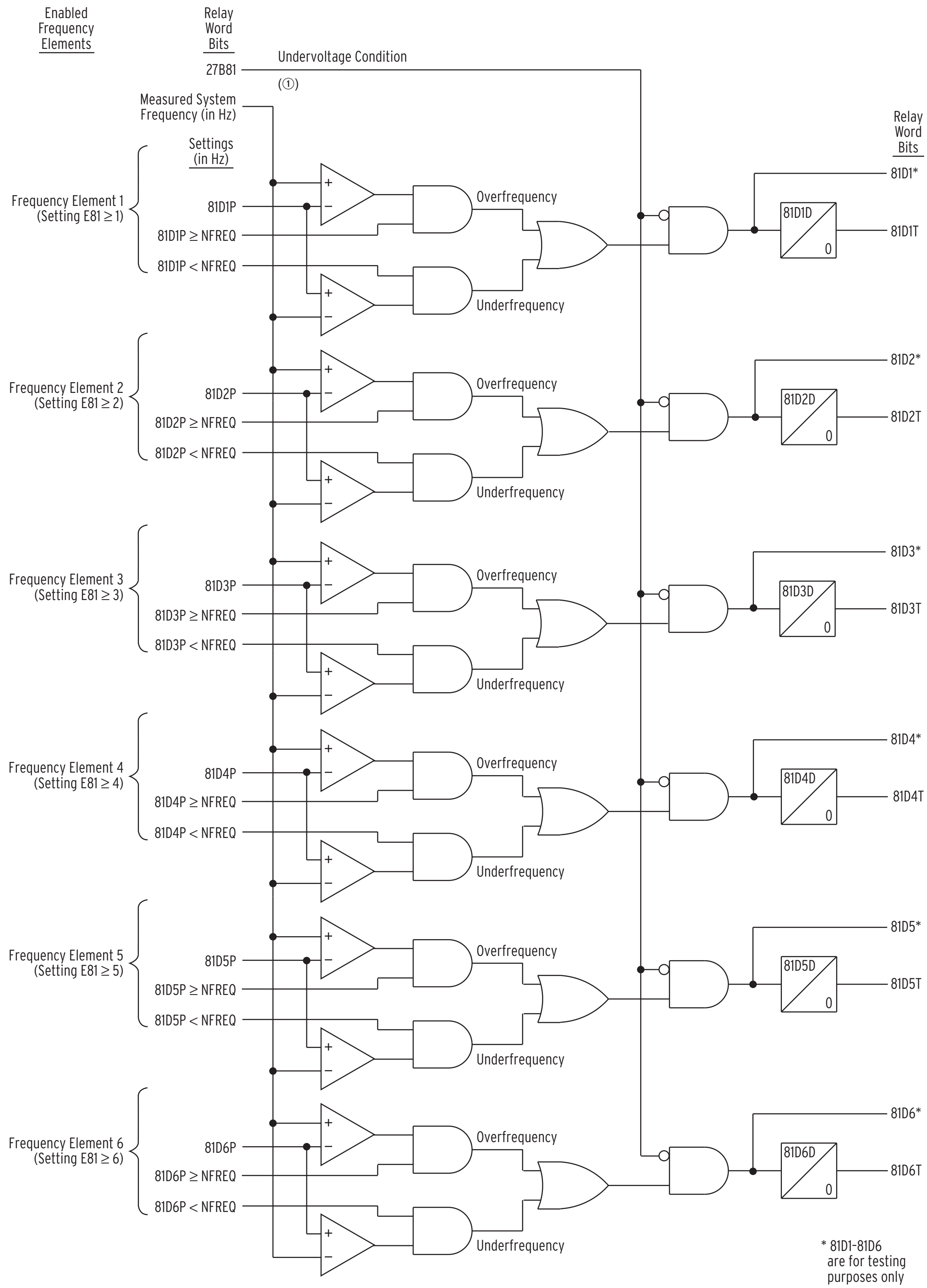
E81 = **N** (none), 1 through 6 as shown in *Figure 4.34*. Frequency is determined from the voltage connected to voltage terminals VA–N.

Frequency Element Settings



① Figure 4.34

Figure 4.33 Undervoltage Block for Frequency Elements



① From Figure 4.33

Figure 4.34 Levels 1–6 Frequency Elements

NOTE: Frequency is determined by a zero-crossing technique on voltage VA. If voltage waveform offset occurs (e.g., because of a fault), then the frequency measurement can be disturbed for a few cycles. A 5-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 4.16 Frequency Elements Settings and Settings Ranges

Setting	Definition	Range
27B81P	undervoltage frequency element block	20.00–150.00 V secondary (wye-connected voltages)
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

Accuracy

Pickup	±0.01 Hz
Timer	±0.25 cycles and ±0.1% of setting

Create Over- and Underfrequency Elements

Refer to *Figure 4.34*.

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

Refer to *Figure 4.34*.

Overfrequency Element Operation

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

81D1 = logical 0 (instantaneous element)

81D1T = logical 0 (time-delayed element)

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

81D1 = logical 1 (instantaneous element)

81D1T = logical 1 (time-delayed element)

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

Underfrequency Element Operation

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

81D2 = logical 1 (instantaneous element)

81D2T = logical 1 (time-delayed element)

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

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

81D2 = logical 0 (instantaneous element)

81D2T = logical 0 (time-delayed element)

Frequency Element Voltage Control

Refer to *Figure 4.33* and *Figure 4.34*.

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

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 a desired logic scheme, using SELOGIC control equations. Even though frequency elements are enabled, the frequency element outputs (Relay Word bits 81D1T–81D6T) do not have to be used.

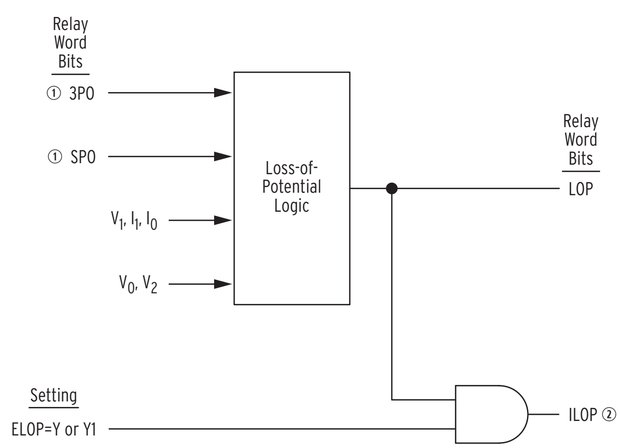
Frequency Element Uses

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

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

Loss-of-Potential Logic

The loss-of-potential (LOP) logic operates as shown in *Figure 4.35*.



① From Figure 5.8; ② to Figure 4.4–Figure 4.12, Figure 4.44, Figure 4.45, Figure 4.46, Figure 4.49, and Figure 4.50

Figure 4.35 Loss-of-Potential Logic

Inputs into the LOP logic are:

- 3PO three-pole open condition (indicates circuit breaker open condition see *Figure 5.7*)
- V_1 positive-sequence voltage (V secondary)
- I_1 positive-sequence current (A secondary)
- V_0 zero-sequence voltage (V secondary)
- I_0 zero-sequence current (A secondary)
- V_2 negative-sequence voltage (V secondary)

The circuit breaker has to be closed (Relay Word bit 3PO = logical 0) for the LOP logic to operate.

Loss-of-potential is declared (Relay Word bit LOP = logical 1) when a 10 percent drop in V_1 is detected, with no corresponding change in I_1 or I_0. If the LOP condition persists for 60 cycles, it latches in. LOP resets (Relay Word bit LOP = logical 0) when all three of the phase voltages return above 40 V secondary, V_0 is less than 5 V secondary, and V_2 is less than 15 percent of V_1.

The loss-of-potential enable setting, ELOP, does not enable or disable the LOP logic. It just routes the LOP Relay Word bit to different logic, as shown in *Figure 4.35* and explained in the remainder of this section.

Note that ILOP disables all distance elements (*Figure 4.4–Figure 4.12*).

LOP is disabled while 3PO or SPO (when APP = 87LSP) is asserted (breaker open). If all three potentials are lost during this time, LOP will not assert when 3PO deasserts (breaker close) because the 10 percent drop in V_1 has already occurred. This is the case for systems using either line-side or bus-side potential transformers. LOP asserts on one or two missing potentials when 3PO deasserts, if phase currents are balanced.

You may provide a SCADA alarm for bus-side potential transformers with the following SELOGIC expression:

SV1 = **3PO**. .

OUT105 = **!3P59 * SV1T + LOP**

See *Figure 4.27*. Relay Word bit 3P59 asserts when A-phase, B-phase, and C-phase voltage magnitudes are greater than setting 59P. Setting 59P should be at least 80 percent of nominal voltage. Relay Word bit 3PO asserts when the circuit breaker is open. Set SV1PU longer than the reclose open-time interval. In this expression, if any phase voltage is less than setting 59P while the circuit breaker is open, or LOP is asserted, the expression is true (logical 1).

If the output is asserted, check the relay input potentials before closing the circuit breaker.

In a system using line-side potential transformers, remove SV1T from the expression. The alarm will assert whenever the line is de-energized and will clear when the circuit breaker is closed if system voltage is normal. If the output is asserted when the circuit breaker is closed, check the relay input potentials.

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), negative-sequence voltage-polarized, zero-sequence voltage-polarized, and positive-sequence voltage-polarized directional elements, plus all distance elements, are disabled by Relay Word bit ILOP (see *Figure 4.44*, *Figure 4.45*, *Figure 4.49*, *Figure 4.50*, and *Figure 4.4–Figure 4.12*). The loss-of-potential condition makes these voltage-polarized directional elements and distance elements unreliable. Thus, they are disabled. The overcurrent elements controlled by these voltage-polarized directional elements are disabled also (unless overridden by conditions explained in the following Setting ELOP = Y discussion).

In *Figure 4.46*, the assertion of ILOP is an additional enable for the channel IP current-polarized directional element. This directional element is not voltage-polarized and is automatically enabled during LOP conditions if ELOP = Y or Y1.

In *Figure 5.10*, if setting ELOP = Y1 and LOP asserts, keying and echo keying in the permissive overreaching transfer trip (POTT) logic are blocked.

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 (see *Figure 4.47*). These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

If setting ELOP = Y1 and a loss-of-potential condition occurs, directional overcurrent elements are blocked.

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-polarized directional elements or any distance elements (as occurs with ELOP = Y or Y1), nor does it enable overcurrent elements set direction forward (as occurs with ELOP = Y).

If setting APP = 87L (SEL-311L is used as a line current differential relay only), setting ELOP is hidden and is internally set to ELOP = N.

Setting EBBPT = Y

The SEL-311L relay provides EBBPT logic to correctly handle busbar voltage throw-over schemes, such as shown in *Figure 4.36*.

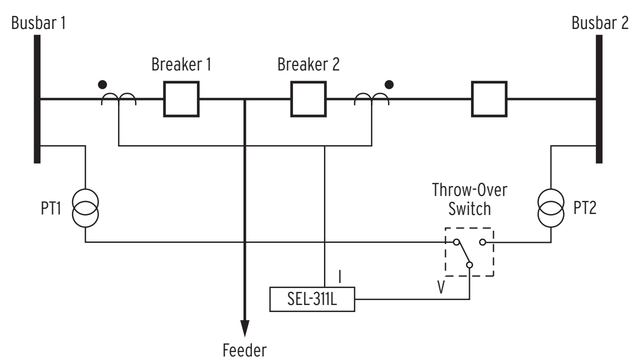


Figure 4.36 Example of Busbar Voltage Switch-Over Scheme

When a fault occurs on the busbar that supplies the SEL-311L with polarizing voltage, all the breakers connected to the busbar trip and the voltage on the bus goes to zero resulting in the relaying polarizing voltage going to zero. With EBBPT = N, LOP logic does not assert because the change in voltage is accompanied by a change in current. However, there may be a case where the current in the relay does not stop flowing because Breaker 2 can still supply the load (the busbar protection only tripped Breaker 1). The result of this is that the distance elements in the SEL-311L have no polarizing voltage and may operate if the load current exceeds the pickup threshold. With EBBPT = Y, LOP logic will assert when the positive-sequence voltage is less than 10 V for three cycles. Therefore, set the Zone 1 phase-to-phase fault detector (50PP1) value greater than the maximum load current. The EBBPT logic is independent of the circuit breaker status and resets when the voltage on all three phases is greater than 40 V.

To enable this new logic in the SEL-311L, the busbar potential transformer logic must be enabled by setting EBBPT = Y. For customers who do not require this scheme, set EBBPT = N.

CCVT Transient Detection Logic

The SEL-311L detects CCVT transients that may cause Zone 1 distance overreach. If CCVT transient blocking is enabled (setting ECCVT = Y), and the relay detects an SIR greater than five during a Zone 1 fault, the relay delays Zone 1 distance element operation for as many as 1.5 cycles, allowing the CCVT output to stabilize.

User settings are not 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-311L 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.

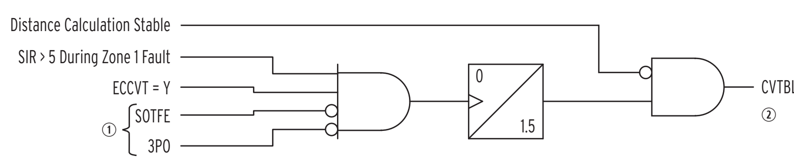
Consider using CCVT transient detection logic when you have either of the following conditions:

- CCVTs with active ferroresonance-suppression circuits (AFSC)
- The possibility of a source-to-line impedance ratio (SIR) greater than 5

CCVT transients may be aggravated when you have:

- A CCVT secondary with a mostly inductive burden
- A low C-value CCVT as defined by the manufacturer

For a description of CCVT transients and transient detection, see the following technical paper available on the SEL website or FaxBack system: *Capacitive Voltage Transformer: Transient Overreach Concerns and Solutions for Distance Relaying*.



① From Figure 5.8; ② to Figure 4.4, Figure 4.7, and Figure 4.10

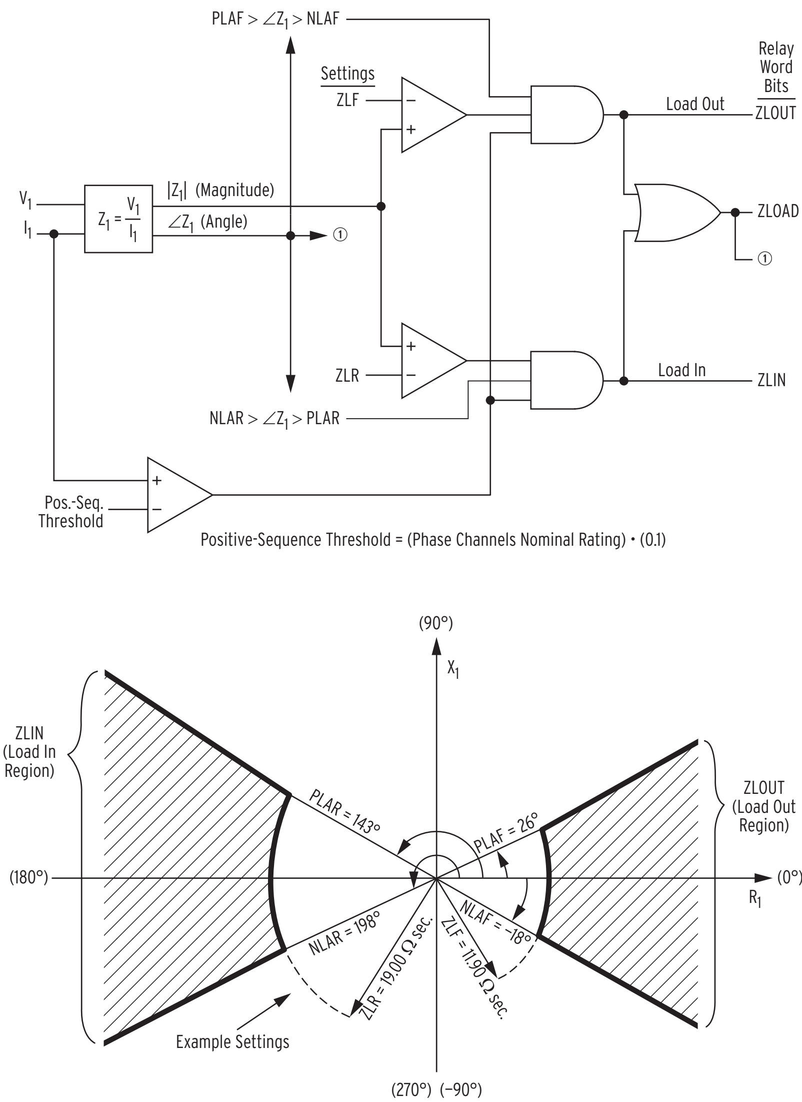
Figure 4.37 CCVT Transient Blocking Logic

Load-Encroachment Logic

The load-encroachment logic (see *Figure 4.38*) and settings are enabled/ disabled with setting ELOAD (= Y or N).

If setting APP = 87L, then setting ELOAD is hidden and is internally set to ELOAD = N.

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 4.50*), which may assert for three-phase load. The distance elements, M1P–M4P, will not operate without directional control. Set !ZLOAD in the phase-overcurrent torque-control equation to block phase-overcurrent operation.



① To Figure 4.50

Figure 4.38 Load-Encroachment Logic With Example Settings

A positive-sequence impedance calculation (Z1) is made in the load-encroachment logic in *Figure 4.38*. 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 (I1) is greater than the Positive-Sequence Threshold shown in *Figure 4.38*. For a balanced load condition, I1 = phase current magnitude.

Forward load (load flowing out) lies within the hatched region labeled ZLOUT. Relay Word bit ZLOUT asserts to logical 1 when the load lies within this hatched region.

Reverse load (load flowing in) lies within the hatched region labeled ZLIN. Relay Word bit ZLIN asserts to logical 1 when the load lies within this hatched region.

Relay Word bit ZLOAD is the OR combination of ZLOUT and ZLIN:

ZLOAD = **ZLOUT + ZLIN**

Settings Ranges

Refer to *Figure 4.38* and *Table 4.17*.

Table 4.17 Load-Encroachment Logic Settings Ranges

Setting	Description and Range
ZLF	Forward Minimum Load Impedance; corresponding to maximum load flowing out
ZLR	Reverse Minimum Load Impedance; corresponding to maximum load flowing in 0.05–64.00 Ω secondary (5 A nominal phase current inputs, IA, IB, IC) 0.25–320.00 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:

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

Step 1. Start with maximum forward load:

a. 800 MVA • (1/3) = 267 MVA per phase

b. 230 kV • (1/ √ 3) = 132.8 kV line-to-neutral

c. 267 MVA • (1/132.8 kV) • (1000 kV/MV) = 2010 A primary

d. 2010 A primary • (1/CT ratio)
= 2010 A primary • (1 A secondary/400 A primary)
= 5.03 A secondary

e. 132.8 kV • (1000 V/kV) = 132800 V primary

f. 132800 V primary • (1/PT ratio)
= 132800 V primary • (1 V secondary/2000 V primary)
= 66.4 V secondary

Step 2. Now, calculate the equivalent secondary impedance:

a. 66.4 V secondary/5.03 A secondary = 13.2 Ω secondary

This Ω secondary value can be calculated more expediently with the following equation:

b. [(line-line voltage in kV)^2 • (CT ratio)]/[(3-phase load in MVA) • (PT ratio)]

Again, for the maximum forward load:

c. [(230)^2 • (400)]/[(800) • (2000)] = 13.2 Ω secondary

Step 3. To provide a margin for setting ZLF, multiply by a factor of 0.9:

a. ZLF = 13.2 Ω secondary • 0.9 = 11.90 Ω secondary

Step 4. For the maximum reverse load:

a. [(230)^2 • (400)]/[(500) • (2000)] = 21.1 Ω secondary

Again, to provide a margin for setting ZLR:

b. ZLR = 21.1 Ω secondary • 0.9 = 19.00 Ω secondary

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 a Phase Time-Overcurrent

Again, from *Figure 4.38*:

ZLOAD = **ZLOUT + ZLIN**

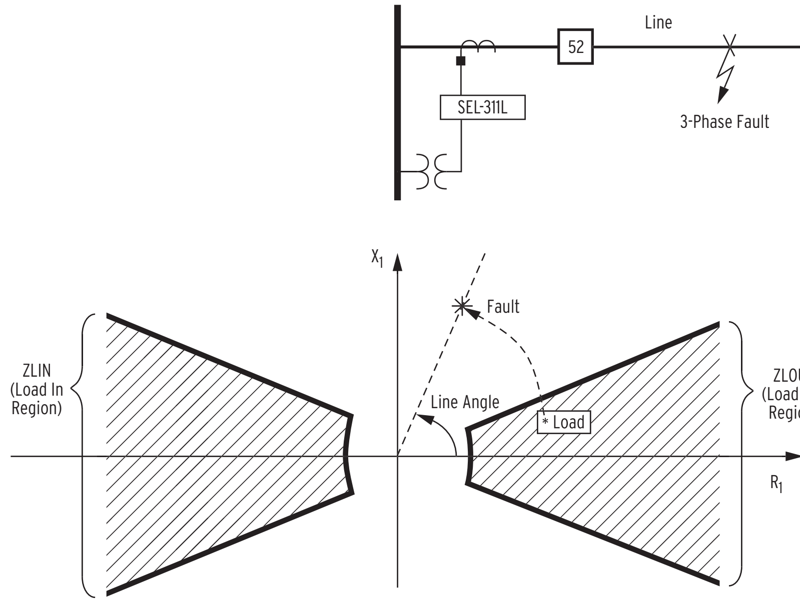


Figure 4.39 Migration of Apparent Positive-Sequence Impedance for a Fault Condition

Refer to *Figure 4.39*. In a load condition, the apparent positive-sequence impedance is within the ZLOUT area, resulting in:

ZLOAD = **ZLOUT + ZLIN** = logical 1 + ZLIN = logical 1

If a three-phase fault occurs, the apparent positive-sequence impedance moves outside the ZLOUT area (and stays outside the ZLIN area, too), resulting in:

ZLOAD = **ZLOUT + ZLIN =** logical 0 + logical 0 = logical 0

Refer to *Figure 4.24*. To prevent phase time-overcurrent element 51PT from operating for high load conditions, make the following SELOGIC control equation torque-control setting:

51PTC = **!ZLOAD**

For a load condition (ZLOAD = logical 1), phase time-overcurrent element 51PT cannot operate with this torque-control setting (regardless of the phase current level):

51PTC = **!(logical 1)** = NOT(logical 1) = logical 0

For a fault condition (ZLOAD = logical 0), phase time-overcurrent element 51PT can operate:

51PTC = **!ZLOAD** = !(logical 0) = NOT(logical 0) = logical 1

Use SEL-321 Relay Application Guide for the SEL-311L

The load-encroachment logic and settings in the SEL-311L are the same as those in the SEL-321. Refer to *Application Guide 93-10: SEL-321 Relay Load-Encroachment Function Setting Guidelines* for applying the load-encroachment logic in the SEL-311L.

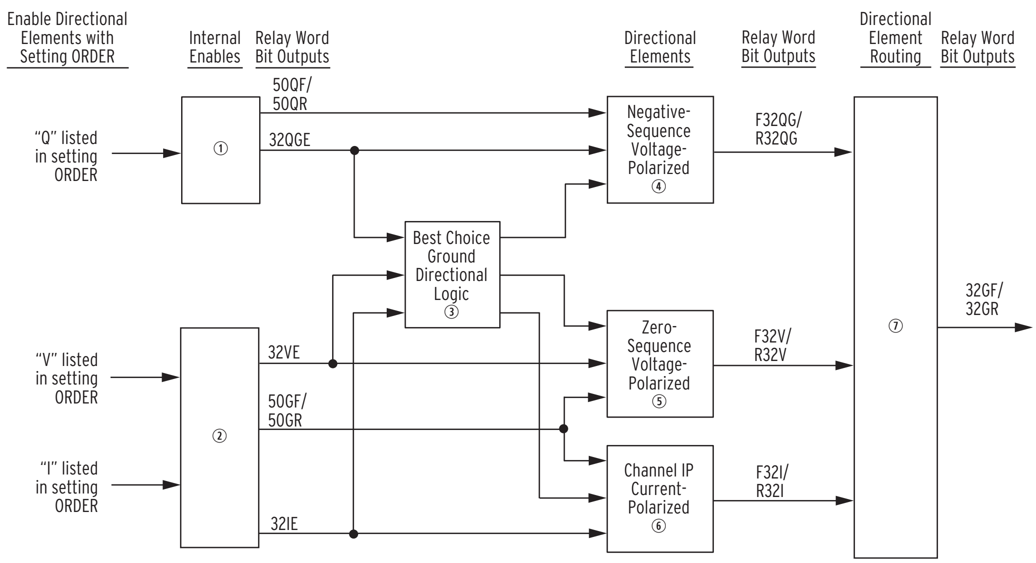
Ground Distance and Residual-Ground Overcurrent Directional Logic

Setting E32 configures directional control for distance and overcurrent elements. Setting E32 and other directional control settings are described in *Directional Control Settings on page 4.79*.

If the correct voltage is present at terminals **VA**, **VB**, and **VC**, 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 IP current-polarized directional element

If voltages are not present at terminals **VA**, **VB**, and **VC**, only the channel IP current-polarized directional element is available.



① Figure 4.41; ② Figure 4.42; ③ Figure 4.43; ④ Figure 4.44; ⑤ Figure 4.45; ⑥ Figure 4.46; ⑦ Figure 4.47

Figure 4.40 General Logic Flow of Directional Control for Ground Distance and Residual-Ground Overcurrent Elements

Figure 4.40 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 4.40* that setting ORDER enables the directional elements. Set ORDER with any combination of Q, V, and I, or set it to OFF. Setting choices Q, V, and I correspond to directional elements as follows:

- Q (Negative-sequence voltage-polarized directional element)
- V (Zero-sequence voltage-polarized directional element)
- I (Channel IP current-polarized directional element)

The **order** in which 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 discussion on setting ORDER in *Directional Control Settings on page 4.79*.

ORDER = OFF does not form part of a valid combination. Either set ORDER = OFF or set some combination of Q, V, and I.

When setting ORDER = OFF, the ground distance elements are disabled, and the residual-ground overcurrent elements are nondirectional, if they are enabled.

Directional Element Enables

Refer to *Figure 4.40*, *Figure 4.41*, and *Figure 4.42*.

The directional element enables, Relay Word bits 32QGE, 32VE, and 32IE have the following correspondence to the directional elements:

- 32QGE (Negative-sequence voltage-polarized directional element)
- 32VE (Zero-sequence voltage-polarized directional element)
- 32IE (Channel IP current-polarized directional element)

Note that *Figure 4.41* has extra directional element enable 32QE, which is used in the logic that controls phase distance elements (see *Figure 4.49*).

The settings involved with 32QGE, 32VE, and 32IE in *Figure 4.41* and *Figure 4.42* (e.g., settings a2, k2, a0) are explained in *Directional Control Settings*.

Best Choice Ground Directional Element Logic

Refer to *Figure 4.40* and *Figure 4.43*.

Relay Word bits 32QGE, 32VE, and 32IE and setting ORDER are used in the Best Choice Ground Directional Element logic in *Figure 4.43*. The Best Choice Ground Directional Element logic determines the order in which 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.

Directional Elements

Refer to *Figure 4.40*, *Figure 4.44*, *Figure 4.45*, and *Figure 4.46*.

The enable output of Best Choice Ground Directional Element logic in *Figure 4.43* determines which directional element will run.

Additionally, note that if enable setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit ILOP asserts), the negative-sequence voltage-polarized and zero-sequence voltage-polarized directional elements are disabled (see *Figure 4.44* and *Figure 4.45*).

The channel IP current-polarized directional element does not use voltage in making direction decisions, thus a loss-of-potential condition does not disable the element, but rather aids in enabling it. When the internal enable 32IE is asserted, the channel IP current-polarized directional element (*Figure 4.46*) is enabled if enable setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit ILOP asserts).

Refer to *Figure 4.35* and accompanying text for more information on loss-of-potential.

Directional Element Routing

Refer to *Figure 4.40* and *Figure 4.47*.

The directional element outputs are routed to the forward (Relay Word bit 32GF) and reverse (Relay Word bit 32GR) logic points.

Loss-of-Potential

Note in *Figure 4.47* 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 IP current-polarized directional element) is not asserted

then the forward logic point (Relay Word bit 32GF) asserts to logical 1, thus enabling the residual-ground overcurrent elements that are set direction forward. These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

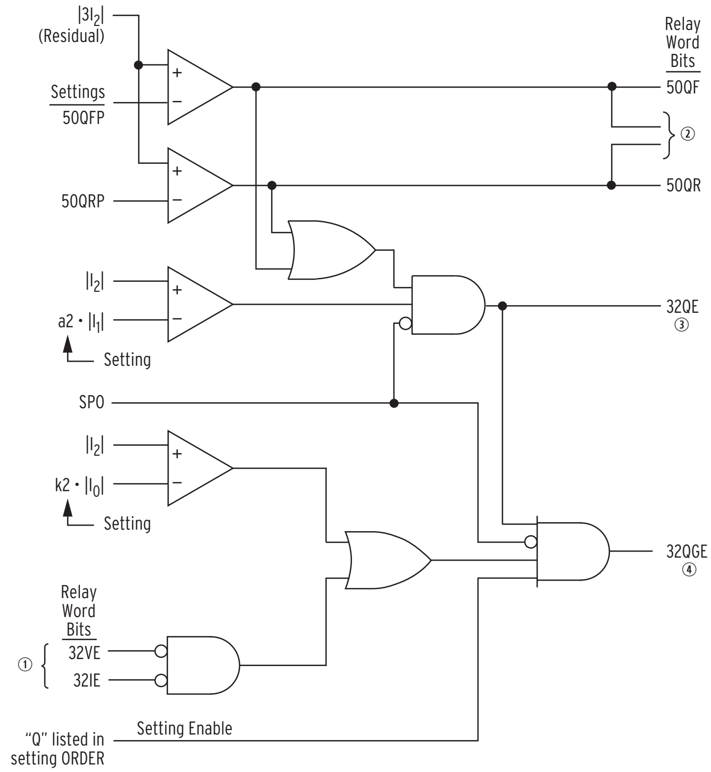
As detailed in *Figure 4.44* and *Figure 4.45*, voltage-based directional elements are disabled during a loss-of-potential condition. Thus, the overcurrent elements that are directionally controlled by these voltage-based directional elements are disabled also. But this disable condition is overridden if setting ELOP = Y.

Refer to *Figure 4.35* and accompanying text for more information on loss-of-potential.

As shown in *Figure 4.4–Figure 4.12*, ILOP also disables all ground distance elements.

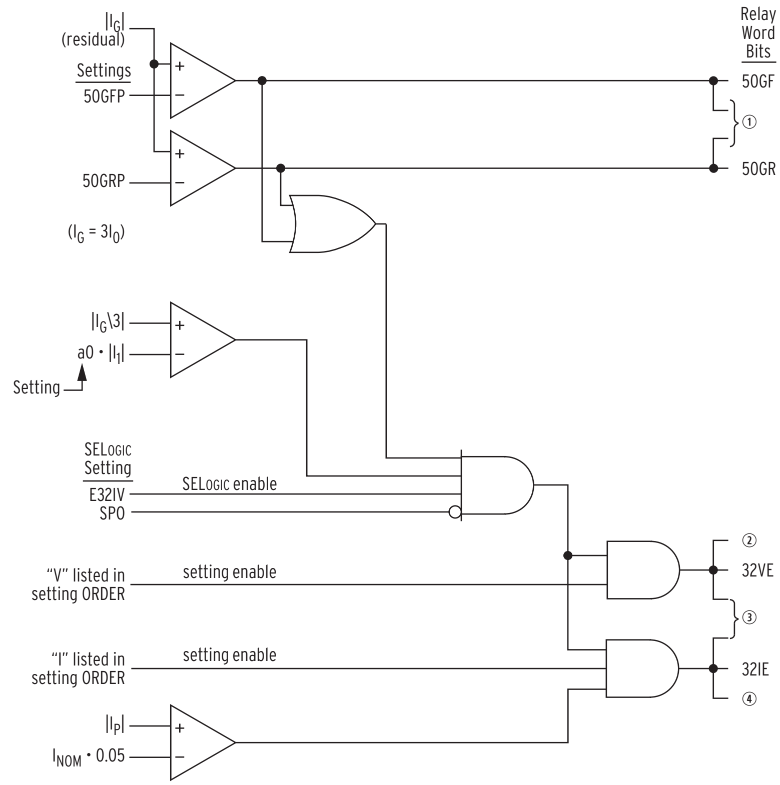
Single-Pole Open

The directional elements are blocked from operation when a single-pole open condition is detected. Note that the single-pole open logic is only enabled when APP = 87LSP.



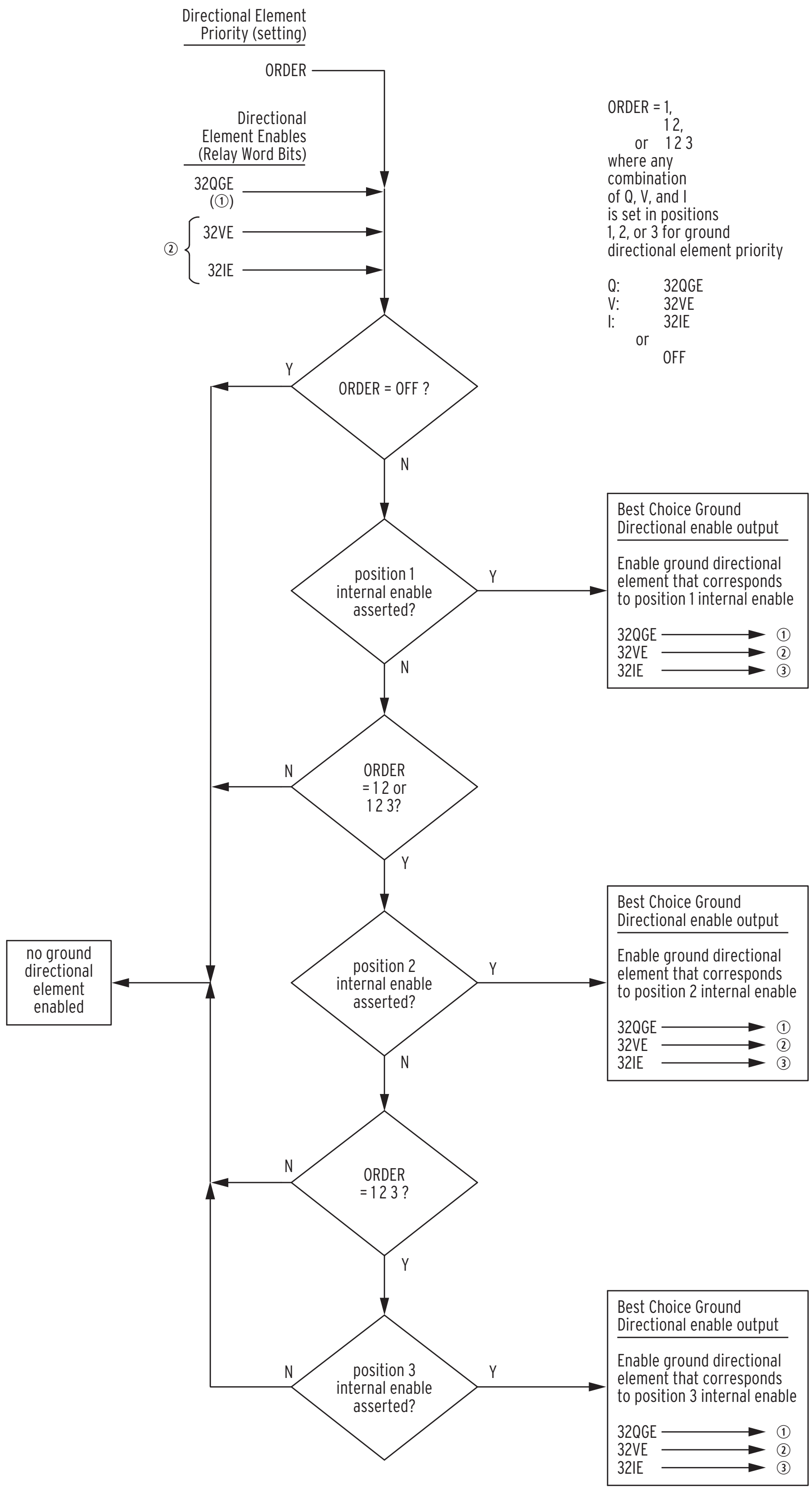
① From Figure 4.42; ② to Figure 4.44 and Figure 4.49; ③ to Figure 4.49; ④ to Figure 4.43 and Figure 4.44

Figure 4.41 Internal Enables (32QE and 32QGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements



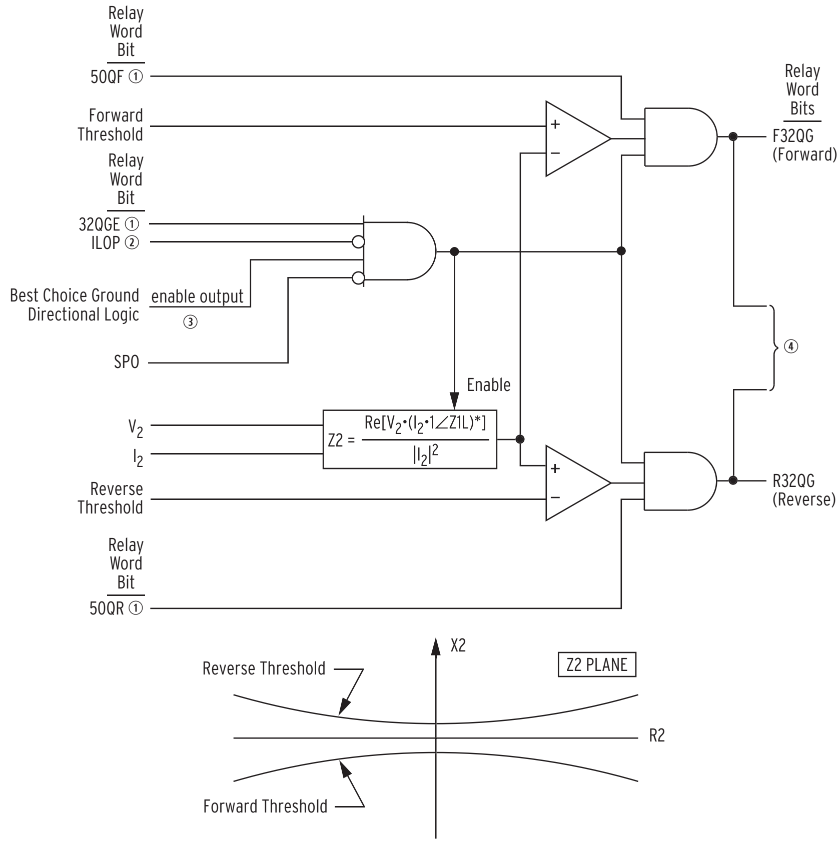
① To Figure 4.45 and Figure 4.46; ② to Figure 4.45; ③ to Figure 4.41 and Figure 4.43; ④ to Figure 4.46

Figure 4.42 Internal Enables (32VE and 32IE) Logic for Zero-Sequence Voltage-Polarized and Channel IP Current-Polarized Directional Elements



① Figure 4.44; ② Figure 4.45; ③ Figure 4.46

Figure 4.43 Best Choice Ground Directional Element Logic



Direction Element Characteristics

Forward Threshold:

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

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

Reverse Threshold:

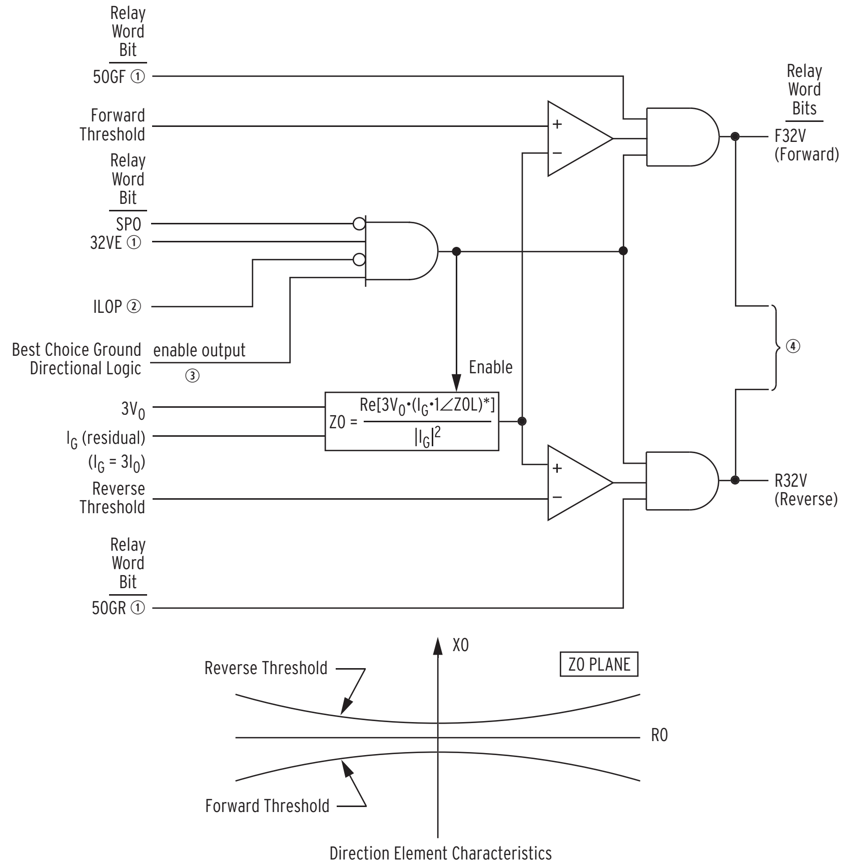
If Z2R Setting ≥ 0, Reverse Threshold = $0.75 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2F Setting < 0, Reverse Threshold = $1.25 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

Note: 1∠Z1L = One Ohm at the Positive-Sequence Line Angle

① From Figure 4.41; ② from Figure 4.35; ③ from Figure 4.43; ④ to Figure 4.47

Figure 4.44 Negative-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual-Ground Overcurrent Elements



Forward Threshold:

If Z0F Setting ≤ 0, Forward Threshold $= 0.75 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

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

Reverse Threshold:

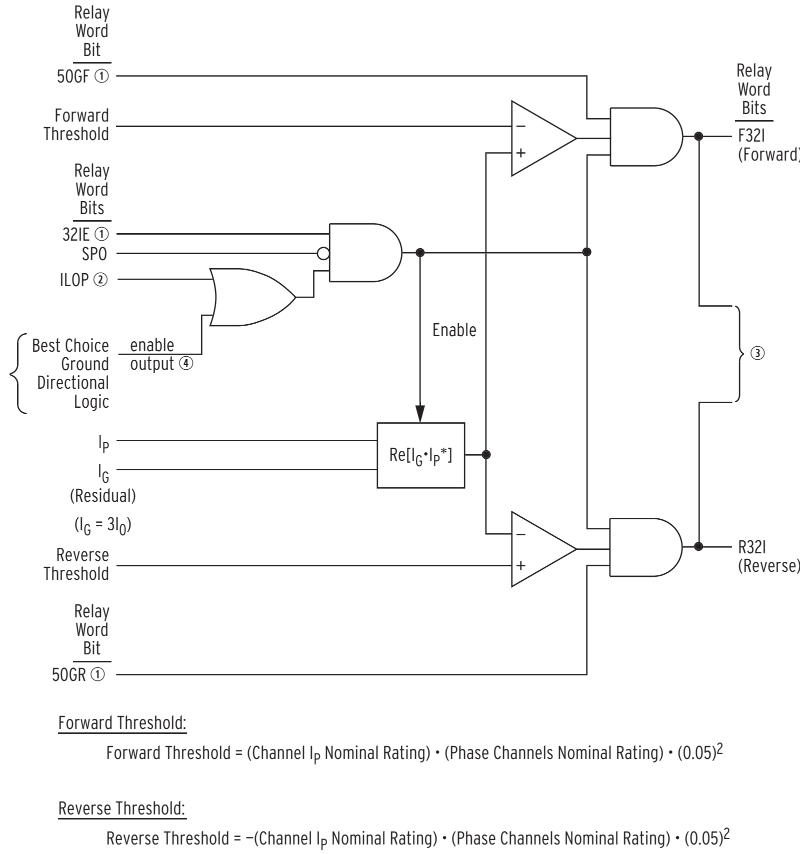
If Z0R Setting ≥ 0, Reverse Threshold $= 0.75 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

If Z0F Setting < 0, Reverse Threshold $= 1.25 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

Note: $1\angle Z0L$ = One Ohm at the Positive-Sequence Line Angle

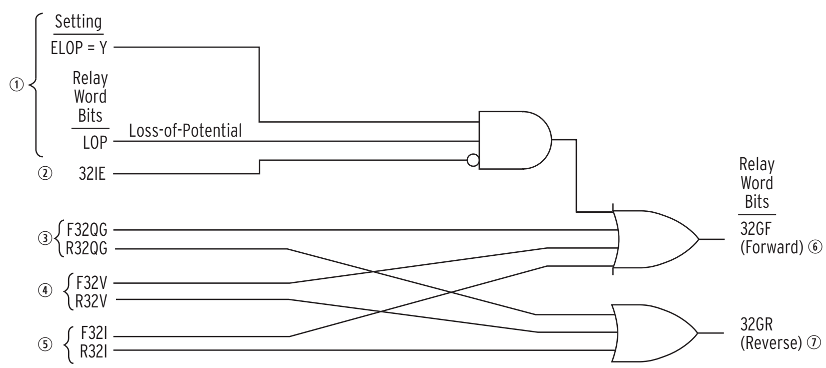
① From Figure 4.42; ② from Figure 4.35; ③ from Figure 4.43; ④ to Figure 4.47

Figure 4.45 Zero-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual-Ground Overcurrent Elements



① From Figure 4.42; ② from Figure 4.35; ③ to Figure 4.47; ④ from Figure 4.43

Figure 4.46 Channel IP Current-Polarized Directional Element for Ground Distance and Residual-Ground Overcurrent Elements



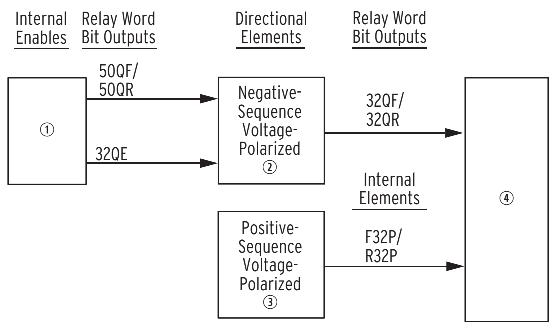
① From Figure 4.35; ② from Figure 4.42; ③ from Figure 4.44; ④ from Figure 4.45; ⑤ from Figure 4.46; ⑥ to Figure 4.7–Figure 4.12 and Figure 4.22; ⑦ to Figure 4.6, Figure 4.9, Figure 4.12, and Figure 4.22

Figure 4.47 Ground Distance and Residual-Ground Directional Logic

Phase Distance and Negative-Sequence Directional Logic

The directional control for phase distance and negative-sequence overcurrent elements is configured by making directional control setting E32. Setting E32 and other directional control settings are described in *Directional Control Settings on page 4.79*.

Negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements control the phase distance elements. The negative-sequence voltage-polarized directional element operates for unbalanced faults, while the positive-sequence voltage-polarized directional element operates for three-phase faults. *Figure 4.48* gives an overview of how the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements are enabled and routed.



① Figure 4.41; ② Figure 4.49; ③ Figure 4.50; ④ Figure 4.14–Figure 4.6 and Figure 4.23

Figure 4.48 General Logic Flow of Directional Control for Negative-Sequence Phase-Overcurrent and Phase Distance Elements

Internal Enables

Refer to *Figure 4.37* and *Figure 4.48*.

The Relay Word bit 32QE enables the negative-sequence voltage-polarized directional element.

The settings involved with 32QE in *Figure 4.41* (e.g., setting a2) are explained in *Directional Control Settings*.

Directional Elements

Refer to *Figure 4.48*, *Figure 4.49*, and *Figure 4.50*.

If enable setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit LOP asserts), the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements and the phase distance elements are disabled by ILOP (see *Figure 4.49* and *Figure 4.50*).

Refer to *Figure 4.35* 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 in *Figure 4.50* 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 4.38*).

Directional Element Routing

Refer to *Figure 4.48* and *Figure 4.49*.

The directional element outputs are routed to the forward (Relay Word bit 32QF) and reverse (Relay Word bit 32QR) logic points.

Loss-of-Potential

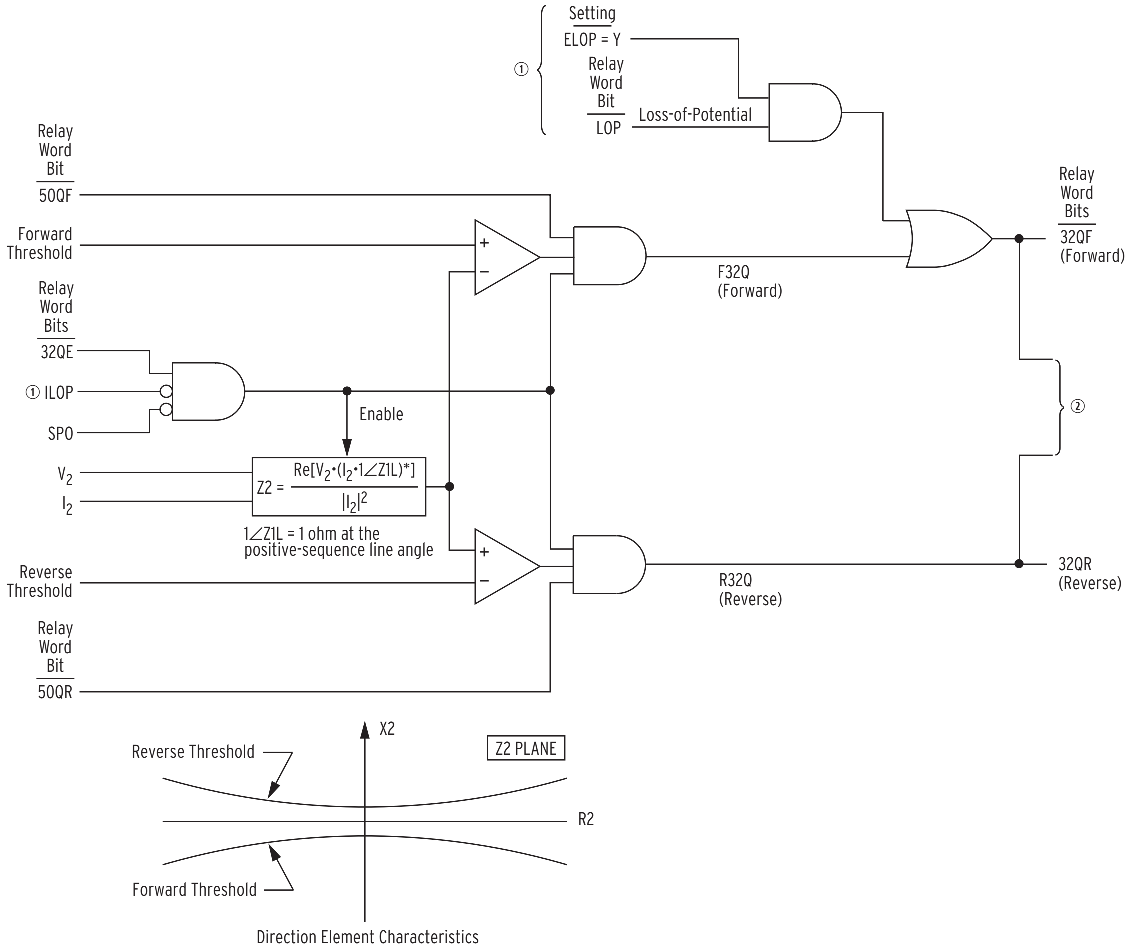
Note if both the following are true:

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

then the forward logic points (Relay Word bit 32QF) assert to logical 1, thus enabling elements that are set direction forward. These direction-forward elements effectively become nondirectional and provide protection during a loss-of-potential condition.

Refer to *Figure 4.35* and accompanying text for more information on loss-of-potential.

As shown in *Figure 4.4–Figure 4.12*, ILOP also disables all phase and ground distance elements.



Forward Threshold:

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

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

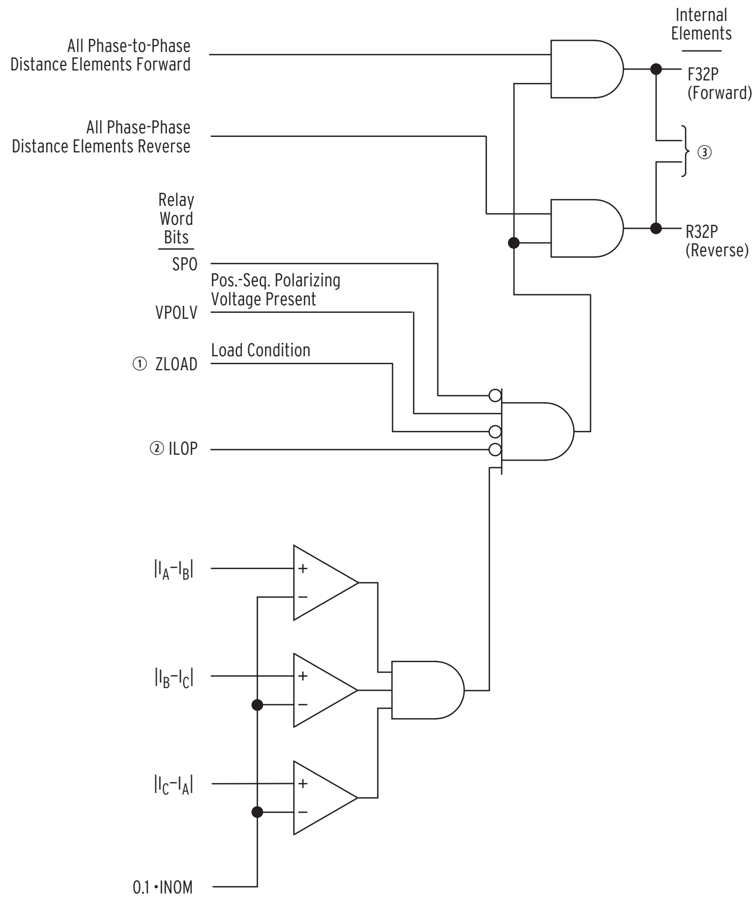
Reverse Threshold:

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

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

① From Figure 4.35; ② to Figure 4.4–Figure 4.6 and Figure 4.23

Figure 4.49 Negative-Sequence Voltage-Polarized Directional Element for Phase Distance and Negative-Sequence Elements



① From Figure 4.38; ② from Figure 4.35; ③ to Figure 4.4–Figure 4.6

Figure 4.50 Positive-Sequence Voltage-Polarized Directional Element for Phase Distance Elements

Directional Control Settings

The directional control for overcurrent elements is configured by making directional control enable setting E32. Setting E32 has setting choices:

- Y (All directional control settings made manually)
- AUTO (Sets most of the directional element settings automatically)

Settings Made Automatically

If the directional control enable setting E32 is set:

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

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 Ω) can use E32 = AUTO. It is best to use the settings in *Table 4.18* if any of the following apply:

- the negative-sequence impedance of the source is greater than $2.5/I_{NOM}$ in Ω
- 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 4.18 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 4.18* 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:

DIR3, DIR4, ORDER, and E32IV

If setting APP = 87L, the E32 setting is hidden and is internally set to E32 = AUTO.

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

Settings

Zone 1/Level 1 and Zone 2/Level 2 elements, except 67P1 and 67P2, are fixed forward and may not be changed by the user.

DIR3-Zone 3/Level 3 Element Direction Setting

DIR4-Zone 4/Level 4 Element Direction Setting

Setting Range:

F = Direction Forward

R = Direction Reverse

Table 4.19 shows the elements that are controlled by each level direction setting.

Table 4.19 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 4.4*) M1PT (*Figure 4.9*)	Z1G (*Figure 4.7*) Z1GT (*Figure 4.15*)	67G1 (*Figure 4.22*) 67G1T (*Figure 4.22*)	67Q1 (*Figure 4.23*) 67Q1T (*Figure 4.23*)
Forward	M2P (*Figure 4.5*) M2PT (*Figure 4.9*)	Z2G (*Figure 4.8*) Z2GT (*Figure 4.15*)	67G2 (*Figure 4.22*) 67G2T (*Figure 4.22*)	67Q2 (*Figure 4.23*) 67Q2T (*Figure 4.23*)
DIR3 = F or R	M3P (*Figure 4.6*) M3PT (*Figure 4.9*)	Z3G (*Figure 4.9*) Z3GT (*Figure 4.15*)	67G3 (*Figure 4.22*) 67G3T (*Figure 4.22*)	67Q3 (*Figure 4.23*) 67Q3T (*Figure 4.23*)
DIR4 = F or R	M4P (*Figure 4.6*) M4PT (*Figure 4.9*)	Z4G (*Figure 4.9*) Z4GT (*Figure 4.15*)	67G4 (*Figure 4.22*) 67G4T (*Figure 4.22*)	67Q4 (*Figure 4.23*) 67Q4T (*Figure 4.23*)

ORDER-Ground Directional Element Priority Setting

Setting Range:

Q (Negative-sequence voltage-polarized directional element)

V (Zero-sequence voltage-polarized directional element)

I (Channel IP current-polarized directional element)

OFF (Ground distance elements disabled; residual-ground overcurrent elements are nondirectional, if enabled)

Setting ORDER can be set with any combination of Q, V, and I. The order in which these directional elements are listed determines the priority in which they operate to provide Best Choice Ground Directional Element logic control. See *Figure 4.43*.

For example, if setting:

ORDER = **QV**.

then the first listed directional element (Q = negative-sequence voltage-polarized directional element; see *Figure 4.44*) 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), then the second listed directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.45*) provides directional control for the ground distance and residual-ground overcurrent elements.

Another example, if setting:

ORDER = **V**

then the zero-sequence voltage-polarized directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.45*) provides directional control for the ground distance and residual-ground overcurrent elements all the time.

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 4.20*.

Table 4.20 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 4.44* and *Figure 4.49*).

If configuration setting E32 = Y, settings Z2F and Z2R (negative-sequence impedance values) are calculated by the user and entered by the user, but setting Z2R must be greater in value than setting Z2F by 0.1 Ω (5A nominal) or 0.5 Ω (1 A nominal).

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

If configuration 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 + 0.1** (Ω secondary; 5A nominal)

Z2R = **Z1MAG/2 + 0.5** (Ω secondary; 1A nominal)

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 4.41*). 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 4.41*). 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 configuration 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 4.41*.

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 configuration setting E32 = AUTO, setting a2 is set automatically at:

a2 = **0.1**.

For setting a2 = 0.1, the negative-sequence current (I_2) magnitude has to be greater than 1/10 of the positive-sequence current (I_1) magnitude in order for the negative-sequence voltage-polarized directional elements to be enabled ( ).

k2-Zero-Sequence Current Restraint Factor, $|I_2|/|I_0|$

Setting Range:

0.10–1.20 (unitless)

Note the directional enable logic outputs in *Figure 4.41*:

- 32QE (enable for the negative-sequence voltage-polarized directional element that controls the phase distance and negative-sequence overcurrent elements)
- 32QGE (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 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 enable (and following negative-sequence voltage-polarized directional element in *Figure 4.44*) to be enabled:

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

Equation 4.2

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.

If both of the internal enables:

- 32VE (enable for the zero-sequence voltage-polarized directional element that controls the ground distance and residual-ground overcurrent elements)
- 32IE (enable for the channel IP current-polarized directional element that controls the ground distance and residual-ground overcurrent elements)

are deasserted, then factor k2 is ignored as a logic enable for the 32QGE enable. If neither the zero-sequence voltage-polarized nor the channel IP current-polarized directional elements are operable, fewer restrictions (i.e., factor k2) are put on the operation of the negative-sequence voltage-polarized directional element.

k2 Set Automatically

If configuration setting E32 = AUTO, setting k2 is set automatically at:

k2 = **0.2**

For setting k2 = 0.2, the negative-sequence current (I_2) magnitude has to be greater than 1/5 of the zero-sequence current (I_0) magnitude in order for the negative-sequence voltage-polarized directional elements to be enabled ($|I_2| > 0.2 \bullet |I_0|$). Again, this presumes at least one of the 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 preceding setting ORDER does not contain V or I (no zero-sequence voltage-polarized or channel IP 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 IP current-polarized directional elements (see *Figure 4.42*). Ideally, the 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 IP current-polarized directional elements (see *Figure 4.42*). Ideally, the 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 configuration setting E32 = AUTO, settings 50GFP and 50GRP are set automatically at:

50GFP = **0.50 A secondary**. (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50GRP = **0.25 A secondary**. (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50GFP = **0.10 A secondary**. (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

50GRP = **0.05 A secondary** (1 A nominal phase current inputs, IA, IB, IC)

a0-Positive-Sequence Current Restraint Factor, $|I_0|/|I_1|$

Setting Range:

0.02–0.50 (unitless)

If preceding setting ORDER does not contain V or I (no zero-sequence voltage-polarized or channel IP current-polarized directional elements are enabled), then setting a0 is not made or displayed.

Refer to *Figure 4.42*.

The a0 factor increases the security of the zero-sequence voltage-polarized and channel IP current-polarized directional elements. It keeps the elements from operating for zero-sequence current (system unbalance), which circulates because of line asymmetries, CT saturation during three-phase faults, etc.

a0 Set Automatically

If configuration setting E32 = AUTO, setting a0 is set automatically at:

a0 = **0.1**

For setting a0 = 0.1, the zero-sequence current (I_0) magnitude has to be greater than 1/10 of the positive-sequence current (I_1) magnitude in order for the zero-sequence voltage-polarized and channel IP 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
(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**)

If preceding setting ORDER does not contain V (no zero-sequence voltage-polarized directional element is enabled), then settings Z0F and Z0R are not made or displayed.

Z0F and Z0R are used to calculate the Forward and Reverse Thresholds, respectively, for the zero-sequence voltage-polarized directional elements (see *Figure 4.45*).

If configuration 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 0.1 Ω (5 A nominal) or 0.5 Ω (1 A nominal).

Z0F and Z0R Set Automatically

If configuration 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 + 0.1** (Ω secondary; 5A nominal)

Z0R = **Z0MAG/2 + 0.5** (Ω secondary; 1A nominal)

E32IV–SELOGIC Control Equation Enable

Refer to *Figure 4.42*.

SELOGIC control equation setting E32IV must be asserted to logical 1 to enable the zero-sequence voltage-polarized and channel IP current-polarized directional elements for directional control of ground distance and residual-ground overcurrent elements.

Most often, this setting is set directly to logical 1:

E32IV = **1** (numeral 1)

For situations where zero-sequence source isolation can occur (e.g., by the opening of a circuit breaker) and result in possible mutual coupling problems for the zero-sequence voltage-polarized and channel IP current-polarized directional elements, SELOGIC control equation setting E32IV should be deasserted to logical 0. In this example, this is accomplished by connecting a circuit breaker auxiliary contact from the identified circuit breaker to the SEL-311L:

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**

will enable 67P1 and 67P1T when the Zone 2 phase distance element asserts (forward).

The default settings for all torque-control equations is logic “1,” or “enabled.” Torque-control equations may not be set directly to logic “0.”

Table 4.21 Torque-Control Settings and Elements

Torque-Control Setting	Controlled Element	Directional and Additional Control Settings
67P1TC	67P1/67P1T	Torque Control
67P2TC	67P2/67P2T	Torque Control
67P3TC	67P3/67P3T	Torque Control
67G1TC	67G1/67G1T	Forward and Torque Control
67G2TC	67G2/67G2T	Forward and Torque Control
67G3TC	67G3/67G3T	DIR 3 = F or R and Torque Control
67G4TC	67G4/67G4T	DIR 4 = F or R and Torque Control
67Q1TC	67Q1/67Q1T	Forward and Torque Control
67Q2TC	67Q2/67Q2T	Forward and Torque Control
67Q3TC	67Q3/67Q3T	DIR 3 = F or R and Torque Control
67Q4TC	67Q4/67Q4T	DIR 4 = F or R and Torque Control
51PTC	51P/51PT	Torque Control
51GTC	51G/51GT	Torque Control
51QTC	51Q/51QT	Torque Control

Setting Negative-Sequence Elements

Setting Negative-Sequence Definite-Time Overcurrent Elements

Negative-sequence instantaneous overcurrent elements 50Q1–50Q4 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 4.23* for more information on negative-sequence instantaneous and definite-time overcurrent elements.

NOTE: You must be an IEEE member to access this document.

Read A. F. Elneweihi, E. O. Schweitzer, M. W. Feltis, "Negative-Sequence Overcurrent Element Application and Coordination in Distribution Protection," available at http://ieeexplore.ieee.org/xpi/tocresult.jsp?isNumber=6449&Page=1 for guidelines on coordinating negative-sequence definite-time overcurrent elements. The coordination example described in this paper uses time-overcurrent elements, but the same principles can be applied to 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 4.51* 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)

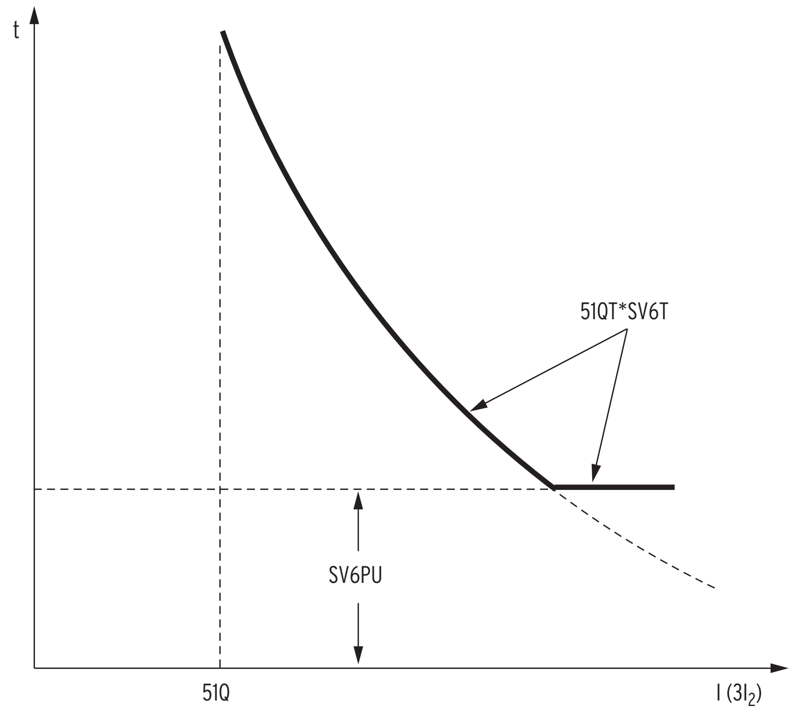


Figure 4.51 Minimum Response Time Added to a Negative-Sequence Time-Overcurrent Element 51QT

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 section. The paper also contains analyses of system unbalances and faults and the negative-sequence current generated by such conditions.

Edmund O. Schweitzer, III, Mark W. Feltis, Ahmed F. Elneweihi, "Improved Sensitivity and Security for Distribution Bus and Feeder Relays," selinc.com/api/download/2460/.

> Appendix I of this paper contains information similar to the first paper in this listing about negative-sequence overcurrent element coordination.

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.

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Section 5

Trip and Target Logic

Overview

The SEL-311L Relay trip logic combines trip decisions from several sources into a single Relay Word bit, useful for controlling trip contacts. The relay also contains line current differential high-speed tripping logic, which bypasses the normal trip logic and directly controls trip contacts. This high-speed trip logic results in 87L trip times as much as 3/4 cycle faster than available using SELOGIC control equations.

Line Current Differential Trips

High-Speed 87L Tripping

For the fastest 87L protection, set EHST equal to the desired number of trip contacts. No trip logic settings are required for line current differential protection when setting EHST ≥ 1. Relay Word bit TRIP87 asserts when line current differential algorithms detect an internal fault, or when a valid direct transfer trip is received on the 87L communications channel. As shown in *Figure 5.4*, when setting EHST ≥ 1, Relay Word bit TRIP87 directly controls one or more high-speed outputs OUT201–OUT206. For example, when EHST = 2, TRIP87 directly controls high-speed outputs OUT201 and OUT202. These high-speed outputs close in less than 10 µs, are trip rated, and interrupt dc trip current, so tripping auxiliary relays are often not required. Use this method to achieve the trip times shown in *Figure 3.6* and *Figure 3.7*.

87L Tripping Via SELOGIC

To qualify 87L protection using a SELOGIC control equation, make setting EHST = N. This disables direct control of high-speed outputs OUT201–OUT206. Place Relay Word bit TRIP87 directly in SELOGIC control equation TR, supervised by the appropriate relay elements and conditions. Place Relay Word bit TRIP in the SELOGIC control equation for high-speed outputs OUT201–OUT206, and/or in the SELOGIC control equations for conventional outputs OUT101–OUT107. Add 3/4 cycle to the trip times shown in *Figure 3.6* and *Figure 3.7* when using 87L protection qualified by SELOGIC control equations. See *Settings Example: 230 kV Transmission Line With Tapped Load on page 9.37* for a more detailed example of qualified 87L tripping. See *Backup Protection Trips on page 5.8* for more information about Relay Word bit TRIP.

87L High-Speed Direct Transfer Tripping

Set EHSDTT = Y to enable direct transfer tripping via the 87L communications channel for two- or three-terminal 87L protection. When setting EHSDTT = Y, the relay asserts Relay Word bit TRIP87 less than 1/2 cycle (plus channel delays) after 87L elements in the relays attached to either Channel X or Channel Y detect an internal fault. Direct transfer tripping is automatically enabled if setting E87L = 3R (three-terminal protection with two communications channels) or when an 87L communications channel fails and setting E87L = 3, even if setting EHSDTT = N. See *Section 3: Line Current Differential Protection* for more information about setting E87L.

The SEL-311L direct transfer trip signals have outstanding security, resulting in less than one unwanted trip per 100 million channel noise bursts. The relay maximizes dependability by transmitting the direct trip signal for at least 8 cycles when an internal fault is detected.

87L Tripping Qualified by the Local Disturbance Detector

SEL strongly recommends setting EDD = Y to increase security of 87L communications. There are no other settings associated with the local disturbance detector. The 87L algorithms have excellent communications security that results in less than one unwanted trip per three million channel noise bursts when setting EDD = N. Setting EDD = Y prevents undesired operations because of channel noise bursts that occur more than to cycles after a load change.

Some equipment failures result in intermittent communications, which can eventually overwhelm the error detection algorithms in the SEL-311L when setting EDD = N. When setting EDD = Y, the relay ensures that the local currents have changed in the previous 10 cycles before allowing current differential trips. 87L trips are not affected at all if the fault causes local 3I1 or 3I0 to change by more than 8 degrees or more than 2 percent of nominal current. For weak or zero-infeed terminals, if the local currents do not change by those amounts, then 87L trips are delayed no more than two cycles. If high speed direct transfer tripping is also enabled with setting EHSDTT = Y, then the tripping delay is limited to about 1/2 cycle more than the channel delay.

Disturbance detector supervision is also enabled when Relay Word bits CHXAL or CHYAL indicate that a communications channel is impaired, even if setting EDD = N.

Bus Stub Protection

The SEL-311L includes bus stub protection logic. Bus stub protection is commonly used for multi-breaker schemes (breaker and one-half, double breaker, or ring-bus applications) when a line disconnect switch is used to remove the line from service. The breakers are closed to maintain bus continuity. The result is a “stub” of bus that must be protected by the differential scheme.

Enable the bus stub protection logic by setting SELOGIC control equation ESTUB to a logical 1 via contact input or other logic setting. The most common application is to wire the line disconnect switch status to an input on the relay. When the line disconnect switch is open, the input is energized and the bus stub protection is enabled. For example, set ESTUB = IN105 to enable the bus stub protection as described above.

NOTE: 87L messages are still sent when ESTUB = logical 1. 87L transmit bit equations T1X–T4Y are unaffected by ESTUB status.

When ESTUB is a logical 1, the following actions take place:

1. No analog data are sent to the remote terminal.
2. The analog data received from the remote terminal are ignored. This means that the metering data from the remote terminal are not displayed.
3. The 87L direct transfer-tripping bits TDTX and TDTY are disabled.
4. The 87L received direct transfer-tripping bits are disabled.

For normal load current or external fault current through the bus stub, the current applied to the SEL-311L will ideally be zero. For a fault on the bus stub, the fault current will be seen by SEL-311L and the local 87L element will operate. The relay at the remote terminal will not detect the fault on the stub.

If the breaker at the remote line terminal is closed to supply some tapped load, the remote relay will see the load current as a differential current. The 87L phase pickup at the remote terminal must be set above any tapped loads. If the remote breaker is closed, the remote 87L will operate for any faults on that section of line.

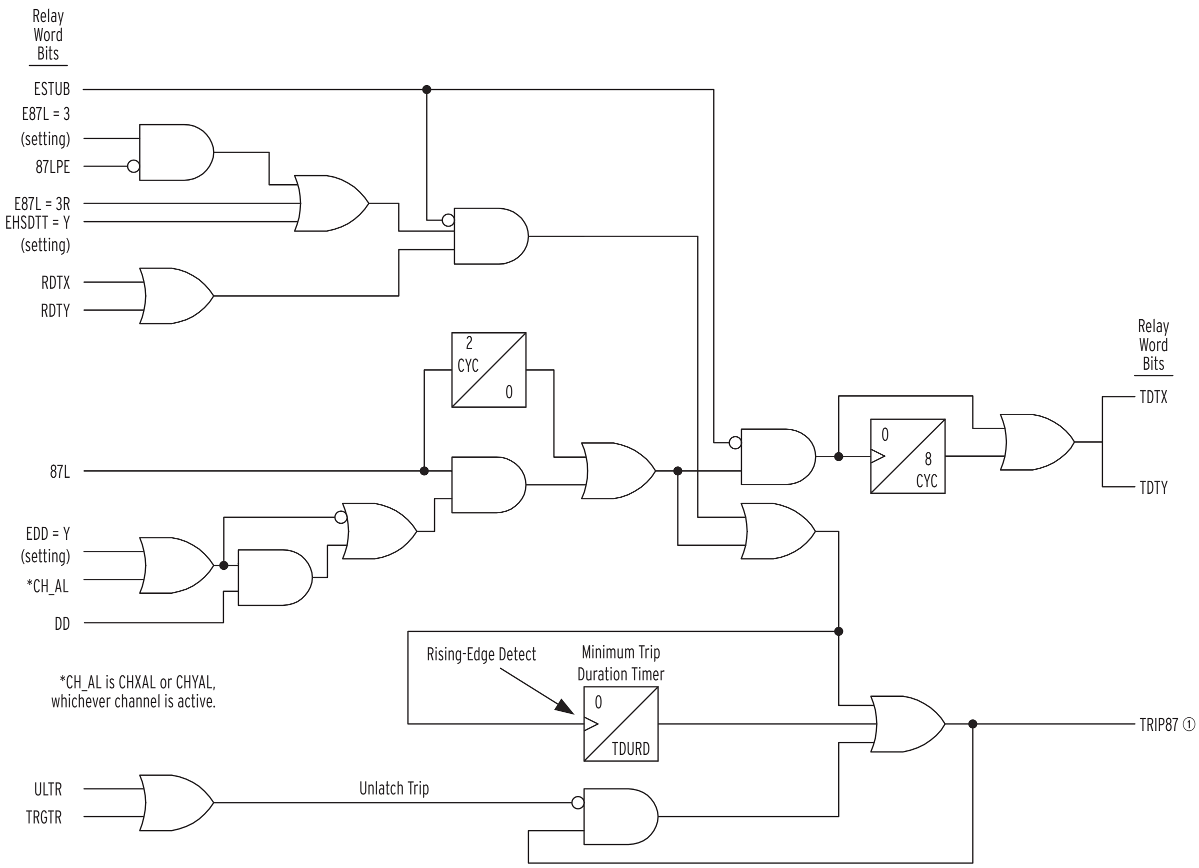


Figure 5.1 Line Current Differential Trip Logic With Direct Transfer Tripping and Local Disturbance Detector Supervision

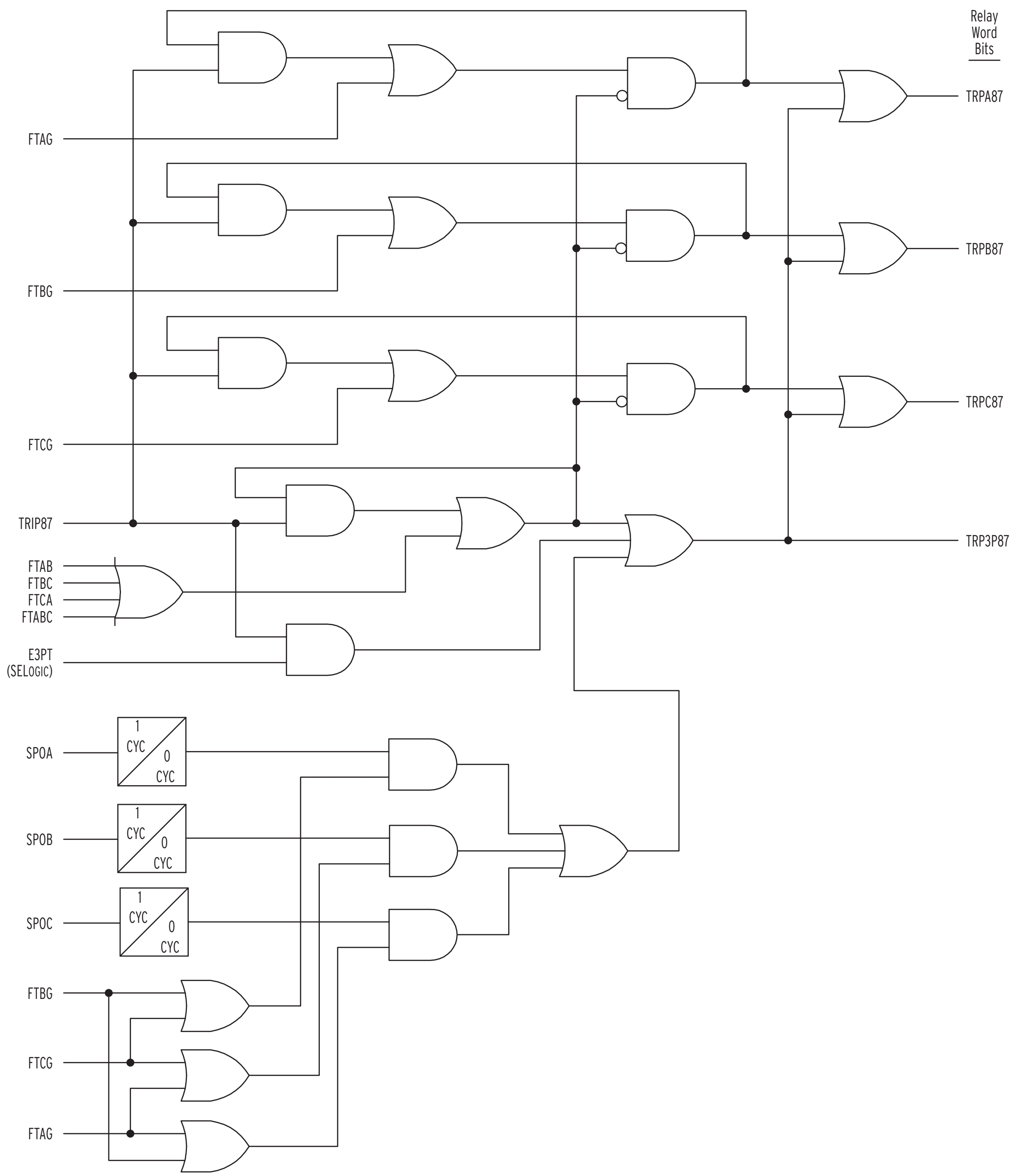


Figure 5.2 Line Current Differential Single-Pole Tripping Logic When APP = 87LSP (SEL-311L-7 Relay Only)

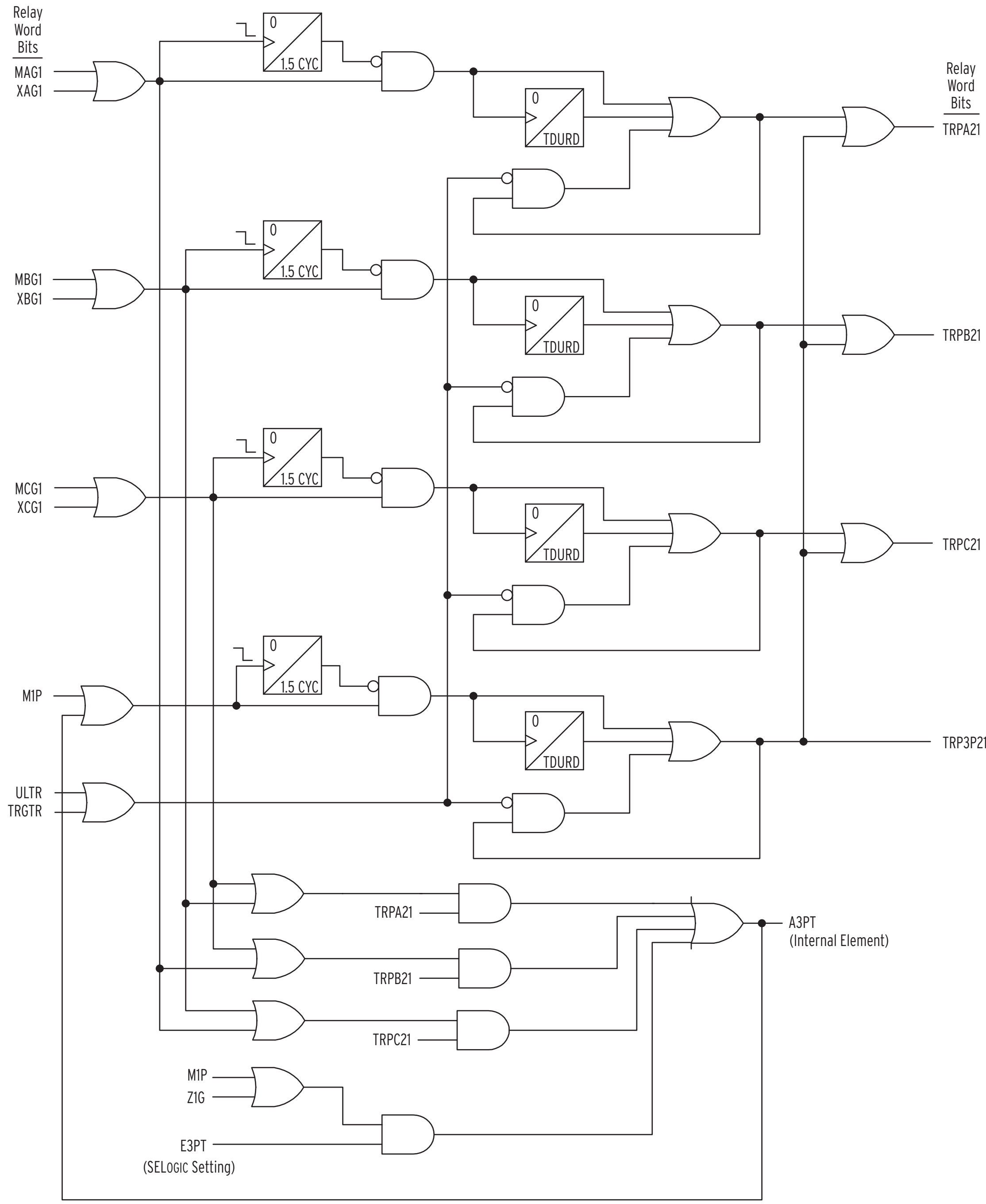


Figure 5.3 Zone 1 Distance Single-Pole Tripping Logic When APP = 87LSP (SEL-311L-7 Relay Only)

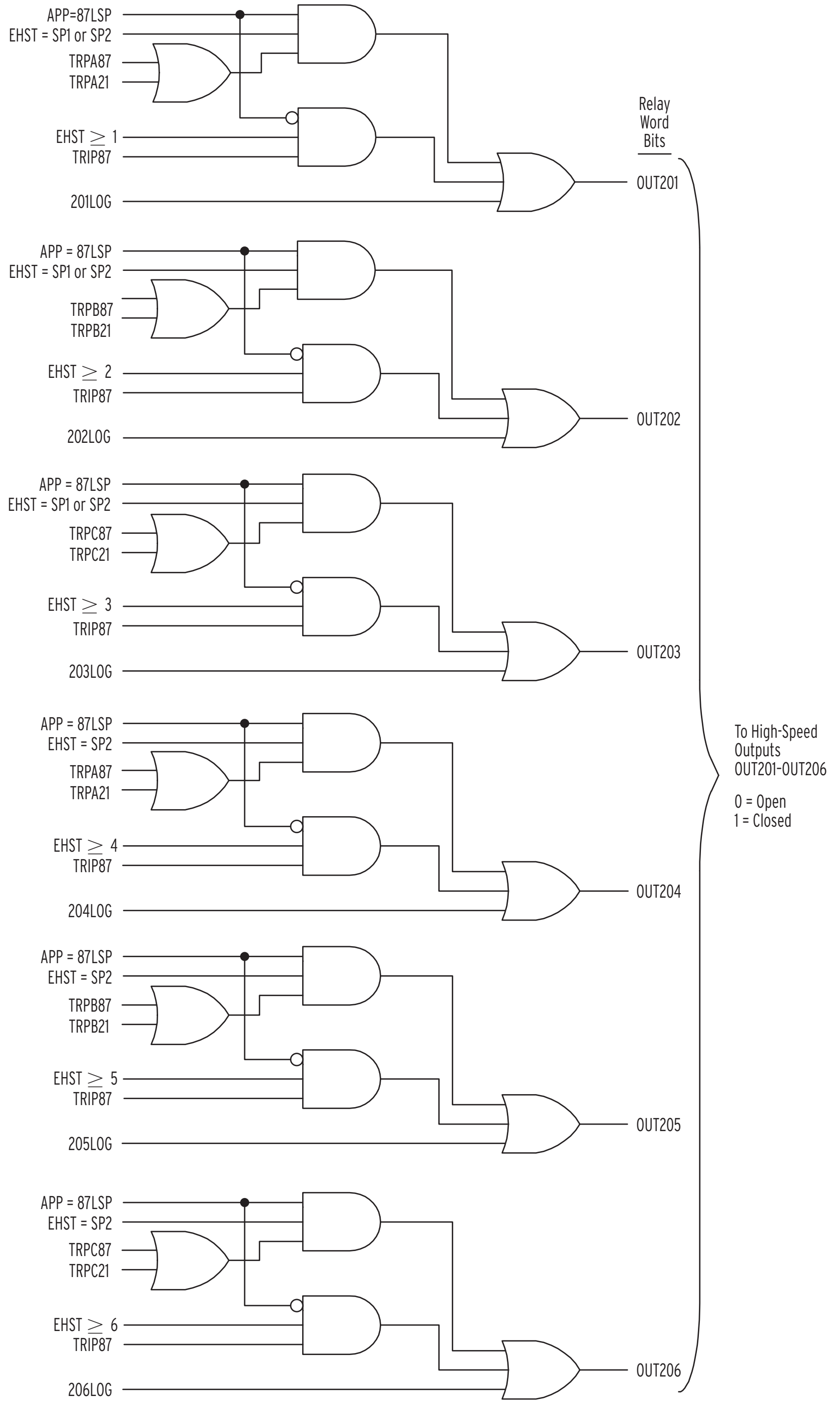


Figure 5.4 High-Speed Output Logic

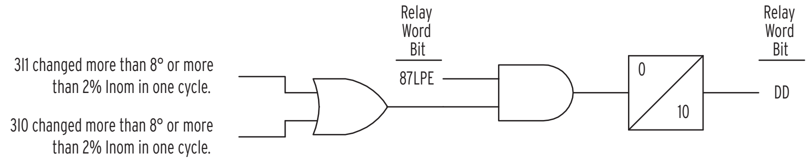


Figure 5.5 Local Disturbance Detector

Trip During Open-Pole Logic

If another fault occurs, it is common to trip the two remaining phases for the following two recloser states:

- During the single-pole open dead time following the original single-pole trip
- During the recloser reset state following a single-pole reclose

Timer setting TOPD (Trip During Open Pole Time Delay) determines the period during which any subsequent single-pole trips are converted to a three-pole trip following the original single-pole trip. Note that the TOP logic is only enabled when APP = 87LSP.

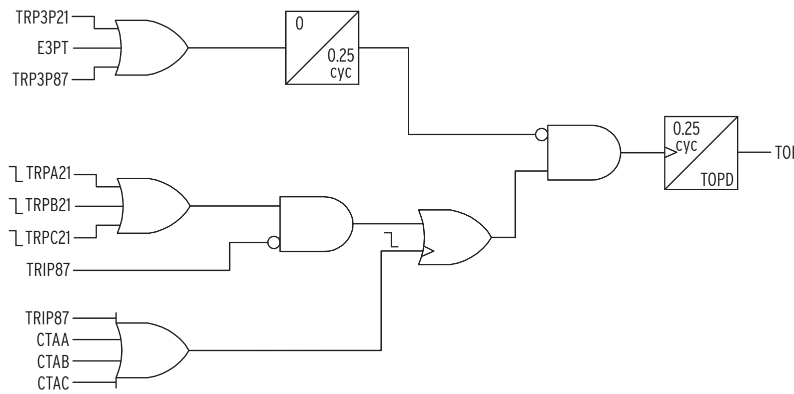


Figure 5.6 Trip on Open Pole Logic

Backup Protection Trips

The trip logic in *Figure 5.7* 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 5.18* for more information on communications-assisted tripping.

DTT Direct Transfer Trip Conditions.

Note in *Figure 5.7* that setting DTT is unsupervised. Any element that asserts in setting DTT will cause Relay Word bit TRIP to assert to logical 1.

Although setting TR is also unsupervised, setting DTT is provided separately from setting TR for target LED purposes. (**COMM** target LED on the front panel illuminates when DTT asserts to logical 1; see *COMM Target LED on page 5.37*).

Typical settings for DTT are:

DTT = **IN106** or DTT = **RMB1A**

where input **IN106** is connected to the output of direct transfer trip communications equipment or receive MIRRORED BIT RMB1A is asserted by the transfer trip condition in a remote SEL relay.

Setting DTT is also used for Direct Underreaching Transfer Trip (DUTT) schemes.

TRSOTF Switch-Onto-Fault Trip Conditions.

Setting TRSOTF is supervised by the switch-onto-fault condition SOTFE. See *Switch-Onto-Fault Trip Logic on page 5.13* for more information on switch-onto-fault logic.

TR Other Trip Conditions.

Setting TR is the SELOGIC control equation trip setting most often used if tripping does not involve communications-assisted trip logic (settings TRCOMM and DTT), switch-onto-fault (setting TRSOTF) trip logic, or 87L trip logic (use high-speed tripping via setting EHST).

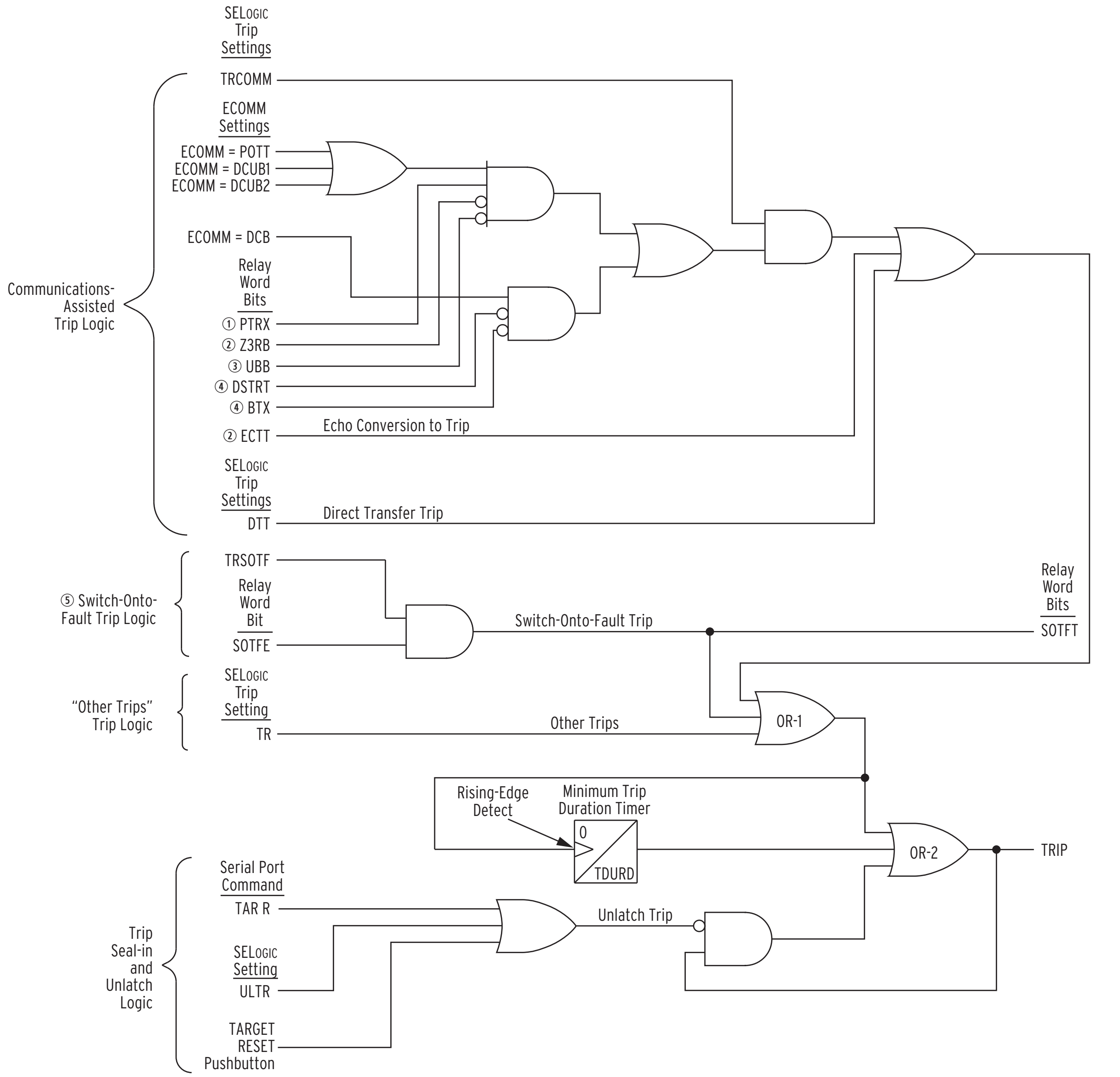
Note in *Figure 5.7* that SELOGIC control equation trip setting TR is unsupervised. Any element that asserts in SELOGIC control equation setting TR will cause Relay Word bit TRIP to assert to logical 1.

ULTR Unlatch Trip Conditions.

TDURD Minimum Trip Duration Time.

This timer establishes the minimum time duration for which the TRIP Relay Word bit asserts. The settable range for this timer is 2–16,000 cycles.

More than one trip setting (or all four trip settings TRCOMM, DTT, TRSOTF, and TR) can be set. For example, in a communications-assisted trip scheme, TRCOMM is set with direction forward overreaching Zone 2 distance elements, TR is set with direction forward underreaching Zone 1 distance elements and other time-delayed elements (e.g., Zone 2 definite-time distance elements), and TRSOTF is set with instantaneous directional and nondirectional elements.



① From Figure 5.12; ② from Figure 5.11; ③ from Figure 5.16; ④ from Figure 5.19; ⑤ from Figure 5.8

Figure 5.7 Trip Logic

Set Trip

Refer to *Figure 5.7*. All trip conditions:

- Communications-Assisted Trip, including Direct Transfer Trip
- Switch-Onto-Fault Trip
- Other Trips

are combined into OR-1 gate. The output of OR-1 gate asserts Relay Word bit TRIP to logical 1, regardless of other trip logic conditions. It also is routed into the Minimum Trip Duration Timer (setting TDURD).

The Minimum Trip Duration Timer (with setting TDURD) outputs a logical 1 for a time duration of “TDURD” cycles any time it sees a rising edge on its input (logical 0 to logical 1 transition), if it is not already timing (timer is reset). The TDURD timer ensures that the TRIP Relay Word bit remains asserted at logical 1 for a minimum of “TDURD” cycles. If the output of OR-1 gate is logical 1 beyond the TDURD time, Relay Word bit TRIP remains asserted at logical 1 for as long as the output of OR-1 gate remains at logical 1, regardless of other trip logic conditions.

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

The **OPEN** command is included in the trip logic in the factory settings:

TR = **... + OC**

Relay Word bit OC asserts for execution of the **OPEN** Command. See *OPE Command (Open Breaker) on page 10.56* for more information on the **OPEN** Command. More discussion follows later on the factory settings for setting TR.

If a user wants to supervise the **OPEN** command with optoisolated input IN105, the following setting is made:

TR = **... + OC * IN105**

With this setting, the **OPEN** command can provide a trip only if optoisolated input IN105 is asserted. This is just one **OPEN** command supervision example—many variations are possible.

To prevent the execution of the **OPEN** command from initiating reclosing, include Relay Word bit OC in the SELOGIC control equation setting 79DTL (Drive-to-Lockout).

A COMM target LED option for the **OPEN** command is discussed in the *Front-Panel Target LEDs on page 5.36*.

Unlatch Trip

Once Relay Word bit TRIP is asserted to logical 1, it remains asserted at logical 1 until all the following conditions come true:

- Minimum Trip Duration Timer stops timing (logic output of the TDURD timer goes to logical 0)
- Output of OR-1 gate in *Figure 5.7* deasserts to logical 0
- One of the following occurs:
  - SELOGIC control equation setting ULTR asserts to logical 1,
  - The front-panel TARGET RESET pushbutton is pressed,
  - Or the **TAR R** (Target Reset) command is executed via the serial port.

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

Other Applications for the Target Reset Function

Note that the combination of the **TARGET RESET** pushbutton and the **TAR R** (Target Reset) serial port command is also available as Relay Word bit TRGTR. See *Figure 5.22* and accompanying text for applications for Relay Word bit TRGTR.

Factory Settings Example (Using Setting TR)

In this example the "communications-assisted" and "switch-onto-fault" trip logic at the top of *Figure 5.7* are not used. The SELOGIC control equation trip setting TR is now the only input into OR-1 gate and flows into the "seal-in and unlatch" logic for Relay Word bit TRIP.

The factory settings for the trip logic SELOGIC control equation settings are:

TR = **M1P + Z1G + M2PT + Z2GT + 51GT + 51QT + OC** (trip conditions)

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

The factory setting for the Minimum Trip Duration Timer setting is:

TDURD = **9.000 cycles**

See the settings sheets in *Section 9: Settings* for setting ranges.

Set Trip

In SELOGIC control equation setting TR = M1P + Z1G + M2PT + Z2GT + 51GT + 51QT + OC:

- Distance elements M1P, M2PT, Z1G, and Z2GT and time-overcurrent elements 51GT and 51QT trip directly. Time-overcurrent and definite-time overcurrent elements can be torque-controlled (e.g., elements 51GT and 51QT are torque controlled by SELOGIC control equation settings 51GTC and 51QTC, respectively). Check torque-control settings to see if any control is applied to time-overcurrent and definite-time overcurrent elements. Such control is not apparent by mere inspection of trip setting TR or any other SELOGIC control equation trip setting.
- Relay Word bit OC asserts for execution of the **OPEN** Command. See *OPE Command (Open Breaker) on page 10.56* for more information on the **OPEN** Command.

With setting TDURD = 9.000 cycles, once the TRIP Relay Word bit asserts via SELOGIC control equation setting TR, it remains asserted at logical 1 for a minimum of 9 cycles.

Unlatch Trip

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

- Both elements must be deasserted before the trip logic unlatches and the TRIP Relay Word bit deasserts to logical 0.

Additional Settings Examples

The factory setting for SELOGIC control equation setting ULTR is a trip element unlatch condition. A circuit breaker status unlatch trip condition can be programmed as shown in the following examples.

Unlatch Trip With 52a Circuit Breaker Auxiliary Contact

A 52a circuit breaker auxiliary contact is wired to optoisolated input IN101.

52A = **IN101** (SELOGIC control equation circuit breaker status setting—see *Optoisolated Inputs on page 7.2*)

ULTR = **!52A**

Input IN101 has to be de-energized (52a circuit breaker auxiliary contact has to be open) before the trip logic unlatches and the TRIP Relay Word bit deasserts to logical 0.

ULTR = **!52A** = NOT(52A)

Unlatch Trip With 52b Circuit Breaker Auxiliary Contact

A 52b circuit breaker auxiliary contact is wired to optoisolated input IN101.

52A = **!IN101**

(SELOGIC control equation circuit breaker status setting—see *Optoisolated Inputs*)

ULTR = **!52A**

Input IN101 must be energized (52b circuit breaker auxiliary contact has to be closed) before the trip logic unlatches and the TRIP Relay Word bit deasserts to logical 0.

Program an Output Contact for Tripping

In the factory settings, the resultant of the trip logic in *Figure 5.7* is routed to output contacts OUT101 and OUT102 with the following SELOGIC control equation settings:

OUT101 = **TRIP**

OUT102 = **TRIP**

The user can also route the trip logic to the high-current interrupting contacts OUT201–OUT206.

If more than two TRIP output contacts are needed, program other output contacts with the TRIP Relay Word bit. Examples of uses for additional TRIP output contacts:

- Keying an external breaker failure relay
- Keying communication equipment in a Direct Transfer Trip scheme

See *Output Contacts on page 7.28* for more information on programming output contacts.

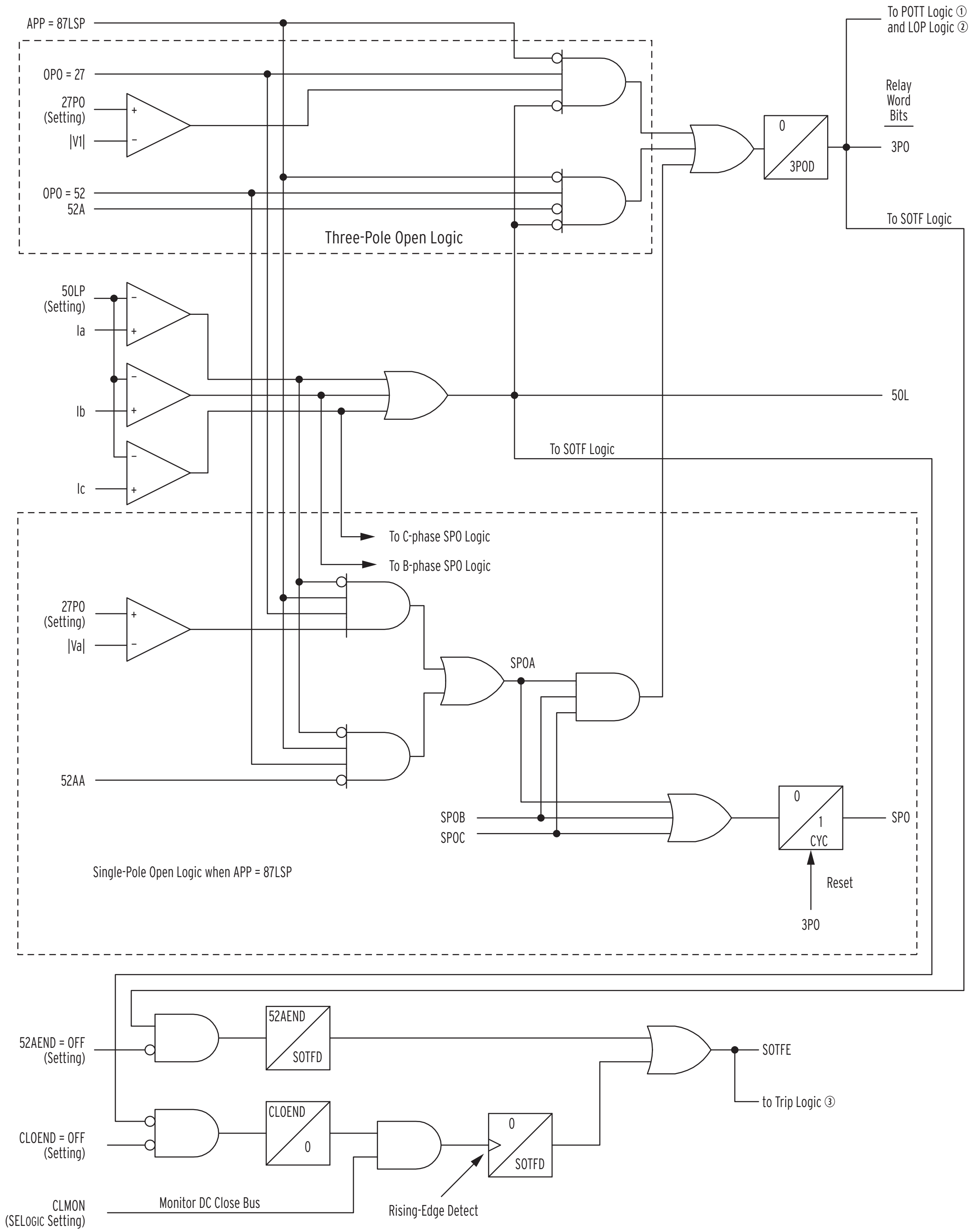
Switch-Onto-Fault Trip Logic

Switch-Onto-Fault (SOTF) trip logic provides a programmable time window for selected elements to trip right after the circuit breaker closes. "Switch-onto-fault" implies that a circuit breaker is closed into an existing fault condition, such as when safety grounds are accidentally left attached to a line. If the circuit breaker is closed into such a condition, the resulting fault needs to be cleared right away and reclosing blocked. An instantaneous element is usually set to trip in the three-pole open (3PO) logic and the SOTF trip logic.

Refer to the switch-onto-fault trip logic in *Figure 5.7* (middle of figure). The SOTF trip logic permits tripping if both the following occur:

- ➤ An element asserts in SELOGIC control equation trip setting TRSOTF
- ➤ Relay Word bit SOTFE is asserted to logical 1

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 5.8* and the following discussion describe the three-pole open (3PO) logic and the SOTF logic.



① To Figure 5.11; ② to Figure 4.35; ③ to Figure 5.7

Figure 5.8 Three-Pole Open Logic (Top) and Switch-Onto-Fault Logic (Bottom)

Three-Pole Open Logic

Three-pole open (3PO) logic is the top half of *Figure 5.8*. It is not affected by enable setting ESOTF (see the settings sheets in *Section 9: Settings*).

The open circuit breaker condition is determined by load current (50L) and either one of:

- ➤ Circuit breaker status (52A = logical 0), recommended
- ➤ Positive-sequence voltage (|V1| < 27PO), not recommended when 87L protection is enabled

Select OPO = 52 if 3PO is determined by circuit breaker status. Select OPO = 27 if 3PO is determined by positive-sequence voltage and if 87L protection is not used.

If OPO = 52, and the circuit breaker is open (52A = logical 0) and current is below phase pickup 50LP (50L = logical 0), then the three-pole open (3PO) condition is true:

3PO = **logical 1** (circuit breaker open)

If OPO = 27, and |V1| is less than setting 27PO, and current is below phase pickup 50LP (50L = logical 0), then the three-pole open (3PO) condition is true:

3PO = **logical 1** (circuit breaker open)

When OPO = 27, 3PO deasserts when the line is energized from any terminal. This defeats line charging inrush logic in the 87L algorithms. If 87L protection is enabled, use setting OPO = 52.

The 3POD dropout time qualifies circuit breaker closure, whether detected by circuit breaker status (52A), positive-sequence voltage, or load current level (50L). When the circuit breaker is closed:

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

Determining Three-Pole Open Condition Without Circuit Breaker Auxiliary Contact (OPO = 52)

If a circuit breaker auxiliary contact is not connected to the SEL-311L and OPO = 52, SELOGIC control equation setting 52A may be set:

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

With SELOGIC control equation setting 52A continually at logical 0, 3PO logic is controlled solely by load detection element 50L. Phase pickup 50LP is set below load current levels.

When the circuit breaker is open, Relay Word bit 50L drops out (= logical 0) and the 3PO condition asserts:

3PO = **logical 1** (circuit breaker open)

When the circuit breaker is closed, Relay Word bit 50L picks up (= logical 0; current above phase pickup 50LP) and the 3PO condition deasserts after the 3POD dropout time:

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

Note that the 3PO condition is also routed to the permissive overreaching transfer trip (POTT) logic (see *Figure 5.11*), loss-of-potential (LOP) logic (see *Figure 4.35*), and line current differential protection logic (see *Figure 3.14*, *Figure 3.16*, and *Figure 3.17*).

Pole-Open Logic When APP = 87LSP (SEL-311L-7 Relay Only)

The pole-open logic when APP = 87LSP is shown in the middle of *Figure 5.8*. The outputs of the pole-open logic are the single-phase pole open indications (SPOA, SPOB, and SPOC), the any-pole-open indication (SPO), and the three-pole open indication (3PO).

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

- Circuit breaker phase status (52AA or 52AB or 52AC = logical 0), recommended
- Phase voltage (|VA| or |VB| or |VC| < 27PO, not recommended when 87L protection is enabled

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.

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. This defeats line charging inrush logic in the 87L algorithms. If 87L protection is enabled, use setting OPO = 52.

The 3POD dropout time qualifies circuit breaker closure, whether detected by circuit breaker status (52A), phase voltage, or load current level (50L). When the circuit breaker is closed:

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

Circuit Breaker Operated Switch-Onto-Fault Logic

Circuit breaker operated switch-onto-fault logic is enabled by making time setting 52AEND (52AEND ≠ OFF). Time setting 52AEND qualifies the three-pole open (3PO) condition and then asserts Relay Word bit SOTFE:

SOTFE = **logical 1**

Note that SOTFE is asserted when the circuit breaker is open. This allows elements set in the SELOGIC control equation trip setting TRSOTF to operate if a fault occurs when the circuit breaker is open (see *Figure 5.7*). 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-311L 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-311L (e.g., **IN105**) to the dc close bus. When a manual close or automatic reclosure occurs, optoisolated input **IN105** is energized. SELOGIC control equation setting CLMON (close bus monitor) monitors the optoisolated input **IN105**:

CLMON = **IN105**

When optoisolated input **IN105** is energized, CLMON asserts to logical 1. At the instant that optoisolated input **IN105** is energized (close bus is energized), the circuit breaker is still open so the output of the CLOEND timer continues to be asserted to logical 1. Thus, the ANDed combination of these conditions latches in the SOTFD timer. The SOTFD timer outputs a logical 1 for a time duration of "SOTFD" cycles any time it sees a rising edge on its input (logical 0 to logical 1 transition), if it is not already timing. The SOTF logic output, SOTFE, asserts to logical 1 for SOTFD time.

Switch-Onto-Fault Logic Output (SOTFE)

Relay Word bit SOTFE is the output of the circuit breaker operated SOTF logic or the close bus operated SOTF logic described previously. Time setting SOTFD in each of these logic paths provides the effective time window for the instantaneous elements in SELOGIC control equation trip setting TRSOTF to trip after the circuit breaker closes (see *Figure 5.7*, middle of figure). Time setting SOTFD is usually set around 30 cycles.

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. In this case, the instantaneous overcurrent element in the SOTF trip logic should be nondirectional.

Communications-Assisted Trip Logic—General Overview

The SEL-311L includes communications-assisted tripping schemes that provide unit-protection for transmission lines with the help of communications. No external coordination devices are required.

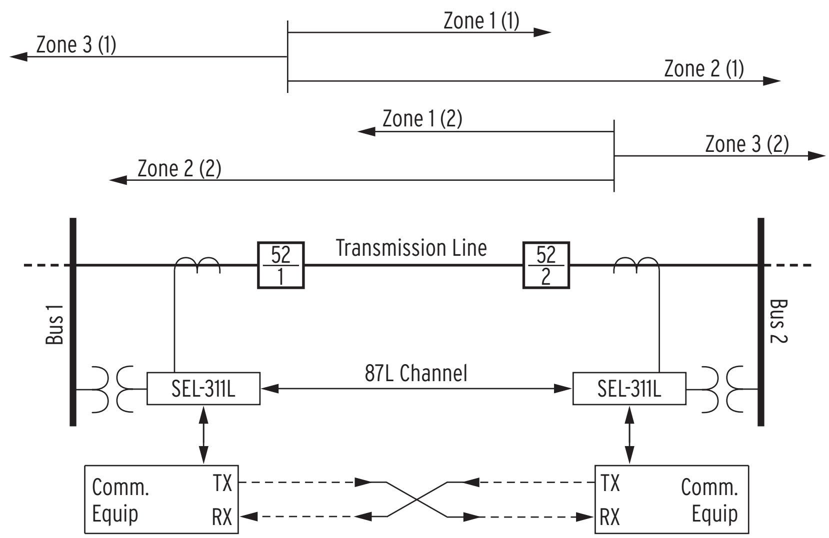


Figure 5.9 Communications-Assisted Tripping Scheme

Refer to *Figure 5.9* and the top half of *Figure 5.7*.

The six available tripping schemes are:

- Direct Transfer Trip (DTT)
- Direct Underreaching Transfer Trip (DUTT)
- Permissive Overreaching Transfer Trip (POTT)
- Permissive Underreaching Transfer Trip (PUTT)
- Directional Comparison Unblocking (DCUB)
- Directional Comparison Blocking (DCB)

Enable Setting ECOMM

The POTT, PUTT, DCUB, and DCB tripping schemes are enabled with enable setting ECOMM. Setting choices are:

ECOMM = **N** (no communications-assisted trip scheme enabled)

ECOMM = **POTT** (POTT or PUTT scheme)

ECOMM = **DCUB1** (DCUB scheme for two-terminal line [communications from one remote terminal])

ECOMM = **DCUB2** (DCUB scheme for three-terminal line [communications from two remote terminals])

ECOMM = **DCB** (DCB scheme)

These tripping schemes can all work in two-terminal or three-terminal line applications. The DCUB scheme requires separate settings choices for these applications (ECOMM = DCUB1 or DCUB2) because of unique DCUB logic considerations.

In most cases, these tripping schemes require Zone/Level 3 elements set direction reverse (setting DIR3 = R); see *Figure 5.9*. Note that Zone 1 and Zone 2 are fixed in the forward direction.

See *Directional Control Settings on page 4.79* 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.

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., dark fiber, 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.

Trip Setting TRCOMM

The POTT, PUTT, DCUB, and DCB tripping schemes use SELOGIC control equation trip setting TRCOMM for those tripping elements that are supervised by the communications-assisted trip logic (see top half of *Figure 5.7*). Setting TRCOMM is typically set with Zone 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, 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). See *Figure 5.19*. These elements are entered in trip setting TRCOMM.

Trip Settings TRSOTF and TR

In a communications-assisted trip scheme, the SELOGIC control equation trip settings TRSOTF and TR can also be used, in addition to setting TRCOMM.

Setting TRSOTF can be set as described in *Switch-Onto-Fault Trip Logic on page 5.13*.

Setting TR 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

and other time-delayed elements (e.g., Level 2 definite-time overcurrent elements).

Trip Setting DTT

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

Use Existing SEL-321 Relay Application Guides for the SEL-311L Relay

The communications-assisted tripping schemes settings in the SEL-311L are very similar to those in the SEL-321 Relay. Existing SEL-321 application guides can also be used in setting up these schemes in the SEL-311L. 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.

Permissive Overreaching Transfer Trip Logic

Enable the Permissive Overreaching Transfer Trip (POTT) logic by setting ECOMM = POTT. The POTT logic in *Figure 5.11* is also enabled for directional comparison unblocking schemes (ECOMM = DCUB1 or ECOMM = DCUB2). The POTT logic performs the following tasks:

- Keys communication equipment to send permissive trip when any element included in the SELOGIC control equation communications-assisted trip equation TRCOMM asserts and the current-reversal logic is not asserted.
- Prevents keying and tripping by the POTT logic following a current reversal.
- Echoes the received permissive signal to the remote terminal.
- Prevents channel lockup during echo and test.
- Provides a secure means of tripping for weak- and/or zero-infeed line terminals.

Use Existing SEL-321 Relay POTT Application Guide for the SEL-311L

Use the existing SEL-321 POTT application guide (AG95-29) to help set up the SEL-311L in a POTT scheme (see *Communications-Assisted Trip Logic—General Overview on page 5.18* for more setting comparison information on the SEL-321/SEL-311L Relays).

External Inputs

See *Optoisolated Inputs on page 7.2* for more information on optoisolated inputs.

PT1-Received Permissive Trip Signal(s)

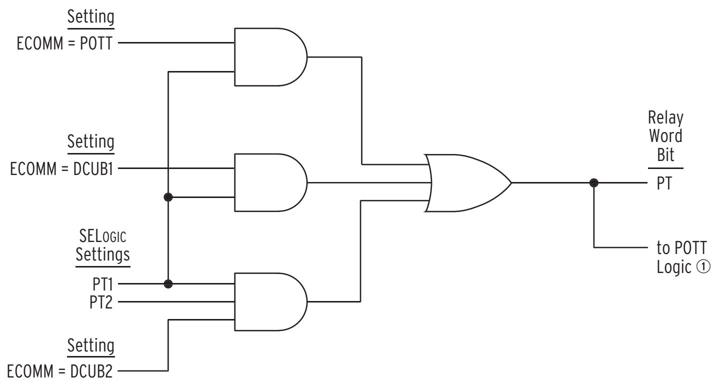
In two-terminal line POTT applications, a permissive trip signal is received from one remote terminal. One optoisolated input on the SEL-311L (e.g., input **IN104**) is driven by a communications equipment receiver output (see *Figure 5.13*). Make SELOGIC control equation setting PT1:

PT1 = **IN104** (two-terminal line application)

In three-terminal line POTT applications, permissive trip signals are received from two remote terminals. Two optoisolated inputs on the SEL-311L (e.g., input **IN104** and **IN106**) are driven by communications equipment receiver outputs (see *Figure 5.14*). Make SELOGIC control equation setting PT1 as follows:

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

SELOGIC control equation setting PT1 in *Figure 5.10* 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 5.11* (for echo keying).



① Figure 5.11

Figure 5.10 Permissive Input Logic Routing to POTT Logic

Also note that SELOGIC control equation setting PT1 in *Figure 5.12* 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 5.7*.

Timer Settings

See *Section 9: Settings* 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 4.0 cycles.

Logic Outputs

The following logic outputs can be tested by assigning them to output contacts. See *Output Contacts on page 7.28* 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 5.7* and the DCUB logic in *Figure 5.15*).

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 5.7*).

Weak-Infeed Logic and Settings

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 to 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.

SEL-311L Weak-Infeed Logic

Enable the weak-infeed logic by setting EWFC = Y.

The SEL-311L provides additional logic (see *Figure 5.11*) 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 for ETDPU time.
- A phase undervoltage or residual overvoltage element is picked up.
- No reverse-looking elements are picked up.
- The circuit breaker is closed.

After these four 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 5.7*) and a trip signal is issued to the local breaker when the conditions described above are true.

Typical phase undervoltage setting (27PPW) is 70–80 percent of the lowest expected system operating voltage. The residual overvoltage setting should be set to approximately twice the expected standing $3V_0$ voltage. With the 59NW element set at twice the nominal standing $3V_0$ voltage, the instrument measures only fault-induced zero-sequence voltage.

KEY-Key Permissive Trip

Signals communications equipment to transmit permissive trip. For example, SELOGIC control equation setting OUT105 is set:

OUT105 = **KEY**

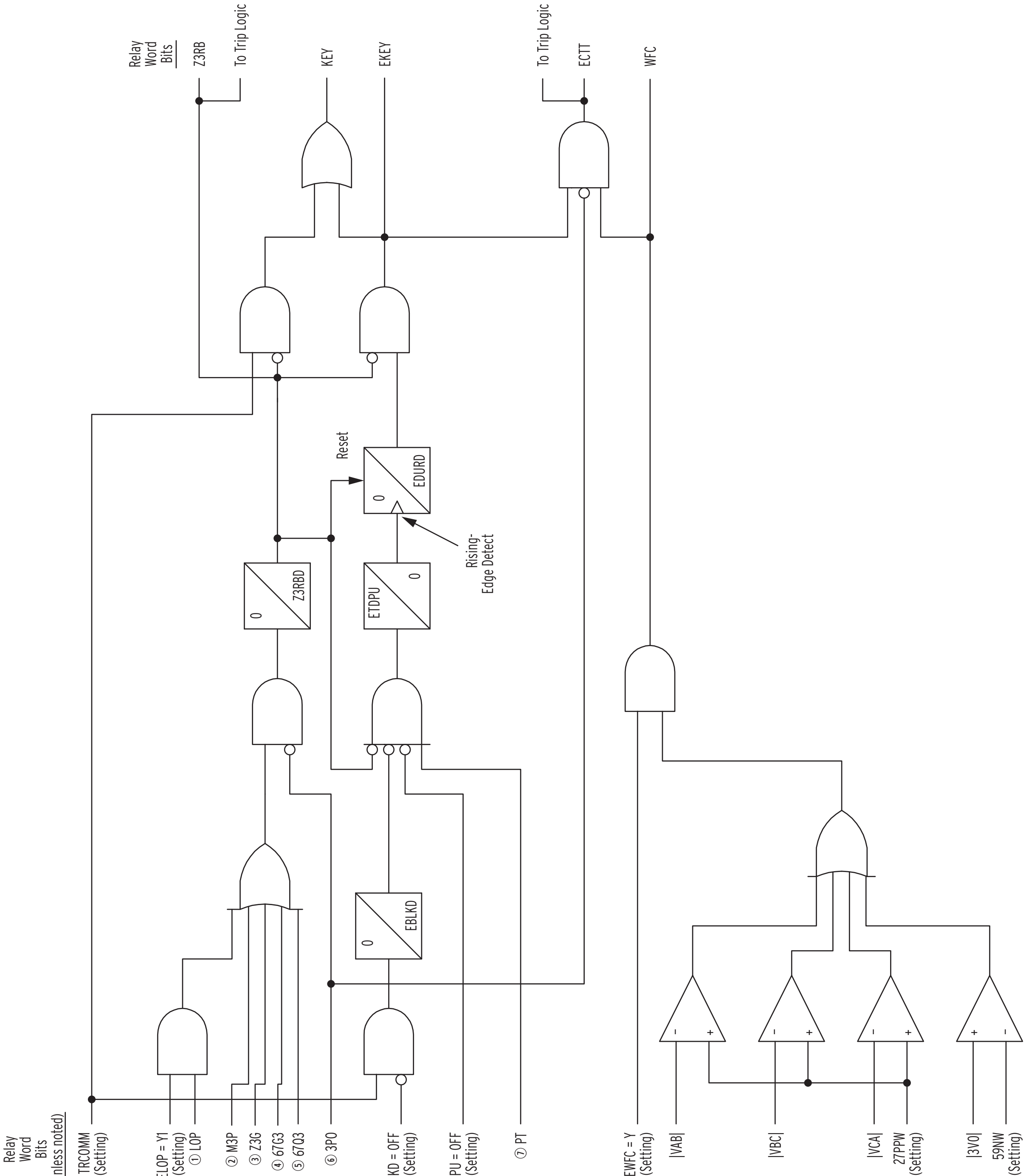
Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.13*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.14*):

OUT107 = **KEY**

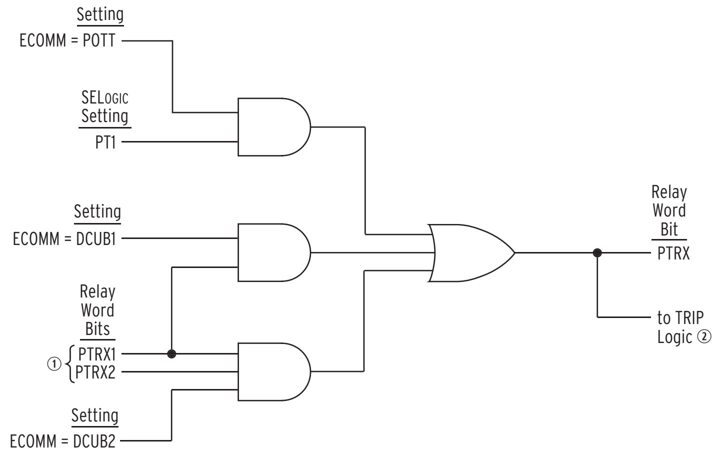
EKEY-Echo Key Permissive Trip

Permissive trip signal keyed by Echo logic (used in testing).



① From Figure 4.35; ② from Figure 4.6; ③ from Figure 4.9; ④ from Figure 4.22; ⑤ from Figure 4.23; ⑥ from Figure 5.8; ⑦ from Figure 5.10

Figure 5.11 POTT Logic



① Figure 5.15; ② Figure 5.7

Figure 5.12 Permissive Input Logic Routing to Trip Logic

Variations for Permissive Underreaching Transfer Trip (PUTT) Scheme

Refer to *Figure 5.9* and *Figure 5.11*. 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 5.13*):

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 5.14*).

Installation Variations

Figure 5.14 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 communication equipment in *Figure 5.14*. Then output contact **OUT107** can be used for another function.

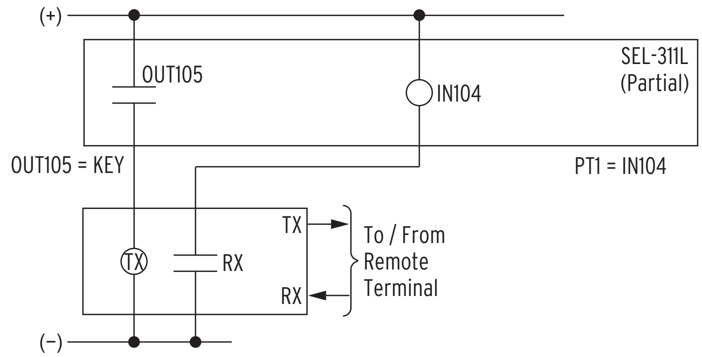


Figure 5.13 SEL-311L Connections to Communications Equipment for a Two-Terminal Line POTT Scheme

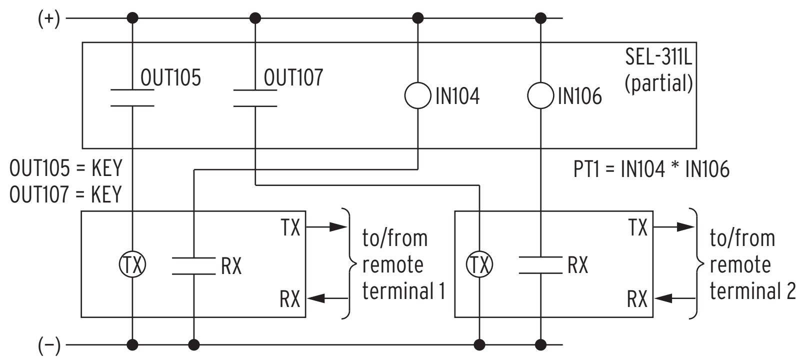


Figure 5.14 SEL-311L Connections to Communications Equipment for a Three-Terminal Line POTT Scheme

Directional Comparison Unblocking Logic

Enable the Directional Comparison Unblocking (DCUB) logic by setting ECOMM = DCUB1 or ECOMM = DCUB2. The DCUB logic in *Figure 5.15* is an extension of the POTT logic in *Figure 5.11*. Thus, the relay requires all the POTT settings and logic, plus settings and logic exclusive to DCUB. The difference between setting choices DCUB1 and DCUB2 is:

DCUB1 directional comparison unblocking scheme for two-terminal line (communications from **one** remote terminal)

DCUB2 directional comparison unblocking scheme for three-terminal line (communications from **two** remote terminals)

The DCUB logic in *Figure 5.15* takes in the loss-of-guard and permissive trip outputs from the communications receivers (see *Figure 5.17* and *Figure 5.18*) and makes permissive (PTRX1/PTRX2) and unblocking block (UBB1/UBB2) logic output decisions.

Use Existing SEL-321 DCUB Application Guide for the SEL-311L

Use the existing SEL-321 DCUB application guide (AG96-19) to help set up the SEL-311L in a DCUB scheme (see *Communications-Assisted Trip Logic—General Overview on page 5.18* for more setting comparison information on the SEL-321/SEL-311LL Relays).

External Inputs

See *Optoisolated Inputs on page 7.2* for more information on optoisolated inputs.

PT1, PT2–Received Permissive Trip Signal(s)

In two-terminal line DCUB applications (setting ECOMM = DCUB1), a permissive trip signal is received from **one** remote terminal. One optoisolated input on the SEL-311L (e.g., input IN104) is driven by a communications equipment receiver output (see *Figure 5.17*). Make SELOGIC control equation setting PT1:

PT1 = **IN104** (two-terminal line application)

In three-terminal line DCUB applications (setting ECOMM = DCUB2), permissive trip signals are received from two remote terminals. Two optoisolated inputs on the SEL-311L (e.g., inputs IN104 and IN106) are driven by communications equipment receiver outputs (see *Figure 5.18*). 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 5.15* for "unblocking block" and "permissive trip receive" logic decisions.

As explained in *Permissive Overreaching Transfer Trip Logic on page 5.20*, the SELOGIC control equation settings PT1 and PT2 in *Figure 5.10* 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 5.11* (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-311L (e.g., input IN105) is driven by a communications equipment receiver output (see *Figure 5.17*). Make SELOGIC control equation setting LOG1:

LOG1 = **IN105** (two-terminal line application)

In three-terminal line DCUB applications (setting ECOMM = DCUB2), loss-of-guard signals are received from two remote terminals. Two optoisolated inputs on the SEL-311L (e.g., input IN105 and IN103) are driven by communications equipment receiver outputs (see *Figure 5.18*). Make SELOGIC control equation settings LOG1 and LOG2 as follows:

LOG1 = **IN105** (three-terminal line application)

LOG2 = **IN103**

SELOGIC control equation settings LOG1 and LOG2 are routed into the DCUB logic in *Figure 5.15* for "unblocking block" and "permissive trip receive" logic decisions.

Timer Settings

See *Section 9: Settings* 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

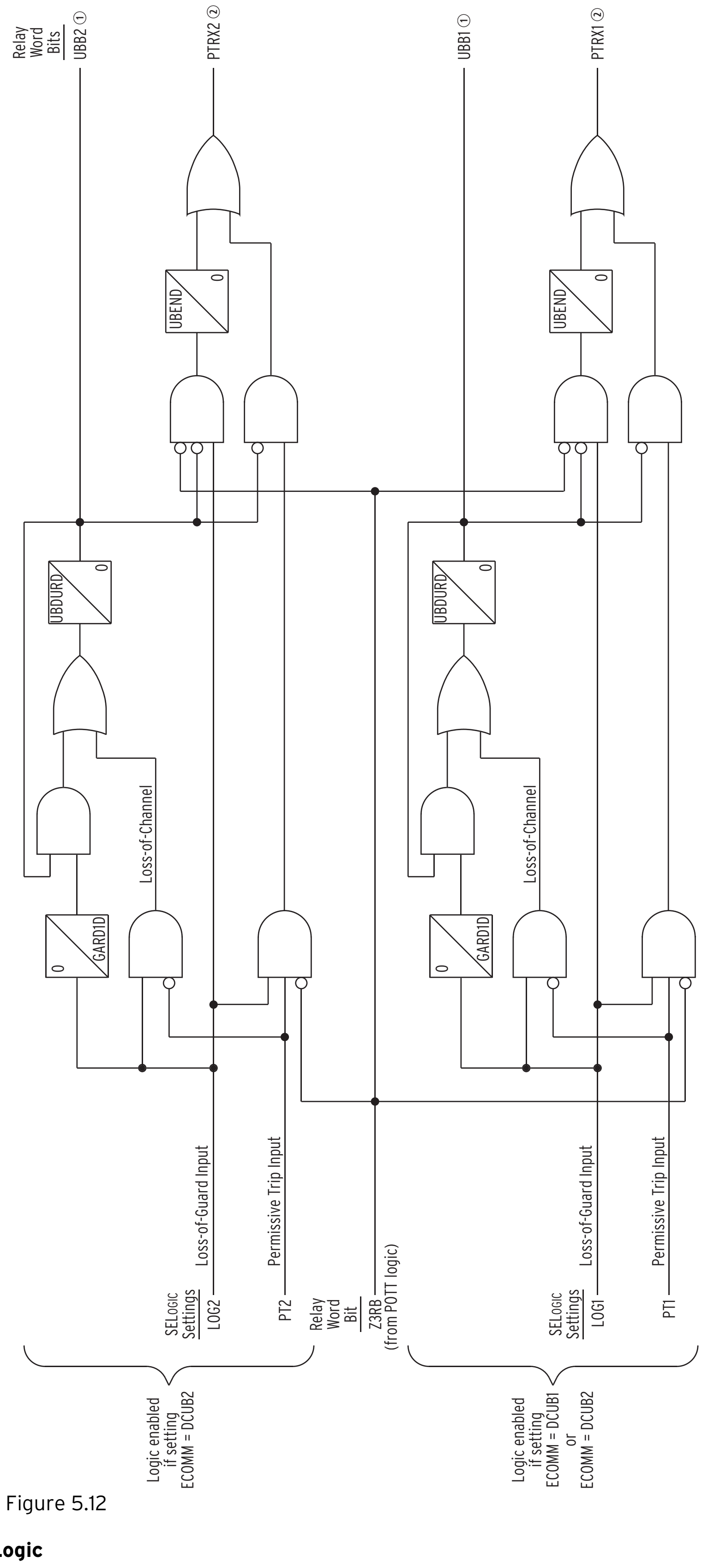
The following logic outputs can be tested by assigning them to output contacts. See *Output Contacts on page 7.28* for more information on output contacts.

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.

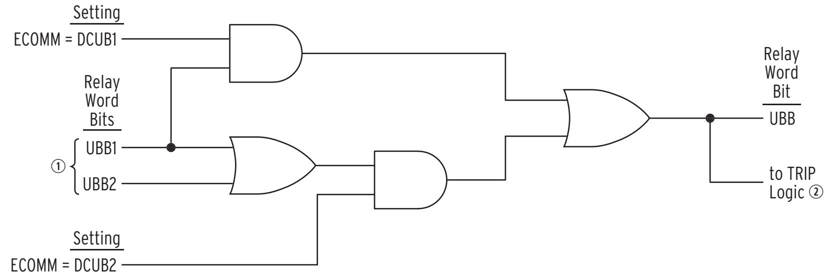
In three-terminal line DCUB applications (setting ECOMM = DCUB2), UBB1 or UBB2 disable tripping if the loss-of-channel condition (for the respective Channel 1 or 2) continues for longer than time UBDURD.

The UBB1 and UBB2 are routed in various combinations in *Figure 5.16* 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 5.7*. When UBB asserts to logical 1, tripping is blocked.



① To Figure 5.16; ② to Figure 5.12

Figure 5.15 DCUB Logic



① from Figure 5.15; ② Figure 5.7

Figure 5.16 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 5.12* 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 5.7*.

Installation Variations

Figure 5.18 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 5.18*. Then output contact OUT107 can be used for another function.

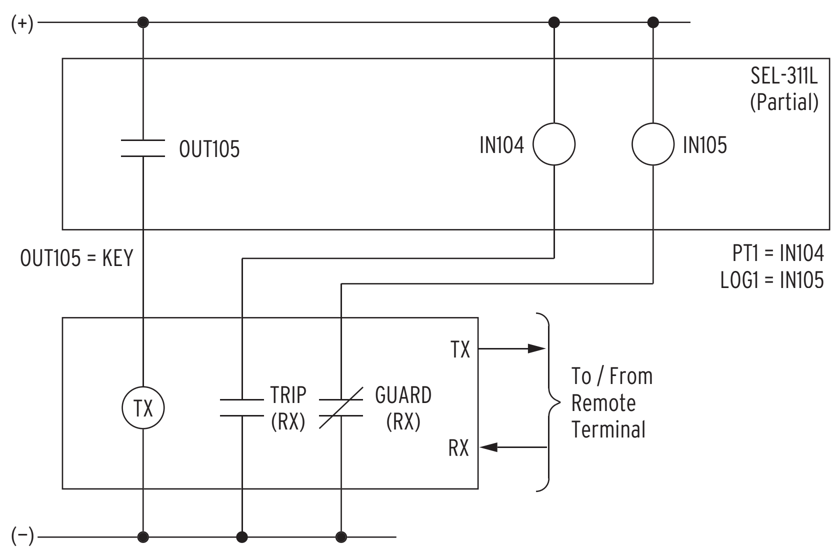


Figure 5.17 SEL-311L Connections to Communications Equipment for a Two-Terminal Line DCUB Scheme (Setting ECOMM = DCUB1)

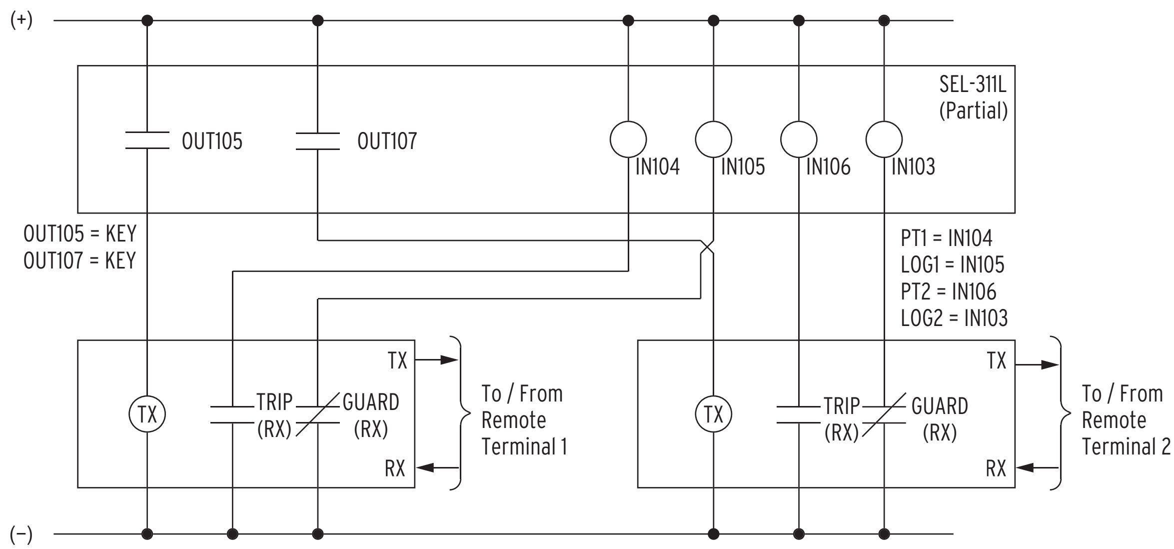


Figure 5.18 SEL-311L Connections to Communications Equipment for a Three-Terminal Line DCUB Scheme (Setting ECOMM = DCUB2)

Directional Comparison Blocking Logic

Enable the Directional Comparison Blocking (DCB) logic by setting ECOMM = DCB. The DCB logic in *Figure 5.19* 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 the block trip send condition by the directional overcurrent following a close-in zero-voltage three-phase fault where the polarizing memory expires. 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-311L

Use the existing SEL-321 DCB application guide (AG93-06) to help set up the SEL-311L in a DCB scheme (see *Communications-Assisted Trip Logic—General Overview on page 5.18* for more setting comparison information on the SEL-321/SEL-311L Relays).

External Inputs

See *Optoisolated Inputs on page 7.2* for more information on optoisolated inputs.

BT–Received Block Trip Signal(s)

In two-terminal line DCB applications, a block trip signal is received from one remote terminal. One optoisolated input on the SEL-311L (e.g., input **IN104**) is driven by a communications equipment receiver output (see *Figure 5.20*). Make SELOGIC control equation setting BT:

BT = **IN104** (two-terminal line application)

In three-terminal line DCB applications, block trip signals are received from two remote terminals. Two optoisolated inputs on the SEL-311L (e.g., input **IN104** and **IN106**) are driven by communications equipment receiver outputs (see *Figure 5.21*). 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 5.19*. The timer output, Relay Word bit BTX, is routed to the trip logic in *Figure 5.7*.

Timer Settings

See *Section 9: Settings* 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 to 2 cycles.

Logic Outputs

The following logic outputs can be tested by assigning them to output contacts. See *Output Contacts on page 7.28* for more information on output contacts.

DSTRT–Directional Carrier Start

Program an output contact for directional carrier start. For example, SELOGIC control equation setting OUT105 is set:

OUT105 = **DSTRT**

Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.20*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.21*):

OUT107 = **DSTRT**

DSTART includes current-reversal guard logic.

NSTRT–Nondirectional Carrier Start

Program an output contact to include nondirectional carrier start, in addition to directional start. For example, SELOGIC control equation setting OUT105 is set:

OUT105 = **DSTRT + NSTRT**

Output contact **OUT105** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.20*).

In a three-terminal line scheme, output contact **OUT107** is set the same as **OUT105** (see *Figure 5.21*):

OUT107 = **DSTRT + NSTRT**

STOP–Stop Carrier

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

OUT106 = **STOP**

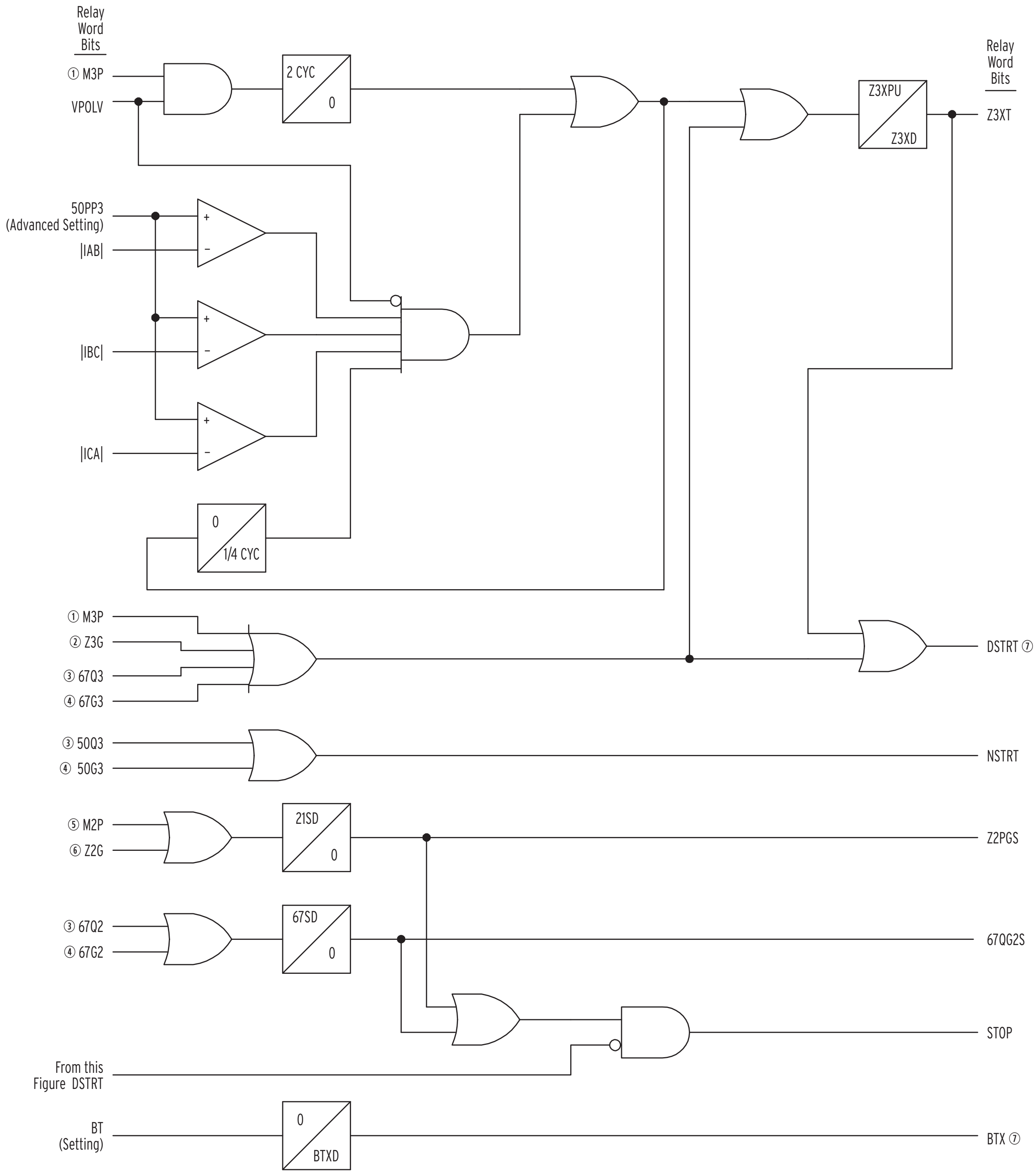
Output contact **OUT106** drives a communications equipment transmitter input in a two-terminal line application (see *Figure 5.20*).

In a three-terminal line scheme, another output contact (e.g., **OUT104**) is set the same as **OUT106** (see *Figure 5.21*):

OUT104 = **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 5.19*. The timer output (BTX) is routed to the trip logic in *Figure 5.7*.



① From Figure 4.6; ② from Figure 4.9; ③ from Figure 4.23;
④ from Figure 4.22; ⑤ from Figure 4.5; ⑥ from Figure 4.8; ⑦ to Figure 5.7

Figure 5.19 DCB Logic

Installation Variations

Figure 5.21 shows output contacts **OUT105**, **OUT106**, **OUT107**, and **OUT104** connected to separate communications equipment, for the two remote terminals. Both output contact pairs are programmed the same

OUT105 = **DSTRT + NSTRT and OUT107**
= DSTRT + NSTRT; OUT106 = STOP and OUT104 = 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 communications equipment in *Figure 5.21*. 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 communications equipment in *Figure 5.21*. Then output contact **OUT104** can be used for another function.

Figure 5.21 also shows communications equipment **RX** (receive) output contacts from each remote terminal connected to separate inputs **IN104** and **IN106** on the SEL-311L. 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 communications equipment **RX** (receive) output contacts in *Figure 5.21*. Then setting BT would be programmed as:

BT = **IN104**

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

In *Figure 5.20* and *Figure 5.21*, 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 settings group where the DCB logic is not enabled.

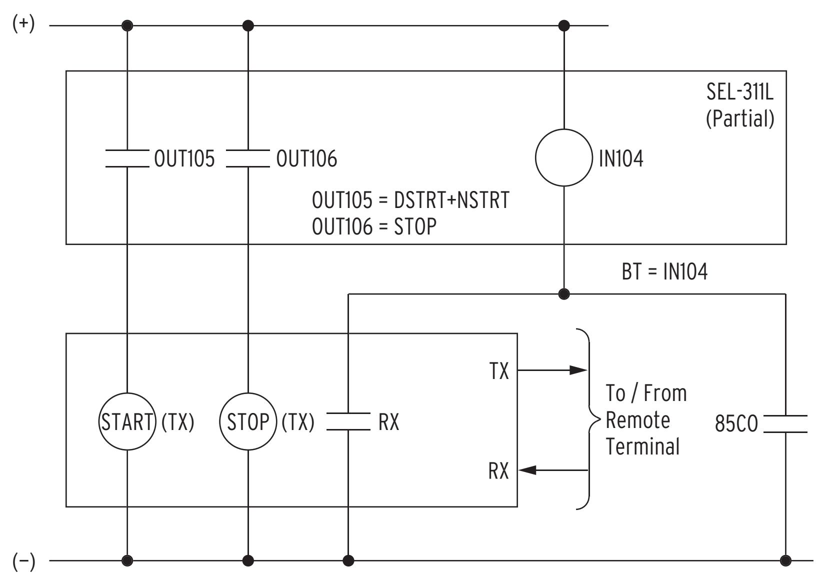


Figure 5.20 SEL-311L Connections to Communications Equipment for a Two-Terminal Line DCB Scheme

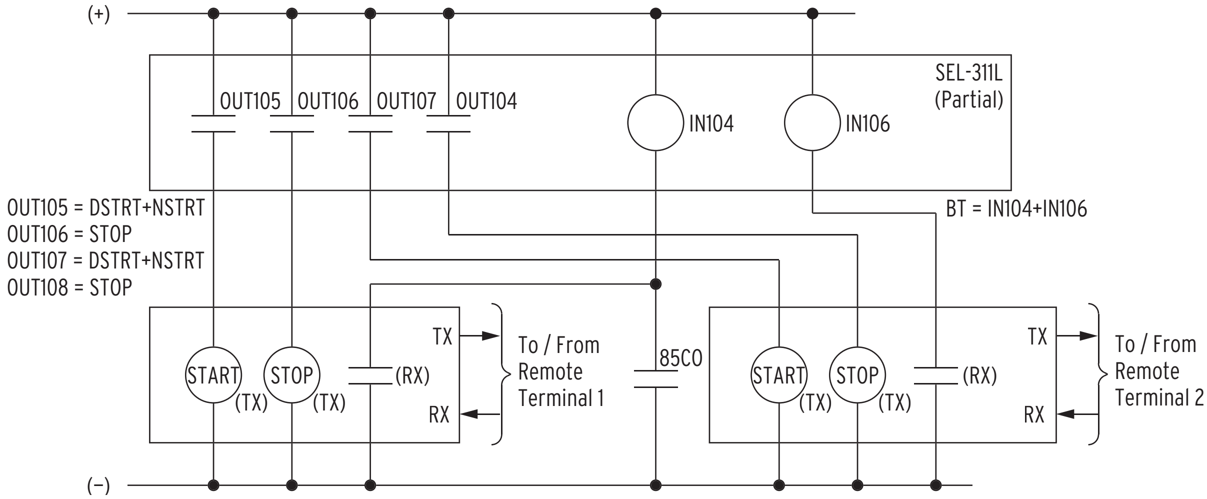


Figure 5.21 SEL-311L Connections to Communications Equipment for a Three-Terminal Line DCB Scheme

Front-Panel Target LEDs

Table 5.1 SEL-311L Front-Panel Target LED Definitions

LED Number	LED Label	Definition
1	EN	Relay Enabled—see *Relay Self-Tests on page 13.14*
2	TRIP	Indication that a trip occurred, by any of the protection or control elements
3	TIME	Time-delayed trip
4	COMM	Communications-assisted trip (not 87L)
5	87	Trip caused by line current differential element or 87L DTT bit
6	50/51	Instantaneous/time-overcurrent trip
7	RS	Recloser reset
8	LO	Recloser locked out
9	A	A-phase involved in the fault
10	B	B-phase involved in the fault
11	C	C-phase involved in the fault
12	G	Ground is involved in the fault
13	1	Zone/Level 1 element picked up at time of trip
14	2	Zone/Level 2 element picked up at time of trip
15	3	Zone/Level 3 element picked up at time of trip
16	87CH FAIL	Line current differential channel failure

Target LEDs numbered 2–6 and 9–15 in *Table 5.1* are updated and then latched for every new assertion (rising edge) of the TRIP or TRIP87 Relay Word bits (or TRPA21, TRPB21, TRPC21 Relay Word bits when APP = 87LSP in the SEL-311L-1-7 Relay). The TRIP Relay Word bit is the output of the backup protection trip logic (see *Figure 5.7*). The TRIP87 Relay Word bit is the output of the 87L trip logic (see *Figure 5.1*). The TRPA21, TRPB21, and TRPC21 Relay Word bits are the special distance element trip bits used to provide a single-pole trip output in the SEL-311L-7 Relay (see *Figure 5.3* and *Figure 5.4*).

Further target LED information follows. Refer also to *Figure 2.2*, *Figure 2.3*, and *Figure 2.4* for the placement of the target LEDs on the front panel.

Additional Target LED Information

TRIP Target LED

The **TRIP** target LED illuminates at the rising edge of the TRIP Relay Word bit.

The **TRIP** target LED is especially helpful in providing front-panel indication for tripping that does not involve protection elements. If the trip is not a protection element generated trip, none of the target LEDs illuminate (3–6 and 9–15), but the **TRIP** target LED still illuminates. Thus, tripping via the front-panel local control (local bits), serial port (remote bits or **OPEN** command), or voltage elements is indicated only by the illumination of the **TRIP** target LED.

TIME Target LED

The **TIME** target LED illuminates at the rising edge of trip if SELOGIC control equation setting FAULT has been asserted for more than 3 cycles. 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 3 cycles after fault inception, the **TIME** target illuminates.

SELOGIC control equation setting FAULT also controls max./min. metering. If FAULT is asserted, maximum/minimum metering is blocked (see *Maximum/Minimum Metering Updating and Storage on page 8.11*). Fault current values are not to be accrued as maximum current values in maximum/minimum metering.

Add Relay Word bit 87L to SELOGIC control equation setting FAULT when the SEL-311L is used without relaying potentials.

COMM Target LED

The **COMM** target LED illuminates at the rising edge of trip if the trip is the sole and direct result of SELOGIC control equation setting TRCOMM and associated communications-assisted trip logic, Relay Word bit ECTT, or SELOGIC control equation setting DTT (see *Figure 5.7*, top half of figure).

Another Application for the COMM Target LED

If none of the traditional communications-assisted trip logic is used (i.e., SELOGIC control equation setting TRCOMM is not used), consideration can be given to using the **COMM** target LED to indicate tripping via remote communications channels (e.g., via serial port commands or SCADA asserting optoisolated inputs). Use SELOGIC control equation setting DTT (Direct Transfer Trip) to accomplish this (see *Figure 5.7*).

For example, if the **OPEN** command or remote bit RB1 (see *CON Command (Control Remote Bit) on page 10.57*) are used to trip via the serial port and they should illuminate the **COMM** target LED, set them in SELOGIC control equation setting DTT:

DTT = **... + OC + RB1**

Additionally, if SCADA asserts optoisolated input **IN104** to trip and it should illuminate the **COMM** target LED, set it in SELOGIC control equation setting DTT also:

DTT = **... + IN104 + ...**

Relay Word bits set in SELOGIC control equation setting DTT do not have to be set in SELOGIC control equation setting TR—both settings directly assert the TRIP Relay Word bit. The only difference between settings DTT and TR is that setting DTT causes the **COMM** target LED to illuminate.

Many other variations of the above DTT settings examples are possible.

79 Target LEDs

If the reclosing relay is turned off (enable setting E79 = N or 79OI1 = 0), all the Device 79 (reclosing relay) target LEDs are extinguished.

50/51 Target LED

The **50/51** target LED illuminates at the rising edge of trip when any overcurrent element (except 50L) in the tripping equation is asserted. This includes 50, 51, 51T, 67, 67T, T50, T51, T51T, and T50T.

FAULT TYPE Target LEDs

A, B, and C Target LEDs

"**A**" (A-phase) target LED is illuminated at 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).

G Target LED

G target LED is illuminated at the rising edge of trip if ground is involved in the fault.

Zone LEDs

Zone/Level LEDs illuminate for the lowest zone number in the tripping equation detected during the fault (M1P, M2P, M3P, Z1G, Z2G, Z2PG2S, Z3G, 50P1, 67P1, 67P2, 67P3, 67G1, 67G2, 67G3, 67Q1, 67Q2, 67QG2S, 67Q3).

87CH FAIL LED

The **87CH FAIL** LED illuminates when the relay detects a problem with any active 87L Communications Channel. See *Section 10: Communications* for more information about the **87CH FAIL** LED.

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 latched target LEDs (target LEDs numbered 2–6 and 9–15 in *Table 5.1*) are extinguished (unlatched).

Other Applications for the Target Reset Function

Refer to the bottom of *Figure 5.7*. The combination of the **TARGET RESET** pushbutton and the **TAR R** (Target Reset) serial port command is available as Relay Word bit TRGTR. Relay Word bit 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.

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 default display (see *Rotating Default Display on page 7.38* and *Rotating Default Display on page 11.10*, also):

SV8 = **(SV8 + SV7T) * !TRGTR**

DP3 = **SV8**

DP3_1 = **BREAKER FAILURE**

DP3_0 = **(blank)**

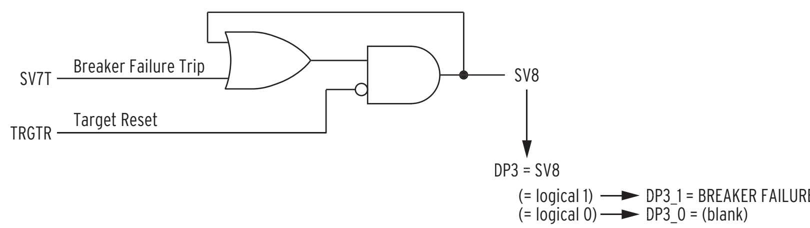
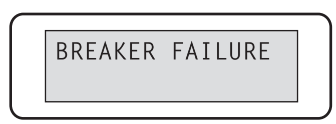


Figure 5.22 Seal-in of Breaker Failure Occurrence for Message Display

If a breaker failure trip has occurred, the momentary assertion of SV7T (breaker failure trip) will cause SV8 in *Figure 5.22* to seal in. Asserted SV8 in turn asserts DP3, causing the message:



to display in the rotating default display.

This message can be removed from the display rotation by pushing the **TARGET RESET** pushbutton (Relay Word bit TRGTR pulses to logical 1, unlatching SV8 and in turn deasserting DP3). Thus, front-panel rotating default displays can be easily reset along with the front-panel targets by pushing the **TARGET RESET** pushbutton.

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Section 6

Close and Reclose Logic

Overview

This section is made up of three sections:

- Close Logic
- Reclose Supervision Logic
- Reclose Logic

Close Logic

This section describes the final logic that controls the close output contact (e.g., OUT103 = CLOSE). This output contact closes the circuit breaker for automatic reclosures and other close conditions (e.g., manual close initiation via serial port or optoisolated inputs).

If automatic reclosing is not needed, but the SEL-311L Relay is to close the circuit breaker for other close conditions (e.g., manual close initiation via serial port or optoisolated inputs), then this section is the only section that needs to be read in this section (particularly the description of SELOGIC control equation setting CL).

Reclose Supervision Logic

This section 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 contact.

Reclose Logic

NOTE: 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 close conditions via SELOGIC control equation setting CL (e.g., manual close initiation via serial port or optoisolated inputs).

