SEL-311L

LINE CURRENT DIFFERENTIAL

PROTECTION AND AUTOMATION SYSTEM

INSTRUCTION MANUAL

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

⚠ **ATTENTION**: Le relais contient des pièces sensibles aux décharges électrostatiques (DES). Quand on travaille sur le relais avec le panneau avant ou du dessus enlevé, les surfaces de travail et le personnel doivent être mis à la terre convenablement pour éviter les dommages à l'équipement.

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

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

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

⚠ **DANGER**: Removal of this front panel exposes circuitry which may cause electrical shock that can result in injury or death.

⚠ **DANGER**: Le retrait du panneau avant expose à la circuiterie qui pourrait être la source de chocs électriques pouvant entraîner des blessures ou la mort.

This product is covered by U.S. Patent Numbers: 5,041,737; 5,208,545; 5,317,472; 5,325,061; 5,349,490; 5,365,396; 5,367,426; 5,479,315; 5,515,227; 5,652,688; 5,694,281; 5,703,745; 5,731,943; 5,790,418; 5,793,750; 5,883,578; 6,028,754: U.S. Patent(s) Pending, and Foreign Patent(s) Granted and Pending.

This product is covered by the standard SEL 10-year warranty. For warranty details, visit www.selinc.com or contact your customer service representative.

MANUAL CHANGE INFORMATION

The date code at the bottom of each page of this manual reflects the creation or revision date. Date codes are changed only on pages that have been revised and any following pages affected by the revisions (i.e., pagination). If significant revisions are made to a section, the date code on all pages of the section will be changed to reflect the revision date.

Each time revisions are made, both the main table of contents and the affected individual section table of contents are regenerated and the date code is changed to reflect the revision date.

Changes in this manual to date are summarized below (most recent revisions listed at top).

Revision Date	Summary of Revisions
The ***Manual Change Information*** section has been created to begin a record of revisions to this manual. All changes will be recorded in this Summary of Revisions table.	
20011112	**Section 1:** – Updated Optoisolated Input Ratings information in ***Relay Specifications***. – Corrected references to figures in ***Section 3*** in ***Relay Element Settings Ranges and Accuracies***. **Section 2:** – Updated table *SEL-311L Relay Line Current Differential Electrical Interface Cable Application*. **Section 3:** – Added ***OPO Open Pole Option (52,27)***. – Corrected ETAP setting indicated in ***Differential Element Settings and Specifications***. – Updated the following figures: *Phase Differential Element 87LA Processing for Channel X. B and C Phases and Channel Y Are Similarly Processed*; *Negative-Sequence Differential Element 87L2 Processing for Channel X. Channel Y Processing Similar*; and *Ground Differential Element 87L2 Processing for Channel X. Channel Y Processing Similar*. **Section 6:** – Corrected the ETAP setting indicated in ***Reclosing Relay Shot Counter***. **Section 9:** – Updated ORDER default setting text in the Settings Sheets. **Section 10:** – Corrected names of the transmit bits in ***Front-Panel LED 87LCH FAIL***. – Updated table *EIA- 422 Clock Polarity Settings for Popular Communications Equipment*.

Revision Date	Summary of Revisions
	Section 14: – Removed ***SELOGIC® Control Equations Variable Timers*** section in the APP = 87L Settings Sheets. **Appendix A:** – Internal changes to correct local control bits operation. – Internal changes to correct SELOGIC TR setting for 87L21 application. – Internal changes to correct counter overflow in INT87 board. **Appendix B:** Added note about the self-extracting Zip file to step 7.
20011017	Added new **Appendix K: SEL-5030 ACSELERATOR™**.
20010820	**Appendix A:** – Internal changes to improve EIA-422 clock detection.
20010717	**Appendix A:** – Internal changes to correct unused CT scaling issue.
20010625	New Manual Release.

SEL-311L INSTRUCTION MANUAL
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FIGURES

SECTION 1: INTRODUCTION AND SPECIFICATIONS

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 Relay 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 Relay implements line current differential protection 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 Relay:

SEL-311L Relay Models

Instruction Manual Sections

Applications

AC/DC Connections

Communications Ports

Communications Connections

Relay Specifications

SEL-311L Relay Models

The SEL-311L Relay has the following standard features:

- Screw-terminal blocks
- Wye-connected voltage inputs
- 8 standard output contacts and 6 fast, high-current interrupting output contacts
- 6 optoisolated contact inputs
- 1 EIA-485 port
- 3 EIA-232 ports
- IRIG-B time synchronization

Select between the following ordering options:

- Horizontal rack mount, or horizontal or vertical panel mount
- 1 A or 5 A current transformers
- 125/250 V or 24/48 V power supply
- Five control input voltage selections

In addition, DNP 3.00 Level 2 Slave is available.

Purchase the SEL-311L Relay 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 Propose Standard PC37.94)
- 1300 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.

Instruction Manual Sections Overview

The following is an overview of the other sections in this instruction manual:

Section 2: Installation describes mounting and wiring the SEL-311L Relay, application and communications connections, and the operation of circuit board jumpers. Figure 2.2 through Figure 2.5 show the SEL-311L Relay front and rear panels.

Section 3: Line Current Differential, Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements describes the operation of:

- Line current differential elements (phase, negative-sequence, and zero-sequence)
- Phase and ground distance elements (phase mho, compensator distance, ground mho, quadrilateral ground, and Zone 1 extension)
- Out-of-step elements
- Instantaneous/definite-time overcurrent elements (phase, residual ground, and negative-sequence)
- Time-overcurrent elements (phase, residual ground, and negative-sequence)
- Voltage elements (single-phase, phase-to-phase, etc.)
- Synchronism check elements
- Frequency elements

Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic describes the operation of:

- Loss-of-potential logic and its effect on distance and directional elements
- CCVT transient detection logic and its effect on Zone 1 distance elements
- Load-encroachment logic and its application to phase distance and overcurrent elements
- Voltage-polarized and current-polarized directional elements
- *Best Choice Ground Directional*™ logic and automatic settings

Section 5: Trip and Target Logic describes the operation of:

- 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:

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

Section 7: Inputs, Outputs, Timers, and Other Control Logic describes the operation of:

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

Section 8: Breaker Monitor and Metering Functions describes the operation of:

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

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

- Time-overcurrent curves (5 US and 5 IEC curves)
- Relay Word bit table and definitions (Relay Word bits are used in SELOGIC control equation settings)
- Settings Sheets 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 Relay. Note that these sheets correspond to the serial port **SET** commands listed in Table 9.1.

See ***Section 14*** for a description of Application Settings APP = 87L, 87L21, and 87L21P.

- Two terminal with tapped load settings example

Section 10: Line Current Differential Communications and Serial Port Communications and Commands describes:

- 87L communications interfaces, channel monitors, and associated settings
- Serial port connector pinout/terminal functions
- Communications cables
- Communications protocol
- Serial port commands

  See ***SHO Command (Show/View Settings)*** in ***Section 10*** for a list of the SEL-311L Relay factory default relay settings.

Section 11: Front-Panel Interface describes the operation of:

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

Section 12: Standard Event Reports and SER describes:

- 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, Troubleshooting, and Commissioning describes:

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

Section 14: Applications Settings for SEL-311L Relays

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

Section 15: Appendices contains the following appendices:

- ***Appendix A: Firmware Versions***
- ***Appendix B: Firmware Upgrade Instructions***
- ***Appendix C: SEL Distributed Port Switch Protocol***
- ***Appendix D: Configuration, Fast Meter, and Fast Operate Commands***
- ***Appendix E: Compressed ASCII Commands***
- ***Appendix F: Setting Negative-Sequence Overcurrent Elements***
- ***Appendix G: Setting SELOGIC® Control Equations***
- ***Appendix H: Distributed Network Protocol (DNP) 3.00 Level 2***
- ***Appendix I: MIRRORED BITS™ Communications***
- ***Appendix J: Example Calculations for 87L Settings***

The ***SEL-311L Relay Command Summary*** briefly describes the serial port commands that are described in detail in ***Section 10: Current Differential Communications and Serial Port Communications and Commands***.

APPLICATIONS

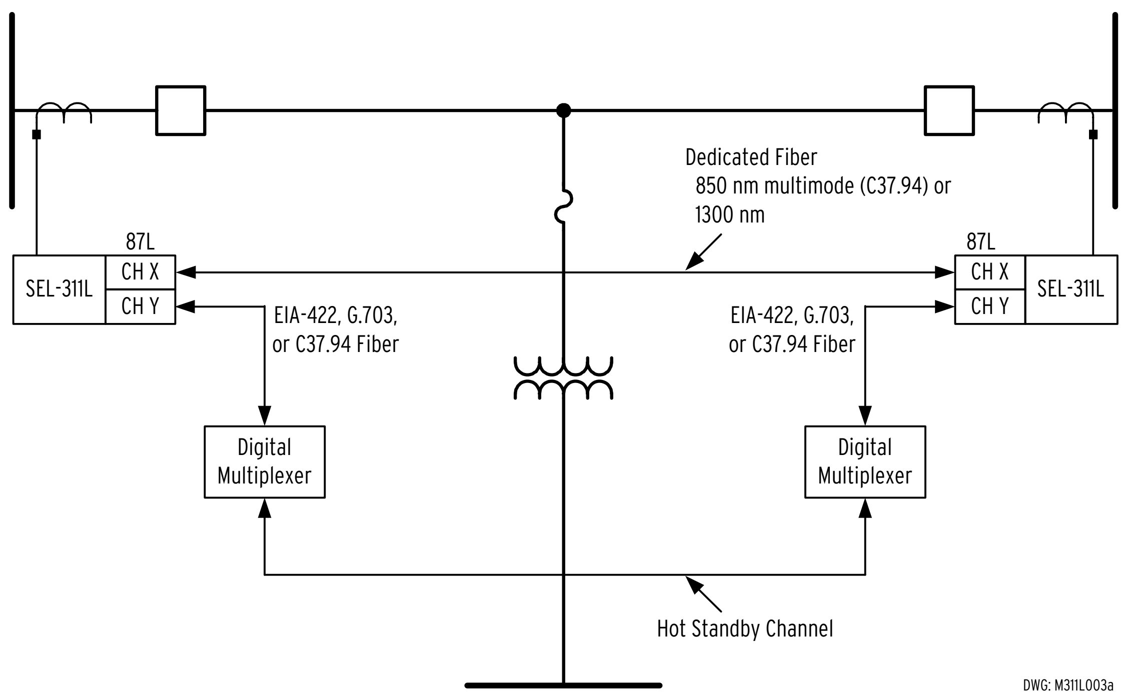


Figure 1.1: Typical Two-Terminal Application With Hot Standby Channel and Tapped Load

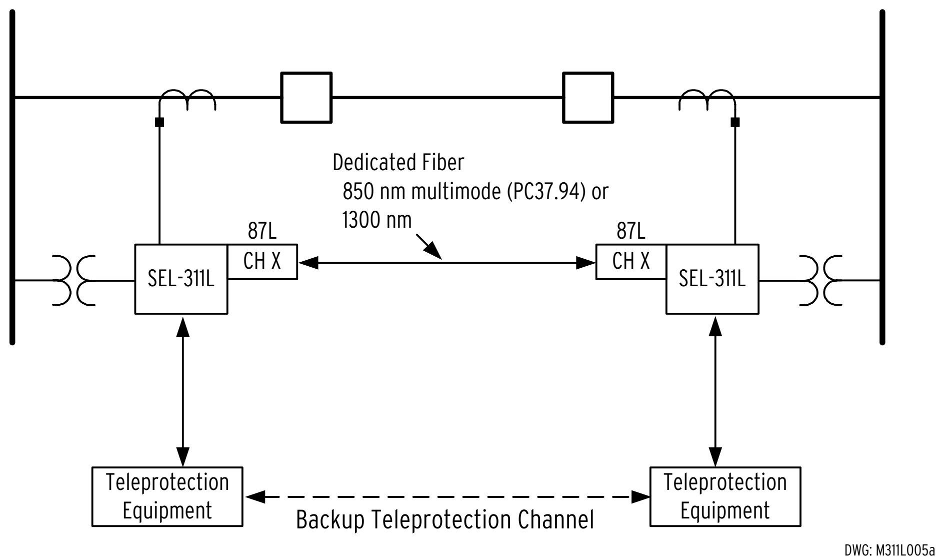


Figure 1.2: Typical Two-Terminal Application With Voltage Inputs

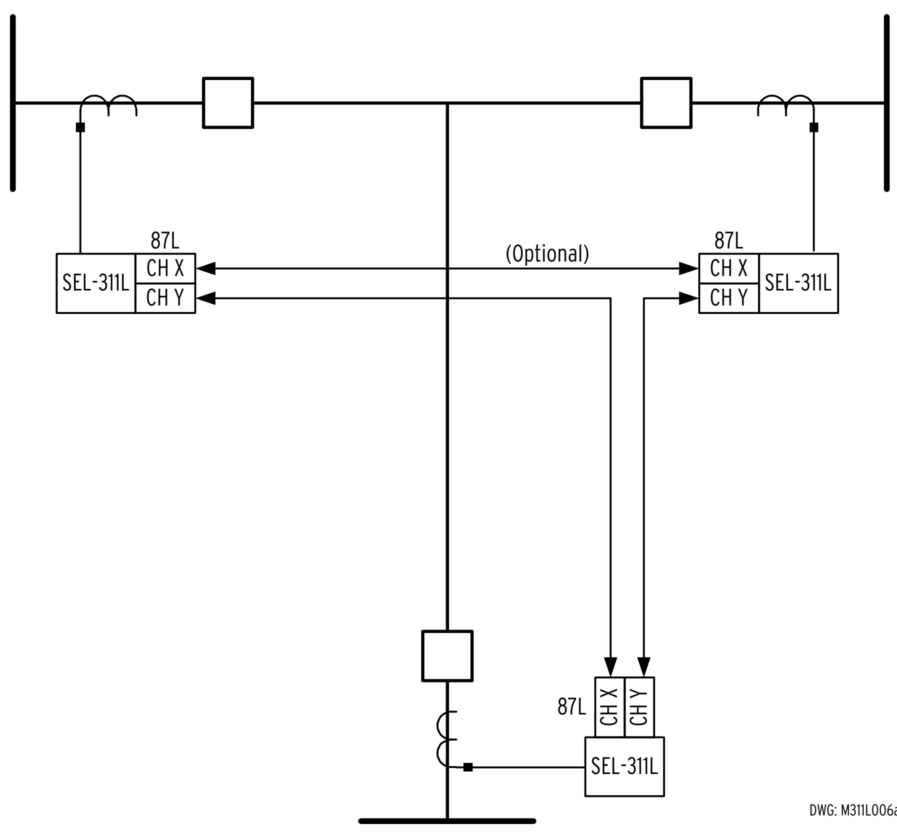


Figure 1.3: Typical Three-Terminal Application With Optional Third Communications Channel

AC/DC Connections

Figure 1.4 and Figure 1.5 show general connection points. See ***General Specifications*** later in this section and ***Section 2: Installation*** for more information on hardware and connections.

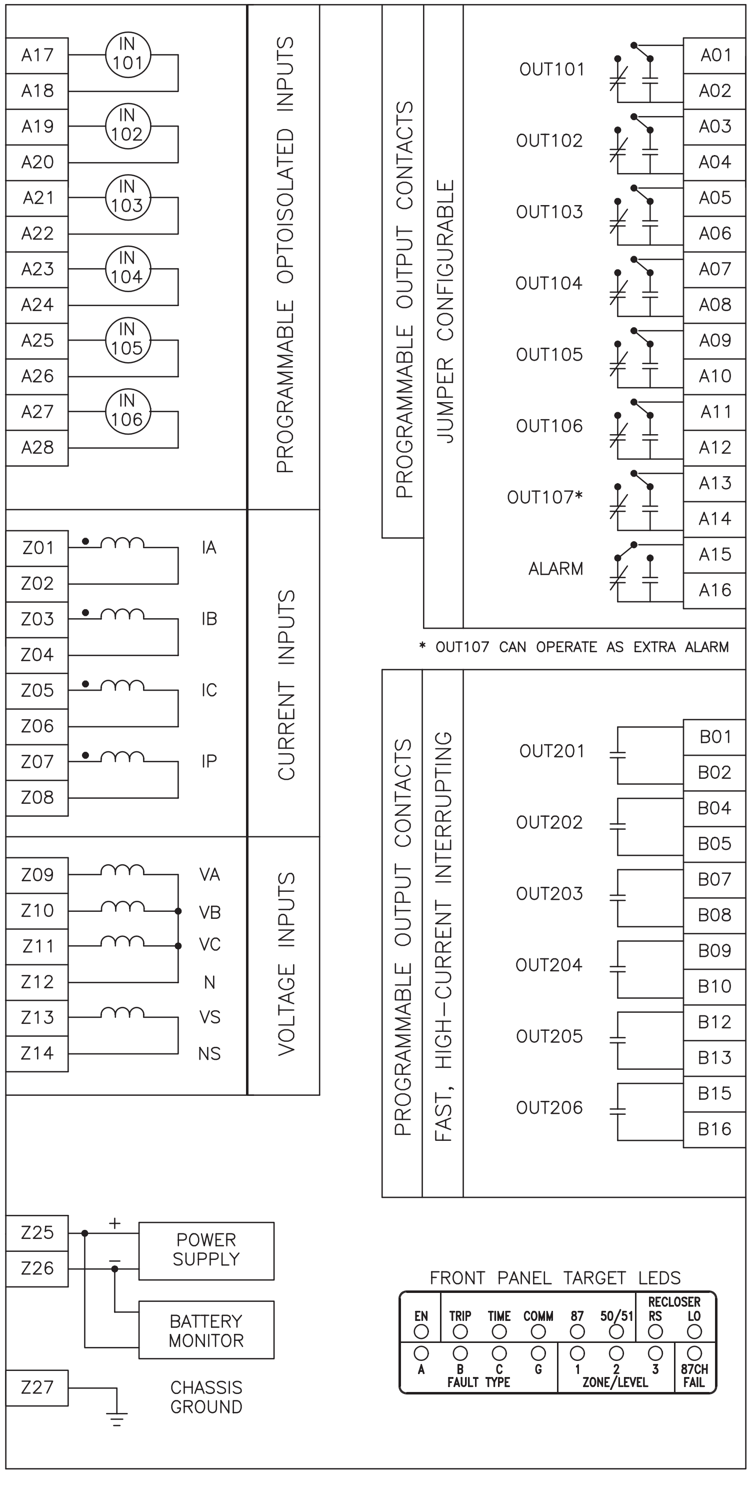
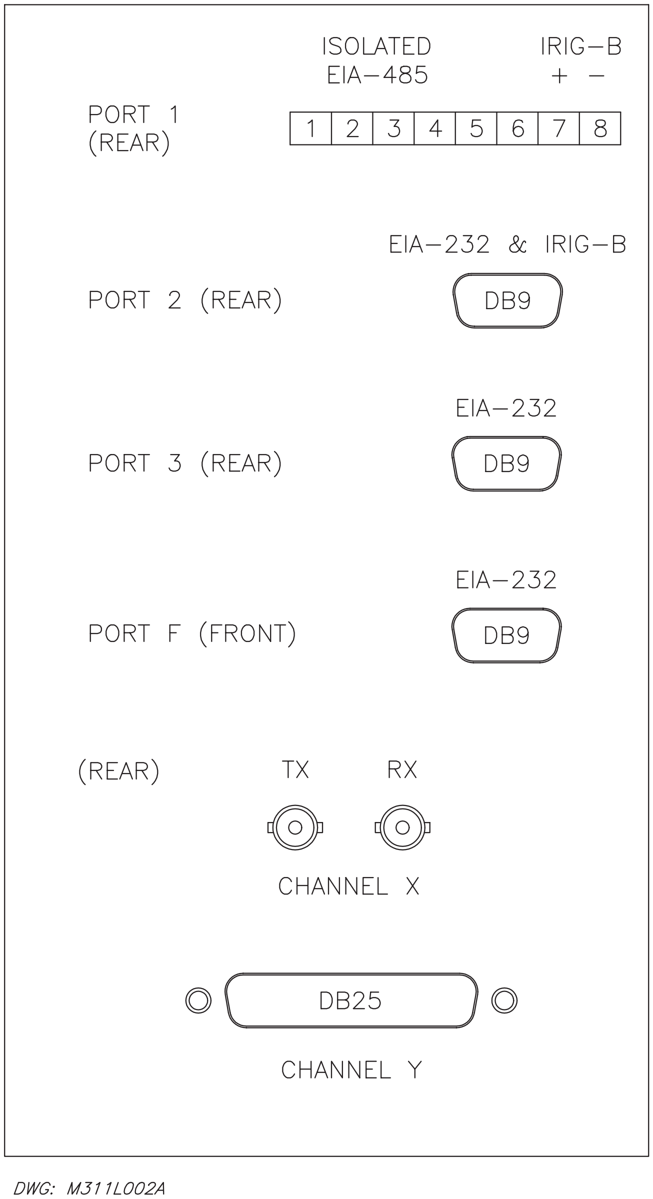


Figure 1.4: SEL-311L Relay Inputs and Outputs



Typical line current differential communications interface.

Figure 1.5: SEL-311L Relay Communications Interfaces

COMMUNICATIONS CONNECTIONS FOR CONTROL, CONFIGURATION, AND INTERROGATION

See ***Port Connector and Communications Cables*** in ***Section 10: Current Differential Communications and Serial Port Communications and Commands*** for more communications connection information.

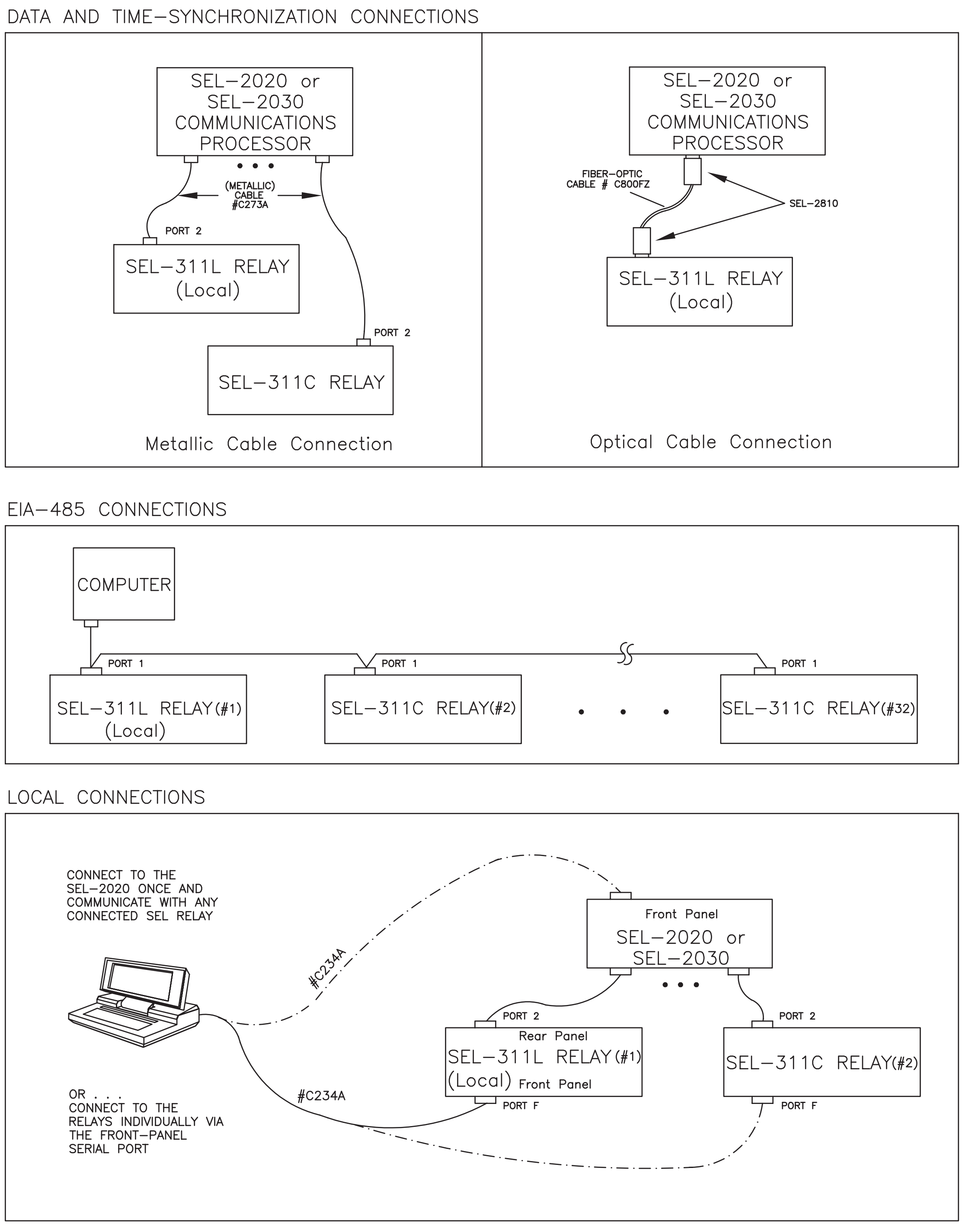


Figure 1.6: SEL-311L Relay Communications Connections Examples

RELAY SPECIFICATIONS

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

General Specifications

Terminal Connections:

Rear Screw-Terminal Tightening Torque:
- Minimum: 8-in-lb (0.8 Nm)
- Maximum: 12-in-lb (1.4 Nm)

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

AC Current Inputs:

5 A nominal
- 15 A continuous, linear to 100 A symmetrical.
- 500 A for 1 second.
- 1250 A for 1 cycle.
- Burden: 0.27 VA @ 5 A
  2.51 VA @ 15 A

1 A nominal
- 3 A continuous, linear to 20 A symmetrical.
- 100 A for 1 second.
- 250 A for 1 cycle.
- Burden: 0.13 VA @ 1 A
  1.31 VA @ 3 A

AC Voltage Inputs:

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

Power Supply:

125/250 Vdc or Vac
- Range: 85–350 Vdc or 85–264 Vac
- Burden: < 15 W

24/48 Vdc
- Range: 20–60 Vdc
- Burden: < 15 W

Output Contacts:
(OUT101-107, ALARM)

Standard
- 30 A make
- 6 A continuous carry at 70°C; 4 A continuous carry at 85°C
- 50 A for one second
- MOV protected: 270 Vac, 360 Vdc, 40 J;
  Pickup time: < 5 ms.
- Breaking Capacity (10,000 operations):

48 V	0.5 A	L/R = 40 ms
125 V	0.3 A	L/R = 40 ms
250 V	0.2 A	L/R = 40 ms

- Cyclic Capacity (2.5 cycles/second):

48 V	0.5 A	L/R = 40 ms
125 V	0.3 A	L/R = 40 ms
250 V	0.2 A	L/R = 40 ms

(OUT 201-206)

High-current interrupting
30 A make
6 A continuous carry at 70°C; 4 A continuous carry at 85°C
50 A for one second
MOV protected: 330 Vdc, 40 J;
Pickup time: < 10 µs;
Dropout time: < 8 ms, typical

Breaking Capacity (10,000 operations):

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

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

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

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

Optoisolated Input Ratings:

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 (settable)
Frequency
Tracking Range: 40.1–65 Hz

Serial Communications Ports:

EIA-232: 1 Front and 2 Rear
EIA-485: 1 Rear, 2100 Vdc isolation
Baud Rate: 300–38400

Differential Communications Ports:

Fiber Optics—ST connector

1300 nm multimode or single mode:

Tx Power:	-18 dBm
Rx Min. Sensitivity:	-58 dBm
Rx Max. Sensitivity:	0 dBm
System Gain:	40 dB

850 nm multimode, PC37.94

	50 µm	62.5 µm
Tx Power:	-23 dBm	-19 dBm
Rx Min. Sensitivity:	-32 dBm	-32 dBm
Rx Max. Sensitivity:	-11 dBm	-11 dBm
System Gain:	9 dB	13 dB

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. Current differential protection does not require external time source.

Operating Temperature Range: -40° to +85°C (-40° to +185°F)

Note: LCD contrast impaired for temperatures below -20°C.

Relay Weight: 3U Rack unit: 16 lbs (7.24 kg)

Type Tests:

Electromagnetic Compatibility Immunity

Electrostatic Discharge: IEC 60255-22-2–1996, Severity Level 4 (8000 V contact, 15,000 V air)

Fast Transient Disturbance: IEC 60255-22-4–1992; IEC 61000-4-4–1995, 4 kV @ 2.5 kHz (4000 V on power supply, 2000 V on inputs and outputs)

Radiated Radio Frequency: IEC 60255-22-3–1989, 10 V/m; IEEE C37.90.2–1995, 35 V/m

Surge Withstand: IEEE C37.90.1–1989, 3000 V oscillatory, 5000 V transient

1 MHz Burst Disturbance: IEC 60255-22-1–1988, Severity Level 3 (2500 V common and 1000 V differential mode)

Environmental		
	Cold:	IEC 60068-2-1–1990, Test Ad; 16 hr. @ –40°C
	Dry Heat:	IEC 60068-2-2–1974, Test Bd; 16 hr. @ +85°C
	Damp Heat, Cyclic:	IEC 60068-2-30–1980, Test Db; 55°C, 6 cycles, 95% humidity
	Vibration:	IEC 60255-21-1–1988, Class 1 IEC 60255-21-2–1988, Class 1 IEC 60255-21-3–1993, Class 2
	Object Penetration:	IEC 60529–1989, IP30
Safety		
	Dielectric Strength:	IEC 60255-5–1977; IEEE C37.90–1989 2500 Vac for 10 seconds on analog inputs; 3100 Vdc for 10 seconds on power supply, optoisolated inputs, and output contacts; 1500 Vac on isolated EIA-422 and G.703 ports.
	Impulse:	IEC 60255-5–1977, 0.5 J, 5000 V
	Laser Safety:	IEC 60825-1–1993; 21 CFR 1040.10; ANSI Z136.1–1993; ANSI Z136.2–1988, eye-safe Class 1 laser product

Certifications: ISO: Relay is designed and manufactured using ISO 9001 certified quality program.

CE Mark.

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 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 Element Settings Ranges and Accuracies

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
Neg.-Seq. Setting Range:	OFF, 0.50 to 5.00 A, 0.01 A steps
Zero-Seq. Setting Range:	OFF, 0.50 to 5.00 A, 0.01 A steps
Accuracy:	±3% ±0.01 Inom

Restraint Characteristic

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 Figure 3.6 and Figure 3.7.

(Refer to ***Line Current Differential Elements*** in ***Section 3: Line Current Differential, Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements*** 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% ±0.01 Inom

Metering Accuracy

Voltages V_A, V_B, V_C, V_S:	±0.67 V secondary
Currents	
I_A, I_B, I_C, I_P (Local):	±0.05 A secondary (5 A nominal) ±0.01 A secondary (1 A nominal)
I_A, I_B, I_C, $3I_2$, $3I_0$, I_1 (Remote):	±3%
I_A, I_B, I_C, $3I_2$, $3I_0$, I_1 (Total):	±3%

Substation Battery Voltage Monitor Specifications

Pickup Range:	20–300 Vdc, 1 Vdc steps
Pickup Accuracy:	±2% 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)
	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 Figure 3.43 and Figure 3.44.

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)
	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 Figure 3.43 and Figure 3.44.

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 Figure 3.43 and Figure 3.44.

Time-Overcurrent Elements

Pickup Range:	OFF, 0.50–16.00 A, 0.01 A steps (5 A nominal) OFF, 0.10–3.20 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 (US) 0.05–1.00, 0.01 steps (IEC)
Curve Timing Accuracy:	±1.50 cycles and ±4% of curve time for current between 2 and 30 multiples of pickup

Under- 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

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 Over- 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

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SECTION 2: INSTALLATION

RELAY MOUNTING

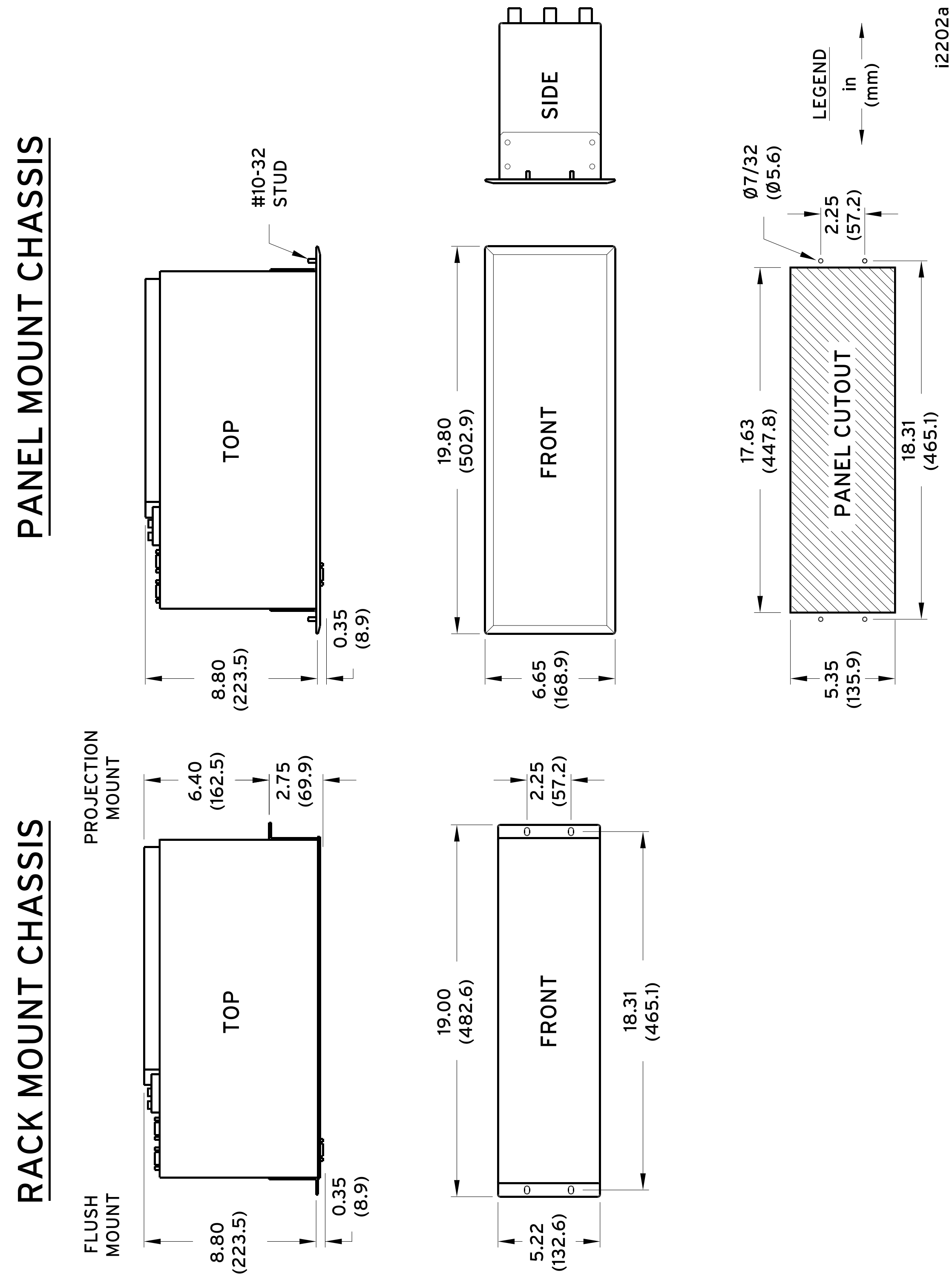


Figure 2.1: SEL-311L Relay Dimensions and Panel-Mount Cutout

The relay can be ordered with the following mounting options:

- Vertical Panel Mount
- Horizontal Panel Mount
- Horizontal Rack Mount

Figure 2.1 provides the relay dimensions and the panel-mount cutout. Refer to Figure 2.2 through Figure 2.5 for example front- and rear-panels drawings.

FRONT- AND REAR-PANEL DIAGRAMS

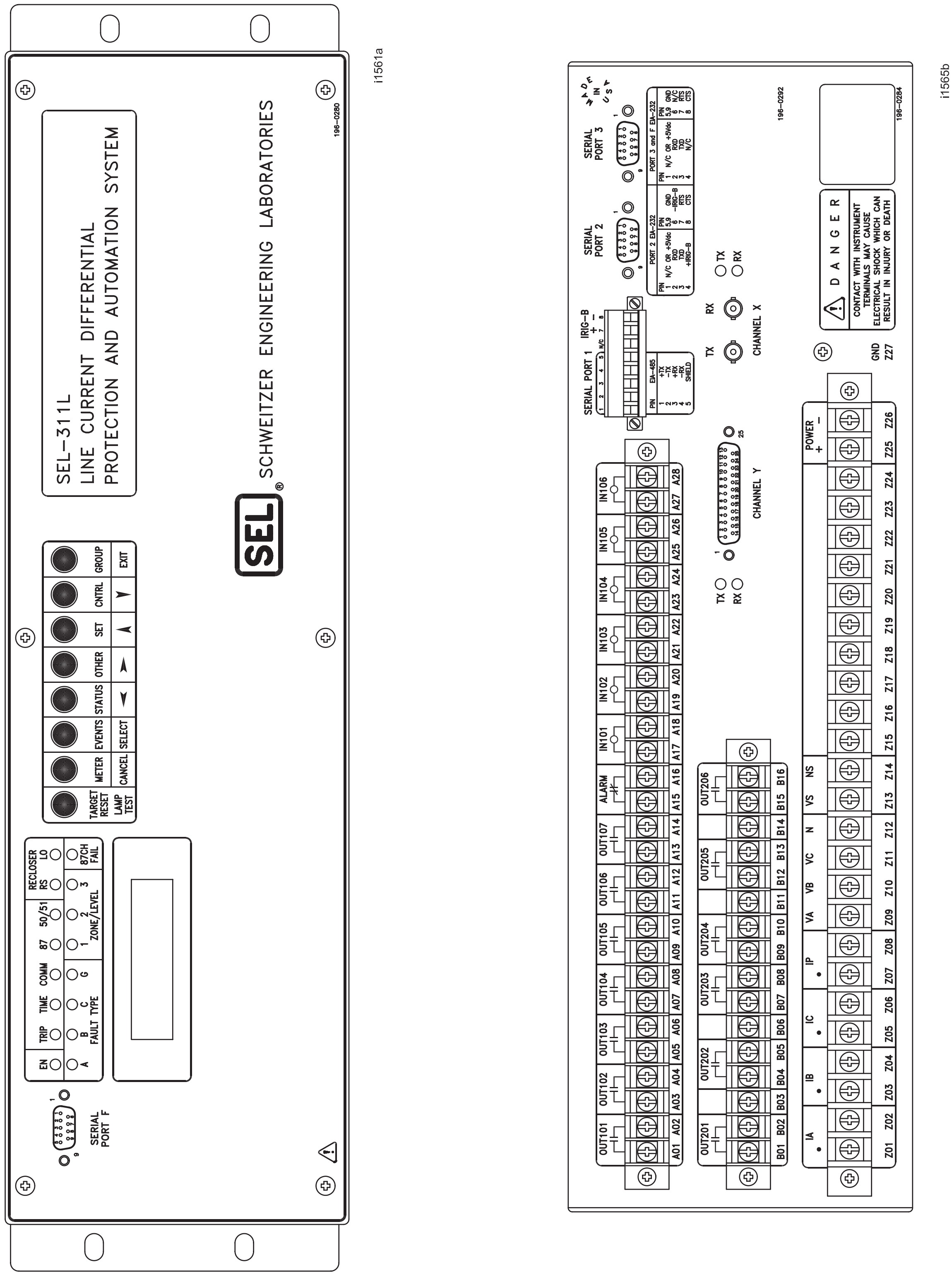


Figure 2.2: SEL-311L Relay Horizontal Rack-Mount Front-Panel and Typical Rear-Panel Drawings

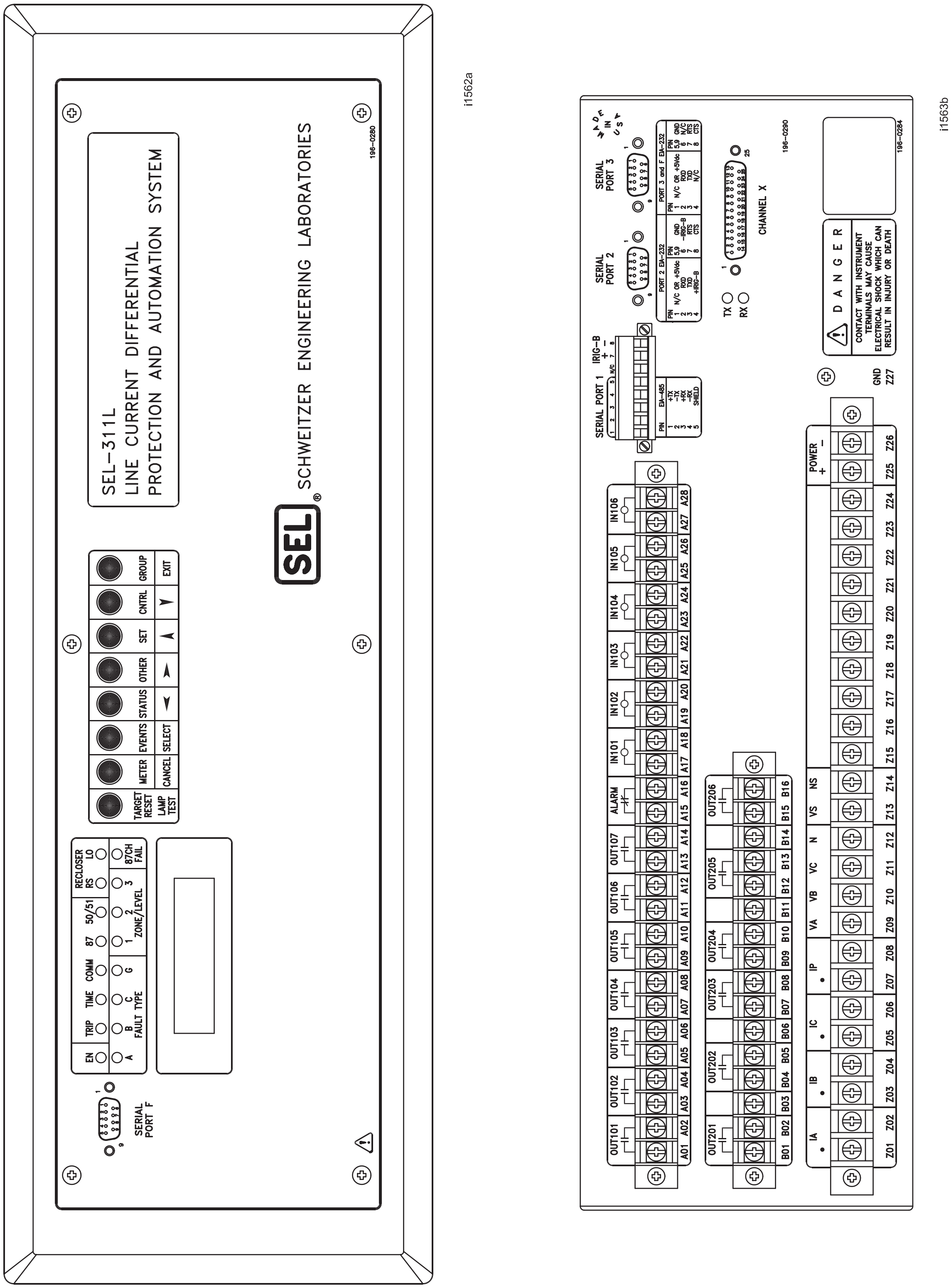


Figure 2.3: SEL-311L Relay Horizontal Panel-Mount Front-Panel and Typical Rear-Panel Drawings

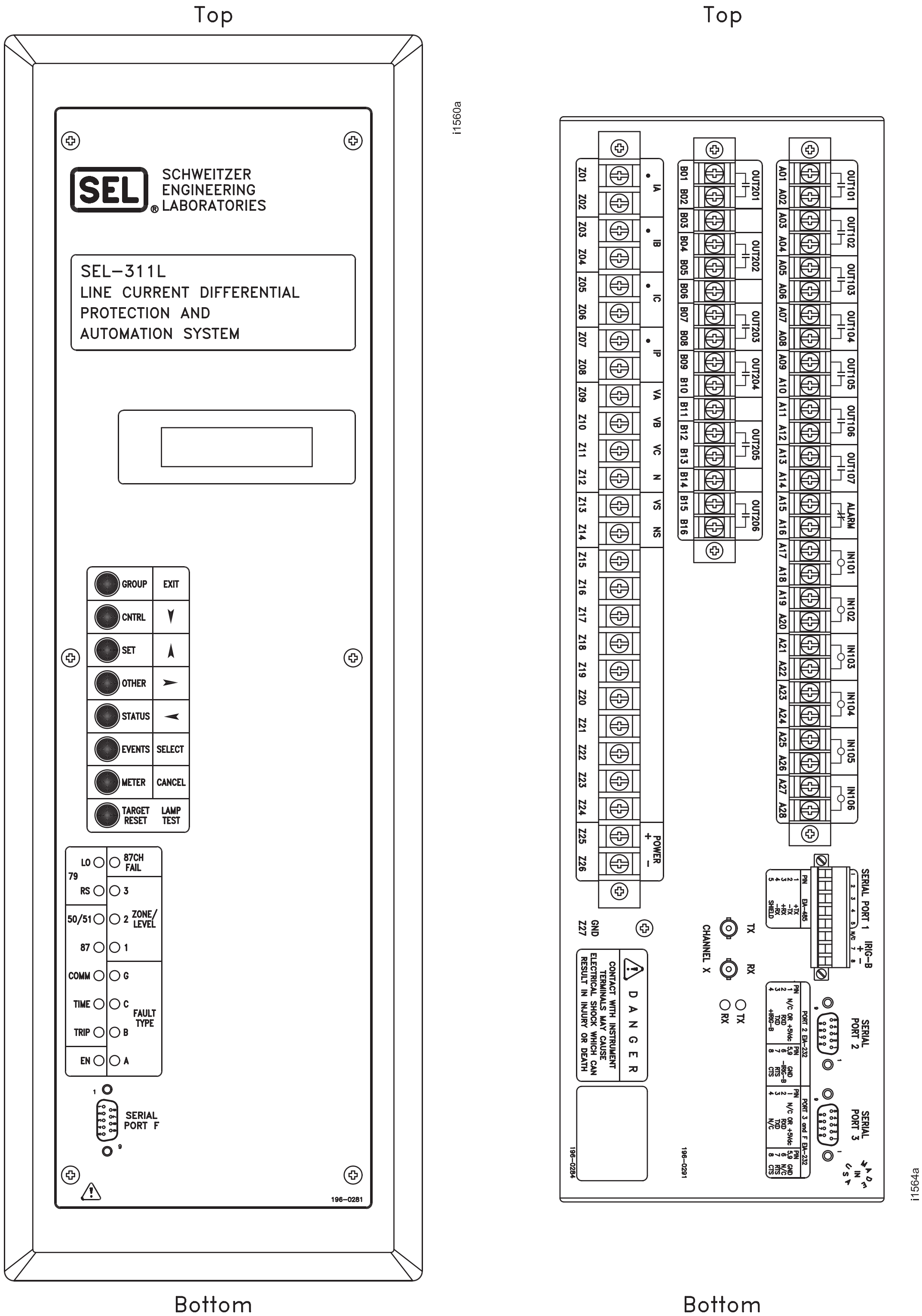


Figure 2.4: SEL-311L Relay Vertical Panel-Mount Front-Panel and Typical Rear-Panel Drawings

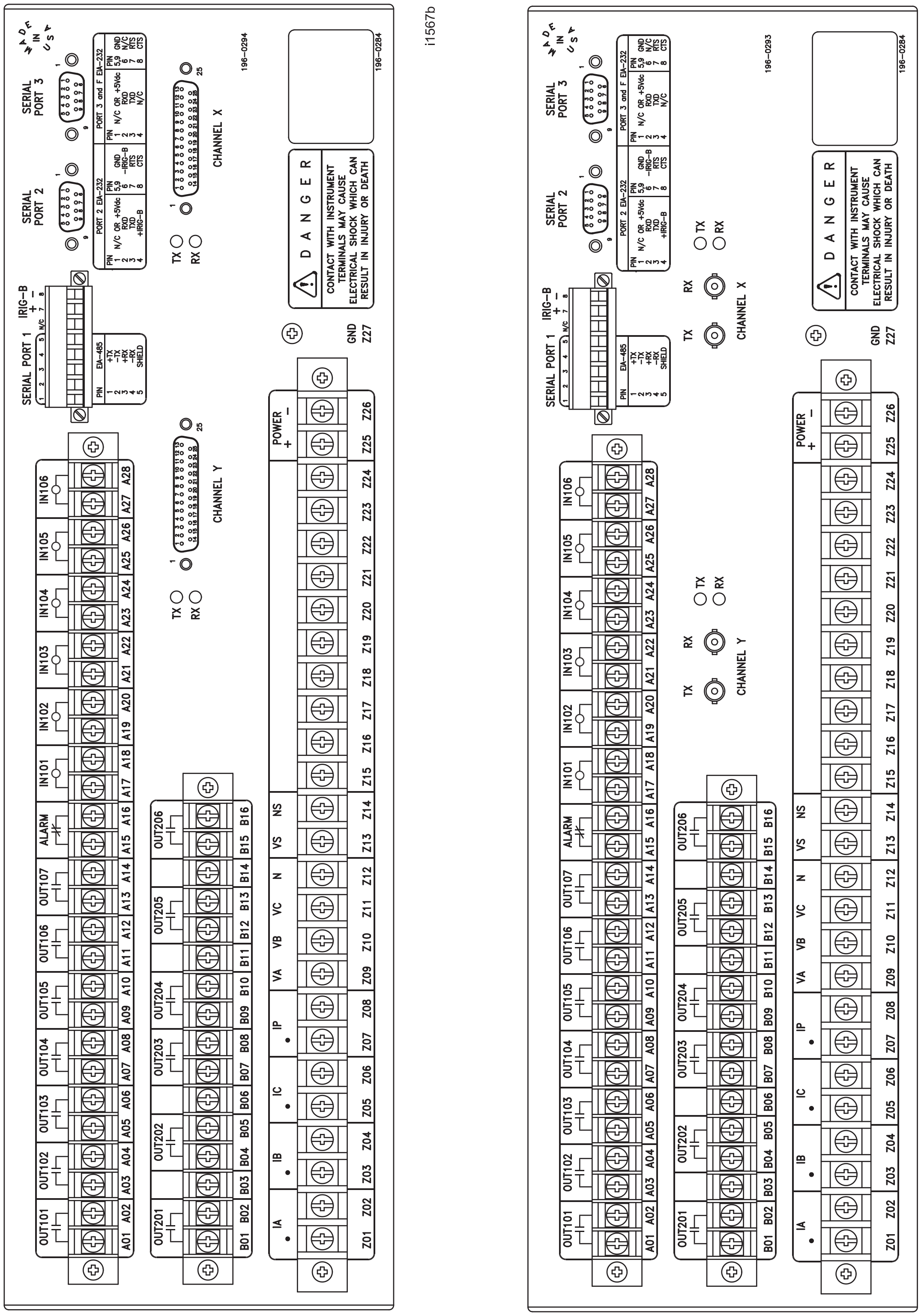


Figure 2.5: SEL-311L Relay Rear-Panel Drawings—DB-25 Connectors at Channel X and Channel Y (Left) and Fiber-Optic Interfaces at Channel X and Channel Y (Right)

Making Rear-Panel Connections

Refer to Figure 2.10, Figure 2.11, and Figure 2.12 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.

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). Refer to ***General Specifications*** in ***Section 1: Introduction and Specifications*** for output contact ratings. Refer to Figure 2.2 through Figure 2.5 for output contact locations.

Use both types of contacts to switch either ac or dc loads.

Optoisolated Inputs

The optoisolated inputs in the SEL-311L Relay (IN101–IN106) are not polarity dependent and are located on the main board. Refer to ***General 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

Note the polarity dots above terminals Z01, Z03, Z05, and Z07. Refer to Figure 2.10, Figure 2.11, and Figure 2.12 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 through Z14. Figure 1.4 shows the internal connection for terminals VA, VB, VC, and VN. 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 up to 150 V rms continuous. Figure 2.11 and Figure 2.12 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 Relay contains the following multifunction communications ports.

Serial Port 1 on all the SEL-311L Relay models is an EIA-485 port (4-wire). The Serial Port 1 plug-in connector accepts wire size AWG 24 to 12. Strip the wires 0.31 inches (8 mm) and install with a small slotted-tip screwdriver. The Serial Port 1 connector has extra positions for IRIG-B time-code signal input (see Table 10.3; 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 Relay models includes the IRIG-B time-code signal input (see Table 10.2; 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 10.2 through Table 10.4 in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***.

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

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.

For example, to connect any EIA-232 port to the 9-pin male connector on a laptop computer, order cable number C234A and specify the length needed (standard length is eight feet). To connect the SEL-311L Relay Port 2 to the SEL-2020 Communications Processor that supplies the communication link and the IRIG-B time synchronization signal, order cable number C273A. For connecting devices at distances over 100 feet, SEL offers fiber-optic transceivers. The SEL-2800 family of transceivers provides fiber-optic links between devices for electrical isolation and long-distance signal transmission. 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 Relay to Other Devices

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

* A corresponding main board jumper must be installed to power the StarComm Modem with +5 Vdc (0.5 A limit) from the SEL-311L Relay. See Figure 2.13 and Table 2.6.

IRIG-B Time-Code Input

The SEL-311L Relay accepts a demodulated IRIG-B time signal to synchronize the relay internal clock with some external source. 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 Relay models (see Table 10.2) by connecting Serial Port 2 of the SEL-311L Relay to an SEL-2020 with Cable C273A, 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 10.3). 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 Relay with up to two line current differential interfaces. Each interface is factory configured as EIA-422, CCITT G.703, IEEE Proposed Standard PC37.94 compliant multimode fiber, or 1300 nm direct fiber. When the SEL-311L Relay arrives, the channels are configured per your ordering options.

Table 2.2 shows the appropriate SEL cable to connect the SEL-311L Relay to some popular multiplexers for the electrical interfaces. Figure 2.6 and Figure 2.7 depict the signal names, pinout and direction at the SEL-311L. All of the electrical 87L channel interface options on the SEL-311L Relay 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: Line Current Differential Communications and Serial Port Communications and Commands*** for channel interface configuration settings, and for channel monitor settings.

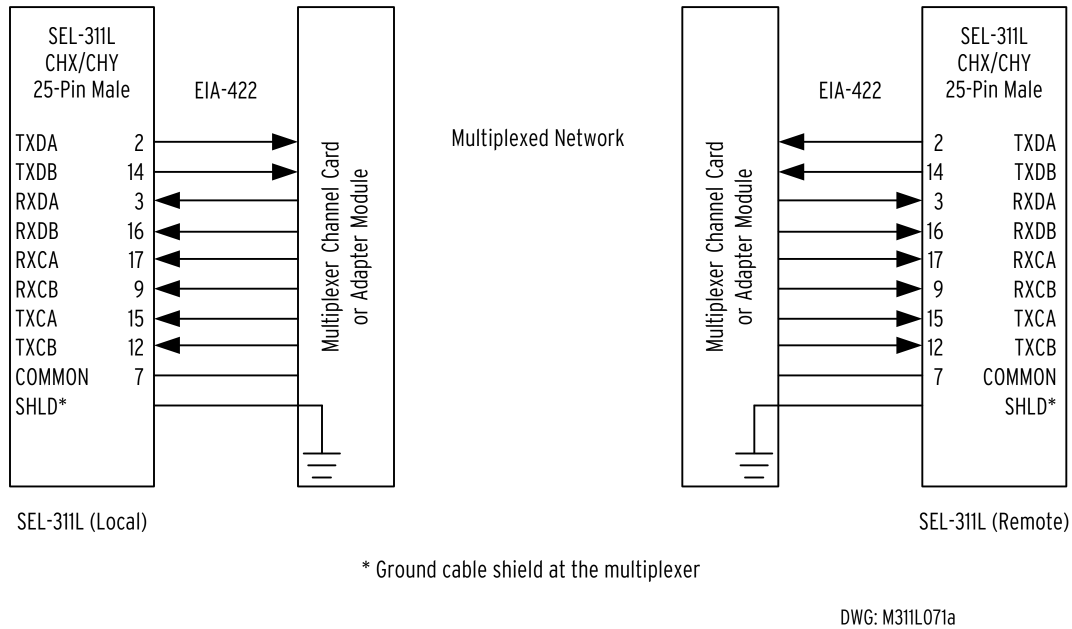


Figure 2.6: Typical EIA-422 Interconnection

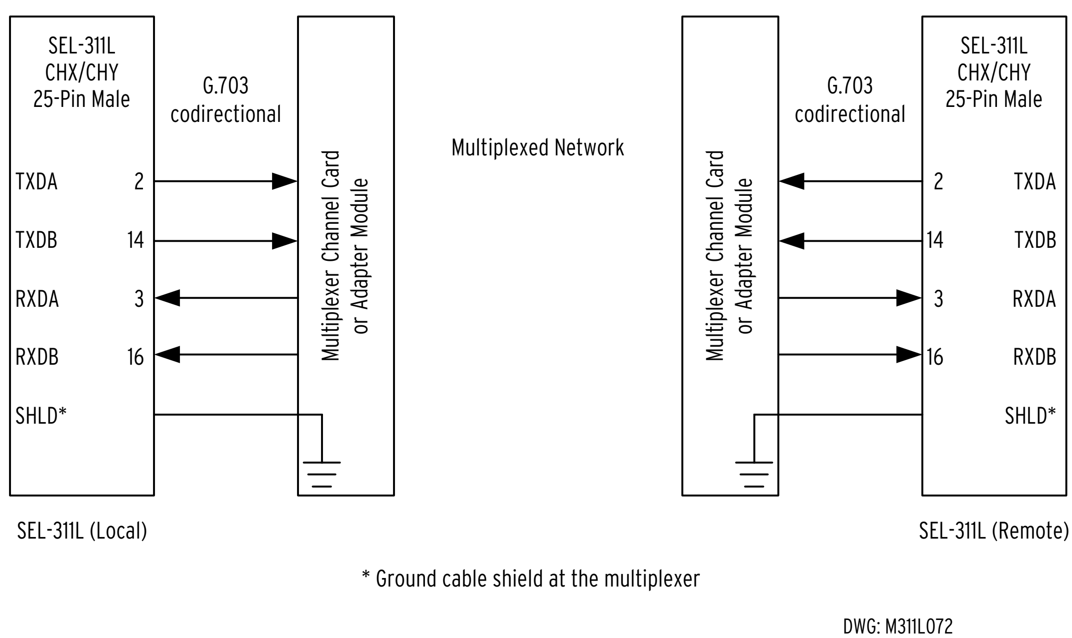


Figure 2.7: Typical G.703 Codirectional Interconnection

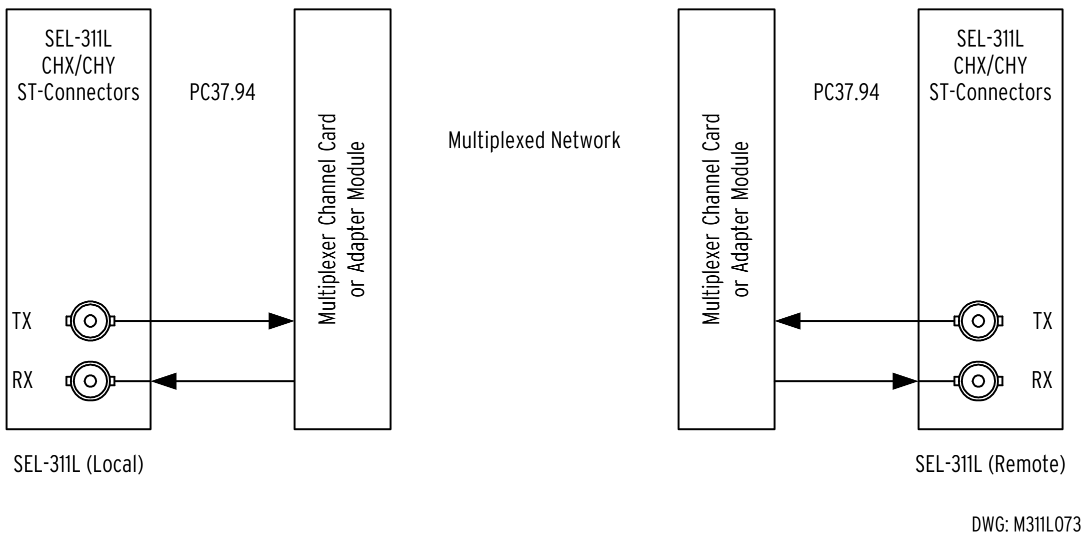


Figure 2.8: IEEE Proposed Standard PC37.94 Fiber to Multiplexer Interface

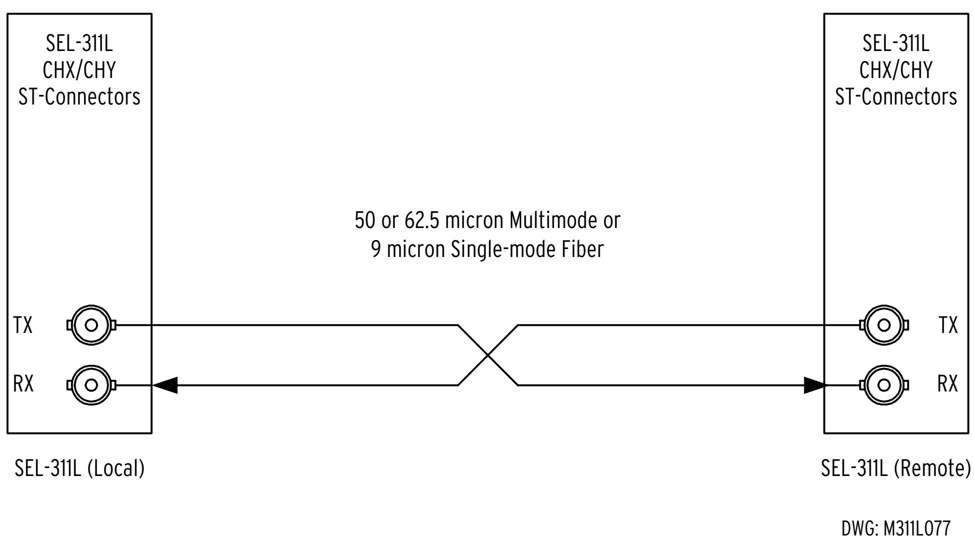
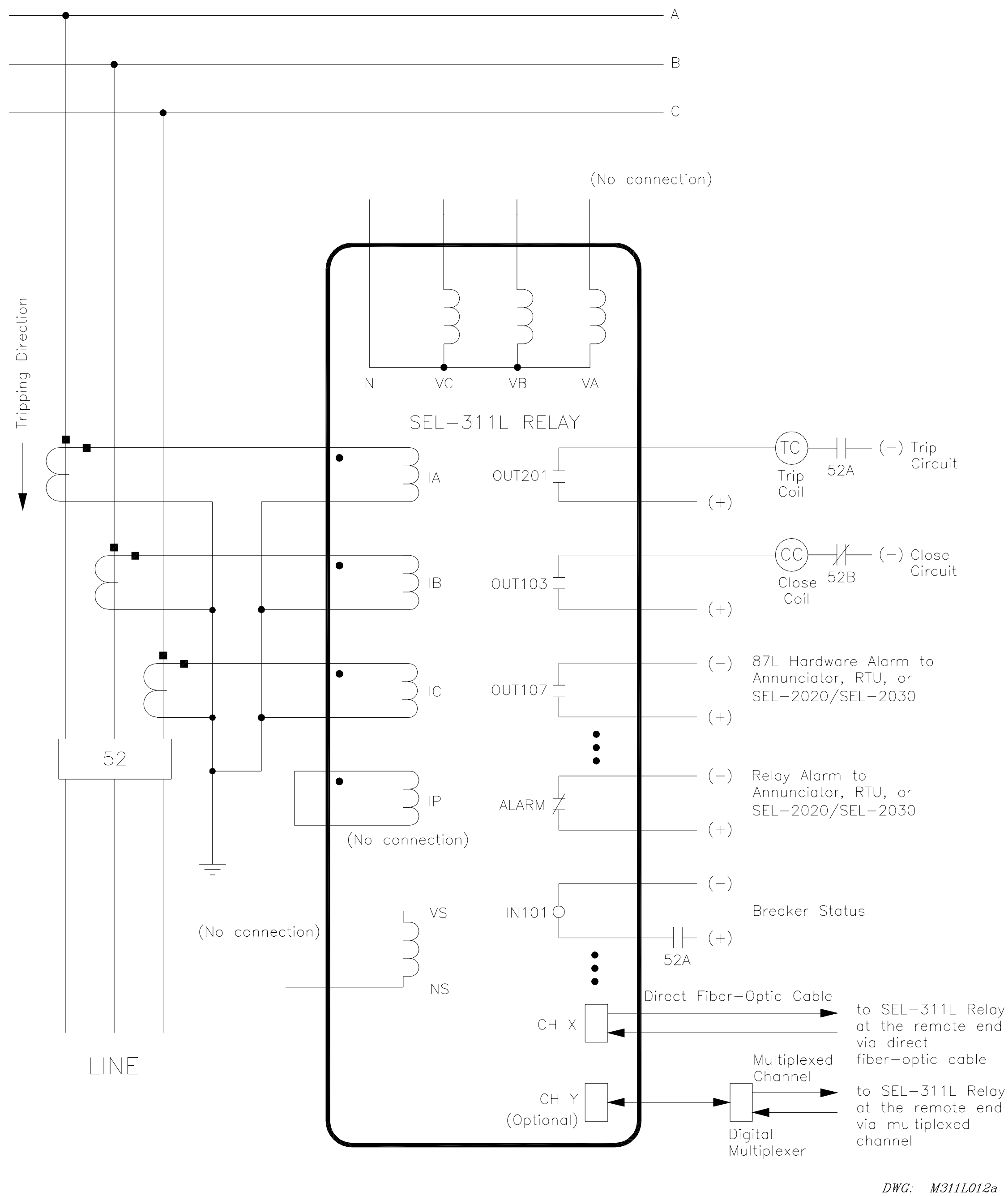


Figure 2.9: 1300 nm Direct Fiber Connection

Table 2.2: SEL-311L Relay Line Current Differential Electrical Interface Cable Application

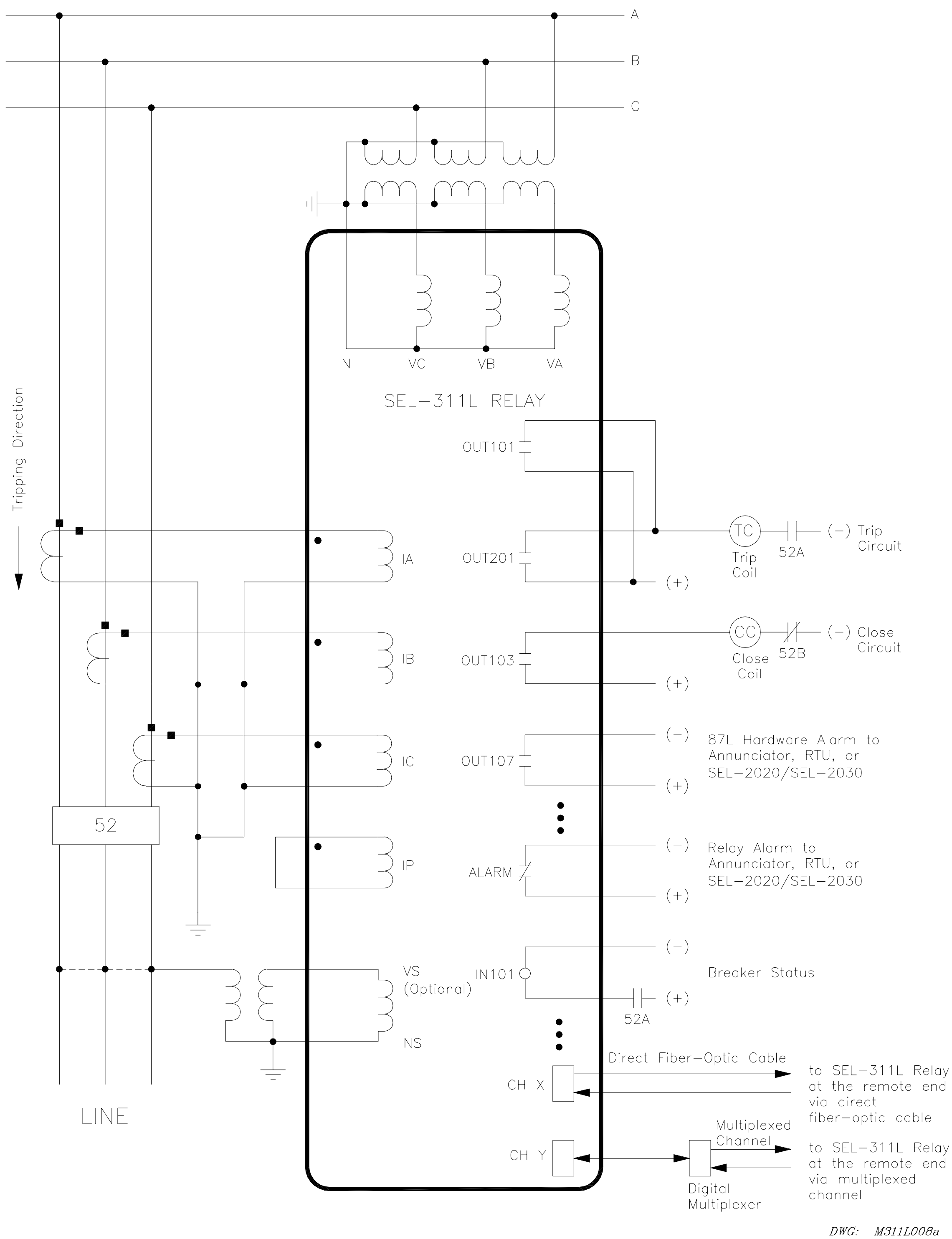
MFG	Product	Channel Card	Interface Adapter	SEL Cable	Interface Type
RFL	IMUX	DS562I	MA406IA	C453	EIA-422; RS-449
RFL	IMUX	DS562I	MA408IA	C452	G.703
Pulsar	FOCUS	64K	N/A	C451	EIA-422; RS-530
Nortel	JMUX	Nx64 Unit 86464-01	86447-90	C450	EIA-422; Terminals

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



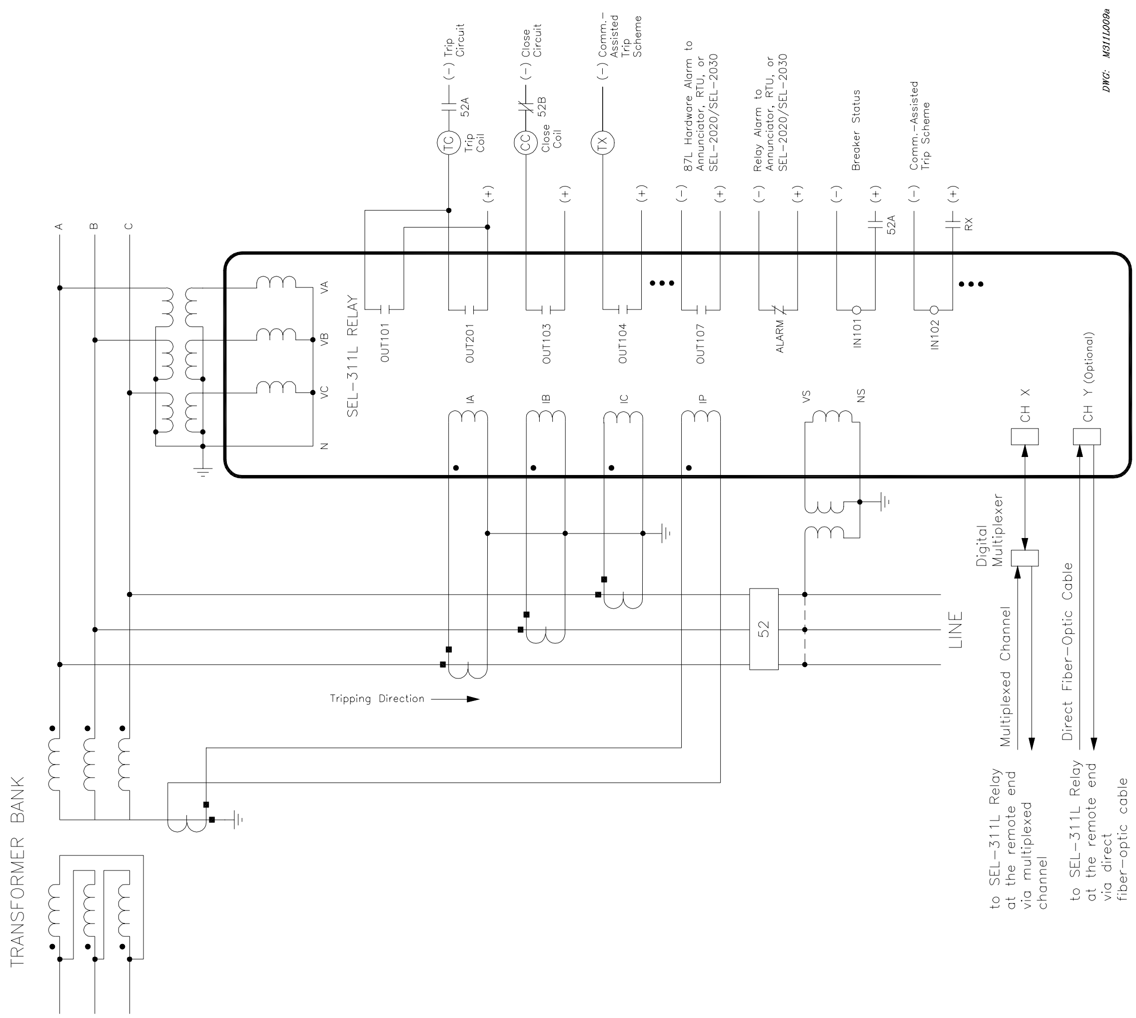
1. Voltage Channels (VA, VB, VC, and VS) and current Channel IP are not used in this application.

Figure 2.10: SEL-311L Relay Provides Line Current Differential Protection (Setting APP = 87L)



1. Voltage Channel VS is used in voltage and synchronism check elements and voltage metering.
2. Current Channel IP does not need to be connected. Channel IP provides current for current polarized directional elements.

Figure 2.11: SEL-311L Relay Provides Line Current Differential, Backup Distance and Overcurrent Protection, Reclosing, and Synch Check for a Transmission Line (Setting APP = 87L21 or 87L21P)



1. Voltage Channel VS does not need to be connected. It is used only in voltage and synchronism check elements and voltage metering.
2. In this example, current Channel IP provides current polarization for a directional element used to control ground elements.

Figure 2.12: SEL-311L Relay 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)

CIRCUIT BOARD CONNECTIONS

Accessing the Relay Circuit Boards

To change circuit board jumpers or replace the clock battery, refer to Figure 2.13 and take the following steps:

1. Deenergize the relay.
2. Remove any cables connected to serial ports or line current differential interfaces on the front and rear panels.
3. Remove the EIA-485 connector.
4. Loosen the six front-panel screws (they remain attached to the front panel), and remove the relay front panel.

⚠ CAUTION	The relay contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with front or top cover removed, work surfaces and personnel must be properly grounded or equipment damage may result.
⚠ DANGER	Removal of this front panel exposes circuitry which may cause electrical shock that can result in injury or death.