This section describes all the reclosing relay settings and logic needed for automatic reclosing (besides the final close logic and reclose supervision logic described in the previous sections).

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.

Close Logic

The close logic in *Figure 6.1* provides flexible circuit breaker closing/automatic reclosing with SELOGIC control equation settings:

52A (breaker status)

52AA (A-phase breaker status when APP = 87LSP)

52AB (B-phase breaker status when APP = 87LSP)

52AC (C-phase breaker status when APP = 87LSP)

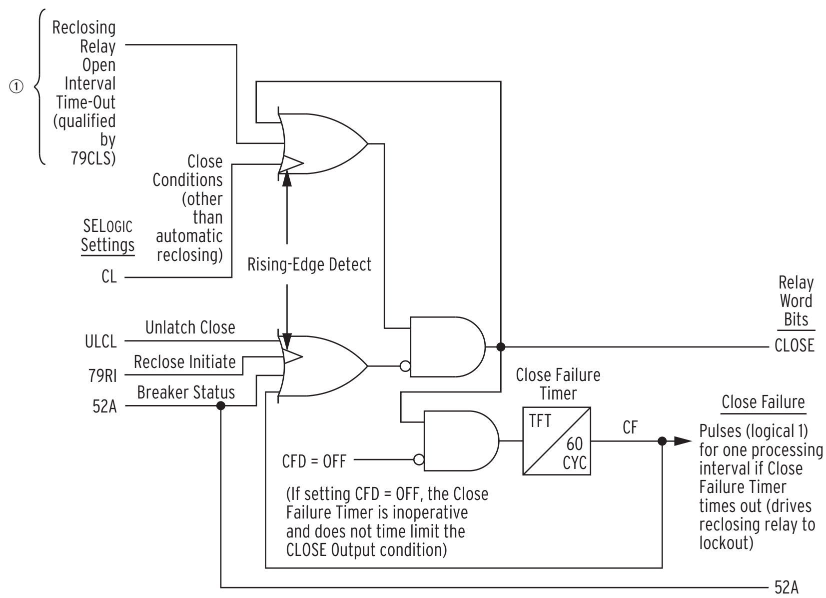
CL (close conditions, other than automatic reclosing)

ULCL (unlatch close conditions, other than circuit breaker status, close failure, or reclose initiation)

and setting:

CFD (Close Failure Time)

See the settings sheet in *Section 9: Settings* for setting ranges.



① From Figure 6.2

Figure 6.1 Close Logic

Set Close

NOTE: When APP = 87LSP, the SELOGIC control equation setting 52A is set as follows and hidden: 52A = 52AA * 52AB * 52AC.

If all the following are true:

- ➤ The unlatch close condition is not asserted (ULCL = 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.
- ➤ A close failure condition does not exist (Relay Word bit CF = 0).

Then the CLOSE Relay Word bit can be asserted to logical 1 if either of the following occurs:

- ➤ A reclosing relay open interval times out (qualified by SELOGIC control equation setting 79CLS—see *Figure 6.2*).
- ➤ Or SELOGIC control equation setting CL goes from logical 0 to logical 1 (rising-edge transition).

The **CLOSE** command is the only value in the close logic in the factory-default settings:

CL = **CC**

Relay Word bit CC asserts for execution of the **CLOSE** Command. See *CLO Command (Close Breaker) on page 10.54* 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 addition 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 and additional conditions may be incorporated by the user.

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).
- ➤ The circuit breaker closes (52A = logical 1).
- ➤ 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 is inoperative if setting CFD = OFF.

Factory Settings Example

The factory settings for the close logic SELOGIC control equation settings are:

52A = **IN101**

CL = **CC**

ULCL = **TRIP + TRIP87**

The factory setting for the Close Failure Timer setting is:

CFD = **60.00 cycles**

See the settings sheets at the end of *Section 9: Settings* for setting ranges.

Set Close

If the Reclosing Relay Open Interval Time-Out logic input at the top of *Figure 6.1* 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)* for more information on the **CLOSE** Command.

Unlatch Close

SELOGIC control equation setting ULCL has a default of TRIP + TRIP87. This prevents the CLOSE Relay Word bit from being asserted any time the TRIP or TRIP87 Relay Word bits are asserted. See *Section 5: Trip and Target Logic*.

SELOGIC control equation setting 52A is set with optoisolated input **IN101**. Input **IN101** is connected to a 52a circuit breaker auxiliary contact. When a closed circuit breaker condition is detected, the CLOSE Relay Word bit is deasserted to logical 0. Setting 52A can handle a 52a or 52b circuit breaker auxiliary contact connected to an optoisolated input (see *Optoisolated Inputs on page 7.2* for more 52A setting examples).

With setting CFD = 60.00 cycles, once the CLOSE Relay Word bit asserts, it remains asserted at logical 1 no longer than a maximum of 60 cycles. If the Close Failure Timer times out, Relay Word bit CF asserts to logical 1, forcing the CLOSE Relay Word bit to logical 0 (opening output 103 with the default setting OUT103 = CLOSE).

Defeat the Close Logic

If SELOGIC control equation circuit breaker auxiliary setting 52A is set with numeral 0 (52A = 0), then the close logic is inoperable and the reclosing relay is defeated (see *Reclosing Relay on page 6.10*). Also, the operation of ground distance elements is delayed by the 3POD time to reset 3PO.

Circuit Breaker Status

Refer to the bottom of *Figure 6.1*. Note that SELOGIC control equation setting 52A (circuit breaker status) is available as Relay Word bit 52A. This makes it convenient to set other SELOGIC control equations. For example, if the following setting is made:

52A = **IN101** (52a auxiliary contact wired to input **IN101**)

or

52A = **!IN101** (52b auxiliary contact wired to input **IN101**)

then if breaker status is used in other SELOGIC control equations, it can be entered as 52A—the user does not have to enter IN101 (for a 52a) or !IN101 (for a 52b). For example, refer to *Rotating Default Display on page 7.38*. If circuit breaker status indication is controlled by display point setting DP2:

DP2 = **IN101**

This can be entered instead as:

DP2 = **52A**

(presuming SELOGIC control equation setting 52A = IN101 is made).

Note that when APP = 87LSP, the SELOGIC control equation setting 52A is set as follows and hidden:

52A = **52AA * 52AB * 52AC**

Program an Output Contact for Closing

In the factory settings, the resultant of the close logic in *Figure 6.1* is routed to output contact **OUT103** with the following SELOGIC control equation:

OUT103 = **CLOSE**

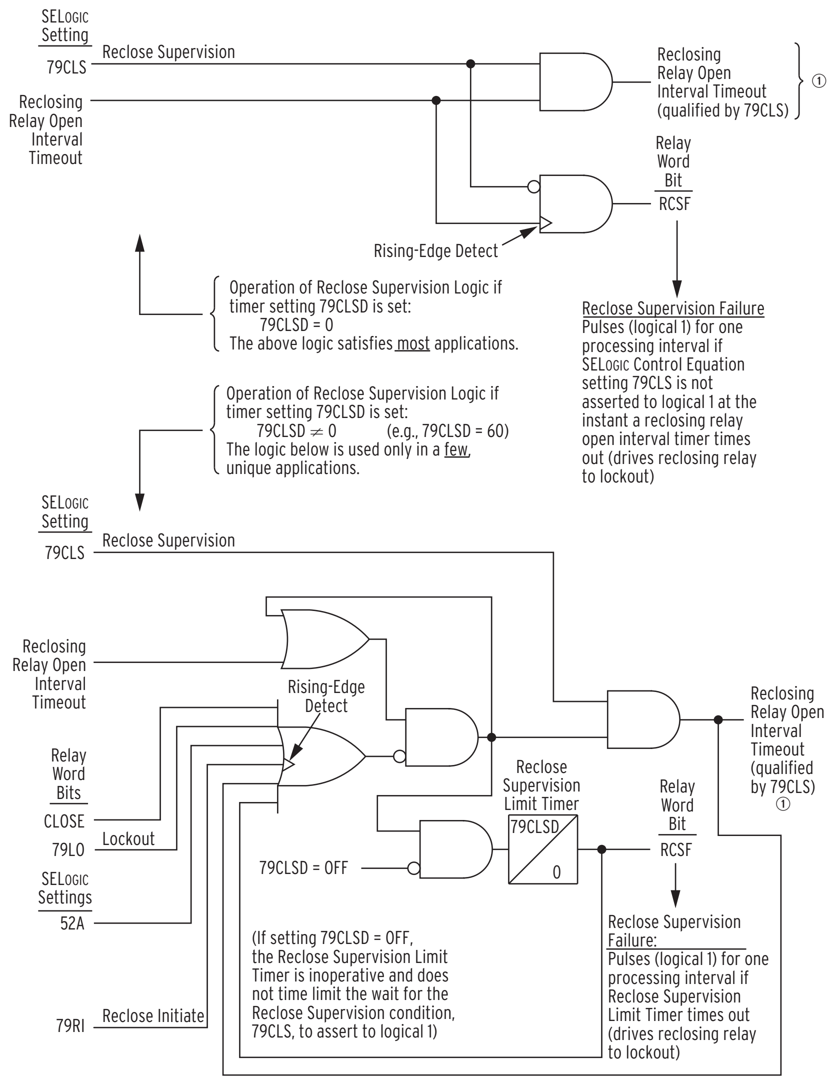
See *Output Contacts on page 7.28* for more information on programming output contacts.

Reclose Supervision Logic

Note that one of the inputs into the close logic in *Figure 6.1* is:

Reclosing Relay Open Interval Time-Out (qualified by 79CLS)

This input into the close logic in *Figure 6.1* is the indication that a reclosing relay open interval has timed out, 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 6.1* is an output of the reclose supervision logic in the following *Figure 6.2*.



① To Figure 6.1

Figure 6.2 Reclose Supervision Logic (Following Open Interval Time-Out)

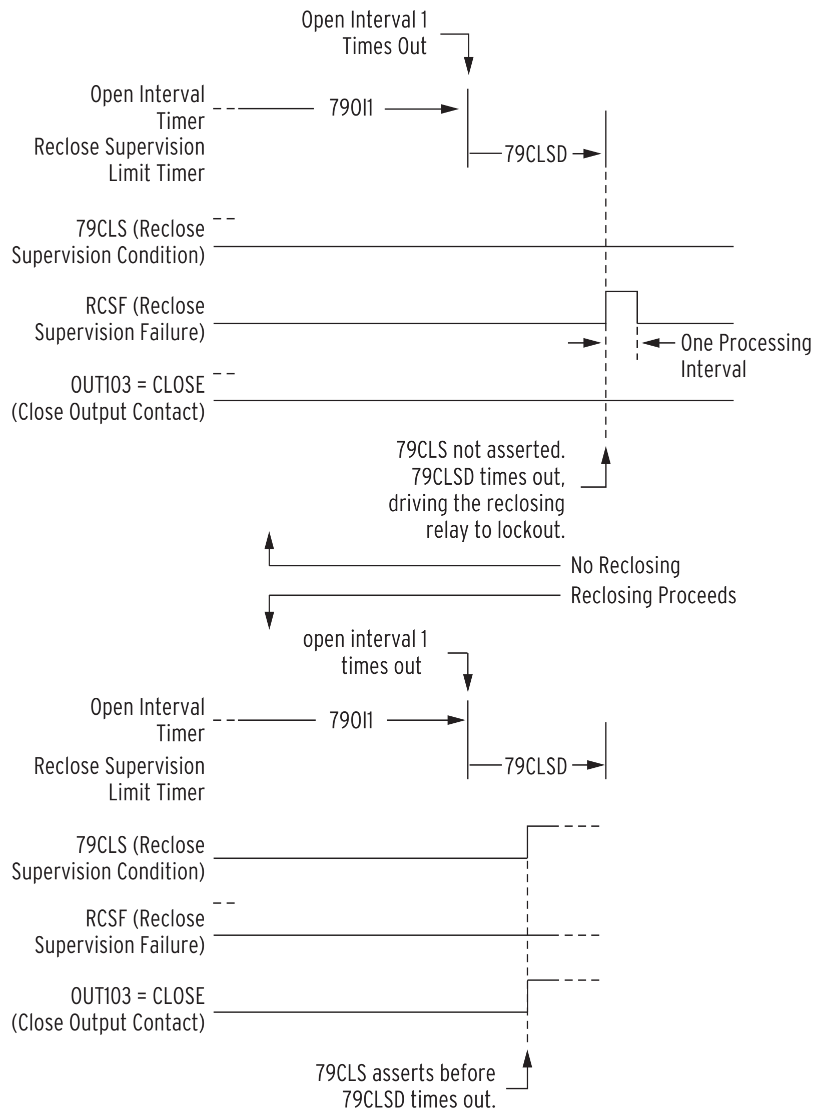


Figure 6.3 Reclose Supervision Limit Timer Operation (Refer to Bottom of Figure 6.2)

Settings and General Operation

Figure 6.2 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 settings sheets at the end of *Section 9: Settings* for setting ranges.

For Most Applications (Top of Figure 6.2)

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 6.2* 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 open interval time-out will propagate onto the final close logic in *Figure 6.1* 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 the Lockout State.

See *Settings Example on page 6.8* and *Additional Settings Example 1 on page 6.8*.

For a Few, Unique Applications (Bottom of Figure 6.2 and Figure 6.3)

For a few unique applications, such as slip between two systems, the Reclose Supervision Limit Time setting is not set equal to zero cycles, e.g.:

79CLSD = **60.00**

With this setting, the logic in the bottom of *Figure 6.2* 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 open interval time-out will propagate onto the final close logic in *Figure 6.1* 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 the Lockout State.

The logic in the bottom of *Figure 6.2* is explained in more detail in the following text.

Set Reclose Supervision Logic (Bottom of Figure 6.2)

Refer to the bottom of *Figure 6.2*. If all the following are true:

- The close logic output CLOSE 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 *Figure 6.2*. Then, when 79CLS asserts to logical 1, the sealed-in reclosing relay open interval time-out condition will propagate through *Figure 6.2* and on to the close logic in *Figure 6.1*.

Unlatch Reclose Supervision Logic (Bottom of Figure 6.2)

Refer to the bottom of *Figure 6.2*. 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 6.1*) 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).

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 above 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 6.1*.

See *Additional Settings Example 2 on page 6.10*.

Settings Example

Refer to the top of *Figure 6.2*.

The example setting for the SELOGIC control equation reclose supervision setting is:

79CLS = **1** (numeral 1)

The example setting for the Reclose Supervision Limit Timer setting is:

79CLSD = **0.00 cycles**

Any time a reclosing relay open interval times out, it propagates immediately through *Figure 6.2* and then on to *Figure 6.1*, 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 6.2* and *Figure 6.4*.

SEL-311L relays are installed at both ends of a transmission line in a high-speed reclose scheme. After both circuit breakers open for a transmission line fault, the SEL-311L(1) Relay recloses circuit breaker 52/1 first, followed by the SEL-311L(2) Relay reclosing circuit breaker 52/2, after a synchronism check across circuit breaker 52/2.

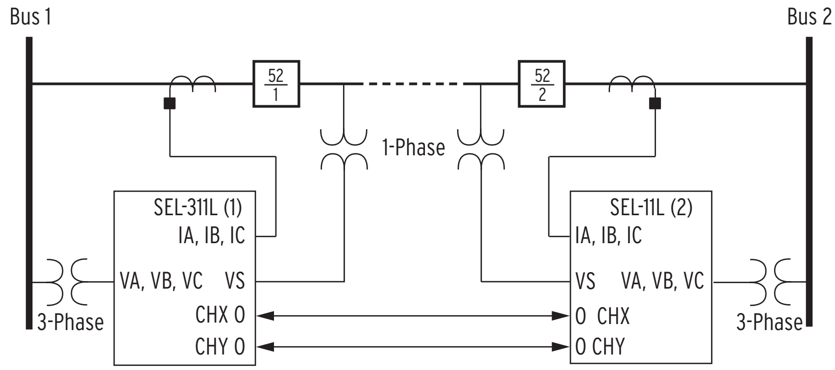


Figure 6.4 SEL-311L Relays in a Two-Terminal Application With Reclosing

SEL-311L(1) Relay

Before allowing circuit breaker 52/1 to be reclosed after an open interval time-out, the SEL-311L(1) Relay verifies that Bus 1 voltage is hot and the transmission line voltage is dead. This requires reclose supervision settings:

79CLSD = **0.00 cycles** (only one check)

79CLS = **3P59 * 27S**

where:

3P59 = all three Bus 1 phase voltages (VA, VB, and VC) are hot

27S = monitored single-phase transmission line voltage (channel VS) is dead

SEL-311L(2) Relay

The SEL-311L(2) Relay verifies that Bus 2 voltage is hot, the transmission line voltage is hot, and in synchronism after the reclosing relay open interval times out, before allowing circuit breaker 52/2 to be reclosed. This requires reclose supervision settings:

79CLSD = **0.00 cycles** (only one check)

79CLS = **25A1**

where:

25A1 = selected Bus 2 phase voltage (VA, VB, VC, VAB, VBC, or VCA) is in synchronism with monitored single-phase transmission line voltage (channel VS) and both are hot

Other Setting Considerations for SEL-311L(1) and SEL-311L(2) Relays

Refer to *Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, Respectively) on page 6.22*.

SELOGIC control equation setting 79STL stalls open interval timing if it asserts to logical 1. If setting 79STL is deasserted to logical 0, open interval timing can continue.

The SEL-311L(1) Relay 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-311L(2) starts open interval timing after circuit breaker 52/1 at the remote end has re-energized the line. The SEL-311L(2) has to see Bus 2 hot, transmission line hot, and in synchronism across open circuit breaker 52/2 for open interval timing to begin. Thus, SEL-311L(2) open interval timing is stalled when the transmission line voltage and Bus 2 voltage are not in synchronism across open circuit breaker 52/2:

79STL = **!25A1** [=NOT(25A1)]

Note that a transient synchronism-check condition across 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-311L(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-311L(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-311L(2) (see *Figure 7.24* and *Figure 7.25*). Note the built-in three-cycle qualification of the synchronism-check voltages shown in *Figure 4.30*.

Additional Settings Example 2

Refer to section *Synchronism-Check Elements on page 4.44*. Also refer to *Figure 6.3* and *Figure 6.4*.

If the synchronizing voltages across open circuit breaker 52/2 are “slipping” with respect to one another, the Reclose Supervision Limit Timer setting 79CLSD should be set greater than zero so there is time for the slipping voltages to come into synchronism. For example:

79CLSD = **60.00 cycles**

79CLS = **25A1**

The status of synchronism-check element 25A1 is checked continuously during the 60-cycle window. If the slipping voltages come into synchronism while timer 79CLSD is timing, synchronism-check element 25A1 asserts to logical 1 and reclosing proceeds.

Under section *Synchronism-Check Elements*, note item 3 under *Synchronism-Check Element Outputs on page 4.52*, Voltages V_P and V_S are “Slipping.” Item 3 describes a last attempt for a synchronism-check reclose before timer 79CLSD times out (or setting 79CLSD = 0.00 and only one check is made).

Reclosing Relay

Note that input:

Reclosing Relay Open Interval Time-Out

in *Figure 6.2* is the logic input that is qualified by SELOGIC control equation setting 79CLS, and then propagated onto the close logic in *Figure 6.1* 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 6.2*. Other aspects of the reclosing relay are also explained. as many as four (4) automatic reclosures (shots) are available.

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 6.14*).

Reclosing Relay States and General Operation

Figure 6.5 explains in general the different states of the reclosing relay and its operation.

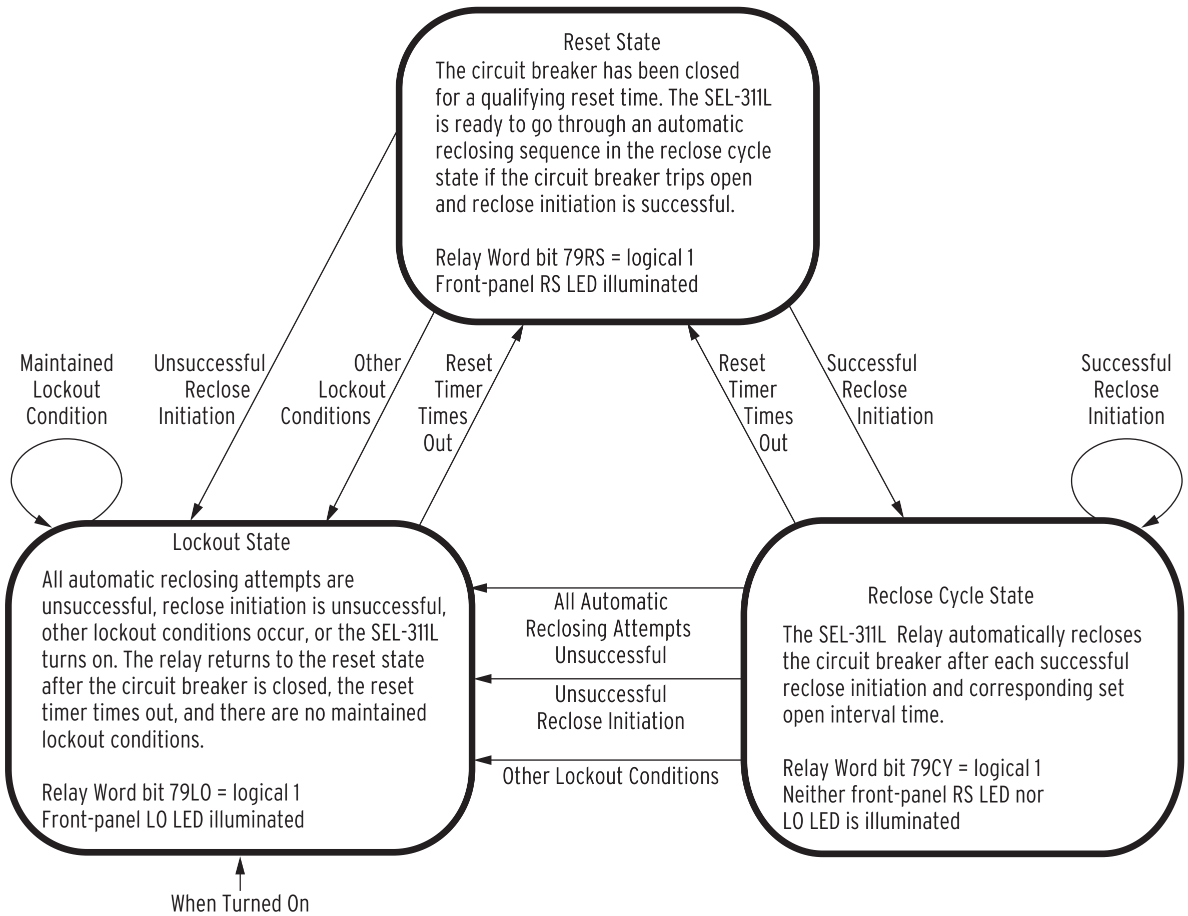


Figure 6.5 Reclosing Relay States and General Operation

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
Reset	79RS	RS
Lockout	79LO	LO
Cycling	79CY	–

The reclosing relay is in one (and only one) of these states (listed in *Table 6.1*) at any time. When in reset or lockout, the corresponding Relay Word bit asserts to logical 1, and the LED illuminates. 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 the time of reclose initiation (e.g., all automatic reclosing attempts are unsuccessful—see *Figure 6.6*).
- Reclose initiation is unsuccessful because of SELOGIC control equation setting 79RIS (see *Reclose Initiate and Reclose Initiate Supervision Settings (79RI and 79RIS, Respectively) on page 6.18*).
- The circuit breaker opens without reclose initiation (e.g., an external trip).
- The shot counter is equal to or greater than last shot, and the circuit breaker is open (e.g., the shot counter is driven to last shot with SELOGIC control equation setting 79DLS while open interval timing is in progress. See *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 6.20*).
- The Close Failure Timer (setting CFD) times out (see *Figure 6.1*).
- 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 6.2* and top of *Figure 6.3*).
- A new reclose initiation occurs while the reclosing relay is timing on an open interval (e.g., flashover in the tank while breaker is open).

The **OPEN** (**OPE**) command can be included in the reclosing relay logic via SELOGIC control equation settings. For example:

79DTL = **... + OC** (drive-to-lockout)

Relay Word bit OC asserts for execution of the **OPE** command. See *OPE Command (Open Breaker) on page 10.56* for more information on the **OPE** command. Also, see *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively)*.

If the **OPE** command is set to trip (TR = … + OC), then the following reclosing relay SELOGIC control equation settings should also be made (presuming that an **OPE** command trip should not initiate reclosing):

79RI = **TRIP + TRIP87**. (reclose initiate)

79DTL =**... + OC** (drive-to-lockout)

Reclosing Relay States After a Settings or Setting Group Change

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 *Reset Timer on page 6.15*).

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 settings sheets at the end of *Section 9: Settings*.

If the reclosing relay is defeated, the following also occur:

- ➤ Both reclosing relay state Relay Word bits (79RS 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 front-panel LEDs RS and LO are both extinguished.

Close Logic Can Still Operate When the Reclosing Relay Is Defeated

If the reclosing relay is defeated, the close logic (see *Figure 6.1*) can still operate if SELOGIC control equation circuit breaker status setting 52A is set to something other than numeral 0. Making the setting 52A = 0 defeats the close logic and also defeats the reclosing relay.

For example, if 52A = IN101, a 52a circuit breaker auxiliary contact is connected to input **IN101**. If the reclosing relay does not exist, the close logic still operates, allowing closing to take place via SELOGIC control equation setting CL (close conditions, other than automatic reclosing). See *Close Logic on page 6.1* for more discussion on SELOGIC control equation settings 52A and CL. Also see *Optoisolated Inputs on page 7.2* for more discussion on SELOGIC control equation setting 52A.

Reclosing Relay Timer Settings

Example open interval and reset timer settings are shown in *Table 6.2*.

Table 6.2 Reclosing Relay Timer Settings and Setting Ranges

Timer Setting (range)	Setting (in cycles)	Definition
79OI1 (0.00–999999 cyc)	30.00	open interval 1 time
79OI2 (0.00–999999 cyc)	600.00	open interval 2 time
79OI3 (0.00–999999 cyc)	0.00	open interval 3 time, shot 3 and shot 4 disabled
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
79CLSD (OFF, 0.00–999999 cyc)	OFF	reclose supervise time l

The operation of these timers is affected by SELOGIC control equation settings discussed later in this section. Also see the settings sheets at the end of *Section 9: Settings*.

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 example settings in *Table 6.2*, the open interval 3 time setting 79OI3 is the first open interval time setting set equal to zero:

79OI3 = **0.00 cycles**

Thus, open interval times 79OI3 and 79OI4 are not operable. In the example settings, both open interval times 79OI3 and 79OI4 are set to zero. But if the settings were:

79OI3 = **0.00 cycles**

79OI4 = **900.00 cycles** (set to some value other than zero)

open interval time 79OI4 would still be inoperative, because a preceding open interval time is set to zero (i.e., 79OI3 = 0.00).

If open interval 1 time setting, 79OI1, is set to zero (79OI1 = 0.00 cycles), no open interval timing takes place, and the reclosing relay is defeated.

The open interval timers time consecutively; they do not have the same beginning time reference point. In the above example settings, open interval 1 time setting, 79OI1, times first. If the 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 timeline in *Figure 6.6*.

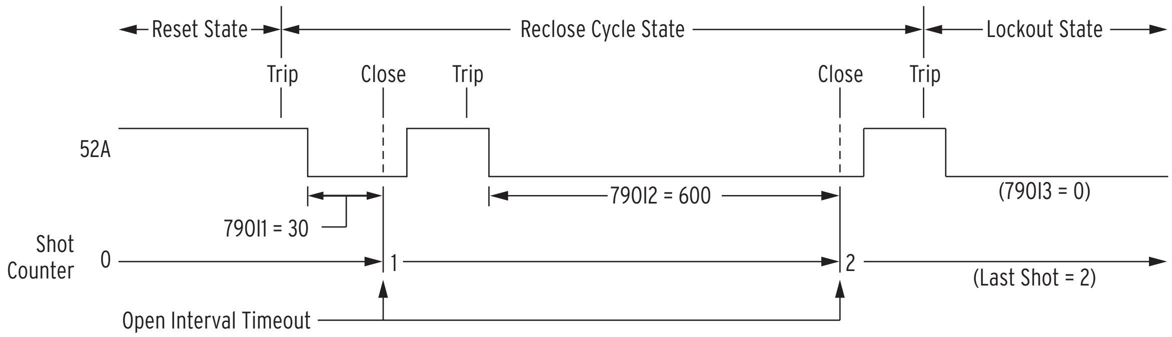


Figure 6.6 Reclosing Sequence From Reset to Lockout With Example Settings

SELOGIC control equation setting 79STL (stall open interval timing) can be set to control open interval timing (see *Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, Respectively) on page 6.22*).

Determination of Number of Reclosures (Last Shot)

The number of reclosures is equal to the number of open interval time settings that precede the first open interval time setting set equal to zero. The “last shot” value is also equal to the number of reclosures.

In the above example settings, two set open interval times precede open interval 3 time, which is set to zero (79OI3 = 0.00):

79OI1 = **30.00**

79OI2 = **600.00**

79OI3 = **0.00**

For this example:

The number of reclosures (last shot) is 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

The reset timer qualifies 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 *Close Logic on page 6.1* for more discussion on SELOGIC control equation setting 52A. Also see *Optoisolated Inputs on page 7.2* 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.

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 6.1*).

Setting 79RSLD is also the reset timer used when the relay powers up, has individual settings changed for the active setting group, or the active setting group is changed (see *Reclosing Relay States After a Settings or Setting Group Change on page 6.13*).

See *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 6.20* for the description of a scenario where there is no reset timing via setting 79RSLD to go 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 6.23*).

Monitoring Open Interval and Reset Timing

Open interval and reset timing can be monitored with the Relay Word bits listed in *Table 6.3*.

Table 6.3 Relay Word Bits Used to Monitor Open Interval and Reset Timing

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 to logical 1. 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 to logical 0. 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. The relay only times on an open interval after successful reclose initiation and if no stall conditions are present (see *Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, Respectively) on page 6.22*).

If the reset timer is actively timing, RSTMN asserts to logical 1. If the reset timer is not timing, RSTMN deasserts to logical 0. See *Block Reset Timing Setting (79BRS)*.

Reclosing Relay Shot Counter

Refer to *Figure 6.6*.

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 6.15*). The shot counter resets back to shot = 0 when the reclosing relay returns to the Reset State.

Table 6.4 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).

Settings Example

Use the shot counter to change the protection functions to coordinate with tapped loads. The settings:

ETAP = **Y**

TR = **(TRIP87 * SH0) + 67P1T + 67G1T + 67Q1T + 51PT + 51GT + 51QT + OC**

will cause a differential trip only on the first trip with overcurrent elements on subsequent trips in the reclose cycle.

Reclosing Relay SELogic Control Equation Settings Overview

Table 6.5 Reclosing Relay SELogic Control Equation Settings Example

SELogic Control Equation Setting	Setting	Definition
79RI	TRIP + TRIP 87	Reclose Initiate
79RIS	52A + 79CY	Reclose Initiate Supervision
79DTL	!IN102 + LB3	Drive-to-Lockout
79DLS	79LO	Drive-to-Last Shot
79SKP	0	Skip Shot
79STL	TRIP	Stall Open Interval Timing
79BRS	0	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 settings:

79RI = **TRIP + TRIP87**

79RIS = **52A + 79CY**

the transition of the TRIP or TRIP87 Relay Word bit from logical 0 to logical 1 initiates open interval timing only if the 52A + 79CY Relay Word bit is at logical 1 (52A = logical 1, or 79CY = logical 1). Input IN101 is assigned as the breaker status input in the factory settings (52A = IN101).

The circuit breaker has to be closed (circuit breaker status 52A = logical 1) at the instant of the first trip of the autoreclose cycle in order for the SEL-311L to successfully initiate reclosing and start timing on the first open interval. The SEL-311L 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-311L is in the reclose cycle state (79CY = logical 1) and the SEL-311L successfully initiates reclosing for each trip. Because of 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, but the circuit breaker status indication is slow—the instantaneous trip (reclose initiation) occurs before the SEL-311L sees the circuit breaker close.

If a flashover occurs in a circuit breaker tank during an open interval (circuit breaker open and the SEL-311L calls for a trip), the SEL-311L goes immediately to lockout.

Additional Settings Example

The preceding settings example initiates open interval timing on the rising edge of the TRIP or TRIP87 Relay Word bits. The following is an example of reclose initiation on the opening of the circuit breaker.

Presume input IN101 is connected to a 52a circuit breaker auxiliary contact (52A = IN101).

With setting:

79RI = **!52A**

the transition of the 52A Relay Word bit from logical 1 to logical 0 (breaker opening) initiates open interval timing. 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 + TRIP87**

the transition of the 52A Relay Word bit from logical 1 to logical 0 initiates open interval timing only if the TRIP or TRIP87 Relay Word bit is at logical 1 (TRIP or TRIP87 = logical 1). Thus, the TRIP or TRIP87 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 or TRIP87 Relay Word bits will still be asserted to logical 1 when the circuit breaker opens (see *Figure 5.1* and *Figure 5.5*).

If the TRIP and TRIP87 Relay Word bits are at logical 0 when the circuit breaker opens (logical 1 to logical 0 transition), the relay goes to the Lockout State. This helps prevent reclose initiation for circuit breaker openings caused by trips external to the relay.

If circuit breaker status indication (52A) is slow, additional setting change ULCL = 0 (unlatch close; refer to *Figure 6.1* and accompanying explanation) may need to be made when 79RI = !52A. ULCL = 0 avoids going to lockout prematurely for an instantaneous trip after an autoreclose by not turning CLOSE off until the circuit breaker status indication tells the relay 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. In the preceding additional setting example, the reclose initiate settings (79RI) includes input **IN101**, that is connected to a 52a breaker auxiliary contact (52A = IN101).

   79RI = **!52A**

   If a 52b breaker auxiliary contact is connected to input **IN101** (52A = !IN101), the reclose initiate setting (79RI) remains the same.

2. 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, open interval timing will be initiated (unless prevented by other means).

3. If the following setting is made:

   79RI = **0** (numeral 0)

   reclosing will never take place (reclosing is never initiated). The reclosing relay is effectively inoperative.

4. 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 front-panel **LO** (Lockout) LED illuminates.

79DTL has a 60-cycle dropout time. This keeps the drive-to-lockout condition up 60 more cycles after 79DTL has reverted back to 79DTL = logical 0. 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 **OPE** command Relay Word bit, OC, asserts for only 1/4 cycle-refer to the following *Settings Example*).
- ➤ Reclose initiation is by the breaker contact opening (e.g., 79RI = !52A—refer to *Additional Settings Example on page 6.18*).

Then the drive-to-lockout condition overlaps reclose initiation and the SEL-311L 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 previously discussed 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. Therefore, 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 at a shot value greater than or equal to the calculated last shot (see *Reclosing Relay Shot Counter on page 6.17*).

Settings Example

The drive-to-lockout example setting is:

79DTL = **!IN102 + LB3 + OC**

Optoisolated input **IN102** is set to operate as a reclose enable switch (see *Optoisolated Inputs on page 7.2*). When Relay Word bit IN102 = logical 1 (reclosing enabled), the relay is not driven to the Lockout State (assuming local bit LB3 = logical 0, too):

!IN102 = **!(logical 1)** = NOT(logical 1) = logical 0

79DTL = **!IN102 + LB3 + OC** = (logical 0) + LB3 = LB3 + OC

When Relay Word bit IN102 = logical 0 (reclosing disabled), the relay is driven to the Lockout State:

!IN102 = **!(logical 0)** = NOT(logical 0) = logical 1

79DTL = **!IN102 + LB3 + OC** = (logical 1) + LB3 + OC = logical 1

Local bit LB3 is set to operate as a manual trip switch (see *Local Control Switches on page 7.5* and *Section 5: Trip and Target Logic*). 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 = **!IN102 + LB3 + OC** = NOT(IN102) + (logical 0) + OC = NOT(IN102) + OC

When Relay Word bit LB3 = logical 1 (manual trip), the relay is driven to the Lockout State:

79DTL = **!IN102 + LB3 + OC** = NOT(IN102) + (logical 1) + OC = logical 1

Relay Word bit OC asserts for execution of the **OPE** command.

The drive-to-last shot setting is:

79DLS = **79LO**

Two open intervals are also set in the example settings, resulting in last shot = 2. 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 = 2):

79DLS = **79LO** = logical 1

Thus, if optoisolated input **IN102** (reclose enable switch) is in the "disable reclosing" position (Relay Word bit IN102 = 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 settings example drives the relay to the Lockout State immediately when the reclose enable switch (optoisolated input **IN102**) is put in the "reclosing disabled" position (Relay Word bit IN102 = logical 0):

79DTL = **!IN102 + ...** = NOT(IN102) + ... = 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 = **!IN102 * (TRIP + TRIP87) + ...**

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 + TRIP87) * 50P3 + ...**

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 6.4*). 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 6.12*).

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 = logical 1 still), the 79SKP setting is still processed. In such conditions (open interval timing has not yet started timing), 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 6.4*). 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*).

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 6.16*).

Settings Example

The skip shot function is not enabled in the example settings:

79SKP = **0** (numeral 0)

The stall open interval timing setting is:

79STL = **TRIP + TRIP87**

After successful reclose initiation, open interval timing does not start as long as the trip condition is present (Relay Word bits TRIP or TRIP87 = logical 1). As discussed previously, if an open interval time has not yet started timing (79STL = logical 1 still), the 79SKP setting is still processed. Once the trip condition goes away (Relay Word bits TRIP and TRIP87 = logical 0), open interval timing can proceed.

Additional Settings Example 1

With skip shot setting:

79SKP = **50P2 * SH0**

if shot = 0 (Relay Word bit SH0 = logical 1) and phase current is above the phase instantaneous overcurrent element 50P2 threshold (Relay Word bit 50P2 = logical 1), at the instant of successful reclose initiation, the shot counter is incremented from shot = 0 to shot = 1. Then, open interval 1 time (setting 79OI1) is skipped, and the relay times on the open interval 2 time (setting 79OI2) instead.

Table 6.6 Open Interval Time Settings Example

Shot	Corresponding Relay Word Bit	Corresponding Open Interval	Open Interval Time Setting
0	SH0	79OI1	30 cycles
1	SH1	79OI2	600 cycles

In *Table 6.6*, 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

Refer to *Figure 6.4* 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 6.16*).

Settings Example 1

The block reset timing setting is:

79BRS = **(51P + 51G) * 79CY**

Relay Word bit 79CY corresponds to the Reclose Cycle State. The reclosing relay is in one of the three reclosing relay states at any one time (see *Figure 6.5*).

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 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.

Additional Settings Example 2

If the block reset timing setting is:

79BRS = **51P + 51G**

then reset timing is blocked if time-overcurrent pickup 51P or 51G is picked up, regardless of the reclosing relay state.

Sequence Coordination Setting (79SEQ)

The sequence coordination setting 79SEQ keeps the relay in step with a downstream tapped load line recloser in a sequence coordination scheme, which prevents overreaching for faults beyond the recloser. This is accomplished by incrementing the shot counter and supervising overcurrent elements with resultant shot counter elements.

In order for the sequence coordination setting 79SEQ to increment the shot counter, both the following conditions must be true:

- No trip present (Relay Word bit TRIP and TRIP87 = logical 0)
- Circuit breaker closed (SELOGIC control equation setting 52A = logical 1, effectively)

The sequence coordination setting 79SEQ is usually set with tapped load overcurrent element pickups. If the above two conditions are both true, and a set overcurrent element pickup asserts for at least 1.25 cycles and then deasserts, the shot counter increments by one count. This assertion/deassertion indicates that a downstream device (e.g., line recloser—see *Figure 6.7*) has operated to clear a fault. Incrementing the shot counter keeps the SEL-311L “in step” with the downstream device, as is shown in the following *Additional Settings Example 1* and *Additional Settings Example 2*.

Every time a sequence coordination operation occurs, the shot counter is incremented, and the reset timer is loaded up with reset time 79RSD. Sequence coordination can increment the shot counter beyond last shot, but no further than shot = 4. The shot counter returns to shot = 0 after the reset timer times out. Reset timing is subject to SELOGIC control equation setting 79BRS.

Sequence coordination operation does not change the reclosing relay state. For example, if the relay is in the Reset State and there is a sequence coordination operation, it remains in the Reset State.

Factory Settings Example

Sequence coordination is not enabled in the factory settings:

79SEQ = **0**

Additional Settings Example 1

With sequence coordination setting:

79SEQ = **79RS * T50P**

sequence coordination is operable only when the relay is in the Reset State (79RS = logical 1). Refer to *Figure 6.7* and *Figure 6.8*.

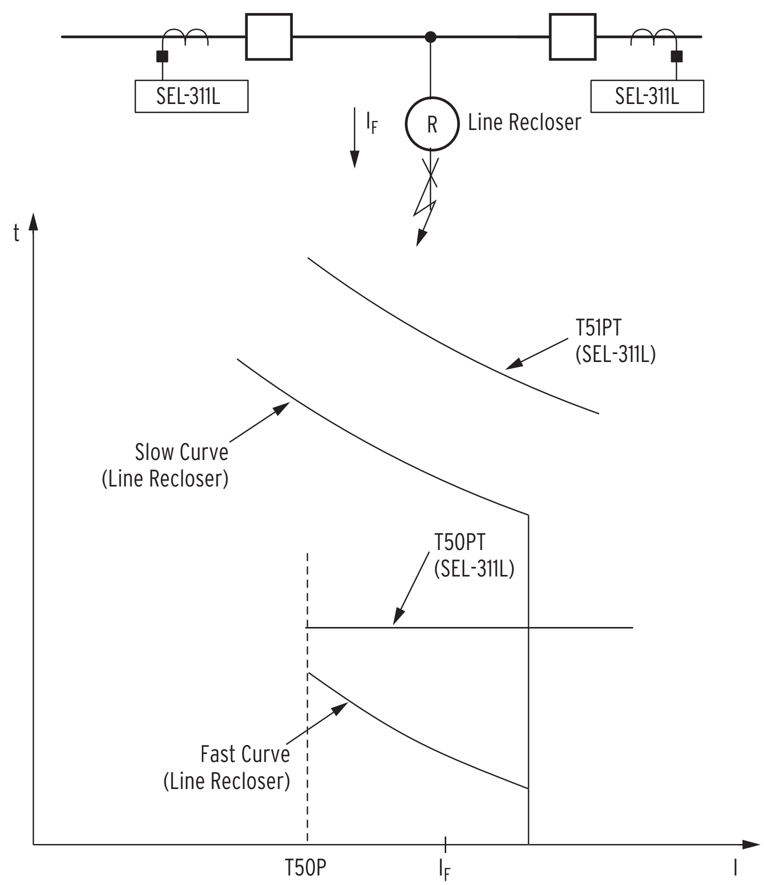


Figure 6.7 Sequence Coordination Between the SEL-311L Relay and a Line Recloser

Assume that the line recloser is set to operate twice on the fast curve and then twice on the slow curve. The slow curve is allowed to operate after two fast curve operations because the fast curves are then inoperative for tripping. The SEL-311L instantaneous/definite-time overcurrent element T50PT is coordinated with the line recloser fast curve. The SEL-311L tapped load phase time-overcurrent element T51PT is coordinated with the line recloser slow curve.

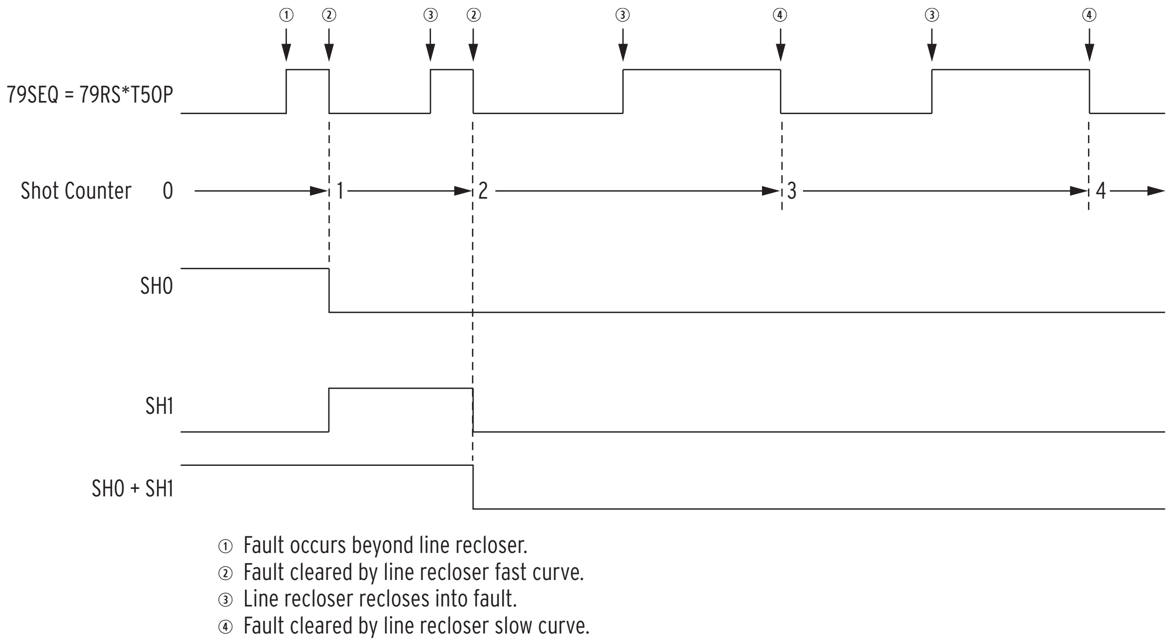


Figure 6.8 Operation of SEL-311L Relay Shot Counter for Sequence Coordination With Line Recloser (Additional Settings Example 1 on page 6.25)

If the SEL-311L is in the Reset State (79RS = logical 1) and then a permanent fault beyond the line recloser occurs (fault current IF in *Figure 6.7*), the line recloser fast curve operates to clear the fault. The SEL-311L also sees the fault. The tapped load instantaneous overcurrent element T50P asserts and then deasserts without tripping, incrementing the relay shot counter from:

shot = **0 to shot = 1**

When the line recloser recloses its circuit breaker, the line recloser fast curve operates again to clear the fault. The SEL-311L also sees the fault again. The tapped load instantaneous overcurrent element T50P asserts and then deasserts without tripping, incrementing the relay shot counter from:

shot = **1 to shot = 2**

The line recloser fast curve is now disabled after operating twice. When the line recloser recloses its circuit breaker, the line recloser slow curve operates to clear the fault. The relay does not operate on its faster-set tapped load instantaneous/definite-time overcurrent element T50PT (T50PT is "below" the line recloser slow curve) because the shot counter is now at shot = 2. For this sequence coordination scheme, the SELOGIC control equation trip equation is:

TR = **T50PT * (SH0 + SH1) + T51PT**

NOTE: Sequence coordination can increment the shot counter beyond last shot in this example (last shot = 2 in this factory-setting example) but no further than shot = 4.

With the shot counter at shot = 2, Relay Word bits SH0 (shot = 0) and SH1 (shot = 1) are both deasserted to logical 0. This keeps the T50PT tapped load instantaneous time-overcurrent element from tripping. The T50P element is still operative, and it can still assert and then deassert, thus continuing the sequencing of the shot counter to shot = 3, etc. The T50PT element cannot cause a trip because shot ≥ 2, and SH0 and SH1 both are deasserted to logical 0.

The following *Additional Settings Example 2* limits sequence coordination shot counter incrementing.

The shot counter returns to shot = 0 after the reset timer (loaded with reset time 79RSD) times out.

Additional Settings Example 2

Review preceding *Additional Settings Example 1*.

Assume that the line recloser in *Figure 6.7* is set to operate twice on the fast curve and then twice on the slow curve for faults beyond the line recloser.

Assume that the SEL-311L is set to operate once on T50PT and then twice on T51PT for faults between the SEL-311L and the line recloser. This results in the following trip setting:

TR = **T50PT * (SH0) + T51PT**

This requires that two open interval settings be made (see *Table 6.2* and *Figure 6.6*). This corresponds to the last shot being:

last shot = **2**

If the sequence coordination setting is:

79SEQ = **79RS * T50P**

and there is a permanent fault beyond the line recloser, the shot counter of the SEL-311L will increment all the way to shot = 4 (see *Figure 6.8*). If there is a coincident fault between the SEL-311L and the line recloser, the SEL-311L will trip and go to the Lockout State. Any time the shot counter is at a value equal to or greater than last shot and the relay trips, it goes to the Lockout State.

To avoid this problem, make the following sequence coordination setting:

79SEQ = **79RS * T50P * SH0**

Refer to *Figure 6.9*.

If the SEL-311L is in the Reset State (79RS = logical 0) with the shot counter reset (shot = 0; SH0 = logical 1) and then a permanent fault beyond the line recloser occurs (fault current IF in *Figure 6.7*), the line recloser fast curve operates to clear the fault. The SEL-311L also sees the fault. The phase time-overcurrent pickup T50P asserts and then deasserts without tripping, incrementing the relay shot counter from:

shot = **0 to shot = 1**

Now the SEL-311L cannot operate on its faster-set phase time-overcurrent element T50PT because the shot counter is at shot = 1 (SH0 = logical 0):

TR = **T50PT * (SH0) + T51PT** = T50PT * (logical 0) + T51PT = T51PT

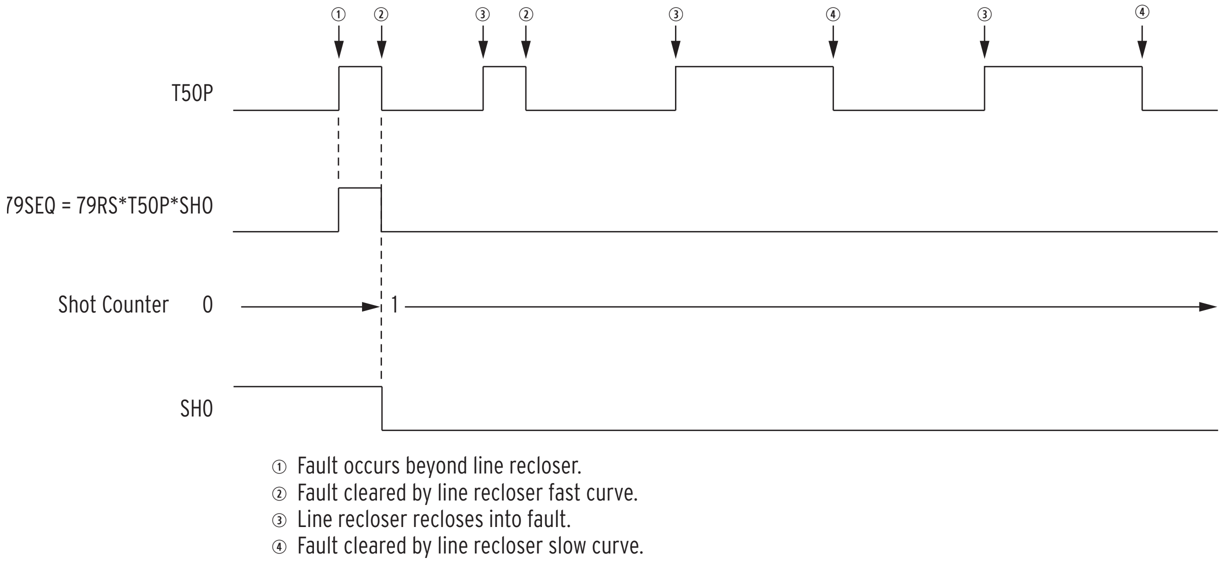


Figure 6.9 Operation of SEL-311L Relay Shot Counter for Sequence Coordination With Line Recloser (Additional Settings Example 2 on page 6.27)

The line recloser continues to operate for the permanent fault beyond it, but the SEL-311L shot counter does not continue to increment. Sequence coordination setting 79SEQ is effectively disabled by the shot counter incrementing from shot = 0 to shot = 1.

79SEQ = **79RS * T50P * SH0** = 79RS * T50P * (logical 0) = logical 0

The shot counter stays at shot = 1.

Thus, if there is a coincident fault between the SEL-311L and the line recloser, the SEL-311L will operate on T51PT and then reclose once, instead of going straight to the Lockout State (shot = 1 < last shot = 2).

As stated earlier, the reset time setting 79RSD takes the shot counter back to shot = 0 after a sequence coordination operation increments the shot counter. Make sure that reset time setting 79RSD is set long enough to maintain the shot counter at shot = 1 as shown in *Figure 6.9*.

Section 7
SELOGIC Control Equation Programming

Overview

This section explains the settings and operation of:

- Optoisolated inputs
  - IN101–IN106
  - IN301–IN308
- Local control switches
  - local bits LB1–LB16
- Remote control switches
  - remote bits RB1–RB16
- Latch control switches
  - latch bits LT1–LT16
- Multiple setting groups
  - group switching settings SS1–SS6
- SELOGIC control equations variables/timers
  - SV1/SV1T–SV16/SV16T
- Output contacts
  - OUT101–OUT107 and ALARM
  - OUT201–OUT212
  - OUT301–OUT312
- Rotating default displays
  - display points DP1–DP16

The above items are relay logic inputs and outputs. They are combined with the line current differential, distance, overcurrent, voltage, 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: Settings* for more information on Relay Word bits and SELOGIC control equation settings. See *Section 10: Communications* for more information on viewing and making SELOGIC control equation settings (commands **SHO L** and **SET L**).

Optoisolated Inputs

Figure 7.1 and *Figure 7.2* show the resultant Relay Word bits that follow corresponding optoisolated inputs for the different SEL-311L 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 1.4*, and *Figure 2.2–Figure 2.8*).

Figure 7.1 is used for the following discussion/examples. The optoisolated inputs in *Figure 7.2* operate similarly.

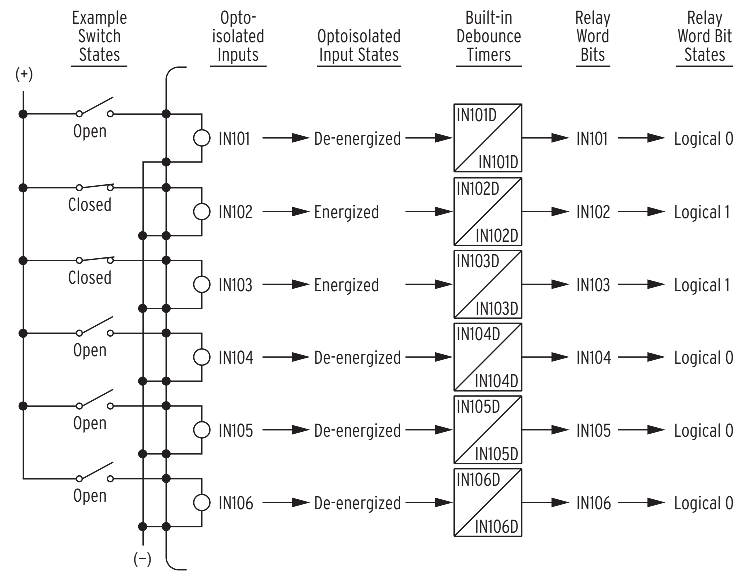


Figure 7.1 Example Operation of Optoisolated Inputs IN101–IN106

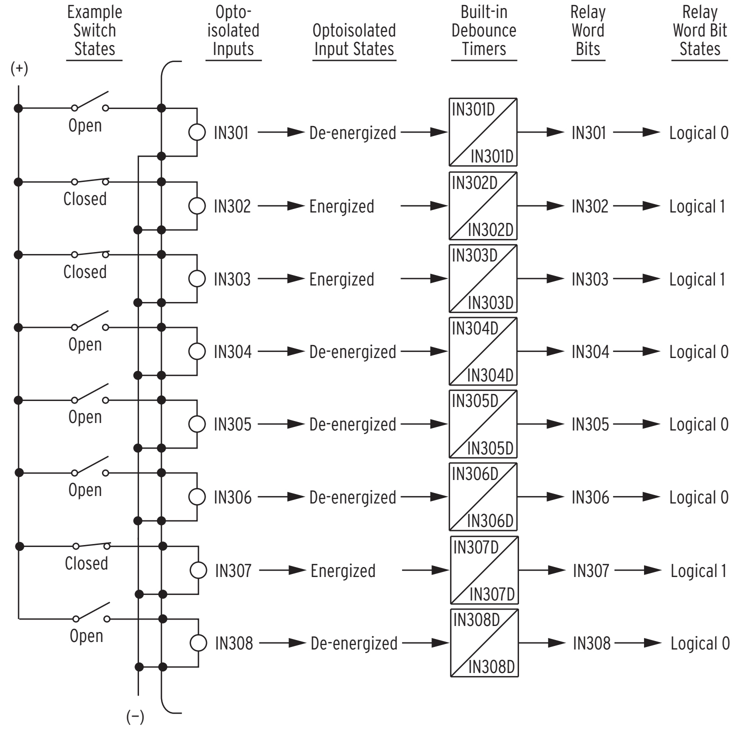


Figure 7.2 Example Operation of Optoisolated Inputs IN301–IN308—Extra I/O Board

Input Debounce Timers

Each input has settable pickup/dropout timers (IN101D–IN106D and IN301D–IN308D) for input energization/de-energization debounce. Note that a given time setting (e.g., IN101D = 0.50) is applied to both the pickup and dropout time for the corresponding input.

Time settings IN101D–IN106D and IN301D–IN308D are settable from 0.00 to 2.00 cycles. The relay takes the entered time setting and internally runs the timer at the nearest 1/8-cycle. For example, if setting IN105D = 0.80, internally the timer runs at the nearest 1/8-cycle: 6/8-cycles (6/8 = 0.75).

For most applications, the input pickup/dropout debounce timers should be set in 1/4-cycle increments.

The relay updates Relay Word bits IN101–IN106 and IN301–IN308 every 1/4-cycle.

If more than 2 cycles of debounce are needed, use a SELOGIC control equation variable timer (see *Figure 7.24* and *Figure 7.25*).

Input Functions

There are no optoisolated input settings such as:

IN101 =

IN102 =

Relay Word bits IN101–IN106 and IN301–IN308, used in SELOGIC control equations, represent the state of optoisolated inputs IN101–IN106 and IN301–IN308.

Settings Example 1

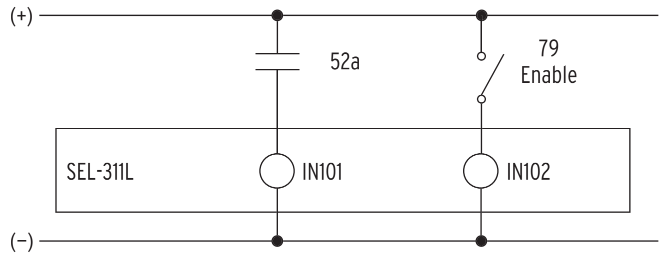


Figure 7.3 Circuit Breaker Auxiliary Contact and Reclose Enable Switch Connected to Optoisolated Inputs IN101 and IN102

The functions for inputs IN101 and IN102 (*Figure 7.3*) are described in the following discussions.

Input IN101

Relay Word bit IN101 (*Figure 7.3*) is used in the settings for the SELOGIC control equation circuit breaker status setting:

52A = **IN101**

Connect input IN101 to a 52a circuit breaker auxiliary contact.

If a 52b circuit breaker auxiliary contact is connected to input IN101, the setting is changed to:

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

See *Close Logic on page 6.2* for more information on SELOGIC control equation setting 52A.

The pickup/dropout timer for input IN101 (IN101D) might be set at:

IN101D = **0.75 cycles**

to provide input energization/de-energization debounce.

Using Relay Word bit IN101 for the circuit breaker status setting 52A does not prevent using Relay Word bit IN101 in other SELOGIC control equation settings.

Input IN102

Relay Word bit IN102 (*Figure 7.3*) is used in the settings for the SELOGIC control equation drive-to-lockout setting:

79DTL = **!IN102 + ...** [=NOT(IN102) + ...]

Connect input IN102 to a reclose enable switch.

When the reclose enable switch is open, input IN102 is de-energized and the reclosing relay is driven to lockout:

79DTL = **!IN102 + ...** = NOT(IN102) + ... = NOT(logical 0) +... = logical 1

When the reclose enable switch is closed, input IN102 is energized and the reclosing relay is enabled, if no other setting condition is driving the reclosing relay to lockout:

79DTL = **!IN102 + ...** = NOT(IN102) + ... = NOT(logical 1) +... = logical 0 + ...

See *Section 6: Close and Reclose Logic* for more information on SELOGIC control equation setting 79DTL.

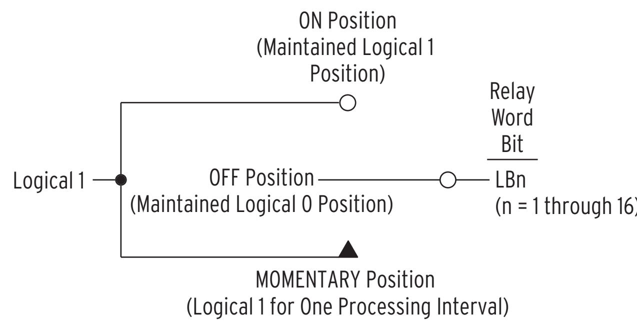
The pickup/dropout timer for input **IN102** (IN102D) in this example might be set at:

IN102D = **1.00 cycle**

to provide input energization/de-energization debounce.

Local Control Switches

The local control switch feature of this relay replaces traditional panel-mounted control switches. Operate the sixteen (16) local control switches by using the front-panel keyboard/display (see *Section 11: Front-Panel Operations*).



The switch representation in this figure is derived from the standard:

Graphics Symbols for Electrical and Electronics Diagrams IEEE Std 315-1975, CSA Z99-1975, ANSI Y32.2-1975, 4.11 Combination Locking and Nonlocking Switch, Item 4.11.1.

Figure 7.4 Local Control Switches Drive Local Bits LB1–LB16

The output of the local control switch in *Figure 7.4* is a Relay Word bit LB*n* (*n* = 1–16), 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.

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. 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: Settings* and *Section 10: Communications*).

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.

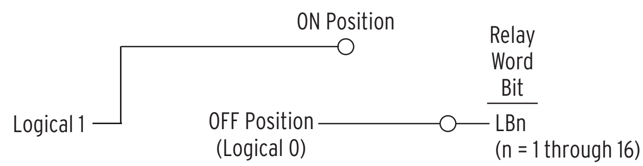


Figure 7.5 Local Control Switch Configured as an ON/OFF Switch

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).

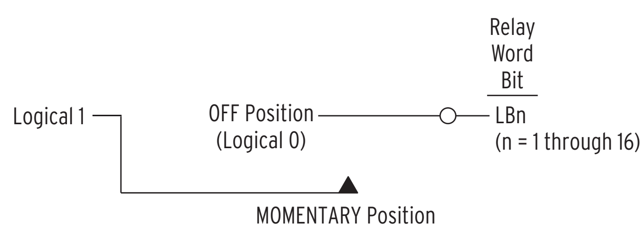


Figure 7.6 Local Control Switch Configured as an OFF/MOMENTARY Switch

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).

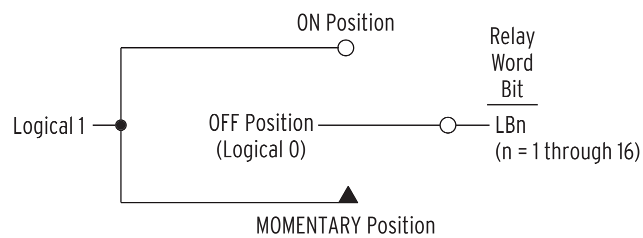


Figure 7.7 Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

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 "nulling out" all the label settings for that switch (see *Section 9: Settings*). 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, as shown in *Table 7.3*.

Table 7.3 Local Bits LB3 and LB4 Used for Manual Trip and Close Functions

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")
	PLB3 = CLOSE	MOMENTARY position

Following *Figure 7.8* and *Figure 7.9* show local control switches with example settings.

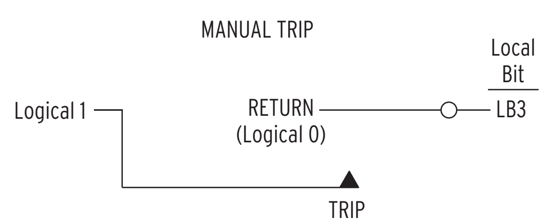


Figure 7.8 Configured Manual Trip Switch Drives Local Bit LB3

Local bit LB3 is set to trip in the following SELOGIC control equation trip setting (see *Figure 5.1*):

TR = **... + LB3 + ...**

To keep reclosing from being initiated for this trip, set local bit LB3 to drive the reclosing relay to lockout for a manual trip (see *Section 6: Close and Reclose Logic*):

79DTL = **... + LB3**

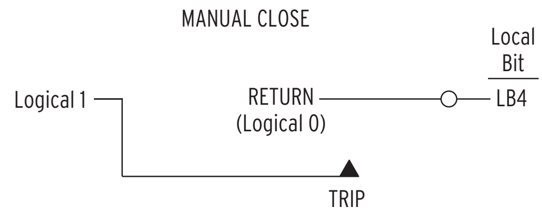


Figure 7.9 Configured Manual Close Switch Drives Local Bit LB4

Local bit LB4 is set to close the circuit breaker in the following SELOGIC control equation setting:

CL = **. . . + LB4 + . . .**

SELOGIC control equation setting CL is for close conditions, other than automatic reclosing or serial port **CLOSE** command (see *Figure 6.1*).

Additional Local Control Switch Application Ideas

Local control switches can be applied to almost any control scheme that traditionally requires front-panel switches. The preceding settings examples are OFF/MOMENTARY switches. Local control switches configured as ON/OFF switches can be used for such applications as:

- Reclosing relay enable/disable
- Ground relay enable/disable
- Remote control supervision
- Sequence coordination enable/disable

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 the local bit feature 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.

Settings Change or Active Setting Group Change

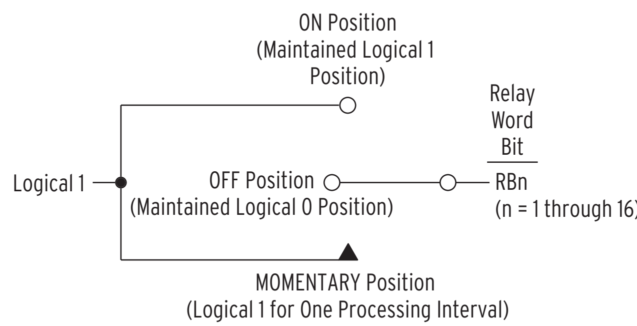
If settings are changed (for the active setting group or one of the other setting groups) or the active setting group is changed, the states of the local bits (Relay Word bits LB1–LB16) are retained, much like in the *Power Loss* explanation.

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

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 serial communications port only (see *CON Command (Control Remote Bit) on page 10.57*).



The switch representation in this figure is derived from the standard:

Graphics Symbols for Electrical and Electronics Diagrams IEEE Std 315-1975, CSA Z99-1975, ANSI Y32.2-1975, 4.11 Combination Locking and Nonlocking Switch, Item 4.11.1.

Figure 7.10 Remote Control Switches Drive Remote Bits RB1–RB16

The outputs of the remote control switches in *Figure 7.10* are Relay Word bits RB*n* (*n* = 1–16), called remote bits. Use these remote bits in SELOGIC control equations.

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

- ON (logical 1)
- OFF (logical 0)
- MOMENTARY (logical 1 for one processing interval)

Remote Bit Application Ideas

With SELOGIC control equations, the remote bits can be used in applications similar to those that local bits are used in (see *Local Control Switches on page 7.5*).

Also, remote bits can be used much as optoisolated inputs are used in operating latch control switches (see discussion following *Figure 7.15*). Pulse (momentarily operate) the remote bits for this application.

Remote Bit States Not Retained When Power Is Lost

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

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

The state of each remote bit (Relay Word bits RB1–RB16) is retained if relay settings are changed (for the active setting group or one of the other setting groups) or the active setting group is changed. If a remote control switch is in the ON position (corresponding remote bit is asserted to logical 1) before a setting change or an active setting group change, it comes back in the ON position (corresponding remote bit is still asserted to logical 1) after the change. If a remote control switch is in the OFF position (corresponding remote bit is deasserted to logical 0) before a settings change or an active setting group change, it comes back in the OFF position (corresponding remote bit is still deasserted to logical 0) after the change.

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

Latch Control Switches

The latch control switch feature of this relay replaces latching relays. Traditional latching relays maintain their output contact state when set. The SEL-311L latch bit retains memory even when control power is lost. If the latch bit is set to a programmable output contact and control power 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 the control power is applied back to the relay, the programmed output contact will go back to the state of the latch bit.

The state of a traditional latching relay output contact is changed by pulsing the latching relay inputs (see *Figure 7.11*). Pulse the set input to close (“set”) the latching relay output contact. Pulse the reset input to open (“reset”) the latching relay output contact. Often the external contacts wired to the latching relay inputs are from remote control equipment (e.g., SCADA, RTU).

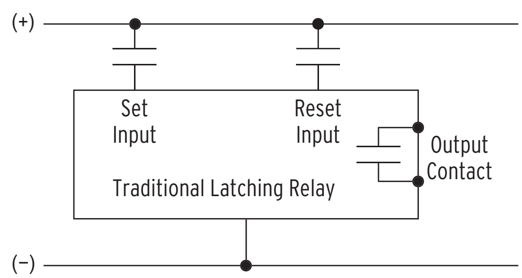


Figure 7.11 Traditional Latching Relay

The sixteen (16) latch control switches in the SEL-311L provide latching relay type functions.

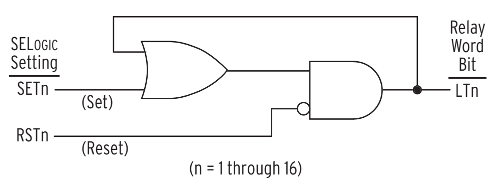


Figure 7.12 Latch Control Switches Drive Latch Bits LT1–LT16

The output of the latch control switch in *Figure 7.12* is a Relay Word bit LT*n* (*n* = 1–16), 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:

SETn (set latch bit LT*n* to logical 1)

RSTn (reset latch bit LT*n* to logical 0)

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

Latch Control Switch Application Ideas

Latch control switches can be used for such applications as:

- ➤ Reclosing relay enable/disable
- ➤ Ground relay enable/disable

Latch control switches can be applied to almost any control scheme. The following is an example of using a latch control switch to enable/disable the reclosing relay in the SEL-311L.

Reclosing Relay Enable/Disable Setting Example

Use a latch control switch to enable/disable the reclosing relay in the SEL-311L. In this example, a SCADA contact is connected to optoisolated input **IN104**. 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.

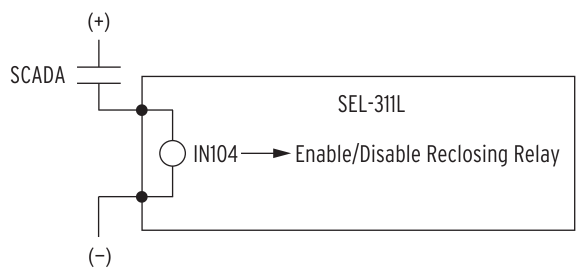


Figure 7.13 SCADA Contact Pulses Input IN104 to Enable/Disable Reclosing Relay

NOTE: Refer to Optoisolated Inputs on page 7.2 and Figure 7.1. Relay Word bit IN104 shows the state of optoisolated input IN104 after the input pickup/dropout debounce timer IN104D. Thus, when using Relay Word bit IN104 in Figure 7.14 and associated SELOGIC control equations, keep in mind any time delay produced by the input pickup/dropout debounce timer IN104D.

If the reclosing relay is enabled and the SCADA contact is pulsed, the reclosing relay is then disabled. If the SCADA contact is pulsed again, the reclosing relay is enabled again. The control operates in a cyclic manner:

pulse to enable ... pulse to disable ... pulse to enable ... pulse to disable ...

This reclosing relay logic is implemented in the following SELOGIC control equation settings and displayed in *Figure 7.14*.

SET1 = **/IN104 * !LT1** [= (rising edge of input **IN104**) AND NOT(LT1)]

RST1 = **/IN104 * LT1** [= (rising edge of input **IN104**) AND LT1]

79DTL = **!LT1** [= NOT(LT1); drive-to-lockout setting]

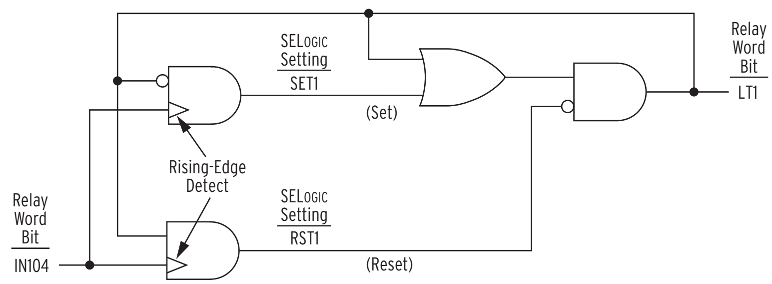


Figure 7.14 Latch Control Switch Controlled by a Single Input to Enable/Disable Reclosing

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 **IN104** to the correct latch control switch input.

If latch bit LT1 = logical 0, input **IN104** is routed to setting SET1 (set latch bit LT1):

SET1 = **/IN104 * !LT1** =/IN104 * NOT(LT1) = /IN104 * NOT(logical 0) = /IN104 = rising edge of input IN104

RST1 = **/IN104 * LT1** = /IN104 * (logical 0) = logical 0

If latch bit LT1 = logical 1, input **IN104** is routed to setting RST1 (reset latch bit LT1):

SET1 = **/IN104 * !LT1** = /IN104 * NOT(LT1) = /IN104 * NOT(logical 1) = /IN104 * (logical 0) = logical 0

RST1 = **/IN104 * LT1** = /IN104 * (logical 1) = /IN104 = rising edge of input IN104

Rising-Edge Operators

Refer to *Figure 7.14* and *Figure 7.15*.

The rising-edge operator in front of Relay Word bit IN104 (/IN104) sees a logical 0 to logical 1 transition as a "rising edge," and /IN104 asserts to logical 1 for one processing interval.

The rising-edge operator on input **IN104** is necessary because any single assertion of optoisolated input **IN104** by the SCADA contact will last for at least a few cycles, and each individual assertion of input **IN104** 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 **IN104** is routed to setting SET1 (as discussed previously):

SET1 = **/IN104** = rising edge of input IN104

If input **IN104** is then asserted for a few cycles by the SCADA contact (see Pulse 1 in *Figure 7.15*), SET1 is asserted to logical 1 for one processing interval. This causes latch bit LT1 to change state to:

LT1 = **logical 1**.

the next processing interval.

With latch bit LT1 now at logical 1 for the next processing interval, input **IN104** is routed to setting RST1 (as discussed previously):

RST1 = **/IN104** = rising edge of input IN104

This would then appear to enable the "reset" input (setting RST1) the next processing interval. But the "rising edge" condition occurred during the preceding processing interval. /IN104 is now at logical 0, so setting RST1 does not assert, even though input **IN104** 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 **IN104** (Pulse 1, Pulse 2, Pulse 3, and Pulse 4 in *Figure 7.15*) changes the state of the latch control switch just once.

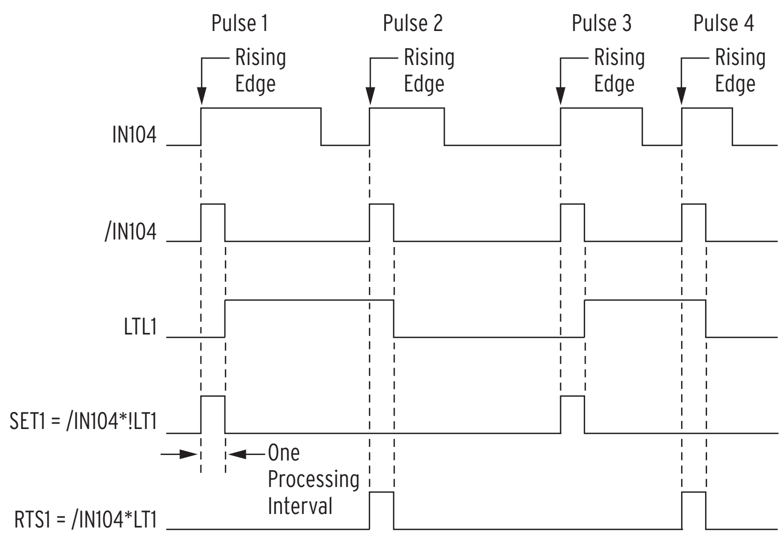


Figure 7.15 Latch Control Switch Operation Timeline

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 **IN104** 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 **IN104** in the previous example. Remote bits (Relay Word bits RB1–RB16) are operated through the serial port. See *Figure 7.10* and *Section 10: Communications* 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

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

NOTE: Although the relay retains the state of a latched bit when power is cycled, the relay cannot hold output contact closure when power is removed from the relay (output contacts go to their de-energized states).

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 *Power Loss* explanation.

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

If the individual settings change or active setting group change causes a change in SELOGIC control equation settings SET*n* or RST*n* (*n* = 1–16), the retained states of the latch bits can be changed, subject to the newly enabled settings 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* = 1–16). Relay Word bits SG1–SG6 indicate the active setting Group 1–6, respectively (see *Table 7.4*).

For example, when setting Group 4 becomes the active setting group, latch bit LT2 should be reset. Make the following SELOGIC control equation settings in setting Group 4:

SV7 = **SG4**

RST2 = **!SV7T + ...** [= NOT(SV7T) + ...]

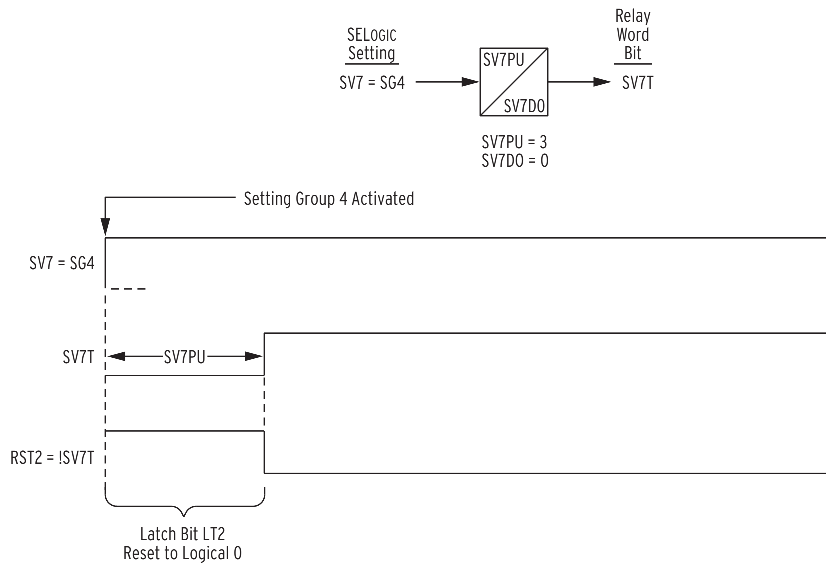


Figure 7.16 Timeline for Reset of Latch Bit LT2 After Active Setting Group Change

In *Figure 7.16*, latch bit LT2 is reset (deasserted to logical 0) when reset setting RST2 asserts to logical 1 for the short time right after setting Group 4 is activated. This logic can be repeated for other latch bits.

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 EEPROM self-test failure. An average of 150 cumulative latch bit state changes per day can be made for a 25-year relay service life.

This requires that SELOGIC control equation settings SET*n* and RST*n* for any given latch bit LT*n* 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** 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*).

In the preceding reclosing relay enable/disable example application (*Figure 7.13–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 7.13–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).

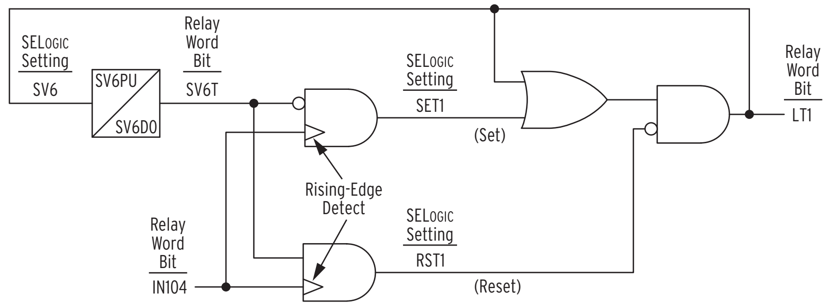


Figure 7.17 Latch Control Switch (With Time Delay Feedback) Controlled by a Single Input to Enable/Disable Reclosing

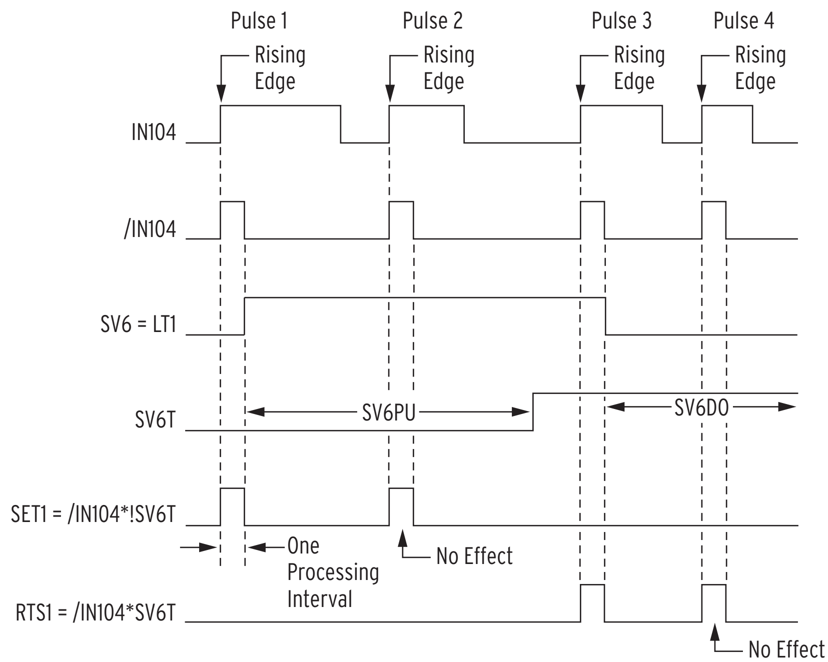


Figure 7.18 Latch Control Switch (With Time Delay Feedback) Operation Timeline

Multiple Setting Groups

The relay has six (6) independent setting groups. Each setting group has complete relay (line current differential, distance, reclosing, 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 7.4 Definitions for Active Setting Group Indication Relay Word Bits SG1–SG6

Relay Word Bit	Definition
SG1	Indication that setting Group 1 is the active setting group
SG2	Indication that setting Group 2 is the active setting group
SG3	Indication that setting Group 3 is the active setting group
SG4	Indication that setting Group 4 is the active setting group
SG5	Indication that setting Group 5 is the active setting group
SG6	Indication that setting Group 6 is the active setting group

For example, if setting Group 4 is the active setting group, Relay Word bit SG4 asserts to logical 1, and the other Relay Word bits, SG1, SG2, SG3, SG5, and SG6, are all deasserted to logical 0.

Selecting the Active Setting Group

The active setting group is selected with 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 Operations*).

SELogic control equation settings SS1–SS6 have priority over the serial port **GROUP** command and the front-panel **GROUP** pushbutton in selecting the active setting group.

Operation of SELogic Control Equation Settings SS1–SS6

Each setting group has its own set of SELogic control equation settings SS1-SS6.

Table 7.5 Definitions for Active Setting Group Switching SELogic Control Equation Settings SS1–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 an example.

EXAMPLE 7.1 Operation of Settings SS1–SS6

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 7.4).

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–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 and the front-panel **GROUP** pushbutton in selecting the active setting group. If any one of SS1–SS6 asserts to logical 1, neither the serial port **GROUP** command nor the front-panel **GROUP** pushbutton can be used to switch the active setting group. But if SS1–SS6 all deassert to logical 0, the serial port **GROUP** command or the front-panel **GROUP** pushbutton can be used to switch the active setting group.

See *Section 10: Communications* for more information on the serial port **GROUP** command. See *Section 11: Front-Panel Operations* 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] and latch bit [LT1–LT16] states are retained during an active setting group change). The output contacts are frozen during an active setting group change, then follow their new SELOGIC control equation settings.

Active Setting Group Switching Example 1

Use a single optoisolated input to switch between two setting groups in the SEL-311L. 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.

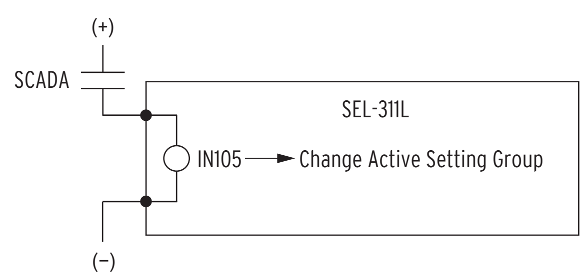


Figure 7.19 SCADA Contact Pulses Input IN105 to Switch Active Setting Group Between Setting Groups 1 and 4

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 7.6*.

Table 7.6 SELOGIC Control Equation Settings for Switching Active Setting Group Between Setting Groups 1 and 4

Setting Group 1	Setting Group 4
SV8 = SG1	SV8 = 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

SELOGIC control equation timer input setting SV8 in *Table 7.6* has logic output SV8T, shown in operation in *Figure 7.20* for both setting Groups 1 and 4.

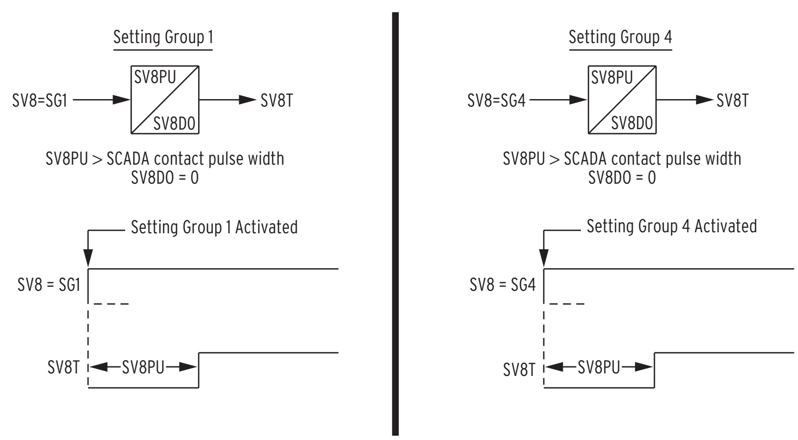


Figure 7.20 SELOGIC Control Equation Variable Timer SV8T Used in Setting Group Switching

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

Timer pickup setting SV8PU is set greater than the pulse width of the SCADA contact (*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 functions of the SELOGIC control equations in *Table 7.6* are explained in the following example.

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 (perhaps set at a cycle or so to qualify the assertion of setting SS4). Optoisolated input IN105 also has its own built-in debounce timer (IN105D; 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. 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 (perhaps set at a cycle or so to qualify the assertion of setting SS1). Optoisolated input IN105 also has its own built-in debounce timer, IN105D (see *Figure 7.1*).

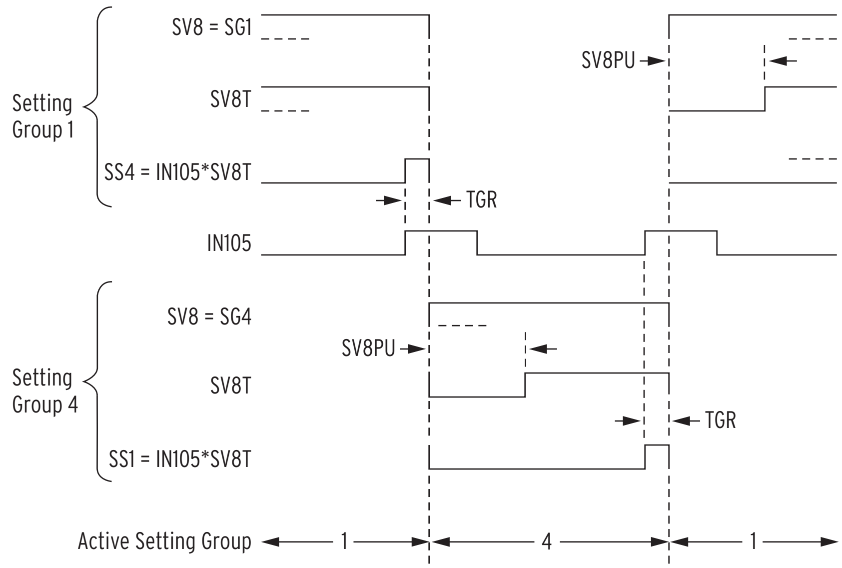


Figure 7.21 Active Setting Group Switching (With Single Input) Timeline

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 7.7*.

Table 7.7 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-311L can be programmed to operate similarly. Use three optoisolated inputs to switch between the six setting groups in the SEL-311L. In this example, optoisolated inputs IN101, IN102, and IN103 on the relay are connected to a rotating selector switch in *Figure 7.22*.

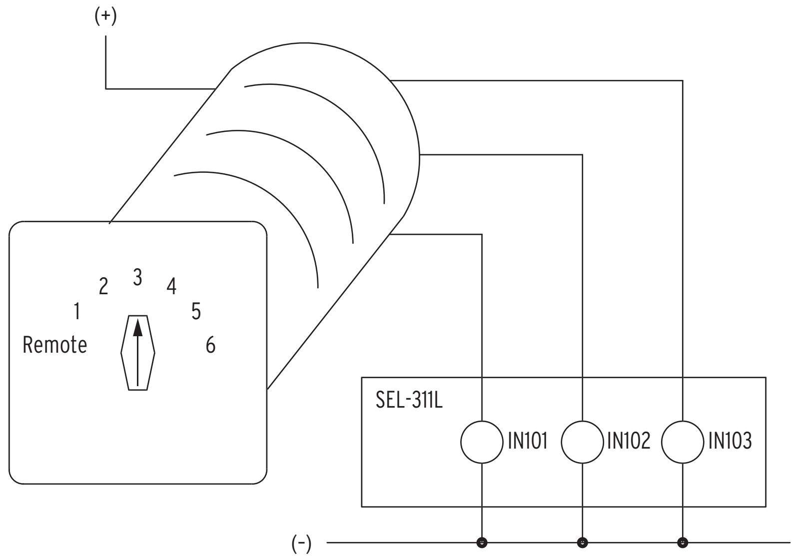


Figure 7.22 Rotating Selector Switch Connected to Inputs IN101, IN102, and IN103 for Active Setting Group Switching

The selector switch has multiple internal contacts arranged to assert inputs **IN101**, **IN102**, and **IN103**, dependent on the switch position. As shown in *Table 7.8*, when the selector switch is moved from one position to another, a different setting group is activated. The logic in *Table 7.7* is implemented in the SELOGIC control equation settings in *Table 7.8*.

Table 7.8 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 7.8* are made in each setting Group 1 through 6.

Selector Switch Starts Out in Position 3

Refer to *Table 7.8* 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 the position 3 to position 5 on the selector switch, the switch passes through the 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 the 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, all inputs **IN101**, **IN102**, and **IN103** are de-energized and all settings SS1–SS6 in *Table 7.8* 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 through 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.

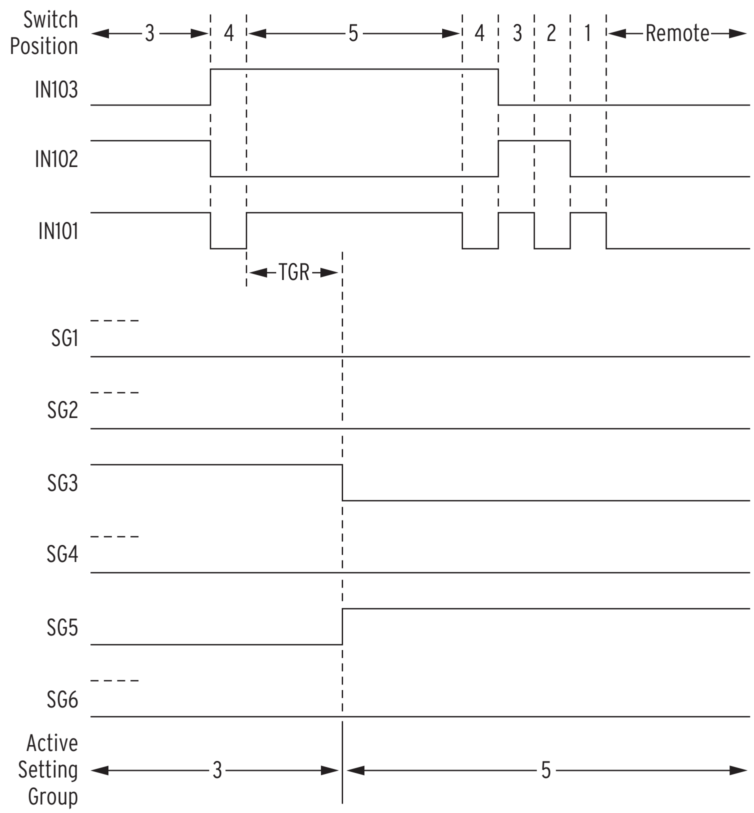


Figure 7.23 Active Setting Group Switching (With Rotating Selector Switch) Timeline

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 SELogic control equation settings SS1–SS6, the active setting group can be changed, subject to the newly enabled SS1–SS6 settings.

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 EEPROM self-test failure. An average of 10 setting groups changes per day can be made for a 25-year relay service life.

This requires that SELOGIC control equation settings SS1–SS6 (see *Table 7.5*) 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–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

Sixteen (16) SELOGIC control equation variables/timers are available. Each SELOGIC control equation variable/timer has a SELOGIC control equation setting input and variable/timer outputs as shown in *Figure 7.24* and *Figure 7.25*.

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* = 1–16).

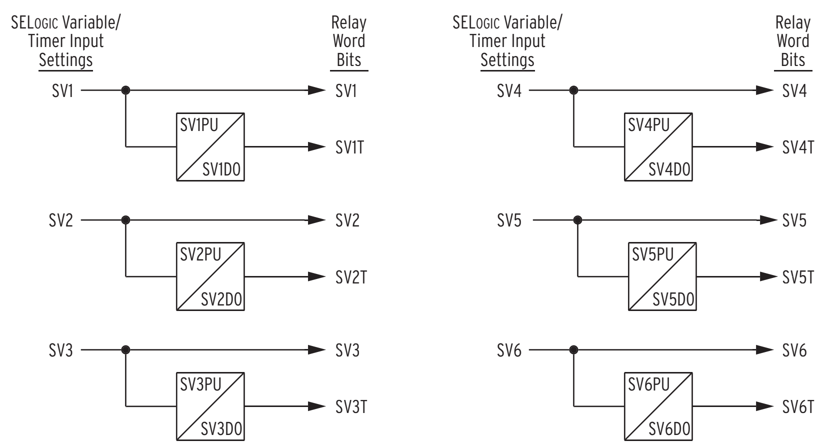


Figure 7.24 SELOGIC Control Equation Variables/Timers SV1/SV1T–SV6/SV6T

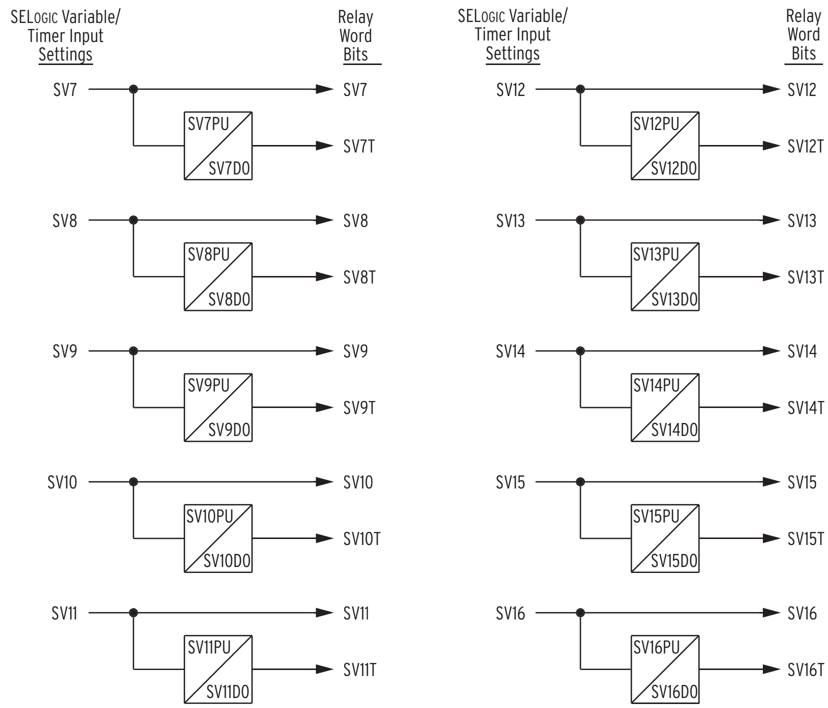


Figure 7.25 SELOGIC Control Equation Variables/Timers SV7/SV7T–SV16/SV16T

Settings Example

In the SELOGIC control equation settings, a SELOGIC control equation timer may be used for a simple breaker failure scheme:

SV1 = **TRIP**

The TRIP Relay Word bit is run through a timer for breaker failure timing. Timer pickup setting SV1PU is set to the breaker failure time (SV1PU = 12 cycles). Timer dropout setting SV1DO is set for a 2-cycle dropout (SV1DO = 2 cycles). The output of the timer (Relay Word bit SV1T) operates output contact **OUT103**.

OUT103 = **SV1T**

Additional Settings Example 1

Another application idea is dedicated breaker failure protection (see *Figure 7.26*):

SV6 = **IN101** (breaker failure initiate)

SV7 = **(SV7 + IN101) * (50P1 + 50G1)**

OUT101 = **SV6T** (retrip)

OUT102 = **SV7T** (breaker failure trip)

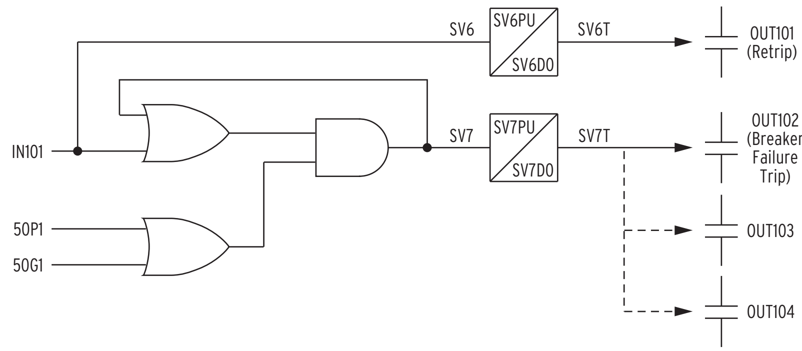


Figure 7.26 Dedicated Breaker Failure Scheme Created With SELOGIC Control Equation Variables/Timers

Note that the above SELOGIC control equation setting SV7 creates a seal-in logic circuit (as shown in *Figure 7.26*) by virtue of SELOGIC control equation setting SV7 being set equal to Relay Word bit SV7 (SELOGIC control equation variable SV7):

SV7 = **(SV7 + IN101) * (50P1 + 50G1)**

Optoisolated input IN101 functions as a breaker failure initiate input. Phase instantaneous overcurrent element 50P1 and residual-ground instantaneous overcurrent element 50G1 function as fault detectors.

Timer pickup setting SV6PU provides retrip delay, if desired (can be set to zero). Timer dropout setting SV6DO holds the retrip output (output contact OUT101) closed for extra time if needed after the breaker failure initiate signal (IN101) goes away.

Timer pickup setting SV7PU provides breaker failure timing. Timer dropout setting SV7DO holds the breaker failure trip output (output contact OUT102) closed for extra time if needed after the breaker failure logic unlatches (fault detectors 50P1 and 50G1 dropout).

Note that *Figure 7.26* suggests the option of having output contacts OUT103 and OUT104 operate as additional breaker failure trip outputs. This is done by making the following SELOGIC control equation settings:

OUT103 = **SV7T** (breaker failure trip)

OUT104 = **SV7T** (breaker failure trip)

Additional Settings Example 2

The seal-in logic circuit in the dedicated breaker failure scheme in *Figure 7.26* can be removed by changing the SELOGIC control equation setting SV7 to:

SV7 = **IN101 * (50P1 + 50G1)**

If the seal-in logic circuit is removed, optoisolated input IN101 (breaker failure initiate) has to be continually asserted for a breaker failure time-out.

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

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

Preceding *Figure 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 + IN101) * (50P1 + 50G1)**

If power is lost to the relay, settings are changed (for the active setting group), or the active setting group is changed, the seal-in logic circuit is "broken" by virtue of Relay Word bit SV7 being reset to logical 0 (assuming input IN101 is not asserted). Relay Word bit SV7T is also reset to logical 0, and timer settings SV7PU and SV7DO load up again.

Output Contacts

Operation of Output Contacts

The SEL-311L contains two types of output contacts. The backup protection hardware controls contacts OUT101–OUT107 and optional output contacts OUT301–OUT312 independent of the line current differential hardware. Use outputs OUT101–OUT107 and optional output contacts OUT301–OUT312 for backup protection tripping, closing, and for control applications.

The line current differential hardware controls special high-speed contacts OUT201–OUT206. Contacts OUT201–OUT206 operate if both the backup protection hardware and the dedicated line current differential hardware are healthy. Use contacts OUT201–OUT206 for high-speed line current differential protection, and for faster backup protection tripping.

The distinction between the two types of contacts is an important application consideration. The following discussion describes each type of contact, as well as how each should be used for several example applications.

Output Contacts OUT101–OUT107

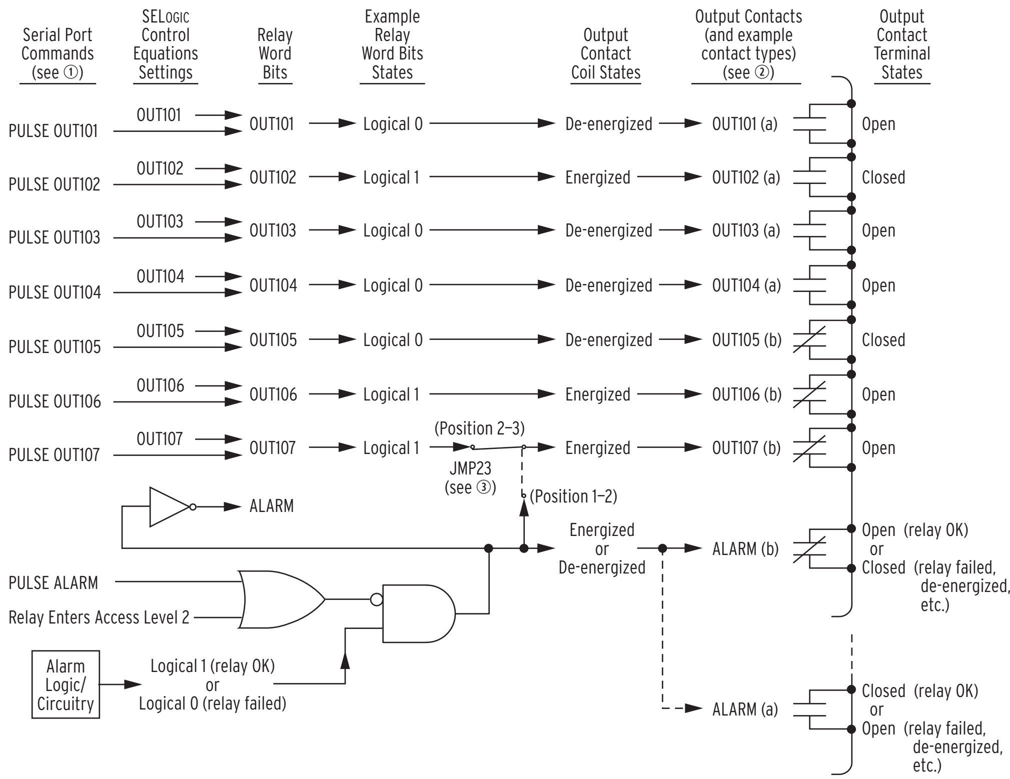
SELOGIC control equations OUT101–OUT107 control contacts OUT101–OUT107. When the SELOGIC control equation evaluates to logical 1 for one of these contacts, the relay closes normally open contacts (a) and opens normally closed contacts (b), as shown in *Figure 7.27*. The **PULSE** command also controls contact outputs. For example, if SELOGIC control equation OUT101 is set to

OUT101 = **TRIP**

when Relay Word bit TRIP asserts, the control coil for OUT101 is energized, and OUT101 closes if it is a normally open contact. Likewise, the command **PULSE OUT101** momentarily energizes the control coil of contact output OUT101, and the contact closes (again assuming OUT101 is a normally open contact). See *Output Contact Jumpers on page 2.29*, for output contact type options.

Notice in *Figure 7.27* that contact output OUT107 also functions as an extra alarm contact when jumper JMP23 is in position 1-2. See *ALARM Output Contact and 87HWAL on page 7.37* for more information about how OUT107 operates when it is configured as an extra alarm, and for information about how OUT107 operates as configured in a standard relay shipment from the factory.

Contacts OUT101–OUT107 are suitable for line current differential and backup protection tripping, closing, and general control functions. All seven contacts are rated for tripping duty, and typically close less than five milliseconds after the corresponding SELOGIC control equation evaluates to logical 1.



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 "a" or "b" type output contacts. See Table 2.4 and Figure 2.20 for more information on selecting output contact type.

③ Main board jumper JMP23 should be left in position 2–3 to allow output contact **OUT107** to operate as an alarm for the 87L hardware. If JMP23 is moved to position 1–2, the 87L hardware alarm function (87HWAL) will not be available.

See Table 2.5 for more information on jumper JMP23.

Figure 7.27 Logic Flow for Example Output Contact Operation

High-Speed Output Contacts OUT201–OUT206

The SEL-311L contains six special high-speed contacts, **OUT201–OUT206**, intended for use as trip contacts by the line current differential protection. These contacts close less than 10 microseconds after their control coil is energized via setting EHST. Contacts **OUT201–OUT206** are rated to interrupt trip current, which helps avoid the added delay caused by tripping auxiliary relays.

Refer to *Figure 7.28*. Notice the OR gates that drive contacts **OUT201–OUT206**. Control each of these contacts with the EHST (Enable High-Speed Trip) setting, OR with the associated SELOGIC control equation OUT201–OUT206, OR with the **PULSE** command. Use setting EHST to achieve the fastest 87L tripping as shown in *Table 7.9*.

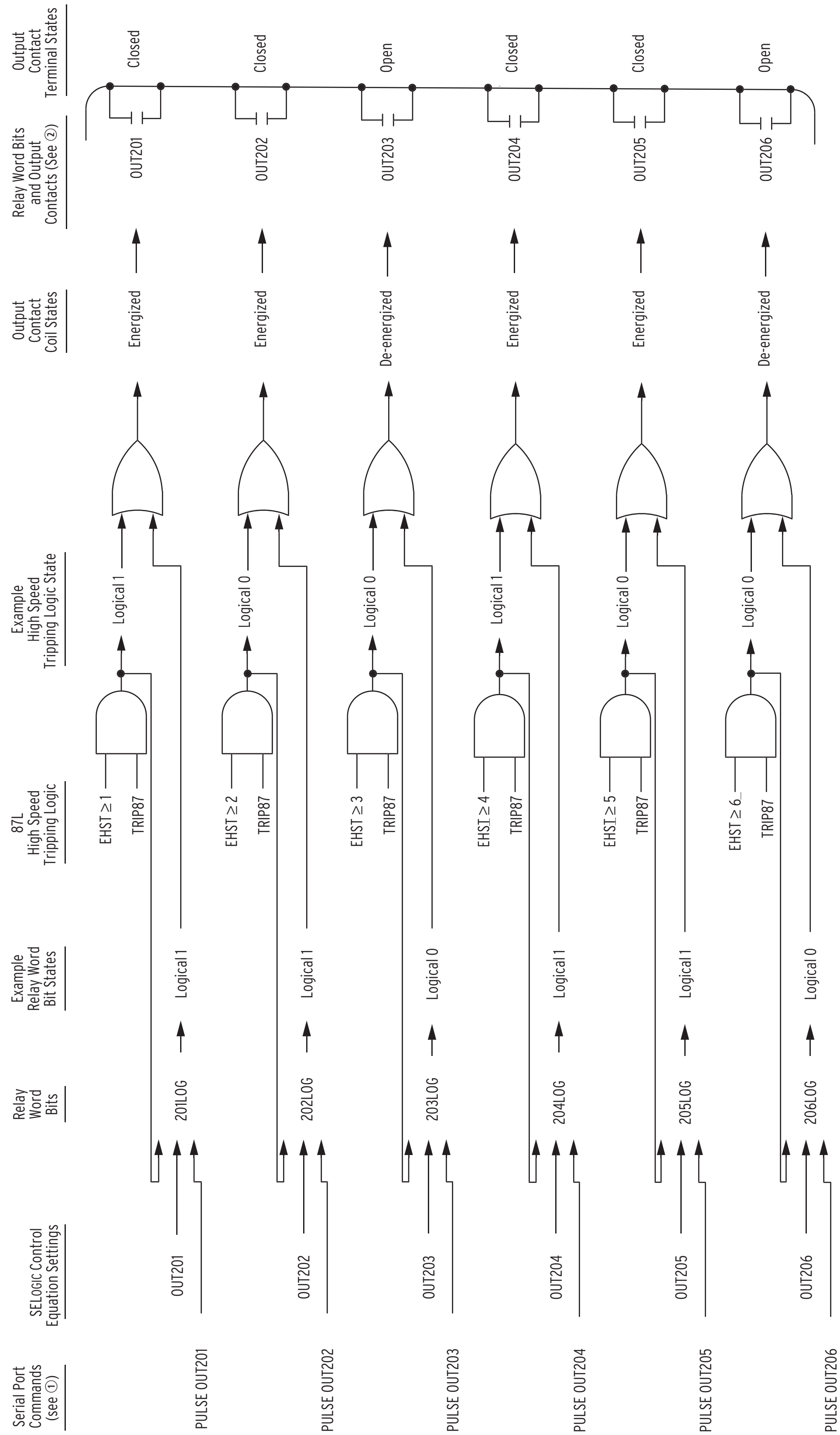
Table 7.9 Operate Time for Contacts OUT201–OUT206

OUT201–OUT206 Application and Control Method	Contact Close Time From Element Assertion
High-Speed 87L tripping via setting EHST	< 10 microseconds
Backup protection tripping via SELOGIC control equations OUT201–OUT206	< 4 milliseconds
87L tripping via SELOGIC control equations OUT201–OUT206	< 11 milliseconds

Refer to the first row of *Table 7.9*. Line current differential protection via setting EHST is fastest because the same 87L hardware that performs 87L protection also controls contacts **OUT201–OUT206**. The relay typically trips via setting EHST less than 1 cycle after an internal fault occurs.

Refer to the third row of *Table 7.9*. Use SELOGIC control equations OUT201–OUT206 for line current differential protection only when qualifying the line current differential trip decision with SELOGIC as shown in *87L Tripping Coordinated With Tapped Load Protection-Example 4 on page 7.35*.

The following sections detail how and why to control contacts **OUT201–OUT206** by using the control methods shown in *Table 7.9*. The examples shown below use Relay Word bits TRIP and TRIP87. See *Section 5: Trip and Target Logic* for more information about how Relay Word bits TRIP and TRIP87 are formed.



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 All six outputs are fixed as "a" type output contacts.

Figure 7.28 Logic Flow for Example Output Contact Operation—OUT201–OUT206

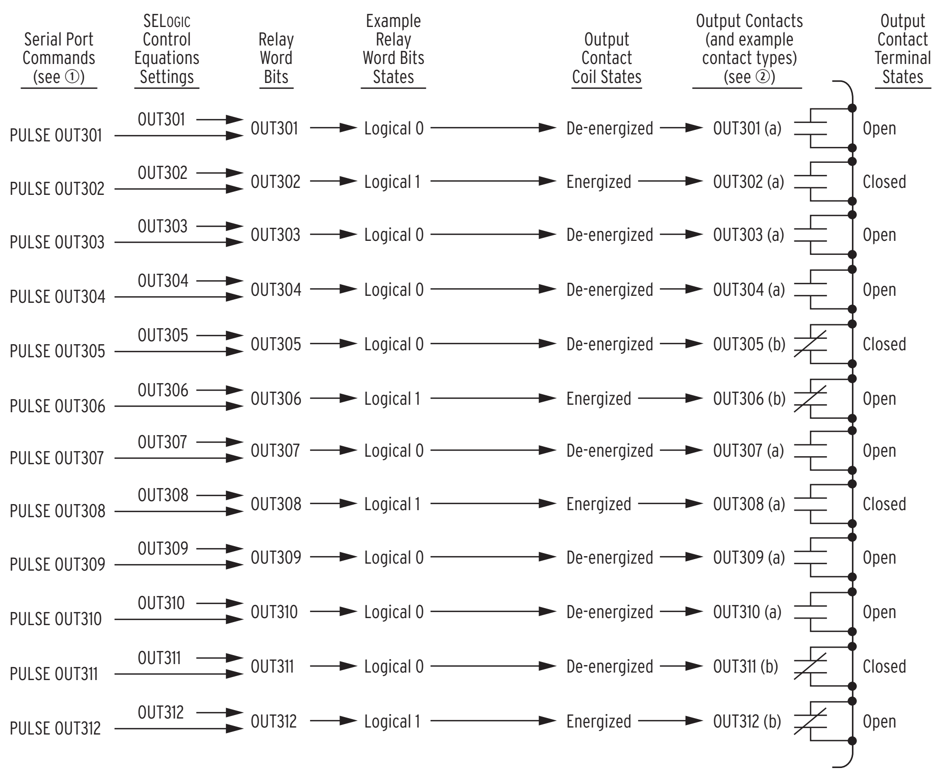
Output Contacts OUT301–OUT312

SELOGIC control equations **OUT301–OUT312** control contacts **OUT301–OUT312**. When the SELOGIC control equation evaluates to logical 1 for one of these contacts, the relay closes normally open contacts (a) and opens normally closed contacts (b), as shown in *Figure 7.29*. The **PULSE** command also controls contact outputs. For example, if SELOGIC control equation OUT301 is set to

OUT301 = **TRIP**

when Relay Word bit TRIP asserts, the control coil for **OUT301** is energized, and **OUT301** closes if it is a normally open contact. Likewise, the command **PULSE OUT301** momentarily energizes the control coil of contact output **OUT301**, and the contact closes (again assuming **OUT301** is a normally open contact). See *Output Contact Jumpers on page 2.29*, for output contact type options.

Contacts **OUT301–OUT312** are suitable for line current differential and backup protection tripping, closing, and general control functions. All seven contacts are rated for tripping duty, and typically close less than five milliseconds after the corresponding SELOGIC control equation evaluates to logical 1.



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 **OUT301–OUT312** are configurable as "a" or "b" type output contacts. See Table 2.4 and Figure 2.20 for more information on selecting output contact type.

③ Main board jumper JMP23 should be left in position 2–3 to allow output contact **OUT107** to operate as an alarm for the 87L hardware. If JMP23 is moved to position 1–2, the 87L hardware alarm function (87HWAL) will not be available.

See Table 2.5 for more information on jumper JMP23.

Figure 7.29 Logic Flow for Example Output Contact Operation

High-Speed 87L Tripping-Example 1

The only trip setting required for high-speed line current differential protection is the Enable High-Speed Trip setting, EHST. Select the total number of contacts enabled for high-speed tripping (1–6). For example, to control high-speed output contacts OUT201 and OUT202 with the line current differential high-speed tripping logic, set

EHST = **2**

and connect output contacts OUT201 and OUT202 directly to the trip coils of the circuit breaker as shown in *Figure 7.30*. Contacts OUT201–OUT206 can interrupt trip current, so tripping auxiliaries may not be required. In this example, contacts OUT201 and OUT202 close less than 10 microseconds after the line current differential protection detects an internal fault, resulting in a typical tripping time less than one cycle.

As a reminder that OUT201 and OUT202 are enabled for high-speed tripping, it is permissible to put the TRIP87 bit in the corresponding SELOGIC control equations:

OUT201 = **TRIP87**

OUT202 = **TRIP87**

This does not change how the relay operates; it only serves as a reminder that OUT201 and OUT202 are trip contacts.

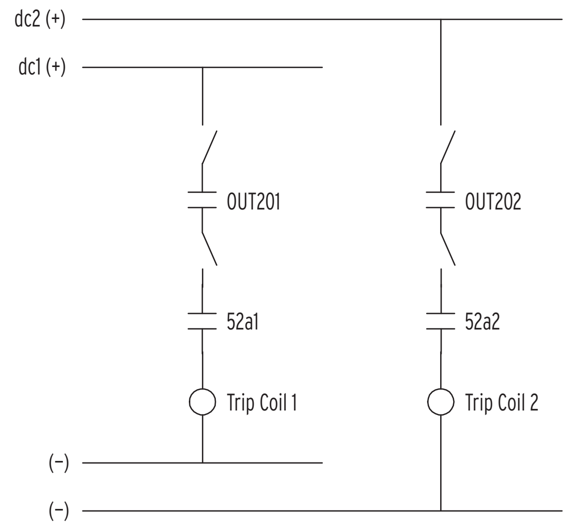


Figure 7.30 High-Speed Trip Contact Connections—Example 1

High-Speed 87L Tripping with Backup Protection Tripping-Example 2

Contacts OUT201–OUT206 can be used for backup protection tripping, even if they are also used for high-speed line current differential tripping. For example, to add backup protection and manual tripping to the previous example, make SELOGIC control equation settings

OUT201 = **TRIP**

OUT202 = **TRIP**

and set EHST = 2. Contacts OUT201 and OUT202 close when either the line current differential protection or the backup protection detects an internal fault. Line current differential protection closes OUT201 and OUT202 via setting EHST = 2, and backup protection closes those contacts via the SELOGIC control equations shown above. As configured in a standard relay shipment, Relay Word bit TRIP also asserts because of the **OPEN** command. In that case, OUT201 and OUT202 also close in response to the **OPEN** command.

As a reminder that OUT201 and OUT202 are enabled for high-speed tripping, it is permissible to put the TRIP87 bit in the SELOGIC control equation for each contact:

OUT201 = **TRIP + TRIP87**

OUT202 = **TRIP + TRIP87**

This does not change how the relay operates; it only serves as a reminder that OUT201 and OUT202 are 87L trip contacts.

Connect contacts OUT201 and OUT202 directly to the circuit breaker trip coil as shown in *Figure 7.30*. Using SELOGIC to route backup protection tripping decisions to the high-speed line current differential contact outputs saves wiring. To avoid loss of backup protection because of a problem in the line current differential hardware, use some of contacts OUT101–OUT107 as separate backup protection tripping contacts, as described in the next section.

High-Speed 87L Tripping With Separate Backup Protection Tripping-Example 3

Contacts OUT101–OUT107 and the ALARM, as well as all backup protection and control functions, continue to operate even if there is a problem in the dedicated line current differential protection hardware. The hardware added to perform line current differential protection does not decrease the reliability of the backup protection. Use this to create a very reliable backup protection scheme, complete with separate tripping contacts. For example, make SELOGIC control equation settings

OUT101 = **TRIP**

OUT102 = **TRIP**

OUT201 = **TRIP + TRIP87**

OUT202 = **TRIP + TRIP87**

and enable high-speed tripping with setting

EHST = **2**

Connect contact OUT101 in parallel with OUT201, and connect OUT102 in parallel with OUT202 as shown in *Figure 7.31*. Given the settings discussed above and the connections shown in *Figure 7.31*, the SEL-311L responds to hardware problems in the following ways:

Problem: 87L communications channel problem.

Action:

1. Switch to the hot standby channel if available, or switch to three-terminal protection mode 3R if appropriate.
2. Assert Relay Word bits CHYAL or CHXAL (Channel Y Alarm or Channel X Alarm) as appropriate.
3. Deassert Relay Word bit 87LPE as appropriate.
4. Illuminate front-panel target 87CH FAIL.

Protection:

1. 87L protection still available if hot standby channel is operable, or if three-terminal protection mode 3R is available.
2. Backup protection is still available via contacts OUT201, OUT202, OUT101, and OUT102 regardless of channel problems, and regardless of the result of the channel problem.

Problem: Problem with dedicated line current differential hardware.

Action:

1. Assert Relay Word 87HWAL (87L Hardware Alarm).
2. Deassert Relay Word bit 87LPE.
3. Illuminate **87CH FAIL** front-panel target.

Protection:

Backup protection still available via contacts **OUT101** and **OUT102**.

Problem: Problem with backup protection hardware.

Action:

1. Close **ALARM** contact.
2. Extinguish **ENABLE** front-panel target.

Protection:

87L and backup protection disabled.

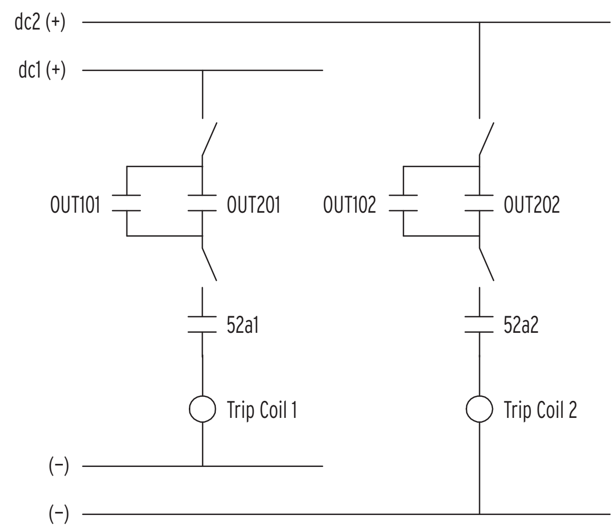


Figure 7.31 High-Speed Trip Contact Connection—Example 3

87L Tripping Coordinated With Tapped Load Protection-Example 4

The SEL-311L contains instantaneous and inverse-time overcurrent elements that operate on total line current (the vector sum of the currents measured at all line terminals). Use these T50 and T51 (see *Figure 3.2–Figure 3.23*) elements and the integral four-shot reclosing relay to coordinate line current differential protection with tapped-load protection. For example, the system in *Figure 7.32* contains a load tapped from the protected line. The tapped load is protected by a fuse. Assume a fault downstream of the tapped load fuse. It may be desirable to trip the transmission line circuit breakers rapidly, then autoreclose. If the fault is still present, then delay line current differential trips to give the tapped load fuse a chance to isolate the fault. This scheme is commonly referred to as fuse-saving. The SEL-311L can accomplish this.

Make setting

EHST = **0**

This puts the high-speed tripping contacts only under control of the backup protection, so SELOGIC control equations can qualify line current differential tipping decisions. Include Relay Word bit TRIP87 in the TR SELOGIC control equation. Include Relay Word bit TRIP in the SELOGIC control equations for trip contacts OUT201 and OUT202. Qualify 87L tripping with the recloser shot counter, so instantaneous tripping is available during recloser shot 0, and delayed tripping is available for other recloser shots. Create the delayed 87L protection for use with later shots by using a SELOGIC Timer/Variable.

OUT201 = **TRIP**

OUT202 = **TRIP**

TR = **TRIP87 * SH0 + SV1T + T51PT + T51QT + T50PT + T50QT . . .**

SV1 = **TRIP87**

Delay SV1T assertion for the maximum expected clearing time for a fault downstream of the tapped load fuse, e.g.,

SV1PU = **60**

SV1DP = **0**

Finally, torque control the tapped-load coordination elements to operate only for internal faults.

T51PTC = **87LA + 87LB + 87LC**

T51QTC = **87L2**

T50PTC = **87LA + 87LB + 87LC**

T50QTC = **87L2**

Connect contact OUT201 and OUT202 directly to the circuit breaker trip coils as shown in *Figure 7.30*. Optionally include contacts OUT101 and OUT102 as shown in *Figure 7.31* and set

OUT101 = **TRIP**

OUT102 = **TRIP**

See *Settings Example: 230 kV Transmission Line With Tapped Load on page 9.37* for more information regarding coordination with tapped loads.

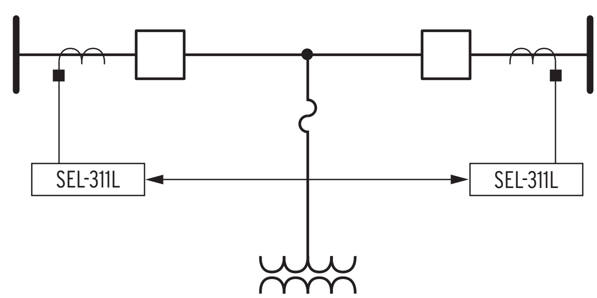


Figure 7.32 Typical Two-Terminal Application With Tapped Load

Use of High-Speed Contacts OUT201-OUT206 With Fast, Sensitive Loads

High-speed contacts OUT201–OUT206 are intended for use as high-speed trip contacts. OUT201–OUT206 can also be used with sensitive, fast contact inputs, such as might be found on some communications gear.

Load sensitivity is described by minimum assertion voltage (per unit of nominal dc control voltage), minimum pickup time (milliseconds to energize the load at nominal control voltage), and load resistance. Use OUT201–OUT206 with any load that satisfies *Equation 7.1* and does not assert below 20 percent of nominal dc control voltage.

$$R_L \leq 500 \bullet T_{pu} \qquad \textbf{Equation 7.1}$$

where:

R_L = load resistance in kΩ

T_{pu} = minimum load response time, in milliseconds

For example, a 125 V contact input on an SEL-311L does not assert below half the nominal dc control voltage. The input draws 4 mA at nominal voltage, so R_L = 125 V / 4 mA = 31 kΩ. With the debounce timer set to 2 ms, this input easily satisfies *Equation 7.1*, with a safety factor of more than 30.

$$31 \leq 500 \bullet 2$$
$$31 \leq 1000 \qquad \textbf{Equation 7.2}$$

ALARM Output Contact and 87HWAL

Refer to *Figure 7.27* and *Relay Self-Tests on page 13.14*.

When the relay is operational, the alarm logic/circuitry keeps the ALARM output contact coil energized. Depending on the ALARM output contact type (a or b), the ALARM output contact closes or opens as demonstrated in *Figure 7.27*. 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.

The Relay Word bit ALARM is deasserted to logical 0 when the relay is operational. When the relay enters Access Level 2, the ALARM Relay Word bit momentarily asserts to logical 1 (and the ALARM output contact coil is de-energized momentarily).

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 7.27* 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.

Contact output OUT107 can be configured in one of the following ways:

- Use it as a regular contact similar to OUT101–OUT106 by placing jumper JMP23 in position 2-3.
- Use it as an extra relay alarm by placing jumper JMP23 in position 1-2.
- Use it as an alarm contact for the 87L hardware by placing jumper JMP23 in position 2-3 and setting OUT107 = 87HWAL.

  This is how OUT107 is configured in a standard relay shipment. Configured this way, Relay Word bit 87HWAL asserts and contact OUT107 closes when an internal problem occurs in the 87L hardware that prevents the relay from performing line current differential protection. (Other Relay Word bits assert for communications channel failures.) It is also possible to configure contact OUT107 as a normally closed alarm contact and set OUT107 = !87HWAL so that loss of control power also closes contact OUT107.

Rotating Default Display

The rotating default display on the relay front panel replaces indicating panel lights. Traditional indicating panel lights are turned on and off by circuit breaker auxiliary contacts, front-panel switches, SCADA contacts, etc. They indicate such conditions as:

- ➤ circuit breaker open/closed
- ➤ reclosing relay enabled/disabled

Traditional Indicating Panel Lights

Figure 7.33 shows traditional indicating panel lights wired in parallel with SEL-311L optoisolated inputs. Input IN101 provides circuit breaker status to the relay, and input IN102 enables/disables reclosing in the relay via the following SELOGIC control equation settings:

52A = **IN101**

79DTL = **!IN102** [= NOT(IN102); drive-to-lockout setting]

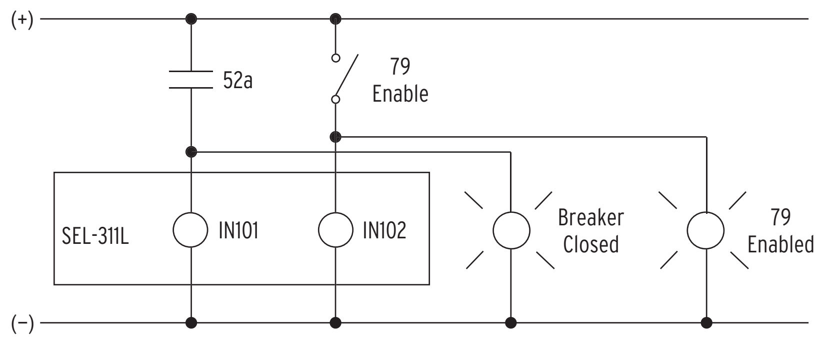


Figure 7.33 Traditional Panel Light Installations

Note that *Figure 7.33* corresponds to *Figure 7.3*.

Reclosing Relay Status Indication

In *Figure 7.33*, 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 7.33*, 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 Default Display

The indicating panel lights are not needed if the rotating default display feature in the SEL-311L is used. *Figure 7.34* shows the elimination of the indicating panel lights through use of the rotating default display.

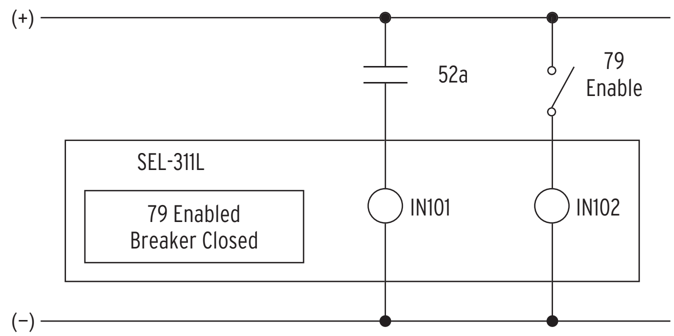


Figure 7.34 Rotating Default Display Replaces Traditional Panel Light Installations

There are sixteen (16) of these default displays available in the SEL-311L. Each default display has two complementary screens (e.g., BREAKER CLOSED and BREAKER OPEN) available.

General Operation of Rotating Default Display Settings

SELOGIC control equation display point setting DP*n* (*n* = 1–16) controls the display of corresponding, complementary text settings:

DP*n*_1 (displayed when DP*n* = logical 1)

DP*n*_0 (displayed when DP*n* = logical 0)

Make each text setting through the serial port, using the command **SET T**. View these text settings by using the serial port command **SHO T** (see *Section 9: Settings* and *Section 10: Communications*). These text settings are displayed on the SEL-311L front-panel display on a time-variable rotation through use of Global setting SCROLD (see *Rotating Default Display on page 11.10* for more specific operation information).

The following settings examples use optoisolated inputs IN101 and IN102 in the display points settings. Local bits (LB1–LB4), latch bits (LT1–LT4), remote bits (RB1–RB8), 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 settings examples provide the replacement solution shown in *Figure 7.34* for the traditional indicating panel lights in *Figure 7.33*.

Reclosing Relay Status Indication

Make SELOGIC control equation display point setting DP1:

DP1 = **IN102**

Make corresponding, complementary text settings:

DP1_1 = **79 ENABLED**

DP1_0 = **79 DISABLED**

Display point setting DP1 controls the display of the text settings.

Reclosing Relay Enabled

In *Figure 7.34*, optoisolated input IN102 is energized to enable the reclosing relay, resulting in:

DP1 = **IN102 = logical 1**

This results in the display of corresponding text setting DP1_1 on the front-panel display:

```
79 ENABLED
```

Reclosing Relay Disabled

In *Figure 7.34*, optoisolated input IN102 is de-energized to disable the reclosing relay, resulting in:

DP1 = **IN102** = logical 0

This results in the display of corresponding text setting DP1_0 on the front-panel display:

```
79 DISABLED
```

Circuit Breaker Status Indication

Make SELOGIC control equation display point setting DP2:

DP2 = **IN101**

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 7.34*, optoisolated input IN101 is energized when the 52a circuit breaker auxiliary contact is closed, resulting in:

DP2 = **IN101** = logical 1

This results in the display of corresponding text setting DP2_1 on the front-panel display:

```
BREAKER CLOSED
```

Circuit Breaker Open

In *Figure 7.34*, optoisolated input IN101 is de-energized when the 52a circuit breaker auxiliary contact is open, resulting in:

DP2 = **IN101** = logical 0

This results in the display of corresponding text setting DP2_0 on the front-panel display:

```
BREAKER OPEN
```

Additional Settings Examples

Display Only One Message

To display just one screen, but not its complement, set only one of the text settings. For example, to display just the BREAKER CLOSED condition, but not the BREAKER OPEN condition, make the following settings:

DP2 = **IN101** (52a circuit breaker auxiliary contact connected to input **IN101**–see *Figure 7.34*)

DP2_1 = **BREAKER CLOSED** (displays when DP2 = logical 1)

DP2_0 = (blank)

Circuit Breaker Closed

In *Figure 7.34*, optoisolated input **IN101** is energized when the 52a circuit breaker auxiliary contact is closed, resulting in:

DP2 = **IN101** = logical 1

This results in the display of corresponding text setting DP2_1 on the front-panel display:

```
BREAKER CLOSED
```

Circuit Breaker Open

In *Figure 7.34*, optoisolated input **IN101** is de-energized when the 52a circuit breaker auxiliary contact is open, resulting in:

DP2 = **IN101** = logical 0

Corresponding text setting DP2_0 is not set (it is “blank”), so no message is displayed on the front-panel display.

Continually Display a Message

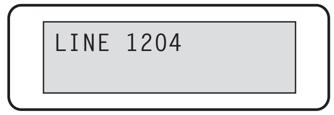
To continually display a message in the rotation, set the SELOGIC control equation display point setting directly to 0 (logical 0) or 1 (logical 1) and the corresponding text setting. For example, if an SEL-311L is protecting a 230 kV transmission line, labeled “Line 1204,” the line name can be continually displayed 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 continual display of text setting DP5_1 on the front-panel display:



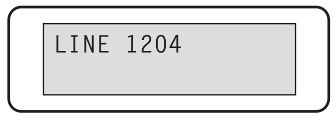
This can also be realized with the following settings:

DP5 = **0** (set directly to logical 0)

DP5_1 = (“blank”)

DP5_0 = **LINE 1204** (displays when DP5 = logical 0)

This results in the continual 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* = 1–16) 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 7.34* and the following discussion of an 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)

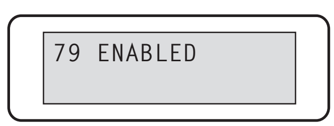
DP1_0 = 79 DISABLED (displayed when DP1 = logical 0)

Reclosing Relay Enabled

In *Figure 7.34*, optoisolated input **IN102** is energized to enable the reclosing relay, resulting in:

DP1 = **IN102** = logical 1

This results in the display of corresponding text setting DP1_1 on the front-panel display:

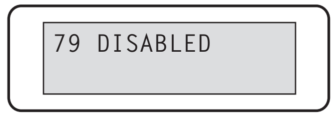


Reclosing Relay Disabled

In *Figure 7.34*, optoisolated input IN102 is de-energized to disable the reclosing relay, resulting in:

DP1 = **IN102** = logical 0

This results in the display of corresponding text setting DP1_0 on the front-panel display:



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”)

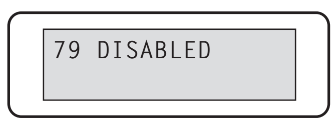
DP1 = **0** (set directly to logical 0)

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 continually displays in the rotating default displays:



Additional Rotating Default Display Example

See *Figure 5.21* and accompanying text in *Section 5: Trip and Target Logic* for an example of resetting a rotating default display with the TARGET RESET pushbutton.

Displaying Time-Overcurrent Elements on the Rotating Default Display

The LCD can display the pickup settings for the time-overcurrent elements in primary units via a special character sequence in the display points equations. 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 settings for 51PP, 51GP, or 51QP.

For example, with the factory-default settings for 51PP and CTR, setting DP1_0 = ::51PP will display 1200.00 A pri.

The relay calculates the value to display by multiplying the 51PP setting (6.00 A secondary) by the CTR setting (200), arriving at 1200.00 A primary. The relay displays the display point DP1_0 because the factory-default SELOGIC control equation DP1 = 0 (logical 0). The calculations for the remaining time-overcurrent elements are similar.

If the display point setting does not match the format correctly, the relay will display the setting text string as it was actually entered, without substituting the time-overcurrent element setting value.

EXAMPLE 7.2 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 default display.

Set the following:

Table 7.10 Settings for Displaying Time-Overcurrent Elements

SET	SET T	SET L
CTR = 200	DP1_0 = PHASE TRIPS AT	DP1 = 0
CTRP = 200	DP2_0 = ::51PP	DP2 = 0
E51P = Y	DP3_0 = NEUTRAL TRIPS AT	DP3 = 0
E51G = Y	DP4_0 = ::51GP	DP4 = 0
51PP = 6		
51GP = 0.75		

Setting DPn = 0 and using the DPn_0 in the text settings allows the setting to permanently rotate in the display. The DPn logic equation can be set to control the text display-turning it on and off under certain conditions. With the relay set as shown above, the LCD will show the following:

```
PHASE TRIPS AT
  1200.00 A pri
```

then,

```
NEUTRAL TRIPS AT
   150.00 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.

For additional format control for the setting elements only, use the following **SET T** control string:

Dpi_j = **XXX;;[;]ABCDE;YYY**

where:

- i is a number between 1 and 16, representing the 16 display points, and j is either 1 or 0 representing logic high or low, respectively.
- XXX is an optional pre-label. YYY is an optional post label that is preceded by a single semicolon (;) character. The label character count is the sum of the characters used in the pre and post labels.
- ABCDE is a relay setting variable from the table below.

Table 7.11 Relay Setting Variables

SET T Setting Variable	Displays Relay Setting Value	Display Format/Resolution	Maximum Label Character Count
;;51PP	51PP	xxxxxxx.xx	6
;;51GP	51GP	xxxxxxx.xx	6
;;51QP	51QP	xxxxxxx.xx	6
;;;000	51PP	xxxxxxx	9
;;;001	51GP	xxxxxxx	9
;;;002	51QP	xxxxxxx	9

For example, setting DP1_0 = OC PU;;51PP;A will display:

```
OC PU  1200.00A
```

Or setting DP1_0 = OC PU;;;001;A will display:

```
OC PU  1200A
```

Displaying Metering Quantities on the Rotating Default Display

Display points can be programmed to display metering quantities automatically, making this information available without the use of pushbuttons. The values shown in *Table 7.12* can be set to automatically display on the rotating LCD screen.

Table 7.12 Mnemonic Settings for Metering on the Rotating Default Display (Sheet 1 of 4)

Mnemonic	Display	Description
IA	I A = x . x x x A y y y °	IA input current
IB	I B = x . x x x A y y y °	IB input current
IC	I C = x . x x x A y y y °	IC input current
IP	I P = x . x x x A y y y °	IN input current
VA	V A = x . x x x K V y y y °	VA input voltage
VB	V B = x . x x x K V y y y °	VB input voltage
VC	V C = x . x x x K V y y y °	VC input voltage
VS	V S = x . x x x K V y y y °	VS input voltage
IG	I G = x . x x x A y y y °	IG = IA + IB +IC (residual)
3IO	3 I O = x . x x x A y y y °	3IO = IG (zero-sequence)
I1	I 1 = x . x x x A y y y °	positive-sequence current
3I2	3 I 2 = x . x x x A y y y °	negative-sequence current
3V0	3 V 0= x . x x x K V y y y °	zero-sequence current
V1	V 1 = x . x x x K V y y y °	positive-sequence voltage
V2	V 2 = x . x x x K V y y y °	negative-sequence voltage

Table 7.12 Mnemonic Settings for Metering on the Rotating Default Display (Sheet 2 of 4)

Mnemonic	Display	Description
MWA	M W A = x x . x x x	A megawatts
MWA	M W B = x x . x x x	B megawatts
MWC	M W C = x x . x x x	C megawatts
MW3	M W 3 P = x x . x x x	three-phase megawatts
MVARA	M V A R A = x x . x x x	A megavolt-amperes reactive
MVARB	M V A R B = x x . x x x	B megavars
MVARC	M V A R C = x x . x x x	C megavars
MVAR3	M V A R 3 P = x x . x x x	three-phase megavars
PFA	P F A = x . x x L E A D	A power factor
PFB	P F B = x . x x L A G	B power factor
PFC	P F C = x . x x L A G	C power factor
PF3	P F 3 P = x . x x L E A D	three-phase power factor
FREQ	F R Q = x x . x	system frequency from VA
VDC	V D C = x x x . x v	DC voltage
IADEM	I A D E M = x . x x x	IA demand current
IAPK	I A P E A K = x . x x x	IA peak current
IBDEM	I B D E M = x . x x x	IB demand current
IBPK	I B P E A K = x . x x x	IB peak current
ICDEM	I C D E M = x . x x x	IC demand current
ICPK	I C P E A K = x . x x x	IC peak current
IPDEM	I P D E M = x . x x x	IP demand current
IPPK	I P P E A K = x . x x x	IP peak current
3I2DEM	3 I 2 D E M = x . x x x	3I2 demand current
3I2PK	3 I 2 P E A K = x . x x x	3I2 peak current
IAL	I A L = x x x x A y y y	IA Local Current
IBL	I B L = x x x x A y y y	IB Local Current
ICL	I C L = x x x x A y y y	IC Local Current
3I0L	3 I 0 L = x x x x A y y y	Local Zero-Sequence Current
3I2L	3 I 2 L = x x x x A y y y	Local Negative-Sequence Current
I1L	I 1 L = x x x x A y y y	Local Positive-Sequence Current
IAX	I A X = x x x x A y y y	IA Channel X Current
IBX	I B X = x x x x A y y y	IB Channel X Current
ICX	I C X = x x x x A y y y	IC Channel X Current
3I0X	3 I 0 X = x x x x A y y y	Channel X Zero-Sequence Current
3I2X	3 I 2 X = x x x x A y y y	Channel X Negative-Sequence Current
I1X	I 1 X = x x x x A y y y	Channel X Positive-Sequence Current
IAY	I A Y = x x x x A y y y	IA Channel Y Current
IBY	I B Y = x x x x A y y y	IB Channel Y Current
ICY	I C Y = x x x x A y y y	IC Channel Y Current
3I0Y	3 I 0 Y = x x x x A y y y	Channel Y Zero-Sequence Current
3I2Y	3 I 2 Y = x x x x A y y y	Channel Y Negative-Sequence Current

Table 7.12 Mnemonic Settings for Metering on the Rotating Default Display (Sheet 3 of 4)

Mnemonic	Display	Description
I1Y	I 1 Y = x x x x A y y y	Channel Y Positive-Sequence Current
IAD	Σ I A = x x x x A y y y	IA Vector Sum Current
IBD	Σ I B = x x x x A y y y	IB Vector Sum Current
ICD	Σ I C = x x x x A y y y	IC Vector Sum Current
3I0D	Σ 3 I 0 = x x x x A y y y	Vector Sum Zero-Sequence Current
3I2D	Σ 3 I 2 = x x x x A y y y	Vector Sum Negative-Sequence Current
I1D	Σ I 1 = x x x x A y y y	Vector Sum Positive-Sequence Current
IAA	α I A = x x x . y y y	IA Alpha Plane
IBA	α I B = x x x . y y y	IB Alpha Plane
ICA	α I C = x x x . y y y	IC Alpha Plane
3I0A	α 3 I 0 = x x x . y y y	Alpha Plane Zero-Sequence
3I2A	α 3 I 2 = x x x . y y y	Alpha Plane Negative-Sequence
I1A	α I 1 = x x x . y y y	Alpha Plane Positive-Sequence
MWADI	M W A I N D E M = x . x x x	A demand megawatts in
MWAPI	M W A I N P K = x . x x x	A peak megawatts in
MWBDI	M W B I N D E M = x . x x x	B demand megawatts in
MWBPI	M W B I N P K = x . x x x	B peak megawatts in
MWCDI	M W C I N D E M = x . x x x	C demand megawatts in
MWCPI	M W C I N P K = x . x x x	C peak megawatts in
MW3DI	M W 3 I N D E M = x . x x x	Three-phase demand megawatts in
MW3PI	M W 3 I N P K = x . x x x	Three-phase peak megawatts in
MVRADI	M V R A I D E M = x . x x x	A demand megavars in
MVRAPI	M V R A I P K = x . x x x	A peak megavars in
MVRBDI	M V R B I D E M = x . x x x	B demand megavars in
MVRBPI	M V R B I P K = x . x x x	B peak megavars in
MVRCDI	M V R C I D E M = x . x x x	C demand megavars in
MVRCPI	M V R C I P K = x . x x x	C peak megavars in
MVR3DI	M V R 3 I D E M = x . x x x	Three-phase demand megavars in
MVR3PI	M V R 3 I P K = x . x x x	Three-phase peak megavars in
MWADO	M W A O D E M = x . x x x	A demand megawatts out
MWAPO	M W A O P K = x . x x x	A peak megawatts out
MWBDO	M W B O D E M = x . x x x	B demand megawatts out
MWBPO	M W B O P K = x . x x x	B peak megawatts out
MWCDO	M W C O D E M = x . x x x	C demand megawatts out
MWCPO	M W C O P K = x . x x x	C peak megawatts out
MW3DO	M W 3 O D E M = x . x x x	Three-phase demand megawatts out
MW3PO	M W 3 O P K = x . x x x	Three-phase peak megawatts out
MVRADO	M V R A O D E M = x . x x x	A demand megavars out
MVRAPO	M V R A O P K = x . x x x	A peak megavars out
MVRBDO	M V R B O D E M = x . x x x	B demand megavars out
MVRBPO	M V R B O P K = x . x x x	B peak megavars out

Table 7.12 Mnemonic Settings for Metering on the Rotating Default Display (Sheet 4 of 4)

Mnemonic	Display	Description
MVRCDO	M V R C O D E M = x . x x x	C demand megavars out
MVRCPO	M V R C O P K = x . x x x	C peak megavars out
MVR3DO	M V R 3 O D E M = x . x x x	Three-phase demand megavars out
MVR3PO	M V R 3 O P K = x . x x x	Three-phase peak megavars out
MWHAI	M W h A I N = x x . x x x	A megawatt-hours in
MWHAO	M W h A O U T = x x . x x x	A megawatt-hours out
MWHBI	M W h B I N = x x . x x x	B megawatt-hours in
MWHBO	M W h B O U T = x x . x x x	B megawatt-hours out
MWHCI	M W h C I N = x x . x x x	C megawatt-hours in
MWHCO	M W h C O U T = x x . x x x	C megawatt-hours out
MWH3I	M W h 3 I N = x x . x x x	Three-phase megawatt-hours in
MWH3O	M W h 3 O U T = x x . x x x	Three-phase megawatt-hours out
MVRHAI	M V A R h A I = x x . x x x	A megavar-hours in
MVRHAO	M V A R h A O = x x . x x x	A megavar-hours out
MVRHBI	M V A R h B I = x x . x x x	B megavar-hours in
MVRHBO	M V A R h B O = x x . x x x	B megavar-hours out
MVRHCI	M V A R h C I = x x . x x x	C megavar-hours in
MVRHCO	M V A R h C O = x x . x x x	C megavar-hours out
MVRH3I	M V A R h 3 I = x x . x x x	Three-phase megavar-hours in
MVRH3O	M V A R h 3 O = x x . x x x	Three-phase megavar-hours out

To program a display point to display one of the metering quantities above, first enter the two-character sequence :: (double colon) followed by the name of the desired metering quantity (IA, VA, MW3, etc.).

If the display point setting does not match the format correctly, the relay will display the setting text string as it was actually entered, without substituting the metering value.

EXAMPLE 7.3 Displaying Metering Values Example

This example demonstrates use of the rotating display to show metering quantities automatically on the rotating default display. This example will set the MW3, MVAR3, PF3, and FREQ to display in the rotating default display.

Set the following:

Table 7.13 Settings for Displaying Metering Values Example

SET T	SET L
DP1_0 = ::MW3	DP1 = 0
DP2_0 = ::MVAR3	DP2 = 0
DP3_0 = ::PF3	DP3 = 0
DP4_0 = ::FREQ	DP4 = 0

Setting DPn = 0 and using the DPn_0 in the text settings allows the setting to permanently rotate in the display. The DPn logic equation can be set to control the text display-turning it on and off under certain conditions. With the relay set as shown above, the LCD will show the following:

```
  MW 3P= XXXX.X
MVAR 3P= XXXX.X
```

then,

```
PF 3P=XX.XX XXXX
FRQ=XX.X
```

Displaying Breaker Monitor Output Information on the Rotating Default Display

Display points can be programmed to display breaker monitor output information automatically, making this information available without using pushbuttons. The values shown *Table 7.14* in can be set to automatically display on the rotating LCD screen.

Table 7.14 Mnemonic Settings for Self-Check Status on the Rotating Default Display

Mnemonic	Display														Description
BRKDATE	R S T		D	A	T	:	m	m	/	d	d	/	y	y	last reset date
BRKTIME	R S T		T	I	M	:	h	h	:	m	m	:	s	s	last reset time
CTRLTR	C T R L			T	R	I	P	S	=	x	x	x	x	x	internal trip count
OPSCNTR	O P S		C	N	T	R	+	A		x	x	x	x	x	internal trip count
CTRLIA	C T R L			I	A	=	x	x	x	x	x		k	A	internal trip Σ IA
CTRLIB	C T R L			I	B	=	x	x	x	x	x		k	A	internal trip Σ IB
CTRLIC	C T R L			I	C	=	x	x	x	x	x		k	A	internal trip Σ IC
EXTTR	E X T	x	T	R	I	P	S	=		x	x	x	x	x	external trip count
EXTIA	E X T		I	A	=		x	x	x	x	x		k	A	external trip Σ IA
EXTIB	E X T		I	B	=		x	x	x	x	x		k	A	external trip Σ IB
EXTIC	E X T		I	C	=		x	x	x	x	x		k	A	external trip Σ IC
WEARA	W E A R			A	=						y	y	y	%	A phase wear monitor
WEARB	W E A R			B	=						y	y	y	%	B phase wear monitor
WEARC	W E A R			C	=						y	y	y	%	C phase wear monitor

To program a display point to display one of the Breaker Monitor outputs above, first enter the two-character sequence :: (double colon) followed by the name of the desired breaker monitor output (EXTTR, CTRLTR, CTRLIA, etc.).

If the display point setting does not match the format correctly, the relay will display the setting text string as it was actually entered, without substituting the breaker monitor output value.

EXAMPLE 7.4 Displaying Breaker Monitor Outputs Example

This example demonstrates use of the rotating display to show metering quantities automatically on the rotating default display. This example will set the EXTTR CTRLTR, CTRLIA, EXTIA, and WEARA to display in the rotating default display.

Set the following:

Table 7.15 Settings for Displaying Breaker Monitor Outputs Example

SET T	SET L
DP1_0 = ::EXTTR	DP1 = 0
DP2_0 = ::CTRLTR	DP2 = 0
DP3_0 = ::CTRLIA	DP3 = 0
DP4_0 = ::EXTIA	DP4 = 0
DP5_0 = ::WEARA	DP5 = 0

Setting DPn = 0 and using the DPn_0 in the text settings allows the setting to permanently rotate in the display. The DPn logic equation can be set to control the text display-turning it on and off under certain conditions. With the relay set as shown above, the LCD will show the following:

```
EXT TRIPS=XXXXX
CTRL TRIPS=XXXXX
```

then,

```
CTRL IA=XXXXXX kA
EXT IA=XXXXXX kA
```

and then,

```
WEAR A=   XXX %
```

Section 8
Metering and Monitoring

Overview

The SEL-311L metering functions include:

- ➤ Instantaneous Metering
- ➤ Demand Metering
- ➤ Energy Metering
- ➤ Maximum/Minimum Metering
- ➤ Synchrophasor Metering

The SEL-311L Relay monitoring functions include:

- ➤ Breaker Monitor
- ➤ Station DC Battery Monitor

This section explains these functions in detail.

Metering

The SEL-311L provides the following metering functions:

- ➤ Instantaneous Metering
- ➤ Demand Metering
- ➤ Maximum/Minimum Metering
- ➤ Energy Metering

All the metering functions listed above, except instantaneous metering, are based on local current and local voltage. The instantaneous metering displays both local and remote quantities.

If potentials are not applied to terminals VA, VB, and VC, the voltage dependent elements are not reported. However, frequency is reported because frequency tracking can be performed using currents.

The magnitudes displayed are in primary values and the angles are referenced to the A-phase voltage if it is greater than 13 V secondary. If the A-phase voltage is 13 V or less, the angles are referenced to the local positive-sequence current. The exception is synchrophasor metering (**MET PM** command), in which case the phase angles are measured relative to an absolute time reference.

Instantaneous Metering

The instantaneous metering in the SEL-311L provides the quantities shown below:

```
=>MET <Enter>

[RID setting]                     Date: mm/dd/yy    Time: hh:mm:ss.sss
[TID setting]

Local             A         B         C        3I0       3I2       I1
I MAG (A Pri) xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx
I ANG (DEG)    xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx

Channel X         A         B         C        3I0       3I2       I1
I MAG (A Pri) xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx
I ANG (DEG)    xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx

Channel Y         A         B         C        3I0       3I2       I1
I MAG (A Pri) xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx
I ANG (DEG)    xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx

Vector Sum        A         B         C        3I0       3I2       I1
I MAG (A Pri) xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx
I ANG (DEG)    xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx

Alpha Plane       A         B         C     ZERO-SEQ   NEG-SEQ   POS-SEQ
RADIUS        xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx
ANG (DEG)      xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx

=>
```

Figure 8.1 Instantaneous Metering (Local and Remote)

The quantities reported depend on the number of terminals that comprise the line current differential scheme, number of channels connected to the relay, and the terminal configuration (2, 3, or 3R) of the SEL-311L.

The current magnitude and angles listed under `Local` in *Figure 8.1* are not available during an 87 channel failure.

The current magnitudes and angles listed under Channel X, Channel Y, and Vector Sum, as well as the alpha plane values, are reported based on the number of terminals, number of channels, and the terminal configuration.

The Vector Sum of currents always represents the total current entering the protected line. Vector Sum is not reported when the terminal configuration is 3R.

Channel X and Channel Y quantities always represent the currents received from the remote relays connected to those respective channels.

POS-SEQ alpha plane radius and angle values are calculated and displayed for completeness only. Positive-sequence alpha plane ratios are not used for protection. The other alpha plane ratio quantities are displayed only when the respective alpha plane calculations are enabled (See *Figure 3.14*, *Figure 3.16*, and *Figure 3.17*).

Figure 8.2 shows the instantaneous meter display for other local quantities.