5. Each circuit board corresponds to a row of rear-panel terminal blocks or connectors and is affixed to a drawout tray.
6. Disconnect circuit board cables as necessary. Removal of the differential board requires removal of the main board first. Ribbon cables can be removed by pushing the extraction ears away from the connector. The 6-conductor power cable can be removed by grasping the power connector wires and pulling away from the circuit board.
7. Grasp the drawout assembly of the board and pull the assembly from the relay chassis.
8. Locate the jumper(s) or battery to be changed (refer to Figure 2.13). Make the desired changes. Note that the output contact jumpers are soldered in place.
9. When finished, slide the drawout assembly into the relay chassis. Reconnect the cables removed in Step 6. Replace the relay front-panel cover.
10. Replace any cables previously connected to serial ports or line current differential interfaces.
11. Reenergize the relay and verify that the ENABLE LED illuminates.

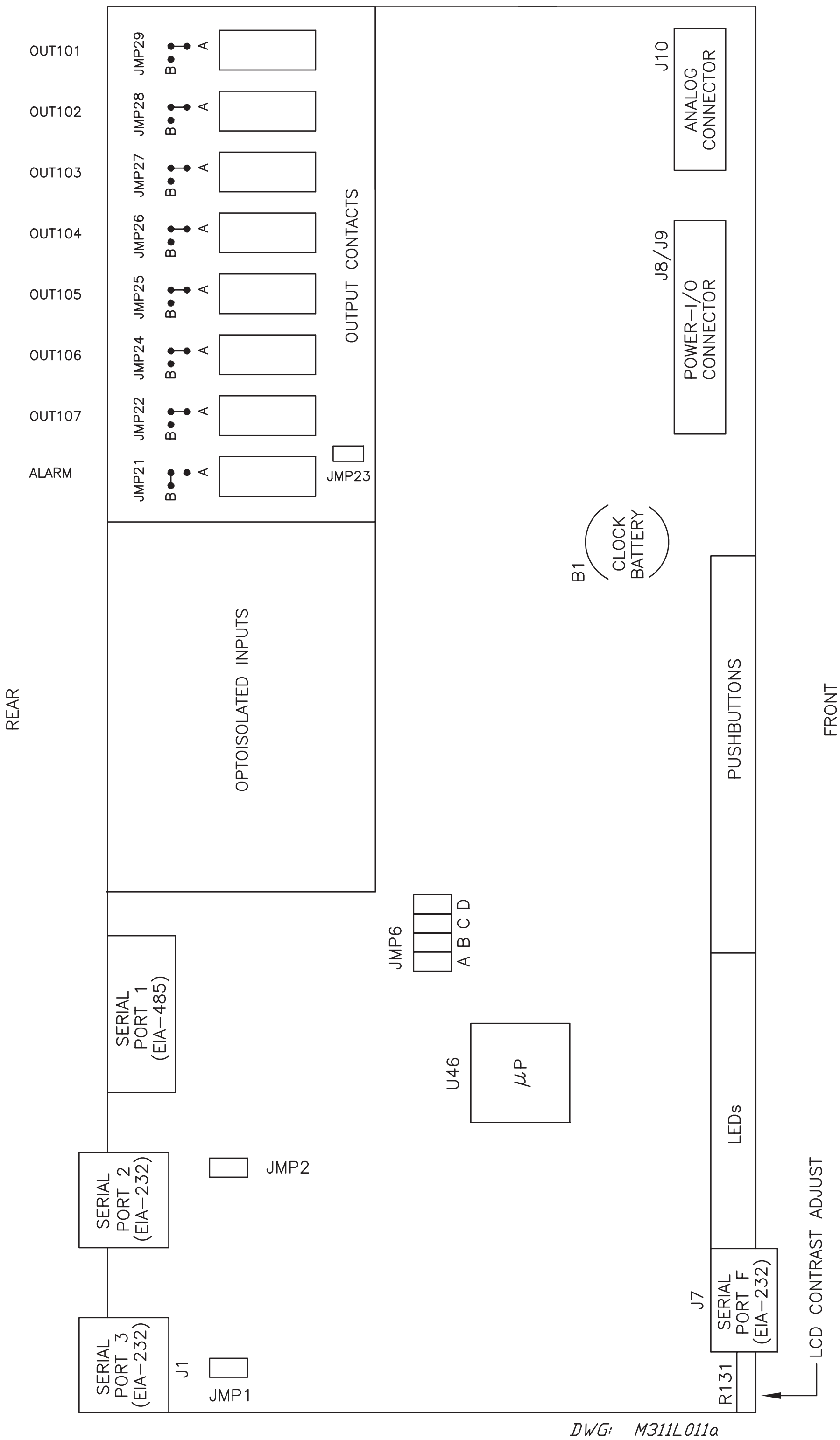


Figure 2.13: Jumper, Connector, and Major Component Locations on the SEL-311L Relay Main Board

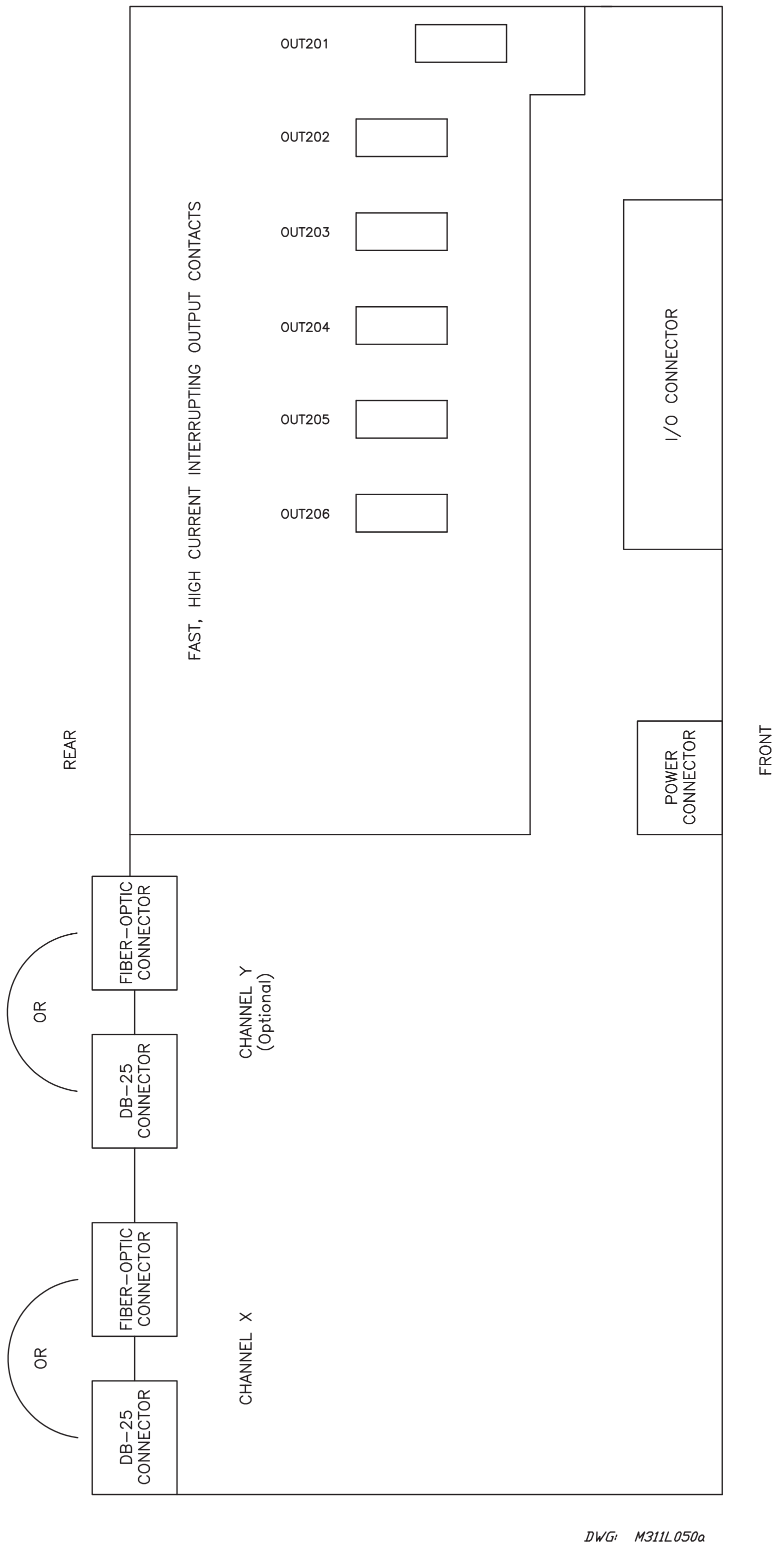


Figure 2.14: Connector and Major Component Locations on the SEL-311L Relay Differential I/O Board

Output Contact Jumpers

Table 2.3 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 equation is asserted, and open when the associated SELOGIC 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 equation is deasserted, and open when the associated SELOGIC equation is asserted. These jumpers are soldered in place.

In Figure 2.13, 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 Figure 7.26 and Figure 7.27 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.

Table 2.3: Output Contact Jumpers and Corresponding Output Contacts

SEL-311L Relay Model Number	Output Contact Jumpers	Corresponding Output Contacts	Reference Figure
All Models	JMP21–JMP29 (but not JMP23)	ALARM–OUT101	Figure 2.13

“Extra Alarm” Output Contact Control Jumper

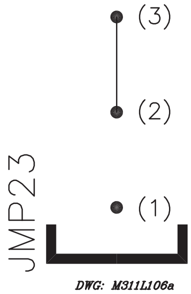
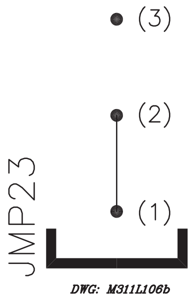
All the SEL-311L Relays have a dedicated alarm output contact labeled ALARM (see Figure 2.2 through Figure 2.5). Often more than one alarm output contact is needed for such applications as local or remote annunciation, backup schemes, etc.

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 2.4).

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 2.4).

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 2.4: 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 7.26). 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 7.26). 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 preceding subsection ***Output Contact Jumpers***). Thus, the dedicated ALARM output contact and the "extra alarm" output contact can be configured as the same output contact type if desired (e.g., both can be configured as "b" type output contacts).

Password and Breaker Jumpers

Table 2.5: Password and Breaker Jumper Operation

Jumper	Jumper Position	Function
Password JMP6-A	ON (in place)	Disable password protection[1] for serial ports and front panel.
	OFF (removed/not in place)	Enable password protection[1] 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[2]. These commands are disabled in a standard relay shipment.
	OFF (removed/not in place)	Disable serial port commands OPEN, CLOSE, and PULSE[2]. These commands are disabled in a standard relay shipment.

[1] View or set the passwords with the PASSWORD command (see ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***).

[2] The OPEN, CLOSE, and PULSE commands are used primarily to assert output contacts for circuit breaker control or testing purposes (see ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***).

Note that JMP6 in Figure 2.13 has multiple jumpers A through D. Jumpers A and B are used (see Table 2.5). Since 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 2.6 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 10.2 in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** 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 2.6: EIA-232 Serial Port Voltage Jumper Positions for Standard Relay Shipments

SEL-311L Relay 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 2.13

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

Refer to Figure 2.13 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, Ray-O-Vac® No. BR2335 or equivalent. At room temperature (25°C), the battery will nominally operate for 10 years with power removed from the relay.

⚠ CAUTION

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

If 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. Follow the instructions in the previous subsection ***Accessing the Relay Circuit Boards*** to remove the relay main board. Remove the battery from beneath the clip and install a new one. The positive side (+) of the battery faces up. Reassemble the relay as described in ***Accessing the Relay Circuit Boards***. Set the relay date and time via serial communications port or front panel (see ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** or ***Section 11: Front-Panel Interface***).

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SECTION 3: LINE CURRENT DIFFERENTIAL, DISTANCE, OUT-OF-STEP, OVERCURRENT, VOLTAGE, SYNCHRONISM CHECK, AND FREQUENCY ELEMENTS

The SEL-311L Line Current Differential Protection and Automation System includes both current 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 key elements.

CURRENT DIFFERENTIAL ELEMENTS

The SEL-311L Relay contains five line current differential elements: one for each phase, and 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 Relay 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.

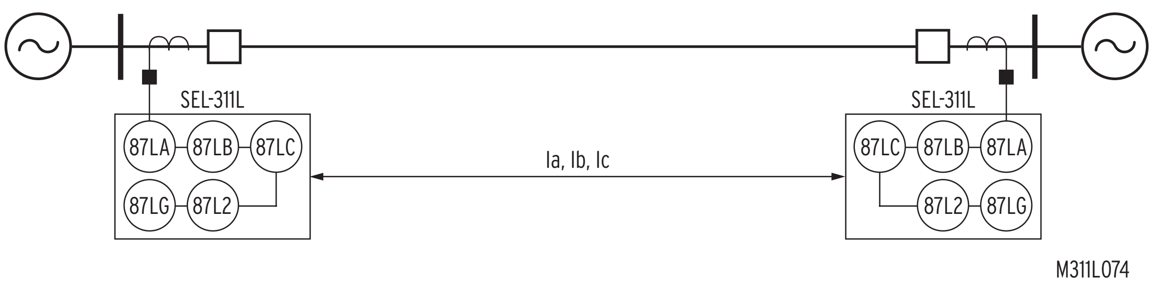

Figure 3.1: SEL-311L Relay Line Current Differential Elements

The SEL-311L Relay 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*** in ***Section 9: Setting the Relay*** 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 (I_R) to local (I_L) currents. There is a separate Alpha plane for every current (phase, negative-sequence, zero-sequence, etc).

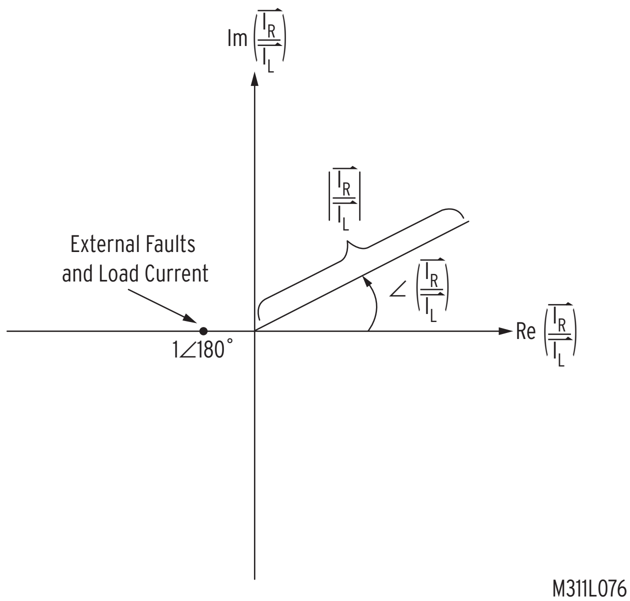

Figure 3.2: Alpha Plane Represents Complex Ratio of Remote-to-Local Currents

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. Five Amps of load current flowing from the local to the remote relay produces an A-phase current of 5∠0° at the local relay, and 5∠180° at the remote relay. The ratio of remote to local current is:

$$\frac{\bar{I}_{AR}}{\bar{I}_{AL}} = \frac{5\angle 180°}{5\angle 0°} = 1\angle 180°$$

$$\frac{\bar{I}_{BR}}{\bar{I}_{BL}} = \frac{5\angle 60°}{5\angle -120°} = 1\angle 180° \qquad \text{Equation 3.1}$$

$$\frac{\bar{I}_{CR}}{\bar{I}_{CL}} = \frac{5\angle -60°}{5\angle 120°} = 1\angle 180°$$

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∠180° 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 Line Current Differential Relay 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.

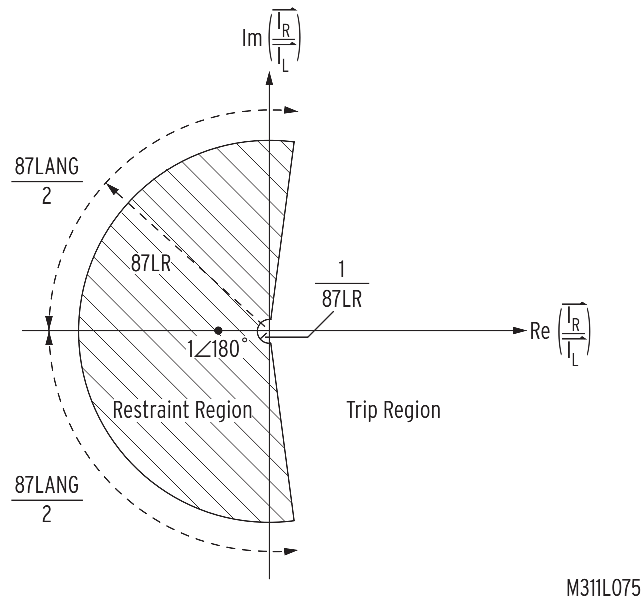

Figure 3.3: SEL-311L Relay Restraint Region Surrounds External Faults

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 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 Relay. In every case, the SEL-311L Relay gives significant improvement in security, sensitivity, speed, dependability, or all four.

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. 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 homogenous 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 $1\angle 0°$. This plots one unit to the right of the origin, as shown in Figure 3.4. If the system is non-homogenous 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.

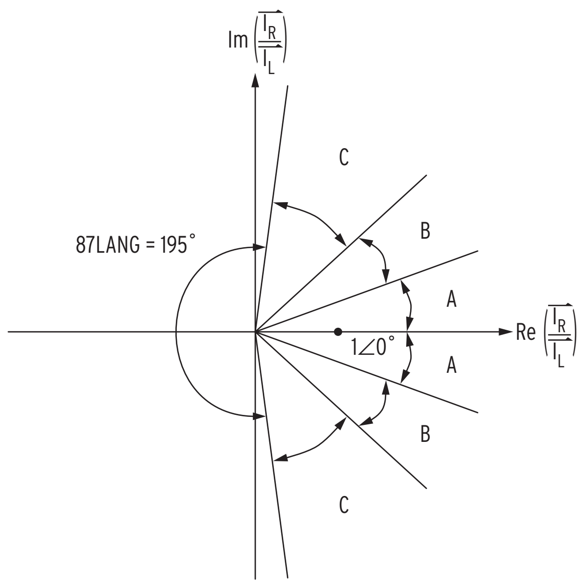

Figure 3.4: Alpha Plane Angel Setting 87LANG Is Based on Maximum Alpha Plane Angle for an External Fault

If the internal fault is not at midline, or if the sources do not have equal strength, the Alpha plane ratio moves away from $1\angle 0°$ 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 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.

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 Relay 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 (counter clockwise 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 non-homogeneity 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 non-homogeneity, 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.

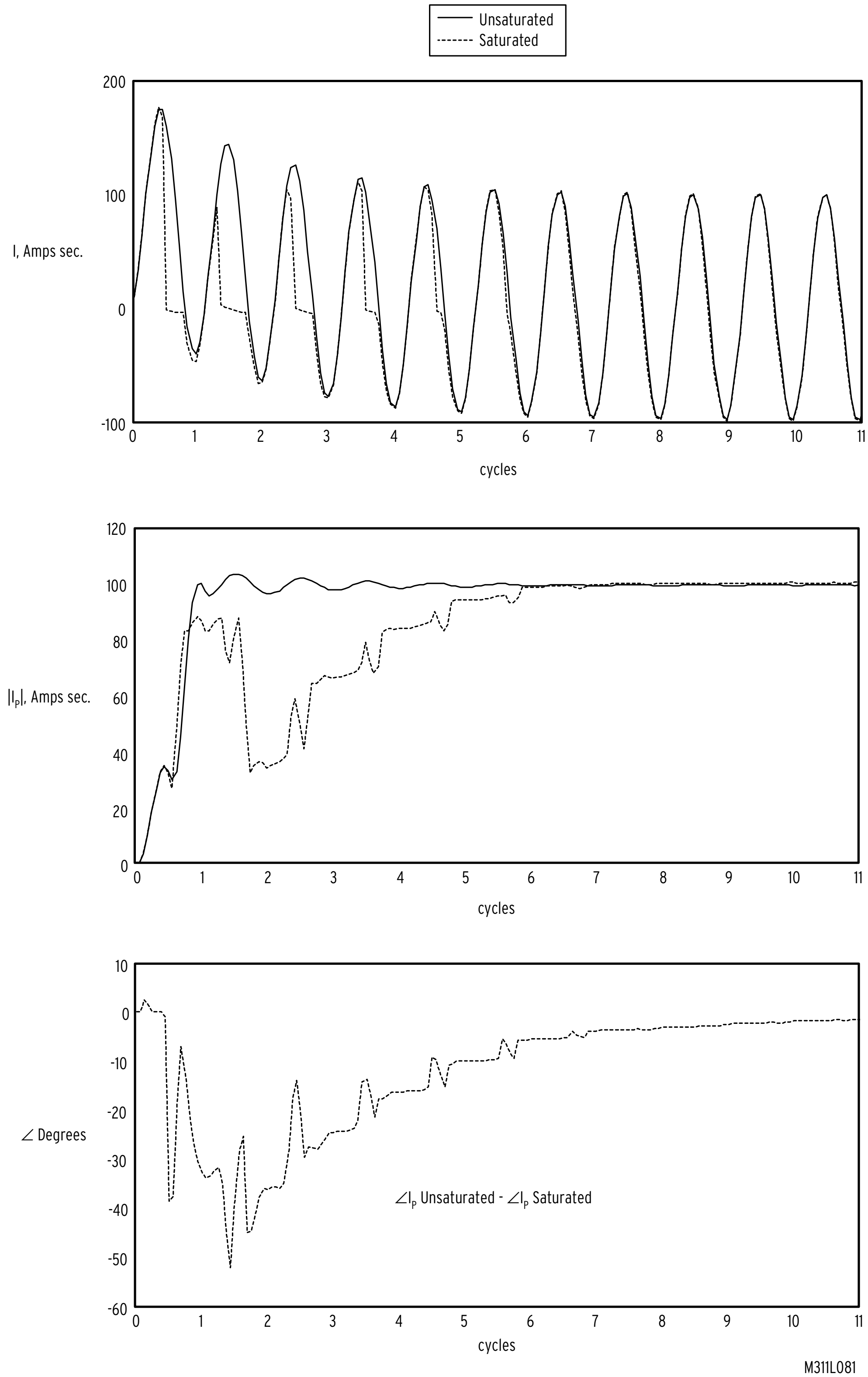

Figure 3.5: CT Saturation Causes Angle Lead and Reduction in Magnitude

Another possible source of phase angle error might be line-charging current. However, since 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 severe combinations of asymmetrical channel delay, system non-homogeneity and load angle, and CT saturation, an internal three-phase fault should lie within about 82 degrees of the positive real axis. System conditions that cause points to lie outside that region can safely be considered non-internal faults (external faults, load current, etc.). All of these conditions are extreme. We shall see that the SEL-311L Relay handles them all easily without settings modifications, 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 which 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 describe above considering maximum load angle, system non-homogeneity, 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.

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. 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 setting used to produce the operate speed curves shown in Figure 3.6 (using high-speed output contacts).

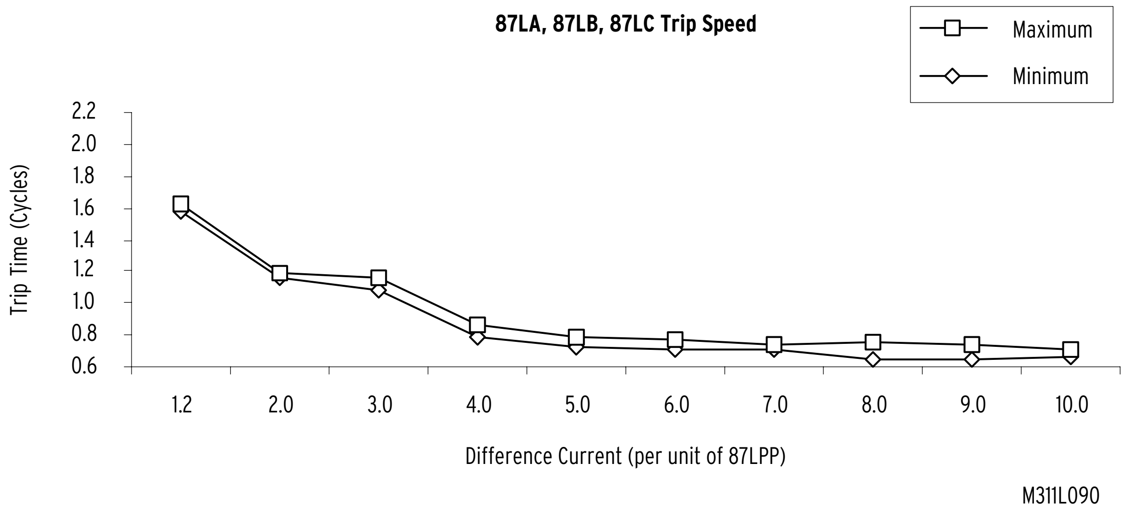

Figure 3.6: Phase 87L Element Trip Speeds for Symmetrical Fault Currents With 87LANG = 195 and 87LR = 6 Using a Direct Fiber Connection

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 homogenous 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 $1\angle0°$ on the negative-sequence Alpha plane, as shown in Figure 3.4. If the system is non-homogenous the angle between the line-end currents is not zero. With 10 degrees of system non-homogeneity, 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 $1\angle0°$ 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 hand 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.

Therefore, the worst-case angle between negative-sequence line end currents is less than the worst-case angle between phase line end currents during an internal fault, because the source angle does not affect the negative-sequence case.

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 which 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 describe 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 during steady state conditions. Line charging current unbalance is usually small. Consider setting 87L2P at 10% of nominal current, or 0.5 A for a 5 A relay. This is the factory default setting for 87L2P.

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).

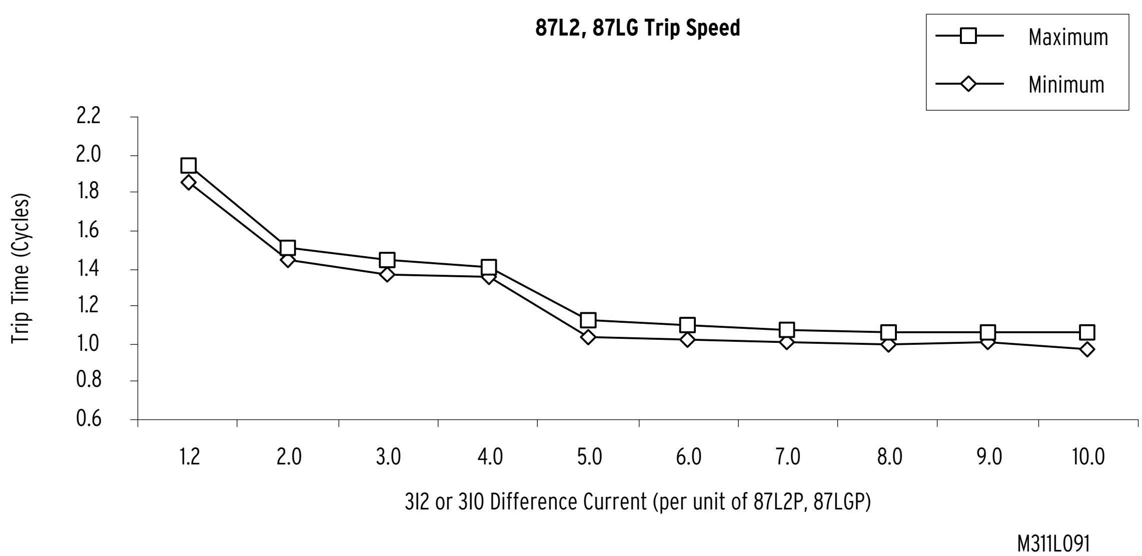

Figure 3.7: 87LG and 87L2 Element Trip Speeds for Symmetrical Fault Currents With 87LANG = 195 and 87LR = 6 Using a Direct Fiber Connection.

These settings give excellent speed and 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 ohms 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 ohms secondary worst case at 1/3 of nominal load current to 45 ohms worst case at nominal load current, as shown in Figure 3.8. This sensitivity is in secondary ohms referenced to the highest CTR.

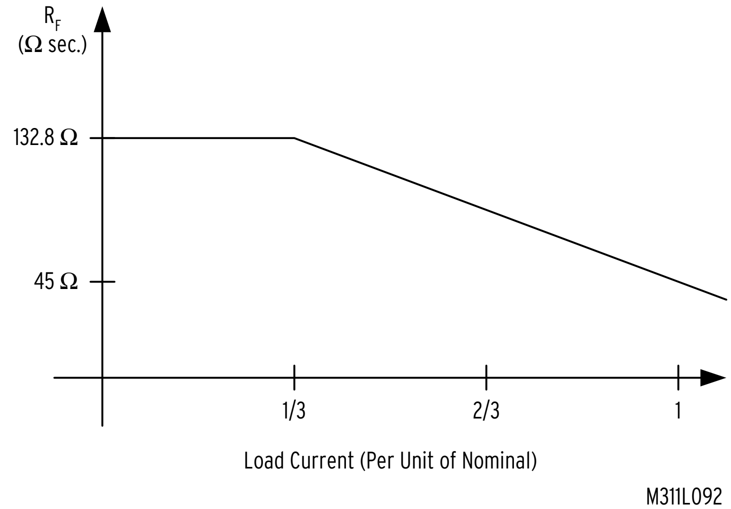

Figure 3.8: Ground Fault Sensitivity of 87L2 and 87LG Elements With 87L2P = 0.5 or 87LGP = 0.5

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 elements.

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. Recall 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.

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. Since 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 which produces CT saturation at one line terminal, the 87L2 element is blocked if all three-phase currents from any line terminal exceed 300% 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% 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.

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 up to 300% 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.

This setting approach favors security. However, given the approach of setting the line current differential elements to detect internal faults even for extreme system conditions, the SEL-311L Relay line current differential elements also give excellent dependability.

SEL-5601 Produces Alpha Plane Plots

Use the SEL-5601 Analytic Assistant to visualize SEL-311L Relay event reports on the Alpha plane. Retrieve differential event reports using the **CEV L** or **EVE C** commands. The SEL-5601 reads compressed SEL-311L Relay event reports and produces Alpha plane plots for phase current, negative-sequence current, or zero-sequence current. For example, Figure 3.9 shows an SEL-5601 screen capture of the Phase A Alpha plane plot for an external fault that produced CT saturation at the local terminal but not at the remote terminal. The saturated and unsaturated current waveforms are shown in Figure 3.5.

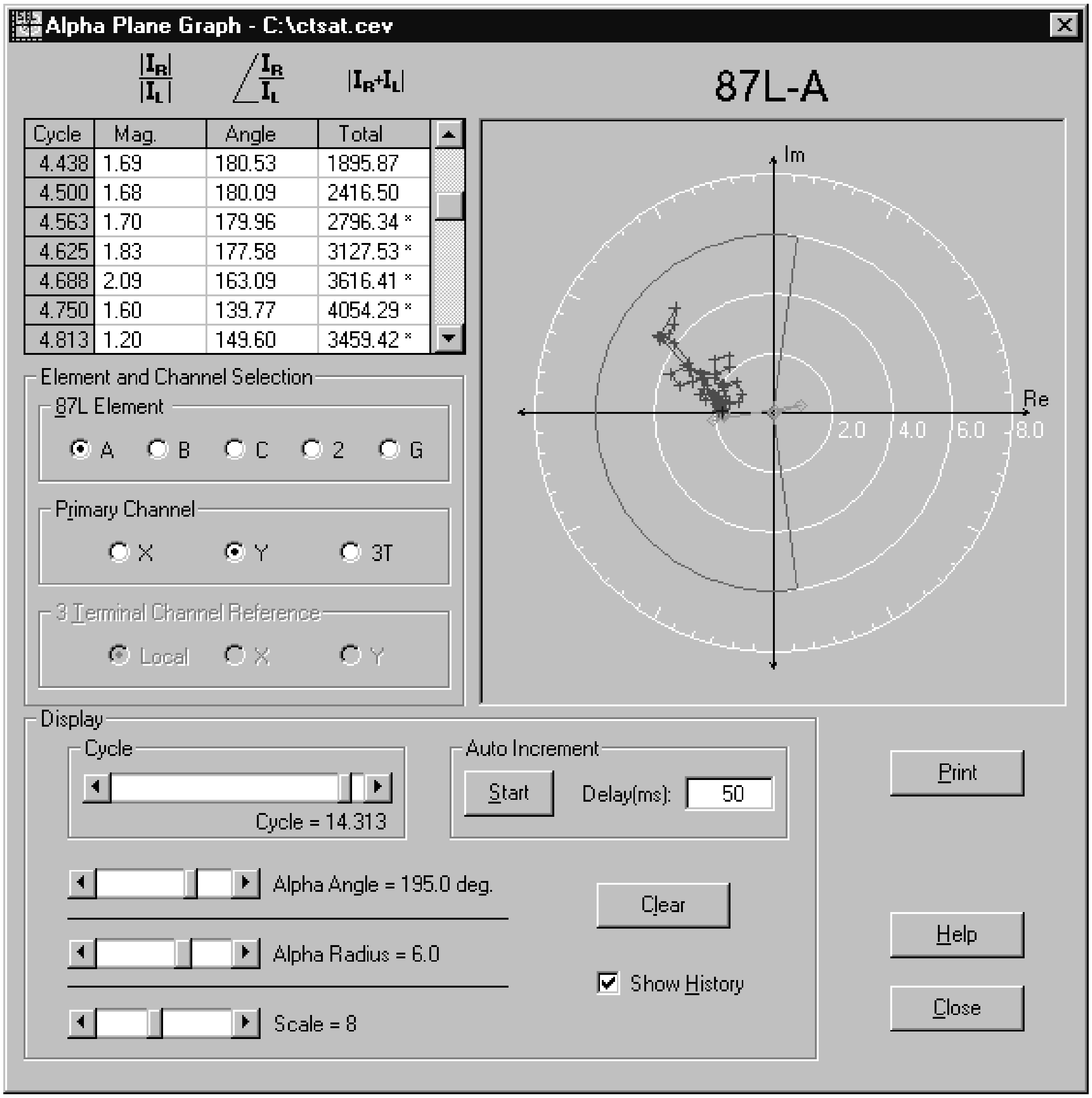

Figure 3.9: SEL-5601 Screen Capture of the Alpha Plane Plot for an External Fault With CT Saturation at One Terminal

Notice that the CT saturation shown in Figure 3.5 is severe, and the restraint region shown in Figure 3.9 easily contains the plot locus.

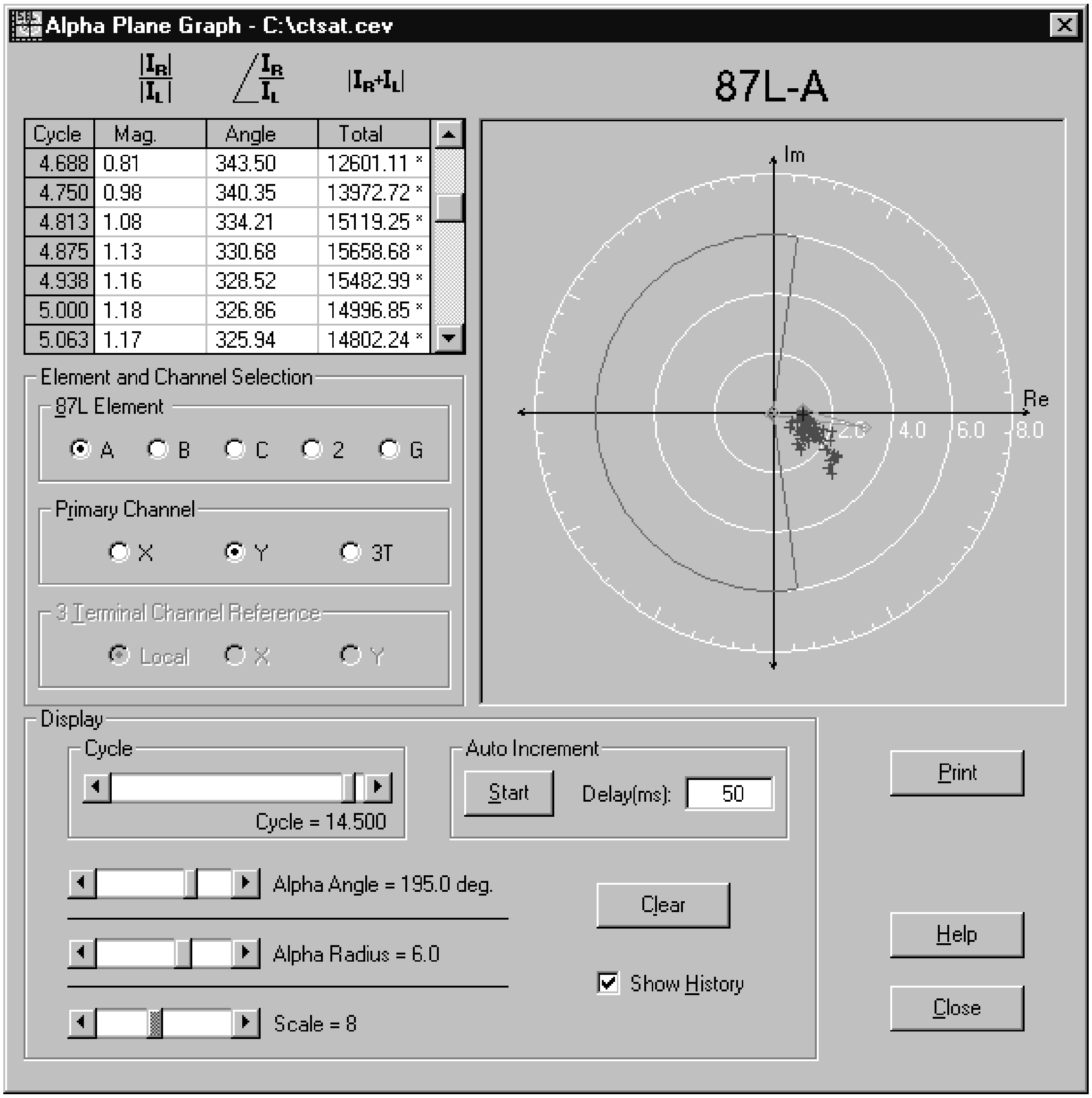

Figure 3.10: SEL-5601 Screen Capture of the Alpha Plane Plot for an Internal Fault With CT Saturation at One Terminal

Figure 3.10 shows the Alpha plane plot generated by applying the waveforms shown in Figure 3.5 as an internal fault. Notice that the locus does not encroach on the restraint characteristic for this internal fault.

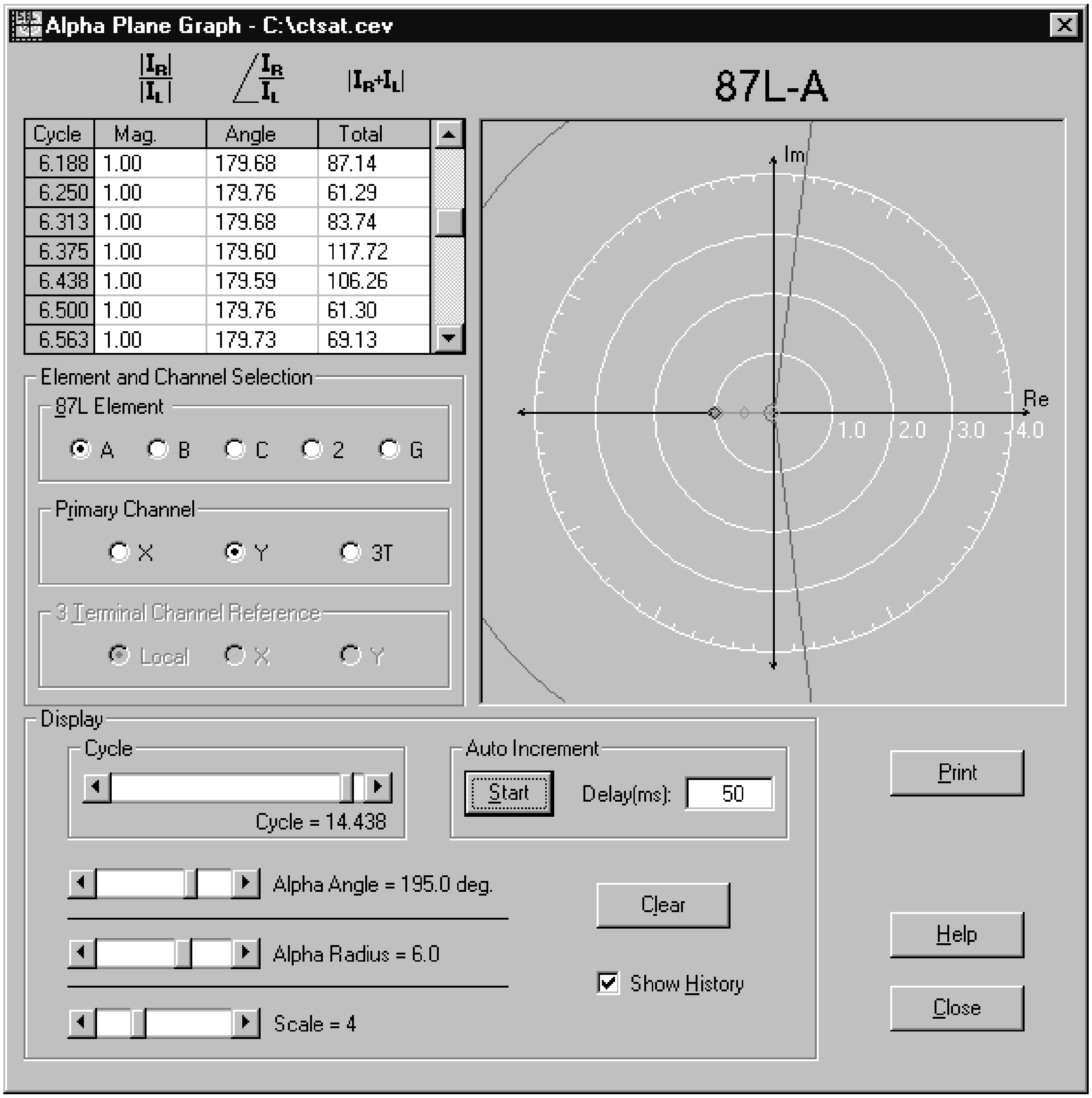

Figure 3.11: SEL-5601 Screen Capture of the Alpha Plane Plot for an External Fault With No CT Saturation

Figure 3.11 shows the Alpha plane plot for an external fault without CT saturation. Notice that the locus is tightly grouped around $1\angle 180°$.

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 3.12. 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 which produce more than 6 • 240 = 1440 A phase difference current. Event reports and meter displays report primary values (current, voltage, power, and energy).

Figure 3.12: SEL-311L Relays Applied With Different CT Ratios

APP (87L, 87L21, 87L21P, 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. 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 3.16, 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)

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 through OUT206. For example, if EHST = 3, the relay controls output contacts OUT201 through OUT203 operate 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.

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: Inputs, Outputs, Timers, and Other Control Logic*** for more information regarding setting EHST and outputs OUT201 through 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)

ESHDTT 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.

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 due to 87L element assertion. Relay Word bit DD does not supervise received direct trip signals. Set EDD = N when weak- or zero-infeed conditions are possible at the local terminal.

Disturbance detector supervision is intended to prevent misoperation due to undetected errors in 87L communications. Undetected errors are transient in nature, so 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*** in ***Section 9: Setting the Relay*** describes how to coordinate with tapped-load protection using these elements.

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 Relay connected to Channel X. Set CTR_Y to match setting CTR in the remote SEL-311L Relay connected to Channel Y. Settings CTR_X and CTR_Y may be different from each other and different from the local CTR setting. This accommodates different CT ratios at all line terminals. All 87L line current differential settings are in secondary Amps, 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 Amps, 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. As mentioned above, set 87L2P above expected line charging current unbalance. As with setting 87LPP, setting 87L2 is in Amps secondary referenced to the relay with the highest CTR setting.

87LGP (OFF, 0.5–5 A Secondary)

The zero-sequence differential element 87L2 restrains when the |3I0| is less than 87LGP. Set 87LGP above expected line charging current unbalance. As with setting 87LPP, setting 87LG is in Amps 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 then 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 Amps, referenced to the relay with the highest CTR setting.

87LR (2.0–8, Unitless)

This setting controls the outside 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 extend 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.

Three-Terminal Protection With the SEL-311L

Three-Terminal Protection Logic

Use the 87L elements and other elements in the SEL-311L Relay for three-terminal line protection. The SEL-311L Relay 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 when calculating the Alpha plane ratio of remote to local current. In other words, the SEL-311L Relay 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, because all three possibilities result in the correct trip/restrain decision.

The SEL-311L Relay processes all 87L elements using all three possible combinations of remote current. 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 3.13. 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 which used the largest ground current as the local current.

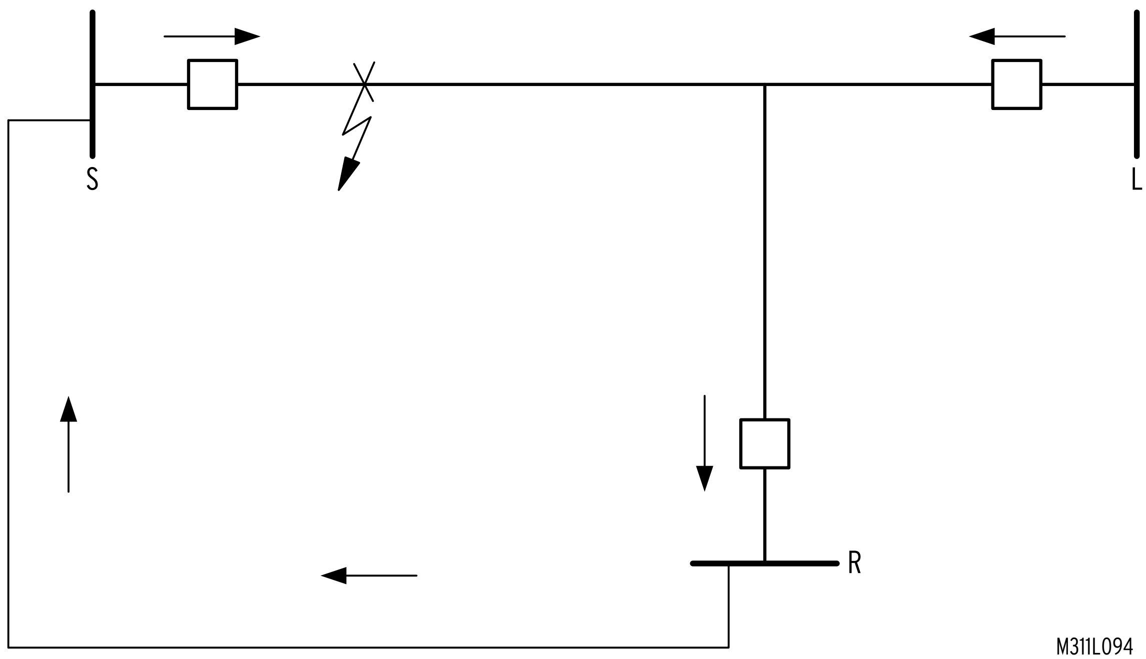

Figure 3.13: Internal Fault on Three-Terminal Line May Produce Outfeed at One Terminal

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 which resulted from using 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 3.14 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 it is 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 one of the other terminal currents as the largest. Assume the relays select Terminal L as the largest current magnitude, and so 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.

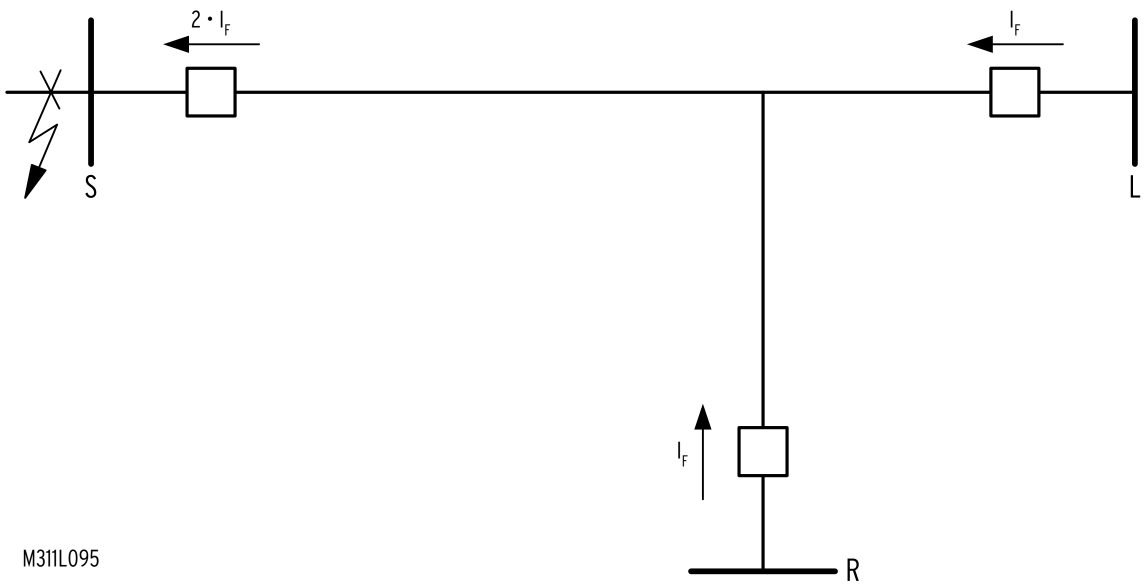

Figure 3.14: External Fault on Three-Terminal Line With Equal Infeed from Two Terminals

To prevent the relay 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.

$$I_F\ Z_B \le \frac{50}{\left(X/R + 1\right)} \qquad \text{Equation 3.2}$$

where: I_F = secondary fault current, per unit of nominal (e.g., I_F sec. / 5)

Z_B = per unit of rated secondary burden (e.g., Z_B sec. / 8 for class C800)

X/R = system X/R ratio

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

Figure 3.15 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 that case, the other two relays automatically disable 87L protection and enable direct-transfer tripping, **even if setting EHSDTT = N**.

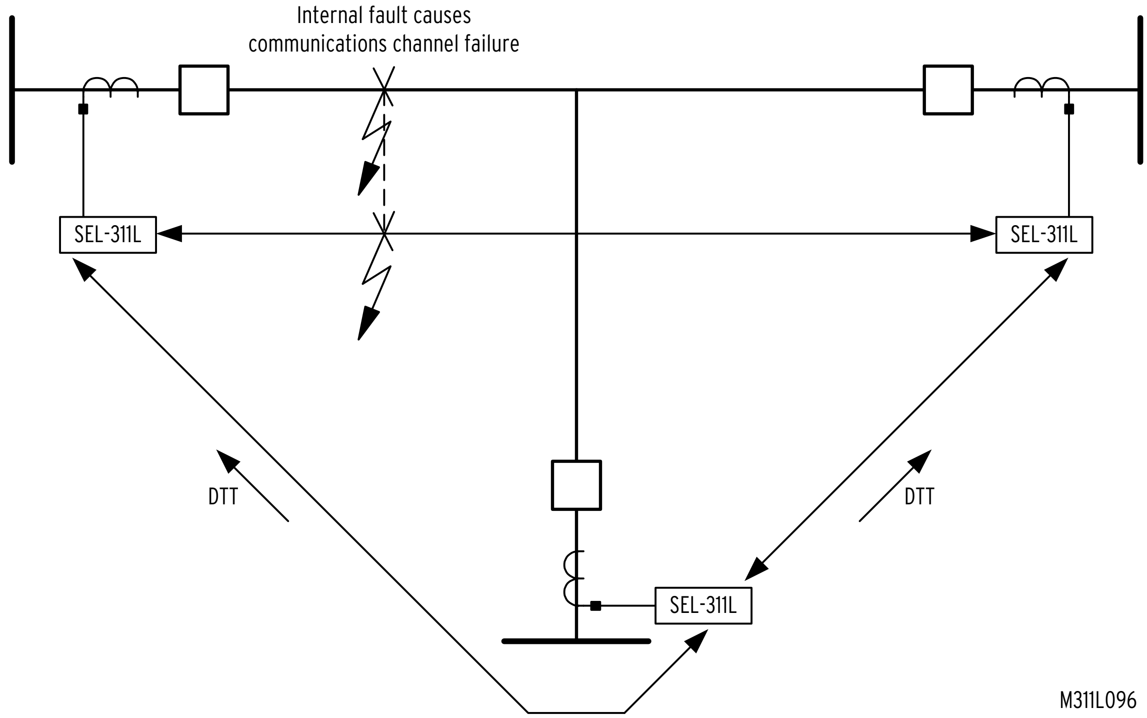

Figure 3.15: Three-Terminal Line With Internal Fault and Channel Failure

Alternatively, install only two communications channels as shown in Figure 3.16. 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.

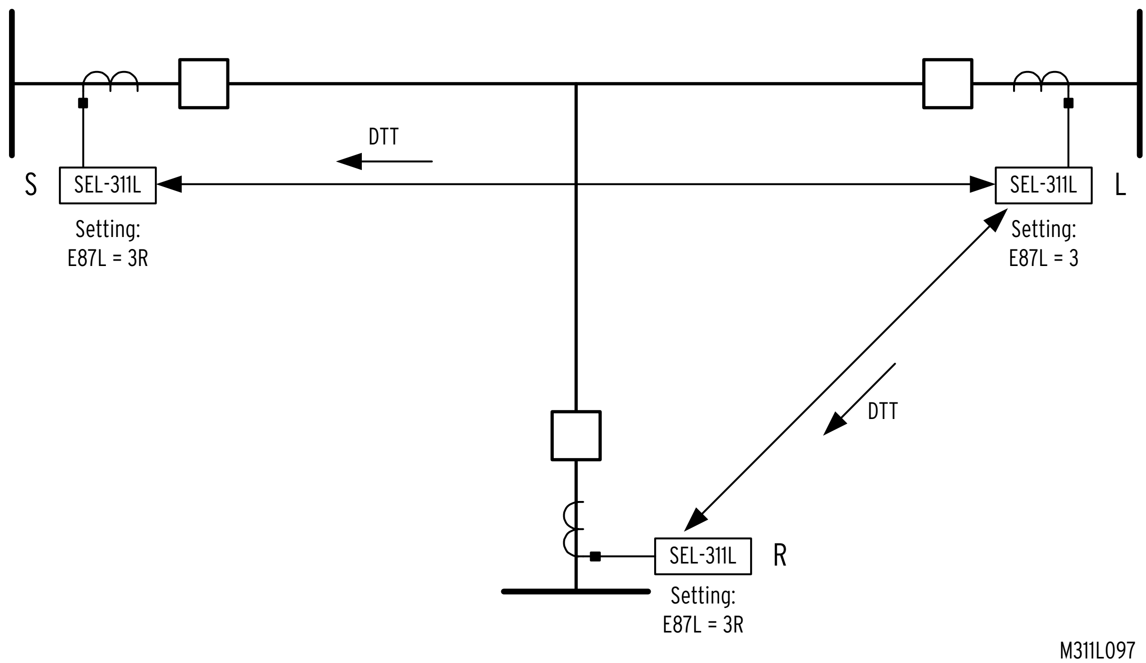

Figure 3.16: SEL-311L Relay Protects Three-Terminal Line Using Only Two Communications Channels

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	B87LA	PQ87LA
B-phase	50RB	50LB	87LOPB	87LBE	CTAB	R87LB	B87LB	PQ87LB
C-phase	50RC	50LC	87LOPC	87LCE	CTAC	R87LC	B87LC	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 BXYZA, BXYZB, BXYZC, BXYZ2, and BXYZG assert if any of the three processing methods asserts the corresponding block bit B87LA, B87LB, B87LC, B87LG, or B87L2.

Differential Element Settings and Specifications

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
Tapped-Load Coordinating Overcurrent Elements:		Y, N
Enable Setting:	ETP	Y, N (Phase)
	ETG	Y, N (Residual Ground)
	ETQ	Y, N (Negative-Sequence)

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 [1]
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

[1] If 51PC is a C curve, this range is 0.05–1.0.

Tapped-Load Phase Inst. 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 [1]
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

[1] If 51GC is a C curve, this range is 0.05–1.0.

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

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 [1]
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

[1] If 51QC is a C curve, this range is 0.05–1.0.

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

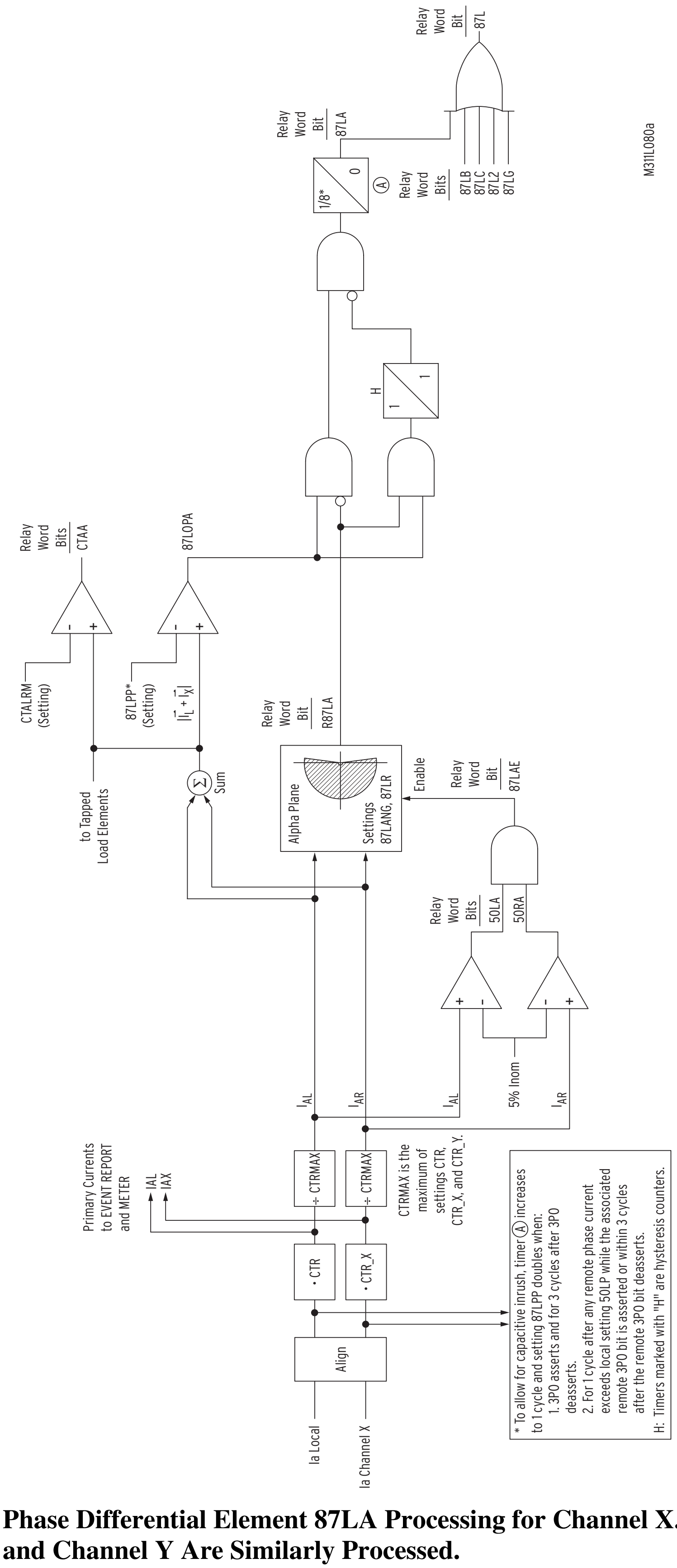

Figure 3.17: Phase Differential Element 87LA Processing for Channel X. B and C Phases and Channel Y Are Similarly Processed.

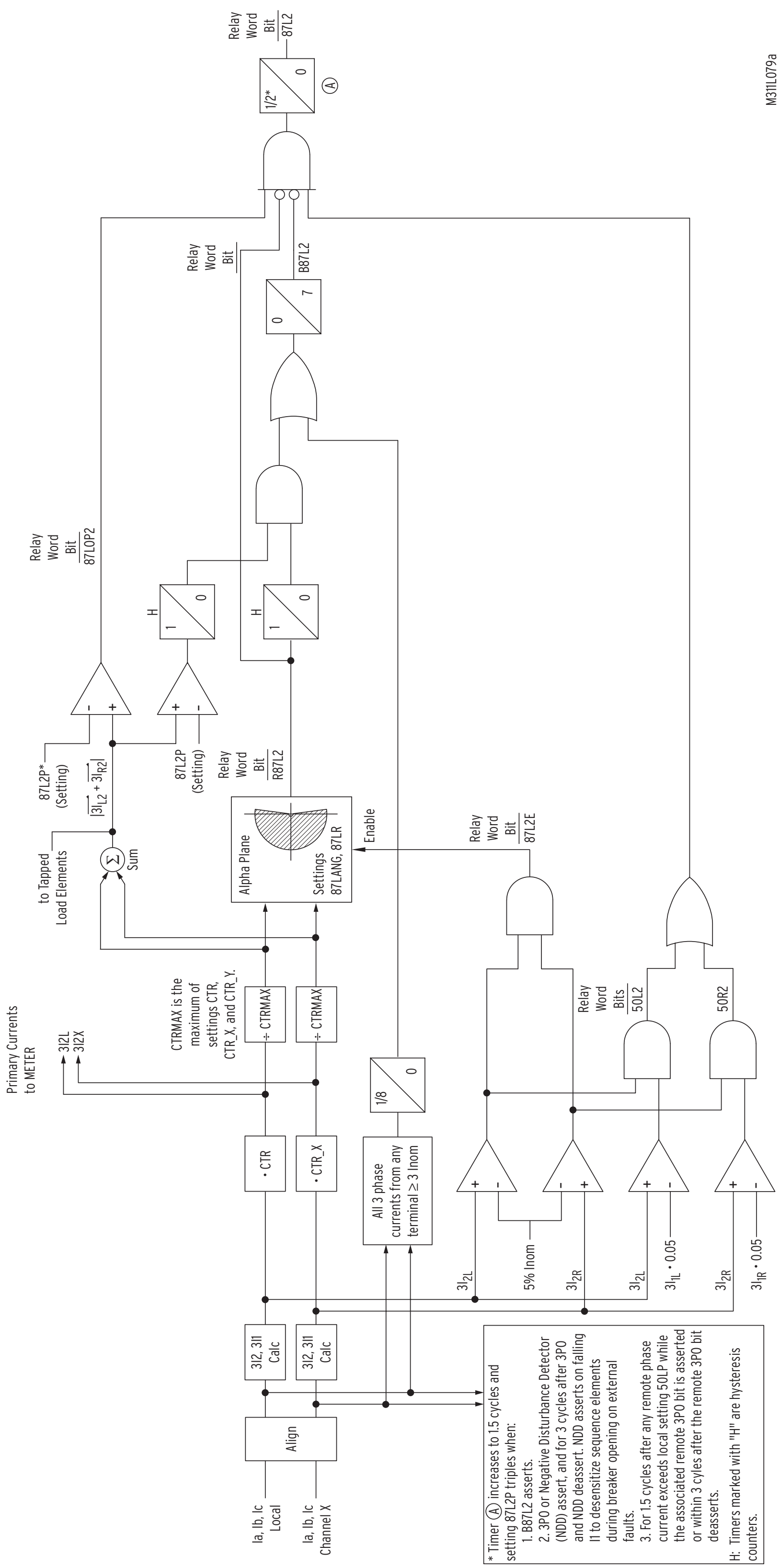

Figure 3.18: Negative-Sequence Differential Element 87L2 Processing for Channel X. Channel Y Processing Similar.

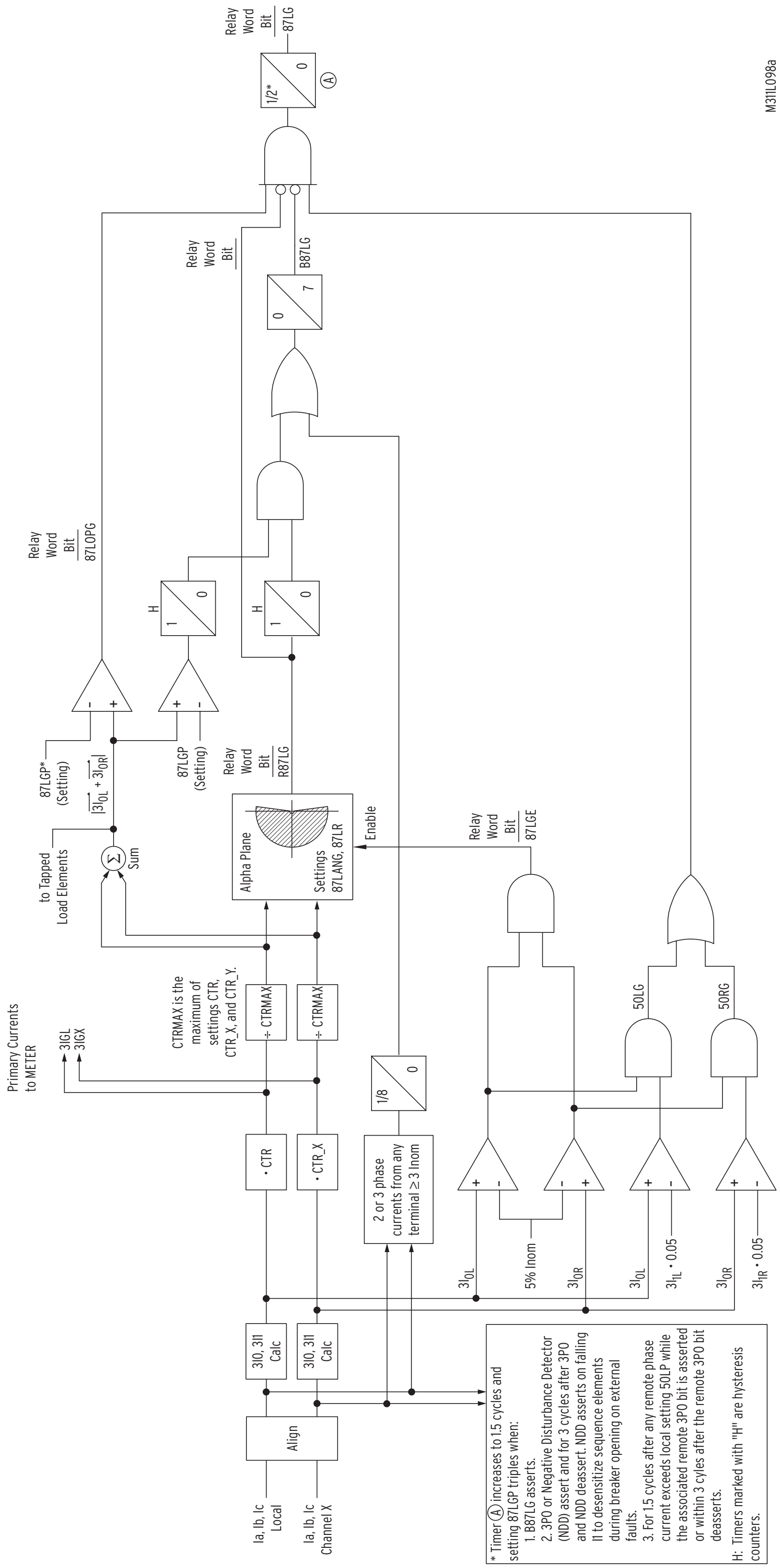

Figure 3.19: Ground Differential Element 87L2 Processing for Channel X. Channel Y Processing Similar.

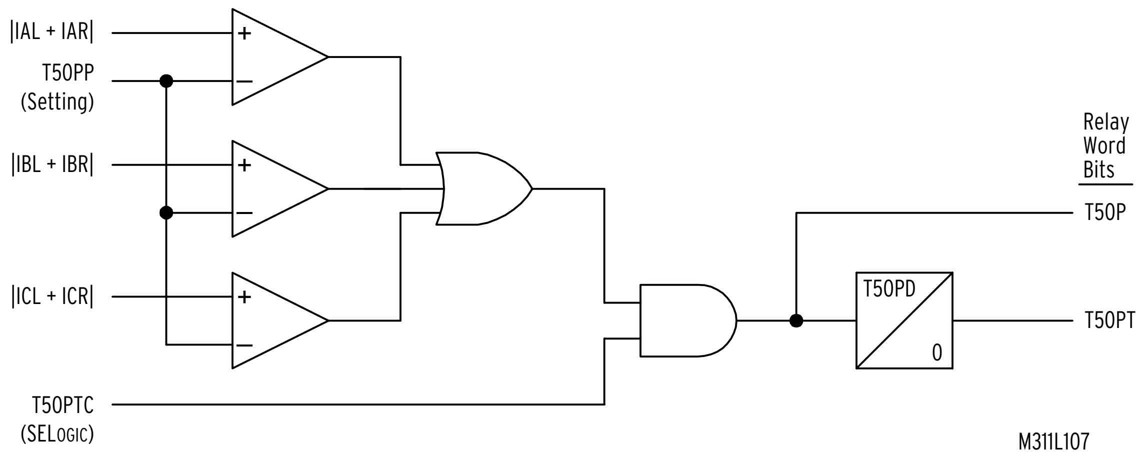

Figure 3.20: Phase Instantaneous and Definite Time Overcurrent Elements

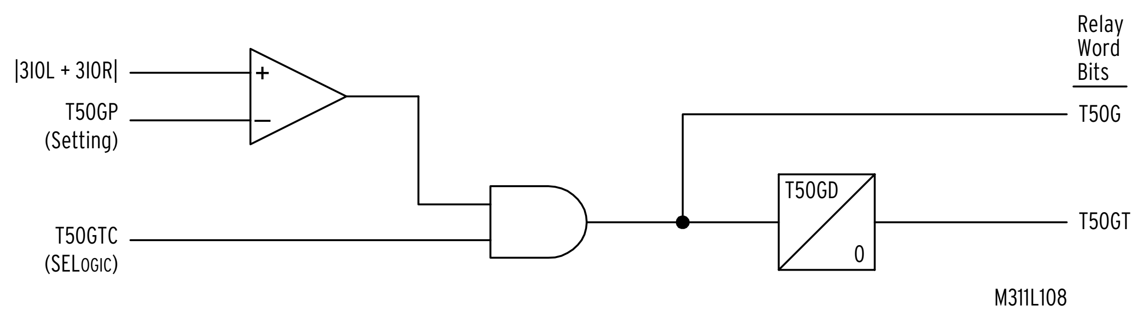

Figure 3.21: Residual Instantaneous and Definite Time Overcurrent Elements

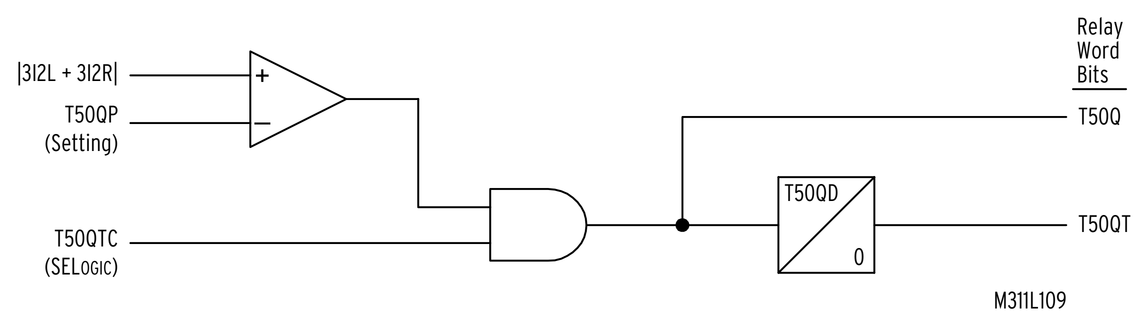

Figure 3.22: Negative-Sequence Instantaneous and Definite Time Overcurrent Elements