```
=>MET B <Enter>

[RID setting]                  Date: mm/dd/yy    Time: hh:mm:ss.sss
[TID setting]

               A         B         C         P         G
I MAG (A)   xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx
I ANG (DEG)  xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx

               A         B         C         S
V MAG (kV)  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx
V ANG (DEG)  xxx.xx    xxx.xx    xxx.xx    xxx.xx

               A         B         C         3P
MW          xxxx.xx   xxxx.xx   xxxx.xx   xxxx.xx
MVAR        xxxx.xx   xxxx.xx   xxxx.xx   xxxx.xx
PF             x.xx      x.xx      x.xx      x.xx
                LEAD      LAG       LEAD      LAG

               I1        3I2       3I0       V1        V2        3V0
MAG         xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx  xxxx.xxx
ANG   (DEG)  xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx    xxx.xx

FREQ (Hz)   xx.xx           VDC (V)    xxx.x

=>
```

Figure 8.2 Instantaneous Meter Display for Local Quantities

Local Demand Metering

The SEL-311L offers the choice between two types of demand metering, settable with the Enable setting:

EDEM = **THM** (Thermal Demand Meter)

or

EDEM = **ROL** (Rolling Demand Meter)

The demand metering settings (in *Table 8.1*) are available via the **SET** command (see *Settings Sheets* at the end of *Section 9: Settings*. Also refer to *MET Command (Metering Data) on page 10.38*).

The SEL-311L provides local demand and local peak demand metering for the following values:

Currents	
$I_{A,B,C}$	Input currents (A primary)
I_G	Residual-ground current (A primary; $I_G = 3_{I0} = I_A + I_B + I_C$)
$3I_2$	Negative-sequence current (A primary)
Power	
$MW_{A,B,C,3P}$	Single- and three-phase megawatts
$MVAR_{A,B,C,3P}$	Single- and three-phase megavars

Depending on enable setting EDEM, these demand and peak demand values are thermal demand or rolling demand values. 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 8.3* 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”).

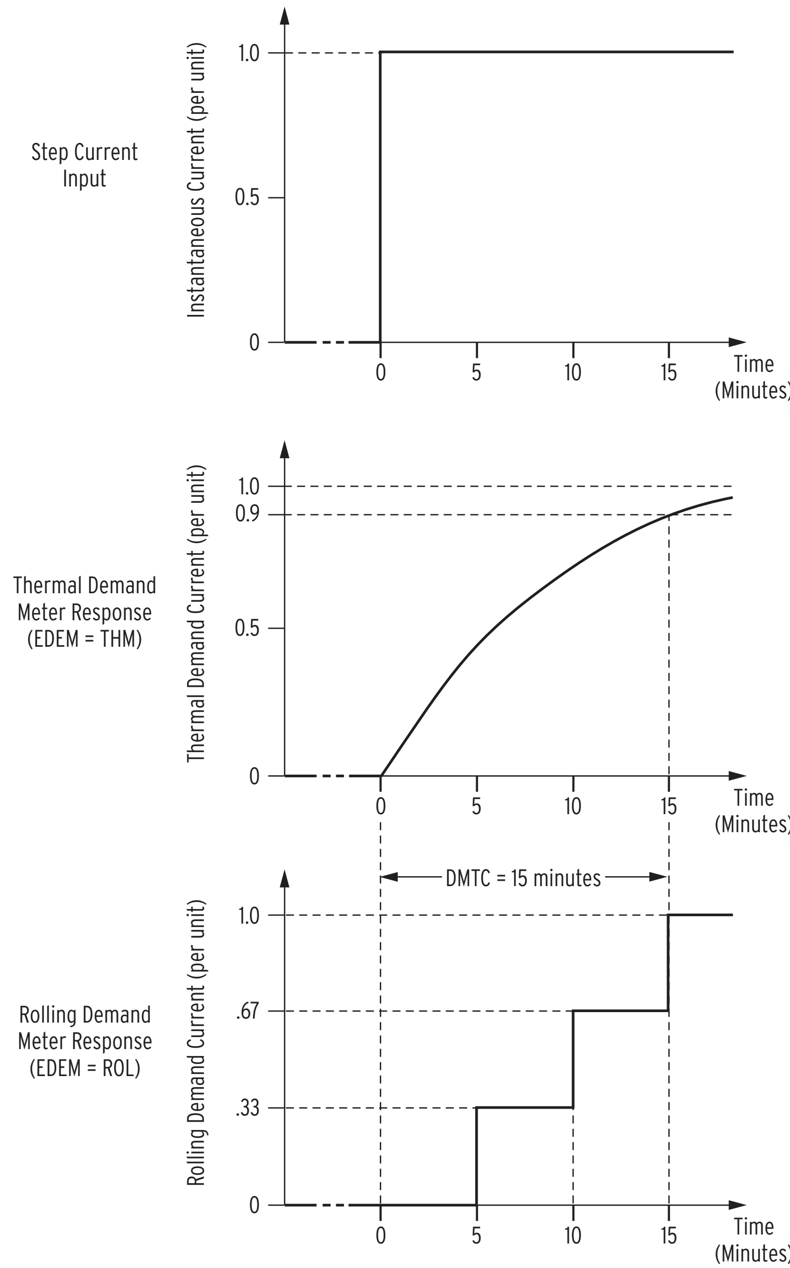


Figure 8.3 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 Minutes)

Thermal Demand Meter Response (EDEM = THM)

The response of the thermal demand meter in *Figure 8.3* (middle) to the step current input (top) is analogous to the parallel RC circuit in *Figure 8.4*.

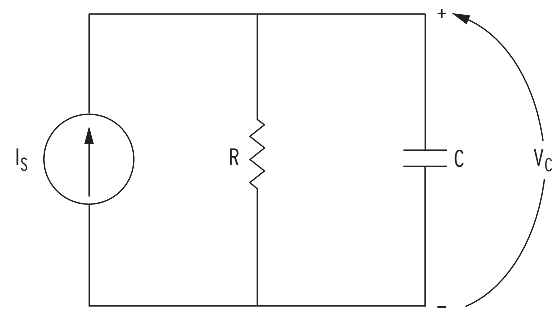


Figure 8.4 Current I_S Applied to Parallel RC Circuit

In the analogy:

- ➤ Current I_S in *Figure 8.4* corresponds to the step current input in *Figure 8.3* (top).
- ➤ Voltage V_C across the capacitor in *Figure 8.4* corresponds to the response of the thermal demand meter in *Figure 8.3* (middle).

If current I_S in *Figure 8.4* has been at zero (I_S = 0.0 per unit) for some time, voltage V_C across the capacitor in *Figure 8.4* is also at zero (V_C = 0.0 per unit). If current I_S is suddenly stepped up to some constant value (I_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 8.3* (middle) to the step current input (top).

In general, just as voltage V_C across the capacitor in *Figure 8.4* cannot change instantaneously, the thermal demand meter response cannot change instantaneously for increasing or decreasing current. The thermal demand meter response time is based on the demand meter time constant setting DMTC (see *Table 8.1*). Note in *Figure 8.3*, 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-311L updates thermal demand values approximately every two seconds.

Rolling Demand Meter Response (EDEM = ROL)

The response of the rolling demand meter in *Figure 8.3* (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 8.1*). Note in *Figure 8.3*, 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 8.3* 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 8.3* (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 3 five-minute intervals in the sliding time-window at "Time = 0 minutes" each integrate into the following five-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 3 five-minute intervals in the sliding time-window at "Time = 5 minutes" each integrate into the following five-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 3 five-minute intervals in the sliding time-window at "Time = 10 minutes" each integrate into the following five-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 3 five-minute intervals in the sliding time-window at "Time = 15 minutes" each integrate into the following five-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

Enable Demand Meter (EDEM) is not visible in application settings 87L, 87L21, and 87L21P.

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 this section.

Table 8.1 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
GDEMP	Residual-ground demand current pickup	0.10–3.20 A {1 A nominal} 0.50–16.0 A {5 A nominal}
QDEMP	Negative-sequence demand current pickup	in 0.01 A steps

The demand current pickup settings in *Table 8.1* are applied to demand current meter outputs as shown in *Figure 8.5*. 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, GDEM, and QDEM) to alarm for high loading or unbalance conditions. Use in other schemes such as the following example.

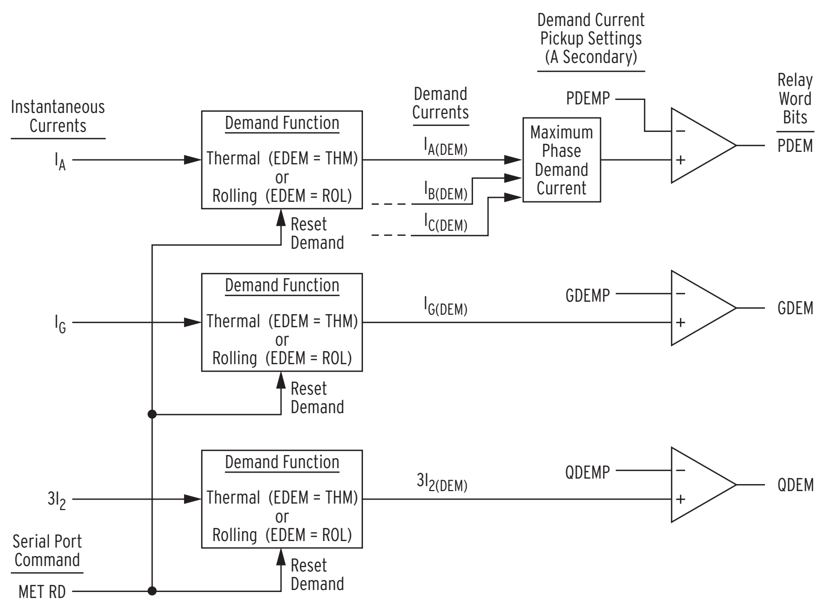


Figure 8.5 Demand Current Logic Outputs

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 8.1*, 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 8.5*, *Figure 8.6*, and *Figure 3.22*.

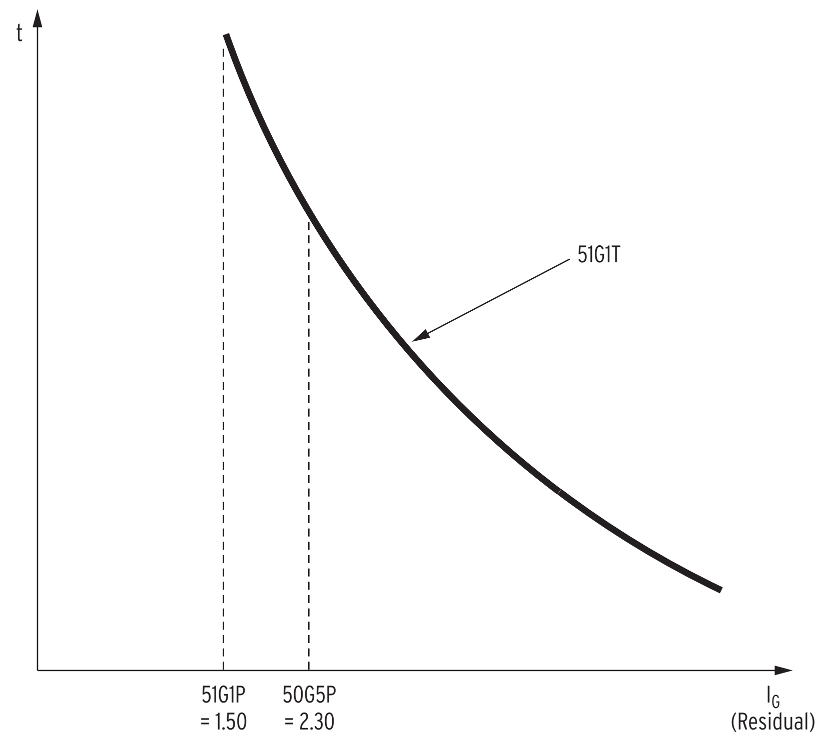


Figure 8.6 Raise Pickup of Residual-Ground Time-Overcurrent Element for Unbalance Current

Residual-Ground Demand Current Below Pickup GDEMP

When unbalance current I_G is low, unbalance demand current $I_{G(DEM)}$ is below corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM is deasserted to logical 0. This results in SELOGIC control equation torque-control setting 51GTC being in the state:

51GTC = **!GDEM + GDEM * 50G2** = NOT(GDEM) + GDEM * 50G2 =
NOT(logical 0) + (logical 0) * 50G2 = logical 1

Thus, the residual-ground time-overcurrent element 51GT operates on its standard pickup:

51GP = **1.50 A secondary**

If a ground fault occurs, the residual-ground time-overcurrent element 51GT operates with the sensitivity provided by pickup 51GP = 1.50 A secondary. The thermal demand meter, even with setting DMTC = 5 minutes, does not respond fast enough to the ground fault to make a change to the effective residual-ground time-overcurrent element pickup—it remains at 1.50 A secondary. Demand meters respond to more "slow moving" general trends.

Residual-Ground Demand Current Goes Above Pickup GDEMP

When unbalance current I_G increases, unbalance demand current $I_{G(DEM)}$ follows, going above corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM asserts to logical 1. This results in SELOGIC control equation torque-control setting 51GTC being in the state:

51GTC = **!GDEM + GDEM * 50G2** = NOT(GDEM) + GDEM * 50G2 =
NOT(logical 1) + (logical 1) * 50G2 = logical 0 + 50G2 = 50G2

Thus, the residual-ground time-overcurrent element 51GT operates with an effective, less-sensitive pickup:

50G2P = **2.30 A secondary**

The reduced sensitivity keeps the residual-ground time-overcurrent element 51GT from tripping on higher unbalance current I_G.

Residual-Ground Demand Current Goes Below Pickup GDEMP Again

When unbalance current I_G decreases again, unbalance demand current $I_{G(DEM)}$ follows, going below corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM deasserts to logical 0. This results in SELOGIC control equation torque-control setting 51GTC being in the state:

51GTC = **!GDEM + GDEM * 50G2** = NOT(GDEM) + GDEM * 50G2 =
NOT(logical 0) + (logical 0) * 50G2 = logical 1

Thus, the residual-ground time-overcurrent element 51GT operates on its standard pickup again:

51GP = **1.50 A secondary**

View or Reset Demand Metering Information

Via Serial Port

See *MET Command (Metering Data) on page 10.38*. The **MET D** command displays demand and peak demand metering for the following values:

Currents	
$I_{A,B,C}$	Input currents (A primary)
I_G	Residual-ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
$3I_2$	Negative-sequence current (A primary)
Power	
$MW_{A,B,C}$	Single-phase megawatts
$MVAR_{A,B,C}$	Single-phase megavars
MW_{3P}	Three-phase megawatts
$MVAR_{3P}$	Three-phase megavars

The **MET RD** command resets the demand metering values. The **MET RP** command resets the peak demand metering values.

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*.

Demand Metering Updating and Storage

The SEL-311L updates demand values approximately every two seconds.

The relay stores peak demand values to nonvolatile storage once per day (it overwrites the previous stored value 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.

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 Updating and Storage on page 8.11*. It is not necessary to suspend demand metering during a fault because fault quantities will not significantly change demand quantities that are calculated using a minimum time constant of five minutes.

Local Energy Metering

View or Reset Energy Metering Information

Via Serial Port

See *MET Command (Metering Data) on page 10.38*. 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*.

Energy Metering Updating and Storage

The SEL-311L updates energy values approximately every two seconds.

The relay stores energy values to nonvolatile storage once per day (it overwrites the previous stored value). Should the relay lose control power, it will restore the energy values saved by the relay at 23:50 hours on the previous day.

Local Maximum/ Minimum Metering

View or Reset Maximum/Minimum Metering Information

Via Serial Port

See *MET Command (Metering Data)*. The **MET M** command displays maximum/minimum metering for the following values:

Currents	
$I_{A,B,C}$	Input currents (A primary)
I_G	Residual-ground current (A primary; $I_G = 3_{I0} = I_A + I_B + I_C$)
I_P	Polarizing current (A primary)
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

The **MET RM** command resets the maximum/minimum metering values.

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **MET M** and **MET RM** are also available via the front-panel METER pushbutton. See *Figure 11.2*.

Maximum/Minimum Metering Updating and Storage

The SEL-311L updates maximum/minimum values, if the following conditions are met:

- SELOGIC control equation setting FAULT is deasserted (= logical 0).
- The factory-default setting is set with time-overcurrent and distance element pickups:
  - FAULT = 51G + 51Q + M2P + Z2G
- If there is a fault, these elements pick up and block updating of maximum/minimum metering values. Maximum/minimum recording resumes one minute after FAULT deasserts.
- The metering value is above the previous maximum or below the previous minimum for two cycles.
- For voltage values, the voltage is above 13 V secondary.
- For current values, the currents are above:
  - 0.25 A secondary {5 A nominal}
  - 0.05 A secondary {1 A nominal}
- Megawatt and megavar values are subject to the above voltage and current thresholds.

The SEL-311L stores maximum/minimum values to nonvolatile storage once per day (it overwrites the previous stored value if it is exceeded). Should the relay lose control power, it will restore the maximum/minimum values saved by the relay at 23:50 hours on the previous day.

Synchrophasor Metering

View Synchrophasor Metering Information Via the Serial Port

See *MET Command (Metering Data) on page 10.38*. The **MET PM** command displays the synchrophasor measurements. For more information, see *View Synchrophasors by Using the MET PM Command on page H.9*.

Breaker Monitor

The breaker monitor in the SEL-311L helps in scheduling circuit breaker maintenance. The breaker monitor is enabled with the Enable setting:

EBMON = **Y**

The breaker monitor settings in *Table 8.3* are available via the **SET G** and **SET L** commands (see *Table 9.1* and also the *Settings Sheets on page 9.71*). Also refer to *BRE Command (Breaker Monitor Data) on page 10.33* and *BRE n Command (Preload/Reset Breaker Wear) on page 10.54*.

The breaker monitor is set with breaker maintenance information provided by circuit breaker manufacturers. This breaker maintenance information lists the number of close/open operations that are permitted for a given current interruption level. The following is an example of breaker maintenance information for an example circuit breaker.

Table 8.2 Breaker Maintenance Information for an Example 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 8.2* is plotted in *Figure 8.7*.

Connect the plotted points in *Figure 8.7* for a breaker maintenance curve. To estimate this breaker maintenance curve in the SEL-311L 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 8.3*.

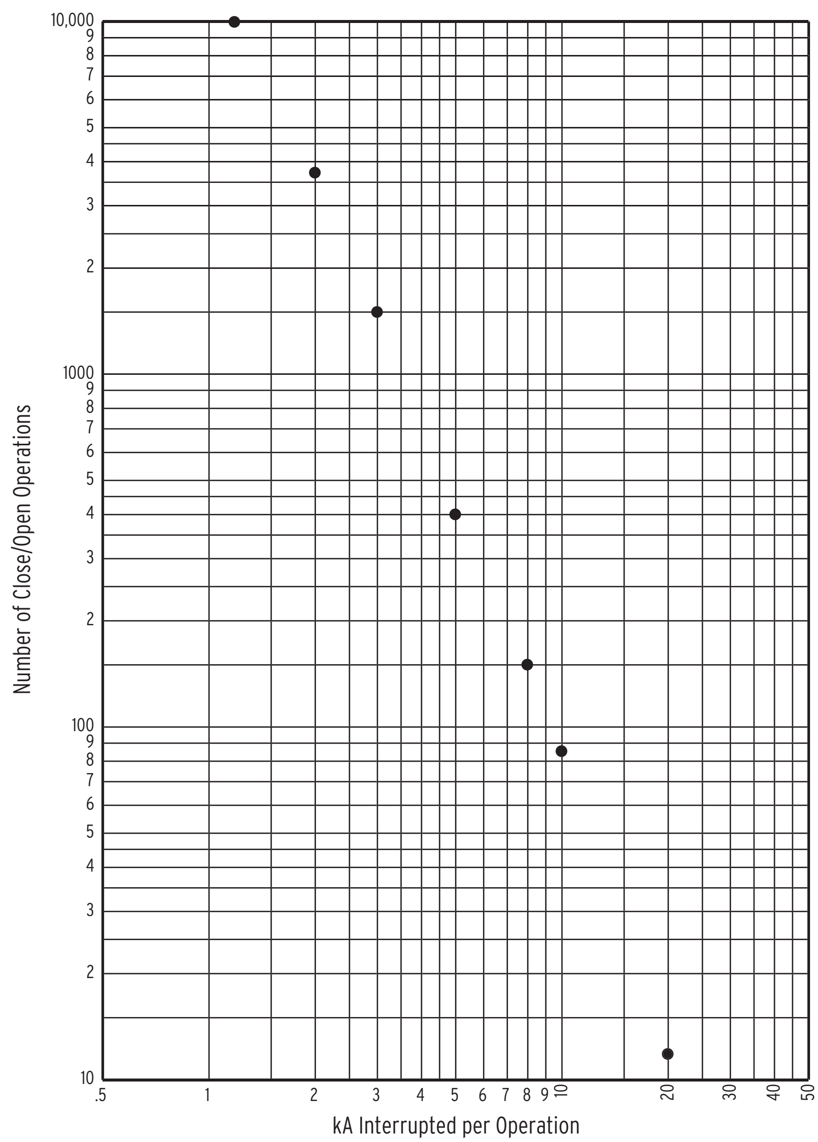


Figure 8.7 Plotted Breaker Maintenance Points for an Example Circuit Breaker

Breaker Monitor Setting Example

Table 8.3 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-middle	0–65000 close/open operations
KASP1[a]	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[a]	kA Interrupted set point 1-maximum	0.00-999.00 kA in 0.01 kA steps
BKMON	SELOGIC control equation breaker monitor initiation setting	Relay Word bits referenced in *Table 9.5* and *Table 9.6*

[a] The ratio of settings KASP3/KASP1 must be: 5 ≤ KASP3/KASP1 ≤ 100.

The following settings are made from the breaker maintenance information in *Table 8.2* and *Figure 8.7*:

COSP1 = **10000**

COSP2 = **150**

COSP3 = **12**

KASP1 = **1.20**

KASP2 = **8.00**

KASP3 = **20.00**

Figure 8.8 shows the resultant breaker maintenance curve.

Breaker Maintenance Curve Details

In *Figure 8.8*, note that set points KASP1, COSP1 and KASP3, COSP3 are set with breaker maintenance information from the two extremes in *Table 8.2* and *Figure 8.7*.

In this example, set point KASP2, COSP2 happens to be from an in-between breaker maintenance point in the breaker maintenance information in *Table 8.2* and *Figure 8.7*, 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 8.7*.

Each phase (A, B, and C) has its own breaker maintenance curve (like that in *Figure 8.8*), because the separate circuit breaker interrupting contacts for phases A, B, and C do not necessarily interrupt the same magnitude current (depending on fault type and loading).

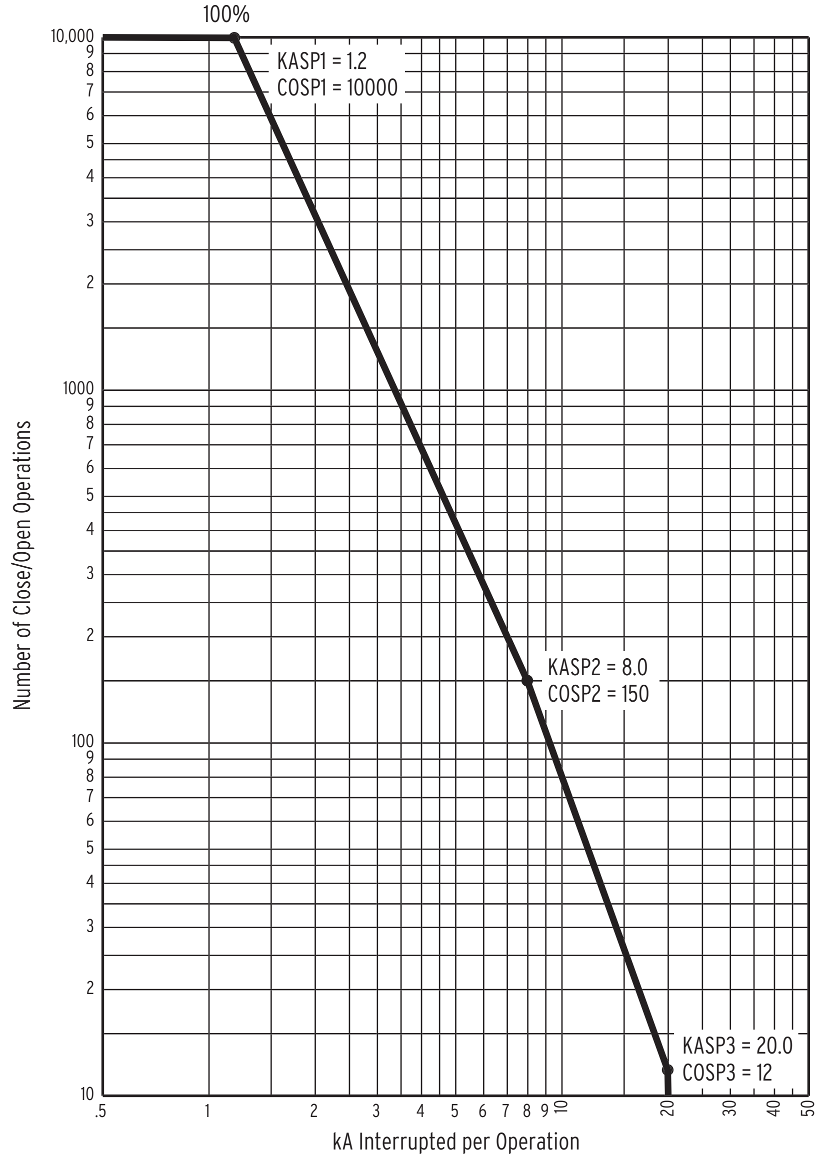


Figure 8.8 SEL-311L Breaker Maintenance Curve for an Example Circuit Breaker

In *Figure 8.8*, note that the breaker maintenance curve levels off horizontally to the left of 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 below set point KASP3, COSP3. This is the maximum interrupted current limit of the circuit breaker (KASP3 = 20.0 kA). If the interrupted current is greater than setting KASP3, the interrupted current is accumulated as a current value equal to setting KASP3.

Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting BKMON

The SELOGIC control equation breaker monitor initiation setting BKMON in *Table 8.3* determines when the breaker monitor reads in current values (Phases A, B, and C) for the breaker maintenance curve and the breaker monitor accumulated currents/trips (see *BRE Command (Breaker Monitor Data) on page 10.33*).

The BKMON setting looks for a rising edge (logical 0 to logical 1 transition) as the indication to read in current values. The acquired current values are then applied to the breaker maintenance curve and the breaker monitor accumulated currents/trips.

For example, the SELOGIC control equation breaker monitor initiation setting may be set:

BKMON = **TRIP** (TRIP is the logic output of *Figure 5.1* and *Figure 5.6*)

Refer to *Figure 8.9*. When BKMON asserts (Relay Word bit TRIP goes from logical 0 to logical 1), the breaker monitor reads in the current values and applies them to the breaker monitor maintenance curve and the breaker monitor accumulated currents/trips.

As detailed in *Figure 8.9*, the breaker monitor actually reads in the current values 1.5 cycles after the assertion of BKMON. This helps especially if an instantaneous trip occurs. The instantaneous element trips when the fault current reaches its pickup setting level. The fault current may still be “climbing” to its full value, after which it levels off. The 1.5-cycle delay reading the current values allows time for the fault current to level off.

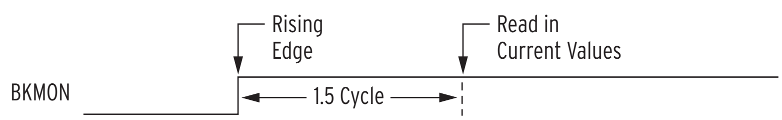


Figure 8.9 Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

See *Figure 8.8* and accompanying text for more information on setting BKMON. The operation of the breaker monitor maintenance curve, when new current values are read in, is explained in the following example.

Breaker Monitor Operation Example

As stated earlier, each phase (A, B, and C) has its own breaker maintenance curve. For this example, presume that the interrupted current values occur on a single phase in *Figure 8.10–Figure 8.13*. Also, presume that the circuit breaker interrupting contacts have no wear initially (brand new or recent maintenance performed).

Note in the following four figures (*Figure 8.10–Figure 8.13*) that the interrupted current in a given figure is the same magnitude for all the interruptions (e.g., in *Figure 8.11*, 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 8.10*. 7.0 kA is interrupted 20 times, 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 8.11*. 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 8.12*. 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 8.13*. 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 8.22*. 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.

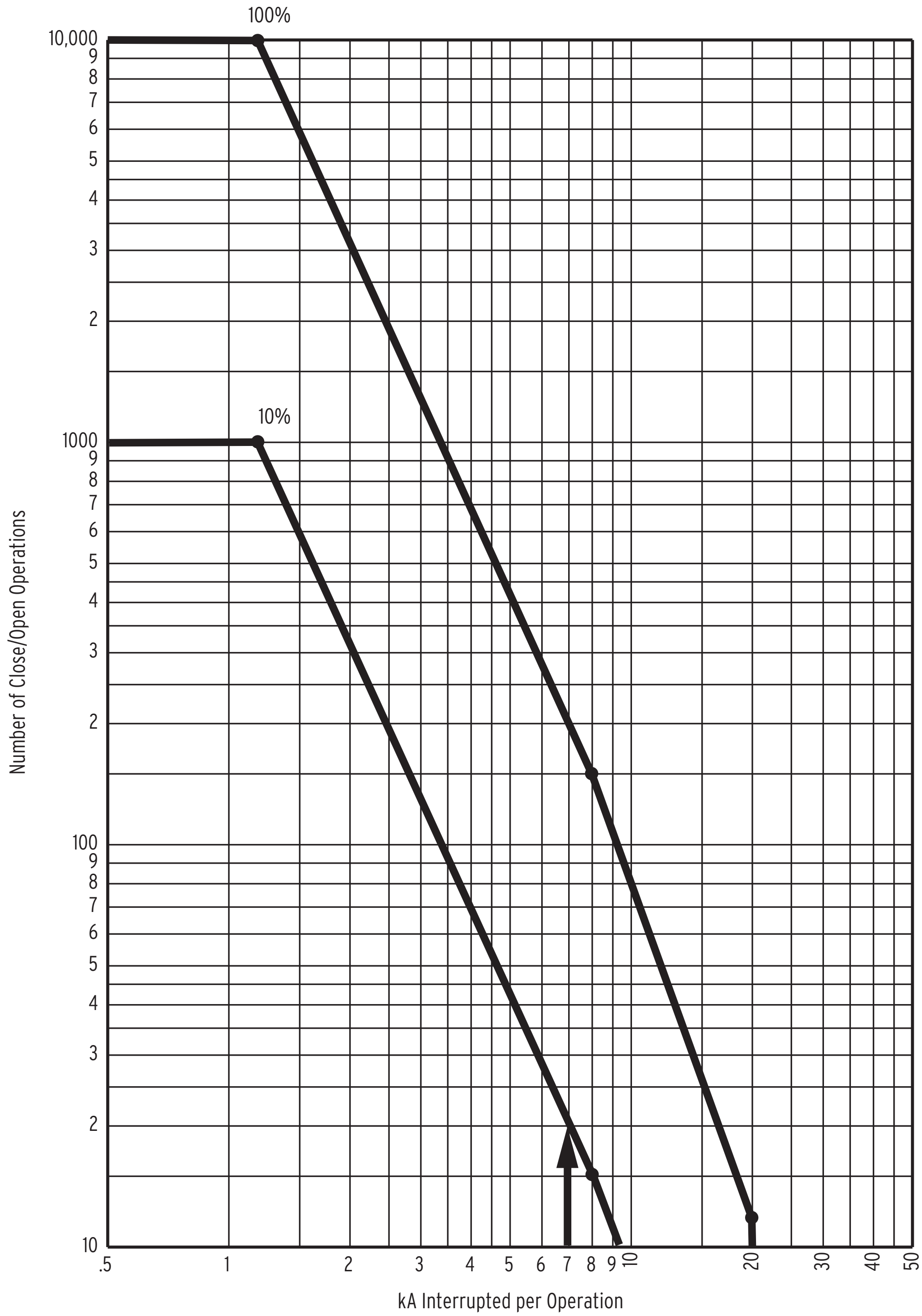


Figure 8.10 Breaker Monitor Accumulates 10 Percent Wear

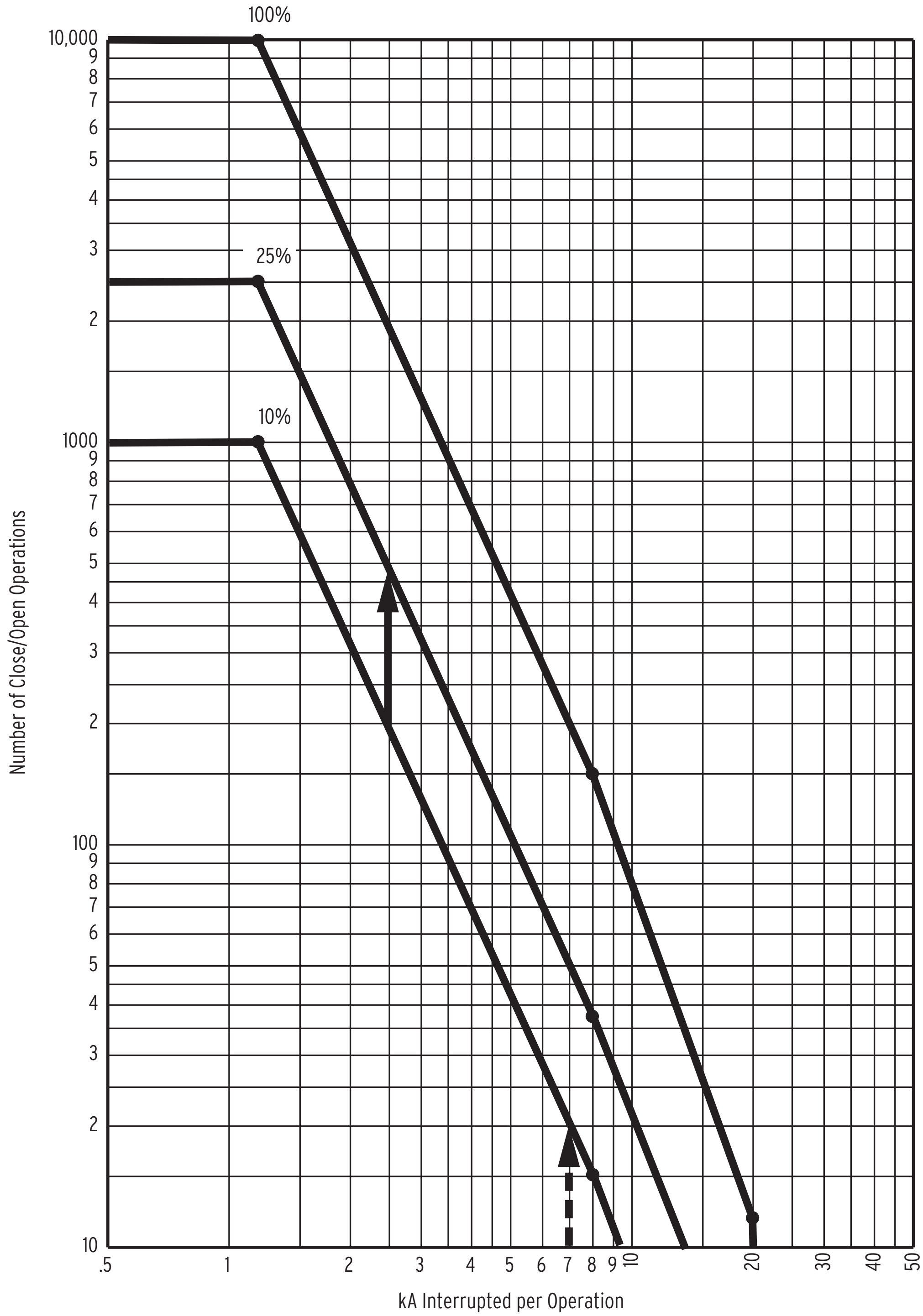


Figure 8.11 Breaker Monitor Accumulates 25 Percent Wear

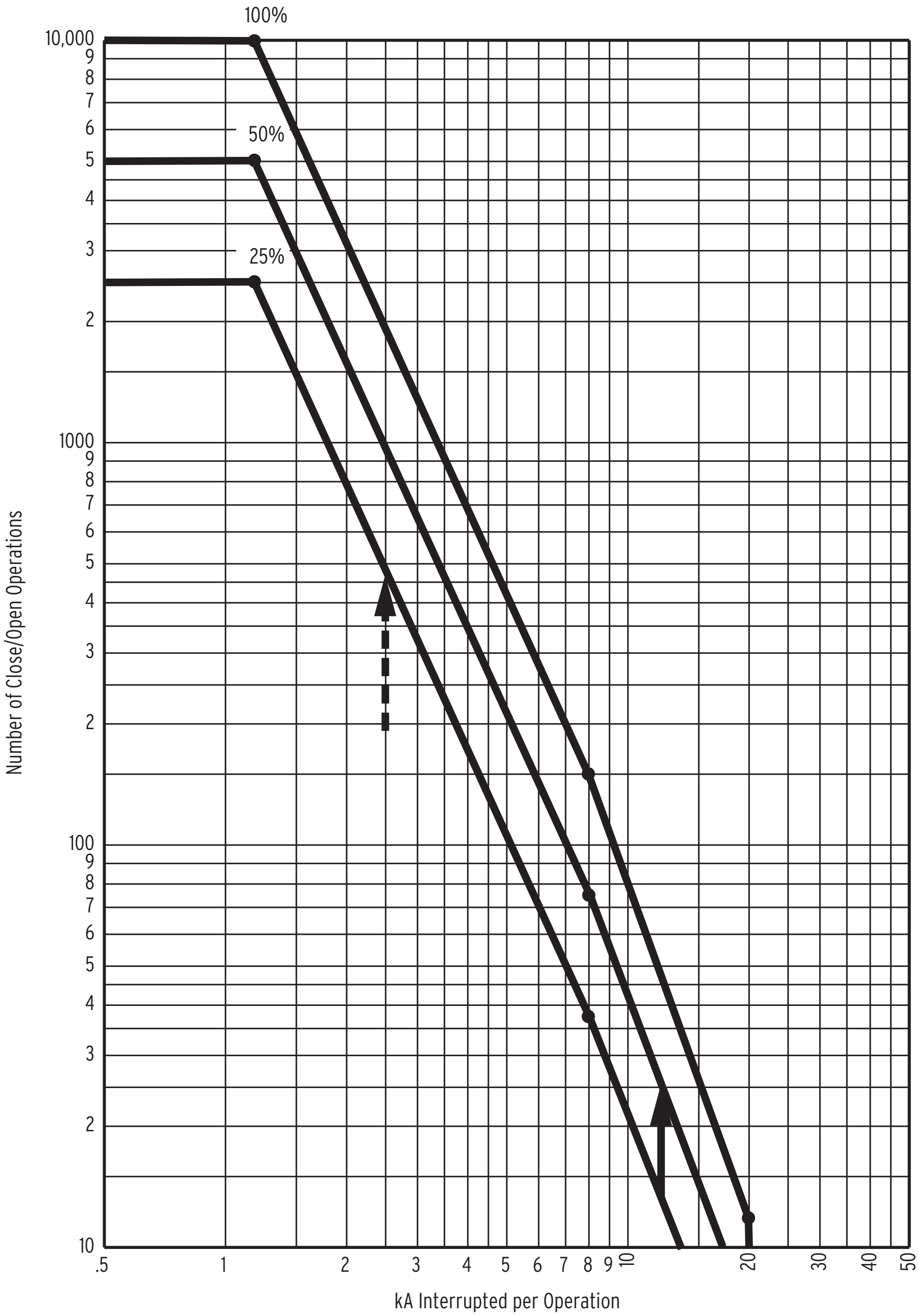


Figure 8.12 Breaker Monitor Accumulates 50 Percent Wear

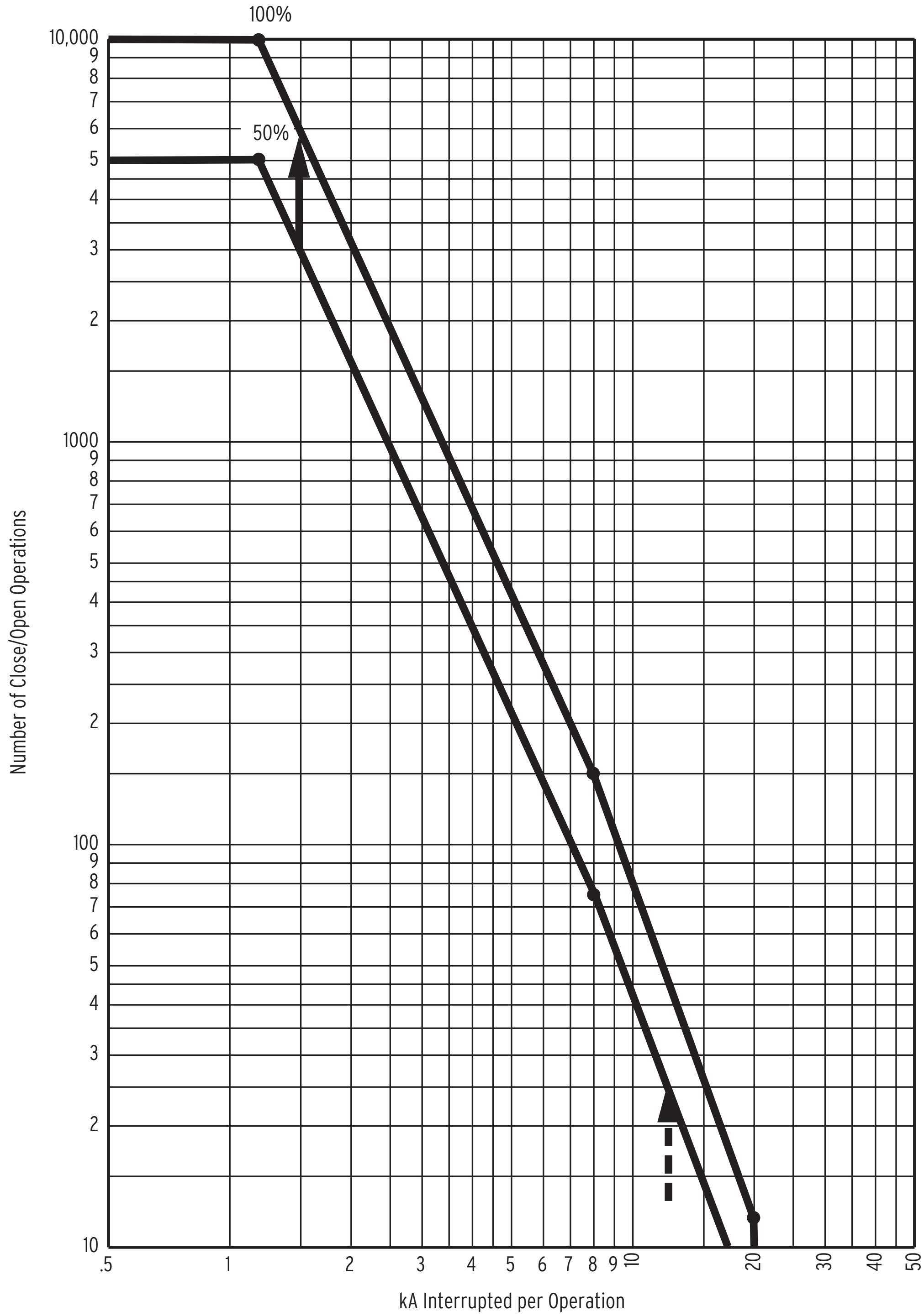


Figure 8.13 Breaker Monitor Accumulates 100 Percent Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100 percent wear level (see *Figure 8.13*), a corresponding Relay Word bit (BCWA, BCWB, or BCWC) asserts.

Table 8.4 Breaker Monitor Output Relay Word Bits

Relay Word Bits	Definition
BCWA	A-phase breaker contact wear has reached the 100% wear level
BCWB	B-phase breaker contact wear has reached the 100% wear level
BCWC	C-phase breaker contact wear has reached the 100% wear level
BCW	BCWA + BCWB + BCWC

Example Applications

These logic outputs can be used to alarm:

OUT105 = **BCW**

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). The accumulated data can only be reset if the **BRE R** command is executed (see the following discussion on the **BRE R** command).

Via Serial Port

See *BRE Command (Breaker Monitor Data) on page 10.33*. The **BRE** command displays the following information:

- Accumulated number of relay-initiated trips
- Accumulated interrupted current from relay-initiated trips
- Accumulated number of externally initiated trips
- Accumulated interrupted current from externally initiated trips
- Percent circuit breaker contact wear for each phase
- Date when the preceding items were last reset (via the **BRE R** command)

See *BRE n Command (Preload/Reset Breaker Wear) on page 10.54*. The **BRE W** command allows the internal trips and currents, the external trips and currents, and the percent breaker wear to be preloaded for each individual phase.

The **BRE R** command resets the accumulated values and the percent wear for all three phases. For example, if breaker contact wear has reached the 100 percent wear level for A-phase, the corresponding Relay Word bit BCWA asserts (BCWA = logical 1). Execution of the **BRE R** command resets the wear levels for all three phases back to 0 percent and consequently causes Relay Word bit BCWA to deassert (BCWA = logical 0).

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **BRE** and **BRE R** are also available via the front-panel **OTHER** pushbutton. See *Figure 11.3*.

Determination of Relay-Initiated Trips and Externally Initiated Trips

See *BRE Command (Breaker Monitor Data) on page 10.33*. 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 Trips) and that generated by externally initiated trips (Ext Trips). The categorization of these data is determined by the status of the TRIP Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON operates.

Refer to *Figure 8.9* and the accompanying explanation. If BKMON newly asserts (logical 0 to logical 1 transition), the relay reads in the current values (Phases A, B, and C). Now the decision has to be made: where is this current and trip count information accumulated? Under relay-initiated trips or externally initiated trips?

To make this determination, the status of the TRIP Relay Word bit is checked at the instant BKMON newly asserts (TRIP is the logic output of *Figure 5.6*). If TRIP is asserted (TRIP = logical 1), the current and trip count information is accumulated under relay-initiated trips (Rly Trips). If TRIP is deasserted (TRIP = logical 0), the current and trip count information is accumulated under externally initiated trips (Ext Trips).

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 8.9–Figure 8.13*).

Setting Example

As discussed previously, the SELOGIC control equation breaker monitor initiation may be set:

BKMON = **TRIP + TRIP87**

Thus, any new assertion of BKMON will be deemed a relay trip, and the current and trip count information is accumulated under relay-initiated trips (Rly Trips).

Additional Example

Refer to *Figure 8.14*. Output contact OUT201 is set to provide tripping:

OUT201 = **TRIP + TRIP87**

Note that optoisolated input IN106 monitors the trip bus. If the trip bus is energized by output contact OUT201, an external control switch, or some other external trip, then IN106 is asserted.

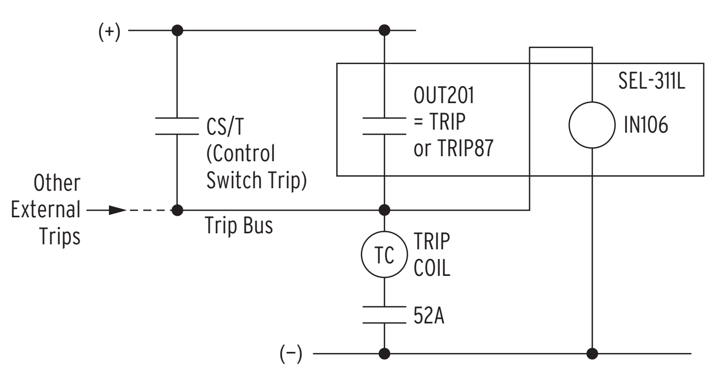


Figure 8.14 Input IN106 Connected to Trip Bus for Breaker Monitor Initiation

If the SELOGIC control equation breaker monitor initiation setting is set:

BKMON = **IN106**

then the SEL-311L breaker monitor sees all trips.

If output contact **OUT201** asserts, energizing the trip bus, the breaker monitor will deem it a relay-initiated trip. This is because when BKMON is newly asserted (input **IN106** energized), the TRIP Relay Word bit is asserted. Thus, the current and trip count information is accumulated under relay-initiated trips (Rly Trips). If EHST = N, placing TRIP87 in the TR equation ensures a differential trip is counted as a relay-initiated trip.

If the control switch trip (or some other external trip) asserts, energizing the trip bus, the breaker monitor will deem it an externally initiated trip. This is because when BKMON is newly asserted (input **IN106** energized), the TRIP Relay Word bit is deasserted. Thus, the current and trip count information is accumulated under externally initiated trips (Ext Trips).

Station DC Battery Monitor

The station dc battery monitor in the SEL-311L 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 **Z25** and **Z26** (see *Figure 1.4*). The station dc battery monitor settings (DCLOP and DCHIP) are available via the **SET G** command (see *Table 9.1* and also *Global Settings on page SET.27*).

DC Under- and Overvoltage Elements

Refer to *Figure 8.15*. 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:

OFF, 20 to 300 Vdc, .01 Vdc increments

This range allows the SEL-311L to monitor nominal battery voltages of 24, 48, 110, 125, and 250 V. When testing the pickup settings DCLOP and DCHIP, do not operate the SEL-311L outside of the power supply limits listed in *Section 1: Introduction and Specifications*.

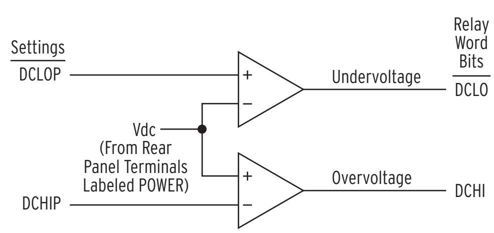


Figure 8.15 DC Under- and Overvoltage Elements

Logic outputs DCLO and DCHI in *Figure 8.15* 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 $V_{dc} <$ pickup setting DCHIP

Create Desired Logic for DC Under- and Overvoltage Alarming

Pickup settings DCLOP and DCHIP are set independently. Thus, they can be set:

DCLOP < DCHIP or DCLOP > DCHIP

Figure 8.16 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.

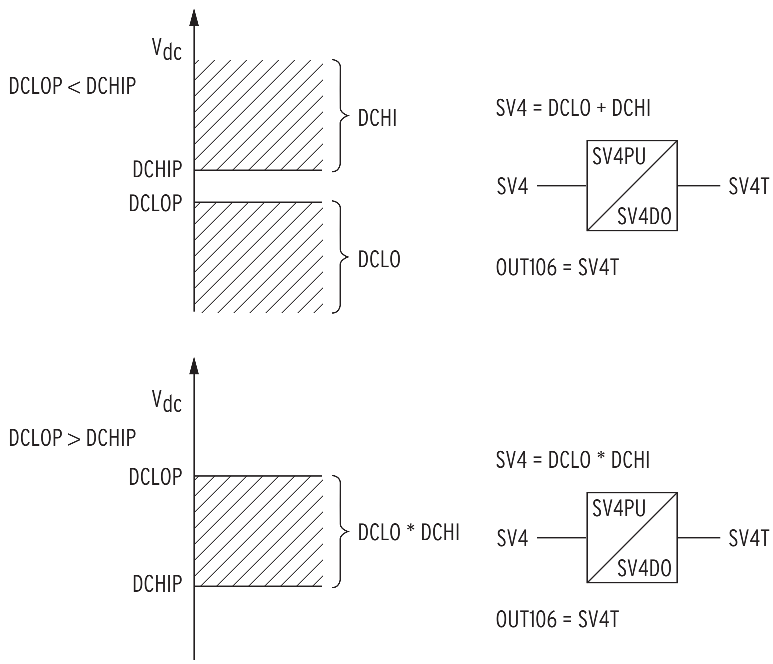


Figure 8.16 Create DC Voltage Elements With SELOGIC Control Equations

DCLO < DCHI (Top of Figure 8.16)

Output contact **OUT106** asserts when:

$V_{dc} \leq$ 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 (Vdc = 0 Vdc)

V_{dc} = < DCLOP

then output contact **OUT106** should logically assert (according to top of *Figure 8.16*), 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 8.16* would probably be a better choice—see following discussion.

DCLO > DCHI (Bottom of Figure 8.16)

Output contact **OUT106** asserts when:

DCHIP $\leq$ V_{dc} $\leq$ DCLOP

Pickup settings DCLOP and DCHIP are set such that output contact **OUT106** asserts when dc battery voltage stays between allowable limits.

If the relay loses power entirely (V_{dc} = 0 Vdc)

V_{dc} = < DCHIP

then output contact **OUT106** should logically deassert (according to bottom of *Figure 8.16*), 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 7.28* (especially ② in *Figure 7.27*). Consider the output contact type (a or b) needed for output contact **OUT106** in the bottom of *Figure 8.16* (dc voltage alarm example).

If SELOGIC control equation setting OUT106 is asserted (OUT106 = SV4T = logical 1; dc voltage OK), the state of output contact **OUT106** (according to contact type) is:

- closed (“a” type output contact)
- open (“b” type output contact)

If SELOGIC control equation setting OUT106 is deasserted (OUT106 = SV4T = logical 0; dc voltage not OK), the state of output contact **OUT106** (according to contact type) is:

- open (“a” type output contact)
- closed (“b” type output contact)

If the relay loses power entirely, all output contacts deassert, and the state of output contact **OUT106** (according to contact type) is:

- open (“a” type output contact)
- closed (“b” type output contact)

Additional Application

Other than alarming, the dc voltage elements can be used to disable reclosing.

For example, if the station dc batteries have a problem and the station dc battery voltage is declining, drive the reclosing relay to lockout:

79DTL = **!SV4T + ...** [= NOT(SV4T) + ...]

Timer output SV4T is from the bottom of *Figure 8.16*. 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

View Station DC Battery Voltage

Via Serial Port

See *MET Command (Metering Data) on page 10.38*. 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 11.2*.

Analyze Station DC Battery Voltage

See *Standard 15/30/60-Cycle Event Reports on page 12.1*. The station dc battery voltage is displayed in column Vdc in the example event report in *Figure 12.3*. 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 5.6*). For example, output contact OUT101 is set to trip:

OUT101 = **TRIP**

When output contact OUT101 closes and energizes the circuit breaker trip coil, any change 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 8.14* and program optoisolated input IN106 (monitoring the trip bus) in the SELOGIC control equation event report generation setting, e.g.:

ER = **/IN106 + ...**

When the trip bus is energized, any change 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-311L 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 6.1*)

When output contact OUT102 closes and energizes the circuit breaker close coil, any change 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 test 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 whenever there is a change in 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 8.16*. Any time 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 Report on page 12.36*).

Operation of Station DC Battery Monitor When AC Voltage Is Powering the Relay

If the SEL-311L has a 125/250 Vac/Vdc supply, it can be powered by ac voltage (85 to 264 Vac) connected to the rear-panel terminals labeled POWER. When powering the relay with ac voltage, the dc voltage elements in *Figure 8.15* 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). Pickup settings DCLOP and DCHIP should be set off (DCLOP = OFF, DCHIP = OFF) because 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.

Section 9
Settings

Overview

Change or view settings with the **SET** and **SHOWSET** serial port commands and the front-panel SET pushbutton. *Table 9.1* lists the serial port **SET** commands.

Table 9.1 Serial Port SET Commands

Command	Settings Type	Description	Settings Sheets[a]
SET *m*	Relay	Line current differential, distance, overcurrent and voltage elements, reclosing relay, timers, etc., for settings group *m* (m = 1, 2, 3, 4, 5, 6).	*1–19*
SET L *m*	Logic	SELOGIC control equations for settings group *m* (*m* = 1, 2, 3, 4, 5, 6).	*20–26*
SET G	Global	Battery and breaker monitors, optoisolated input debounce timers, synchrophasors, etc.	*27–29*
SET R	SER	Sequential Events Recorder trigger conditions.	*30*
SET T	Text	Front-panel default display, local control text, and reclosing relay labels.	*31–34*
SET P *m*	Port	Serial port settings for Serial Port *m* (*m* = 1, 2, 3, or F). The Ethernet port, if available, is designated as PORT 5 or PORT 6. (PORT 6 is not available at this time.)	*35–38*
SET X	Channel	Differential communications Channel X settings.	*39*
SET Y	Channel	Differential communications Channel Y settings.	*39*

[a] Located at the end of this section.

View settings with the respective serial port **SHOWSET** commands (**SHO**, **SHO L**, **SHO G**, **SHO R**, **SHO T**, **SHO P**, **SHO X**, and **SHO Y**). See *SHO Command (Show/View Settings) on page 10.43*.

Settings Changes Via the Front Panel

The relay front-panel **SET** pushbutton provides access to the Relay, Global, Port, and Channel settings only. Thus, the corresponding Relay, Global, Port, and Channel settings sheets that follow in this section can also be used when making these settings via the front panel. Refer to *Figure 11.3* for information on settings changes via the front panel.

Settings Changes Via the Serial Port

NOTE: In this manual, commands you type appear in bold/uppercase: **METER**. Computer keys you press appear in bold/brackets: **<Enter>**.

See *Section 10: Communications* for information on serial port communications and relay access levels. The **SET** commands in *Table 9.1* operate at Access Level 2 (screen prompt: =>>). To change a specific setting, enter the command:

SET *n m s* TERSE

where:

n = L, G, R, T, P, X, or Y (parameter ***n*** is not entered for the Relay settings. See *Table 9.1*).

m = group (1…6) or port (1…3, F). The relay selects the active group or port if ***m*** is not specified.

s = the name of the specific setting you wish to jump to and begin setting. If ***s*** is not entered, the relay starts at the first setting.

TERSE = instructs the relay to skip the SHOWSET 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 9.2*.

Table 9.2 SET Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains setting and moves to the next setting.
^ <Enter>	Returns to previous setting.
< <Enter>	Returns to previous section.
> <Enter>	Moves to next section.
END<Enter>	Exits editing session, then prompts you to save the settings.
<Ctrl> X	Aborts editing session without saving changes.

The relay checks each entry to ensure that it is within the setting range. If it is not, an `Out of Range` message is generated, and the relay prompts for the setting again.

When all the settings are entered, the relay displays the new settings and prompts for approval to enable them. Answer **Y <Enter>** to enable the new settings. If changes are made to Global, SER, Text, or Channel settings (see *Table 9.1*), the relay is disabled while it saves the new settings. If changes are made to a Port setting, the relay is not disabled while it saves the new settings.

If changes are made to the Relay or Logic settings for the active setting group (see *Table 9.1*), the relay is disabled while it saves the new settings. The **ALARM** contact closes momentarily (for b contact, opens for an a contact; see *Figure 7.27*) and the **EN** LED extinguishes (see *Table 5.1*) while the relay is disabled. The relay is disabled for about one second. If Logic settings are changed for the active group, the relay can be disabled for as long as 15 seconds.

If changes are made to the Relay or Logic settings for a setting group other than the active setting group (see *Table 9.1*), the relay is not disabled while it saves the new settings. The **ALARM** contact closes momentarily (for b contact, opens for an a contact; see *Figure 7.27*), but the **EN** LED remains on (see *Table 5.1*) while the new settings are saved.

Time-Overcurrent Curves

The following information describes the curve timing for the curve and time dial settings made for the time-overcurrent elements (see *Figure 4.24*, *Figure 4.25* and *Figure 4.26–Figure 4.31*). The U.S. and IEC time-overcurrent relay curves are shown in *Figure 9.1–Figure 9.10*.

Curves U1, U2, and U3 (*Figure 9.1–Figure 9.3*) conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

Definitions

t_p = operating time in seconds

t_r = electromechanical induction-disk emulation reset time in seconds (if you select electromechanical reset setting)

TD = time dial setting

M = applied multiples of pickup current [for operating time (t_p), M>1; for reset time (t_r), $M \leq 1$].

Table 9.3 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 9.4 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)	$t_p = TD \bullet \left(\frac{80.0}{(M^2 - 1)}\right)$	$t_r = TD \bullet \left(\frac{80.0}{(1 - M^2)}\right)$	*Figure 9.8*
C4 (Long-Time Inverse)	$t_p = TD \bullet \left(\frac{120.0}{(M - 1)}\right)$	$t_r = TD \bullet \left(\frac{120.0}{(1 - M)}\right)$	*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*

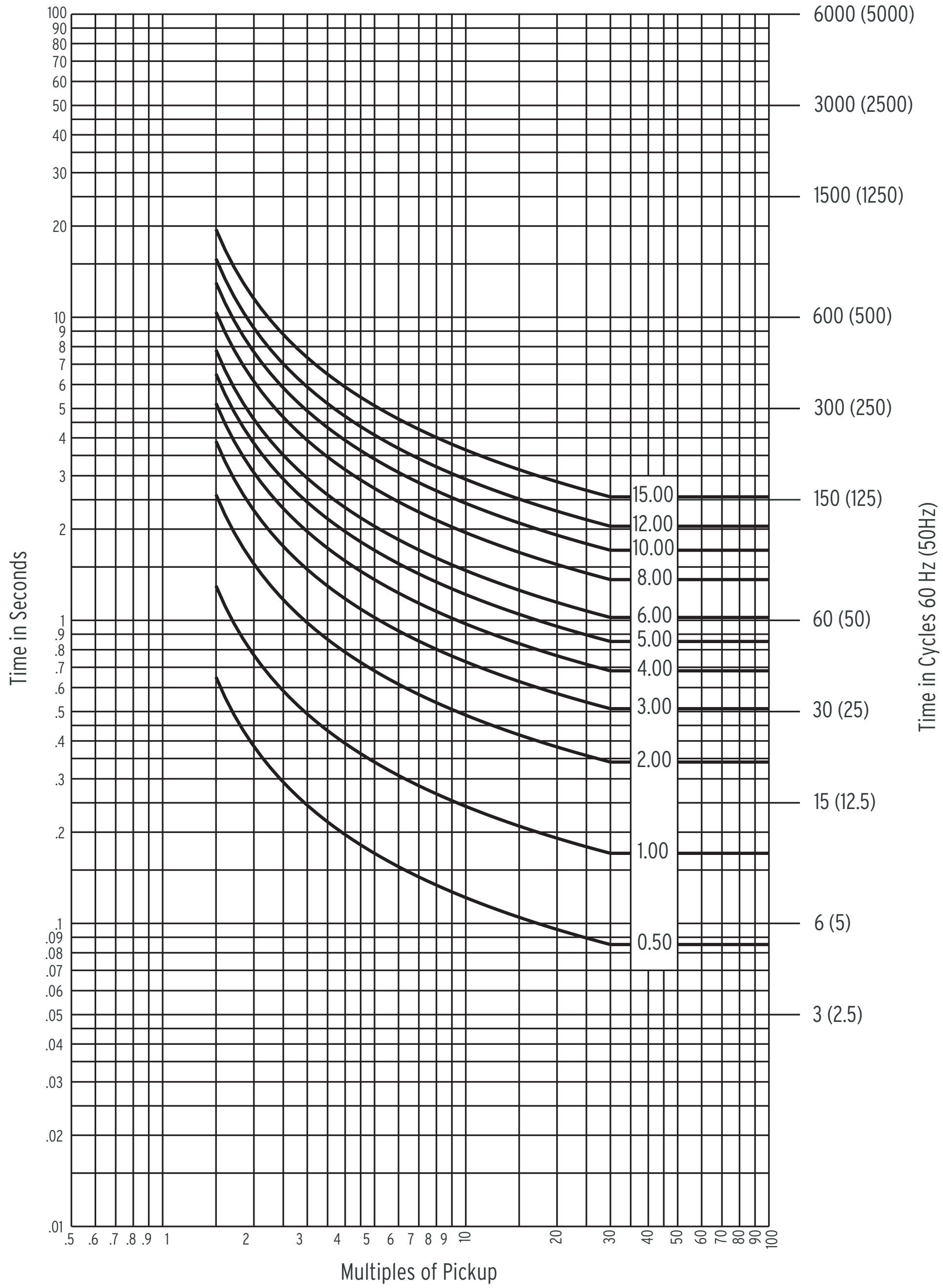


Figure 9.1 U. S. Moderately Inverse Curve: U1

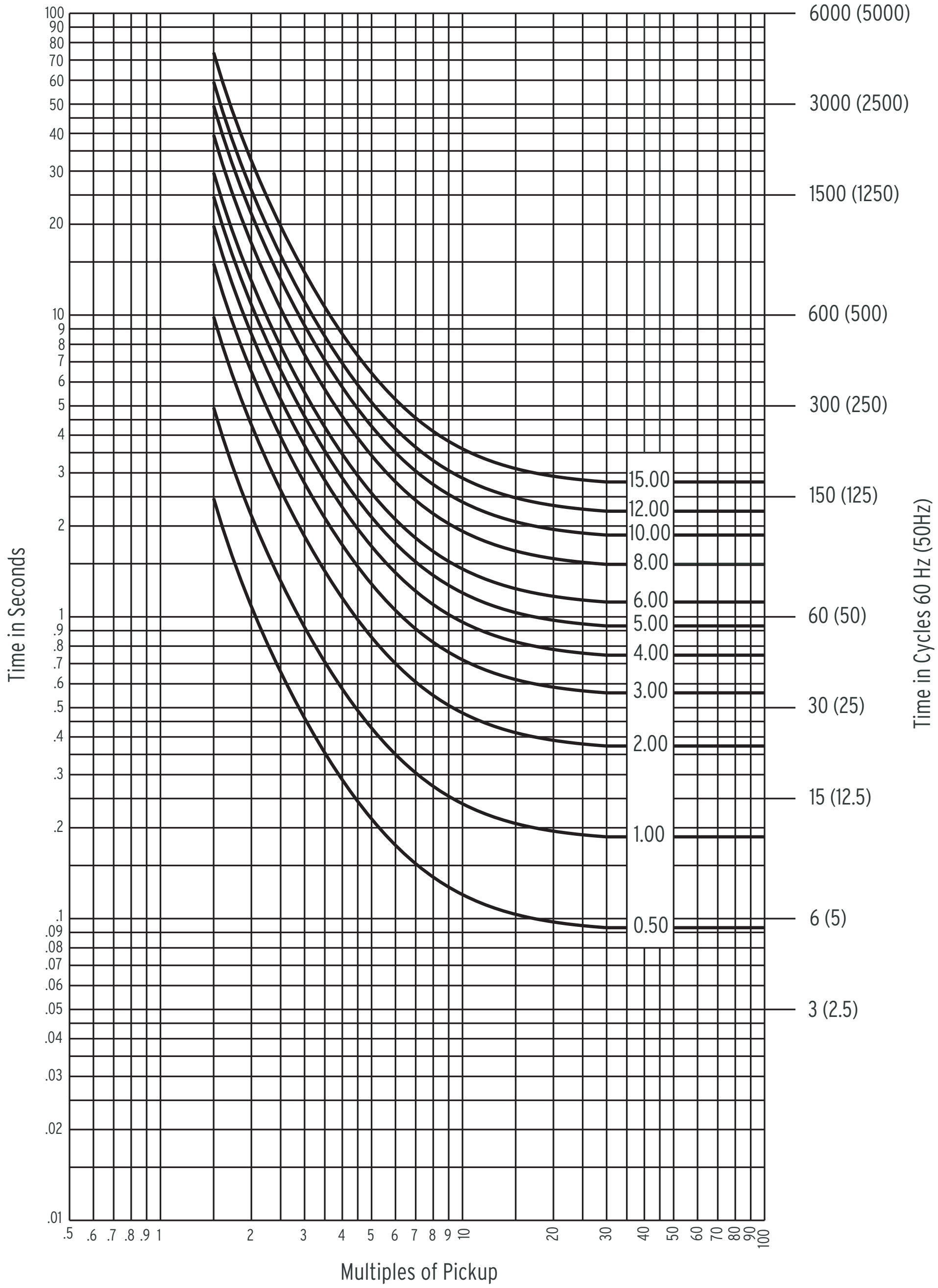


Figure 9.2 U. S. Inverse Curve: U2

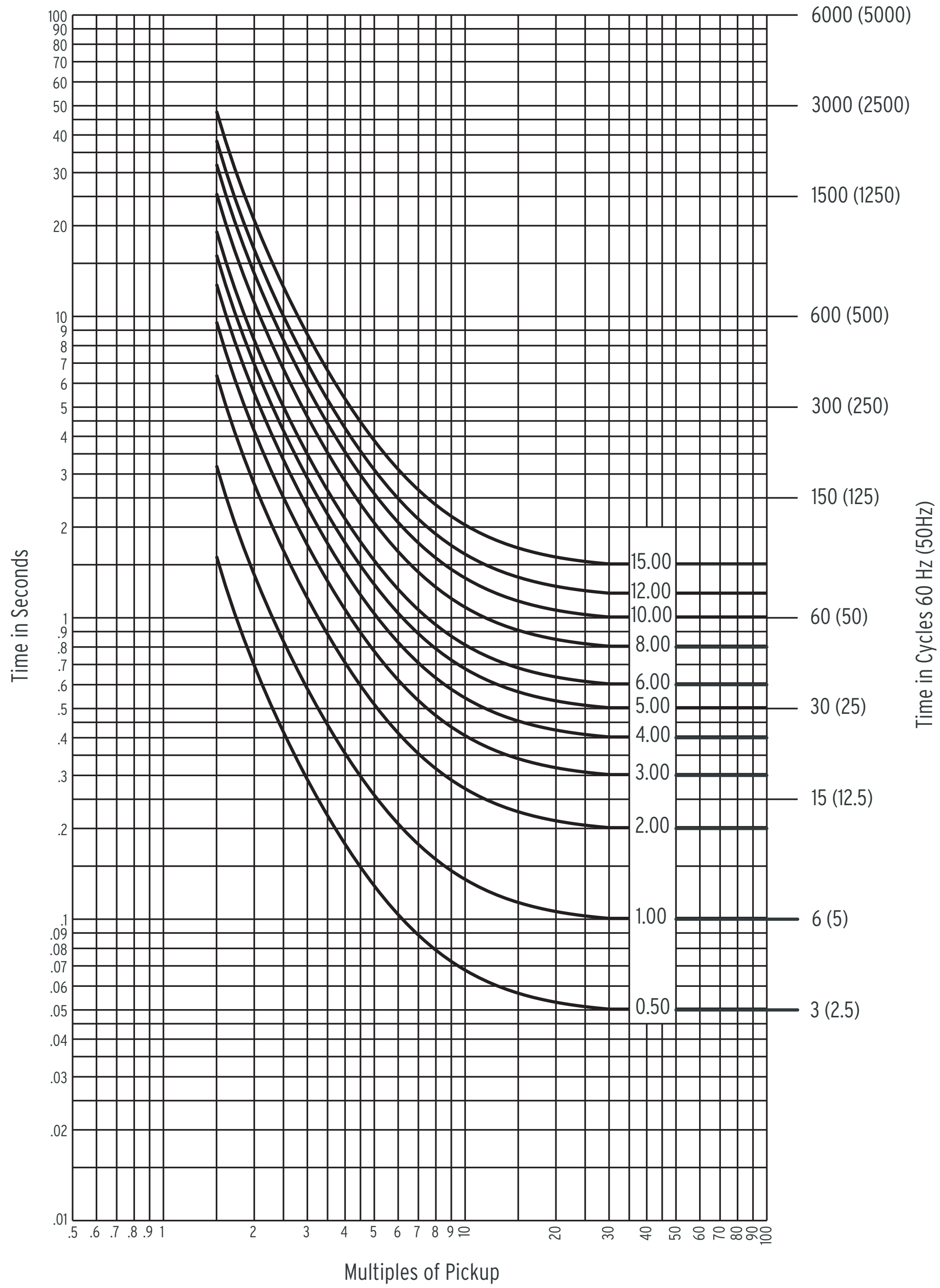


Figure 9.3 U. S. Very Inverse Curve: U3

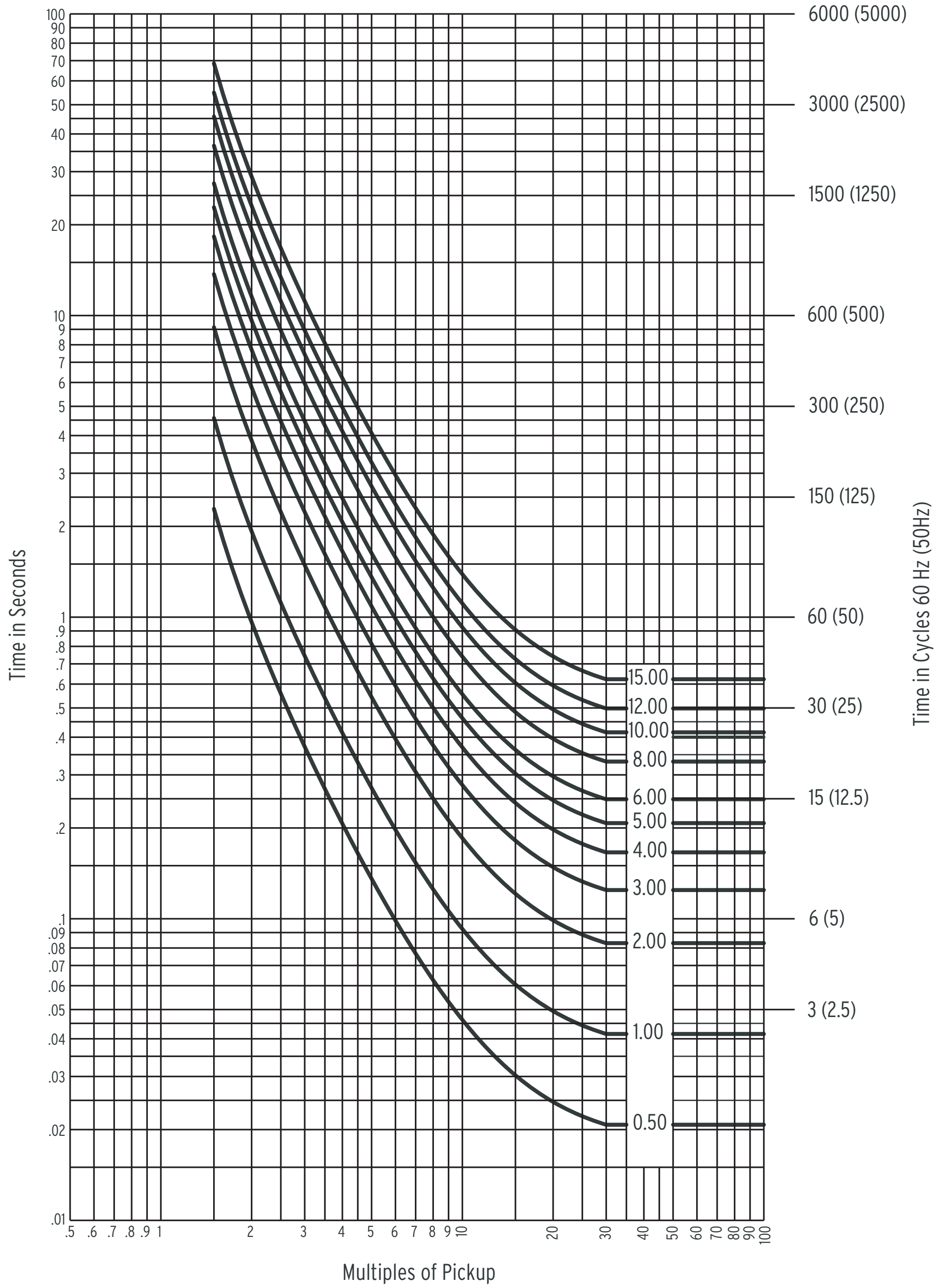


Figure 9.4 U. S. Extremely Inverse Curve: U4

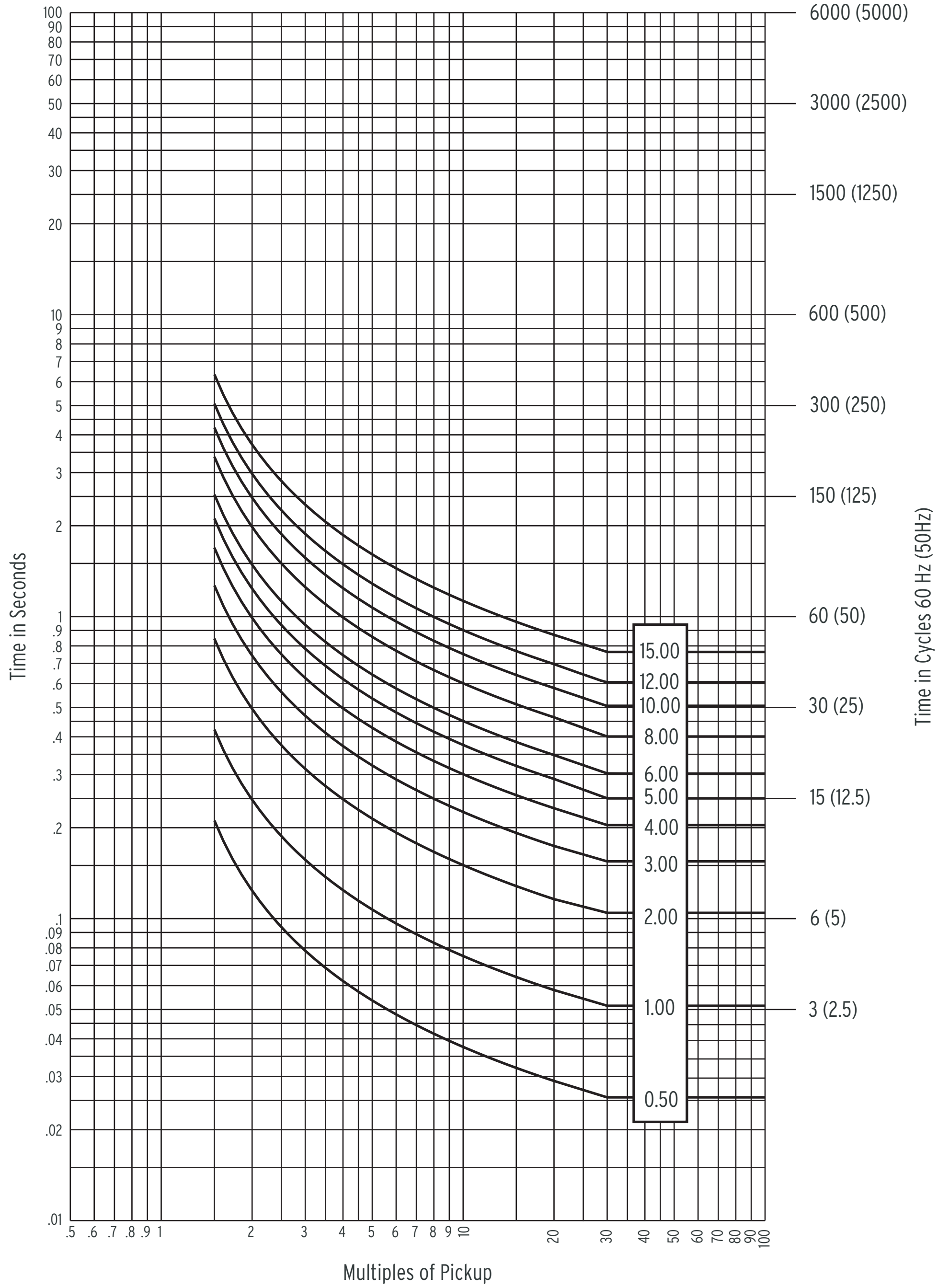


Figure 9.5 U. S. Short-Time Inverse Curve: U5

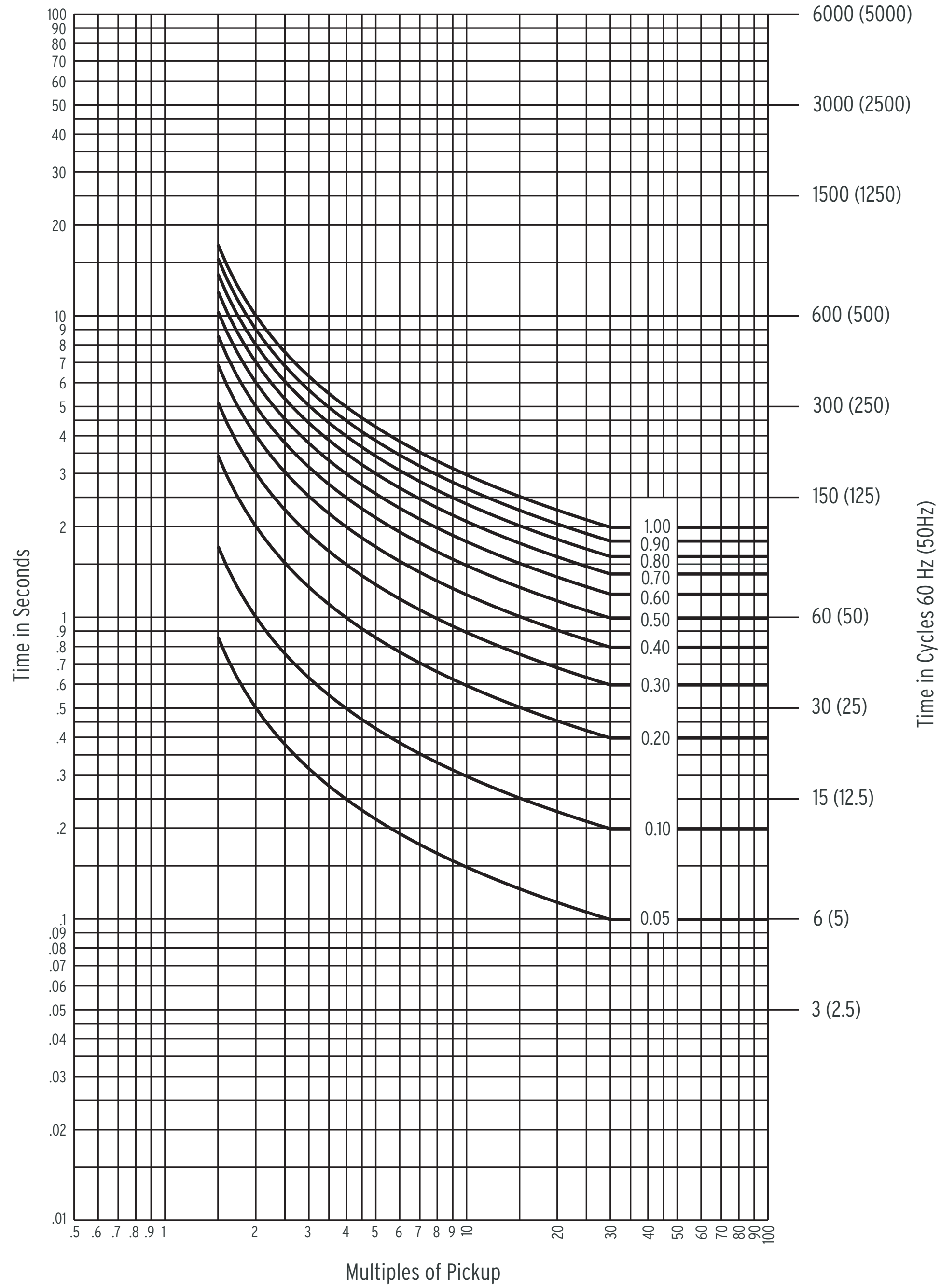


Figure 9.6 IEC Class A Curve (Standard Inverse): C1

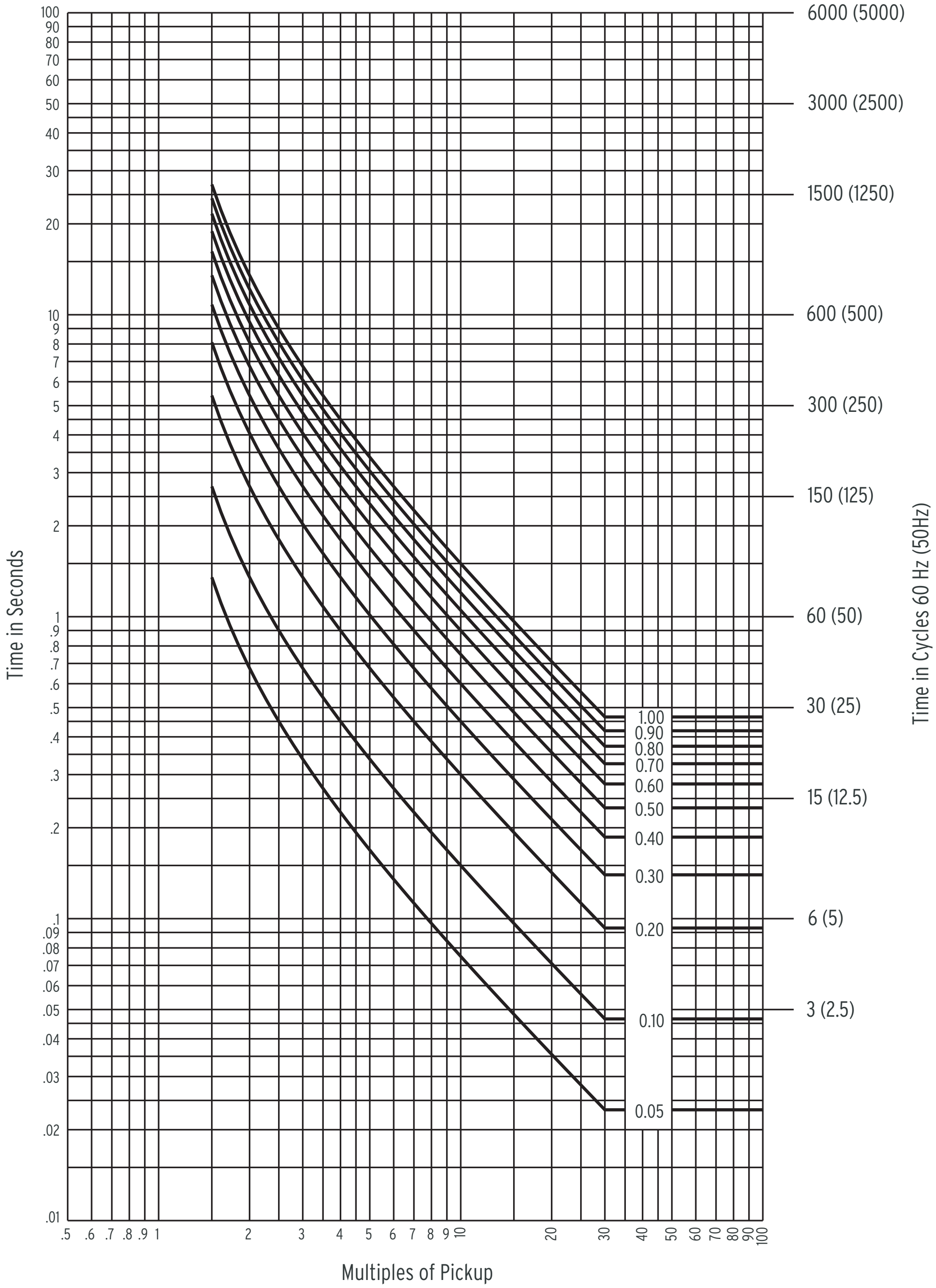


Figure 9.7 IEC Class B Curve (Very Inverse): C2

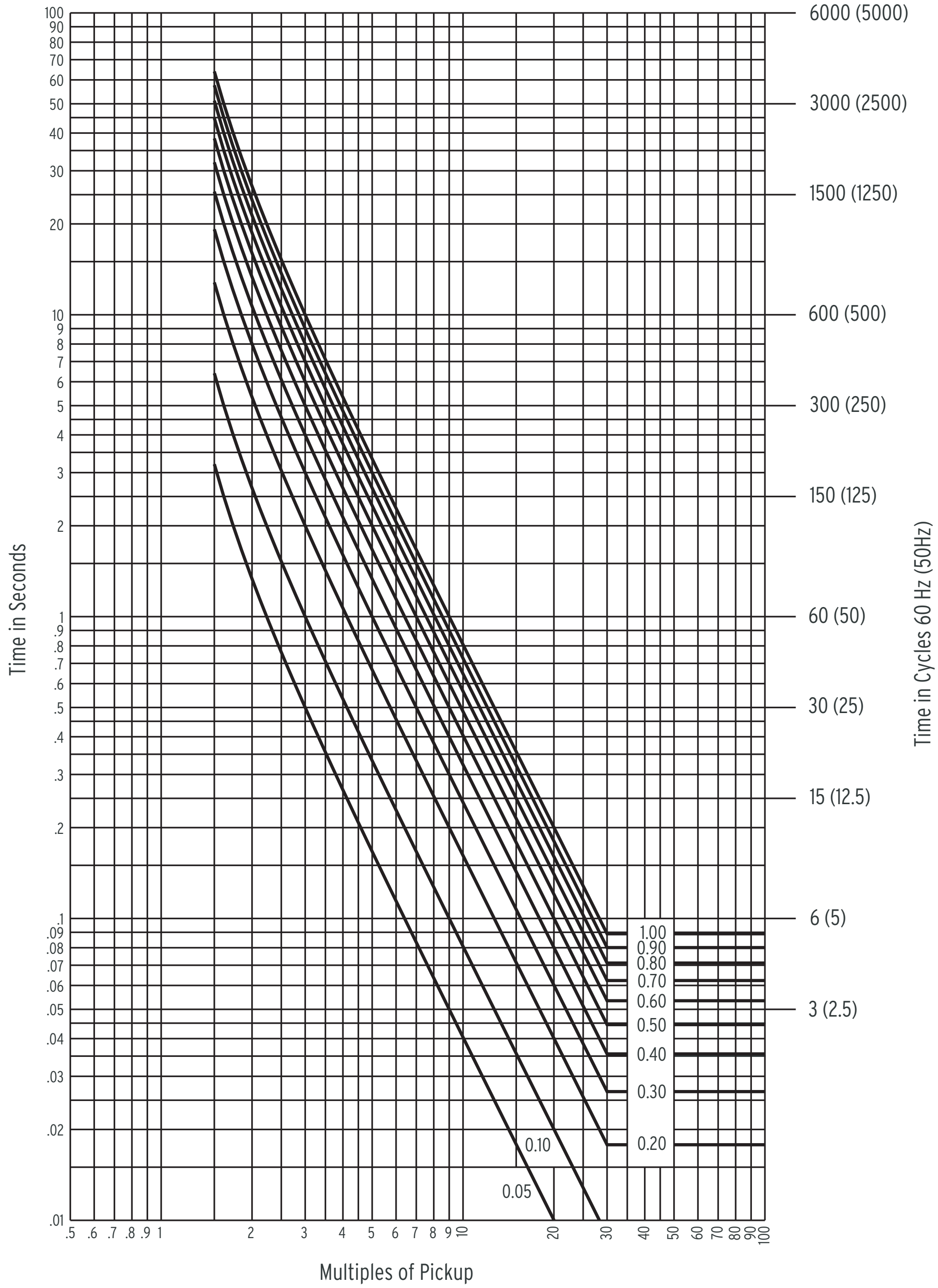


Figure 9.8 IEC Class C Curve (Extremely Inverse): C3

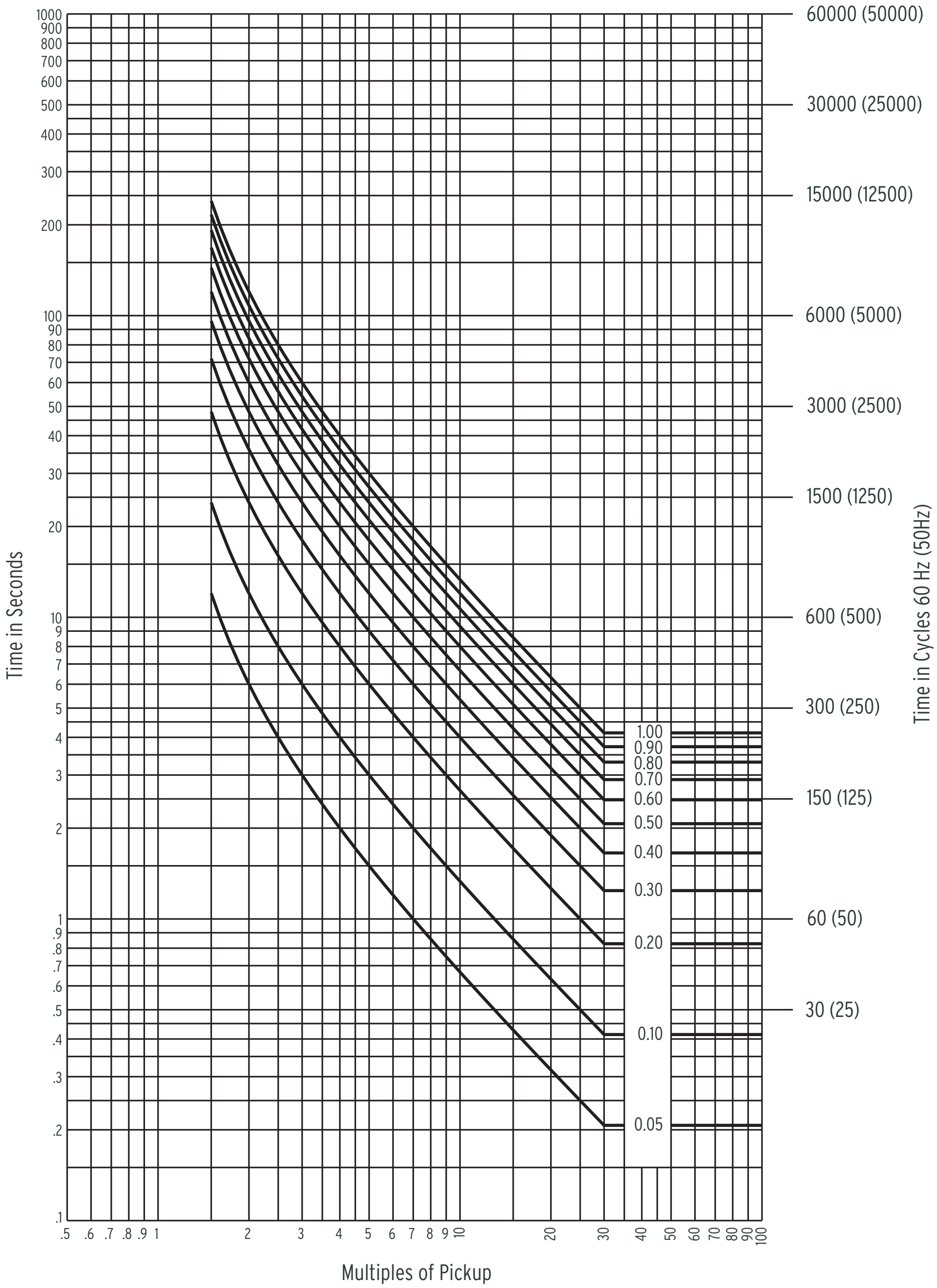


Figure 9.9 IEC Long-Time Inverse Curve: C4

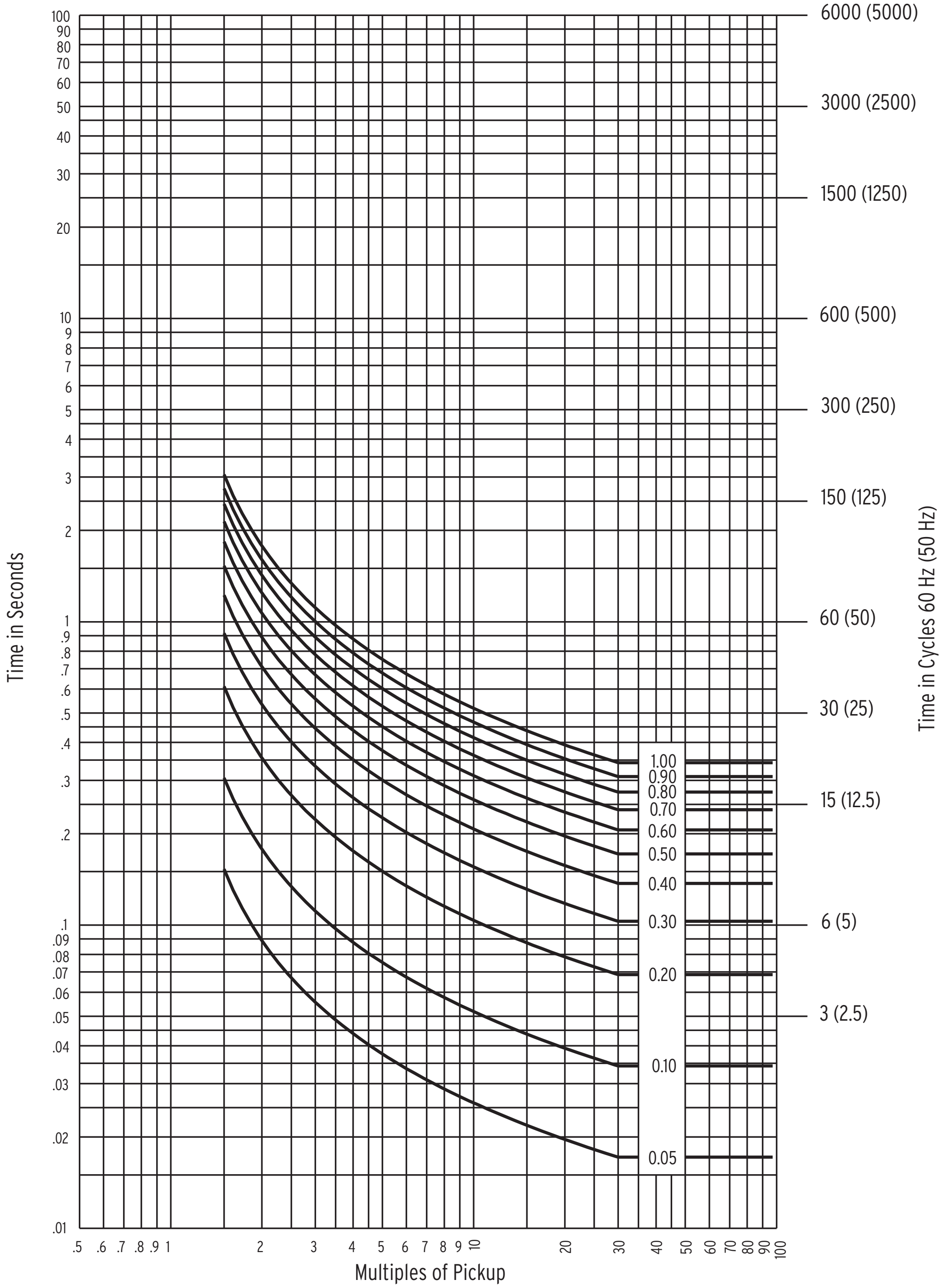


Figure 9.10 IEC Short-Time Inverse Curve: C5

Relay Word Bits (Used in SELOGIC Control Equations)

Relay Word bits are used in SELOGIC control equation settings. Numerous SELOGIC control equation settings examples are given in *Section 3–Section 8*. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). *Appendix I: 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 10.51*). Rows 0 and 1 are reserved for the display of the two front-panel target LED rows.

Table 9.5 SEL-311L Relay Word Bits (Sheet 1 of 3)

Row	Relay Word Bits						
0	EN	TRP	TIME	COMM	87	50_51	RCRS	RCLO
1	A	B	C	G	ZONE1	ZONE2	ZONE3	87CHFAIL
2	M1P	M1PT	Z1G	Z1GT	M2P	M2PT	Z2G	Z2GT
3	Z1T	Z2T	50P1	67P1	67P1T	50G1	67G1	67G1T
4	51G	51GT	51GR	LOP	ILOP	ZLOAD	ZLOUT	ZLIN
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
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
11	SV1	SV2	SV3	SV4	SV1T	SV2T	SV3T	SV4T
12	SV5	SV6	SV7	SV8	SV5T	SV6T	SV7T	SV8T
13	SV9	SV10	SV11	SV12	SV9T	SV10T	SV11T	SV12T
14	SV13	SV14	SV15	SV16	SV13T	SV14T	SV15T	SV16T
15	MAB1	MBC1	MCA1	MAB2	MBC2	MCA2	CVTBL	SOTFT
16	MAG1	MBG1	MCG1	MAG2	MBG2	MCG2	DCHI	DCLO
17	BCW	BCWA	BCWB	BCWC	FIDEN	FSA	FSB	FSC
18	SG1	SG2	SG3	SG4	SG5	SG6	OC	CC
19	CLOSE	CF	TRGTR	52A	3PO	SOTFE	VPOLV	50L
20	PDEM	GDEM	QDEM	TRIP	50QF	50QR	50GF	50GR
21	32QF	32QR	32GF	32GR	32VE	32QGE	32IE	32QE
22	F32I	R32I	F32Q	R32Q	F32QG	R32QG	F32V	R32V
23	*	*	IN106[a]	IN105[a]	IN104[a]	IN103[a]	IN102[a]	IN101[a]
24	ALARM[b]	OUT107[b]	OUT106[b]	OUT105[b]	OUT104[b]	OUT103[b]	OUT102[b]	OUT101[b]
25	M3P	M3PT	Z3G	Z3GT	M4P	M4PT	Z4G	Z4GT
26	Z3T	Z4T	50P2	67P2	67P2T	50P3	67P3	67P3T
27	50G2	67G2	67G2T	50G3	67G3	67G3T	*	*
28	51P	51PT	51PR	Z1X	59VA	MAB3	MBC3	MCA3
29	MAG3	MBG3	MCG3	27S	59S	*	59VP	59VS

Table 9.5 SEL-311L Relay Word Bits (Sheet 2 of 3)

Row	Relay Word Bits						
30	SF	25A1	25A2	RCSF	OPTMN	RSTMN	*	PMDOK
31	79RS	79CY	79LO	SH0	SH1	SH2	SH3	SH4
32	MAB4	MBC4	MCA4	MAG4	MBG4	MCG4	TSOK	TIRIG
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
36	50G4	67G4	67G4T	*	MPP1	MABC1	MPP2	MABC2
37	50Q1	67Q1	67Q1T	50Q2	67Q2	67Q2T	59N1	59N2
38	50Q3	67Q3	67Q3T	50Q4	67Q4	67Q4T	59Q	59V1
39	51Q	51QT	51QR	*	*	Z2PGS	67QG2S	BTX
40	Z3XT	DSTRT	NSTRT	STOP	Z3RB	KEY	EKEY	ECTT
41	PTRX	UBB1	UBB2	UBB	WFC	PT	PTRX1	PTRX2
42	27A	27B	27C	59A	59B	59C	3P27	3P59
43	27AB	27BC	27CA	59AB	59BC	59CA	*	*
44	201LOG	202LOG	203LOG	204LOG	205LOG	206LOG	*	*
45	52AA[c]	52AB[c]	52AC[c]	*	MPP3	MABC3	MPP4	MABC4
46	SPOA[c]	SPOB[c]	SPOC[c]	SPO[c]	E3PT[c]	ESTUB	TOP	*
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
52	81D1	81D2	81D3	81D4	81D5	81D6	27B81	*
53	81D1T	81D2T	81D3T	81D4T	81D5T	81D6T	87HWAL	87BSY
54	OUT301	OUT302	OUT303	OUT304	OUT305	OUT306	OUT307	OUT308
55	OUT309	OUT310	OUT311	OUT312	*	OSBC	OSBB	OSBA
56	IN308	IN307	IN306	IN305	IN304	IN303	IN302	IN301
57	TRPA21	TRPB21	TRPC21	TRP3P21	*	LOPFDP	LOPFD	LOPRST
58	OUT201[b]	OUT202[b]	OUT203[b]	OUT204[b]	OUT205[b]	OUT206[b]	87LPE	DD
59	FTABC	FTAG	FTBG	FTCG	FTAB	FTBC	FTCA	FTSE
60	87L	87LA	87LB	87LC	87L2	87LG	CHYAL	CHXAL
61	87LOPA	87LAE	R87LA	CTAA	PQ87LA	TRIP87	BXYZ2	BXYZG
62	87LOPB	87LBE	R87LB	CTAB	PQ87LB	BXYZA	BXYZB	BXYZC
63	87LOPC	87LCE	R87LC	CTAC	PQ87LC	T51PT	T50P	T50PT
64	87LOP2	87L2E	R87L2	B87L2	PQ87L2	T51QT	T50Q	T50QT
65	87LOPG	87LGE	R87LG	B87LG	PQ87LG	T51GT	T50G	T50GT
66	RDTY	TDTY	TESTY	3POY	RDTX	TDTX	TESTX	3POX
67	R4X	R3X	R2X	R1X	T4X	T3X	T2X	T1X
68	R4Y	R3Y	R2Y	R1Y	T4Y	T3Y	T2Y	T1Y
69	DBADY	AVAY	RBADY	ROKY	DBADX	AVAX	RBADX	ROKX
70	50LA	50RA	50LB	50RB	50LC	50RC	50L2	50R2

Table 9.5 SEL-311L Relay Word Bits (Sheet 3 of 3)

Row	Relay Word Bits							
71	50LG	50RG	T51P	T51PR	T51G	T51GR	T51Q	T51QR
72	87L2T	87LGT	P87L2	P87LG	TRPA87[c]	TRPB87[c]	TRPC87[c]	TRP3P87[c]
73	CTALA	CTALB	CTALC	CTFLG	LCTFLG	P5SEL	P6SEL	LNKFAIL

[a] See Figure 7.1 for more information on the operation of optoisolated inputs IN101–IN106.
[b] All output contacts, except OUT201–OUT206, can be a or b type contacts. See Figure 2.20 and Figure 7.27 for more information on the operation of output contacts OUT101– OUT107 and ALARM. See Figure 2.20 and Figure 7.28 for more information on the operation of output contacts OUT201–OUT206. See Figure 7.29 for more information on the operation of output contacts OUT301-OUT312.
[c] Only functional in SEL-311L-7 Relay when APP = 87LSP.

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 1 of 18)

Row	Bit	Definition	Primary Application
0	EN	Relay Enabled (see *Table 5.1*)	Target
	TRP	Relay Trip	
	TIME	Time Trip	
	COMM	Communications-Assisted Trip	
	87	Line Current Differential Trip	
	50_51	Instantaneous and Time-Overcurrent Trip	
	RCRS	Recloser in Reset State	
	RCLO	Recloser in Lockout State	
1	A	A-phase is involved in the fault (see *Table 5.1*)	
	B	B-phase is involved in the fault	
	C	C-phase is involved in the fault	
	G	Residual-ground element tripped for fault or residual-ground current above pickup of residual-ground element at time of trip	
	ZONE1	Fault in Zone 1/Level 1	
	ZONE2	Fault in Zone 2/Level 2	
	ZONE3	Fault in Zone 3/Level 3	
	87CHFAIL	Differential Channel Failure	
2	M1P	Zone 1 phase distance, instantaneous (see *Figure 4.4*)	Tripping, Control
	M1PT	Zone 1 phase distance, time-delayed	
	Z1G	Zone 1 mho and/or quad. distance, instantaneous	
	Z1GT	Zone 1 ground distance, time-delayed	
	M2P	Zone 2 phase distance, instantaneous	
	M2PT	Zone 2 phase distance, time-delayed	
	Z2G	Zone 2 mho and/or quad. distance, instantaneous	
	Z2GT	Zone 2 ground distance, time-delayed	
3	Z1T	Zone 1 phase and/or ground distance, time-delayed	
	Z2T	Zone 2 phase and/or ground distance, time-delayed	
	50P1	Level 1 phase instantaneous overcurrent element (A, B, or C) (above pickup setting 50P1P)	
	67P1	Level 1 torque-controlled phase instantaneous overcurrent element (derived from 50P1)	
	67P1T	Level 1 phase definite-time overcurrent element 67P1T timed out (derived from 67P1)	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 2 of 18)

Row	Bit	Definition	Primary Application
	50G1	Level 1 residual-ground instantaneous overcurrent element (residual-ground current above pickup setting 50G1P)	
	67G1	Level 1 torque-controlled residual-ground instantaneous overcurrent element (derived from 50G1)	
	67G1T	Level 1 residual-ground definite-time overcurrent element 67G1T timed out (derived from 67G1)	
4	51G	Residual-ground current above pickup setting 51GP for residual-ground time-overcurrent element 51GT	Testing, Control
	51GT	Residual-ground time-overcurrent element 51GT timed out	Tripping
	51GR	Residual-ground time-overcurrent element 51GT reset	Testing
	LOP	Loss-of-potential	Testing, Special directional control schemes
	ILOP	Internal loss-of-potential	Distance directional control enable
	ZLOAD	ZLOUT + ZLIN	Special phase overcurrent element control
	ZLOUT	Load encroachment “load out” element	
	ZLIN	Load encroachment “load in” element	
5	LB1	Local Bit 1 asserted	Local control via front panel—replacing traditional panel-mounted control switches
	LB2	Local Bit 2 asserted	
	LB3	Local Bit 3 asserted	
	LB4	Local Bit 4 asserted	
	LB5	Local Bit 5 asserted	
	LB6	Local Bit 6 asserted	
	LB7	Local Bit 7 asserted	
	LB8	Local Bit 8 asserted	
6	LB9	Local Bit 9 asserted	
	LB10	Local Bit 10 asserted	
	LB11	Local Bit 11 asserted	
	LB12	Local Bit 12 asserted	
	LB13	Local Bit 13 asserted	
	LB14	Local Bit 14 asserted	
	LB15	Local Bit 15 asserted	
	LB16	Local Bit 16 asserted	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 3 of 18)

Row	Bit	Definition	Primary Application
7	RB1	Remote Bit 1 asserted	Remote control via serial port
	RB2	Remote Bit 2 asserted	
	RB3	Remote Bit 3 asserted	
	RB4	Remote Bit 4 asserted	
	RB5	Remote Bit 5 asserted	
	RB6	Remote Bit 6 asserted	
	RB7	Remote Bit 7 asserted	
	RB8	Remote Bit 8 asserted	
8	RB9	Remote Bit 9 asserted	
	RB10	Remote Bit 10 asserted	
	RB11	Remote Bit 11 asserted	
	RB12	Remote Bit 12 asserted	
	RB13	Remote Bit 13 asserted	
	RB14	Remote Bit 14 asserted	
	RB15	Remote Bit 15 asserted	
	RB16	Remote Bit 16 asserted	
9	LT1	Latch Bit 1 asserted	Latched control—replacing traditional latching relays
	LT2	Latch Bit 2 asserted	
	LT3	Latch Bit 3 asserted	
	LT4	Latch Bit 4 asserted	
	LT5	Latch Bit 5 asserted	
	LT6	Latch Bit 6 asserted	
	LT7	Latch Bit 7 asserted	
	LT8	Latch Bit 8 asserted	
10	LT9	Latch Bit 9 asserted	
	LT10	Latch Bit 10 asserted	
	LT11	Latch Bit 11 asserted	
	LT12	Latch Bit 12 asserted	
	LT13	Latch Bit 13 asserted	
	LT14	Latch Bit 14 asserted	
	LT15	Latch Bit 15 asserted	
	LT16	Latch Bit 16 asserted	
11	SV1	SELOGIC control equation variable timer input SV1 asserted	Testing, Seal-in functions, etc. (see *Figure 7.26*)
	SV2	SELOGIC control equation variable timer input SV2 asserted	
	SV3	SELOGIC control equation variable timer input SV3 asserted	
	SV4	SELOGIC control equation variable timer input SV4 asserted	
	SV1T	SELOGIC control equation variable timer output SV1T asserted	Control
	SV2T	SELOGIC control equation variable timer output SV2T asserted	
	SV3T	SELOGIC control equation variable timer output SV3T asserted	
	SV4T	SELOGIC control equation variable timer output SV4T asserted	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 4 of 18)

Row	Bit	Definition	Primary Application
12	SV5	SELOGIC control equation variable timer input SV5 asserted	Testing, Seal-in functions, etc. (see *Figure 7.26*)
	SV6	SELOGIC control equation variable timer input SV6 asserted	
	SV7	SELOGIC control equation variable timer input SV7 asserted	
	SV8	SELOGIC control equation variable timer input SV8 asserted	
	SV5T	SELOGIC control equation variable timer output SV5T asserted	Control
	SV6T	SELOGIC control equation variable timer output SV6T asserted	
	SV7T	SELOGIC control equation variable timer output SV7T asserted	
	SV8T	SELOGIC control equation variable timer output SV8T asserted	
13	SV9	SELOGIC control equation variable timer input SV9 asserted	Testing, Seal-in functions, etc. (see *Figure 7.26*
	SV10	SELOGIC control equation variable timer input SV10 asserted	
	SV11	SELOGIC control equation variable timer input SV11 asserted	
	SV12	SELOGIC control equation variable timer input SV12 asserted	
	SV9T	SELOGIC control equation variable timer output SV9T asserted	Control
	SV10T	SELOGIC control equation variable timer output SV10T asserted	
	SV11T	SELOGIC control equation variable timer output SV11T asserted	
	SV12T	SELOGIC control equation variable timer output SV12T asserted	
14	SV13	SELOGIC control equation variable timer input SV13 asserted	Testing, Seal-in functions, etc. (see *Figure 7.26*
	SV14	SELOGIC control equation variable timer input SV14 asserted	
	SV15	SELOGIC control equation variable timer input SV15 asserted	
	SV16	SELOGIC control equation variable timer input SV16 asserted	
	SV13T	SELOGIC control equation variable timer output SV13T asserted	Control
	SV14T	SELOGIC control equation variable timer output SV14T asserted	
	SV15T	SELOGIC control equation variable timer output SV15T asserted	
	SV16T	SELOGIC control equation variable timer output SV16T asserted	
15	MAB1	Mho AB phase distance zone 1, instantaneous	Testing
	MBC1	Mho BC phase distance zone 1, instantaneous	
	MCA1	Mho CA phase distance zone 1, instantaneous	
	MAB2	Mho AB phase distance zone 2 instantaneous	
	MBC2	Mho BC phase distance zone 2, instantaneous	
	MCA2	Mho CA phase distance zone 2, instantaneous	
	CVTBL	CCVT transient blocking logic active	Indication, Testing
	SOTFT	Switch-onto-fault trip	
16	MAG1	Mho ground distance A-phase, zone 1	Testing
	MBG1	Mho ground distance B-phase, zone 1	
	MCG1	Mho ground distance C-phase, zone 1	
	MAG2	Mho ground distance A-phase, zone 2	
	MBG2	Mho ground distance B-phase, zone 2	
	MCG2	Mho ground distance C-phase, zone 2	
	DCHI	Station dc battery instantaneous overvoltage element	Indication
	DCLO	Station dc battery instantaneous undervoltage element	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 5 of 18)

Row	Bit	Definition	Primary Application
17	BCW	BCWA + BCWB + BCWC	
	BCWA	A-phase breaker contact wear has reached 100% wear level (see *Breaker Monitor on page 8.12*)	
	BCWB	B-phase breaker contact wear has reached 100% wear level (see *Breaker Monitor on page 8.12*)	
	BCWC	C-phase breaker contact wear has reached 100% wear level (see *Breaker Monitor on page 8.12*)	
	FIDEN	SEL-311L Main Board Fault Identification Logic Enabled. This Relay Word bit will not assert if FTSE is enabled.	Internal control
	FSA	A-phase to ground or B-C phases to ground fault identification logic output used in distance element logic	
	FSB	B-phase to ground or A-C phases to ground fault identification logic output used in distance element logic	
	FSC	C-phase to ground or A-B phases to ground fault identification logic output used in distance element logic	
18	SG1	Setting group 1 active (see *Table 7.4*)	Indication
	SG2	Setting group 2 active (see *Table 7.4*)	
	SG3	Setting group 3 active (see *Table 7.4*)	
	SG4	Setting group 4 active (see *Table 7.4*)	
	SG5	Setting group 5 active (see *Table 7.4*)	
	SG6	Setting group 6 active (see *Table 7.4*)	
	OC	Asserts 1/4 cycle for Open Command execution (see *OPE Command (Open Breaker) on page 10.56*)	Control
	CC	Asserts 1/4 cycle for Close Command execution (see *CLO Command (Close Breaker) on page 10.54*)	
19	CLOSE	Close logic output asserted (see *Figure 6.1*)	Output contact assignment
	CF	Close failure condition (asserts for 1/4 cycle)	Control
	TRGTR	Target Reset. TRGTR pulses to logical 1 for one processing interval when either the TARGET RESET pushbutton is pushed or the **TAR R** serial port command is executed	
	52A	Circuit breaker status (asserts to logical 1 when circuit breaker is closed)	
	3PO	Three-pole open condition	
	SOTFE	Switch-onto-fault condition	
	VPOLV	Positive-sequence polarization voltage valid	Indication
	50L	Phase instantaneous overcurrent element for closed circuit breaker detection (any phase current above pickup setting 50LP)	
20	PDEM	Phase demand current above pickup setting PDEMP	
	GDEM	Residual-ground demand current above pickup setting GDEMP	
	QDEM	Negative-sequence demand current above pickup setting QDEMP	
	TRIP	Trip logic output asserted	Output contact assignment

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 6 of 18)

Row	Bit	Definition	Primary Application
	50QF	Forward direction negative-sequence overcurrent threshold exceeded	Directional threshold
	50QR	Reverse direction negative-sequence overcurrent threshold exceeded	
	50GF	Forward direction residual-ground overcurrent threshold exceeded	
	50GR	Reverse direction residual-ground overcurrent threshold exceeded	
21	32QF	Forward directional control routed to phase-distance elements	Directional control
	32QR	Reverse directional control routed to phase-distance elements	
	32GF	Forward directional control routed to ground distance elements	
	32GR	Reverse directional control routed to ground distance elements	
	32VE	Enable for zero-sequence voltage-polarized directional element	
	32QGE	Enable for negative-sequence voltage-polarized	
	32IE	Enable for channel IP current-polarized directional element	
	32QE	Enable for negative-sequence voltage-polarized directional element	
22	F32I	Forward channel IP current-polarized directional element	
	R32I	Reverse channel IP current-polarized directional element	
	F32Q	Forward negative-sequence voltage-polarized directional element	
	R32Q	Reverse negative-sequence voltage-polarized directional element	
	F32QG	Forward negative-sequence voltage-polarized directional element	
	R32QG	Reverse negative-sequence voltage-polarized directional element	
	F32V	Forward zero-sequence voltage-polarized directional element	
	R32V	Reverse zero-sequence voltage-polarized directional element	
23	*		
	*		
	IN106	Optoisolated input IN106 asserted	Relay input status, Control via optoisolated inputs
	IN105	Optoisolated input IN105 asserted	
	IN104	Optoisolated input IN104 asserted	
	IN103	Optoisolated input IN103 asserted	
	IN102	Optoisolated input IN102 asserted	
	IN101	Optoisolated input IN101 asserted	
24	ALARM	ALARM output contact indicating that relay failed or **PULSE ALARM** command executed	Relay output status, Control
	OUT107	Output contact OUT107 asserted	
	OUT106	Output contact OUT106 asserted	
	OUT105	Output contact OUT105 asserted	
	OUT104	Output contact OUT104 asserted	
	OUT103	Output contact OUT103 asserted	
	OUT102	Output contact OUT102 asserted	
	OUT101	Output contact OUT101 asserted	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 7 of 18)

Row	Bit	Definition	Primary Application
25	M3P	Zone 3 phase distance, instantaneous	Tripping, Control
	M3PT	Zone 3 phase distance, time-delayed	
	Z3G	Zone 3 mho and/or quad. distance, instantaneous	
	Z3GT	Zone 3 ground distance, time-delayed	
	M4P	Zone 4 phase distance, instantaneous	
	M4PT	Zone 4 phase distance, time-delayed	
	Z4G	Zone 4 mho and/or quad. distance, instantaneous	
	Z4GT	Zone 4 ground distance, time-delayed	
26	Z3T	Zone 3 phase and/or ground distance, time-delayed	
	Z4T	Zone 4 phase and/or ground distance, time-delayed	
	50P2	Level 2 Phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P2P)	
	67P2	Level 2 torque-controlled phase instantaneous overcurrent element (derived from 50P2)	
	67P2T	Level 2 phase definite-time overcurrent element 67P2T timed out (derived from 67P2)	
	50P3	Level 3 Phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P3P)	
	67P3	Level 3 torque-controlled phase instantaneous overcurrent element (derived from 50P3)	
	67P3T	Level 3 phase definite-time overcurrent element 67P3T timed out (derived from 67P3)	
27	50G2	Level 2 residual-ground instantaneous overcurrent element (residual-ground current above pickup setting 50G2P)	
	67G2	Level 2 torque-controlled residual-ground instantaneous overcurrent element (derived from 50G2)	
	67G2T	Level 2 residual-ground definite-time overcurrent element 67G2T timed out (derived from 67G2)	
	50G3	Level 3 residual-ground instantaneous overcurrent element (residual-ground current above pickup setting 50G3P)	
	67G3	Level 3 torque-controlled residual-ground instantaneous overcurrent element (derived from 50G3)	
	67G3T	Level 3 residual-ground definite-time overcurrent element 67G3T timed out (derived from 67G3)	
	*		
	*		
28	51P	Maximum phase current above pickup setting 51PP for phase time-overcurrent element 51PT	Testing, Control
	51PT	Phase time-overcurrent element 51PT timed out	Tripping
	51PR	Phase time-overcurrent element 51PT reset	Testing
	Z1X	Zone 1 extension element picked up	Indication
	59VA	Channel VA voltage window element (channel VA voltage between threshold settings 25VLO and 25VHI)	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 8 of 18)

Row	Bit	Definition	Primary Application
	MAB3	Mho AB phase distance zone 3 instantaneous	Testing
	MBC3	Mho BC phase distance zone 3, instantaneous	
	MCA3	Mho CA phase distance zone 3, instantaneous	
29	MAG3	Mho ground distance A-phase, zone 3	
	MBG3	Mho ground distance B-phase, zone 3	
	MCG3	Mho ground distance C-phase, zone 3	
	27S	Channel VS instantaneous undervoltage element (channel VS voltage below pickup setting 27SP)	
	59S	Channel VS instantaneous overvoltage element (channel VS voltage above pickup setting 59SP)	
	*		
	59VP	Phase voltage window element (selected phase voltage [VP] between threshold settings 25VLO and 25VHI)	
	59VS	Channel VS voltage window element (channel VS voltage between threshold settings 25VLO and 25VHI)	
30	SF	Slip frequency between voltages VP and VS less than setting 25SF	
	25A1	Synchronism-check element	
	25A2	Synchronism-check element	
	RCSF	Reclose supervision failure (asserts for 1/4 cycle)	
	OPTMN	Open-interval timer is timing (see *Reclosing Relay on page 6.10*)	
	RSTMN	Reset timer is timing (see *Reclosing Relay on page 6.10*)	
	*		
	PMDOK	Phasor Measurement Data OK (see *Synchrophasor Relay Word Bits on page H.8*)	
31	79RS	Reclosing relay in the Reset State	
	79CY	Reclosing relay in the Reclose Cycle State	
	79LO	Reclosing relay in the Lockout State	
	SH0	Reclosing relay shot counter = 0 (see *Table 6.4*)	
	SH1	Reclosing relay shot counter = 1 (see *Table 6.4*)	
	SH2	Reclosing relay shot counter = 2 (see *Table 6.4*)	
	SH3	Reclosing relay shot counter = 3 (see *Table 6.4*)	
	SH4	Reclosing relay shot counter = 4 (see *Table 6.4*)	
32	MAB4	Mho AB phase distance zone 4, instantaneous	
	MBC4	Mho BC phase distance zone 4, instantaneous	
	MCA4	Mho CA phase distance zone 4, instantaneous	
	MAG4	Mho ground distance A-phase, zone 4	
	MBG4	Mho ground distance B-phase, zone 4	
	MCG4	Mho ground distance C-phase, zone 4	
	TSOK	Time Synchronization OK (see *Synchrophasor Relay Word Bits on page H.8*)	
	TIRIG	Relay time is based on IRIG-B time source (see *Synchrophasor Relay Word Bits on page H.8*)	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 9 of 18)

Row	Bit	Definition	Primary Application
33	XAG1	Quadrilateral ground distance A-phase, zone 1	
	XBG1	Quadrilateral ground distance B-phase, zone 1	
	XCG1	Quadrilateral ground distance C-phase, zone 1	
	XAG2	Quadrilateral ground distance A-phase, zone 2	
	XBG2	Quadrilateral ground distance B-phase, zone 2	
	XCG2	Quadrilateral ground distance C-phase, zone 2	
	XAG3	Quadrilateral ground distance A-phase, zone 3	
	XBG3	Quadrilateral ground distance B-phase, zone 3	
34	XCG3	Quadrilateral ground distance C-phase, zone 3	
	XAG4	Quadrilateral ground distance A-phase, zone 4	
	XBG4	Quadrilateral ground distance B-phase, zone 4	
	XCG4	Quadrilateral ground distance C-phase, zone 4	
	OSTI	Out-of-step trip entering zone 5	
	OSTO	Out-of-step trip leaving zone 5	
	OST	Out-of-Step Trip Condition	Tripping
	50ABC	Positive-Sequence current above threshold to enable OOS logic	Indication
35	X5ABC	Zone 5, out-of-step distance element, instantaneous	Testing
	X6ABC	Zone 6, out-of-step distance element, instantaneous	
	OSB	Out-of-step block condition declaration	
	OSB1	Out-of-step Block, Zone 1	
	OSB2	Out-of-step Block, Zone 2	
	OSB3	Out-of-step Block, Zone 3	
	OSB4	Out-of-step Block, Zone 4	
	UBOSB	Unblock out-of-step blocking	
36	50G4	Level 4 residual-ground instantaneous overcurrent element (residual-ground current above pickup setting 50G4P)	Tripping
	67G4	Level 4 torque-controlled residual-ground instantaneous overcurrent element (derived from 50G4	
	67G4T	Level 4 residual-ground definite-time overcurrent element 67G4T timed out (derived from 67G4)	
	*		
	MPP1	Zone 1 phase-to-phase compensator distance element	
	MABC1	Zone 1 three-phase compensator distance element	
	MPP2	Zone 2 phase-to-phase compensator distance element	
	MABC2	Zone 2 three-phase compensator distance element	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 10 of 18)

Row	Bit	Definition	Primary Application
37	50Q1[a]	Level 1 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q1P)	
	67Q1	Level 1 torque-controlled negative-sequence instantaneous overcurrent element (derived from 50Q1)	
	67Q1T	Level 1 torque-controlled negative-sequence definite-time overcurrent element 67Q1T timed out (derived from 67Q1)	
	50Q2[a]	Level 2 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q2P)	
	67Q2	Level 2 torque-controlled negative-sequence instantaneous overcurrent element (derived from 50Q2)	
	67Q2T	Level 2 torque-controlled negative-sequence definite-time overcurrent element 67Q2T timed out (derived from 67Q2)	
	59N1	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N1P)	
	59N2	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N2P)	
38	50Q3[a]	Level 3 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q3P)	
	67Q3	Level 3 torque-controlled negative-sequence instantaneous overcurrent element (derived from 50Q3)	
	67Q3T	Level 3 torque-controlled negative-sequence definite-time overcurrent element 67Q3T timed out (derived from 67Q3)	
	50Q4[a]	Level 4 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q4P)	
	67Q4	Level 4 torque-controlled negative-sequence instantaneous overcurrent element (derived from 50Q4)	
	67Q4T	Level 4 torque-controlled negative-sequence definite-time overcurrent element 67Q4T timed out (derived from 67Q4)	
	59Q	Negative-sequence instantaneous overvoltage element (negative-sequence voltage above pickup setting 59QP)	
	59V1	Positive-sequence instantaneous overvoltage element (positive-sequence voltage above pickup setting 59V1P)	
39	51Q[a]	Negative-sequence current above pickup setting 51QP for negative-sequence time-overcurrent element 51QT	Testing, Control
	51QT	Negative-sequence time-overcurrent element 51QT timed out	Tripping
	51QR	Negative-sequence time-overcurrent element 51QT reset	Testing
	*		
	*		
	Z2PGS	Zone 2 phase and ground short delay element	DCB Logic
	67QG2S	Negative-sequence and residual directional overcurrent short delay element	See *Figure 5.18*
	BTX	Block extension picked up	
40	Z3XT	Current-reversal guard timer picked up	
	DSTRT	Directional start element picked up	
	NSTRT	Nondirectional start element picked up	
	STOP	Stop element picked up	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 11 of 18)

Row	Bit	Definition	Primary Application
	Z3RB	Current-reversal guard asserted	POTT Logic
	KEY	Transmit permissive trip signal	See *Figure 5.10*
	EKEY	Echo received permissive trip signal	
	ECTT	Echo conversion to trip signal	
41	PTRX	Permissive trip signal to Trip logic	
	UBB1	Unblocking block 1 from DCUB logic	
	UBB2	Unblocking block 2 from DCUB logic	
	UBB	Unblocking block to trip logic	
	WFC	Weak-infeed condition detected	
	PT	Permissive trip signal to POTT logic	
	PTRX1	Permissive trip 2 signal from DCUB logic	
	PTRX2	Permissive trip 2 signal from DCUB logic	
42	27A	A-phase instantaneous undervoltage element (A-phase voltage below pickup setting 27P)	Control
	27B	B-phase instantaneous undervoltage element (B-phase voltage below pickup setting 27P)	
	27C	C-phase instantaneous undervoltage element (C-phase voltage below pickup setting 27P)	
	59A	A-phase instantaneous overvoltage element (A-phase voltage above pickup setting 59P)	
	59B	B-phase instantaneous overvoltage element (B-phase voltage above pickup setting 59P)	
	59C	C-phase instantaneous overvoltage element (C-phase voltage above pickup setting 59P)	
	3P27	27A * 27B * 27C	
	3P59	59A * 59B * 59C	
43	27AB	AB phase-to-phase instantaneous undervoltage element (AB phase-to-phase voltage below pickup setting 27PP)	
	27BC	BC phase-to-phase instantaneous undervoltage element (BC phase-to-phase voltage below pickup setting 27PP)	
	27CA	CA phase-to-phase instantaneous undervoltage element (CA phase-to-phase voltage below pickup setting 27PP)	
	59AB	AB phase-to-phase instantaneous overvoltage element (AB phase-to-phase voltage above pickup setting 59PP)	
	59BC	BC phase-to-phase instantaneous overvoltage element (BC phase-to-phase voltage above pickup setting 59PP)	
	59CA	CA phase-to-phase instantaneous overvoltage element (CA phase-to-phase voltage above pickup setting 59PP)	
	*		
	*		
44	201LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1	Testing
	202LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1	
	203LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1	
	204LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 12 of 18)

Row	Bit	Definition	Primary Application
	205LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1	
	206LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1	
	*		
	*		
45	52AA	Circuit Breaker Pole A Status (asserts to a logical 1 when breaker Pole A is closed, active when APP = 87LSP)	Tripping
	52AB	Circuit Breaker Pole B Status (asserts to a logical 1 when breaker Pole B is closed, active when APP = 87LSP)	
	52AC	Circuit Breaker Pole C Status (asserts to a logical 1 when breaker Pole C is closed, active when APP = 87LSP)	
	*		
	MPP3	Zone 3 phase-to-phase compensator distance element	
	MABC3	Zone 3 three-phase compensator distance element	
	MPP4	Zone 4 phase-to-phase compensator distance element	
	MABC4	Zone 4 three-phase compensator distance element	
46	SPOA	A-phase open condition (active when APP = 87LSP)	
	SPOB	B-phase open condition (active when APP = 87LSP)	
	SPOC	C-phase open condition (active when APP = 87LSP)	
	SPO	Any single-phase open condition (active when APP = 87LSP)	
	E3PT	Enable three-pole tripping (active when APP = 87LSP)	
	ESTUB	Enable bus stub tripping	
	TOP	Trip open pole detected	
	*		
47	RMB8A	Channel A, received bit 8	Relay-to-relay communication (see *Appendix E*)
	RMB7A	Channel A, received bit 7	
	RMB6A	Channel A, received bit 6	
	RMB5A	Channel A, received bit 5	
	RMB4A	Channel A, received bit 4	
	RMB3A	Channel A, received bit 3	
	RMB2A	Channel A, received bit 2	
	RMB1A	Channel A, received bit 1	
48	TMB8A	Channel A, transmit bit 8	
	TMB7A	Channel A, transmit bit 7	
	TMB6A	Channel A, transmit bit 6	
	TMB5A	Channel A, transmit bit 5	
	TMB4A	Channel A, transmit bit 4	
	TMB3A	Channel A, transmit bit 3	
	TMB2A	Channel A, transmit bit 2	
	TMB1A	Channel A, transmit bit 1	
49	RMB8B	Channel B, received bit 8	
	RMB7B	Channel B, received bit 7	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 13 of 18)

Row	Bit	Definition	Primary Application
	RMB6B	Channel B, received bit 6	
	RMB5B	Channel B, received bit 5	
	RMB4B	Channel B, received bit 4	
	RMB3B	Channel B, received bit 3	
	RMB2B	Channel B, received bit 2	
	RMB1B	Channel B, received bit 1	
50	TMB8B	Channel B, transmit bit 8	
	TMB7B	Channel B, transmit bit 7	
	TMB6B	Channel B, transmit bit 6	
	TMB5B	Channel B, transmit bit 5	
	TMB4B	Channel B, transmit bit 4	
	TMB3B	Channel B, transmit bit 3	
	TMB2B	Channel B, transmit bit 2	
	TMB1B	Channel B, transmit bit 1	
51	LBOKB	Channel B, received MIRRORED BIT data OK in loopback mode	Testing, Indication
	CBADB	Channel B, channel unavailability over threshold	
	RBADB	Channel B, outage duration over threshold	
	ROKB	Channel B, received MIRRORED BIT data OK	
	LBOKA	Channel A, received MIRRORED BIT data OK in loopback mode	
	CBADA	Channel A, channel unavailability over threshold	
	RBADA	Channel A, outage duration over threshold	
	ROKA	Channel A, received MIRRORED BIT data OK	
52	81D1	Level 1 instantaneous frequency element (with corresponding pickup setting 81D1P)	Testing
	81D2	Level 2 instantaneous frequency element (with corresponding pickup setting 81D2P)	
	81D3	Level 3 instantaneous frequency element (with corresponding pickup setting 81D3P)	
	81D4	Level 4 instantaneous frequency element (with corresponding pickup setting 81D4P)	
	81D5	Level 5 instantaneous frequency element (with corresponding pickup setting 81D5P)	
	81D6	Level 6 instantaneous frequency element (with corresponding pickup setting 81D6P)	
	27B81	Undervoltage element for frequency element blocking (any phase voltage below pickup setting 27B81P)	
	*		
53	81D1T	Level 1 definite-time frequency element 81D1T timed out (derived from 81D1)	Tripping, Control
	81D2T	Level 2 definite-time frequency element 81D2T timed out (derived from 81D2)	
	81D3T	Level 3 definite-time frequency element 81D3T timed out (derived from 81D3)	
	81D4T	Level 4 definite-time frequency element 81D4T timed out (derived from 81D4)	
	81D5T	Level 5 definite-time frequency element 81D5T timed out (derived from 81D5)	
	81D6T	Level 6 definite-time frequency element 81D6T timed out (derived from 81D6)	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 14 of 18)

Row	Bit	Definition	Primary Application
	87HWAL	Differential board self-test alarm	Testing
	87BSY	Main board diagnostic alarm	
54	OUT301	State of output contact OUT301	Tripping, Control
	OUT302	State of output contact OUT302	
	OUT303	State of output contact OUT303	
	OUT304	State of output contact OUT304	
	OUT305	State of output contact OUT305	
	OUT306	State of output contact OUT306	
	OUT307	State of output contact OUT307	
	OUT308	State of output contact OUT308	
55	OUT309	State of output contact OUT309	
	OUT310	State of output contact OUT310	
	OUT311	State of output contact OUT311	
	OUT312	State of output contact OUT312	
	*		
	OSBC	Out-of-step block, C-phase	
	OSBB	Out-of-step block, B-phase	
	OSBA	Out-of-step block, A-phase	
56	IN308	Optoisolated input **IN308** asserted	
	IN307	Optoisolated input **IN307** asserted	
	IN306	Optoisolated input **IN306** asserted	
	IN305	Optoisolated input **IN305** asserted	
	IN304	Optoisolated input **IN304** asserted	
	IN303	Optoisolated input **IN303** asserted	
	IN302	Optoisolated input **IN302** asserted	
	IN301	Optoisolated input **IN301** asserted	
57	TRPA21	A-phase Zone1 distance trip output (active when APP = 87LSP)	
	TRPB21	B-phase Zone1 distance trip output (active when APP = 87LSP)	
	TRPC21	C-phase Zone1 distance trip output (active when APP = 87LSP)	
	TRP3P21	Three-pole Zone1 distance trip output (active when APP = 87LSP)	
	*		
	LOPFDP	Loss-of-potential—unbalanced voltages with balanced currents	
	LOPFD	Loss-of-potential—block signal based on positive- or zero-sequence current check	
	LOPRST	LOP Reset condition based on detection of healthy voltages	
58	OUT201	State of output contact OUT201	
	OUT202	State of output contact OUT202	
	OUT203	State of output contact OUT203	
	OUT204	State of output contact OUT204	
	OUT205	State of output contact OUT205	
	OUT206	State of output contact OUT206	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 15 of 18)

Row	Bit	Definition	Primary Application
	87LPE	87L protection enabled	
	DD	Disturbance detector	
59	FTABC	ABC fault type declaration	
	FTAG	AG fault type declaration	
	FTBG	BG fault type declaration	
	FTCG	CG fault type declaration	
	FTAB	AB fault type declaration	
	FTBC	BC fault type declaration	
	FTCA	CA fault type declaration	
	FTSE	Fault Type selection logic enabled	
60	87L	ORed combination of 87LA, 87LB, 87LC, 87L2, and 87LG	Testing, Control
	87LA	A-Phase differential trip output	
	87LB	B-Phase differential trip output	
	87LC	C-Phase differential trip output	
	87L2	Negative-sequence differential trip output	
	87LG	Zero-sequence differential trip output	
	CHYAL	Status of Channel Y (see *Section 10*)	Alarming
	CHXAL	Status of Channel X (see *Section 10*)	
61	87LOPA	A-Phase differential current enable level detector	Testing, Control
	87LAE	A-Phase differential calculation enable	
	R87LA	A-Phase restraint region detection output	
	CTAA	A-Phase CT alarm level detector	Alarming
	PQ87LA	Protection quality 87LA alarm	
	TRIP87	Line current differential trip logic output asserted	Tripping
	BXYZ2	Negative-sequence CT saturation and outfeed block	Testing, Control
	BXYZG	Zero-sequence CT saturation and outfeed block	
62	87LOPB	B-Phase differential current enable level detector	
	87LBE	B-Phase differential calculation enable	
	R87LB	B-Phase restraint region detection output	
	CTAB	B-Phase CT alarm level detector	Alarming
	PQ87LB	Protection quality 87LB alarm	
	BXYZA	A-phase CT saturation and outfeed block	Testing, Control
	BXYZB	B-phase CT saturation and outfeed block	
	BXYZC	C-phase CT saturation and outfeed block	
63	87LOPC	C-Phase differential current enable level detector	
	87LCE	C-Phase differential calculation enable	
	R87LC	C-Phase restraint region detection output	
	CTAC	C-Phase CT alarm level detector	Alarming
	PQ87LC	Protection quality 87LC alarm	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 16 of 18)

Row	Bit	Definition	Primary Application
	T51PT	Tapped load phase time-overcurrent element T51PT timed out	Tripping
	T50P	Tapped load phase instantaneous overcurrent element above pickup setting T50P	
	T50PT	Delayed definite-time phase-overcurrent element timed out	
64	87LOP2	Negative-sequence current enable level detector	Testing, Control
	87L2E	Negative-sequence differential calculation enable	
	R87L2	Negative-sequence restraint region detection output	
	B87L2	Extended 87L2 block	
	PQ87L2	Protection quality 87L2 alarm	Alarming
	T51QT	Tapped load negative-sequence time-overcurrent element T51QT timed out	Tripping
	T50Q	Tapped load negative-sequence instantaneous overcurrent element above pickup setting T50QP	
	T50QT	Delayed definite-time negative-sequence overcurrent element timed out	
65	87LOPG	Zero-sequence current enable level detector	Testing, Control
	87LGE	Zero-sequence differential calculation enable	
	R87LG	Zero-sequence restraint region detection output	
	B87LG	Extended 87LG block	
	PQ87LG	Protection quality 87LG alarm	Alarming
	T51GT	Tapped load residual time-overcurrent element T51GT timed out	Tripping
	T50G	Tapped load residual instantaneous overcurrent element above pickup setting T50GP	
	T50GT	Delayed definite-time residual overcurrent element timed out	
66	RDTY	Differential Channel Y receive direct trip	
	TDTY	Differential Channel Y transmit direct trip	
	TESTY	Differential Channel Y in test mode (see *Section 10*)	Testing
	3POY	Differential Channel Y receive three-pole open	
	RDTX	Differential Channel X receive direct trip	Tripping
	TDTX	Differential Channel X transmit direct trip	
	TESTX	Differential Channel X in test mode (see *Section 10*)	Testing
	3POX	Differential Channel X receive three-pole open	
67	R4X	Received Channel X bit 4 (see *Section 10*)	Control
	R3X	Received Channel X bit 3 (see *Section 10*)	
	R2X	Received Channel X bit 2 (see *Section 10*)	
	R1X	Received Channel X bit 1 (see *Section 10*)	
	T4X	Transmitted Channel X bit 4 (see *Section 10*)	
	T3X	Transmitted Channel X bit 3 (see *Section 10*)	
	T2X	Transmitted Channel X bit 2 (see *Section 10*)	
	T1X	Transmitted Channel X bit 1 (see *Section 10*)	
68	R4Y	Received Channel Y bit 4 (see *Section 10*)	
	R3Y	Received Channel Y bit 3 (see *Section 10*)	
	R2Y	Received Channel Y bit 2 (see *Section 10*)	
	R1Y	Received Channel Y bit 1 (see *Section 10*)	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 17 of 18)

Row	Bit	Definition	Primary Application
	T4Y	Transmitted Channel Y bit 4 (see *Section 10*)	
	T3Y	Transmitted Channel Y bit 3 (see *Section 10*)	
	T2Y	Transmitted Channel Y bit 2 (see *Section 10*)	
	T1Y	Transmitted Channel Y bit 1 (see *Section 10*)	
69	DBADY	One-way delay on Channel Y exceeds setting DBADYP (see *Section 10*)	Alarming, Testing
	AVAY	Channel Y unavailability exceeds setting AVAYP (see *Section 10*)	
	RBADY	Channel Y dropout exceeds setting RBADYP (see *Section 10*)	
	ROKY	Channel Y instantaneous receive status (see *Section 10*)	
	DBADX	One-way delay on Channel X exceeds setting DBADXP (see *Section 10*)	
	AVAX	Channel X unavailability exceeds setting AVAXP (see *Section 10*)	
	RBADX	Channel X dropout exceeds setting RBADXP (see *Section 10*)	
	ROKX	Channel X instantaneous receive status (see *Section 10*)	
70	50LA	Local A-phase overcurrent element output	Testing
	50RA	Remote A-phase overcurrent element output	
	50LB	Local B-phase overcurrent element output	
	50RB	Remote B-phase overcurrent element output	
	50LC	Local C-phase overcurrent element output	
	50RC	Remote C-phase overcurrent element output	
	50L2	Local 3I2 overcurrent element output	
	50R2	Remote 3I2 overcurrent element output	
71	50LG	Local 3I0 overcurrent element output	
	50RG	Remote 3I0 overcurrent element output	
	T51P	Tapped load phase time-overcurrent pickup	
	T51PR	Tapped load phase time-overcurrent reset	
	T51G	Tapped load ground time-overcurrent pickup	
	T51GR	Tapped load ground time-overcurrent reset	
	T51Q	Tapped load negative-sequence time-overcurrent pickup	
	T51QR	Tapped load negative-sequence time-overcurrent reset	
72	87L2T	Negative-sequence difference time-overcurrent time-out	
	87LGT	Zero-sequence difference time-overcurrent time-out	
	P87L2	Negative-sequence difference time-overcurrent pickup	
	P87LG	Zero-sequence difference time-overcurrent pickup	
	TRPA87	A-phase differential trip output (active when APP = 87LSP)	Tripping
	TRPB87	B-phase differential trip output (active when APP = 87LSP)	
	TRPC87	C-phase differential trip output (active when APP = 87LSP)	
	TRP3P87	Three-pole differential trip output (active when APP = 87LSP)	

Table 9.6 Relay Word Bit Definitions for the SEL-311L (Sheet 18 of 18)

Row	Bit	Definition	Primary Application
73	CTALA	Aϕ CT Alarm	
	CTALB	Bϕ CT Alarm	
	CTALC	Cϕ CT Alarm	
	CTFLG	CT Alarm (any phase)	
	LCTFLG	Local CT Alarm (any phase)	
	P5SEL	Asserts when Port 5 is selected	
	P6SEL	Asserts when Port 6 is selected	
	LNKFAIL	Asserts when the active Ethernet port is down	

[a] See Section 4: Protection Functions for special instructions on setting negative-sequence overcurrent elements.

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

The SEL-311L has two identifier labels:

- the Relay Identifier (RID)

  The Relay Identifier is typically used to identify the relay or the type of protection scheme.

- the Terminal Identifier (TID)

  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

Phase and polarizing current transformer ratios are set independently. CTR_X and CTR_Y may be set differently than CTR.

Line Settings (Only Applicable if Potentials Are Available)

Line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG are used in distance relaying, fault locator (see *Fault Location on page 12.6*) and in automatically making directional element settings Z2F, Z2R, Z0F, and Z0R (see *Settings Made Automatically on page 4.79*). A corresponding line length setting (LL) is also used in the fault locator.

The line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG are set in Ω secondary. To convert line impedance (Ω primary) 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 (wye-connected)

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 the same length of line is measured in kilometers rather than miles, then enter:

LL = **24.14 (kilometers)**

Enable Settings

The Enable settings (E87L–EBMON) control the setting subgroups that follow. For example, setting EBMON = Y will enable the breaker monitor settings that immediately follow it. Hence, the Enable settings are used to limit the number of settings that need to be made.

Other System Parameters

The Global settings NFREQ and PHROT allow you to configure the SEL-311L 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.

Application Settings

Application settings are available to reduce the number of settings to be made for applications that may not require the full features of the SEL-311L.

By setting APP = 311L, all the settings are shown. If APP is set equal to 87L, 87L21, or 87L21P, then a reduced group of settings is selected. *Section 14: Application Settings for SEL-311L Relays* contains the settings sheets for APP = 87L, 87L21, 87L21P, and 87LSP. The following list contains summaries for each APP setting.

- 87L
  - Basic line current differential and overcurrent backup, including tapped load coordination.
  - All settings related to elements requiring potentials applied to the relay are hidden.
  - Some SELOGIC control equations, programmable displays, and advanced functions are also hidden.
  - MIRRORED BITS communications are enabled.
- 87L21
  - Includes all of the elements of the 87L application setting as well as three zones of distance protection.
  - SELOGIC control equations and programmable display points are also enabled.
- 87L21P
  - Includes all the elements of the 87L21 application setting plus communications-assisted tripping schemes.
- 87LSP
  - Includes all the elements and settings available in the SEL-311L application plus additional elements and settings that support single-pole line current differential protection and single-pole Zone1 backup distance protection.

NOTE: Application 87LSP is only available in the SEL-311L-7.

Settings Example: 230 kV Transmission Line With Tapped Load

Use the SEL-311L to protect a transmission line with transformer tapped load. *Figure 9.11* shows a 230 kV transmission line with SEL-311L protection at Stations S and R. A tap midway between Stations S and R supplies power to a large industrial load. This example explains the calculation of settings for the SEL-311L at Station S that protects the 230 kV circuit between substations S, R, and the transformer bank at bus T. Note that this same scheme may be used on lower voltage applications such as 69 kV.

The primary protection is differential overcurrent with tapped load total overcurrent elements (T50/T51). High-speed differential elements (87L) provide torque control for the tapped load elements; T50/T51 elements are blocked until the corresponding 87L element asserts. Backup step distance and single-ended time-overcurrent elements operate for faults on the 230 kV line. Zone 1 provides instantaneous protection while Zone 2 provides torque control for the phase time-overcurrent element. This time overcurrent is coordinated with the load transformer protection. Zone 3 provides the overreaching backup protection usually provided by Zone 2.

In this example, maximize line security (trip saving) while still providing adequate line protection. Backup overcurrent settings provide protection for faults on the 230 kV system only. The differential elements ensure that the fault is in the protected line or on the tap. Tapped load overcurrent elements are set to coordinate with primary protection on the tap transformers. To achieve high-speed tripping with T50 elements over the entire protected line, accept a small risk of tripping for a fault between the transformer breakers and bushings. The 230 kV delta/13.8 kV grounded wye transformers on the tap ensure that zero-sequence quantities seen by the SEL-311L are due to transmission system faults. This example assumes that the transformer secondaries are not paralleled for normal operation.

To avoid the compromises that must be made with tapped lines, such as loss of sensitivity and delayed tripping, install a third SEL-311L and communications at the tap point even if no breaker is present. A third SEL-311L provides high-speed, high-sensitivity, protection of the transmission line without overreaching for faults on the tap. This example considers two-terminal protection only.

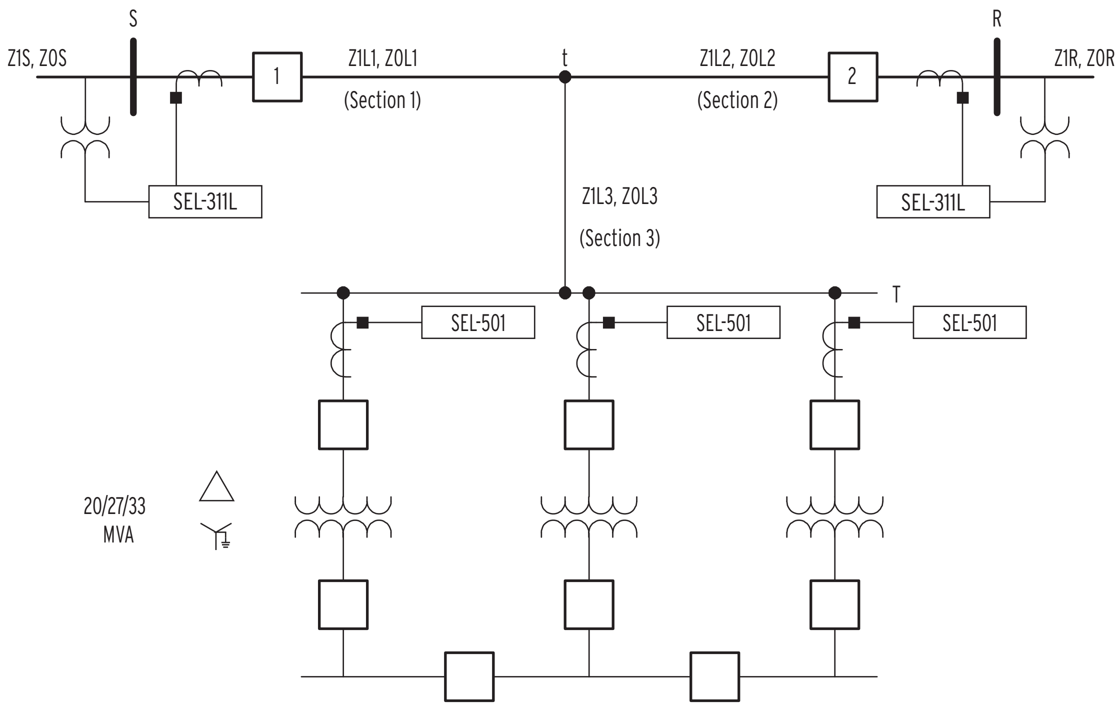


Figure 9.11 230 kV Model Power System

Table 9.7 Model Power System Data (Sheet 1 of 2)

Parameter	Primary	Secondary
HV system line-to-line voltage	230 kV	
Transformer secondary line-to-line voltage	13.8 kV	
Nominal frequency	60 Hz	
Line lengths		
➤ S-t (Section 1)	10 miles	
➤ t-R (Section 2)	10 miles	
➤ t-T (Section 3)	15 miles	
Line impedances		
➤ Z1L1 = Z1L2	5.93 Ω ∠84.70° primary	0.71 Ω ∠84.70° secondary
➤ Z0L1 = Z0L2	19.33 Ω ∠73.00° primary	2.32 Ω ∠73.00° secondary
➤ Z1L3	8.90 Ω ∠84.70° primary	1.07 Ω ∠84.70° secondary
➤ Z0L3	28.00 Ω ∠73.00° primary	3.36 Ω ∠73.00° secondary
Transformer rating (each)	230 kV delta / 13.8 kV wye 20 / 27 /33 MVA	
Transformer impedance	211.6 Ω primary (8%, 20 MVA, 230 kV)	25.39 Ω secondary
Source S impedances Z1S = Z0S	10 Ω ∠87° primary	1.20 Ω ∠87° secondary
Source R impedances Z1R = Z0R	35 Ω ∠87° primary	4.20 Ω ∠87° secondary
PTR (potential transformer ratio)	230 kV : 115 V = 2000 : 1	
CTR (current transformer ratio)	1200 : 5 = 240 : 1	
CT burden class at station S and R	C800	
CT burden at station S and R	1.0 Ω	
Phase rotation	ABC	
87L Communications	Single Channel	

Table 9.7 Model Power System Data (Sheet 2 of 2)

Parameter	Primary	Secondary
Line charging current	16 A primary	
Maximum forward load at station S, including tapped load	1100 A	
Maximum reverse load at station S	600 A	
Maximum tapped load (firm)	200 A (79.7 MVA)	
Maximum load unbalance	5%	

Convert the impedances to secondary Ω as follows:

$$k = \frac{CTR}{PTR} = \frac{240}{2000} = 0.12$$

Equation 9.1

$$Z_{secondary} = k \bullet Z_{primary}$$

Equation 9.2

For example:

$$\begin{aligned} Z_{1L1(secondary)} &= Z_{1L2(secondary)} \\ &= k \bullet Z_{1L1(primary)} \\ &= 0.12 \bullet (5.93\ \Omega\ \angle 84.7°) \\ &= 0.71\ \Omega\ \angle 84.7° \end{aligned}$$

Equation 9.3

Perform a system fault study with the transformers at base load during the study. The load at Station S is 104 A at –25.1 degrees. Total load on the tap is 144.4 A at –25.3 degrees.

Table 9.8 Primary Fault Study Data, as Seen by Terminal S (Differential Current in Parentheses) (Sheet 1 of 2)

Fault Location	Fault Type	I_A		I_B		I_C		I_R		Zf Apparent Impedance at Station S	
		A	∠O	A	∠O	A	∠O	A	∠O	A	∠O
R	ABC	6081.0 (9874.6	–85.6 –86.2)	6081.0 (9874.6	154.4 153.8)	6081.0 (9874.6	34.4 33.8)	0 (0)		11.8	84.5
	AG	4654.9 (8442.2	–82.2 –84.4)	491.4 (131.2	89.7 –134.1)	659.1 (132.9	83.1 83.3)	3538.9 (8397.3	–78.3 –84.9)	11.8	84.3
	BC	103.9 (144.6	–25.1 –25.3)	5311.6 (8614.9	–175.9 –176.4)	5221.1 (8488.6	4.7 4.1)	0 (0)		11.8	84.5
	BCG	525.9 (118.6	–87 –25.9)	5769.9 (9501.4	166.3 161.0)	5353.3 (9120.6	23.9 27.6)	3081.3 (7311.9	102.8 96.3)	11.8	84.5
T[a]	ABC	4694.1 (6521	–85.4 –85.6)	4694.1 (6521	154.6 154.4)	4694.1 (6521	34.6 34.4)	0 (0)		18.3	84.6
	AG	3194.1 (4584.6	–79.4 –80)	70.3 (128.3	144.5 –132.9)	204.7 (133.6	84.6 81.6)	2946.8 (4535.5	–79.2 –80.8)	18.3	83.8
	BC	103.9 (144.4	–25.1 –25.3)	4110.4 (5710.2	–175.8 –176)	4020.1 (5584.8	4.9 4.8)	0 (0)		18.3	84.6
	BCG	143.5 (119.1	–58.0 –26.9)	4428.6 (6174.0	169.2 167.9)	4036.3 (5651.7	21.5 22.4)	2252.4 (3466.9	103.3 101.8)	18.3	84.6

Table 9.8 Primary Fault Study Data, as Seen by Terminal S (Differential Current in Parentheses) (Sheet 2 of 2)

Fault Location	Fault Type	I_A		I_B		I_C		I_R		Zf Apparent Impedance at Station S	
		A	∠O	A	∠O	A	∠O	A	∠O	A	∠O
T secondary	ABC	439.6 (609.8	–81.9 –82.7)	439.6 (609.8	158.1 157.3)	439.6 (609.8	38.1 37.3)	0 (0)		292.1	81.8
	AG	239.4 (329.8	–98.9 –100.3)	103.9 (144.4	–145.1 –145.3)	320.2 (443.9	67.6 66.4)	0 (0)		404.0	76.4
	BC	299.2 (415.8	–31.4 –32)	439.6 (609.8	158.1 157.3)	152.7 (210.6	–3.1 –4.1)	0 (0)		303.8	54.8
	BCG	317.7 (436.9	–53.5 –54.4)	439.6 (609.8	158.1 157.3)	237.2 (330.9	22.6 21.2)	0 (0)		306.0	64.4

[a] As seen by Station S, faults at Station T with Station R open produce approximately 90% of Station R fault current.

Settings and Descriptions for This Example

The following information shows you how to complete the settings for this application.

Identifier Labels and Configuration Settings (See Settings Explanations on page 9.34)

Relay Identifier (30 characters)	RID = SEL-311L 87L
Terminal Identifier (30 characters)	TID = EXAMPLE: BUS S, BREAKER 1
Local Phase (IA, IB, IC) Current Transformer Ratio (1–6000)	CTR = 240
Application (87L, 87L21, 87L21P, 311L)	APP = 311L

APP = 311L displays all available settings in the relay. This example requires settings that are not available in the special application settings.

Line Current Differential Configuration Settings

Relay operating mode (2, 3R, N)	E87L = 2

The relay has one differential channel. Set E87L = 2 for a two-terminal line.

High-speed tripping (1–6, N)	EHST = N

High-speed tripping is not needed with torque-controlled tapped load overcurrent elements.

Enable high-speed direct transfer trip (Y, N)	EHSDTT = N
Enable disturbance detect (Y, N)	EDD = N

Set EHSDTT = N. The 87L elements are used only for tapped load element torque control. High-speed direct transfer trip is not required. Disturbance detector supervision ensures the relay detects a change in the local currents before allowing a trip because of 87L element assertion. Because the 87L elements are used for torque control in this example, disturbance detect is not required. Set EDD = N.

Tapped-load coordination (Y, N)	ETAP = Y

Set ETAP = Y for protection of a line with a tapped load.

Enable Open CT Logic (Y, N)	EOCTL = N

Set EOCTL = Y to enable open-CT detection.

CTR at terminal connected to Channel X (1–6000)	CTR_X = 240

Enter the current transformer ratio used in the SEL-311L at Station R.

Minimum Difference Current Enable Level Settings (E87L = 2 or 3)

Phase 87L (OFF, 1.00–10.00 A secondary)	87LPP = 1.00

In an 87L protection application, set 87LPP above line charging current and maximum load current. This example uses the 87L elements as torque control for the tapped load elements. Torque-control element settings can be more sensitive than protection settings.

Set 87LPP = 1.0 A. With projected tap transformer load of 200 A primary or 0.83 A secondary, the 87L phase element does not assert under steady-state load, but may operate momentarily on cold load pickup.

3I2 Negative-sequence 87L (OFF, 0.50–5.00 A secondary)	87L2P = OFF

Backup protection is provided for faults on the 230 kV system only. Negative-sequence tapped load protection could detect unbalanced faults on the load transformer secondary if required by the application. In this example, set 87L2P = OFF.

Ground 87L (OFF, 0.50–5.00 A secondary)	87LGP = 0.50

The 87LG is used for torque control of the tapped load elements. Verify that 87LG does not assert under normal unbalanced load.

$$\frac{[(\text{Max. Tap Load}) \bullet (\text{Max. unbalance}) \bullet 1.25 \text{ margin}]}{\text{CTR}}$$

$$= 200 \bullet 0.05 \bullet \frac{1.25}{240} = 0.05\,\text{A}$$

Equation 9.4

87LG element logic requires 5 percent unbalance to operate. Check element sensitivity when attempting to operate on high resistance faults. In this example, at maximum load = 1100A, 3I0 = 1100 • 0.05 / 240 = 0.23 A for 87LG to operate.

Set 87LGP to its minimum level of 0.50 A.

Phase difference current alarm pickup (0.50–10.00 A secondary)	CTALRM = 0.99

Set this element above maximum tap load plus line charging current to alarm on CT error. Inrush may cause a momentary operation. Add time delay if you wish to avoid nuisance alarms.

$$(\text{Max. Load} + \text{Line Charging}) \bullet \frac{1.1}{\text{CTR}}$$

$$= 216 \bullet \frac{1.1}{240} = 0.99\text{A}$$

Equation 9.5

Restraint Region Characteristic Settings (E87L = 2 or 3)

Outer Radius (2.0–8.0)	87LR = 6.0

87LR and 87LANG are used to set the relay Alpha-Plane characteristic shown in *Figure 3.3*. The default value of 6 is satisfactory for most applications. The setting can be reduced for improved sensitivity or increased for improved security. See *Section 3: Line Current Differential Protection* for application considerations.

Excessive CT saturation will adversely affect differential operation. Calculate the relay burden limit at the highest fault current as follows:

$$Z_B < \frac{7.5V_S}{I_F\left(\frac{X}{R} + 1\right)}$$

$$= \frac{7.5 \bullet 800}{\left(\frac{13279}{240}\right) \bullet (19.1 + 1)} = 5.4$$

Equation 9.6

where:

Z_B is the CT burden (Ω)
I_F is the secondary fault current (A secondary)
X is the system source reactance
R is the system source resistance
13279 is the value for a three-phase fault at Station S in front of Relay 1
V_S is the nominal voltage class of the CT (e.g., 800 for a C800)

Do not exceed this CT burden.

Angle (90°–270°)	87LANG = 195

The default value of 195 is satisfactory for most applications. However, 87LANG may be increased for improved security for cases of severe communication asymmetry or CT saturation.

Tapped-Load Coordinating Overcurrent Element Settings (If ETAP = Y)

Phase element (Y, N)	ETP = Y
Residual ground element (Y, N)	ETG = Y
Negative-sequence element (Y, N)	ETQ = N

Tapped-Load Phase Time-Overcurrent Element Settings (If ETP = Y)

Pickup (OFF, 0.50–16.00 A secondary)	T51PP = 3.33

Set the time-overcurrent phase element (T51PP) to coordinate with tap overcurrent protection. Tapped-load overcurrent elements use differential current, which is the vector sum of Station S and Station R secondary current (e.g., $IA_{Differential} = IA_{Station\ R} + IA_{Station\ S}$). This example uses four times the maximum load to overcome cold load pickup:

$$\text{Pickup} = \text{Max. Load} \bullet \frac{4.0}{\text{CTR}} = 200\text{A} \bullet \frac{4.0}{240} = 3.33$$

Equation 9.7

Select curve and time dial to coordinate with the tap protection devices on the transformer HV side.

Curve (U1–U5; C1–C5)	T51PC = U3
Time dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)	T51PTD = 1.00
Electromechanical reset delay (Y, N)	T51PRS = Y

Use consistent overcurrent relay reset methods to avoid misoperation. All relays in this example use electromechanical reset emulation.

Tapped-Load Phase Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	T50PP = 13.36

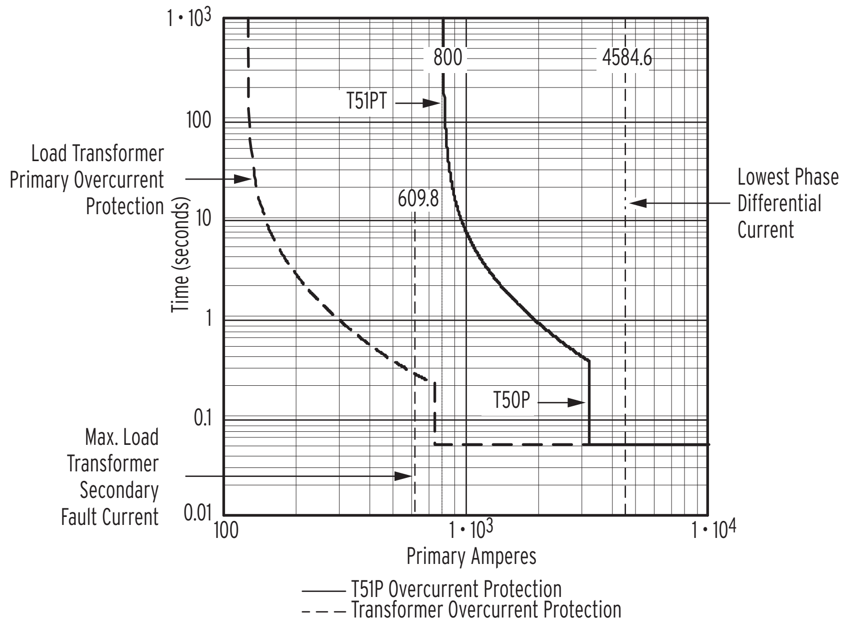
Set the tapped-load phase instantaneous overcurrent element to quickly clear a line fault up to the transformer high side. While this setting technically violates the “trip saving” philosophy because the relay can operate for a fault between the transformer and breaker, this setting is a reasonable compromise. The difference in exposure is about 30 feet of cable versus miles of transmission line. A simultaneous operation of the transformer breaker and the line breakers is possible. Station T is re-energized after reclosing.

Set the pickup to look into the transformer high side with a setting midway between the lowest phase differential current during a fault at Station T and the largest phase differential current at Station T during a fault on the low voltage side of the load transformers. Note that T50 never operates for a transformer secondary fault.

$$\text{Pickup} = \frac{(\text{Station T HV fault} + \text{Station T LV fault})}{2 \bullet \text{CTR}}$$

$$= \frac{(4584.6 + 609.8 \bullet 3.0)}{2 \bullet 240} = 13.36\text{A}$$

Equation 9.8



Time delay (OFF, 0.00–16000.00 cycles)	T50PD = 0.00

No time delay is needed because the tapped load phase instantaneous overcurrent element does not see faults on the load transformer secondary.

Tapped-Load Residual-Ground Time-Overcurrent Element Settings (If ETG = Y)

Pickup (OFF, 0.50–16.00 A secondary)	T51GP = 2.0

Because the transformers are connected delta-wye and T51G is a differential element, T51G only asserts for faults on the transmission line.

Set the T51GP = 2.0 A to detect a high resistance ground fault on the transmission line.

(V secondary / T51GP) • (PTR / CTR)
= (66.4 / 2.0) • (2000 / 240)
= 276.7 Ω Primary

Curve (U1–U5; C1–C5)	T51GC = U3
Time dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)	T51GTD = 1.00
Electromechanical reset delay (Y, N)	T51GRS = Y

Tapped-Load Residual-Ground Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	T50GP = 7.2

Set the tapped-load ground overcurrent element with differential current. Because the transformers are connected delta-wye, and T51G is a differential element, T51G will only assert for faults on the transmission line. Use a setting of 50 percent of minimum residual current for a fault at Station T for this example.

3466.9 A • 0.50 / 240 = 7.22

While this setting technically violates the "trip saving" philosophy, because the relay can operate on faults between the transformer and breaker, this setting is a reasonable compromise.

Time delay (OFF, 0.00–16000.00 cycles)	T50GD = 0.00

Backup Protection Transformer Ratio Settings

Polarizing (IPOL) Current Transformer Ratio (1–6000)	CTRP = 200

If a zero-sequence polarizing CT is available for directional control of the ground relays, enter the CTR and include I in the ORDER setting (e.g., ORDER = QVI). This example does not have a polarizing current transformer. The setting may remain at the default value.

Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00)	PTR = 2000
Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00)	PTRS = 2000

Set the potential transformer ratio PTR = 2000. The synchronizing PTR setting PTRS is not used. The setting may remain at the default value.

Line Parameter Settings (See Settings Explanations on page 9.34)

Positive-sequence line impedance magnitude 0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.})	Z1MAG = 1.42
Positive-sequence line impedance angle (5.00–90.00 degrees)	Z1ANG = 84.7

Set line impedances to the shortest protected line section S to R to ensure that the relay sets the Z2R and Z0R thresholds correctly when E32 = AUTO.

Zero-sequence line impedance magnitude (0.05–255.00 Ω secondary {5 A nom.}; (0.25–1275.00 Ω secondary {1 A nom.})	Z0MAG = 4.64
Zero-sequence line impedance angle (5.00–90.00 degrees)	Z0ANG = 73.00
Line length (0.10–999.00, unitless)	LL = 20.00

Enter the secondary line parameters for the line section S to R.

Distance Element Zones Enable Settings

Mho phase distance element zones (N, 1–4, 1C–4C) (see *Figure 4.1–Figure 4.3*)	E21P = 3
Mho ground distance element zones (N, 1–4) (see *Figure 4.4–Figure 4.6*)	E21MG = 3
Quadrilateral ground distance element zones (N, 1–4) (see *Figure 4.7–Figure 4.9*)	E21XG = N

Zone 1 elements underreach with no intentional time delay. Zone 2 phase is an overreaching element used to torque control 51P. Note, Zone 2 phase distance must reach to Station T in the presence of infeed. This reach requires a setting that may overreach the adjacent Zone 1 and cause miscoordination if Zone 2 is allowed to trip after a definite time. Zone 3 overreaching time-delayed elements detect faults beyond Station R and function as a traditional Zone 2 time-delayed element.

Instantaneous/Definite-Time Overcurrent Enable Settings

Phase element levels (N, 1–3) (see *Figure 4.19*)	E50P = N
Residual ground element levels (N, 1–4) (see *Figure 4.22*)	E50G = N
Negative-sequence element levels (N, 1–4) (see *Figure 4.23*)	E50Q = N

Instantaneous overcurrent elements are not required in this application.

Time-Overcurrent Enable Settings

Phase element (Y, N) (see *Figure 4.24*)	E51P = Y
Residual ground element (Y, N) (see *Figure 4.25*)	E51G= Y
Negative-sequence element (Y, N) (see *Figure 4.26*)	E51Q= N

Use 51PT and 51GT to provide backup protection for the protected 230 kV line.

Other Enable Settings

Directional control (Y, AUTO) (see *Directional Control Settings on page 4.79*)	E32 = AUTO

Enable Best Choice Ground Directional Element Logic with E32 = AUTO. This automatically calculates and sets Z2F, Z2R, 50QFP, 50QRP, a2, k2, 50GRP, a0, Z0F, and Z0R. These settings must be made manually if E32 = Y.

Out-of-Step (Y, N) (see *Figure 4.17*)	EOOS = N

Out-of-step is not used in this example. Set EOOS = N to disable out-of-step elements.

Load encroachment (Y, N) (see *Figure 4.38*)	ELOAD = N

Load encroachment is not required in this example.

At maximum load, Zload = (67 / 4.58) = 14.6 Ω, which is much larger than distance element settings.

Set ELOAD = N to disable load-encroachment elements.

Switch-onto-fault (Y, N) (see *Figure 5.7*)	ESOTF = N

The SOTF logic permits tripping by specified protection elements for a definable time after circuit breaker(s) close. Specify these elements in the TRSOTF SELOGIC control equation.

Apply SOTF when using line-side relaying potentials. Because this example uses bus-side relaying potentials, set ESOTF = N.

Voltage elements (Y, N) (see *Figure 4.27*, *Figure 4.28*, *Figure 4.29*, and *Figure 4.30*)	EVOLT = N

Voltage elements are not enabled in this example. Set EVOLT = N.

Synchronism check (Y, N) (see *Figure 4.30* and *Figure 4.31*)	E25 = N

Synchronism-check elements are not enabled in this example. Set E25 = N.

Frequency elements (N, 1–6)	E81 = N

Frequency elements are not enabled in this example. Set E81 = N.

Fault location (Y, N) (see *Table 12.1* and *Fault Location on page 12.6*)	EFLOC = Y

Fault location is enabled in this example. Set EFLOC = Y.

Loss-of-potential (Y, Y1, N) (see *Figure 4.35*)	ELOP = Y1

Set ELOP = Y1 to disable all voltage-polarized directional overcurrent elements and distance elements during a loss-of-potential.

Enable busbar PT LOP logic (Y, N) (see *Figure 4.36*)	EBBPT = N

Busbar PT LOP logic is not enabled in this example. Set EBBPT = N.

Communications-assisted trip scheme (N, DCB, POTT, DCUB1, DCUB2) (see *Communications-Assisted Trip Logic—General Overview on page 5.18*)	ECOMM = N
Reclosures (N, 1–4) (see *Reclosing Relay on page 6.10*)	E79 = 1

Use single shot reclosing in this example. Set E79 = 1.

Zone 1 extension (Y, N) (see *Figure 4.14*)	EZ1EXT = N

Zone 1 extension is not used. Set EZ1EXT = N.

CCVT transient detection (Y, N) (see *Figure 4.37*)	ECCVT = Y

CCVT transients can cause Zone 1 distance elements to overreach. If CCVT transient blocking is enabled and the relay detects a Source Impedance Ratio (SIR) greater than five during a fault, the relay delays Zone 1 tripping for as many as 1.5 cycles, allowing the CCVT to stabilize. Other settings are not required. The relay automatically adapts to different system SIR conditions and determines whether the 1.5-cycle delay is needed. In this example, the CCVTs use active ferroresonance suppression. Set ECCVT = Y.

SELOGIC control equation Variable Timers (N, 1–16) (see *Figure 7.25* and *Figure 7.26*)	ESV = N

Set ESV = N. No SELOGIC variables are required.

SELOGIC Latch Bits (N, 1–16)	ELAT = 16

Set ELAT = N. No latches are required.

SELOGIC Display Points (N, 1–16)	EDP = 16

Use two display points in this example. Set EDP = 2.

Demand Metering (THM = Thermal; ROL = Rolling) (see *Figure 8.3*)	EDEM = THM
Advanced settings (Y, N)	EADVS = N

Selecting Advanced Settings = N allows the relay to automatically calculate 50PP2, 50PP3, 50PP4, XGPOL, TANG, 50L2, 50L3, 50L4, 50GZ2, 50GZ3, 50GZ4, k0M, k0A, X1B6, X1B5, R1L6, R1L5, and UBOSBF elements.

Mho Phase Distance Elements

Zone 1 OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} (see *Figure 4.4*)	Z1P = 1.13

Set Z1P to 75–90 percent of distance from Station S to Station R.

$$Z1P = Z1MAG \bullet 80\% = 1.41\ \Omega \bullet 0.8 = 1.13\ \Omega$$

Zone 2 OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} (see *Figure 4.5*)	Z2P = 2.75

The Zone 2 phase distance element must detect faults along the entire length of the protected HV circuit including the transformer high voltage terminals at Station T. Find the apparent distance in secondary Ω as "seen" by Bus S with a fault at the high voltage terminals of the transformer. Bus R should be in service to account for infeed.

Set Zone 2 phase distance equal to the fault study phase-to-phase impedance at station T times a margin of 125 percent.

$$Z2P = 18.3\ \Omega \bullet (CTR / PTR) \bullet 1.25 = 2.75\ \Omega$$

This element torque controls the phase time-overcurrent element 51PT.

Zone 3 OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} (see *Figure 4.6*)	Z3P = 1.76

Set Zone 3 to overreach Station R without reaching beyond Zone 1 protection of the next line. In this example, set Z3P to 125 percent • Z1MAG.

$$Z3P = Z1MAG \bullet 1.25 = 1.41\ \Omega \bullet 1.25 = 1.76\ \Omega$$

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.} (see *Figure 4.4*)	50PP1 = 0.5

Set 50PP1 to its minimum value when LOP logic is enabled.

Mho Ground Distance Elements

Zone 1 OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} (see *Figure 4.7*)	Z1MG = 1.13

Set Z1MG to 75–90 percent of distance from Station S to Station R.

$$Z1MG = Z1MAG \bullet 80\% = 1.41\ \Omega \bullet 0.8 = 1.13\ \Omega$$

Zone 2 OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} (see *Figure 4.8*)	Z2MG = 2.75

Zone 2 ground distance protection must detect faults along the entire length of the protected HV circuit as far as the transformer high voltage terminals at Station T. Find the apparent distance in secondary Ω as “seen” by Bus S with a fault at the high voltage terminals of the transformer. Bus R should be in service to account for infeed.

Set Zone 2 ground distance reach equal to the fault study phase-ground impedance (AG) at station T times a margin of 125 percent.

$$Z2MG = 18.3\ \Omega \bullet (CTR / PTR) \bullet 1.25 = 2.75\ \Omega$$

This element will be used to torque control the phase time-overcurrent element 51GT.

Zone 3 OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} (see *Figure 4.9*)	Z3MG = 1.76

Set Z3MG to the same values as Z3P.

Quadrilateral and Mho Ground Distance Fault Detector Settings

Zone 1 phase current FD 0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} (see *Figure 4.7* and *Figure 4.10*)	50L1 = 0.5
Zone 1 residual current FD 0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} (see *Figure 4.7* and *Figure 4.10*)	50GZ1 = 0.5

Set 50L1 and 50GZ1 to their minimum values when LOP logic is enabled.

Zero-Sequence Compensation (ZSC) Settings (See Ground Distance Elements on page 4.11)

Zone 1 ZSC factor magnitude (0.000–6.000 unitless)	k0M1 = 0.766
Zone 1 ZSC factor angle (–180.0° to +180.0°)	k0A1 = –16.74

Zero-sequence current compensation adjusts the apparent reach of a ground distance element so that it is equal to the phase element reach. Ground distance elements and phase distance elements can then be set to the same values. Calculate Zone 1 zero-sequence current compensation factor with either the primary or secondary values of the positive-sequence and zero-sequence line impedance.

$$\begin{aligned} k01 &= \frac{Z_{0L1} - Z_{1L1}}{3 \bullet Z_{1L1}} \\ &= \frac{4.64\angle 73.00° - 1.42\angle 84.7°}{3 \bullet 1.42\angle 84.7°} \\ &= 0.766\angle -16.74° \end{aligned}$$

Equation 9.9

Mho Phase Distance Element Time Delays (See Figure 4.15)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	Z1PD = OFF
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	Z2PD = OFF
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	Z3PD = OFF

Use common time delays to reduce the likelihood of a timer reset during an evolving fault. Separate phase and ground time delays are set OFF.

Quadrilateral and Mho Ground Distance Element Time Delays (See Figure 4.15)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	Z1GD = OFF
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	Z2GD = OFF
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	Z3GD = OFF

Common Phase/Ground Distance Element Time Delay (See Figure 4.15)

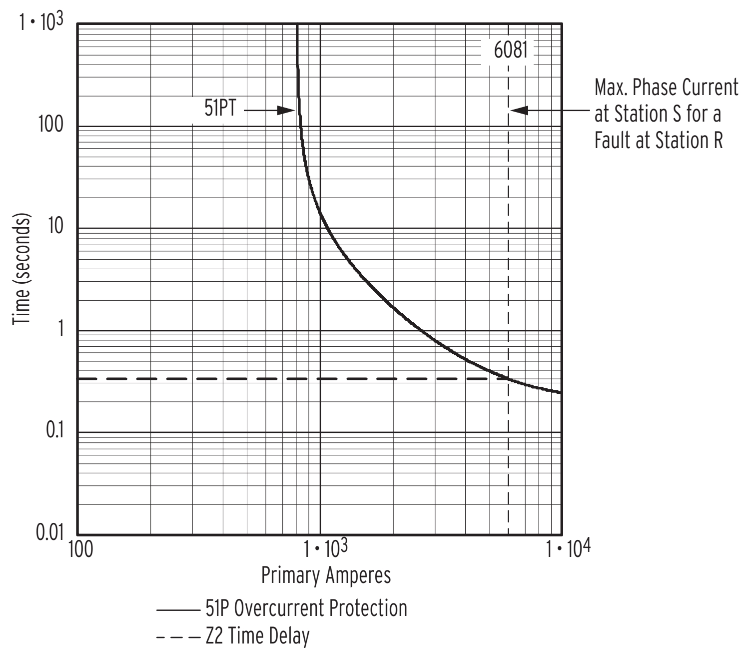
Zone 1 time delay (OFF, 0.00–16000.00 cycles)	Z1D = OFF
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	Z2D = OFF
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	Z3D = 20.0

Phase Time-Overcurrent Element (See Figure 4.24)

Pickup OFF, 0.25–16.00 A secondary {5 A nom.}; OFF, 0.05–3.20 A secondary {1 A nom.}	51PP = 3.33
Curve (U1–U5, C1–C5) (see *Figure 9.1–Figure 9.10*)	51PC = U3
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)	51PTD = 2.00
Electromechanical Reset (Y, N)	51PRS = Y

See SELOGIC torque-control equation T51PTC.

Set 51PP to the same value as T51PP. Set 51PC to the same curve as T51PC. Set 51PTD so that the maximum current seen by Station S for a fault at Station R (6081 A) asserts 51PT in the Zone 3 delay time of 20 cycles.

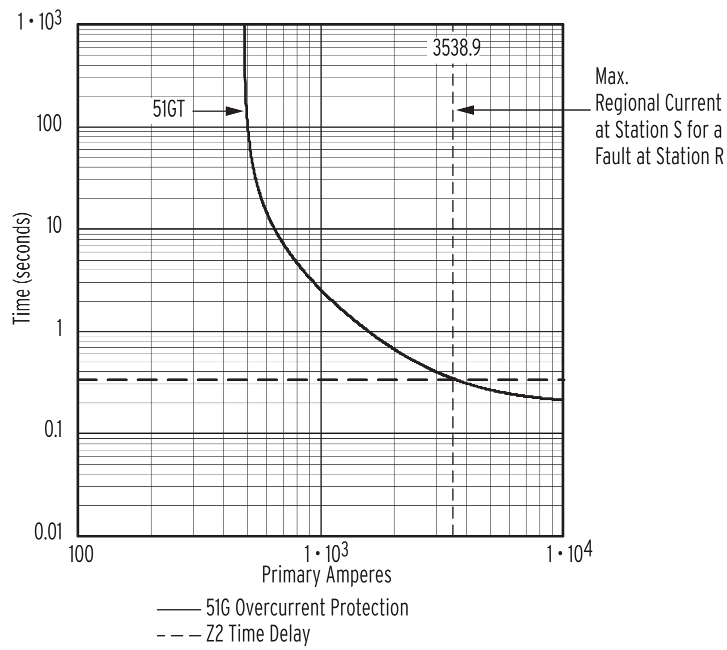


Residual-Ground Time-Overcurrent Element (See Figure 4.25)

Pickup (OFF, 0.25–16.00 A secondary {5 A nom.}; OFF, 0.05–3.20 A secondary {1 A nom.}	51GP = 2.0
Curve (U1–U5, C1–C5) (see *Figure 9.1–Figure 9.10*)	51GC = U3
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)	51GTD = 2.0
Electromechanical Reset (Y, N)	51GRS = Y

See SELOGIC torque-control equation T51GTC.

Set 51GP to the same value as T51GP. Set 51GC to the same curve as T51GC. Set 51GTD so that the maximum residual fault current seen by Station S for a fault at Station R (3538.9 A) asserts 51GT in the Zone 3 delay time of 20 cycles.



Zone/Level 3 Directional Control

Zone/Level 3 direction: Forward, Reverse (F, R)	DIR3 = F

Directional Elements (See Directional Control Settings on page 4.79)

Make setting ORDER if preceding enable setting E32 = Y or AUTO.

Ground directional element priority: combination of Q, V, or I	ORDER = QV

Reclosing Relay (See Table 6.2 and Table 6.4)

Make the following settings if preceding enable setting E79 = 1–4.

Open interval 1 time 0.00–999999.00 cycles in 0.25-cycle steps	79OI1 = 17.17
Reset time from reclose cycle 0.00–999999.00 cycles in 0.25-cycle steps	79RSD = 1800
Reset time from lockout 0.00–999999.00 cycles in 0.25-cycle steps	79RSLD = 1800
Reclose supervision time limit OFF, 0.00–999999.00 cycles in 0.25-cycle steps (set 79CLSD = 0.00 for most applications; see *Figure 6.2*)	79CLSD = 0.0

Set 79OI1 to the minimum dead time that will allow the fault arc to extinguish and the arc path to cool sufficiently for the reclose to be successful. A common estimate (Power System Protection by P. M. Anderson; IEEE Press, 1999, pg 880) is:

$$\begin{aligned} T_{MIN} &= 10.5 + \frac{V_{LL}(kV)}{34.5} \\ &= \left(10.5 + \frac{230}{34.5}\right) \\ &= 17.17 \text{ cycles} \end{aligned}$$

Equation 9.10

Set both reset timers to 30 seconds, or 1800 cycles.

Demand Metering Settings (See Figure 8.3 and Figure 8.5)

Time constant (5, 10, 15, 30, 60 minutes)	DMTC = 60
Phase pickup OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}	PDEMP = OFF
Residual ground pickup OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}	GDEMP = OFF
Negative-sequence pickup OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}	QDEMP = OFF

Demand metering elements are not used in this example. The settings are left at default values.

Other Settings

Minimum trip duration time 2.00–16000.00 cycles in 0.25-cycle steps (see *Figure 5.7*)	TDURD = 9.00
Close failure time delay OFF, 0.00–16000.00 cycles in 0.25-cycle steps (see *Figure 6.1*)	CFD = 60.00
Three-pole open time delay 0.00–60.00 cycles in 0.25-cycle steps (usually set for no more than a cycle; see *Figure 5.8*)	3POD = 0.5
Open pole option (52, 27)	OPO = 52

Do not use OPO = 27 in an application that requires 87L elements for tripping. OPO = 27 can compromise logic that manages charging current inrush when a power line is energized.

Load detection phase pickup OFF, 0.25–100.00A {5 A nom.}; 0.05–20.00 A {1 A nom.} (see *Figure 5.7*)	50LP = 0.25

Trip Logic Equations (See Figure 5.1)

Direct trip conditions	TR = M1P + Z1G + M3PT + Z3GT + 51PT + 51GT + T51PT + T50P + T51GT + T50G + OC

Set the unconditional trip equation TR with Zone1 phase and ground distance elements, phase and ground time-overcurrent elements, Zone 3 time-delayed elements, and tapped load differential elements. Zone 1 phase and ground elements provide instantaneous tripping between Stations S and R, but do not cover the entire length of line from tap t to Station T. Phase and ground time-overcurrent elements provide backup coverage for the entire protected line. Zone 3 elements provide overreaching time-delayed tripping between Stations S and R, but do not cover the entire length of line from tap t to Station T. T50P provides instantaneous tripping among Stations S and R, and T. T50G provides instantaneous tripping among Stations S, R, and T. T51PT and T51GT provide time-delayed tripping among Stations S, R, and T.

Direct transfer trip conditions	DTT = 0
Unlatch trip conditions	ULTR = !(50L + 51G)

Close Logic Equations (See Figure 6.1)

Circuit breaker status (used in *Figure 5.7*, also)	52A = IN101

Connect the circuit breaker 52a contact to IN101. See *Section 2: Installation* for examples of breaker status connections.

Close conditions (other than automatic reclosing or **CLOSE** command)	CL = CC
Unlatch close conditions	ULCL = TRIP

See *Unlatch Close on page 6.3*.

Reclosing Relay Equations (See Reclosing Relay on page 6.10)

Reclose initiate	79RI = M1P + Z1G + T50P + T50G

Initiate a reclose for all instantaneous faults on the protected line section.

Reclose initiate supervision	79RIS = 1
Drive-to-lockout	79DTL = !IN102 + OC

Use a switch connected to IN102 to enable reclosing. Drive the recloser to lockout when IN102 (reclose enable) deasserts. Use open command **OC** to block reclosing during a manual breaker trip.

Drive-to-last shot	79DLS = 0
Skip shot	79SKP = 0
Stall open interval timing	79STL = 0
Block reset timing	79BRS = 0
Sequence coordination	79SEQ = 0
Reclose supervision (see *Figure 6.2*)	79CLS = 1

Reclose supervision is normally used with synchronized closing. Set 79CLS = 1 to allow reclosing to proceed after the open interval time-out.

Torque-Control Equations for Time-Overcurrent Elements

Phase element (see *Figure 4.24*)	51PTC = M2P
Residual ground element (see *Figure 4.25*)	51GTC = Z2G

Time-overcurrent elements 51PT and 51GT using Zone 2 distance elements for torque control will operate in the forward direction only.

Torque-Control Equations for Tapped Load Time-Overcurrent Elements

Phase inverse time (see *Figure 3.21*)	T51PTC = 87LA + 87LB + 87LC
Ground inverse time (see *Figure 3.22*)	T51GTC = 87LG
Phase instantaneous (see *Figure 3.18*)	T50PTC = 87LA + 87LB + 87LC
Ground instantaneous (see *Figure 3.19*)	T50GTC = 87LG

Use 87L elements for tapped load torque control for increased security during CT saturation and 87 channel asymmetry.

Output Contact Equations (See Figure 7.27)

Output Contact **OUT101**	OUT101 = TRIP
Output Contact **OUT102**	OUT102 = TRIP
Output Contact **OUT103**	OUT103 = CLOSE
Output Contact **OUT104**	OUT104 = 0
Output Contact **OUT105**	OUT105 = 0
Output Contact **OUT106**	OUT106 = 0
Output Contact **OUT107**	OUT107 = 87HWAL

Output Contact Equations-Differential Board (See Figure 7.28)

Output Contact **OUT201**	OUT201 = 0
Output Contact **OUT202**	OUT202 = 0
Output Contact **OUT203**	OUT203 = 0
Output Contact **OUT204**	OUT204 = 0
Output Contact **OUT205**	OUT205 = 0
Output Contact **OUT206**	OUT206 = 0

Use **OUT201–OUT206** for high-speed, high-current interrupting applications.

Display Point Equations (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

Display Point DP1	DP1 = 52A
Display Point DP2	DP2 = CHXAL

Setting Group Selection Equations (See Table 7.5)

Select Setting Group 1	SS1 = 0
Select Setting Group 2	SS2 = 0
Select Setting Group 3	SS3 = 0
Select Setting Group 4	SS4 = 0
Select Setting Group 5	SS5 = 0
Select Setting Group 6	SS6 = 0

Other Equations

Event report trigger conditions (see *Section 12*)	ER = 87L + M2P + Z2G + 51P + 51G
Fault indication (used in time target logic—see *Table 5.1*; used also to suspend demand metering updating and peak recording and block max./min. metering—see *Local Demand Metering on page 8.3* and *Local Maximum/ Minimum Metering on page 8.11*)	FAULT = T51P + T51G + M2P + Z2G
Block synchronism-check elements (see *Figure 4.30*)	BSYNCH = 0
Close bus monitor (see *Figure 5.7*)	CLMON = 0
Breaker monitor initiation (see *Figure 8.9*)	BKMON = 0
Enable for zero-sequence voltage-polarized and channel IP current-polarized directional elements (see *Figure 4.42*)	E32IV = 1
Enable bus stub protection	ESTUB = 0

87L Transmit Bit Equations

Channel X, transmit bit 1	T1X = 0
Channel X, transmit bit 2	T2X = 0
Channel Y, transmit bit 1	T1Y = 0
Channel Y, transmit bit 2	T2Y = 0

Group settings (SET G) remain at their default values.

Display Point Labels (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

Display if DP1 = logical 1 (16 characters)	DP1_1 = BREAKER CLOSED
Display if DP1 = logical 0 (16 characters)	DP1_0 = BREAKER OPEN
Display if DP2 = logical 1 (16 characters)	DP2_1 = CHANNEL X ALARM
Display if DP2 = logical 0 (16 characters)	DP2_0 =

Reclosing Relay Labels (See Functions Unique to the Front-Panel Interface on page 11.5)

Reclosing Relay Last Shot Label (14 char.)	79LL = 0
Reclosing Relay Shot Counter Label (14 char.)	79SL = 0

Sequential Event Report Settings

SER Trigger List 1	SER1 = M2P, Z2G, 51P, 51G, T51P, T51G, LOP, 52A, 87L
SER Trigger List 2	SER2 =
SER Trigger List 3	SER3 =

Channel X settings remain at their default values.

Settings Example: 230 kV Transmission Line Single-Pole Tripping (SEL-311L-7 Relay Only)

The SEL-311L line current differential and Zone 1 distance functions can provide single-pole tripping when APP = 87LSP (note that single-pole tripping capability in the SEL-311L is an ordering option). Use the SEL-311L to protect a transmission line with single-pole tripping to improve system transient stability, minimize fault impacts to systems and reduce power quality concerns. *Figure 9.12* shows a 230 kV transmission line with SEL-311L protection at Stations S and R. The system is similar to the one in the previous setting example except that there is no tapped load on the transmission line.

The primary protection is line current differential. This application example uses one-shot reclosing and recloses the circuit breakers for single-phase-to-ground faults. Multi-phase faults lock out the recloser and block reclosing.

The Zone 1 distance element provides instantaneous single-pole tripping. The Zone 2 distance and directional ground time-overcurrent elements operate as three-pole tripping backup protection. The directional ground time-overcurrent element is set to detect high-impedance ground faults that may not be seen by the distance elements. Note that the Zone 2 distance and the overcurrent backup protection provide three-pole tripping backup protection only.

During a single-pole open interval, certain distance and directional elements are disabled. All mho distance elements associated with the open phase are disabled. For example, if the A-phase pole is open, the AG, AB, and CA mho distance elements are disabled. The BG, CG, and BC mho distance elements operate to detect faults that may occur during the pole-open time. All ground directional and quadrilateral distance elements are disabled during the pole open interval.

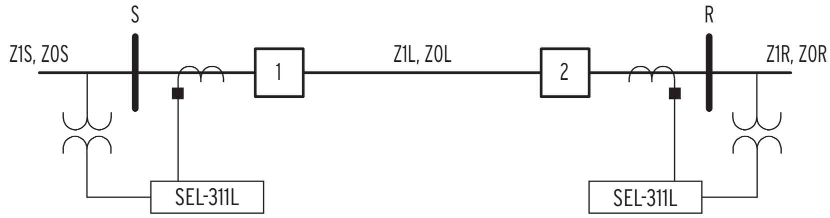


Figure 9.12 230 kV Model Power System

Table 9.9 Model Power System Data

Parameter	Primary	Secondary
HV system line-to-line voltage	230 kV	115 V
Nominal frequency	60 Hz	
Line lengths S-R	20 miles	
Line impedances Z1L Z0L	 11.86 Ω ∠84.70° 38.66 Ω ∠73.00°	 1.42 Ω ∠84.70° 4.64 Ω ∠73.00°
Source S impedances Z1S = Z0S	10 Ω ∠87°	1.20 Ω ∠87°
Source R impedances Z1R = Z0R	35 Ω ∠87°	4.20 Ω ∠87°
PTR (potential transformer ratio)	230 kV:115 V = 2000:1	
CTR (current transformer ratio)	1200:5 = 240:1	
CT burden class at station S and R	C800	
CT burden at station S and R	1.0 Ω	
Phase rotation	ABC	
87L Communications	Single Channel	
Line charging current	16 A	0.07 A
Maximum forward load at station S	1100 A	4.58 A
Maximum reverse load at station S	600 A	2.5 A
Maximum load unbalance	5%	

Convert the impedances to secondary Ω as follows:

$$k = \frac{CTR}{PTR} = \frac{240}{2000} = 0.12$$

Equation 9.11

$$Z_{secondary} = k \bullet Z_{primary}$$

Equation 9.12

For example:

$$\begin{aligned} Z_{1L(secondary)} &= k \bullet Z_{1L(primary)} \\ &= 0.12 \bullet (11.86\ \Omega\ \angle 84.7°) \\ &= 1.42\ \Omega\ \angle 84.7° \end{aligned}$$

Equation 9.13

Settings and Descriptions for This Example

The following information shows you how to complete the settings for this application.

Identifier Labels and Configuration Settings (See Settings Explanations on page 9.34)

Relay Identifier (30 characters)	RID = SEL-311L 87L SPT
Terminal Identifier (30 characters)	TID = EXAMPLE: BUS S, BREAKER 1
Local Phase (IA, IB, IC) Current Transformer Ratio (1–6000)	CTR = 240
Application (87L, 87L21, 87L21P, 87LSP, 311L)	APP = 87LSP

APP = 87LSP displays all available settings in the relay. This example requires settings that are not available in the special application settings.

Line Current Differential Configuration Settings

High-speed tripping (SP1, SP2, N)	EHST = SP1

In this single-breaker application, choose SP1 to use the first three of six high-speed contact outputs to single-pole trip A-, B-, and C-phase breakers. Choose the SP2 setting for ring-bus or breaker-and-half applications.

Enable high-speed direct transfer trip (Y, N)	EHSDTT = N
Enable delta current detect (Y, N)	EDD = Y

Disturbance detector supervision ensures the relay detects a change in the local currents before allowing a trip resulting from 87L element assertion.

Enable Open CT Logic (Y, N)	EOCTL = N

Set EOCTL = Y to enable open-CT detection.

CTR at terminal connected to Channel X (1–6000)	CTR_X = 240

Enter the current transformer ratio used in the SEL-311L at Station R.

Minimum Difference Current Enable Level Settings

Phase 87L (OFF, 1.00–10.00 A secondary)	87LPP = 5.60

In an 87L protection application, set 87LPP above line charging current and maximum tap load current. To increase 87L element security in the case of losing a CT at either terminal of the line, set this difference current enable level above the maximum through-load current plus line charging current. Set 87LPP = 5.6 A, 20 percent above the maximum load plus the charging current.

3I2 Negative-sequence 87L (OFF, 0.50–5.00 A secondary)	87L2P = OFF
Ground 87L (OFF, 0.50–5.00 A secondary)	87LGP = 0.50

Use 87LG element to detect high-impedance ground faults. Verify that 87LG does not assert under normal load unbalance.

87LG element logic requires 5 percent unbalance to operate. Check element sensitivity when attempting to operate on high-impedance faults. In this example, at maximum load = 1100A, 3I0 = 1100 • 0.05 / 240 = 0.23 A for 87LG to operate.

Set 87LGP to its minimum level of 0.50 A.

Phase difference current alarm pickup (0.50–10.00 A secondary)	CTALRM = 5.10

Set this element above maximum through-load plus line charging current to alarm on CT error. Cold load inrush may cause a momentary operation. Add time delay if you wish to avoid nuisance alarms.

(Max. Load + Line Charging) • 1.1 / CTR = 1116 • 1.1 / 240 = 5.10 A

Restraint Region Characteristic Settings (E87L = 2 or 3)

Outer Radius (2.0–8.0)	87LR = 6.0
Angle (90°–270°)	87LANG = 195

Refer to *Settings Example: 230 kV Transmission Line With Tapped Load on page 9.37* for discussion on selecting 87LR and 87LANG.

Backup Protection Transformer Ratio Settings

Polarizing (IPOL) Current Transformer Ratio (1–6000)	CTRP = 200
Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00)	PTR = 2000
Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00)	PTRS = 2000

This application example does not use the polarizing current channel. The related setting CTRP may remain at the default value. Set the potential transformer ratio PTR = 2000. The synchronizing PTR setting PTRS is not used. The setting may remain at the default value.

Line Parameter Settings (See Settings Explanations on page 9.34)

Positive-sequence line impedance magnitude 0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.}	Z1MAG = 1.42
Positive-sequence line impedance angle (5.00–90.00 degrees)	Z1ANG = 84.7
Zero-sequence line impedance magnitude 0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.}	Z0MAG = 4.64
Zero-sequence line impedance angle (5.00–90.00 degrees)	Z0ANG = 73.00
Line length (0.10–999.00, unitless)	LL = 20.00

Enter the secondary line parameters for the line section S to R.

Distance Element Zones Enable Settings

Mho phase distance element zones (N, 1–4, 1C–4C) (see *Figure 4.1–Figure 4.3*)	E21P = 2
Mho ground distance element zones (N, 1–4) (see *Figure 4.4–Figure 4.6*)	E21MG = 2
Quadrilateral ground distance element zones (N, 1–4) (see *Figure 4.7–Figure 4.9*)	E21XG = N

Zone 1 elements underreach with no intentional time delay. Zone 2 elements overreach as the backup to cover the next station. Zone 3, Zone 4 and quadrilateral elements are not used in this application example.

Instantaneous/Definite-Time Overcurrent Enable Settings

Phase element levels (N, 1–3) (see *Figure 4.19*)	E50P = N
Residual ground element levels (N, 1–4) (see *Figure 4.22*	E50G = N
Negative-sequence element levels (N, 1–4) (see *Figure 4.23*)	E50Q = N

Instantaneous overcurrent elements are not required in this application.

Time-Overcurrent Enable Settings

Phase element (Y, N) (see *Figure 4.24*)	E51P = N
Residual ground element (Y, N) (see *Figure 4.25*)	E51G= Y
Negative-sequence element (Y, N) (see *Figure 4.26*)	E51Q= N

Use 51GT to provide backup protection for the protected 230 kV line.

Other Enable Settings

Directional control (Y, AUTO) (see *Directional Control Settings on page 4.79*)	E32 = AUTO

Enable Best Choice Ground Directional Element Logic with E32 = AUTO. This automatically calculates and sets Z2F, Z2R, 50QFP, 50QRP, a2, k2, 50GRP, a0, Z0F, and Z0R. These settings must be made manually if E32 = Y.

Out-of-Step (Y, N) (see *Figure 4.17*)	EOOS = N

Out-of-step is not used in this example. Set EOOS = N to disable out-of-step elements. Refer to SEL *Application Guide 97-13, SEL-321-5 Relay Out-of-Step Logic*, for details if your application requires out-of-step blocking.

Load encroachment (Y, N) (see *Figure 4.38*)	ELOAD = N

Load encroachment is not required in this example.

At maximum load, Zload = (67 / 4.58) = 14.6 Ω, which is much larger than distance element settings.

Set ELOAD = N to disable load-encroachment elements.

Switch-onto-fault (Y, N) (see *Figure 5.7*)	ESOTF = N

The SOTF logic permits tripping by specified protection elements for a definable time after circuit breaker(s) close. Specify these elements in the TRSOTF SELOGIC control equation.

Apply SOTF when using line-side relaying potentials. Because this example uses bus-side relaying potentials, set ESOTF = N.

Voltage elements (Y, N) (see *Figure 4.27–Figure 4.30*)	EVOLT = N

Voltage elements are not enabled in this example. Set EVOLT = N.

Synchronism check (Y, N) (see *Figure 4.30* and *Figure 4.31*)	E25 = N

Synchronism-check elements are not necessary for single-pole tripping and reclosing. Set E25 = N.

Frequency elements (N, 1–6)	E81 = N

Frequency elements are not enabled in this example. Set E81 = N.

Fault location (Y, N) (see *Table 12.1* and *Fault Location on page 12.6*)	EFLOC = Y

Fault location is enabled in this example. Set EFLOC = Y.

Loss-of-potential (Y, Y1, N) (see *Figure 4.35*)	ELOP = Y1

Set ELOP = Y1 to disable all voltage-polarized directional overcurrent elements and distance elements during a loss-of-potential.

Enable busbar PT LOP logic (Y, N) (see *Figure 4.36*)	EBBPT = N

Busbar PT LOP logic is not enabled in this example. Set EBBPT = N.

Communications-assisted trip scheme (N, DCB, POTT, DCUB1, DCUB2) (see *Communications-Assisted Trip Logic—General Overview on page 5.18*)	ECOMM = N

This example uses distance elements as a backup to the differential overcurrent elements. There are no communication channels for the backup protection. Set ECOMM = N.

Reclosures (N, 1–4) (see *Reclosing Relay on page 6.10*)	E79 = 1

Use single shot reclosing in this example. Set E79 = 1.

Zone 1 extension (Y, N) (see *Figure 4.14*)	EZ1EXT = N

Zone 1 extension is not used. Set EZ1EXT = N.

CCVT transient detection (Y, N) (see *Figure 4.37*)	ECCVT = Y

CCVT transients can cause Zone 1 distance elements to overreach. If CCVT transient blocking is enabled and the relay detects a Source Impedance Ratio (SIR) greater than five during a fault, the relay delays Zone 1 tripping for as many as 1.5 cycles, allowing the CCVT to stabilize. Other settings are not required. The relay automatically adapts to different system SIR conditions and determines whether the 1.5 cycle delay is needed. In this example, the CCVTs use active ferroresonance suppression. Set ECCVT = Y.

SELOGIC control equation Variable Timers (N, 1–16) (see *Figure 7.25* and *Figure 7.26*)	ESV = N

Set ESV = N. No SELOGIC variables are required.

SELOGIC Latch Bits (N, 1–16)	ELAT = 16

Set ELAT = N. No latches are required.

SELOGIC Display Points (N, 1–16)	EDP = 16

Use two display points in this example. Set EDP = 2.

Demand Metering (THM = Thermal; ROL = Rolling) (see *Figure 8.3*)	EDEM = THM
Advanced settings (Y, N)	EADVS = N

Selecting Advanced Settings = N allows the relay to automatically calculate 50PP2, 50PP3, 50PP4, XGPOL, TANG, 50L2, 50L3, 50L4, 50GZ2, 50GZ3, 50GZ4, k0M, k0A, X1B6, X1B5, R1L6, R1L5, and UBOSBF elements.

Mho Phase Distance Elements

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} (see *Figure 4.4*)	Z1P = 1.13

Set Z1P to 75–90 percent of distance from Station S to Station R.

$$Z1P = Z1MAG \cdot 80\% = 1.41\ \Omega \cdot 0.8 = 1.13\ \Omega$$

Zone 2 OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} (see *Figure 4.5*)	Z2P = 1.70

The Zone 2 phase distance element must detect faults along the entire length of the protected HV circuit. Set Zone 2 phase distance equal to 120 percent of the line length to ensure coverage even under remote infeed from Station R.

$$Z2P = 1.41\ \Omega \cdot (CTR / PTR) \cdot 1.2 = 1.7\ \Omega$$

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.} (see *Figure 4.4*)	50PP1 = 0.5

Set 50PP1 to its minimum value when LOP logic is enabled.

Mho Ground Distance Elements

Zone 1 OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} (see *Figure 4.7*)	Z1MG = 1.13

Set Z1MG to 75–90 percent of distance from Station S to Station R.

$$Z1MG = Z1MAG \bullet 80\% = 1.41\ \Omega \bullet 0.8 = 1.13\ \Omega$$

Zone 2 OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} (see *Figure 4.8*)	Z2MG = 1.70

Zone 2 ground distance protection must detect faults along the entire length of the protected HV circuit. Set Zone 2 ground distance reach equal to 120 percent of the line length to ensure coverage under remote infeed from Station R.

$$Z2MG = 1.41\ \Omega \bullet (CTR / PTR) \bullet 1.2 = 1.7\ \Omega$$

Quadrilateral and Mho Ground Distance Fault Detector Settings

Zone 1 phase current FD 0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} (see *Figure 4.7* and *Figure 4.10*)	50L1 = 0.5
Zone 1 residual ground current FD 0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} (see *Figure 4.7* and *Figure 4.10*)	50GZ1 = 0.5

Set 50L1 and 50GZ1 to their minimum values when LOP logic is enabled.

Zero-Sequence Compensation (ZSC) Settings (See Ground Distance Elements on page 4.11)

Zone 1 ZSC factor magnitude (0.000–6.000 unitless)	k0M1 = 0.766
Zone 1 ZSC factor angle (–180.0° to +180.0°)	k0A1 = –16.74

Zero-sequence current compensation adjusts the apparent reach of a ground distance element so that it is equal to the phase element reach. Ground distance elements and phase distance elements can then be set to the same values. Calculate Zone 1 zero-sequence current compensation factor with either the primary or secondary values of the positive-sequence and zero-sequence line impedance.

$$\begin{aligned} k01 &= \frac{Z_{0L1} - Z_{1L1}}{3 \bullet Z_{1L1}} \\ &= \frac{4.64\angle 73.00^\circ - 1.42\angle 84.7^\circ}{3 \bullet 1.42\angle 84.7^\circ} \\ &= 0.766\angle -16.74^\circ \end{aligned}$$

Equation 9.14

Mho Phase Distance Element Time Delays (See Figure 4.15)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	Z1PD = OFF
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	Z2PD = OFF

Use common time delays to reduce the likelihood of a timer reset during an evolving fault. Separate phase and ground time delays are set OFF.

Quadrilateral and Mho Ground Distance Element Time Delays (See Figure 4.15)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	Z1GD = OFF
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	Z2GD = OFF

Common Phase/Ground Distance Element Time Delay (See Figure 4.15)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	Z1D = OFF
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	Z2D = 20

Residual-Ground Time-Overcurrent Element (See Figure 4.25)

Pickup OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}	51GP = 0.5
Curve (U1–U5, C1–C5) (see *Figure 9.1–Figure 9.10*)	51GC = U3
Time Dial 0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5	51GTD = 2.0
Electromechanical Reset (Y, N)	51GRS = Y

See SELOGIC torque-control equation T51GTC.

Set 51GP above the maximum unbalance caused by line asymmetry, instrumentation transformers, and other system asymmetries. Measure the maximum unbalance residual-ground current during the maximum load and three-phase faults. Set 51GP above this measured unbalance plus 10 percent margin to achieve good security and sensitivity. Set 51Gp = 0.5, well above the unbalance, 0.23 A, from the maximum load. Set 51GC and 51GTD to the same curve and time dial as the one used in the next line section to ensure proper coordination.

Directional Elements (See Directional Control Settings on page 4.79)

(Make setting ORDER if preceding enable setting E32 = Y or AUTO.)

Ground directional element priority: combination of Q, V, or I	ORDER = QV

Reclosing Relay (See Table 6.2 and Table 6.3)

(Make the following settings if preceding enable setting E79 = 1–4.)

Open interval 1 time 0.00–999999.00 cycles in 0.25-cycle steps	79OI1 = 30
Reset time from reclose cycle 0.00–999999.00 cycles in 0.25-cycle steps	79RSD = 1800
Reset time from lockout 0.00–999999.00 cycles in 0.25-cycle steps	79RSLD = 1800
Reclose supervision time limit (OFF, 0.00–999999.00 cycles in 0.25-cycle steps) (set 79CLSD = 0.00 for most applications; see *Figure 6.5*)	79CLSD = 0.0

Set 79OI1 to the minimum dead time that will allow the fault arc to extinguish and the arc path to cool sufficiently for the reclose to be successful. A common estimate (*Power System Protection* by P. M. Anderson; IEEE Press, 1999, pg 880) is:

$$\begin{aligned} T_{MIN} &= 10.5 + \frac{V_{LL}(kV)}{34.5} \\ &= \left(10.5 + \frac{230}{34.5}\right) \\ &= 17.17 \text{ cycles} \end{aligned}$$

Equation 9.15

Use a conservative dead time of 30 cycles to ensure that the arc has extinguished.

Set both reset timers to 30 seconds, or 1800 cycles.

Demand Metering Settings (See Figure 8.3 and Figure 8.5)

Time constant (5, 10, 15, 30, 60 minutes)	DMTC = 60
Phase pickup OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}	PDEMP = OFF
Residual ground pickup OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}	GDEMP = OFF
Negative-sequence pickup OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}	QDEMP = OFF

Demand metering elements are not used in this example. The settings are left at default values.

Other Settings

Minimum trip duration time 2.00–16000.00 cycles in 0.25-cycle steps (see *Figure 5.6*)	TDURD = 9.00
Trip open pole dropout delay 2.00–8000.00 cycles in 0.25-cycle steps	TOPD = 60.00
Close failure time delay OFF, 0.00–16000.00 cycles in 0.25-cycle steps (see *Figure 6.1*)	CFD = 60.00
Three-pole open time delay 0.00-60.00 cycles in 0.25-cycle steps) (usually set for no more than a cycle; see *Figure 5.7*	3POD = 0.5
Open pole option (52, 27)	OPO = 52

Do not use OPO = 27 in an application that requires 87L elements for tripping. OPO = 27 can compromise logic that manages charging current inrush when a power line is energized.

Load detection phase pickup OFF, 0.25–100.00A {5 A nom.}; 0.05–20.00 A {1 A nom.} (see *Figure 5.7*)	50LP = 0.25

Trip Logic Equations (See Figure 5.1)

Direct trip conditions	TR = Z2T + 51GT + OC

Set the unconditional trip equation TR with residual-ground time-overcurrent elements and Zone 2 time-delayed elements. Residual-ground time-overcurrent element provides backup coverage for the entire protected line. Zone 2 elements provide overreaching time-delayed tripping between Stations S and R. The trip equation includes the Open Command, OC, so that system operators can remotely open the circuit breaker.

Direct transfer trip conditions	DTT = 0
Enable three-pole tripping	E3PT = TOP
Unlatch trip conditions	ULTR = SPO + 3PO

Close Logic Equations (See Figure 6.1)

Circuit breaker status (used in *Figure 5.7*, also)	52AA = IN101
Circuit breaker status	52AB = IN102
Circuit breaker status	52AC = IN103

Connect the circuit breaker 52AA, 52AB and 52AC contacts to IN101–IN103. See *Section 2: Installation* for examples of breaker status connections.

Close conditions (other than automatic reclosing or **CLOSE** command)	CL = CC
Unlatch close conditions	ULCL = TRIP

See *Unlatch Close on page 6.3*.

Reclosing Relay Equations (See Reclosing Relay on page 6.10)

Reclose initiate	79RI = TRPA87 + TRPB87 + TRPC87 + TRPA21 + TRPB21 + TRPC21

Initiate a reclose only for single-phase ground faults that generate differential overcurrent or Zone 1 distance trips. All other time-delayed distance backup elements trip three poles. They do not initiate the recloser.

Reclose initiate supervision	79RIS = 1
Drive-to-lockout	79DTL = !IN104 + OC + TRP3P87 + TRIP + TRP3P21

Use a switch connected to **IN104** to enable reclosing. Drive the recloser to lockout when **IN104** (reclose enable) deasserts. Use open command OC to block reclosing during a manual breaker trip. Multiphase faults also lockout the recloser.

Drive-to-last shot	79DLS = 0
Skip shot	79SKP = 0
Stall open interval timing	79STL = 0
Block reset timing	79BRS = 0
Sequence coordination	79SEQ = 0
Reclose supervision (see *Figure 6.2*)	79CLS = 1

Reclose supervision is normally used with synchronized closing. It is not necessary to check synchronism for single-phase reclosing. Set 79CLS = 1 to allow reclosing to proceed after the open interval time-out.

Torque-Control Equations for Time-Overcurrent Elements

Residual-ground element (see *Figure 4.24*)	51GTC = 32GF

Time-overcurrent element 51GT using the Best Choice Ground Directional Element for torque control will operate in the forward direction only.

Output Contact Equations (See Figure 7.27)

Output Contact **OUT101**	OUT101 = CLOSE
Output Contact **OUT102**	OUT102 = 0
Output Contact **OUT103**	OUT103 = 0
Output Contact **OUT104**	OUT104 = 0
Output Contact **OUT105**	OUT105 = 0
Output Contact **OUT106**	OUT106 = 0
Output Contact **OUT107**	OUT107 = 87HWAL

Output Contact Equations—Differential Board (See Figure 7.28)

Output Contact **OUT201**	OUT201 = TRIP
Output Contact **OUT202**	OUT202 = TRIP
Output Contact **OUT203**	OUT203 = TRIP
Output Contact **OUT204**	OUT204 = 0
Output Contact **OUT205**	OUT205 = 0
Output Contact **OUT206**	OUT206 = 0
Output Contact **OUT301**	OUT301 = 0
Output Contact **OUT302**	OUT302 = 0
Output Contact **OUT303**	OUT303 = 0
Output Contact **OUT304**	OUT304 = 0
Output Contact **OUT305**	OUT305 = 0
Output Contact **OUT306**	OUT306 = 0
Output Contact **OUT307**	OUT307 = 0
Output Contact **OUT308**	OUT308 = 0
Output Contact **OUT309**	OUT309 = 0
Output Contact **OUT310**	OUT310 = 0
Output Contact **OUT311**	OUT311 = 0
Output Contact **OUT312**	OUT312 = 0

Use **OUT101** to close the breaker circuit. Use **OUT201–OUT203** for high-speed, high-current interrupting trips. **OUT201–OUT203** have built-in single-pole tripping elements of TRPA87 or TRPA21, TRPB87 or TRPB21, and TRPC87 or TRPC21, correspondingly. Add TRIP to **OUT201–OUT203** to trip all three poles with backup protection elements. **OUT204–OUT205** are not used for this single-breaker application.

Display Point Equations (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

Display Point DP1	DP1 = 52AA * 52AB * 52AC
Display Point DP2	DP2 = CHXAL

Setting Group Selection Equations (See Table 7.4)

Select Setting Group 1	SS1 = 0
Select Setting Group 2	SS2 = 0
Select Setting Group 3	SS3 = 0
Select Setting Group 4	SS4 = 0
Select Setting Group 5	SS5 = 0
Select Setting Group 6	SS6 = 0

Other Equations

Event report trigger conditions (see *Section 12*)	ER = 87L + M2P + Z2G + 51G
Fault indication (used in time target logic—see *Table 5.1*; used also to suspend demand metering updating and peak recording and block max./min. metering—see *Local Demand Metering on page 8.3* and *Local Maximum/Minimum Metering on page 8.11*)	FAULT = 51G + M2P + Z2G
Block synchronism-check elements (see *Figure 4.30*)	BSYNCH = 0
Close bus monitor (see *Figure 5.7*)	CLMON = 0
Breaker monitor initiation (see *Figure 8.9*)	BKMON = 0
Enable for zero-sequence voltage-polarized and channel IP current-polarized directional elements (see *Figure 4.4*)	E32IV = 1
Enable bus stub protection	ESTUB = 0

87L Transmit Bit Equations

Channel X, transmit bit 1	T1X = 0
Channel X, transmit bit 2	T2X = 0
Channel Y, transmit bit 1	T1Y = 0
Channel Y, transmit bit 2	T2Y = 0

Group settings (**SET G**) remain at their default values.

Display Point Labels (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

Display if DP1 = logical 1 (16 characters)	DP1_1 = BREAKER CLOSED
Display if DP1 = logical 0 (16 characters)	DP1_0 = BREAKER OPEN
Display if DP2 = logical 1 (16 characters)	DP2_1 = CHANNEL X ALARM
Display if DP2 = logical 0 (16 characters)	DP2_0 =

Reclosing Relay Labels (See Functions Unique to the Front-Panel Interface on page 11.5)

Reclosing Relay Last Shot Label (14 char.)	79LL = 0
Reclosing Relay Shot Counter Label (14 char.)	79SL = 0

Sequential Event Report Settings

SER Trigger List 1	SER1 = M2P, Z2G, 51G, LOP, 52AA, 52AB, 52AC, 87L
SER Trigger List 2	SER2 =
SER Trigger List 3	SER3 =

Channel X settings remain at their default values.

Settings Sheets

The settings sheets that follow include the definition and input range for each setting in the relay. Refer to *Relay Elements on page 1.9* for information on 5 A nominal and 1 A nominal ordering options and how they influence overcurrent element setting ranges.

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SEL-311L Settings Sheets (APP = 311L)

Relay Settings (Serial Port Command SET and Front Panel)

Identifier Labels and Configuration Settings (See Settings Explanations on page 9.34)

Relay Identifier (30 characters)

RID = ______________________________

Terminal Identifier (30 characters)

TID = ______________________________

Local Phase (IA, IB, IC) Current Transformer Ratio (1–6000)	**CTR**	=________
Application (87L, 87L21, 87L21P, 87LSP, 311L) [APP = 87LSP for SEL-311L-7 only]	**APP**	=________

Line Current Differential Configuration Settings

If the relay has two channels, the following choices are available:		
Relay operating mode (2, 3, 3R, N)		
If the relay has one channel, the following choices are available:		
Relay operating mode (2, 3R, N)	**E87L**	=________
If E87L ≠ N, the following choices are available:		
High-speed tripping (1–6, N)	**EHST**	=________
If 87L = 2 or 3, the following choices are available:		
Enable high-speed direct transfer trip (Y, N)	**EHSDTT**	=________
Enable delta current detect (Y, N)	**EDD**	=________
Tapped-load coordination (Y, N)	**ETAP**	=________
If the relay has two channels and E87L = 2:		
Enable Open CT Logic (Y, N)	**EOCTL**	=________
If E87L = 2 or 3R:		
Primary channel (X, Y)	**PCHAN**	=________
If the relay has two channels and E87L = 2:		
Hot-standby channel feature (Y, N)	**EHSC**	=________
If PCHAN = X or EHSC = Y or E87L = 3:		
CTR at terminal connected to Channel X (1–6000)	**CTR_X**	=________

If EADDCX = G:		
Channel X transmit address (1–16)	**TA_X**	=_________
Channel X receive address (1–16)	**RA_X**	=_________
If PCHAN = Y or EHSC = Y or E87L = 3:		
CTR at terminal connected to Channel Y (1–6000)	**CTR_Y**	=_________
If EADDCY = G:		
Channel Y transmit address (1–16)	**TA_Y**	=_________
Channel Y receive address (1–16)	**RA_Y**	=_________

Minimum Difference Current Enable Level Settings (E87L = 2 or 3)

Phase 87L (OFF, 1.00–10.00 A secondary)	**87LPP**	=_________
$3I_2$ Negative-sequence 87L (OFF, 0.50–5.00 A secondary)	**87L2P**	=_________
Ground 87L (OFF, 0.50–5.00 A secondary)	**87LGP**	=_________
Phase difference current alarm pickup (0.50–10.00 A secondary)	**CTALRM**	=_________

Restraint Region Characteristic Settings (E87L = 2 or 3)

Outer Radius (2.0–8.0)	**87LR**	=_________
Angle (90°–270°)	**87LANG**	=_________

Tapped-Load Coordinating Overcurrent Element Settings (If ETAP = Y)

Phase element (Y, N)	**ETP**	=_________
Residual ground element (Y, N)	**ETG**	=_________
Negative-sequence element (Y, N)	**ETQ**	=_________

Tapped-Load Phase Time-Overcurrent Element Settings (If ETP = Y)

Pickup (OFF, 0.50–16.00 A secondary)	**T51PP**	=_________
Curve (U1–U5; C1–C5)	**T51PC**	=_________
Time dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)	**T51PTD**	=_________
Electromechanical reset delay (Y, N)	**T51PRS**	=_________

Tapped-Load Phase Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	**T50PP**	=_________
Time delay (OFF, 0.00–16000.00 cycles)	**T50PD**	=_________

Tapped-Load Residual-Ground Time-Overcurrent Element Settings (If ETG = Y)

Pickup (OFF, 0.50–16.00 A secondary)	**T51GP**	=_________
Curve (U1–U5; C1–C5)	**T51GC**	=_________
Time dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)	**T51GTD**	=_________
Electromechanical reset delay (Y, N)	**T51GRS**	=_________

Tapped-Load Residual-Ground Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	**T50GP**	=_________
Time delay (OFF, 0.00–16000.00 cycles)	**T50GD**	=_________

Tapped-Load Negative-Sequence Time-Overcurrent Element Settings (If ETQ = Y)

Pickup (OFF, 0.50–16.00 A secondary)	**T51QP**	=_________
Curve (U1–U5; C1–C5)	**T51QC**	=_________
Time dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)	**T51QTD**	=_________
Electromechanical reset delay (Y, N)	**T51QRS**	=_________

Tapped-Load Negative-Sequence Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	**T50QP**	=_________
Time delay (OFF, 0.00–16000.00 cycles)	**T50QD**	=_________

Backup Protection Transformer Ratio Settings

Polarizing (IPOL) Current Transformer Ratio (1–6000)	**CTRP**	=_________
Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00)	**PTR**	=_________
Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00)	**PTRS**	=_________

Line Parameter Settings (See Settings Explanations on page 9.34)

Positive-sequence line impedance magnitude		
0.05–255.00 Ω secondary 5 A nom.; 0.25–1275.00 Ω secondary 1 A nom.	**Z1MAG**	=_________
Positive-sequence line impedance angle		
(5.00–90.00 degrees)	**Z1ANG**	=_________
Zero-sequence line impedance magnitude		
0.05–255.00 Ω secondary 5 A nom.; 0.25–1275.00 Ω secondary 1 A nom.	**Z0MAG**	=_________

Zero-sequence line impedance angle (5.00–90.00 degrees)	**Z0ANG**	=________
Line length (0.10–999.00, unitless)	**LL**	=________

Distance Element Zones Enable Settings

Mho phase distance element zones (N, 1–4, 1C–4C) (see *Figure 4.1–Figure 4.3*)	**E21P**	=________
Mho ground distance element zones (N, 1–4) (see *Figure 4.4–Figure 4.6*)	**E21MG**	=________
Quadrilateral ground distance element zones (N, 1–4) (see *Figure 4.7–Figure 4.9*)	**E21XG**	=________

Instantaneous/Definite-Time Overcurrent Enable Settings

Phase element levels (N, 1–3) (see *Figure 4.19*)	**E50P**	=________
Residual ground element levels (N, 1–4) (see *Figure 4.22*)	**E50G**	=________
Negative-sequence element levels (N, 1–4) (see *Figure 4.23*)	**E50Q**	=________

Time-Overcurrent Enable Settings

Phase element (Y, N) (see *Figure 4.24*)	**E51P**	=________
Residual ground element (Y, N) (see *Figure 4.25*)	**E51G**	=________
Negative-sequence element (Y, N) (see *Figure 4.26*)	**E51Q**	=________

Other Enable Settings

Directional control (Y, AUTO) (see *Directional Control Settings on page 4.79*)	**E32**	=________
Out-of-Step (Y, N) (see *Figure 4.17*)	**EOOS**	=________
Load encroachment (Y, N) (see *Figure 4.38*)	**ELOAD**	=________
Switch-onto-fault (Y, N) (see *Figure 5.7*)	**ESOTF**	=________
Voltage elements (Y, N) (see *Figure 4.27*, *Figure 4.28*, *Figure 4.29*, and *Figure 4.30*)	**EVOLT**	=________
Synchronism check (Y, N) (see *Figure 4.30* and *Figure 4.31*)	**E25**	=________
Frequency elements (N, 1–6)	**E81**	=________
Fault location (Y, N) (see *Table 12.1* and *Fault Location on page 12.6*)	**EFLOC**	=________
Loss-of-potential (Y, Y1, N) (see *Figure 4.35*)	**ELOP**	=________
Enable busbar PT LOP logic (Y, N) (see *Setting EBBPT = Y on page 4.61*)	**EBBPT**	=________

Communications-assisted trip scheme (N, DCB, POTT, DCUB1, DCUB2) (see *Communications-Assisted Trip Logic—General Overview on page 5.18*)	**ECOMM**	= ________
Reclosures (N, 1–4) (see *Reclosing Relay on page 6.10*)	**E79**	= ________
Zone 1 extension (Y, N) (see *Figure 4.14*)	**EZ1EXT**	= ________
CCVT transient detection (Y, N) (see *Figure 4.37*)	**ECCVT**	= ________
SELOGIC control equation Variable Timers (N, 1–16) (see *Figure 7.24* and *Figure 7.25*)	**ESV**	= ________
SELOGIC Latch Bits (N, 1–16)	**ELAT**	= ________
SELOGIC Display Points (N, 1–16)	**EDP**	= ________
Demand Metering (THM = Thermal; ROL = Rolling) (see *Figure 8.3*)	**EDEM**	= ________
Advanced settings (Y, N)	**EADVS**	= ________

Mho Phase Distance Elements

Number of mho phase distance element settings dependent on preceding enable setting E21P = 1–4.

Zone 1 (see *Figure 4.4*)		
OFF, 0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom.	**Z1P**	= ________
Zone 2 (see *Figure 4.5*)		
OFF, 0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom.	**Z2P**	= ________
Zone 3 (see *Figure 4.6*)		
OFF, 0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom.	**Z3P**	= ________
Zone 4 (see *Figure 4.6*)		
OFF, 0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom.	**Z4P**	= ________

Mho Phase Distance Fault Detector Settings

Zone 1 phase-to-phase current FD (see *Figure 4.4*)		
0.5–170.00 A secondary 5 A nom.; 0.1–34.00 A secondary 1 A nom.	**50PP1**	= ________
Zone 2 phase-to-phase current FD (see *Figure 4.5*) *Setting active when 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.	**50PP2**	= ________

Zone 3 phase-to-phase current FD (see *Figure 4.6*) *Setting active when 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. **50PP3** =________

Zone 4 phase-to-phase current FD (see *Figure 4.6*) *Setting active when 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. **50PP4** =________

Mho Ground Distance Elements

Number of mho ground distance element settings dependent on preceding enable setting E21MG = 1–4.

Zone 1 (see *Figure 4.7*)

OFF, 0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom. **Z1MG** =________

Zone 2 (see *Figure 4.8*)

OFF, 0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom. **Z2MG** =________

Zone 3 (see *Figure 4.9*)

OFF, 0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom. **Z3MG** =________

Zone 4 (see *Figure 4.9*)

OFF, 0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom. **Z4MG** =________

Quadrilateral Ground Distance Elements

Number of quadrilateral ground distance element settings dependent on preceding enable setting E21XG = 1–4.

Zone 1 reactance (see *Figure 4.10*)

OFF, 0.05–64.00 Ω secondary 5 A nom.; OFF, 0.25–320.00 Ω secondary 1 A nom. **XG1** =________

Zone 2 reactance (see *Figure 4.11*)

OFF, 0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom. **XG2** =________

Zone 3 reactance (see *Figure 4.12*)

OFF, 0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom. **XG3** =________

Zone 4 reactance (see *Figure 4.12*)

OFF, 0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom. **XG4** =________

Zone 1 resistance (see *Figure 4.10*)

0.05–50.00 Ω secondary 5 A nom.; 0.25–250.00 Ω secondary 1 A nom. **RG1** =________

Zone 2 resistance (see *Figure 4.11*)		
0.05–50.00 Ω secondary 5 A nom.; 0.25–250.00 Ω secondary 1 A nom.	**RG2**	= ________
Zone 3 resistance (see *Figure 4.12*)		
0.05–50.00 Ω secondary 5 A nom.; 0.25–250.00 Ω secondary 1 A nom.	**RG3**	= ________
Zone 4 resistance (see *Figure 4.12*)		
0.05–50.00 Ω secondary 5 A nom.; 0.25–250.00 Ω secondary 1 A nom.	**RG4**	= ________
Quadrilateral ground polarizing quantity (I2, IG) (see *Figure 4.10–Figure 4.12*) *Setting active when EADVS = Y; otherwise setting is made automatically.*	**XGPOL**	= ________
Nonhomogeneous correction angle (–45.0° to +45.0°) *Setting active when 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 (see *Figure 4.7* and *Figure 4.10*)		
0.50–100.00 A secondary 5 A nom.; 0.10–20.00 A secondary 1 A nom.	**50L1**	= ________
Zone 2 phase current FD (see *Figure 4.8* and *Figure 4.11*) *Setting active when EADVS = Y; otherwise setting is made automatically.*		
0.50–100.00 A secondary 5 A nom.; 0.10–20.00 A secondary 1 A nom.	**50L2**	= ________
Zone 3 phase current FD (see *Figure 4.9* and *Figure 4.12*) *Setting active when EADVS = Y; otherwise setting is made automatically.*		
0.50–100.00 A secondary 5 A nom.; 0.10–20.00 A secondary 1 A nom.	**50L3**	= ________
Zone 4 phase current FD (see *Figure 4.9* and *Figure 4.12*) *Setting active when EADVS = Y; otherwise setting is made automatically.*		
0.50–100.00 A secondary 5 A nom.; 0.10–20.00 A secondary 1 A nom.	**50L4**	= ________
Zone 1 residual current FD (see *Figure 4.7* and *Figure 4.10*)		
0.50–100.00 A secondary 5 A nom.; 0.10–20.00 A secondary 1 A nom.	**50GZ1**	= ________
Zone 2 residual current FD (see *Figure 4.8* and *Figure 4.11*) *Setting active when EADVS = Y; otherwise setting is made automatically.*		
0.50–100.00 A secondary 5 A nom.; 0.10–20.00 A secondary 1 A nom.	**50GZ2**	= ________

Zone 3 residual current FD (see *Figure 4.9* and *Figure 4.12*)
Setting active when EADVS = Y; otherwise setting is made automatically.

0.50–100.00 A secondary 5 A nom.; 0.10–20.00 A secondary 1 A nom.	**50GZ3**	=________

Zone 4 residual current FD (see *Figure 4.9* and *Figure 4.12*)
Setting active when EADVS = Y; otherwise setting is made automatically.

0.50–100.00 A secondary 5 A nom.; 0.10–20.00 A secondary 1 A nom.	**50GZ4**	=________

Zero-Sequence Compensation (ZSC) Settings (See Distance Elements on page 4.1)

Zone 1 ZSC factor magnitude (0.000–6.000 unitless)	**k0M1**	=________
Zone 1 ZSC factor angle (–180.0° to +180.0°)	**k0A1**	=________
Zones 2, 3, and 4 ZSC factor magnitude (0.000–6.000 unitless) *Setting active when EADVS = Y; otherwise setting is made automatically.*	**k0M**	=________
Zones 2, 3, and 4 ZSC factor angle (–180.0° to +180.0°) *Setting active when EADVS = Y; otherwise setting is made automatically.*	**k0A**	=________

Mho Phase Distance Element Time Delays (See Figure 4.15)

Number of mho phase distance element time delay settings dependent on preceding enable setting E21P = 1–4.

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1PD**	=________
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2PD**	=________
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3PD**	=________
Zone 4 time delay (OFF, 0.00–16000.00 cycles)	**Z4PD**	=________

Quadrilateral and Mho Ground Distance Element Time Delays (See Figure 4.15)

Number of time delay element settings dependent on the larger of preceding enable settings E21MG = 1–4 or E21XG = 1–4.

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1GD**	=________
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2GD**	=________
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3GD**	=________
Zone 4 time delay (OFF, 0.00–16000.00 cycles)	**Z4GD**	=________

Common Phase/Ground Distance Element Time Delay (See Figure 4.15)

Number of time delay element settings dependent on the smaller of preceding enable setting E21P = 1–4 and the larger of preceding enable settings E21MG = 1–4 or E21XG = 1–4.

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1D**	=
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2D**	=
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3D**	=
Zone 4 time delay (OFF, 0.00–16000.00 cycles)	**Z4D**	=

Phase Inst./Def.-Time Overcurrent Elements (See Figure 4.19)

Number of phase element pickup settings dependent on preceding enable setting E50P = 1–3.

Level 1		
OFF, 0.25–100.00 A secondary 5 A nom.; 0.05–20.00 A secondary 1 A nom.	**50P1P**	=
Level 2		
OFF, 0.25–100.00 A secondary 5 A nom.; 0.05–20.00 A secondary 1 A nom.	**50P2P**	=
Level 3		
OFF, 0.25–100.00 A secondary 5 A nom.; 0.05–20.00 A secondary 1 A nom.	**50P3P**	=

Phase Definite-Time Overcurrent Element Time Delays (See Figure 4.19)

Number of phase element time delay settings dependent on preceding enable setting E50P = 1–3.

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps)	**67P1D**	=
Level 2 (0.00–16000.00 cycles in 0.25-cycle steps)	**67P2D**	=
Level 3 (0.00–16000.00 cycles in 0.25-cycle steps)	**67P3D**	=

Residual-Ground Inst./Def.-Time Overcurrent Elements (See Figure 4.22)

Number of residual-ground element pickup settings dependent on preceding enable setting E50G = 1–4.

Level 1		
OFF, 0.25–100.00 A secondary 5 A nom.; 0.05–20.00 A secondary 1 A nom.	**50G1P**	=
Level 2		
OFF, 0.25–100.00 A secondary 5 A nom.; 0.05–20.00 A secondary 1 A nom.	**50G2P**	=

Level 3

OFF, 0.25–100.00 A secondary 5 A nom.;
0.05–20.00 A secondary 1 A nom. **50G3P** =__________

Level 4

OFF, 0.25–100.00 A secondary 5 A nom.;
0.05–20.00 A secondary 1 A nom. **50G4P** =__________

Residual-Ground Definite-Time Overcurrent Element Time Delay (See Figure 4.22)

Number of residual-ground element time delay settings dependent on preceding enable setting E50G = 1–4.

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) **67G1D** =__________

Level 2 (0.00–16000.00 cycles in 0.25-cycle steps) **67G2D** =__________

Level 3 (0.00–16000.00 cycles in 0.25-cycle steps) **67G3D** =__________

Level 4 (0.00–16000.00 cycles in 0.25-cycle steps) **67G4D** =__________

Negative-Sequence Inst./Def.-Time Overcurrent Elements (See Figure 4.23)

Number of negative-sequence element time delay settings dependent on preceding enable setting E50Q = 1–4; see Section 4: Protection Functions for information on setting negative-sequence overcurrent elements.

Level 1

OFF, 0.25–100.00 A secondary 5 A nom.;
0.05–20.00 A secondary 1 A nom. **50Q1P** =__________

Level 2

OFF, 0.25–100.00 A secondary 5 A nom.;
0.05–20.00 A secondary 1 A nom. **50Q2P** =__________

Level 3

OFF, 0.25–100.00 A secondary 5 A nom.;
0.05–20.00 A secondary 1 A nom. **50Q3P** =__________

Level 4

OFF, 0.25–100.00 A secondary 5 A nom.;
0.05–20.00 A secondary 1 A nom. **50Q4P** =__________

Negative-Sequence Definite-Time Overcurrent Element Time Delay (See Figure 4.23)

Number of negative-sequence element time delay settings dependent on preceding enable setting E50Q = 1–4; see Section 4: Protection Functions for information on setting negative-sequence overcurrent elements.

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) **67Q1D** =__________

Level 2 (0.00–16000.00 cycles in 0.25-cycle steps) **67Q2D** =__________

Level 3 (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q3D**	=________
Level 4 (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q4D**	=________

Phase Time-Overcurrent Element (See Figure 4.24)

Make the following settings if preceding enable setting E51P = Y.

Pickup		
OFF, 0.25–16.00 A secondary 5 A nom.; 0.05–3.20 A secondary 1 A nom.	**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)	**51PTD**	=________
Electromechanical Reset (Y, N)	**51PRS**	=________

Residual-Ground Time-Overcurrent Element (See Figure 4.25)

Make the following settings if preceding enable setting E51G = Y.

Pickup		
OFF, 0.25–16.00 A secondary 5 A nom.; 0.05–3.20 A secondary 1 A nom.	**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)	**51GTD**	=________
Electromechanical Reset (Y, N)	**51GRS**	=________

Negative-Sequence Time-Overcurrent Element (See Figure 4.25)

Make the following settings if preceding enable setting E51Q = Y; see Section 4: Protection Functions for information on setting negative-sequence overcurrent elements.

Pickup		
OFF, 0.25–16.00 A secondary 5 A nom.; 0.05–3.20 A secondary 1 A nom.	**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)	**51QTD**	=________
Electromechanical Reset (Y, N)	**51QRS**	=________

Out-of-Step Settings (See Figure 4.16 and Figure 4.17)

Make the following settings if preceding enable setting EOOS = Y.

Block Zone 1 (Y, N)	**OOSB1**	=________
Block Zone 2 (Y, N)	**OOSB2**	=________
Block Zone 3 (Y, N)	**OOSB3**	=________

Block Zone 4 (Y, N)	**OOSB4**	= ________
Out-of-Step block time delay (0.50–8000.00 cycles)	**OSBD**	= ________
Enable Out-of-Step tripping (N, I, O)	**EOOST**	= ________
Out-of-Step trip delay (0.50–8000.00 cycles)	**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.	**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.	**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.	**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.	**R1R5**	= ________
Zone 6 reactance—Bottom (*Setting active when EADVS = Y; otherwise setting is made automatically.)* –96.00 to –0.05 Ω secondary 5 A nom.; –480.00 to –0.25 Ω secondary 1 A nom.	**X1B6**	= ________
Zone 5 reactance—Bottom (*Setting active when EADVS = Y; otherwise setting is made automatically.*) –96.00 to –0.05 Ω secondary 5 A nom.; –480.00 to –0.25 Ω secondary 1 A nom.	**X1B5**	= ________
Zone 6 resistance—Left (*Setting active when EADVS = Y; otherwise setting is made automatically.*) –70.00 to –0.05 Ω secondary 5 A nom.; –350.00 to –0.25 Ω secondary 1 A nom.	**R1L6**	= ________
Zone 5 resistance—Left (*Setting active when EADVS = Y; otherwise setting is made automatically.*) –70.00 to –0.05 Ω secondary 5 A nom.; –350.00 to –0.25 Ω secondary 1 A nom.	**R1L5**	= ________
Positive-Sequence current supervision 1–100 A secondary 5 A nom.; 0.2–20 A secondary 1 A nom.	**50ABCP**	= ________
Negative-Sequence current unblock delay (0.5–120.0 cycles)	**UBD**	= ________
Out-of-Step angle change unblock rate (1–10 unitless) (*Setting active when EADVS = Y; otherwise setting is made automatically.*)	**UBOSBF**	= ________

Load-Encroachment Elements (See Figure 4.38)

Make the following settings if preceding enable setting ELOAD = Y.

Forward load impedance

0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom.	**ZLF**	= ________

Reverse load impedance

0.05–64.00 Ω secondary 5 A nom.; 0.25–320.00 Ω secondary 1 A nom.	**ZLR**	= ________
Positive forward load angle (–90.00° to +90.00°)	**PLAF**	= ________
Negative forward load angle (–90.00° to +90.00°)	**NLAF**	= ________
Positive reverse load angle (+90.00° to +270.00°)	**PLAR**	= ________
Negative reverse load angle (+90.00° to +270.00°)	**NLAR**	= ________

Zone/Level 3 and 4 Directional Control

Zone/Level 3 direction: Forward, Reverse (F, R)	**DIR3**	= ________
Zone/Level 4 direction: Forward, Reverse (F, R)	**DIR4**	= ________

Directional Elements (See Directional Control Settings on page 4.79)

Make setting ORDER if preceding enable setting E32 = Y or AUTO.

Ground directional element priority: combination of OFF, Q, V, or I	**ORDER**	= ________

Make settings Z2F, Z2R, 50QFP, 50QRP, a2, and k2 if preceding enable setting E32 = Y. If E32 = AUTO, these settings are made automatically.

Forward directional Z2 threshold

–64.00–64.00 Ω secondary 5 A nom.; –320.00–320.00 Ω secondary 1 A nom.	**Z2F**	= ________

Reverse directional Z2 threshold

–64.00–64.00 Ω secondary 5 A nom.; –320.00–320.00 Ω secondary 1 A nom.	**Z2R**	= ________

Forward directional 3I2 pickup

0.25–5.00 A secondary 5 A nom.; 0.05–1.00 A secondary 1 A nom.	**50QFP**	= ________

Reverse directional 3I2 pickup

0.25–5.00 A secondary 5 A nom.; 0.05–1.00 A secondary 1 A nom.	**50QRP**	= ________
Positive-sequence current restraint factor, I2/I1 (0.02–0.50, unitless)	**a2**	= ________
Zero-sequence current restraint factor, I2/I0 (0.10–1.20, unitless)	**k2**	= ________

Make settings 50GFP, 50GRP, and a0 if preceding enable setting E32 = Y and preceding setting ORDER contains V or I. If E32 = AUTO and ORDER contains V or I, these settings are made automatically.

Forward directional 3I0 pickup		
0.25–5.00 A secondary 5 A nom.; 0.05–1.00 A secondary 1 A nom.	**50GFP**	=________
Reverse directional 3I0 pickup		
0.25–5.00 A secondary 5 A nom.; 0.05–1.00 A secondary 1 A nom.	**50GRP**	=________
Positive-sequence current restraint factor, I0/I1 (0.02–0.50, unitless)	**a0**	=________

Make settings Z0F and Z0R if preceding enable setting E32 = Y and preceding setting ORDER contains V. If E32 = AUTO and ORDER contains V, these settings are made automatically.

Forward directional Z0 threshold		
–64.00–64.00 Ω secondary 5 A nom.; –320.00–320.00 Ω secondary 1 A nom.	**Z0F**	=________
Reverse directional Z0 threshold		
–64.00–64.00 Ω secondary 5 A nom.; –320.00–320.00 Ω secondary 1 A nom.	**Z0R**	=________

Voltage Elements (See Figure 4.27, Figure 4.28, and Figure 4.29)

Make the following settings if preceding enable setting EVOLT = Y

Phase undervoltage pickup (OFF, 0.0–150.0 V secondary)	**27P**	=________
Phase overvoltage pickup (OFF, 0.0–150.0 V secondary)	**59P**	=________
Zero-sequence (3V0) overvoltage pickup (OFF, 0.0–150.0 V secondary)	**59N1P**	=________
Zero-sequence (3V0) overvoltage pickup (OFF, 0.0–150.0 V secondary)	**59N2P**	=________
Negative-sequence (V2) overvoltage pickup (OFF, 0.0–100.0 V secondary)	**59QP**	=________
Positive-sequence (V1) overvoltage pickup (OFF, 0.0–150.0 V secondary)	**59V1P**	=________
Channel VS undervoltage pickup (OFF, 0.0–150.0 V secondary)	**27SP**	=________
Channel VS overvoltage pickup (OFF, 0.0–150.0 V secondary)	**59SP**	=________
Phase-to-phase undervoltage pickup (OFF, 0.0–260.0 V secondary)	**27PP**	=________
Phase-to-phase overvoltage pickup (OFF, 0.0–260.0 V secondary)	**59PP**	=________

Synchronism-Check Elements (See Figure 4.30 and Figure 4.31)

Make the following settings if preceding enable setting E25 = Y.

Voltage window—low threshold (0.00–150.00 V secondary)	**25VLO**	= ________
Voltage window—high threshold (0.00–150.00 V secondary)	**25VHI**	= ________
Maximum slip frequency (0.005–0.500 Hz)	**25SF**	= ________
Maximum angle 1 (0.00°–80.00°)	**25ANG1**	= ________
Maximum angle 2 (0.00°–80.00°)	**25ANG2**	= ________
Synchronizing phase (VA, VB, VC, VAB, VBC, VAC)	**SYNCP**	= ________
Breaker close time for angle compensation (OFF, 1.00–60.00 cycles in 0.25-cycle steps)	**TCLOSD**	= ________

Frequency Elements (See Figure 4.33 and Figure 4.34)

Make the following settings if preceding enable setting E81 = 1–6.

Phase undervoltage block (20.00–150.00 V secondary, 150 V wye-connected voltage inputs)	**27B81P**	= ________
Level 1 pickup (OFF, 41.00–65.00 Hz)	**81D1P**	= ________
Level 1 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D1D**	= ________
Level 2 pickup (OFF, 41.00–65.00 Hz)	**81D2P**	= ________
Level 2 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D2D**	= ________
Level 3 pickup (OFF, 41.00–65.00 Hz)	**81D3P**	= ________
Level 3 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D3D**	= ________
Level 4 pickup (OFF, 41.00–65.00 Hz)	**81D4P**	= ________
Level 4 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D4D**	= ________
Level 5 pickup (OFF, 41.00–65.00 Hz)	**81D5P**	= ________
Level 5 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D5D**	= ________
Level 6 pickup (OFF, 41.00–65.00 Hz)	**81D6P**	= ________
Level 6 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D6D**	= ________

Reclosing Relay (See Table 6.2 and Table 6.4)

Make the following settings if preceding enable setting 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 6.2*)	**79CLSD**	=_________

Switch-Onto-Fault (See Figure 5.7)

Make the following settings if preceding enable setting 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 5.10)

Make the following settings if preceding enable setting ECOMM = POTT, DCUB1, or DCUB2

Zone (level) 3 reverse block time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**Z3RBD**	=_________
Echo block time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)	**EBLKD**	=_________
Echo time delay pickup (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)	**ETDPU**	=_________
Echo duration time delay (0.00–16000.00 cycles in 0.25-cycle steps)	**EDURD**	=_________
Weak-infeed enable (Y, N)	**EWFC**	=_________
WIF phase-to-phase undervoltage (0.0–260.0 V secondary)	**27PPW**	=_________
WIF zero-sequence (3V0) overvoltage (0.0–150.0 V secondary)	**59NW**	=_________

Additional DCUB Trip Scheme Settings (See Figure 5.14)

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 5.18)

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 only available when you set a Serial Port Protocol Setting 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 only available when you set a Serial Port Protocol Setting 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 4.14)

Make the following settings if preceding enable setting EZ1EXT = Y.

Zone 1 extension delay time (0.00–16000.00 cycles)	**Z1EXTD**	= __________
Zone 1 distance multiplier (1.00–4.00)	**Z1EXTM**	= __________

Demand Metering Settings (See Figure 8.3 and Figure 8.5)

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.	**PDEMP**	= __________

Residual ground pickup

OFF, 0.50–16.00 A secondary 5 A nom.; 0.10–3.20 A secondary 1 A nom. **GDEMP** =__________

Negative-sequence pickup

OFF, 0.50–16.00 A secondary 5 A nom.; 0.10–3.20 A secondary 1 A nom. **QDEMP** =__________

Other Settings

Minimum trip duration time (2.00–16000.00 cycles in 0.25-cycle steps) (see *Figure 5.6*) **TDURD** =__________

Trip open pole drop-out delay (2.00–8000 cycles) (only available in the SEL-311L-7 Relay and APP = 87LSP) **TOPD** =__________

Close failure time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) (see *Figure 6.1*) **CFD** =__________

Three-pole open time delay (0.00–60.00 cycles in 0.25-cycle steps) (usually set for no more than a cycle; see *Figure 5.7*) **3POD** =__________

Open pole option (52, 27) **OPO** =__________

Three-pole open undervoltage (0.0–150.0 V secondary) **27PO** =__________

Load detection phase pickup

OFF, 0.25–100.00A 5 A nom.; 0.05–20.00 A 1 A nom. (see *Figure 5.7*) **50LP** =__________

SELogic Control Equation Variable Timers (See Figure 7.24 and Figure 7.25)

Number of timer pickup/dropout settings dependent on preceding enable setting ESV = 1–16.

SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV1PU** =__________

SV1 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV1DO** =__________

SV2 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV2PU** =__________

SV2 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV2DO** =__________

SV3 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV3PU** =__________

SV3 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV3DO** =__________

SV4 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV4PU** =__________

SV4 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV4DO** =__________

SV5 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV5PU** =__________

SV5 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV5DO** =__________

SV6 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV6PU** =__________

SV6 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) **SV6DO** =__________

SV7 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7PU**	=_________
SV7 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7DO**	=_________
SV8 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8PU**	=_________
SV8 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8DO**	=_________
SV9 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9PU**	=_________
SV9 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9DO**	=_________
SV10 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10PU**	=_________
SV10 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10DO**	=_________
SV11 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11PU**	=_________
SV11 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11DO**	=_________
SV12 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12PU**	=_________
SV12 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12DO**	=_________
SV13 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13PU**	=_________
SV13 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13DO**	=_________
SV14 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14PU**	=_________
SV14 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14DO**	=_________
SV15 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15PU**	=_________
SV15 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15DO**	=_________
SV16 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16PU**	=_________
SV16 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16DO**	=_________

SELogic Control Equation Settings

SELogic control equation settings consist of Relay Word bits (see Table 9.5 and Table 9.6) 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 through Section 8. SELogic control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). Appendix I: Setting SELogic Control Equations gives SELogic control equation details, examples, and limitations.

Trip Logic Equations (See Figure 5.6)

Direct trip conditions	**TR**	=________________
Communications-assisted trip conditions	**TRCOMM**	=________________
Switch-onto-fault trip conditions	**TRSOTF**	=________________
Direct transfer trip conditions	**DTT**	=________________
Unlatch trip conditions	**ULTR**	=________________

Communications-Assisted Trip Scheme Input Equations

Permissive trip 1 (used for ECOMM = POTT, DCUB1, or DCUB2; see *Figure 5.9*, *Figure 5.11*, and *Figure 5.14*)	**PT1**	=________________
Loss-of-guard 1 (used for ECOMM = DCUB1 or DCUB2; see *Figure 5.14*)	**LOG1**	=________________
Permissive trip 2 (used for ECOMM = DCUB2; see *Figure 5.9* and *Figure 5.14*)	**PT2**	=________________
Loss of guard 2 (used for ECOMM = DCUB2; see *Figure 5.14*)	**LOG2**	=________________
Block trip (used for ECOMM = DCB; see *Figure 5.18*)	**BT**	=________________

Close Logic Equations (See Figure 6.1)

Circuit breaker status (used in *Figure 5.7*, also)	**52A**	=________________
Close conditions (other than automatic reclosing or **CLOSE** command)	**CL**	=________________
Unlatch close conditions	**ULCL**	=________________

Reclosing Relay Equations (See Reclosing Relay on page 6.10)

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 6.2*)	**79CLS**	=________________

Latch Bits Set/Reset Equations (See Figure 7.12)

Set Latch Bit LT1	**SET1**	=________________
Reset Latch Bit LT1	**RST1**	=________________
Set Latch Bit LT2	**SET2**	=________________
Reset Latch Bit LT2	**RST2**	=________________
Set Latch Bit LT3	**SET3**	=________________
Reset Latch Bit LT3	**RST3**	=________________
Set Latch Bit LT4	**SET4**	=________________
Reset Latch Bit LT4	**RST4**	=________________
Set Latch Bit LT5	**SET5**	=________________
Reset Latch Bit LT5	**RST5**	=________________
Set Latch Bit LT6	**SET6**	=________________
Reset Latch Bit LT6	**RST6**	=________________
Set Latch Bit LT7	**SET7**	=________________
Reset Latch Bit LT7	**RST7**	=________________
Set Latch Bit LT8	**SET8**	=________________
Reset Latch Bit LT8	**RST8**	=________________
Set Latch Bit LT9	**SET9**	=________________
Reset Latch Bit LT9	**RST9**	=________________
Set Latch Bit LT10	**SET10**	=________________
Reset Latch Bit LT10	**RST10**	=________________
Set Latch Bit LT11	**SET11**	=________________
Reset Latch Bit LT11	**RST11**	=________________
Set Latch Bit LT12	**SET12**	=________________
Reset Latch Bit LT12	**RST12**	=________________
Set Latch Bit LT13	**SET13**	=________________
Reset Latch Bit LT13	**RST13**	=________________
Set Latch Bit LT14	**SET14**	=________________
Reset Latch Bit LT14	**RST14**	=________________

Set Latch Bit LT15	**SET15**	=____________
Reset Latch Bit LT15	**RST15**	=____________
Set Latch Bit LT16	**SET16**	=____________
Reset Latch Bit LT16	**RST16**	=____________

Torque-Control Equations for Inst./Def.-Time Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0.

Level 1 phase (see *Figure 4.19*)	**67P1TC**	=____________
Level 2 phase (see *Figure 4.19*)	**67P2TC**	=____________
Level 3 phase (see *Figure 4.19*)	**67P3TC**	=____________
Level 1 residual ground (see *Figure 4.22*)	**67G1TC**	=____________
Level 2 residual ground (see *Figure 4.22*)	**67G2TC**	=____________
Level 3 residual ground (see *Figure 4.22*)	**67G3TC**	=____________
Level 4 residual ground (see *Figure 4.22*)	**67G4TC**	=____________
Level 1 negative-sequence (see *Figure 4.23*)	**67Q1TC**	=____________
Level 2 negative-sequence (see *Figure 4.23*)	**67Q2TC**	=____________
Level 3 negative-sequence (see *Figure 4.23*)	**67Q3TC**	=____________
Level 4 negative-sequence (see *Figure 4.23*)	**67Q4TC**	=____________

Torque-Control Equations for Time-Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0.

Phase element (see *Figure 4.24*)	**51PTC**	=____________
Residual ground element (see *Figure 4.25*)	**51GTC**	=____________
Negative-sequence element (see *Figure 4.26*)	**51QTC**	=____________

Torque-Control Equations for Tapped Load Time-Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0.

Phase inverse time (see *Figure 3.21*)	**T51PTC**	=____________
Ground inverse time (see *Figure 3.22*)	**T51GTC**	=____________
Negative-sequence time (see *Figure 3.23*)	**T51QTC**	=____________

Torque-Control Equations for Tapped Load Inst./Def.-Time Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0.

Phase instantaneous (see *Figure 3.18*)	**T50PTC**	=________________
Ground instantaneous (see *Figure 3.19*)	**T50GTC**	=________________
Negative-sequence instantaneous (see *Figure 3.20*)	**T50QTC**	=________________

87L Element Torque-Control Equation

Note: torque-control equation settings cannot be set directly to logical 0

87L torque control (see *Figure 3.15*)	**87LTC**	=________________

SELOGIC Control Equation Variable Timer Input Equations (See Figure 7.24 and Figure 7.25)

SELOGIC control equation Variable SV1	**SV1**	=________________
SELOGIC control equation Variable SV2	**SV2**	=________________
SELOGIC control equation Variable SV3	**SV3**	=________________
SELOGIC control equation Variable SV4	**SV4**	=________________
SELOGIC control equation Variable SV5	**SV5**	=________________
SELOGIC control equation Variable SV6	**SV6**	=________________
SELOGIC control equation Variable SV7	**SV7**	=________________
SELOGIC control equation Variable SV8	**SV8**	=________________
SELOGIC control equation Variable SV9	**SV9**	=________________
SELOGIC control equation Variable SV10	**SV10**	=________________
SELOGIC control equation Variable SV11	**SV11**	=________________
SELOGIC control equation Variable SV12	**SV12**	=________________
SELOGIC control equation Variable SV13	**SV13**	=________________
SELOGIC control equation Variable SV14	**SV14**	=________________
SELOGIC control equation Variable SV15	**SV15**	=________________
SELOGIC control equation Variable SV16	**SV16**	=________________

Output Contact Equations (See Figure 7.27)

Output Contact OUT101	**OUT101**	=________________
Output Contact OUT102	**OUT102**	=________________
Output Contact OUT103	**OUT103**	=________________
Output Contact OUT104	**OUT104**	=________________

Output Contact OUT105	**OUT105**	=____________
Output Contact OUT106	**OUT106**	=____________
Output Contact OUT107	**OUT107**	=____________

Output Contact Equations—Differential Board (See Figure 7.28)

Output Contact OUT201	**OUT201**	=____________
Output Contact OUT202	**OUT202**	=____________
Output Contact OUT203	**OUT203**	=____________
Output Contact OUT204	**OUT204**	=____________
Output Contact OUT205	**OUT205**	=____________
Output Contact OUT206	**OUT206**	=____________

Output Contact Equations—Extra I/O Board

Output Contact OUT301	**OUT301**	=____________
Output Contact OUT302	**OUT302**	=____________
Output Contact OUT303	**OUT303**	=____________
Output Contact OUT304	**OUT304**	=____________
Output Contact OUT305	**OUT305**	=____________
Output Contact OUT306	**OUT306**	=____________
Output Contact OUT307	**OUT307**	=____________
Output Contact OUT308	**OUT308**	=____________
Output Contact OUT309	**OUT309**	=____________
Output Contact OUT310	**OUT310**	=____________
Output Contact OUT311	**OUT311**	=____________
Output Contact OUT312	**OUT312**	=____________

Display Point Equations (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

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*)	**ER**	=______________________
Fault indication (used in time target logic—see *Table 5.1*; used also to suspend demand metering updating and peak recording and block max./min. metering—see *Local Demand Metering on page 8.3* and *Local Maximum/Minimum Metering on page 8.11*)	**FAULT**	=______________________
Block synchronism-check elements (see *Figure 4.30*)	**BSYNCH**	=______________________
Close bus monitor (see *Figure 5.7*)	**CLMON**	=______________________
Breaker monitor initiation (see *Figure 8.9*)	**BKMON**	=______________________
Enable for zero-sequence voltage-polarized and channel IP current-polarized directional elements (see *Figure 4.42*)	**E32IV**	=______________________
Enable bus stub protection	**ESTUB**	=______________________

Mirrored Bits Transmit Equations (See Appendix E: Mirrored Bits Communications)

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**	=____________

87L Transmit Bit Equations

Channel X, transmit bit 1	**T1X**	=____________
Channel X, transmit bit 2	**T2X**	=____________
Channel X, transmit bit 3	**T3X**	=____________
Channel X, transmit bit 4	**T4X**	=____________
Channel Y, transmit bit 1	**T1Y**	=____________
Channel Y, transmit bit 2	**T2Y**	=____________
Channel Y, transmit bit 3	**T3Y**	=____________
Channel Y, transmit bit 4	**T4Y**	=____________

Global Settings

Settings Group Change Delay (See Multiple Setting Groups on page 7.17)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps)	**TGR**	= ____________

Power System Configuration and Date Format (See Settings Explanations on page 9.34)

Nominal frequency (50 Hz, 60 Hz)	**NFREQ**	= ____________
Phase rotation (ABC, ACB)	**PHROT**	= ____________
Date format (MDY, YMD)	**DATE_F**	= ____________

Front-Panel Display Operation (See Section 11: Front-Panel Operations)

Front-panel display time-out (0.00–30.00 minutes in 0.01-minute steps)	**FP_TO**	= ____________

(If FP_TO = 0, no time-out occurs and display remains on last display screen, e.g., continually display metering.)

Front-panel display update rate (1–60 seconds)	**SCROLD**	= ____________

Event Report Parameters (See Section 12: Analyzing Events)

Length of event report (15, 30, 60 cycles)	**LER**	= ____________
Length of pre-fault in event report (1–14 cycles in 1-cycle steps for LER = 15) (1–29 cycles in 1-cycle steps for LER = 30) (1–59 cycles in 1-cycle steps for LER = 60)	**PRE**	= ____________

Station DC Battery Monitor (See Figure 8.15 and Figure 8.16)

DC battery instantaneous undervoltage pickup (OFF, 20–300 Vdc)	**DCLOP**	= ____________
DC battery instantaneous overvoltage pickup (OFF, 20–300 Vdc)	**DCHIP**	= ____________

Optoisolated Input Timers

Input IN101 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN101D**	= ____________
Input IN102 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN102D**	= ____________
Input IN103 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN103D**	= ____________
Input IN104 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN104D**	= ____________

Input IN105 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN105D**	=________
Input IN106 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN106D**	=________
Input IN301 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN301D**	=________
Input IN302 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN302D**	=________
Input IN303 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN303D**	=________
Input IN304 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN304D**	=________
Input IN305 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN305D**	=________
Input IN306 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN306D**	=________
Input IN307 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN307D**	=________
Input IN308 debounce time (0.00–2.00 cycles in 0.25-cycle steps)	**IN308D**	=________

Breaker Monitor Settings (See Breaker Monitor on page 8.12)

Breaker monitor enable (Y, N)	**EBMON**	=________

Make the following settings if preceding enable setting 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 in 0.01 kA steps)	**KASP1**	=________
kA Interrupted set point 2—mid. (0.00–999.00 kA primary in 0.01 kA steps)	**KASP2**	=________
kA Interrupted set point 3—max. (0.00–999.00 kA primary in 0.01 kA steps)	**KASP3**	=________

Synchronized Phasor Settings (See Appendix H: SEL Synchrophasors)

Synchronized Phasor Measurement (Y, N)	**EPMU**	=

Make the following settings if preceding enable setting EPMU = Y.

PMU Hardware ID	**PMID**	=
Phasor Data Set, Voltages (V1, ALL)	**PHDATAV**	=
Voltage Angle Compensation Factor (–179.99 to +180 degrees)	**VCOMP**	=
Phasor Data Set, Currents (ALL, NA)	**PHDATAI**	=
Current Angle Compensation Factor (–179.99 to +180 degrees)	**ICOMP**	=
Time Source Type (IRIG, IEEE)	**TS_TYPE**	=

Sequential Events Recorder

Sequential Events Recorder settings are comprised of three trigger lists. Each trigger list can include as many as 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See Sequential Events Recorder Report on page 12.36.

SER Trigger List 1

SER1 = ______________________________

SER Trigger List 2

SER2 = ______________________________

SER Trigger List 3

SER3 = ______________________________

Text Label Settings

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**	= ___________

Date_____________

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 (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

Display if DP1 = logical 1 (16 characters)	**DP1_1**	=________________
Display if DP1 = logical 0 (16 characters)	**DP1_0**	=________________
Display if DP2 = logical 1 (16 characters)	**DP2_1**	=________________
Display if DP2 = logical 0 (16 characters)	**DP2_0**	=________________
Display if DP3 = logical 1 (16 characters)	**DP3_1**	=________________
Display if DP3 = logical 0 (16 characters)	**DP3_0**	=________________
Display if DP4 = logical 1 (16 characters)	**DP4_1**	=________________
Display if DP4 = logical 0 (16 characters)	**DP4_0**	=________________
Display if DP5 = logical 1 (16 characters)	**DP5_1**	=________________
Display if DP5 = logical 0 (16 characters)	**DP5_0**	=________________
Display if DP6 = logical 1 (16 characters)	**DP6_1**	=________________
Display if DP6 = logical 0 (16 characters)	**DP6_0**	=________________
Display if DP7 = logical 1 (16 characters)	**DP7_1**	=________________
Display if DP7 = logical 0 (16 characters)	**DP7_0**	=________________
Display if DP8 = logical 1 (16 characters)	**DP8_1**	=________________
Display if DP8 = logical 0 (16 characters)	**DP8_0**	=________________
Display if DP9 = logical 1 (16 characters)	**DP9_1**	=________________
Display if DP9 = logical 0 (16 characters)	**DP9_0**	=________________
Display if DP10 = logical 1 (16 characters)	**DP10_1**	=________________
Display if DP10 = logical 0 (16 characters)	**DP10_0**	=________________
Display if DP11 = logical 1 (16 characters)	**DP11_1**	=________________
Display if DP11 = logical 0 (16 characters)	**DP11_0**	=________________
Display if DP12 = logical 1 (16 characters)	**DP12_1**	=________________
Display if DP12 = logical 0 (16 characters)	**DP12_0**	=________________
Display if DP13 = logical 1 (16 characters)	**DP13_1**	=________________
Display if DP13 = logical 0 (16 characters)	**DP13_0**	=________________

Display if DP14 = logical 1 (16 characters)	**DP14_1**	=________________
Display if DP14 = logical 0 (16 characters)	**DP14_0**	=________________
Display if DP15 = logical 1 (16 characters)	**DP15_1**	=________________
Display if DP15 = logical 0 (16 characters)	**DP15_0**	=________________
Display if DP16 = logical 1 (16 characters)	**DP16_1**	=________________
Display if DP16 = logical 0 (16 characters)	**DP16_0**	=________________

Reclosing Relay Labels (See Functions Unique to the Front-Panel Interface on page 11.5)

Reclosing Relay Last Shot Label (14 char.)	**79LL**	=________________
Reclosing Relay Shot Counter Label (14 char.)	**79SL**	=________________

Port Settings

Protocol Settings (See Below)

Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B, MBGA, MBGB, TELNET)	**PROTO**	=________________

Protocol Settings Set PROTO = SEL for standard SEL ASCII protocol. For SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD. Refer to Appendix C for details on the LMD protocol. For Distributed Network Protocol (DNP), set PROTO = DNP. Refer to Appendix F for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, MB8B, MBGA, or MBGB. Refer to Appendix E for details on MIRRORED BITS. To enable Telnet-to-relay communications on **PORT 5** and **PORT 6**, the **PORT 1** PROTO setting must be set to TELNET. Setting PROTO = TELNET disables **PORT 1** for EIA-485 communications.

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) *(38400 is not available on Port 1)*	**SPEED**	=________________
Data Bits (6, 7, 8) *This setting is available when PROTO = SEL or LMD.*	**BITS**	=________________
Parity (O, E, N) {Odd, Even, None} *This setting is available when PROTO = SEL or LMD.*	**PARITY**	=________________
Stop Bits (1, 2) *This setting is available when PROTO = SEL or LMD.*	**STOP**	=________________
Time-out (0–30 minutes) *This setting is available when PROTO = SEL or LMD. 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.*	**T_OUT**	=________________
DTA Meter Format (Y, N) *Set DTA = Y to allow an SEL DTA or SEL DTA2 to communicate with the relay. This setting is available when PROTO = SEL or LMD. Note that when DTA = Y, the date format must be set to MDY in the Global setting DATE_F.*	**DTA**	=________________

Send Auto Messages to Port (Y, N) *This setting is available when PROTO = SEL or LMD. Set AUTO = Y to allow automatic messages at the serial port.* **AUTO** = ____________

Enable Hardware Handshaking (Y, N, MBT) *MBT is available when PROTO = MBA or MBB. (Refer to* MIRRORED BITS *Protocol for the Pulsar 9600 Baud Modem on page E.5* *for details on setting MBT.) Set RTSCTS = Y to enable hardware handshaking. With RTSCTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line. Setting RTSCTS is not applicable to serial Port 1 (EIA-485) or a port configured for SEL Distributed Port Switch Protocol.* **RTSCTS** = ____________

Fast Operate Enable (Y, N) *This setting is available when PROTO = SEL or LMD. 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 D: SEL Communications Processors *for the description of the SEL-311L Relay Fast Operate commands. When PROTO = TELNET, FASTOP is set to Y and is hidden.* **FASTOP** = ____________

LMD Settings

LMD Prefix (@, #, $, %, &)	**PREFIX**	= ____________
LMD Address (1–99)	**ADDR**	= ____________
LMD Settling Time (0–30 seconds)	**SETTLE**	= ____________

TELNET Settings (PORT 1 only)

Telnet Port for Relay Access (1–65534)	**TPORT**	= ____________
Telnet Port Timeout (1–30 min)	**TIDLE**	= ____________

Ethernet Port Settings (PORT 5 and PORT 6 only)

IP Address (xxx.xxx.xxx.xxx)	**IPADDR**	= ____________
Subnet Mask (xxx.xxx.xxx.xxx)	**SUBNETM**	= ____________
Default Router (xxx.xxx.xxx.xxx)	**DEFRTR**	= ____________
Enable TCP Keep-Alive (Y, N)	**ETCPKA**	= ____________
TCP Keep-Alive Idle Range (1–20 s) *If ETCPKA = Y*	**KAIDLE**	= ____________
TCP Keep-Alive Interval Range (1–20 s) *If ETCPKA = Y*	**KAINTV**	= ____________
TCP Keep-Alive Count Range (1–20 s) *If ETCPKA = Y*	**KACNT**	= ____________
Operating Mode (FIXED, FAILOVER)	**NETMODE**	= ____________
Failover Time-out (OFF, 0.1–65.00 sec) *If NETMODE = FAILOVER*	**FTIME**	= ____________
Enable Telnet (Y, N)	**ETELNET**	= ____________
Telnet Port for Card Access (1–65534) *If ETELNET = Y*	**TPORTC**	= ____________

Telnet Port Timeout (1–30 min) *If ETELNET = Y*	**TIDLE**	= ______________
Enable FTP Server (Y, N) *If ETELNET = Y*	**EFTPSERV**	= ______________
FTP Username (20 characters) *If EFTPSERV = Y*	**FTPUSER**	= ______________
FTP Connect Banner *If EFTPSERV = Y*	**FTPCBAN**	= ______________
FTP Idle Timeout (5–255 minutes) *If EFTPSERV = Y*	**FTPIDLE**	= ______________
Enable HTTP Server (Y, N)	**EHTTP**	= ______________
HTTP TCP/IP Port (1–65535) *If EHTTP = Y*	**HTTPPORT**	= ______________
HTTP Web Server Timeout (1–30 minutes) *If EHTTP = Y*	**HTTPIDLE**	= ______________
Enable IEC 61850 Protocol (Y, N) *If IEC 61850 is available*	**E61850**	= ______________
Enable IEC 61850 GSE (Y, N) *If IEC 61850 is available*	**EGSE**	= ______________

DNP Settings

DNP Address (0–65534)	**DNPADR**	= ______________
Class for event data (0 for no event, 1–3)	**ECLASS**	= ______________
Time-set request interval, minutes (0 for never, 1–32767)	**TIMERQ**	= ______________
Currents scaling (0–3 decimal places)	**DECPLA**	= ______________
Voltages scaling (0–3 decimal places)	**DECPLV**	= ______________
Miscellaneous data scaling (0–3 decimal places)	**DECPLM**	= ______________
Select/Operate time-out interval, seconds (0.0–30.0)	**STIMEO**	= ______________
Number of data-link retries (0 for no confirm, 1–15)	**DRETRY**	= ______________
Data Link Time-out interval, seconds (0–5)	**DTIMEO**	= ______________
Minimum Delay from DCD to transmission, seconds (0.00–1.00)	**MINDLY**	= ______________
Maximum Delay from DCD to transmission, seconds (0.00–1.00)	**MAXDLY**	= ______________
Transmission delay from RTS assertion, seconds (OFF, 0.00–30.00)	**PREDLY**	= ______________
Post-transmit RTS deassertion delay, seconds (0.00–30.00)	**PSTDLY**	= ______________
Analog reporting deadband, counts (0–32767)	**ANADB**	= ______________
Allow Unsolicited Reporting (Y/N)	**UNSOL**	= ______________
Enable unsolicited messages when the relay turns on (Y/N)	**PUNSOL**	= ______________
Address of master to Report to (0–65534)	**REPADR**	= ______________
Number of events to transmit on (1–200)	**NUMEVE**	= ______________
Age of oldest event to force transmit on, seconds (0.0–60.0)	**AGEEVE**	= ______________

Time-out for confirmation of unsolicited message, seconds (0–50)	**UTIMEO**	=______

MB Settings

MIRRORED BITS RX Bad Pickup (1–10000 seconds)	**RBADPU**	=______
PPM MIRRORED BITS Channel Bad Pickup (1–10000)	**CBADPU**	=______
MIRRORED BITS Receive Identifier (1–4) *This setting is unavailable if PROTO is set to MBGA or MBGB.*	**RXID**	=______
MIRRORED BITS Transmit Identifier (1–4) *This setting is unavailable if PROTO is set to MBGA or MBGB.*	**TXID**	=______
MIRRORED BITS Receive Default State (string of 1s, 0s or Xs) 87654321	**RXDFLT**	=______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB1PU**	=______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB1DO**	=______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB2PU**	=______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB2DO**	=______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB3PU**	=______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB3DO**	=______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB4PU**	=______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB4DO**	=______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB5PU**	=______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB5DO**	=______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB6PU**	=______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB6DO**	=______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB7PU**	=______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB7DO**	=______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB8PU**	=______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB8DO**	=______

Channel Settings

87L Channel X Configuration Settings

Channel X address check (Y, G, N)	**EADDCX**	=______
If EADDCX = Y		
Channel X transmit address (1–16) *This setting is unavailable if EADDCX is set to G.*	**TA_X**	=______

Channel X receive address (1–16) *This setting is unavailable if EADDCX is set to G.*	**RA_X**	= ________
Continuous dropout alarm (1–1000 seconds)	**RBADXP**	= ________
Packets lost in last 10,000 (1–5000)	**AVAXP**	= ________
One-way channel delay alarm (1–24 ms)	**DBADXP**	= ________
If CHANX type is EIA-422		
EIA-422 receive clock edge detect (R = Rising; F = Falling)	**RC422X**	= ________
EIA-422 transmit clock edge detect (R = Rising; F = Falling)	**TC422X**	= ________
If CHANX type is not EIA-422		
Timing source (I = Internal; E = External)	**TIMRX**	= ________

87L Channel Y Configuration Settings

Channel Y address check (Y, G, N)	**EADDCY**	= ________
If EADDCY = Y		
Channel Y transmit address (1–16) *This setting is unavailable if EADDCY is set to G.*	**TA_Y**	= ________
Channel Y receive address (1–16) *This setting is unavailable if EADDCY is set to G.*	**RA_Y**	= ________
Continuous dropout alarm (1–1000 seconds)	**RBADYP**	= ________
Packets lost in last 10,000 (1–5000)	**AVAYP**	= ________
One-way channel delay alarm (1–24 ms)	**DBADYP**	= ________
If CHANY type is EIA-422		
EIA-422 receive clock edge detect (R = Rising; F = Falling)	**RC422Y**	= ________
EIA-422 transmit clock edge detect (R = Rising; F = Falling)	**TC422Y**	= ________
If CHANY type is not EIA-422		
Timing source (I = Internal; E = External)	**TIMRY**	= ________

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Section 10
Communications

Overview

The SEL-311L Relay provides:

- ➤ Line current differential communications
- ➤ Communications with EIA-232 and EIA-485 serial ports
- ➤ Communications with Ethernet ports

The first part of this section describes line current differential (87L) communications, the 87L channel monitors, and settings related to 87L communications. The rest of the section describes serial and Ethernet communications used to set, control, and interrogate the relay.

A communications interface and protocol are required for communicating with the relay. A communications interface is the physical connection on a device. Serial ports that conform to the EIA-232 standard (often called RS-232) use DB-9 or DB-25 connectors as the physical interface, whereas Ethernet ports use RJ45, ST, or LC connectors as the physical interface. Once a physical connection has been established, use a communications protocol to interact with the relay. A communications protocol is a language used to perform operations and collect data.

87L Interfaces

Order the relay with as many as two line current differential interfaces. Each interface is factory configured as one of the following:

- ➤ EIA-422
- ➤ CCITT G.703
- ➤ IEEE C37.94-Compatible 850 nm Multimode Fiber-Optic Interface
- ➤ IEEE C37.94-Compatible Modulated 1300 nm Single-mode Fiber-Optic Interface
- ➤ 1300 nm Single or Multimode Fiber-Optic Interface
- ➤ 1550 nm Single-mode Direct Fiber-Optic Interface

When the SEL-311L arrives, the interfaces are configured in accordance with the purchase order. Channel configuration settings support optimization of the interface for the channel in a particular application. The following sections describe each interface and their channel configuration settings.

Use the **SET X** command to access the channel configuration settings and channel monitor settings for line current differential channel interface X. Use the **SET Y** command for channel interface Y. Alternatively, use the front-panel **SET** command (see *Figure 11.3*).

Channel Configuration Settings

EIA-422 Interface

The EIA-422 interface supplied in an SEL-311L is isolated from the chassis to 1500 V rms. Therefore the signal common is also isolated from the chassis, preventing ground loops. To preserve that isolation, ground the cable shield only at the multiplexer. Refer to *Table 2.3* for the EIA-422 cable appropriate to your application. All of the cables shown in *Table 2.3* connect the shield at the multiplexer end only. The DB-25 connector pinout on the SEL-311L is shown in *Figure 2.12*, and is per RS-530. *Figure 2.12* also shows the direction of signal flow for an EIA-422 interface.

Use the **SET Y** or **SET X** commands to select the clock polarity for transmit and receive clocks. The receive clock polarity settings (RC422X and RC422Y) indicate the clock edge on which the data should change. The transmit clock polarity clock settings (TC422X and TC422Y) indicate clock sampling edges. For example, set TC422X = R if the multiplexer is set to sample transmit data on the rising edge of the transmit clock (rising edge of signal TXCB on DB-25 pin 12, falling edge of signal TXCA on DB-25 pin 15). Set RC422X = R if the multiplexer is set to change receive data on the rising edge of the receive clock (rising edge of signal RXCB on DB-25 pin 9, falling edge of signal RXCA on DB-25 pin 17).

Table 10.1 shows clock polarity settings for some popular EIA-422 interface communications equipment.

Table 10.1 EIA-422 Clock Polarity Settings for Popular Communications Equipment

Manufacturer	Product	Channel Card	Interface Adapter	DCE Tx/Rx Clock Polarity Setting	SEL-311L Tx/Rx Clock Polarity Setting
SEL	SEL-3094	N/A	EIA-422	SW3 = A SW4 = A	RC422 = F TC422 = F
RFL	IMUX	DS562I	MA406IA	RXICP = Normal TXICP = Normal	RC422 = F TC422 = R
Pulsar	FOCUS	64k	N/A	N/A	RC422 = R TC422 = R
General Electric	JMUX	Nx64 Unit 86464-01	86447-90	Transmit = INT ↑ Receive = INT ↑	RC422 = F TC422 = R
Telco Sys	DCB/ Route 24	HSD 2476-62	N/A	N/A	RC422 = F TC422 = R

Unlike other interfaces available with the SEL-311L, the EIA-422 interface can operate at either 64 kbps or 56 kbps. The SEL-311L automatically adapts to either data rate. There is no data rate setting. The transmit and receive clocks must be of identical frequency. This requirement is satisfied by all commercially available multiplexer equipment.

Back-to-Back Connections

Use the SEL-3094 Interface Converter to supply the required external clock for back-to-back EIA-422 connections, as shown in *Figure 10.1*. Set the SEL-311L transmit and receive clock polarity to F (falling) and set the SEL-3094 as shown in *Table 10.2*.

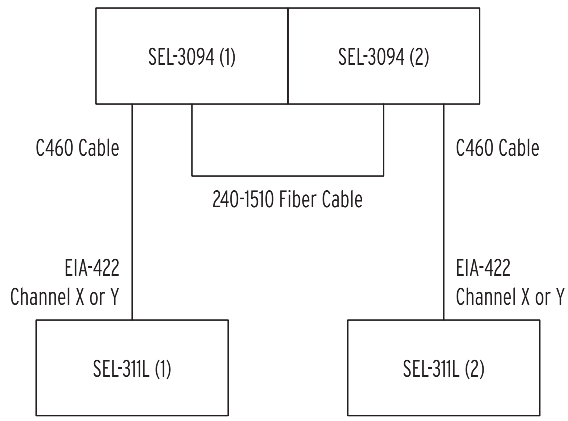


Figure 10.1 Back-to-Back EIA-422 Connection Using the SEL-3094

Table 10.2 SEL-3094 Settings

Dip Switch	Position SEL-3094 (1)	Position SEL-3094 (2)	Function
1	B	B	DCE
2	B	A	B-Internal Clock, A-External Clock
3–10	A	A	All Other

CCITT G.703 Codirectional Interface

The G.703 interface is transformer isolated from the chassis to 1500 V rms. Because each differential pair is transformer isolated, there is no signal common. To prevent ground loops, ground the cable shield only at the multiplexer. Refer to *Table 2.3* for the G.703 cable appropriate to your application. All of those cables connect the shield at the multiplexer end only. The DB-25 connector pinout on the SEL-311L and the direction of signal flow is shown in *Figure 2.13*.

For relay-to-multiplexer connections, use the **SET X** or **SET Y** commands to make setting TIMRX = E (TIMRY = E for Channel Y). No clock polarity selections are necessary because the synchronizing clock is embedded in the transmit and receive data. A typical relay-to-multiplexer connection for a G.703 interface is shown in *Figure 2.12*. The multiplexer must provide a clear channel (64 kbps) for use with the G.703 codirectional interface. If your network or multiplexer equipment cannot provide a clear channel, contact the factory.

Back-to-Back Connections

For back-to-back connections, use the **SET X** or **SET Y** commands to make setting TIMRX = E (TIMRY = E for Channel Y) in one relay, and TIMRX = I (TIMRY = I for Channel Y) in the other relay. The relay with TIMRY = E synchronizes to the relay with setting TIMRY = I, providing error-free operation. Connect the relays as shown in *Figure 10.2*.

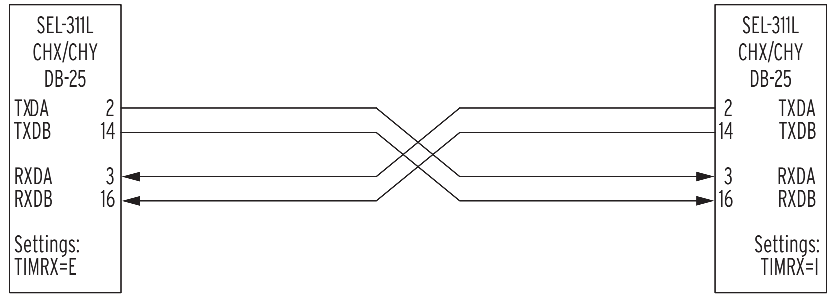


Figure 10.2 Back-to-Back CCITT G.703 Connection

IEEE C37.94-Compatible Fiber-Optic Interface

NOTE: The SEL-311L communicates with IEEE C37.94-compliant multiplexers. However, the relay itself is not IEEE C37.94-compliant, because it does not support the Yellow Alarm bit.

IEEE Standard C37.94 defines a direct relay-to-multiplexer interface over inexpensive multimode fiber-optic cable. This prevents problems associated with grounding electrical interfaces. It also provides excellent noise immunity. The standard defines the data structure and encoding as well as the physical interface (ST connector, 850 nm light wavelength, 50 or 62 µm multimode fiber) ensuring that all IEEE C37.94 compliant relays interface with all IEEE C37.94 compliant multiplexers.

The SEL-311L is available with two options that are compatible with the IEEE C37.94 interface. The first (option C on the SEL-311L Model Option Table) uses the interface as defined by the IEEE standard, i.e. ST connector, 850nm wavelength, and 50 or 62µm multimode fiber. The second (option H on the SEL-311L Model Option Table) uses the data structure and encoding defined by IEEE C37.94, as well as ST connectors, but uses a 1300 nm wavelength, and 9µm single-mode fiber.

Connect the SEL-311L to an IEEE C37.94 compliant multiplexer as shown in *Figure 2.14*. Use the **SET X** or **SET Y** commands to make setting TIMRX = E (TIMRY = E for Channel Y) in both relays. This configures the SEL-311L to synchronize the transmit data rate to exactly match the receive data rate set by the multiplexer.

IEEE C37.94 defines several troubleshooting aids, including a Yellow Alarm bit. The SEL-311L does not report the status of the receive Yellow Alarm bit, nor does it generate a Yellow Alarm bit. Consult the documentation provided with your multiplexer to determine when and if the multiplexer asserts the Yellow Alarm indicators.

Back-to-Back Connections

For back-to-back connections, use the **SET X** or **SET Y** commands to make setting TIMRX = E (TIMRY = E for Channel Y) in one relay, and TIMRX = I (TIMRY = I for Channel Y) in the other relay. The relay with TIMRY = E synchronizes to the relay with setting TIMRY = I, providing error-free operation.

The IEEE C37.94-compatible interface is suitable for distances as long as 2 km (850 nm multimode fiber) or 15 km (1300 nm single-mode fiber) either between the relay and the multiplexer or directly between relays. For longer haul direct-fiber applications using multimode or single-mode fiber, order the 1300 nm or 1500 nm fiber-optic interfaces described next.

1300 nm Single-Mode or Multimode Fiber-Optic Interface

The 1300 nm Fiber-Optic Interface on the SEL-311L uses eye-safe lasers and sensitive detectors to achieve 40 dB of system gain. This yields as long as an 80 km link on a pair of 9 micron single-mode fibers (30 km for 62.5 micron multimode fibers).

Back-to-Back Connections

For direct-fiber installations, use the **SET X** or **SET Y** commands to make setting TIMRX = E (TIMRY = E for Channel Y) in one relay, and TIMRX = I (TIMRY = I for Channel Y) in the other relay. The relay with TIMRY = E synchronizes to the relay with setting TIMRY = I, providing error-free operation. Connect the relays as shown in *Figure 2.15*.

Even though the 1300 nm direct-fiber interface provided on the SEL-311L is eye safe, you should never look into a fiber transmitter or into a fiber.

Example Link Budget for 1300 nm Lasers on 62.5 Micron Multimode Fiber

Loss Data:

Connector Loss:	2.0 dB per connector
Splice Loss (Fusion):	0.4 dB per splice
Fiber Loss @ 1300 nm:	1.0 dB per km

Budget:

SEL-311L 1300 nm Fiber Interface System Gain:	40.0 dB
Connector Loss (4 connectors):	–8.0 dB
Splice Loss (3 splices):	–1.2 dB
Available Gain:	30.8 dB

Maximum 62.5 µm Cable Length: (30.8 dB) / (1.0 dB/km) = 30.8 km.

1550 nm Single-Mode Fiber-Optic Interface

The 1550 nm Fiber-Optic Interface on the SEL-311L uses eye-safe lasers and sensitive detectors to achieve 40 dB of system gain. This yields as long as a 120 km link on a pair of 9 micron single-mode fibers.

Back-to-Back Connections

For direct-fiber installations, use the **SET X** or **SET Y** commands to make setting TIMRX = E (TIMRY = E for Channel Y) in one relay, and TIMRX = I (TIMRY = I for Channel Y) in the other relay. The relay with TIMRY = E synchronizes to the relay with setting TIMRY = I, providing error-free operation. Connect the relays as shown in *Figure 2.16*.

Even though the 1550 nm direct-fiber interface provided on the SEL-311L is eye safe, you should never look into a fiber transmitter or into a fiber.

Dual Channel Applications

Order the SEL-311L with combinations of as many as two of the channel interfaces described above for use in hot-standby two-terminal applications or three-terminal applications. Each channel interface is totally independent. Configure each without regard to the configuration of the other. In addition, the channel configurations need not depend on the function of the channel. Configure each channel regardless of whether it is the primary or standby channel in a two-terminal configuration, or whether it is used in a three-terminal application. (Use the **SET** command to choose how each channel is used with settings E87L and PCHAN.) For example, if a pair of SEL-311L relays are equipped with a 1300 nm direct-fiber interface on Channel X, and an EIA-422 interface on Channel Y, and they are connected as shown in *Figure 10.3*, then the following settings may be appropriate depending on the multiplexer equipment:

Relay 1: Channel X	Relay 1: Channel Y
TIMRX = E	RC422Y = F
	TC422Y = R

Relay 2: Channel X	Relay 2: Channel Y
TIMRX = I	RC422Y = F
	TC422Y = R

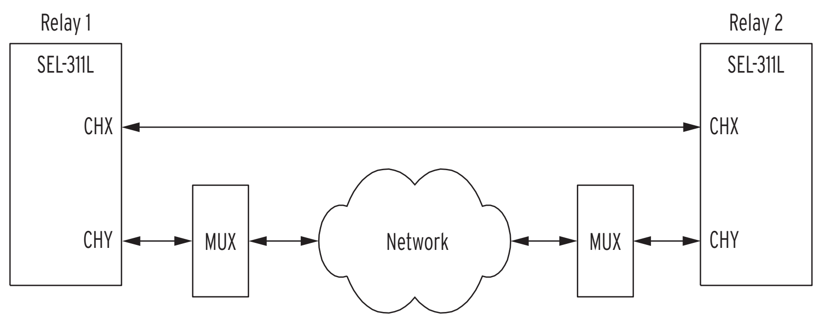


Figure 10.3 Typical Hot-Standby Connection Using Direct Fiber and Multiplexed EIA-422

In addition, the Channel Monitor settings described below are totally independent of channel assignment. Set each channel monitor as required by the particular channel application, and per expected channel performance.

87L Monitoring

The SEL-311L provides the following to indicate problems with the 87L interface and/or channel and aid in troubleshooting:

➤ Front-panel **87CH FAIL** indicator (LED) that illuminates when the relay detects a problem on either Channel X or Channel Y.

➤ Rear-panel **TX** and **RX** indicators that illuminate when the relay transmits and receives valid 87L packets from another line current differential relay.

➤ Interface and channel testing with loopback, end-to-end, and back-to-back tests.

➤ Communications report

This section describes these features and settings, which are applicable to all interface types. See *Section 13: Testing and Troubleshooting* for a description of how to use these features to troubleshoot an interface and/or channel problem.

Front-Panel 87CH FAIL LED

The availability monitor detects channel degradation or failure by counting lost packets. A packet is lost if it is not received, is received out of order, is corrupted, or contains an incorrect address. The delay monitor measures round trip channel delay, and alarms if the estimated one-way delay exceeds a threshold.

Together, the two monitors continuously check each channel for excessive delay, continuous dropout, and packets lost out of the previous 10,000. Relay Word bits CHXAL and CHYAL assert when any of those three parameters exceed a user-defined threshold. CHXAL and CHYAL do not affect protection, and are not an indication that 87L protection is not available. Relay Word bit 87LPE deasserts when 87L protection is not available due to a channel problem. When either CHXAL or CHYAL assert, or when 87LPE deasserts, front-panel LED **87CH FAIL** illuminates. Several settings control the alarm thresholds for the channel monitors, as described below. Access those settings described below with the **SET X** and **SET Y** commands. There are no settings associated with 87LPE.

Setting EADDCX and EADDCY (Address Checking)

Set EADDCX = Y (EADDCY = Y for Channel Y) to enable receive message address checking. Transmitted messages contain an address field. When EADDCX = Y, the transmitting relay places the address defined by setting TA_X (or setting TA_Y for Channel Y) in the transmitted message. The receiving relay checks to ensure that the address contained in the message matches the local RA_X setting (or RA_Y setting for Channel Y). If the received address does not match the receive address setting, the relay discards the message as if it were corrupted.

Address checking serves two purposes.

➤ The first purpose is to avoid misoperations due to inadvertent loopbacks in the network or multiplexer equipment.

An inadvertent loopback might also occur if light from a fiber-optic transmitter reflects off a surface and returns to a receiver. To effectively detect inadvertent loopbacks, set RA_X different than TA_X.

- The second purpose is to avoid misoperations due to misrouted communications links.

  To effectively detect misrouted communications links, set RA_X and TA_X uniquely for each SEL-311L connected to the network. For direct-fiber connections, set RA_X and TA_X uniquely for each SEL-311L with a fiber pair in a bundle, or for each SEL-311L with a fiber pair routed through a patch panel.

Set EADDCX = G (EADDCY = G for Channel Y) to enable the receive message address checking in the group settings. This allows a unique addressing scheme in each setting group. Use this setting when the SEL-311L is applied as a substitute line relay with multiple address configuration. This setting is also ideal for applications using the SEL-2126 Fiber-Optic Transfer Switch.

Settings RBADXP, RBADYP, AVAXP, and AVAYP (Availability Monitors)

Settings RBADXP and AVAXP (RBADYP and AVAYP for Channel Y) together detect channel loss and degradation. When no acceptable packets have been received for longer than setting RBADXP (in seconds), Relay Word bit RBADX asserts. This asserts Relay Word bit CHXAL and illuminates front-panel LED **87CH FAIL**.

When the number of packets corrupted or lost from the previous 10,000 packets exceeds setting AVAXP, Relay Word bit AVAX asserts. This asserts Relay Word bit CHXAL, and illuminates front-panel LED **87CH FAIL**. Use Relay Word bit CHXAL to assert an alarm, turn on a display point, etc.

Together, AVAXP and RBADXP detect short-term interruptions and long-term degradation of the communications circuit. After the problem is repaired, Relay Word bit AVAX resets itself in less than 15 seconds, and RBADX resets itself instantly. Settings AVAYP and RBADYP and Relay Word bits AVAY and RBADY operate the same for Channel Y.

Settings DBADXP and DBADYP (Channel Delay Monitors)

⚠CAUTION
Longer channel delays result in slower tripping times. The operate speeds shown in Figure 3.6 and Figure 3.7 were measured using a back-to-back connection. One-way channel delay times that exceed the automatic compensation capability of the SEL-311L (35 milliseconds) can result in misoperation.

Setting DBADXP (DBADYP for Channel Y) detects longer than expected channel delays. Such increased delays might be caused by channel reroutes on a switched network. When the estimated one-way channel delay exceeds setting DBADXP (in milliseconds), Relay Word bit DBADX asserts. This asserts Relay Word bit CHXAL, and illuminates front-panel LED **87CH FAIL**.

During installation, inspect the estimated one-way channel delay, using the **COMM X** or **COMM Y** commands described later in this section. Verify that this delay is as expected. Set DBADXP two to five milliseconds higher than the maximum expected or tolerable one-way channel delay. Setting DBADYP and Relay Word bit DBADY operate similarly for Channel Y.

Relay Word Bits CHXAL and CHYAL

The bits described above are combined into a single Relay Word bit for each channel, CHXAL or CHYAL. When any of AVAX, RBADX, or DBADX assert, CHXAL asserts. Similarly for Channel Y, when any of AVAY, RBADY, or DBADY assert, CHYAL asserts. Default factory settings use CHXAL and CHYAL to enable display points, alerting operators to a problem.

Relay Word Bits ROKX and ROKY

ROKX or ROKY assert if both of the previous two received packets on Channel X or Channel Y contain no errors. They are an instantaneous, unfiltered indication of channel health. The relay uses ROKX and ROKY to produce the other Relay Word bits described above. ROKX and ROKY can be useful for testing.

Relay Word Bit 87LPE

87LPE asserts when 87L protection is enabled. The relay monitors the available channels and determines if enough information is available from each remote relay to perform protection in either two-terminal or three-terminal mode. When the relay cannot perform 87L protection, Relay Word bit 87LPE deasserts. There are no settings associated with Relay Word bit 87LPE.

Hot Standby

Front-panel LED **87LCH FAIL** illuminates when the relay detects a problem on either 87L Channel X or Y. When the hot-standby feature is enabled, a channel problem on one of the two 87L channels will cause the **87CH FAIL** LED to illuminate in only the relay that cannot receive valid 87L data. In all other cases (two-terminal mode without hot-standby, or three-terminal mode), the **87CH FAIL** LED illuminates in both relays attached to the affected channel.

Use programmable Display Points and 87L Transmit/Receive bits to generate a local indication of a transmit problem in a hot-standby application. Transmit the status of the Channel Y alarm bit, CHYAL, using one of the four transmit bits of Channel X (T1X, T2X, T3X, or T4X). Likewise transmit the status of the Channel X alarm bit, CHXAL, using one of the four transmit bits of Channel Y (T1Y, T2Y, T3Y, or T4Y). Then use a local display point to signal a problem on either channel in either direction.

For example, assume a two-terminal application has a direct fiber connection on Channel Y, which is the primary protection channel, and a multiplexer connection on Channel X, which is the hot-standby channel. The direct fiber connection uses fiber pair A4B79. The multiplexed connection uses Channel 5 in Multiplexer A. In each relay, use the **SET L** command to make the following settings:

T1Y = **CHXAL**

T1X = **CHYAL**

DP1 = **R1Y**

DP2 = **CHXAL**

DP3 = **R1X**

DP4 = **CHYAL**

DP5 = **87LPE**

Using the **SET T** command, make the following text settings:

DP1_1 = **MX A CH5 TX FAIL**

DP1_0 =

DP2_1 = **MX A CH5 RX FAIL**

DP2_0 =

DP3_1 = **A4B79 TX FAIL**

DP3_0 =

DP4_1 = **A4B79 RX FAIL**

DP4_0 =

DP5_1 =

DP5_0 = **87L DISABLED**

The SEL-311L front-panel LCD displays the appropriate message when a problem occurs on either channel, in either direction. This alerts operators to the problem, and gives valuable assistance in troubleshooting the problem.

Rear-Panel TX/RX LED

Each channel interface has two rear-panel LEDs that help in troubleshooting installation problems. The RX LED illuminates when the channel is enabled and receives valid packets from another SEL-311L. The RX LED extinguishes if the channel is disabled, if there are sufficient data errors to prevent the relay from recognizing the packet boundaries, if the receive data are entirely absent, or, in the case of an EIA-422 port, if the externally supplied RX clock stops.

The TX LED illuminates when the channel is enabled and transmits valid packets. The TX LED extinguishes if the channel is disabled, or in the case of an EIA-422 interface, if the externally supplied TX clock stops.

Interface and Channel Testing

The relay alarm contact will close when the TST command is used.

The **TST** command temporarily modifies the channel configuration without changing settings. Upon exiting test mode, the relay reconfigures the channels per the channel settings.

The **TST** command enables short-term or long-term internal or external loopback tests, end-to-end tests, or back-to-back tests. The **TST** command can also be used to disable differential communications at both ends for testing local distance backup protection. In a current differential scheme, the relays at all line terminals must be blocked from tripping when any of the relays is being testing. Otherwise, a false current differential signal may be produced because of the test currents injected in one relay, while load currents are still applied to the other relays.

To enter the **TST** command, type **TST X** or **TST Y** for Channel X or Y, respectively. To end the test mode before the duration timer expires, type **TST X C** or **TST Y C**. After entering the **TST** command, the relay warns that protection and tripping are still enabled. Cut out the 87L trip contacts to avoid misoperations. This enables you to perform channels tests while backup protection remains enabled. All applied faults and load current appear as internal faults when the communications channel is looped back.

All channel monitor functions remain operational during test mode. This allows you to monitor the channel for errors during the test.

```
=>>TST X <Enter>
Entering Test Mode on Channel X.

WARNING!!!  Tripping is enabled in test mode.  !!!WARNING
Press Ctrl X now to abort. Type "TST X C" to end test mode.

  Disable 87L Communications: Yes or No (Y,N)           ? N <Enter>
  Enable Loop-Back: Internal, External or None (I,E,N)   ? E <Enter>
  Timing Source: Internal or External (I,E)             ? I <Enter>
  Test Mode Duration: 1 - 30 min. or Infinite (1-30,INF) ? 30 <Enter>

Are you sure (Y/N) ? Y <Enter>
Test Mode Enabled on Channel X.
Channel X: Test Mode
Channel Y: Normal Mode

=>>TST C X <Enter>
Channel X: Normal Mode
Channel Y: Normal Mode
=>>
```

Figure 10.4 Example of Test Mode

The **TST** command presents several options.

- The first option disables current differential communications.

  Select **Y** to disable both the local and remote relay communications to allow for local distance backup testing. Note that when this mode is enabled, the 87CHFAIL bit will assert and the associated front-panel LED will illuminate. When this mode is enabled, all other test options, except for the test mode duration setting, are hidden. Select **N** to select from the remaining test mode options.

  When the test mode duration expires, the differential communications will be restored. Communications may also be restored by using the **TST X C** command.

- The second option enables loopback operation.

  Choose either internal or external loopback operation to disable receive address checking for that channel, regardless of the EADDCX and EADDCY settings.

  - Select internal loopback to test the internal SEL-311L hardware without external connections.

    Internal loopback connects the SEL-311L transmitter to the receiver. While in internal loopback the relay continues to transmit 87L data.

  - Select external loopback to loop the channel anywhere outside the SEL-311L.

    Loop the channel back at the SEL-311L connector, at the multiplexer, anywhere in the network, or at the far end.

- Select None to perform end-to-end or back-to-back tests.
- If external or no loopback is selected, the relay prompts for the channel timing source.

  This selection overrides setting TIMRX or TIMRY.

  - Select internal timing if the channel is looped before it reaches the communications equipment.
  - Select external timing if the channel is looped after it reaches the communications equipment.

- ➤ Select the duration of the temporary test configuration from 1 to 30 minutes.
  - ➢ Enter a duration to prevent accidentally leaving the relay in test mode after the test.

    After the duration timer expires, the relay reconfigures itself per the Channel X and Channel Y settings.
  - ➢ For tests longer than 30 minutes, enter INF, and be certain to end the test mode with the **TST X C** or **TST Y C** command after testing is complete.

Communications Report

Like MIRRORED BITS, the 87L Channel Monitor creates a detailed report containing all of the previous 256 channel problems. The relay maintains a separate report for each active channel. Retrieve a summary of the report by using the **COMM X** or **COMM Y** commands. Retrieve the entire report by using the **COMM X L** or **COMM Y L** commands. Filter both the summary report and the extended report by selecting start and stop dates, or start and stop records. For example, the command **COMM X L 5/26/01 5/30/01 <Enter>** displays and summarizes all of the problems encountered on and between those dates.

Use the **COMM X C** and **COMM Y C** commands to clear the COMM reports.

The screen capture below shows an example COMM report.

```
=>>COMM Y L <Enter>
SEL-311L                         Date: 05/26/01    Time: 09:27:03.269
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311L-R100-V0-Z001001-D20010625       CID=BAFD
Summary for 87L Channel Y

Channel Status Alarms
    ROKY = 1    DBADY = 0    RBADY = 0    AVAY = 0

For 05/24/01 13:37:01.631 to 05/26/01 09:27:04.248

    COMMUNICATION LOG SUMMARY        COMMUNICATION STATISTICS
    # of Error records  29           Last error          Data Error
    Data Error          20           Longest failure           4.685 sec.
    Dropout              9           Lost Packets, prev. 24 hours      407

    Test Mode Entered    0           One Way Delay (Ping-Pong)     0.4 msec.

Error                  Recovery
#   Date     Time          Date     Time          Duration  Cause
  1 05/26/01 09:23:54.041  05/26/01 09:23:54.042     0.001  Data Error
  2 05/26/01 09:23:53.888  05/26/01 09:23:54.040     0.152  Dropout Error
  3 05/26/01 09:23:53.885  05/26/01 09:23:53.888     0.003  Data Error
  4 05/26/01 09:23:53.882  05/26/01 09:23:53.885     0.003  Dropout Error
  5 05/26/01 09:23:53.870  05/26/01 09:23:53.882     0.011  Data Error
  6 05/26/01 09:23:53.851  05/26/01 09:23:53.870     0.020  Dropout Error
  7 05/26/01 09:23:53.847  05/26/01 09:23:53.851     0.003  Data Error
  8 05/26/01 09:23:53.846  05/26/01 09:23:53.847     0.001  Dropout Error
  9 05/26/01 09:23:53.843  05/26/01 09:23:53.846     0.003  Data Error

.
.
.

 25 05/26/01 09:23:51.554  05/26/01 09:23:51.654     0.100  Dropout Error
 26 05/26/01 09:23:51.550  05/26/01 09:23:51.554     0.003  Data Error
 27 05/24/01 13:37:04.688  05/24/01 13:37:04.689     0.001  Data Error
 28 05/24/01 13:37:00.003  05/24/01 13:37:04.688     4.685  Dropout Error
 29 05/24/01 13:37:00.000  05/24/01 13:37:00.003     0.003  Data Error

=>>
```

Figure 10.5 Example COMM Report

Ethernet Interfaces

Physical Layer Options

The SEL-311L provides optional dual failover Ethernet ports with two physical layer options. Both ports (Port 5 and Port 6) are configured with Port 5 settings. The physical layer options are the following:

- ➤ Two 10/100BASE-T ports that support 10/100 Mbps rates on RJ45 connectors
- ➤ Two 100BASE-FX ports that support 100 Mbps rates on LC connectors

Using Redundant Ethernet Ports

The SEL-311L is optionally equipped with two 100BASE-TX copper or 100BASE-FX fiber-optic Ethernet ports. Use two Ethernet ports in redundant network architectures, or force the relay to use a single Ethernet port even though it is equipped with two ports.

Redundant Ethernet Network Using FAILOVER Mode

Make the following settings in Port 5 to configure the relay for FAILOVER mode.

- ➤ NETMODE = FAILOVER
- ➤ FTIME = desired timeout for the active port before failover to the backup port (0.10–65.00 seconds and OFF)

Use the internal failover switch to connect the relay to redundant networks as shown in *Figure 10.6*.

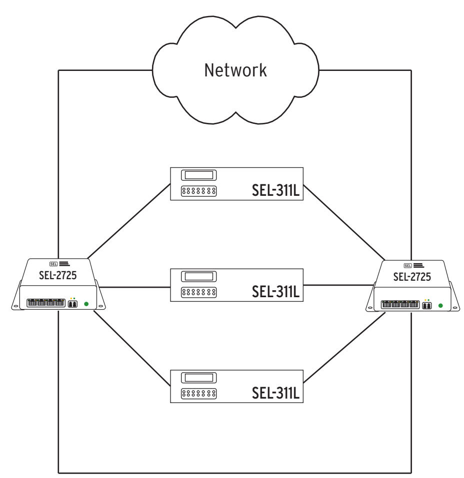


Figure 10.6 Failover Network Topology

On startup the relay communicates using Port 5. If the relay detects a link failure on Port 5, and the link status on Port 6 is healthy, the relay activates Port 6 after time FTIME. If the link status on Port 5 returns to normal before time FTIME, the failover timer resets and operation continues on Port 5.

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 Port 6, if the relay detects a link failure on Port 6, and the link status on Port 5 is healthy, the relay activates Port 5 after time FTIME.

Network Connection Using Fixed Connection Mode

Force the relay to use Ethernet Port 5 even when it is equipped with two Ethernet ports by making settings NETMODE = FIXED. Port 6 is disabled when setting NETMODE = FIXED.

Ethernet Status Relay Word Bits

The SEL-311L Ethernet status is available through the Relay Word bits shown in *Table 10.3*.

Table 10.3 Ethernet Status Indicators

Relay Word Bit	Description
P5SEL	Asserts when Port 5 is selected
P6SEL	Asserts when Port 6 is selected
LNKFAIL	Asserts when the active Ethernet port is down

Indicators

The green LED is on when the link is operational. The red LED blinks when there is transmit or receive activity.

Cables

The following Ethernet cables are compatible with the SEL-311L.

SEL Part No.	Description
C807	Duplex fiber cable LC/ST or LC/LC
C627	Shielded Cat 5 patch cable RJ45/RJ45 straight through
C628	Shielded Cat 5 patch cable RJ45/RJ45 crossover

Serial Port Interfaces

Terminal Software

You can use a variety of terminal emulation programs on your personal computer to communicate with the relay.

For the best display, use VT-100 terminal emulation or the closest variation.

The default settings for all serial ports are:

- Baud Rate = 2400
- Data Bits = 8
- Parity = N
- Stop Bits = 1

To change the port settings, use the **SET P** command (see *Section 9: Settings*) or the front-panel **SET** pushbutton (see *Section 11: Front-Panel Operations*).

Communications Devices

Devices useful for communications include the following:

- SEL-2032, SEL-2030, and SEL-2020 Communications Processors
- SEL-2505 or SEL-2506 Remote I/O Modules
- SEL-2100 Logic Processor
- SEL-DTA2 Display Transducer Adapter

Physical Layer

The SEL-311L provides EIA-232 and EIA-485 physical layers for serial communications as shown below.

- Three EIA-232 serial ports:
  - one EIA-232 port on the front
  - two EIA-232 ports on the rear
- One EIA-485 port on the rear

Connect the serial port to a computer serial port for local communications or to a modem for remote communications.

All EIA-232 serial ports support RTS/CTS hardware handshaking. RTS/CTS handshaking is not supported on the EIA-485 Serial Port 1. To enable hardware handshaking, use the **SET P** command (or front-panel SET pushbutton) to set RTSCTS = Y. Disable hardware handshaking by setting RTSCTS = N.

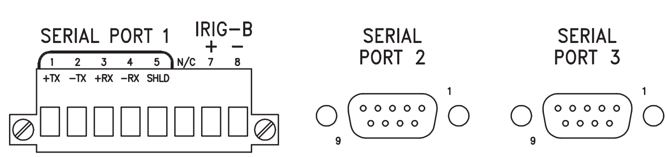
- If RTS_CTS = N, the relay permanently asserts the RTS line.
- If RTSCTS = Y, the relay deasserts RTS when it is unable to receive characters.
- If RTSCTS = Y, the relay does not send characters until the CTS input is asserted.

The serial port physical interfaces (DB-9 connectors and screw-terminal connector) support a communications interface, power supply for communications interface converters, and time-synchronization source (IRIG-B), as shown in *Table 10.4*.

Table 10.4 Physical Interfaces

Port	Communications Interface	Demodulated IRIG-B	+5 Vdc Power Supply
Port 1	EIA-485	X	X
Port 2	EIA-232	X	X
Port 3	EIA-232		X
Port 4	EIA-232		

Figure 10.7 shows the serial port physical interfaces (connectors) on the relay rear panel.



(female chassis connector, as viewed from outside)

Figure 10.7 Serial Port Connectors

Connector pinout for the EIA-232 ports and terminal functions for the EIA-485 port are as shown in *Table 10.5* and *Table 10.6*, respectively, with descriptions as shown in *Table 10.7*.

Table 10.5 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 Multifunction Serial Port Voltage Jumpers on page 2.31.

Table 10.6 Terminal Functions for EIA-485 Serial Port 1

Terminal	Function
1	+TX
2	–TX
3	+RX
4	–RX
5	SHIELD
6	N/C
7	+IRIG-B
8	–IRIG-B

Table 10.7 Serial Communications Port Pin/Terminal Function Definitions

Pin Function	Definition
N/C	No Connection
+5 Vdc (0.5 A limit)	5 Vdc Power Connection
RXD, RX	Receive Data
TXD, TX	Transmit Data
IRIG-B	IRIG-B Time-Code Input
GND	Ground
SHIELD	Grounded Shield
RTS	Request To Send
CTS	Clear To Send
DCD	Data Carrier Detect
DTR	Data Terminal Ready
DSR	Data Set Ready

Several optional SEL transceivers are available to provide alternative communications interfaces, including EIA-485 and fiber-optic.

IRIG-B

Refer to *Figure 2.2–Figure 2.5*. Note that demodulated IRIG-B time code can be input into Serial Port 1 or Serial Port 2 on any of the SEL-311L models. This is easily handled by connecting Serial Port 2 of the SEL-311L to an SEL-2032 with an SEL-C273A cable (see cable diagrams that follow in this section).

Note that demodulated IRIG-B time code can be input into the connector for Serial Port 1. If demodulated IRIG-B time code is input into this connector, it should not be input into Serial Port 2, and vice versa.

Relay Word Bit TIRIG

TIRIG asserts when the relay time is based on an IRIG-B time source. In the event that the relay is not synchronized to a connected IRIG-B time source (TIRIG = logical 0), the troubleshooting steps detailed in *IRI Command (Synchronize to IRIG-B Time Code) on page 10.38* should be used.

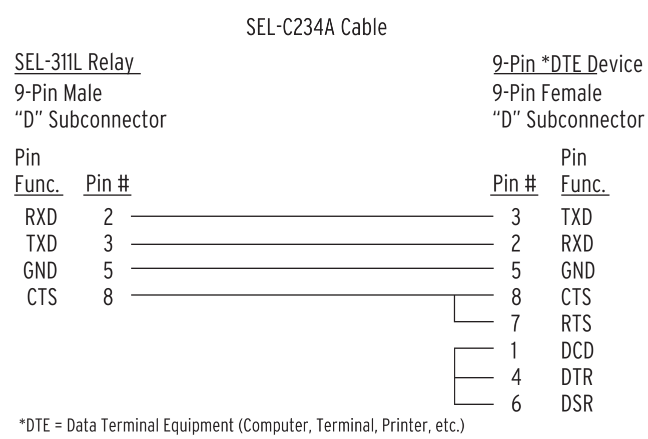
Relay Word Bit TSOK

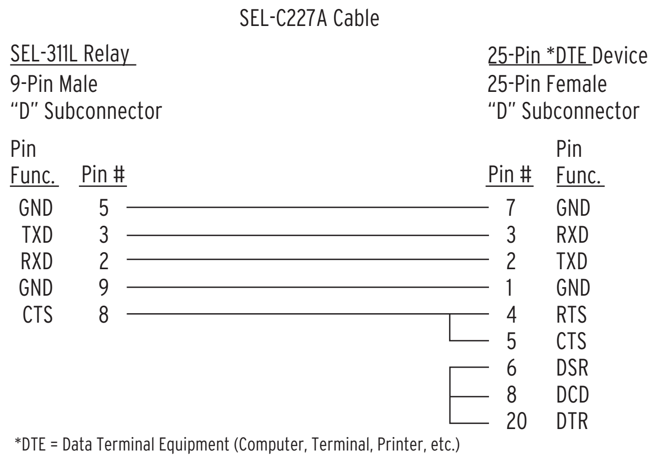
TSOK asserts to indicate that the IRIG-B time source is of sufficient accuracy for synchrophasor measurement. See *Appendix H: SEL Synchrophasors* for more information regarding the SEL Fast Message Synchrophasor Protocol.

Cables

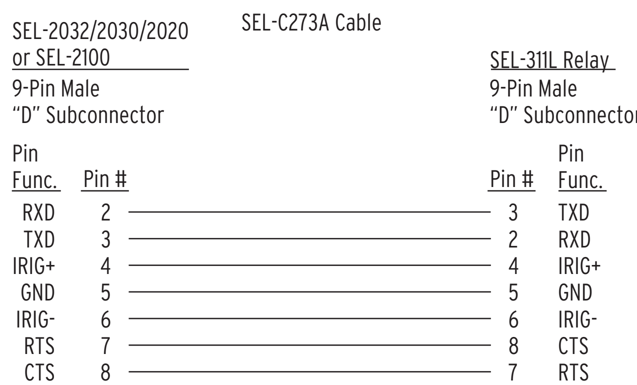
The following EIA-232 cables are compatible with the SEL-311L. The cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-311L to other devices. SEL provides fiber-optic transceivers and cable for communications links with improved safety, noise immunity, and distance as compared to copper links. The equivalent fiber cables are listed following each copper cable description. These and other cables are available from SEL. Contact the factory for more information.

SEL-311L to Computer

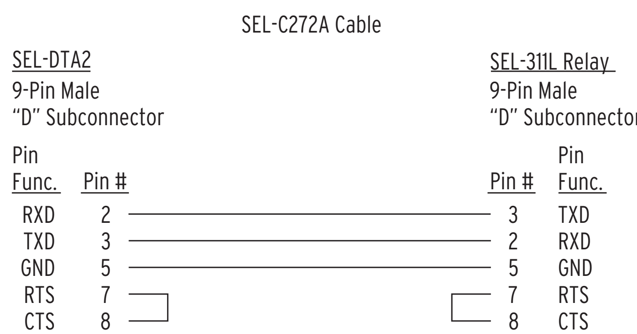




SEL-311L to SEL-2032, SEL-2030, SEL-2020, or SEL-2100



SEL-311L to SEL-DTA2



SEL-311L to Dial-Up Modem, 5 Vdc Powered

SEL-C220 Cable

Dial-Up Modem
25-Pin Male
"D" Subconnector

SEL-311L Relay
9-Pin Male
"D" Subconnector

Pin Func.	Pin #	Pin #	Pin Func.
GND	72	5	GND
TXD (IN)	2	3	TXD
DTR (IN)	20	7	RTS
RXD (OUT)	3	2	RXD
CD (OUT)	8	8	CTS
PWR (IN)	10	1	+5 VDC
GND	1	9	GND

SEL-311L to Modem or Other DCE

SEL-C222 Cable

SEL-311L Relay
9-Pin Male
"D" Subconnector

**DCE Device
25-Pin Male
"D" Subconnector

Pin Func.	Pin #	Pin #	Pin Func.
GND	5	7	GND
TXD	3	2	TXD (IN)
RTS	7	20	DTR (IN)
RXD	2	3	RXD (OUT)
CTS	8	8	CD (OUT)
GND	9	1	GND

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

For communications as far as 80 kilometers and for electrical isolation of communications ports, use the SEL-2800 family of fiber-optic transceivers. Contact SEL for more details on these devices.

Communications Protocols

This section explains the communications protocols used by the SEL-311L, except the 87L communications protocols. You can set and operate the relay via the communications ports.

Serial Port Protocols

SEL

Set the serial port PROTO setting to SEL (PROTO = SEL) to access the following protocols, which are described in more detail later in this section:

- ASCII
- Compressed ASCII
- Fast Meter
- Fast Operate
- Fast SER (Unsolicited Sequential Events Recorder (SER) Protocol)
- Fast Synchrophasor
- DTA

SEL Distributed Port Switch Protocol (LMD)

The SEL Distributed Port Switch Protocol (PROTO = LMD) permits multiple SEL relays to share a common communications channel. See *Appendix C: SEL Distributed Port Switch Protocol* for more information. The same protocols are available as when PROTO = SEL.

MIRRORED BITS Communications

The SEL-311L supports MIRRORED BITS relay-to-relay communications on two ports simultaneously. See *Appendix E: MIRRORED BITS Communications* for more information.

DNP3

Set the serial port PROTO setting to DNP (PROTO = DNP) to enable the Distributed Network Protocol (DNP3) protocol, which meets DNP3 Level 2 requirements. See *Appendix F: DNP3 Communications* for more information.

Ethernet Protocols

As with other communications interfaces, you must choose a data exchange protocol that operates over the Ethernet network link to exchange data. The SEL-311L supports FTP, Telnet, HTTP (web server), ping, and IEC 61850 protocols.

You should carefully design your Ethernet network to maximize reliability, minimize system administration effort, and provide adequate security. Work with a networking professional to design your substation Ethernet network.

FTP Server

Use the single File Transfer Protocol (FTP) session to access the following files:

File	Description
CFG.XML	Configuration read-only file in XML format
ERR.TXT	Error read-only file in text format
SET_61850.CID	IEC61850 CID read-write file
.s19	Firmware upgrade write-only file

FTP is a standard TCP/IP protocol for exchanging files. A free FTP application is included with most web browser software. You can also obtain a free or inexpensive FTP application from the internet. When you connect to the relay's Ethernet card, you will find files stored in the root (top-level) directory.

Telnet Server

Use the single Telnet-to-card session (TPORTC default setting is Port 1024) to connect to the Ethernet port SEL ASCII protocol and work with the Ethernet card. Use the single Telnet-to-host session (TPORT default setting is Port 23) to connect to the relay (host) to use the following protocols, which are described in more detail below:

- SEL ASCII
- Compressed ASCII
- Fast Meter
- Fast Operate

Telnet is a terminal connection across a TCP/IP network that operates in a manner very similar to a direct serial port connection to one of the relay ports. As with FTP, Telnet is a part of TCP/IP. A free Telnet application is included with most computer operating systems, or you can obtain low-cost or free Telnet applications on the internet.

Web Server (HTTP)

When Port 5 setting EHTTP = Y, the relay serves read-only 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. To begin using the embedded read-only web server, launch your web browser, and browse to http://IPADDR, where IPADDR is the Port 5 setting IPADDR (e.g., http://192.168.1.2). The relay responds with a login screen as shown in *Figure 10.8*.

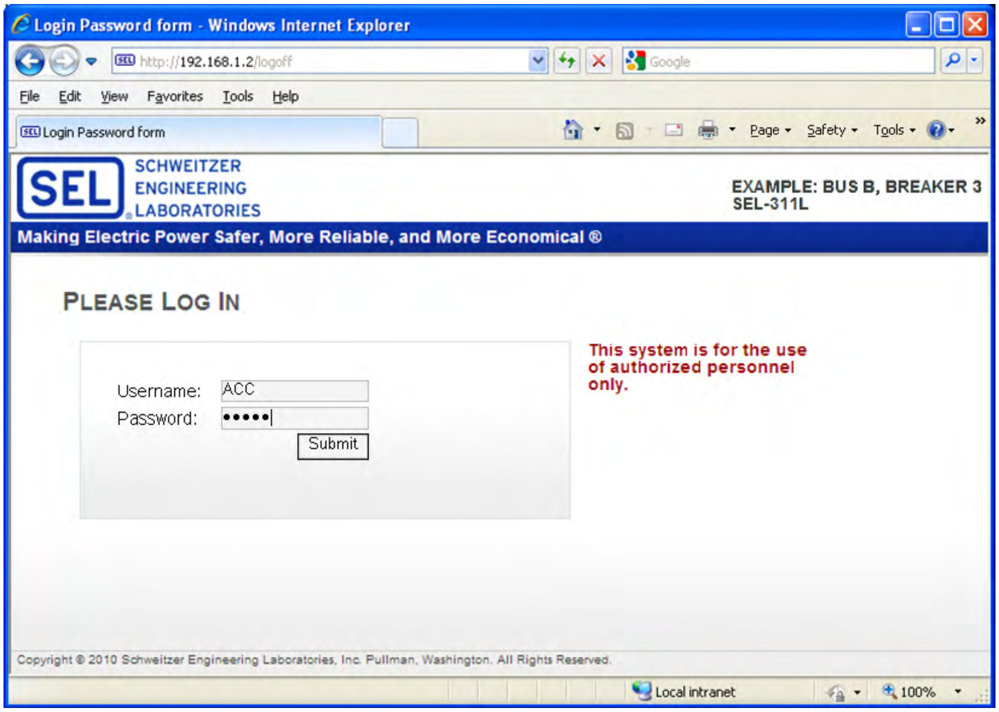


Figure 10.8 Web Server Login Screen

Enter **ACC** for the Username, type in the relay Access Level 1 password, then select `Submit`. The only username allowed is **ACC**. The relay responds with the homepage shown in *Figure 10.9*. 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 once per second based on the clock contained in your PC.

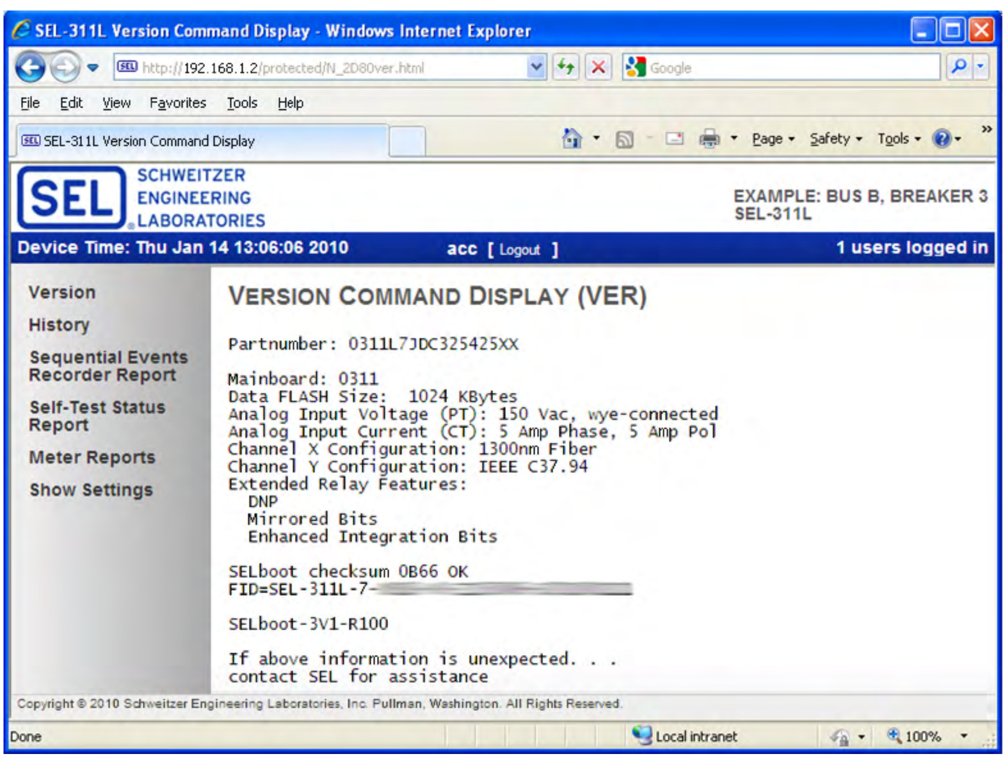


Figure 10.9 Web Server Homepage and Response to Version Menu Selection

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 10.10*.

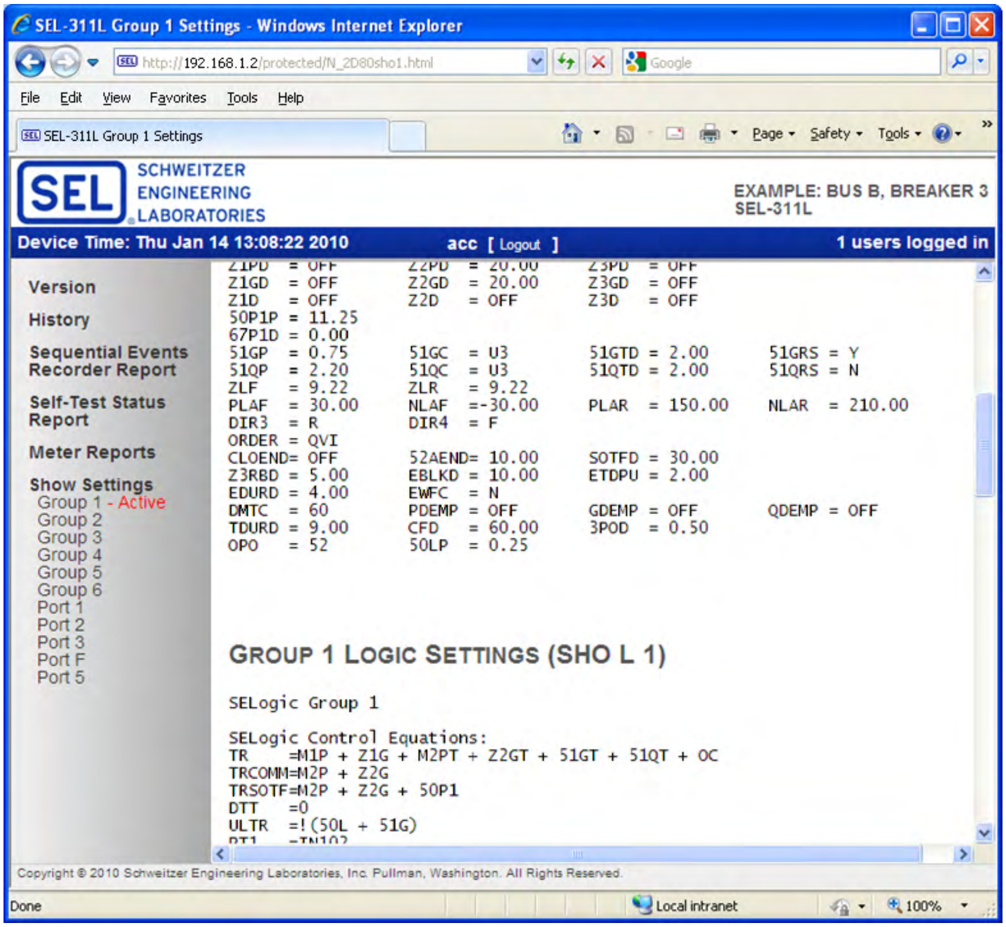


Figure 10.10 Web Server Show Settings Screen

The Meter Reports screens update automatically about every five seconds.

To log out, either close the web browser window or select **[Logout]** in the banner bar near the top of the webpage.

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.

IEC 61850

Use as many as six sessions of MMS over a TCP network to exchange data with the relay. Use GOOSE to do real-time data exchange with as many as 16 incoming messages and 8 outgoing messages. For more details on the IEC 61850 protocol see *Appendix G: IEC 61850 Communications*.

General Protocols

SEL ASCII Protocol

SEL ASCII protocol provides an interface that is compatible with terminals or terminal emulators that support ASCII. The protocol is described in more detail in the *SEL ASCII Protocol Details on page 10.25*.

SEL Compressed ASCII Protocol

SEL Compressed ASCII protocol provides compressed versions of some of the relay ASCII commands. The protocol is described in *Appendix D: SEL Communications Processors*.

SEL Fast Meter Protocol

SEL Fast Meter protocol supports binary messages to transfer metering and control messages. The protocol is described in *Appendix D: SEL Communications Processors*.

SEL Fast Operate Protocol

SEL Fast Operate protocol supports binary messages to control Relay Word bits. SEL Fast Operate protocol is available on any serial port. Turn it off by setting FAST_OP = N, a SET P setting. The protocol is described in *Appendix D: SEL Communications Processors*.

SEL Fast SER Protocol

SEL Fast SER (Sequential Events Recorder) protocol provides unsolicited SER events to an automated data collection system. SEL Fast SER protocol is described in *Appendix D: SEL Communications Processors*.

SEL Fast Message Synchrophasor Protocol

SEL Fast Message Synchrophasor Protocol consists of general Fast Messages that transport measured synchrophasor information. The protocol is described in *Appendix H: SEL Synchrophasors*.

SEL DTA

When the serial port protocol is set to SEL and the DTA setting is Y, the AUTO setting is hidden and forced to Y. With DTA set to Y, the SEL-311L supports the SEL-DTA2 Display Transducer Adapter analog transducer function with the exception of relay status information. Note that when DTA = Y, the date format must be set to MDY in the Global setting DATE_F. Otherwise, the DTA protocol might lock up for multiple faults.

SEL ASCII Protocol Details

SEL ASCII protocol is designed for manual and automatic communications.

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

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

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

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

   <STX><MESSAGE LINE 1><CRLF>

   <MESSAGE LINE 2><CRLF>

   •
   •
   •

   <LAST MESSAGE LINE><CRLF>< ETX>

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

3. The relay implements XON/XOFF flow control.

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

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

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

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

Control Characters	Keystrokes	Action
XON:	**<Ctrl + Q>**	hold down the Control key and press Q
XOFF:	**<Ctrl + S>**	hold down the Control key and press S
CAN:	**<Ctrl + X>**	hold down the Control key and press X

Automatic Messages

When the serial port AUTO setting is Y, the relay sends automatic messages to indicate specific conditions. The automatic messages are described in *Table 10.8*.

Table 10.8 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: Analyzing Events*.
Group Switch	The relay displays the active settings group after a group switch occurs. See *GRO n Command (Change Active Setting Group) on page 10.55*.
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 10.48*.

Access Levels

Commands can be issued to the relay via the serial port to view metering values, change relay settings, etc. The available serial port commands are listed in *Table 10.9*. The commands can be accessed only from the corresponding access level as shown in *Table 10.9*. The access levels are:

NOTE: In this manual, commands you type appear in bold/uppercase: **STATUS**. Computer keys you press appear in bold/brackets: **<Enter>**.

Access Level	Status
Access Level 0	lowest access level
Access Level 1	general information only
Access Level B	all Level 1 commands plus breaker control commands
Access Level 2	the highest operational access level; all Level B commands plus setting and test commands
Access Level C	is a privileged access level; should only be used to change Access Level C password

Access Level 0

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

```
=
```

This is referred to as Access Level 0. The only commands available at Access Level 0 are the **ACC** command, the **CAS** command, the **ID** command, the **QUI** command, and the **EXI** command.

Enter the **ACC** command at the Access Level 0 prompt:

```
=ACC <Enter>
```

The **ACC** command takes the relay to Access Level 1 (see *ACC Command (Go to Access Level 1)* and in the *Relay Command Explanations* section for more detail).

The **CAS** command displays the relay's Compressed ASCII configuration data.

Use the **ID** command to display the relay's firmware identification information, including the relay's part number.