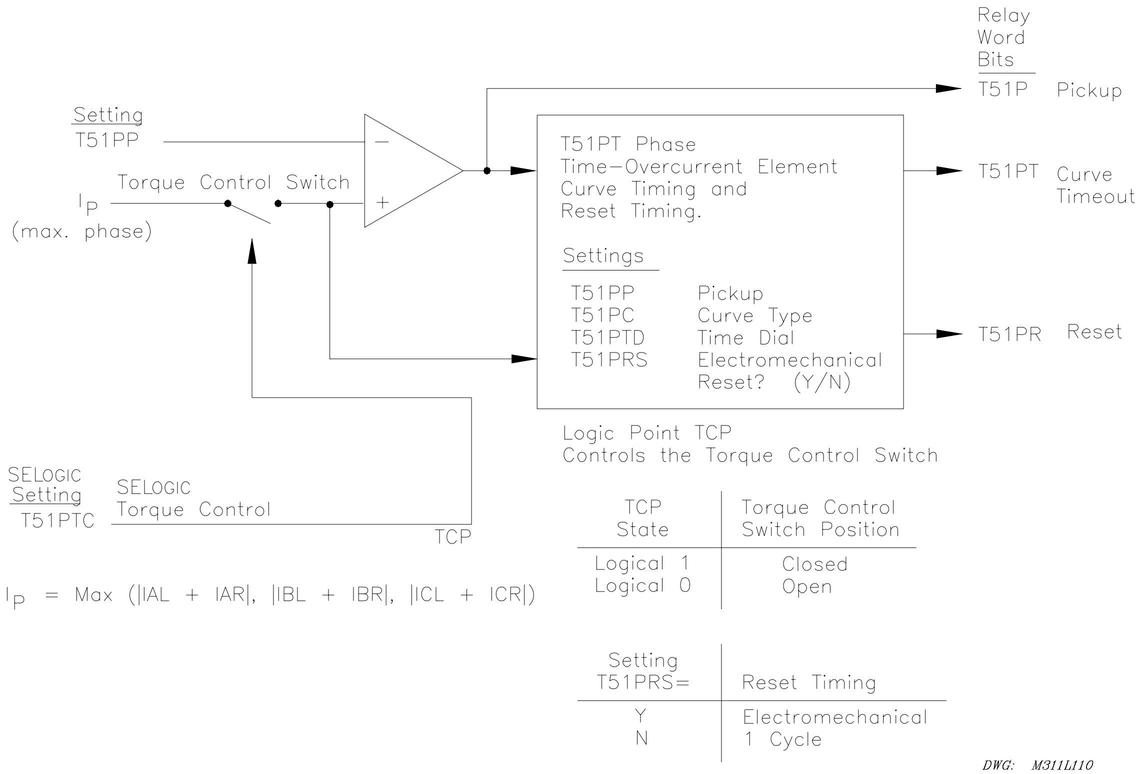

Figure 3.23: Phase Time-Overcurrent Elements

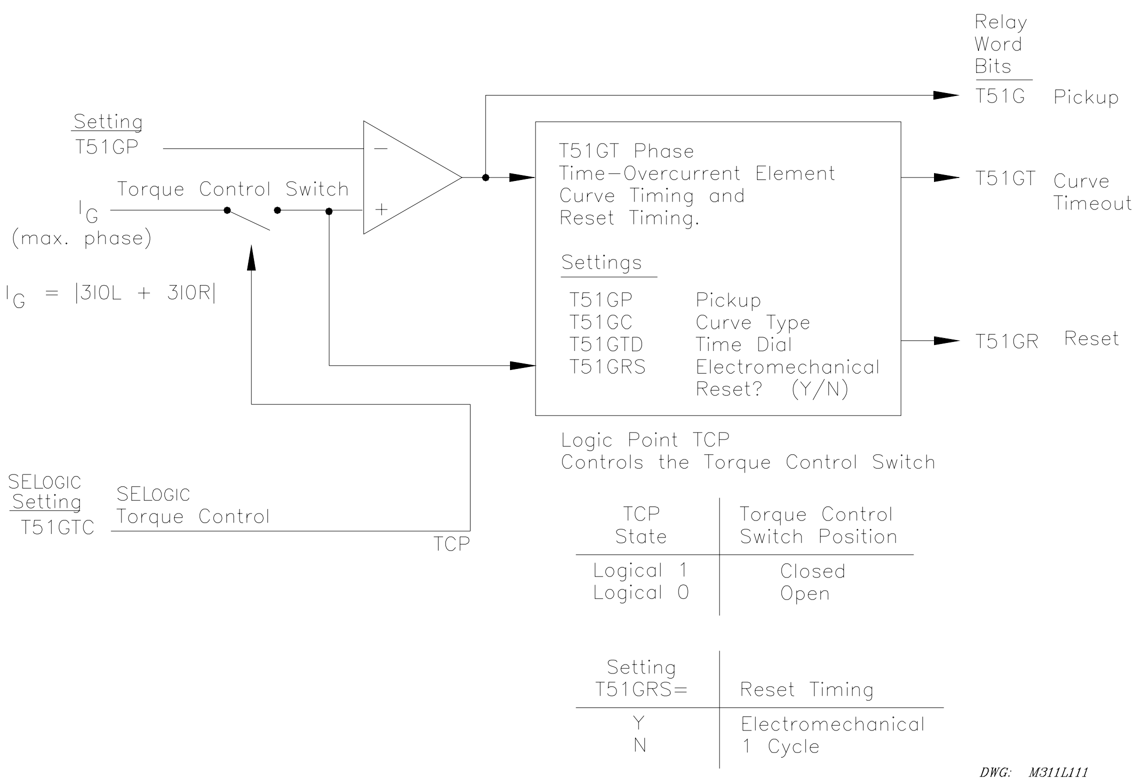

Figure 3.24: Residual Ground Time-Overcurrent Elements

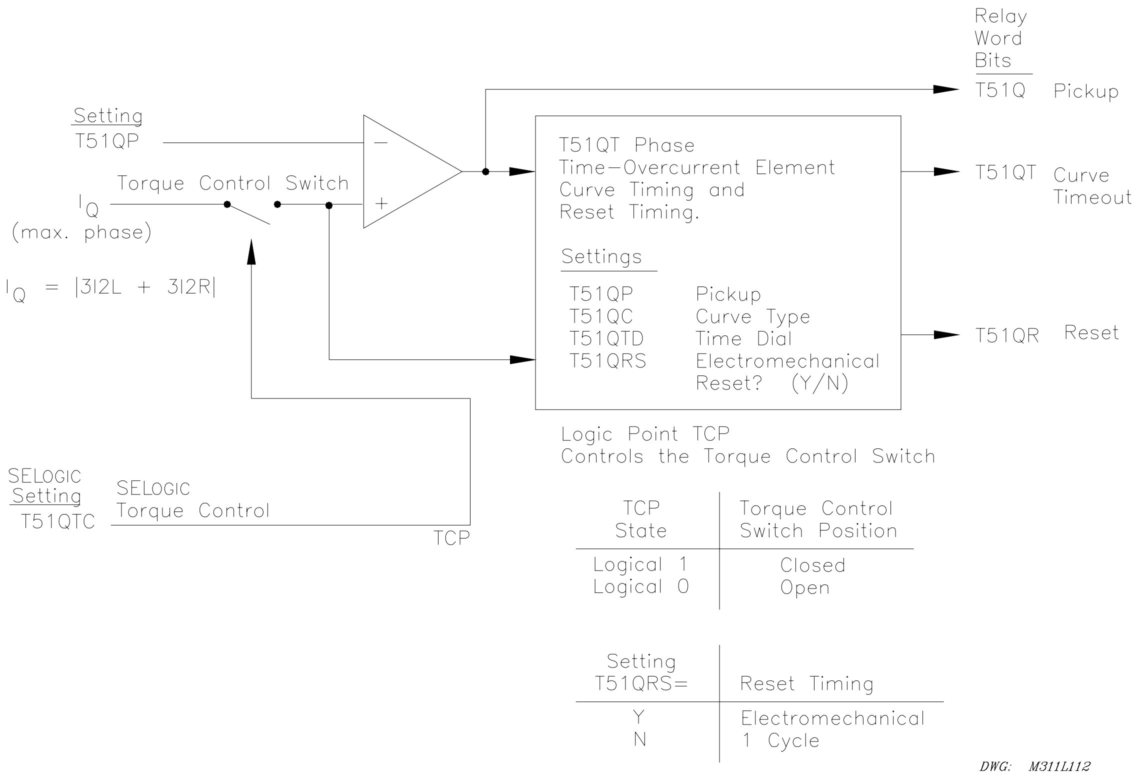

Figure 3.25: Negative-Sequence Time-Overcurrent Elements

DISTANCE ELEMENTS

Mho Phase Distance Elements

The SEL-311L Relay has four independent zones of mho phase distance protection. All zones are independently set. Zone 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 Relay 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 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 Figures 12.6 and 12.7 in ***Chapter 12: Standard Event Reports and SER*** 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 3.4 shows the different calculations used for the positive-sequence polarized mho elements and compensator-distance mho elements. Notice that the positive-sequence polarized mho element equation is the solution of Equation 3.3 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.

$$0 = \text{Re}\left[(Z \bullet I - V) \bullet V_1\text{mem}^*\right] \qquad \text{Equation 3.3}$$

Table 3.4: Phase Distance Calculations

	Positive-Sequence Polarized Mho Element	**Compensator-Distance Mho Element**
Distance Calculation in a Digital Relay	$\text{mAB} = \dfrac{\text{Re}(V_{AB} \bullet V_{AB1}\text{mem}^*)}{\text{Re}(1\angle Z \bullet I_{AB} \bullet V_{AB1}\text{mem}^*)}$ Phase A-B $\text{mBC} = \dfrac{\text{Re}(V_{BC} \bullet V_{BC1}\text{mem}^*)}{\text{Re}(1\angle Z \bullet I_{BC} \bullet V_{BC1}\text{mem}^*)}$ Phase B-C $\text{mCA} = \dfrac{\text{Re}(V_{CA} \bullet V_{CA1}\text{mem}^*)}{\text{Re}(1\angle Z \bullet I_{CA} \bullet V_{CA1}\text{mem}^*)}$ Phase C-A Z = Impedance measurement at the line angle	$\text{mPP} = \text{Im}\left[(V_{AB} - Z \bullet I_{AB}) \bullet (V_{BC} - Z \bullet I_{BC})^*\right]$ Phase-to-Phase Element $\text{mABC} = \text{Im}\left[(V_{AB} - Z \bullet I_{AB}) \bullet (-jV_{AB} - 0.25 \bullet V_C\text{mem})^*\right]$ 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. rZ = Replica line impedance at operating or balance point.

As mentioned previously, a digital relay mho element tests the angle between a line drop-compensated voltage and a polarizing (reference) voltage. Figure 3.26 through Figure 3.28 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.

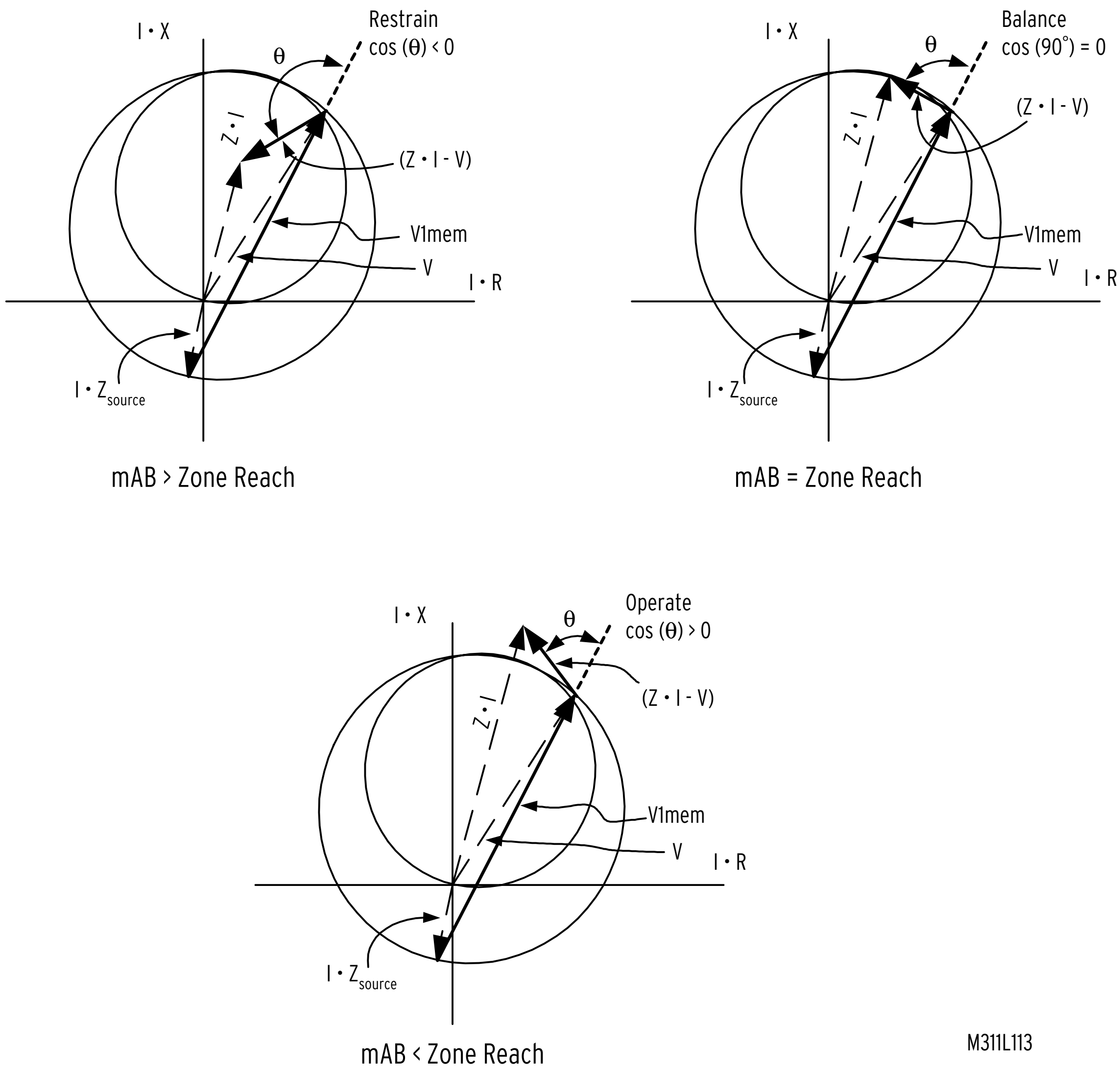

Figure 3.26: Positive-Sequence Polarized Mho Element With Reach Equal to Line Impedance

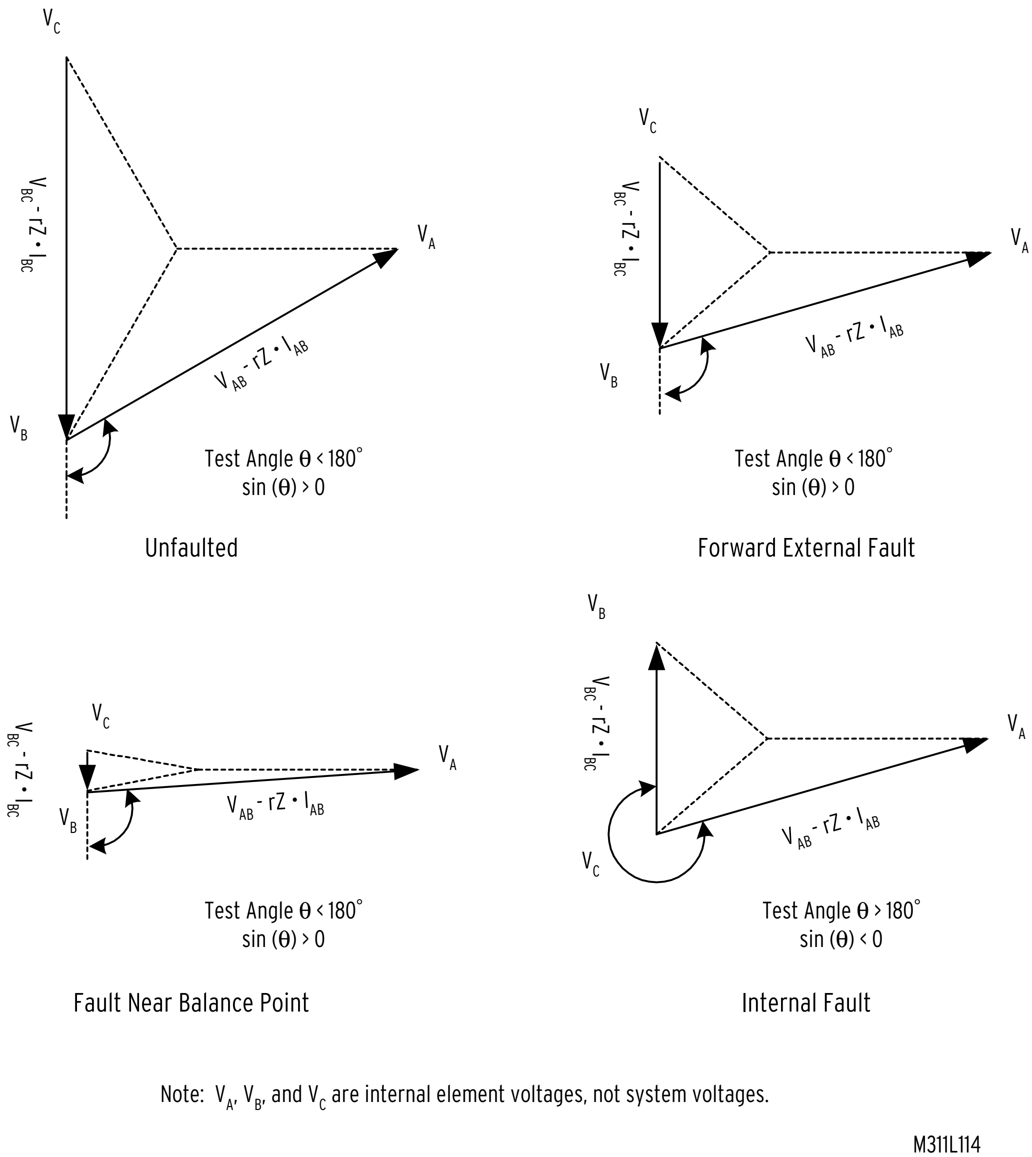

Figure 3.27: Compensator-Distance Phase-to-Phase Element Operation

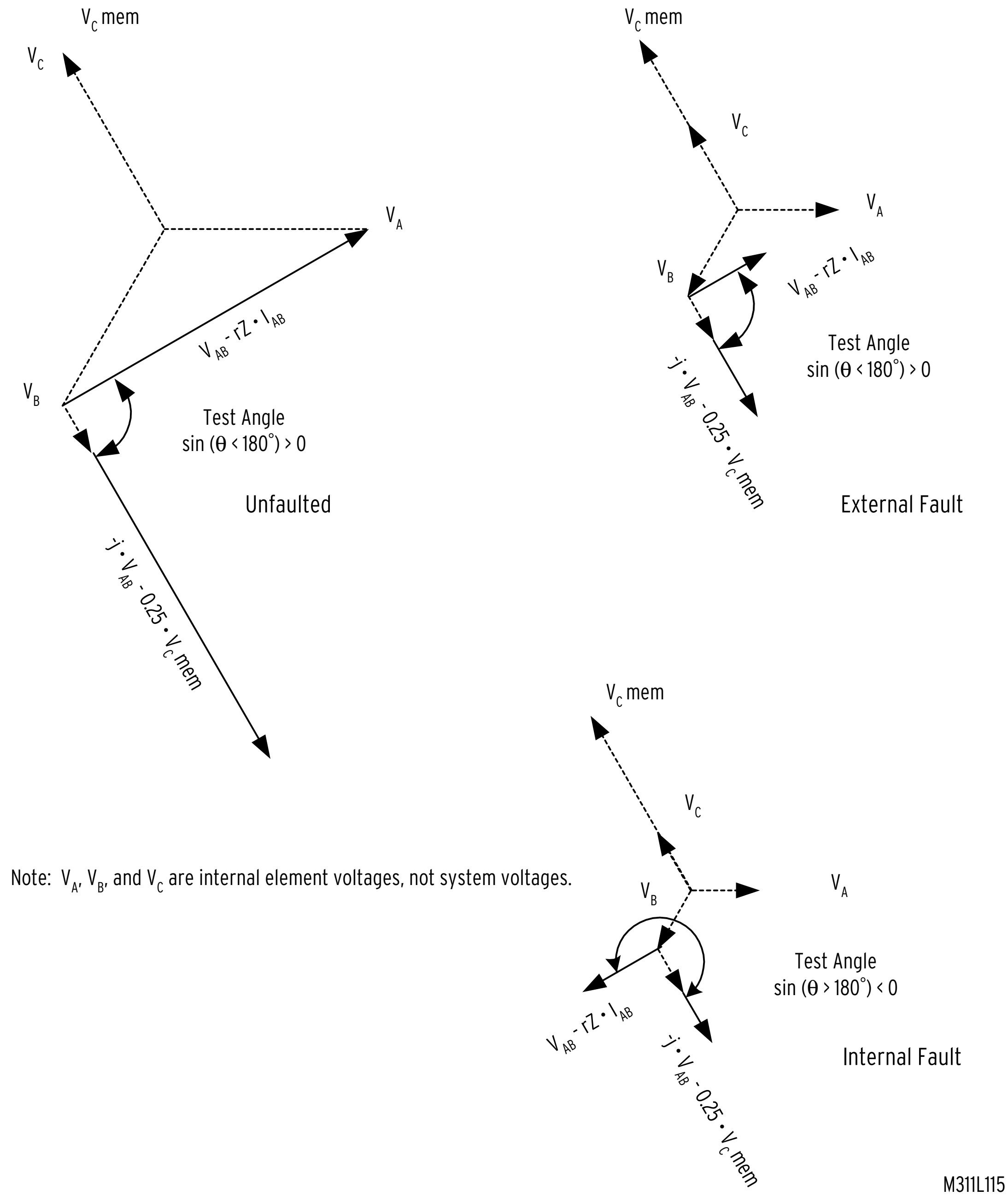

Figure 3.28: Compensator-Distance Three-Phase Element Operation

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 ***Application Guide AG96-16: Applying SEL Distance Relays on Lines with Power Transformers or Open Delta VTs*** for more information.

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

  79DTL = MABC2 * !MPP2 …

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

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). If EADVS = N and compensator distance elements are selected, E21MG is set to "N" and hidden. If EADVS = Y, setting E21MG is visible and the user may apply ground distance relaying along with compensator distance phase relaying.

Mho Phase Distance Elements (Zones 1–4)

Enable Setting:	E21P
Setting range for Mho Phase Distance Elements (Z1P through 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): **Note:** If setting EADVS = N, settings 50PP2–50PP4 are at minimum values and are hidden.	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 3.43 and Figure 3.44.

Mho Phase Distance Elements

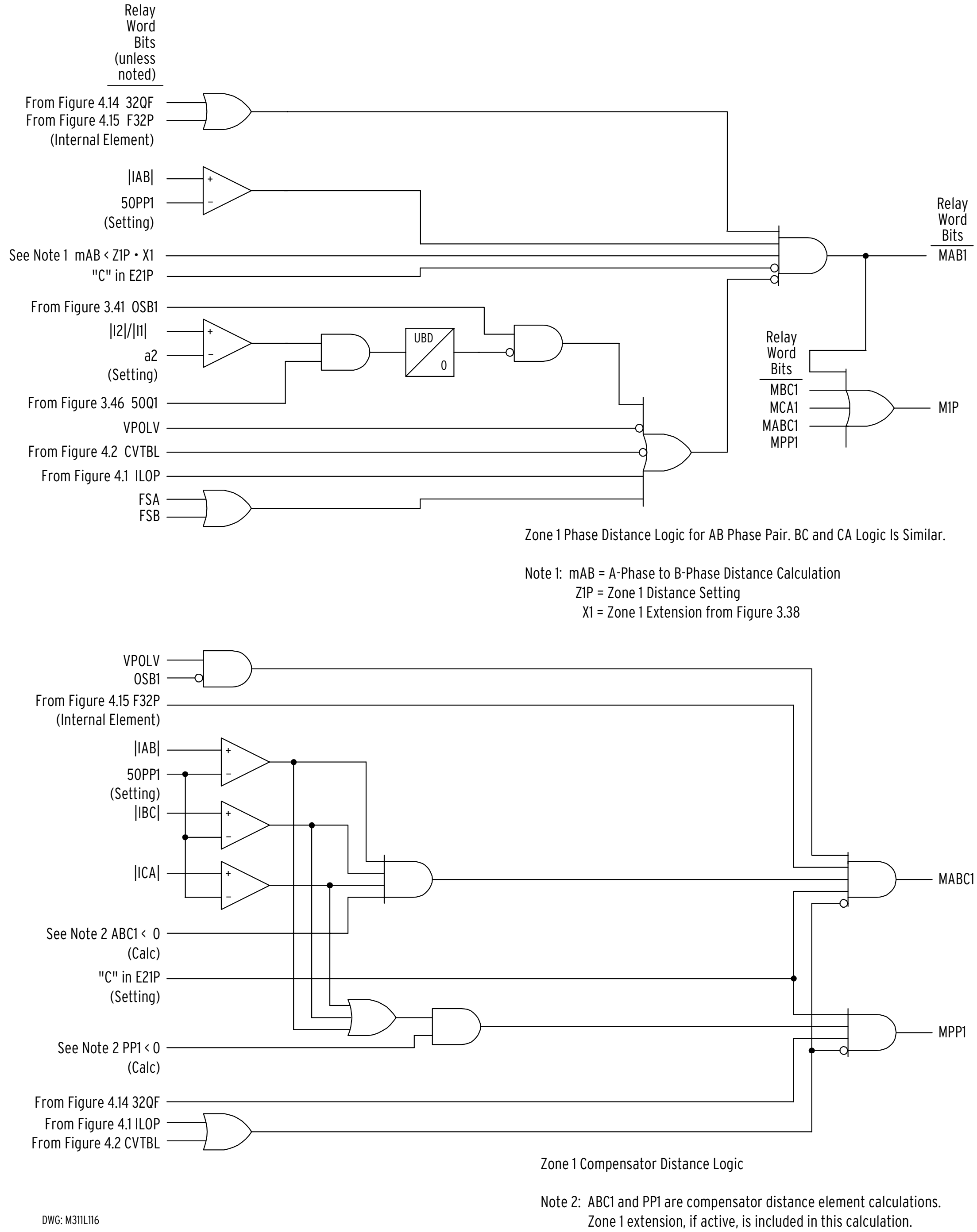

Figure 3.29: Zone 1 AB Phase Distance Logic

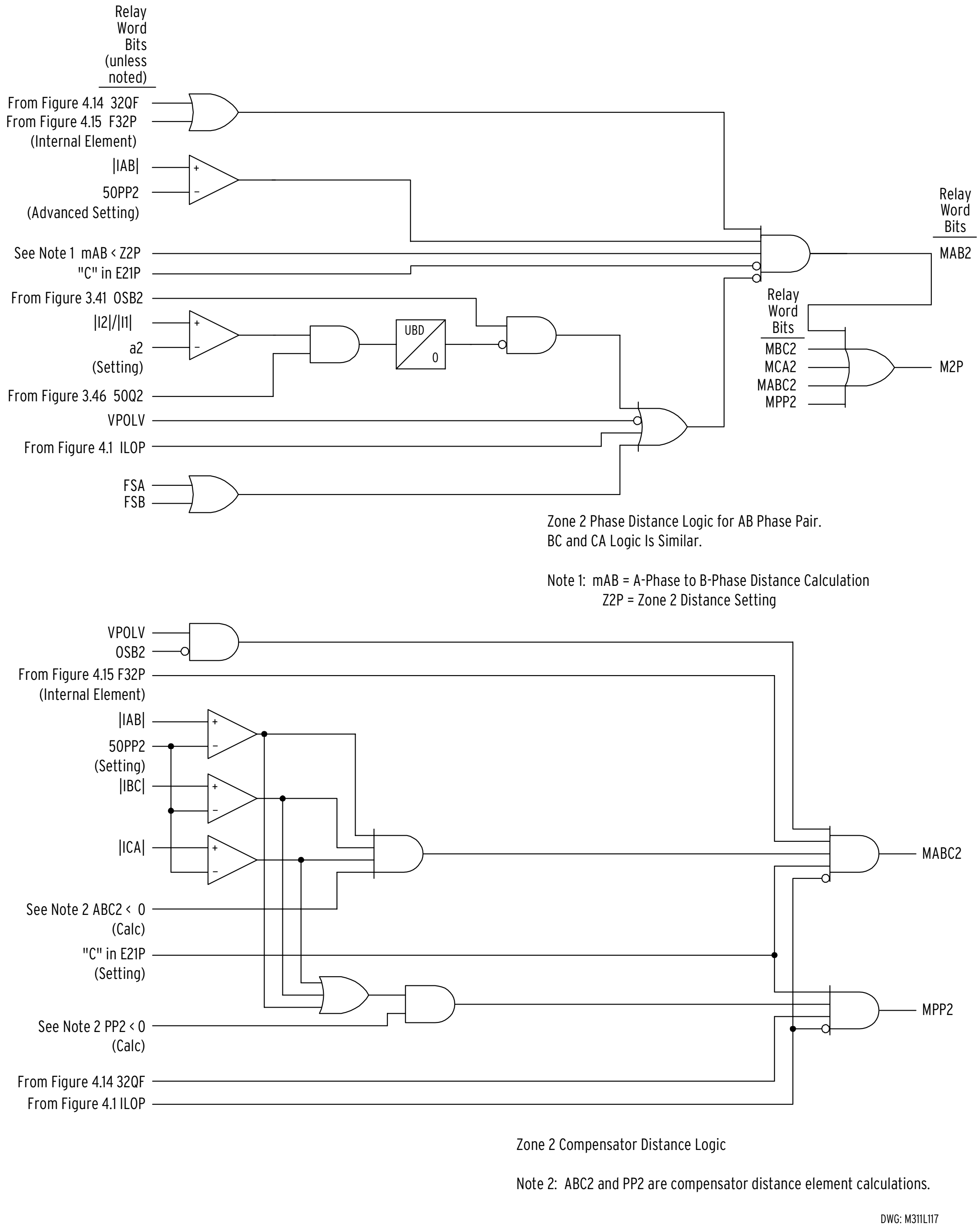

Figure 3.30: Zone 2 AB Phase Distance Logic

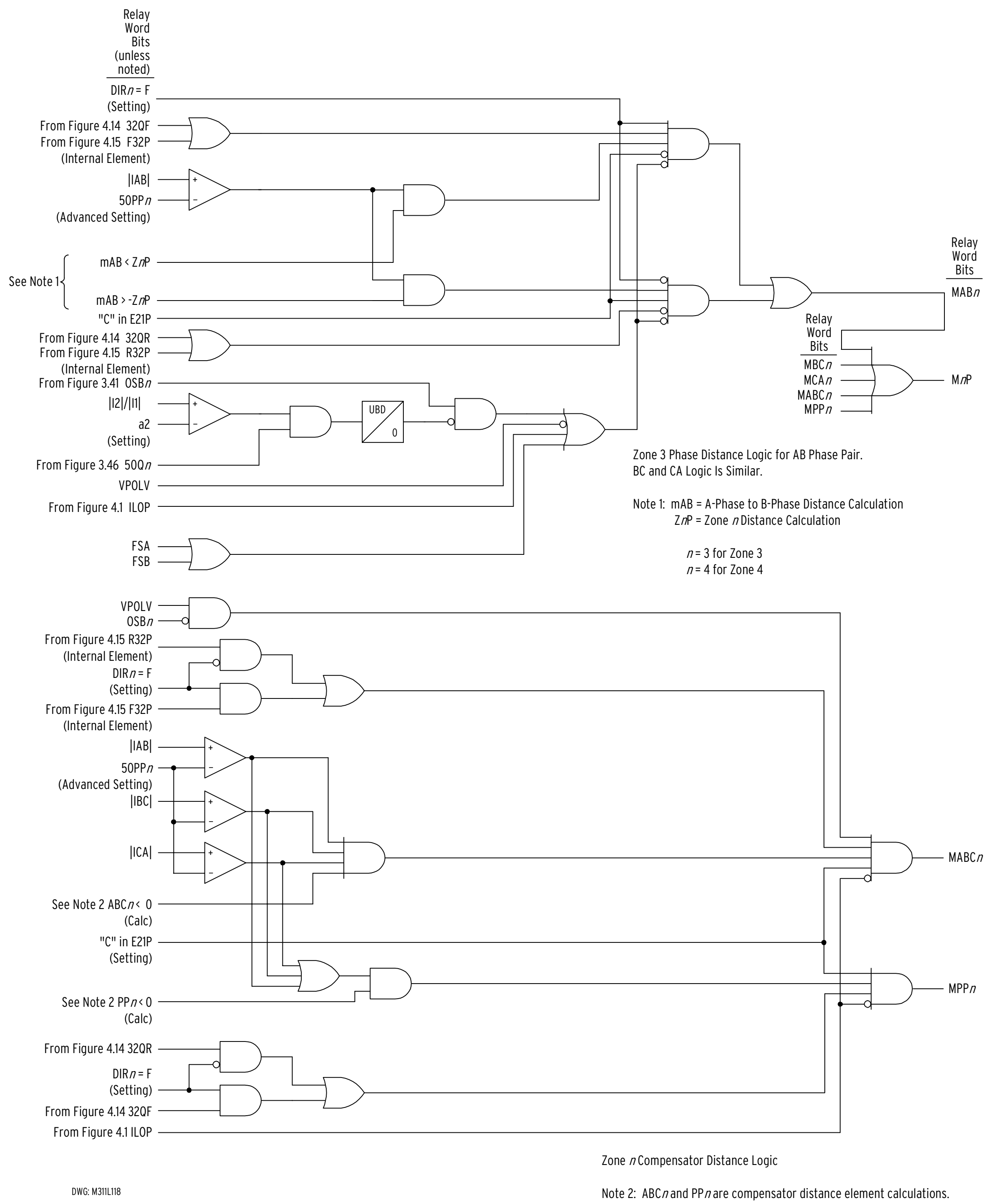

Figure 3.31: Zones 3 and 4 AB Phase Distance Logic

Ground Distance Elements

The SEL-311L Relay 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).

Impedance Reach (Zones 1–4)

Enable Setting:	E21MG Mho Ground E21XG Quadrilateral Ground
Settings range for Mho elements (Z1MG through 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 through 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 through 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 $30 \le SIR \le 60$ ±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 through 50L4 and 50GZ1 through 50GZ4): **Note:** If EADVS = N, levels 2–4 fault detectors are set at their minimum values and are hidden.	0.50–100.00 Amps secondary, 0.01 A steps (5 A nominal) 0.10–20.00 Amps 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 3.43 and Figure 3.44.

Other Settings

Settings range for zero sequence compensation (ZSC) factor magnitude:

k0M1 = 0.000–6.000 unitless (Zone 1)
k0M = 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 = -180.0 to +180.0 degrees (Zone 1)
k0A = -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 non-homogenous correction angle (hidden and set to -3 when EADVS = N):

TANG = -45 to +45 degrees (advanced setting)