```
=ID <Enter>
"FID=SEL-311L-R200-V0-Z005003-D20031106","08E3"
"CID=151E","0259"
"DEVID=EXAMPLE: BUS B, BREAKER 3","0866"
"DEVCODE=50","030C"
"PARTNO=0311L0HDD4254XX","0611"
"CONFIG=111122","038B"
=
```

Access Level 1

When the relay is in Access Level 1, the relay sends the following prompt:

```
=>
```

Commands **2AC** through **TRI** in *Table 10.9* are available from Access Level 1. For example, enter the **MET** command at the Access Level 1 prompt to view metering data:

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

The **2AC** command allows the relay to go to Access Level 2. Enter the **2AC** command at the Access Level 1 prompt:

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

The **BAC** command allows the relay to go to Access Level B. 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 **BRE *n*** through **PUL** in *Table 10.9* are available from Access Level B. For example, enter the **CLO** command at the Access Level B prompt to close the circuit breaker:

```
==>CLO <Enter>
```

While the relay is in Access Level B, any of the Access Level 1 and Access Level 0 commands are also available (commands **ACC** through **TRI** in *Table 10.9*).

The **2AC** command allows the relay to go to Access Level 2. Enter the **2AC** command at the Access Level B prompt:

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

Access Level 2

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

```
=>>
```

Commands **CON** through **VER** in *Table 10.9* are available from Access Level 2. For example, enter the **SET** command at the Access Level 2 prompt to make relay settings:

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

While the relay is in Access Level 2, any of the Access Level 1, Access Level B, and Access Level 0 commands are also available (commands **ACC** through **VER** in *Table 10.9*).

Access Level C

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

The **CAL** command allows the relay to go to Access Level C. Enter the **CAL** command at the Access Level 2 prompt:

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

Relay Command Explanations

Command Summary

Table 10.9 alphabetically lists the serial port commands within a given access level. Much of the information available from the serial port commands is also available via the front-panel pushbuttons. The correspondence between the serial port commands and the front-panel pushbuttons is also given in *Table 10.9*. See *Section 11: Front-Panel Operations* for more information on the front-panel pushbuttons.

The serial port commands at the different access levels offer varying levels of control:

- ➤ The Access Level 1 commands primarily allow the user to look at information only (settings, metering, etc.), not change it.
- ➤ The Access Level B commands primarily allow the user to operate output contacts or change the active setting group.
- ➤ The Access Level 2 commands primarily allow the user to change relay settings.

Again, a higher access level can access the serial port commands in a lower access level. The commands are shown in uppercase letters, but they can also be entered with lowercase letters.

Table 10.9 Serial Port Command Summary (Sheet 1 of 2)

Access Level	Prompt	Serial Port Command	Command Description	Corresponding Front-Panel Pushbutton
0	=	**ACC**	Go to Access Level 1	
0	=	**CAS**	Compressed ASCII configuration data	
0	=	**ID**	Relay identification and configuration information	STATUS
0	=>	**QUI**	Quit to Access Level 0	
1	=>	**2AC**	Go to Access Level 2	
1	=>	**BAC**	Go to Access Level B	
1	=>	**BRE**	Breaker monitor data	OTHER
1	=>	**CEV**	Compressed event report	
1	=>	**CHIS**	Compressed history	
1	=>	**COM**	MIRRORED BITS communications statistics	
1	=>	**CST**	Compressed status report	
1	=>	**CSU**	Compressed event summary	
1	=>	**DAT**	View/change date	OTHER
1	=>	**DNP**	Set/Show DNP map	
1	=>	**EVE**	Event reports	
1	=>	**EXI**	Quit to Access Level 0 and close Telnet session	
1	=>	**GRO**	Display active setting group number	GROUP
1	=>	**HIS**	Event summaries/histories	EVENTS
1	=>	**IRI**	Synchronize to IRIG-B	
1	=>	**MET**	Differential metering data	METER

Table 10.9 Serial Port Command Summary (Sheet 2 of 2)

Access Level	Prompt	Serial Port Command	Command Description	Corresponding Front-Panel Pushbutton
1	=>	**MET B**	Backup metering data	METER
1	=>	**SER**	Sequential Events Recorder	
1	=>	**SHO**	Show/view settings	SET
1	=>	**STA**	Relay self-test status	STATUS
1	=>	**SUM**	Display event summary	EVENTS
1	=>	**TAR**	Display relay element status	OTHER
1	=>	**TIM**	View/change time	OTHER
1	=>	**TRI**	Trigger an event report	
1	=>	**VER**	Display version and configuration information	
B	==>	**BRE** *n*	Preload/reset breaker wear	OTHER
B	==>	**CLO**	Close breaker	
B	==>	**GRO** *n*	Change active setting group	GROUP
B	==>	**OPE**	Open breaker	
B	==>	**PUL**	Pulse output contact	CNTRL
B	==>	**TEST DB**	Pulse as many as 10 binaries (Relay Word bits) for *s* seconds.	
2	=>>	**CAL**	Go to Access Level C	
2	=>>	**CON**	Control remote bit	
2	=>>	**COP**	Copy setting group	
2	=>>	**INI**	Change/accept new I/O options	
2	=>>	**L_D**	Load new firmware	
2	=>>	**LOO**	Enable loopback testing of MIRRORED BITS channels	
2	=>>	**PAS**	View/change passwords	SET
2	=>>	**SET**	Change settings	SET
2	=>>	**TST**	Test differential communications channels	

The relay responds with "Invalid Access Level" if a command is entered from an access level lower than the specified access level for the command. The relay responds:

```
Invalid Command
```

to commands not listed above or entered incorrectly.

Many of the command responses display the following header at the beginning:

```
SEL-311L                      Date: 10/12/99    Time: 16:15:39.372
EXAMPLE: BUS B, BREAKER 3
```

The definitions are:

SEL-311L Response	Definition
SEL-311L	This is the RID setting (the relay is shipped with the default setting RID = SEL-311L; see *Identifier Labels on page 9.34*).
EXAMPLE: BUS B, BREAKER 3:	This is the TID setting (the relay is shipped with the default setting TID = EXAMPLE: BUS B, BREAKER 3; see *Identifier Labels*).
Date:	This is the date the command response was given (except for relay response to the **EVE** or **SUM** 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** or **SUM** command, where it is the time the event occurred).

The serial port command explanations that follow in the *Relay Command Explanations on page 10.29* are in the same order as the commands listed in *Table 10.9*.

The following commands are available on any of the serial ports and through Telnet-to-host (relay) communications.

Access Level 0 Commands

ACC Command (Go to Access Level 1)

The **ACC** command provides entry to Access Level 1. Different commands are available at the different access levels as shown in *Table 10.9*.

ACC moves from any access level to Access Level 1.

⚠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.

Password Requirements and Default Passwords. Passwords are required if the main board Password jumper is not in place. Passwords are not required (Password jumper = OFF) if the main board Password jumper is in place (Password jumper = ON). Refer to *Table 2.6* for Password jumper information. See *PAS Command (Change Passwords) on page 10.59* for more information on passwords.

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	CLARKE

Access Level Attempt (Password Required). Assume the following conditions: Password jumper = OFF (not in place), Access Level = 0.

At the Access Level 0 prompt, enter the **ACC** command:

```
=ACC <Enter>
```

Because the Password jumper is not in place, the relay asks for the Access Level 1 password to be entered:

```
Password: ? @@@@@@
```

The relay responds:

```
SEL-311L                         Date: 10/12/99    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3

Level 1
=>
```

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

If the entered password is incorrect, the relay asks for the password again (Password: ?). The relay will ask up to three times. If the requested password is incorrectly entered three times, the relay closes the **ALARM** contact for one second and remains at Access Level 0 ("=" prompt).

Access Level Attempt (Password Not Required). Assume the following conditions: Password jumper = ON (in place), Access Level = 0.

At the Access Level 0 prompt, enter the **ACC** command:

```
=ACC <Enter>
```

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

```
SEL-311L                         Date: 10/12/99    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3

Level 1
=>
```

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

The above two examples demonstrate how to go from Access Level 0 to Access Level 1. The procedure to go from Access Level 1 to Access Level B, Access Level 1 to Access Level 2, Access Level B to Access Level 2, or Access Level 2 to Access Level C is much the same, with command **BAC**, **2AC**, or **CAL** entered at the access level screen prompt. The relay closes the **ALARM** contact for one second after a successful Level B, Level 2, or Level C access. If access is denied, the **ALARM** contact closes for one second.

CAS Command

The Compressed ASCII configuration provides data for an external computer to extract data from other Compressed ASCII commands. For details on this and other Compressed ASCII commands see *Appendix D: SEL Communications Processors*.

ID Command

Enter **ID** over a serial port to obtain relay identification and configuration information.

Table 10.10 ID Command

Command	Description	Access Level
ID	Return a list of relay identification codes	0, 1, 2

Each line of the **ID** command report contains an identification code and a line checksum. The SEL-311L presents these codes in the following order:

- FID: reports the firmware identification string
- BFID: reports the Boot firmware identification string
- CID: reports the checksum of the firmware
- DEVID: reports the device identification (DID setting)
- DEVCODE: reports the Modbus device code
- PARTNO: reports the device part number
- CONFIG: reports the device configuration (e.g., nominal current and nominal frequency)

QUI Command (Quit Access Level)

The **QUI** command returns the relay to Access Level 0.

To return to Access Level 0, enter the command:

```
=>QUI <Enter>
```

The relay sets the port access level to 0 and responds:

```
SEL-311L                          Date: 10/12/99    Time: 16:32:10.747
EXAMPLE: BUS B, BREAKER 3

=
```

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 C: SEL Distributed Port Switch Protocol* for details on SEL Distributed Port Switch Protocol [LMD]).

Access Level 1 Commands

2AC and BAC Commands

See previous discussion on *Access Levels on page 10.26*.

BRE Command (Breaker Monitor Data)

Use the **BRE** command to view the breaker monitor report.

```
=>BRE <Enter>

SEL-311L                          Date: 10/12/99    Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

Rly Trips=      9
 IA=       40.7 IB=       41.4 IC=       53.8 kA

Ext Trips=      3
 IA=        0.8 IB=        0.9 IC=        1.1 kA

Percent wear: A=   4 B=   4 C=   6

LAST RESET 10/12/99 15:32:59
=>
```

See *BRE n Command (Preload/Reset Breaker Wear) on page 10.54* in *Access Level B* commands and *Breaker Monitor on page 8.12* for further details on the breaker monitor.

CEV Command

Displays event report in Compressed ASCII format. For details on this and other Compressed ASCII commands see *Appendix D: SEL Communications Processors*.

CHIS Command

Display history in Compressed ASCII format. For details on this and other Compressed ASCII commands see *Appendix D: SEL Communications Processors*.

COM Command (Communication Data)

The **COM** command displays integral relay-to-relay (MIRRORED BITS) communications performance data. For more information on MIRRORED BITS, see *Appendix E: MIRRORED BITS Communications*. To get a summary report, enter the **COM *n*** command with the channel parameter (*n* = A, B, X, or Y). **COM A** and **COM B** report performance for MIRRORED BITS Channels A and B, respectively. **COM X** and **COM Y** report performance for 87L Channels X and Y. This section describes the MIRRORED BITS reports. See *Communications Report on page 10.12*, for information on **COM X** and **COM Y**.

```
=>COM A <Enter>

SEL-311L                          Date: 10/12/99    Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311L-R100-V0-Z001001-D20010625       CID=FF27
Summary for Mirrored Bits channel A

For 10/05/99 18:36:09.279 to 10/10/99 18:36:11.746

    Total failures      1                   Last error
    Relay Disabled      1
    Data error          0                   Longest Failure     2.458 sec.
    Re-Sync             0
    Underrun            0                   Unavailability  0.996200
    Overrun             0
    Parity error        0
    Framing error       0                   Loop-back    0
    Bad Re-Sync         0
=>
```

If the channel specifier is omitted or not one of the identified parameters, then the report defaults to Channel X. Use the L parameter to get a summary report, followed by a listing of the COMM records.

```
=>COM A L <Enter>

SEL-311L                          Date: 10/12/99    Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311L-R100-V0-Z001001-D20010625       CID=FF27
Summary for Mirrored Bits channel A

For 10/05/99 17:18:12.993 to 10/10/99 18:37:36.123

    Total failures      4                   Last error
    Relay Disabled      2
    Data error          0                   Longest Failure     2.835 sec.
    Re-Sync             0
    Underrun            1                   Unavailability  0.000003
    Overrun             0
    Parity error        1
    Framing error       0                   Loop-back    0
    Bad Re-Sync         0

    Failure                Recovery
#   Date     Time          Date     Time          Duration  Cause
1   10/05/99 18:36:09.279  10/05/9918:37:36.114      2.835
2   10/06/99 13:18:09.236  10/06/99 13:18:09.736     0.499  Parity error
3   10/07/99 11:43:35.547  10/07/99 11:43:35.637     0.089  Underrun
4   10/09/99 17:18:12.993  10/09/99 17:18:13.115     0.121

=>
```

There may be as many as 255 records in the extended report. To limit the number of COMM records displayed in the report to the 10 most recent records, type **COM *n* 10 L <Enter>**. To select lines 10 through 20 of the COMM records for display in the report, type **COM *n* 10 20 L <Enter>**. To reverse the order of the COMM records in the report, supply a range of row numbers, with the larger number first, i.e., **COM *n* 40 10 L <Enter>**. To display all the COMM records that started on a particular day, supply that date as a parameter, i.e., **COM *n* 2/8/98 L <Enter>**. To display all the COMM records that started between a range of dates, supply both dates as parameters, i.e., **COM *n* 2/21/98 2/7/98 L <Enter>**. Reversing the order of the dates will reverse the order of the records in the report. To receive a summary report for a subset of the records, use one of the above methods while omitting the L parameter.

To clear the COMM records, type **COM *n* C <Enter>**. The prompting message `Are you sure (Y/N) ?` is displayed. Typing **N <Enter>** aborts the clearing operation with the message `Canceled`. If both MIRRORED BITS channels are enabled, omitting the channel specifier in the clear command will cause both channels to be cleared.

CST Command

Display status data in Compressed ASCII format. For details on this and other Compressed ASCII commands see *Appendix D: SEL Communications Processors*.

CSU Command

Display long summary event report in Compressed ASCII format. For details on this and other Compressed ASCII commands see *Appendix D: SEL Communications Processors*.

DAT Command (View/Change Date)

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

NOTE: After setting date or time, allow at least 60 seconds before powering down the relay or the new setting may be lost.

To set the date, type **DAT mm/dd/yy <Enter>** if the DATE_F setting is MDY. If the DATE_F is set to YMD, **enter DAT yy/mm/dd <Enter>**. To set the date to June 1, 1999, enter when DATE_F = MDY:

```
=>DAT 6/1/99 <Enter>
06/01/99
=>
```

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

EVE Command (Event Reports)

Use the **EVE** command to view event reports. See *Section 12: Analyzing Events* for further details on retrieving event reports.

GRO Command (Display Active Setting Group Number)

Use the **GRO** command to display the active settings group number. See *GRO n Command (Change Active Setting Group) on page 10.55* and *Multiple Setting Groups on page 7.17* for further details on settings groups.

HIS Command (Event Summaries/History)

HIS x displays event summaries or allows you to clear event summaries (and corresponding event reports and event summaries) from nonvolatile memory.

If no parameters are specified with the **HIS** command:

```
=>HIS <Enter>
```

the relay displays the most recent event summaries in reverse chronological order.

If *x* is the letter E:

```
=>HIS E <Enter>
```

the relay displays the most recent event summaries in reverse chronological order. The leading number is a unique event identifier between 1 and 32767 that can be used with the **SUM** or **CSU** commands to view event summaries for that event.

If *x* is a number:

```
=>HIS x <Enter>
```

the relay displays the *x* most recent event summaries. The maximum number of available event summaries is a function of the LER (length of event report) setting.

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

The event summaries include the date and time the event was triggered, the type of event, the fault location, the maximum phase current in the event, the power system frequency, the number of the active setting group, the reclose shot count, and the front-panel targets.

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

```
=>HIS <Enter>
SEL-311L                           Date: 10/12/99    Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

#     DATE      TIME     EVENT   LOCAT  CURR  FREQ GRP SHOT TARGETS

1  10/01/99 08:33:00.365 TRIG  $$$$$$$     1 60.00  3    2
2  10/02/99 20:32:58.361 ER    $$$$$$$   231 60.00  2    2
3  10/03/99 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:

Table 10.11 Event Types

Event Type	Faulted Phase
AG	A-phase to ground
BG	B-phase to ground
CG	C-phase to ground
AB	A-B phase-to-phase
BC	B-C phase-to-phase
CA	C-A phase-to-phase
ABG	A-B phase-to-phase to ground
BCG	B-C phase-to-phase to ground
CAG	C-A phase-to-phase to ground
ABC	three-phase

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 is disabled or does not run successfully, $$$$$$$ is listed in the LOCAT column. 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:

Event Type	Description
TRIP	event report generated by assertion of Relay Word bit TRIP
ER	event report generated by assertion of SELOGIC control equation event report trigger setting ER
PULSE	event report generated by execution of the **PUL** (Pulse) command
TRIG	event report generated by execution of the **TRI** (Trigger) command

The TARGETS column will display any of the following illuminated front-panel target LEDs if the event report is generated by a trip (assertion of TRIP Relay Word bit):

TIME COMM 87 50/51 Zone 1 Zone 2 Zone 3

For more information on front-panel target LEDs, see *Section 5: Trip and Target Logic*. For more information on event reports, see *Section 12: Analyzing Events*.

For more information on event summaries, see *SUM Command (Long Summary Event Report) on page 10.50*.

INI Command (Initialize Interface Boards)

Access Levels 1, B, 2

The **INITIO** command reports the number and type of interface boards in the relay from Access Levels 1 and B. If the number or type of interface boards has changed since the last application of power, **INITIO** will confirm that the interface boards present are correct from Access Level 2.

```
=>>INI <Enter>

I/O BOARD       INPUTS    OUTPUTS
Main              6         7
1                 0         6
2                 No Board Connected

=>>
```

IRI Command (Synchronize to IRIG-B Time Code)

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

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

```
=>IRI <Enter>
```

If the relay successfully synchronizes to IRIG, it sends the following header and access level prompt:

```
SEL-311L                          Date: 10/12/99    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3

=>
```

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

```
IRIG-B DATA ERROR

=>
```

If an IRIG-B signal is present, the relay synchronizes its internal clock with IRIG-B. It is not necessary to issue the **IRI** command to synchronize the relay clock with IRIG-B. Use the **IRI** command to determine if the relay is properly reading the IRIG-B signal.

In addition, the Relay Word bit TIRIG = logical 1 when the relay is properly reading an IRIG-B signal,

MET Command (Metering Data)

MET k. The numerical modifier *k* is an optional parameter to specify the number of times (1–32767) to repeat the meter display. The **MET** command provides the currents and vector sums and ratios used in the differential calculations. This provides an easily accessible way of checking connections and ensuring no steady-state conditions exist that could cause a relay misoperation. The local positive-sequence current is reference-all other current angles are referenced to that.

The vector sum of the currents shows the quality of the CT and communication channels under normal conditions. Under perfect ratio matching and communications, the vector sum would indicate the line charging current. The alpha plane display shows where each phase and sequence current plots in the operating characteristic. Both the vector sum and alpha plane values can be used to evaluate the quality of the protection elements.

A typical display of **MET** data follows. Note that currents are displayed in primary values while settings are in secondary values. In this case Channel Y is a standby channel. Channel X is used for calculated values. Asterisks are displayed when values are not available.

```
=>MET <Enter>

SEL-311L                          Date: 06/05/01    Time: 10:28:50.360
EXAMPLE: BUS B, BREAKER 3

Local              A         B         C       3I0       3I2        I1
I MAG (A Pri)   386.444   385.401   385.597     2.838     1.747   385.813
I ANG (DEG)       -0.10   -119.90    119.80     -2.60    -19.00      0.00

Channel X  PRIM    A         B         C       3I0       3I2        I1
I MAG (A Pri)   385.644   387.077   395.563    32.567    30.969   389.172
I ANG (DEG)      179.60     59.50    -56.10     14.80    133.70   -179.00

Channel Y  STBY    A         B         C       3I0       3I2        I1
I MAG (A Pri)   386.082   385.349   395.433    31.476    32.077   388.685
I ANG (DEG)      179.70     59.80    -55.70     15.20    136.40   -178.70

Vector Sum         A         B         C       3I0       3I2        I1
I MAG (A Pri)     2.173     4.378    29.665    35.285    29.427     7.551
I ANG (DEG)       68.10     -7.60     12.20     13.40    132.10   -115.90

Alpha Plane        A         B         C    ZERO-SEQ   NEG-SEQ   POS-SEQ
RADIUS            0.990     1.000     1.020     0.000     0.000     1.000
ANG (DEG)        179.60    179.40    175.80      0.00      0.00    178.90

=>
```

MET B k–Instantaneous Metering. The **MET B** commands provide access to the local 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 groups: Instantaneous Differential, Instantaneous Backup, Demand, Energy, and Maximum/Minimum.

The **MET B k** command displays instantaneous magnitudes (and angles if applicable) of the following quantities:

Currents	$I_{A,B,C,P}$	Input currents (A primary)
	I_G	Residual-ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C,S}$	Wye-connected voltage inputs (kV primary)
Power	$MW_{A,B,C}$	Single-phase megawatts
	MW_{3P}	Three-phase megawatts
	$MVAR_{A,B,C}$	Single- and three-phase megavars
	$MVAR_{3P}$	Three-phase megavars
Power Factor	$PF_{A,B,C,3P}$	Single- and 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 on voltage channel VA)
Station DC	VDC (V)	Voltage at **POWER** terminals (input into station battery monitor

The angles are referenced to the A-phase voltage if it is greater than 13 V secondary; otherwise, the angles are referenced to positive-sequence current. The angles range from –179.99 to 180.00 degrees.

To view instantaneous metering values, enter the command:

```
=>MET B 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-311L is shown below.

```
=>MET B <Enter>

SEL-311L                          Date: 10/12/99    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3

                 A         B         C         P         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 D–Demand Metering. The **MET D** command displays the demand and peak demand values of the following quantities:

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

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

The output from an SEL-311L is shown:

```
=>MET D <Enter>

SEL-311L                          Date: 10/12/99    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3
            IA        IB         IC          IG        3I2
DEMAND     188.6     186.6      191.8       4.5       4.7
PEAK       188.6     186.6      191.8       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 01/27/97 15:31:51.238   LAST PEAK RESET 01/27/97 15:31:56.239
=>
```

Reset the accumulated demand values, using the **MET RD** command. Reset the peak demand values, using the **MET RP** command. For more information on demand metering, see *Local Demand Metering on page 8.3*.

MET E-Energy Metering. The **MET E** command displays the following quantities:

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 command:

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

The output from an SEL-311L is shown:

```
=>MET E <Enter>

SEL-311L                    Date: 03/01/00    Time: 15:11:24.056
EXAMPLE: BUS B, BREAKER 3
        MWhA      MWhB      MWhC     MWh3P    MVARhA    MVARhB    MVARhC    MVARh3P
IN       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
OUT     36.0      36.6      36.7     109.2       5.1       5.2       5.3      15.6
LAST RESET 02/10/00 23:31:28.864

=>
```

Reset the energy values, using the **MET RE** command. For more information on energy metering, see *Local Energy Metering on page 8.10*.

MET M—Maximum/Minimum Metering. The **MET M** command displays the maximum and minimum values of the following quantities:

Currents	$I_{A,B,C,P}$	Input currents (A primary)
	I_G	Residual-ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C,S}$	Wye-connected voltage inputs (kV primary)
Power	MW_{3P}	Three-phase megawatts
	$MVAR_{3P}$	Three-phase megavars
Reset Time		Last time the maximum/minimum meter was reset

To view maximum/minimum metering values, enter the command:

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

The output from an SEL-311L is shown:

```
=>MET M <Enter>

SEL-311L                          Date: 10/12/99    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3
              Max    Date      Time             Min    Date      Time
IA(A)       196.8  10/01/99  15:00:42.574      30.0  10/01/99  14:51:02.391
IB(A)       195.0  10/01/99  15:05:19.558      31.8  10/01/99  14:50:55.536
IC(A)       200.4  10/01/99  15:00:42.578      52.2  10/01/99  14:51:02.332
IP(A)        42.6  10/01/99  14:51:02.328      42.6  10/01/99  14:51:02.328
IG(A)        42.0  10/01/99  14:50:55.294      42.0  10/01/99  14:50:55.294
VA(kV)       11.7  10/01/99  15:01:01.576       3.4  10/01/99  15:00:42.545
VB(kV)       11.7  10/01/99  15:00:42.937       2.4  10/01/99  15:00:42.541
VC(kV)       11.7  10/01/99  15:00:42.578       3.1  10/01/99  15:00:42.545
VS(kV)       11.7  10/01/99  15:01:01.576       3.4  10/01/99  15:00:42.545
MW3P          6.9  10/01/99  15:00:44.095       0.4  10/01/99  15:00:42.545
MVAR3P        1.0  10/01/99  15:00:42.578       0.1  10/01/99  15:00:42.545
LAST RESET 01/27/99 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 *Local Maximum/ Minimum Metering on page 8.11*.

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 H.9*.

To view synchrophasor metering values, enter the command:

```
=>MET PM [time] [k] <Enter>
```

where *time* is an optional parameter to specify the exact time to display the synchrophasor measurements, and *k* is an optional parameter to specify the number of times (1–32767) to repeat the meter display. If *time* is not specified, the meter report is displayed at the current time. If *k* is not specified, the meter report is displayed once. The *time* and *k* parameters cannot be used simultaneously. The time should be input in 24-hour format (i.e., 15:11:00.000). If fractional seconds are input, they will be truncated. If the TSOK Relay Word bit is not set when at the specified trigger time, the relay responds:

```
Aborted: Relay word bit TSOK is not set.
=>
```

When valid time parameters are entered, the relay responds:

```
Synchronized Phasor Measurement Data Will be Displayed at hh:mm:ss.000
```

One **MET PM [*time*]** command may be pending on a single port at any one time. If a **MET PM [*time*]** command is entered while another command is pending, the old request will be canceled and the new request will be pending. **MET PM** commands entered without the time parameter will not affect any pending **MET PM [*time*]** commands.

The following shows the output from an SEL-311L:

```
=>MET PM <Enter>

                                  Date: 03/31/2006    Time: 15:11:00.000
Time Quality   Maximum time synchronization error:    0.000 (ms)  TSOK = 1

Synchrophasors
                     Phase Voltages            Pos. Sequence Voltage
                 VA        VB        VC                V1
MAG (kV)        134.140   131.646   128.600           131.447
ANG (DEG)       129.896    10.262  -111.764           129.48

                     Phase Currents            Pos. Sequence Current
                 IA        IB        IC                I1
MAG (A)         365.261   359.225   379.917           367.912
ANG (DEG)       114.930    -2.786  -120.238           117.338

FREQ (Hz) 60.029

Digitals

SV3    SV4    SV5    SV6    SV7    SV8    SV9    SV10
 0      0      0      0      0      0      0      0
SV11   SV12   SV13   SV14   SV15   SV16
 0      0      0      0      0      0

=>
```

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: Analyzing Events*.

SHO Command (Show/View Settings)

Use the **SHO** command to view relay settings, SELOGIC control equations, Global settings, serial port settings, sequential events recorder (SER) settings, and text label settings. Below are the **SHO** command options.

Table 10.12 SHO Command Options

SHO Commands	Function
SHO *n*	Show relay settings. *n* specifies the setting group (1, 2, 3, 4, 5, or 6); *n* defaults to the active setting group if not listed.
SHO A	Show all settings, even hidden settings.
SHO C	Show calibration settings.
SHO L *n*	Show SELOGIC control equation settings. *n* specifies the setting group (1, 2, 3, 4, 5, or 6); *n* defaults to the active setting group if not listed.
SHO G	Show Global settings.
SHO P *n*	Show serial port settings. *n* specifies the port (1, 2, 3, or F); *n* defaults to the active port if not listed. The Ethernet port, if available, is designated as PORT 5 or PORT 6. (PORT 6 is not available at this time.)
SHO R	Show sequential events recorder (SER) settings.
SHO T	Show text label settings.
SHO X	Show differential Channel X settings.
SHO Y	Show differential Channel Y settings.

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 **SHOWSET** commands for the SEL-311L, showing all the factory-default settings.

```
=>SHO <Enter>
Group 1

Group Settings:
RID   =SEL-311L                        TID   =EXAMPLE: BUS B, BREAKER 3
CTR   = 200       APP   = 311L
E87L  = 2         EHST  = 2         EHSDTT= N
EDD   = Y         ETAP  = N         EOCTL= N
PCHAN = X         EHSC  = N         CTR_X = 200
87LPP = 6.00      87L2P = 0.50      87LGP = OFF       CTALRM= 0.50
87LR  = 6.0       87LANG= 195
CTRP  = 200       PTR   = 2000.00  PTRS  = 2000.00
Z1MAG = 7.80      Z1ANG = 84.00
Z0MAG = 24.80     Z0ANG = 81.50     LL    = 100.00
E21P  = 3         E21MG = 3         E21XG = 3
E50P  = 1         E50G  = N         E50Q  = N
E51P  = N         E51G  = Y         E51Q  = Y
E32   = AUTO      EOOS  = N         ELOAD = Y         ESOTF = Y
EVOLT = N         E25   = N         E81   = N         EFLOC = Y
ELOP  = Y         ECOMM = POTT      E79   = N         EZ1EXT= N
ECCVT = N         ESV   = N         ELAT  = 16        EDP   = 16

Press RETURN to continue

EDEM  = THM       EADVS = N
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 = 11.25
67P1D = 0.00
51GP  = 0.75      51GC  = U3        51GTD = 2.00      51GRS = Y
51QP  = 2.20      51QC  = U3        51QTD = 2.00      51QRS = N
ZLF   = 9.22      ZLR   = 9.22
PLAF  = 30.00     NLAF  =-30.00     PLAR  = 150.00    NLAR  = 210.00
DIR3  = R         DIR4  = F
ORDER = QVI

Press RETURN to continue

CLOEND= OFF       52AEND= 10.00     SOTFD = 30.00
Z3RBD = 5.00      EBLKD = 10.00     ETDPU = 2.00
EDURD = 4.00      EWFC  = N
DMTC  = 60        PDEMP = OFF       GDEMP = OFF       QDEMP = OFF
TDURD = 9.00      TOPD = 2          CFD   = 60.00     3POD  = 0.50
OPO   = 52        50LP  = 0.25

=>
```

```
=>SHO L <Enter>
SELogic Group 1

SELogic Control Equations:
TR    =M1P + Z1G + M2PT + Z2GT + 51GT + 51QT + OC
TRCOMM=M2P + Z2G
TRSOTF=M2P + Z2G + 50P1
DTT   =0
ULTR  =!(50L + 51G)
PT1   =IN102
52A   =IN101
CL    =CC
ULCL  =TRIP + TRIP87
SET1  =0
RST1  =0
SET2  =0
RST2  =0
SET3  =0
RST3  =0
SET4  =0
RST4  =0

Press RETURN to continue

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

Press RETURN to continue

SET15 =0
RST15 =0
SET16 =0
RST16 =0
67P1TC=1
51GTC =1
51QTC =1
87LTC =1
OUT101=TRIP
OUT102=TRIP
OUT103=CLOSE
OUT104=KEY
OUT105=0
OUT106=0
OUT107=87HWAL
OUT201=TRIP + TRIP87
OUT202=TRIP + TRIP87
OUT203=0
OUT204=0
OUT205=0
OUT206=0
OUT301=0
OUT302=0
OUT303=0
OUT304=0
OUT305=0
OUT306=0
OUT307=0
OUT308=0
OUT309=0
OUT310=0
OUT311=0
OUT312=0

Press RETURN to continue
```

(Continued on next page)

(Continued from previous page)

```
DP1   =52A
DP2   =CHXAL
DP3   =CHYAL
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

Press RETURN to continue

SS5   =0
SS6   =0
ER    =/B87L2 + /M2P + /Z2G + /51G + /51Q + /50P1 + /LOP
FAULT =51G + 51Q + M2P + Z2G
BSYNCH=0
CLMON =0
E32IV =1
ESTUB =0
T1X   =0
T2X   =0
T3X   =0
T4X   =0
T1Y   =0
T2Y   =0
T3Y   =0
T4Y   =0

=>
```

```
=>SHO G <Enter>

Global Settings:
TGR    = 1800.00  NFREQ = 60       PHROT = ABC
DATE_F= MDY       FP_TO = 15.00    SCROLD= 5
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     IN301= 0.00      IN302= 0.00
IN303D= 0.00      IN304D= 0.00     IN305= 0.00      IN306= 0.00
IN307D= 0.00      IN308D= 0.00
EBMON = N

=>
```

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

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

=>
```

```
=>SHO R <Enter>

Sequential Events Recorder trigger lists:
SER1  =87L,87L2,87LG,87LA,87LB,87LC
SER2  =TRIP,TRIP87,CLOSE,LOP
SER3  =M1P,Z1G,M2P,Z2G,M3P,Z3G,67G2T,51GT,KEY,Z3RB,PTRX

=>
```

```
=>SHO T <Enter>

Text Labels:
NLB1  =              CLB1  =        SLB1  =        PLB1  =
NLB2  =              CLB2  =        SLB2  =        PLB2  =
NLB3  =              CLB3  =        SLB3  =        PLB3  =
NLB4  =              CLB4  =        SLB4  =        PLB4  =
NLB5  =              CLB5  =        SLB5  =        PLB5  =
NLB6  =              CLB6  =        SLB6  =        PLB6  =
NLB7  =              CLB7  =        SLB7  =        PLB7  =
NLB8  =              CLB8  =        SLB8  =        PLB8  =
NLB9  =              CLB9  =        SLB9  =        PLB9  =
NLB10 =              CLB10 =        SLB10 =        PLB10 =
NLB11 =              CLB11 =        SLB11 =        PLB11 =
NLB12 =              CLB12 =        SLB12 =        PLB12 =
NLB13 =              CLB13 =        SLB13 =        PLB13 =
NLB14 =              CLB14 =        SLB14 =        PLB14 =
NLB15 =              CLB15 =        SLB15 =        PLB15 =
NLB16 =              CLB16 =        SLB16 =        PLB16 =
DP1_1 =BREAKER CLOSED   DP1_0 =BREAKER OPEN

Press RETURN to continue

DP2_1 =CHANNEL X ALARM  DP2_0 =
DP3_1 =CHANNEL Y ALARM  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  =                 79SL  =

=>
```

```
=>SHO X <Enter>
EADDCX= Y        TA_X  = 1        RA_X  = 2
RBADXP= 1        AVAXP = 10       DBADXP= 10
TIMRX = E

=>
```

```
=>SHO Y <Enter>
EADDCY= Y        TA_Y  = 3        RA_Y  = 4
RBADYP= 1        AVAYP = 10       DBADYP= 10
TIMRY = E

=>
```

STA Command (Relay Self-Test Status)

The **STA** command displays the status report, showing the relay self-test information.

To view a status report, enter the command:

```
=>STA n <Enter>
```

where *n* is an optional parameter to specify the number of times (1–32767) to repeat the status display. If *n* is not specified, the status report is displayed once.

The output of an SEL-311L with wye-connected voltage inputs and no extra I/O board is shown:

```
==>>STA <Enter>

SEL-311L                          Date: 06/16/2006    Time: 04:13:05.735
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311L-1-R400-V0-Z101005-D20060616       CID=FCF1

SELF TESTS

W=Warn    F=Fail

       IA      IB      IC      IP      VA      VB      VC      VS      MOF
OS     0      -1      -0      -3      -1       3      -1       1      -1

       +5V_PS  +5V_REG -5V_REG +12V_PS -12V_PS +15V_PS -15V_PS
PS      4.96    5.04   -4.98    11.97  -12.01   14.99  -15.12

MB     TEMP    RAM     ROM     A/D     CR_RAM  EEPROM  IO_BRD
        32.2   OK      OK      OK      OK      OK      N/A

87L    RAM     ROM     CHAN X  CHAN Y  FPGA    BOARD
       OK      OK      OK      N/A     OK      OK

CC     RAM     ROM     PORT 5  PORT 6  FPGA    BOARD   DPRAM   PS
       OK      OK      LINK    N/A     OK      OK      OK      OK

 Relay Enabled

=>
```

STA Command Row and Column Definitions.

Table 10.13 STA Command Row and Column Definitions (Sheet 1 of 2)

Row Label	Definition
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.
PS	PS = Power Supply; displays power supply voltages in Vdc for the power supply outputs.
TEMP	Displays the internal relay temperature in degrees Celsius.
RAM, ROM, CR_RAM (critical RAM), EEPROM, and DPRAM	These tests verify that the relay memory components are functional. The columns display OK if memory is functioning properly; the columns display FAIL if the memory area has failed.
A/D	Analog to Digital converter status.
CHAN X	Indicates present status of 87L Channel X. FAIL indicates an active channel has a problem. OK indicates an active channel is functional. N/A indicates that channel is not active.
CHAN Y	Indicates present status of 87L Channel Y. FAIL indicates an active channel has a problem. OK indicates an active channel is functional. N/A indicates that channel is not active.
FPGA	Indicates health of the FPGA on the dedicated 87L or Ethernet card hardware. FAIL indicates a problem.
BOARD	Indicates the health of the dedicated 87L or Ethernet card hardware. FAIL indicates a problem.

Table 10.13 STA Command Row and Column Definitions (Sheet 2 of 2)

Row Label	Definition
PORT 5/PORT 6	Indicates link established on Ethernet port.
Relay Enabled/Relay Disabled	Indicates the status of the backup protection. If backup protection is Disabled, 87L protection is also disabled.
Line Current Differential Protection Disabled/Enabled	Indicates the status of 87L protection. If 87L protection is disabled, backup protection may still be enabled and functional. 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:

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

If you select “N” or “n,” the relay displays:

```
Canceled
```

and aborts the command.

If you select “Y,” the relay displays:

```
Rebooting the relay
```

The relay then restarts (just like turning off, then turning on the relay), and all diagnostics are rerun before the relay is enabled.

Refer to *Section 13: Testing and Troubleshooting* for self-test thresholds (in *Table 13.5*) and corrective actions.

SUM Command (Long Summary Event Report)

The **SUM** command displays a long summary event report (see *TRI Command (Trigger Event Report) on page 10.52*). The long summary event report is displayed on all ports with AUTO = Y whenever an event is generated.

To view a summary event report, enter the command:

```
=>SUM |ACK| n | N(ext) | <Enter>
```

where:

no parameters Display the newest chronological summary event.

ACK Acknowledge the oldest unacknowledged summary event report available on this port, or if a number is supplied, acknowledge the specified summary.

n Display (or acknowledge if ACK present) the summary event with this corresponding number in the **HIS E** command.

N(ext) View oldest unacknowledged summary event report.

TAR Command (Display Relay Element Status)

The **TAR** command displays the status of front-panel target LEDs or relay elements, whether they are asserted or deasserted. The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. The first two rows correspond to *Table 10.14*. All rows of the Relay Word are described in *Section 9: Settings*.

A Relay Word bit is either at a logical 1 (asserted) or a logical 0 (deasserted). Relay Word bits are used in SELOGIC control equations. See *Section 9: Settings* and *Appendix I: Setting SELOGIC Control Equations*.

The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL relays. But execution of the equivalent **TAR** command via the front-panel display does remap the bottom row of the front-panel target LEDs (see *Figure 11.3*, pushbutton OTHER).

The **TAR** command options are:

TAR Commands	Function
TAR *n k*	Shows Relay Word row number *n* (0–73). *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.
TAR *name k*	Shows Relay Word row containing Relay Word bit name (e.g., **TAR 50P1** displays Relay Word Row 3). Valid names are shown in *Table 9.5* and *Table 9.6*. *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.
TAR R	Clears front-panel tripping target LEDs; TRIP, TIME, COMM, SOTF, 50_51, A, B, C, G, Zone 1, Zone 2, and Zone 3. Unlatches the trip logic for testing purposes (see *Figure 5.1* and *Figure 5.6*). Shows Relay Word Row 0.

Table 10.14 SEL-311L Relay Word and Its Correspondence to TAR Command

TAR 0 (Front-Panel LEDs)	EN	TRIP	TIME	COMM	87	50_51	RCRS	RCLO
TAR 1 (Front-Panel LEDs)	A	B	C	G	ZONE1	ZONE2	ZONE3	87CH FAIL

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      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0

79RS   79CY   79LO   SH0    SH1    SH2    SH3    SH4
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0

=>
```

Note that the 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 = 2 (SH2 = logical 1). Command **TAR 31** will report the same data, because the SH1 bit is in Row 31 of the Relay Word.

TIM Command (View/Change Time)

TIM displays the relay clock. To set the clock, type **TIM** and the desired setting, then press **<Enter>**. Separate the hours, minutes, and seconds with colons, semicolons, spaces, commas, or slashes. To set the clock to 11:30 PM enter:

NOTE: After setting date or time, allow at least 60 seconds before powering down the relay or the new setting may be lost.

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

TRI Command (Trigger Event Report)

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

```
=>TRI [time] <Enter>
```

where *time* is an optional 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 truncated.

When valid time parameters are entered, the relay responds:

```
An event will trigger at hh:mm:ss

=>
```

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.

The following shows the output from an SEL-311L:

```
Triggered

=>
```

If the serial port AUTO setting = Y, the relay sends the summary event report:

```
=>

SEL-311L                          Date: 06/01/01    Time: 22:12:06.248
EXAMPLE: BUS B, BREAKER 3

Event: TRIG      Location: $$$$$$$            Trip Time: --:--:--.---
#: 00004  Shot:    Freq:  60.01  Group: 1     Close Time: --:--:--.---
Targets:                                                     Breaker: Open

                  Local                Channel X              Channel Y
PreFault:   IA    IB    IC   3I2    IA    IB    IC   3I2    IA    IB    IC   3I2
MAG(A)    1028  1028  1030     4 XXXXX XXXXX XXXXX XXXXX  1028  1019  1012    14
ANG(DEG)-160.9  79.0 -40.7-168.2 XXX.X XXX.X XXX.X XXX.X  19.5-100.8 139.5 -74.2
Fault:
MAG(A)    1028  1028  1031     4 XXXXX XXXXX XXXXX XXXXX  1029  1016  1014    10
ANG(DEG)-161.2  78.8 -41.0 125.8 XXX.X XXX.X XXX.X XXX.X  18.9-101.1 139.1 -74.2

87L Channel Status                                N:4->1  RNX  TNX  RNY  TNY

TRIG     Channel X:            Channel Y:  OK            0000 0000 0000 0000

                                         Local
PreFault:     IA     IB     IC      IP     IG    3I2       VA       VB       VC
MAG(A/kV)   1004   1005   1009      0      6      0  131.440  132.280  132.020
ANG(DEG)    0.00-120.20 119.94 -14.22 132.09 -93.22     0.00  -119.98   120.02
Fault:
MAG(A/kV)   1005   1006   1009      1      6      0  131.440  132.280  132.010
ANG(DEG)   -0.24-120.43 119.66  75.78 120.78 -10.22    -0.08  -120.07   119.93

=>
```

See *Section 12: Analyzing Events* for more information on event reports.

Recall this event summary with the **SUM** command.

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-311L follows.

```
=>VER <Enter>
Partnumber: 0311L7HDD425425XX

Mainboard: 0311
Data FLASH Size:  1024 KBytes
Analog Input Voltage (PT): 150 Vac, wye-connected
Analog Input Current (CT): 5 Amp Phase, 5 Amp Pol
Channel X Configuration: 1300nm Fiber
Channel Y Configuration: 1300nm Fiber
Extended Relay Features:
  DNP
  Mirrored Bits
  Enhanced Integration Bits

SELboot checksum 0B66 OK
FID=SEL-311L-7-R500-V0-Z105006-D20140325

SELboot-3V1-R100

If above information is unexpected. . .
contact SEL for assistance
=>
```

Access Level B Commands

BRE n Command (Preload/Reset Breaker Wear)

Use the **BRE W** command to preload breaker monitor data.

```
==>BRE W <Enter>
Breaker Wear Preload

Internal Trips (0-65000)            ITRIP   =     0      ? 11 <Enter>
Internal Current (0.00-99999 kA)    IA      = 0.00       ? 40.7 <Enter>
                                    IB      = 0.00       ? 40.8 <Enter>
                                    IC      = 0.00       ? 40.8 <Enter>

External Trips (0-65000)            EXTRIP  =     0      ? 3 <Enter>
External Current (0.00-99999 kA)    IA      = 0.00       ? 0.8 <Enter>
                                    IB      = 0.00       ? 0.9 <Enter>
                                    IC      = 0.00       ? 1.1 <Enter>

Percent Wear (0-100%)               A-phase = 0          ? 25 <Enter>
                                    B-phase = 0          ? 28 <Enter>
                                    C-phase = 0          ? 24 <Enter>

Are you sure (Y/N) ? Y <Enter>

SEL-311L                        Date: 05/10/02    Time: 13:14:56.631
EXAMPLE: BUS B, BREAKER 3

Rly Trips=     11
 IA=     40.7 IB=     40.7 IC=     40.7 kA

Ext Trips=      3
 IA=      0.8 IB=      0.8 IC=      1.1 kA

Percent wear: A=  25 B=  28 C=  24

LAST RESET 00/00/00 00:00:00
==>
```

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 <Enter>

SEL-311L                        Date: 10/13/99    Time: 10:12:45.627
EXAMPLE: BUS B, BREAKER 3

Rly Trips=      0
 IA=       0.0 IB=       0.0 IC=       0.0 kA

Ext Trips=      0
 IA=       0.0 IB=       0.0 IC=       0.0 kA

Percent wear: A=   0 B=   0 C=   0

LAST RESET 02/03/99 05:41:07
==>
```

See *Breaker Monitor on page 8.12* for further details on the breaker monitor.

CLO Command (Close Breaker)

The **CLO** command asserts Relay Word bit CC for 1/4 cycle. Relay Word bit CC can then be programmed into the SELOGIC control equation CL 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 6.1*.

See the *Set Close* discussion, following *Figure 6.1*, for more information concerning Relay Word bit CC and its recommended use, as used in the factory settings.

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 *Table 2.6*). If the Breaker jumper is not in place (Breaker jumper = OFF), the relay does not execute the **CLO** command and responds:

```
Aborted: No Breaker Jumper
```

GRO n Command (Change Active Setting Group)

The **GRO** command displays the active settings group. The **GRO *n*** command changes the active setting group to setting Group *n*. To change to settings Group 2, enter the following:

```
==>GRO 2 <Enter>
Change to Group 2
Are you sure (Y/N) ? Y <Enter>
 Changing
Active Group = 2
==>
```

The relay switches to Group 2 and pulses the ALARM contact. If the serial port AUTO setting = Y, the relay sends the group switch report:

```
==>
SEL-311L                         Date: 10/13/99    Time: 10:12:45.627
EXAMPLE: BUS B, BREAKER 3

Active Group = 2
==>
```

If any of the SELOGIC control equations settings SS1–SS6 are asserted to logical 1, the active setting group may not be changed with the **GRO** command. SELOGIC control equations settings SS1–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 3 with the **GRO 3** command will not be accepted:

```
==>GRO 3 <Enter>
Change to Group 3
Are you sure (Y/N) ? Y <Enter>
  Changing
No group change (see manual)
Active Group = 1
==>
```

For more information on setting group selection, see *Multiple Setting Groups on page 7.17*.

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 SELOGIC control equation TR to assert the TRIP Relay Word bit, which in turn asserts an output contact (e.g., OUT101 = TRIP) to trip a circuit breaker. See *Figure 5.6*.

See the discussion following *Figure 5.6* for more information concerning Relay Word bit OC and its recommended use, as used in the factory settings.

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 *Table 2.6*). 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
```

PUL Command (Pulse Output Contact)

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

PUL *x y*

where:

x = the output name (e.g. OUT101, OUT107, ALARM, OUT206—see *Figure 7.27* and *Figure 7.28*).

y = is the pulse duration (1–30 seconds). If *y* is not specified, the pulse duration defaults to 1 second.

To pulse OUT101 for 5 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 *Table 2.6*). If the Breaker jumper is not in place (Breaker jumper = OFF), the relay does not execute the **PUL** command and responds:

```
Aborted:  No Breaker Jumper
```

The relay generates an event report if any of the OUT101–OUT107 or OUT201–OUT206 contacts are pulsed. The **PUL** command is primarily used for testing purposes.

TEST DB Command

On relays equipped with Ethernet ports, use the **TEST DB *name01* [*name02. . .name10*][*s*]** command to pulse as many as 10 binaries (Relay Word bits), where *name01 . . . name10* are the Device Word bits that are to be pulsed and *s* is the number of seconds to pulse the binaries. The range for *s* is 1 to 30 seconds with a default of one second. If the binary is a logical 0, the command will pulse it to one. If the binary is a logical 1, the command will pulse it to zero. This command affects both SER and IEC 61850 communications.

Access Level 2 Commands

CAL Command

See *ACC Command (Go to Access Level 1) on page 10.31* for a discussion about using passwords and changing access levels.

CON Command (Control Remote Bit)

The **CON** command is a two-step command that allows you to control Relay Word bits RB1–RB16. At the Access Level 2 prompt, type **CON**, a space, and the number of the remote bit you wish to control (1–16). The relay responds by repeating your command followed by a colon. At the colon, type the Control subcommand you want to perform (see *Table 10.15*).

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

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

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

Table 10.15 SEL-311L CON Subcommands

Subcommand	Description
SRB *n*	Set Remote Bit *n* (“ON” position)
CRB *n*	Clear Remote Bit *n* (“OFF” position)
PRB *n*	Pulse Remote Bit *n* for 1/4 cycle (“MOMENTARY” position)

See *Remote Control Switches on page 7.9* for more information.

COP *m n* Command (Copy Setting Group)

Copy relay and SELOGIC control equation settings from setting Group *m* to setting Group *n* with the **COP *m n*** command. Setting group numbers range from 1 to 6. After entering settings into one setting group with the **SET** and **SET L**, commands, copy them to the other groups with the **COP** command. Use the **SET** and **SET L** commands to modify the copied settings. The ALARM output pulses if you copy settings into the active group.

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
=>>
```

LOO Command (Enable MIRRORED BITS Loopback Testing)

The **LOO** command is used for testing the MIRRORED BITS communications channel. For more information on MIRRORED BITS, see *Appendix E: MIRRORED BITS Communications*. With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing will be wrong and ROK will be deasserted. The **LOO** command tells the MIRRORED BITS software to temporarily expect to see its own data looped back as its input. In this mode, LBOK will assert if error-free data are received.

The **LOO** command with just the channel specifier enables loopback mode on that channel for 5 minutes, during which the inputs are forced to the default values.

```
=>>LOO A <Enter>
```

Loopback will be enabled on MIRRORED BITS channel A for the next 5 minutes.

The RMB values will be forced to default values while loopback is enabled.

```
Are you sure (Y/N) ?
=>>
```

If only one MIRRORED BITS port is enabled, the channel specifier may be omitted. To enable loopback mode for other than the default 5 minutes, enter the desired number of minutes (1–5000) as a command parameter. To allow the looped-back data to modify the RMB values, include the DATA parameter.

```
=>>LOO 10 DATA <Enter>
```

Loopback will be enabled on MIRRORED BITS channel A for the next 10 minutes.

The RMB values will be allowed to change while loopback is enabled.

```
Are you sure (Y/N) ? N <Enter>
Canceled.
=>>
```

To disable loopback mode before the selected number of minutes, re-issue the **LOO** command with the R parameter. If both MIRRORED BITS channels are enabled, omitting the channel specifier in the disable command will cause both channels to be disabled.

```
=>>LOO R <Enter>
loopback is disabled on both channels.
=>>
```

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 as listed below:

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

The **PAS**sword command allows you to change existing passwords at Access Level 2. 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
=>>
```

Similarly, **PAS B**, **PAS 2**, and **PAS C** can be used to change the Level B, Level 2, and Level C passwords, respectively.

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 Password jumper in place (Password jumper = ON). Refer to *Table 2.6* and *Table 2.7* for Password jumper information. While the password protection is disabled by setting the main board Password jumper in place (Password jumper = ON), lost or forgotten passwords can be assigned a new password, by using the **PAS *x*** command at Access Level 2. The relay will prompt for a new password and a confirmation of the new password.

If you wish to disable password protection for a specific access level [even if the Password jumper is not in place (Password jumper = OFF)], simply set the password to DISABLE. For example, **PAS 1 DISABLE** disables password protection for Level 1.

Passwords may include as many as 12 characters. See *Table 10.16* for valid characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 characters, with at least one special character or digit and mixed case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks. Examples of valid, distinct strong passwords include:

- Ot3579A24.68
- Ih2dcs4u-Iwg
- .351s.Nt9g-t

Table 10.16 Valid Password Characters

Alpha	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz
Numeric	0123456789
Special	! “ # $ % & ‘ ( ) * , - . / : ; < = > ? @ [\ ] ^ _ ` {	} ~

The relay shall issue 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.
=>>
```

SET Command (Change Settings)

The **SET** command allows the user to view or change the relay settings—see *Table 9.1*.

TST Command (Differential Channel Testing)

⚠CAUTION
Because the current from the local relay will be looped back into the relay, it is important to remove the relay from trip circuits prior to putting it into the TST mode.

The **TST** command is used for configuring the differential channels for testing or can be used to disable differential communications for testing local distance backup protection. By itself, the **TST** command will give normal or test mode status of the differential channels, as shown below.

```
=>>TST <Enter>
Channel X: Test Mode
Channel Y: Test Mode
```

NOTE: The relay alarm contact will close when the **TST** command is used.

When followed by the channel designation (**TST X** or **TST Y**), a dialog will begin to put the channel into a loopback back-to-back or end-to-end test, as shown below.

```
=>>TST X <Enter>
Entering Test Mode on Channel X.

WARNING!!!  Tripping is enabled in test mode.  !!!WARNING
Press Ctrl X now to abort. Type "TST X C" to end test mode.

  Disable 87L Communications: Yes or No (Y,N)   ? N <Enter>
  Enable Loop-Back: Internal, External or None (I,E,N)   ? I <Enter>
  Test Mode Duration: 1 - 30 min. or Infinite (1-30,INF) ? 20 <Enter>

Are you sure (Y/N) ? Y <Enter>
Test Mode Enabled on Channel X.
Channel X: Test Mode
Channel Y: Normal Mode
=>>
```

Ethernet Port Command Explanations

The following commands are available through Telnet-to-card (Ethernet port) communications.

Access Level 0

ACC

Enter **ACC** over Telnet on an optional Ethernet port to move to Access Level 1 on that port. Ethernet ports do not support the password jumper.

Table 10.17 ACC Command

Command	Description	Access Level
ACC	Go to Access Level 1 (monitoring)	0, 1, 2

EXIT

Use the **EXIT** command to properly terminate a Telnet session, which includes setting the port access level to zero and setting the target row to zero.

ID

Enter **ID** over Telnet on an optional Ethernet port to obtain Ethernet card identification and configuration information.

Table 10.18 ID Command

Command	Description	Access Level
ID	Return a list of Ethernet card identification codes	0, 1, 2

Each line of the **ID** command report contains an identification code and a line checksum. The SEL-311L presents these codes in the following order, but the optional iedName, type, and configVersion codes will only be displayed if IEC 61850 is enabled (E61850 = Y). The optional codes are taken from the IED element in the CID file and can be used to verify that the device has the expected CID file:

- FID: the firmware identification string
- BFID: the Boot firmware identification string
- CID: the checksum of the firmware
- iedName: the IED name (e.g., SEL_311L_OtterTail)
- type: the IED type (e.g., SEL_311L)
- configVersion: the CID file configuration version (e.g., ICD-311L-R100-V0-Z001001-D20060512)

QUI

Enter **QUIT** over Telnet on an optional Ethernet port to return the relay to Access Level 0 on that port.

Access Level 1

2AC

Enter **2AC** over Telnet on an optional Ethernet port to move to Access Level 2 on that port. Ethernet ports do not support the password jumper.

Table 10.19 2AC Command

Command	Description	Access Level
2AC	Go to Access Level 2 (full relay control)	1, 2

GOOSE

Use the **GOOSE** command to display transmit and receive GOOSE messaging information, which can be used for troubleshooting. The **GOOSE** command variants and options are shown in *Table 10.20*.

Table 10.20 GOOSE Command Variants

Command Variant	Description	Access Level
GOOSE	Display GOOSE information.	1
GOOSE count	Display GOOSE information count times.	1

The information displayed for each GOOSE IED is described in the following table.

IED	Description
`Transmit GOOSE Control Reference`	This field represents the GOOSE control reference information that includes the IED name, ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and GSEControl name (GSE Control Block Name) (e.g., SEL_311L_1CFG/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_311L_1CFG/LLN0GOGooseDSet13).
`MultiCastAddr` (Multicast Address)	This hexadecimal field represents the GOOSE multicast address.
`Ptag`	This three-bit decimal field represents the priority tag value, where spaces are used if the priority tag is unknown.
`Vlan`	This 12-bit decimal field represents the virtual LAN (Local Area Network) value, where spaces are used if the virtual LAN is unknown.
`StNum` (State Number)	This hexadecimal field represents the state number that increments with each state change.
`SqNum` (Sequence Number)	This hexadecimal field represents the sequence number that increments with each GOOSE message sent.
`TTL` (Time to Live)	This field contains the time (in ms) before the next message is expected.

IED	Description
Code	This text field contains warning or error condition text when appropriate that is abbreviated as follows: **Code Abbreviation** — **Explanation** OUT OF SEQUENC — Out of sequence error CONF REV MISMA — Configuration Revision mismatch NEED COMMISSIO — Needs Commissioning TEST MODE — Test Mode MSG CORRUPTED — Message Corrupted TTL EXPIRED — Time to live expired HOST DISABLED — Optional code for when the host is disabled or becomes unresponsive after the **GOO** command has been issued
Transmit Data Set Reference	This field represents the DataSetReference (Data Set Reference) that includes the IED name, LN0 lnClass (Logical Node Class), and GSEControl datSet (Data Set Name) (e.g., SEL_311L_1/LLN0$DSet13).
Receive Data Set Reference	This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and datSet (Data Set Name) (e.g., SEL_311L_1CFG/LLN0$DSet13).

An example response to the **GOOSE** commands is shown in *Figure 10.11*.

```
#>>GOO <Enter>
GOOSE Transmit Status
----------------------------------------------------------------------------
SEL-311L_LineCFG/LLN0$GO$GooseDSet13
                      2:5     1256      347       6
   Data Set: SEL-311L_LineCFG/LLN0$GooseDSet13

GOOSE Receive Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
----------------------------------------------------------------------------
SEL-311L_Line_DifferentialCFG/LLN0$GO$GooseDSet13
   01-03-A7-00-00-01  3:1     1253758689 4786543985 123456
   Data Set: SEL-311L_Line_DifferentialCFG/LLN0$GooseDSet13

SEL-387E_Current_DifferentialCFG/LLN0$GO$GooseDSet13
   01-03-A7-00-00-01  3:23    12568945   34         0
   Data Set: SEL-387E_Current_DifferentialCFG/LLN0$GooseDSet13

SEL-421_Distance1CFG/LLN0$GO$GooseDSet13
   01-03-A7-00-00-01  3:343   1945       34456      456
   Data Set: SEL-421_DistanceCFG/LLN0$GooseDSet13

SEL-487B_Bus_DifferentialCFG/LLN0$GO$GooseDSet13
   01-03-A7-00-00-01  3:5     12568945   34783456   123456
   Data Set: SEL-487B_Bus_DifferentialCFG/LLN0$GooseDSet13

#>>
```

Figure 10.11 GOOSE Command Response

HELP

The **HELP** command gives a list of commands available at the present access level. You can also get a description of any particular command; type **HELP** followed by the name of the command for help on that command.

Table 10.21 HELP Command

Command	Description	Access Level
HELP	Display a list of each command available at the present access level with a one-line description	1, 2
HELP *command*	Display information on the command ***command***	1, 2

MAC

Use the **MAC** command to display the MAC addresses of PORT 5 and PORT 6, as shown below.

```
Port 5 MAC Address:  00-30-A7-00-00-00
Port 6 MAC Address:  00-30-A7-23-23-23
```

STA

STA. Enter **STA** over Telnet on an optional Ethernet port to obtain a status report for the Ethernet card. Items in the **STA** report are the header, failures, warnings, Ethernet link status, and communications card operational status.

Table 10.22 STA Command

Command	Description	Access Level
STA	Return the relay status	1
STA	Return the relay status and show a new hardware configuration prompt	2

The self-test status fields shown below are the same as those shown at the bottom of a **STA** report obtained using a serial port, with the exceptions of CR_RAM and NON_VOL. The CR_RAM and NON_VOL fields are combined with the ROM field in the serial port **STA** report. When CR_RAM is FAIL, there is a failure in the nonvolatile Ethernet card configuration. When NON_VOL is FAIL, there is a failure with the nonvolatile CID file. The other fields are defined in *Relay Command Explanations on page 10.29*.

```
Date: 04/24/2006   Time: 16:54:22

FID = SEL-E3-X120-V0-Z001001-D20060424                  CID = 78E5

  HOST  PORT 5  PORT 6  RAM   ROM   FPGA  DPRAM  CR_RAM  NON_VOL   PS
  OK    LINK    NOLINK  OK    OK    OK    OK     OK      OK        OK

Device  Enabled
```

STA C and STA R. The optional Ethernet card latches all self-test warnings and failures to capture transient out-of-tolerance conditions. Enter **STA C** or **STA R** over Telnet on an optional Ethernet port to restart the Ethernet card and reset their self-test status.

Table 10.23 STA C and STA R Commands

Command	Description	Access Level
STA C	Reset the relay	2
STA R	Reset the relay	2

This page intentionally left blank

SEL-311L-1, -7 Relay Command Summary

Access Level 0 Command	The screen prompt is: =
ACC	Enter **ACC** at a serial port or over Telnet on an optional Ethernet port to move to Access Level 1 on that port. If you are using a serial port and the password jumper is not in place, the relay will require entry of the Access Level 1 password prior to moving to the new access level. Ethernet ports do not support the password jumper
CAS	Display Compressed ASCII configuration data.
EXIT	End a Telnet session (applies to the optional Ethernet port).
ID	Enter **ID** at a serial port to obtain relay identification and configuration information. Enter **ID** over Telnet on an optional Ethernet port to obtain Ethernet card identification and configuration information.
QUI	Enter **QUIT** at a serial port with PROTO = SEL or over Telnet on an optional Ethernet port to return the relay to Access Level 0 on that port. Enter **QUIT** at a serial port with PROTO = LMD to terminate the SEL Distributed Port Switch Protocol (LMD) connection and return the relay to Access Level 0 on that port.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering), not change it. The screen prompt is: =>
2AC	Enter **2AC** at a serial port or over Telnet on an optional Ethernet port to move to Access Level 2 on that port. If you are using a serial port and the password jumper is not in place, the relay will require entry of the Access Level 2 password prior to moving to the new access level. Ethernet ports do not support the password jumper.
BAC	Enter Breaker Access Level (Access Level B). If the main board password jumper is not in place, the relay prompts for entry of the Access Level B password.
BRE	Display breaker monitor data (trips, interrupted current, wear).
CEV [*n* S*x* L*y* L R C P]	Display compressed event report (parameters in [ ] are optional)
where: ***n***	event number (1–40 if LER = 15; 1–21 if LER = 30; 1–11 if LER = 60; defaults to 1).
S*x*	*x* samples per cycle (4 or 16); defaults to 4. If S*x* parameter is present, it overrides the L parameter.
L*y*	*y* cycles event report length (1–LER) for filtered event reports, (1–LER + 1) for raw event reports, defaults to LER if not specified.
L	16 samples per cycle; overridden by the S*x* parameter, if present.
R	specifies raw (unfiltered) data; defaults to 16 samples per cycle unless overridden by the S*x* parameter. Defaults to LER + 1 cycles in length unless overridden with the L*y* parameter.
C	specifies 16 samples per cycle, LER-cycle length.
P	precise to synchrophasor-level accuracy.
CHIS	Display compressed history.
COM *p d1*	Show a communications summary report for events occurring on date *d1* on MIRRORED BITS Channel *p*.
COM *p d1 d2*	Show a communications summary report for events occurring between dates *d1* and *d2* on MIRRORED BITS Channel *p*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS Channel *p*.
COM *p n*	Show a communications summary for latest *n* events on MIRRORED BITS Channel *p*.
COM *p* L	Show a long format communications summary report for all events on MIRRORED BITS Channel *p*.
COM C *p*	Clear the communications summary report for Channel *p*.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering), not change it. The screen prompt is: =>
CST	Display compressed status report.
CSU	Display compressed event summary.
DAT	Show date.
DAT m/d/y	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT y/m/d	Enter date in this manner if Date Format setting DATE_F = YMD.
DNP [type]	Show DNP map.
EVE *n*	Show event report number *n* with 1/4-cycle resolution.
EVE B *n*	Show event report number *n* for backup elements (not including differential).
EVE C *n*	Show compressed event report number *n* for use with SEL-5601-2 SYNCHROWAVE Event Software.
EVE L *n*	Show event report number *n* with 1/16-cycle resolution.
EVE P *n*	Show event report *n* with synchrophasor-level accuracy time alignment.
EVE R *n*	Show raw event report number *n* with 1/16-cycle resolution.
GOO	Display transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GRO	Display active group number.
HELP	List the commands available at the present access level (applies to the optional Ethernet port).
HIS *n*	Show brief summary of the *n* latest event reports.
HIS C	Clear the brief summary and corresponding event reports.
INI	Display input/output contact information.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MAC	Display the MAC addresses of **PORT 5** and **PORT 6** (applies to the optional Ethernet port).
MET *k*	Display instantaneous metering data. Enter *k* for repeat count.
MET B k	Display instantaneous metering data for local terminal including voltage. Enter *k* for repeat count.
MET D	Display demand and peak demand data. Enter **MET RD** or **MET RP** to reset.
MET E	Display energy metering data. Enter **MET RE** to reset.
MET M	Display maximum/minimum metering data. Enter **MET RM** to reset.
MET PM [*time*] [*k*]	Display synchrophasor measurements (available when TSOK = logical 1). Enter time to display the synchrophasor for an exact specified time, in 24-hour format. Enter *k* for repeat count.
SER *d1*	Show rows in the Sequential Events Recorder (SER) event report from date *d1*.
SER *d1 d2*	Show rows in the Sequential Events Recorder (SER) event report from date *d1* to *d2*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
SER *m n*	Show rows *m* through *n* in the Sequential Events Recorder (SER) event report.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER C	Clear the Sequential Events Recorder (SER).
SHO *n*	Show relay settings (overcurrent, reclosing, timers, etc.) for Group *n*.
SHO G	Show Global settings.
SHO L *n*	Show SELOGIC control equation settings for Group *n*.
SHO P *n*	Show Port *n* settings.
SHO R	Show Sequential Events Recorder (SER) settings.
SHO T	Show text label settings.
STA	Enter **STA** at a serial port to obtain a status report for the relay. Enter **STA** over Telnet on an optional Ethernet port to obtain a status report for the Ethernet card.
SUM	Show newest event summary.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering), not change it. The screen prompt is: =>
SUM A	Acknowledge oldest event summary.
SUM N	View oldest unacknowledged event report.
SUM N [A]	Display or acknowledge event summary number "N."
TAR *n k*	Display Relay Word row. If *n* = 0 through 51, display row *n*. If *n* is an element name (e.g., 50P1) display the row containing element *n*. Enter *k* for repeat count.
TAR R	Reset the front-panel tripping targets.
TIM	Show or set time (24-hour time). Show time presently in the relay by entering just TIM. Example time 22:47:36 is entered with command **TIM 22:47:36**.
TRI [*time*]	Trigger an event report. Enter time to trigger an event at an exact specified time, in 24-hour format.
VER	Display version and configuration information.

Access Level B Commands	Access Level B commands primarily allow the user to operate output contacts. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
BRE *n*	Enter **BRE W** to preload breaker wear. Enter **BRE R** to reset breaker monitor data.
CLO	Close the circuit breaker.
GRO *n*	Change active group to Group *n*.
OPE	Open the circuit breaker.
PUL *n k*	Pulse output contact *n* (OUT101–OUT107, ALARM) for *k* (1–30) seconds. Parameter *n* must be specified; *k* defaults to 1 if not specified.
TEST DB name01 [name02. . .name10] [*s*]	Pulse as many as 10 binaries (Relay Word bits) for *s* seconds.

Access Level 2 Commands	The Access Level 2 commands allow unlimited access to relay settings, parameters, and output contacts. All Access Level 1 and Access Level B commands are available from Access Level 2. The screen prompt is: =>>
CAL	Go to Access Level C.
CON *n*	Control Remote Bit RB*n* (Remote Bit *n*; *n* = 1 through 8). Execute **CON *n*** and the relay responds: `CONTROL RBn`. Then reply with one of the following: **SRB *n*** set Remote Bit *n* (assert RB*n*). **CRB *n*** clear Remote Bit *n* (deassert RB*n*). **PRB *n*** pulse Remote Bit *n* (assert RB*n* for 1/4 cycle).
COP *m n*	Copy relay and logic settings from Group *m* to Group *n*.
DNP [type]	Set DNP map.
L_D	Load new firmware.
LOO	Set MIRRORED BITS port to loop back.
PAS 1	Change Access Level 1 password.
PAS B	Change Access Level B password.
PAS 2	Change Access Level 2 password.
SET *n*	Change relay settings (overcurrent, reclosing, timers, etc.) for Group *n*.
SET G	Change Global settings.
SET L *n*	Change SELOGIC control equation settings for Group *n*.
SET P *n*	Change Port *n* settings.
SET R	Change Sequential Events Recorder (SER) settings.
SET T	Change text label settings.

Access Level 2 Commands	The Access Level 2 commands allow unlimited access to relay settings, parameters, and output contacts. All Access Level 1 and Access Level B commands are available from Access Level 2. The screen prompt is: =>>
STA C or R	Enter **STA C** at a serial port to restart the relay. Enter **STA C** over Telnet on an optional Ethernet port to restart the Ethernet card.
TST {chn}	Test the differential communication channel or disable differential communications to test local distance backup protection. If channel (X or Y) is specified, a question string will follow to configure the channel for testing. With no channel identifier, the command will return each channel status.
TST {chn} C	Clear or disable the test mode for the differential communication channel.

Section 11
Front-Panel Operations

Overview

This section describes how to get information, make settings, and execute control operations from the relay front panel. It also describes the default displays.

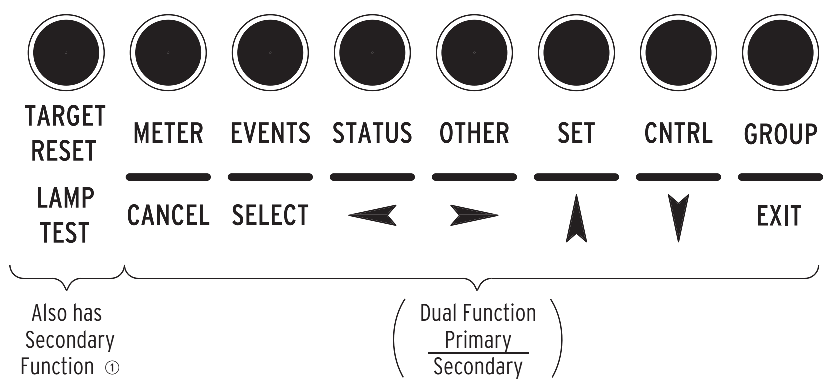
Front-Panel Pushbutton Operation

Overview

Note in *Figure 11.1* that most of the pushbuttons have dual functions (primary/secondary).

A primary function is selected first (e.g., **METER** pushbutton).

After a primary function is selected, the pushbuttons revert to operating on their secondary functions (**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 activated again when the present selected function (e.g. metering) is exited (press **EXIT** pushbutton) or the display goes back to the default display after no front-panel activity for a settable time period (see global setting *FP_TO* in the *Settings Sheets* at the end of *Section 9: Settings*; the relay is shipped with FP_TO = 15 minutes).



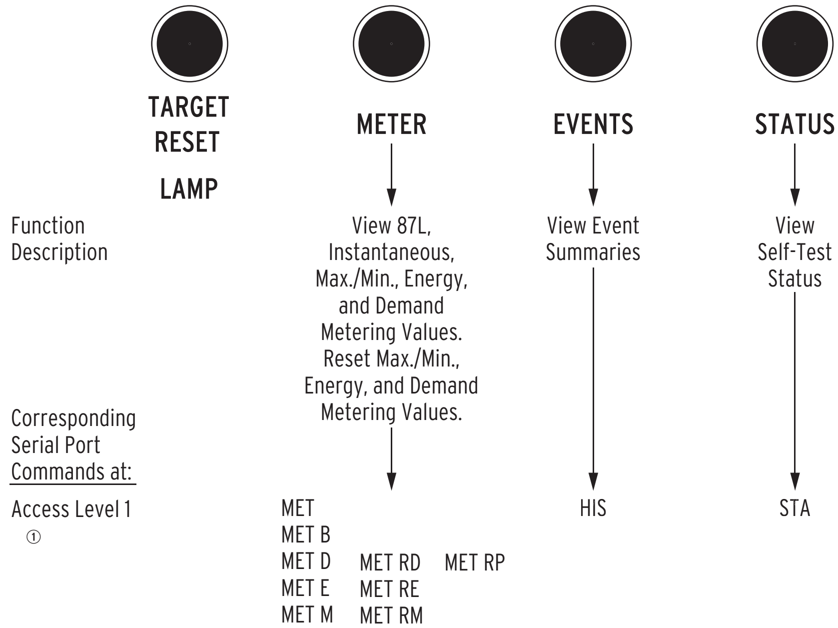
① See Figure 11.4.

Figure 11.1 SEL-311L 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 10.6*. 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 10.38*.

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*.



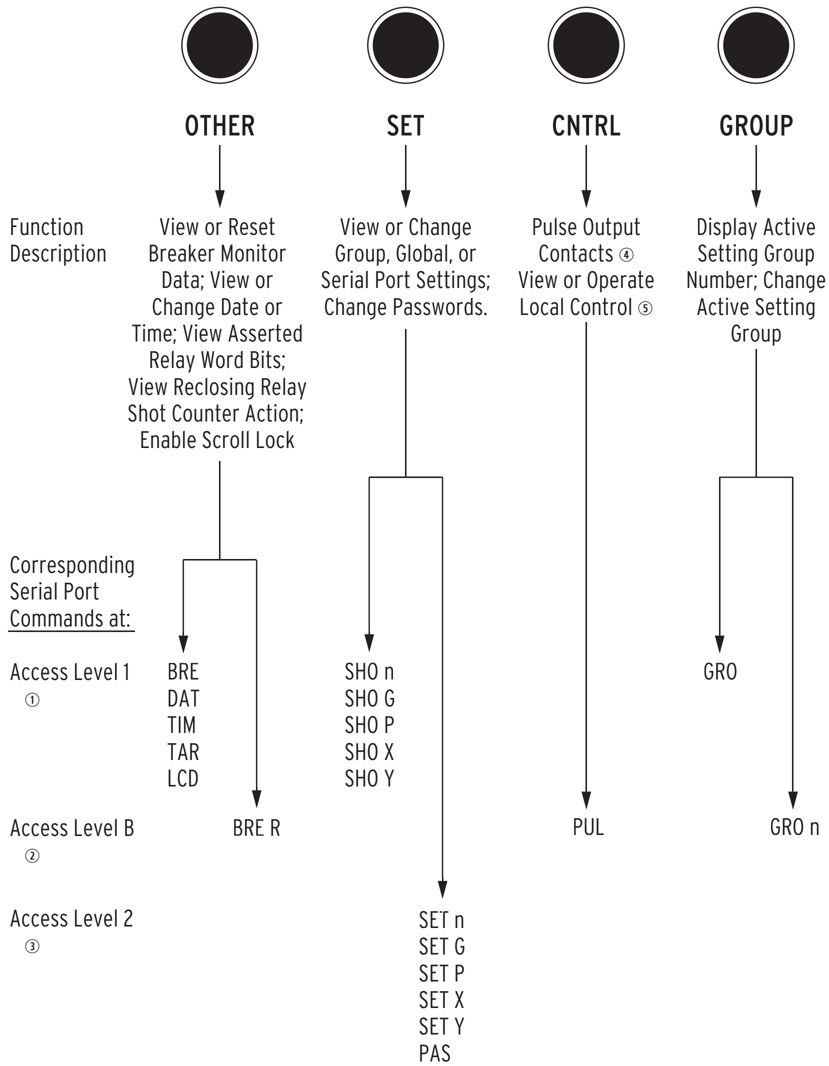
① Front-panel pushbutton functions that correspond to Access Level 1 serial port commands do not require the entry of the Access Level 1 password through the front panel.

Figure 11.2 SEL-311L Front-Panel Pushbuttons–Primary Functions

Front-Panel Password Security

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 10.59* for the list of default passwords and for more information on changing passwords.

To enter the Access Level B and Access Level 2 passwords from the front panel (if required), use the left/right arrow pushbuttons to underscore a password digit position. Then use the up/down arrow pushbuttons to change the digit. Press the **SELECT** pushbutton once the correct Access Level B or Access Level 2 password is ready to enter.



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 Password jumper is not in place (see Table 2.6).

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 Password jumper is not in place (see Table 2.6).

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 SEL-311L 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*).

When changing settings, use the left/right arrows to underscore a desired function. Then press the **SELECT** pushbutton to select the function.

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

Press the **CANCEL** pushbutton to abort a setting change procedure and return to the previous display. Press the **EXIT** pushbutton to return to the default display and have the primary pushbutton functions activated again (see *Figure 11.2* and *Figure 11.3*).

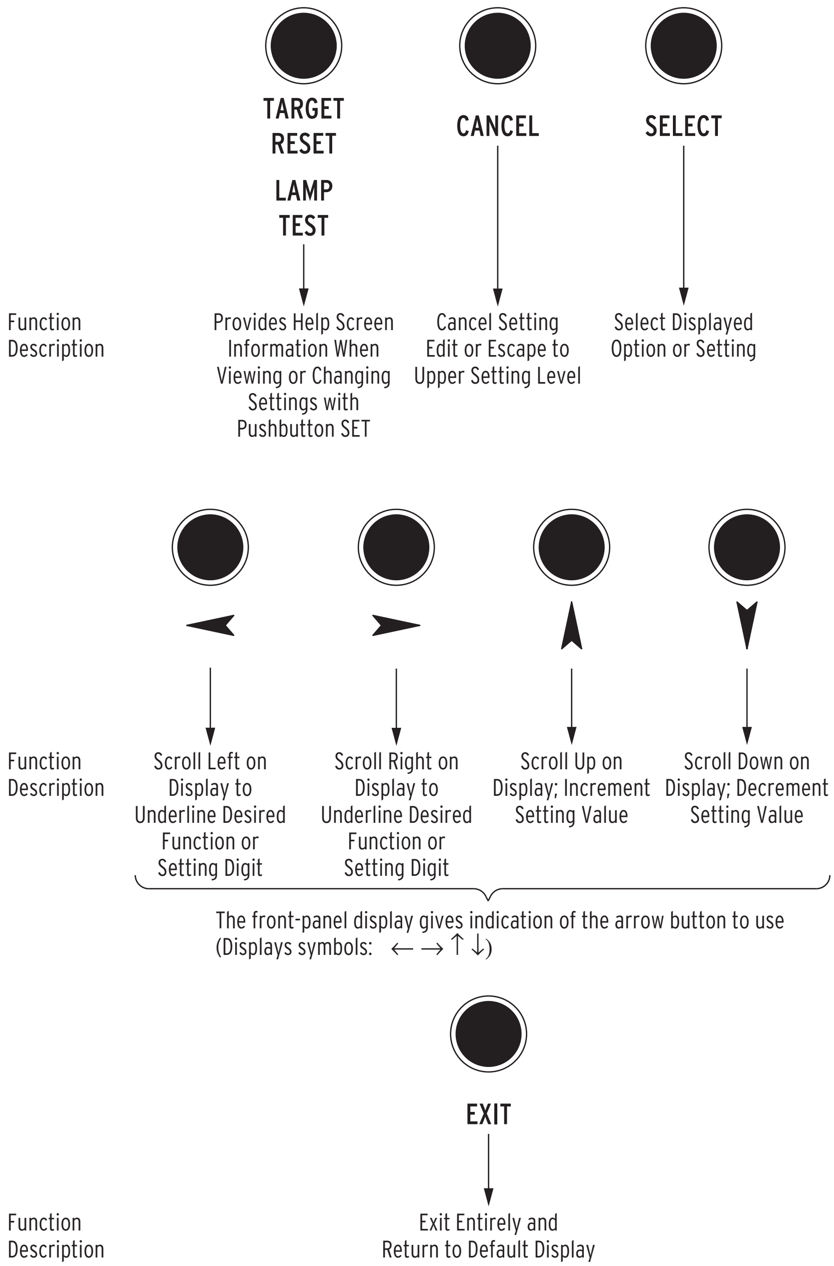


Figure 11.4 SEL-311L Front-Panel Pushbuttons–Secondary Functions

Functions Unique to the Front-Panel Interface

Three front-panel primary functions do not have serial port command equivalents. These are:

- ➤ 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 button and select function `79`. Upon selecting function `79`, the following screen appears (shown here with demonstration settings):

```
SET RECLOSURES=2
RECLOSE COUNT =0
```

or

```
SET RECLOSURES=2
RECLOSE COUNT =2
```

If reclosing functions are disabled (see *Reclosing Relay on page 6.10*), the following screen appears:

```
No Reclosing set
```

The corresponding text label settings (shown with example settings) are:

79LL = **SET RECLOSURES** (Last Shot Label-limited to 14 characters)

79SL = **RECLOSE COUNT** (Shot Counter Label-limited to 14 characters)

If neither 79LL nor 79SL is set, upon selecting function 79, the following screen appears (shown here with demonstration settings):

```
              =2
              =2
```

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: Settings* and *SHO Command (Show/View Settings) on page 10.43*).

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 demonstration settings, thus two reclosures (shots) are possible in a reclose sequence.

The bottom numeral in the above example screen [RECLOSE COUNT = 0 (or RECLOSE COUNT = 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 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. The reclosing relay shot counter screen still appears as:

```
SET RECLOSURES=2
RECLOSE COUNT =0
```

The first open interval (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 (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 closed, the reclosing relay reset timer times out (79RSLD = 300), 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–LB16. These local bits are available as Relay Word bits and are used in SELOGIC control equations (see *Table 9.5* and *Table 9.6*).

Local control can emulate the switch types shown in *Figure 11.5–Figure 11.7*.

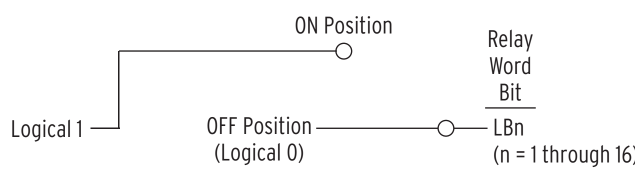


Figure 11.5 Local Control Switch Configured as an ON/OFF Switch

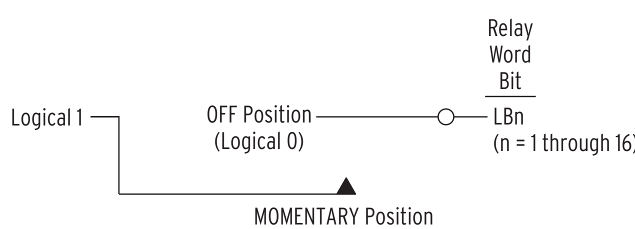


Figure 11.6 Local Control Switch Configured as an OFF/MOMENTARY Switch

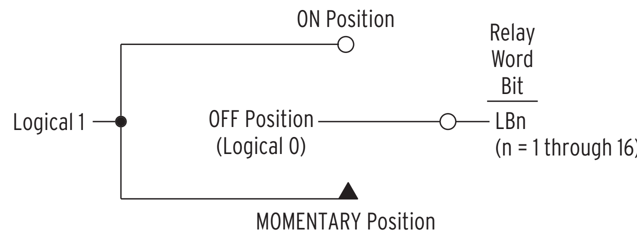


Figure 11.7 Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

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: Settings* and *SHO Command (Show/View Settings) on page 10.43*). 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:

TR = **...+LB3 +...** (Trip setting includes LB3)

CL = **...+ LB4 +...** (Close setting includes LB4)

NLB3 = **MANUAL TRIP**

CLB3 = **RETURN**

PLB3 = **TRIP**

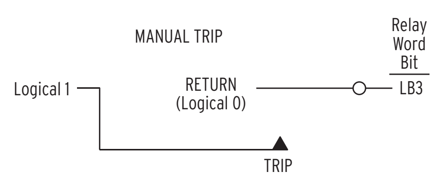
NLB4 = **MANUAL CLOSE**

CLB4 = **RETURN**

PLB4 = **CLOSE**

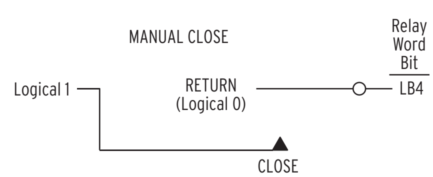
Press the **CNTRL** pushbutton, and the first set local control switch displays

```
MANUAL TRIP   ←→
Position: RETURN
```



Press the right arrow pushbutton, and scroll to the next set local control switch:

```
MANUAL CLOSE ←→
Position: RETURN
```



The `MANUAL TRIP: RETURN/TRIP` and `MANUAL CLOSE: RETURN/CLOSE` switches are both OFF/MOMENTARY switches (see *Figure 11.6*).

There are no more local control switches in the example setting. Press the right arrow pushbutton, and scroll to the `OUTPUT CONTACT TESTING` function:

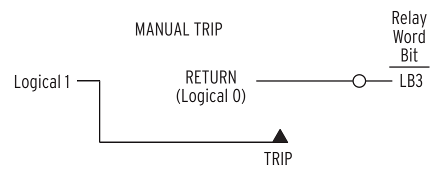
```
Output Contact←→
Testing
```

This front-panel function provides the same function as the serial port **PUL** command (see *Figure 11.3*).

Operate Local Control (With Example Settings)

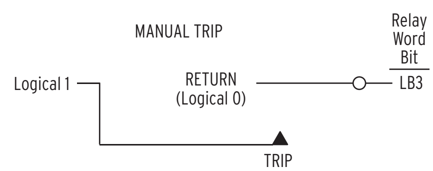
Press the right arrow pushbutton, and scroll back to the first set local control switch in the example settings:

```
MANUAL TRIP   ←→
Position: RETURN
```



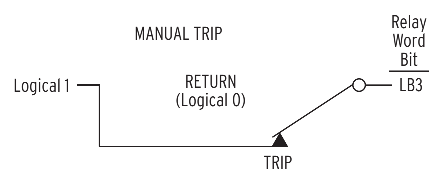
Press the **SELECT** pushbutton, and the operate option for the displayed local control switch displays:

```
MANUAL TRIP
Trip ? Yes No ←→
```



Scroll left with the left arrow button and then select `Yes`. The display then shows the new local control switch position:

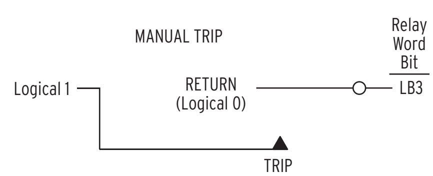
```
MANUAL TRIP
Position: TRIP
```



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; 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:

```
MANUAL TRIP   ←→
Position: RETURN
```



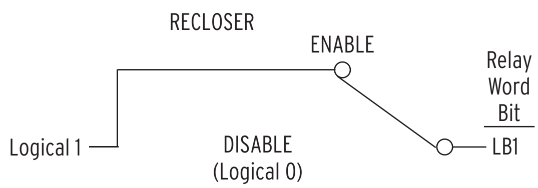
The `MANUAL CLOSE` switch is an OFF/MOMENTARY type switch, like the `MANUAL TRIP` switch, and operates similarly.

See *Local Control Switches on page 7.5* for details on how local bit outputs LB3 and LB4 are set in SELOGIC control equation settings to respectively trip and close a circuit breaker.

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.

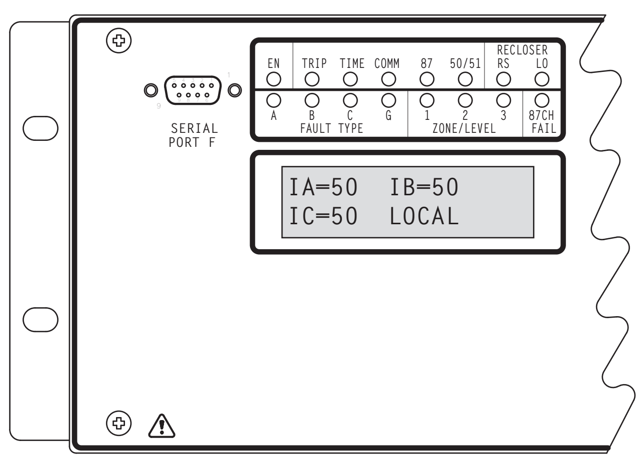
For example, suppose the local control switch with local bit output LB1 is configured as an ON/OFF type switch (see *Figure 11.5*). Additionally, suppose it is used to enable/disable reclosing. If local bit LB1 is at logical 1, reclosing is enabled:



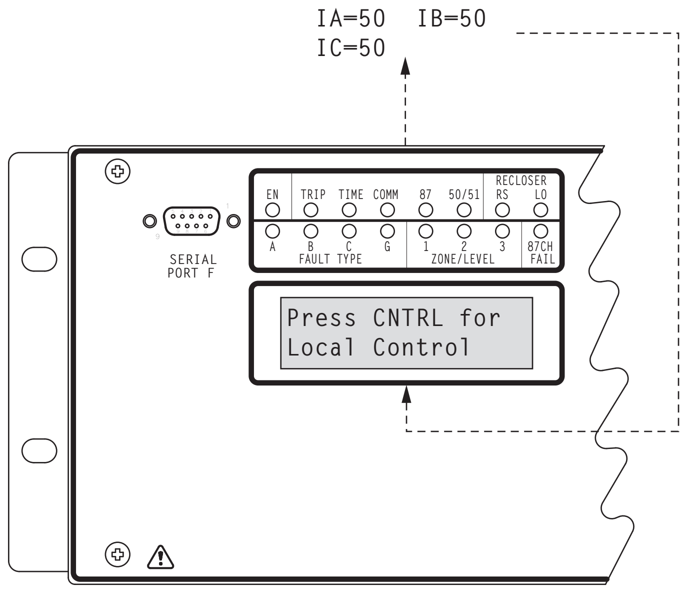
If power to the relay is turned off and then turned on again, local bit LB1 remains at logical 1, and reclosing is still enabled. This is similar to a traditional panel, where enabling/disabling of reclosing and other functions is accomplished by panel-mounted switches. If dc control voltage to the panel 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.

Rotating Default Display

The local and remote channel IA, IB, and IC current values (in primary A) display continually if no local control is operational (i.e., no corresponding switch position label settings were made) and no display point labels are enabled for display.



The Press CNTRL for Local Control message displays in rotation (display time = SCROLD) 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., `CHANNEL X ALARM` and `CHANNEL Y ALARM`) are enabled for display, they also enter into the display rotation (display time = SCROLD).

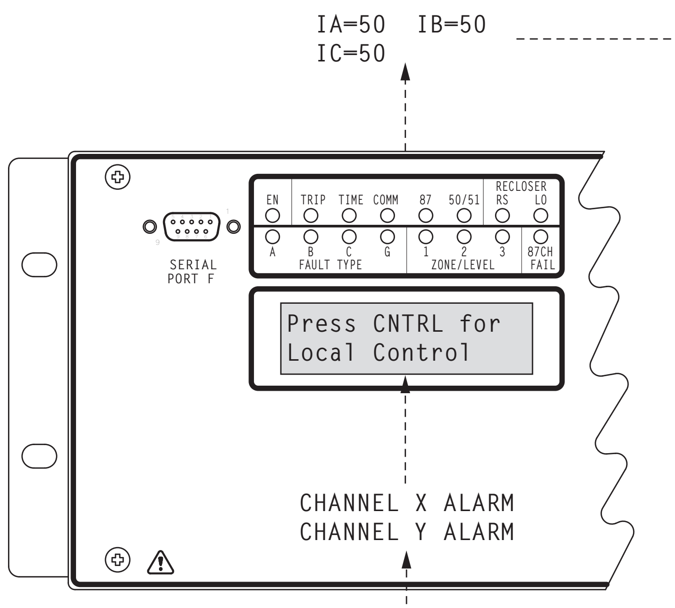


Figure 11.8 demonstrates the correspondence between changing display point states (e.g., DP2 and DP3) and enabled display point labels (DP2_1/DP2_0 and DP3_1/DP3_0, respectively). The display time is equal to Global setting SCROLD for each screen.

The display point example settings are:

DP2 = **CHXAL** (alarm condition on Channel X)

DP3 = **CHYAL** (alarm condition on Channel Y)

Display Points 2 and 3 are used to help diagnostics when the **87CH FAIL** LED illuminates.

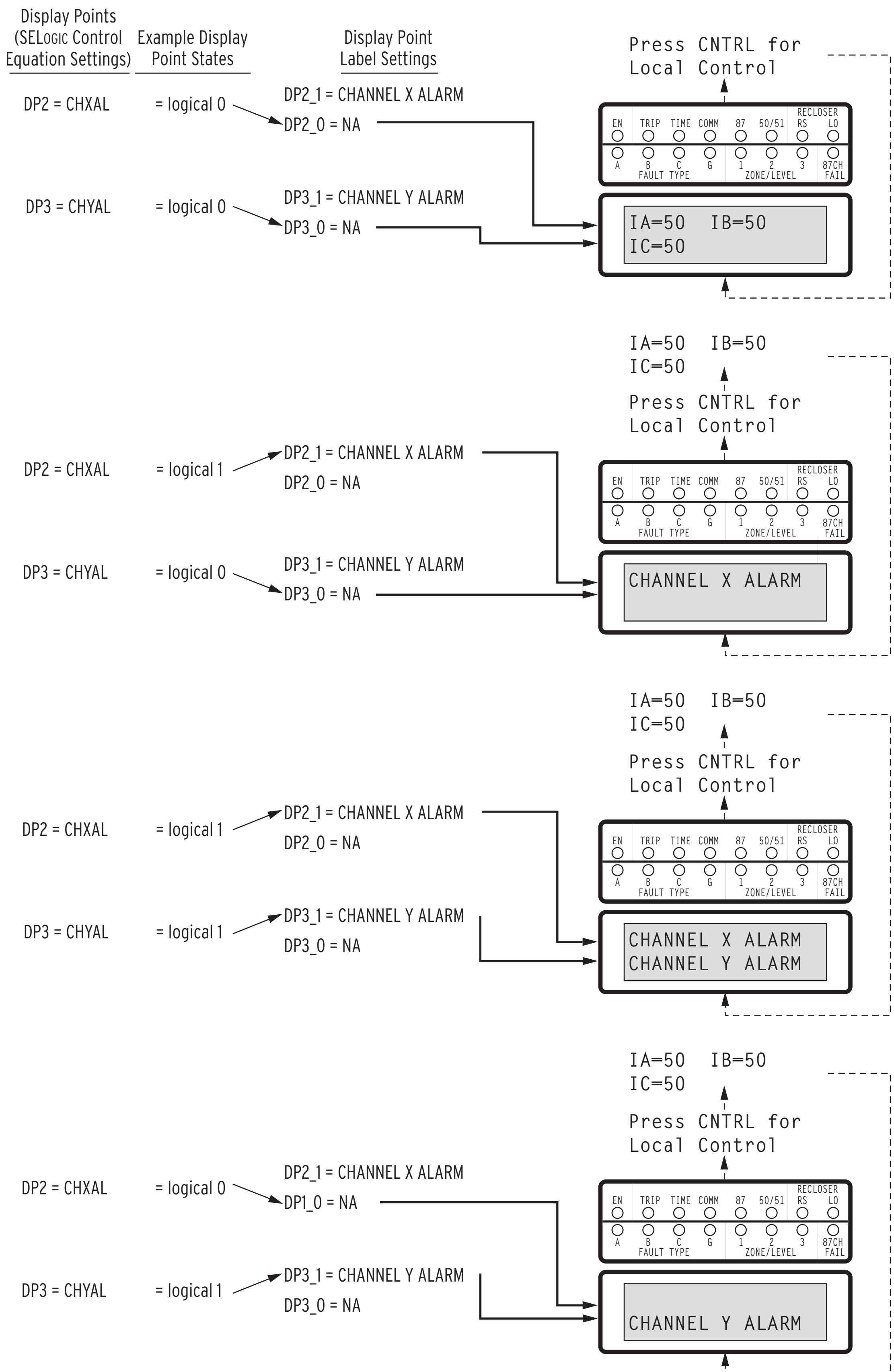


Figure 11.8 Correspondence Between Changing Display Point States and Enabled Display Point Labels

In the preceding example, only two display points (DP2 and DP3) 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 (display time = SCROLD) on the front-panel display. The SCROLD setting is made with the **SET G** command and reviewed with the **SHO G** command.

Display point label settings are set with the **SET T** command or viewed with the **SHO T** command via the serial port (see *Section 9: Settings* and *SHO Command (Show/View Settings) on page 10.43*).

For more detailed information on the logic behind the rotating default display, see *Rotating Default Display on page 7.38*.

Scroll Lock Control of Front-Panel LCD

The rotating default display can be locked on a single screen. (See *Rotating Default Display*). 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 every eight seconds for one second 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. Wait for the first press to display the next screen as the active 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
```

Additional Rotating Default Display Example

See *Figure 5.3* and accompanying text in *Section 5: Trip and Target Logic* for an example of resetting a rotating default display with the **TARGET RESET** pushbutton.

Section 12
Analyzing Events

Overview

The SEL-311L Relay provides two separate event reports:

- ➤ Standard 15/30/60-cycle oscillographic event reports for backup protection
- ➤ Standard 15/30/60-cycle oscillographic event reports for line current differential protection

In addition, the SEL-311L also provides Sequential Events Recorder (SER) reports.

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

The relay generates (triggers) line current differential and backup protection 15/30/60-cycle event reports simultaneously by both fixed and programmable conditions. These reports show information for 15, 30, or 60 continuous cycles. At least forty 15-cycle, twenty-one 30-cycle, or eleven 60-cycle reports are maintained for both backup and line current differential protection. If more reports are triggered, the latest event report overwrites the oldest event report. See *Figure 12.3* for an example standard 15-cycle backup event report and *Figure 12.4* for an example standard 15-cycle differential event report.

The relay adds lines in the sequential events recorder (SER) report for a change of state of a programmable condition. The SER lists date and time-stamped lines of information each time a programmed condition changes state. The relay stores the latest 512 lines of the SER report in nonvolatile memory. If the report fills up, newer rows overwrite the oldest rows in the report. See *Figure 12.7* for an example SER report.

Standard 15/30/60-Cycle Event Reports

NOTE: Figure 12.3 and Figure 12.4 are on multiple pages.

See *Figure 12.3* and *Figure 12.4* for example event reports.

Event Report Length (Settings LER and PRE)

The SEL-311L provides user-programmable event report length and pre-fault length. Event report length is 15, 30, or 60 cycles. Pre-fault length ranges from 1 to 59 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 SET G LER setting. Set the pre-fault length with the SET G PRE setting. See the **SET G** command in *Table 9.1* and corresponding *Settings Sheets on page 9.71* for instructions on setting the LER and PRE settings.

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

Standard Event Report Triggering

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

- Relay Word bit TRIP asserts
- Relay Word bit TRIP87 or TRPA21 or TRPB21 or TRPC21 asserts
- Programmable SELOGIC control equation setting ER asserts
- **TRI** (Trigger Event Reports) serial port command executed
- Output contacts OUT101–OUT107, OUT201–OUT206 and OUT301-OUT312 pulsed via the serial port or front-panel **PUL** (Pulse output contact) command

Relay Word Bit TRIP

Refer to *Figure 5.6*. If Relay Word bit TRIP asserts to logical 1, 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.

For example, SELOGIC control equation trip setting TR is unsupervised. Any trip condition that asserts in setting TR causes the TRIP Relay Word bit to assert immediately. The Relay Word bit TRIP asserts, and an event report is automatically generated. Thus, any element in setting TR does not have to be entered in SELOGIC control equation setting ER.

Relay Word bits TRIP is usually assigned to an output contact for tripping a circuit breaker (e.g., SELOGIC control equation setting OUT201 = TRIP).

Programmable SELOGIC Control Equation Setting ER

The programmable SELOGIC control equation event report trigger setting ER is set to trigger standard event reports for conditions other than trip conditions. When setting ER sees a logical 0 to logical 1 transition, it generates an event report (if the SEL-311L is not already generating a report that encompasses the new transition). The factory setting is:

ER = **/B87L2 + /M2P + /Z2G + /51G + /51Q + /50P1 + /LOP**

The elements in this example setting are:

B87L2	Block negative-sequence differential trip when asserted.
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 4.24*).
51Q	Negative-sequence current above pickup setting 51QP for negative-sequence time-overcurrent element 51QT (see *Figure 4.25*).
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 I: 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, for example, a breaker failure condition occurs. If at the inception of a ground fault, pickup indicator 51G asserts and an event report is generated, include /51G in the ER setting:

ER = **... + /51G + ... = logical 1** (for one processing interval)

Even though the 51G pickup indicator remains 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. Other operators in the setting ER SELOGIC control equation can trigger event reports while 51G is still asserted.

Falling-edge operators \ are also used to generate event reports. See *Figure I.2* in *Appendix I: Setting SELOGIC Control Equations* for more information on falling-edge operators.

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

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 output contacts OUT101–OUT107, OUT201–OUT206, or OUT301-OUT312 assert 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 *Section 11: Front-Panel Operations* (*Figure 11.3*) for more information on the **TRI** (Trigger Event Report) and **PUL** (Pulse Output Contact) commands.

Event Summary

Each time the relay generates a standard event report, it also generates a corresponding event summary (see *Figure 12.1*). Event summaries contain the following information:

- Relay and terminal identifiers (settings RID and TID)
- Date and time when the event was triggered
- Event type
- Fault location
- Breaker Trip Time
- Recloser shot count at the trigger time
- System frequency at trigger time
- Active Settings Group
- Breaker Close Time
- Front-panel fault type targets at the time of trip
- Breaker Status (open or closed)
- Phase (**IA**, **IB**, **IC**, **VA**, **VB**, **VC**), calculated residual-ground (I_G = $3I_0$), directional polarizing current IP, and negative-sequence ($3I_2$) currents, along with phase angles for pre-fault and fault quantities.
- Differential currents.
- MIRRORED BITS status if MIRRORED BITS are enabled.
- Differential channel transmit and receive bit status.

The relay includes event summary information in the standard event report. The identifiers, date, and time information are at the top of the standard event report, and the other information follows as channel row data and summary data at the end. See *Figure 12.3*.

NOTE: Figure 12.3 and Figure 12.4 are on multiple pages.

Figure 12.1 corresponds to the full-length standard 15-cycle event reports in *Figure 12.3* and *Figure 12.4*.

```
=>SUM <Enter>

SEL-311L                          Date: 06/15/01    Time: 10:25:24.810
EXAMPLE: BUS B, BREAKER 3

Event: BCG T     Location:   49.12             Trip Time: 10:25:24.818
#: 00085  Shot:    Freq:  60.00  Group: 1     Close Time: --:--:--.---
Targets: 87 ZONE2                                              Breaker: Open

                  Local                Channel X             Channel Y
PreFault:   IA    IB    IC   3I2    IA    IB    IC   3I2    IA    IB    IC   3I2
MAG(A)     224   225   227     4   226   224   230     2 XXXXX XXXXX XXXXX XXXXX
ANG(DEG)-149.4  90.6 -28.8 118.4  30.4 -89.3 154.8  19.4 XXX.X XXX.X XXX.X XXX.X
Fault:
MAG(A)     224  1640  1485  2234   226  1510  1647  1630 XXXXX XXXXX XXXXX XXXXX
ANG(DEG)-149.8  25.0-127.8 -58.6  30.1   9.1-140.1-160.6 XXX.X XXX.X XXX.X XXX.X

87L Channel Status                                N:4->1  RNX  TNX  RNY  TNY

TRIG     Channel X:  OK       Channel Y:               0000 0000 0000 0000
TRIP     Channel X:  OK       Channel Y:               0000 0000 0000 0000

                                         Local
PreFault:     IA     IB     IC     IP     IG    3I2       VA       VB       VC
MAG(A/kV)    220    221    223      0      2      2  129.410  129.600  129.540
ANG(DEG)    2.20-117.67 122.55  79.37 169.37-121.63     0.00  -119.91   120.01
Fault:
MAG(A/kV)    219   1584   1429      0    684   2188  148.480   65.200   65.180
ANG(DEG)    1.44 176.15  23.53  79.37  94.17  90.37    -1.24  -116.75   123.20

=>>
```

Figure 12.1 Example Event Summary

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

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

Event Type

The "Event:" field shows the event type. The possible event types and their descriptions are shown in *Table 12.1*. Note the correspondence to the preceding event report triggering conditions (see *Standard Event Report Triggering on page 12.2*).

Table 12.1 Event Types

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	Two phase-to-ground faults. Appends T if TRIP asserted.
TRIP	Assertion of Relay Word bit TRIP (relay could not determine 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.

Fault Location

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 or if EFLOC = N, `$$$$$$` is listed in the field. 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 9.1* and corresponding *Settings Sheets on page 9.71* for information on the line parameter settings.

(Event Summary Number)

Unique event identifier of the event summary found in the **HIS E** command. See *Section 10: Communications*.

Shot

Reclosing Shot Count at trigger time. See *Section 6: Close and Reclose Logic*.

Frequency

System frequency at trigger time.

Group

Active settings group at trigger time.

Trip and Close Times

Trip and close times follow 52A Relay Word bit contact changes during the event. A blank value indicates that a trip or close did not occur.

Targets

If there is no rising edge of TRIP, TRIP87, TRPA21, TRPB21, OR TRPC21 in the report, the Targets field is blank. The targets include the following:

- ZONE/LEVEL 1–3
- TIME
- COMM
- 87
- 50/51

See *Front-Panel Target LEDs on page 5.36*.

Currents and Voltages

Pre-fault current and voltage magnitudes and phase angles are selected from the first cycle of the event report. Fault currents and voltages use the same data as the fault locator. If the fault locator does not operate, the fault data are sampled one and one-quarter cycles after the event report is triggered.

Retrieving Full-Length Standard Event Reports

The latest event reports for both backup and line current differential protection are stored in nonvolatile memory. Each event report includes five sections:

- Analog information, such as current, voltage, station battery, and V1Mem
- Protection and control elements, contact outputs, and optoisolated inputs
- Communications and MIRRORED BITS elements
- Event summary
- Group, SELOGIC control equations, and Global settings

Use the **EVE** command to retrieve line current differential reports. Use the **EVE B** command to retrieve backup protection event reports. There are several options to customize the report format. The general command format is:

EVE [B] [*n* S*x* L*y* L R A D C M P]

n	Event number (1 to number of events stored), corresponding to the number displayed in the HIS report. Defaults to 1 if not listed, where 1 is the most recent event.
S*x*	Display *x* samples per cycle (4 or 16); defaults to 4 if not listed.
L*y*	Display *y* cycles of data (1 to LER). Defaults to LER value if not listed. Unfiltered reports (R parameter) display an extra cycle of data.
L	Display 16 samples per cycle; same as the S16 parameter.
R	Specifies the unfiltered (raw) event report. Defaults to 16 samples per cycle unless overridden with the S*x* parameter.
A	Specifies that only the analog section of the event is displayed (current, voltage, station battery, polarizing voltage).
D	Specifies that only the digital section (protection and control elements) of the event is displayed.
C	Display the report in Compressed ASCII format. SEL-5601-2 SYNCHROWAVE Event Software uses the EVE C report for generating the alpha plane plot.
M	Specifies only that the communication elements section of the event is displayed.
B	Display backup protection event report. If switch B is not present, the line current differential event report will be displayed.
P	Precise to synchrophasor-level accuracy for signal content at nominal frequency. This option is available 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, the P option is ignored because it only pertains to analog data.

Table 12.2 presents example uses of the **EVE** command.

Table 12.2 Example EVE Commands

Serial Port Command	Description
EVE	Display the most recent event report at 1/4-cycle resolution.
EVE 2	Display the second event report at 1/4-cycle resolution.
EVE S16 L10	Display 10 cycles of the most recent report at 1/16-cycle resolution.
EVE C 2	Display the second report in Compressed ASCII format at 1/4-cycle resolution.
EVE L	Display most recent report at 1/16-cycle resolution.
EVE R	Display most recent report at 1/16-cycle resolution; analog and digital data are unfiltered (raw).
EVE 2 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	Display the unfiltered analog section of the second event report at 1/4-cycle resolution.
EVE B	Display the most recent event report for backup protection at 1/4-cycle resolution.

If an event report is requested that does not exist, the relay responds `Invalid Event.`

Synchrophasor-Level Accuracy in Event Reports

The SEL-311L 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 1 µs digit is always displayed as zero. The `Time:` value contains the time stamp of the analog value associated with the trigger point. Furthermore, the `FREQ` column in the analog section of the report is replaced by a `DT` column. DT means "Difference Time." It represents the difference time in units of microseconds from another row. The trigger point shall have a DT value of 0000 because the trigger time corresponds to the time displayed in the event report header. The DT value for rows preceding the trigger point is referenced to the following row (so they increment backward 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 12.2 shows how an event report is modified with the P parameter.

```
=>>EVE P <Enter>

SEL-311L                          Date: 03/15/2006    Time: 11:31:14.889770
EXAMPLE: BUS B, BREAKER 3         TSOK = 1

FID=SEL-311L-1-R207-V0-Z008004-D20060320       CID=4212


      Currents (Amps Pri)           Voltages (kV Pri)         V1
    IA    IB    IC    IP    IG     VA     VB     VC     VS    Mem    DT  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
  -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 12.2 Example Synchrophasor-Level Precise Event Report 1/16-Cycle Resolution

Compressed ASCII Event Reports

The SEL-311L provides Compressed ASCII event reports to facilitate event report storage and display. The SEL-2020 Communications Processor and SYNCHROWAVE Event take advantage of the Compressed ASCII format. Use the **EVE C** command or **CEV** command to capture Compressed ASCII event reports. The Compressed ASCII event report contains both the backup and differential event report information.

See the **CEVENT** command discussion in *Appendix D: SEL Communications Processors* for further information.

The Compressed ASCII event reports contain information from backup and line current differential elements. The following table shows the currents available in a compressed event report and the corresponding signal name.

Signal Name in CEV Report	Description
IA, IB, IC	Local currents used by backup protection (e.g., 50, 51, 21...)
IAL, IBL, ICL	Local currents used by 87L protection and aligned to remote currents
IAX, IBX, ICX IAY, IBY, ICY	Remote current from Channel X and Channel Y

When plotted with SEL event report software, the compressed event report also calculates various magnitudes, angles, and sequence quantities calculated from the phase currents shown in the table.

Filtered and Unfiltered Event Reports

The SEL-311L samples the basic power system measurands (ac voltage, ac current, station battery, and optoisolated inputs) 16 times per power system cycle. The relay filters the measurands to remove transient signals. The relay operates on the filtered values and reports them in the event report.

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

- ➤ Power system harmonics on the voltage and current channels
- ➤ Decaying dc offset during fault conditions on current channels
- ➤ Optoisolated input contact bounce
- ➤ Transients on the station dc battery channel Vdc (power input terminals Z25 and Z26)

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*).

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

Clearing Standard Event Report Buffer

The **HIS C** command clears the event summaries and corresponding standard event reports from nonvolatile memory. See *Section 10: Communications* for more information on the **HIS** (Event Summaries/History) command.

Standard Event Report Column Definitions for Backup Protection

Refer to the example event report in *Figure 12.3* to view event report columns (note: *Figure 12.3* is on multiple pages). This example event report displays rows of information each 1/4 cycle and was retrieved with the **EVE B** command.

The columns contain ac current, ac voltage, station dc battery voltage, and directional polarizing voltage (V1Mem).

Current, Voltage, and Frequency Columns in the Backup Protection Event Report

Table 12.3 summarizes the backup event report current, voltage, and frequency columns.

Table 12.3 Standard Event Report Current, Voltage, and Frequency Columns (Backup Protection) (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)
IP	Current measured by channel IP (primary A)
IG	Calculated residual current IG = 3I0 = IA + IB + IC (primary A)
VA	Voltage measured by channel VA (primary kV)
VB	Voltage measured by channel VB (primary kV)

Table 12.3 Standard Event Report Current, Voltage, and Frequency Columns (Backup Protection) (Sheet 2 of 2)

Column Heading	Definition
VC	Voltage measured by channel VC (primary kV)
VS	Voltage measured by channel VS (primary kV)
V1Mem	Positive-sequence memory voltage (primary kV)
FREQ	Frequency of Channel VA (not available with P parameter)
DT	Difference time referenced to previous row (only available with P parameter)
Vdc	Voltage measured at power input terminals Z25 and Z26 (Vdc)

Note that the ac values change from positive to negative in *Figure 12.3*, indicating the sinusoidal nature of the waveforms.

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

- *Figure 12.5* shows how event report current column data relate to the actual sampled waveform and rms values.
- *Figure 12.6* shows how event report column data can be converted to phasor rms values.

Output, Input, Protection, and Control Columns

Table 12.4 and *Table 12.7* summarize the event report output, input, protection, and control columns for backup and differential protection, respectively. See *Table 9.6* for more information on the Relay Word bits shown in *Table 12.4*, *Table 12.5*, and *Table 12.7*.

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Backup Protection) (Sheet 1 of 6)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
All columns		.	Element/input/output not picked up or not asserted, unless otherwise stated
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 ZAB1
	MAB3	3	If Zone 3 AB phase-to-phase distance element (MAB3) set, not ZAB1 or ZAB2
	MAB4	4	If Zone 4 AB phase-to-phase distance element (MAB4) set, not ZAB1 or ZAB2 or ZAB3
ZPP[b]	MPP1	1	If Zone 1 phase-to-phase distance element (MPP1) set
	MPP2	2	If Zone 2 phase-to-phase distance element (MPP2) set, not ZPP1
	MPP3	3	If Zone 3 phase-to-phase distance element (MPP2) set, not ZPP1 or ZPP2
	MPP4	4	If Zone 4 phase-to-phase distance element (MPP4) set, not ZPP1, ZPP2, or ZPP3
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 ZBC1
	MBC3	3	If Zone 3 BC phase-to-phase distance element (MBC3) set, not ZBC1 or ZBC2
	MBC4	4	If Zone 4 BC phase-to-phase distance element (MBC4) set, not ZBC1 or ZBC2 or ZBC3

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Backup Protection) (Sheet 2 of 6)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
Z3P[b]	MABC1	1	If Zone 1 3-phase distance element (MABC1) set
	MABC2	2	If Zone 2 3-phase distance element (MABC2) set, not Z3P1
	MABC3	3	If Zone 3 3-phase distance element (MABC3) set, not Z3P1 or Z3P2
	MABC4	4	If Zone 4 3-phase distance element (MABC4) set, not Z3P1, Z3P2, or Z3P3
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 ZCA1
	MCA3	3	If Zone 3 CA phase-to-phase distance element (MCA3) set, not ZCA1 or ZCA2
	MCA4	4	If Zone 4 CA phase-to-phase distance element (MCA4) set, not ZCA1 or ZCA2 or ZCA3
ZAG	ZAG1	1	If Zone 1 AG element (XAG1 or MAG1) set
	ZAG2	2	If Zone 2 AG element (XAG2 or MAG2) set, not ZAG1
	ZAG3	3	If Zone 3 AG element (XAG3 or MAG3) set, not ZAG1 or ZAG2
	ZAG4	4	If Zone 4 AG element (XAG4 or MAG4) set, not ZAG1 or ZAG2 or ZAG3
ZBG	ZBG1	1	If Zone 1 BG element (XBG1 or MBG1) set
	ZBG2	2	If Zone 2 BG element (XBG2 or MBG2) set, not ZBG1
	ZBG3	3	If Zone 3 BG element (XBG3 or MBG3) set, not ZBG1 or ZBG2
	ZBG4	4	If Zone 4 BG element (XBG4 or MBG4) set, not ZBG1 or ZBG2 or ZBG3
ZCG	ZCG1	1	If Zone 1 CG element (XCG1 or MCG1) set
	ZCG2	2	If Zone 2 CG element (XCG2 or MCG2) set, not ZCG1
	ZCG3	3	If Zone 3 CG element (XCG3 or MCG3) set, not ZCG1 or ZCG2
	ZCG4	4	If Zone 4 CG element (XCG4 or MCG4) set, not ZCG1 or ZCG2 or ZCG3
OOS	OSB	t	OOS timing
	OST	B	OOS Block (OSB*!OST)
		T	OOS Trip (OST)
VPOL	VPOLV	V	VPOLV asserted
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 after having timed out (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	50P3	3	50P3 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

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Backup Protection) (Sheet 3 of 6)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
50Q 1 2	50Q1, 50Q2	1	50Q1 asserted
		2	50Q2 asserted
		b	both 50Q1 and 50Q2 asserted
50Q 3 4	50Q3, 50Q4	3	50Q3 asserted
		4	50Q4 asserted
		b	both 50Q3 and 50Q4 asserted
32 Q	F32Q	Q	Forward negative-sequence directional element F32Q picked up.
	R32Q	q	Reverse negative-sequence directional element R32Q picked up.
32 QVI	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	67P3	3	67P3 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 G	GDEM	*	Residual-ground demand ammeter element 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.

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Backup Protection) (Sheet 4 of 6)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
27 PP	27AB, 27BC, 27CA	A	AB phase-to-phase instantaneous undervoltage element 27AB picked up.
		B	BC phase-to-phase instantaneous undervoltage element 27BC picked up.
		C	CA phase-to-phase instantaneous undervoltage element 27CA picked up
		a	27AB and 27CA elements picked up.
		b	27AB and 27BC elements picked up.
		c	27BC and 27CA elements picked up.
		3	27AB, 27BC, and 27CA elements picked up.
27 S	27S	*	Channel VS instantaneous undervoltage element 27S picked up.
59 P	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.

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Backup Protection) (Sheet 5 of 6)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
81 5 6	81D5, 81D6	5 6 b	Level 5 instantaneous frequency element asserted. Level 6 instantaneous frequency element asserted. Level 5 and 6 instantaneous frequency elements asserted.
79	RCSF, CF, 79RS, 79CY, 79LO	. S F R C L	Reclosing relay nonexistent. Reclose supervision failure condition (RCSF asserts for only 1/4 cycle). Close failure condition (CF asserts for only 1/4 cycle). Reclosing relay in Reset State (79RS). Reclosing relay in Reclose Cycle State (79CY). Reclosing relay in Lockout State (79LO).
Time	OPTMN, RSTMN	o r	Recloser open interval timer is timing. Recloser reset interval timer is timing.
Shot	SH0, SH1, SH2 SH3, SH4	. 0 1 2 3 4	Reclosing relay nonexistent. shot = 0 (SH0). shot = 1 (SH1). shot = 2 (SH2). shot = 3 (SH3). shot = 4 (SH4).
Zld	ZLIN, ZLOUT	i o	Load encroachment “load in” element ZLIN picked up. Load encroachment “load out” element ZLOUT picked up.
LOP	LOP	*	Loss-of-potential element LOP picked up.
Vdc	DCHI, DCLO	H L b	Station battery instantaneous overvoltage element DCHI picked up. Station battery instantaneous undervoltage element DCLO picked up. Both DCHI and DCLO asserted.
Out1 1 2[c]	OUT101, OUT102	1 2 b	Output contact OUT101 asserted. Output contact OUT102 asserted. Both OUT101 and OUT102 asserted.
Out1 3 4[c]	OUT103, OUT104	3 4 b	Output contact OUT103 asserted. Output contact OUT104 asserted. Both OUT103 and OUT104 asserted.
Out1 5 6[c]	OUT105, OUT106	5 6 b	Output contact OUT105 asserted. Output contact OUT106 asserted. Both OUT105 and OUT106 asserted.
Out1 7 A[c]	OUT107, ALARM	7 A b	Output contact OUT107 asserted. Output contact ALARM asserted. Both OUT107 and ALARM asserted.
Out2 1 2	OUT201, OUT202	1 2 b	Output contact OUT201 asserted. Output contact OUT202 asserted. Both OUT201 and OUT202 asserted.
Out2 3 4	OUT203, OUT204	3 4 b	Output contact OUT203 asserted. Output contact OUT204 asserted. Both OUT203 and OUT204 asserted.
Out2 5 6	OUT205, OUT206	5 6 b	Output contact OUT205 asserted. Output contact OUT206 asserted. Both OUT205 and OUT206 asserted.

Table 12.4 Output, Input, Protection, and Control Element Event Report Columns (Backup Protection) (Sheet 6 of 6)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
Out3 1 2	OUT301, OUT302	1	Output contact OUT301 asserted.
		2	Output contact OUT302 asserted.
		b	Both OUT301 and OUT302 asserted.
Out3 3 4	OUT303, OUT304	3	Output contact OUT303 asserted.
		4	Output contact OUT304 asserted.
		b	Both OUT303 and OUT304 asserted.
Out3 5 6	OUT305, OUT306	5	Output contact OUT305 asserted.
		6	Output contact OUT306 asserted.
		b	Both OUT305 and OUT306 asserted.
Out3 7 8	OUT307, OUT308	7	Output contact OUT307 asserted.
		8	Output contact OUT308 asserted.
		b	Both OUT307 and OUT308 asserted.
Out3 9 0	OUT309, OUT310	9	Output contact OUT309 asserted.
		10	Output contact OUT310 asserted.
		b	Both OUT311 and OUT312 asserted.
Out3 1 2	OUT311, OUT312	11	Output contact OUT311 asserted.
		12	Output contact OUT312 asserted.
		b	Both OUT311 and OUT312 asserted.
In1 1 2	IN101, IN102	1	Optoisolated input IN101 asserted.
		2	Optoisolated input IN102 asserted.
		b	Both IN101 and IN102 asserted.
In1 3 4	IN103, IN104	3	Optoisolated input IN103 asserted.
		4	Optoisolated input IN104 asserted.
		b	Both IN103 and IN104 asserted.
In1 5 6	IN105, IN106	5	Optoisolated input IN105 asserted.
		6	Optoisolated input IN106 asserted.
		b	Both IN105 and IN106 asserted.
In3 1 2	IN301, IN302	1	Optoisolated input IN301 asserted.
		2	Optoisolated input IN302 asserted.
		b	Both IN301 and IN302 asserted.
In3 3 4	IN303, IN304	3	Optoisolated input IN303 asserted.
		4	Optoisolated input IN304 asserted.
		b	Both IN303 and IN304 asserted.
In3 5 6	IN305, IN306	5	Optoisolated input IN305 asserted.
		6	Optoisolated input IN306 asserted.
		b	Both IN305 and IN306 asserted.
In3 7 8	IN307, IN308	7	Optoisolated input IN307 asserted.
		8	Optoisolated input IN308 asserted.
		b	Both In307 and IN308 asserted.

[a] This column is visible only when positive-sequence, polarized phase mho elements are enabled (E21P does not contain "C").
[b] This column is visible only when compensator distance mho elements are enabled (E21P contains "C").
[c] Output contacts can be A or B type contacts (see Table 2.5 and Figure 7.27–Figure 7.28).

Table 12.5 Communication Elements Event Report Columns (Backup Protection) (Sheet 1 of 3)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
3PO	3PO	*	Three-pole open condition 3PO asserted.
SOTF	SOTF	*	Switch-onto-fault condition SOTF asserted.
PT	PT	*	Permissive trip signal to POTT logic PT asserted.
PTRX	PTRX1, PTRX2	1 2 b	Permissive trip 1 signal from DCUB logic PTRX1 asserted. Permissive trip 2 signal from DCUB logic PTRX2 asserted. Both PTRX1 and PTRX2 asserted
Z3RB	Z3RB	*	Zone /Level 3 reverse block Z3RB asserted.
KEY	KEY	*	Key permissive trip signal KEY asserted.
EKEY	EKEY	*	Echo key EKEY asserted.
ECTT	ECTT	*	Echo conversion to trip condition ECTT asserted.
WFC	WFC	*	Weak-infeed condition WFC asserted.
UBB	UBB1, UBB2	1 2 b	Unblocking block 1 from DCUB logic UBB1 asserted. Unblocking block 2 from DCUB logic UBB2 asserted. Both UBB1 and UBB2 asserted.
Z3XT	Z3XT	*	Logic output from Zone/Level 3 extension timer Z3XT asserted.
DSTR	DSTRT	*	Directional carrier start DSTRT asserted.
NSTR	NSTRT	*	Nondirectional carrier start NSTRT asserted.
STOP	STOP	*	Carrier stop STOP asserted.
BTX	BTX	*	Block trip input extension BTX asserted.
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.

Table 12.5 Communication Elements Event Report Columns (Backup Protection) (Sheet 2 of 3)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
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.
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 A 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[a]	Hex value of Relay Word 5, LB1–LB8, Local Bits
Lcl RW 6	LB9–LB16	00–FF Hex[a]	Hex value of Relay Word 6, LB9–LB16, Local Bits
Rem RW 7	RB1–RB8	00–FF Hex[a]	Hex value of Relay Word 7, RB1–RB8, Remote Bits
Rem RW 8	RB9–RB16	00–FF Hex[a]	Hex value of Relay Word 8, RB9–RB16, Remote Bits

Table 12.5 Communication Elements Event Report Columns (Backup Protection) (Sheet 3 of 3)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
Ltch RW 9	LT1–LT8	00–FF Hex[a]	Hex value of Relay Word 9, LT1–LT8, Latch Bits
Ltch RW 10	LT9–LT16	00–FF Hex[a]	Hex value of Relay Word 10, LT9–LT16, Latch Bits
SELOGIC 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	 SV1, SV1T SV2, SV2T SV3, SV3T SV4, SV4T SV5, SV5T SV6, SV6T SV7, SV7T SV8, SV8T SV9, SV9T SV10, SV10T SV11, SV11T SV12, SV12T SV13, SV13T SV14, SV14T SV15, SV15T SV16, SV16T	 p T d	 SELOGIC control equation variable timer input SV_ asserted; timer timing on pickup time; timer output SV_T not asserted. SELOGIC control equation variable timer input SV_ asserted; timer timed out on pickup time; timer output SV_T asserted. 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.

[a] Hexadecimal values are constructed with the highest numbered bit (e.g., LB8) being the least significant, as follows:

LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8	
1	0	0	0	1	0	1	0	= 8A Hex

Example Standard 15-Cycle Event Report (Backup Protection)

The following example standard 15-cycle event report in *Figure 12.3* also corresponds to the example sequential events recorder (SER) report in *Figure 12.7*. The circled numbers in *Figure 12.3* correspond to the SER row numbers in *Figure 12.7*. The row explanations follow *Figure 12.7*.

In *Figure 12.3*, the arrow (>) in the column following the V1Mem column identifies the “trigger” row. This is the row that corresponds to the Date and Time values at the top of the event report.

The asterisk (*) in the column following the V1Mem column identifies the row corresponding to the “fault” values listed in the event summary report. See *Currents and Voltages on page 12.6*. The phase current is calculated from the row identified with the asterisk and the row one quarter-cycle previous (see *Figure 12.3* and *Table 12.1*). 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.

```
=>>EVE B <Enter>

SEL-311L                        Date: 12/01/03    Time: 10:25:24.810
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311L-7-R201-V0-Z005003-D20031203       CID=151D

      Currents (Amps Pri)            Voltages (kV Pri)          V1
    IA    IB    IC    IP    IG     VA     VB     VC     VS    Mem  FREQ Vdc
[1]
    49  -212   163     0     0   23.9 -122.3   98.3    0.0   24.2 60.00  23
   215   -65  -153     0    -3  127.2  -42.8  -84.4   -0.0  127.2 60.00  23
   -50   211  -164    -1    -3  -23.8  122.3  -98.4   -0.0  -24.1 60.00  23
  -216    65   152    -1     1 -127.2   42.9   84.3    0.0 -127.3 60.00  23
[2]
    48  -212   163     0    -1   23.7 -122.2   98.4    0.0   24.1 60.00  23
   215   -66  -153     0    -4  127.3  -43.0  -84.3   -0.0  127.3 60.00  23
   -48   211  -164     0    -1  -23.6  122.2  -98.5   -0.0  -24.0 60.00  23
  -215    65   151    -1     1 -127.3   43.1   84.2    0.0 -127.3 60.00  23
[3]
    47  -212   163    -1    -2   23.5 -122.2   98.5    0.0   23.9 60.00  23
   215   -66  -152     0    -3  127.3  -43.2  -84.1   -0.0  127.3 60.00  23
   -48   211  -164     0    -1  -23.4  122.1  -98.6   -0.0  -23.8 60.00  23
  -216    66   151     0     1 -127.3   43.3   84.0    0.0 -127.3 60.00  23
[4]
    47  -212   163     0    -2   23.2 -122.1   98.7    0.0   23.7 60.00  23
   215   -72  -156     0   -13  128.8  -41.3  -81.6   -0.0  127.3 60.00  23
   -48   381  -524    -1  -191  -20.8  110.9  -80.0   -0.0  -23.7 60.00  23
  -216   744  -433    -1    95 -138.4   28.5   62.4    0.0 -124.6 60.00  23>
[5]
    47  -445   918     0   520   21.5  -81.2   54.1    0.0   23.1 60.00  23
   215 -1555  1164     0  -176  146.4  -18.0  -45.3   -0.0  118.0 60.00  23
   -48   216  -834     0  -666  -24.6   62.7  -46.9   -0.0  -22.1 60.00  23
  -216  1594 -1205    -1   173 -146.5   17.9   45.3    0.0 -111.3 60.00  23
[6]
    47  -183   798    -1   662   24.5  -62.7   46.9    0.0   21.2 60.00  23
   215 -1567  1176     0  -176  146.5  -18.0  -45.2   -0.0  106.2 60.00  23
   -48   205  -823     0  -666  -24.4   62.6  -47.0   -0.0  -20.5 60.00  23
  -216  1586 -1198    -1   172 -146.5   18.0   45.2    0.0 -102.4 60.00  23
[7]
    46  -187   803     0   662   24.3  -62.6   47.0    0.0   20.0 60.00  23
   215 -1573  1183     0  -175  146.5  -18.1  -45.1   -0.0   99.6 60.00  23*
   -47   197  -816    -1  -666  -24.1   62.6  -47.1   -0.0  -19.6 60.00  23
  -216  1582 -1195    -1   171 -146.5   18.2   45.1    0.0  -97.4 60.00  23
[8]
    46  -188   805     0   663   24.0  -62.6   47.1    0.0   19.3 60.00  23
   215 -1576  1187     1  -174  146.5  -18.2  -45.1   -0.0   95.8 60.00  23
   -47   192  -812     0  -667  -23.9   62.6  -47.2   -0.0  -19.1 60.00  23
  -217  1581 -1194    -2   170 -146.6   18.2   45.0    0.0  -94.7 60.00  23
[9]
    46  -188   805     0   663   23.8  -62.6   47.2    0.0   18.9 60.00  23
   216 -1578  1190     0  -172  146.6  -18.3  -45.0   -0.0   93.8 60.00  23
   -47   189  -808    -1  -666  -23.7   62.6  -47.2   -0.0  -18.7 60.00  23
  -216  1580 -1195    -1   169 -146.6   18.3   45.0    0.0  -93.1 60.00  23
[10]
    46  -185   804     0   665   23.5  -62.6   47.2    0.0   18.5 60.00  23
   215 -1579  1193     0  -171  146.6  -18.4  -44.9   -0.0   92.6 60.00  23
   -46   149  -723    -1  -620  -30.8   61.7  -64.1   -0.0  -18.3 60.00  23
  -154  1156  -782    -1   220 -140.5   33.2   54.0    0.0  -93.9 60.00  23
[11]
    22   -48   318     0   292   35.1  -91.3   88.7    0.0   18.2 60.00  23
    45  -365   182     0  -138  130.6  -42.5  -76.4   -0.0   99.2 60.00  23
     0    -8    -1    -1    -9  -31.1  123.3  -95.7   -0.0  -19.9 60.00  23
     0     0     0    -1     0 -126.7   37.1   89.6    0.0 -106.1 60.00  23
[12]
    -1     0     0     0    -1   30.0 -125.0   94.8    0.0   22.5 60.00  23
    -1    -1    -1     0    -3  126.7  -37.2  -89.5   -0.0  111.3 60.00  23
     0     0    -1     0    -1  -29.9  124.9  -94.9   -0.0  -24.4 60.00  23
     0     0     0    -1     0 -126.8   37.3   89.4    0.0 -115.2 60.00  23
[13]
    -1    -1     0    -1    -2   29.8 -124.9   95.0    0.0   25.8 60.00  23
    -1    -1    -1     0    -3  126.8  -37.5  -89.3   -0.0  118.1 60.00  23
     0    -1    -1    -1    -2  -29.7  124.9  -95.1   -0.0  -26.8 60.00  23
     0     0     0    -1     0 -126.8   37.6   89.2    0.0 -120.3 60.00  23
[14]
    -1     0     0     0    -1   29.6 -124.9   95.1    0.0   27.5 60.00  23
    -1    -1    -2     0    -4  126.8  -37.6  -89.2   -0.0  121.9 60.00  23
     0    -1    -1     0    -2  -29.5  124.8  -95.2   -0.0  -28.1 60.00  23
     0     0     0    -1     0 -126.9   37.7   89.1    0.0 -123.2 60.00  23
[15]
     0     0     0    -1     0   29.4 -124.8   95.2    0.0   28.4 60.00  23
    -1    -1    -1     0    -3  126.9  -37.8  -89.1   -0.0  124.1 60.00  23
     0    -1     0     0    -1  -29.3  124.8  -95.3   -0.0  -28.7 60.00  23
     1     0     0    -1     1 -126.9   37.9   89.0    0.0 -124.9 60.00  23
```

(Continued on next page)

(Continued from previous page)

```
Protection and Contact I/O Elements

21       V 51  50     32 67     Dm 27 59    25  81  TS
ZZZZZZ O P     P G Q   Q P G Q           V  5  2    ih ZLV Out1 Out2 Out3   In1 In3
ABCABC O O     1 1313  V 1 1313 P   P  P 1  9S 71357mo l0d 1357 135  135791 135 1357
BCAGGG S L PGQ 232424 QI 232424 QG PPSPPSQN VFAB2469et dPc 246A 246  246802 246 2468
[1]
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
[2]
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
[3]
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
...... . V ... ...... .. ...... .. ........ ...*...... o.. .... ...  ...... ... ....
[4]
...... . V ... ...... .. ...... .. ........ .......... o.. .... ...  ...... ... ....
...... . V ... ...... .. ...... .. ........ .......... o.. .... ...  ...... ... ....
...... . V .p. ...... .. ...... .. ........ .......... o.. .... ...  ...... ... ....
...... . V .pp ...... .. ...... .. ........ .......... ... .... ...  ...... ... ....   ⑭
[5]                                                                                    ⑬
...... . V .pp ...... QQ ...... .. ........ .......... ... .... ...  ...... ... ....   ⑫
.2.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....   ⑱
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
[6]
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....   ⑩
[7]
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
[8]
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...... ... ....
[9]
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...
[10]
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...                ⑨
[11]                                                                                   ⑦
.2.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...
...... . V .pp ...... QQ ...... .. ........ .......... ... b... b..  ...                ⑧
...... . V .rp ...... QQ ...... .. ........ .......... ... b... b..  ...
...... . V .rr ...... QQ ...... .. ........ .......... ... b... b..  ...
[12]
...... . V .rr ...... .. ...... .. ........ .......... ... b... b..  ...
...... . V .rr ...... .. ...... .. ........ .......... ... b... b..  ...
...... . V .rr ...... .. ...... .. ........ .......... ... b... b..  ...
...... . V .r. ...... .. ...... .. ........ .......... ... b... b..  ...
[13]
...... . V .r. ...... .. ...... .. ........ .......... ... b... b..  ...
...... . V .r. ...... .. ...... .. ........ .......... ... b... b..  ...
...... . V .r. ...... .. ...... .. ........ .......... ... b... b..  ...
...... . V .r. ...... .. ...... .. ........ .......... ... b... b..  ...
[14]                                                                                   ①
...... . V .r. ...... .. ...... .. ........ .......... ... b... b..  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... b..  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... b..  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... ...  ...
[15]                                                                                   ②
...... . V .r. ...... .. ...... .. ........ .......... ... .... ...  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... ...  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... ...  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... ...  ...
```

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```
Communication Elements                     Control 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 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[2]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[3]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[4]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................>
[5]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................        ②
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[6]
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[7]
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[8]
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[9]
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[10]
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[11]                                                                                   ⑦
.* ...*.... ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[12]
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[13]
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[14]
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
[15]
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
```

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```
Event: BCG T  Location:   49.12  Shot:    Frequency:  60.00
Targets: 87 ZONE2
Currents (A Pri), ABCPGQ:    219  1584  1429     0   684  2188

Group 1

Group Settings:
RID   =SEL-311L                       TID   =EXAMPLE: BUS B, BREAKER 3
CTR   = 200      APP   = 311L
E87L  = 2        EHST  = 2        EHSDTT= N
EDD   = Y        ETAP  = N        EOCTL= N
PCHAN = X        EHSC  = N        CTR_X = 200
87LPP = 6.00     87L2P = 0.50     87LGP = OFF      CTALRM= 0.50
87LR  = 6.0      87LANG= 195
CTRP  = 200      PTR   = 2000.00  PTRS  = 2000.00
Z1MAG = 7.80     Z1ANG = 84.00
Z0MAG = 24.80    Z0ANG = 81.50    LL    = 100.00
E21P  = 3        E21MG = 3        E21XG = 3
E50P  = 1        E50G  = N        E50Q  = N
E51P  = N        E51G  = Y        E51Q  = Y
E32   = AUTO     EOOS  = N        ELOAD = Y        ESOTF = Y
EVOLT = N        E25   = N        E81   = N        EFLOC = Y
ELOP  = Y        ECOMM = POTT     E79   = N        EZ1EXT= N
ECCVT = N        ESV   = N        ELAT  = N        EDP   = 3
EDEM  = THM      EADVS = N
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 = 11.25
67P1D = 0.00
51GP  = 0.75     51GC  = U3       51GTD = 2.00     51GRS = Y
51QP  = 2.20     51QC  = U3       51QTD = 2.00     51QRS = N
ZLF   = 9.22     ZLR   = 9.22
PLAF  = 30.00    NLAF  =-30.00    PLAR  = 150.00   NLAR  = 210.00
DIR3  = R        DIR4  = F
ORDER = QVI
CLOEND= OFF      52AEND= 10.00    SOTFD = 30.00
Z3RBD = 5.00     EBLKD = 10.00    ETDPU = 2.00
EDURD = 4.00     EWFC  = N
DMTC  = 60       PDEMP = OFF      GDEMP = OFF      QDEMP = OFF
TDURD = 9.00     CFD   = 60.00    3POD  = 0.50     OPO   = 52

50LP  = 0.25

SELogic group 1

SELogic Control Equations:
TR    =M1P + Z1G + M2PT + Z2GT + 51GT + 51QT + OC
TRCOMM=M2P + Z2G
TRSOTF=M2P + Z2G + 50P1
DTT   =0
ULTR  =!(50L + 51G)
PT1   =IN102
52A   =IN101
CL    =CC
ULCL  =TRIP + TRIP87
67P1TC=1

51GTC =1
51QTC =1
OUT101=TRIP
OUT102=TRIP
OUT103=CLOSE
OUT104=KEY
OUT105=0
OUT106=0
OUT107=87HWAL
OUT201=TRIP + TRIP87
OUT202=TRIP + TRIP87
OUT203=0
OUT204=0
OUT205=0
OUT206=0
OUT301=0
OUT302=0
OUT303=0
OUT304=0
```

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```
OUT305=0
OUT306=0
OUT307-0
OUT308=0
OUT309=0
OUT310=0
OUT311=0
OUT312=0
DP1   =52A
DP2   =CHXAL
DP3   =CHYAL
SS1   =0
SS2   =0
SS3   =0
SS4   =0
SS5   =0
SS6   =0
ER    =/PQ87LA + /PQ87LB + /PQ87LC + /PQ87L2 + /M2P + /Z2G + /51G + /51Q
        + /50P1 + /LOP
FAULT =51G + 51Q + M2P + Z2G
BSYNCH=0
CLMON =0
E32IV =1

T1X   =0
T2X   =0
T3X   =0
T4X   =0
T1Y   =0
T2Y   =0
T3Y   =0
T4Y   =0

Global Settings:
TGR   = 1800.00  NFREQ = 60       PHROT = ABC
DATE_F= MDY      FP_TO = 15.00    SCROLD= 5
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     IN301D= 0.00     IN302D= 0.00
IN303D= 0.00     IN304D= 0.00     IN305D= 0.00     IN306D= 0.00
IN307D= 0.00     IN308D= 0.00
EBMON = N

=>
```

Figure 12.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Backup Protection)

Table 12.6 Standard Event Report Current and Frequency Columns (Line Current Differential)

Column Heading		Definition
Local	IA	Local A-phase current
	IB	Local B-phase current
	IC	Local C-phase current
Channel X	IA	IA current received at Channel X
	IB	IB current received at Channel X
	IC	IC current received at Channel X
Channel Y	IA	IA current received at Channel Y
	IB	IB current received at Channel Y
	IC	IC current received at Channel Y
Total	IA	Sum of all A-phase terminal currents.
	IB	Sum of all B-phase terminal currents.
	IC	Sum of all C-phase terminal currents.
FREQ		Frequency measured by the relay

Table 12.7 Output, Input and Protection, and Control Element Event Report Columns (Line Current Differential) (Sheet 1 of 4)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
87LA	87LA	*	87LA asserted
87LB	87LB	*	87LB asserted
87LC	87LC	*	87LC asserted
87LG	87LG	*	87LG asserted
87L2	87L2	*	87L2 asserted
87LL	87L	*	87L asserted
Rstr A	R87LA	*	R87LA asserted
Rstr B	R87LB	*	R87LB asserted
Rstr C	R87LC	*	R87LC asserted
Rstr G	R87LG	*	R87LG asserted
Rstr 2	R87L2	*	R87L2 asserted
T51P	T51P, T51PT, T51PR	r	Tap load time-overcurrent phase element timing to reset
		p	Tap load time-overcurrent phase element picked up and timing
		T	Tap load time-overcurrent phase element timed out
		l	Tap load time-overcurrent phase element timing to reset after having timed out (not electromechanical reset)
T50P	T50P, T50PT, T50PR	*	Tap load inst./def.-time overcurrent element picked up
		T	Tap load inst./def.-time overcurrent trip element asserted
T51G	T51G, T51GT, T51GR	r	Tap load time-overcurrent ground element timing to reset
		p	Tap load time-overcurrent ground element picked up and timing
		T	Tap load time-overcurrent ground element timed out
		l	Tap load time-overcurrent ground element timing to reset after having timed out (not electromechanical reset)
T50G	T50G, T50GT, T50GR	*	Tap load inst./def.-time overcurrent ground element picked up
		T	Tap load inst./def.-time overcurrent ground trip element asserted
T51Q	T51Q, T51QR, T51QT	r	Tap load time-overcurrent negative-seq. element timing to reset
		p	Tap load time-overcurrent negative-seq. element picked up and timing
		T	Tap load time-overcurrent negative-seq. element timed out
		l	Tap load time-overcurrent negative-seq. element timing to reset after having timed out (not electromechanical reset)

Table 12.7 Output, Input and Protection, and Control Element Event Report Columns (Line Current Differential) (Sheet 2 of 4)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
T50Q	T50Q, T50QR, T50QT	*	Tap load inst./def.-time overcurrent negative-seq. element picked up
		T	Tap load inst./def.-time overcurrent negative-seq. trip element asserted
FTSA	FTSA	*	FTA or FTAB or FTCA or FTABC asserted
FTSB	FTSB	*	FTB or FTAB or FTBC or FTABC asserted
FTSC	FTSC	*	FTC or FTBC or FTCA or FTABC asserted
FTSE	FTSE	*	FTSE asserted
B87G	B87LG	*	B87LG asserted
B872	B87L2	*	B87L2 asserted
R1	R1X, R1Y	b	Differential channel receive bit R1X and R1Y asserted
		X	Differential channel receive bit R1X asserted
		Y	Differential channel receive bit R1Y asserted
R2	R2X, R2Y	b	Differential channel receive bit R2X and R2Y asserted
		X	Differential channel receive bit R2X asserted
		Y	Differential channel receive bit R2Y asserted
R3	R3X, R3Y	b	Differential channel receive bit R3X and R3Y asserted
		X	Differential channel receive bit R3X asserted
		Y	Differential channel receive bit R3Y asserted
R4	R4X, R4Y	b	Differential channel receive bit R4X and R4Y asserted
		X	Differential channel receive bit R4X asserted
		Y	R4Y asserted
T1	T1X, T1Y	b	Differential channel transmit bit T1X and T1Y asserted
		X	Differential channel transmit bit T1X asserted
		Y	Differential channel transmit bit T1Y asserted
T2	T2X, T2Y	b	Differential channel transmit bit T2X and T2Y asserted
		X	Differential channel transmit bit T2X asserted
		Y	Differential channel transmit bit T2Y asserted

Table 12.7 Output, Input and Protection, and Control Element Event Report Columns (Line Current Differential) (Sheet 3 of 4)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
T3	T3X, T3Y	b	Differential channel transmit bit T3X and T3Y asserted
		X	Differential channel transmit bit T3X asserted
		Y	Differential channel transmit bit T3Y asserted
T4	T4X, T4Y	b	Differential channel transmit bit T4X and T4Y asserted
		X	Differential channel transmit bit T4X asserted
		Y	Differential channel transmit bit T4Y asserted
RDT	RDTX, RDTY	b	Differential channel direct trip bit RDTX and RDTY asserted
		X	Differential channel direct trip bit RDTX asserted
		Y	Differential channel direct trip bit RDTY asserted
TDT	TDTX, TDTY	b	Differential channel direct trip bit TDTX and TDTY asserted
		X	Differential channel direct trip bit TDTX asserted
		Y	Differential channel direct trip bit TDTY asserted
DD	DD	*	DD asserted
ROK	ROKX, ROKY	b	Both Channels X and Y are receiving valid data
		X	Channel X is receiving valid data
		Y	Channel Y is receiving valid data
Out1 1 2	OUT101, OUT102	1	OUT101 asserted
		2	OUT102 asserted
		b	Both OUT101 and OUT102 asserted
Out1 3 4	OUT103, OUT104	1	OUT103 asserted
		2	OUT104 asserted
		b	Both OUT103 and OUT104 asserted
Out1 5 6	OUT105, OUT106	1	OUT105 asserted
		2	OUT106 asserted
		b	Both OUT105 and OUT106 asserted
Out1 7 A	OUT107, ALARM	7	OUT107 asserted
		A	ALARM asserted
		b	Both OUT107 and ALARM asserted
Out2 1 2	OUT201, OUT202	1	OUT201 asserted
		2	OUT202 asserted
		b	Both OUT201 and OUT202 asserted
Out2 3 4	OUT203, OUT204	1	OUT203 asserted
		2	OUT204 asserted
		b	Both OUT203 and OUT204 asserted

Table 12.7 Output, Input and Protection, and Control Element Event Report Columns (Line Current Differential) (Sheet 4 of 4)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
Out2 5 6	OUT205, OUT206	1	OUT205 asserted
		2	OUT206 asserted
		b	Both OUT205 and OUT206 asserted
Out3 1 2	OUT301, OUT302	1	OUT201 asserted
		2	OUT202 asserted
		b	Both OUT201 and OUT202 asserted
Out3 3 4	OUT303, OUT304	1	OUT203 asserted
		2	OUT204 asserted
		b	Both OUT203 and OUT204 asserted
Out3 5 6	OUT305, OUT306	1	OUT305 asserted
		2	OUT306 asserted
		b	Both OUT305 and OUT306 asserted
Out3 7 8	OUT307, OUT308	1	OUT307 asserted
		2	OUT308 asserted
		b	Both OUT307 and OUT308 asserted
Out3 9 0	OUT309, OUT310	1	OUT309 asserted
		2	OUT310 asserted
		b	Both OUT309 and OUT310 asserted
Out3 1 2	OUT311, OUT312	1	OUT311 asserted
		2	OUT312 asserted
		b	Both OUT311 and OUT312 asserted
In1 1 2	IN101, IN102	1	IN101 asserted
		2	IN102 asserted
		b	Both IN101 and IN102 asserted
In1 3 4	IN103, IN104	1	IN103 asserted
		2	IN104 asserted
		b	Both IN103 and IN104 asserted
In1 5 6	IN105, IN106	1	IN105 asserted
		2	IN106 asserted
		b	Both IN105 and IN106 asserted
In3 1 2	IN301, IN302	1	IN301 asserted
		2	IN302 asserted
		b	Both IN301 and IN302 asserted
In3 3 4	IN303, IN304	1	IN303 asserted
		2	IN304 asserted
		b	Both IN303 and IN304 asserted
In3 5 6	IN305, IN306	1	IN305 asserted
		2	IN306 asserted
		b	Both IN305 and IN306 asserted
In3 7 8	IN307, IN308	1	IN307 asserted
		2	IN308 asserted
		b	Both IN307 and IN308 asserted

Example Standard 15-Cycle Event Report (Differential Protection)

The example standard 15-cycle event report in *Figure 12.4* also corresponds to the example sequential events recorder (SER) report in *Figure 12.7*. The boxed numbers in *Figure 12.4* correspond to the SER row numbers in *Figure 12.7*. The row explanations follow *Figure 12.7*.

```
=>EVE <Enter>

SEL-311L                          Date: 12/01/03    Time: 10:25:24.810
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311L-7-R201-V0-Z003005-D20031203       CID=151D

                  Terminal Currents (Amps Pri)
         Local          Channel X           Total
   IA    IB    IC    IA    IB    IC    IA    IB    IC
[1]
  -148   221   -71   149  -220    58     1     1   -13
  -169   -44   216   171    44  -223     2     0    -7
   148  -221    71  -150   221   -58    -2     0    13
   169    45  -215  -169   -44   223     0     1     8
[2]
  -148   221   -72   149  -221    59     1     0   -13
  -169   -45   216   171    44  -223     2    -1    -7
   147  -221    71  -149   220   -57    -2    -1    14
   169    44  -215  -172   -43   221    -3     1     6
[3]
  -147   221   -71   149  -220    58     2     1   -13
  -169   -44   215   170    43  -222     1    -1    -7
   146  -222    72  -148   221   -59    -2    -1    13
   169    44  -216  -170   -43   223    -1     1     7
[4]
  -146   221   -72   148  -220    58     2     1   -14
  -170   -43   215   171    42  -222     1    -1    -7
   147  -221    72  -149   220   -59    -2    -1    13
   170    34  -266  -170   -51   162     0   -17  -104>
[5]
  -147   592  -629   148   147  -529     1   739 -1158
  -169   568   -94   171   653  -493     2  1221  -587
   147 -1026  1317  -148  -576  1263    -1 -1602  2580
   170 -1300   645  -171 -1382  1018    -1 -2682  1663
[6]
  -147   968 -1332   147   514 -1283     0  1482 -2615
  -170  1338  -682   171  1427 -1051     1  2765 -1733
   146  -931  1296  -148  -478  1243    -2 -1409  2539
   170 -1310   655  -171 -1407  1028    -1 -2717  1683
[7]
  -147   957 -1321   148   510 -1271     1  1467 -2592
  -170  1333  -679   172  1422 -1048     2  2755 -1727*
   146  -939  1304  -148  -491  1255    -2 -1430  2559
   171 -1318   663  -171 -1402  1025     0 -2720  1688
[8]
  -146   946 -1313   148   499 -1264     2  1445 -2577
  -171  1328  -673   171  1417 -1042     0  2745 -1715
   146  -937  1304  -148  -492  1256    -2 -1429  2560
   171 -1324   671  -171 -1408  1041     0 -2732  1712
[9]
  -146   944 -1311   147   496 -1263     1  1440 -2574
  -171  1328  -674   171  1410 -1037     0  2738 -1711
   145  -937  1305  -147  -486  1250    -2 -1423  2555
   171 -1324   671  -171 -1413  1036     0 -2737  1707
[10]
  -146   943 -1311   147   495 -1254     1  1438 -2565
  -171  1329  -677   171  1416 -1041     0  2745 -1718
   146  -940  1308  -147  -490  1252    -1 -1430  2560
   170 -1326   674  -171 -1408  1030    -1 -2734  1704
[11]
  -129   805 -1073   130   416 -1069     1  1221 -2142
  -108   890  -395   109  1000  -635     1  1890 -1030
    56  -336   418   -57  -173   443    -1  -509   861
    22  -224    55   -23  -293   117    -1  -517   172
[12]
     0     1     0     1     0     0     1     1     0
     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0
```

Figure 12.5 and Figure 12.6

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```
[13]
     0     0     0     0     1     0     0     1     0
     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0
     0     0    -1     0     0     0     0     0    -1
[14]
     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0
[15]
     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0
     0    -1     0     0     0     0     0    -1     0

      87L Protection and Contact I/O Elements

              T T T       BB
87L    Rstr  555555 FTS  88 R    T    RT   R Out1 Out2 Out3   In1 In3
             101010      77           DD D O 1357 135  135791 135 1357
ABCG2L ABCG2 PPGGQQ ABCE G2 1234 1234 TT D K 246A 246  246802 246 2468
[1]
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
[2]
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
[3]
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
[4]
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....      ⑬
...... ***.. ...... .... .. .... .... .. * X .... ...  ...... ... ....>     ⑫
[5]
...... ***.. ...... ...* .. .... .... .. * X .... ...  ...... ... ....      ⑰
.**..* *.... ...... .*** .. .... .... .b * X b4.. b..  ...... ... ....      ⑱
.**.** *.... ...... .**. .. .... .... .b * X b4.. b..  ...... ... ....      ⑮
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....      ⑯
[6]                                                                         ⑪
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
[7]
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
[8]
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
[9]
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
[10]
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
[11]                                                                        ⑦
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b... b..  ...... ... ....
.**.** *.... ...... .**. .. .... .... Xb * X b... b..  ...... ... ....      ⑥
.*..** *.... ...... .*.* .. .... .... Xb * X b... b..  ...... ... ....      ⑤
[12]
....** *.... ...... .*** .. .... .... Xb * X b... b..  ...... ... ....      ④
....** ..... ...... .... .. .... .... Xb * X b... b..  ...... ... ....
...... ..... ...... .... .. .... .... Xb * X b... b..  ...... ... ....      ③
...... ..... ...... .... .. .... .... Xb * X b... b..  ...... ... ....
```

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```
[13]
...... ..... ...... .... .. .... .... Xb * X b... b..  ...... ... ....
...... ..... ...... .... .. .... .... Xb * X b... b..  ...... ... ....
...... ..... ...... .... .. .... .... X. * X b... b..  ...... ... ....
...... ..... ...... .... .. .... .... .. * X b... b..  ...... ... ....
[14]                                                                  ①
...... ..... ...... .... .. .... .... .. * X b... b..  ...... ... ....
...... ..... ...... .... .. .... .... .. * X .... b..  ...... ... ....
...... ..... ...... .... .. .... .... .. * X .... b..  ...... ... .... ②
...... ..... ...... .... .. .... .... .. * X .... ...  ...... ... ....
[15]
...... ..... ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ..... ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ..... ...... .... .. .... .... .. * X .... ...  ...... ... ....
...... ..... ...... .... .. .... .... .. * X .... ...  ...... ... ....

Event: BCG T  Location:   49.12  Shot:    Frequency:  60.00
Targets: 87 ZONE2
Currents (A Pri), ABCPGQ:    219  1584  1429     0   684  2188

Group 1

Group Settings:
RID   =SEL-311L                       TID   =EXAMPLE: BUS B, BREAKER 3
CTR   = 200      APP   = 311L
E87L  = 2        EHST  = 2        EHSDTT= N
EDD   = Y        ETAP  = N        EOCTL = N
PCHAN = X        EHSC  = N        CTR_X = 200
87LPP = 6.00     87L2P = 0.50     87LGP = OFF      CTALRM= 0.50
87LR  = 6.0      87LANG= 195
CTRP  = 200      PTR   = 2000.00  PTRS  = 2000.00
Z1MAG = 7.80     Z1ANG = 84.00
Z0MAG = 24.80    Z0ANG = 81.50    LL    = 100.00
E21P  = 3        E21MG = 3        E21XG = 3
E50P  = 1        E50G  = N        E50Q  = N
E51P  = N        E51G  = Y        E51Q  = Y
E32   = AUTO     EOOS  = N        ELOAD = Y        ESOTF = Y
EVOLT = N        E25   = N        E81   = N        EFLOC = Y
ELOP  = Y        ECOMM = POTT     E79   = N        EZ1EXT= N
ECCVT = N        ESV   = N        ELAT  = N        EDP   = 3
EDEM  = THM      EADVS = N
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 = 11.25
67P1D = 0.00
51GP  = 0.75     51GC  = U3       51GTD = 2.00     51GRS = Y
51QP  = 2.20     51QC  = U3       51QTD = 2.00     51QRS = N
ZLF   = 9.22     ZLR   = 9.22
PLAF  = 30.00    NLAF  =-30.00    PLAR  = 150.00   NLAR  = 210.00
DIR3  = R        DIR4  = F
ORDER = QVI
CLOEND= OFF      52AEND= 10.00    SOTFD = 30.00
Z3RBD = 5.00     EBLKD = 10.00    ETDPU = 2.00
EDURD = 4.00     EWFC  = N
DMTC  = 60       PDEMP = OFF      GDEMP = OFF      QDEMP = OFF
TDURD = 9.00     CFD   = 60.00    3POD  = 0.50     OPO   = 52
50LP  = 0.25

SELogic group 1

SELogic Control Equations:
TR    =M1P + Z1G + M2PT + Z2GT + 51GT + 51QT + OC
TRCOMM=M2P + Z2G
TRSOTF=M2P + Z2G + 50P1
DTT   =0
ULTR  =!(50L + 51G)
PT1   =IN102
52A   =IN101
CL    =CC
ULCL  =TRIP + TRIP87
67P1TC=1
51GTC =1
51QTC =1
```

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```
87LTC=1
OUT101=TRIP
OUT102=TRIP
OUT103=CLOSE
OUT104=KEY
OUT105=0
OUT106=0
OUT107=87HWAL
OUT201=TRIP + TRIP87
OUT202=TRIP + TRIP87
OUT203=0
OUT204=0
OUT205=0
OUT206=0
OUT301=0
OUT302=0
OUT303=0
OUT304=0
OUT305=0
OUT306=0
OUT307=0
OUT308=0
OUT309=0
OUT310=0
OUT311=0
OUT312=0
DP1   =52A
DP2   =CHXAL
DP3   =CHYAL
SS1   =0
SS2   =0
SS3   =0
SS4   =0
SS5   =0
SS6   =0
ER    =/PQ87LA + /PQ87LB + /PQ87LC + /PQ87L2 + /M2P + /Z2G + /51G + /51Q
        + /50P1 + /LOP
FAULT =51G + 51Q + M2P + Z2G
BSYNCH=0
CLMON =0
E32IV =1
ESTUB =0
T1X   =0
T2X   =0
T3X   =0
T4X   =0
T1Y   =0
T2Y   =0
T3Y   =0
T4Y   =0

Global Settings:
TGR    = 1800.00  NFREQ = 60       PHROT = ABC
DATE_F= MDY       FP_TO = 15.00    SCROLD= 5
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     IN301D= 0.00     IN302D= 0.00
IN303D= 0.00      IN304D= 0.00     IN305D= 0.00     IN306D= 0.00
IN304D= 0.00      IN308D= 0.00
EBMON = N

=>
```

Figure 12.4 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Differential Protection)

Figure 12.5 and *Figure 12.6* look in detail at one cycle of B-phase total current (column Total IB) identified in *Figure 12.4*. *Figure 12.5* shows how the event report ac current column data relate to the actual filtered waveform and rms values. *Figure 12.6* shows how the event report current column data can be converted to phasor rms values. Voltages are processed similarly.

Refer to cycle 6 of the analog section of *Figure 12.3* and *Figure 12.4*. Notice that the currents decrease to about 0 at row 1 of cycle 6 in the backup event report, and not until row 4 of cycle 6 in the line current differential report. The currents in the line current differential report are delayed by approximately one-half cycle plus channel delay by the data alignment processing algorithms.

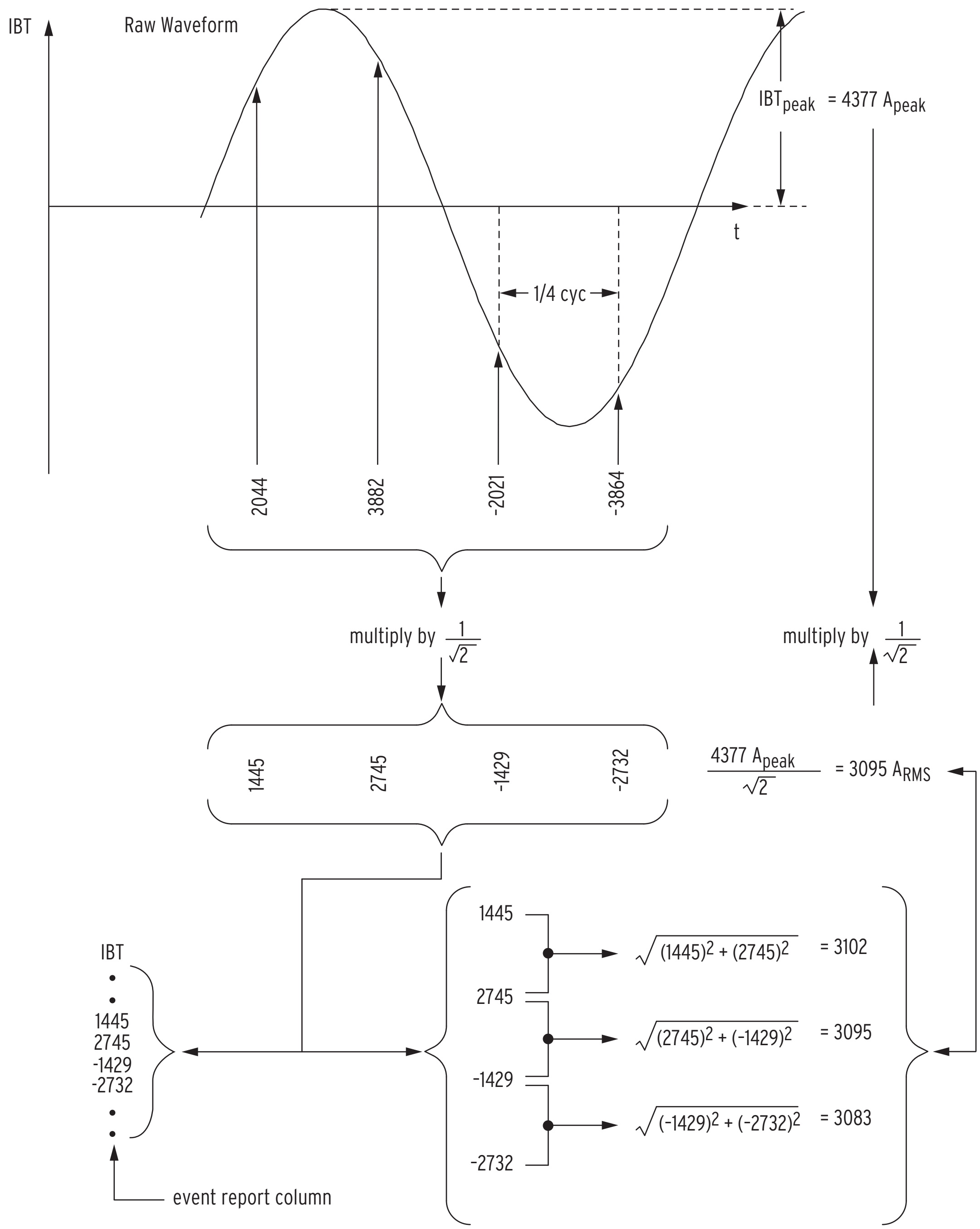

Figure 12.5 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 12.5*, note that any two rows of current data from the event report in *Figure 12.4*, 1/4-cycle apart, can be used to calculate rms current values.

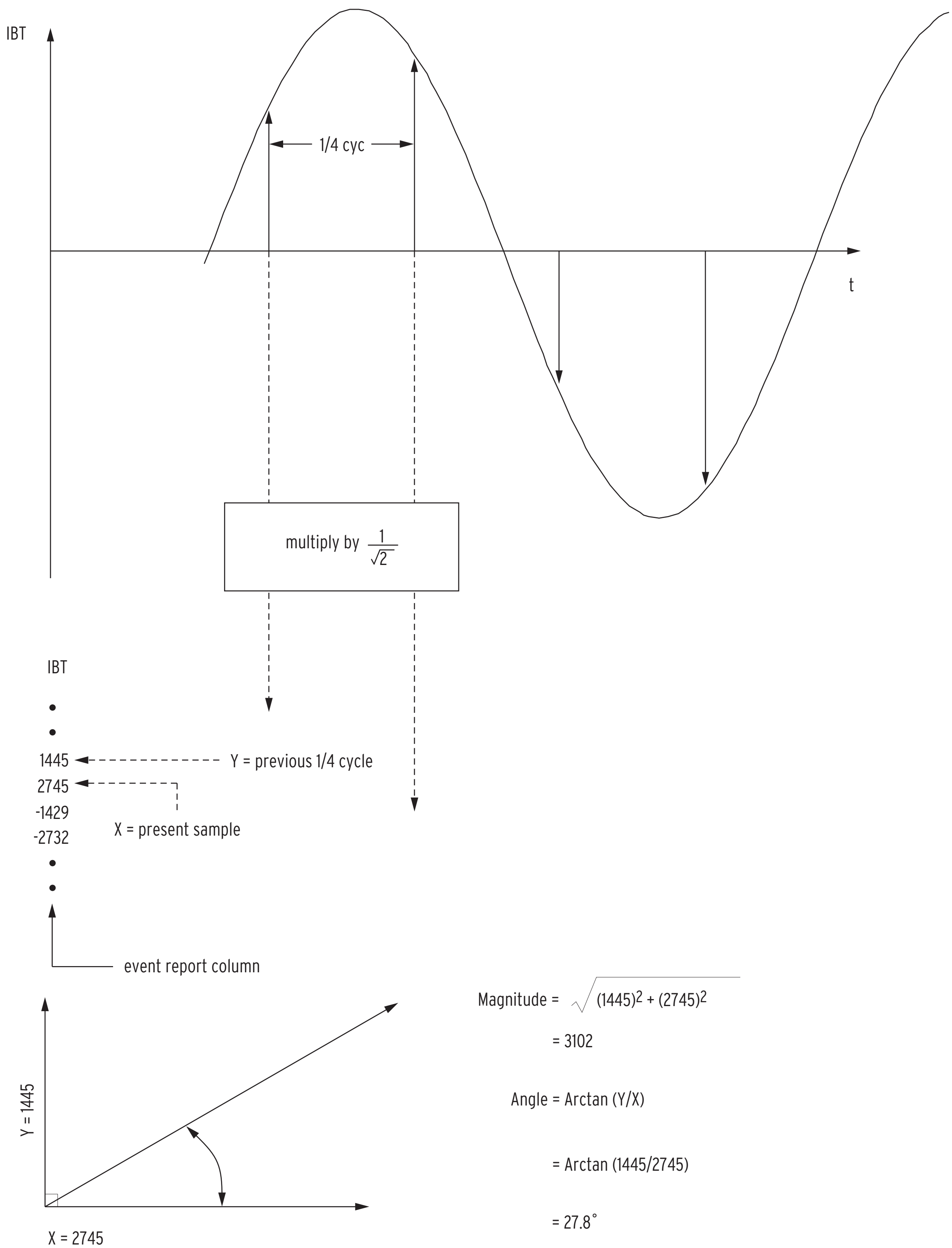

Figure 12.6 Derivation of Phasor RMS Current Values From Event Report Current Values

In *Figure 12.6*, note that two rows of current data from the event report in *Figure 12.4*, 1/4 cycle apart, can be used to calculate phasor rms current values. In *Figure 12.6*, at the present sample, the phasor rms current value is:

IBT = 3102 A ∠ 27.8°

The present sample (IBT = 2745 A) is the real part of the rms current value that relates to the phasor RMS current value:

3102 A • cos(27.8°) = 2745 A

Sequential Events Recorder Report

See *Figure 12.7* for an example Sequential Events Recorder (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 = **87L, 87L2, 87LG, 87LA, 87LB, 87LC**

SER2 = **TRIP, TRIP87, CLOSE, LOP**

SER3 = **M1P, Z1G, M2P, Z2G, M3P, Z3G, 67G2T, 51GT, KEY, Z3RB, PTRX**

The elements are Relay Word bits referenced in *Table 9.6*. The relay monitors each element in the SER lists every 1/4-cycle for backup elements and every 1/16-cycle for differential elements. If an element changes state, the relay time-tags the changes in the SER. For example, setting SER3 contains distance and time-overcurrent element pickups. Thus, any time one of these elements picks up or drops out, the relay time-tags the change in the SER.

The relay adds a message to the SER to indicate when the relay turns on or a settings change (to active setting group) conditions:

`Relay newly powered up` or `Relay settings changed`

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

Making SER Trigger Settings

Enter as many as 24 element names in each of the SER settings via the **SET R** command. See *Table 9.5* and *Table 9.6* for references to valid relay element (Relay Word bit) names. See the **SET R** command in *Table 9.1* and corresponding *Settings Sheets* at the end of *Section 9: Settings*. Use commas 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 SER report for any change of state in any one of the elements listed in the SER1, SER2, or SER3 trigger settings. Nonvolatile memory is used to store the latest 512 rows of the SER 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 (1) state change every three minutes can be made for a 25-year relay service life.**

Retrieving SER Reports

The relay saves the latest 512 rows of the SER in nonvolatile memory. Row 1 is the most recently triggered row, and row 512 is the oldest. View the SER report by date or SER row number as outlined in *Table 12.8*.

Table 12.8 Example SER Serial Port Commands and Results

Example SER Serial Port Commands	Format
SER	If **SER** is entered with no numbers following it, all available rows are displayed (up to row number 512). They display with the oldest row at the beginning (top) of the report and the latest row (row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 17	If **SER** is entered with a single number following it (**17** in this example), the first 17 rows are displayed, if they exist. They display with the oldest row (row 17) at the beginning (top) of the report and the latest row (row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 10 33	If **SER** is entered with two numbers following it (**10** and **33** in this example; 10 < 33), all the rows between (and including) rows 10 and 33 are displayed, if they exist. They display with the oldest row (row 33) at the beginning (top) of the report and the latest row (row 10) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 47 22	If **SER** is entered with two numbers following it (**47** and **22** in this example; 47 > 22), all the rows between (and including) rows 47 and 22 are displayed, if they exist. They display with the newest row (row 22) at the beginning (top) of the report and the oldest row (row 47) at the end (bottom) of the report. Reverse chronological progression through the report is down the page and in ascending row number.
SER 3/30/97	If **SER** is entered with one date following it (date **3/30/97** in this example), all the rows on that date are displayed, if they exist. They display with the oldest row at the beginning (top) of the report and the latest row at the end (bottom) of the report, for the given date. Chronological progression through the report is down the page and in descending row number.
SER 2/17/97 3/23/97	If **SER** is entered with two dates following it (date **2/17/97** chronologically precedes date **3/23/97** in this example), all the rows between (and including) dates 2/17/97 and 3/23/97 are displayed, if they exist. They display with the oldest row (date 2/17/97) at the beginning (top) of the report and the latest row (date 3/23/97) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 3/16/97 1/5/97	If **SER** is entered with two dates following it (date **3/16/97** chronologically follows date **1/5/97** in this example), all the rows between (and including) dates 1/5/97 and 3/16/97 are displayed, if they exist. They display with the latest row (date 3/16/97) at the beginning (top) of the report and the oldest row (date 1/5/97) at the end (bottom) of the report. Reverse chronological progression through the report is down the page and in ascending row number.

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

If the requested SER event report rows do not exist, the relay responds: `No SER Data`.

Clearing SER Report

Clear the SER report from nonvolatile memory with the **SER C** command as shown in the following example:

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

Example SER Report

An example SER report is shown in *Figure 12.7*.

```
=>SER <Enter>

SEL-311L                          Date: 06/15/01    Time: 11:13:43.271
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311L-R100-V0-Z001001-D20010625       CID=396E

#     DATE      TIME          ELEMENT           STATE

18    06/15/01  10:25:24.816  TRIP87            Asserted
17    06/15/01  10:25:24.816  87LC              Asserted
16    06/15/01  10:25:24.816  87L               Asserted
15    06/15/01  10:25:24.819  87LB              Asserted
14    06/15/01  10:25:24.818  M2P               Asserted
13    06/15/01  10:25:24.818  TRIP              Asserted
12    06/15/01  10:25:24.818  KEY               Asserted
11    06/15/01  10:25:24.822  87L2              Asserted
10    06/15/01  10:25:24.823  M1P               Asserted
9     06/15/01  10:25:24.914  M1P               Deasserted
8     06/15/01  10:25:24.918  M2P               Deasserted
7     06/15/01  10:25:24.918  KEY               Deasserted
6     06/15/01  10:25:24.924  87LC              Deasserted
5     06/15/01  10:25:24.925  87LB              Deasserted
4     06/15/01  10:25:24.934  87L2              Deasserted
3     06/15/01  10:25:24.934  87L               Deasserted
2     06/15/01  10:25:24.966  TRIP87            Deasserted
1     06/15/01  10:25:24.969  TRIP              Deasserted

=>
```

Figure 12.7 Example SER Event Report

Give special attention to the time stamps associated with SER 15 and 14. SER 15 has an “older” time stamp than SER 14. This is not an error. The time stamp is accurate and correct. The differential elements are processed 16 times per power system cycle. This means they are also time-stamped and written to the SER buffer every millisecond. However, the backup protection elements are only processed four times per power system cycle. They are then written to the SER buffer at the end of the quarter-cycle processing interval. This is the most accurate way to show the relative time stamps of the elements with a high-speed differential processing interval and a quarter-cycle backup protection-processing interval. Note that this occasional discrepancy between the sequence number order and the relative time stamps will never be greater than 3 ms.

The SER event report rows in *Figure 12.7* are explained in *Table 12.9*, numbered in correspondence to the # column. The circled numbered comments in *Figure 12.3* and *Figure 12.4* also correspond to the # column numbers in *Figure 12.7*.

Table 12.9 Explanation of Row Entries for Figure 12.7

SER Row No.	Explanation
18, 17, 16	Differential element 87LC asserts which calls for a differential trip, TRIP87. Element 87L, which is 87LA + 87LB + 87LC + 87L2 + 87LG, also asserts.
15	B-phase differential element 87LB asserts.
14	The Zone 2 distance element M2P asserts.
13	TRIP asserts.
12	The POTT scheme asserts Relay Word bit KEY, which closes OUT104.
11	Negative-sequence differential element 87L2 asserts.
10	The Zone 1 distance element M1P asserts.
9–3	Protection elements deassert as the breaker opens, and fault is interrupted.
2, 1	TRIP and TRIP87 deassert. At first glance, SER records 1 and 2 do not appear to correspond to the event report (*Figure 12.4*) with OUT101 = TRIP and OUT201 = TRIP + TRIP87. In *Figure 12.4*, OUT201 deasserts 1/2 cycle after OUT101. This is because the dedicated line current differential hardware controls outputs OUT201–OUT206. The 1/2-cycle delay reflects the time necessary for the result of the OUT201 equation to be passed to the line current differential hardware and for the contact status to be passed back to the backup protection processor where the event report is created. Refer to *High-Speed Output Contacts OUT201–OUT206 on page 7.29* for an in-depth explanation of the TRIP and TRIP87 logic.

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Section 13
Testing and Troubleshooting

Overview

This section provides guidelines for determining and establishing test routines for the SEL-311L Relay. Included are discussions on testing philosophies, methods, and tools. Relay self-tests and troubleshooting procedures are shown at the end of the section.

Testing Philosophy

Protective relay testing may be divided into three categories:

- acceptance
- commissioning
- maintenance

The categories are differentiated by when they take place in the life cycle of the relay as well as by the test complexity.

The paragraphs below describe when to perform each type of test, the goals of testing at that time, and the relay functions that you need to test at each point. This information is intended as a guideline for testing SEL relays.

Acceptance Testing

1. When:
    a. When qualifying a relay model to be used on the utility system.
2. Goals:
    a. Ensure that the relay meets published critical performance specifications such as operating speed and element accuracy.
    b. Ensure that the relay meets the requirements of the intended application.
    c. Gain familiarity with relay settings and capabilities.
3. What to test:
    a. All protection elements and logic functions critical to the intended application.

SEL performs detailed acceptance testing on all new relay models and versions. We are certain the relays we ship meet their published specifications. It is important for you to perform acceptance testing on a relay if you are unfamiliar with its operating theory, protection scheme logic, or settings. This helps ensure the accuracy and correctness of the relay settings when you issue them.

Commissioning Testing

1. When:
   a. When installing a new protection system.
2. Goals:
   a. Ensure that all system ac and dc connections are correct.
   b. Ensure that the relay functions as intended using your settings.
   c. Ensure that all auxiliary equipment operates as intended.
3. What to test:
   a. All connected or monitored inputs and outputs, polarity and phase rotation of ac connections, simple check of protection elements.

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

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.

Step 1. Commissioning tests should verify that the relay is properly connected to the power system and all auxiliary equipment.

Step 2. Verify control signal inputs and outputs.

Step 3. Check breaker auxiliary inputs, SCADA control inputs, and monitoring outputs.

Step 4. Use an ac connection check to verify that the relay current and voltage inputs are of the proper magnitude and phase rotation.

Step 5. 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.

Step 6. At commissioning time, use the relay **METER** command to verify the ac current and voltage magnitude and phase rotation.

Step 7. Use the **PULSE** command to verify relay output contact operation.

Step 8. Use the **TARGET** command to verify optoisolated input operation.

Maintenance Testing

1. When:
   a. At regularly scheduled intervals or when there is an indication of a problem with the relay or system.
2. Goals:
   a. Ensure that the relay is measuring ac quantities accurately.
   b. Ensure that scheme logic and protection elements are functioning correctly.
   c. Ensure that auxiliary equipment is functioning correctly.
3. What to test:
   a. Anything not shown to have operated during an actual fault within the past maintenance interval.

SEL relays use extensive self-testing capabilities and feature detailed metering and event reporting functions that lower the utility dependence on routine maintenance testing.

Use the SEL relay reporting functions as maintenance tools.

Step 1. 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.

Step 2. Review relay event reports in detail after each fault.

Step 3. Using the event report current, voltage, and relay element data, you can determine that the relay protection elements are operating properly.

Step 4. Using the event report input and output data, you can determine that the relay is asserting outputs at the correct instants and that auxiliary equipment is operating properly.

At the end of your maintenance interval, the only items that need testing are those that have not operated during the maintenance interval.

The basis of this testing philosophy is simple: If the relay is correctly set and connected, is measuring properly, and no self-test has failed, there is no reason to test it further.

Each time a fault occurs, the protection system is tested. Use event report data to determine areas requiring attention. 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

Use the features listed in *Table 13.1* to assist you during relay testing.

Table 13.1 Features Useful for Relay Testing

Commands	Description
MET and **MET B**	The **MET** command will show local and remote currents (magnitude and phase angle) referenced to the local A-phase current. The vector sum and the vector ratio in the Alpha protection plane will be displayed. Use this information, with load applied to the protected line, to validate the ac current connections at all terminals. The **MET B** command displays the local current and voltage (if applied) magnitude and phase angle, as well as metering data. In addition, the command shows power system frequency and the dc voltage applied to the relay power supply terminals. See *Section 10: Communications* and *Section 11: Front-Panel Operations*.
TST	Use the **TST** command from Access Level 2 to display the protection status of the differential communication channels. Use the **TST X** or **TST Y** commands to place the channel in a loopback or end-to-end test mode. Use this feature to check the integrity and quality of the differential channels.
EVENT	The relay generates a 15-, 30-, or 60-cycle event report in response to faults or disturbances. Each report contains current and voltage information, relay element states, and input/output contact information. If you question the relay response or your test method, use the event report for more information. The **EVENT** (**EVE**) command is available at the serial ports. See *Section 12: Analyzing Events*.
SUM	The relay generates an event summary for each oscillographic event report. Use the **SUM** command to view and acknowledge the event summaries. Use the event summary to quickly verify proper relay operation. Compare the reported fault current and voltage magnitudes and angles against the reported fault location and fault type. If you question the relay response, or your test method, obtain the oscillographic event report for a more detailed analysis. See *Section 12: Analyzing Events* for more information on the event summary.
SER	The relay provides a Sequential Events Recorder (SER) event report that time-tags changes in relay element and input/output contact states. The SER provides a convenient means to verify the pickup/dropout of any element in the relay. The **SER** command is available at the serial ports. See *Section 12: Analyzing Events*.
TARGET	Use the **TARGET** (**TAR**) 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 serial ports and the front panel. See *Section 10: Communications* and *Section 11: Front-Panel Operations*.
PULSE	Use the **PULSE** (**PUL**) command to test the contact output circuits. The **PULSE** command is available at the serial ports and the front panel. See *Section 10: Communications*.

IMPORTANT! In loopback mode the received current is the same as the local current. This condition may be interpreted by the relay as an internal fault, so care should be taken to disable trip outputs.

NOTE: The relay alarm contact will close when the TST command is used.

Low-Level Test Interface

The SEL-311L 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 using secondary injection testing
- ➤ By applying low magnitude ac voltage signals to the low-level test interface

Access the test interface by removing the relay front panel.

Figure 13.1 shows the low-level interface connections. This drawing also appears on the inside of the relay front panel. Remove the ribbon cable between the two modules to access the outputs of the input module and the inputs to the processing module (relay main board).

⚠**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.

You can test the relay processing module by using signals from the SEL-RTS Low-Level Relay Test System. Never apply voltage signals greater than 9 volts peak-peak to the low-level test interface. *Figure 13.1* shows the signal scaling factors.

You can test the input module two different ways:

- ➤ 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.
- ➤ Replace the ribbon cable, press the front-panel **METER** pushbutton, and compare the relay readings to other accurate instruments in the relay input circuits.

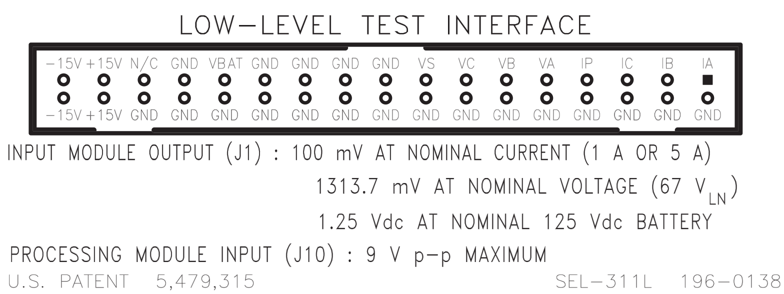

Figure 13.1 Low-Level Test Interface

Test Methods

Test the pickup and dropout of relay elements by using one of three methods:

- ➤ target command indication
- ➤ output contact closure
- ➤ 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-311L, 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 Front-Panel Indicators

Display the state of relay elements, inputs, and outputs by using the front-panel or serial port **TAR** commands. Use this method to verify the pickup settings of protection elements.

Access the front-panel **TAR** command from the front-panel **OTHER** pushbutton menu.

Step 1. To display the state of the 51PT element on the front-panel display, press the **OTHER** pushbutton.

Step 2. Cursor to the TAR option, and press **SELECT**.

Step 3. 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 B. See *Table 9.6* for the correspondence between the Relay Word elements and the **TAR** command.

Step 4. To view the 51PT element status from the serial 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 Operations* for further details on displaying element status via the **TAR** commands.

Testing Via Output Contacts

You can set the relay to operate an output contact for testing a single element.

Use the **SET L** command (SELOGIC control equations) to set an output contact (e.g., **OUT101–OUT206** for Model 0311L00x) to the element under test.

The available elements are the Relay Word bits referenced in *Table 9.6*.

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 SELOGIC setting:

OUT104 = **51PT**

Time-overcurrent curve and time-dial information can be found in *Section 9: Settings*. Do not forget to reenter the correct relay settings when you are finished testing and are 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–SER3). See *Section 12: Analyzing Events*.

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.

Testing Alpha Plane 87L Elements

Introduction

Test Alpha Plane 87L elements for operation speed and security, and for element accuracy. To test for operation speed and security, optionally apply pre-fault load current, then switch to an internal or external fault. Because the SEL-311L often trips in less than one cycle, transient effects in the fault currents do impact operation speed. In some instances, it may be necessary to test by using Comtrade files from an EMTP simulation or a real-time simulator. The operate speeds depicted in *Figure 3.6* and *Figure 3.7* are from fault inception to closure of high-speed output contacts **OUT201–OUT206** by using setting EHST. The tests used symmetrical fault currents only, so they can be easily reproduced.

SEL-5601-2 SYNCHROWAVE Event Software produces alpha plane plots from SEL-311L compressed event reports. The alpha plane plot gives a quick visual indication that is especially useful for evaluating 87L element security.

To test element accuracy, test the operate elements 87LOPA, 87LOPB, 87LOPC, 87LOP2, and 87LOPG, and also test the alpha plane restraint elements R87LA, R87LB, R87LC, R87L2, and R87LG. The relay trips when the restraint element deasserts to indicate that the alpha plane ratio falls outside the restraint region, and the operate element asserts to indicate that the differential current is above the differential current pickup setting.

This section details a test procedure suitable for testing the accuracy of the 87L elements in the SEL-311L.

The test procedure outlined below assumes the following factory-default settings:

E87L = **2** Two-terminal protection

87LPP = **6** 6 A secondary phase line current differential pickup setting

87L2P = **0.5** 0.5 A secondary negative-sequence line current differential pickup setting

87LANG = **195** Restraint region subtends 195 degrees

87LR = **6** Restraint region outside radius is six; inside radius is 1/6

The test procedure alters those settings for the operate element tests to isolate the element under test. The test procedure also disables the disturbance detector (EDD = N) to allow the use of slowly changing currents.

SEL-311L 87L Element Test Procedure

1. Purpose:
    a. Test the accuracy of phase and negative-sequence 87L elements.
    b. Test the ground 87L element with an identical procedure.
2. Test Outline:
    a. Test the phase 87L element accuracy for A-phase. (B- and C-phase optional)
    b. Then test the negative-sequence 87L element accuracy. (Detailed test procedure follows.)

Test Phase 87L Element Accuracy

Test the phase operate element 87LOPA.

Step 1. To test the operate element, apply a low-current internal three-phase fault.

Step 2. Increase the difference current until the relay trips.

Test the phase restraint element R87LA.

Step 1. To test the restraint element, apply currents at the local relay, with zero current applied to the remote relay.

This simulates a weak-infeed internal fault, deasserts restraint element R87LA, and causes both relays to trip.

Step 2. Increase the magnitude of the currents at the remote relay until the restraint bit R87LA asserts.

Step 3. Continue to increase the magnitude of the remote currents until restraint bit R87LA deasserts.

Step 4. Repeat with various phase angles applied between local and remote currents.

Step 5. Finally, apply an internal fault with equal current at each relay.

Step 6. Change the angle of the current on the remote relay until restraint element R87LA in the local relay solidly asserts.

This approach is graphically depicted in *Figure 13.2*.

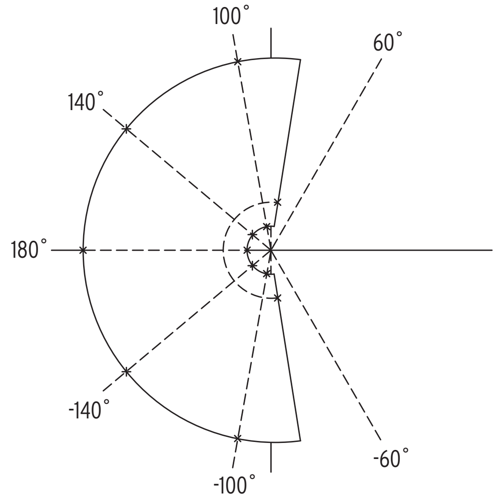

Figure 13.2 Alpha Plane Element Accuracy Test Points

Phase operate elements 87LOPB and 87LOPC, and phase restraint elements 87LRB and 87LRC are identical to the A-phase elements, and are not tested here. They may be tested with an identical procedure.

Test Negative-Sequence 87L Element Accuracy

Test the negative-sequence operate element 87LOP2.

Step 1. To test the negative-sequence operate element, apply a low-grade internal three-phase fault.

Step 2. Then increase one phase current (creating negative-sequence current at one end) until the relay trips.

Step 3. Keep the test current magnitudes less than three times nominal current to avoid having the CT saturation detection logic block the 87L2 element.

Test the negative-sequence restraint element R87L2.

Step 1. To test the restraint element, apply a single-phase current to the local relay.

This simulates a weak-infeed internal fault, deasserts the restraint element R87L2, and causes both relays to trip.

Step 2. Then increase the remote current until the R87L2 asserts in the local relay.

Step 3. Continue to increase the remote current until R87L2 deasserts.

Step 4. Finally, apply an internal ground fault with equal current at each relay.

Step 5. Change the angle of the current on the remote relay until restraint element R87L2 solidly asserts.

This approach is graphically depicted in *Figure 13.2*.

Ground operate element 87LOPG and ground restraint element R87L2 are not tested here. They may be tested with an identical procedure.

Required Equipment

- ➤ Two SEL-311L Relays with established 87L communications interface
- ➤ Three-phase secondary injection test equipment, or low-level test equipment such as the SEL-AMS Adaptive Multichannel Source
- ➤ PC with terminal emulation software
- ➤ An SEL-C234A cable

Test Setup

Step 1. Ensure the relay is set appropriately.

Step 2. Connect three-phase secondary injection current sources or low-level test sources to the relays.

Step 3. Connect the PC to the relays with an SEL-C234A cable.

Step 4. Establish communications.

Test Procedure

The following procedure assumes Inom = 5 A. If Inom = 1 A, adjust the applied currents and pickup settings accordingly.

Phase 87L Element Tests

Step 1. Make settings 87L2P = OFF, 87LGP = OFF, 87LPP = 6.0.

Step 2. Apply the following currents:

Local Relay: IA = 2.5 A < 0 degrees
IB = 2.5 A < –120 degrees
IC = 2.5 A < 120 degrees

Remote Relay: IA = 2.5 A < 0 degrees
IB = 2.5 A < –120 degrees
IC = 2.5 A < 120 degrees

Step 3. Increase IA in the remote relay at 0 degrees until the relay trips.

Step 4. Record the remote A-phase current that causes the relay to trip.

Step 5. Ensure that the current is within the range indicated.

3.4 A < __________ < 3.6 A

Step 6. Return A-phase current to 2.5 A.

Step 7. Repeat with the B- and C-phase currents if desired.

Expect similar results.

Step 8. Apply the following currents:

Local Relay: IA = 2.33 A ∠0 degrees
Remote Relay: IA = 0 A ∠180 degrees

Step 9. In the local relay, use the **TAR R87LA 10000** command to display the R87LA Relay Word bit 10,000 times, or use the front-panel **TAR** command to display Relay Word row 57.

Step 10. Ensure bit R87LA is deasserted.

Step 11. Increase the remote A-phase current at 180 degrees until the R87LA bit solidly asserts.

Step 12. Record the remote A-phase current required to solidly assert R87LA in *Table 13.2*.

Step 13. Ensure that the current is within the expected range indicated.

Table 13.2 Phase Restraint Element Pickup Test Results (Inner Radius)

Remote Current Angle	Remote Current at Which R87LA Asserts		
	Min.	Actual	Max.
180	0.377		0.400
140	0.377		0.400
100	0.377		0.400
60	No assertion		No assertion
0	No assertion		No assertion
–60	No assertion		No assertion
–100	0.377		0.400
–140	0.377		0.400

Step 14. Apply the following currents:

Local Relay: IA = 2.33 A ∠0 degrees
Remote Relay: IA = 13 A ∠180 degrees[a]

[a] The SEL-311L is rated to withstand 3 • Inom indefinitely.

Step 15. In the local relay, use the **TAR R87LA 10000** command to display the R87LA Relay Word bit 10,000 times, or use the front-panel **TAR** command to display Relay Word row 57.

Step 16. Ensure bit R87LA is asserted.

Step 17. Increase the remote A-phase current at 180 degrees until the R87LA bit is no longer solidly asserted (until it begins to deassert).

Step 18. Record the remote A-phase current required to begin to deassert R87LA in *Table 13.3*.

Step 19. Ensure that the current is within the expected range indicated in the table.

Step 20. Repeat *Step 8* through *Step 19* for each remote current angle shown in *Table 13.2* and *Table 13.3*.

Table 13.3 Phase Restraint Element Dropout Test Results (Outer Radius)

Remote Current Angle	Remote Current at Which R87LA Deasserts		
	Min.	Actual	Max.
180	13.58		14.42
140	13.58		14.42
100	13.58		14.42
–100	13.58		14.42
–140	13.58		14.42

Step 21. Apply the following currents:

Local Relay: IA = 5 A $\angle$0 degrees
Remote Relay: IA = 5 A $\angle$0 degrees

Step 22. In the local relay, use the **TAR R87LA 10000** command to display the R87LA Relay Word bit 10,000 times, or use the front-panel **TAR** command to display Relay Word row 57.

Step 23. Ensure bit R87LA is deasserted.

Step 24. Increase the angle of the remote IA from zero until Relay Word bit R87LA is solidly asserted.

Step 25. Record the angle of IA required to solidly assert R87LA.

Step 26. Ensure that the angle is within the range expected:

80 degrees < _________ < 85 degrees

Step 27. Decrease the angle of the remote IA from zero (more negative) until Relay Word bit R87LA is solidly asserted.

Step 28. Record the angle of IA required to solidly assert R87LA.

Step 29. Ensure that the angle is within the range expected:

–85 degrees < _________ < –80 degrees

Negative-Sequence 87L Element Tests

Step 1. Make settings 87L2P = 0.5, 87LGP = OFF, 87LPP = OFF.

Step 2. Apply the following currents:

Local Relay: IA = 0.75 A < 0 degrees
IB = 0.75 A < –120 degrees
IC = 0.75 A < 120 degrees
Remote Relay: IA = 0.75 A < 0 degrees
IB = 0.75 A < –120 degrees
IC = 0.75 A < 120 degrees

Step 3. Increase IA in the remote relay at 0 degrees until the relay trips.

Step 4. Record the remote A-phase current that causes the relay to trip.

Step 5. Ensure that the current is within the range indicated.

1.19 A < __________ < 1.31 A

Step 6. Return the remote relay A-phase current to 0.75 A.

Step 7. Repeat with the B- and C-phase currents if desired.

Expect similar results.

Step 8. Apply the following currents:

Local Relay: IA = 2.33 A $\angle$0 degrees
Remote Relay: IA = 0 A $\angle$180 degrees

Step 9. In the local relay, use the **TAR R87L2 10000** command to display the R87L2 Relay Word bit 10,000 times, or use the front-panel **TAR** command to display Relay Word row 57.

Step 10. Ensure bit R87L2 is deasserted.

Step 11. Increase the remote A-phase current at 180 degrees until the R87L2 bit solidly asserts.

Step 12. Record the remote A-phase current required to solidly assert R87L2 in *Table 13.4*.

Step 13. Ensure that the current is within the expected range indicated.

Table 13.4 Negative-Sequence Restraint Element Pickup Test Results (Inner Radius)

Remote Current Angle	Remote Current at Which R87L2 Asserts		
	Min.	Actual	Max.
180	0.377		0.400
140	0.377		0.400
100	0.377		0.400
60	No assertion		No assertion
0	No assertion		No assertion
–60	No assertion		No assertion
–100	0.377		0.400
–140	0.377		0.400

Step 14. Apply the following currents:

Local Relay: IA = 2.33 A ∠0 degrees

Remote Relay: IA = 13 A ∠180 degrees[a]

[a] The SEL-311L is rated to withstand 3 • Inom indefinitely.

Step 15. In the local relay, use the **TAR R87L2 10000** command to display the R87L2 Relay Word bit 10,000 times, or use the front-panel **TAR** command to display Relay Word row 57.

Step 16. Ensure bit R87L2 is asserted.

Step 17. Increase the remote A-phase current at 180 degrees until the R87L2 bit is no longer solidly asserted (until it begins to deassert).

Step 18. Record the remote A-phase current required to begin to deassert R87L2 in *Table 13.5*.

Step 19. Ensure that the current is within the expected range indicated.

Step 20. Repeat *Step 8* through *Step 19* for each remote current angle shown in *Table 13.4* and *Table 13.5*.

Table 13.5 Negative-Sequence Restraint Element Dropout Test Results (Outer Radius)

Remote Current Angle	Remote Current at Which R87L2 Deasserts		
	Min.	Actual	Max.
180	13.58		14.42
140	13.58		14.42
100	13.58		14.42
–100	13.58		14.42
–140	13.58		14.42

Step 21. Apply the following currents:

Local Relay: IA = 5 A ∠0 degrees

Remote Relay: IA = 5 A ∠0 degrees

Step 22. In the local relay, use the **TAR R87L2 10000** command to display the R87L2 Relay Word bit 10,000 times, or use the front-panel **TAR** command to display Relay Word row 57.

Step 23. Ensure bit R87L2 is deasserted.

Step 24. Increase the angle on the remote IA from zero until Relay Word bit R87L2 is solidly asserted.

Step 25. Record the angle of IA required to solidly assert R87L2.

Step 26. Ensure that the angle is within the range expected:

80 degrees < _________ < 85 degrees

Step 27. Decrease the angle on the remote IA from zero (more negative) until Relay Word bit R87L2 is solidly asserted.

Step 28. Record the angle of IA required to solidly assert R87LA.

Step 29. Ensure that the angle is within the range expected:

–85 degrees < _________ < –80 degrees

Relay Self-Tests

The relay runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see *Table 13.6*):

- Protection Disabled: The relay disables overcurrent elements and trip/close logic. All output contacts are de-energized. The EN front-panel LED is extinguished.
- ALARM Output: The ALARM output contact signals an alarm condition by going to its de-energized state.
  - If the ALARM output contact is a B contact (normally closed), it closes for an alarm condition or if the relay is de-energized.
  - If the ALARM output contact is an A contact (normally open), it opens for an alarm condition or if the relay is de-energized.

  Alarm condition signaling can be a single 5-second pulse (Pulsed) or permanent (Latched).
- Line Current Differential Protection Disabled: The relay disables 87L protection and de-energizes outputs OUT201–OUT206. Relay Word bit 87LPE deasserts and Relay Word bit 87HWAL asserts.
- The relay generates automatic STATUS reports at the serial port for warnings and failures.
- The relay displays failure messages on the relay LCD display for failures.
- For certain failures, the relay automatically restarts as many as three times within 24 hours. A “diagnostic restart” entry is recorded in the Sequential Events Recorder (SER), but the

automatic restart may occur before Relay Word bits ALARM and 87HWAL are recorded in the SER and before front-panel failure messages are displayed.

- When an Ethernet communications card is not installed, all communications card self-check statuses indicate N/A, except BOARD, which indicates ABSENT.

Use the serial port **STATUS** command or front-panel **STATUS** pushbutton to view relay self-test status.

Table 13.6 Relay Self-Tests (Sheet 1 of 2)

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
IA, IB, IC, IP, VA, VB, VC, VS Offset	Warning	30 mV	No	Pulsed	Measures the dc offset at each of the input channels every 10 seconds.
Master Offset	Warning	20 mV	No	Pulsed	Measures the dc offset at the A/D every 10 seconds.
	Failure	30 mV	Yes	Latched	
+5 V PS	Warning	+4.80 V +5.20 V	No	Pulsed	Measures the +5 V power supply every 10 seconds.
	Failure	+4.65 V +5.40 V	Yes	Latched	
+5 V REG	Warning	+4.75 V +5.20 V –4.75 V –5.25 V	No	Pulsed	Measures the regulated 5 V power supply every 10 seconds.
	Failure	+4.50 V +5.40 V –4.50 V –5.50 V	Yes	Latched	
+12 V PS	Warning	+11.50 V +12.50 V	No	Pulsed	Measures the 12 V power supply every 10 seconds.
	Failure	+11.20 V +14.00 V	Yes	Latched	
+15 V PS	Warning	+14.40 V +15.60 V	No	Pulsed	Measures the 15 V power supply every 10 seconds.
	Failure	+14.00 V +16.00 V	Yes	Latched	
TEMP	Warning	–40° C +85° C	No		Measures the temperature at the A/D voltage reference every 10 seconds.
RAM	Failure		Yes	Latched	Performs a read/write test on system RAM every 60 seconds.
ROM	Failure	checksum	Yes	Latched	Performs a checksum test on the relay program memory every 10 seconds.
A/D	Failure		Yes	Latched	Validates proper number of conversions each 1/4 cycle.
CR_RAM	Failure	checksum	Yes	Latched	Performs a checksum test on the active copy of the relay settings every 10 seconds.
EEPROM	Failure	checksum	Yes	Latched	Performs a checksum test on the nonvolatile copy of the relay settings every 10 seconds.
I/O BRD	Failure		No	Pulsed	Verifies correct I/O board is installed. Identifies when a board is changed or disconnected.

Table 13.6 Relay Self-Tests (Sheet 2 of 2)

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
87L RAM	Failure		87L only disabled	87HWAL asserted; ALARM pulsed	Periodically performs a read/write test at each RAM location.
87L ROM	Failure	checksum	87L only disabled	87HWAL asserted; ALARM pulsed	Performs a checksum test on program storage ROM.
CHAN X CHAN Y	Failure		Determined by 87LPE	None	See *87L Monitoring on page 10.7*.
FPGA	Failure		87L only disabled	87HWAL asserted; ALARM pulsed	Ensures FPGA configures properly.
BOARD	Failure		87L only disabled	87HWAL asserted; ALARM pulsed	Checks each processing interval to ensure dedicated 87L hardware responds and the watchdog timer has not expired.
CC RAM	Failure		No	Pulsed	Periodically performs a read/write test at each RAM location.
CC ROM	Failure		No	Pulsed	Periodically performs a program comparison with RAM.
PORT 5	Link No Link				Link established on Ethernet port. No link established on Ethernet port.
PORT 6	Link No Link				Link established on Ethernet port. No link established on Ethernet port.
FPGA	Failure		No	Pulsed	Ensures FPGA configured properly.
BOARD	Failure		No	Pulsed	Checks to ensure Ethernet port hardware responds and watchdog timer has not expired.
DPRAM	Failure		No	Pulsed	Ensures dual port RAM configures properly.
PS	Failure		No	Pulsed	Continually measures the input voltage supplied from the relay.
The following self-tests are performed by dedicated circuitry in the microprocessor and the SEL-311L main board. Failures in these tests shut down the microprocessor and are not shown in the STATUS report.					
Microprocessor Crystal	Failure		Yes	Latched	The relay monitors the microprocessor crystal. If the crystal fails, the relay displays `CLOCK STOPPED` on the LCD display. The test runs continuously.
Microprocessor	Failure		Yes	Latched	The microprocessor examines each program instruction, memory access, and interrupt. The relay displays `VECTOR nn` on the LCD upon detection of an invalid instruction, memory access, or spurious interrupt. The test runs continuously.

Relay Troubleshooting

Inspection Procedure

Complete the following procedure before disturbing the relay. After you finish the inspection, proceed to the *Troubleshooting Procedure*.

Step 1. Measure and record the power supply voltage at the power input terminals.

Step 2. Check to see that the power is on.

Step 3. Do not turn the relay off.

Step 4. Measure and record the voltage at all control inputs.

Step 5. Measure and record the state of all output relays.

Troubleshooting Procedure

All Front-Panel LEDs Dark

1. Input power not present or 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.

Step 1. Remove the relay front panel by removing the six front-panel screws.

Step 2. Press any front-panel button.

The relay should turn on the LCD backlighting.

Step 3. Locate the contrast adjust potentiometer adjacent to the serial port connector.

Step 4. Use a small screwdriver to adjust the potentiometer.

Step 5. Replace the relay front panel.

Relay Does Not Respond to Commands From Device Connected to Serial Port

Step 1. Ensure that the communications device is connected to the relay.

Step 2. Verify relay or communications device baud rate setting and other communications parameters.

Step 3. Check for a cabling error.

Relay serial port may have received an XOFF, halting communications.

Step 4. Type **<Ctrl + Q>** to send relay an XON and restart communications.

Relay may be set to LMD protocol, which requires an address to turn on the serial port.

Step 5. View the port setting by using the front-panel **SET** buttons to see if the port is set to LMD and to see the address.

Relay Does Not Respond to Commands From Device Connected to Ethernet Port

Step 1. Ensure that the communications device is connected to the Ethernet port.

Step 2. Verify relay or communications device parameters, such as IP address, port, etc.

Step 3. Check for a cabling error.

Step 4. If the system is processing an event record, wait several seconds.

Step 5. For a possible Ethernet card failure, issue the **STA** command from a serial port or check front-panel status to verify that the Ethernet card is functional.

Relay Does Not Respond to Faults

Step 1. Verify that the **87CH FAIL** front-panel LED is extinguished.

Step 2. Verify that the relay is properly set.

Step 3. Verify that the test source is properly set.

Step 4. Verify that the test connections are correct by using the **MET** command.

Step 5. Ensure that the analog input cable between transformer secondary and main board is not loose or defective.

Step 6. Inspect the relay self-test status with the **STA** command or with the front-panel **STATUS** pushbutton.

87CH FAIL LED Is Illuminated

The **87CH FAIL** LED illuminates when the relay detects a problem with any enabled 87L communications channel. The following steps isolate the problem to one channel, to either the transmit or receive direction on that channel, and then further isolate the problem if possible based on the channel interface type. The **87CH FAIL** LED can take as long as 15 seconds to extinguish after the problem is resolved.

Step 1. Determine which channel has a problem, and verify channel configuration.

a. If the relay is equipped with two channel interfaces, determine if both channel interfaces are being used.

b. If only one channel interface is in use, but the relay is equipped with two channel interfaces, ensure setting PCHAN selects the intended channel.

c. Inspect Relay Word Bits CHXAL and CHYAL with the front-panel **TAR** command, or with the serial port **TAR CHXAL** or **TAR CHYAL** commands. CHXAL asserts when the relay detects a problem on Channel X. CHYAL asserts when the relay detects a problem on Channel Y.

d. Inspect the channel settings by using **SHO X** or **SHO Y** commands, and verify the settings are as intended.

This is very important. If more than one setting is in error, or if there is a setting error combined with some other problem, it can be very difficult to diagnose problems with the troubleshooting steps outlined below.

Step 2. Determine if there is a channel delay problem.

a. Inspect Relay Word bit DBADX or DBADY.

DBADX asserts if half the round trip channel delay on Channel X exceeds the DBADXP setting. DBADY asserts if half the round trip channel delay on Channel Y exceeds the DBADYP setting.

b. Either increase setting DBADXP or DBADYP to exceed the delay reported by the **COM X** or **COM Y** commands, or rectify the excessive channel delay.

Step 3. Determine if there is a transmit or receive problem.

a. Inspect Relay Word bits AVAX and RBADX for Channel X, or AVAY and RBADY for Channel Y.

If either bit is asserted then that channel has a problem in the receive direction. If neither bit is asserted, go to *Step s*.

If the RX LED is illuminated, the local relay is receiving valid packets from the remote relay. If the RX LED is not illuminated, go to *Step j*.

b. Verify that the associated address settings are correct in remote and local relays. (RA_X, TA_X using the **SET X** command, or RA_Y and TA_Y using the **SET Y** command.)

The Last Error field in the report generated by the **COMM X** or **COMM Y** commands indicates Address Error if the address settings in both relays are not correct.

c. If the address settings are correct (as verified by the **COMM X** or **COMM Y** commands), issue the **COMM X C** or **COMM Y C** commands.

d. Wait a few minutes and issue the **COMM X** or **COMM Y** command again.

If the report logs new errors, then the communications link is probably unreliable or noisy. However, this may also be caused by incorrect timer source or clock polarity settings in the relay.

e. For EIA-422 interfaces, ensure clock polarity settings TC422X, RC422X, TC422Y, or RC422Y are correct for the connected DCE.

f. For other interfaces, ensure settings TIMRX or TIMRY are correct.

g. If channel X is connected to a multiplexer, or to any DCE, verify that setting TIMRX = E.

h. If channel X is connected directly to another relay, ensure TIMRX = E in one relay, and TIMRX = I in the other relay.

i. Likewise, ensure setting TIMRY is correct for channel Y.

   If the problem persists, the communications link is probably noisy or unreliable.

j. If the **RX** LED is extinguished, the local relay is not receiving valid packets from the remote relay.

k. Verify setting E87L is not OFF.

l. If E87L is 2 or 3R, and the relay is equipped with two channel interfaces, verify that PCHAN selects the appropriate primary channel.

m. If E87L is 2 and the relay is equipped with two channel interfaces, verify hot-standby enable setting EHSC = Y if appropriate.

n. For either EIA-422 or G.703 interfaces, verify that the relay-to-multiplexer cable is fully seated at both the relay and the multiplexer, and that it has the proper pinout.

o. For an EIA-422 interface, verify that the RX clock is connected in the communications cable.

   Loss of the RX clock extinguishes the **RX** LED for an EIA-422 interface. See *Figure 2.13* and *Figure 2.12* for connector pinouts.

p. For fiber interfaces, swap the transmit and receive fibers at the rear panel of the relay.

q. If this does not rectify the problem, verify with an optical power meter that received power is more than –58 dBm for a 1300 nm direct fiber interface and more than –32 dBm for an IEEE C37.94-compatible interface.

r. For all interface types, verify that the remote relay channel settings are correct and that the rear-panel **TX** LED is illuminated on the remote relay.

   If the remote relay **TX** LED is illuminated and the local relay **RX** LED is extinguished, the transmit data that leave the remote relay do not arrive at the local relay.

s. If AVAX, RBADX, and DBADX are all deasserted, then there is a receive problem in the remote relay. Repeat *Step 3.* for the remote relay.

Step 4. If the problem persists, contact the factory for assistance.

Relay Calibration

The SEL-311L is factory calibrated. If you suspect that the relay is out of calibration, please contact the factory.

Technical Support

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

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Phone: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

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Section 14

Application Settings for SEL-311L Relays

Overview

Application Settings in the SEL-311L Relay reduce the number of settings for users who do not require all of the relay features. Some functions are disabled and their settings hidden, while others are reduced in scope and complexity (e.g., one overcurrent element rather than four).

This section describes four SEL-311L applications:

- 87L–Differential Protection With Overcurrent Backup
- 87L21–Differential Protection With Step-Distance Backup
- 87L21P–Differential Protection With Piloted Step-Distance Backup
- 87LSP–Single-Pole Differential Protection With Three-Pole Backup

NOTE: Single-pole differential protection with three-pole backup is available only for SEL-311L-7 relay.

Following the descriptions of all four applications are the application settings sheets:

- *SEL-311L Settings Sheets (APP = 87L)*
- *SEL-311L Settings Sheets (APP = 87L21)*
- *SEL-311L Settings Sheets (APP = 87L21P)*
- *SEL-311L Settings Sheets (APP = 87LSP)*

87L—Differential Protection With Overcurrent Backup

Set APP = 87L in the SEL-311L to configure the relay for differential protection with two backup phase-overcurrent and two ground-overcurrent elements (50P1T/51PT/50G1T/51GT). These elements operate only if differential protection is disabled by a communications channel failure. No potentials are required by the relay in this application.

When APP = 87L, the SEL-311L:

1. Configures itself as a full-function differential relay. All differential and tapped load settings are available.
2. Enables two phase-overcurrent and two ground-overcurrent elements:
   a. 50P-instantaneous/definite-time phase-overcurrent element (E50P = 1)
   b. 50G-instantaneous/definite-time ground-overcurrent element (E50G = 1)
   c. 51P-inverse-time phase-overcurrent element (E51P = Y)
   d. 51G-inverse-time ground-overcurrent element (E51G = Y)
3. Hides settings for:
   a. Polarizing (IPOL) CT Ratio (CTRP)
   b. Phase (VA, VB, VC) PT Ratio (PTR)
   c. Synchronism Voltage (VS) PT Ratio (PTRS)
   d. Positive-Sequence Line Impedance Magnitude (Z1MAG)
   e. Positive-Sequence Line Impedance Angle (Z1ANG)
   f. Zero-Sequence Line Impedance Magnitude (Z0MAG)
   g. Zero-Sequence Line Impedance Angle (Z0ANG)
   h. Line Length (LL)
   i. Directional control (E32 = AUTO)
   j. SELOGIC variables (ESV = 1)
   k. SELOGIC Display points (EDP = 3)
   l. Demand metering (EDEM = THM)
4. Disables and hides settings for:
   a. Mho phase distance elements (E21P = N)
   b. Mho ground distance elements (E21MG = N)
   c. Quadrilateral ground distance elements (E21XG = N)
   d. 50Q-instantaneous/definite-time negative-sequence overcurrent elements (E50Q = N)
   e. 51Q-inverse-time negative-sequence overcurrent elements (E51Q = N)
   f. Out-of-step elements (EOOS = N)

g. Load-encroachment elements (ELOAD = N)
h. Switch-onto-fault (ESOTF = N)
i. Voltage elements (EVOLT = N)
j. Synchronism-check elements (E25 = N)
k. Frequency elements (E81 = N)
l. Fault locator (EFLOC = N)
m. Loss-of-potential (ELOP = N)
n. Communications-assisted trip schemes (ECOMM = N)
o. Reclosing (E79 = N)
p. CCVT transient protection (ECCVT = N)
q. SELOGIC Latch bits (ELAT = N)
r. Advanced settings (EADVS = N)
s. Ground directional element priority (ORDER = OFF)

5. Changes default SELOGIC control equations to:
    a. TR = 67P1T + 67G1T + 51PT + 51GT + OC
    b. 67P1TC = !87LPE + 87HWAL
    c. 67G1TC = !87LPE + 87HWAL
    d. 51PTC = !87LPE + 87HWAL
    e. 51GTC = !87LPE + 87HWAL
    f. T51QTC = 87L
    g. T50PTC = 87L
    h. T50GTC = 87L
    i. T50QTC = 87L
    j. ER = /B87L2 + /50P1 + /50G1 + /51P + /51G

NOTE: T51QTC, T50PTC, T50GTC, and T50QTC settings are visible when T50 and T51 functions are enabled.

6. Makes no changes to:
    a. Global settings
    b. Port settings
    c. Text settings
    d. SER settings
    e. Differential Channel X settings
    f. Differential Channel Y settings

If additional capability is needed, the relay can be returned to the setting APP = 311L to make all of the SEL-311L settings visible. It is important to remember that changing from APP = 311L to APP = 87L changes settings in the SEL-311L. Changing from APP = 87L to APP = 311L makes more SEL-311L settings visible but does not change any other settings. If SEL-311L functions are used after setting APP is changed from 87L to 311L, do not change setting APP back to 87L.

Application Settings

From Access Level 2, set the SEL-311L application setting to “87L” as shown below.

```
=>>SET APP TERSE <Enter>

Identifier and Configuration Settings:
Application (87L,87L21,87L21P,311L)            APP   = 311L      ? 87L <Enter>

Line Current Differential Configuration Settings:

Number of 87L Terminals (2,3,3R,N)             E87L  = 2         ?  END <Enter>
Save Changes(Y/N)? Y <Enter>
Settings saved
=>>
```

The following settings are available when APP = 87L. See the appropriate instruction manual section for settings description and explanation.

```
==>SHO <Enter>
Group 1

Group Settings:
RID   =SEL-311L                       TID   =EXAMPLE: BUS B, BREAKER 3
CTR   = 200      APP   = 87L
E87L  = 2        EHST  = 2        EHSDTT= N
EDD   = Y        ETAP  = N        EOCTL = N
PCHAN = X        EHSC  = Y        CTR_X = 200      CTR_Y = 200
87LPP = 6.00     87L2P = 0.50     87LGP = OFF      CTALRM= 0.50
87LR  = 6.0      87LANG= 195
50P1P = OFF
67P1D = 0.00
50G1P = OFF
67G1D = 0.00
51PP  = OFF      51PC  = U3       51PTD = 2.00     51PRS = N
51GP  = OFF      51GC  = U3       51GTD = 2.00     51GRS = Y
SV1PU = 0.50     SV1DO = 0.00
==>
```

```
=>>SHO L <Enter>
SELogic Group 1

SELogic Control Equations:
TR    =M1P + Z1G + M2PT + Z2GT + 67G1T + 51GT + OC
TRSOTF=M2P + Z2G + 50P1
DTT   =0
ULTR  =!(50L + 51G)
52A   =IN101
CL    =CC
ULCL  =TRIP + TRIP87
67P1TC=1
67G1TC=1
51GTC =32GF
OUT101=TRIP
OUT102=TRIP
OUT103=CLOSE
OUT104=0
OUT105=0
OUT106=0
OUT107=87HWAL

Press RETURN to continue

OUT201=TRIP + TRIP87
OUT202=TRIP + TRIP87
OUT203=0
OUT204=0
OUT205=0
OUT206=0
OUT301=0
OUT302=0
OUT303=0
OUT304=0
OUT305=0
OUT306=0
OUT307=0
OUT308=0
OUT309=0
OUT310=0
OUT311=0
OUT312=0
DP1   =52A
DP2   =CHXAL
DP3   =CHYAL
SS1   =0
SS2   =0
SS3   =0
SS4   =0
SS5   =0
SS6   =0
ER    =/B87L2 + /M2P + /Z2G + /51G + /50P1 + /LOP
FAULT =87L + M2P + Z2G + 51G
ESTUB =0
T1X   =0

Press RETURN to continue

T2X   =0
T3X   =0
T4X   =0
T1Y   =0
T2Y   =0
T3Y   =0
T4Y   =0
=>>
```

87L21—Differential Protection With Step-Distance Backup

Set APP = 87L21 in the SEL-311L to configure the relay for differential protection and:

- Three zones of phase and ground step-distance backup protection.

  Unused zones may be set to OFF. For example, set overreaching ground distance elements OFF when neighboring protection uses directional ground overcurrent.

- Two directional ground-overcurrent elements (67G1T/51GT).

  These elements may be used to coordinate with existing directional ground overcurrent protection schemes.

- One phase-overcurrent element (50P1).

  This element may be used with switch-onto-fault logic. Consider using switch-onto-fault logic when applying line-side PTs, and when relay potentials are unavailable before breaker closing.

When APP = 87L21, the SEL-311L:

1. Configures itself as a full-function differential relay. All differential and tapped load settings are available.
2. Configures itself as a three-zone step-distance phase-mho and ground-mho relay for distance protection (E21P = 4, E21MG = 4; these settings are hidden).
3. Enables overcurrent elements:
   a. 50P-instantaneous/definite-time phase-overcurrent element (E50P = 1; this setting is hidden).
   b. 50G-instantaneous/definite-time ground-overcurrent element (E50G = 3; this setting is hidden).
   c. 51G-inverse-time ground-overcurrent element (E51G = Y; this setting is hidden).
4. Displays the Enable settings for:
   a. Loss-of-potential (ELOP = Y1)
   b. Reclosing (E79 = N)
   c. CCVT transient protection (ECCVT = N)
   d. SELOGIC variables (ESV = N)
   e. SELOGIC Latch bits (ELAT = N)
   f. SELOGIC Display points (EDP = 3)
5. Hides settings for:
   a. Directional control (E32 = AUTO)
   b. Switch-onto-fault (ESOTF = Y)
   c. Fault locator (EFLOC = Y)

   d. Demand metering (EDEM = THM)
   e. Phase-mho and ground-mho overcurrent fault detectors

      (50PP*n* = 0.5), (50L*n* = 0.5), (50GZ*n* = 0.5), (5 A nominal) (*n* = 1, 2, 3)

      (50PP*n* = 0.1), (50L*n* = 0.1), (50GZ*n* = 0.1), (1 A nominal) (*n* = 1, 2, 3)

6. Disables and hides settings for:
   a. Quadrilateral ground distance elements (E21XG = N)
   b. 50Q-instantaneous/definite-time negative-sequence overcurrent elements (E50Q = N)
   c. 51P-inverse-time phase-overcurrent element (E51P = N)
   d. 51Q-inverse-time negative-sequence overcurrent elements (E51Q = N)
   e. Out-of-step elements (EOOS = N)
   f. Load-encroachment elements (ELOAD = N)
   g. Voltage elements (EVOLT = N)
   h. Synchronism-check elements (E25 = N)
   i. Frequency elements (E81 = N)
   j. Communications-assisted trip schemes (ECOMM = N)
   k. Advanced settings (EADVS = N)
7. Automatically calculates:
   a. Directional settings. See *Settings Made Automatically on page 4.79*.
   b. Zero-sequence compensation factors (k0M1, k0A1, k0M, k0A) as

$$\begin{aligned} \mathrm{k0M1}\angle\mathrm{k0A1} &= \mathrm{k0M}\angle\mathrm{k0A} \\ &= \frac{(\mathrm{Z0MAG}\angle\mathrm{Z0ANG} - \mathrm{Z1MAG}\angle\mathrm{Z1ANG})}{3 \bullet \mathrm{Z1MAG}\angle\mathrm{Z1ANG}} \end{aligned}$$

Equation 14.1

8. Changes default SELOGIC control equations to:
   a. TR = M1P + Z1G + M2PT + Z2GT + 67G1T + 51GT + OC
   b. 51GTC = 32GF
   c. T51PTC = 87L
   d. T51GTC = 87L
   e. T51QTC = 87L
   f. T50PTC = 87L
   g. T50GTC = 87L
   h. T50QTC = 87L
   i. ER = /B87L2 + /M2P + /Z2G + /51G + /50P1 + /LOP
   j. FAULT = 87L + M2P + Z2G + 51G

NOTE: T51PTC, T51GTC, T51QTC, T50PTC, T50GTC, and T50QTC settings are visible when T50 and T51 functions are enabled.

9. Makes no changes to:
   a. Global settings
   b. Port settings
   c. Text settings
   d. SER settings
   e. 87 communications Channel X settings
   f. 87 communications Channel Y settings

If additional capability is needed, the relay may be returned to the setting APP = 311L to make all of the SEL-311L settings visible. It is important to remember that changing from APP = 311L to APP = 87L21 changes settings in the SEL-311L. Changing from APP = 87L21 to APP = 311L makes more SEL-311L settings visible, but does not change any other settings. If SEL-311LL functions are used after setting APP is changed from 87L21 to 311L, do not change setting APP back to 87L21.

Application Settings

From Access Level 2, set the SEL-311L application setting to “87L21” as shown below.

```
=>>SET APP TERSE <Enter>

Identifier and Configuration Settings:
Application (87L,87L21,87L21P,311L)           APP   = 311L     ? 87L21 <Enter>

Line Current Differential Configuration Settings:

Number of 87L Terminals (2,3,3R,N)            E87L  = 2        ?  END <Enter>
Save Changes(Y/N)? Y <Enter>
Settings saved
=>>
```

The following settings are available when APP = 87L21. See the appropriate instruction manual section for settings description and explanation.

```
==>SHO <Enter>
Group 1

Group Settings:
RID   =SEL-311L                      TID   =EXAMPLE: BUS B, BREAKER 3
CTR   = 200      APP   = 87L21
E87L  = 2        EHST  = 2        EHSDTT= N
EDD   = Y        ETAP  = N        EOCTL = N
PCHAN = X        EHSC  = N        CTR_X = 200
87LPP = 6.00     87L2P = 0.50     87LGP = OFF      CTALRM= 0.50
87LR  = 6.0      87LANG= 195
CTRP  = 200      PTR   = 2000.00  PTRS  = 2000.00
Z1MAG = 7.80     Z1ANG = 84.00
Z0MAG = 24.80    Z0ANG = 81.50    LL    = 100.00
ELOP  = Y1       E79   = N
ECCVT = N        ESV   = N        ELAT  = N        EDP   = 3
Z1P   = 6.24     Z2P   = 9.36     Z3P   = OFF
Z1MG  = 6.24     Z2MG  = 9.36     Z3MG  = OFF
Z1PD  = OFF      Z2PD  = 20.00    Z3PD  = OFF
Z1GD  = OFF      Z2GD  = 20.00    Z3GD  = OFF
Z1D   = OFF      Z2D   = OFF      Z3D   = OFF

Press RETURN to continue
50P1P = OFF
67P1D = 0.00
50G1P = OFF
67G1D = 0.00
51GP  = OFF      51GC  = U3       51GTD = 2.00     51GRS = Y
DIR3  = R
CLOEND= OFF      52AEND= 10.00    SOTFD = 30.00
TDURD = 9.00     CFD   = 60.00

==>
```

```
=>>SHO L <Enter>
SELogic Group 1

SELogic Control Equations:
TR    =67P1T + 67G1T + 51PT + 51GT + OC
ULTR  =!(50L + 51G)
52A   =IN101
CL    =CC
ULCL  =TRIP + TRIP87
67P1TC=!87LPE + 87HWAL
67G1TC=!87LPE + 87HWAL
51PTC =!87LPE + 87HWAL
51GTC =!87LPE + 87HWAL
OUT101=TRIP
OUT102=TRIP
OUT103=CLOSE
OUT104=0
OUT105=0
OUT106=0
OUT107=87HWAL
OUT201=TRIP + TRIP87

Press RETURN to continue
OUT202=TRIP + TRIP87
OUT203=0
OUT204=0
OUT205=0
OUT206=0
OUT301=0
OUT302=0
OUT303=0
OUT304=0
OUT305=0
OUT306=0
OUT307=0
OUT308=0
OUT309=0
OUT310=0
OUT311=0
OUT312=0
ER    =/B87L2 + /50P1 + /50G1 + /51P + /51G
ESTUB =0

T1X   =0
T2X   =0
T3X   =0
T4X   =0
T1Y   =0
T2Y   =0
T3Y   =0
T4Y   =0

=>>
```

87L21P—Differential Protection With Piloted Step-Distance Backup

Set APP = 87L21P in the SEL-311L to configure the relay for differential protection, including

➤ Four zones of phase- and ground-distance backup protection.

Unused zones may be set to OFF. For example, set overreaching ground distance elements OFF when neighboring protection uses directional ground overcurrent.

➤ Communications-assisted trip logic.

Six available tripping schemes provide transmission line protection with the help of communications. No external coordination devices are required. See *Section 5: Trip and Target Logic*.

➤ Four directional ground-overcurrent elements (67G1T/67G2T/67G3T/51GT).

These elements may be used to coordinate with existing directional ground-overcurrent protection schemes, provide fast piloted tripping for forward faults, and provide Zone 3 reverse-fault blocking for communications-assisted schemes.

➤ One phase-overcurrent element (50P1).

This element may be used with switch-onto-fault logic. Consider using switch-onto-fault logic when applying line-side PTs and when relay potentials are unavailable before breaker closing.

When APP = 87L21P, the SEL-311L:

1. Configures itself as a full-function differential relay. All differential and tapped load settings are available.
2. Configures itself as a four-zone step-distance phase-mho and ground-mho relay for distance protection (E21P = 4, E21MG = 4; these settings are hidden).
3. Enables one phase-overcurrent and four ground-overcurrent elements:
   a. 50P-instantaneous/definite-time phase-overcurrent element (E50P = 1; this setting is hidden).
   b. 50G1-3-instantaneous/definite-time ground-overcurrent element (E50G = 3; this setting is hidden).
   c. 51G-inverse-time ground-overcurrent element (E51G = Y; this setting is hidden)
4. Displays the Enable settings for:
   a. Loss-of-potential (ELOP = Y1)
   b. Communications-assisted trip schemes (ECOMM = N)
   c. Reclosing (E79 = N)
   d. CCVT transient protection (ECCVT = N)
   e. SELOGIC variables (ESV = N)

   f. SELOGIC Latch bits (ELAT = N)
   g. SELOGIC Display points (EDP = 3)

5. Hides settings for:
   a. Directional control (E32 = AUTO)
   b. Switch-onto-fault (ESOTF = Y)
   c. Fault locator (EFLOC = Y)
   d. Demand metering (EDEM = THM)
   e. Phase-mho and ground-mho overcurrent fault detectors

      (50PP*n* = 0.5), (50L*n* = 0.5), (50GZ*n* = 0.5), (5 A nominal) (*n* = 1, 2, 3)

      (50PP*n* = 0.1), (50L*n* = 0.1), (50GZ*n* = 0.1), (1 A nominal) (*n* = 1, 2, 3)

6. Disables and hides settings for:
   a. Quadrilateral ground distance elements (E21XG = N)
   b. 50Q-instantaneous/definite-time negative-sequence overcurrent elements (E50Q = N)
   c. 51P-inverse-time phase-overcurrent element (E51P = N)
   d. 51Q-inverse-time negative-sequence overcurrent elements (E51Q = N)
   e. Out-of-step elements (EOOS = N)
   f. Load-encroachment elements (ELOAD = N)
   g. Voltage elements (EVOLT = N)
   h. Synchronism-check elements (E25 = N)
   i. Frequency elements (E81 = N)
   j. Advanced settings (EADVS = N)

7. Automatically calculates:
   a. Directional settings. See *Settings Made Automatically on page 4.79*.
   b. Zero-sequence compensation factors (k0M1, k0A1, k0M, k0A) as

$$\mathrm{k0M1}\angle\mathrm{k0A1} = \mathrm{k0M}\angle\mathrm{k0A} = \frac{(\mathrm{Z0MAG}\angle\mathrm{Z0ANG} - \mathrm{Z1MAG}\angle\mathrm{Z1ANG})}{3 \bullet \mathrm{Z1MAG}\angle\mathrm{Z1ANG}}$$

Equation 14.2

8. Changes default SELOGIC control equations to:
   a. TR = M1P + Z1G + M2PT + Z2GT + 67G2T + 51GT + OC
   b. TRCOMM = M2P +Z2G + 67G2 (Visible when ECOMM ≠ N)
   c. 51GTC = 32GF
   d. T51PTC = 87L
   e. T51GTC = 87L
   f. T51QTC = 87L
   g. T50PTC = 87L

NOTE: T51PTC, T51GTC, T51QTC, T50PTC, T50GTC, and T50QTC settings are visible when T50 and T51 functions are enabled.

h. T50GTC = 87L
i. T50QTC = 87L
j. ER = /B87L2 + /M2P + /Z2G + /51G + /50P1 + /LOP
k. FAULT = 87L + M2P + Z2G + 51G

9. Makes no changes to:
   a. Global settings
   b. Port settings
   c. Text settings
   d. SER settings
   e. 87 communications Channel X settings
   f. 87 communications Channel Y settings

If additional capability is needed, the relay can be returned to the setting APP = 311L to make all of the SEL-311L settings visible. It is important to remember that changing from APP = 311L to APP = 87L21P changes settings in the SEL-311L. Changing from APP = 87L21P to APP = 311L makes more SEL-311L settings visible but does not change any other settings. If SEL-311L functions are used after setting APP is changed from 87L21P to 311L, do not change setting APP back to 87L21P.

Application Settings

From Access Level 2, set the SEL-311L application setting to “87L21P” as shown below:

```
=>>SET APP TERSE <Enter>

Identifier and Configuration Settings:
Application (87L,87L21,87L21P,311L)            APP   = 311L      ? 87L21P <Enter>

Line Current Differential Configuration Settings:

Number of 87L Terminals (2,3,3R,N)             E87L  = 2         ?  END <Enter>
Save Changes(Y/N)? Y <Enter>
Settings saved
=>>
```

The following settings are available when APP = 87L21P. See the appropriate instruction manual section for settings description and explanation.

```
==>SHO <Enter>
Group 1

Group Settings:
RID   =SEL-311L                          TID   =EXAMPLE: BUS B, BREAKER 3
CTR   = 200       APP   = 87L21P
E87L  = 2         EHST  = 2         EHSDTT= N
EDD   = N         ETAP  = N         EOCTL = N
PCHAN = X         EHSC  = N         CTR_X = 200
87LPP = 6.00      87L2P = 0.50      87LGP = OFF       CTALRM= 0.50
87LR  = 6.0       87LANG= 195
CTRP  = 200       PTR   = 2000.00  PTRS  = 2000.00
Z1MAG = 7.80      Z1ANG = 84.00
Z0MAG = 24.80     Z0ANG = 81.50     LL    = 100.00
ELOP  = Y1        ECOMM = N         E79   = N
ECCVT = N         ESV   = N         ELAT  = N         EDP   = 3
Z1P   = 6.24      Z2P   = 9.36      Z3P   = 2.34      Z4P   = OFF
Z1MG  = 6.24      Z2MG  = 9.36      Z3MG  = 2.34      Z4MG  = OFF
Z1PD  = OFF       Z2PD  = 20.00     Z3PD  = OFF       Z4PD  = OFF
Z1GD  = OFF       Z2GD  = 20.00     Z3GD  = OFF       Z4GD  = OFF
Z1D   = OFF       Z2D   = OFF       Z3D   = OFF       Z4D   = OFF

Press RETURN to continue
50P1P = OFF
67P1D = 0.00
50G1P = OFF       50G2P = OFF       50G3P = OFF
67G1D = 0.00      67G2D = 0.00      67G3D = 0.00
51GP  = OFF       51GC  = U3        51GTD = 2.00      51GRS = Y
DIR3  = R         DIR4  = F
CLOEND= OFF       52AEND= 10.00     SOTFD = 30.00
TDURD = 9.00      CFD   = 60.00

==>
```

```
=>>SHO L <Enter>
SELogic Group 1

SELogic Control Equations:
TR    =M1P + Z1G + M2PT + Z2GT + 67G2T + 51GT + OC
TRSOTF=M2P + Z2G + 50P1
DTT   =0
ULTR  =!(50L + 51G)
52A   =IN101
CL    =CC
ULCL  =TRIP + TRIP87
67P1TC=1
67G1TC=1
67G2TC=1
67G3TC=1
51GTC =32GF
OUT101=TRIP
OUT102=TRIP
OUT103=CLOSE
OUT104=0
OUT105=0

Press RETURN to continue
OUT106=0
OUT107=87HWAL
OUT201=TRIP + TRIP87
OUT202=TRIP + TRIP87
OUT203=0
OUT204=0
OUT205=0
OUT206=0
OUT301=0
OUT302=0
OUT303=0
OUT304=0
OUT305=0
OUT306=0
OUT307=0
OUT308=0
OUT309=0
OUT310=0
OUT311=0
OUT312=0
DP1   =52A
DP2   =CHXAL
DP3   =CHYAL
SS1   =0
SS2   =0
SS3   =0
SS4   =0
SS5   =0
SS6   =0
ER    =/B87L2 + /M2P + /Z2G + /51G + /50P1 + /LOP
FAULT =87L + M2P + Z2G + 51G
ESTUB =0

Press RETURN to continue

T1X   =0
T2X   =0
T3X   =0
T4X   =0
T1Y   =0
T2Y   =0
T3Y   =0
T4Y   =0

=>>
```

87LSP—Single-Pole Tripping Differential Protection With Three-Pole Tripping Backup

NOTE: Single-pole tripping differential protection with three-pole backup is available only for SEL-311L-6 and SEL-311L-7 relays.

Set APP = 87LSP in the SEL-311L to configure the relay for single-pole tripping differential protection and:

➤ Four zones of phase- and ground-distance three-pole tripping backup protection.

  Unused zones may be set to OFF. For example, set overreaching ground distance elements OFF when neighboring protection uses directional ground overcurrent.

➤ Three-pole tripping communications-assisted trip logic.

  Six available tripping schemes provide transmission line protection with the help of communications. No external coordination devices are required. See *Section 5: Trip and Target Logic*.

➤ Directional ground and negative-sequence overcurrent elements for three-pole tripping backup protection.

  These elements may be used to coordinate with existing directional ground-overcurrent protection schemes, provide fast piloted tripping for forward faults, and provide Zone 3 reverse-fault blocking for communications-assisted schemes.

➤ Phase-overcurrent elements.

  These elements may be used with switch-onto-fault logic. Consider using switch-onto-fault logic when applying line-side PTs and when relay potentials are unavailable before breaker closing.

When APP = 87LSP, the SEL-311L:

1. Configures itself as a full-function, single-pole tripping, differential relay. Only two-terminal differential protection is available.
2. Configures high-speed output contacts for single-pole tripping.
3. Displays the Enable settings for:
   a. Mho phase distance protection (E21P = 3 and the compensator distance elements are hidden)
   b. Mho ground distance protection (E21MG = 3)
   c. Quadrilateral ground distance protection (E21XG = 3)
   d. 50P-instantaneous/definite-time phase-overcurrent elements (E50P = 1)
   e. 50G-instantaneous/definite-time ground-overcurrent elements (E50G = N)
   f. 50Q-instantaneous/definite-time negative-sequence overcurrent elements (E50Q = N)
   g. 51P-inverse-time phase-overcurrent element (E51P = N)
   h. 51G-inverse-time ground overcurrent elements (E51G = Y)

i. 51Q-inverse-time negative-sequence overcurrent elements (E51Q = Y)

j. Directional control (E32 = AUTO)

k. Out-of-step elements (EOOS = N)

l. Load-encroachment elements (ELOAD = N)

m. Switch-onto-fault (ESOTF = Y)

n. Voltage elements (EVOLT = N)

o. Synchronism-check elements (E25 = N)

p. Frequency elements (E81 = N)

q. Loss-of-potential (ELOP = Y)

r. Communications-assisted trip schemes (ECOMM = N)

s. Reclosing (E79 = N)

t. Zone 1 extension (EZ1EXT = N)

u. CCVT transient protection (ECCVT = N)

v. SELOGIC variables (ESV = N)

w. SELOGIC Latch bits (ELAT = 16)

x. SELOGIC Display points (EDP = 16)

y. Demand metering (EDEM = THM)

z. Advanced settings (EADVS = N)

aa. Hides and disables settings for Breaker Monitor (EBMON = N)

ab. Trip Open Pole Dropout delay (TOPD = 2)

4. Automatically calculates:

   a. Directional settings. See *Settings Made Automatically on page 4.79*.

   b. Zero-sequence compensation factors (k0M1, k0A1, k0M, k0A) as

$$\begin{aligned} k0M1\angle k0A1 &= k0M\angle k0A \\ &= \frac{(Z0MAG\angle Z0ANG - Z1MAG\angle Z1ANG)}{3 \bullet Z1MAG\angle Z1ANG} \end{aligned}$$

Equation 14.3

5. Hides and sets the following settings as indicated:

   a. Number of 87L Terminals (E87L = 2)

   b. Tapped Load Coordination (ETAP = N)

   c. 52A (52A = 52AA * 52AB * 52AC)

6. Changes default SELOGIC control equations to:

   a. ULTR = SPO + 3PO

   b. 52AA = IN101

   c. 52AB = IN102

   d. 52AC = IN103

   e. OUT201 = TRIP

   f. OUT202 = TRIP

   g. OUT203 = TRIP

7. Makes no changes to:
   a. Port settings
   b. Text settings
   c. SER settings
   d. 87 communications Channel X settings
   e. 87 communications Channel Y settings

Application Settings

From Access Level 2, set the SEL-311L application setting to "87LSP" as shown below.

```
=>>SET APP TERSE <Enter>

Identifier and Configuration Settings:
Application (87L,87L21,87L21P,87LSP,311L)        APP   = 311L      ? 87LSP <Enter>

Line Current Differential Configuration Settings:

High Speed Tripping (SP1,SP2,N)                  EHST  = SP1       ?  END <Enter>
Save Changes(Y/N)? Y <Enter>
Settings saved
=>>
```

The following settings are available when APP = 87LSP. See the appropriate instruction manual section for settings description and explanation.

```
==>SHO <Enter>
Group 1

Group Settings:
RID   =SEL-311L                       TID   =EXAMPLE: BUS B, BREAKER 3
CTR   = 200      APP   = 87LSP    EHST  = SP1      EHSDTT= N
EDD   = N        EOCTL = N
PCHAN = X        EHSC  = N        CTR_X = 200
87LPP = 6.00     87L2P = OFF      87LGP = 0.05     CTALRM= 0.50
87LR  = 6.0      87LANG= 195
CTRP  = 200      PTR   = 2000.00  PTRS  = 2000.00
Z1MAG = 7.80     Z1ANG = 84.00
Z0MAG = 24.80    Z0ANG = 81.50    LL    = 100.00
E21P  = 3        E21MG = 3        E21XG = 3
E50P  = 1        E50G  = N        E50Q  = N
E51P  = N        E51G  = Y        E51Q  = Y
E32   = AUTO     EOOS  = N        ELOAD = Y        ESOTF = Y
EVOLT = N        E25   = N        E81   = N        EFLOC = Y
ELOP  = Y        ECOMM = N        E79   = N        EZ1EXT= N
ECCVT = N        ESV   = N        ELAT  = 16       EDP   = 16
EDEM  = THM      EADVS = N

Press RETURN to continue
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 = 11.25
67P1D = 0.00
51GP  = 0.75     51GC  = U3       51GTD = 2.00     51GRS = Y
51QP  = 2.20     51QC  = U3       51QTD = 2.00     51QRS = N
ZLF   = 9.22     ZLR   = 9.22
PLAF  = 30.00    NLAF  =-30.00    PLAR  = 150.00   NLAR  = 210.00
DIR3  = R        DIR4  = F
ORDER = QVI
CLOEND= OFF      52AEND= 10.00    SOTFD = 30.00

Press RETURN to continue
DMTC  = 60       PDEMP = OFF      GDEMP = OFF      QDEMP = OFF
TDURD = 9.00     TOPD  = 2.00     CFD   = 60.00    3POD  = 0.50     OPO   = 52
50LP  = 0.25

==>
```

```
=>>SHO L <Enter>
SELogic Group 1

SELogic Control Equations:
TR    =M1P + Z1G + M2PT + Z2GT + 51GT + 51QT + OC
TRSOTF=M2P + Z2G + 50P1
DTT   =0
E3PT  =0
ULTR  =SPO + 3PO
52AA  =IN101
52AB  =IN102
52AC  =IN103
CL    =CC
ULCL  =TRIP + TRIP87
SET1  =0
RST1  =0
SET2  =0
RST2  =0
SET3  =0
RST3  =0
SET4  =0

Press RETURN to continue
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

Press RETURN to continue
RST14 =0
SET15 =0
RST15 =0
SET16 =0
RST16 =0
67P1TC=1
51GTC =1
51QTC =1
OUT101=TRIP
OUT102=TRIP
OUT103=CLOSE
OUT104=0
OUT105=0
OUT106=0
OUT107=87HWAL
OUT201=TRIP
OUT202=TRIP
OUT203=TRIP
OUT204=0
OUT205=0

Press RETURN to continue
OUT206=0
OUT301=0
OUT302=0
OUT303=0
OUT304=0
OUT305=0
OUT306=0
OUT307=0
OUT308=0
OUT309=0
OUT310=0
OUT311=0
OUT312=0
DP1   =52A
DP2   =CHXAL
DP3   =CHYAL
DP4   =0
DP5   =0
```

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```
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

Press RETURN to continue
SS4   =0
SS5   =0
SS6   =0
ER    =/B87L2 + /M2P + /Z2G + /51G + /51Q + /50P1 + /LOP
FAULT =51G + 51Q + M2P + Z2G
BSYNCH=0
CLMON =0
E32IV =1
ESTUB =0
T1X   =0
T2X   =0
T3X   =0
T4X   =0
T1Y   =0
T2Y   =0
T3Y   =0
T4Y   =0