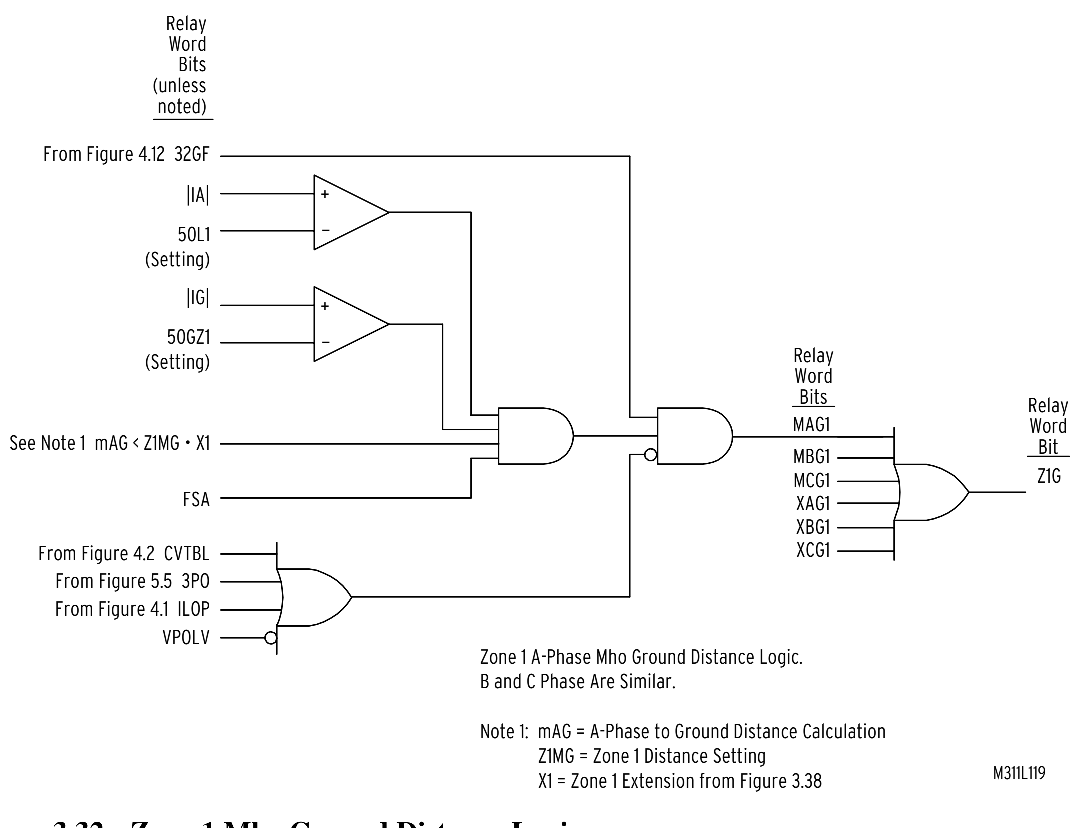

Figure 3.32: Zone 1 Mho Ground Distance Logic

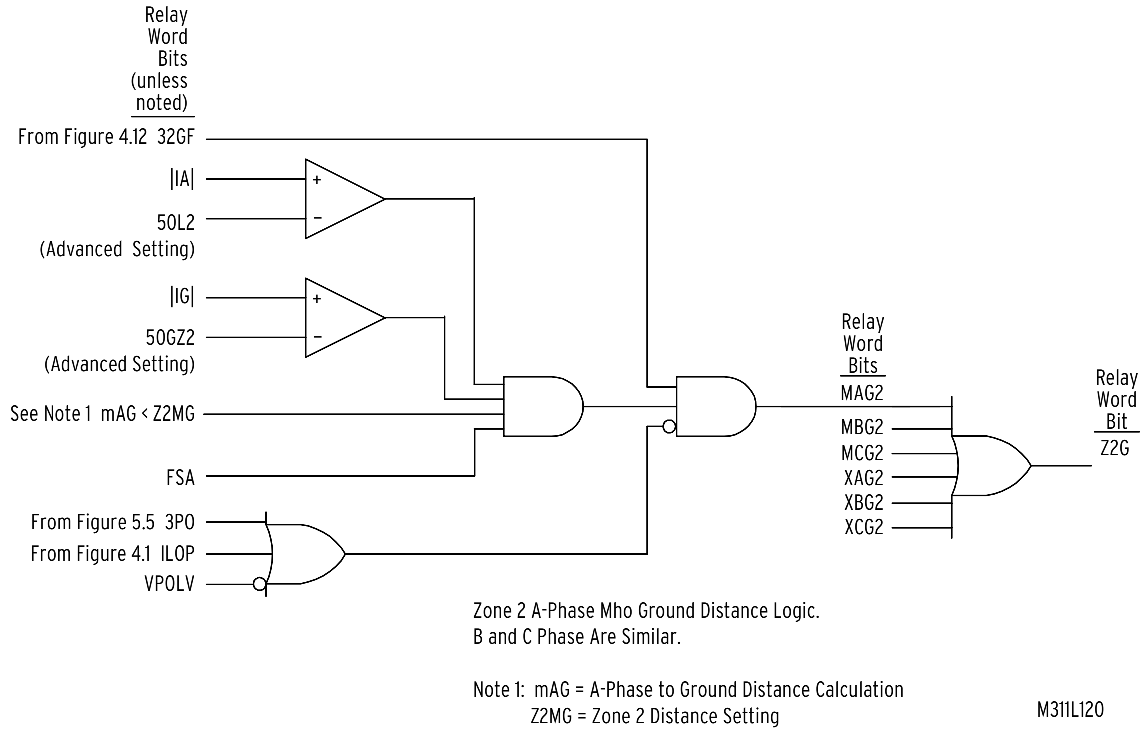

Figure 3.33: Zone 2 Mho Ground Distance Logic

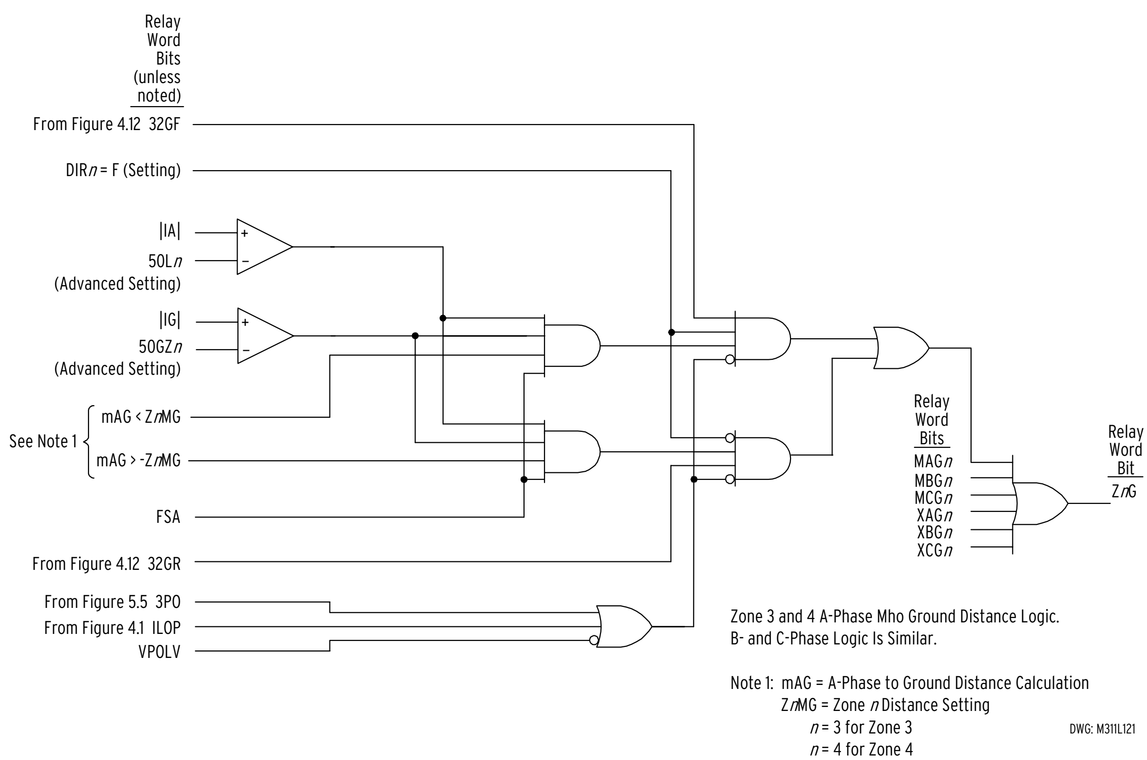

Figure 3.34: Zones 3 and 4 Mho Ground Distance Logic

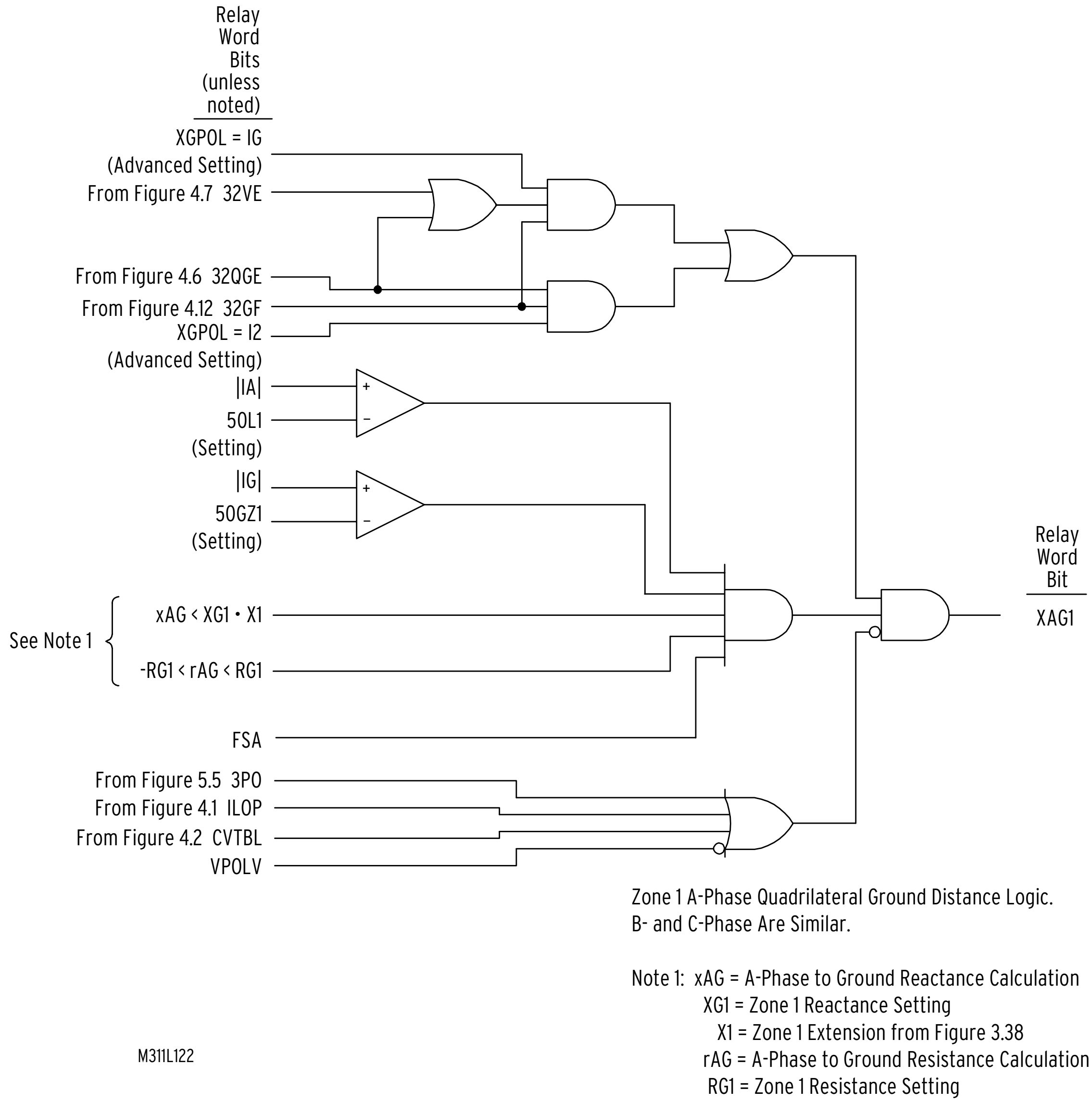

Figure 3.35: Zone 1 Quadrilateral Ground Distance Logic

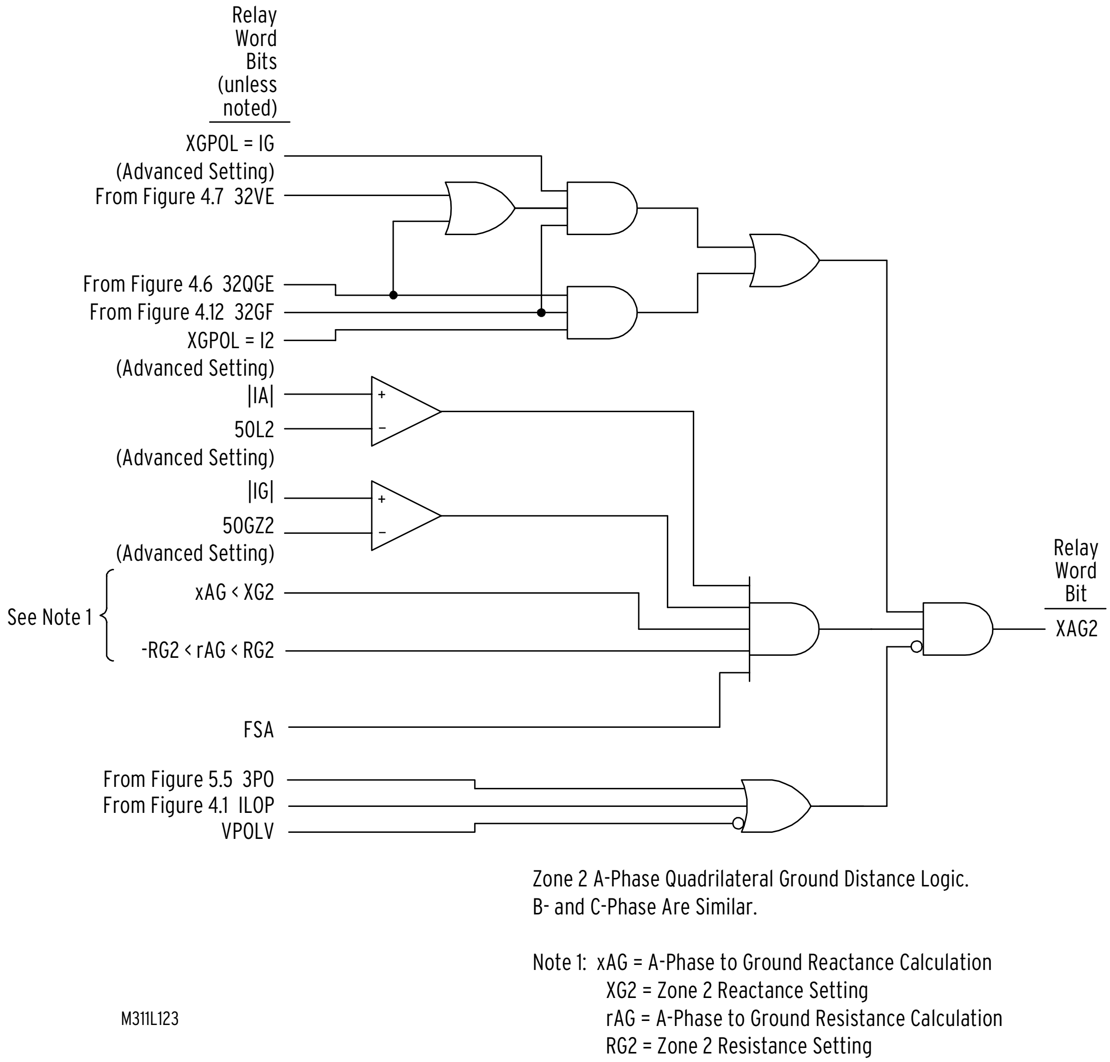

Figure 3.36: Zone 2 Quadrilateral Ground Distance Logic

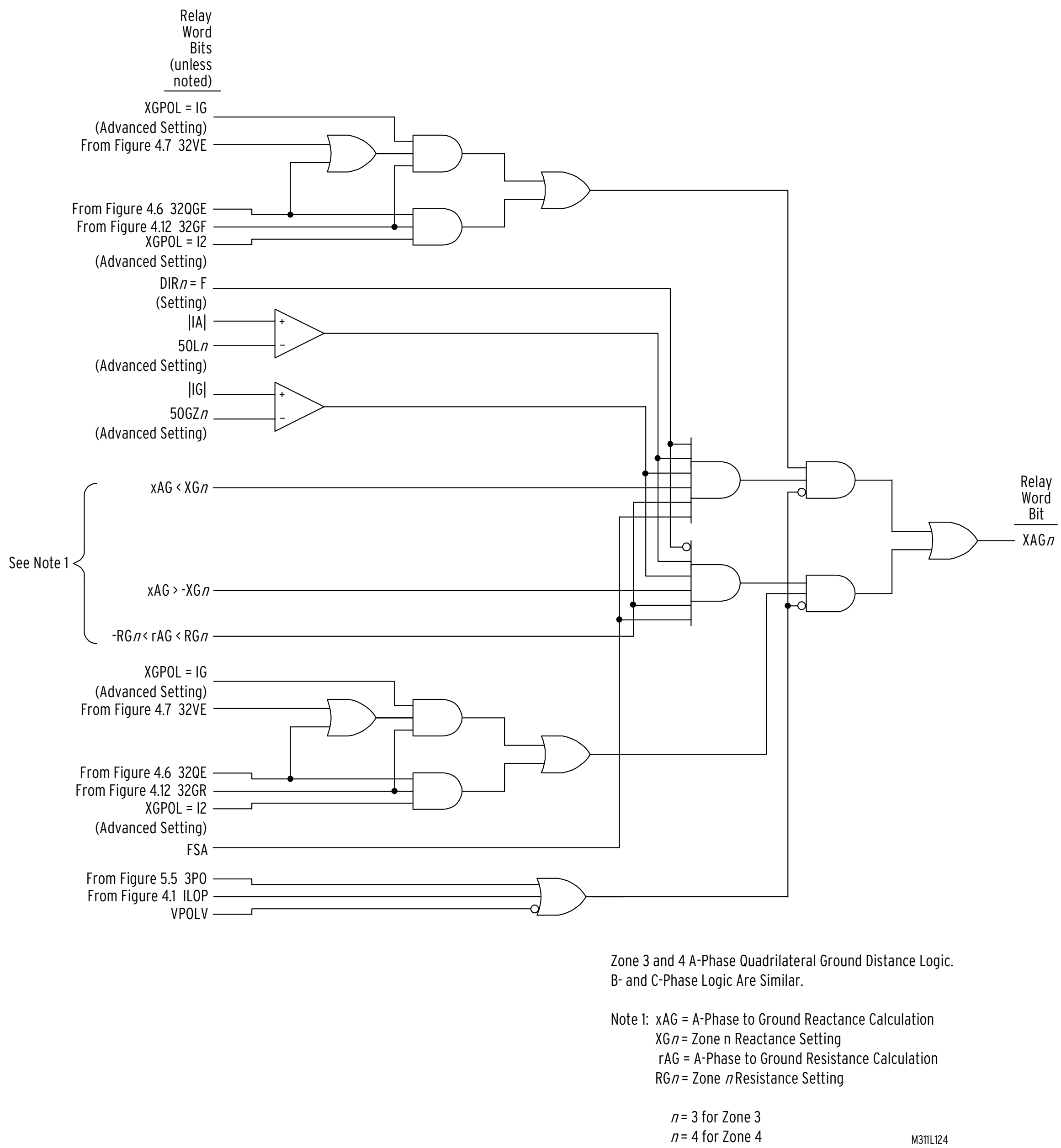

Figure 3.37: Zones 3 and 4 Quadrilateral Ground Distance Logic

Additional Distance Element Supervision

The SEL-311L Relay 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.

Zone 1 Extension

See Figure 3.38. 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.

Settings

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 Relay will not allow the Z1EXTM setting.

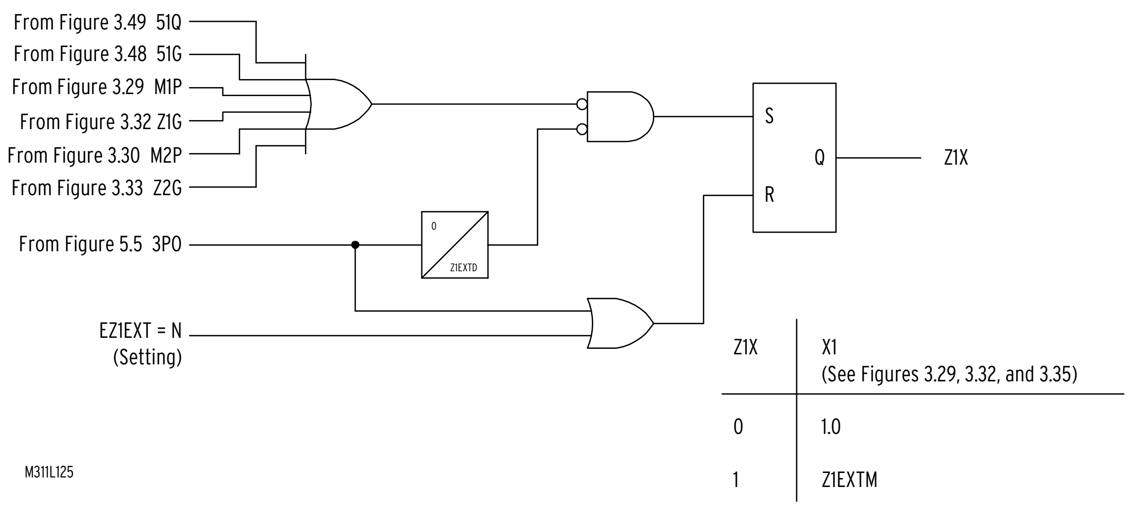

Figure 3.38: Zone 1 Extension Logic

Zone Time Delay Elements

The SEL-311L Relay supports two philosophies of zone timing: independent or common timing (see Figure 3.39). 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.

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

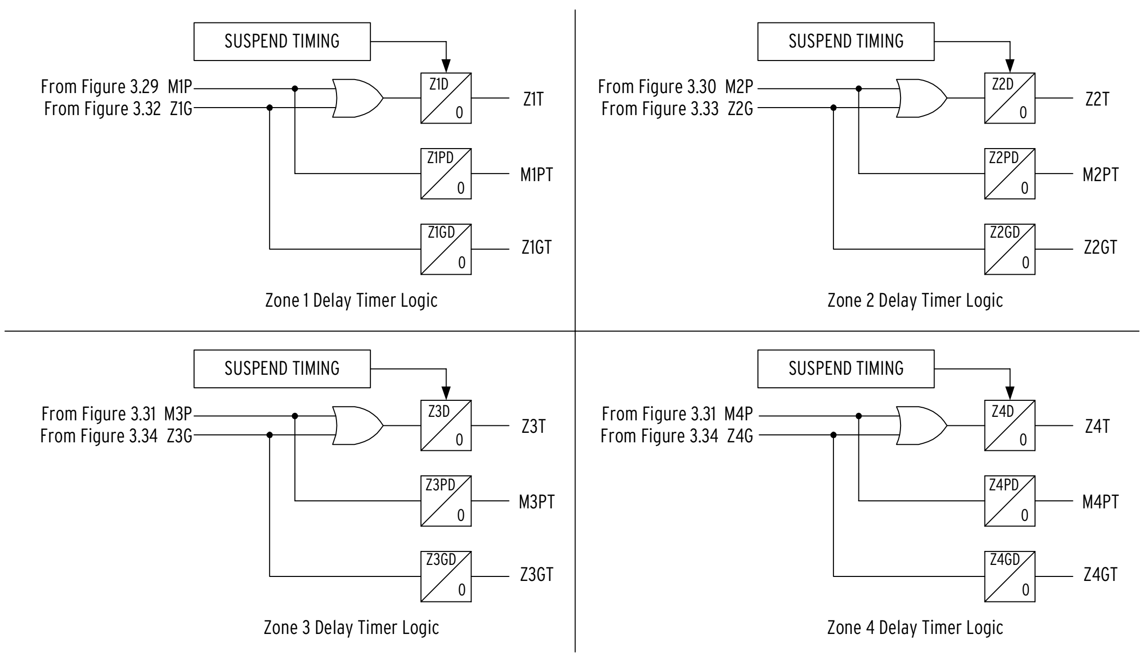

Figure 3.39: Zone Timing Elements

OUT-OF-STEP (OOS) CHARACTERISTICS

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

The OOS relay word outputs are used for alarming or controlling other equipment.

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

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.

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

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

The timer setting UBOSBD, shown in Figure 3.37, 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 that 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.

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

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 3.43 and Figure 3.44
Negative-Sequence Current Unblock Time Delay:	UBD (see Figure 3.29 through Figure 3.31)
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 3.5: 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

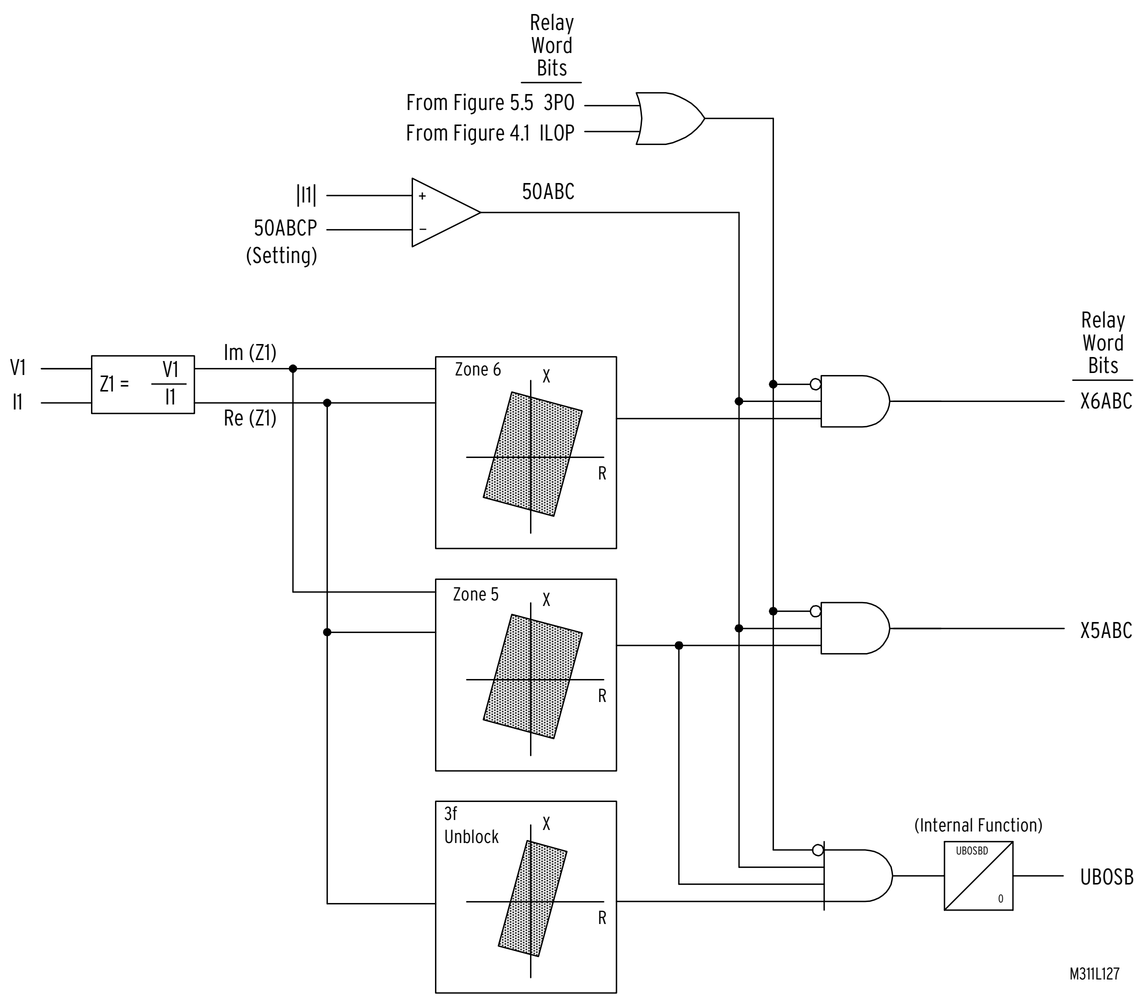

Figure 3.40: Out-of-Step Zone Detection Logic

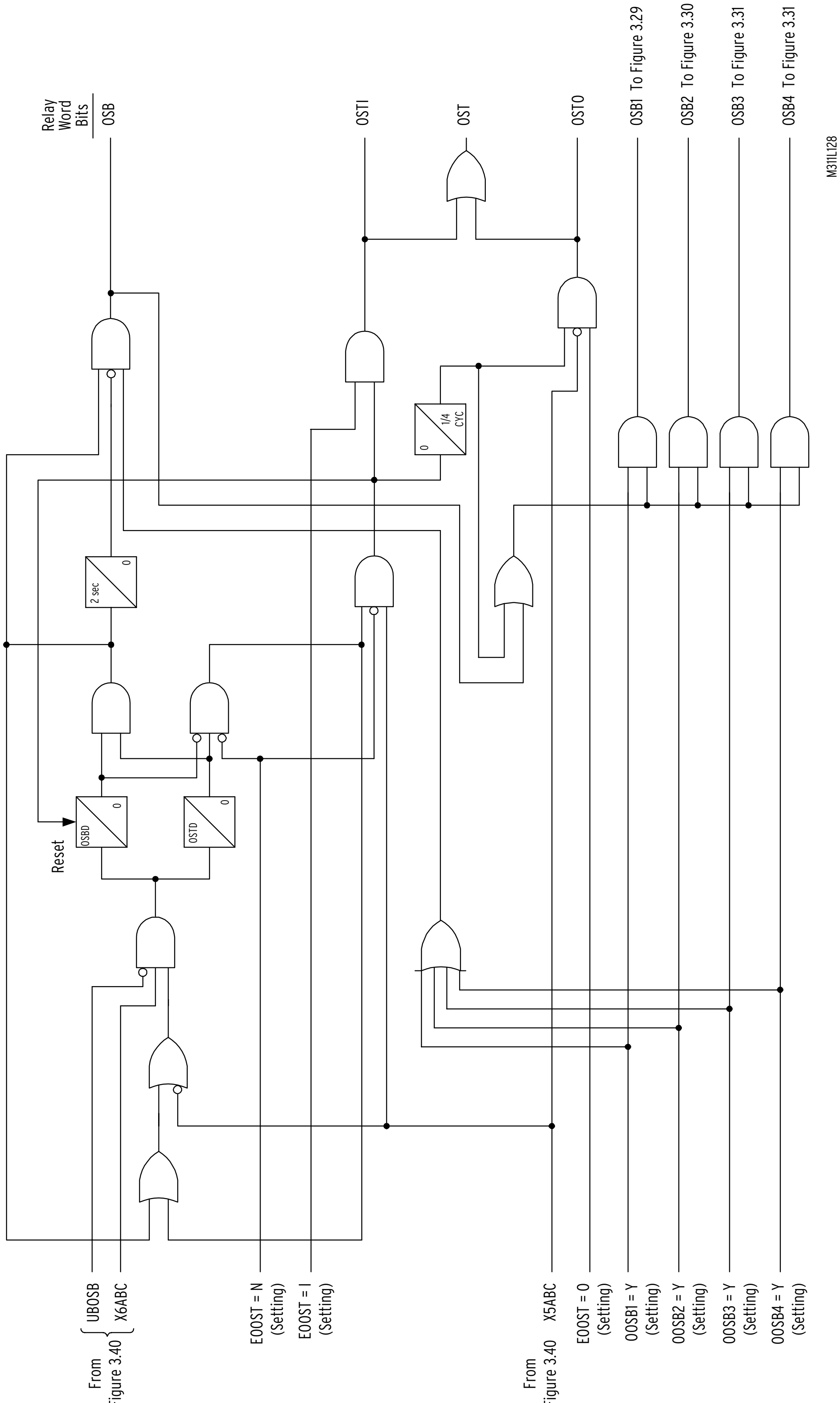

Figure 3.41: Out-of-Step Logic

Overcurrent Protection

The SEL-311L Relay 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 due to channel loss). Configure the torque control equations for each of the overcurrent elements to suite 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: Inputs, Outputs, Timers and Other Control Logic***.

For directional element logic refer to ***Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic***.

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 3.42.

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

Settings Ranges

Settings range for pickup settings 50P1P through 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)

Settings range for definite-time settings 67P1D through 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 3.42. The pickup settings for each level (50P1P through 50P3P) are compared to the magnitudes of the individual phase currents I_A, I_B, and I_C. The logic outputs in Figure 3.42 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
= 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 3.42 and Table 12.3).

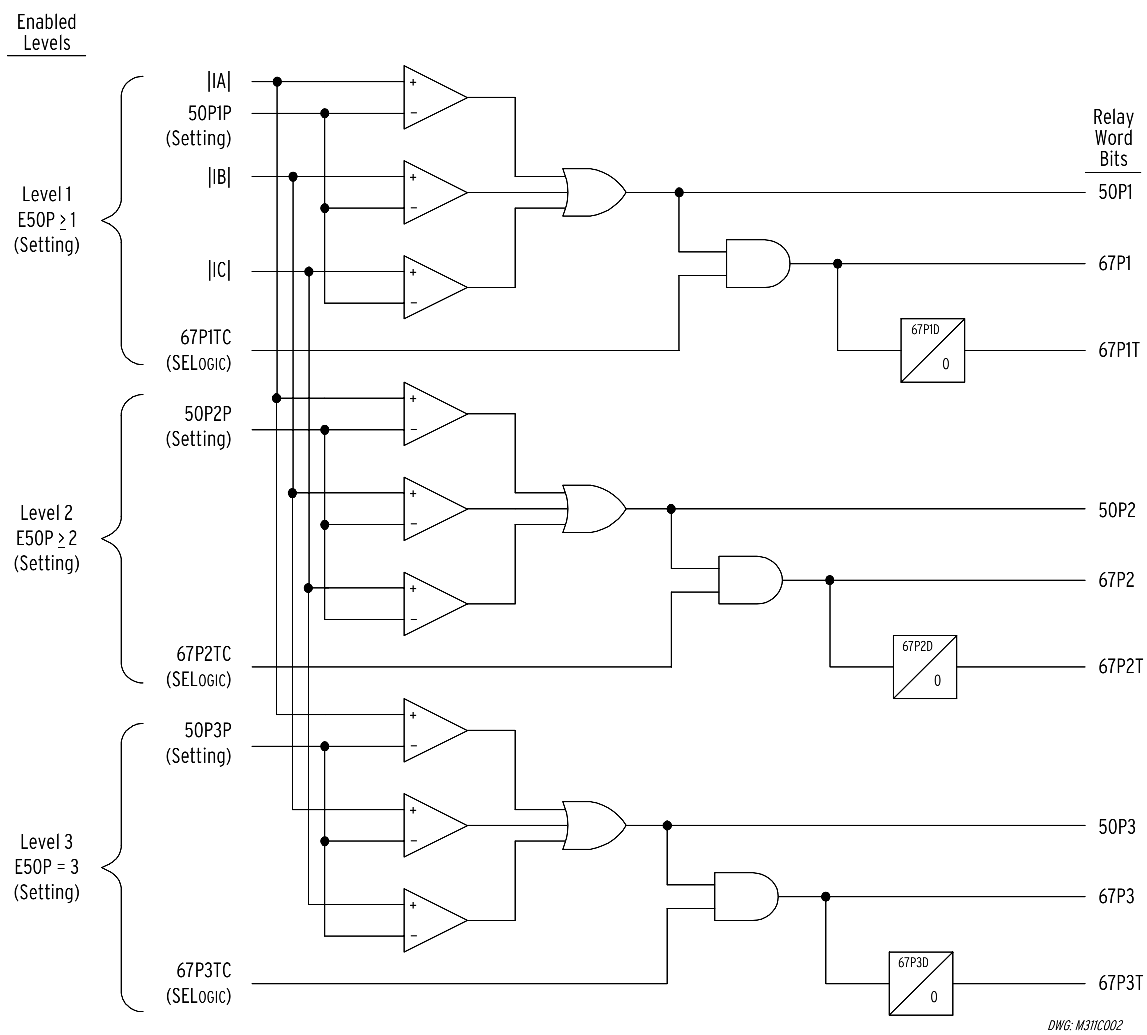

Figure 3.42: Levels 1 through 3 Phase Instantaneous/Definite-Time Overcurrent Elements

Torque Control

Levels 1 through 3 in Figure 3.42 have corresponding SELOGIC control equation torque control settings 67P1TC through 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.

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)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** for a list of the factory default settings.

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*** at the end of ***Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic***.

Pickup and Reset Time Curves

Figure 3.43 and Figure 3.44 show pickup and reset time curves applicable to all nondirectional instantaneous overcurrent elements in the SEL-311L Relay (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 3.43 is adjusted as follows:

multiples of pickup setting ≤ 4: add 0.25 cycle

multiples of pickup setting > 4: add 0.50 cycle

Figure 3.43: SEL-311L Relay Nondirectional Instantaneous Overcurrent Element Pickup Time Curve

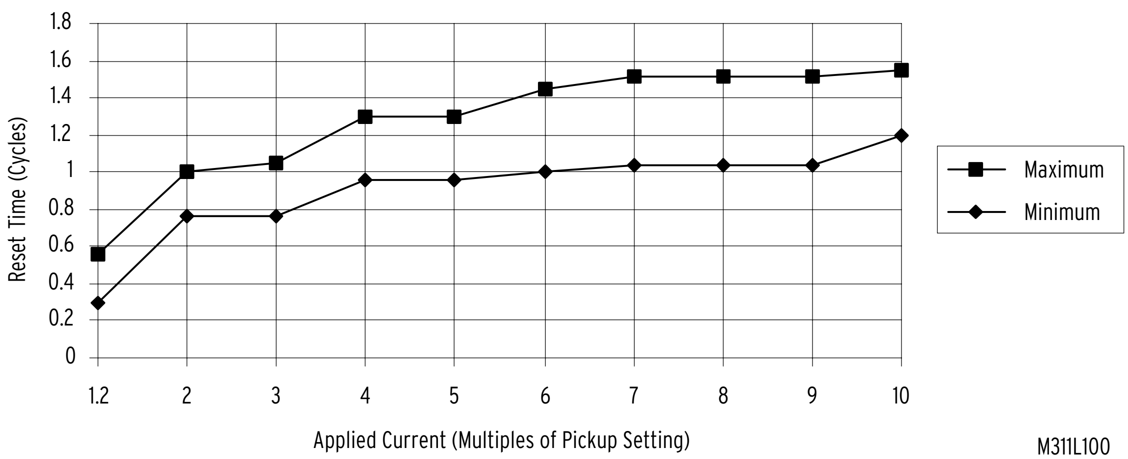

Figure 3.44: SEL-311L Relay Nondirectional Instantaneous Overcurrent Element Reset Time Curve

Residual Ground Instantaneous/Definite-Time Overcurrent Elements

Four levels of residual ground instantaneous/definite-time overcurrent elements are available. The different levels are enabled with the E50G enable setting, as shown in Figure 3.45.

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 3.45, follow the explanation given for Figure 3.42 in the preceding ***Phase Instantaneous/Definite-Time Overcurrent Elements*** subsection, 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 3.45 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 4.12 in ***Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic*** for more information on directional control.

If potentials are not applied to terminals VA, VB, and VC, you have the following options (refer to ***Section 4: Loss-of-Potential, CCVT Transient detection, Load-Encroachment, and Directional Element Logic*** 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.

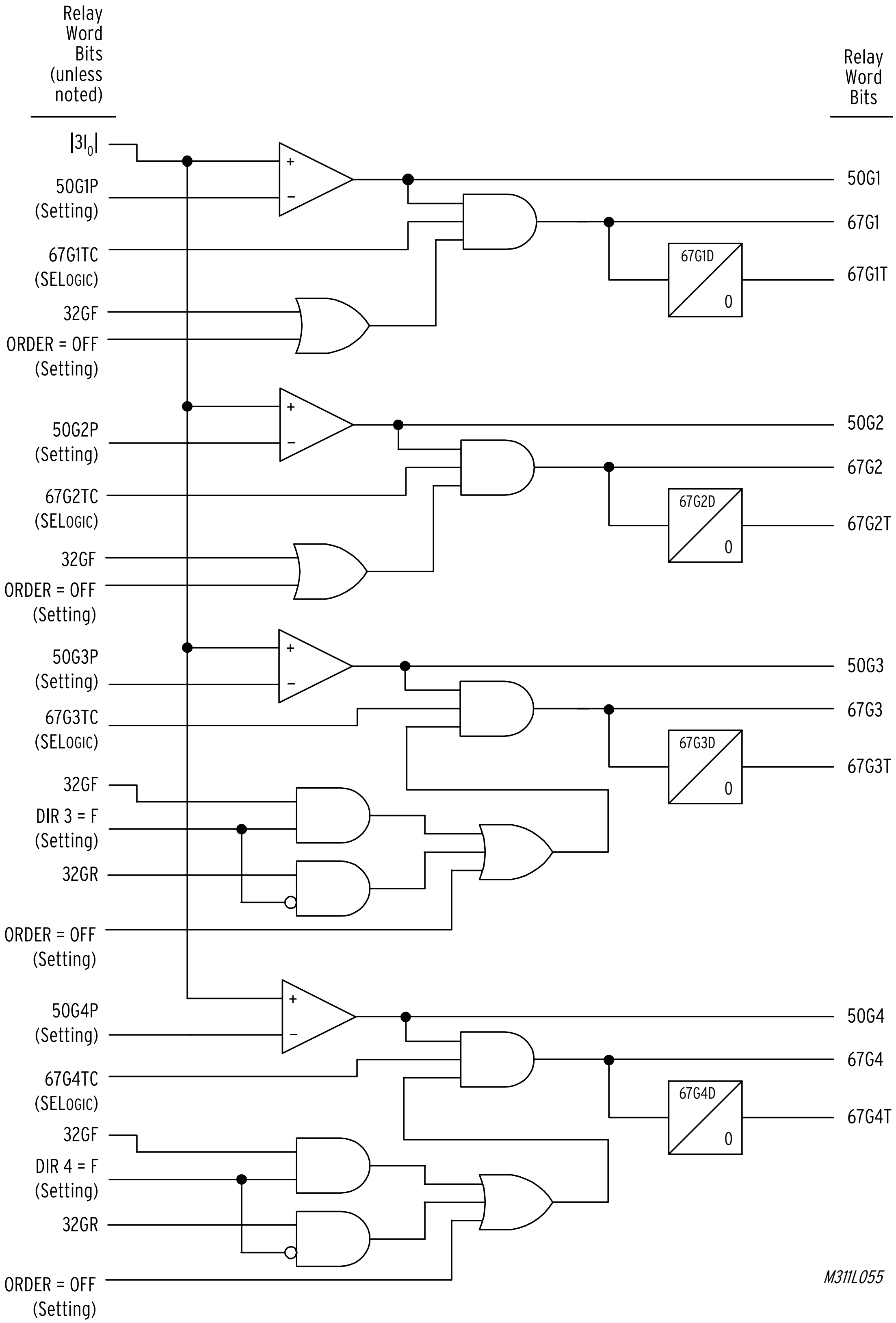

Figure 3.45: Levels 1 Through 4 Residual Ground Instantaneous/Definite-Time Overcurrent Elements With Directional and Torque Control

Settings Ranges

Setting range for pickup settings 50G1P through 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)

Setting range for definite-time settings 67G1D through 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 3.43 and Figure 3.44.

Negative-Sequence Instantaneous/Definite-Time Overcurrent Elements

IMPORTANT: See ***Appendix F*** 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 3.46.

To understand the operation of Figure 3.46, follow the explanation given for Figure 3.42 in the preceding ***Phase Instantaneous/Definite-Time Overcurrent Elements*** subsection, 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 3.46, 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 4.14 in ***Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic*** for more information on this optional directional control.

In cases where the SEL-311L Relay 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 3.46 and ***Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic***.

Settings Ranges

Settings range for pickup settings 50Q1P through 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)

Settings range for definite-time settings 67Q1D through 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 3.43 and Figure 3.44.