=>>
```

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SEL-311L Settings Sheets (APP = 87L)

Relay Settings

Identifier Labels and Configuration Settings (See Settings Explanations on page 9.34)

Relay Identifier (30 characters)

RID = ______________________________

Terminal Identifier (30 characters)

TID = ______________________________

Local Phase (IA, IB, IC) Current Transformer Ratio (1–6000) **CTR** = __________

Application (87L, 87L21, 87L21P, 87LSP, 311L) **APP** = 87L

Line Current Differential Configuration Settings

If the relay has two channels, the following choices are available:

Relay operating mode (2, 3, 3R, N)

If the relay has one channel, the following choices are available:

Relay operating mode (2, 3R, N) **E87L** = __________

If E87L ≠ N, the following choices are available:

High-speed tripping (1–6, N) **EHST** = __________

If 87L = 2 or 3, the following choices are available:

Enable high-speed direct transfer trip (Y, N) **EHSDTT** = __________

Enable delta current detect (Y, N) **EDD** = __________

Tapped-load coordination (Y, N) **ETAP** = __________

If the relay has two channels and E87L = 2:

Enable Open CT Logic (Y, N) **EOCTL** = __________

If the relay has two channels and E87L = 2 or 3R:

Primary channel (X, Y) **PCHAN** = __________

If the relay has two channels and E87L = 2:

Hot-standby channel feature (Y, N) **EHSC** = __________

If PCHAN = X or EHSC = Y or E87L = 3:

CTR at terminal connected to Channel X (1–6000) **CTR_X** = __________

If EADDCX = G:

Channel X transmit address (1–16) **TA_X** = __________

Channel X receive address (1–16) **RA_X** = __________

If PCHAN = Y or EHSC = Y or E87L = 3:

CTR at terminal connected to Channel Y (1–6000)	**CTR_Y**	=________

If EADDCY = G:

Channel Y transmit address (1–16)	**TA_Y**	=________
Channel Y receive address (1–16)	**RA_Y**	=________

Minimum Difference Current Enable Level Settings (E87L = 2 or 3)

Phase 87L (OFF, 1.00–10.00 A secondary)	**87LPP**	=________
$3I_2$ Negative-sequence 87L (OFF, 0.50–5.00 A secondary)	**87L2P**	=________
Ground 87L (OFF, 0.50–5.00 A secondary)	**87LGP**	=________
Phase difference current alarm pickup 0.50–10.00 A secondary	**CTALRM**	=________

Restraint Region Characteristic Settings (E87L = 2 or 3)

Outer Radius (2.0–8.0)	**87LR**	=________
Angle (90°–270°)	**87LANG**	=________

Tapped-Load Coordinating Overcurrent Element Settings (If ETAP = Y)

Phase element (Y, N)	**ETP**	=________
Residual ground element (Y, N)	**ETG**	=________
Negative-sequence element (Y, N)	**ETQ**	=________

Tapped-Load Phase Time-Overcurrent Element Settings (If ETP = Y)

Pickup (OFF, 0.50–16.00 A secondary)	**T51PP**	=________
Curve (U1–U5; C1–C5)	**T51PC**	=________
Time Dial 0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5	**T51PTD**	=________
Electromechanical reset delay (Y, N)	**T51PRS**	=________

Tapped-Load Phase Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	**T50PP**	=________
Time delay (OFF, 0.00–16000.00 cycles)	**T50PD**	=________

Tapped-Load Residual-Ground Time-Overcurrent Element Settings (If ETG = Y)

Pickup (OFF, 0.50–16.00 A secondary)	**T51GP**	=________
Curve (U1–U5; C1–C5)	**T51GC**	=________

Time Dial

0.50–15.00 for curves U1–U5;
0.05–1.00 for curves C1–C5 **T51GTD** =__________

Electromechanical reset delay (Y, N) **T51GRS** =__________

Tapped-Load Residual-Ground Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary) **T50GP** =__________

Time delay (OFF, 0.00–16000.00 cycles) **T50GD** =__________

Tapped-Load Negative-Sequence Time-Overcurrent Element Settings (If ETQ = Y)

Pickup (OFF, 0.50–16.00 A secondary) **T51QP** =__________

Curve (U1–U5; C1–C5) **T51QC** =__________

Time Dial

0.50–15.00 for curves U1–U5;
0.05–1.00 for curves C1–C5 **T51QTD** =__________

Electromechanical reset delay (Y, N) **T51QRS** =__________

Tapped-Load Negative-Sequence Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary) **T50QP** =__________

Time delay (OFF, 0.00–16000.00 cycles) **T50QD** =__________

Phase Inst./Def.-Time Overcurrent Elements (See Figure 4.19)

Level 1

OFF, 0.25–100.00 A secondary {5 A nom.};
0.05–20.00 A secondary {1 A nom.} **50P1P** =__________

Phase Definite-Time Overcurrent Element Time Delays (See Figure 4.19)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) **67P1D** =__________

Residual-Ground Inst./Def.-Time Overcurrent Elements (See Figure 4.22)

Level 1

OFF, 0.25–100.00 A secondary {5 A nom.};
0.05–20.00 A secondary {1 A nom.} **50G1P** =__________

Residual-Ground Definite-Time Overcurrent Element Time Delay (See Figure 4.22)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) **67G1D** =__________

Phase Time-Overcurrent Element (See Figure 4.24)

Pickup		
OFF, 0.25–16.00 A secondary {5 A nom.}; 0.05–3.20 A secondary {1 A nom.}	**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	**51PTD**	=________
Electromechanical Reset (Y, N)	**51PRS**	=________

Residual-Ground Time-Overcurrent Element (See Figure 4.25)

Pickup		
OFF, 0.25–16.00 A secondary {5 A nom.}; 0.05–3.20 A secondary {1 A nom.}	**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)	**51GTD**	=________
Electromechanical Reset (Y, N)	**51GRS**	=________

Channel A MIRRORED BITS Settings

These settings are only available when you set a Serial Port Protocol Setting 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 only available when you set a Serial Port Protocol Setting 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**	=________

SELOGIC Control Equation Settings

SELOGIC control equation settings consist of Relay Word bits (see Table 9.5 and Table 9.6) 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 through Section 8. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). Appendix I: Setting SELOGIC Control Equations gives SELOGIC control equation details, examples, and limitations.

Trip Logic Equations (See Figure 5.6)

Direct trip conditions	**TR**	=________________
Unlatch trip conditions	**ULTR**	=________________

Close Logic Equations (See Figure 6.1)

Circuit breaker status (used in *Figure 5.7*, also)	**52A**	=________________
Close conditions (other than automatic reclosing or **CLOSE** command)	**CL**	=________________
Unlatch close conditions	**ULCL**	=________________

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 4.19*)	**67P1TC**	=________________
Level 1 residual ground (see *Figure 4.22*)	**67G1TC**	=________________

Torque-Control Equations for Time-Overcurrent Elements

[Note: torque-control equation settings cannot be set directly to logical 0]

Phase element (see *Figure 4.24*)	**51PTC**	=________________
Residual ground element (see *Figure 4.25*)	**51GTC**	=________________

Torque-Control Equations for Tapped Load Time-Overcurrent Elements

[Note: torque-control equation settings cannot be set directly to logical 0]

Phase inverse time (see *Figure 3.21*)	**T51PTC**	=________________
Ground inverse time (see *Figure 3.22*)	**T51GTC**	=________________
Negative-sequence time (see *Figure 3.23*)	**T51QTC**	=________________

Torque-Control Equations for Tapped Load Inst./ Def.-Time Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Phase instantaneous (see *Figure 3.18*)	**T50PTC**	=________________
Ground instantaneous (see *Figure 3.19*)	**T50GTC**	=________________
Negative-sequence instantaneous (see *Figure 3.20*)	**T50QTC**	=________________

87L Element Torque-Control Equation

Note: torque-control equation settings cannot be set directly to logical 0

87L torque control (see *Figure 3.15*)	**87LTC**	=________________

Output Contact Equations (See Figure 7.27)

Output Contact OUT101	**OUT101**	=________________
Output Contact OUT102	**OUT102**	=________________
Output Contact OUT103	**OUT103**	=________________
Output Contact OUT104	**OUT104**	=________________
Output Contact OUT105	**OUT105**	=________________
Output Contact OUT106	**OUT106**	=________________
Output Contact OUT107	**OUT107**	=________________

Output Contact Equations—Differential Board (See Figure 7.28)

Output Contact OUT201	**OUT201**	=________________
Output Contact OUT202	**OUT202**	=________________
Output Contact OUT203	**OUT203**	=________________
Output Contact OUT204	**OUT204**	=________________
Output Contact OUT205	**OUT205**	=________________
Output Contact OUT206	**OUT206**	=________________

Output Contact Equations—Extra I/O Board

Output Contact OUT301	**OUT301**	=________________
Output Contact OUT302	**OUT302**	=________________
Output Contact OUT303	**OUT303**	=________________
Output Contact OUT304	**OUT304**	=________________
Output Contact OUT305	**OUT305**	=________________
Output Contact OUT306	**OUT306**	=________________

Output Contact OUT307	**OUT307**	= ____________
Output Contact OUT308	**OUT308**	= ____________
Output Contact OUT309	**OUT309**	= ____________
Output Contact OUT310	**OUT310**	= ____________
Output Contact OUT311	**OUT311**	= ____________
Output Contact OUT312	**OUT312**	= ____________

Other Equations

Event report trigger conditions (see *Section 12: Analyzing Events*)	**ER**	= ____________
Enable bus stub protection	**ESTUB**	= ____________

MIRRORED BITS Transmit Equations (See Appendix E: MIRRORED BITS Communications)

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**	= ____________

87L Transmit Bit Equations

Channel X, transmit bit 1	**T1X**	= ____________
Channel X, transmit bit 2	**T2X**	= ____________
Channel X, transmit bit 3	**T3X**	= ____________

Channel X, transmit bit 4	**T4X**	=________________
Channel Y, transmit bit 1	**T1Y**	=________________
Channel Y, transmit bit 2	**T2Y**	=________________
Channel Y, transmit bit 3	**T3Y**	=________________
Channel Y, transmit bit 4	**T4Y**	=________________

Global Settings

Settings Group Change Delay (See Multiple Setting Groups on page 7.17)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps)	**TGR**	=________

Power System Configuration and Date Format (See Settings Explanations on page 9.34)

Nominal frequency (50 Hz, 60 Hz)	**NFREQ**	=________
Phase rotation (ABC, ACB)	**PHROT**	=________
Date format (MDY, YMD)	**DATE_F**	=________

Front-Panel Display Operation (See Section 11: Front-Panel Operations)

Front-panel display time-out (0.00–30.00 minutes in 0.01-minute steps)	**FP_TO**	=________

(If FP_TO = 0, no time-out occurs and display remains on last display screen, e.g., continually display metering.)

Front-panel display update rate (1–60 seconds)	**SCROLD**	=________

Event Report Parameters (See Section 12: Analyzing Events)

Length of event report (15, 30, 60 cycles)	**LER**	=________
Length of pre-fault in event report (1–14 cycles in 1-cycle steps for LER = 15) (1–29 cycles in 1-cycle steps for LER = 30) (1–59 cycles in 1-cycle steps for LER = 60)	**PRE**	=________

Station DC Battery Monitor (See Figure 8.15 and Figure 8.16)

DC battery instantaneous undervoltage pickup OFF, 20–300 Vdc	**DCLOP**	=________
DC battery instantaneous overvoltage pickup OFF, 20–300 Vdc	**DCHIP**	=________

Optoisolated Input Timers

Input IN101 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN101D**	= ________
Input IN102 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN102D**	= ________
Input IN103 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN103D**	= ________
Input IN104 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN104D**	= ________
Input IN105 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN105D**	= ________
Input IN106 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN106D**	= ________
Input IN301 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN301D**	= ________
Input IN302 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN302D**	= ________
Input IN303 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN303D**	= ________
Input IN304 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN304D**	= ________
Input IN305 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN305D**	= ________
Input IN306 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN306D**	= ________
Input IN307 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN307D**	= ________
Input IN308 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN308D**	= ________

Breaker Monitor Settings (See Breaker Monitor on page 8.12)

Breaker monitor enable (Y, N)	**EBMON**	= ________

(Make the following settings if preceding enable setting 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 in 0.01 kA steps	**KASP1**	= ________
kA Interrupted set point 2—mid. 0.00–999.00 kA primary in 0.01 kA steps	**KASP2**	= ________
kA Interrupted set point 3—max. 0.00–999.00 kA primary in 0.01 kA steps	**KASP3**	= ________

Synchronized Phasor Settings (See Appendix H: SEL Synchrophasors)

Synchronized Phasor Measurement (Y, N)	**EPMU**	=________________

Make the following settings if preceding enable setting EPMU = Y.

PMU Hardware ID	**PMID**	=________________
Phasor Data Set, Voltages (V1, ALL)	**PHDATAV**	=________________
Voltage Angle Comp. Factor (–179.99 to +180 degrees)	**VCOMP**	=________________
Phasor Data Set, Currents (ALL, NA)	**PHDATAI**	=________________
Current Angle Comp. Factor (–179.99 to +180 degrees)	**ICOMP**	=________________
Time Source Type (IRIG, IEEE)	**TS_TYPE**	=________________

Sequential Events Recorder Settings

Sequential Events Recorder settings are composed of three trigger lists. Each trigger list can include as many as 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See Sequential Events Recorder Report on page 12.36.

SER Trigger List 1
SER1 =____

SER Trigger List 2
SER2 =____

SER Trigger List 3
SER3 =____

Text Label Settings

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 (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

Display if DP1 = logical 1 (16 characters)	**DP1_1**	=
Display if DP1 = logical 0 (16 characters)	**DP1_0**	=
Display if DP2 = logical 1 (16 characters)	**DP2_1**	=
Display if DP2 = logical 0 (16 characters)	**DP2_0**	=
Display if DP3 = logical 1 (16 characters)	**DP3_1**	=
Display if DP3 = logical 0 (16 characters)	**DP3_0**	=
Display if DP4 = logical 1 (16 characters)	**DP4_1**	=

Display if DP4 = logical 0 (16 characters)	**DP4_0**	=
Display if DP5 = logical 1 (16 characters)	**DP5_1**	=
Display if DP5 = logical 0 (16 characters)	**DP5_0**	=
Display if DP6 = logical 1 (16 characters)	**DP6_1**	=
Display if DP6 = logical 0 (16 characters)	**DP6_0**	=
Display if DP7 = logical 1 (16 characters)	**DP7_1**	=
Display if DP7 = logical 0 (16 characters)	**DP7_0**	=
Display if DP8 = logical 1 (16 characters)	**DP8_1**	=
Display if DP8 = logical 0 (16 characters)	**DP8_0**	=
Display if DP9 = logical 1 (16 characters)	**DP9_1**	=
Display if DP9 = logical 0 (16 characters)	**DP9_0**	=
Display if DP10 = logical 1 (16 characters)	**DP10_1**	=
Display if DP10 = logical 0 (16 characters)	**DP10_0**	=
Display if DP11 = logical 1 (16 characters)	**DP11_1**	=
Display if DP11 = logical 0 (16 characters)	**DP11_0**	=
Display if DP12 = logical 1 (16 characters)	**DP12_1**	=
Display if DP12 = logical 0 (16 characters)	**DP12_0**	=
Display if DP13 = logical 1 (16 characters)	**DP13_1**	=
Display if DP13 = logical 0 (16 characters)	**DP13_0**	=
Display if DP14 = logical 1 (16 characters)	**DP14_1**	=
Display if DP14 = logical 0 (16 characters)	**DP14_0**	=
Display if DP15 = logical 1 (16 characters)	**DP15_1**	=
Display if DP15 = logical 0 (16 characters)	**DP15_0**	=
Display if DP16 = logical 1 (16 characters)	**DP16_1**	=
Display if DP16 = logical 0 (16 characters)	**DP16_0**	=

Reclosing Relay Labels (See Functions Unique to the Front-Panel Interface on page 11.5)

Reclosing Relay Last Shot Label (14 char.)	**79LL**	=
Reclosing Relay Shot Counter Label (14 char.)	**79SL**	=

Port Settings

Protocol Settings (See Below)

Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B, MBGA, MBGB, TELNET)	**PROTO**	=________

Protocol Settings Set PROTO = SEL for standard SEL ASCII protocol. For SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD. Refer to Appendix C for details on the LMD protocol. For Distributed Network Protocol (DNP), set PROTO = DNP. Refer to Appendix F for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, MB8B, MBGA, or MBGB. Refer to Appendix E for details on MIRRORED BITS. To enable Telnet-to-relay communications on **PORT 5** and **PORT6**, the **PORT 1** PROTO setting must be set to TELNET. Setting PROTO = TELNET disables **PORT 1** for EIA-485 communications.

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) *(38400 is not available on Port 1)*	**SPEED**	=________
Data Bits (6, 7, 8) *This setting is available when PROTO = SEL or LMD.*	**BITS**	=________
Parity (O, E, N) {Odd, Even, None} *This setting is available when PROTO = SEL or LMD.*	**PARITY**	=________
Stop Bits (1, 2) *This setting is available when PROTO = SEL or LMD.*	**STOP**	=________
Time-out (0–30 minutes) *This setting is available when PROTO = SEL or LMD. 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.*	**T_OUT**	=________
DTA Meter Format (Y, N) *Set DTA = Y to allow an SEL DTA or SEL DTA2 to communicate with the relay. This setting is available when PROTO = SEL or LMD. Note that when DTA = Y, the date format must be set to MDY in the Global setting DATE_F.*	**DTA**	=________
Send Auto Messages to Port (Y, N) *This setting is available when PROTO = SEL or LMD. Set AUTO = Y to allow automatic messages at the serial port.*	**AUTO**	=________
Enable Hardware Handshaking (Y, N, MBT) *MBT is available when PROTO = MBA or MBB. (Refer to* MIRRORED BITS Protocol for the Pulsar 9600 Baud Modem on page E.5 *for details on setting MBT.) Set RTSCTS = Y to enable hardware handshaking. With RTSCTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line. Setting RTSCTS is not applicable to serial Port 1 (EIA-485) or a port configured for SEL Distributed Port Switch Protocol.*	**RTSCTS**	=________
Fast Operate Enable (Y, N) *This setting is available when PROTO = SEL or LMD. 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 D: SEL Communications Processors *for the description of the* SEL-311L *Relay Fast Operate commands. When PROTO = TELNET, FASTOP is set to Y and is hidden.*	**FASTOP**	=________

LMD Settings

LMD Prefix (@, #, $, %, &)	**PREFIX**	= ____________
LMD Address (1–99)	**ADDR**	= ____________
LMD Settling Time (0–30 seconds)	**SETTLE**	= ____________

TELNET Settings (PORT 1 only)

Telnet Port for Relay Access (1–65534)	**TPORT**	= ____________
Telnet Port Timeout (1–30 min)	**TIDLE**	= ____________

Ethernet Port Settings (PORT 5 and PORT 6 only)

IP Address (xxx.xxx.xxx.xxx)	**IPADDR**	= ____________
Subnet Mask (xxx.xxx.xxx.xxx)	**SUBNETM**	= ____________
Default Router (xxx.xxx.xxx.xxx)	**DEFRTR**	= ____________
Enable TCP Keep-Alive (Y, N)	**ETCPKA**	= ____________
TCP Keep-Alive Idle Range (1–20 s) *If ETCPKA = Y*	**KAIDLE**	= ____________
TCP Keep-Alive Interval Range (1–20 s) *If ETCPKA = Y*	**KAINTV**	= ____________
TCP Keep-Alive Count Range (1–20 s) *If ETCPKA = Y*	**KACNT**	= ____________
Operating Mode (FIXED, FAILOVER)	**NETMODE**	= ____________
Failover Time-out (OFF, 0.1–65.00 sec) *If NETMODE = FAILOVER*	**FTIME**	= ____________
Enable Telnet (Y, N)	**ETELNET**	= ____________
Telnet Port for Card Access (1–65534) *If ETELNET = Y*	**TPORTC**	= ____________
Telnet Port Timeout (1–30 min) *If ETELNET = Y*	**TIDLE**	= ____________
Enable FTP Server (Y, N) *If ETELNET = Y*	**EFTPSERV**	= ____________
FTP Username (20 characters) *If EFTPSERV = Y*	**FTPUSER**	= ____________
FTP Connect Banner *If EFTPSERV = Y*	**FTPCBAN**	= ____________
FTP Idle Timeout (5–255 minutes) *If EFTPSERV = Y*	**FTPIDLE**	= ____________
Enable HTTP Server (Y, N)	**EHTTP**	= ____________
HTTP TCP/IP Port (1–65535) *If EHTTP = Y*	**HTTPPORT**	= ____________
HTTP Web Server Timeout (1–30 minutes) *If EHTTP = Y*	**HTTPIDLE**	= ____________
Enable IEC 61850 Protocol (Y, N) *If IEC 61850 is available*	**E61850**	= ____________
Enable IEC 61850 GSE (Y, N) *If IEC 61850 is available*	**EGSE**	= ____________

DNP Settings

DNP Address (0–65534)	**DNPADR**	= ____________
Class for event data (0 for no event, 1–3)	**ECLASS**	= ____________
Time-set request interval, minutes (0 for never, 1–32767)	**TIMERQ**	= ____________
Currents scaling (0–3 decimal places)	**DECPLA**	= ____________
Voltages scaling (0–3 decimal places)	**DECPLV**	= ____________
Miscellaneous data scaling (0–3 decimal places)	**DECPLM**	= ____________
Select/Operate time-out interval, seconds (0.0–30.0)	**STIMEO**	= ____________
Number of data-link retries (0 for no confirm, 1–15)	**DRETRY**	= ____________
Data Link Time-out interval, seconds (0–5)	**DTIMEO**	= ____________
Minimum Delay from DCD to transmission, seconds (0.00–1.00)	**MINDLY**	= ____________
Maximum Delay from DCD to transmission, seconds (0.00–1.00)	**MAXDLY**	= ____________
Transmission delay from RTS assertion, seconds (OFF, 0.00–30.00)	**PREDLY**	= ____________
Post-transmit RTS deassertion delay, seconds (0.00–30.00)	**PSTDLY**	= ____________
Analog reporting deadband, counts (0–32767)	**ANADB**	= ____________
Allow Unsolicited Reporting (Y/N)	**UNSOL**	= ____________
Enable unsolicited messages when the relay turns on (Y/N)	**PUNSOL**	= ____________
Address of master to Report to (0–65534)	**REPADR**	= ____________
Number of events to transmit on (1–200)	**NUMEVE**	= ____________
Age of oldest event to force transmit on, seconds (0.0–60.0)	**AGEEVE**	= ____________
Time-out for confirmation of unsolicited message, seconds (0–50)	**UTIMEO**	= ____________

MB Settings

PPM MIRRORED BITS Channel Bad Pickup (1–10000)	**CBADPU**	= ____________
MIRRORED BITS Receive Identifier (1–4) *This setting is unavailable if PROTO is set to MBGA or MBGB.*	**RXID**	= ____________
MIRRORED BITS Transmit Identifier (1–4) *This setting is unavailable if PROTO is set to MBGA or MBGB.*	**TXID**	= ____________
MIRRORED BITS Receive Default State (string of 1s, 0s or Xs) 87654321	**RXDFLT**	= ____________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB1PU**	= ____________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB1DO**	= ____________

MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB2PU**	= ______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB2DO**	= ______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB3PU**	= ______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB3DO**	= ______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB4PU**	= ______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB4DO**	= ______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB5PU**	= ______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB5DO**	= ______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB6PU**	= ______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB6DO**	= ______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB7PU**	= ______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB7DO**	= ______
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB8PU**	= ______
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB8DO**	= ______

Channel Settings

87L Channel X Configuration Settings

Channel X address check (Y, G, N)	**EADDCX**	= ______
If EADDCX = Y		
Channel X transmit address (1–16) *This setting is unavailable if EADDCX is set to G.*	**TA_X**	= ______
Channel X receive address (1–16) *This setting is unavailable if EADDCX is set to G.*	**RA_X**	= ______
Continuous dropout alarm (1–1000 seconds)	**RBADXP**	= ______
Packets lost in last 10,000 (1–5000)	**AVAXP**	= ______
One-way channel delay alarm (1–24 ms)	**DBADXP**	= ______
If CHANX type is EIA-422		
EIA-422 receive clock edge detect (R = Rising; F = Falling)	**RC422X**	= ______
EIA-422 transmit clock edge detect (R = Rising; F = Falling)	**TC422X**	= ______
If CHANX type is not EIA-422		
Timing source (I = Internal; E = External)	**TIMRX**	= ______

87L Channel Y Configuration Settings

Channel Y address check (Y, G, N)	**EADDCY**	=________
If EADDCY = Y		
Channel Y transmit address (1–16) *This setting is unavailable if EADDCY is set to G.*	**TA_Y**	=________
Channel Y receive address (1–16) *This setting is unavailable if EADDCY is set to G.*	**RA_Y**	=________
Continuous dropout alarm (1–1000 seconds)	**RBADYP**	=________
Packets lost in last 10,000 (1–5000)	**AVAYP**	=________
One-way channel delay alarm (1–24 ms)	**DBADYP**	=________
If CHANY type is EIA-422		
EIA-422 receive clock edge detect (R = Rising; F = Falling)	**RC422Y**	=________
EIA-422 transmit clock edge detect (R = Rising; F = Falling)	**TC422Y**	=________
If CHANY type is not EIA-422		
Timing source (I = Internal; E = External)	**TIMRY**	=________

SEL-311L Settings Sheets (APP = 87L21)

Relay Settings

Identifier Labels and Configuration Settings (See Settings Explanations on page 9.34)

Relay Identifier (30 characters)

RID = ______________________________

Terminal Identifier (30 characters)

TID = ______________________________

Local Phase (IA, IB, IC) Current Transformer Ratio (1–6000)	CTR	= __________
Application (87L, 87L21, 87L21P, 87LSP, 311L)	APP	= **87L21**

Line Current Differential Configuration Settings

If the relay has two channels, the following choices are available:

Relay operating mode (2, 3, 3R, N)

If the relay has one channel, the following choices are available:

Relay operating mode (2, 3R, N)	**E87L**	= __________

If E87L ≠ N, the following choices are available:

High-speed tripping (1–6, N)	**EHST**	= __________

If 87L = 2 or 3, the following choices are available:

Enable high-speed direct transfer trip (Y, N)	**EHSDTT**	= __________
Enable delta current detect (Y, N)	**EDD**	= __________
Tapped-load coordination (Y, N)	**ETAP**	= __________

If the relay has two channels and E87L = 2:

Enable Open CT Logic (Y, N)	**EOCTL**	= __________

If the relay has two channels and E87L = 2 or 3R:

Primary channel (X, Y)	**PCHAN**	= __________

If the relay has two channels and E87L = 2:

Hot-standby channel feature (Y, N)	**EHSC**	= __________

If PCHAN = X or EHSC = Y or E87L= 3:

CTR at terminal connected to Channel X (1–6000)	**CTR_X**	= __________

If EADDCX = G:

Channel X transmit address (1–16)	**TA_X**	= __________

Channel X receive address (1–16)	**RA_X**	=________
If PCHAN = Y or EHSC = Y or E87L = 3:		
CTR at terminal connected to Channel Y (1–6000)	**CTR_Y**	=________
If EADDCY = G:		
Channel Y transmit address (1–16)	**TA_Y**	=________
Channel Y receive address (1–16)	**RA_Y**	=________

Minimum Difference Current Enable Level Settings (E87L = 2 or 3)

Phase 87L (OFF, 1.00–10.00 A secondary)	**87LPP**	=________
$3I_2$ Negative-sequence 87L (OFF, 0.50–5.00 A secondary)	**87L2P**	=________
Ground 87L (OFF, 0.50–5.00 A secondary)	**87LGP**	=________
Phase difference current alarm pickup (0.50–10.00 A secondary)	**CTALRM**	=________

Restraint Region Characteristic Settings (E87L = 2 or 3)

Outer Radius (2.0–8.0)	**87LR**	=________
Angle (90°–270°)	**87LANG**	=________

Tapped-Load Coordinating Overcurrent Element Settings (If ETAP = Y)

Phase element (Y, N)	**ETP**	=________
Residual ground element (Y, N)	**ETG**	=________
Negative-sequence element (Y, N)	**ETQ**	=________

Tapped-Load Phase Time-Overcurrent Element Settings (If ETP = Y)

Pickup (OFF, 0.50–16.00 A secondary)	**T51PP**	=________
Curve (U1–U5; C1–C5)	**T51PC**	=________
Time dial		
0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5	**T51PTD**	=________
Electromechanical reset delay (Y, N)	**T51PRS**	=________

Tapped-Load Phase Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	**T50PP**	=________
Time delay (OFF, 0.00–16000.00 cycles)	**T50PD**	=________

Tapped-Load Residual-Ground Time-Overcurrent Element Settings (If ETG = Y)

Pickup (OFF, 0.50–16.00 A secondary)	**T51GP**	= ________
Curve (U1–U5; C1–C5)	**T51GC**	= ________
Time dial 0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5	**T51GTD**	= ________
Electromechanical reset delay (Y, N)	**T51GRS**	= ________

Tapped-Load Residual-Ground Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	**T50GP**	= ________
Time delay (OFF, 0.00–16000.00 cycles)	**T50GD**	= ________

Tapped-Load Negative-Sequence Time-Overcurrent Element Settings (If ETQ = Y)

Pickup (OFF, 0.50–16.00 A secondary)	**T51QP**	= ________
Curve (U1–U5; C1–C5)	**T51QC**	= ________
Time dial 0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5	**T51QTD**	= ________
Electromechanical reset delay (Y, N)	**T51QRS**	= ________

Tapped-Load Negative-Sequence Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	**T50QP**	= ________
Time delay (OFF, 0.00–16000.00 cycles)	**T50QD**	= ________

Backup Protection Transformer Ratio Settings

Polarizing (IPOL) Current Transformer Ratio (1–6000)	**CTRP**	= ________
Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00)	**PTR**	= ________
Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00)	**PTRS**	= ________

Line Parameter Settings (See Settings Explanations on page 9.34)

Positive-sequence line impedance magnitude 0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.}	**Z1MAG**	= ________
Positive-sequence line impedance angle (5.00–90.00 degrees)	**Z1ANG**	= ________

Zero-sequence line impedance magnitude

0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.}	**Z0MAG**	=________
Zero-sequence line impedance angle (5.00–90.00 degrees)	**Z0ANG**	=________
Line length (0.10–999.00, unitless)	**LL**	=________

Other Enable Settings

Loss-of-potential (Y, Y1, N) (see *Figure 4.35*)	**ELOP**	=________
Reclosures (N, 1–4) (see *Reclosing Relay on page 6.10*)	**E79**	=________
CCVT transient detection (Y, N) (see *Figure 4.37*)	**ECCVT**	=________
SELOGIC control equation Variable Timers (N, 1–16) (see *Figure 7.24* and *Figure 7.25*)	**ESV**	=________
SELOGIC Latch Bits (N, 1–16)	**ELAT**	=________
SELOGIC Display Points (N, 1–16)	**EDP**	=________

Mho Phase Distance Elements

Zone 1 (see *Figure 4.4*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z1P**	=________

Zone 2 (see *Figure 4.5*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z2P**	=________

Zone 3 (see *Figure 4.6*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z3P**	=________

Mho Ground Distance Elements

Zone 1 (see *Figure 4.7*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z1MG**	=________

Zone 2 (see *Figure 4.8*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z2MG**	=________

Zone 3 (see *Figure 4.9*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z3MG**	=________

Mho Phase Distance Element Time Delays (See Figure 4.15)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1PD**	=________
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2PD**	=________
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3PD**	=________

Quadrilateral and Mho Ground Distance Element Time Delays (See Figure 4.15)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1GD**	=________
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2GD**	=________
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3GD**	=________

Common Phase/Ground Distance Element Time Delay (See Figure 4.15)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1D**	=________
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2D**	=________
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3D**	=________

Phase Inst./Def.-Time Overcurrent Elements (See Figure 4.19)

Level 1

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50P1P**	=________

Phase Definite-Time Overcurrent Element Time Delays (See Figure 4.19)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps)	**67P1D**	=________

Residual-Ground Inst./Def.-Time Overcurrent Elements (See Figure 4.22)

Level 1

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50G1P**	=________

Residual-Ground Definite-Time Overcurrent Element Time Delay (See Figure 4.22)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps)	**67G1D**	=________

Residual-Ground Time-Overcurrent Element (See Figure 4.25)

Pickup

OFF, 0.25–16.00 A secondary {5 A nom.}; 0.05–3.20 A secondary {1 A nom.}	**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	**51GTD**	=________
Electromechanical Reset (Y, N)	**51GRS**	=________

Zone/Level 3 Directional Control

Zone/Level 3 direction: Forward, Reverse (F, R)	**DIR3**	=________

Reclosing Relay (See Table 6.2 and Table 6.4)

Make the following settings if preceding enable setting 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 6.2*)	**79CLSD**	=________

Switch-Onto-Fault (See Figure 5.7)

Make the following settings if preceding enable setting 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**	=________

Channel A MIRRORED BITS Settings

These settings are only available when you set a Serial Port Protocol Setting 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 only available when you set a Serial Port Protocol Setting 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**	= ________

Other Settings

Minimum trip duration time 2.00–16000.00 cycles in 0.25-cycle steps (see *Figure 5.1*)	**TDURD**	= ________
Close failure time delay OFF, 0.00–16000.00 cycles in 0.25-cycle steps (see *Figure 6.1*)	**CFD**	= ________

SELOGIC Control Equation Variable Timers (See Figure 7.24 and Figure 7.25)

Number of timer pickup/dropout settings dependent on preceding enable setting ESV = 1–16.

SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1PU**	= ________
SV1 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1DO**	= ________
SV2 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2PU**	= ________
SV2 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2DO**	= ________
SV3 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3PU**	= ________
SV3 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3DO**	= ________
SV4 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4PU**	= ________
SV4 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4DO**	= ________
SV5 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5PU**	= ________
SV5 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5DO**	= ________
SV6 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6PU**	= ________
SV6 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6DO**	= ________
SV7 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7PU**	= ________
SV7 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7DO**	= ________

SV8 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8PU**	=_________
SV8 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8DO**	=_________
SV9 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9PU**	=_________
SV9 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9DO**	=_________
SV10 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10PU**	=_________
SV10 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10DO**	=_________
SV11 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11PU**	=_________
SV11 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11DO**	=_________
SV12 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12PU**	=_________
SV12 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12DO**	=_________
SV13 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13PU**	=_________
SV13 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13DO**	=_________
SV14 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14PU**	=_________
SV14 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14DO**	=_________
SV15 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15PU**	=_________
SV15 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15DO**	=_________
SV16 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16PU**	=_________
SV16 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16DO**	=_________

SELOGIC Control Equation Settings

SELOGIC control equation settings consist of Relay Word bits (see Table 9.5 and Table 9.6) 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 through Section 8. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). Appendix I: Setting SELOGIC Control Equations gives SELOGIC control equation details, examples, and limitations.

Trip Logic Equations (See Figure 5.6)

Direct trip conditions	**TR**	=_________________________
Switch-onto-fault trip conditions	**TRSOTF**	=_________________________
Direct transfer trip conditions	**DTT**	=_________________________
Unlatch trip conditions	**ULTR**	=_________________________

Close Logic Equations (See Figure 6.1)

Circuit breaker status (used in *Figure 5.7*, also)	**52A**	=________________
Close conditions (other than automatic reclosing or **CLOSE** command)	**CL**	=________________
Unlatch close conditions	**ULCL**	=________________

Reclosing Relay Equations (See Reclosing Relay on page 6.10)

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 6.2*)	**79CLS**	=________________

Latch Bits Set/Reset Equations (See Figure 7.12)

Set Latch Bit LT1	**SET1**	=________________
Reset Latch Bit LT1	**RST1**	=________________
Set Latch Bit LT2	**SET2**	=________________
Reset Latch Bit LT2	**RST2**	=________________
Set Latch Bit LT3	**SET3**	=________________
Reset Latch Bit LT3	**RST3**	=________________
Set Latch Bit LT4	**SET4**	=________________
Reset Latch Bit LT4	**RST4**	=________________
Set Latch Bit LT5	**SET5**	=________________
Reset Latch Bit LT5	**RST5**	=________________
Set Latch Bit LT6	**SET6**	=________________
Reset latch Bit LT6	**RST6**	=________________
Set Latch Bit LT7	**SET7**	=________________
Reset Latch Bit LT7	**RST7**	=________________
Set Latch Bit LT8	**SET8**	=________________
Reset Latch Bit LT8	**RST8**	=________________

Set Latch Bit LT9	**SET9**	=________________
Reset Latch Bit LT9	**RST9**	=________________
Set Latch Bit LT10	**SET10**	=________________
Reset Latch Bit LT10	**RST10**	=________________
Set Latch Bit LT11	**SET11**	=________________
Reset Latch Bit LT11	**RST11**	=________________
Set Latch Bit LT12	**SET12**	=________________
Reset Latch Bit LT12	**RST12**	=________________
Set Latch Bit LT13	**SET13**	=________________
Reset Latch Bit LT13	**RST13**	=________________
Set Latch Bit LT14	**SET14**	=________________
Reset latch Bit LT14	**RST14**	=________________
Set Latch Bit LT15	**SET15**	=________________
Reset Latch Bit LT15	**RST15**	=________________
Set Latch Bit LT16	**SET16**	=________________
Reset Latch Bit LT16	**RST16**	=________________

Torque-Control Equations for Inst./Def.-Time Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Level 1 phase (see *Figure 4.19*)	**67P1TC**	=________________
Level 1 residual ground (see *Figure 4.22*)	**67G1TC**	=________________

Torque-Control Equations for Time-Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Residual ground element (see *Figure 4.25*)	**51GTC**	=________________

Torque-Control Equations for Tapped Load Time-Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Phase inverse time (see *Figure 3.21*)	**T51PTC**	=________________
Ground inverse time (see *Figure 3.22*)	**T51GTC**	=________________
Negative-sequence time (see *Figure 3.23*)	**T51QTC**	=________________

Torque-Control Equations for Tapped Load Inst./Def.-Time Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Phase instantaneous (see *Figure 3.18*)	**T50PTC**	=________________
Ground instantaneous (see *Figure 3.19*)	**T50GTC**	=________________
Negative-sequence instantaneous (see *Figure 3.20*)	**T50QTC**	=________________

87L Element Torque-Control Equation

Note: torque-control equation settings cannot be set directly to logical 0

87L torque control (see *Figure 3.15*)	**87LTC**	=________________

SELOGIC Control Equation Variable Timer Input Equations (See Figure 7.24 and Figure 7.25)

SELOGIC control equation Variable SV1	**SV1**	=________________
SELOGIC control equation Variable SV2	**SV2**	=________________
SELOGIC control equation Variable SV3	**SV3**	=________________
SELOGIC control equation Variable SV4	**SV4**	=________________
SELOGIC control equation Variable SV5	**SV5**	=________________
SELOGIC control equation Variable SV6	**SV6**	=________________
SELOGIC control equation Variable SV7	**SV7**	=________________
SELOGIC control equation Variable SV8	**SV8**	=________________
SELOGIC control equation Variable SV9	**SV9**	=________________
SELOGIC control equation Variable SV10	**SV10**	=________________
SELOGIC control equation Variable SV11	**SV11**	=________________
SELOGIC control equation Variable SV12	**SV12**	=________________
SELOGIC control equation Variable SV13	**SV13**	=________________
SELOGIC control equation Variable SV14	**SV14**	=________________
SELOGIC control equation Variable SV15	**SV15**	=________________
SELOGIC control equation Variable SV16	**SV16**	=________________

Output Contact Equations (See Figure 7.27)

Output Contact OUT101	**OUT101**	=________________
Output Contact OUT102	**OUT102**	=________________
Output Contact OUT103	**OUT103**	=________________

Output Contact **OUT104**	**OUT104**	=________________
Output Contact **OUT105**	**OUT105**	=________________
Output Contact **OUT106**	**OUT106**	=________________
Output Contact **OUT107**	**OUT107**	=________________

Output Contact Equations—Differential Board (See Figure 7.28)

Output Contact **OUT201**	**OUT201**	=________________
Output Contact **OUT202**	**OUT202**	=________________
Output Contact **OUT203**	**OUT203**	=________________
Output Contact **OUT204**	**OUT204**	=________________
Output Contact **OUT205**	**OUT205**	=________________
Output Contact **OUT206**	**OUT206**	=________________

Output Contact Equations—Extra I/O Board

Output Contact **OUT301**	**OUT301**	=________________
Output Contact **OUT302**	**OUT302**	=________________
Output Contact **OUT303**	**OUT303**	=________________
Output Contact **OUT304**	**OUT304**	=________________
Output Contact **OUT305**	**OUT305**	=________________
Output Contact **OUT306**	**OUT306**	=________________
Output Contact **OUT307**	**OUT307**	=________________
Output Contact **OUT308**	**OUT308**	=________________
Output Contact **OUT309**	**OUT309**	=________________
Output Contact **OUT310**	**OUT310**	=________________
Output Contact **OUT311**	**OUT311**	=________________
Output Contact **OUT312**	**OUT312**	=________________

Display Point Equations

(See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

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 7.5)

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*)	**ER**	=________________
Fault indication (used in time target logic—see *Table 5.1*; used also to suspend demand metering updating and peak recording and block max./min. metering—see *Local Demand Metering* and *Local Maximum/Minimum Metering on page 8.11*)	**FAULT**	=________________
Block synchronism-check elements (see *Figure 4.30*)	**BSYNCH**	=________________
Close bus monitor (see *Figure 5.7*)	**CLMON**	=________________
Breaker monitor initiation (see *Figure 8.9*)	**BKMON**	=________________
Enable bus stub protection	**ESTUB**	=________________

MIRRORED BITS Transmit Equations (See Appendix E)

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**	=______________

87L Transmit Bit Equations

Channel X, transmit bit 1	**T1X**	=______________
Channel X, transmit bit 2	**T2X**	=______________
Channel X, transmit bit 3	**T3X**	=______________
Channel X, transmit bit 4	**T4X**	=______________
Channel Y, transmit bit 1	**T1Y**	=______________
Channel Y, transmit bit 2	**T2Y**	=______________
Channel Y, transmit bit 3	**T3Y**	=______________
Channel Y, transmit bit 4	**T4Y**	=______________

Global Settings

Settings Group Change Delay (See Multiple Setting Groups on page 7.17)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps)	**TGR**	=__________

Power System Configuration and Date Format (See Settings Explanations on page 9.34)

Nominal frequency (50 Hz, 60 Hz)	**NFREQ**	=__________
Phase rotation (ABC, ACB)	**PHROT**	=__________
Date format (MDY, YMD)	**DATE_F**	=__________

Front-Panel Display Operation (See Section 11)

Front-panel display time-out 0.00–30.00 minutes in 0.01-minute steps	**FP_TO**	=__________

(If FP_TO = 0, no time-out occurs and display remains on last display screen, e.g., continually display metering.)

Front-panel display update rate (1–60 seconds)	**SCROLD**	=__________

Event Report Parameters (See Section 12)

Length of event report (15, 30, 60 cycles)	**LER**	=__________
Length of pre-fault in event report (1–14 cycles in 1-cycle steps for LER = 15) (1–29 cycles in 1-cycle steps for LER = 30) (1–59 cycles in 1-cycle steps for LER = 60)	**PRE**	=__________

Station DC Battery Monitor (See Figure 8.15 and Figure 8.16)

DC battery instantaneous undervoltage pickup OFF, 20–300 Vdc	**DCLOP**	=__________
DC battery instantaneous overvoltage pickup OFF, 20–300 Vdc	**DCHIP**	=__________

Optoisolated Input Timers

Input IN101 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN101D**	=__________
Input IN102 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN102D**	=__________
Input IN103 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN103D**	=__________
Input IN104 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN104D**	=__________

Input IN105 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN105D**	=__________
Input IN106 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN106D**	=__________
Input IN301 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN301D**	=__________
Input IN302 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN302D**	=__________
Input IN303 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN303D**	=__________
Input IN304 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN304D**	=__________
Input IN305 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN305D**	=__________
Input IN306 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN306D**	=__________
Input IN307 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN307D**	=__________
Input IN308 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN308D**	=__________

Breaker Monitor Settings (See Breaker Monitor on page 8.12)

Breaker monitor enable (Y, N)	**EBMON**	=__________

Make the following settings if preceding enable setting 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 in 0.01 kA steps	**KASP1**	=__________
kA Interrupted set point 2—mid. 0.00–999.00 kA primary in 0.01 kA steps	**KASP2**	=__________
kA Interrupted set point 3—max. 0.00–999.00 kA primary in 0.01 kA steps	**KASP3**	=__________

Synchronized Phasor Settings (See Appendix H: SEL Synchrophasors)

Synchronized Phasor Measurement (Y, N)	**EPMU**	=__________________________

Make the following settings if preceding enable setting EPMU = Y.

PMU Hardware ID	**PMID**	=__________________________
Phasor Data Set, Voltages (V1, ALL)	**PHDATAV**	=__________________________
Voltage Angle Comp. Factor (–179.99 to +180 degrees)	**VCOMP**	=__________________________
Phasor Data Set, Currents (ALL, NA)	**PHDATAI**	=__________________________

Current Angle Comp. Factor (–179.99 to +180 degrees)	**ICOMP**	= ____________
Time Source Type (IRIG, IEEE)	**TS_TYPE**	= ____________

Sequential Events Recorder Settings

Sequential Events Recorder settings are composed of three trigger lists. Each trigger list can include as many as 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See Sequential Events Recorder Report on page 12.36.

SER Trigger List 1
SER1 = ____________

SER Trigger List 2
SER2 = ____________

SER Trigger List 3
SER3 = ____________

Test Label Settings

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 (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

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

Display if DP8 = logical 1 (16 characters)	**DP8_1**	=________________
Display if DP8 = logical 0 (16 characters)	**DP8_0**	=________________
Display if DP9 = logical 1 (16 characters)	**DP9_1**	=________________
Display if DP9 = logical 0 (16 characters)	**DP9_0**	=________________
Display if DP10 = logical 1 (16 characters)	**DP10_1**	=________________
Display if DP10 = logical 0 (16 characters)	**DP10_0**	=________________
Display if DP11 = logical 1 (16 characters)	**DP11_1**	=________________
Display if DP11 = logical 0 (16 characters)	**DP11_0**	=________________
Display if DP12 = logical 1 (16 characters)	**DP12_1**	=________________
Display if DP12 = logical 0 (16 characters)	**DP12_0**	=________________
Display if DP13 = logical 1 (16 characters)	**DP13_1**	=________________
Display if DP13 = logical 0 (16 characters)	**DP13_0**	=________________
Display if DP14 = logical 1 (16 characters)	**DP14_1**	=________________
Display if DP14 = logical 0 (16 characters)	**DP14_0**	=________________
Display if DP15 = logical 1 (16 characters)	**DP15_1**	=________________
Display if DP15= logical 0 (16 characters)	**DP15_0**	=________________
Display if DP16= logical 1 (16 characters)	**DP16_1**	=________________
Display if DP16= logical 0 (16 characters)	**DP16_0**	=________________

Reclosing Relay Labels (See Functions Unique to the Front-Panel Interface on page 11.5)

Reclosing Relay Last Shot Label (14 char.)	**79LL**	=________________
Reclosing Relay Shot Counter Label (14 char.)	**79SL**	=________________

Port Settings

Protocol Settings (See Below)

Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B, MBGA, MBGB, TELNET)	**PROTO**	=________________

Protocol Settings Set PROTO = SEL for standard SEL ASCII protocol. For SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD. Refer to Appendix C for details on the LMD protocol. For Distributed Network Protocol (DNP), set PROTO = DNP. Refer to Appendix F for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, MB8B, MBGA, or MBGB. Refer to Appendix E for details on MIRRORED BITS. To enable Telnet-to-relay communications on **PORT 5** and **PORT6**, the **PORT 1** PROTO setting must be set to TELNET. Setting PROTO = TELNET disables **PORT 1** for EIA-485 communications.

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) *(38400 is not available on Port 1)*	**SPEED**	=________________
Data Bits (6, 7, 8) *This setting is available when PROTO = SEL or LMD.*	**BITS**	=________________
Parity (O, E, N) {Odd, Even, None} *This setting is available when PROTO = SEL or LMD.*	**PARITY**	=________________
Stop Bits (1, 2) *This setting is available when PROTO = SEL or LMD.*	**STOP**	=________________
Time-out (0–30 minutes) *This setting is available when PROTO = SEL or LMD. 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.*	**T_OUT**	=________________
DTA Meter Format (Y, N) *Set DTA = Y to allow an SEL DTA or SEL DTA2 to communicate with the relay. This setting is available when PROTO = SEL or LMD. Note that when DTA = Y, the date format must be set to MDY in the Global setting DATE_F.*	**DTA**	=________________
Send Auto Messages to Port (Y, N) *This setting is available when PROTO = SEL or LMD. Set AUTO = Y to allow automatic messages at the serial port.*	**AUTO**	=________________
Enable Hardware Handshaking (Y, N, MBT) *MBT is available when PROTO = MBA or MBB. (Refer to* ***Mirrored Bits Protocol for the Pulsar 9600 Baud Modem on page E.5*** *for details on setting MBT.) Set RTSCTS = Y to enable hardware handshaking. With RTSCTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line. Setting RTSCTS is not applicable to serial Port 1 (EIA-485) or a port configured for SEL Distributed Port Switch Protocol.*	**RTSCTS**	=________________
Fast Operate Enable (Y, N) *This setting is available when PROTO = SEL or LMD. 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 D: SEL Communications Processors*** *for the description of the SEL-311L Relay Fast Operate commands. When PROTO = TELNET, FASTOP is set to Y and is hidden.*	**FASTOP**	=________________

LMD Settings

LMD Prefix (@, #, $, %, &)	**PREFIX**	=________________
LMD Address (1–99)	**ADDR**	=________________
LMD Settling Time (0–30 seconds)	**SETTLE**	=________________

TELNET Settings (PORT 1 only)

Telnet Port for Relay Access (1–65534)	**TPORT**	=________________
Telnet Port Timeout (1–30 min)	**TIDLE**	=________________

Ethernet Port Settings (PORT 5 and PORT 6 only)

IP Address (xxx.xxx.xxx.xxx)	**IPADDR**	=
Subnet Mask (xxx.xxx.xxx.xxx)	**SUBNETM**	=
Default Router (xxx.xxx.xxx.xxx)	**DEFRTR**	=
Enable TCP Keep-Alive (Y, N)	**ETCPKA**	=
TCP Keep-Alive Idle Range (1–20 s) *If ETCPKA = Y*	**KAIDLE**	=
TCP Keep-Alive Interval Range (1–20 s) *If ETCPKA = Y*	**KAINTV**	=
TCP Keep-Alive Count Range (1–20 s) *If ETCPKA = Y*	**KACNT**	=
Operating Mode (FIXED, FAILOVER)	**NETMODE**	=
Failover Time-out (OFF, 0.1–65.00 sec) *If NETMODE = FAILOVER*	**FTIME**	=
Enable Telnet (Y, N)	**ETELNET**	=
Telnet Port for Card Access (1–65534) *If ETELNET = Y*	**TPORTC**	=
Telnet Port Timeout (1–30 min) *If ETELNET = Y*	**TIDLE**	=
Enable FTP Server (Y, N) *If ETELNET = Y*	**EFTPSERV**	=
FTP Username (20 characters) *If EFTPSERV = Y*	**FTPUSER**	=
FTP Connect Banner *If EFTPSERV = Y*	**FTPCBAN**	=
FTP Idle Timeout (5–255 minutes) *If EFTPSERV = Y*	**FTPIDLE**	=
Enable HTTP Server (Y, N)	**EHTTP**	=
HTTP TCP/IP Port (1–65535) *If EHTTP = Y*	**HTTPPORT**	=
HTTP Web Server Timeout (1–30 minutes) *If EHTTP = Y*	**HTTPIDLE**	=
Enable IEC 61850 Protocol (Y, N) *If IEC 61850 is available*	**E61850**	=
Enable IEC 61850 GSE (Y, N) *If IEC 61850 is available*	**EGSE**	=

DNP Settings

DNP Address (0–65534)	**DNPADR**	=
Class for event data (0 for no event, 1–3)	**ECLASS**	=
Time-set request interval, minutes (0 for never, 1–32767)	**TIMERQ**	=
Currents scaling (0–3 decimal places)	**DECPLA**	=
Voltages scaling (0–3 decimal places)	**DECPLV**	=
Miscellaneous data scaling (0–3 decimal places)	**DECPLM**	=
Select/Operate time-out interval, seconds (0.0–30.0)	**STIMEO**	=
Number of data-link retries (0 for no confirm, 1–15)	**DRETRY**	=

Data Link Time-out interval, seconds (0–5)	**DTIMEO**	= ____________
Minimum Delay from DCD to transmission, seconds (0.00–1.00)	**MINDLY**	= ____________
Maximum Delay from DCD to transmission, seconds (0.00–1.00)	**MAXDLY**	= ____________
Transmission delay from RTS assertion, seconds (OFF, 0.00–30.00)	**PREDLY**	= ____________
Post-transmit RTS deassertion delay, seconds (0.00–30.00)	**PSTDLY**	= ____________
Analog reporting deadband, counts (0–32767)	**ANADB**	= ____________
Allow Unsolicited Reporting (Y/N)	**UNSOL**	= ____________
Enable unsolicited messages when the relay turns on (Y/N)	**PUNSOL**	= ____________
Address of master to Report to (0–65534)	**REPADR**	= ____________
Number of events to transmit on (1–200)	**NUMEVE**	= ____________
Age of oldest event to force transmit on, seconds (0.0–60.0)	**AGEEVE**	= ____________
Time-out for confirmation of unsolicited message, seconds (0–50)	**UTIMEO**	= ____________

MB Settings

PPM MIRRORED BITS Channel Bad Pickup (1–10000)	**CBADPU**	= ____________
MIRRORED BITS Receive Identifier (1–4) *This setting is unavailable if PROTO is set to MBGA or MBGB.*	**RXID**	= ____________
MIRRORED BITS Transmit Identifier (1–4) *This setting is unavailable if PROTO is set to MBGA or MBGB.*	**TXID**	= ____________
MIRRORED BITS Receive Default State (string of 1s, 0s or Xs) 87654321	**RXDFLT**	= ____________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB1PU**	= ____________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB1DO**	= ____________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB2PU**	= ____________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB2DO**	= ____________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB3PU**	= ____________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB3DO**	= ____________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB4PU**	= ____________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB4DO**	= ____________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB5PU**	= ____________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB5DO**	= ____________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB6PU**	= ____________

MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB6DO**	=
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB7PU**	=
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB7DO**	=
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB8PU**	=
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB8DO**	=

Channel Settings

87L Channel X Configuration Settings

Channel X address check (Y, G, N)	**EADDCX**	=
If EADDCX = Y		
Channel X transmit address (1–16) *This setting is unavailable if EADDCX is set to G.*	**TA_X**	=
Channel X receive address (1–16) *This setting is unavailable if EADDCX is set to G.*	**RA_X**	=
Continuous dropout alarm (1–1000 seconds)	**RBADXP**	=
Packets lost in last 10,000 (1–5000)	**AVAXP**	=
One-way channel delay alarm (1–24 ms)	**DBADXP**	=
If CHANX type is EIA-422		
EIA-422 receive clock edge detect (R = Rising; F = Falling)	**RC422X**	=
EIA-422 transmit clock edge detect (R = Rising; F = Falling)	**TC422X**	=
If CHANX type is not EIA-422		
Timing source (I = Internal; E = External)	**TIMRX**	=

87L Channel Y Configuration Settings

Channel Y address check (Y, G, N)	**EADDCY**	=
If EADDCY = Y		
Channel Y transmit address (1–16) *This setting is unavailable if EADDCY is set to G.*	**TA_Y**	=
Channel Y receive address (1–16) *This setting is unavailable if EADDCY is set to G.*	**RA_Y**	=
Continuous dropout alarm (1–1000 seconds)	**RBADYP**	=
Packets lost in last 10,000 (1–5000)	**AVAYP**	=
One-way channel delay alarm (1–24 ms)	**DBADYP**	=
If CHANY type is EIA-422		
EIA-422 receive clock edge detect (R = Rising; F = Falling)	**RC422Y**	=
EIA-422 transmit clock edge detect (R = Rising; F = Falling)	**TC422Y**	=

If CHANY type is not EIA-422

Timing source (I = Internal; E = External) **TIMRY** =________

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SEL-311L Settings Sheets (APP = 87L21P)

Relay Settings

Identifier Labels and Configuration Settings (See Settings Explanations on page 9.34)

Relay Identifier (30 characters)

RID = ____________________

Terminal Identifier (30 characters)

TID = ____________________

Local Phase (IA, IB, IC) Current Transformer Ratio (1–6000)	**CTR**	= ________
Application (87L, 87L21, 87L21P, 87LSP, 311L)	**APP**	= 87L21P

Line Current Differential Configuration Settings

If the relay has two channels, the following choices are available:		
Relay operating mode (2, 3, 3R, N)		
If the relay has one channel, the following choices are available:		
Relay operating mode (2, 3R, N)	**E87L**	= ________
If E87L ≠ N, the following choices are available:		
High-speed tripping (1–6, N)	**EHST**	= ________
If 87L = 2 or 3, the following choices are available:		
Enable high-speed direct transfer trip (Y, N)	**EHSDTT**	= ________
Enable delta current detect (Y, N)	**EDD**	= ________
Tapped-load coordination (Y, N)	**ETAP**	= ________
If the relay has two channels and E87L = 2:		
Enable Open CT Logic (Y, N)	**EOCTL**	= ________
If the relay has two channels and E87L = 2 or 3R:		
Primary channel (X, Y)	**PCHAN**	= ________
If the relay has two channels and E87L = 2:		
Hot-standby channel feature (Y, N)	**EHSC**	= ________
If PCHAN = X or EHSC = Y or E87L = 3:		
CTR at terminal connected to Channel X (1–6000)	**CTR_X**	= ________
If EADDCX = G:		
Channel X transmits address (1–16)	**TA_X**	= ________
Channel X receive address (1–16)	**RA_X**	= ________

If PCHAN = Y or EHSC = Y or E87L = 3:

CTR at terminal connected to Channel Y (1–6000)	**CTR_Y**	=__________

If EADDCY = G:

Channel Y transmit address (1–16)	**TA_Y**	=__________
Channel Y receive address (1–16)	**RA_Y**	=__________

Minimum Difference Current Enable Level Settings (E87L = 2 or 3)

Phase 87L (OFF, 1.00–10.00 A secondary)	**87LPP**	=__________
$3I_2$ Negative-sequence 87L (OFF, 0.50–5.00 A secondary)	**87L2P**	=__________
Ground 87L (OFF, 0.50–5.00 A secondary)	**87LGP**	=__________
Phase difference current alarm pickup (0.50–10.00 A secondary)	**CTALRM**	=__________

Restraint Region Characteristic Settings (E87L = 2 or 3)

Outer Radius (2.0–8.0)	**87LR**	=__________
Angle (90°–270°)	**87LANG**	=__________

Tapped-Load Coordinating Overcurrent Element Settings (If ETAP = Y)

Phase element (Y, N)	**ETP**	=__________
Residual ground element (Y, N)	**ETG**	=__________
Negative-sequence element (Y, N)	**ETQ**	=__________

Tapped-Load Phase Time-Overcurrent Element Settings (If ETP = Y)

Pickup (OFF, 0.50–16.00 A secondary)	**T51PP**	=__________
Curve (U1–U5; C1–C5)	**T51PC**	=__________
Time Dial		
0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5	**T51PTD**	=__________
Electromechanical reset delay (Y, N)	**T51PRS**	=__________

Tapped-Load Phase Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	**T50PP**	=__________
Time delay (OFF, 0.00–16000.00 cycles)	**T50PD**	=__________

Tapped-Load Residual-Ground Time-Overcurrent Element Settings (If ETG = Y)

Pickup (OFF, 0.50–16.00 A secondary)	**T51GP**	=__________
Curve (U1–U5; C1–C5)	**T51GC**	=__________

Time dial		
0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5	**T51GTD**	= ________
Electromechanical reset delay (Y, N)	**T51GRS**	= ________

Tapped-Load Residual-Ground Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	**T50GP**	= ________
Time delay (OFF, 0.00–16000.00 cycles)	**T50GD**	= ________

Tapped-Load Negative-Sequence Time-Overcurrent Element Settings (If ETQ = Y)

Pickup (OFF, 0.50–16.00 A secondary)	**T51QP**	= ________
Curve (U1–U5; C1–C5)	**T51QC**	= ________
Time Dial		
0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5	**T51QTD**	= ________
Electromechanical reset delay (Y, N)	**T51QRS**	= ________

Tapped-Load Negative-Sequence Inst./Def.-Time Overcurrent Element Settings

Pickup (OFF, 0.50–16.00 A secondary)	**T50QP**	= ________
Time Delay (OFF, 0.00–16000.00 cycles)	**T50QD**	= ________

Backup Protection Transformer Ratio Settings

Polarizing (IPOL) Current Transformer Ratio (1–6000)	**CTRP**	= ________
Phase (VA, VB, VC)		
Potential Transformer Ratio (1.00–10000.00)	**PTR**	= ________
Synchronism Voltage (VS)		
Potential Transformer Ratio (1.00–10000.00)	**PTRS**	= ________

Line Parameter Settings (See Settings Explanations on page 9.34)

Positive-sequence line impedance magnitude		
0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.}	**Z1MAG**	= ________
Positive-sequence line impedance angle (5.00–90.00 degrees)	**Z1ANG**	= ________
Zero-sequence line impedance magnitude		
0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.}	**Z0MAG**	= ________

Zero-sequence line impedance angle (5.00–90.00 degrees)	**Z0ANG**	=________
Line length (0.10–999.00, unitless)	**LL**	=________

Other Enable Settings

Loss-of-potential (Y, Y1, N) (see *Figure 4.35*)	**ELOP**	=________
Enable busbar PT LOP logic (Y, N) (see *Setting EBBPT = Y on page 4.61*)	**EBBPT**	=________
Communications-assisted trip scheme (N, DCB, POTT, DCUB1, DCUB2) (see *Communications-Assisted Trip Logic—General Overview on page 5.18*)	**ECOMM**	=________
Reclosures (N, 1–4) (see *Reclosing Relay on page 6.10*)	**E79**	=________
CCVT transient detection (Y, N) (see *Figure 4.37*)	**ECCVT**	=________
SELOGIC control equation Variable Timers (N, 1–16) (see *Figure 7.24* and *Figure 7.25*)	**ESV**	=________
SELOGIC Latch Bits (N, 1–16)	**ELAT**	=________
SELOGIC Display Points (N, 1–16)	**EDP**	=________

Mho Phase Distance Elements

Zone 1 (see *Figure 4.4*)		
OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z1P**	=________
Zone 2 (see *Figure 4.5*)		
OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z2P**	=________
Zone 3 (see *Figure 4.6*)		
OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z3P**	=________
Zone 4 (see *Figure 4.6*)		
OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.})	**Z4P**	=________

Mho Ground Distance Elements

Zone 1 (see *Figure 4.7*)		
OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z1MG**	=________
Zone 2 (see *Figure 4.8*)		
OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z2MG**	=________

Zone 3 (see *Figure 4.9*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z3MG**	=________

Zone 4 (see *Figure 4.9*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**Z4MG**	=________

Mho Phase Distance Element Time Delays (See Figure 4.15)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1PD**	=________
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2PD**	=________
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3PD**	=________
Zone 4 time delay (OFF, 0.00–16000.00 cycles)	**Z4PD**	=________

Quadrilateral and Mho Ground Distance Element Time Delays (See Figure 4.15)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1GD**	=________
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2GD**	=________
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3GD**	=________
Zone 4 time delay (OFF, 0.00–16000.00 cycles)	**Z4GD**	=________

Common Phase/Ground Distance Element Time Delay (See Figure 4.15)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1D**	=________
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2D**	=________
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3D**	=________
Zone 4 time delay (OFF, 0.00–16000.00 cycles)	**Z4D**	=________

Phase Inst./Def.-Time Overcurrent Elements (See Figure 4.19)

Level 1

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50P1P**	=________

Phase Definite-Time Overcurrent Element Time Delays (See Figure 4.19)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps)	**67P1D**	=________

Residual-Ground Inst./Def.-Time Overcurrent Elements (See Figure 4.22)

Level 1

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50G1P**	=________

Level 2

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50G2P**	=________

Level 3

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50G3P**	=________

Residual-Ground Definite-Time Overcurrent Element Time Delay (See Figure 4.22)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps)	**67G1D**	=________
Level 2 (0.00–16000.00 cycles in 0.25-cycle steps)	**67G2D**	=________
Level 3 (0.00–16000.00 cycles in 0.25-cycle steps)	**67G3D**	=________

Residual-Ground Time-Overcurrent Element (See Figure 4.25)

Pickup

OFF, 0.25–16.00 A secondary {5 A nom.}; 0.05–3.20 A secondary {1 A nom.}	**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	**51GTD**	=________
Electromechanical Reset (Y, N)	**51GRS**	=________

Zone/Level 3 and 4 Directional Control

Zone/Level 3 direction: Forward, Reverse (F, R)	**DIR3**	=________
Zone/Level 4 direction: Forward, Reverse (F, R)	**DIR4**	=________

Reclosing Relay (See Table 6.2 and Table 6.4)

Make the following settings if preceding enable setting 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 **79CLSD** = ________
(set 79CLSD = 0.00 for most applications; see *Figure 6.2*)

Switch-Onto-Fault (See Figure 5.6)

Make the following settings if preceding enable setting 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 5.10)

Make the following settings if preceding enable setting ECOMM = POTT, DCUB1, or DCUB2.

Zone (level) 3 reverse block time delay

0.00–16000.00 cycles in 0.25-cycle steps **Z3RBD** = ________

Echo block time delay

OFF, 0.00–16000.00 cycles in 0.25-cycle steps **EBLKD** = ________

Echo time delay pickup

OFF, 0.00–16000.00 cycles in 0.25-cycle steps **ETDPU** = ________

Echo duration time delay

0.00–16000.00 cycles in 0.25-cycle steps **EDURD** = ________

Weak-infeed enable (Y, N) **EWFC** = ________

WIF phase-to-phase undervoltage (0.0–260.0 V secondary) **27PPW** = ________

WIF zero-sequence (3V0) overvoltage (0.0–150.0 V secondary) **59NW** = ________

Additional DCUB Trip Scheme Settings (See Figure 5.14)

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 5.18)

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 only available when you set a Serial Port Protocol Setting 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 only available when you set a Serial Port Protocol Setting 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**	=

Other Settings

Minimum trip duration time

2.00–16000.00 cycles in 0.25-cycle steps (see *Figure 5.6*)	**TDURD**	= ________

Close failure time delay

OFF, 0.00–16000.00 cycles in 0.25-cycle steps (see *Figure 6.1*)	**CFD**	= ________

SELOGIC Control Equation Variable Timers (See Figure 7.24 and Figure 7.25)

Number of timer pickup/dropout settings dependent on preceding enable setting ESV = 1–16.

SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1PU**	= ________
SV1 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1DO**	= ________
SV2 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2PU**	= ________
SV2 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2DO**	= ________
SV3 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3PU**	= ________
SV3 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3DO**	= ________
SV4 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4PU**	= ________
SV4 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4DO**	= ________
SV5 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5PU**	= ________
SV5 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5DO**	= ________
SV6 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6PU**	= ________
SV6 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6DO**	= ________
SV7 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7PU**	= ________
SV7 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7DO**	= ________
SV8 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8PU**	= ________
SV8 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8DO**	= ________
SV9 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9PU**	= ________
SV9 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9DO**	= ________
SV10 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10PU**	= ________
SV10 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10DO**	= ________
SV11 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11PU**	= ________
SV11 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11DO**	= ________
SV12 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12PU**	= ________
SV12 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12DO**	= ________
SV13 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13PU**	= ________

SV13 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13DO**	=________
SV14 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14PU**	=________
SV14 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14DO**	=________
SV15 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15PU**	=________
SV15 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15DO**	=________
SV16 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16PU**	=________
SV16 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16DO**	=________

SELOGIC Control Equation Settings

SELOGIC control equation settings consist of Relay Word bits (see Tables 9.3 and 9.4) 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 through Section 8. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). Appendix I: Setting SELOGIC Control Equations gives SELOGIC control equation details, examples, and limitations.

Trip Logic Equations (See Figure 5.6)

Direct trip conditions	**TR**	=____________________
Communications-assisted trip conditions	**TRCOMM**	=____________________
Switch-onto-fault trip conditions	**TRSOTF**	=____________________
Direct transfer trip conditions	**DTT**	=____________________
Unlatch trip conditions	**ULTR**	=____________________

Communications-Assisted Trip Scheme Input Equations

Permissive trip 1 (used for ECOMM = POTT, DCUB1, or DCUB2; see *Figure 5.9*, *Figure 5.11*, and *Figure 5.14*)	**PT1**	=____________________
Loss-of-guard 1 (used for ECOMM = DCUB1 or DCUB2; see *Figure 5.14*)	**LOG1**	=____________________
Permissive trip 2 (used for ECOMM = DCUB2; see *Figure 5.9* and *Figure 5.14*)	**PT2**	=____________________
Loss of guard 2 (used for ECOMM = DCUB2; see *Figure 5.14*)	**LOG2**	=____________________
Block trip (used for ECOMM = DCB; see *Figure 5.18*)	**BT**	=____________________

Close Logic Equations (See Figure 6.1)

Circuit breaker status (used in *Figure 5.7*, also)	**52A**	=____________________

Close conditions (other than automatic reclosing or **CLOSE** command)	**CL**	= ______________
Unlatch close conditions	**ULCL**	= ______________

Reclosing Relay Equations (See Reclosing Relay on page 6.10)

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 6.2*)	**79CLS**	= ______________

Latch Bits Set/Reset Equations (See Figure 7.12)

Set Latch Bit LT1	**SET1**	= ______________
Reset Latch Bit LT1	**RST1**	= ______________
Set Latch Bit LT2	**SET2**	= ______________
Reset Latch Bit LT2	**RST2**	= ______________
Set Latch Bit LT3	**SET3**	= ______________
Reset Latch Bit LT3	**RST3**	= ______________
Set Latch Bit LT4	**SET4**	= ______________
Reset Latch Bit LT4	**RST4**	= ______________
Set Latch Bit LT5	**SET5**	= ______________
Reset Latch Bit LT5	**RST5**	= ______________
Set Latch Bit LT6	**SET6**	= ______________
Reset latch Bit LT6	**RST6**	= ______________
Set Latch Bit LT7	**SET7**	= ______________
Reset Latch Bit LT7	**RST7**	= ______________
Set Latch Bit LT8	**SET8**	= ______________
Reset Latch Bit LT8	**RST8**	= ______________
Set Latch Bit LT9	**SET9**	= ______________
Reset Latch Bit LT9	**RST9**	= ______________

Set Latch Bit LT10	**SET10**	=________________
Reset Latch Bit LT10	**RST10**	=________________
Set Latch Bit LT11	**SET11**	=________________
Reset Latch Bit LT11	**RST11**	=________________
Set Latch Bit LT12	**SET12**	=________________
Reset Latch Bit LT12	**RST12**	=________________
Set Latch Bit LT13	**SET13**	=________________
Reset Latch Bit LT13	**RST13**	=________________
Set Latch Bit LT14	**SET14**	=________________
Reset latch Bit LT14	**RST14**	=________________
Set Latch Bit LT15	**SET15**	=________________
Reset Latch Bit LT15	**RST15**	=________________
Set Latch Bit LT16	**SET16**	=________________
Reset Latch Bit LT16	**RST16**	=________________

Torque-Control Equations for Inst./Def.-Time Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Level 1 phase (see *Figure 4.19*)	**67P1TC**	=________________
Level 1 residual ground (see *Figure 4.22*)	**67G1TC**	=________________
Level 2 residual ground (see *Figure 4.22*)	**67G2TC**	=________________
Level 3 residual ground (see *Figure 4.22*)	**67G3TC**	=________________

Torque-Control Equations for Time-Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Residual ground element (see *Figure 4.25*)	**51GTC**	=________________

Torque-Control Equations for Tapped Load Time-Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Phase inverse time (see *Figure 3.21*)	**T51PTC**	=________________
Ground inverse time (see *Figure 3.22*)	**T51GTC**	=________________
Negative-sequence time (see *Figure 3.23*)	**T51QTC**	=________________

87L Element Torque-Control Equation

Note: torque-control equation settings cannot be set directly to logical 0

87L torque control (see *Figure 3.15*)	**87LTC**	=________________

Torque-Control Equations for Tapped Load Inst./Def.-Time Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Phase instantaneous (see *Figure 3.18*)	**T50PTC**	= ____________
Ground instantaneous (see *Figure 3.19*)	**T50GTC**	= ____________
Negative-sequence instantaneous (see *Figure 3.20*)	**T50QTC**	= ____________

87L Element Torque-Control Equation

Note: torque-control equation settings cannot be set directly to logical 0

87L torque control (see *Figure 3.14*)	**87LTC**	= ____________

SELOGIC Control Equation Variable Timer Input Equations (See Figure 7.24 and Figure 7.25)

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

Output Contact Equations (See Figure 7.27)

Output Contact OUT101	**OUT101**	= ____________
Output Contact OUT102	**OUT102**	= ____________
Output Contact OUT103	**OUT103**	= ____________

Output Contact OUT104	**OUT104**	=	______________
Output Contact OUT105	**OUT105**	=	______________
Output Contact OUT106	**OUT106**	=	______________
Output Contact OUT107	**OUT107**	=	______________

Output Contact Equations—Differential Board (See Figure 7.28)

Output Contact OUT201	**OUT201**	=	______________
Output Contact OUT202	**OUT202**	=	______________
Output Contact OUT203	**OUT203**	=	______________
Output Contact OUT204	**OUT204**	=	______________
Output Contact OUT205	**OUT205**	=	______________
Output Contact OUT206	**OUT206**	=	______________

Output Contact Equations—Extra I/O Board

Output Contact OUT301	**OUT301**	=	______________
Output Contact OUT302	**OUT302**	=	______________
Output Contact OUT303	**OUT303**	=	______________
Output Contact OUT304	**OUT304**	=	______________
Output Contact OUT305	**OUT305**	=	______________
Output Contact OUT306	**OUT306**	=	______________
Output Contact OUT307	**OUT307**	=	______________
Output Contact OUT308	**OUT308**	=	______________
Output Contact OUT309	**OUT309**	=	______________
Output Contact OUT310	**OUT310**	=	______________
Output Contact OUT311	**OUT311**	=	______________
Output Contact OUT312	**OUT312**	=	______________

Display Point Equations (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

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 7.5)

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*)	**ER**	=________________
Fault indication (used in time target logic—see *Table 5.1*; used also to suspend demand metering updating and peak recording and block max./min. metering—see *Local Demand Metering on page 8.3* and *Local Maximum/Minimum Metering on page 8.11*)	**FAULT**	=________________
Block synchronism-check elements (see *Figure 4.30*)	**BSYNCH**	=________________
Close bus monitor (see *Figure 5.7*)	**CLMON**	=________________
Breaker monitor initiation (see *Figure 8.9*)	**BKMON**	=________________
Enable bus stub protection	**ESTUB**	=________________

MIRRORED BITS Transmit Equations (See Appendix E: MIRRORED BITS Communications)

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**	=________________

87L Transmit Bit Equations

Channel X, transmit bit 1	**T1X**	=________________
Channel X, transmit bit 2	**T2X**	=________________
Channel X, transmit bit 3	**T3X**	=________________
Channel X, transmit bit 4	**T4X**	=________________
Channel Y, transmit bit 1	**T1Y**	=________________
Channel Y, transmit bit 2	**T2Y**	=________________
Channel Y, transmit bit 3	**T3Y**	=________________
Channel Y, transmit bit 4	**T4Y**	=________________

Global Settings

Settings Group Change Delay (See Multiple Setting Groups on page 7.17)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps)	**TGR**	=________

Power System Configuration and Date Format (See Settings Explanations on page 9.34)

Nominal frequency (50 Hz, 60 Hz)	**NFREQ**	=________
Phase rotation (ABC, ACB)	**PHROT**	=________
Date format (MDY, YMD)	**DATE_F**	=________

Front-Panel Display Operation (See Section 11: Front-Panel Operations)

Front-panel display time-out

0.00–30.00 minutes in 0.01-minute steps	**FP_TO**	=________

(If FP_TO = 0, no time-out occurs and display remains on last display screen, e.g., continually display metering.)

Front-panel display update rate (1–60 seconds)	**SCROLD**	=________

Event Report Parameters (See Section 12: Analyzing Events)

Length of event report (15, 30, 60 cycles)	**LER**	=________

Length of pre-fault in event report

(1–14 cycles in 1-cycle steps for LER = 15) (1–29 cycles in 1-cycle steps for LER = 30) (1–59 cycles in 1-cycle steps for LER = 60)	**PRE**	=________

Station DC Battery Monitor (See Figure 8.9 and Figure 8.10)

DC battery instantaneous undervoltage pickup

OFF, 20–300 Vdc	**DCLOP**	=________

DC battery instantaneous overvoltage pickup

OFF, 20–300 Vdc	**DCHIP**	=________

Optoisolated Input Timers

Input IN101 debounce time

0.00–2.00 cycles in 0.25-cycle steps	**IN101D**	=________

Input IN102 debounce time

0.00–2.00 cycles in 0.25-cycle steps	**IN102D**	=________

Input IN103 debounce time

0.00–2.00 cycles in 0.25-cycle steps	**IN103D**	=________

Input IN104 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN104D**	=________
Input IN105 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN105D**	=________
Input IN106 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN106D**	=________
Input IN301 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN301D**	=________
Input IN302 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN302D**	=________
Input IN303 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN303D**	=________
Input IN304 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN304D**	=________
Input IN305 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN305D**	=________
Input IN306 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN306D**	=________
Input IN307 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN307D**	=________
Input IN308 debounce time 0.00–2.00 cycles in 0.25-cycle steps	**IN308D**	=________

Breaker Monitor Settings (See Breaker Monitor on page 8.12)

Breaker monitor enable (Y, N)	**EBMON**	=________

Make the following settings if preceding enable setting 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 in 0.01 kA steps	**KASP1**	=________
kA Interrupted set point 2—mid. 0.00–999.00 kA primary in 0.01 kA steps	**KASP2**	=________
kA Interrupted set point 3—max. 0.00–999.00 kA primary in 0.01 kA steps	**KASP3**	=________

Synchronized Phasor Settings (See Appendix H: SEL Synchrophasors)

Synchronized Phasor Measurement (Y, N)	**EPMU**	= ____________

Make the following settings if preceding enable setting EPMU = Y.

PMU Hardware ID	**PMID**	= ____________
Phasor Data Set, Voltages (V1, ALL)	**PHDATAV**	= ____________
Voltage Angle Comp. Factor (–179.99 to +180 degrees)	**VCOMP**	= ____________
Phasor Data Set, Currents (ALL, NA)	**PHDATAI**	= ____________
Current Angle Comp. Factor (–179.99 to +180 degrees)	**ICOMP**	= ____________
Time Source Type (IRIG, IEEE)	**TS_TYPE**	= ____________

Sequential Events Recorder Settings

Sequential Events Recorder settings are composed of three trigger lists. Each trigger list can include as many as 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See Sequential Events Recorder Report on page 12.36.

SER Trigger List 1
SER1 = ____

SER Trigger List 2
SER2 = ____

SER Trigger List 3
SER3 = ____

Text Label Settings

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 (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

Display if DP1 = logical 1 (16 characters)	**DP1_1**	=
Display if DP1 = logical 0 (16 characters)	**DP1_0**	=
Display if DP2 = logical 1 (16 characters)	**DP2_1**	=
Display if DP2 = logical 0 (16 characters)	**DP2_0**	=
Display if DP3 = logical 1 (16 characters)	**DP3_1**	=
Display if DP3 = logical 0 (16 characters)	**DP3_0**	=
Display if DP4 = logical 1 (16 characters)	**DP4_1**	=

Display if DP4 = logical 0 (16 characters)	**DP4_0**	=________________
Display if DP5 = logical 1 (16 characters)	**DP5_1**	=________________
Display if DP5 = logical 0 (16 characters)	**DP5_0**	=________________
Display if DP6 = logical 1 (16 characters)	**DP6_1**	=________________
Display if DP6 = logical 0 (16 characters)	**DP6_0**	=________________
Display if DP7 = logical 1 (16 characters)	**DP7_1**	=________________
Display if DP7 = logical 0 (16 characters)	**DP7_0**	=________________
Display if DP8 = logical 1 (16 characters)	**DP8_1**	=________________
Display if DP8 = logical 0 (16 characters)	**DP8_0**	=________________
Display if DP9 = logical 1 (16 characters)	**DP9_1**	=________________
Display if DP9 = logical 0 (16 characters)	**DP9_0**	=________________
Display if DP10 = logical 1 (16 characters)	**DP10_1**	=________________
Display if DP10 = logical 0 (16 characters)	**DP10_0**	=________________
Display if DP11 = logical 1 (16 characters)	**DP11_1**	=________________
Display if DP11 = logical 0 (16 characters)	**DP11_0**	=________________
Display if DP12 = logical 1 (16 characters)	**DP12_1**	=________________
Display if DP12 = logical 0 (16 characters)	**DP12_0**	=________________
Display if DP13 = logical 1 (16 characters)	**DP13_1**	=________________
Display if DP13 = logical 0 (16 characters)	**DP13_0**	=________________
Display if DP14 = logical 1 (16 characters)	**DP14_1**	=________________
Display if DP14 = logical 0 (16 characters)	**DP14_0**	=________________
Display if DP15 = logical 1 (16 characters)	**DP15_1**	=________________
Display if DP15 = logical 0 (16 characters)	**DP15_0**	=________________
Display if DP16 = logical 1 (16 characters)	**DP16_1**	=________________
Display if DP16 = logical 0 (16 characters)	**DP16_0**	=________________

Reclosing Relay Labels (See Functions Unique to the Front-Panel Interface on page 11.5)

Reclosing Relay Last Shot Label (14 char.)	**79LL**	=________________
Reclosing Relay Shot Counter Label (14 char.)	**79SL**	=________________

Port Settings

Protocol Settings (See Below)

Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B, MBGA, MBGB, TELNET)	**PROTO**	= ____________

Protocol Settings Set PROTO = SEL for standard SEL ASCII protocol. For SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD. Refer to Appendix C for details on the LMD protocol. For Distributed Network Protocol (DNP), set PROTO = DNP. Refer to Appendix F for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, MB8B, MBGA, or MBGB. Refer to Appendix E for details on MIRRORED BITS. To enable Telnet-to-relay communications on **PORT 5** and **PORT6**, the **PORT 1** PROTO setting must be set to TELNET. Setting PROTO = TELNET disables **PORT 1** for EIA-485 communications.

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) *(38400 is not available on Port 1)*	**SPEED**	= ____________
Data Bits (6, 7, 8) *This setting is available when PROTO = SEL or LMD.*	**BITS**	= ____________
Parity (O, E, N) {Odd, Even, None} *This setting is available when PROTO = SEL or LMD.*	**PARITY**	= ____________
Stop Bits (1, 2) *This setting is available when PROTO = SEL or LMD.*	**STOP**	= ____________
Time-out (0–30 minutes) *This setting is available when PROTO = SEL or LMD. 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.*	**T_OUT**	= ____________
DTA Meter Format (Y, N) *Set DTA = Y to allow an SEL DTA or SEL DTA2 to communicate with the relay. This setting is available when PROTO = SEL or LMD. Note that when DTA = Y, the date format must be set to MDY in the Global setting DATE_F.*	**DTA**	= ____________
Send Auto Messages to Port (Y, N) *This setting is available when PROTO = SEL or LMD. Set AUTO = Y to allow automatic messages at the serial port.*	**AUTO**	= ____________
Enable Hardware Handshaking (Y, N, MBT) *MBT is available when PROTO = MBA or MBB. (Refer to* MIRRORED BITS Protocol for the Pulsar 9600 Baud Modem on page E.5 *for details on setting MBT.) Set RTSCTS = Y to enable hardware handshaking. With RTSCTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line. Setting RTSCTS is not applicable to serial Port 1 (EIA-485) or a port configured for SEL Distributed Port Switch Protocol.*	**RTSCTS**	= ____________
Fast Operate Enable (Y, N) *This setting is available when PROTO = SEL or LMD. 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 D: SEL Communications Processors *for the description of the* SEL-311L *Relay Fast Operate commands. When PROTO = TELNET, FASTOP is set to Y and is hidden.*	**FASTOP**	= ____________

LMD Settings

LMD Prefix (@, #, $, %, &)	**PREFIX**	=
LMD Address (1–99)	**ADDR**	=
LMD Settling Time (0–30 seconds)	**SETTLE**	=

TELNET Settings (PORT 1 only)

Telnet Port for Relay Access (1–65534)	**TPORT**	=
Telnet Port Timeout (1–30 min)	**TIDLE**	=

Ethernet Port Settings (PORT 5 and PORT 6 only)

IP Address (xxx.xxx.xxx.xxx)	**IPADDR**	=
Subnet Mask (xxx.xxx.xxx.xxx)	**SUBNETM**	=
Default Router (xxx.xxx.xxx.xxx)	**DEFRTR**	=
Enable TCP Keep-Alive (Y, N)	**ETCPKA**	=
TCP Keep-Alive Idle Range (1–20 s) *If ETCPKA = Y*	**KAIDLE**	=
TCP Keep-Alive Interval Range (1–20 s) *If ETCPKA = Y*	**KAINTV**	=
TCP Keep-Alive Count Range (1–20 s) *If ETCPKA = Y*	**KACNT**	=
Operating Mode (FIXED, FAILOVER)	**NETMODE**	=
Failover Time-out (OFF, 0.1–65.00 sec) *If NETMODE = FAILOVER*	**FTIME**	=
Enable Telnet (Y, N)	**ETELNET**	=
Telnet Port for Card Access (1–65534) *If ETELNET = Y*	**TPORTC**	=
Telnet Port Timeout (1–30 min) *If ETELNET = Y*	**TIDLE**	=
Enable FTP Server (Y, N) *If ETELNET = Y*	**EFTPSERV**	=
FTP Username (20 characters) *If EFTPSERV = Y*	**FTPUSER**	=
FTP Connect Banner *If EFTPSERV = Y*	**FTPCBAN**	=
FTP Idle Timeout (5–255 minutes) *If EFTPSERV = Y*	**FTPIDLE**	=
Enable HTTP Server (Y, N)	**EHTTP**	=
HTTP TCP/IP Port (1–65535) *If EHTTP = Y*	**HTTPPORT**	=
HTTP Web Server Timeout (1–30 minutes) *If EHTTP = Y*	**HTTPIDLE**	=
Enable IEC 61850 Protocol (Y, N) *If IEC 61850 is available*	**E61850**	=
Enable IEC 61850 GSE (Y, N) *If IEC 61850 is available*	**EGSE**	=

DNP Settings

DNP Address (0–65534)	**DNPADR**	= ____________
Class for event data (0 for no event, 1–3)	**ECLASS**	= ____________
Time-set request interval, minutes (0 for never, 1–32767)	**TIMERQ**	= ____________
Currents scaling (0–3 decimal places)	**DECPLA**	= ____________
Voltages scaling (0–3 decimal places)	**DECPLV**	= ____________
Miscellaneous data scaling (0–3 decimal places)	**DECPLM**	= ____________
Select/Operate time-out interval, seconds (0.0–30.0)	**STIMEO**	= ____________
Number of data-link retries (0 for no confirm, 1–15)	**DRETRY**	= ____________
Data Link Time-out interval, seconds (0–5)	**DTIMEO**	= ____________
Minimum Delay from DCD to transmission, seconds (0.00–1.00)	**MINDLY**	= ____________
Maximum Delay from DCD to transmission, seconds (0.00–1.00)	**MAXDLY**	= ____________
Transmission delay from RTS assertion, seconds (OFF, 0.00–30.00)	**PREDLY**	= ____________
Post-transmit RTS deassertion delay, seconds (0.00–30.00)	**PSTDLY**	= ____________
Analog reporting deadband, counts (0–32767)	**ANADB**	= ____________
Allow Unsolicited Reporting (Y/N)	**UNSOL**	= ____________
Enable unsolicited messages when the relay turns on (Y/N)	**PUNSOL**	= ____________
Address of master to Report to (0–65534)	**REPADR**	= ____________
Number of events to transmit on (1–200)	**NUMEVE**	= ____________
Age of oldest event to force transmit on, seconds (0.0–60.0)	**AGEEVE**	= ____________
Time-out for confirmation of unsolicited message, seconds (0–50)	**UTIMEO**	= ____________

MB Settings

PPM MIRRORED BITS Channel Bad Pickup (1–10000)	**CBADPU**	= ____________
MIRRORED BITS Receive Identifier (1–4) *This setting is unavailable if PROTO is set to MBGA or MBGB.*	**RXID**	= ____________
MIRRORED BITS Transmit Identifier (1–4) *This setting is unavailable if PROTO is set to MBGA or MBGB.*	**TXID**	= ____________
MIRRORED BITS Receive Default State (string of 1s, 0s or Xs) 87654321	**RXDFLT**	= ____________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB1PU**	= ____________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB1DO**	= ____________

MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB2PU**	=________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB2DO**	=________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB3PU**	=________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB3DO**	=________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB4PU**	=________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB4DO**	=________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB5PU**	=________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB5DO**	=________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB6PU**	=________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB6DO**	=________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB7PU**	=________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB7DO**	=________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB8PU**	=________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB8DO**	=________

Channel Settings

87L Channel X Configuration Settings

Channel X address check (Y, G, N)	**EADDCX**	=________
If EADDCX = Y		
Channel X transmit address (1–16) *This setting is unavailable if EADDCX is set to G.*	**TA_X**	=________
Channel X receive address (1–16) *This setting is unavailable if EADDCX is set to G.*	**RA_X**	=________
Continuous dropout alarm (1–1000 seconds)	**RBADXP**	=________
Packets lost in last 10,000 (1–5000)	**AVAXP**	=________
One-way channel delay alarm (1–24 ms)	**DBADXP**	=________
If CHANX type is EIA-422		
EIA-422 receive clock edge detect (R = Rising; F = Falling)	**RC422X**	=________
EIA-422 transmit clock edge detect (R = Rising; F = Falling)	**TC422X**	=________
If CHANX type is not EIA-422		
Timing source (I = Internal; E = External)	**TIMRX**	=________

87L Channel Y Configuration Settings

Channel Y address check (Y, G, N)	**EADDCY**	= ________
If EADDCY = Y		
Channel Y transmit address (1–16) *This setting is unavailable if EADDCY is set to G.*	**TA_Y**	= ________
Channel Y receive address (1–16) *This setting is unavailable if EADDCY is set to G.*	**RA_Y**	= ________
Continuous dropout alarm (1–1000 seconds)	**RBADYP**	= ________
Packets lost in last 10,000 (1–5000)	**AVAYP**	= ________
One-way channel delay alarm (1–24 ms)	**DBADYP**	= ________
If CHANY type is EIA-422		
EIA-422 receive clock edge detect (R = Rising; F = Falling)	**RC422Y**	= ________
EIA-422 transmit clock edge detect (R = Rising; F = Falling)	**TC422Y**	= ________
If CHANY type is not EIA-422		
Timing source (I = Internal; E = External)	**TIMRY**	= ________

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SEL-311L Settings Sheets (APP = 87LSP)

Relay Settings

Identifier Labels and Configuration Settings (See Settings Explanations on page 9.34)

Relay Identifier (30 characters)

RID = ______________________________

Terminal Identifier (30 characters)

TID = ______________________________

Local Phase (IA, IB, IC) Current Transformer Ratio (1–6000) **CTR** = __________

Application (87L, 87L21, 87L21P, 87LSP, 311L) **APP** = 87LSP

Line Current Differential Configuration Settings

Enable high-speed direct transfer trip (Y, N) **EHSDTT** = __________

Enable delta current detect (Y, N) **EDD** = __________

If the relay has two channels and E87L = 2:

Enable Open CT Logic (Y, N) **EOCTL** = __________

If the relay has two channels:

Primary channel (X, Y) **PCHAN** = __________

If the relay has two channels:

Hot-standby channel feature (Y, N) **EHSC** = __________

If PCHAN = X or EHSC = Y:

CTR at terminal connected to Channel X (1–6000) **CTR_X** = __________

If EADDCX = G:

Channel X transmit address (1–16) **TA_X** = __________

Channel X receive address (1–16) **RA_X** = __________

If PCHAN = Y or EHSC = Y:

CTR at terminal connected to Channel Y (1–6000) **CTR_Y** = __________

If EADDCY = G:

Channel Y transmit address (1–16) **TA_Y** = __________

Channel Y receive address (1–16) **RA_Y** = __________

Minimum Difference Current Enable Level Settings

Phase 87L (OFF, 1.00–10.00 A secondary)	**87LPP**	=________
$3I_2$ Negative-sequence 87L (OFF, 0.50–5.00 A secondary)	**87L2P**	=________
Ground 87L (OFF, 0.50–5.00 A secondary)	**87LGP**	=________
Phase difference current alarm pickup 0.50–10.00 A secondary	**CTALRM**	=________

Restraint Region Characteristic Settings

Outer Radius (2.0–8.0)	**87LR**	=________
Angle (90°–270°)	**87LANG**	=________

Backup Protection Transformer Ratio Settings

Polarizing (IPOL) Current Transformer Ratio (1–6000)	**CTRP**	=________
Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00)	**PTR**	=________
Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00)	**PTRS**	=________

Line Parameter Settings (See Settings Explanations on page 9.34)

Positive-sequence line impedance magnitude 0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.}	**Z1MAG**	=________
Positive-sequence line impedance angle (5.00–90.00 degrees)	**Z1ANG**	=________
Zero-sequence line impedance magnitude 0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.}	**Z0MAG**	=________
Zero-sequence line impedance angle (5.00–90.00 degrees)	**Z0ANG**	=________
Line length (0.10–999.00, unitless)	**LL**	=________

Distance Element Zones Enable Settings

Mho phase distance element zones (N, 1–4) (see *Figure 4.1–Figure 4.3*)	**E21P**	=________
Mho ground distance element zones (N, 1–4) (see *Figure 4.4–Figure 4.6*)	**E21MG**	=________
Quadrilateral ground distance element zones (N, 1–4) (see *Figure 4.7–Figure 4.9*)	**E21XG**	=________

Instantaneous/Definite-Time Overcurrent Enable Settings

Phase element levels (N, 1–3) (see *Figure 4.19*)	**E50P**	= _________
Residual ground element levels (N, 1–4) (see *Figure 4.22*)	**E50G**	= _________
Negative-sequence element levels (N, 1–4) (see *Figure 4.23*)	**E50Q**	= _________

Time-Overcurrent Enable Settings

Phase element (Y, N) (see *Figure 4.24*)	**E51P**	= _________
Residual ground element (Y, N) (see *Figure 4.25*)	**E51G**	= _________
Negative-sequence element (Y, N) (see *Figure 4.26*)	**E51Q**	= _________

Other Enable Settings

Directional control (Y, AUTO) (see *Directional Control Settings on page 4.79*)	**E32**	= _________
Out-of-Step (Y, N) (see *Figure 4.17*)	**EOOS**	= _________
Load encroachment (Y, N) (see *Figure 4.38*)	**ELOAD**	= _________
Switch-onto-fault (Y, N) (see *Figure 5.7*)	**ESOTF**	= _________
Voltage elements (Y, N) (see *Figure 4.27–Figure 4.30*)	**EVOLT**	= _________
Synchronism check (Y, N) (see *Figure 4.30* and *Figure 4.31*)	**E25**	= _________
Frequency Elements (N, 1–6)	**E81**	= _________
Fault location (Y, N) (see *Table 12.1* and *Fault Location on page 12.6*)	**EFLOC**	= _________
Loss-of-potential (Y, Y1, N) (see *Figure 4.35*)	**ELOP**	= _________
Enable busbar PT LOP logic (Y, N) (see *Setting EBBPT = Y on page 4.61*)	**EBBPT**	= _________
Communications-assisted trip scheme (N, DCB, POTT, DCUB1, DCUB2) (see *Communications-Assisted Trip Logic—General Overview on page 5.18*)	**ECOMM**	= _________
Reclosures (N, 1–4) (see *Reclosing Relay on page 6.10*)	**E79**	= _________
Zone 1 extension (Y, N) (see *Figure 4.14*)	**EZ1EXT**	= _________
CCVT transient detection (Y, N) (see *Figure 4.37*)	**ECCVT**	= _________
SELOGIC control equation Variable Timers (N, 1–16) (see *Figure 7.24* and *Figure 7.25*)	**ESV**	= _________
SELOGIC Latch Bits (N, 1–16)	**ELAT**	= _________
SELOGIC Display Points (N, 1–16)	**EDP**	= _________
Demand Metering (THM = Thermal; ROL = Rolling) (see *Figure 8.3*)	**EDEM**	= _________
Advanced settings (Y, N)	**EADVS**	= _________

Mho Phase Distance Elements

(Number of mho phase distance element settings dependent on preceding enable setting E21P = 1–4.)

Zone 1 (see *Figure 4.4*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} **Z1P** =__________

Zone 2 (see *Figure 4.5*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} **Z2P** =__________

Zone 3 (see *Figure 4.6*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} **Z3P** =__________

Zone 4 (see *Figure 4.6*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} **Z4P** =__________

Mho Phase Distance Fault Detector Settings

Zone 1 phase-to-phase current FD (see *Figure 4.4*)

0.5–170.00 A secondary {5 A nom.}; 0.1–34.00 A secondary {1 A nom.} **50PP1** =__________

Zone 2 phase-to-phase current FD (see *Figure 4.5*) *Setting active when 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.} **50PP2** =__________

Zone 3 phase-to-phase current FD (see *Figure 4.6*) *Setting active when 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.} **50PP3** =__________

Zone 4 phase-to-phase current FD (see *Figure 4.6*) *Setting active when 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.} **50PP4** =__________

Mho Ground Distance Elements

(Number of mho ground distance element settings dependent on preceding enable setting E21MG = 1–4.)

Zone 1 (see *Figure 4.7*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} **Z1MG** =__________

Zone 2 (see *Figure 4.8*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} **Z2MG** =__________

Zone 3 (see *Figure 4.9*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} — **Z3MG** = ________

Zone 4 (see *Figure 4.9*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} — **Z4MG** = ________

Quadrilateral Ground Distance Elements

(Number of quadrilateral ground distance element settings dependent on preceding enable setting E21XG = 1–4.)

Zone 1 reactance (see *Figure 4.10*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; OFF, 0.25–320.00 Ω secondary {1 A nom.} — **XG1** = ________

Zone 2 reactance (see *Figure 4.11*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} — **XG2** = ________

Zone 3 reactance (see *Figure 4.12*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} — **XG3** = ________

Zone 4 reactance (see *Figure 4.12*)

OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.} — **XG4** = ________

Zone 1 resistance (see *Figure 4.10*)

0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.} — **RG1** = ________

Zone 2 resistance (see *Figure 4.11*)

0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.} — **RG2** = ________

Zone 3 resistance (see *Figure 4.12*)

0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.} — **RG3** = ________

Zone 4 resistance (see *Figure 4.12*)

0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.} — **RG4** = ________

Quadrilateral ground polarizing quantity (I2, IG) (see *Figure 4.10–Figure 4.12*) *Setting active when EADVS = Y; otherwise setting is made automatically.* — **XGPOL** = ________

Nonhomogeneous correction angle (–45.0° to +45.0°) *Setting active when 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 (see *Figure 4.7* and *Figure 4.10*)

0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} **50L1** =________

Zone 2 phase current FD (see *Figure 4.8* and *Figure 4.11*)
Setting active when EADVS = Y; otherwise setting is made automatically.

0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} **50L2** =________

Zone 3 phase current FD (see *Figure 4.9* and *Figure 4.12*)
Setting active when EADVS = Y; otherwise setting is made automatically.

0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} **50L3** =________

Zone 4 phase current FD (see *Figure 4.9* and *Figure 4.12*)
Setting active when EADVS = Y; otherwise setting is made automatically.

0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} **50L4** =________

Zone 1 residual current FD (see *Figure 4.7* and *Figure 4.10*)

0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} **50GZ1** =________

Zone 2 residual current FD (see *Figure 4.8* and *Figure 4.11*)
Setting active when EADVS = Y; otherwise setting is made automatically.

0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} **50GZ2** =________

Zone 3 residual current FD (see *Figure 4.9* and *Figure 4.12*)
Setting active when EADVS = Y; otherwise setting is made automatically.

0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} **50GZ3** =________

Zone 4 residual current FD (see *Figure 4.9* and *Figure 4.12*)
Setting active when EADVS = Y; otherwise setting is made automatically.

0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.} **50GZ4** =________

Zero-Sequence Compensation (ZSC) Settings (See Ground Distance Elements on page 4.11)

Zone 1 ZSC factor magnitude (0.000–6.000 unitless) **k0M1** =________

Zone 1 ZSC factor angle (–180.0° to +180.0°) **k0A1** =________

Zones 2, 3, and 4 ZSC factor magnitude (0.000–6.000 unitless) *Setting active when EADVS = Y; otherwise setting is made automatically.*	**k0M**	=________
Zones 2, 3, and 4 ZSC factor angle (–180.0° to +180.0°) *Setting active when EADVS = Y; otherwise setting is made automatically*.	**k0A**	=________

Mho Phase Distance Element Time Delays (See Figure 4.15)

(Number of mho phase distance element time delay settings dependent on preceding enable setting E21P = 1–4.)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1PD**	=________
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2PD**	=________
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3PD**	=________
Zone 4 time delay (OFF, 0.00–16000.00 cycles)	**Z4PD**	=________

Quadrilateral and Mho Ground Distance Element Time Delays (See Figure 4.15)

(Number of time delay element settings dependent on the larger of preceding enable settings E21MG = 1–4 or E21XG = 1–4.)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1GD**	=________
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2GD**	=________
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3GD**	=________
Zone 4 time delay (OFF, 0.00–16000.00 cycles)	**Z4GD**	=________

Common Phase/Ground Distance Element Time Delay (See Figure 4.15)

(Number of time delay element settings dependent on the smaller of preceding enable setting E21P = 1–4 and the larger of preceding enable settings E21MG = 1–4 or E21XG = 1–4.)

Zone 1 time delay (OFF, 0.00–16000.00 cycles)	**Z1D**	=________
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	**Z2D**	=________
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	**Z3D**	=________
Zone 4 time delay (OFF, 0.00–16000.00 cycles)	**Z4D**	=________

Phase Inst./Def.-Time Overcurrent Elements (See Figure 4.19)

(Number of phase element pickup settings dependent on preceding enable setting E50P = 1–3.)

Level 1

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50P1P**	=________

Level 2

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50P2P**	=________

Level 3

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.} **50P3P** =__________

Phase Definite-Time Overcurrent Element Time Delays (See Figure 4.19)

(Number of phase element time delay settings dependent on preceding enable setting E50P = 1–3.)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) **67P1D** =__________

Level 2 (0.00–16000.00 cycles in 0.25-cycle steps) **67P2D** =__________

Level 3 (0.00–16000.00 cycles in 0.25-cycle steps) **67P3D** =__________

Residual-Ground Inst./Def.-Time Overcurrent Elements (See Figure 4.22)

(Number of residual-ground element pickup settings dependent on preceding enable setting E50G = 1–4.)

Level 1

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.} **50G1P** =__________

Level 2

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.} **50G2P** =__________

Level 3

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.} **50G3P** =__________

Level 4

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.} **50G4P** =__________

Residual-Ground Definite-Time Overcurrent Element Time Delay (See Figure 4.22)

(Number of residual-ground element time delay settings dependent on preceding enable setting E50G = 1–4.)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) **67G1D** =__________

Level 2 (0.00–16000.00 cycles in 0.25-cycle steps) **67G2D** =__________

Level 3 (0.00–16000.00 cycles in 0.25-cycle steps) **67G3D** =__________

Level 4 (0.00–16000.00 cycles in 0.25-cycle steps) **67G4D** =__________

Negative-Sequence Inst./Def.-Time Overcurrent Elements (See Figure 4.23)

Important: See Section 4: Protection Functions for information on setting negative-sequence overcurrent elements.

(Number of negative-sequence element time delay settings dependent on preceding enable setting E50Q = 1–4)

Level 1

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50Q1P**	=_________

Level 2

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50Q2P**	=_________

Level 3

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50Q3P**	=_________

Level 4

OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}	**50Q4P**	=_________

Negative-Sequence Definite-Time Overcurrent Element Time Delay (See Figure 4.23)

Important: See Section 4: Protection Functions for information on setting negative-sequence overcurrent elements.

(Number of negative-sequence element time delay settings dependent on preceding enable setting E50Q = 1–4.)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q1D**	=_________
Level 2 (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q2D**	=_________
Level 3 (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q3D**	=_________
Level 4 (0.00–16000.00 cycles in 0.25-cycle steps)	**67Q4D**	=_________

Phase Time-Overcurrent Element (See Figure 4.24)

(Make the following settings if preceding enable setting E51P = Y.)

Pickup

OFF, 0.25–16.00 A secondary {5 A nom.}; 0.05–3.20 A secondary {1 A nom.}	**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	**51PTD**	=_________
Electromechanical Reset (Y, N)	**51PRS**	=_________

Residual-Ground Time-Overcurrent Element (See Figure 4.25)

(Make the following settings if preceding enable setting E51G = Y.)

Pickup		
OFF, 0.25–16.00 A secondary {5 A nom.}; 0.05–3.20 A secondary {1 A nom.}	**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)	**51GTD**	=________
Electromechanical Reset (Y, N)	**51GRS**	=________

Negative-Sequence Time-Overcurrent Element (See Figure 4.26)

Important: See Section 4: Protection Functions for information on setting negative-sequence overcurrent elements.

(Make the following settings if preceding enable setting E51Q = Y.)

Pickup		
OFF, 0.25–16.00 A secondary {5 A nom.}; 0.05–3.20 A secondary {1 A nom.}	**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	**51QTD**	=________
Electromechanical Reset (Y, N)	**51QRS**	=________

Out-of-Step Settings (See Figure 4.16 and Figure 4.17)

(Make the following settings if preceding enable setting EOOS = Y.)

Block Zone 1 (Y, N)	**OOSB1**	=________
Block Zone 2 (Y, N)	**OOSB2**	=________
Block Zone 3 (Y, N)	**OOSB3**	=________
Block Zone 4 (Y, N)	**OOSB4**	=________
Out-of-Step block time delay (0.50–8000.00 cycles)	**OSBD**	=________
Enable Out-of-Step tripping (N, I, O)	**EOOST**	=________
Out-of-Step trip delay (0.50–8000.00 cycles)	**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.}	**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.}	**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.}	**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.}	**R1R5**	= ________

Zone 6 reactance—Bottom *Setting active when EADVS = Y; otherwise setting is made automatically*.

–96.00 to –0.05 Ω secondary {5 A nom.}; –480.00 to –0.25 Ω secondary {1 A nom.}	**X1B6**	= ________

Zone 5 reactance—Bottom *Setting active when EADVS = Y; otherwise setting is made automatically.*

–96.00 to –0.05 Ω secondary {5 A nom.}; –480.00 to –0.25 Ω secondary {1 A nom.}	**X1B5**	= ________

Zone 6 resistance—Left *Setting active when EADVS = Y; otherwise setting is made automatically.*

–70.00 to –0.05 Ω secondary {5 A nom.}; –350.00 to –0.25 Ω secondary {1 A nom.}	**R1L6**	= ________

Zone 5 resistance—Left *Setting active when EADVS = Y; otherwise setting is made automatically.*

–70.00 to –0.05 Ω secondary {5 A nom.}; –350.00 to –0.25 Ω secondary {1 A nom.}	**R1L5**	= ________

Positive-sequence current supervision

1–100 A secondary {5 A nom.}; 0.2–20 A secondary {1 A nom.}	**50ABCP**	= ________
Negative-sequence current unblock delay (0.5–120.0 cycles)	**UBD**	= ________
Out-of-Step angle change unblock rate (1–10 unitless) S*etting active when EADVS = Y; otherwise setting is made automatically.*	**UBOSBF**	= ________

Load-Encroachment Elements (See *Figure 4.24*)

(Make the following settings if preceding enable setting ELOAD = Y.)

Forward load impedance

0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**ZLF**	= ________

Reverse load impedance

0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}	**ZLR**	= ________
Positive forward load angle (–90.00° to +90.00°)	**PLAF**	= ________
Negative forward load angle (–90.00° to +90.00°)	**NLAF**	= ________
Positive reverse load angle (+90.00° to +270.00°)	**PLAR**	= ________
Negative reverse load angle (+90.00° to +270.00°)	**NLAR**	= ________

Zone/Level 3 and 4 Directional Control

Zone/Level 3 direction: Forward, Reverse (F, R)	**DIR3**	=________
Zone/Level 4 direction: Forward, Reverse (F, R)	**DIR4**	=________

Directional Elements (See Directional Control Settings on page 4.79)

(Make setting ORDER if preceding enable setting E32 = Y or AUTO.)

Ground directional element priority: combination of OFF, Q, V, or I	**ORDER**	=________

(Make settings Z2F, Z2R, 50QFP, 50QRP, a2, and k2 if preceding enable setting E32 = Y. If E32 = AUTO, these settings are made automatically.)

Forward directional Z2 threshold		
–64.00–64.00 Ω secondary {5 A nom.}; –320.00–320.00 Ω secondary {1 A nom.}	**Z2F**	=________
Reverse directional Z2 threshold		
–64.00–64.00 Ω secondary {5 A nom.}; –320.00–320.00 Ω secondary {1 A nom.}	**Z2R**	=________
Forward directional 3I2 pickup		
0.25–5.00 A secondary {5 A nom.}; 0.05–1.00 A secondary {1 A nom.}	**50QFP**	=________
Reverse directional 3I2 pickup		
0.25–5.00 A secondary {5 A nom.}; 0.05–1.00 A secondary {1 A nom.}	**50QRP**	=________
Positive-sequence current restraint factor, I2/I1 (0.02–0.50, unitless)	**a2**	=________
Zero-sequence current restraint factor, I2/I0 (0.10–1.20, unitless)	**k2**	=________

(Make settings 50GFP, 50GRP, and a0 if preceding enable setting E32 = Y and preceding setting ORDER contains V or I. If E32 = AUTO and ORDER contains V or I, these settings are made automatically.)

Forward directional 3I0 pickup		
0.25–5.00 A secondary {5 A nom.}; 0.05–1.00 A secondary {1 A nom.}	**50GFP**	=________
Reverse directional 3I0 pickup		
0.25–5.00 A secondary {5 A nom.}; 0.05–1.00 A secondary {1 A nom.}	**50GRP**	=________
Positive-sequence current restraint factor, I0/I1 (0.02–0.50, unitless)	**a0**	=________

(Make settings Z0F and Z0R if preceding enable setting E32 = Y and preceding setting ORDER contains V. If E32 = AUTO and ORDER contains V, these settings are made automatically.)

Forward directional Z0 threshold		
–64.00–64.00 Ω secondary {5 A nom.} –320.00–320.00 Ω secondary {1 A nom.}	**Z0F**	= ________
Reverse directional Z0 threshold		
–64.00–64.00 Ω secondary {5 A nom.} –320.00–320.00 Ω secondary {1 A nom.}	**Z0R**	= ________

Voltage Elements (See Figure 4.26–Figure 4.28)

(Make the following settings if preceding enable setting EVOLT = Y)

Phase undervoltage pickup (OFF, 0.0–150.0 V secondary)	**27P**	= ________
Phase overvoltage pickup (OFF, 0.0–150.0 V secondary)	**59P**	= ________
Zero-sequence (3V0) overvoltage pickup		
OFF, 0.0–150.0 V secondary	**59N1P**	= ________
Zero-sequence (3V0) overvoltage pickup		
OFF, 0.0–150.0 V secondary	**59N2P**	= ________
Negative-sequence (V2) overvoltage pickup		
OFF, 0.0–100.0 V secondary	**59QP**	= ________
Positive-sequence (V1) overvoltage pickup		
OFF, 0.0–150.0 V secondary	**59V1P**	= ________
Channel VS undervoltage pickup		
OFF, 0.0–150.0 V secondary	**27SP**	= ________
Channel VS overvoltage pickup (OFF, 0.0–150.0 V secondary)	**59SP**	= ________
Phase-to-phase undervoltage pickup		
OFF, 0.0–260.0 V secondary	**27PP**	= ________
Phase-to-phase overvoltage pickup		
OFF, 0.0–260.0 V secondary	**59PP**	= ________

Synchronism-Check Elements (See Figure 4.30 and Figure 4.31)

(Make the following settings if preceding enable setting E25 = Y.)

Voltage window—low threshold (0.00–150.00 V secondary)	**25VLO**	= ________
Voltage window—high threshold (0.00–150.00 V secondary)	**25VHI**	= ________
Maximum slip frequency (0.005–0.500 Hz)	**25SF**	= ________
Maximum angle 1 (0.00°∠80.00°)	**25ANG1**	= ________
Maximum angle 2 (0.00°∠80.00°)	**25ANG2**	= ________

Date____________

Synchronizing phase (VA, VB, VC, VAB, VBC, VAC)	**SYNCP**	=_________
Breaker close time for angle compensation OFF, 1.00–60.00 cycles in 0.25-cycle steps	**TCLOSD**	=_________

Frequency Elements (See Figure 4.33 and Figure 4.34)

(Make the following settings if preceding enable setting E81 = 1–6.)

Phase undervoltage block 20.00–150.00 V secondary, 150 V wye-connected voltage inputs	**27B81P**	=_________
Level 1 pickup (OFF, 41.00–65.00 Hz)	**81D1P**	=_________
Level 1 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D1D**	=_________
Level 2 pickup (OFF, 41.00–65.00 Hz)	**81D2P**	=_________
Level 2 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D2D**	=_________
Level 3 pickup (OFF, 41.00–65.00 Hz)	**81D3P**	=_________
Level 3 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D3D**	=_________
Level 4 pickup (OFF, 41.00–65.00 Hz)	**81D4P**	=_________
Level 4 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D4D**	=_________
Level 5 pickup (OFF, 41.00–65.00 Hz)	**81D5P**	=_________
Level 5 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D5D**	=_________
Level 6 pickup (OFF, 41.00–65.00 Hz)	**81D6P**	=_________
Level 6 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	**81D6D**	=_________

Reclosing Relay (See *Table 6.2* and *Table 6.4*)

(Make the following settings if preceding enable setting 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 6.2*)	**79CLSD**	= ________

Switch-Onto-Fault (See Figure 5.7)

(Make the following settings if preceding enable setting 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 5.10)

(Make the following settings if preceding enable setting ECOMM = POTT, DCUB1, or DCUB2.)

Zone (level) 3 reverse block time delay

0.00–16000.00 cycles in 0.25-cycle steps	**Z3RBD**	= ________

Echo block time delay

OFF, 0.00–16000.00 cycles in 0.25-cycle steps	**EBLKD**	= ________

Echo time delay pickup

OFF, 0.00–16000.00 cycles in 0.25-cycle steps	**ETDPU**	= ________

Echo duration time delay

0.00–16000.00 cycles in 0.25-cycle steps	**EDURD**	= ________
Weak-infeed enable (Y, N)	**EWFC**	= ________
WIF phase-to-phase undervoltage (0.0–260.0 V secondary)	**27PPW**	= ________
WIF zero-sequence (3V0) overvoltage (0.0–150.0 V secondary)	**59NW**	= ________

Additional DCUB Trip Scheme Settings (See Figure 5.14)

(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 only available when you set a Serial Port Protocol Setting 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 only available when you set a Serial Port Protocol Setting 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 4.14)

(Make the following settings if preceding enable setting EZ1EXT = Y.)

Zone 1 extension delay time (0.00–16000.00 cycles)	**Z1EXTD**	=________
Zone 1 distance multiplier (1.00–4.00)	**Z1EXTM**	=________

Demand Metering Settings (See Figure 8.3 and Figure 8.5)

(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.}	**PDEMP**	=________

Residual ground pickup

OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}	**GDEMP**	= ________

Negative-sequence pickup

OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}	**QDEMP**	= ________

Other Settings

Minimum trip duration time

2.00–16000.00 cycles in 0.25-cycle steps (see *Figure 5.7*)	**TDURD**	= ________

Trip open pole drop-out delay

2.00–8000 cycles (see *Figure 5.6*)	**TOPD**	= ________

Close failure time delay

OFF, 0.00–16000.00 cycles in 0.25-cycle steps (see *Figure 6.1*)	**CFD**	= ________

Three-pole open time delay

0.00–60.00 cycles in 0.25-cycle steps (usually set for no more than a cycle; see *Figure 5.8*)	**3POD**	= ________
Open pole option (52, 27)	**OPO**	= ________
Three-pole open undervoltage (0.0–150.0 V secondary)	**27PO**	= ________

Load detection phase pickup (see *Figure 5.8*)

OFF, 0.25–100.00 A{5 A nom.}; 0.05–20.00 A {1 A nom.}	**50LP**	= ________

SELOGIC Control Equation Variable Timers (See Figure 7.24 and Figure 7.25)

(Number of timer pickup/dropout settings dependent on preceding enable setting ESV = 1–16.)

SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1PU**	= ________
SV1 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV1DO**	= ________
SV2 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2PU**	= ________
SV2 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV2DO**	= ________
SV3 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3PU**	= ________
SV3 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV3DO**	= ________
SV4 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4PU**	= ________
SV4 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV4DO**	= ________
SV5 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5PU**	= ________
SV5 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV5DO**	= ________
SV6 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6PU**	= ________
SV6 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)	**SV6DO**	= ________

SV7 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7PU**	=__________
SV7 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV7DO**	=__________
SV8 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8PU**	=__________
SV8 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV8DO**	=__________
SV9 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9PU**	=__________
SV9 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV9DO**	=__________
SV10 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10PU**	=__________
SV10 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV10DO**	=__________
SV11 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11PU**	=__________
SV11 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV11DO**	=__________
SV12 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12PU**	=__________
SV12 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV12DO**	=__________
SV13 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13PU**	=__________
SV13 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV13DO**	=__________
SV14 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14PU**	=__________
SV14 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV14DO**	=__________
SV15 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15PU**	=__________
SV15 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV15DO**	=__________
SV16 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16PU**	=__________
SV16 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	**SV16DO**	=__________

SELOGIC Control Equation Settings

SELOGIC control equation settings consist of Relay Word bits (see Table 9.5 and Table 9.6) 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 through Section 8. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). Appendix I: Setting SELOGIC Control Equations gives SELOGIC control equation details, examples, and limitations.

Trip Logic Equations (See Figure 5.6)

Direct trip conditions	**TR**	= ________________
Communications-assisted trip conditions	**TRCOMM**	= ________________
Switch-onto-fault trip conditions	**TRSOTF**	= ________________
Direct transfer trip conditions	**DTT**	= ________________
Enable three-pole tripping	**E3PT**	= ________________
Unlatch trip conditions	**ULTR**	= ________________

Communications-Assisted Trip Scheme Input Equations

Permissive trip 1 (used for ECOMM = POTT, DCUB1, or DCUB2; see *Figure 5.9*, *Figure 5.11*, and *Figure 5.14*)	**PT1**	= ________________
Loss-of-guard 1 (used for ECOMM = DCUB1 or DCUB2; see *Figure 5.14*)	**LOG1**	= ________________
Permissive trip 2 (used for ECOMM = DCUB2; see *Figure 5.9* and *Figure 5.14*)	**PT2**	= ________________
Loss of guard 2 (used for ECOMM = DCUB2; see *Figure 5.14*)	**LOG2**	= ________________
Block trip (used for ECOMM = DCB; see *Figure 5.18*)	**BT**	= ________________

Close Logic Equations (See Figure 6.1)

Circuit breaker status (used in *Figure 5.7*, also)	**52AA**	= ________________
Circuit breaker status (used in *Figure 5.7*, also)	**52AB**	= ________________
Circuit breaker status (used in *Figure 5.7*, also)	**52AC**	= ________________
Close conditions (other than automatic reclosing or **CLOSE** command)	**CL**	= ________________
Unlatch close conditions	**ULCL**	= ________________

Reclosing Relay Equations (See Reclosing Relay on page 6.10)

Reclose initiate	**79RI**	= ________________
Reclose initiate supervision	**79RIS**	= ________________
Drive-to-lockout	**79DTL**	= ________________

Date____________

Drive-to-last shot	**79DLS**	=__________________
Skip shot	**79SKP**	=__________________
Stall open interval timing	**79STL**	=__________________
Block reset timing	**79BRS**	=__________________
Sequence coordination	**79SEQ**	=__________________
Reclose supervision (see *Figure 6.2*)	**79CLS**	=__________________

Latch Bits Set/Reset Equations (See Figure 7.12)

Set Latch Bit LT1	**SET1**	=__________________
Reset Latch Bit LT1	**RST1**	=__________________
Set Latch Bit LT2	**SET2**	=__________________
Reset Latch Bit LT2	**RST2**	=__________________
Set Latch Bit LT3	**SET3**	=__________________
Reset Latch Bit LT3	**RST3**	=__________________
Set Latch Bit LT4	**SET4**	=__________________
Reset Latch Bit LT4	**RST4**	=__________________
Set Latch Bit LT5	**SET5**	=__________________
Reset Latch Bit LT5	**RST5**	=__________________
Set Latch Bit LT6	**SET6**	=__________________
Reset latch Bit LT6	**RST6**	=__________________
Set Latch Bit LT7	**SET7**	=__________________
Reset Latch Bit LT7	**RST7**	=__________________
Set Latch Bit LT8	**SET8**	=__________________
Reset Latch Bit LT8	**RST8**	=__________________
Set Latch Bit LT9	**SET9**	=__________________
Reset Latch Bit LT9	**RST9**	=__________________
Set Latch Bit LT10	**SET10**	=__________________
Reset Latch Bit LT10	**RST10**	=__________________
Set Latch Bit LT11	**SET11**	=__________________
Reset Latch Bit LT11	**RST11**	=__________________
Set Latch Bit LT12	**SET12**	=__________________
Reset Latch Bit LT12	**RST12**	=__________________

Set Latch Bit LT13	**SET13**	= ________________
Reset Latch Bit LT13	**RST13**	= ________________
Set Latch Bit LT14	**SET14**	= ________________
Reset latch Bit LT14	**RST14**	= ________________
Set Latch Bit LT15	**SET15**	= ________________
Reset Latch Bit LT15	**RST15**	= ________________
Set Latch Bit LT16	**SET16**	= ________________
Reset Latch Bit LT16	**RST16**	= ________________

Torque-Control Equations for Inst./Def.-Time Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Level 1 phase (see *Figure 4.19*)	**67P1TC**	= ________________
Level 2 phase (see *Figure 4.19*)	**67P2TC**	= ________________
Level 3 phase (see *Figure 4.19*)	**67P3TC**	= ________________
Level 1 residual ground (see *Figure 4.22*)	**67G1TC**	= ________________
Level 2 residual ground (see *Figure 4.22*)	**67G2TC**	= ________________
Level 3 residual ground (see *Figure 4.22*)	**67G3TC**	= ________________
Level 4 residual ground (see *Figure 4.22*)	**67G4TC**	= ________________
Level 1 negative-sequence (see *Figure 4.23*)	**67Q1TC**	= ________________
Level 2 negative-sequence (see *Figure 4.23*)	**67Q2TC**	= ________________
Level 3 negative-sequence (see *Figure 4.23*)	**67Q3TC**	= ________________
Level 4 negative-sequence (see *Figure 4.23*)	**67Q4TC**	= ________________

Torque-Control Equations for Time-Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Phase element (see *Figure 4.24*)	**51PTC**	= ________________
Residual ground element (see *Figure 4.25*)	**51GTC**	= ________________
Negative-sequence element (see *Figure 4.25*)	**51QTC**	= ________________

Torque-Control Equations for Tapped Load Time-Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Phase inverse time (see *Figure 3.21*)	**T51PTC**	= ________________
Ground inverse time (see *Figure 3.22*)	**T51GTC**	= ________________
Negative-sequence time (see *Figure 3.23*)	**T51QTC**	= ________________

Torque-Control Equations for Tapped Load Inst./Def.-Time Overcurrent Elements

Note: torque-control equation settings cannot be set directly to logical 0

Phase instantaneous (see *Figure 3.18*)	**T50PTC**	=________________
Ground instantaneous (see *Figure 3.19*)	**T50GTC**	=________________
Negative-sequence instantaneous (see *Figure 3.20*)	**T50QTC**	=________________

87L Element Torque-Control Equation

Note: torque-control equation settings cannot be set directly to logical 0

87L torque control (see *Figure 3.15*)	**87LTC**	=________________

SELOGIC Control Equation Variable Timer Input Equations (See Figure 7.24 and Figure 7.25)

SELOGIC control equation Variable SV1	**SV1**	=________________
SELOGIC control equation Variable SV2	**SV2**	=________________
SELOGIC control equation Variable SV3	**SV3**	=________________
SELOGIC control equation Variable SV4	**SV4**	=________________
SELOGIC control equation Variable SV5	**SV5**	=________________
SELOGIC control equation Variable SV6	**SV6**	=________________
SELOGIC control equation Variable SV7	**SV7**	=________________
SELOGIC control equation Variable SV8	**SV8**	=________________
SELOGIC control equation Variable SV9	**SV9**	=________________
SELOGIC control equation Variable SV10	**SV10**	=________________
SELOGIC control equation Variable SV11	**SV11**	=________________
SELOGIC control equation Variable SV12	**SV12**	=________________
SELOGIC control equation Variable SV13	**SV13**	=________________
SELOGIC control equation Variable SV14	**SV14**	=________________
SELOGIC control equation Variable SV15	**SV15**	=________________
SELOGIC control equation Variable SV16	**SV16**	=________________

Output Contact Equations (See Figure 7.27)

Output Contact OUT101	**OUT101**	=________________
Output Contact OUT102	**OUT102**	=________________
Output Contact OUT103	**OUT103**	=________________
Output Contact OUT104	**OUT104**	=________________

Output Contact OUT105	**OUT105**	=
Output Contact OUT106	**OUT106**	=
Output Contact OUT107	**OUT107**	=

Output Contact Equations—Differential Board (See Figure 7.28)

Output Contact OUT201	**OUT201**	=
Output Contact OUT202	**OUT202**	=
Output Contact OUT203	**OUT203**	=
Output Contact OUT204	**OUT204**	=
Output Contact OUT205	**OUT205**	=
Output Contact OUT206	**OUT206**	=

Output Contact Equations—Extra I/O Board

Output Contact OUT301	**OUT301**	=
Output Contact OUT302	**OUT302**	=
Output Contact OUT303	**OUT303**	=
Output Contact OUT304	**OUT304**	=
Output Contact OUT305	**OUT305**	=
Output Contact OUT306	**OUT306**	=
Output Contact OUT307	**OUT307**	=
Output Contact OUT308	**OUT308**	=
Output Contact OUT309	**OUT309**	=
Output Contact OUT310	**OUT310**	=
Output Contact OUT311	**OUT311**	=
Output Contact OUT3112	**OUT312**	=

Display Point Equations (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

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 7.5)

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*)	**ER**	=______________
Fault indication (used in time target logic—see *Table 5.1*; used also to suspend demand metering updating and peak recording and block max./min. metering—see *Local Demand Metering on page 8.3* and *Local Maximum/Minimum Metering on page 8.11*)	**FAULT**	=______________
Block synchronism-check elements (see *Figure 4.30*)	**BSYNCH**	=______________
Close bus monitor (see *Figure 5.7*)	**CLMON**	=______________
Breaker monitor initiation (see *Figure 8.9*)	**BKMON**	=______________
Enable for zero-sequence voltage-polarized and channel IP current-polarized directional elements (see *Figure 4.42*)	**E32IV**	=______________
Enable bus stub protection	**ESTUB**	=______________

MIRRORED BITS Transmit Equations (See Appendix E: MIRRORED BITS Communications)

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**	= ________________

87L Transmit Bit Equations

Channel X, transmit bit 1	**T1X**	= ________________
Channel X, transmit bit 2	**T2X**	= ________________
Channel X, transmit bit 3	**T3X**	= ________________
Channel X, transmit bit 4	**T4X**	= ________________
Channel Y, transmit bit 1	**T1Y**	= ________________
Channel Y, transmit bit 2	**T2Y**	= ________________
Channel Y, transmit bit 3	**T3Y**	= ________________
Channel Y, transmit bit 4	**T4Y**	= ________________

Date____________

Global Settings

Settings Group Change Delay (See Multiple Setting Groups on page 7.17)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps)	**TGR**	=________

Power System Configuration and Date Format (See Settings Explanations on page 9.34)

Nominal frequency (50 Hz, 60 Hz)	**NFREQ**	=________
Phase rotation (ABC, ACB)	**PHROT**	=________
Date format (MDY, YMD)	**DATE_F**	=________

Front-Panel Display Operation (See Section 11: Front-Panel Operations)

Front-panel display time-out

0.00–30.00 minutes in 0.01-minute steps	**FP_TO**	=________

(If FP_TO = 0, no time-out occurs and display remains on last display screen, e.g., continually display metering.)

Front-panel display update rate (1–60 seconds)	**SCROLD**	=________

Event Report Parameters (See Section 12: Analyzing Events)

Length of event report (15, 30, 60 cycles)	**LER**	=________

Length of pre-fault in event report

(1–14 cycles in 1-cycle steps for LER = 15)

(1–29 cycles in 1-cycle steps for LER = 30)

(1–59 cycles in 1-cycle steps for LER = 60)	**PRE**	=________

Station DC Battery Monitor (See Figure 8.3 and Figure 8.4)

DC battery instantaneous undervoltage pickup

OFF, 20–300 Vdc	**DCLOP**	=________

DC battery instantaneous overvoltage pickup

OFF, 20–300 Vdc	**DCHIP**	=________

Optoisolated Input Timers

Input IN101 debounce time

0.00–2.00 cycles in 0.25-cycle steps	**IN101D**	=________

Input IN102 debounce time

0.00–2.00 cycles in 0.25-cycle steps	**IN102D**	=________

Input IN103 debounce time

0.00–2.00 cycles in 0.25-cycle steps	**IN103D**	=________

Input IN104 debounce time
0.00–2.00 cycles in 0.25-cycle steps **IN104D** = __________

Input IN105 debounce time
0.00–2.00 cycles in 0.25-cycle steps **IN105D** = __________

Input IN106 debounce time
0.00–2.00 cycles in 0.25-cycle steps **IN106D** = __________

Input IN301 debounce time
0.00–2.00 cycles in 0.25-cycle steps **IN301D** = __________

Input IN302 debounce time
0.00–2.00 cycles in 0.25-cycle steps **IN302D** = __________

Input IN303 debounce time
0.00–2.00 cycles in 0.25-cycle steps **IN303D** = __________

Input IN304 debounce time
0.00–2.00 cycles in 0.25-cycle steps **IN304D** = __________

Input IN305 debounce time
0.00–2.00 cycles in 0.25-cycle steps **IN305D** = __________

Input IN306 debounce time
0.00–2.00 cycles in 0.25-cycle steps **IN306D** = __________

Input IN307 debounce time
0.00–2.00 cycles in 0.25-cycle steps **IN307D** = __________

Input IN308 debounce time
0.00–2.00 cycles in 0.25-cycle steps **IN308D** = __________

Synchronized Phasor Settings (See Appendix H: SEL Synchrophasors)

Synchronized Phasor Measurement (Y, N) **EPMU** = __________________________

Make the following settings if preceding enable setting EPMU = Y.

PMU Hardware ID **PMID** = __________________________

Phasor Data Set, Voltages (V1, ALL) **PHDATAV** = __________________________

Voltage Angle Comp. Factor (–179.99 to +180 degrees) **VCOMP** = __________________________

Phasor Data Set, Currents (ALL, NA) **PHDATAI** = __________________________

Current Angle Comp. Factor (–179.99 to +180 degrees) **ICOMP** = __________________________

Time Source Type (IRIG, IEEE) **TS_TYPE** = __________________________

Sequential Events Recorder Settings

Sequential Events Recorder settings are composed of three trigger lists. Each trigger list can include as many as 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See Sequential Events Recorder Report on page 12.36.

SER Trigger List 1
SER1 = ____________________

SER Trigger List 2
SER2 = ____________________

SER Trigger List 3
SER3 = ____________________

Text Label Settings

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**	=

Date____________

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 (See Rotating Default Display on page 7.38 and Rotating Default Display on page 11.10)

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

Display if DP9 = logical 1 (16 characters)	**DP9_1**	=________________
Display if DP9 = logical 0 (16 characters)	**DP9_0**	=________________
Display if DP10 = logical 1 (16 characters)	**DP10_1**	=________________
Display if DP10 = logical 0 (16 characters)	**DP10_0**	=________________
Display if DP11 = logical 1 (16 characters)	**DP11_1**	=________________
Display if DP11 = logical 0 (16 characters)	**DP11_0**	=________________
Display if DP12 = logical 1 (16 characters)	**DP12_1**	=________________
Display if DP12 = logical 0 (16 characters)	**DP12_0**	=________________
Display if DP13 = logical 1 (16 characters)	**DP13_1**	=________________
Display if DP13 = logical 0 (16 characters)	**DP13_0**	=________________
Display if DP14 = logical 1 (16 characters)	**DP14_1**	=________________
Display if DP14 = logical 0 (16 characters)	**DP14_0**	=________________
Display if DP15 = logical 1 (16 characters)	**DP15_1**	=________________
Display if DP15 = logical 0 (16 characters)	**DP15_0**	=________________
Display if DP16 = logical 1 (16 characters)	**DP16_1**	=________________
Display if DP16 = logical 0 (16 characters)	**DP16_0**	=________________

Reclosing Relay Labels (See Functions Unique to the Front-Panel Interface on page 11.5)

Reclosing Relay Last Shot Label (14 char.)	**79LL**	=________________
Reclosing Relay Shot Counter Label (14 char.)	**79SL**	=________________

Port Settings

Protocol Settings (See Below)

Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B, MBGA, MBGB, TELNET)	**PROTO**	= ______________

Protocol Settings Set PROTO = SEL for standard SEL ASCII protocol. For SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD. Refer to Appendix C for details on the LMD protocol. For Distributed Network Protocol (DNP), set PROTO = DNP. Refer to Appendix F for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, MB8B, MBGA, or MBGB. Refer to Appendix E for details on MIRRORED BITS. To enable Telnet-to-relay communications on **PORT 5** and **PORT6**, the **PORT 1** PROTO setting must be set to TELNET. Setting PROTO = TELNET disables **PORT 1** for EIA-485 communications.

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) *(38400 is not available on Port 1)*	**SPEED**	= ______________
Data Bits (6, 7, 8) *This setting is available when PROTO = SEL or LMD.*	**BITS**	= ______________
Parity (O, E, N) {Odd, Even, None} *This setting is available when PROTO = SEL or LMD.*	**PARITY**	= ______________
Stop Bits (1, 2) *This setting is available when PROTO = SEL or LMD.*	**STOP**	= ______________
Time-out (0–30 minutes) *This setting is available when PROTO = SEL or LMD. 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.*	**T_OUT**	= ______________
DTA Meter Format (Y, N) *Set DTA = Y to allow an SEL DTA or SEL DTA2 to communicate with the relay. This setting is available when PROTO = SEL or LMD. Note that when DTA = Y, the date format must be set to MDY in the Global setting DATE_F.*	**DTA**	= ______________
Send Auto Messages to Port (Y, N) *This setting is available when PROTO = SEL or LMD. Set AUTO = Y to allow automatic messages at the serial port.*	**AUTO**	= ______________
Enable Hardware Handshaking (Y, N, MBT) *MBT is available when PROTO = MBA or MBB. (Refer to* MIRRORED BITS Protocol for the Pulsar 9600 Baud Modem on page E.5 *for details on setting MBT.) Set RTSCTS = Y to enable hardware handshaking. With RTSCTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line. Setting RTSCTS is not applicable to serial Port 1 (EIA-485) or a port configured for SEL Distributed Port Switch Protocol.*	**RTSCTS**	= ______________
Fast Operate Enable (Y, N) *This setting is available when PROTO = SEL or LMD. 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 D: SEL Communications Processors *for the description of the* SEL-311L *Relay Fast Operate commands. When PROTO = TELNET, FASTOP is set to Y and is hidden.*	**FASTOP**	= ______________

LMD Settings

LMD Prefix (@, #, $, %, &)	**PREFIX**	=________
LMD Address (1–99)	**ADDR**	=________
LMD Settling Time (0–30 seconds)	**SETTLE**	=________

TELNET Settings (PORT 1 only)

Telnet Port for Relay Access (1–65534)	**TPORT**	=________
Telnet Port Timeout (1–30 min)	**TIDLE**	=________

Ethernet Port Settings (PORT 5 and PORT 6 only)

IP Address (xxx.xxx.xxx.xxx)	**IPADDR**	=________
Subnet Mask (xxx.xxx.xxx.xxx)	**SUBNETM**	=________
Default Router (xxx.xxx.xxx.xxx)	**DEFRTR**	=________
Enable TCP Keep-Alive (Y, N)	**ETCPKA**	=________
TCP Keep-Alive Idle Range (1–20 s) *If ETCPKA = Y*	**KAIDLE**	=________
TCP Keep-Alive Interval Range (1–20 s) *If ETCPKA = Y*	**KAINTV**	=________
TCP Keep-Alive Count Range (1–20 s) *If ETCPKA = Y*	**KACNT**	=________
Operating Mode (FIXED, FAILOVER)	**NETMODE**	=________
Failover Time-out (OFF, 0.1–65.00 sec) *If NETMODE = FAILOVER*	**FTIME**	=________
Enable Telnet (Y, N)	**ETELNET**	=________
Telnet Port for Card Access (1–65534) *If ETELNET = Y*	**TPORTC**	=________
Telnet Port Timeout (1–30 min) *If ETELNET = Y*	**TIDLE**	=________
Enable FTP Server (Y, N) *If ETELNET = Y*	**EFTPSERV**	=________
FTP Username (20 characters) *If EFTPSERV = Y*	**FTPUSER**	=________
FTP Connect Banner *If EFTPSERV = Y*	**FTPCBAN**	=________
FTP Idle Timeout (5–255 minutes) *If EFTPSERV = Y*	**FTPIDLE**	=________
Enable HTTP Server (Y, N)	**EHTTP**	=________
HTTP TCP/IP Port (1–65535) *If EHTTP = Y*	**HTTPPORT**	=________
HTTP Web Server Timeout (1–30 minutes) *If EHTTP = Y*	**HTTPIDLE**	=________
Enable IEC 61850 Protocol (Y, N) *If IEC 61850 is available*	**E61850**	=________
Enable IEC 61850 GSE (Y, N) *If IEC 61850 is available*	**EGSE**	=________

DNP Settings

DNP Address (0–65534)	**DNPADR**	= ____________
Class for event data (0 for no event, 1–3)	**ECLASS**	= ____________
Time-set request interval, minutes (0 for never, 1–32767)	**TIMERQ**	= ____________
Currents scaling (0–3 decimal places)	**DECPLA**	= ____________
Voltages scaling (0–3 decimal places)	**DECPLV**	= ____________
Miscellaneous data scaling (0–3 decimal places)	**DECPLM**	= ____________
Select/Operate time-out interval, seconds (0.0–30.0)	**STIMEO**	= ____________
Number of data-link retries (0 for no confirm, 1–15)	**DRETRY**	= ____________
Data Link Time-out interval, seconds (0–5)	**DTIMEO**	= ____________
Minimum Delay from DCD to transmission, seconds (0.00–1.00)	**MINDLY**	= ____________
Maximum Delay from DCD to transmission, seconds (0.00–1.00)	**MAXDLY**	= ____________
Transmission delay from RTS assertion, seconds (OFF, 0.00–30.00)	**PREDLY**	= ____________
Post-transmit RTS deassertion delay, seconds (0.00–30.00)	**PSTDLY**	= ____________
Analog reporting deadband, counts (0–32767)	**ANADB**	= ____________
Allow Unsolicited Reporting (Y/N)	**UNSOL**	= ____________
Enable unsolicited messages when the relay turns on (Y/N)	**PUNSOL**	= ____________
Address of master to Report to (0–65534)	**REPADR**	= ____________
Number of events to transmit on (1–200)	**NUMEVE**	= ____________
Age of oldest event to force transmit on, seconds (0.0–60.0)	**AGEEVE**	= ____________
Time-out for confirmation of unsolicited message, seconds (0–50)	**UTIMEO**	= ____________

MB Settings

PPM MIRRORED BITS Channel Bad Pickup (1–10000)	**CBADPU**	= ____________
MIRRORED BITS Receive Identifier (1–4) *This setting is unavailable if PROTO is set to MBGA or MBGB.*	**RXID**	= ____________
MIRRORED BITS Transmit Identifier (1–4) *This setting is unavailable if PROTO is set to MBGA or MBGB.*	**TXID**	= ____________
MIRRORED BITS Receive Default State (string of 1s, 0s or Xs) 87654321	**RXDFLT**	= ____________
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB1PU**	= ____________
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB1DO**	= ____________

MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB2PU**	=
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB2DO**	=
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB3PU**	=
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB3DO**	=
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB4PU**	=
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB4DO**	=
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB5PU**	=
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB5DO**	=
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB6PU**	=
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB6DO**	=
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB7PU**	=
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB7DO**	=
MIRRORED BITS RMB_ Pickup Debounce msgs (1–8)	**RMB8PU**	=
MIRRORED BITS RMB_ Dropout Debounce msgs (1–8)	**RMB8DO**	=

Channel Settings

87L Channel X Configuration Settings

Channel X address check (Y, G, N)	**EADDCX**	=
If EADDCX = Y		
Channel X transmit address (1–16) *This setting is unavailable if EADDCX is set to G.*	**TA_X**	=
Channel X receive address (1–16) *This setting is unavailable if EADDCX is set to G.*	**RA_X**	=
Continuous dropout alarm (1–1000 seconds)	**RBADXP**	=
Packets lost in last 10,000 (1–5000)	**AVAXP**	=
One-way channel delay alarm (1–24 ms)	**DBADXP**	=
If CHANX type is EIA-422		
EIA-422 receive clock edge detect (R = Rising; F = Falling)	**RC422X**	=
EIA-422 transmit clock edge detect (R = Rising; F = Falling)	**TC422X**	=
If CHANX type is not EIA-422		
Timing source (I = Internal; E = External)	**TIMRX**	=

87L Channel Y Configuration Settings

Channel Y address check (Y, G, N)	**EADDCY**	=

If EADDCY = Y

Channel Y transmit address (1–16) *This setting is unavailable if EADDCY is set to G.*	**TA_Y**	=________
Channel Y receive address (1–16) *This setting is unavailable if EADDCY is set to G.*	**RA_Y**	=________
Continuous dropout alarm (1–1000 seconds)	**RBADYP**	=________
Packets lost in last 10,000 (1–5000)	**AVAYP**	=________
One-way channel delay alarm (1–24 ms)	**DBADYP**	=________

If CHANY type is EIA-422

EIA-422 receive clock edge detect (R = Rising; F = Falling)	**RC422Y**	=________
EIA-422 transmit clock edge detect (R = Rising; F = Falling)	**TC422Y**	=________

If CHANY type is not EIA-422

Timing source (I = Internal; E = External)	**TIMRY**	=________

Appendix A
Firmware and Manual Versions

Firmware

Determining the Firmware Version in Your Relay

NOTE: The hardware of SEL-311L-1, -7 Relays that originally shipped with firmware revision R500 or higher differs from the hardware of SEL-311L-1, -7 Relays that originally shipped with R4xx series firmware. Relays with R4xx firmware revisions can be upgraded to firmware revision R500 and later, but R4xx firmware revisions cannot be loaded on SEL-311L-1, -7 Relays shipped with firmware revision R500 and higher.

NOTE: The hardware of SEL-311L-1, -7 Relays with R4xx series firmware and R5xx series firmware differs from the hardware of SEL-311L-1, -7 Relays with R2xx series firmware. R4xx and R5xx firmware revisions cannot be loaded on SEL-311L-1, -7 Relays shipped with R2xx series firmware. R2xx firmware is not compatible with R4xx or R5xx hardware.

To find the firmware revision number in your relay, view the status report by using the serial port **STATUS** (**STA**) command or the front-panel **STATUS** pushbutton. The status report displays the firmware identification (FID) string:

FID=SEL-311L-R100-V0-Z001001-D20010625

The SEL-311L Relay provides a means of interpreting the FID string. The FID string is included near the top of each long event report. The string format follows:

FID = SEL-311L - R[RN] - V[VS] - Z[ES] - D[DC]

where:

[RN] = Revision Number (e.g., 100)
[VS] = Version Specification
[ES] = External Software Version (e.g., 001001)
[DC] = Date Code (e.g., YYYYMMDD=20010625)

Table A.1 lists the firmware versions, a description of modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

Table A.1 Firmware Revision History (Sheet 1 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-311L-1-R502-V0-Z106006-D20141106 SEL-311L-7-R502-V0-Z106006-D20141106 Note: Firmware revision R502 is compatible with Ethernet and non-Ethernet versions of the SEL-311L-1, -7 that were originally shipped with R5xx firmware.	➤ Modified default settings when APP = 87LSP to reduce the number of settings changes necessary for single-pole tripping applications.	20141106
SEL-311L-1-R501-V0-Z106006-D20140918 SEL-311L-7-R501-V0-Z106006-D20140918	**Note:** This firmware version did not production release.	20140918
SEL-311L-1-R500-V0-Z105006-D20140325 SEL-311L-7-R500-V0-Z105006-D20140325 Note: R500 firmware is suitable for upgrading relays from R402 through R414.	➤ Made fault location and fault impedance available via IEC 61850 MMS. ➤ Modified **SER** and **COM** commands so they now display proper time stamps. In previous firmware, **SER** and **COM** command time-stamp entries could, on rare occasion, be in error by as long as 10 ms when IRIG was not connected to the relay.	20140325

Table A.1 Firmware Revision History (Sheet 2 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-311L-1-R414-V0-Z105006-D20130307 SEL-311L-7-R414-V0-Z105006-D20130307 SEL-311L-1-R215-V0-Z011005-D20130307 SEL-311L-7-R215-V0-Z011005-D20130307	➤ Corrected breaker monitor function to properly handle test settings that prevented the relay from enabling. ➤ Improved handling of TIRIG Relay Word bit when the relay is disconnected from a communications processor. ➤ Corrected inconsistency in hide rules when enabling compensator-distance elements. ➤ Improved accuracy of the timestamp in SER reports for current differential elements and COM reports by as many as 9 ms when IRIG is connected. ➤ **SEND** command is no longer supported by SELBOOT. ➤ Improved RAM self-tests to restart relay as many as three times in 24 hours. ➤ Properly forced receive MIRRORED BITS to default value indicated by RXDFLT setting during a port setting change. ➤ Modified SER reports to include settings change and power-up messages.	20130307
SEL-311L-1-R413-V0-Z105006-D20110504 SEL-311L-7-R413-V0-Z105006-D20110504	➤ Modified MMS controls operation to be independent of GOOSE enable setting. ➤ Corrected behavior of MMS Breaker Open/Close operation.	20110504
SEL-311L-1-R412-V0-Z105006-D20101112 SEL-311L-7-R412-V0-Z105006-D20101112	➤ Increased processing rate to prevent possible CPU error in 60 Hz applications when IEC 61850 protocols are enabled.	20101112
SEL-311L-1-R411-V0-Z105006-D20100616 SEL-311L-7-R411-V0-Z105006-D20100616 SEL-311L-1-R214-V0-Z011005-D20100616 SEL-311L-7-R214-V0-Z011005-D20100616	➤ Added 87LTC torque control and associated SELOGIC setting. ➤ Initialized UBOSBD timer properly following settings change. ➤ Improved UBOSBD timer performance for cases where impedance trajectory crosses Zone 5 boundary multiple times. ➤ Corrected OSBB and OSBC operation when single-phase logic is enabled on systems with ACB rotation. ➤ Repaired logic for "G" front-panel target when 51GT or 50G1–50G4 are used in the trip equations. ➤ Corrected Fast Message configuration block to indicate synchrophasor support. ➤ Repaired date roll-over problem when IRIG updates time near midnight. ➤ Forced EOCTL and TOPD settings to correct values when the APP setting is changed. ➤ Enabled disturbance detector supervision for 87L trips during a channel alarm.	20100616
SEL-311L-1-R410-V0-Z104006-D20100312 SEL-311L-7-R410-V0-Z104006-D20100312	➤ Enabled disturbance detector supervision by default with Group setting EDD = Y. ➤ Added Relay Word bits LNKFAIL, P5SEL, and P6SEL to support Ethernet failover. ➤ Added Port 5 settings to support Ethernet failover and embedded web server. ➤ Delayed changing Relay Word bits SG1–SG6 until the group change is complete. Previously, these bits changed just before the settings group changed. ➤ Changed event reports to use the CTR, CTRN, PTR, and PTRS that were in effect at the time of the trigger. In prior firmware versions, changes to those settings could change the currents and voltages reported in previously stored events. ➤ Removed extra carriage return from the end of each line of the ID command response. ➤ Improved A/D converter self-test for real-time detection of failed components.	20100312

Table A.1 Firmware Revision History (Sheet 3 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-311L-1-R213-V0-Z010005-D20100312 SEL-311L-7-R213-V0-Z010005-D20100312	➤ Enabled disturbance detector supervision by default with group setting EDD = Y. ➤ Delayed changing Relay Word bits SG1–SG6 until the group change is complete. Previously, those bits changed just before the settings group changed. ➤ Changed event reports to use the CTR, CTRN, PTR, and PTRS that were in effect at the time of event trigger. In prior firmware versions, changes to those settings could change the currents and voltages reported in previously stored events. ➤ Removed extra carriage return from the end of each line of the **ID** command response. ➤ Improved A/D converter self-test for real-time detection of failed components.	20100312
SEL-311L-1-R408-V0-Z103005-D20090205 SEL-311L-7-R408-V0-Z103005-D20090205 SEL-311L-1-R212-V0-Z010004-D20090205 SEL-311L-7-R212-V0-Z010004-D20090205	➤ Updated LOP logic to correctly deal with busbar faults when busbar voltage switch-over schemes are used for voltage polarization. ➤ Updated LOP logic to prevent erroneous resetting while the relay is not frequency tracking.	20090205
SEL-311L-1-R406-V0-Z102005-D20071101 SEL-311L-7-R406-V0-Z102005-D20071101 SEL-311L-1-R210-V0-Z009004-D20071101 SEL-311L-7-R210-V0-Z009004-D20071101	➤ Corrected Channel X or Y status on the front panel when E87L = 3. ➤ Added 4U vertical panel-mount option.	20071101
SEL-311L-1-R405-V0-Z102005-D20070822 SEL-311L-7-R405-V0-Z102005-D20070822 SEL-311L-1-R209-V0-Z009004-D20070622 SEL-311L-7-R209-V0-Z009004-D20070622	➤ Improved DNP responsiveness when an Ethernet card is installed. ➤ Internal change to improve manufacturability.	20070822
SEL-311L-1-R404-V0-Z102005-D20070622 SEL-311L-7-R404-V0-Z102005-D20070622 SEL-311L-1-R209-V0-Z009004-D20070622 SEL-311L-7-R209-V0-Z009004-D20070622	➤ Changed Target Reset Logic to keep Relay Targets EN, RS, LO, 87CH FAIL asserted when the Target Reset pushbutton is pressed. ➤ Corrected possibility of indeterminate DNP3 response times. ➤ Modified 87CH Fail front-panel target LED logic so that it will not assert when Line Current Differential Protection is not enabled (E87 = N). ➤ Added 87L to the Relay Event Report History and Summary Report when 87L or TRIP87 Relay Word Bits are asserted. ➤ Corrected Status Report errors when connected to DTA port.	20070622
SEL-311L-1-R403-V0-Z102005-D20060829 SEL-311L-7-R403-V0-Z102005-D20060829	➤ Added new Channel X and Channel Y address check setting option. When selected, the Channel X and Channel Y transmit and receive address settings are moved into the Group settings structure for more flexible operation, such as in a bus transfer scheme. ➤ Corrected dc battery monitor malfunction that may result in erroneous values after a setting or group change.	20060829
SEL-311L-1-R402-V0-Z101005-D20060801 SEL-311L-7-R402-V0-Z101005-D20060801 **Note:** With the addition of Ethernet capabilities, introduced in R402, the main board changes made to support this functionality are not backwards compatible with any previous versions of firmware (R2*xx*).	➤ Added support for Ethernet card and IEC 61850. ➤ Added new breaker-level command, **TEST DB**.	20060801

Table A.1 Firmware Revision History (Sheet 4 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-311L-1-R208-V0-Z009004-D20060728 SEL-311L-7-R208-V0-Z009004-D20060728	➤ Added new Channel X and Channel Y address check setting option. When selected, the Channel X and Channel Y transmit and receive address settings are moved into the Group settings structure for more flexible operation, such as in a bus transfer scheme. ➤ Corrected dc battery monitor malfunction that may result in erroneous values after a setting or group change. ➤ Corrected firmware upgrade issue where calibration settings are lost if upgrading from R203 and earlier to R207.	20060728
SEL-311L-1-R207-V0-Z008004-D20060320 SEL-311L-7-R207-V0-Z008004-D20060320	Protection ➤ Added support for new SEL Fast Message Synchrophasor protocol, event reporting, and metering. ➤ Changed DCUB default setting GARD1D from 1 cycle to 10 cycles. ➤ Modified LOP reset logic to include V_2 check and increased V_{ph} thresholds. ➤ Changed Frequency Element Undervoltage Block dropout timer from 5 cycles to 30 cycles. Settings ➤ Lowered minimum pickup setting for time-overcurrent elements to 0.05 • I_{nom}. ➤ Tapped-Load Coordinating Overcurrent Element Settings: changed Group settings ETP, ETG, and ETQ behavior when ETAP was set to N. ETP, ETG, and ETQ are now hidden and forced to N for this case. ➤ Corrected substation battery monitor implementation to allow both Relay Word bits DCLO and DCHI to assert when DCLOP is set higher than DCHIP. Reporting ➤ Changed default event report and compressed event report command length to follow Global Setting LER. ➤ Power Factor values found in DNP and ASCII communication now match in resolution when polled simultaneously. ➤ Changed Digital Input Data for regular and compressed Event Reports. Now Digital Data corresponds to raw or filtered analog values displayed. ➤ Added Rollover feature for all Energy Values when accessed through the front panel or ASCII port. All Energy Values rollover at 100000. Communication ➤ Lowered Port 1 maximum speed from 38.4 kbps to 19.2 kbps. ➤ Added new Protocol settings MBGA and MBGB, which when set, move MIRRORED BITS related settings into Group settings structure for more flexible operation, such as in bus-transfer schemes.	20060320
SEL-311L-1-R206-V0-Z007003-D20050429 SEL-311L-7-R206-V0-Z007003-D20050429	➤ Corrected issue where the relay may intermittently respond with asterisks (*****) data for current differential metering on the front-panel HMI and in the Fast Meter response when Fast Meter is used on Port 3.	20050429

Table A.1 Firmware Revision History (Sheet 5 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-311L-1-R205-V0-Z007003-D20050405 SEL-311L-7-R205-V0-Z007003-D20050405	➤ Corrected issue with Status command (STA) to properly indicate Line Current Differential Protection Disabled when active channel is in alarm. ➤ Corrected inconsistency in hide rules when enabling compensator distance elements. ➤ Corrected issue where negative- and zero-sequence current differential elements do not operate in stub bus applications when current differential communications is interrupted. ➤ Improved dependability of current differential transmit/receive bits and direct-transfer trip bits by reducing resynch time for the digital elements. ➤ Corrected issue where elements in compensator distance protection may not properly operate for high-impedance lines under high-fault current conditions. ➤ Corrected issue where a serial port set to DNP3 protocol may not properly initialize.	20050405
SEL-311L-1-R203-V0-Z006003-D20040412 SEL-311L-7-R203-V0-Z006003-D20040412	➤ Added improved relay diagnostics to detect and correct soft memory errors. ➤ Corrected issue where the relay can declare an erroneous Dual Port RAM failure during relay initialization. ➤ Corrected issue where changing the EDP setting causes the relay to change certain SELOGIC settings to default. ➤ Corrected issue where event reports triggered back-to-back are not recorded as such. ➤ Corrected issue where the relay does not respond to a direct-transfer-trip when in a three-terminal application and one communications channel is disabled. ➤ Corrected issue where if ECOMM is enabled, the relay does not confirm that three levels of directional overcurrent are enabled, and that Zone 3 is set to reverse. ➤ Corrected issue where the relay does not display the current differential values on the front-panel instantaneous meter screen. ➤ Added DNP3 analog and binary setting maps to the file transfer system to provide complete ACSELERATOR SEL-5030 compatibility. ➤ Corrected issue where event summaries do not report the correct fault current if LER is 30 cycles or more, and PRE is 15 cycles or more.	20040412
SEL-311L-1-R201-V0-Z005003-D20031203 SEL-311L-7-R201-V0-Z005003-D20031203	➤ Initial version.	20031203

Ethernet Card Firmware

NOTE: This information only applies to relays equipped with optional Ethernet cards.

Table A.2 lists the Ethernet card firmware versions, a description of modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

Table A.2 Ethernet Card Firmware Revision History

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-E3-R114-V0-Z001001-D20190111	➤ Resolved an issue where certain Ethernet traffic could cause the Ethernet card to safely restart.	20190222
SEL-E3-R113-V0-Z001001-D20160812	➤ Enhanced Telnet interface to issue a QUIT command when a session is terminated. ➤ Modified GOOSE processing to initialize values following a diagnostic restart or **STA C** command.	20160812
SEL-E3-R112-V0-Z001001-D20140313	➤ Modified IEC 61850 processing to ensure that when exactly four buffered reports are enabled, Ethernet communications are maintained. In previous firmware, if E61850 = Y, IEC 61850 buffered reports are enabled via an MMS command, and exactly four buffered reports are defined in the CID file, the Ethernet card can cease all communication, including GOOSE messages.	20140313
SEL-E3-R111-V0-Z001001-D20111031	➤ Corrected error message generated in response to 61850 MMS control failure. ➤ Corrected GOOSE reception issue after Ethernet failover operation. ➤ SEL-E3-R110 not released.	20111031
SEL-E3-R109-V0-Z001001-D20110517	➤ Improved IEC 61850 conformance.	20110517
SEL-E3-R108-V0-Z001001-D20100226	➤ Added select before operate (SBO) and enhanced security SBO modes to 61850 MMS. ➤ Added web server. ➤ Activated Ethernet Port 6 and added Ethernet failover.	20100312
SEL-E3-R107-V0-Z001001-D20090205	➤ Improved IEC 61850 security (see selinc.com/support/security-notifications for details).	20090205
SEL-E3-R106-V0-Z001001-D20081022	➤ Updated IEC 61850 firmware to streamline MMS processing and improve TCP/IP connections. ➤ Improved security (see selinc.com/support/security-notifications for details).	20081022
SEL-E3-R105-V0-Z001001-D20080808	➤ Corrected timing issue on disconnection or connection that would result in an Ethernet port failure.	20080808
SEL-E3-R104-V0-Z001001-D20080110	➤ Enhanced IEC 61850 functionality with KEMA certification updates. ➤ Made improvements to IEC 61850 control operation priorities when using IEC 61850 GOOSE messaging. ➤ Improved CID parse failure notification for the **STA** and **ID** commands.	20080110
SEL-E3-R102-V0-Z001001-D20060814	➤ Initial version.	20060801

Newer Ethernet card firmware (R104 and higher) uses a different software library from earlier versions and is unable to process version 001 CID files. ACSELERATOR Architect SEL-5032 Software generates CID files from ICD files so the ICD file version number and CID file version number are the same. If downloaded to the Ethernet card, an incompatible CID file will generate file parse errors during processing and disable the IEC 61850 protocol.

If you perform an Ethernet card firmware upgrade that spans different file version compatibilities, the relay may not be able to process the stored CID file. See *Ethernet Card Firmware Upgrade Instructions on page B.17* for CID file conversion procedures.

See *Table A.3* for compatibilities between Architect, ICD/CID file, and Ethernet card firmware versions.

Table A.3 Architect CID File Compatibility

Architect Software Version	Architect ICD/CID File Version	Ethernet Card Firmware
R.1.1.69.0 or later	Ver 002	R104–R107
R1.1.91.3 or later	Ver 003	R108
R1.1.95.0 or later	Ver 004	R109–R114

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 revisions are listed at the top.

Table A.4 Instruction Manual Revision History (Sheet 1 of 9)

Date Code	Summary of Revisions
20250127	Appendix B ➤ Removed references to CD throughout.
20221103	Section 1 ➤ Added UKCA Mark to *Specifications*.
20211203	Section 1 ➤ Updated *Type Tests* in *Specifications*.
20191107	Section 1 ➤ Updated *Specifications*.
20190809	Section 3 ➤ Updated *SYNCHROWAVE Event Produces Alpha Plane Plots*. Command Summary ➤ Updated definition for **EVE C *n***. Section 12 ➤ Updated the C option definition of the **EVE** command. ➤ Updated *Compressed ASCII Event Reports*. Section 13 ➤ Updated *Introduction* under *Testing Alpha Plane 87L Elements*. Appendix J ➤ Updated entire appendix.
20190222	Preface ➤ Updated *Trademarks* in *General Information*. Appendix A ➤ Updated for Ethernet card firmware version R114.

Table A.4 Instruction Manual Revision History (Sheet 2 of 9)

Date Code	Summary of Revisions
20170602	Section 1 ➤ Updated references to IEEE C37.94. ➤ Updated *Specifications*. Section 2 ➤ Updated references to IEEE C37.94. Section 10 ➤ Updated references to IEEE C37.94. Section 13 ➤ Updated references to IEEE C37.94.
20160812	Appendix A ➤ Updated for Ethernet card firmware version R113. ➤ Updated *Table A.3: ACSELERATOR Architect CID File Compatibility*.
20160715	Section 4 ➤ Enhanced the *Directional Control Settings* subsection to include a description of specific applications for the E32 setting.
20160122	Section 1 ➤ Updated *Specifications*.
20150126	Preface ➤ Updated *Safety Information*. Section 1 ➤ Updated *Specifications*.
20141106	Section 3 ➤ Updated *Synchronism-Check Elements.* Section 4 ➤ Updated *Figure 4.37: Load-Encroachment Logic With Example Settings.* Section 10 ➤ Added *VER command*. Appendix A ➤ Updated for firmware version R502.
20140325	Appendix A ➤ Added margin notes to clarify firmware versions that are supported by specific hardware. ➤ Updated for firmware versions R500. ➤ Modified the summary of revisions description of the **SEND** command for firmware versions R414 and R215. Appendix F Clarified the DNP quantity, where the Fault Type can be a combination of multiple Event Causes and Fault Types. Appendix G ➤ Added fault location quantities to *Table G.5: Logical Device: PRO*.
20140313	Appendix A ➤ Updated for Ethernet card firmware versions R112 (see *Table A.2* and *Table A.3*).
20130307	Section 3 ➤ Modified the description of the use case for the 87L Torque Control Equation and changed the reference to *Figure 3.18: Differential Element 87L Processing.* ➤ Added a paragraph to *Three-Terminal Protection With the SEL-311L* to explain the 87L restraint region during internal faults with outflow, external faults with CT saturation, and terminal(s) with open breaker(s) or low current. Section 4 ➤ Added section describing setting guidelines for ORDER and negative-sequence impedance directional thresholds.

Table A.4 Instruction Manual Revision History (Sheet 3 of 9)

Date Code	Summary of Revisions
	Section 13 ➤ Added descriptions of number of times the relay automatically restarts after a diagnostic failure and the message that is displayed in the SER. Appendix A ➤ Updated for firmware version R414. Appendix F ➤ Modified the *Configurable Data Mapping* section to clarify acceptable DNP map values.
20120628	Section 1 ➤ Updated description of Dielectric Strength. ➤ Updated *Specifications*.
20111031	Section 10 ➤ Corrected description of Ethernet failover operation in *Redundant Ethernet Network Using FAILOVER Mode*. Appendix A ➤ Updated for Ethernet card firmware version R111 (see *Table A.2*).
20110517	Appendix A ➤ Updated for Ethernet card firmware version R109 (see *Table A.2*). ➤ Updated for ICD file 004 (see *Table A.3*). Appendix G ➤ Removed references to 001 and 002L ICD files. ➤ Added description of ICD file 004. ➤ Updated ACSI Conformance Statements.
20110504	Appendix A ➤ Updated for firmware version R413.
20101122	Settings Sheets ➤ Added RBADPU setting under *Port Settings*. Section 10 ➤ Updated the Ethernet cable table in *Cables*. ➤ Clarified *TEST DB Command* regarding relays with Ethernet ports. Section 12 ➤ Added description of remote and local currents in *Compressed ASCII Event Reports*. Appendix B ➤ Updated information in *Overview*. ➤ Added *Table B.1: Relays Not Covered by These Instructions*.
20101112	Appendix A ➤ Updated for firmware version R412.
20100616	Section 3 ➤ Added new 87LTC SELOGIC Equation setting. Section 4 ➤ Removed mention of distance calculation smoothness detection. Section 5 ➤ Updated description of disturbance detector supervision. Section 8 ➤ Included description of POS-SEQ Alpha Plane metering quantity. Settings Sheets ➤ Added new 87LTC SELOGIC Equation setting. Section 10 ➤ Added mention of QUI and EXI commands available from Access Level 0.

Table A.4 Instruction Manual Revision History (Sheet 4 of 9)

Date Code	Summary of Revisions
	Appendix A ➤ Updated for firmware versions R411 and R214. ➤ Clarified first bulleted item in Firmware Revision History for R205.
20100312	Section 1 ➤ Updated Ethernet card specifications to include dual-failover functionality. Section 5 ➤ Changed description of Local Disturbance Detector. Section 9 ➤ Added Relay Word bits LNKFAIL, P5SEL, and P6SEL. ➤ Added Port 5 settings for dual failover Ethernet and embedded web server. Section 10 ➤ Added description and example uses of dual failover Ethernet in fixed and failover modes of operation. ➤ Added description of embedded web server with screen shots of sample web pages. ➤ Changed default value of EDD from N to Y in the settings screen capture. Section 12 ➤ Changed default value of EDD from N to Y in the settings screen capture. Section 14 ➤ Added Port 5 settings for dual failover Ethernet and embedded web server to all applications settings sheets. ➤ Changed default value of EDD from N to Y in the settings screen capture. Appendix A ➤ Updated for firmware versions R213 and R410. ➤ Updated for Ethernet card firmware version R108. Appendix G ➤ Updated for select before operate (SBO) and enhanced security SBO. ➤ Added dual failover Ethernet descriptions. ➤ Added description of SEL-311L ICD file version 003. ➤ Renamed protocol implementation conformance statement to SEL-311L-specific statement.
20090205	Section 4 ➤ Added *Setting EBBPT = Y*. Section 9 ➤ Added example EBBPT setting to *Settings Example: 230 kV Transmission Line With Tapped Load* and *Settings Example: 230 kV Transmission Line Single-Pole Tripping*. Settings Sheets ➤ Added EBBPT setting. Section 10 ➤ Added reference to Access Level C. Section 14 Application Settings Sheets (87L21P and 87LSP) ➤ Added EBBPT setting. Appendix A ➤ Updated for firmware versions R408 and R212.
20081022	Appendix A ➤ Updated for Ethernet card firmware version R106.
20080808	Appendix A ➤ Updated for Ethernet card firmware version R105.

Table A.4 Instruction Manual Revision History (Sheet 5 of 9)

Date Code	Summary of Revisions
20080110	**Appendix A** ➤ Added *Ethernet Port Firmware*. **Appendix B** ➤ Added *F. Verify or Restart IEC 61850 Operation* to *Ethernet Card Firmware Upgrade Instructions*. **Appendix G** ➤ Added *SEL ICD File Versions*. ➤ Added *Table G.5: Logical Nodes Summary*. ➤ Updated *Table G.6: Logical Device: PRO* and *Table G.9: Logical Device: ANN*.
20071101	**Section 1** ➤ Noted additional 4U vertical panel-mount option. **Section 2** ➤ Noted additional 4U vertical panel-mount option. ➤ Added *Figure 2.8*, 4U vertical panel-mount figure. **Appendix A** ➤ Updated for firmware versions R406 and R210.
20070822	**Section 1** ➤ Updated fiber optics-ST connector distance limitations in the *Specifications*. **Section 7** ➤ Corrected error where 51GP element referenced the CTRP setting. **Section 10** ➤ Updated **PAS** command to reflect the new password structure. ➤ Updated channel specifier information under **COM** Command (Communication Data). ➤ Added comment about relay and SEL-DTA compatibility. **Appendix A** ➤ Updated for firmware version R405. ➤ Updated *Table A.3*. **Appendix H** ➤ Updated number of synchrophasor magnitude and angle pairs transmitted in *Table H.8*.
20070622	**Sections 10 and 13** ➤ Added note to indicate that the Relay Alarm contact closes when given the **TST** command. **Appendix A** ➤ Updated for firmware version R404.
20060829	**Appendix A** ➤ Updated for firmware version R403. **Appendix G** ➤ Corrected object model information. ➤ Added Logical Device table. ➤ Added more detail in *Report Processing*. ➤ Added Protocol Implementation Conformance Statement (PICS).
20060801	**Section 1** ➤ Added IEC 61850 communications and Ethernet connectivity to list of ordering options. ➤ Deleted the figure SEL-311L *Relay Communications Interfaces*. ➤ Added Ethernet Communications Ports specifications. ➤ Corrected Distance Limitations under *Differential Communications Port*. **Section 2** ➤ Added four rear-panel drawings that show 10/100BASE-T and 100BASE-FX Ethernet. **Section 9** ➤ Added Telnet and Ethernet Port settings to the Settings Sheets.

Table A.4 Instruction Manual Revision History (Sheet 6 of 9)

Date Code	Summary of Revisions
	Section 10 ➤ Added *Ethernet Interfaces*, *Ethernet Protocols*, and *Ethernet Card Command Explanations*. Command Summary ➤ Added Ethernet port commands and organized commands by access level. Section 13 ➤ Added Ethernet port self-tests to *Table 13.6*. ➤ Added *Relay Does Not Respond to Commands From Device Connected to Ethernet Port*. Section 14 ➤ Added Telnet and Ethernet Port settings to the Settings Sheets for the Application Examples. Appendix A ➤ Updated for firmware version R402. Appendix B ➤ Added *Ethernet Card Firmware Upgrade Instructions*. Appendix G ➤ Added a new appendix, *Appendix G: IEC 61850 Communications*.
20060728	Setting Sheets ➤ Added TA_X and RA_X settings. ➤ Added TA_Y and RA_Y settings. ➤ Added G to EADDCX and EADDCY settings in *Channel Settings*. Section 10 ➤ Added description of option G for EADDCX and EADDCY settings to *Setting EADDCX and EADDCY (Address Checking)*. Section 14 Application Setting Sheets ➤ Added TA_X and RA_X settings. ➤ Added TA_Y and RA_Y settings. ➤ Added G to EADDCX and EADDCY settings in *Channel Settings*. Appendix A ➤ Updated for firmware version R208.
20060320	Reverse of Cover ➤ Moved Cautions, Warnings, and Dangers to the *Preface*. Preface ➤ Added Cautions, Warnings, and Dangers that previously were displayed on the reverse of the cover. ➤ Added new appendix, *Appendix H: SEL Synchrophasors,* to manual overview. Section 1 ➤ Updated serial communications baud rate range for Port 1. ➤ Added time-code input accuracy for synchrophasor measurement. ➤ Modified Time-Overcurrent element pickup range. ➤ Added synchrophasor accuracy. ➤ Modified metering accuracy. ➤ Added Distance Limitations to the Differential Communications Port specifications. ➤ Added a Surge Withstand Capability type test specification. Section 2 ➤ Modified *Figure 2.1* to explain projection rack mounting option. ➤ Rotated the rear-panel drawing in *Figure 2.4*. ➤ Updated 4U Horizontal Rack-Mount Front-Panel drawings, *Figure 2.6* and *Figure 2.7*. ➤ Under *IRIG-B Time-Code Input*, added a note that the IRIG-B time signal does not update the relay internal year.

Table A.4 Instruction Manual Revision History (Sheet 7 of 9)

Date Code	Summary of Revisions
	Section 3 ➤ Removed 87L OR gate from *Figure 3.17*. ➤ Added *Figure 3.18*. Section 4 ➤ Removed compensator distance elements hide rule text. ➤ Added text to explain common timer behavior when an enable is set to off. ➤ Modified Time-Overcurrent element pickup range in *Table 4.9*, *Table 4.11*, and *Table 4.12*. ➤ Corrected the Operate label in the Internal Fault portion of *Figure 4.1*. ➤ Under *Fixed Angle Synchronism Check*, corrected the CL setting. ➤ Modified *Figure 4.33*. ➤ Added V_2 input to *Figure 4.35*. Section 6 ➤ Added Lockout State initiation condition. Section 7 ➤ Added *Figure 7.2*. Section 8 ➤ Added synchrophasor metering angular reference note. ➤ Added *Synchrophasor Metering*. ➤ Under *Instantaneous Metering*, clarified information about current magnitude and angles during an 87 channel failure. Section 9 ➤ Put the time-overcurrent curves equation in a table format. ➤ Added Global synchrophasor settings to *Table 9.1*. ➤ Added new Relay Word bits PMDOK, TSOK, and TIRIG to *Table 9.5*. ➤ Added new Relay Word bit definitions for PMDOK, TSOK, and TIRIG to *Table 9.6*. Settings Sheets ➤ Modified Time-Overcurrent element pickup ranges throughout. ➤ Added Channel A MIRRORED BITS settings EMBA, RXIDA, and TXIDA to Group settings. ➤ Added Channel B MIRRORED BITS settings EMBB, RXIDB, and TXIDB to Group settings. ➤ Added Synchronized Phasor settings EPMU, PMID, PHDATAV, VCOMP, PHDATAI, and ICOMP to Global settings. ➤ Added MBGA and MBGB parameters to Port setting PROTO. ➤ Updated serial communications baud rate range for Port 1. ➤ Updated settings hide rules for Port settings BITS, PARITY, STOP, T_OUT, AUTO, RTSCTS, and FASTOP. ➤ Added hide rule for Port settings RXID and TXID when PROTO is set to MBGA or MBGB. Section 10 ➤ Under *MET Command (Metering Data)* added a sentence stating that asterisks are displayed when values are not available. ➤ Added new Relay Word bit definitions TSOK and TIRIG to IRIG-B section. ➤ Added new SEL Fast Message Synchrophasor protocol to communications protocol list. ➤ Added TIRIG note to **IRI** command explanation. ➤ Added **MET PM** command explanation. ➤ Added [time] parameter to **TRI** command. ➤ Added P parameter to **CEV** command. ➤ Added P parameter to **EVE** command. Section 11 ➤ Corrected *Figure 11.4*.

Table A.4 Instruction Manual Revision History (Sheet 8 of 9)

Date Code	Summary of Revisions
	Section 12 ➤ Added *Make SER Settings With Care*. ➤ Added P parameter to **EVE** command. ➤ Added *Synchrophasor-Level Accuracy*. ➤ Added P parameter note and DT column information to *Table 12.3*. ➤ Added *Figure 12.2*. Section 14 Application Settings Sheets ➤ Modified Time-Overcurrent element pickup ranges throughout. ➤ Added Channel A MIRRORED BITS settings EMBA, RXIDA, and TXIDA to Group settings. ➤ Added Channel B MIRRORED BITS settings EMBB, RXIDB, and TXIDB to Group settings. ➤ Added Synchronized Phasor settings EPMU, PMID, PHDATAV, VCOMP, PHDATAI, and ICOMP to Global settings. ➤ Added MBGA and MBGB parameters to Port setting PROTO. ➤ Updated serial communications baud rate range for Port 1. ➤ Updated settings hide rules for Port settings BITS, PARITY, STOP, T_OUT, AUTO, RTSCTS, and FASTOP. ➤ Added hide rule for Port settings RXID and TXID when PROTO is set to MBGA or MBGB. Appendix A ➤ Updated for firmware version R207. Appendix B ➤ Inserted latest version of *Firmware Upgrade Instructions*. Appendix D ➤ Added SEL Fast Message Synchrophasor protocol to *Table D.1*. ➤ Added *SEL Fast Message Synchrophasor*. Appendix E ➤ Updated serial communications baud rate range for Port 1. ➤ Added MBGA and MBGB parameters to Port setting PROTO. ➤ Added hide rule for Port settings RXID and TXID when PROTO is set to MBGA or MBGB. ➤ Added text explanations for MBGA and MBGB applications. ➤ Added *Table E.1*. Appendix F ➤ Clarified the text under *Collision Avoidance*. Appendix G ➤ Added a new appendix entitled SEL *Synchrophasors*. Appendix J ➤ Updated the name of ACSELERATOR SEL-5030 Software to ACSELERATOR QuickSet SEL-5030 Software.
20050429	Appendix A ➤ Updated for firmware version R206.
20050405	Section 1 ➤ Added 1300 nm single-mode fiber information. ➤ Updated *Figure 1.1*. ➤ Updated *Specifications*. Section 2 ➤ Added *Figure 2.7*. ➤ Added *Table 2.1*. Section 3 ➤ Updated *Figure 3.17*, *Figure 3.19*, and *Figure 3.20*.

Table A.4 Instruction Manual Revision History (Sheet 9 of 9)

Date Code	Summary of Revisions
	Section 4 ➤ Updated curves in *Table 4.13*. ➤ Added details on zone single-pole tripping (see *Distance Element Operating Time Curves at Nominal Frequency*). ➤ Updated *Figure 4.40* and *Figure 4.48*. Section 5 ➤ Updated *Figure 5.4*. Section 7 ➤ Updated *Figure 7.26*. ➤ Added section Output Contacts OUT301–OUT312. ➤ Added *Figure 7.29*. Section 9 ➤ Added Relay Word Bits CTALA, CTALB, CTALC, CTFLG, and LCTFLG to *Table 9.5*. Section 10 ➤ Added 1300 nm single-mode fiber to 87L Interfaces. ➤ Added command **TST {chn} C** to Command Summary. Appendix A ➤ Updated for firmware version R205. Appendix F ➤ Updated *Table F.10*.
20040412	Section 3 ➤ Updated *Table 3.2* and accompanying text. Section 14 ➤ Added TOPD setting to APP = 87LSP settings rule description. ➤ Changed ULTR SELOGIC control equation in settings list for APP = 87LSP. ➤ Added EOCTL setting to the APP settings sheets. ➤ Added TOPD setting to APP = 87LSP settings sheets. Appendix A ➤ Updated for firmware version R203.
20031203	➤ Initial version.

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Appendix B
Firmware Upgrade Instructions

Overview

From time to time, SEL issues firmware upgrades. The instructions that follow explain how you can install new firmware in your SEL-300 series relay.

If the relay is equipped with Ethernet communications, upgrade the Ethernet card firmware to the latest available version, or ensure the Ethernet card firmware is the latest available version, *before* upgrading the relay firmware. The obtain the latest available version, contact SEL customer service. Issue the **STATUS** command to the Ethernet card to compare the Ethernet firmware version number to the revision. Follow the *Ethernet Card Firmware Upgrade Instructions on page B.17*, then return here and continue to upgrade the relay firmware.

Relay Firmware Upgrade Instructions

Introduction

These firmware upgrade instructions apply to SEL-300 series relays except those listed in *Table B.1*.

Table B.1 Relays Not Covered by These Instructions

SEL-311C-1, -2
SEL-321 (uses EPROM)
SEL-351 Relays equipped with Ethernet

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 any communications port. This procedure is described in the following steps.

NOTE: SEL strongly recommends that you upgrade firmware at the location of the relay and with a *direct connection* from the personal computer to 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.

Perform the firmware upgrade process in the following sequence:

A. Prepare the Relay

B. Establish a Terminal Connection

C. Save Settings and Other Data

D. Start SELBOOT

E. Download Existing Firmware

F. Upload New Firmware

G. Check Relay Self-Tests

H. Verify Settings, Calibration, Status, Breaker Wear, and Metering

I. Return the Relay to Service

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- Personal computer (PC)
- Terminal emulation software that supports 1K Xmodem or Xmodem (these instructions use HyperTerminal from a Microsoft Windows operating system)
- Serial communications cable (SEL Cable SEL-C234A or equivalent)
- Firmware Upgrade Instructions (these instructions)

Optional Equipment

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

- SEL-5010 Relay Assistant Software or ACSELERATOR QuickSet SEL-5030 Software

  The SEL-5010 has a feature that guides you through the conversion process. This upgrade guide will assist you with steps C, D, E, F, and G of these upgrade instructions. If you do not have the latest SEL-5010 software, please contact your customer service representative or the factory for details on getting the SEL-5010.
- Your relay instruction manual

Upgrade Procedure

A. Prepare the Relay

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. From the relay front panel, press the **SET** pushbutton.

Step 4. Use the arrow pushbuttons to navigate to PORT.

Step 5. Press the **SELECT** pushbutton.

Step 6. Use the arrow pushbuttons to navigate to the relay serial port you plan to use (usually the front port).

Step 7. Press the **SELECT** pushbutton.

Step 8. With SHOW selected, press the **SELECT** pushbutton.

Step 9. Press the down arrow pushbutton to scroll through the port settings; write down the value for each setting.

Step 10. At the `EXIT SETTINGS?` prompt, select `Yes` and press the **SELECT** pushbutton.

Step 11. Connect an SEL Cable SEL-C234A (or equivalent) serial communications cable to the relay serial port selected in *Step 6* above.

B. Establish a Terminal Connection

To establish communication between the relay and a PC, you must be able to modify the computer serial communications parameters (i.e., data transmission rate, data bits, parity) and set the file transfer protocol to 1K Xmodem or Xmodem protocol.

Step 1. Connect a serial communications cable to the computer serial port.

a. Check the computer for a label identifying the serial communications ports.

b. Choose a port and connect an SEL Cable SEL-C234A (or equivalent) serial communications cable to the PC serial port.

If there is no identification label, connect the cable to any computer serial port. Note that you might later change this computer serial port to a different port to establish communication between the relay and the computer.

Step 2. Disconnect any other serial port connection(s).

Step 3. From the computer, open **HyperTerminal**.

On a PC running Windows, you would typically click **Start > Programs > Accessories**.

Step 4. Enter a name, select any icon, and click **OK** (*Figure B.1*).

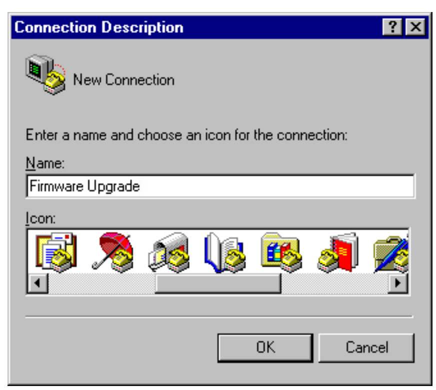


Figure B.1 Establishing a Connection

Step 5. Select the computer serial port you are using to communicate with the relay (*Figure B.2*) and click **OK**. This port matches the port connection that you made in *Step 1 on page B.3*.

Figure B.2 Determining the Computer Serial Port

Step 6. Establish serial port communications parameters.

The settings for the computer (*Figure B.3*) must match the relay settings you recorded earlier.

a. Enter the serial port communications parameters (*Figure B.3*) that correspond to the relay settings you recorded in *Step 9 on page B.2*.

If the computer settings do not match the relay settings, change the computer settings to match the relay settings.

b. Click **OK**.

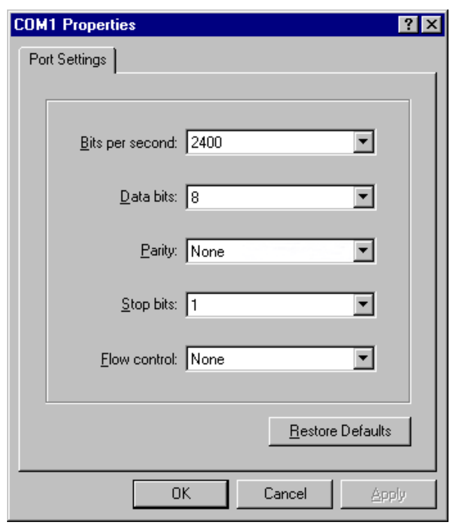


Figure B.3 Determining Communications Parameters for the Computer

Step 7. Set the terminal emulation to VT100.

a. From the **File** menu, choose **Properties**.

b. Select the **Settings** tab in the **Firmware Upgrade Properties** dialog box (*Figure B.4*).

c. Select **VT100** from the **Emulation** list box and click **OK**.

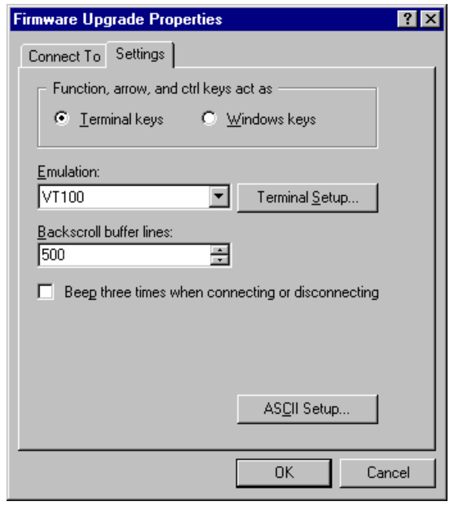


Figure B.4 Setting Terminal Emulation

Step 8. Confirm serial communication.

Press **<Enter>**. In the terminal emulation window, you should see the Access Level 0 = prompt, similar to that in *Figure B.5*.

If this is successful, proceed to *C. Save Settings and Other Data on page B.6*.

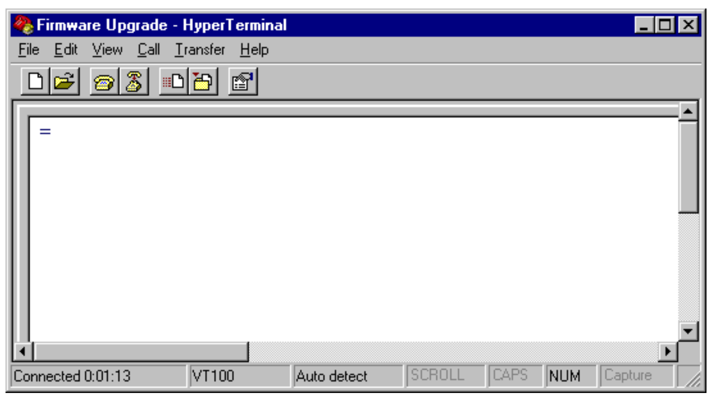


Figure B.5 Terminal Emulation Startup Prompt

Failure to Connect

If you do not see the 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 9. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 10. Correct the port setting.

a. From the **File** menu, choose **Properties**.

You should see a dialog box similar to *Figure B.6*.

b. Select a different port in the **Connect using** list box.

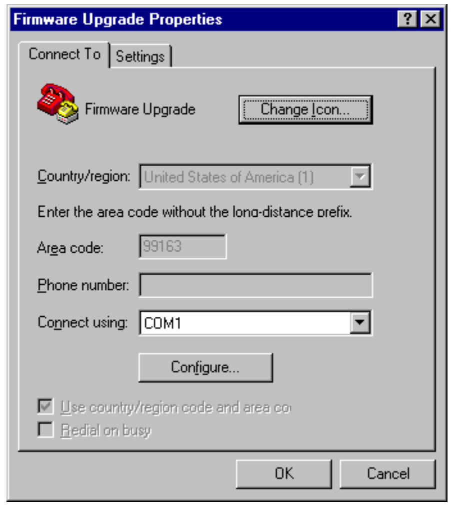


Figure B.6 Correcting the Port Setting

Step 11. Correct the communications parameters.

a. From the filename **Properties** dialog box shown in *Figure B.6*, click **Configure**.

You will see a dialog box similar to *Figure B.7*.

b. Change the settings in the appropriate list boxes to match the settings you recorded in *Step 9 on page B.2* and click **OK** twice to return to the terminal emulation window.

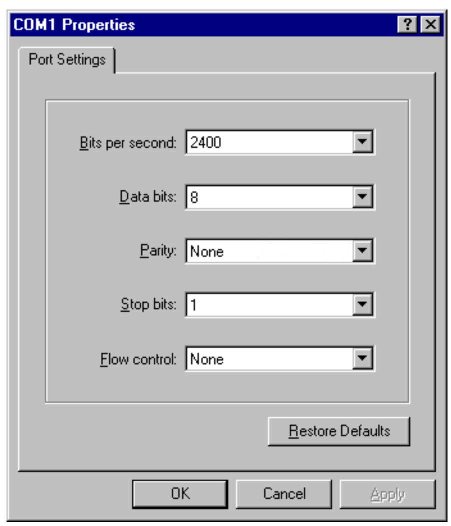


Figure B.7 Correcting the Communications Parameters

Step 12. Press **<Enter>**. In the terminal emulation window, you should see the Access Level 0 = prompt, similar to that in *Figure B.5*.

C. Save Settings and Other Data

Before upgrading firmware, retrieve and record any History (**HIS**), Event (**EVE**), Metering (**MET**), Breaker Wear Monitor (**BRE**), Communications Log Summary (**COM X** or **COM Y**), or Sequential Events Recorder (**SER**) data that you want to retain (see the relay instruction manual for these procedures).

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 has a password jumper in place. With this jumper in place, the relay is unprotected from unauthorized access (see the relay instruction manual).

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

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 or QuickSet to record the existing relay settings and proceed to *D. Start SELBOOT*. Otherwise, perform the following steps.

Step 1. From the **Transfer** menu in **HyperTerminal**, select **Capture Text**.

Step 2. Enter a directory and file name for a text file where you will record 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**, and **SHO T**.

NOTE: Settings classes can vary among SEL relays. See the relay instruction manual for a listing.

Step 5. From the **Transfer** menu in **HyperTerminal**, select **Capture Text** and select **Stop**.

The computer saves the text file you created to the directory you specified in *Step 2 on page B.7*.

Step 6. Write down the present relay data transmission setting (SPEED).

This setting is SPEED in the **SHO P** relay settings output. The SPEED value should be the same as the value you recorded in *A. Prepare the Relay on page B.2*.

D. Start SELBOOT

Step 1. Find and record the firmware identification (FID) string.

a. From the **File** menu, choose **Properties**.

b. Select the **Settings** tab in the **Properties** dialog box (*Figure B.4*).

c. Click **ASCII Setup**.

You should see a dialog box similar to *Figure B.8*.

d. Under **ASCII Receiving**, select the check box to **Append line feeds to incoming line ends**.

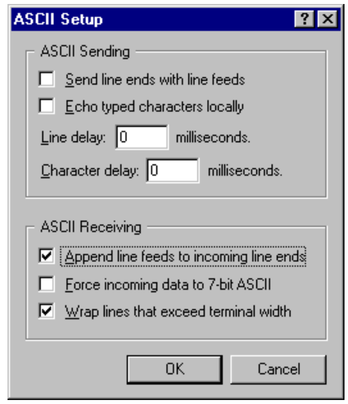


Figure B.8 Preparing HyperTerminal for ID Command Display

e. Click **OK** twice to go back to the terminal emulation window.

f. Type **ID <Enter>** and record the FID number the relay displays.

g. Repeat *Step a* through *Step c*, then uncheck the **Append line feeds to incoming line ends** check box. (This feature can cause problems when uploading firmware to the relay.)

Step 2. 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 3. Wait for the SELBOOT program to load.

The front-panel LCD screen displays the SELBOOT firmware number (e.g., `SLBT-3xx-R100`). The number following the `R` is the SELBOOT revision number. This number is different from the relay firmware revision number.

After SELBOOT loads, the computer will display the SELBOOT !> prompt.

Step 4. 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.9*.

```
!>HELP <Enter>
SELboot-3xx-Rxxx
bau "rate"  ; Set baud rate to 300, 1200, 2400, 4800, 9600, 19200, or 38400 baud
era         ; Erase the existing relay firmware
exi         ; Exit this program and restart the device
fid         ; Print the relays firmware id
rec         ; Receive new firmware for the relay using xmodem
sen         ; Send the relays firmware to a pc using xmodem
hel         ; Print this list

FLASH Type : 040         Checksum = 370E  OK
```

Figure B.9 List of Commands Available in SELBOOT

Establish a High-Speed Connection

Step 5. Type **BAU 38400 <Enter>** at the SELBOOT !> prompt.

Match Computer Communications Speed to the Relay

Step 6. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 7. 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.10*).

d. Click **OK** twice.

Step 8. Press **<Enter>** to check for the SELBOOT !> prompt indicating that serial communication is successful.

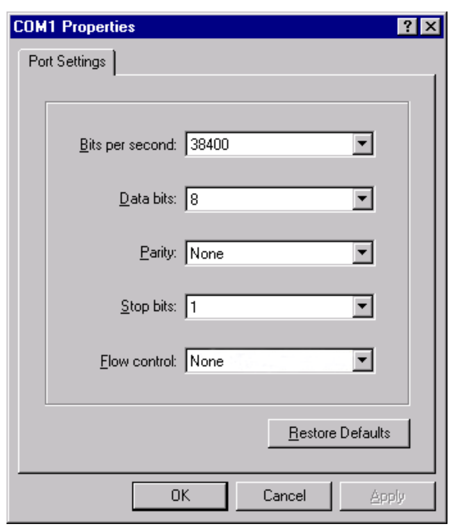


Figure B.10 Matching Computer to Relay Parameters

E. Download Existing Firmware

Copy the firmware presently in the relay, in case the new firmware upload is unsuccessful. To make a backup of the existing firmware, the computer will need as much as 3 MB of free disk space. This backup procedure takes 5–10 minutes at 38400 bps.

Step 1. Type **SEN <Enter>** at the SELBOOT !> prompt to initiate the firmware transfer from the relay to the computer.

Step 2. From the **Transfer** menu in **HyperTerminal**, select **Receive File**.

You should see a dialog box similar to *Figure B.11*.

Step 3. Enter the path of a folder on the computer hard drive where you want to record the existing relay firmware.

Step 4. Select **1K Xmodem** if this protocol is available on the PC.

If the computer does not have **1K Xmodem**, choose **Xmodem**.

Step 5. Click **Receive**.

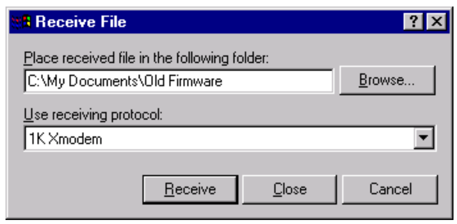


Figure B.11 Example Receive File Dialog Box

Step 6. Enter a filename that clearly identifies the existing firmware version (*Figure B.12*), using the version number from the FID you recorded earlier in *Step 1 on page B.7* and click **OK**.

SEL lists the firmware revision number first, then the product number.

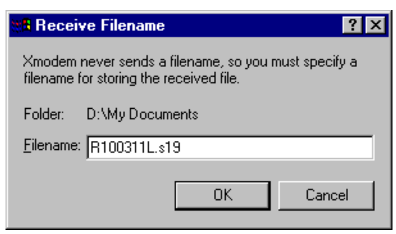


Figure B.12 Example Filename Identifying Old Firmware Version

If Xmodem times out before the download completes, repeat the process from *Step 1 on page B.10*.

NOTE: HyperTerminal stored any path you entered in Step 3 and any file name you entered in Step 6 during the earlier download attempt; this saves you from reentering these on a subsequent attempt.

For a successful download, you should see a dialog box similar to *Figure B.13*. After the transfer, the relay responds with the following:

```
Download completed successfully!
```

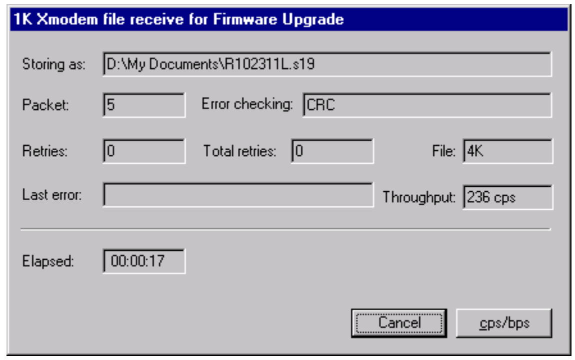


Figure B.13 Downloading Old Firmware

F. Upload New Firmware

Step 1. Obtain the latest available firmware version from SEL customer service in preparation to load the firmware.

Step 2. Type **REC <Enter>** at the SELBOOT !> prompt to command the relay to receive new firmware.

```
!>REC <Enter>
Caution! -  This command erases the relays firmware.
If you erase the firmware, new firmware must be loaded into the relay
before it can be put back into service.
```

The relay asks whether you want to erase the existing firmware.

```
Are you sure you wish to erase the existing firmware? (Y/N) Y <Enter>
```

Step 3. Type **Y** to erase the existing firmware and load new firmware. (To abort, type **N** or press **<Enter>**).

The relay responds with the following:

```
Erasing
Erase successful
Press any key to begin transfer, then start transfer at the PC <Enter>
```

Step 4. Press **<Enter>** to start the file transfer routine.

Step 5. Send new firmware to the relay.

a. From the **Transfer** menu in **HyperTerminal**, choose **Send File** (*Figure B.14*).

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. Select **Send** to send the file containing the new firmware.

You should see a dialog box similar to *Figure B.14*. Incrementing numbers in the **Packet** box and a bar advancing from left to right in the **File** box indicate that a transfer is in progress.

Receiving software takes 10–15 minutes at 38400 bps, depending on the relay. If you see no indication of a transfer in progress within a few minutes after selecting **Send**, use the **REC** command again and reattempt the transfer.

NOTE: Unsuccessful uploads can result from Xmodem time-out, a power failure, loss of communication between the relay and the computer, or voluntary cancelation. Check connections, reestablish communication, and start again at Step 2 on page B.11.

If you want to reload the previous firmware, begin at Step 2 on page B.11 and use the firmware you saved in E. Download Existing Firmware on page B.10. Contact the factory for assistance in achieving a successful firmware upgrade.

After the transfer completes, the relay displays the following:

```
Upload completed successfully. Attempting a 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.

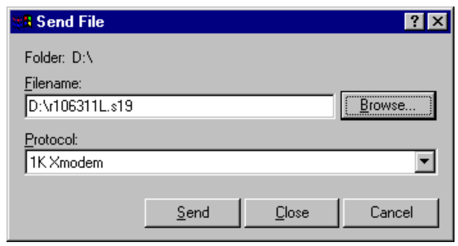


Figure B.14 Selecting New Firmware to Send to the Relay

NOTE: The relay restarts in SELBOOT if relay power fails while receiving new firmware. Upon power up, the relay serial port will be at the default 2400 baud. Perform the steps beginning in B. Establish a Terminal Connection on page B.3 to increase the serial connection data speed. Then resume the firmware upgrade process at F. Upload New Firmware on page B.11.

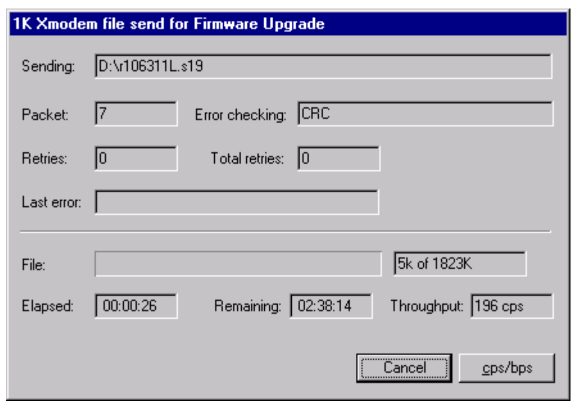


Figure B.15 Transferring New Firmware to the Relay

Step 6. Press **<Enter>** and confirm that the Access Level 0 = prompt appears on the computer screen.

Step 7. If you see the Access Level 0 = prompt, proceed to *G. Check Relay Self-Tests on page B.13*.

No Access Level 0 = Prompt

If no Access Level 0 = prompt appears in the terminal emulation window, one of three things could have occurred. Refer to *Table B.2* to determine the best solution.

Table B.2 Troubleshooting New Firmware Upload

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 *A. Prepare the Relay on page B.2*).	Change the computer terminal speed to match the relay data transmission rate you recorded in *A. Prepare the Relay* (see *Match Computer Communications Speed to the Relay 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 *A. Prepare the Relay*. Step 3. From the **Call** menu, choose **Connect** to reestablish communication. Step 4. Press **<Enter>** to check for the Access Level 0 = prompt indicating that serial communication is successful. Step 5. If you get no response, proceed to *Match Computer Communications Speed to the Relay*.
The restart was successful, but the relay data transmission rate reverted to 2400 bps (the settings have been reset to default).	Match the computer terminal speed to a relay data transmission rate of 2400 bps. Step 1. From the **Call** menu, choose **Disconnect** to terminate relay communication. Step 2. Change the communications software settings to 2400 bps, 8 data bits, no parity, and 1 stop bit (see *Match Computer Communications Speed to the Relay*). Step 3. From the **Call** menu, choose **Connect** to reestablish communication. Step 4. Press **<Enter>** to check for the Access Level 0 = prompt indicating successful serial communication. 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 *G. Check Relay Self-Tests*.
The restart was unsuccessful, in which case the relay is in SELBOOT.	Reattempt to upload the new firmware (beginning at *Step 5* under *Establish a High-Speed Connection on page B.9*) or contact the factory for assistance.

G. 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 *H. Verify Settings, Calibration, Status, Breaker Wear, and Metering on page B.15*.

IO_BRD Fail Status Message

Perform this procedure only if you have only an IO_BRD Fail Status message; for additional fail messages, proceed to *CR_RAM, EEPROM, and IO_BRD Fail Status Messages on page B.14*.

Step 1. From Access Level 2, type **INI <Enter>** to reinitialize the I/O board(s). If this command is unavailable, go to *CR_RAM, EEPROM, and IO_BRD Fail Status Messages*.

The relay asks the following:

```
Are the new I/O board(s) correct (Y/N)?
```

a. Type **Y <Enter>**.

b. After a brief interval (as long as a minute), the **EN** LED will illuminate.

If the **EN** LED does not illuminate and you see a SELBOOT !> prompt, type **EXI <Enter>** to exit SELBOOT. After a brief interval, the **EN** LED will illuminate. Check for Access Level 0 = prompt.

c. Use the **ACC** and **2AC** commands and type the corresponding passwords to reenter Access Level 2.

NOTE: Depending upon the relay, n can be 1–6, G, P, L, T, R, X, or Y.

d. Enter the **SHO *n*** command to view relay settings and verify that these match the settings you saved (see *Backup Relay Settings on page B.7*).

Step 2. If the settings do not match, reenter the settings you saved earlier.

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, where *n* can be 1–6, G, P, L, T, R, X, or Y (depending upon the settings classes in the relay).

Step 3. Use the **PAS** command to set the relay passwords.

For example, type **PAS 1 <Enter>** to set the Access Level 1 password.

Use a similar format for other password levels. SEL relay passwords are case sensitive, so the relay treats lowercase and uppercase letters as different letters.

Step 4. Go to *H. Verify Settings, Calibration, Status, Breaker Wear, and Metering*.

CR_RAM, EEPROM, and IO_BRD Fail Status Messages

Step 1. Use the **ACC** and **2AC** commands with the associated passwords to enter Access Level 2.

The factory-default passwords are in effect; use the default relay passwords listed in the **PAS** command description in the relay instruction manual.

Step 2. Type **R_S <Enter>** to restore factory-default settings in the relay (type **R_S 1 <Enter>** for a 1 A SEL-387 or 1 A SEL-352 relay).

The relay asks whether to restore default settings. If the relay does not accept the **R_S** (or **R_S 1**) command, contact your customer service representative or the factory for assistance.

Step 3. Type **Y <Enter>**.

NOTE: If the relay prompts you to enter a part number, use either the number from the firmware envelope label or the number from the new part number sticker (if supplied).

The relay can take as long as two minutes to restore default settings. The relay then reinitializes, and the EN LED illuminates.

Step 4. Press **<Enter>** to check for the Access Level 0 = prompt indicating that serial communication is successful.

Step 5. Use the **ACC** and **2AC** commands and type the corresponding passwords to reenter Access Level 2.

Step 6. Restore the original 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, where *n* can be 1–6, G, P, L, T, R, X, or Y (depending upon the settings classes available in the relay).

Step 7. Use the **PAS** command to set the relay passwords.

For example, type **PAS 1 <Enter>** to set the Access Level 1 password.

Use a similar format for other password levels. SEL relay passwords are case sensitive, so the relay treats lowercase and uppercase letters as different letters.

Step 8. If any failure status messages still appear on the relay display, see *Section 13: Testing and Troubleshooting* or contact your customer service representative or the factory for assistance.

H. Verify Settings, Calibration, Status, Breaker Wear, and Metering

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 on page B.7*).

If the settings do not match, reenter the settings you saved earlier (see *Step 6* under *CR_RAM, EEPROM, and IO_BRD Fail Status Messages on page B.14*).

Step 3. Type **SHO C <Enter>** to verify the relay calibration settings.

If the settings do not match the settings contained in the text file you recorded in *C. Save Settings and Other Data on page B.6*, contact your customer service representative or the factory for assistance.

Step 4. Use the firmware identification string (FID) to verify download of the correct firmware.

a. From the **File** menu, choose **Properties**.

b. Select the **Settings** tab in the **Firmware Upgrade Properties** dialog box (*Figure B.4*).

c. Click **ASCII Setup**.

You should see a dialog box similar to *Figure B.16*.

d. Under **ASCII Receiving**, select the check box to **Append line feeds to incoming line ends**.

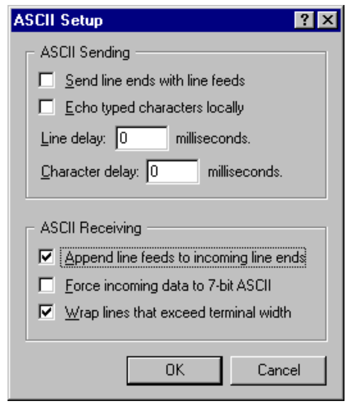


Figure B.16 Preparing HyperTerminal for ID Command Display

e. Click **OK** twice to return to the terminal emulation window.

f. Type **ID <Enter>** and compare the number the relay displays against the number from the firmware envelope label.

g. If the label FID and part number match the relay display, proceed to *Step 5*.

h. For a mismatch between a displayed FID or part number, and the firmware envelope label, reattempt the upgrade or contact the factory for assistance.

Step 5. Type **STA <Enter>** and verify that all relay self-test parameters are within tolerance.

Step 6. 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*n*** command to reload the percent contact wear values for each pole of Circuit Breaker *n* (*n* = 1, 2, 3, or 4) you recorded in *C. Save Settings and Other Data on page B.6*.

Step 7. Apply current and voltage signals to the relay.

Step 8. Type **MET <Enter>** and verify that the current and voltage signals are correct.

Step 9. Use the **TRIGGER** and **EVENT** commands to verify that the magnitudes of the current and voltage signals you applied to the relay match those displayed in the event report.

If these values do not match, check the relay settings and wiring.

I. Return the Relay to Service

Step 1. Follow your company procedures for returning a relay to service.

Step 2. Autoconfigure the SEL 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.

The relay is now ready for your commissioning procedure.

Ethernet Card Firmware Upgrade Instructions

Introduction

Perform the firmware upgrade process in the following sequence:

A. Prepare the Relay

NOTE: This section only applies to products equipped with an optional Ethernet port.

B. Establish an FTP Connection and Transfer New Firmware

C. Establish a Telnet Connection

D. Verify Firmware Transfer

E. Verify or Restart IEC 61850 Operation (Optional)

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- ➤ Personal computer (PC)
- ➤ FTP client software (may be included with the PC operating system)
- ➤ Firmware upgrade instructions (these instructions)

Upgrade Procedure

A. Prepare the Relay

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. Apply the following **PORT 1** setting and leave all others at default.

PROTO = TELNET

Step 4. These instructions assume that the Ethernet port (**PORT 5**) settings are set as follows:

NOTE: Use IP settings (IPADDR, SUBNETM, DEFRTR) that are compatible with your PC's network settings.

IPADDR = 10.201.0.213

SUBNETM = 255.255.0.0

DEFRTR = 10.201.0.1

ETELNET = Y

TPORTC = 1024

EFTPSERV = Y

FTPUSER = 2AC

B. Establish an FTP Connection and Transfer New Firmware

The following instructions use the Microsoft Windows command line and FTP client to establish an FTP connection between a PC and the relay. Consult your operating system or FTP client manuals if your equipment or software differs. These instructions assume that both devices are on the same side of any firewalls.

Step 1. Connect an Ethernet cable from the relay Ethernet port to an Ethernet switch and another cable from the PC Ethernet port to the same Ethernet switch.

Alternatively, connect a crossover Ethernet cable between the relay Ethernet port (**PORT 5**) and the PC Ethernet port.

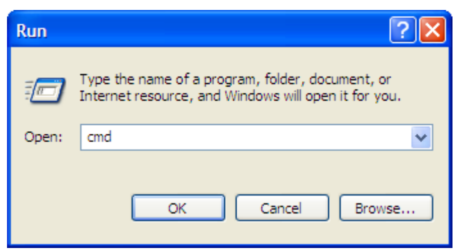
Step 2. Copy the firmware upgrade file to the root directory of the PC's primary drive (usually C:\).

Step 3. Open a Command Prompt window.

a. Click **Start > Run**.

b. Type **cmd** in the dialog box.

c. Click **OK**.



Step 4. In the Command Prompt window, set the current directory to the root of the primary drive (usually C:\).

a. Type **C: <Enter>**.

b. Type **cd \ <Enter>**.

Step 5. In the Command Prompt window, type **FTP <IP Address> <Enter>** (substitute the IP address of the Ethernet port for *<IP Address>*, e.g., **FTP 10.201.0.213**).

Step 6. When prompted, type the relay FTPUSER username (the default username is 2AC) and press **<Enter>**. After that, type the FTP user password (the default password is TAIL) and press **<Enter>**.

Step 7. Set the FTP file transfer mode to Binary by typing **BIN <Enter>** at the FTP prompt.

Step 8. Transfer the new firmware to the relay by typing **PUT C:\filename.s19 <Enter>** at the FTP prompt (substitute the firmware file name for *filename.s19*).

Step 9. The FTP file transfer will begin immediately. As the transfer progresses, and upon completion, messages similar to the following will be displayed.

```
200 PORT Command okay.
150 File status okay; about to open data connection.
226 Closing data connection.
ftp: 2926780 bytes sent in 46.80 Seconds
62.54 Kbytes/sec.
```

Step 10. Type **QUIT <Enter>** to exit the FTP session when the transfer is complete.

Step 11. (Optional) Delete the firmware upgrade file from the root directory of the computer's primary drive by typing **DELETE C:\filename.s19 <Enter>** at the command prompt.

C. Establish a Telnet Connection

To establish a Telnet-to-card connection, perform the following steps.

Step 1. Click **Start > Run**.

Step 2. Type **cmd <Enter>** to launch a Command Prompt window.

Step 3. Type **Telnet <IP Address> port** at the prompt (e.g., **Telnet 10.201.0.213 1024**).

Step 4. Press **<Enter>** several times until you see the # prompt.

D. Verify Firmware Transfer

To verify the firmware transfer completed properly, perform the following steps after establishing a Telnet connection.

Step 1. Issue a Status (**STA**) command.

Step 2. Verify that the Status report does not include any warnings or failures.

Step 3. Verify that the Status report includes `Device Enabled` at the end of the report.

Step 4. Verify that the Status report FID matches the FID of the firmware you transferred.

E. Verify or Restart IEC 61850 Operation (Optional)

SEL-300 series relays with optional IEC 61850 protocol require the presence of one valid CID file to enable the protocol. You should only transfer a CID file to the relay if you want to implement a change in the IEC 61850 configuration or if new Ethernet card firmware does not support the current CID file version. If you transfer an invalid CID file, the relay will disable the IEC 61850 protocol, because it no longer has a valid configuration. To restart IEC 61850 protocol operation, you must transfer a valid CID file to the relay.

Perform the following steps to verify that the IEC 61850 protocol is still operational after an Ethernet card firmware upgrade and if not, re-enable it. This procedure assumes that IEC 61850 was operational with a valid CID file immediately before initiating the Ethernet card firmware upgrade.

Step 1. Establish an FTP connection to the relay Ethernet port (see *B. Establish an FTP Connection and Transfer New Firmware on page B.18*).

Step 2. Open the ERR.TXT file for reading.

If the ERR.TXT file contains error messages relating to CID file parsing, this indicates that the relay has disabled the IEC 61850 protocol. If this file is empty, the relay found no errors during CID file processing and IEC 61850 should remain enabled. Skip to *Step 3* if ERR.TXT is empty.

If the IEC 61850 protocol has been disabled because of an upgrade-induced CID file incompatibility, you can use ACSELERATOR Architect SEL-5032 Software to convert the existing CID file and make it compatible again.

a. Install the Architect software upgrade that supports your required CID file version.

b. Run Architect and open the project that contains the existing CID file for the relay.

c. Download the CID file to the relay.

Upon connecting to the relay, Architect will detect the upgraded Ethernet card firmware and prompt you to allow it to convert the existing CID file to a supported version. Once converted, downloaded, and processed, the valid CID file allows the relay to re-enable the IEC 61850 protocol.

Step 3. In the Telnet session, type **GOO <Enter>**.

Step 4. View the GOOSE status and verify that the transmitted and received messages are as expected.

If you are upgrading both relay firmware and Ethernet card firmware, return to *Upgrade Procedure on page B.2*.

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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Appendix C
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.

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 settings:

- PREFIX: One character to precede the address.

  This should be a character that does not occur in the course of other communications with the relay. Valid choices are one of the following:

  - @
  - #
  - $
  - %
  - &

  The default is @.
- ADDR: Two-character ASCII address.

  The range is 01 to 99. The default is 01.
- SETTLE: Time in seconds that transmission is delayed after the request to send (RTS line) asserts.

  This delay accommodates transmitters with a slow rise time.

Operation

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** (**QUI**) 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 multi-drop network do not have the same prefix setting.

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

Appendix D
SEL Communications Processors

SEL Communications Protocols

The SEL-311L Relay supports the protocols and command sets shown in *Table D.1*.

Table D.1 Supported Serial Command Sets

Command Set	Description
SEL ASCII	Use this protocol to send ASCII commands and receive ASCII responses that are human-readable with an appropriate terminal emulation program.
SEL Compressed ASCII	Use this protocol to send ASCII commands and receive Compressed ASCII responses that are comma-delimited for use with spreadsheet and database programs or for use by intelligent electronic devices.
SEL Fast Message Synchrophasor	Use this protocol to send measured synchrophasor information.
SEL Fast Meter	Use this protocol to send binary commands and receive binary meter and target responses.
SEL Fast Operate	Use this protocol to send binary control commands.
SEL Fast SER	Use this protocol to receive binary Sequential Events Recorder unsolicited responses.

SEL ASCII Commands

We originally designed SEL ASCII commands for communication between the relay and a human operator via a keyboard and monitor or a printing terminal. A computer with a serial port can also use the SEL ASCII protocol to communicate with the relay, collect data, and issue commands.

SEL Compressed ASCII Commands

The relay supports a subset of SEL ASCII commands identified as Compressed ASCII commands. Each of these commands results in a comma-delimited message that includes a checksum field. Most spreadsheet and database programs can directly import comma-delimited files. Devices with embedded processors connected to the relay can execute software to parse and interpret comma-delimited messages without expending the customization and maintenance labor needed to interpret nondelimited messages. The relay calculates a checksum for each line by numerically summing all of the bytes that precede the checksum field in the message. The program that uses the data can detect transmission errors in the message by summing the characters of the received message and comparing this sum to the received checksum.

Most commands are available only in SEL ASCII or Compressed ASCII format. Selected commands have versions in both standard SEL ASCII and Compressed ASCII formats. Compressed ASCII reports generally have fewer characters than conventional SEL ASCII reports because the compressed reports reduce blanks, tabs, and other “white space” between data fields to a single comma.

Table D.2 lists the Compressed ASCII commands and contents of the command responses.

Table D.2 Compressed ASCII Commands

Command	Response	Access Level
BNAME	ASCII names of Fast Meter status bits	0
CASCII	Configuration data of all Compressed ASCII commands available at access levels > 0	0
CEVENT	Event report	1
CHISTORY	List of events	1
CSTATUS	Relay self-test status results	1
CSUMMARY	Summary of an event report	1
DNAME	ASCII names of digital I/O reported in Fast Meter	0
ID	Relay identification	0
SNS	ASCII names for SER data reported in Fast Meter	0

Interleaved ASCII and Binary Messages

SEL relays have two separate data streams that share the same physical serial port. Human data communications with the relay consist of ASCII character commands and reports that you view using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information; the ASCII data stream continues after the interruption. This mechanism uses a single communications channel for ASCII communication (transmission of an event report, for example) 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. However, you do not need a device to interleave data streams to use the binary or ASCII commands. Note that XON, XOFF, and CAN operations operate on only the ASCII data stream.

An example of using these interleaved data streams is when the SEL-311L communicates with an SEL communications processor. These SEL communications processors perform auto-configuration by using a single data stream and SEL Compressed ASCII and binary messages. In subsequent operations, the SEL communications processor uses the binary data stream for Fast Meter, and Fast Operate messages to populate a local database and to perform SCADA operations. At the same time that a binary data stream is in progress, you can connect transparently to the SEL-311L and use the ASCII data stream for commands and responses.

SEL Fast Message Synchrophasor

SEL Fast Message Synchrophasor is a protocol that consists of general Fast Messages that transport measured synchrophasor information. The protocol is described in *Appendix H: SEL Synchrophasors*.