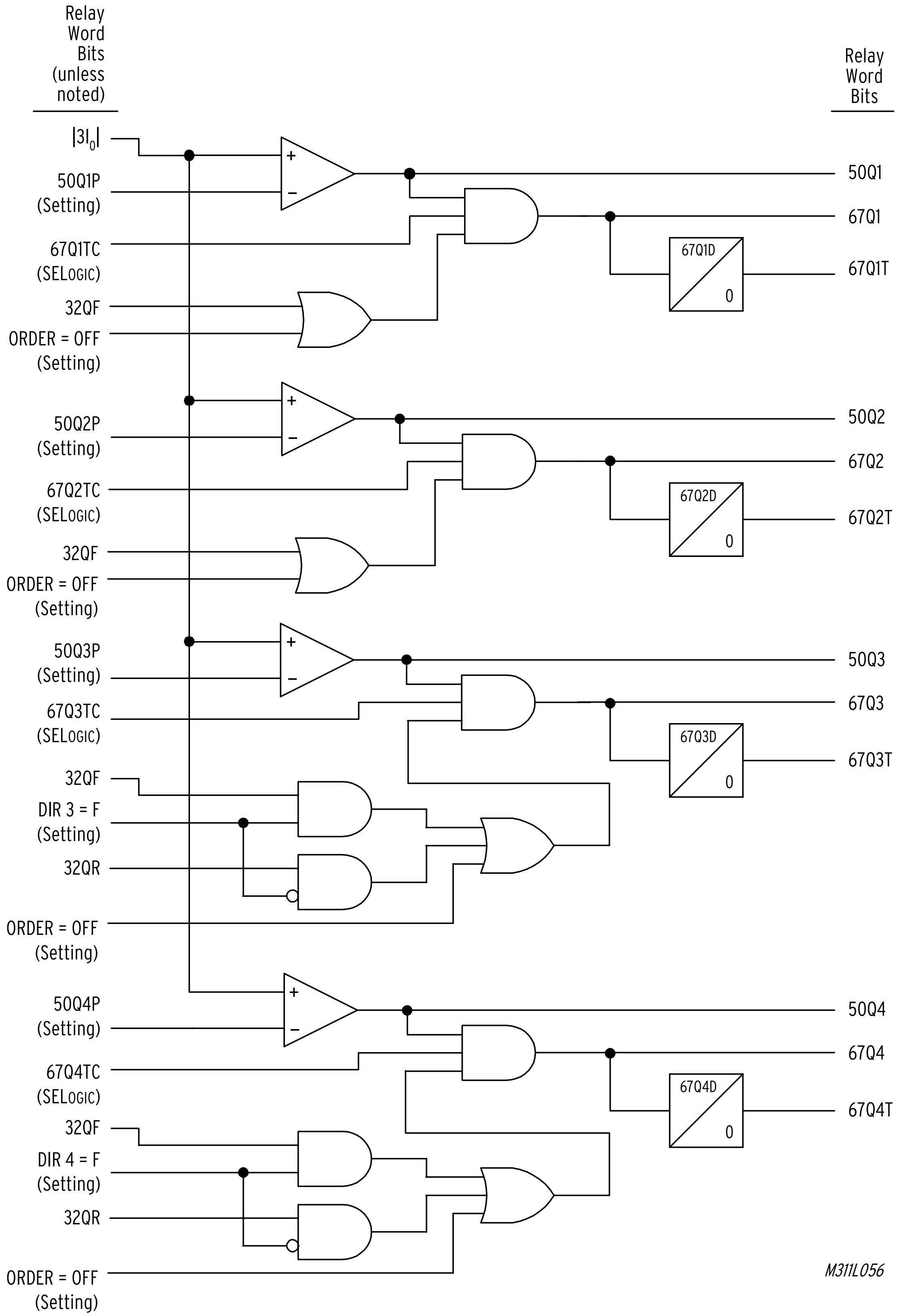

Figure 3.46: Levels 1 Through 4 Negative-Sequence Instantaneous/Definite-Time Overcurrent Elements With Directional and Torque Control

TIME-OVERCURRENT ELEMENTS

Phase Time-Overcurrent Elements

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

Table 3.6: Available Phase Time-Overcurrent Elements

Time-Overcurrent Element	Enabled with Setting	Operating Current	See Figure
51PT	E51P = Y	I_{ABC}, maximum of A-, B-, and C-phase currents	Figure 3.47

51PT Element Settings Ranges

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

Table 3.7: Phase Time-Overcurrent Element (Maximum Phase) Settings

Setting	Definition	Range
51PP	pickup	0.50–16.00 A secondary (5 A nominal phase current inputs, IA, IB, IC) 0.10–3.20 A secondary (1 A nominal phase current inputs, IA, IB, IC)
51PC	curve type	U1–U5 (US curves) see Figure 9.1–Figure 9.10 C1–C5 (IEC curves)
51PTD	time dial	0.50–15.00 (US curves) see Figure 9.1–Figure 9.10 0.05–1.00 (IEC curves)
51PRS	electromechanical reset timing	Y = Enable electromechanical reset timing N = 1 cycle reset delay
51PTC	SELOGIC control equation torque control setting	Relay Word bits referenced in Tables 9.3 and 9.4 or set directly to logical 1—see note below

Note: SELOGIC control equation torque control settings (e.g., 51PTC) cannot be set directly to logical 0.

See ***Section 9: Setting the Relay*** for additional time-overcurrent element setting information.

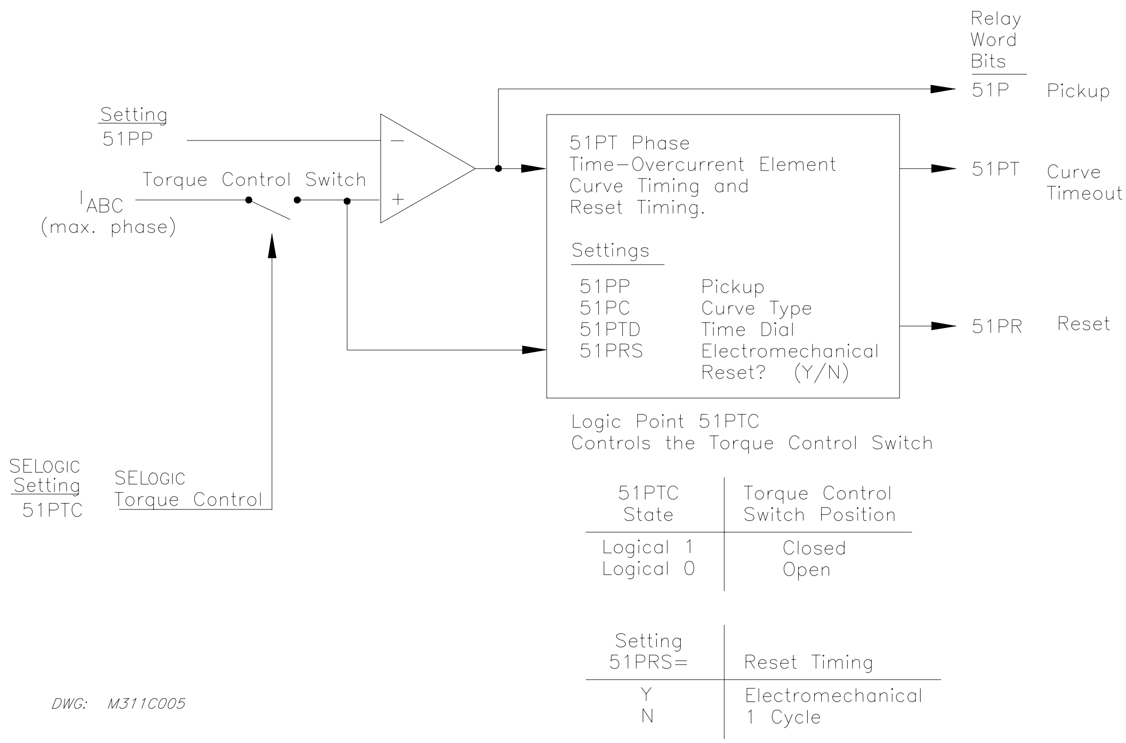

Figure 3.47: Phase Time-Overcurrent Element 51PT

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 3.47 are the Relay Word bits shown in Table 3.8.

Table 3.8: 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 ***Trip Logic*** in ***Section 5: Trip and Target Logic***.
51PT	Phase time-overcurrent element is timed out on its curve.	Tripping and other control applications. See ***Trip Logic*** in ***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 3.47 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 $I_{ABC} \le$ 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 $I_{ABC} \le$ pickup setting 51PP

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

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

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

Torque Control Switch Open

If the Torque Control Switch in Figure 3.47 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 3.47.

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.

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)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** for a list of the factory default settings.

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*** at the end of ***Section 4: Loss-of-Potential, CCVT Transient Protection, Load-Encroachment, and Directional Element Logic***.

Reset Timing Details (51PT Element Example)

Refer to Figure 3.47.

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*** in ***Section 9: Setting the Relay*** for reset curve equations.

Setting 51PRS = N

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

Residual Ground Time-Overcurrent Element

To understand the operation of Figure 3.48, follow the explanation given for Figure 3.47 in the preceding ***Phase Time-Overcurrent Elements*** subsection, substituting residual ground current I_G ($I_G = 3I_0 = I_A + I_B + I_C$) for maximum phase current I_{ABC} and substituting like settings and Relay Word bits.

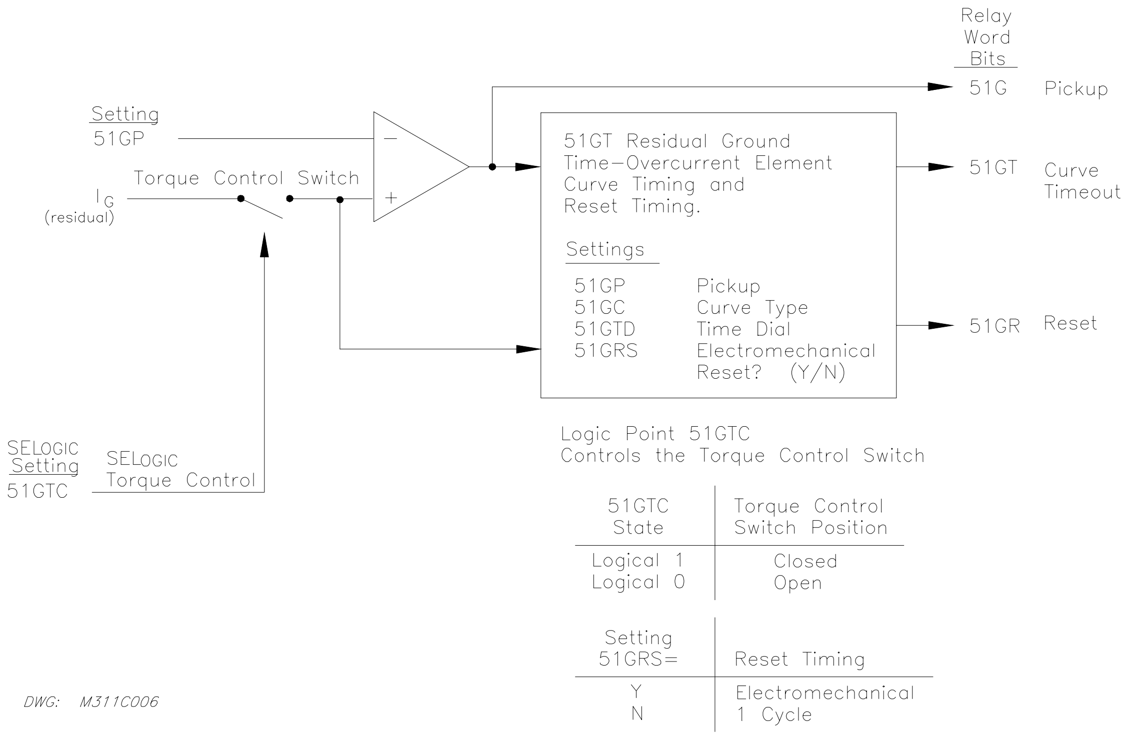

Figure 3.48: Residual Ground Time-Overcurrent Element 51GT

Settings Ranges

Table 3.9: Residual Ground Time-Overcurrent Element Settings

Setting	Definition	Range
51GP	pickup	OFF, 0.50–16.00 A secondary (5 A nominal phase current inputs, IA, IB, IC) OFF, 0.10–3.20 A secondary (1 A nominal phase current inputs, IA, IB, IC)
51GC	curve type	U1–U5 (US curves) see Figure 9.1–Figure 9.10 C1–C5 (IEC curves)
51GTD	time dial	0.50–15.00 (US curves) see Figure 9.1–Figure 9.10 0.05–1.00 (IEC curves)
51GRS	electromechanical reset timing	Y = Enable electromechanical reset timing N = 1 cycle reset delay
51GTC	SELOGIC control equation torque control setting	Relay Word bits referenced in Tables 9.3 and 9.4 or set directly to logical 1—see note below.

Note: 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: Setting the Relay*** 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 3.49, follow the explanation given for Figure 3.47 in the preceding ***Phase Time-Overcurrent Elements*** subsection, 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.

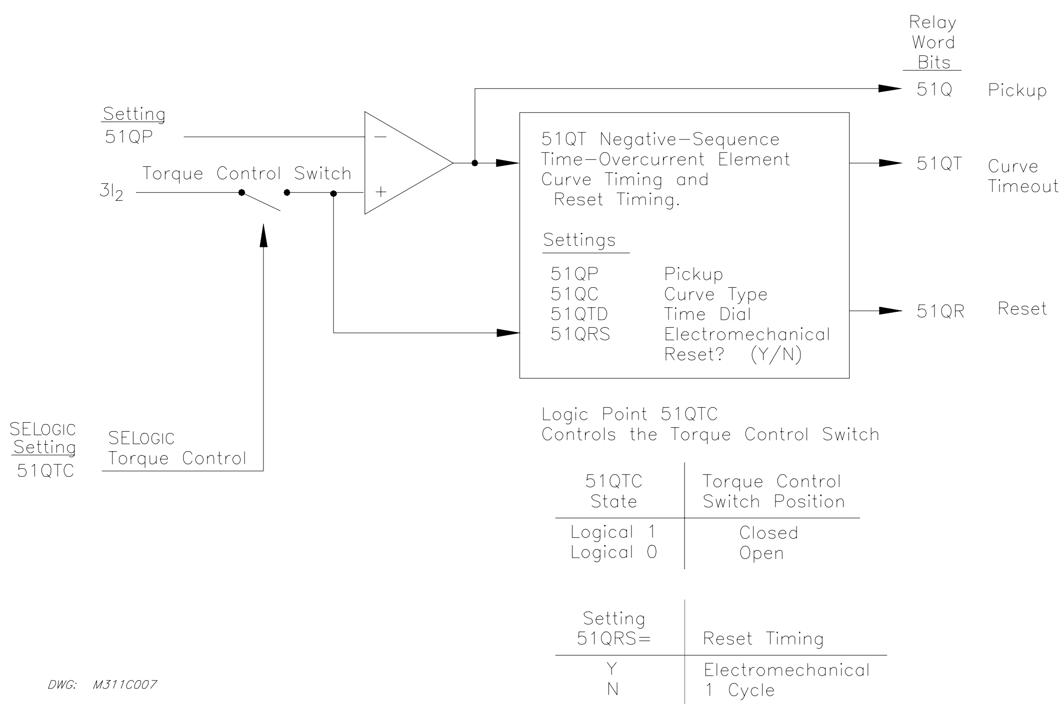

Figure 3.49: Negative-Sequence Time-Overcurrent Element 51QT

IMPORTANT: See ***Appendix F*** for information on setting negative-sequence overcurrent elements.

Settings Ranges

Table 3.10: Negative-Sequence Time-Overcurrent Element Settings

Setting	Definition	Range
51QP	pickup	OFF, 0.50–16.00 A secondary (5 A nominal phase current inputs, IA, IB, IC) OFF, 0.10–3.20 A secondary (1 A nominal phase current inputs, IA, IB, IC)
51QC	curve type	U1–U5 (US curves) see Figure 9.1–Figure 9.10 C1–C5 (IEC curves)
51QTD	time dial	0.50–15.00 (US curves) see Figure 9.1–Figure 9.10 0.05–1.00 (IEC curves)
51QRS	electromechanical reset timing	Y = Enable electromechanical reset timing N = 1 cycle reset delay
51QTC	SELOGIC control equation torque control setting	Relay Word bits referenced in Tables 9.3 and 9.4 or set directly to logical 1—see note below.

Note: 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: Setting the Relay*** 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 Relay voltage elements by making the enable setting:

EVOLT = Y

Voltage Values

Voltage elements operate from the voltage values shown in Table 3.11.

Table 3.11: Voltage Values Used by Voltage Elements

Voltage	Description
V_A	A-phase voltage, from SEL-311L Relay rear-panel voltage input VA
V_B	B-phase voltage, from SEL-311L Relay rear-panel voltage input VB
V_C	C-phase voltage, from SEL-311L Relay 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 Relay rear-panel voltage input VS—see note below.

Note: Voltage V_S is used in the synchronism check elements described in the following subsection ***Synchronism Check Elements***. Voltage V_S is also used in the three voltage elements described at the end of Table 3.12 and in Figure 3.52. These voltage elements are independent of the synchronism check elements, even though voltage V_S is used in both.

Voltage Element Settings

Table 3.12 lists available voltage elements and the corresponding voltage inputs and settings ranges for the SEL-311L Relay (see Figure 1.4 for voltage input connection).

Table 3.12: Voltage Elements Settings and Settings Ranges

Voltage Element (Relay Word bits)	Operating Voltage	Pickup Setting/Range	See Figure
27A	V_A	27P	Figure 3.50
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		

Voltage Element (Relay Word bits)	Operating Voltage	Pickup Setting/Range	See Figure
27AB	V_{AB}	27PP OFF, 0.00–260.00 V secondary	Figure 3.51
27BC	V_{BC}		
27CA	V_{CA}		
59AB	V_{AB}	59PP OFF, 0.00–260.00 V secondary	
59BC	V_{BC}		
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 $⅓ (V_A + a^2V_B + aV_C)$	59QP OFF, 0.00–100.00 V secondary	
59V1	V_1 $⅓ (V_A + aV_B + a^2V_C)$	59V1P OFF, 0.00–150.00 V secondary	
27S	V_S	27SP OFF, 0.00–150.00 V secondary	Figure 3.52
59S	V_S	59SP OFF, 0.00–150.00 V secondary	

Accuracy

Pickup: ±1 V and ±5% of setting

Transient Overreach: < 5% of setting

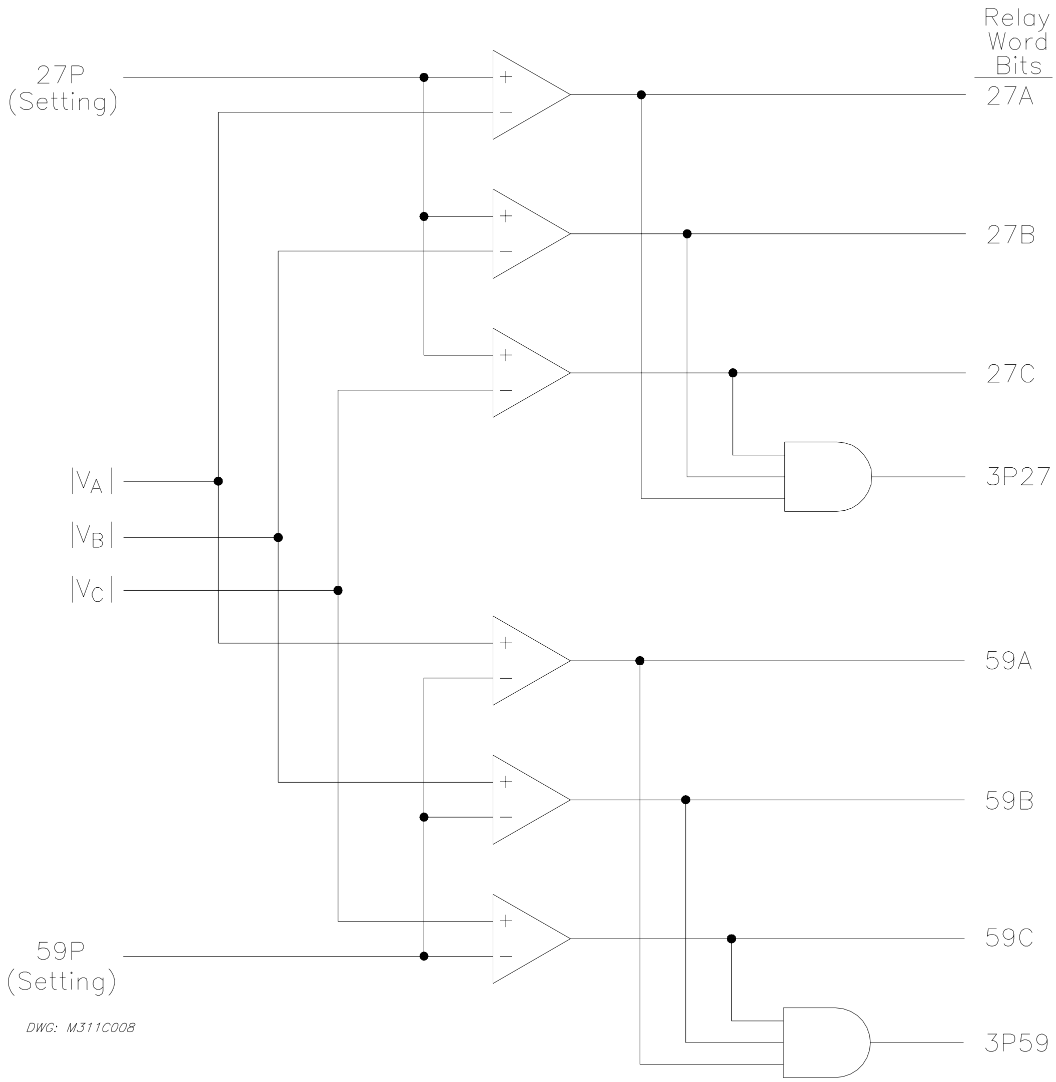

Figure 3.50: Single-Phase and Three-Phase Voltage Elements

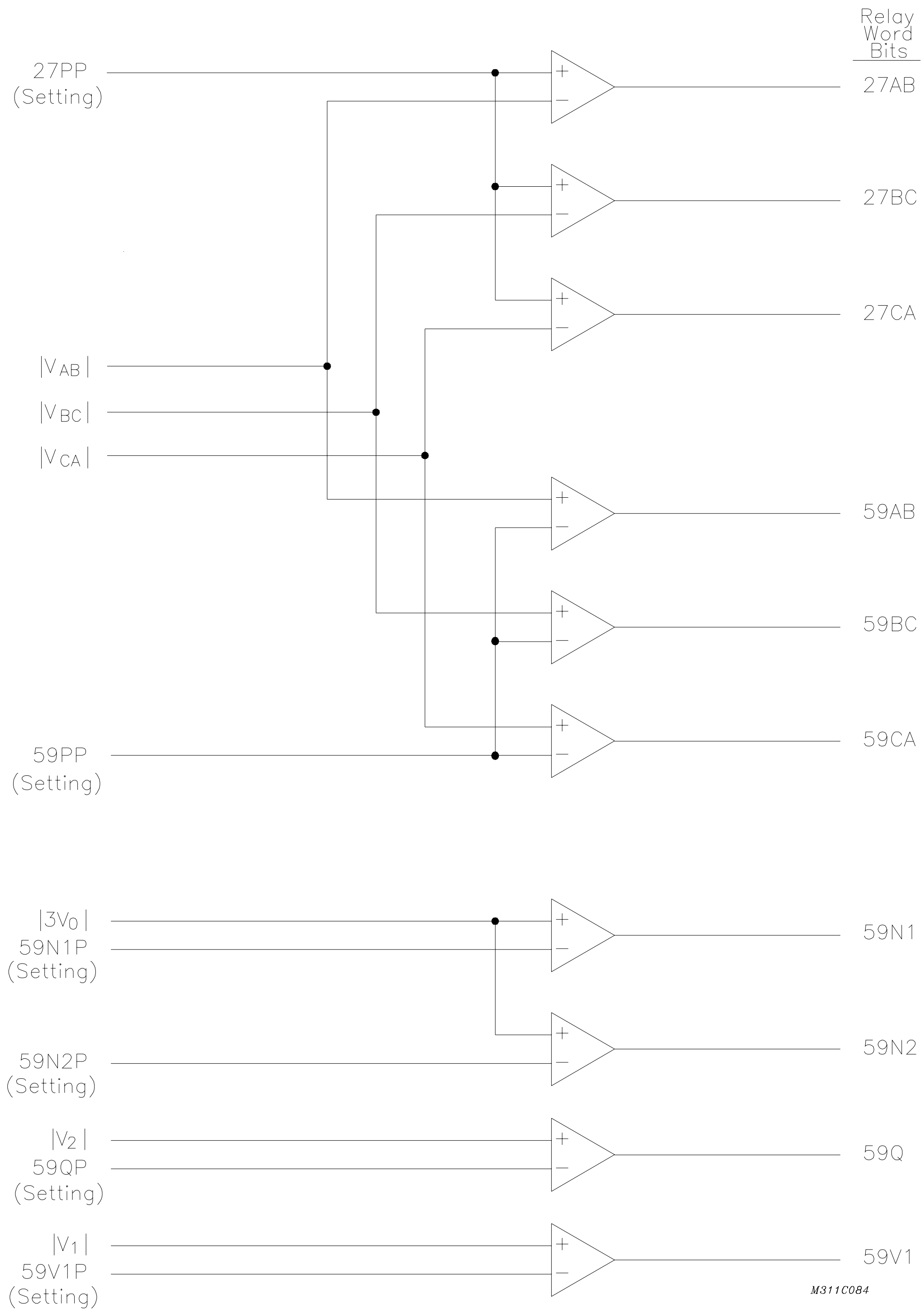

Figure 3.51: Phase-to-Phase and Sequence Voltage Elements

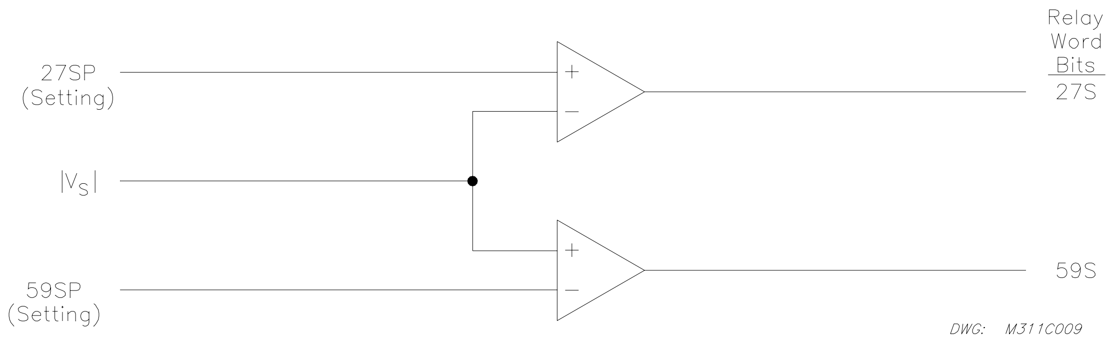

Figure 3.52: Channel VS Voltage Elements

Voltage Element Operation

Note that the voltage elements in Table 3.12 and Figure 3.50 through Figure 3.52 are a combination of "undervoltage" (Device 27) and "overvoltage" (Device 59) type elements. Undervoltage elements (Device 27) assert when the operating voltage goes below the corresponding pickup setting. Overvoltage elements (Device 59) assert when the operating voltage goes above the corresponding pickup setting.

Undervoltage Element Operation Example

Refer to Figure 3.50 (top of the figure).

Pickup setting 27P is compared to the magnitudes of the individual phase voltages V_A, V_B, and V_C. The logic outputs in Figure 3.50 are the following Relay Word bits:

27A = 1 (logical 1), if V_A < pickup setting 27P
= 0 (logical 0), if $V_A \geq$ pickup setting 27P

27B = 1 (logical 1), if V_B < pickup setting 27P
= 0 (logical 0), if $V_B \geq$ pickup setting 27P

27C = 1 (logical 1), if V_C < pickup setting 27P
= 0 (logical 0), if $V_C \geq$ pickup setting 27P

3P27 = 1 (logical 1), if all three Relay Word bits 27A, 27B, and 27C are asserted (27A = 1, 27B = 1, and 27C = 1)
= 0 (logical 0), if at least one of the Relay Word bits 27A, 27B, or 27C is deasserted (e.g., 27A = 0)

Overvoltage Element Operation Example

Refer to Figure 3.50 (bottom of the figure).

Pickup setting 59P is compared to the magnitudes of the individual phase voltages V_A, V_B, and V_C. The logic outputs in Figure 3.50 are the following Relay Word bits:

59A = 1 (logical 1), if V_A > pickup setting 59P
= 0 (logical 0), if $V_A \leq$ pickup setting 59P

59B = 1 (logical 1), if V_B > pickup setting 59P
= 0 (logical 0), if $V_B \leq$ pickup setting 59P

59C = 1 (logical 1), if V_C > pickup setting 59P
= 0 (logical 0), if $V_C \leq$ pickup setting 59P

3P59 = 1 (logical 1), if all three Relay Word bits 59A, 59B, and 59C are asserted (59A = 1, 59B = 1, and 59C = 1)
= 0 (logical 0), if at least one of the Relay Word bits 59A, 59B, or 59C is deasserted (e.g., 59A = 0)

Synchronism Check Elements

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

E25 = Y

Figure 2.11 and Figure 2.12 in ***Section 2: Installation*** 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 3.53). They have separate angle settings (see Figure 3.54).

Fixed Angle Synchronism Check

To implement a simple fixed-angle synchronism check scheme, set TCLOSD = OFF and 25SF = 0.500. With these settings, the synchronism check is performed as described in the top of Figure 3.54.

If there is the possibility of a high slip frequency, exercise caution if synchronism check elements 25A1 or 25A2 are used to close a circuit breaker. A high slip frequency and a slow breaker close could result in closing the breaker outside the synchronism check window. Qualify the breaker close command with a time delay, such as:

SV1 = 25A1

CL = CC + SV1T

Set SV1PU with enough pickup delay to insure that the slip frequency is low enough for the circuit breaker to close within the synchronism check window.

Dynamic Synchronism Check

The remainder of this discussion assumes TCLOSD is <u>not</u> set to OFF. With TCLOSD not set to OFF, the synchronism check is performed as described in either the top or bottom of Figure 3.54, depending on the slip frequency.

If the voltages are static (voltages not slipping with respect to one another), the two synchronism check elements operate as shown in the top of Figure 3.54. The angle settings are checked for synchronism check closing.

If the voltages are not static (voltages slipping with respect to one another), the two synchronism check elements operate as shown in the bottom of Figure 3.54. The angle difference is compensated by breaker close time, and the breaker is ideally closed at a zero degree phase angle difference, to minimize system shock.

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

Synchronism Check Elements Settings

Table 3.13: 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 Tables 9.3 and 9.4

Accuracy

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

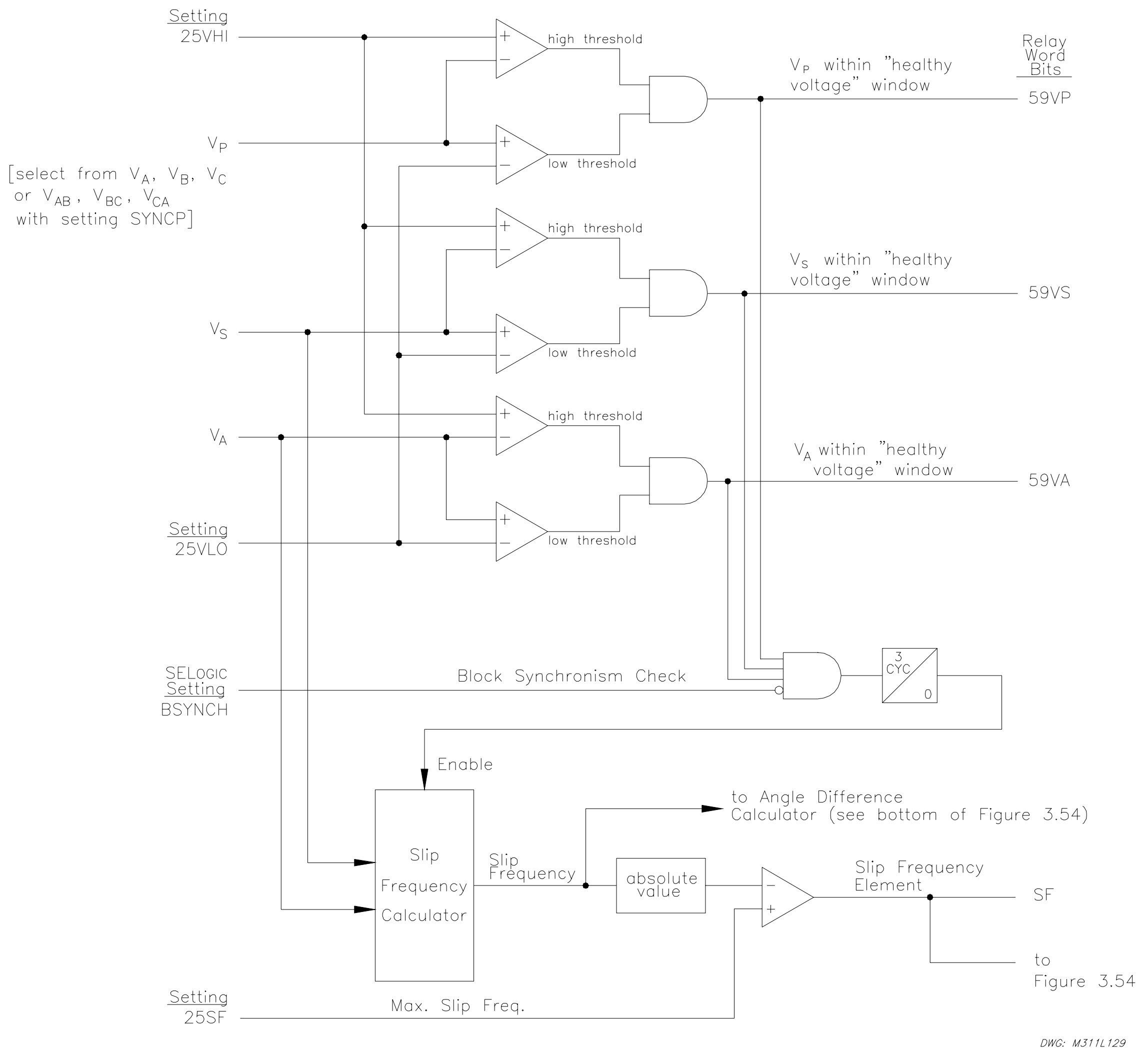

Figure 3.53: Synchronism Check Voltage Window and Slip Frequency Elements

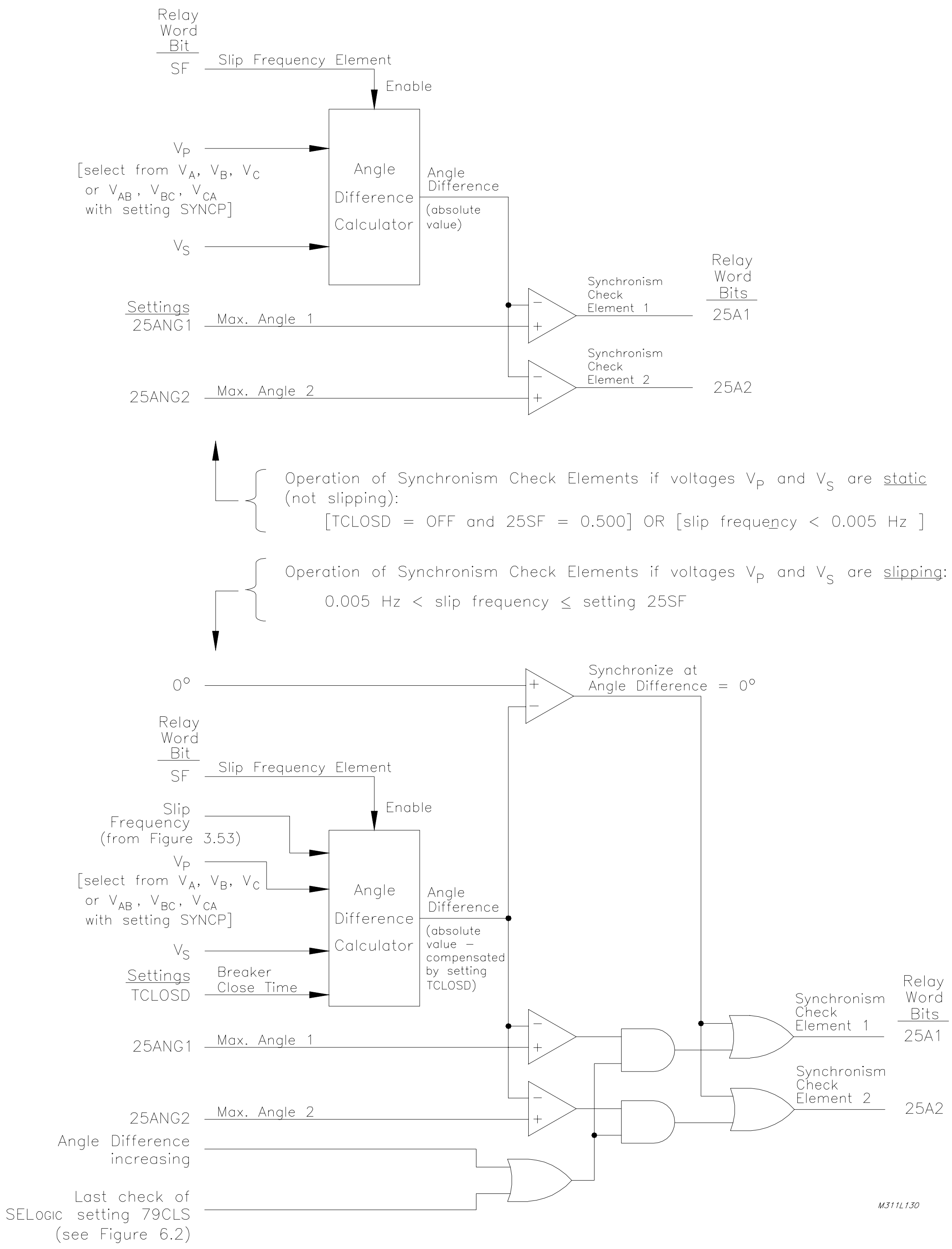

Figure 3.54: Synchronism Check Elements

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 Relay 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 and Figures 2.11 and 2.12).

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 3.53 and Figure 3.54.

Voltage Window

Refer to Figure 3.53.

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 assure "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 $\sqrt{3}$ 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 3.53.

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 3.53.