SEL Fast Meter, Fast Operate, and Fast SER

SEL Fast Meter is a binary message that you solicit with binary commands. Fast Operate is a binary message for control. The relay can also send unsolicited Fast SER messages automatically. If the relay is connected to an SEL communications processor, these messages provide the mechanism that the communications processor uses for SCADA or DCS functions that occur simultaneously with ASCII interaction.

Transparent Communications

Transparent communications allow a master device to communicate directly with an SEL-311L or other IED through the SEL-2032, SEL-2030, and SEL-2020 Communications Processors. You enter the transparent communications mode by using the **PORT** command from the SEL communications processor command set or by using a special user-defined command string you set with the TRANS setting (see **SET U** section in this section).

When you connect to an SEL IED, the SEL communications processor automatically issues a **QUIT** command to the SEL IED before completing the connection. This way, initial access to the SEL-311L will be at Level 0, requiring the user to know the relay password(s) to access it. When the transparent connection is terminated, the SEL communications processor reissues the STARTUP string to restore the SEL-311L to the necessary access level for data collection and control.

While you are transparently communicating through the SEL communications processor, Fast Meter and Fast Message binary data continue to be collected and Fast Operate control operations continue to be sent. If you attempt a Fast Meter or Fast Operate request via the transparent connection, your request and the automatic request may collide, leading to neither taking place. If you plan to use Fast Meter or Fast Operate commands while transparently connected, you should disable any automatic Fast Meter collection and Fast Operate control to avoid these collisions.

Direct Transparent Mode

⚠CAUTION
The Direct Transparent mode (D parameter) typically should not be used when transparently connecting to SEL devices. SEL interleaved binary messages (binary 20METER, 20TARGET, etc.) are not supported during Direct Transparent mode connections.

The SEL communications processor normally uses data buffering when transferring data through transparently connected ports. Some non-SEL IED protocols are intolerant of this data buffering because the buffering introduces random inter-character time delays into the data stream. The SEL communications processor includes a Direct Transparent mode that eliminates these inter-character delays while maintaining the buffering effectiveness. The Direct Transparent mode inter-character delay is typically less than one millisecond and never exceeds two milliseconds. The Direct Transparent mode is available on any rear-panel Master port, and it is *not* available on the front-panel Master port.

To select the Direct Transparent mode, add the D parameter to the **PORT** command (**PORT *n* D**, where *n* selects the port number). The SEL communications processor passes characters through rapidly, without significant buffering delays. Therefore, no handshaking is required if the Master and Slave port baud rates match. Hardware handshaking may be required if the Master and Slave port baud rates do not match. Software handshaking (XON/XOFF) is not supported by the SEL communications processor in Direct Transparent mode, regardless of the ON_XOFF port setting. However, XON/XOFF characters pass through the transparent port connection, allowing the connected devices to use software handshaking independent of the SEL communications processor.

SEL Communications Processors

SEL offers SEL communications processors, the SEL-2032, the SEL-2030, and the SEL-2020, powerful tools for system integration and automation. These devices provide a single point of contact for integration networks with a star topology as shown in *Figure D.1*.

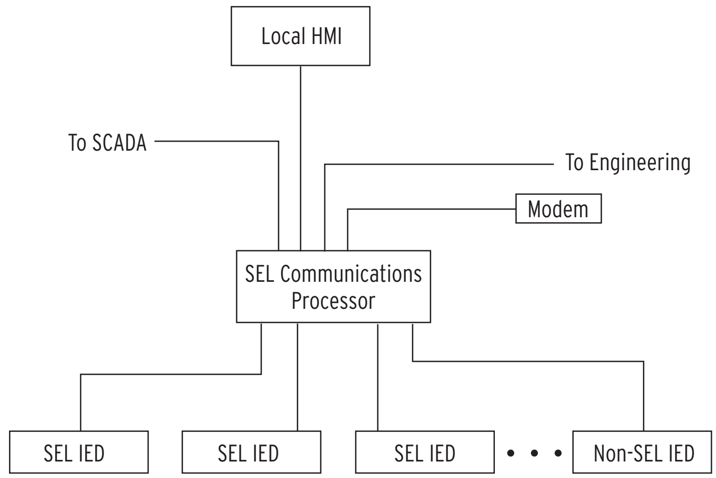

Figure D.1 SEL Communications Processor Star Integration Network

In the star topology network in *Figure D.1* the SEL communications processor offers the following substation integration functions:

- Collection of real-time data from SEL and non-SEL IEDs
- Calculation, concentration, and aggregation of real-time IED data into databases for SCADA, HMI, and other data consumers
- Access to the IEDs for engineering functions including configuration, report data retrieval, and control through local serial, remote dial-in, and Ethernet network connections
- Simultaneous collection of SCADA data and engineering connection to SEL IEDs over a single cable
- Distribution of IRIG-B time-synchronization signal to IEDs based on external IRIG-B input, internal clock, or protocol interface
- Automated dial-out on alarms

SEL communications processors have 16 serial ports plus a front port. This port configuration does not limit the size of a substation integration project, because you can create a multitiered solution as shown in *Figure D.2*. In this multitiered system, the lower-tier SEL communications processors forward data to the upper-tier SEL communications processor that serves as the central point of access to substation data and station IEDs.

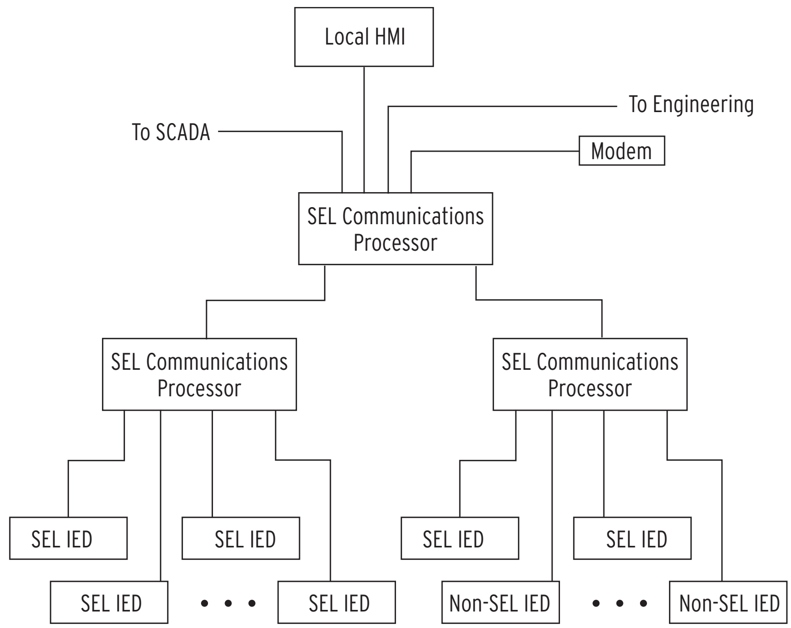

Figure D.2 Multitiered SEL Communications Processor Architecture

You can add additional communications processors to provide redundancy and eliminate possible single points of failure. SEL communications processors provide an integration solution with a reliability comparable to that of SEL relays. In terms of MTBF (mean time between failures), SEL communications processors are 100 to 1000 times more reliable than computer-based and industrial technology-based solutions.

Configuration of an SEL communications processor is different from other general-purpose integration platforms. You can configure SEL communications processors with a system of communication-specific keywords and data movement commands rather than programming in C or another general-purpose computer language. SEL communications processors offer the protocol interfaces listed in *Table D.3*.

Table D.3 SEL Communications Processors Protocol Interfaces

Protocol	Connect to
DNP3 Level 2 Slave	DNP3 masters
Modbus RTU	Modbus masters
SEL ASCII/Fast Message Slave	SEL protocol masters
SEL ASCII/Fast Message Master	SEL protocol slaves including other communications processors and SEL relays
ASCII and Binary auto messaging	SEL and non-SEL IED master and slave devices
Modbus Plus[a]	Modbus Plus peers with global data and Modbus Plus masters
FTP (File Transfer Protocol)[b]	FTP clients
Telnet[b]	Telnet servers and clients
UCA2 GOMSFE[b]	UCA2 protocol masters
UCA2 GOOSE[b]	UCA2 protocol and peers

[a] Requires SEL-2711 Modbus Plus protocol card.
[b] Requires SEL-2701 Ethernet Processor.

SEL Communications Processor and Relay Architecture

You can apply SEL communications processors and SEL relays in a limitless variety of applications that integrate, automate, and improve station operation. Most system integration architectures using SEL communications processors involve either developing a star network or enhancing a multi-drop network.

Developing Star Networks

The simplest architecture using both the SEL-311L and an SEL communications processor is shown in *Figure D.1*. In this architecture, the SEL communications processor collects data from the SEL-311L and other station IEDs. The SEL communications processor acts as a single point of access for local and remote data consumers (local HMI, SCADA, engineers). The communications processor also provides a single point of access for engineering operations including configuration and the collection of report-based information.

By configuring a data set optimized to each data consumer, you can significantly increase the usage efficiency on each link. A system that uses an SEL communications processor to provide a protocol interface to an RTU will have a shorter lag time (data latency); communication overhead is much less for a single data exchange conversation to collect all substation data (from a communications processor) than for many conversations required to collect data directly from each individual IED. You can further reduce data latency by connecting and SEL communications processor directly to the SCADA master and eliminating redundant communication processing in the RTU.

The SEL communications processor is responsible for the protocol interface, so you can install, test, and even upgrade the system in the future without disturbing protective relays and other station IEDs. This insulation of the protective devices from the communications interface assists greatly in situations where different departments are responsible for SCADA operation, communication, and protection.

SEL communications processors equipped with an SEL-2701 can provide a UCA2 interface to SEL-311L relays and other serial IEDs. The SEL-311L data appear in models in a virtual device domain. The combination of the SEL-2701 with an SEL communications processor offer a significant cost savings because you can use existing IEDs or purchase less expensive IEDs. For full details on applying the SEL-2701 with an SEL communications processor, see the *SEL-2701 Ethernet Processor Instruction Manual*.

The engineering connection can use either an Ethernet network connection through the SEL-2701 or a serial port connection. This versatility will accommodate the channel that is available between the station and the engineering center. SEL software can use either a serial port connection or an Ethernet network connection from an engineering workstation to the relays in the field.

Enhancing Multi-Drop Networks

You can also use an SEL communications processor to enhance a multi-drop architecture similar to the one shown in *Figure D.3*. In this example, the SEL communications processor enhances a system that uses the SEL-2701 with an Ethernet HMI multi-drop network. In the example, there are two Ethernet networks, the SCADA LAN and the Engineering LAN. The SCADA LAN provides real-time data directly to the SCADA Control Center via a protocol gateway and to the HMI (Human Machine Interface).

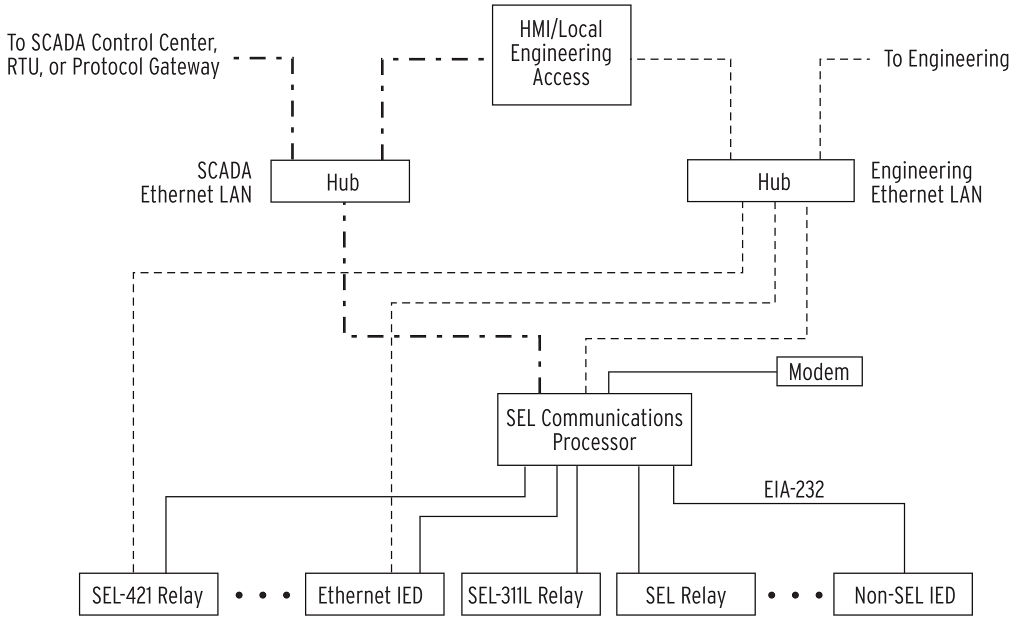

Figure D.3 Enhancing Multi-Drop Networks With SEL Communications Processors

In this example, the SEL communications processor provides the following enhancements when compared to a system that employs only the multi-drop network:

- ➤ Ethernet access for IEDs with serial ports
- ➤ Backup engineering access through the dial-in modem
- ➤ IRIG-B time signal distribution to all station IEDs
- ➤ Integration of IEDs without Ethernet
- ➤ Single point of access for real-time data for SCADA, HMI, and other uses
- ➤ Significant cost savings by use of existing IEDs with serial ports

SEL Communications Processor Example

This example demonstrates some of the data and control points available in the SEL communications processor when you connect an SEL-311L. The physical configuration used in this example is shown in *Figure D.4*.

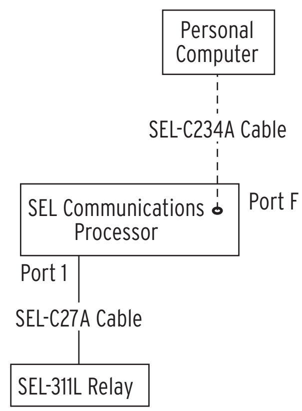

Figure D.4 Example SEL Relay and SEL Communications Processor Configuration

Table D.4 shows the Port 1 settings for the SEL communications processor.

Table D.4 SEL Communications Processor Port 1 Settings

Setting Name	Setting	Description
DEVICE	S	Connected device is an SEL device
CONFIG	Y	Allow autoconfiguration for this device
PORTID	"Relay 1"	Name of connected relay[a]
BAUD	19200	Channel speed of 19200 bits per second[a]
DATABIT	8	Eight data bits[a]
STOPBIT	1	One stop bit
PARITY	N	No parity
RTS_CTS	Y	Hardware flow control enabled
TIMEOUT	5	Idle timeout that terminates transparent connections of 5 minutes

[a] Automatically collected by the SEL communications processor during autoconfiguration.

Data Collection

Table D.5 lists the automatic messages that are available in the SEL-311L.

Table D.5 SEL Communications Processor Data Collection Automessages

Message	Data Collected
20METER	Power system metering data
20DEMAND	Demand and peak demand metering data
20TARGET	Selected Relay Word bit elements
20HISTORY	History Command (ASCII)
20STATUS	Status Command (ASCII)
20EVENT	Standard 4 sample/cycle event report (data only)
20EVENTS	Standard 4 sample/cycle event report (data with settings)
20EVENTL	Long 16 sample/cycle event report (data with settings)

Table D.6 shows the automessage (Set A) settings for the SEL communications processor. In this example the SEL communications processor is configured to collect metering and target data from the SEL-311L via the three automatic messages: 20TARGET, 20 METER, and 20DEMAND.

Table D.6 SEL Communications Processor Port 1 Automatic Messaging Settings

Setting Name	Setting	Description
AUTOBUF	Y	Save unsolicited messages
STARTUP	"ACC\nOTTER\n"	Automatically log in at Access Level 1
SEND_OPER	Y	Send Fast Operate messages for remote bit and breaker bit control
REC_SER	N	Automatic sequential event recorder data collection disabled
NOCONN	NA	No SELOGIC control equation entered to selectively block connections to this port
MSG_CNT	3	Three automessages
ISSUE1	P00:00:01.0	Issue Message 1 every second
MESG1	20METER	Collect metering data
ISSUE2	P00:00:01.0	Issue Message 2 every second
MESG2	20TARGET	Collect Relay Word bit data
ISSUE3	P00:01:00.0	Issue Message 3 every minute
MESG3	20DEMAND	Collect demand metering data
ARCH_EN	N	Archive memory disabled
USER	0	No USER region registers reserved

Table D.7 shows the map of regions in the SEL communications processor for data collected from the SEL-311L in the example.

Table D.7 SEL Communications Processor Port 1 Region Map

Region	Data Collection Message Type	Region Name	Description
D1	Binary	METER	Relay metering data
D2	Binary	TARGET	Relay Word bit data
D3	Binary	DEMAND	Demand metering data
D4–D8	n/a	n/a	Unused
A1–A3	n/a	n/a	Unused
USER	n/a	n/a	Unused

SEL-311L Metering Data

Table D.8 shows the list of meter data available in the SEL communications processor and the location and data type for the memory area within D1 (Data Region 1). The type field indicates the data type and size. The type “int” is a 16-bit integer. The type “float” is a 32-bit IEEE floating-point number. Use the communications processor map **PORT D1** command to view this information.

Table D.8 Communications Processor METER Region Map (Sheet 1 of 2)

Data Item	Starting Address	Type
_YEAR	2000h	int
DAY_OF_YEAR	2001h	int
TIME(ms)	2002h	int[2]
MONTH	2004h	char
DATE	2005h	char
YEAR	2006h	char
HOUR	2007h	char
MIN	2008h	char
SECONDS	2009h	char
MSEC	200Ah	int
IA	200Bh	float[2]
IB	200Fh	float[2]
IC	2013h	float[2]
IP	2017h	float[2]
VA	201Bh	float[2]
VB	201Fh	float[2]
VC	2023h	float[2]
VS	2027h	float[2]
FREQ	202Bh	float[2]
VBAT	202Fh	float[2]
IAX	2033h	float[2]
IBX	2037h	float[2]
ICX	203Bh	float[2]
IAY	203Fh	float[2]

Table D.8 Communications Processor METER Region Map (Sheet 2 of 2)

Data Item	Starting Address	Type
IBY	2043h	float[2]
ICY	2047h	float[2]
IAT	204Bh	float[2]
IBT	204Fh	float[2]
ICT	2053h	float[2]
IAB(A)	2057h	float[2]
IBC(A)	205Bh	float[2]
ICA(A)	205Fh	float[2]
VAB(V)	2063h	float[2]
VBC(V)	2067h	float[2]
VCA(V)	206Bh	float[2]
PA(MW)	206Fh	float
QA(MVAR	2071h	float
PB(MW)	2073h	float
QB(MVAR)	2075h	float
PC(MW)	2077h	float
QC(MVAR	2079h	float
P(MW)	207Bh	float
Q(MVAR)	207Dh	float
I0(A)	207Fh	float[2]
I1(A)	2083h	float[2]
I2(A)	2087h	float[2]
V0(V)	208Bh	float[2]
V1(V)	208Fh	float[2]
V2(V)	2093h	float[2]

Relay Word Bit Information

Table D.9 lists the Relay Word bit data available in the SEL communications processor for the memory area within D2 (Data Region 2).

Table D.9 Communications Processor TARGET Region (Sheet 1 of 2)

Address	Relay Word Bits (in Bits 7–0)							
	7	6	5	4	3	2	1	0
2804h	*	*	*	STSET	*	*	*	*
2805h	See *Table 9.5*, Row 0							
2806h	See *Table 9.5*, Row 1							
2807h	See *Table 9.5*, Row 2							
2808h	See *Table 9.5*, Row 3							
2809h	See *Table 9.5*, Row 4							
280Ah	See *Table 9.5*, Row 5							
280Bh	See *Table 9.5*, Row 6							
280Ch	See *Table 9.5*, Row 7							
280Dh	See *Table 9.5*, Row 8							

Table D.9 Communications Processor TARGET Region (Sheet 2 of 2)

Address	Relay Word Bits (in Bits 7–0)							
	7	6	5	4	3	2	1	0
280Eh	See *Table 9.5*, Row 9							
280Fh	See *Table 9.5*, Row 10							
2810h	See *Table 9.5*, Row 11							
. . .	. . .							
284Eh	See *Table 9.5*, Row 73							

SEL-311L Demand Data

Table D.10 shows the list of demand data available in the SEL communications processor and the location and data type for the memory areas within D3 (Data Region 3). The type field indicates the data type and size. The type "int" is a 16-bit integer. The type "float" is a 32-bit IEEE floating-point number. Use the communications processor map **PORT:33** command to view this information.

Table D.10 Communications Processor DEMAND Region Map (Sheet 1 of 2)

Data Item	Starting Address	Type
_YEAR	3000h	int
DAY_OF_YEAR	3001h	int
TIME(ms)	3002h	int[2]
MONTH	3004h	char
DATE	3005h	char
YEAR	3006h	char
HOUR	3007h	char
MIN	3008h	char
SECONDS	3009h	char
MSEC	300Ah	int
IA	300Bh	float
IB	300Dh	float
IC	300Fh	float
IG	3011h	float
3I2	3013h	float
PA+	3015h	float
PB+	3017h	float
PC+	3019h	float
P3+	301Bh	float
QA+	301Dh	float
QB+	301Fh	float
QC+	3021h	float
Q3+	3023h	float
PA–	3025h	float
PB–	3027h	float
PC–	3029h	float
P3–	302Bh	float

Table D.10 Communications Processor DEMAND Region Map (Sheet 2 of 2)

Data Item	Starting Address	Type
QA–	302Dh	float
QB–	302Fh	float
QC–	3031h	float
Q3–	3033h	float

Control Points

The SEL communications processor can pass control messages, called Fast Operate messages, to the SEL-311L.

When Fast Operate functions are enabled, the SEL communications processor automatically sends messages to the relay in response to changes in remote bits RB1–RB16 or breaker bits BR1–BR4 on the corresponding SEL communications processor port. For example, if you set RB1 on Port 1 in the SEL communications processor, it automatically sets RB01 in the SEL-311L connected to that serial port. *Table D.11* shows the relationship between the SEL communications processor Remote Bits and the SEL-311L Remote Bits.

Follow these steps to enable Fast Operate messages that set or clear remote bits or breaker bits.

Step 1. Set the FASTOP setting equal to Y in the SEL-311L port settings for the port connected to the SEL communications processor.

The SEL-311L breaker jumper must be in the proper position; see *Table 2.4*.

Step 2. Enable Fast Operate messages in the communications processor by setting the auto-message setting SEND_OPER equal to Y.

Step 3. Toggle the corresponding Set and Clear elements SRB1–16, CRB1–16, SBR1–4, and CBR1–4.

To pulse, instead of set or clear, remote bits, set auto-message setting SEND_OPER equal to YP instead of Y. Note that SEND_OPER equal to YP applies to remote bits only; breaker bit operation is the same for both SEND_OPER = Y and SEND_OPER = YP.

Table D.11 Remote Bit Correspondence to the SEL-311L

Remote Bit in SEL Communications Processor:	Corresponding SEL-311L Relay Word Bit:
RB1	RB01
RB2	RB02
RB3	RB03
RB4	RB04
...	...
RB15	RB15
RB16	RB16

Fast Operate breaker bits operate differently from remote bits. For example, when you set BR1 on Serial Port 1 of the SEL communications processor, the SEL communications processor sends a message to the SEL-311L that asserts the open command bit OC3 for one processing interval. Likewise, if you clear BR1, the SEL communications processor sends a message to the SEL-311L that asserts the close command bit CC3 for one processing interval.

Table D.12 shows how the breaker bits in the SEL communications processor are mapped to the **OPEN** Command and **CLOSE** Command Relay Word bits in the SEL-311L. For three-phase tripping and closing applications, use BR1 only.

Table D.12 Breaker Bit Correspondence to the SEL-311L

Breaker Bits in SEL Communications Processor:	Corresponding SEL-311L Relay Word Bit:	
	When BRn is set:	When BRn is cleared:
BR1	Pulse OC3	Pulse CC3

See *OPE Command (Open Breaker) on page 10.56* and *CLO Command (Close Breaker) on page 10.54* for more information on the Open and Close Command Relay Word bits in the SEL-311L.

Appendix E

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.

NOTE: Configure the port before connecting it to another MIRRORED BITS device. Otherwise, the relay will appear to be locked out.

SEL products support several variations of MIRRORED BITS communications protocols. Through port settings, you can set the SEL-311L Relay for compatible operation with SEL-300 series relays, SEL-400 series relays, SEL-600 series relays, the SEL-2505 Remote I/O Modules, and the SEL-2100 Protection Logic Processors. These devices use MIRRORED BITS communications to exchange the states of eight logic bits.

The PROTO = MB*c* option (*c* = A or B) is provided for compatibility with older SEL products that only support this version of MIRRORED BITS. Use PROTO = MB8*c* if each relay supports this MIRRORED BITS version. Use the RTSCTS = MBT option if your application includes Pulsar MBT9600 modems.

SEL Application Guide AG 2002-23, *Applying Two* SEL*-351S Relays to Provide Automatic Source Transfer for Critical Loads*, provides an example of how to use MIRRORED BITS in the SEL-351S Relay. These same principles may be used with the SEL-311L.

Figure E.1 shows this example with the SEL-311L.

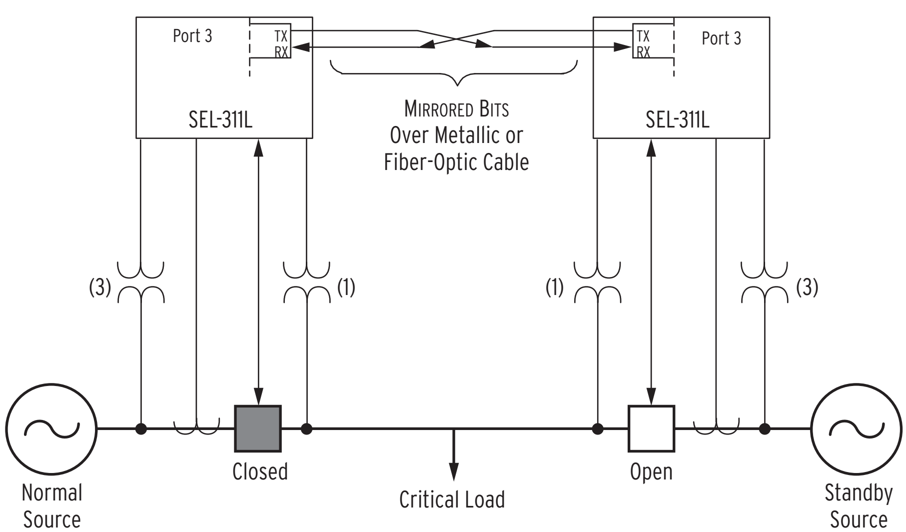

Figure E.1 Automatic Source Transfer Application

Communications Channels and Logical Data Channels

The SEL-311L 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 := MBA for MIRRORED BITS communications Channel A or PROTO := MBB for MIRRORED BITS communications Channel B.

Transmitted bits include TMB1A–TMB8A and TMB1B–TMB8B. The last letter (A or B) designates with which channel 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). In operation compatible with other SEL products, you can use the eight logical data channels for TMB1 through TMB8, as shown in *Figure E.2*.

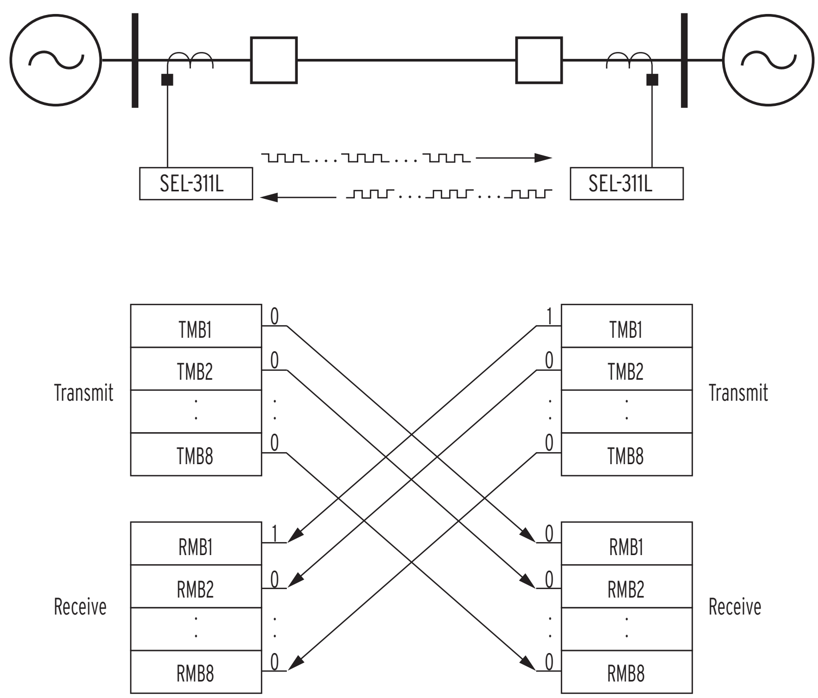

Figure E.2 Relay-to-Relay Logic Communication

Operation

Message Transmission

Depending on the settings, the SEL-311L transmits a Mirrored Bits communications message every 1/8 to 1/2 of an electrical cycle (see *Table E.3*). 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.

NOTE: When Mirrored Bits serial port settings are changed, the received Mirrored Bits reset to zero regardless of the RXDFLT setting.

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 RMB*n*, 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 at least eight (require eight consecutive occurrences to pass). The pickup and dropout security count settings are separate.

A pickup/dropout security counter operates identically to a pickup/dropout timer, except that the counter uses units counted received messages instead of time. An SEL-311L communicating with another SEL-311L 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-311L). 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-311L, 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-311L will delay a bit by 1/4 cycle because the SEL-311L is receiving new MIRRORED BITS messages each 1/8 cycle from the SEL-321.

Channel Synchronization

When an SEL-311L detects a communications error, it deasserts ROKA or ROKB. If a node detects two consecutive communications errors, it transmits an attention message, which includes its TXID setting.

When a node receives an attention message, it checks to see if its TXID is included.

If its own TXID is included and at least one other TXID is included, the node transmits data.

If its own TXID is not included, the node deasserts ROK*c*, includes its TXID in the attention message, and transmits the new attention message.

If its own TXID is the only TXID included, the relay assumes the message is corrupted unless the loopback mode has been enabled. If loopback is not enabled, the node deasserts ROK*c* and transmits the attention message with its TXID included. If loopback is enabled, the relay transmits data.

In summary, when a node detects two consecutive errors, it transmits attention until it receives an attention with its own TXID included. If three or four relays are connected in a ring topology, then the attention message will go all the way around the loop, and eventually will be received by the originating node. It will then be killed and data transmission will resume. This method of synchronization allows the relays to determine reliably which byte is the first byte of the message. It also forces mis-synchronized UARTs to become re-synchronized. On the downside, this method takes down the entire loop for a receive error at any node in the loop. This decreases availability. It also makes one-way communications impossible.

Loopback Testing

Use the **LOOP** 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.

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 *Table E.1*)

Table E.1 Error Types Reported by the Communications Report

Error Type	Description
Parity error	Data failed UART parity check.
Underrun	Three MIRRORED BITS messages transmitted without one being received.
Overrun	UART data buffer overrun.
Re-sync	The MIRRORED BITS device at the other end of the link detected an error.
Data error	Received data were not self-consistent, or the address was wrong.
Relay disabled	Relay protection functions disabled as when the relay turns on or a change in settings or settings group.
Loop Back	Loop back enabled. Error conditions followed by "(L)" occurred while the system was in loopback mode.
Framing error	The UART did not detect a stop bit in the received MIRRORED BITS data.

Use the **COMM** 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 **COMM** record will only show the initial cause, but the **COMM** 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, RBADA or RBADB.

When channel unavailability exceeds a user-settable threshold, the relay will assert a user-accessible flag, hereafter called CBAD*c*.

MIRRORED BITS Protocol for the Pulsar 9600 Baud Modem

To use a Pulsar MBT-9600 modem, set setting PROTO = MBA or MBB, SPEED = 9600, and RTSCTS = MBT. The PROTO setting enables MIRRORED BITS communications protocol Channel A or B on this port. The relay also injects a delay (idle time) of one processing interval between messages. The SEL-311L port settings associated with MIRRORED BITS communications are shown in *Table E.2*.

NOTE: The MBT-9600 modem requires +5 Vdc on Pin 1 of the serial port DB-9 connector. Refer to Table 2.7 for information on jumper settings to connect power to Pin 1 of the appropriate serial port.

With one of these options set, the relay will transmit a message every 1/2 power system cycle and the relay will deassert the RTS signal on the EIA-232 connector. Also, the relay will monitor the CTS signal on the EIA-232 connector, which the modem will deassert if the channel has too many errors. The modem uses the relay RTS signal to determine whether the new (MB8*c*) or old (MB*c*) MIRRORED BITS protocol is in use.

Settings

The SEL-311L port settings associated with MIRRORED BITS communications are shown in *Table E.2*. Set PROTO = MB8A to enable the MIRRORED BITS communications protocol Channel A on this port. Set PROTO = MB8B to enable the MIRRORED BITS communications protocol Channel B on this port.

Table E.2 MIRRORED BITS

Name	Description	Range	Default
PROTO	Protocol	SEL, DNP, MBA, MBB, MB8A, MB8B, MBGA, MBGB	SEL
SPEED	Baud Rate	300, 1200, 2400, 4800, 9600, 19200, 38400[a]	9600
RTSCTS	Enable Hardware Handshaking	Y, N, MBT[b]	N
RBADPU	MIRRORED BITS RX Bad Pickup Time	1–10000 s	60
CBADPU	PPM MIRRORED BITS Channel Bad Pickup	1–10000 s	1000
TXID	MIRRORED BITS Transmit Identifier[c]	1–4	2
RXID	MIRRORED BITS Receive Identifier[c]	1–4	1
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] 38400 is not available on Port 1.
[b] MBT is available when PROTO = MBA or MBB.
[c] This setting is unavailable if PROTO is set to MBGA or MBGB.

As a function of the settings for SPEED, the message transmission periods are shown in *Table E.3*.

Table E.3 Message Transmission Periods

SPEED	SEL-321	SEL-311L
38400	1 message per 1/8 cycle	1 message per 1/4 cycle
19200	1 message per 1/8 cycle	1 message per 1/4 cycle
9600	1 message per 1/4 cycle	1 message per 1/4 cycle
4800	1 message per 1/2 cycle	1 message per 1/2 cycle

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 CBADA is asserted. The times used in the calculation are those that are available in the **COMM** records. See the *COM Command (Communication Data) on page 10.34* for a description of the **COMM** records.

Set the RXID of the local relay to match the TXID of the remote relay. For example, in the three-terminal case, where Relay X transmits to Relay Y, Relay Y transmits to Relay Z, and Relay Z transmits to Relay X:

	TXID	RXID
Relay X	1	3
Relay Y	2	1
Relay Z	3	2

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 RMB1A–RMB8A, where *X* represents the most recently received valid value. Note that when MIRRORED BITS serial port settings are changed, the receive MIRRORED BITS reset to zero regardless of the RXDFLT setting.

Supervise the transfer of received data (or default data) to RMB1A–RMB8A with the MIRRORED BITS pickup and dropout security counters. Set the pickup and dropout counters individually for each bit.

Use the MBGA and MBGB settings for applications, such as bus transfer schemes, that require MIRRORED BITS settings to reside in the Group settings. The affected settings include the MIRRORED BITS transmit identifier (TXID) and receive identifier (RXID), which are moved from the Port settings to the Group settings. Moving these settings allows them to be changed with a group switch, allowing for the communications flexibility required by specific applications.

In addition, when PROTO is set to MBGA or MBGB, MIRRORED BITS can be enabled or disabled on a group-by-group basis, minimizing nuisance communications alarms. Set MIRRORED BITS Enable setting EMBA or EMBB to Y to enable MIRRORED BITS communication for that group.

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Appendix F
DNP3 Communications

The SEL-311L Relay provides a DNP3 (Distributed Network Protocol) Level 2 Slave interface for direct network connections to the relay. This section covers the following topics:

- ➤ Introduction to DNP3
- ➤ DNP3 in the SEL-311L
- ➤ DNP3 Documentation, Object Tables, and Data Maps

Introduction to DNP3

A SCADA (Supervisory Control and Data Acquisition) manufacturer developed DNP3 from the lower layers of IEC 60870-5. DNP3 was designed for use in telecontrol applications. The protocol has become popular for both local substation data collection and telecontrol. DNP is one of the protocols included in the IEEE Recommended Practice for Data Communication between Remote Terminal Units and Intelligent Electronic Devices in a Substation.

The DNP User's Group maintains and publishes DNP standards. See the DNP User's Group website, www.dnp.org, for more information on DNP standards, implementers of DNP, and tools for working with DNP.

DNP3 Specifications

DNP3 is a protocol with many features and many ways to accomplish tasks. DNP3 is defined in a series of specifications known as the Basic 4. A companion specification called the Subset Definitions simplifies DNP3 implementation by providing three standard interoperable implementation levels. The levels are listed in *Table F.1*.

Table F.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

Each level is a proper superset of the next lower-numbered level. A higher subset level device can act as a master to a lower subset level device. For example, a typical SCADA master is a Level 3 device and can poll a Level 2 or Level 1 device by using only the data types and functions that the lower-level device uses. A lower-level device can also poll a higher-level device. For example, a Level 1 device can poll a Level 3 device, but the Level 1 device can only access the features and data available in Level 1.

In addition to the Basic 4 and the Subset Definitions, 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 DNP.

Data Handling

Objects

DNP3 uses a system of data references called objects, which the Basic 4 standard object library defines. Each subset level specification requires a minimum implementation of object types and also recommends several optional object types. Object types are commonly referred to as objects. DNP 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 DNP device.

If there can be more than one instance of a type of object, then 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 has three variations: 0, 1, and 2. Use Variation 0 to request the default variation. Variation 1 is used to specify binary input values only and Variation 2 is used 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 DNP message exchanges except unsolicited data. DNP terminology describes all points from the perspective of the master. Binary points for control that move from the master to the remote are called Binary Outputs, while binary status points within the remote are called Binary Inputs.

Function Codes

Each DNP 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 F.2*.

Table F.2 Selected DNP3 Function Codes

Function Code	Function	Description
1	Read	Request data from the remote
2	Write	Send data to the remote
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. DNP masters use qualifier codes to compose the shortest, most concise message possible when requesting points from a DNP remote.

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, that specifies points in the range 4 to 16.

Access Methods

DNP has many features that help it obtain maximum possible message efficiency. Requests are sent with the least number of bytes using special objects, variations, and qualifiers that reduce the message size. Other features eliminate the continual exchange of data values that are not changing. These features optimize use of bandwidth and maximize performance over any speed connection.

DNP event data collection eliminates the need to use bandwidth to transmit values that have not changed. Event data are records of when observed measurements changed. For binary points, the remote device (DNP slave) logs changes from logical 1 to logical 0 and from logical 0 to logical 1. For analog points, the remote device logs changes that exceed a deadband. DNP remote devices collect event data in a buffer that the master can either request or the relay can send to the master without a request message. Data sent from the remote to the master without a polling request are called unsolicited data.

DNP data fit into one of four event classes: 0, 1, 2, or 3. Class 0 is reserved for reading the present value data (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 remotes 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.

DNP also supports static polling, simple polling of the present value of data points within the remote. By combining event data, unsolicited polling, and static polling, you can operate your system in one of the four access methods shown in *Table F.3*.

The access methods listed in *Table F.3* are 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 because of the elimination of polling messages from the master required by polled report-by-exception. You must also consider overall system size and the volume of data communication expected to properly evaluate which access method provides optimum performance for your application.

Table F.3 DNP 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	Remote 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

DNP masters use Object 12 control relay output block to perform DNP binary control operations. The control relay output block has both a trip/close selection and a code selection. The trip/close selection allows a single DNP 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 DNP master implementations.

The control relay output block code selection specifies either a latch or pulse operation on the point. In many cases, DNP remotes have only a limited subset of the possible combinations of the code field. Sometimes, DNP remotes assign special operation characteristics to the latch and pulse selections. *Table F.12* and *Table F.13* describe control point operation for the SEL-311L.

Conformance Testing

In addition to the protocol specifications, the DNP User's 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 remote will be fully interoperable (work together properly for all implemented features). Conformance testing does help to standardize the testing procedure and move the DNP implementers toward a higher level of interoperability. The SEL-311L is certified as having passed DNP3 Level 2 Slave conformance tests by a third-party organization, and the conformance certificate is on file at SEL and listed on the DNP User's Group website (www.dnp.org).

Data Link Layer Operation

DNP 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 DNP device. While this feature helps you recognize a failed device or failed communications link quickly, it also adds significant overhead to the DNP conversation. Consider for your individual application whether you require this link integrity function at the expense of overall system speed and performance.

The DNP 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 network medium, you must 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 network as a star topology of point-to-point connections or use carrier detection on a multi-drop 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 network allows for spontaneous data transmission including unsolicited event data transmissions, you also must use application confirmation to provide a retry mechanism for messages lost because of data collisions.

DNP3 in the SEL-311L

The SEL-311L is a DNP3 Level 2 remote (slave) device. Additional implementation documentation describing DNP in the relay is in *DNP3 Documentation on page F.10*.

Data Access

NOTE: Because unsolicited messaging only operates properly in some situations, for maximum performance and minimum risk of configuration problems, use the polled report-by-exception access method. Configure the master to perform at least 10 event polls for every integrity poll.

You can use any of the data access methods listed in *Table F.4*. *Table F.4* also lists the SEL-311L DNP3 settings. You must configure the DNP master for the data access method you select.

Table F.4 DNP Access Methods

Access Method	Master Polling	SEL-311L Settings
Polled static	Class 0	Set ECLASS to 0; UNSOL to No
Polled report-by-exception	Class 0 occasionally, Class 1, 2, 3 frequently	Set ECLASS to the desired event class; UNSOL to No
Unsolicited report-by-exception	Class 0 occasionally, optional Class 1, 2, 3 less frequently; mainly relies on unsolicited messages	Set ECLASS to the desired event class; set UNSOL to Yes and PUNSOL to Yes or No; set NUMEVE and AGEEVE.
Quiescent	Class 0, 1, 2, 3 never; relies completely on unsolicited messages	Set ECLASS to the desired event class; set UNSOL and PUNSOL to Yes; set NUMEVE and AGEEVE.

In both the unsolicited report-by-exception and quiescent polling methods shown in *Table F.4*, you must make a selection for the PUNSOL setting. This setting enables or disables unsolicited data reporting when the relay turns on. If your master can send the DNP message to enable unsolicited reporting from the SEL-311L, you should set PUNSOL to No.

While automatic unsolicited data transmission when the relay turns on is convenient, problems can result if your master is not prepared to start receiving data immediately the relay turns on. If the master does not acknowledge the unsolicited data with an Application Confirm, the relay will resend the information 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 relays simultaneously begin sending data and waiting for acknowledgment messages.

If the SEL-311L does not receive an Application Confirm in response to unsolicited data, it will wait for UTIMEO seconds and then repeat the unsolicited message. *Figure F.1* provides an example with URETRY = 2.

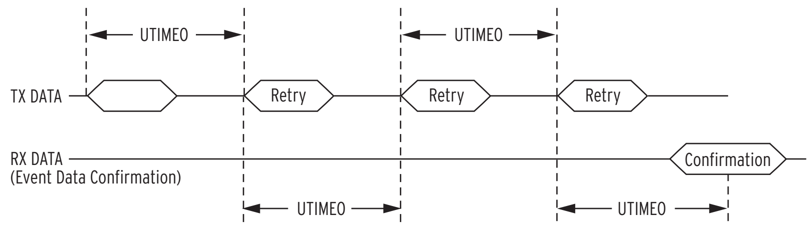

Figure F.1 Application Confirmation Timing

Collision Avoidance

If your application uses unsolicited reporting, you must select a polled mode (polled static or polled report-by-exception) 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.

The relay 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-311L 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. If you use the settings of 0.10 seconds for MAXDLY and 0.05 seconds for MINDLY, the SEL-311L 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 F.2*).

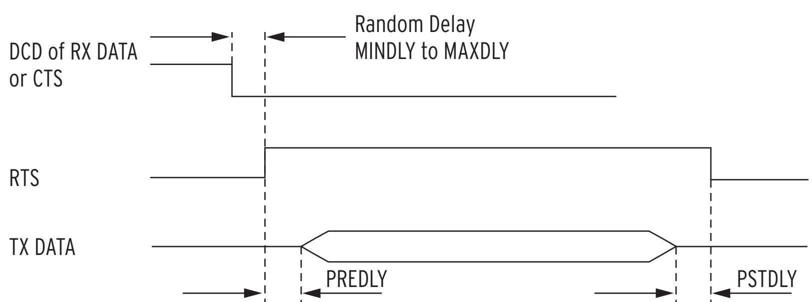

Figure F.2 Message Transmission Timing

Transmission Control

If you use a media transceiver (for example, EIA-232 to EIA-485) or a radio system for your DNP network, you may need to adjust data transmission properties. Use the PREDLY and PSTDLY settings to provide a delay between RTS signal control and data transmission (see *Figure F.2*). For example, an EIA-485 transceiver typically requires 10 to 20 ms to change from receive to transmit. If you set the pre-delay to 30 ms, you will avoid data loss resulting from data transmission beginning at the same time as RTS signal assertion.

Event Data

DNP event data objects contain change-of-state and time-stamp information that the SEL-311L collects and stores in a buffer. You can configure the SEL-311L to either report the data without a polling request from the master (unsolicited data) or hold the data until the master requests the information with an event poll message.

Analog inputs are mapped into Objects 30 and 32 as shown in *Table F.9*. These values are reported in primary units. An event-class message is generated whenever an input exceeds the ANADB deadband setting after scaling is applied. Angles will only generate events if both the magnitude and angle exceed the deadband setting. All analog inputs, other than fault information inputs, are scanned at approximately a one-second rate and use the scan initiation time as the time stamp. Because these objects use integer data, scaling must be used to send digits after the decimal point and avoid rounding to a simple integer value.

With no scaling, the value of 12.632 would be sent as 13. With a scaling setting of 1, the value transmitted is 126. With a 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.

Set the default analog value scaling with the DECPLA, DECPLV, and DECPLM settings. Application of event reporting dead bands occurs after scaling in the DECPLA, DECPLV, and DECPLM. For example, if you set DECPLA to 2 and ANADB 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 relay to report a new event value.

The relay uses the NUMEVE and AGEEVE settings to decide when to send unsolicited data to the master. The relay sends an unsolicited report when the total number of events accumulated in the event buffer reaches NUMEVE. The relay also sends an unsolicited report if the age of the oldest event in the buffer exceeds AGEEVE. The SEL-311L has the buffer capacities listed in *Table F.5*.

Table F.5 SEL-311L Event Buffer Capacity

Type	Maximum Number of Events
Binary	1024
Analog	256
Counters	128

Binary Controls

The SEL-311L provides more than one way to control individual points within the relay. The relay maps incoming control points either to remote bits within the relay or to internal command bits that cause circuit breaker operations. *Table F.12* and *Table F.13* list control points and control methods available in the SEL-311L.

A DNP technical bulletin *(Control Relay Output Block Minimum Implementation 9701-002)* recommends that you use one point per Object 12, control block output relay. 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 DNP message to specify operation of the points shown in *Control Point Operation on page F.19*.

Time Synchronization

The accuracy of DNP time synchronization is insufficient for most protection and oscillography needs. DNP time synchronization provides backup time synchronization in the event the relay loses primary synchronization through the IRIG-B input. Enable time synchronization with the TIMERQ setting and use Object 50, Variation 1, and Object 52, Variation 2, to set the time via a DNP master.

DNP Settings

The DNP protocol settings that become available when you select DNP on a serial port are shown in *Table F.6*. The DNP protocol settings are in the port settings for the port that you select for the DNP protocol. You can use DNP on serial ports, Port 1–Port 3, but you can only enable DNP on one port at a time.

Table F.6 SEL-311L Port DNP Protocol Settings

Name	Description	Range	Default
DNPADR	DNP address	0–65534	0
ECLASS	Class for event data	0–3	2
TIMERQ	Time-set request interval (0–32767 minutes)	0–32767	0
DECPLA	Currents scaling	0–3	1
DECPLV	Voltages scaling	0–3	1
DECPLM	Miscellaneous data scaling	0–3	1
STIMEO	Select/operate time-out	0.0–30.0 seconds	1.0
DRETRY	Data-link retries	0–15	3
DTIMEO	Data-link time-out	0.0–5.0 seconds	1.0
MINDLY	Minimum delay from DCD to Tx	0.00–1.00 seconds	0.05
MAXDLY	Maximum delay from DCD to Tx	0.00–1.00 seconds	0.10
PREDLY	Settle time from RTS on to Tx; Off disables PSTDLY	OFF, 0.00–30.00 seconds	0.00
PSTDLY	Settle time from Tx to RTS off; hidden if PREDLY set to Off	0.00–30.00 seconds	0.00
ANADB	Analog reporting deadband	0–32767	100
UNSOL	Enable Unsolicited reporting; hidden and set to N if ECLASS set to Off	Y, N	N
PUNSOL	Enable Unsolicited reporting when the relay turns on; hidden if UNSOL set to N	Y, N	N
REPADR	DNP address to which the relay reports unsolicited data	0–65534	0
NUMEVE	Number of events on which the relay transmits unsolicited data; hidden if UNSOL set to N	1–200	10
AGEEVE	Age of oldest event on which the relay transmits unsolicited data; hidden if UNSOL set to N	0.0–60.0 seconds	2.0
UTIMEO	Period at which to retry unsolicited responses after URETRY attempts	0–50	2

Configurable Data Mapping

A powerful feature of the SEL-311L DNP implementation is the ability to remap analog and binary inputs. Remapping is the process of selecting data from the default map and organizing these data into a smaller data set optimized for the application.

The analog and binary input points (Objects 1, 2, 30, and 32) may be remapped via the **DNP** command. The map is composed of two lists of indices, one for the analog inputs (30 and 32) and the other for the binary inputs (1 and 2). The indices correspond to those given by the relay default DNP data map. The order the inputs occur in the list determines the index that the corresponding value is reported as to the DNP master. If a value is not in the list, it is not available to the DNP master. All 1225 binary input points and 148 analog input points may be included in the list but may occur only once. The maps are stored in nonvolatile memory. The **DNP** command is only available if DNP has been selected on one of the ports. The **DNP** command has the following format:

DNP [*type*]

where *type* may be A, B, S, T, or omitted.

If the **DNP** command is issued without parameters, the relay displays both the analog and the binary maps, which have the following format:

```
==>DNP<STX>
Analogs  =112 28 17 35 1 56 57 58 59 60 61 62 63 64 65 \
   66 67 100 101 102 103
Binaries =    Default Map<ETX>
==>
```

If the **DNP** command is issued with an S parameter, the relay displays only the analog map; likewise, a T parameter causes the relay to display only the binary map. If the map checksum is determined to be invalid, the map will be reported as corrupted during a display command, as follows:

```
==>DNP T<STX>
Binaries = Map Corrupted<ETX>
==>
```

If the map is determined to be corrupted, DNP will respond to all master data requests with an unknown point error. If the **DNP** command is issued with an A or B parameter at Access Level 2 or greater, the relay requests that the user enter indices for the corresponding list, where a parameter of A specifies the analog list and B specifies the binary list. The relay accepts lines of indices until a line without a final continuation character (\) is entered. Each line of input is constrained to 80 characters, but all of the points may be remapped using multiple lines with continuation characters (\) at the end of the intermediate lines. If a single, blank line is entered as the first line, the remapping is disabled for that type (i.e., the relay uses the default analog or binary map). For example, the first example remap could be produced with the following commands:

```
==>DNP A
Enter the new DNP Analog map
112 28 17 \<CR>
35 1 56 57 58 59 60 61 62 63 64 65 66 67 100 101 102 \<CR>
103<CR>
==>DNP B
Enter the new DNP Binary map
<CR>
==>
```

DNP3 Documentation

Device Profile

Table F.7 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 F.7 SEL-311L DNP3 Device Profile (Sheet 1 of 2)

Parameter	Value
Vendor name	Schweitzer Engineering Laboratories
Device name	SEL-311L Recloser Control
Highest DNP request level	Level 2
Highest DNP response level	Level 2
Device function	Slave
Notable objects, functions, and/or qualifiers supported	None
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 On	Always
Executes control Latch Off	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.

Table F.7 SEL-311L DNP3 Device Profile (Sheet 2 of 2)

Parameter	Value
Sends static data in unsolicited responses	Never
Default counter object/variation	Object 20, Variation 6
Counter roll-over	16 bits
Sends multifragment responses	No

Object List

Table F.8 lists the objects and variations with supported function codes and qualifier codes available in the SEL-311L. The list of supported objects conforms to the format laid out in the DNP specifications and includes both supported and unsupported objects. Those that are supported include the function and qualifier codes. The objects that are not supported are shown without any corresponding function and qualifier codes.

Table F.8 SEL-311L DNP Object List (Sheet 1 of 5)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
1	0	Binary Input—All Variations	1	0, 1, 6, 7, 8		
1	1	Binary Input	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
1	2[e]	Binary Input With Status	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
2	0	Binary Input Change—All Variations	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[f]	Binary Input Change With Relative Time	1	6, 7, 8	129	17, 28
10	0	Binary Output—All Variations	1	0, 1, 6, 7, 8		
10	1	Binary Output				
10	2[e]	Binary Output Status	1	0, 1, 6, 7, 8	129	0, 1
12	0	Control Block—All Variations				
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
12	2	Pattern Control Block				
12	3	Pattern Mask				
20	0	Binary Counter—All Variations	1	0, 1, 6, 7, 8		
20	1	32-Bit Binary Counter				
20	2	16-Bit Binary Counter				
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter Without Flag	1	0, 1, 6, 7, 8	129	0, 1, 7, 8, 17, 28

Table F.8 SEL-311L DNP Object List (Sheet 2 of 5)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
20	6[e]	16-Bit Binary Counter Without Flag	1	0, 1, 6, 7, 8	129	0, 1,7, 8, 17, 28
20	7	32-Bit Delta Counter Without Flag				
20	8	16-Bit Delta Counter Without Flag				
21	0	Frozen Counter—All Variations				
21	1	32-Bit Frozen Counter				
21	2	16-Bit Frozen Counter				
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter With Time of Freeze				
21	6	16-Bit Frozen Counter With Time of Freeze				
21	7	32-Bit Frozen Delta Counter With Time of Freeze				
21	8	16-Bit Frozen Delta Counter With Time of Freeze				
21	9	32-Bit Frozen Counter Without Flag				
21	10	16-Bit Frozen Counter Without Flag				
21	11	32-Bit Frozen Delta Counter Without Flag				
21	12	16-Bit Frozen Delta Counter Without Flag				
22	0	Counter Change Event—All Variations	1	6, 7, 8		
22	1	32-Bit Counter Change Event Without Time	1	6, 7, 8	129	17, 28
22	2[e]	16-Bit Counter Change Event Without Time	1	6, 7, 8	129, 130	17, 28
22	3	32-Bit Delta Counter Change Event Without Time				
22	4	16-Bit Delta Counter Change Event Without Time				
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

Table F.8 SEL-311L DNP Object List (Sheet 3 of 5)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
22	7	32-Bit Delta Counter Change Event With Time				
22	8	16-Bit Delta Counter Change Event With Time				
23	0	Frozen Counter Event—All Variations				
23	1	32-Bit Frozen Counter Event Without Time				
23	2	16-Bit Frozen Counter Event Without Time				
23	3	32-Bit Frozen Delta Counter Event Without Time				
23	4	16-Bit Frozen Delta Counter Event Without Time				
23	5	32-Bit Frozen Counter Event With Time				
23	6	16-Bit Frozen Counter Event With Time				
23	7	32-Bit Frozen Delta Counter Event With Time				
23	8	16-Bit Frozen Delta Counter Event With Time				
30	0	Analog Input—All Variations	1	0, 1, 6, 7, 8		
30	1	32-Bit Analog Input	1	0, 1, 6, 7, 8	129	0, 1,7, 8,
30	2	16-Bit Analog Input	1	0, 1, 6, 7, 8	129	0, 1, 7, 8,
30	3	32-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8	129	0, 1, 7, 8,
30	4[e]	16-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8	129	0, 1,7, 8,
31	0	Frozen Analog Input—All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input With Time of Freeze				
31	4	16-Bit Frozen Analog Input With Time of Freeze				
31	5	32-Bit Frozen Analog Input Without Flag				
31	6	16-Bit Frozen Analog Input Without Flag				

Table F.8 SEL-311L DNP Object List (Sheet 4 of 5)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
32	0	Analog Change Event—All Variations	1	6, 7, 8		
32	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129	17, 28
32	2[e]	16-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130	17, 28
32	3	32-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32	4	16-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
33	0	Frozen Analog Event—All Variations				
33	1	32-Bit Frozen Analog Event Without Time				
33	2	16-Bit Frozen Analog Event Without Time				
33	3	32-Bit Frozen Analog Event With Time				
33	4	16-Bit Frozen Analog Event With Time				
40	0	Analog Output Status—All Variations	1	0, 1, 6, 7, 8		
40	1	32-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
40	2[e]	16-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 7, 8,
41	0	Analog Output Block—All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date—All Variations				
50	1	Time and Date	1, 2	7, 8 index=0	129	07, quantity=1
50	2	Time and Date With Interval				
51	0	Time and Date CTO—All Variations				
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO				07, quantity=1
52	0	Time Delay—All Variations				
52	1	Time Delay, Coarse				

Table F.8 SEL-311L DNP Object List (Sheet 5 of 5)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
52	2	Time Delay, Fine			129	07, quantity=1
60	0	All Classes of Data	1, 20, 21	6		
60	1	Class 0 Data	1	6		
60	2	Class 1 Data	1, 20, 21	6, 7, 8		
60	3	Class 2 Data	1, 20, 21	6, 7, 8		
60	4	Class 3 Data	1, 20, 21	6, 7, 8		
70	1	File Identifier				
80	1	Internal Indications	2	0, 1 index=7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary—Coded Decimal				
101	2	Medium Packed Binary—Coded Decimal				
101	3	Large Packed Binary—Coded Decimal				
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] Supports request, but response contains no data.

Reference Data Map

Table F.9 shows the SEL-311L default data map. The default map makes a wide range of data in the relay available. If your DNP3 master does Class 0 polls (polls of all present value points), a default map response will be quite large. Use the custom DNP mapping functions of the SEL-311L to reduce the data map to the points that your application requires.

The relay scales analog values by the indicated settings or fixed scaling indicated in the description. Analog dead bands for event reporting use the indicated settings, or ANADB if you have specified no setting.

Table F.9 DNP3 Default Data Map (Sheet 1 of 3)

Object	Index	Description
01,02	000–599	Relay Word, where RCLO is 0 and CTALA is 591.
01,02	600–1199	Relay Word from the SER, encoded same as inputs 000–599 with 600 added.
01,02	1200–1215	Relay front-panel targets, where 1215 is A, 1208 is 87CH-FAIL, 1207 is EN and 1200 is RCLO.
01,02	1216–1219	Power factor leading for A-, B-, C-, and 3-phase.
01,02	1220	Relay Disabled.
01,02	1221	Relay diagnostic failure.
01,02	1222	Relay diagnostic warning.
01,02	1223	New relay event available.
01,02	1224	Settings change or relay restart.
10,12	00–15	Remote bits RB1–RB16.
10,12	16	Pulse Open command OC.
10,12	17	Pulse Close command CC.
10,12	18	Reset demands.
10,12	19	Reset demand peaks.
10,12	20	Reset energies.
10,12	21	Reset breaker monitor.
10,12	22	Reset front-panel targets.
10,12	23	Read next relay event.
10,12	24–31	Remote bit pairs RB1–RB16.
10,12	32	Open/Close pair OC & CC.
20,22	00	Active settings group.
20,22	01	Internal breaker trips.
20,22	02	External breaker trips.
30,32	00[a], 01[b]	IA magnitude and angle.
30,32	02[a], 03[b]	IB magnitude and angle.
30,32	04[a], 05[b]	IC magnitude and angle.
30,32	06[a], 07[b]	IP magnitude and angle.
30,32	08[c], 09[b]	VA magnitude (kV) and angle.
30,32	10[c], 11[b]	VB magnitude (kV) and angle.
30,32	12[c], 13[b]	VC magnitude (kV) and angle.
30,32	14[c], 15[b]	VS magnitude (kV) and angle.
30,32	16[a], 17[b]	3I0 magnitude and angle.
30,32	18[a], 19[b]	I1 magnitude and angle.
30,32	20[a], 21[b]	3I2 magnitude and angle.
30,32	22[c], 23[b]	3V0 magnitude (kV) and angle.
30,32	24[c], 25[b]	V1 magnitude (kV) and angle.
30,32	26[c], 27[b]	V2 magnitude (kV) and angle.
30,32	28-31[d]	MW A-, B-, C-, and 3-phase.
30,32	32-35[d]	MVAR A-, B-, C-, and 3-phase.

Table F.9 DNP3 Default Data Map (Sheet 2 of 3)

Object	Index	Description
30,32	36-39[b]	Power factor A-, B-, C-, and 3-phase.
30,32	40[b]	Frequency.
30,32	41[b]	VDC.
30,32	42[d], 43[d]	A-phase MWhr in and out.
30,32	44[d], 45[d]	B-phase MWhr in and out.
30,32	46[d], 47[d]	C-phase MWhr in and out.
30,32	48[d], 49[d]	3-phase MWhr in and out.
30,32	50[d], 51[d]	A-phase MVARhr in and out.
30,32	52[d], 53[d]	B-phase MVARhr in and out.
30,32	54[d], 55[d]	C-phase MVARhr in and out.
30,32	56[d], 57[d]	3-phase MVARhr in and out.
30,32	58–62[a]	Demand IA, IB, IC, IG, and 3I2 magnitudes.
30,32	63–66[d]	A-, B-, C-, and 3-phase demand MW in.
30,32	67–70[d]	A-, B-, C-, and 3-phase demand MVAR in.
30,32	71–74[d]	A-, B-, C-, and 3-phase demand MW out.
30,32	75–78[d]	A-, B-, C-, and 3-phase demand MVAR out.
30,32	79–83[a]	Peak demand IA, IB, IC, IG, and 3I2 magnitudes.
30,32	84–87[d]	A-, B-, C-, and 3-phase peak demand MW in.
30,32	88–91[d]	A-, B-, C-, and 3-phase peak demand MVAR in.
30,32	92–95[d]	A-, B-, C-, and 3-phase peak demand MW out.
30,32	96–99[d]	A-, B-, C-, and 3-phase peak demand MVAR out.
30,32	100–102[d]	Breaker contact wear percentage (A, B, C).
30	103[e]	Fault type (see table for definition).
30	104[d]	Fault location.
30	105[e]	Fault current.
30	106[b]	Fault frequency.
30	107[e]	Fault settings group.
30	108[e]	Fault recloser shot counter.
30	109–111[e]	Fault time in DNP format (high, middle, and low 16 bits).
30,32	112[a], 113[b]	IAX magnitude and angle.
30,32	114[a], 115[b]	IBX magnitude and angle.
30,32	116[a], 117[b]	ICX magnitude and angle.
30,32	118[a], 119[b]	3I0X magnitude and angle.
30,32	120[a], 121[b]	I1X magnitude and angle.
30,32	122[a], 123[b]	3I2X magnitude and angle.
30,32	124[a], 125[b]	IAY magnitude and angle.
30,32	126[a], 127[b]	IBY magnitude and angle.
30,32	128[a], 129[b]	ICY magnitude and angle.
30,32	130[a], 131[b]	3I0Y magnitude and angle.
30,32	132[a], 133[b]	I1Y magnitude and angle.
30,32	134[a], 135[b]	3I2Y magnitude and angle.

Table F.9 DNP3 Default Data Map (Sheet 3 of 3)

Object	Index	Description
30,32	136[a], 137[b]	IAT magnitude and angle.
30,32	138[a], 139[b]	IBT magnitude and angle.
30,32	140[a], 141[b]	ICT magnitude and angle.
30,32	142[a], 143[b]	3I0T magnitude and angle.
30,32	144[a], 145[b]	I1T magnitude and angle.
30,32	146[a], 147[b]	3I2T magnitude and angle.
40,41	00	Active settings group.

[a] Default current scaling DECPLA on magnitudes and angles multiplied by 100.
[b] Multiplied by 100.
[c] Default voltage scaling DECPLV on magnitudes and angles multiplied by 100.
[d] Default miscellaneous scaling DECPLM.
[e] No scaling.

Relay Word Bits

The Relay Word bits and status indications mapped into Objects 1 and 2 (Indices 000–599 and 1200–1223, respectively) are shown in *Table 9.5*. These inputs are scanned approximately once per second to generate events. Times reported with these event objects are the times at which the scanner observed bit changes. These times may be significantly delayed from when the actual change occurred and should not be used for sequence-of-events determination.

Use the Relay Word bits table (*Table 9.5*) and the following directions to determine the point index (Point_Index) of a Relay Word bit.

Step 1. Find the desired Relay Word bit in the table.

Step 2. Note the Relay Word column and row numbers.

a. Determine the column number (Column_Number) by counting from 0 to 7 in a right-to-left direction.

b. Read the first row number (First_Row, usually 2) and the Relay Word bit row number (Row_Number) from the table.

c. The following equation can now be used to calculate the point index.

$$\text{Point\_Index} = [(\text{Row Number} - \text{First Row}) \bullet 8] + \text{Column\_Number}$$

Equation F.1

Relay Word bits mapped into Objects 1 and 2 (Indices 600–1199) are derived from the Sequential Events Recorder (SER) and carry the time stamp of actual occurrence. Only the Relay Word bits in the SER trigger settings SER1–SER3 (SET R) will generate events. Reads of Indices 0–599 and static reads of Indices 600–1199 will return the same data.

Fault Information

Fault information is also mapped into Objects 30 and 32 analog inputs. These inputs are updated when a binary output index is pulsed instead of with a scan. Information for multiple faults is available because the DNP implementation uses the same data as the **HISTORY** command. The **HISTORY** command presents faults in a last-in, first-out (LIFO) sequence because the latest event is the one of most interest. However, this DNP implementation loads the fault information in a first-in, first-out (FIFO) sequence because another fault may occur before all faults are read.

Read the “New relay event available” binary input point index 1223 to determine whether unread fault (event summary) data are available. The master must pulse the “Read next relay event” binary output point index 23 to latch new data into the event registers. Because multiple unread event summaries may be available, the previous sequence should be repeated until all available event summaries are read.

Object 30, Fault Type, is a 16-bit composite value, where the upper byte value indicates an event cause as shown in *Table F.10* and a fault type as shown in *Table F.11*. The upper byte may contain more than one Event Cause. Similarly, the lower byte may contain any combination of Fault Type bits. For example, a Fault Type of 3079 decimal would translate to 0C07 hexadecimal and indicate a Trip Element and Event Report (ER) element asserted at the trigger row of the event report (C hexadecimal = 12 decimal = 8 + 4) and all three phases were involved (7 hexadecimal = 7 decimal = 1 + 2 + 4).

Table F.10 Object 30, Fault Type Upper Byte—Event Cause

Byte Value	Description
1	Trigger command
2	Pulse command
4	Trip element
8	Event report element

Table F.11 Object 30, Fault Type Lower Byte—Fault Type

Bit	Description
0	Indeterminate
1	A-phase
2	B-phase
4	C-phase
8	Ground

Control Point Operation

Use the Trip and Close operations with Object 12 control relay output block command messages to operate the points shown in *Table F.12*. Pulse operations provide a pulse with a duration of one protection processing interval. Because the SEL-311L allows only one control bit to be pulsed at a time, send consecutive control bits in consecutive messages.

Table F.12 Object 12 Trip/Close Pair Operation

Index	Close	Trip
0–15	Set RB01–RB16	Clear RB01–RB16
16–23	Pulse RB01–RB16	No action
24	Pulse RB2	Pulse RB1
25	Pulse RB4	Pulse RB3
26	Pulse RB6	Pulse RB5
27	Pulse RB8	Pulse RB7
28	Pulse RB10	Pulse RB9
29	Pulse RB12	Pulse RB11
30	Pulse RB14	Pulse RB13
31	Pulse RB16	Pulse RB15
32	Pulse CC	Pulse OC

The SEL-311L assigns some special operations to the code portion of the control relay output block command. The special operations are shown in *Table F.13*. Pulse operations provide a pulse duration of one protection-processing interval.

Table F.13 Object 12 Code Selection Operation

Index	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
0–15	Set RB01–RB16	Clear RB01—RB16	Pulse RB01—RB16	Clear RB01—RB16
16–23	Pulse	No action	Pulse	No action
24	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1
25	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3
26	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5
27	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7
28	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9
29	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11
30	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13
31	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15
32	Pulse CC	Pulse OC	Pulse CC	Pulse OC

Appendix G
IEC 61850 Communications

Features

The SEL-311L Relay supports the following features by using Ethernet and IEC 61850:

- **SCADA**—Use as many as six MMS sessions of buffered and unbuffered reports.

  Remote Bits (RB1–RB16) and the CC (**CLOSE** Command) bit are mapped to the CSWI logical node. See the CC bit in *Table G.5*, and the Control column in *Table G.7* for details on which logical nodes and names are used for these bits. This information can be useful with MMS browsers. Assertion of a CC control input will assert the SEL-311L CC bit and deassert the OC (**OPEN** Command) bit, whereas deassertion of a CC control input will deassert the CC bit and assert the OC bit. Controls support the following control models:

  - Direct-with-normal-security
  - Select-before-operate (SBO)
  - SBO-with-enhanced-security

- **Real-Time Status and Control**—Use GOOSE with as many as 16 incoming (receive) and as many as 8 outgoing (transmit) messages.

  Remote Bits (RB1–RB16), the OC (**OPEN** Command) bit, and the CC (**CLOSE** Command) bit can also be mapped from GOOSE receive messages by using ACSELERATOR Architect SEL-5032 software. GOOSE provides separate bits for opening and closing the breaker because GOOSE repetitively sends the same information, which could inadvertently open or close a breaker if only a single bit were provided.

NOTE: The SEL-311L supports one CID file, which should be transferred only if a change in the relay configuration is required. If an invalid CID file is transferred, the relay will no longer have a valid IEC 61850 configuration, and the protocol will stop operating. To restart protocol operation, a valid CID must be transferred to the relay.

- **Configuration**—Use FTP client software or Architect to transfer the Substation Configuration Language (SCL) Configured IED Description (CID) file to the relay.
- **Commissioning and Troubleshooting**—Use software such as MMS Object Explorer and AX-S4 MMS from Sisco, Inc., to browse the relay logical nodes and verify functionality.
- **Firmware Upgrades**—Use FTP client software to transfer the Ethernet card firmware upgrade file to the relay.

This appendix presents the information you need to use the IEC 61850 features of the SEL-311L:

- *Introduction to IEC 61850 on page G.2*
- *IEC 61850 Operation on page G.3*

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 G.1*.

Table G.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 multi-drop 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 these documents.

IEC 61850 Operation

Ethernet Networking

IEC 61850 and Ethernet networking model options are only available when ordering a new SEL-311L. The options are not available as field upgrades. In addition to IEC 61850, the Ethernet cards provide support protocols and data exchange, including FTP and Telnet, to SEL devices. Access the SEL-311L Port 5 settings to configure all of the Ethernet settings for Port 5 and Port 6, including IEC 61850 network settings.

The SEL-311L supports IEC 61850 services, including transport of Logical Node objects, over TCP/IP. The relay can coordinate a maximum of six concurrent IEC 61850 sessions.

Object Models

The IEC 61850 standard relies heavily on the Abstract Communication Service Interface (ACSI) models to define a set of services and the responses to those services. In terms of network behavior, abstract modeling enables all IEDs to act identically. These abstract models are used to create objects (data items) and services that exist independently of any underlying protocols. These objects are in conformance with the Common Data Class (CDC) specification IEC 61850-7-3, which describes the type and structure of each element within a Logical Node. CDCs for status, measurements, controllable analogs and statuses, and settings all have unique CDC attributes. Each CDC attribute belongs to a set of functional constraints that groups the attributes into specific categories such as status (ST), description (DC), and substituted value (SV). Functional constraints, CDCs, and CDC attributes are used as building blocks for defining Logical Nodes.

UCA2 used GOMSFE (Generic Object Models for Substation and Feeder Equipment) to present data from station IEDs as a series of objects called models or bricks. The IEC working group has incorporated GOMSFE concepts into the standard, with some modifications to terminology; one change was the renaming of bricks to logical nodes. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function. For example, the MMXU logical node (polyphase measurement unit) contains measurement data and other points associated with three-phase metering including voltages and currents. Each IED may contain many functions such as protection, metering, and control. Multiple logical nodes represent the functions in multifunction devices.

Logical nodes can be organized into logical devices that are similar to directories on a computer disk. As represented in the IEC 61850 network, each physical device can contain many logical devices and each logical device can contain many logical nodes. Many relays, meters, and other IEC 61850 devices contain one primary logical device where all models are organized.

IEC 61850 devices are capable of self-description. You do not need to refer to the specifications for the logical nodes, measurements, and other components to request data from another IEC 61850 device. IEC 61850 clients can request and display a list and description of the data available in an IEC 61850 server device. This process is similar to the autoconfiguration process used within SEL communications processors (SEL-2032 and SEL-2030). Simply run an

MMS browser to query devices on an IEC 61850 network and discover what data are available. Self-description also permits extensions to both standard and custom data models. Instead of having to look up data in a profile stored in its database, an IEC 61850 client can simply query an IEC 61850 device and receive a description of all logical devices, logical nodes, and available data.

Unlike other Supervisory Control and Data Acquisition (SCADA) protocols that present data as a list of addresses or indices, IEC 61850 presents data with descriptors in a composite notation made up of components. *Table G.2* shows how the A-phase current expressed as MMXUAphsA$cVal is broken down into its component parts.

Table G.2 Example IEC 61850 Descriptor Components

Component		Description
MMXU	Logical Node	Polyphase measurement unit
A	Data Object	Phase to ground amperes
phsA	Sub-Data Object	A-phase
cVal	Data Attribute	Complex value

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 logical nodes are grouped under logical devices for organization based on function. See *Table G.3* for descriptions of the Logical Devices in an SEL-311L. See *Logical Nodes on page G.7* for descriptions of the LNs that make up these Logical Devices.

Table G.3 SEL-311L Logical Devices

Logical Device	Logical Node
ANN	Annunciator elements—alarms, status values
CFG	Configuration elements—datasets and report control blocks
CON	Control elements—remote bits
MET	Metering or measuring elements—currents, voltages, power, etc.
PRO	Protection elements—protection functions and breaker control

MMS

Manufacturing Messaging Specification (MMS) provides services for the application-layer transfer of real-time data within a substation LAN. MMS was developed as a network independent data exchange protocol for industrial networks in the 1980s and standardized as ISO 9506.

In theory, you can map IEC 61850 to any protocol. However, it can become unwieldy and quite complicated to map objects and services to a protocol that only provides access to simple data points via registers or index numbers. MMS supports complex named objects and flexible services that enable mapping to IEC 61850 in a straightforward manner. This was why the UCA users group used MMS for UCA from the start, and why the IEC chose to keep it for IEC 61850.

GOOSE

The Generic Object Oriented Substation Event (GOOSE) object within IEC 61850 is for high-speed control messaging. IEC 61850 GOOSE automatically broadcasts messages containing status, controls, and measured values onto the network for use by other devices. IEC 61850 GOOSE sends the message several times, increasing the likelihood that other devices receive the messages.

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) in each outgoing message and an Ethernet multicast group address. Devices that receive GOOSE messages use the text identification and multicast group to identify and filter incoming GOOSE messages.

File Services

The Ethernet File System allows reading or writing data as files. The File System supports FTP. The File System provides:

- A means for the device to transfer data as files.
- A hierarchal file structure for the device data (root level only for the SEL-311L).

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:

- IED Capability Description file (.ICD)
- System Specification Description (.SSD) file
- Substation Configuration Description file (.SCD)
- Configured IED Description file (.CID)

The ICD file describes the capabilities of an IED, including information on LN and GOOSE support. The SSD file describes the single-line diagram of the substation and the required LNs. The SCD file contains information on all IEDs, communications configuration data, and a substation description. The CID file, of which there may be several, describes a single instantiated IED within the project, and includes address information.

Reports

SEL-311L supports buffered and unbuffered report control blocks in the report model as defined in IEC 61850-8-1:2004(E).

Supplemental Software

Examine the data structure and values of the supported IEC 61850 LNs with an MMS browser such as MMS Object Explorer and AX-S4 MMS from Sisco, Inc.

The settings needed to browse an SEL-311L with an MMS Browser are shown below:

OSI-PSEL (Presentation Selector)	00000001

OSI-SSEL (Session Selector)	0001
OSI-TSEL (Transport Selector)	0001

Time Stamps and Quality

In addition to the various data values, the two attributes quality and t (time stamp) are available at any time. The time stamp is determined when data or quality change is detected.

GOOSE Processing

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) via the installed Ethernet port.

Link-layer priority tagging and virtual LAN is supported as described in Annex C of IEC 61850-8-1:2004(E).

IEC 61850 Configuration

Settings

Table G.4 lists IEC 61850 settings. IEC 61850 settings are only available if your device includes the optional IEC 61850 protocol.

Table G.4 IEC 61850 Settings

Label	Description	Range	Default
E61850	IEC 61850 interface enable	Y, N	N
EGSE	Outgoing IEC 61850 GSE message enable	Y[a], N	N

[a] Requires E61850 set to Y to send IEC 61850 GSE messages.

Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with Architect software.

Architect

Architect software enables protection and integration engineers to design and commission IEC 61850 substations containing SEL IEDs.

Engineers can use Architect to:

- Organize and configure all SEL IEDs in a substation project.
- Configure incoming and outgoing GOOSE messages.
- Read non-SEL IED Capability Description (ICD) and Configured IED Description (CID) files and determine the available IEC 61850 messaging options.
- Load device settings and IEC 61850 CID files into SEL IEDs.
- Generate ICD files that will provide SEL IED descriptions to other manufacturers' tools so they can use SEL GOOSE messages and reporting features.
- Configure protection, logic, control, and communication settings of all SEL IEDs in the substation.

Architect provides a Graphical User Interface (GUI) for engineers to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, the engineer first places icons representing IEDs in a substation container, then edits the outgoing GOOSE messages or creates new ones for each IED. The engineer may also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain. Architect has the capability to read other manufacturers' ICD and CID files, enabling the engineer 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 higher supports multiple ICD file versions for each type of IED in a project. Because relays with different Ethernet card firmware may require different CID file versions, this allows users to 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 desire 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.

As of this writing, Architect comes with three versions of the SEL-311L ICD file. These versions are:

- **002 (Short LN Prefixes):** This file has Logical Node prefixes and instances constrained to seven characters or less. This file is recommended for most applications with Ethernet card firmware R104–R107 (relay firmware R406–R408), especially in IEC 61850 installations where Logical Node names must meet this criterion.
- **003 (Short LN Prefixes):** This file is similar to version 002, but includes select-before-operate (SBO) and SBO-with-enhanced-security controls. This file can be used with and is recommended for Ethernet card firmware R108 (relay firmware R410).
- **004 (Firmware R410 and higher, Default):** This file is similar to version 003 but uses Enum strings (instead of the ordinal numbers) for the values of enumeration attributes. This file can only be used for Ethernet card firmware R109 (relay firmware R410) and higher.

CID File Conversion

If you attempt to download a version 003 CID file to a relay with Ethernet card firmware R109 (relay firmware R410), Architect will automatically accept the file without conversion.

Logical Nodes

Table G.5 through *Table G.8* show the Logical Nodes (LNs) supported in the SEL-311L and the associated Relay Word bits or measured quantities. Any differences between ICD file versions are also indicated in the tables. *Table G.5* shows the LNs associated with protection elements, defined as Logical Device PRO.

Table G.5 Logical Device: PRO (Sheet 1 of 4)

Logical Node	Status	Relay Word Bit	Comment
M1PPDIS1	Str.general	M1P	
M1PPDIS1	Op.general	M1PT	
Z1GPDIS2	Str.general	Z1G	
Z1GPDIS2	Op.general	Z1GT	
M2PPDIS3	Str.general	M2P	
M2PPDIS3	Op.general	M2PT	
Z2GPDIS4	Str.general	Z2G	
Z2GPDIS4	Op.general	Z2GT	
M3PPDIS5	Str.general	M3P	
M3PPDIS5	Op.general	M3PT	
Z3GPDIS6	Str.general	Z3G	
Z3GPDIS6	Op.general	Z3GT	
M4PPDIS7	Str.general	M4P	
M4PPDIS7	Op.general	M4PT	
Z4GPDIS8	Str.general	Z4G	
Z4GPDIS8	Op.general	Z4GT	
P1PIOC1	Op.general	50P1	
G1PIOC2	Op.general	50G1	
Q1PIOC3	Op.general	50Q1	
P2PIOC4	Op.general	50P2	
G2PIOC5	Op.general	50G2	
Q2PIOC6	Op.general	50Q2	
P3PIOC7	Op.general	50P3	
G3PIOC8	Op.general	50G3	
Q3PIOC9	Op.general	50Q3	
G4PIOC10	Op.general	50G4	
Q4PIOC11	Op.general	50Q4	
P1PTOC1	Str.general	67P1	
P1PTOC1	Op.general	67P1T	
G1PTOC2	Str.general	67G1	
G1PTOC2	Op.general	67G1T	
Q1PTOC3	Str.general	67Q1	
Q1PTOC3	Op.general	67Q1T	
P2PTOC4	Str.general	67P2	
P2PTOC4	Op.general	67P2T	
G2PTOC5	Str.general	67G2	
G2PTOC5	Op.general	67G2T	
Q2PTOC6	Str.general	67Q2	
Q2PTOC6	Op.general	67Q2T	
P3PTOC7	Str.general	67P3	
P3PTOC7	Op.general	67P3T	

Table G.5 Logical Device: PRO (Sheet 2 of 4)

Logical Node	Status	Relay Word Bit	Comment
G3PTOC8	Str.general	67G3	
G3PTOC8	Op.general	67G3T	
Q3PTOC9	Str.general	67Q3	
Q3PTOC9	Op.general	67Q3T	
G4PTOC10	Str.general	67G4	
G4PTOC10	Op.general	67G4T	
Q4PTOC11	Str.general	67Q4	
Q4PTOC11	Op.general	67Q4T	
PPTOC12	Str.general	51P1	
PPTOC12	Op.general	51P1T	
GPTOC13	Str.general	51G1	
GPTOC13	Op.general	51G1T	
QPTOC14	Str.general	51Q1	
QPTOC14	Op.general	51Q1T	
D87LPDIF1	Str.general		87LOPA + 87LOPB + 87LOPC + 87LOPG + 87LOP2
D87LPDIF1	Str.PhsA	87LOPA	
D87LPDIF1	Str.PhsB	87LOPB	
D87LPDIF1	Str.PhsC	87LOPC	
D87LPDIF1	Str.neut	87LOPG	
D87LPDIF1	Str.neg	87LOP2	
D87LPDIF1	Op.general	87L	
D87LPDIF1	Op.PhsA	87LA	
D87LPDIF1	Op.PhsB	87LB	
D87LPDIF1	Op.PhsC	87LC	
D87LPDIF1	Op.neut	87LG	
D87LPDIF1	Op.neg	87L2	
T51PDIF2	Str.general	T51P	
T51PDIF2	Str.neut	T51G	
T51PDIF2	Str.neg	T51Q	
T51PDIF2	Op.general	T51PT	
T51PDIF2	Op.neut	T51GT	
T51PDIF2	Op.neg	T51QT	
T50PDIF3	Str.general	T50P	
T50PDIF3	Str.neut	T50G	
T50PDIF3	Str.neg	T50Q	
T50PDIF3	Op.general	T50PT	
T50PDIF3	Op.neut	T50GT	
T50PDIF3	Op.neg	T50QT	
POTTPSCH1	Str.general	KEY	
POTTPSCH1	Op.general		N/A
POTTPSCH1	ProTx.stVal	KEY	

Table G.5 Logical Device: PRO (Sheet 3 of 4)

Logical Node	Status	Relay Word Bit	Comment
POTTPSCH1	ProRx.stVal	PTRX	
POTTPSCH1	Echo.general	EKEY	
POTTPSCH1	WeiOp.general	ECTT	
POTTPSCH1	RvABlk.general	Z3RB	
DCBPSCH2	Str.general		M2P OR Z2G OR 67G2 OR 67Q2
DCBPSCH2	Op.general		Z2PGS OR 67QG2S
DCBPSCH2	ProTx.stVal		DSTRT OR NSTRT OR TRIP
DCBPSCH2	ProRx.stVal	BTX	
DCBPSCH2	RvABlk.general	Z3XT	
DCUBPSCH3	Str.general	KEY	
DCUBPSCH3	Op.general		N/A
DCUBPSCH3	ProTx.stVal	KEY	
DCUBPSCH3	ProRx.stVal	PTRX	
DCUBPSCH3	Echo.general	EKEY	
DCUBPSCH3	WeiOp.general	ECTT	
DCUBPSCH3	RvABlk.general	Z3RB	
GFRDIR1	Dir.general	32GF	
GRRDIR2	Dir.general	32GR	
F32QRDIR3	Dir.general	F32Q	
R32QRDIR4	Dir.general	R32Q	
OSTRPSB1	Op.general	OST	
OSB1RPSB2	Str.general	OSB	
OSB1RPSB2	BlkZn.stVal	OSB1	
OSB2RPSB3	Str.general	OSB	
OSB2RPSB3	BlkZn.stVal	OSB2	
OSB3RPSB4	Str.general	OSB	
OSB3RPSB4	BlkZn.stVal	OSB3	
OSB4RPSB5	Str.general	OSB	
OSB4RPSB5	BlkZn.stVal	OSB4	
RSYN1	Rel.stVal		25A1 + 25A2
TRPPTRC1	Tr.general		TRPA21 + TRPB21 + TRPC21 + TRP3P21
TRPPTRC1	Tr.phsA	TRPA21	
TRPPTRC1	Tr.phsB	TRPB21	
TRPPTRC1	Tr.phsC	TRPC21	
TRIPPTRC2	Tr.general	TRIP	
TRP87PTRC3	Tr.general		TRIP87 + TRP3P87
TRP87PTRC3	Tr.phsA	TRPA87	
TRP87PTRC3	Tr.phsB	TRPB87	
TRP87PTRC3	Tr.phsC	TRPC87	
BCCSWI1	Pos.stVal	52A	Double-bit status (1 = off, 2 = on)
BCCSWI1	Pos.ctlVal	CC	This value is actually a control value not a status value.

Table G.5 Logical Device: PRO (Sheet 4 of 4)

Logical Node	Status	Relay Word Bit	Comment
BCCSWI1	OpOpn.general	OC	
BCCSWI1	OpCls.general	CC	
BS1XCBR1	OpCnt.stVal		Operations count from BRE report.
BS1XCBR1	Pos.stVal	52A	Double-bit status (1 = off, 2 = on)
BS2XCBR2	OpCnt.stVal		Operations count from BRE report.
BS2XCBR2	PosA.stVal	52AA	Double-bit status (1 = off, 2 = on)
BS3XCBR3	OpCnt.stVal		Operations count from BRE report.
BS3XCBR3	PosB.stVal	52AB	Double-bit status (1 = off, 2 = on)
BS4XCBR4	OpCnt.stVal		Operations count from BRE report.
BS4XCBR4	PosC.stVal	52AC	Double-bit status (1 = off, 2 = on)
FLTRFLO	FltZ.instCval.f		Fault impedance
FLTRFLO	FltZ.ang.f		Fault impedance angle
FLTRFLO	FltDiskm.instMag.f		Fault location

Table G.6 shows the LNs associated with measuring elements, defined as Logical Device MET.

Table G.6 Logical Device: MET (Sheet 1 of 2)

Logical Node	Measurand	Comment
METMMXU1	TotW.instMag	Three-phase MW
METMMXU1	TotVAr.instMag	Three-phase VAR
METMMXU1	TotPF.instMag	Power factor
METMMXU1	Hz.instMag	Measured frequency
METMMXU1	PhV.phsA.instCVal.mag	A-phase voltage magnitude
METMMXU1	PhV.phsA.instCVal.ang	A-phase voltage angle
METMMXU1	PhV.phsB.instCVal.mag	B-phase voltage magnitude
METMMXU1	PhV.phsB.instCVal.ang	B-phase voltage angle
METMMXU1	PhV.phsC.instCVal.mag	C-phase voltage magnitude
METMMXU1	PhV.phsC.instCVal.ang	C-phase voltage angle
METMMXU1	A.phsA.instCVal.mag	A-phase current magnitude
METMMXU1	A.phsA.instCVal.ang	A-phase current angle
METMMXU1	A.phsB.instCVal.mag	B-phase current magnitude
METMMXU1	A.phsB.instCVal.ang	B-phase current angle
METMMXU1	A.phsC.instCVal.mag	C-phase current magnitude
METMMXU1	A.phsC.instCVal.ang	C-phase current angle
METMSQI1	SeqA.c1.instCVal.mag	Positive-sequence current magnitude
METMSQI1	SeqA.c1.instCVal.ang	Positive-sequence current angle
METMSQI1	SeqA.c2.instCVal.mag	Negative-sequence current magnitude
METMSQI1	SeqA.c2.instCVal.ang	Negative-sequence current angle
METMSQI1	SeqA.c3.instCVal.mag	Zero-sequence current magnitude
METMSQI1	SeqA.c3.instCVal.ang	Zero-sequence current angle
METMSQI1	SeqV.c1.instCVal.mag	Positive-sequence voltage magnitude

Table G.6 Logical Device: MET (Sheet 2 of 2)

Logical Node	Measurand	Comment
METMSQI1	SeqV.c1.instCVal.ang	Positive-sequence voltage angle
METMSQI1	SeqV.c2.instCVal.mag	Negative-sequence voltage magnitude
METMSQI1	SeqV.c2.instCVal.ang	Negative-sequence voltage angle
METMSQI1	SeqV.c3.instCVal.mag	Zero-sequence voltage magnitude
METMSQI1	SeqV.c3.instCVal.ang	Zero-sequence voltage angle

Table G.7 shows the LNs associated with control elements, defined as Logical Device CON.

Table G.7 Logical Device: CON

Logical Node	Status	Control	Relay Word Bit	Comment
RBGGIO1	SPCSO01.stVal	SPCSO01.ctlVal	RB1	
RBGGIO2	SPCSO02.stVal	SPCSO02.ctlVal	RB2	
RBGGIO3	SPCSO03.stVal	SPCSO03.ctlVal	RB3	
RBGGIO4	SPCSO04.stVal	SPCSO04.ctlVal	RB4	
RBGGIO5	SPCSO05.stVal	SPCSO05.ctlVal	RB5	
RBGGIO6	SPCSO06.stVal	SPCSO06.ctlVal	RB6	
RBGGIO7	SPCSO07.stVal	SPCSO07.ctlVal	RB7	
RBGGIO8	SPCSO08.stVal	SPCSO08.ctlVal	RB8	
RBGGIO9	SPCSO09.stVal	SPCSO09.ctlVal	RB9	
RBGGIO10	SPCSO10.stVal	SPCSO10.ctlVal	RB10	
RBGGIO11	SPCSO11.stVal	SPCSO11.ctlVal	RB11	
RBGGIO12	SPCSO12.stVal	SPCSO12.ctlVal	RB12	
RBGGIO13	SPCSO13.stVal	SPCSO13.ctlVal	RB13	
RBGGIO14	SPCSO14.stVal	SPCSO14.ctlVal	RB14	
RBGGIO15	SPCSO15.stVal	SPCSO15.ctlVal	RB15	
RBGGIO16	SPCSO16.stVal	SPCSO16.ctlVal	RB16	

Table G.8 shows the LNs associated with the annunciation element, defined as Logical Device ANN.

Table G.8 Logical Device: ANN (Sheet 1 of 4)

Logical Node	Status	Relay Word Bit	Comment
IN1GGIO1	Ind01.stVal	IN101	
IN1GGIO1	Ind02.stVal	IN102	
IN1GGIO1	Ind03.stVal	IN103	
IN1GGIO1	Ind04.stVal	IN104	
IN1GGIO1	Ind05.stVal	IN105	
IN1GGIO1	Ind06.stVal	IN106	
OUT1GGIO2	Ind01.stVal	OUT101	
OUT1GGIO2	Ind02.stVal	OUT102	
OUT1GGIO2	Ind03.stVal	OUT103	
OUT1GGIO2	Ind04.stVal	OUT104	

Table G.8 Logical Device: ANN (Sheet 2 of 4)

Logical Node	Status	Relay Word Bit	Comment
OUT1GGIO2	Ind05.stVal	OUT105	
OUT1GGIO2	Ind06.stVal	OUT106	
OUT1GGIO2	Ind07.stVal	OUT107	
OUT1GGIO2	Ind08.stVal	ALARM	
OUT2GGIO3	Ind01.stVal	OUT201	
OUT2GGIO3	Ind02.stVal	OUT202	
OUT2GGIO3	Ind03.stVal	OUT203	
OUT2GGIO3	Ind04.stVal	OUT204	
OUT2GGIO3	Ind05.stVal	OUT205	
OUT2GGIO3	Ind06.stVal	OUT206	
SVGGIO4	Ind01.stVal	SV1	
SVGGIO4	Ind02.stVal	SV2	
SVGGIO4	Ind03.stVal	SV3	
SVGGIO4	Ind04.stVal	SV4	
SVGGIO4	Ind05.stVal	SV5	
SVGGIO4	Ind06.stVal	SV6	
SVGGIO4	Ind07.stVal	SV7	
SVGGIO4	Ind08.stVal	SV8	
SVGGIO4	Ind09.stVal	SV9	
SVGGIO4	Ind10.stVal	SV10	
SVGGIO4	Ind11.stVal	SV11	
SVGGIO4	Ind12.stVal	SV12	
SVGGIO4	Ind13.stVal	SV13	
SVGGIO4	Ind14.stVal	SV14	
SVGGIO4	Ind15.stVal	SV15	
SVGGIO4	Ind16.stVal	SV16	
SVTGGIO5	Ind01.stVal	SV1T	
SVTGGIO5	Ind02.stVal	SV2T	
SVTGGIO5	Ind03.stVal	SV3T	
SVTGGIO5	Ind04.stVal	SV4T	
SVTGGIO5	Ind05.stVal	SV5T	
SVTGGIO5	Ind06.stVal	SV6T	
SVTGGIO5	Ind07.stVal	SV7T	
SVTGGIO5	Ind08.stVal	SV8T	
SVTGGIO5	Ind09.stVal	SV9T	
SVTGGIO5	Ind10.stVal	SV10T	
SVTGGIO5	Ind11.stVal	SV11T	
SVTGGIO5	Ind12.stVal	SV12T	
SVTGGIO5	Ind13.stVal	SV13T	
SVTGGIO5	Ind14.stVal	SV14T	
SVTGGIO5	Ind15.stVal	SV15T	

Table G.8 Logical Device: ANN (Sheet 3 of 4)

Logical Node	Status	Relay Word Bit	Comment
SVTGGIO5	Ind16.stVal	SV16T	
LTGGIO6	Ind01.stVal	LT1	
LTGGIO6	Ind02.stVal	LT2	
LTGGIO6	Ind03.stVal	LT3	
LTGGIO6	Ind04.stVal	LT4	
LTGGIO6	Ind05.stVal	LT5	
LTGGIO6	Ind06.stVal	LT6	
LTGGIO6	Ind07.stVal	LT7	
LTGGIO6	Ind08.stVal	LT8	
LTGGIO6	Ind09.stVal	LT9	
LTGGIO6	Ind10.stVal	LT10	
LTGGIO6	Ind11.stVal	LT11	
LTGGIO6	Ind12.stVal	LT12	
LTGGIO6	Ind13.stVal	LT13	
LTGGIO6	Ind14.stVal	LT14	
LTGGIO6	Ind15.stVal	LT15	
LTGGIO6	Ind16.stVal	LT16	
RMBAGGIO7	Ind01.stVal	RMB1A	
RMBAGGIO7	Ind02.stVal	RMB2A	
RMBAGGIO7	Ind03.stVal	RMB3A	
RMBAGGIO7	Ind04.stVal	RMB4A	
RMBAGGIO7	Ind05.stVal	RMB5A	
RMBAGGIO7	Ind06.stVal	RMB6A	
RMBAGGIO7	Ind07.stVal	RMB7A	
RMBAGGIO7	Ind08.stVal	RMB8A	
TMBAGGIO8	Ind01.stVal	TMB1A	
TMBAGGIO8	Ind02.stVal	TMB2A	
TMBAGGIO8	Ind03.stVal	TMB3A	
TMBAGGIO8	Ind04.stVal	TMB4A	
TMBAGGIO8	Ind05.stVal	TMB5A	
TMBAGGIO8	Ind06.stVal	TMB6A	
TMBAGGIO8	Ind07.stVal	TMB7A	
TMBAGGIO8	Ind08.stVal	TMB8A	
RMBBGGIO9	Ind01.stVal	RMB1B	
RMBBGGIO9	Ind02.stVal	RMB2B	
RMBBGGIO9	Ind03.stVal	RMB3B	
RMBBGGIO9	Ind04.stVal	RMB4B	
RMBBGGIO9	Ind05.stVal	RMB5B	
RMBBGGIO9	Ind06.stVal	RMB6B	
RMBBGGIO9	Ind07.stVal	RMB7B	
RMBBGGIO9	Ind08.stVal	RMB8B	

Table G.8 Logical Device: ANN (Sheet 4 of 4)

Logical Node	Status	Relay Word Bit	Comment
TMBBGGIO10	Ind01.stVal	TMB1B	
TMBBGGIO10	Ind02.stVal	TMB2B	
TMBBGGIO10	Ind03.stVal	TMB3B	
TMBBGGIO10	Ind04.stVal	TMB4B	
TMBBGGIO10	Ind05.stVal	TMB5B	
TMBBGGIO10	Ind06.stVal	TMB6B	
TMBBGGIO10	Ind07.stVal	TMB7B	
TMBBGGIO10	Ind08.stVal	TMB8B	
TLEDGGIO11	Ind01.stVal	EN	
TLEDGGIO11	Ind02.stVal	TRP	
TLEDGGIO11	Ind03.stVal	TIME	
TLEDGGIO11	Ind04.stVal	COMM	
TLEDGGIO11	Ind05.stVal	87	
TLEDGGIO11	Ind06.stVal	50_51	
TLEDGGIO11	Ind07.stVal	RCRS	
TLEDGGIO11	Ind08.stVal	RCLO	
TLEDGGIO11	Ind09.stVal	A	
TLEDGGIO11	Ind10.stVal	B	
TLEDGGIO11	Ind11.stVal	C	
TLEDGGIO11	Ind12.stVal	G	
TLEDGGIO11	Ind13.stVal	ZONE1	
TLEDGGIO11	Ind14.stVal	ZONE2	
TLEDGGIO11	Ind15.stVal	ZONE3	
TLEDGGIO11	Ind16.stVal	87CH_FAIL	

Protocol Implementation Conformance Statement: SEL-311L

The tables 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 G.9 PICS for A-Profit 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	N	

Table G.10 PICS for T-Profile Support

Profile		Client	Server	Value/Comment
T1	TCP/IP	N	Y	
T2	OSI	N	N	
T3	GOOSE/GSSE	Y	Y	Only GOOSE, not GSSE
T4	GSSE	N	N	
T5	Time Sync	N	N	

Refer to the ACSI Conformance statements in the Reference Manual for information on the supported services.

MMS Conformance

The Manufacturing Message Specification (MMS) stack provides the basis for many IEC 61850 Protocol services. *Table G.11* defines the service support requirement and restrictions of the MMS services in the SEL-300 series 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 G.11 MMS Service Supported Conformance (Sheet 1 of 3)

MMS Service Supported CBB	Client-CR	Server-CR
	Supported	Supported
status		Y
getNameList		Y
identify		Y
rename		
read		Y
write		Y
getVariableAccessAttributes		Y
defineNamedVariable		
defineScatteredAccess		
getScatteredAccessAbilities		
deleteVariableAccess		
defineNamedVariableList		
getNamedVariableListAttributes		Y
deleteNamedVariableList		
defineNamedType		
getNamedTypeAttributes		
deleteNamedType		
input		
output		
takeControl		
relinquishControl		
defineSemaphore		
deleteSemaphore		
reportPoolSemaphoreStatus		

Table G.11 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
reportSemaphoreStatus		
initiateDownloadSequence		
downloadSegment		
terminateDownloadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
requestDomainDownload		
requestDomainUpload		
loadDomainContent		
storeDomainContent		
deleteDomain		
getDomainAttributes		Y
createProgramInvocation		
deleteProgramInvocation		
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventAction		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		
getAlarmEnrollmentSummary		
readJournal		
writeJournal		

Table G.11 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR	Server-CR
	Supported	Supported
initializeJournalStatus		
createJournal		
deleteJournal		
fileOpen		
fileRead		
fileClose		
fileRename		
fileDelete		
unsolicitedStatus		
informationReport		Y
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		Y
cancel		Y
getDataExchangeAttributes		
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		
reportAccessControlList		
getAccessControlListAttributes		
reportAccessControlObjects		
deleteAccessControlList		
alterAccessControl		
reconfigureProgramInvocation		

Table G.12 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table G.12 MMS Parameter CBB

MMS Parameter CBB	Client-CR	Server-CR
	Supported	Supported
STR1		Y
STR2		Y
VNAM		Y
VADR		Y
VALT		Y
TPY		Y
VLIS		Y
CEI		

The following Variable Access conformance statements are listed in the order specified in the IEC 61850 standard, Part 8-1. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table G.13 AlternateAccessSelection Conformance Statement

AlternateAccessSelection	Client-CR	Server-CR
	Supported	Supported
accessSelection		Y
component		Y
index		
indexRange		
allElements		
alternateAccess		Y
selectAccess		Y
component		Y
index		
indexRange		
allElements		

Table G.14 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR	Server-CR
	Supported	Supported
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y
variableListName		Y

Table G.15 VariableSpecification Conformance Statement

VariableSpecification	Client-CR	Server-CR
	Supported	Supported
name		Y
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table G.16 Read Conformance Statement

Read	Client-CR	Server-CR
	Supported	Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		Y
listOfAccessResult		Y

Table G.17 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR	Server-CR
	Supported	Supported
Request		
name		
address		
Response		
mmsDeletable		
address		
typeSpecification		

Table G.18 DefineNamedVariableList Conformance Statement

DefineVariableAccessAttributes	Client-CR	Server-CR
	Supported	Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table G.19 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR	Server-CR
	Supported	Supported
Request		
ObjectName		
Response		
mmsDeletable		Y
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y

Table G.20 DeleteNamedVariableList Conformance Statement

DeleteNamedVariableList	Client-CR	Server-CR
	Supported	Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table G.21 GOOSE Conformance

	Subscriber	Publisher	Value/Comment
GOOSE Service	Y	Y	
SendGOOSEMessages		Y	
GetGoReference			
GetGOOSEElementNumber			
GetGoCBValues		Y	
SetGoCBValues			
GSENotSupported			
GOOSE Control Block (GoCB)		Y	

ACSI Conformance Statements

Table G.22 ACSI Basic Conformance Statement

		Client/ Subscriber	Server/ Publisher	Value/ Comments
	Client-Server Roles			
B11	Server side of (TWO-PARTY-APPLICATION-ASSOCIATION)		Y	
B12	Client side of (TWO-PARTY-APPLICATION-ASSOCIATION)			
	SCSMs Supported			
B21	SCSM: IEC 6185-8-1 used		Y	
B22	SCSM: IEC 6185-9-1 used			
B23	SCSM: IEC 6185-9-2 used			
B24	SCSM: other			
	Generic Substation Event Model (GSE)			
B31	Publisher side		Y	
B32	Subscriber side	Y		
	Transmission of Sampled Value Model (SVC)			
B41	Publisher side			
B42	Subscriber side			

Table G.23 ACSI Models Conformance Statement (Sheet 1 of 2)

		Client/ Subscriber	Server/ Publisher	Value/ Comments
	If Server or Client Side (B11/12) is Supported			
M1	Logical device		Y	
M2	Logical node		Y	
M3	Data		Y	
M4	Data set		Y	
M5	Substitution			
M6	Setting group control			
	Reporting			
M7	Buffered report control		Y	
M7-1	sequence-number		Y	
M7-2	report-time-stamp		Y	
M7-3	reason-for-inclusion		Y	
M7-4	data-set-name		Y	
M7-5	data-reference		Y	
M7-6	buffer-overflow		Y	
M7-7	entryID		Y	
M7-8	BufTim		Y	
M7-9	IntgPd		Y	
M7-10	GI		Y	
M7-11	conf-revision		Y	
M8	Unbuffered report control		Y	
M8-1	sequence-number		Y	
M8-2	report-time-stamp		Y	
M8-3	reason-for-inclusion		Y	
M8-4	data-set-name		Y	
M8-5	data-reference		Y	
M8-6	BufTim		Y	
M8-7	IntgPd		Y	
M8-8	GI		Y	
M8-9	conf-revision		Y	
	Logging			
M9	Log control			
M9-1	IntgPd			
M10	Log			
M11	Control		Y	
	If GSE (B31/32) is Supported			
M12	GOOSE		Y	
M13	GSSE			

Table G.23 ACSI Models Conformance Statement (Sheet 2 of 2)

		Client/ Subscriber	Server/ Publisher	Value/ Comments
	If SVC (41/42) is Supported			
M14	Multicast SVC			
M15	Unicast SVC			
	If Server or Client Side (B11/12) Supported			
M16	Time		Y	
M17	File Transfer			

Table G.24 ACSI Service Conformance Statement (Sheet 1 of 3)

Services		AA: TP/MC	Client (C)	Server (S)	Comments
	Server				
S1	ServerDirectory	TP		Y	
	Application Association				
S2	Associate			Y	
S3	Abort			Y	
S4	Release			Y	
	Logical Device				
S5	LogicalDeviceDirectory	TP		Y	
	Logical Node				
S6	LogicalNodeDirectory	TP		Y	
S7	GetAllDataValues	TP		Y	
	Data				
S8	GetDataValues	TP		Y	
S9	SetDataValues	TP			
S10	GetDataDirectory	TP		Y	
S11	GetDataDefinition	TP		Y	
	Data Set				
S12	GetDataSetValues	TP		Y	
S13	SetDataSetValues	TP			
S14	CreateDataSet	TP			
S15	DeleteDataSet	TP			
S16	GetDataSetDirectory	TP		Y	
	Substitution				
S17	SetDataValues	TP			
	Setting Group Control				
S18	SelectActiveSG	TP			
S19	SelectEditSG	TP			
S20	SetSGValues	TP			
S21	ConfirmEditSGValues	TP			
S22	GetSGValues	TP			
S23	GetSGCBValues	TP			

Table G.24 ACSI Service Conformance Statement (Sheet 2 of 3)

Services		AA: TP/MC	Client (C)	Server (S)	Comments
		Reporting			
		Buffered report control block (BRCB)			
S24	Report	TP		Y	
S24-1	data-change (dchg)			Y	
S24-2	qchg-change (qchg)			Y	
S24-3	data-update (dupd)				
S25	GetBRCBValues	TP		Y	
S26	SetBRCBValues	TP		Y	
		Unbuffered report control block (URCB)			
S27	Report	TP		Y	
S27-1	data-change (dchg)			Y	
S27-2	qchg-change (qchg)			Y	
S27-3	data-update (dup				
S28	GetURCBValues	TP		Y	
S29	SetURCBValues	TP		Y	
		Logging			
		Log control block			
S30	GetLCBValues	TP			
S31	SetLCBValues	TP			
		Log			
S32	QueryLogByTime	TP			
S33	QueryLogByEntry	TP			
S34	GetLogStatusValues	TP			
		Generic Substation Event Model (GSE)			
		GOOSE-CONTROL-BLOCK			
S35	SendGOOSEMessage	MC		Y	
S36	GetReference	TP			
S37	GetGOOSEElementNumber	TP			
S38	GetGoCBValues	TP		Y	
S39	SetGoCBValues	TP			
		GSSE-CONTROL-BLOCK			
S40	SendGSSEMessage	MC			
S41	GetReference	TP			
S42	GetGSSEElementNumber	TP			
S43	GetGsCBValues	TP			
S44	SetGsCBValues	TP			
		Transmission of Sampled Value Model (SVC)			
		Multicast SVC			
S45	SendMSVMessage	MC			
S46	GetMSVCBValues	TP			
S47	SetMSVCBValues	TP			

Table G.24 ACSI Service Conformance Statement (Sheet 3 of 3)

Services		AA: TP/MC	Client (C)	Server (S)	Comments
		Unicast SVC			
S48	SendUSVMessage	TP			
S49	GetUSVCBValues	TP			
S50	SetUSVCBValues	TP			
		Control			
S51	Select				
S52	SelectWithValue	TP		Y	
S53	Cancel	TP		Y	
S54	Operate	TP		Y	
S55	Command-Termination	TP		Y	
S56	TimeActivated-Operate	TP			
		File Transfer			
S57	GetFile	TP			
S58	SetFile	TP			
S59	DeleteFile	TP			
S60	GetFileAttributeValues	TP			
		Time			
T1	Time resolution of internal clock			20	nearest negative power of 2 in seconds
T2	Time accuracy of internal clock			31	T0 T1 T2 T3 T4 T5
T3	Supported TimeStamp resolution	-		31	nearest negative power of 2 in seconds

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Appendix H
SEL Synchrophasors

Overview

The SEL-311L provides Phasor Measurement Control Unit (PMCU) capabilities when connected to an IRIG-B time source with an accuracy of ±10 µs or better. Synchrophasor data are available via the **MET PM** ASCII command and the SEL Fast Message Unsolicited Write message.

Introduction

Synchrophasor measurement refers to the concept of providing measurements taken on a synchronized schedule at precise instants in time. 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 SEL-311L relays, to synchronize the gathering of power system data. The accurate clock allows precise event report analysis and other off-line analysis functions.

The value of synchrophasor data increases greatly when the data can be shared over a communications network in real time. 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

The SEL-311L Global settings class contains the synchrophasor settings, including the choice of transmitted synchrophasor data set. The Port settings class selects which serial port(s) can be used for Synchrophasor Protocol use. See *Settings on page H.6*.

The SEL-311L timekeeping function generates status Relay Word bits that are important for synchrophasor measurement. See *Synchrophasor Relay Word Bits on page H.8*.

When synchrophasor measurement is enabled, the SEL-311L creates the synchrophasor data set at a user-defined rate. Synchrophasor data are available in ASCII format over a serial port set to PROTO = SEL.

Synchrophasor data are collected with an SEL communications processor (i.e., SEL-2032) or a dedicated synchrophasor processor.

The SEL Fast Message Synchrophasor Protocol is able to share the same physical port with separate data streams; see *Interleaved ASCII and Binary Messages on page D.2*.

Synchrophasor measurement provides the option to display event report data aligned to a high-accuracy time source. See *Synchrophasor-Level Accuracy in Event Reports on page 12.8*.

Synchrophasor Measurement

The phasor measurement unit in the SEL-311L measures three voltages and three currents at each one-second instant, as determined by the IRIG-B time source. The phase angle is measured relative to an absolute reference, which is represented by a cosine function in *Figure H.1*. The reference is consistent with the phase reference defined in the C37.118 standard. During steady-state conditions, the SEL-311L synchrophasor values can be directly compared to values from other phasor measurement units that conform to C37.118. Synchrophasor values are available for the full frequency range of the SEL-311L.

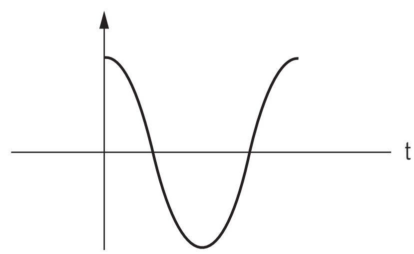

Figure H.1 Phase Reference

The TSOK Relay Word bit asserts when the SEL-311L has determined that the IRIG-B time source has sufficient accuracy and the synchrophasor data meet the specified accuracy. Synchrophasors are still measured if the time source accuracy threshold is not met; however, the data are not time-synchronized to any external reference, as indicated by Relay Word bit TSOK = logical 0. The **MET PM** command is not available in this case.

External Equipment Compensation

The instrumentation transformers (PTs or CTs) and the interconnecting cables may shift the measured signal, as shown in *Figure H.2*.

This angular shift is entered into the relay as Global settings VCOMP and ICOMP, which are internally added to the measured phasor angles to create the corrected phasor angles as shown in *Figure H.2*. The VCOMP and ICOMP settings may be positive or negative in value.

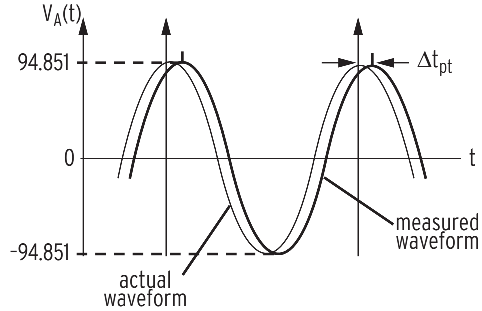

Figure H.2 Waveform at Relay Terminals May Have a Phase Shift

If the shift of the measured signal is known in the time domain, it can be converted into an angular shift using *Equation H.1*.

$$\text{Compensation Angle} = \frac{\Delta t_{pt}}{\left(\frac{1}{\text{freq}}\right)} \cdot 360° = \Delta t_{pt} \cdot \text{freq} \cdot 360°$$

Equation H.1

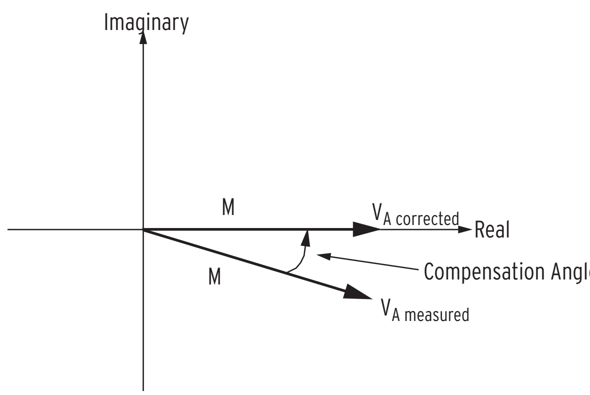

Figure H.3 Correction of Measured Phase Angle

Protocol Operation

SEL Fast Message Unsolicited Write (synchrophasor) messages are general Fast Messages (A546h) that transport measured synchrophasor information.

Transmit Mode Control

The SEL-311L begins transmitting synchrophasors when an enable message is received from the connected device. 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-311L 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 H.1–Table H.3 list the Synchrophasor Fast Message protocol formats, including the specific construction of the enable and disable messages. SEL *Application Guide AG2002-08* 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-311L implementation.

Table H.1 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 message. 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)	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 H.8.
[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 settings, as shown in Table H.8.

Table H.2 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
	Reserved	00
Message Period	Data message period	nnnn[a]
Check Word	2-byte CRC-16 check code for message	XXXX

[a] See Table H.4.

Table H.3 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
	Reserved	00
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-311L will acknowledge the request (if an acknowledge was requested) and begin transmitting synchrophasors. If the requested message period is not permitted, the SEL-311L will respond with a bad data message (if an acknowledge was requested), and will not transmit any synchrophasor data. *Table H.4* 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-311L 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 PMCU functions of the SEL-311L with SEL Fast Message commands, including commands to start and stop synchrophasor data transmission.

Table H.4 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

Settings

The phasor measurement control unit (PMCU) settings are listed in *Table H.5*. The Global enable setting EPMU must be set to Y before the remaining SEL-311L synchrophasor settings are available. No synchrophasor data collection can take place when EPMU = N. Use the serial port settings in *Table H.6* to transmit data by using the SEL Fast Message Synchrophasor Protocol.

Table H.5 SEL-311L Global Settings for Synchrophasors

Global Setting	Description	Default
EPMU	Enable Synchronized Phasor Measurement (Y, N)	N[a]
PMID	PMU Hardware ID	1
PHDATAV	Phasor Data Set, Voltages (V1, ALL)	V1
VCOMP	Voltage Angle Compensation Factor (–179.99 to 180 degrees)	0.00
PHDATAI[b]	Phasor Data Set, Currents (ALL, NA)	NA
ICOMP	Current Angle Compensation Factor (–179.99 to 180 degrees)	0.00
TS_TYPE	Time Source Type (IRIG, IEEE)	IRIG

[a] Set EPMU = Y to access the remaining settings.
[b] Setting hidden when PHDATAV = V1.

Certain settings in *Table H.5* are hidden, depending on the status of other settings. For example, if PHDATAV = V1, the PHDATAI setting is hidden to limit the number of settings for your synchrophasor application.

Table H.6 SEL-311L Serial Port Settings for Synchrophasors

Port Setting	Description	Default
PROTO	Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B, MBGA, MBGB)[a]	SEL[b]
SPEED	Baud Rate (300 to 38400)[c]	2400
BITS	Data Bits (6, 7, 8)	8
PARITY	Parity (O, E, N)	N
STOP	Stop Bits (1,2)	1
RTSCTS	Enable Hardware Handshaking (Y, N, MBT)	N
FASTOP	Fast Operate Enable (Y, N)	N

[a] Some of the other PROTO setting choices may not be available.
[b] Set PROTO = SEL to enable (on this port) the SEL Fast Message Synchrophasor Protocol.
[c] Maximum Port 1 speed is 19200.

Descriptions of Synchrophasor Settings

Definitions for the settings in *Table H.5* follow.

EPMU

This setting enables synchrophasor operation.

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 H.8*.

- PHDATAV = V1 will transmit only positive-sequence voltage, V1
- PHDATAV = ALL will transmit V1, VA, VB, and VC

Table H.8 describes the order of synchrophasors inside the data packet.

The VCOMP setting allows correction for any steady-state voltage phase errors (from the potential transformers 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 H.8*.

- PHDATAI = ALL will transmit I1, IA, IB, and IC
- PHDATAI = NA will not transmit any currents

Table H.8 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).

TS_TYPE

This setting defines the type of connected clock.

When TS_TYPE is set to IRIG, the IRIG message is expected to contain seconds, minutes, hours, and days. The IRIG source gives no additional information to the SEL-311L as to its accuracy. The SEL-311L qualifies the IRIG field to ensure that the time is valid, and then asserts the TIRIG and TSOK Relay Word bits. The local time, as received by the IRIG source, is used for all synchrophasor time values. Under these conditions, the specified SEL-311L synchrophasor accuracy does not include the inaccuracy of the IRIG time source.

When TS_TYPE is set to IEEE, the IRIG message is expected to conform to the IEEE C37.118 standard. Note that time sources conforming to IEEE C37.118 may be marked as IEEE 1344 compliant. The IRIG message includes a UTC offset, time quality information, a year, and a parity bit. The SEL-311L qualifies the IRIG field to ensure that the time is valid, checks for a time quality value better than or equal to ±10 µs, and checks for the consistent parity. If all conditions are met, the TSOK Relay Word bit asserts. As in the IRIG case, the TIRIG Relay Word bit asserts when the time field has valid data and does not include additional checks. When the Time Source Type is set to IEEE, the UTC time value is used in the Synchrophasor Fast Message. The **MET PM** command still displays the local time.

Synchrophasor Relay Word Bits

The Time-Synchronization Relay Word bits in *Table H.7* indicate the present status of the timekeeping function of the SEL-311L. See *IRIG-B on page 10.17*.

Table H.7 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 accuracy is of sufficient accuracy for synchrophasor measurement and satisfies TS_TYPE requirements.
PMDOK	Phasor Measurement Data OK. Asserts when the SEL-311L is enabled, synchrophasors are enabled (Global setting EPMU = Y), and TSOK is asserted.

View Synchrophasors by Using the MET PM Command

The **MET PM** serial port ASCII command may be used to view the SEL-311L synchrophasor measurements. See *MET Command (Metering Data) on page 10.38* 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 PHDATAV and PHDATAI. The **MET PM** command can function even when no serial ports are sending Fast Message Synchrophasor data.

The **MET PM** command only displays data when the Relay Word bit TSOK = logical 1. *Figure H.4* shows a sample **MET PM** command response. The synchrophasor data are also available in QuickSet, and have a similar format to *Figure H.4*.

The **MET PM [*time*]** command can be used to direct the SEL-311L 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 H.4* 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 ignores the fractional seconds.

See *MET PM—Synchrophasor Metering on page 10.42* for complete command options, and error messages.

```
=>MET PM <Enter>

                                  Date: 03/31/2006    Time: 15:11:00.000
Time Quality   Maximum time synchronization error:    0.000 (ms)  TSOK = 1


Synchrophasors
                     Phase Voltages             Pos. Sequence Voltage
                 VA        VB        VC                 V1
MAG (kV)        134.140   131.646   128.600            131.447
ANG (DEG)       129.896    10.262  -111.764            129.48

                     Phase Currents             Pos. Sequence Current
                 IA        IB        IC                 I1
MAG (A)         365.261   359.225   379.917            367.912
ANG (DEG)       114.930    -2.786  -120.238            117.338

FREQ (Hz) 60.029

Digitals

SV3    SV4    SV5    SV6    SV7    SV8    SV9    SV10
 0      0      0      0      0      0      0      0
SV11   SV12   SV13   SV14   SV15   SV16
 0      0      0      0      0      0

=>
```

Figure H.4 Sample MET PM Command Response

The Maximum time synchronization error field is taken directly from the TQUAL status field of the IRIG-B message. If TS_TYPE = IRIG, the maximum time synchronization error will be displayed as $.$$$.

Communications Bandwidth

A phasor measurement control unit (PMCU) 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 = PMU should be set as high as possible, but no higher than 19200 baud, to allow for the largest possible number of message period requests to be successful.

The SEL-311L 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 H.8* 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 H.8* 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 H.8 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

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Appendix I
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: Settings* (see also the *Settings Sheets on page 9.71*). See *SHO Command (Show/View Settings) on page 10.43* for a list of the factory settings included in a standard shipment of an SEL-311L Relay.

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)

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

- (logical 0)

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

Complete listings of Relay Word bits and their descriptions are referenced in *Table 9.5* and *Table 9.6*.

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 4.24*. Read the text that accompanies *Figure 4.24* (*Table 4.10* and following text). The following Relay Word bits are the logic outputs of the phase time-overcurrent element:

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
- ➤ Timing to reset (one-cycle reset or electromechanical emulation—see setting 51PRS)

Relay Word Bit Application Examples—Phase Time-Overcurrent Element 51PT

Common uses for Relay Word bits 51P, 51PT, and 51PR:

- ➤ 51P testing (e.g., assign to an output contact for pickup testing)
- ➤ trip unlatch logic (see SELOGIC control equation unlatch trip setting ULTR example later in this section)
- ➤ 51PT trip logic (see SELOGIC control equation trip setting TR example later in this section)
- ➤ 51PR 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 unusual 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 such functions as the following:

- 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 by using one or more of the six SELOGIC control equation operators listed in *Table I.1*.

Table I.1 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 I.1*.

SELOGIC Control Equation Parentheses Operator ( )

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

SV7 = **(SV7+IN101) * (50P1+50G1)**

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

SELOGIC Control Equation NOT Operator !

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

EXAMPLE I.1 NOT Operator ! Applied to Single Element

The internal circuit breaker status logic in the SEL-311L operates on 52a circuit breaker auxiliary contact logic. The SELOGIC control equation circuit breaker status setting is labeled 52A. See Optoisolated Inputs on page 7.2 and Close Logic on page 6.2 for more information on SELOGIC control equation circuit breaker status setting 52A.

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

The opposite is true for a 52b circuit breaker auxiliary contact. When a circuit breaker is closed, the 52b circuit breaker auxiliary contact is open. When the circuit breaker is open, the 52b contact is closed.

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

52A = **IN101**

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

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

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

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

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

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

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

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

EXAMPLE I.2 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 Section 5: Trip and Target Logic.

In this factory-setting example, the unlatch condition comes true only when both the 50L (low-set 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 Rising-Edge Operator /

The rising-edge operator / is applied to individual Relay Word bits only—not to groups of elements within parentheses. In this example, the SELOGIC control equation event report generation setting uses rising-edge operators:

ER = **/51P + /51G + /OUT103**

The Relay Word bits in this example are:

51P	Maximum phase current above pickup setting 51PP for phase time-overcurrent element 51PT (see *Figure 3.21*)
51G	Maximum residual-ground current above pickup setting 51GP for residual-ground time-overcurrent element 51GT (see *Figure 3.21*)
OUT103	Output contact **OUT103** is set as a breaker failure trip output (see *Output Contacts on page 7.28*)

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 I.1* demonstrates the action of the rising-edge operator / on the individual elements in setting ER.

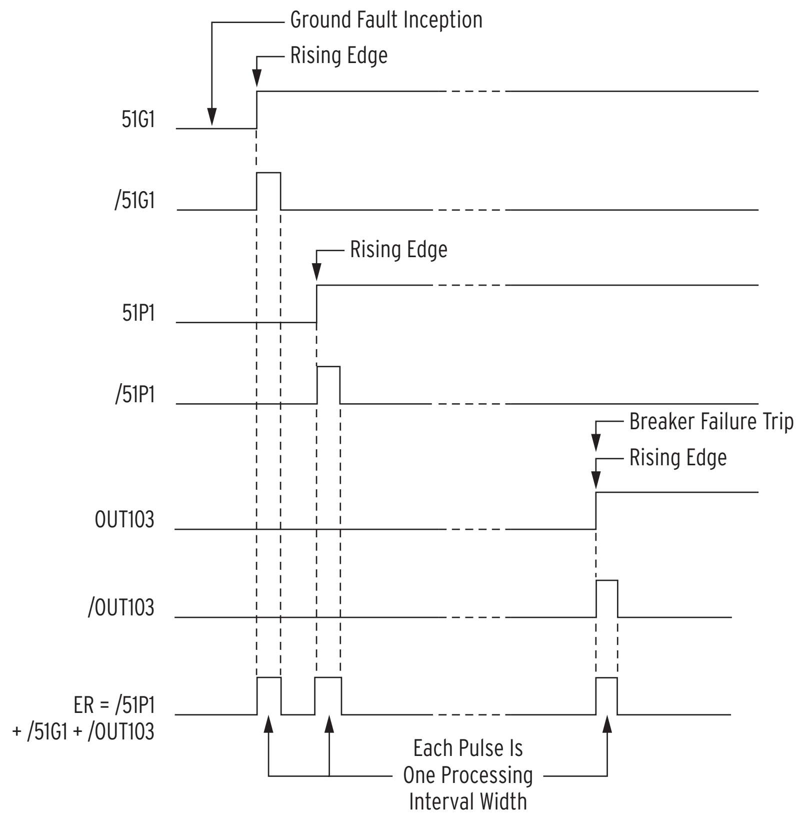


Figure I.1 Result of Rising-Edge Operators on Individual Elements in Setting ER

Note in *Figure I.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 I.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 similarly 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 out-of-step block element:

ER = **... + \OSB**

This allows recovery from a power swing condition to be observed. *Figure I.2* demonstrates the action of the falling-edge operator \ on the out-of-step blocking element in setting ER.

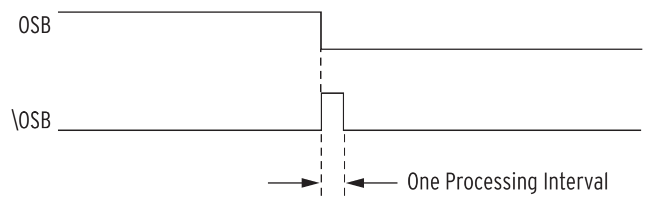


Figure I.2 Result of Falling-Edge Operator on a Deasserting Out-of-Step Blocking Element

All SELOGIC Control Equations Must Be Set

All SELOGIC control equations must be set 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 = 51PT + 51GT + 50P1 * SH0)
- 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, 51P1TC) cannot be set directly to logical 0.

SELOGIC control equations can be set directly to:

- 1 (logical 1)
- 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 10.43*, 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 the *Settings Sheets on page 9.71*) 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 through 51QTC for the overcurrent elements. In the **factory settings** included in a standard shipment of an SEL-311L, these are all set directly to logical 1. See these factory settings in *SHO Command (Show/View Settings) on page 10.43*.

If one of these torque-control settings is set directly to logical 1, e.g.,

67QTC = **1** (set directly to logical 1)

then the corresponding overcurrent element is subject only to the directional control. See *Figure 3.19* for negative-sequence overcurrent element 67QTC logic.

SELOGIC Control Equation Limitations

Any single SELOGIC control equation setting is limited to 15 Relay Word bits that can be combined together with the SELOGIC control equation operators listed in *Table I.1*. If this limit must be exceeded, use a SELOGIC control equation variable (SELOGIC control equation settings SV1–SV16) as an intermediate setting step.

For example, assume that the trip equation (SELOGIC control equation trip setting TR) needs more than 15 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 SV1. Next use the resultant SELOGIC control equation variable output (Relay Word bit SV1) in the SELOGIC control equation trip setting TR.

Note that the SELOGIC control equation variables (SELOGIC control equation settings SV1 through 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.

The SELOGIC control equation settings as a whole are limited to no more than 447 elements and 49 rising-edge or falling-edge operators.

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

After SELOGIC control equation settings changes have been made and the settings are saved, the SEL-311L responds with the following message:

```
xxx Elements and yy Edges remain available
```

indicating 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 processes the Relay Words, SELOGIC, and backup protection algorithms every 1/4 cycle and performs associated updates at the end of the 1/4-cycle interval. However, the differential protection algorithms are processed every 1/16 cycle. The Relay Word bits remain in their current state, asserted or deasserted, until the next processing interval. The setting, EHST = Y, allows the high-speed differential processing to directly trip the high-speed output contacts (**OUT201–OUT206**) without delays from the 1/4-cycle processing interval.

Appendix J
Example Calculations for 87L Settings

87LANG Setting Considerations

This section describes calculations useful in determining the optimal alpha plane angle setting: 87LANG. The alpha plane characteristic angle is adjustable from 90° to 270°. Remember that while a larger angle setting does permit greater security for out-of-section faults, making 87LANG too large affects the dependability for internal faults.

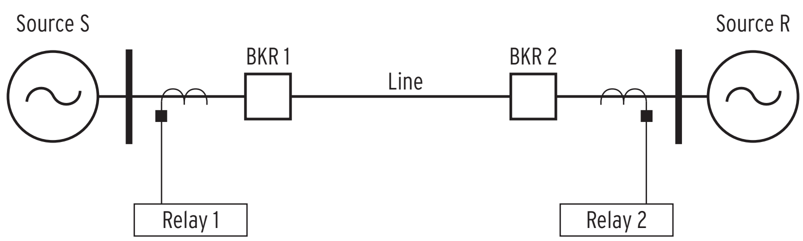
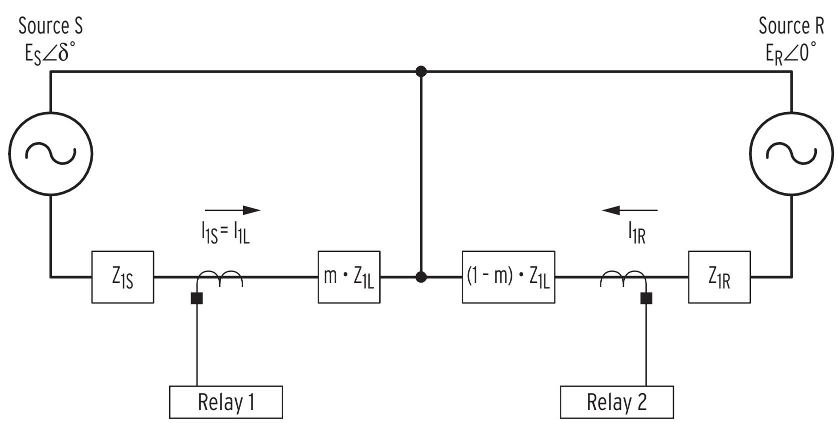


Figure J.1 Example System Single Line



Z_{1S} = Source S Positive-Sequence Impedance

Z_{1R} = Source R Positive-Sequence Impedance

Z_{1L} = Line Positive-Sequence Impedance

m = Per-unit distance from Breaker 1 (BKR 1)

I_{1S} = Positive-Sequence current measured by Relay 1 (local relay current, I_{1L}, for our example)

I_{1R} = Positive-Sequence current measured by Relay 2 (remote relay current, I_{1R}, for our example)

Figure J.2 Sequence Connection Diagram for an Internal Three-Phase Fault

Figure J.2 shows the positive-sequence connection diagram for an internal three-phase fault shown in *Figure J.1*. If I_{1S} and I_{1R} are equal in magnitude and phase, then $I_{AR} / I_{AL} = 1\angle 0°$. For this to occur given a fault placed at *m* = 0.5, the system twist angle (δ) must be zero, and Sources S and R must have equal strength (where *m* = per-unit distance from Bus S). How do source impedances, δ, and fault location m affect I_{AR} / I_{AL}?

Calculating I_{AR}/I_{AL} for Phase Faults

We can use positive-sequence currents from each line terminal to evaluate three-phase faults (see *Equation J.1* and *Equation J.2*). *Equation J.3* shows the ratio of remote to local positive-sequence currents. Note that $I_{1R} / I_{1L} = I_{AR} / I_{AL}$ for balanced faults.

$$I_{1S} = \frac{E_S\angle\delta°}{Z_{1S} + mZ_{1L}}$$

Equation J.1

$$I_{1R} = \frac{E_R\angle 0°}{Z_{1R} + (1 - m) \cdot Z_{1L}}$$

Equation J.2

$$\frac{I_{1R}}{I_{1S}} = \frac{I_{AR}}{I_{AL}} = \frac{E_R\angle 0°}{E_S\angle\delta°} \cdot \frac{[Z_{1S} + m \cdot Z_{1L}]}{[Z_{1R} + (1 - m) \cdot Z_{1L}]}$$

Equation J.3

From *Equation J.3*, we conclude the following:

1. If the system is homogeneous (i.e., $\angle Z_{1S} = \angle Z_{1L} = \angle Z_{1R}$), then $\angle(I_{1R} / I_{1S})$ is zero when δ = 0°. In our default settings, we assumed δ = 10°. Given the following system:
   - System Voltage: 230 kV_{LL}
   - Line Length: 10 miles
   - Line Impedance: 0.8 Ω/mi (8.0 Ω primary total)
   - Source S and R Impedance: ½ Z_{LINE}
   - Current Transformer Ratio: 1200/5 (240:1)

   Increasing δ greater than 10° causes the secondary line current to exceed 6 A. In actual practice, we expect the source impedances to be much lower. From this we conclude that 10° is a reasonable maximum value for δ.

2. If the system is nonhomogeneous, this too can create an angle difference between I_{1R} and I_{1S}. The extent of the angle difference depends in part on the fault location. For example, if Source R and the Line have the same angle and $\angle Z_{1S}$ is 10° less than $\angle Z_{1R}$, a fault at *m* = 0 creates a 10° difference between the remote and local currents. Moving the fault location to *m* = 1 creates a 3.3° difference between the phase currents. As a worst case study, the nonhomogeneous angle difference can add with the angle difference caused by δ = 10°. If the $\angle Z_{1S}$ is 10° greater than $\angle Z_{1R}$ for the fault at *m* = 0, the nonhomogeneous system angle and system load angle errors cancel: I_{AR} and I_{AL} are then in phase.

Calculating I_{2R}/I_{2L} for Ground Faults

Equation J.4 and *Equation J.5* show the local terminal negative-sequence currents as a function of total negative-sequence current (I_{2T}). *Equation J.6* shows the ratio of remote to local negative-sequence currents shown in *Figure J.3*. Note *Equation J.6* differs from *Equation J.3* only by the ratio of local and remote source voltages. This means that the negative-sequence ratio is not affected by load flow magnitude. Because the phase, negative- and zero-sequence 87L elements all use 87LANG to establish the restraint characteristic angle, the limiting case is that set by the phase differential elements. Any increase in alpha plane coverage caused by ($E_R\angle 0°/ E_S\angle\delta°$) serves to increase the security of the 87L2 and 87LG elements without sacrificing sensitivity.

$$I_{2S} = I_{2T} \bullet \frac{[(1-m) \bullet Z_{2L} + Z_{2R}]}{[Z_{2S} + Z_{2L} + Z_{2R}]}$$

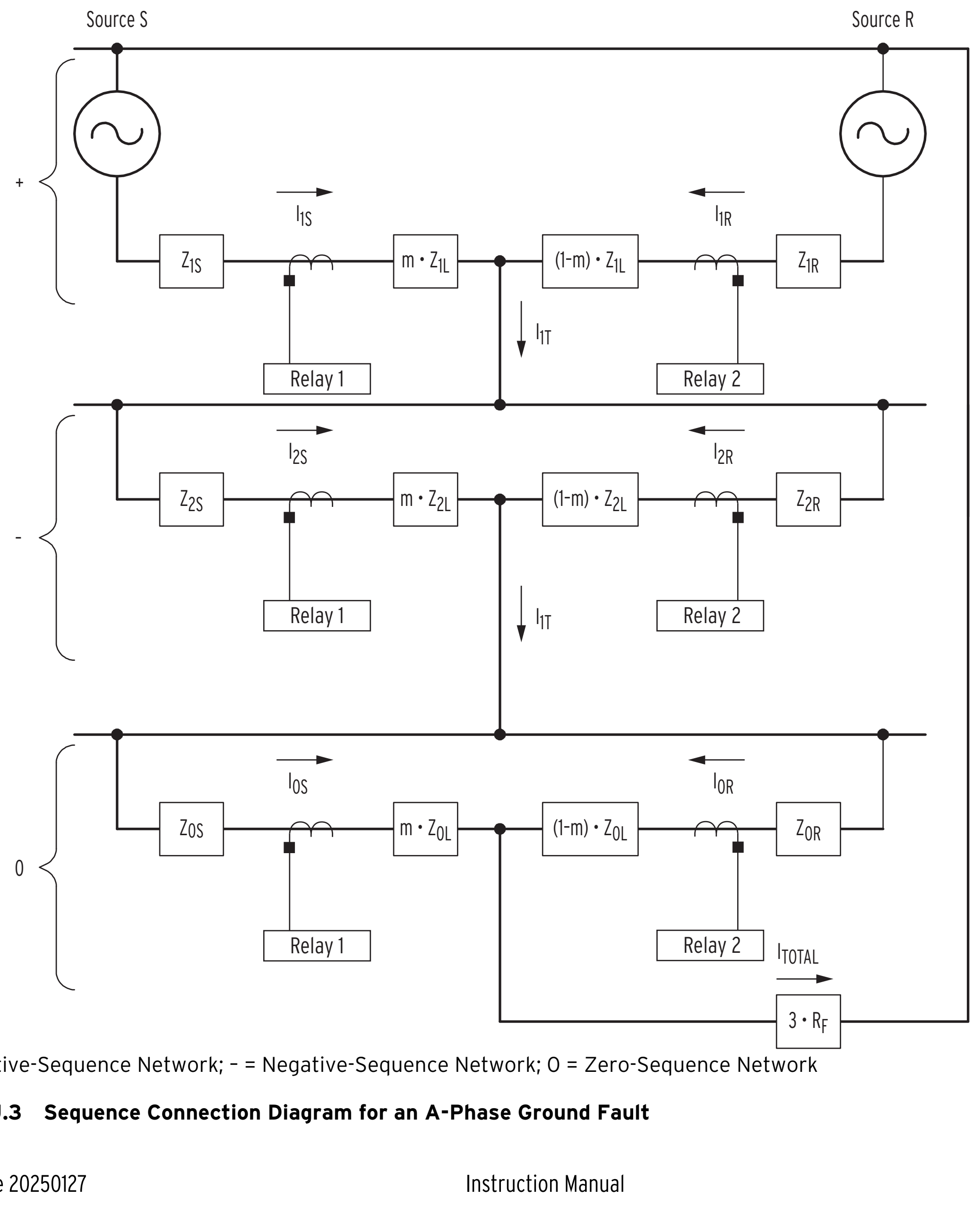
Equation J.4

$$I_{2R} = I_{2T} \bullet \frac{[m \bullet Z_{2L} + Z_{2S}]}{[Z_{2S} + Z_{2L} + Z_{2R}]}$$

Equation J.5

$$\frac{I_{2R}}{I_{2S}} = \frac{[Z_{1S} + m \bullet Z_{1L}]}{[Z_{1R} + (1-m) \bullet Z_{1L}]}$$

Equation J.6



+ = Positive-Sequence Network; – = Negative-Sequence Network; 0 = Zero-Sequence Network

Figure J.3 Sequence Connection Diagram for an A-Phase Ground Fault

Summary

System nonhomogeneity and non-zero load angle can add to create a 20° angular difference between I_{AR} and I_{AL}. Continuing with our worst-case scenario for setting 87LANG, we must consider the additional sources of angle errors from CT saturation (40°) and communication channel asymmetry (22.5°). The sum of these worst-case errors, and assuming that they all occur simultaneously, is 82.5°. Given this analysis, set 87LANG = 195°.

Line Charging Current Calculation Examples

500 kV OH Transmission Line: 100 Miles of Single 1113 MCM Conductor

$$I = 2 \bullet \pi \bullet f \bullet C \bullet V_{L-N} \text{ [A per-phase, per mile]}$$

Equation J.7

$$C = \frac{0.0388}{\log_{10}(D_{EQ}/r)} 1 \; [\mu F]$$

Equation J.8

where:

D_{EQ}[a]= Equivalent spacing between three conductors: $[D_{EQ} = (D_{AB} \bullet D_{BC} \bullet D_{CA})^{1/3}]$ (ft)

r = Conductor radius (ft) (1113 MCM ACSR, 0.6465 in = 0.0539 ft)

l = Conductor length (miles) (100 miles)

C = Shunt capacitance (*Equation J.8*: 0.01265 µF/mi • 100 mi = 1.265 µF)

f = system frequency (60 Hz)

V_{L-N} = system phase-neutral voltage (500 / √ 3 kV)

@ V = 500 kV / √ 3, $I_{1CHARGING}$ = 137.6 A primary for a line length = 100 miles

@ V = 2886 V, $I_{2CHARGING}$ = 1.37 A primary for the same line length, with 1% unbalance

[a] Assuming a conductor spacing of 50 ft between the conductors of a horizontal line configuration (D_{EQ} = 63 ft).

If the current transformer ratio for this 500 kV application is 400:1 (2000/5), the phase charging currents are 0.334 A secondary, and the negative-sequence charging current ($3I_2$) is 0.01A secondary. Make setting 87L2P = 0.5 for excellent security and sensitivity.

For weak systems, consider the maximum voltage unbalance that can be caused by an external unbalanced fault. This can be significantly higher than the one percent voltage unbalance assumed above, and can cause the charging current unbalance to approach the phase charging current.

15 kV Underground Cable: 5 Miles

$$C = \frac{0.0169 \bullet n \bullet k}{G} 1 \ [\mu F]$$ **Equation J.9**

where:

C = cable capacitance (see *Equation J.9*, 0.2345 • (5.28) • (5 mi) = 6.19 µF)
n = number of conductors (3)
k = cable dielectric constant (3.7)
$V_{L\text{-}N}$ = system phase-neutral voltage (15 / √ 3 kV)
G = cable geometric factor (shaped differs from circular, etc. Our example assumes a G = 0.8)
l = cable length in 1,000s of feet (5 mi • 5.28 kft/mi)
@ V = 8.66 kV, $I_{1CHARGING}$ = 60.6 A primary for a 15-mile long cable
@ V = 86.6 V, $I_{2CHARGING}$ = 0.60 A primary for the same cable length

If the current transformer ratio for this 15 kV application is 60:1 (300/5), the phase charging current is 1 A secondary, and the negative-sequence charging current ($3I_2$) is 0.03 A secondary. Again, make setting 87L2P = 0.5 A for excellent security and sensitivity.

As with the overhead line example, also consider the maximum voltage unbalance caused by an external unbalanced fault. This voltage unbalance can cause considerable charging current unbalance, up to the phase charging current.

Ground Fault Resistance Coverage With 87L2P = 0.5 A

In both examples, setting 87L2P = 0.5 A secondary allows ground fault resistance coverage to as much as the result of *Equation J.10*:

$$R_F = \frac{66.4 V}{0.5 A} = 132.8 \ \Omega \text{ secondary}$$ **Equation J.10**

Equation J.10 assumes load current less than 1/3 of nominal secondary current. See *Figure 3.8* for ground fault resistance coverage with more load current.

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Appendix K
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 K.1*.

Visit selinc.com to obtain the latest versions of the software listed in *Table K.1*.

Table K.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, utilize 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-311L does not support the freeform logic described in the QuickSet instruction manual.

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SEL-311L-1, -7 Relay Command Summary

Access Level 0 Command	The screen prompt is: =
ACC	Enter **ACC** at a serial port or over Telnet on an optional Ethernet port to move to Access Level 1 on that port. If you are using a serial port and the password jumper is not in place, the relay will require entry of the Access Level 1 password prior to moving to the new access level. Ethernet ports do not support the password jumper
CAS	Display Compressed ASCII configuration data.
EXIT	End a Telnet session (applies to the optional Ethernet port).
ID	Enter **ID** at a serial port to obtain relay identification and configuration information. Enter **ID** over Telnet on an optional Ethernet port to obtain Ethernet card identification and configuration information.
QUI	Enter **QUIT** at a serial port with PROTO = SEL or over Telnet on an optional Ethernet port to return the relay to Access Level 0 on that port. Enter **QUIT** at a serial port with PROTO = LMD to terminate the SEL Distributed Port Switch Protocol (LMD) connection and return the relay to Access Level 0 on that port.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering), not change it. The screen prompt is: =>
2AC	Enter **2AC** at a serial port or over Telnet on an optional Ethernet port to move to Access Level 2 on that port. If you are using a serial port and the password jumper is not in place, the relay will require entry of the Access Level 2 password prior to moving to the new access level. Ethernet ports do not support the password jumper.
BAC	Enter Breaker Access Level (Access Level B). If the main board password jumper is not in place, the relay prompts for entry of the Access Level B password.
BRE	Display breaker monitor data (trips, interrupted current, wear).
CEV [*n* S*x* L*y* L R C P]	Display compressed event report (parameters in [ ] are optional)
where: ***n***	event number (1–40 if LER = 15; 1–21 if LER = 30; 1–11 if LER = 60; defaults to 1).
S*x*	*x* samples per cycle (4 or 16); defaults to 4. If S*x* parameter is present, it overrides the L parameter.
L*y*	*y* cycles event report length (1–LER) for filtered event reports, (1–LER + 1) for raw event reports, defaults to LER if not specified.
L	16 samples per cycle; overridden by the S*x* parameter, if present.
R	specifies raw (unfiltered) data; defaults to 16 samples per cycle unless overridden by the S*x* parameter. Defaults to LER + 1 cycles in length unless overridden with the L*y* parameter.
C	specifies 16 samples per cycle, LER-cycle length.
P	precise to synchrophasor-level accuracy.
CHIS	Display compressed history.
COM *p d1*	Show a communications summary report for events occurring on date *d1* on MIRRORED BITS Channel *p*.
COM *p d1 d2*	Show a communications summary report for events occurring between dates *d1* and *d2* on MIRRORED BITS Channel *p*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS Channel *p*.
COM *p n*	Show a communications summary for latest *n* events on MIRRORED BITS Channel *p*.
COM *p* L	Show a long format communications summary report for all events on MIRRORED BITS Channel *p*.
COM C *p*	Clear the communications summary report for Channel *p*.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering), not change it. The screen prompt is: =>
CST	Display compressed status report.
CSU	Display compressed event summary.
DAT	Show date.
DAT m/d/y	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT y/m/d	Enter date in this manner if Date Format setting DATE_F = YMD.
DNP [type]	Show DNP map.
EVE *n*	Show event report number *n* with 1/4-cycle resolution.
EVE B *n*	Show event report number *n* for backup elements (not including differential).
EVE C *n*	Show compressed event report number *n* for use with SEL-5601-2 SYNCHROWAVE Event Software.
EVE L *n*	Show event report number *n* with 1/16-cycle resolution.
EVE P *n*	Show event report *n* with synchrophasor-level accuracy time alignment.
EVE R *n*	Show raw event report number *n* with 1/16-cycle resolution.
GOO	Display transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GRO	Display active group number.
HELP	List the commands available at the present access level (applies to the optional Ethernet port).
HIS *n*	Show brief summary of the *n* latest event reports.
HIS C	Clear the brief summary and corresponding event reports.
INI	Display input/output contact information.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MAC	Display the MAC addresses of **PORT 5** and **PORT 6** (applies to the optional Ethernet port).
MET *k*	Display instantaneous metering data. Enter *k* for repeat count.
MET B k	Display instantaneous metering data for local terminal including voltage. Enter *k* for repeat count.
MET D	Display demand and peak demand data. Enter **MET RD** or **MET RP** to reset.
MET E	Display energy metering data. Enter **MET RE** to reset.
MET M	Display maximum/minimum metering data. Enter **MET RM** to reset.
MET PM [*time*] [*k*]	Display synchrophasor measurements (available when TSOK = logical 1). Enter time to display the synchrophasor for an exact specified time, in 24-hour format. Enter *k* for repeat count.
SER *d1*	Show rows in the Sequential Events Recorder (SER) event report from date *d1*.
SER *d1 d2*	Show rows in the Sequential Events Recorder (SER) event report from date *d1* to *d2*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
SER *m n*	Show rows *m* through *n* in the Sequential Events Recorder (SER) event report.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER C	Clear the Sequential Events Recorder (SER).
SHO *n*	Show relay settings (overcurrent, reclosing, timers, etc.) for Group *n*.
SHO G	Show Global settings.
SHO L *n*	Show SELOGIC control equation settings for Group *n*.
SHO P *n*	Show Port *n* settings.
SHO R	Show Sequential Events Recorder (SER) settings.
SHO T	Show text label settings.
STA	Enter **STA** at a serial port to obtain a status report for the relay. Enter **STA** over Telnet on an optional Ethernet port to obtain a status report for the Ethernet card.
SUM	Show newest event summary.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering), not change it. The screen prompt is: =>
SUM A	Acknowledge oldest event summary.
SUM N	View oldest unacknowledged event report.
SUM N [A]	Display or acknowledge event summary number "N."
TAR *n k*	Display Relay Word row. If *n* = 0 through 51, display row *n*. If *n* is an element name (e.g., 50P1) display the row containing element *n*. Enter *k* for repeat count.
TAR R	Reset the front-panel tripping targets.
TIM	Show or set time (24-hour time). Show time presently in the relay by entering just TIM. Example time 22:47:36 is entered with command **TIM 22:47:36**.
TRI [*time*]	Trigger an event report. Enter time to trigger an event at an exact specified time, in 24-hour format.
VER	Display version and configuration information.

Access Level B Commands	Access Level B commands primarily allow the user to operate output contacts. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
BRE *n*	Enter **BRE W** to preload breaker wear. Enter **BRE R** to reset breaker monitor data.
CLO	Close the circuit breaker.
GRO *n*	Change active group to Group *n*.
OPE	Open the circuit breaker.
PUL *n k*	Pulse output contact *n* (OUT101–OUT107, ALARM) for *k* (1–30) seconds. Parameter *n* must be specified; *k* defaults to 1 if not specified.
TEST DB name01 [name02. . .name10] [*s*]	Pulse as many as 10 binaries (Relay Word bits) for *s* seconds.

Access Level 2 Commands	The Access Level 2 commands allow unlimited access to relay settings, parameters, and output contacts. All Access Level 1 and Access Level B commands are available from Access Level 2. The screen prompt is: =>>
CAL	Go to Access Level C
CON *n*	Control Remote Bit RB*n* (Remote Bit *n*; *n* = 1 through 8). Execute **CON *n*** and the relay responds: `CONTROL RBn`. Then reply with one of the following: **SRB *n*** set Remote Bit *n* (assert RB*n*). **CRB *n*** clear Remote Bit *n* (deassert RB*n*). **PRB *n*** pulse Remote Bit *n* (assert RB*n* for 1/4 cycle).
COP *m n*	Copy relay and logic settings from Group *m* to Group *n*.
DNP [type]	Set DNP map.
L_D	Load new firmware.
LOO	Set MIRRORED BITS port to loop back.
PAS 1	Change Access Level 1 password.
PAS B	Change Access Level B password.
PAS 2	Change Access Level 2 password.
SET *n*	Change relay settings (overcurrent, reclosing, timers, etc.) for Group *n*.
SET G	Change Global settings.
SET L *n*	Change SELOGIC control equation settings for Group *n*.
SET P *n*	Change Port *n* settings.
SET R	Change Sequential Events Recorder (SER) settings.
SET T	Change text label settings.

Access Level 2 Commands	The Access Level 2 commands allow unlimited access to relay settings, parameters, and output contacts. All Access Level 1 and Access Level B commands are available from Access Level 2. The screen prompt is: =>>
STA C or R	Enter **STA C** at a serial port to restart the relay. Enter **STA C** over Telnet on an optional Ethernet port to restart the Ethernet card.
TST {chn}	Test the differential communication channel or disable differential communications to test local distance backup protection. If channel (X or Y) is specified, a question string will follow to configure the channel for testing. With no channel identifier, the command will return each channel status.
TST {chn} C	Clear or disable the test mode for the differential communication channel.

SEL-311L-1, -7 Relay Command Summary

Access Level 0 Command	The screen prompt is: =
ACC	Enter **ACC** at a serial port or over Telnet on an optional Ethernet port to move to Access Level 1 on that port. If you are using a serial port and the password jumper is not in place, the relay will require entry of the Access Level 1 password prior to moving to the new access level. Ethernet ports do not support the password jumper
CAS	Display Compressed ASCII configuration data.
EXIT	End a Telnet session (applies to the optional Ethernet port).
ID	Enter **ID** at a serial port to obtain relay identification and configuration information. Enter **ID** over Telnet on an optional Ethernet port to obtain Ethernet card identification and configuration information.
QUI	Enter **QUIT** at a serial port with PROTO = SEL or over Telnet on an optional Ethernet port to return the relay to Access Level 0 on that port. Enter **QUIT** at a serial port with PROTO = LMD to terminate the SEL Distributed Port Switch Protocol (LMD) connection and return the relay to Access Level 0 on that port.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering), not change it. The screen prompt is: =>
2AC	Enter **2AC** at a serial port or over Telnet on an optional Ethernet port to move to Access Level 2 on that port. If you are using a serial port and the password jumper is not in place, the relay will require entry of the Access Level 2 password prior to moving to the new access level. Ethernet ports do not support the password jumper.
BAC	Enter Breaker Access Level (Access Level B). If the main board password jumper is not in place, the relay prompts for entry of the Access Level B password.
BRE	Display breaker monitor data (trips, interrupted current, wear).
CEV [*n* S*x* L*y* L R C P]	Display compressed event report (parameters in [ ] are optional)
where: ***n***	event number (1–40 if LER = 15; 1–21 if LER = 30; 1–11 if LER = 60; defaults to 1).
S*x*	*x* samples per cycle (4 or 16); defaults to 4. If S*x* parameter is present, it overrides the L parameter.
L*y*	*y* cycles event report length (1–LER) for filtered event reports, (1–LER + 1) for raw event reports, defaults to LER if not specified.
L	16 samples per cycle; overridden by the S*x* parameter, if present.
R	specifies raw (unfiltered) data; defaults to 16 samples per cycle unless overridden by the S*x* parameter. Defaults to LER + 1 cycles in length unless overridden with the L*y* parameter.
C	specifies 16 samples per cycle, LER-cycle length.
P	precise to synchrophasor-level accuracy.
CHIS	Display compressed history.
COM *p d1*	Show a communications summary report for events occurring on date *d1* on MIRRORED BITS Channel *p*.
COM *p d1 d2*	Show a communications summary report for events occurring between dates *d1* and *d2* on MIRRORED BITS Channel *p*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS Channel *p*.
COM *p n*	Show a communications summary for latest *n* events on MIRRORED BITS Channel *p*.
COM *p* L	Show a long format communications summary report for all events on MIRRORED BITS Channel *p*.
COM C *p*	Clear the communications summary report for Channel *p*.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering), not change it. The screen prompt is: =>
CST	Display compressed status report.
CSU	Display compressed event summary.
DAT	Show date.
DAT m/d/y	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT y/m/d	Enter date in this manner if Date Format setting DATE_F = YMD.
DNP [type]	Show DNP map.
EVE *n*	Show event report number *n* with 1/4-cycle resolution.
EVE B *n*	Show event report number *n* for backup elements (not including differential).
EVE C *n*	Show compressed event report number *n* for use with SEL-5601-2 SYNCHROWAVE Event Software.
EVE L *n*	Show event report number *n* with 1/16-cycle resolution.
EVE P *n*	Show event report *n* with synchrophasor-level accuracy time alignment.
EVE R *n*	Show raw event report number *n* with 1/16-cycle resolution.
GOO	Display transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GRO	Display active group number.
HELP	List the commands available at the present access level (applies to the optional Ethernet port).
HIS *n*	Show brief summary of the *n* latest event reports.
HIS C	Clear the brief summary and corresponding event reports.
INI	Display input/output contact information.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MAC	Display the MAC addresses of **PORT 5** and **PORT 6** (applies to the optional Ethernet port).
MET *k*	Display instantaneous metering data. Enter *k* for repeat count.
MET B k	Display instantaneous metering data for local terminal including voltage. Enter *k* for repeat count.
MET D	Display demand and peak demand data. Enter **MET RD** or **MET RP** to reset.
MET E	Display energy metering data. Enter **MET RE** to reset.
MET M	Display maximum/minimum metering data. Enter **MET RM** to reset.
MET PM [*time*] [*k*]	Display synchrophasor measurements (available when TSOK = logical 1). Enter time to display the synchrophasor for an exact specified time, in 24-hour format. Enter *k* for repeat count.
SER *d1*	Show rows in the Sequential Events Recorder (SER) event report from date *d1*.
SER *d1 d2*	Show rows in the Sequential Events Recorder (SER) event report from date *d1* to *d2*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
SER *m n*	Show rows *m* through *n* in the Sequential Events Recorder (SER) event report.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER C	Clear the Sequential Events Recorder (SER).
SHO *n*	Show relay settings (overcurrent, reclosing, timers, etc.) for Group *n*.
SHO G	Show Global settings.
SHO L *n*	Show SELOGIC control equation settings for Group *n*.
SHO P *n*	Show Port *n* settings.
SHO R	Show Sequential Events Recorder (SER) settings.
SHO T	Show text label settings.
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