The synchronism check element Slip Frequency Calculator in Figure 3.53 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 V_A] (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 3.53, 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 3.54 runs if the slip frequency is less than the maximum slip frequency setting 25SF (Relay Word bit SF is asserted).

Voltages V_P and V_S are "Static"

Refer to top of Figure 3.54.

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:

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

Voltages V_P and V_S are "Slipping"

Refer to bottom of Figure 3.54.

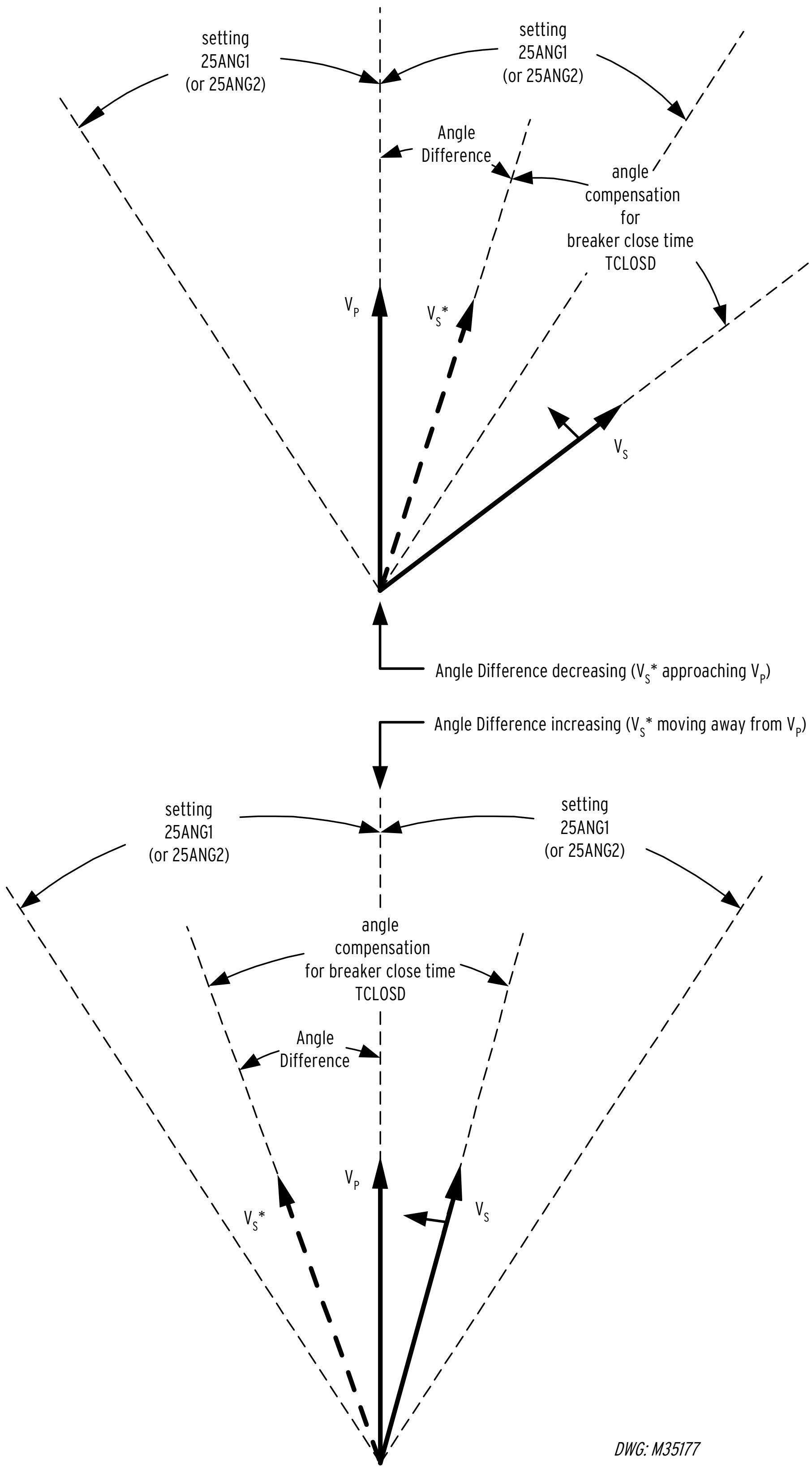

Figure 3.55: Angle Difference Between V_P and V_S Compensated by Breaker Close Time ($f_P < f_S$ and V_P Shown as Reference in This Example)

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 3.55). The Angle Difference Calculator calculates the Angle Difference between voltages V_P and V_S, compensated with the breaker close time:

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

Angle Difference Example (Voltages V_p and V_s are "Slipping")

Refer to bottom of Figure 3.54 and Figure 3.55.

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:

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

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:

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

During the breaker close time (TCLOSD), the voltage angle difference between voltages V_P and V_S changes by 6 degrees. This 6 degree angle compensation is applied to voltage V_S, resulting in derived voltage V_S*, as shown in Figure 3.55.

Note: The angle compensation in Figure 3.55 appears much greater than 6 degrees. Figure 3.55 is for general illustrative purposes only.

The top of Figure 3.55 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 3.55 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. In order to initiate circuit breaker closing when V_S* is in phase with V_P (Angle Difference = 0 degrees), V_S* has to slip around another revolution, relative to V_P.

Synchronism Check Element Outputs

Synchronism check element outputs (Relay Word bits 25A1 and 25A2 in Figure 3.54) 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 3.54.

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 3.54. 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 3.55 shows the Angle Difference decreasing—V_S* is approaching V_P. When V_S* is in phase with V_P (Angle Difference = 0 degrees), synchronism check elements 25A1 and 25A2 assert to logical 1.

2. The bottom of Figure 3.55 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*** in ***Section 6: Close and Reclose Logic***.

   Refer to the bottom of Figure 6.2 in ***Section 6: Close and Reclose Logic***. 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 in ***Section 6: Close and Reclose Logic***. If timer 79CLSD is set to zero (79CLSD = 0.00), SELOGIC control equation setting 79CLS (Reclose Supervision) is checked only once to see if it is asserted to logical 1. If it is not asserted to logical 1, the relay goes to the Lockout State.

   Refer to the top of Figure 3.55. Ideally, circuit breaker closing is initiated when V_S* is in phase with V_P (Angle Difference = 0 degrees). Then when the circuit breaker main contacts finally close, V_S is in phase with V_P, minimizing system shock. But with time limitations imposed by timer 79CLSD, this may not be possible. To try to avoid going to the Lockout State, the following logic is employed:

If 79CLS has not asserted to logical 1 while timer 79CLSD is timing (or timer 79CLSD is set to zero and only one check of 79CLS is made), the synchronism check logic at the bottom of Figure 3.54 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 in ***Section 6: Close and Reclose Logic***. Element 25A2 operates similarly.

Synchronism Check Applications for Automatic Reclosing and Manual Closing

Refer to ***Close Logic*** and ***Reclose Supervision Logic*** in ***Section 6: Close and Reclose Logic***.

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

e.g., 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):

e.g., 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 3.57. Frequency is determined from the voltage connected to voltage terminals VA-N.

Frequency Element Settings

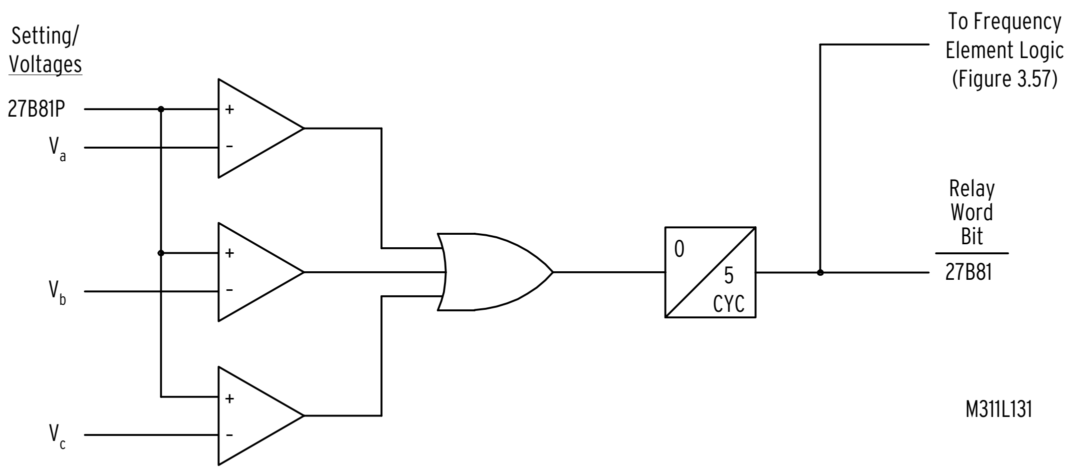

Figure 3.56: Undervoltage Block for Frequency Elements

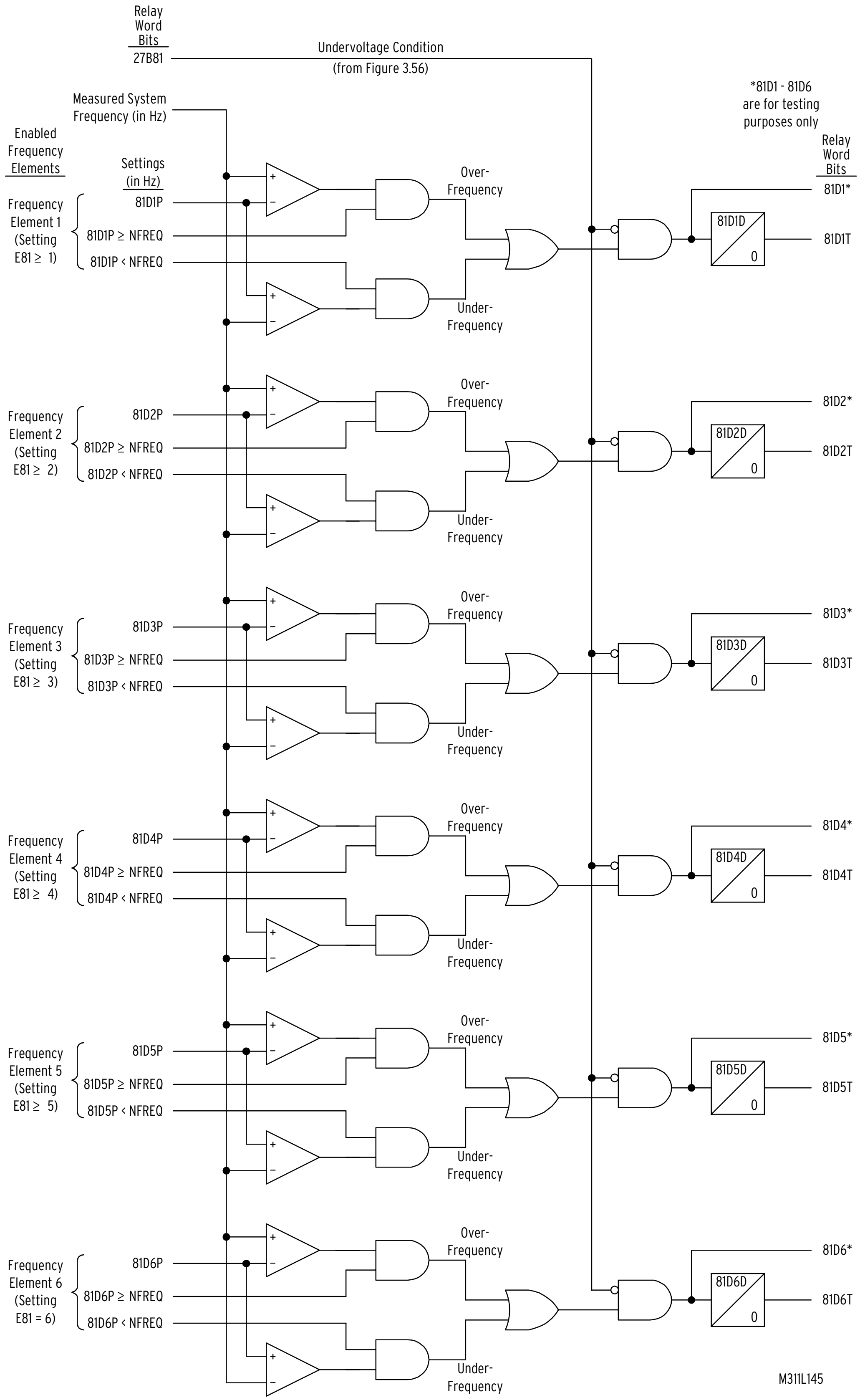

Figure 3.57: Levels 1 Through 6 Frequency Elements

Table 3.14: 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 3.57.

Note that pickup settings 81D1P through 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 3.57.

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 3.56 and Figure 3.57.

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

Frequency Element Uses

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

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

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TABLES

FIGURES

SECTION 4: LOSS-OF-POTENTIAL, CCVT TRANSIENT DETECTION, LOAD-ENCROACHMENT, AND DIRECTIONAL ELEMENT LOGIC

INTRODUCTION

The SEL-311L Relay provides loss-of-potential (LOP) detection, CCVT transient detection, load encroachment detection, and voltage-polarized directional and distance elements when voltages are connected to terminals VA, VB, and VC. Distance element operation is described in ***Section 3: Line Current Differential, Distance, Out-of-Step, Overcurrent, Voltage, and Synchronism Check Elements***. This section describes the LOP, CCVT, and load-encroachment logic, and also describes the operation of current and voltage polarized directional elements.

When voltages are not applied to the relay, or when an LOP condition exists, current polarized directional elements are still available. The voltage-polarized directional elements and distance elements are disabled. Overcurrent elements controlled by voltage-polarized directional elements are either disabled, or become nondirectional based on setting ELOP as described below.

LOSS-OF-POTENTIAL LOGIC

The loss-of-potential (LOP) logic operates as shown in Figure 4.1.

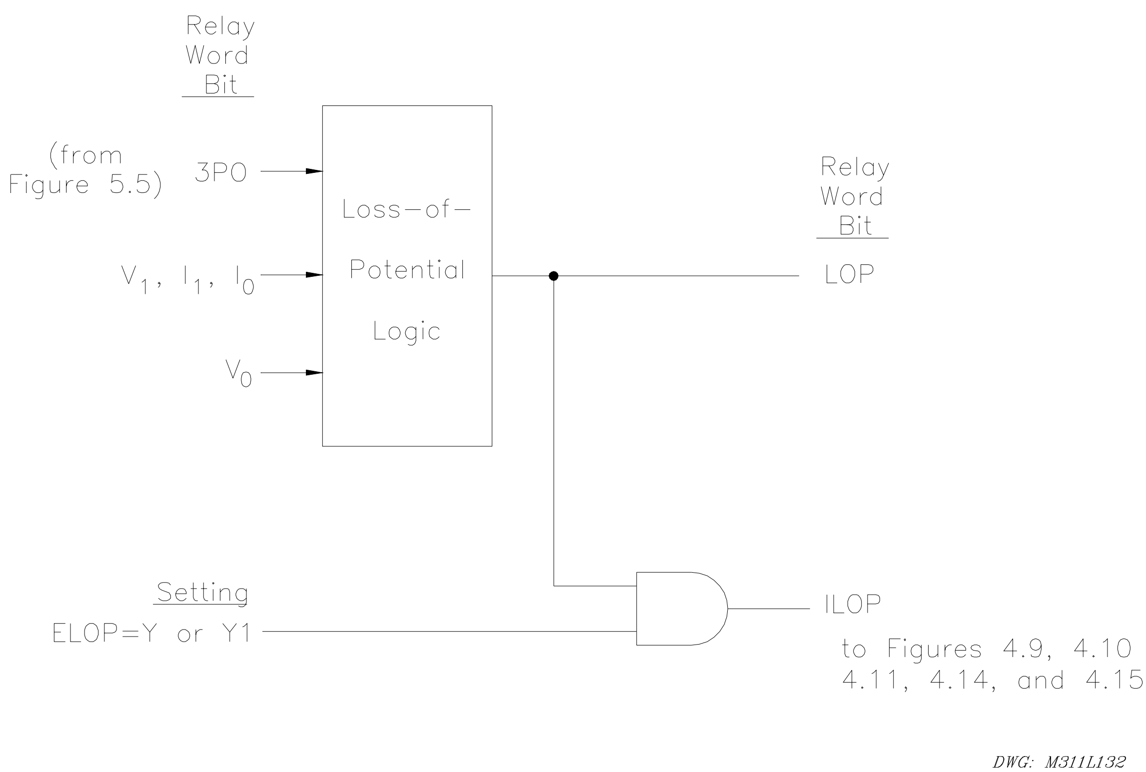


Figure 4.1: Loss-of-Potential Logic

Inputs into the LOP logic are:

- 3PO three-pole open condition (indicates circuit breaker open condition see Figure 5.5)
- 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)

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 30 V secondary and V_0 is less than 5 V secondary.

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 4.1 and explained in the remainder of this subsection.

Note that ILOP disables all distance elements (Figure 3.29 through Figure 3.37).

LOP is disabled while 3PO is asserted (breaker open). If all three potentials are lost during this time, LOP will not assert when 3PO deasserts (breaker close) since 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 3.50. 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 deenergized 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 4.9, Figure 4.10, Figure 4.14, Figure 4.15, and Figure 3.29 through

Figure 3.37). 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 4.11, 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 5.8, 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 4.12). 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.

CCVT Transient Detection Logic

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

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 Relay 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***.

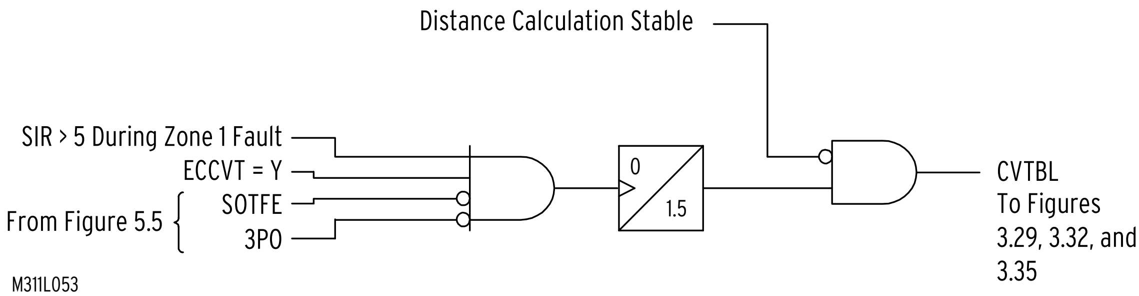


Figure 4.2: CCVT Transient Blocking Logic

Load-Encroachment Logic

The load-encroachment logic (see Figure 4.3) 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 4.15), which may assert for three-phase load. The distance elements, M1P through M4P, will not operate without directional control. Set !ZLOAD in the phase overcurrent torque control equation to block phase overcurrent operation.

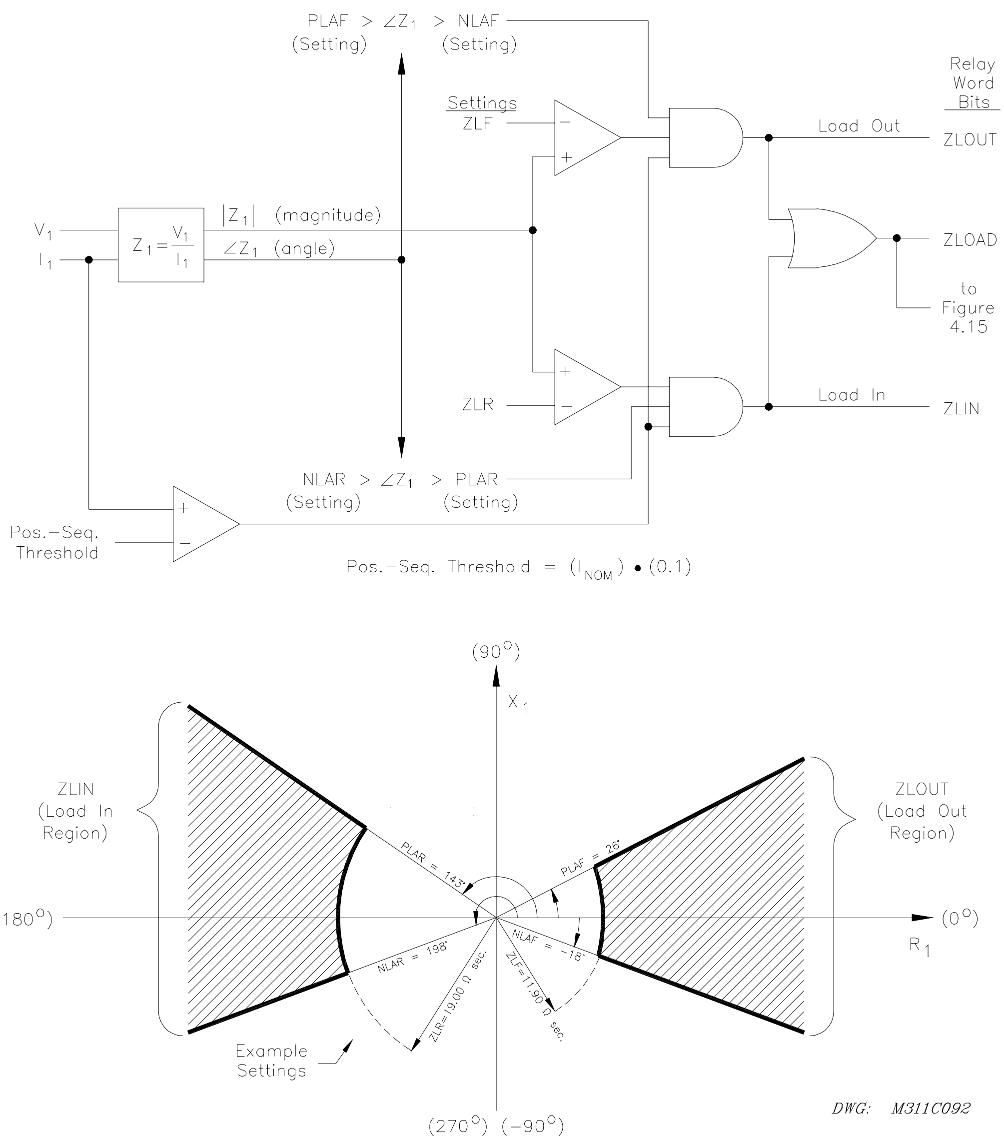


Figure 4.3: Load-Encroachment Logic with Example Settings

A positive-sequence impedance calculation (Z_1) is made in the load-encroachment logic in Figure 4.3. Load is largely a balanced condition, so apparent positive-sequence impedance is a good load measure. The load-encroachment logic only operates if the positive-sequence current (I_1) is greater than the Positive-Sequence Threshold shown in Figure 4.3. For a balanced load condition, I_1 = phase current magnitude.

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

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

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

ZLOAD = ZLOUT + ZLIN

Settings Ranges

Refer to Figure 4.3.

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

Start with maximum forward load:

800 MVA • (1/3) = 267 MVA per phase

230 kV • (1/$\sqrt{3}$) = 132.8 kV line-to-neutral

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

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

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

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

Now, calculate the equivalent secondary impedance:

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:

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

Again, for the maximum forward load:

$[(230)^2 \cdot (400)]/[(800) \cdot (2000)] = 13.2\ \Omega$ secondary

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

ZLF = 13.2 Ω secondary • 0.9 = 11.90 Ω secondary

For the maximum reverse load:

$[(230)^2 \cdot (400)]/[(500) \cdot (2000)] = 21.1\ \Omega$ secondary

Again, to provide a margin for setting ZLR:

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 = $180° - \cos^{-1}(0.80) = 180° - 37° = 143°$
Setting NLAR = $180° + \cos^{-1}(0.95) = 180° + 18° = 198°$

Apply Load-Encroachment Logic to a Phase Time-Overcurrent

Again, from Figure 4.3:

ZLOAD = ZLOUT + ZLIN

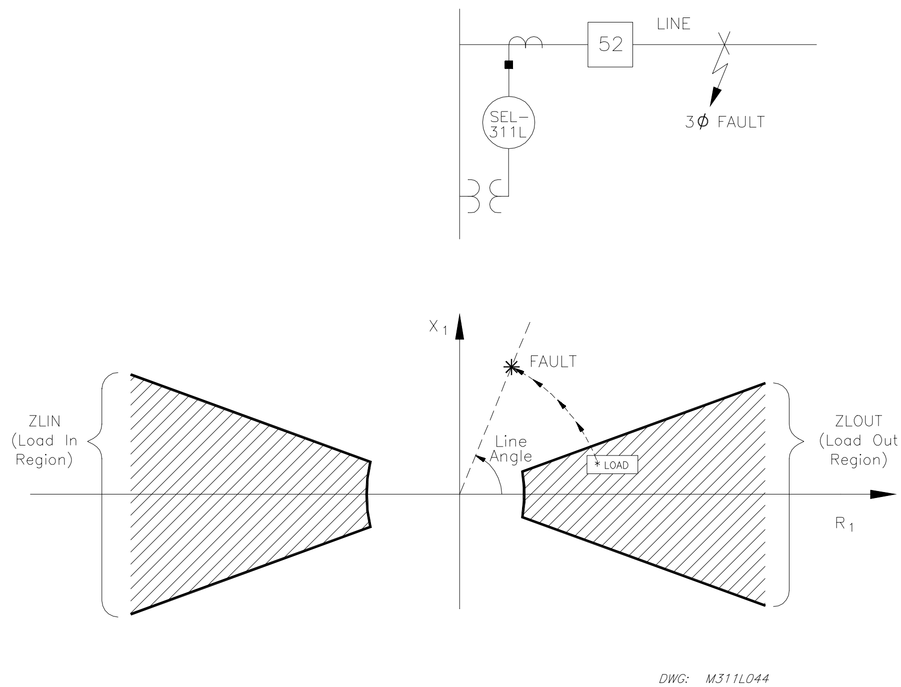


Figure 4.4: Migration of Apparent Positive-Sequence Impedance for a Fault Condition

Refer to Figure 4.4. In a load condition, the apparent positive-sequence impedance is <u>within</u> 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 <u>outside</u> the ZLOUT area (and stays outside the ZLIN area, too), resulting in :

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

Refer to Figure 3.47 in ***Section 3: Line Current Differential, Distance, Out-of-Step, Overcurrent, Voltage, and Synchronism Check Elements***. 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 <u>cannot</u> 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 <u>can</u> operate:

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

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

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

DIRECTIONAL CONTROL FOR GROUND DISTANCE AND RESIDUAL GROUND OVERCURRENT ELEMENTS

Setting E32 configures directional control for distance and overcurrent elements. Setting E32 and other directional control settings are described in the following subsection ***Directional Control Settings***.

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.

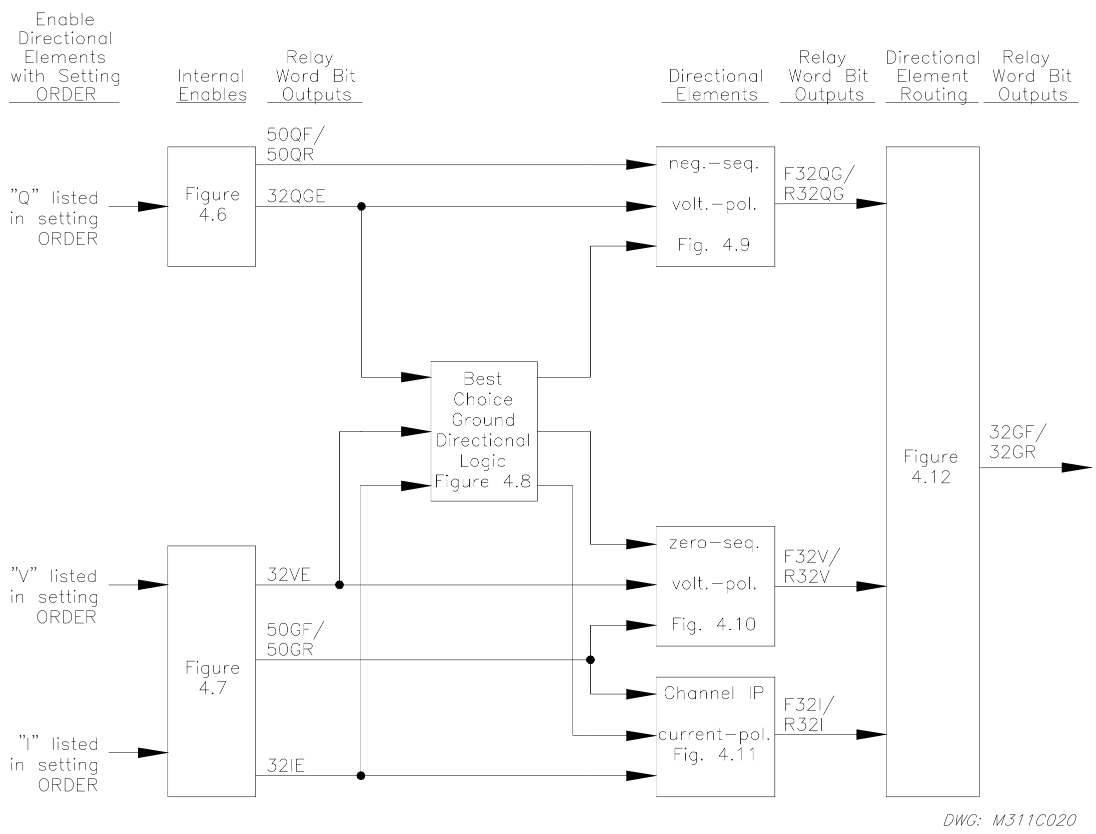


Figure 4.5: General Logic Flow of Directional Control for Ground Distance and Residual Ground Overcurrent Elements

Figure 4.5 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 4.5 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*™ logic control. See discussion on setting ORDER in the following subsection ***Directional Control Settings***.

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 4.5, Figure 4.6, and Figure 4.7.

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 4.6 has extra directional element enable 32QE, which is used in the logic that controls phase distance elements (see Figure 4.14).

The settings involved with 32QGE, 32VE, and 32IE in Figure 4.6 and Figure 4.7 (e.g., settings a2, k2, a0) are explained in the following subsection ***Directional Control Settings***.

Best Choice Ground Directional Logic

Refer to Figure 4.5 and Figure 4.8.

Relay Word bits 32QGE, 32VE, and 32IE and setting ORDER are used in the *Best Choice Ground Directional* logic in Figure 4.8. The *Best Choice Ground Directional* 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 4.5, Figure 4.9, Figure 4.10, and Figure 4.11.

The enable output of *Best Choice Ground Directional* logic in Figure 4.8 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 4.9 and Figure 4.10).

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 4.11) is enabled if enable setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit ILOP asserts).

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

Directional Element Routing

Refer to Figure 4.5 and Figure 4.12.

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 4.12 that if all the following are true:

- enable setting ELOP = Y,
- a loss-of-potential condition occurs (Relay Word bit LOP asserts),
- and 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 4.9 and Figure 4.10, 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 4.1 and accompanying text for more information on loss-of-potential.

As shown in Figure 3.29 through Figure 3.37, ILOP also disables all ground distance elements.

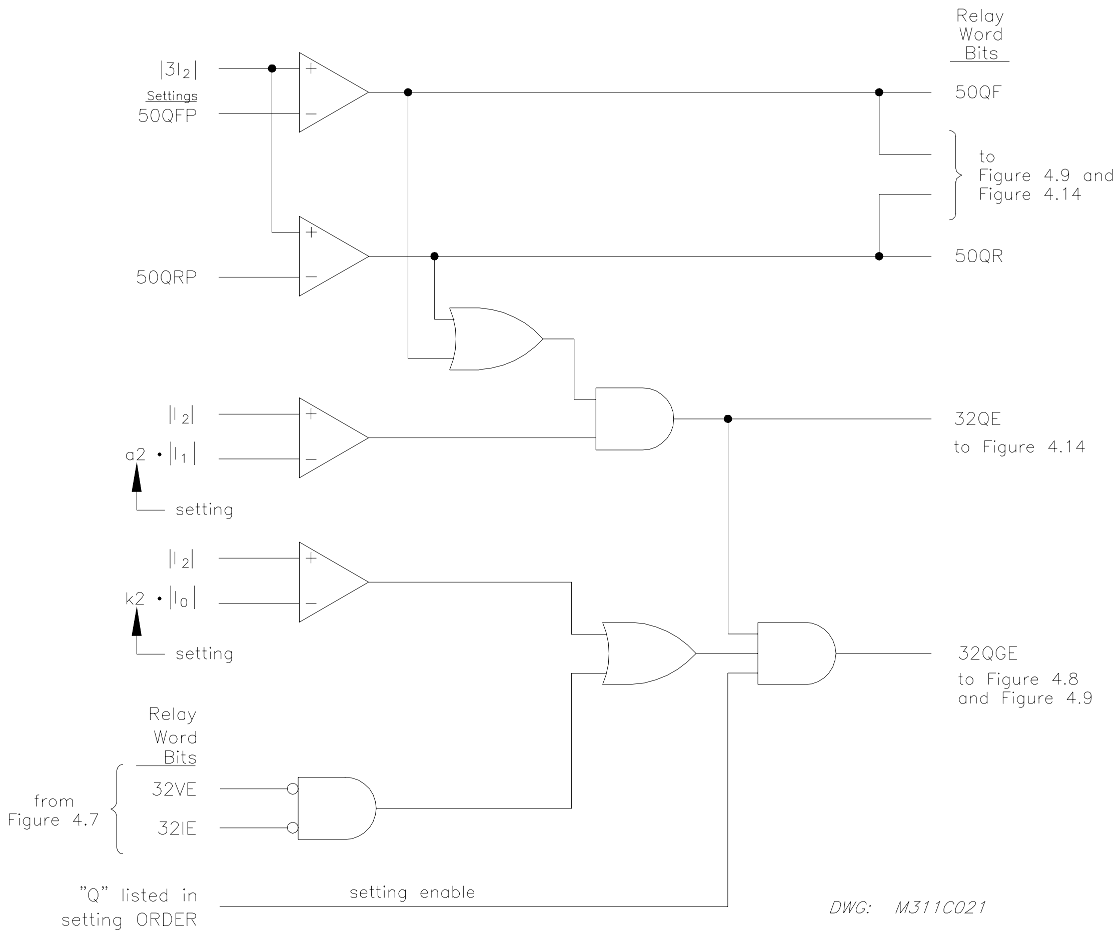


Figure 4.6: Internal Enables (32QE and 32QGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements

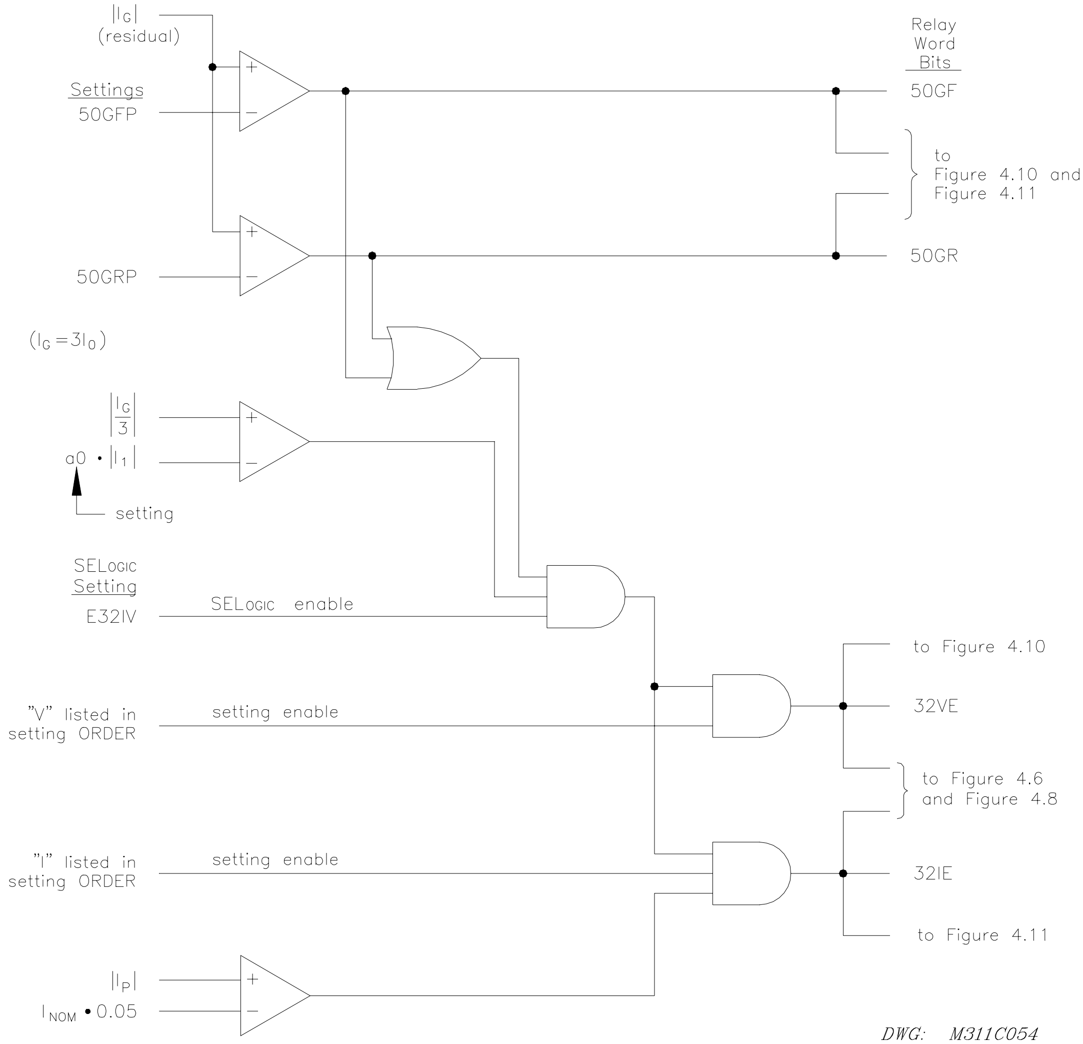


Figure 4.7: Internal Enables (32VE and 32IE) Logic for Zero-Sequence Voltage-Polarized and Channel IP Current-Polarized Directional Elements

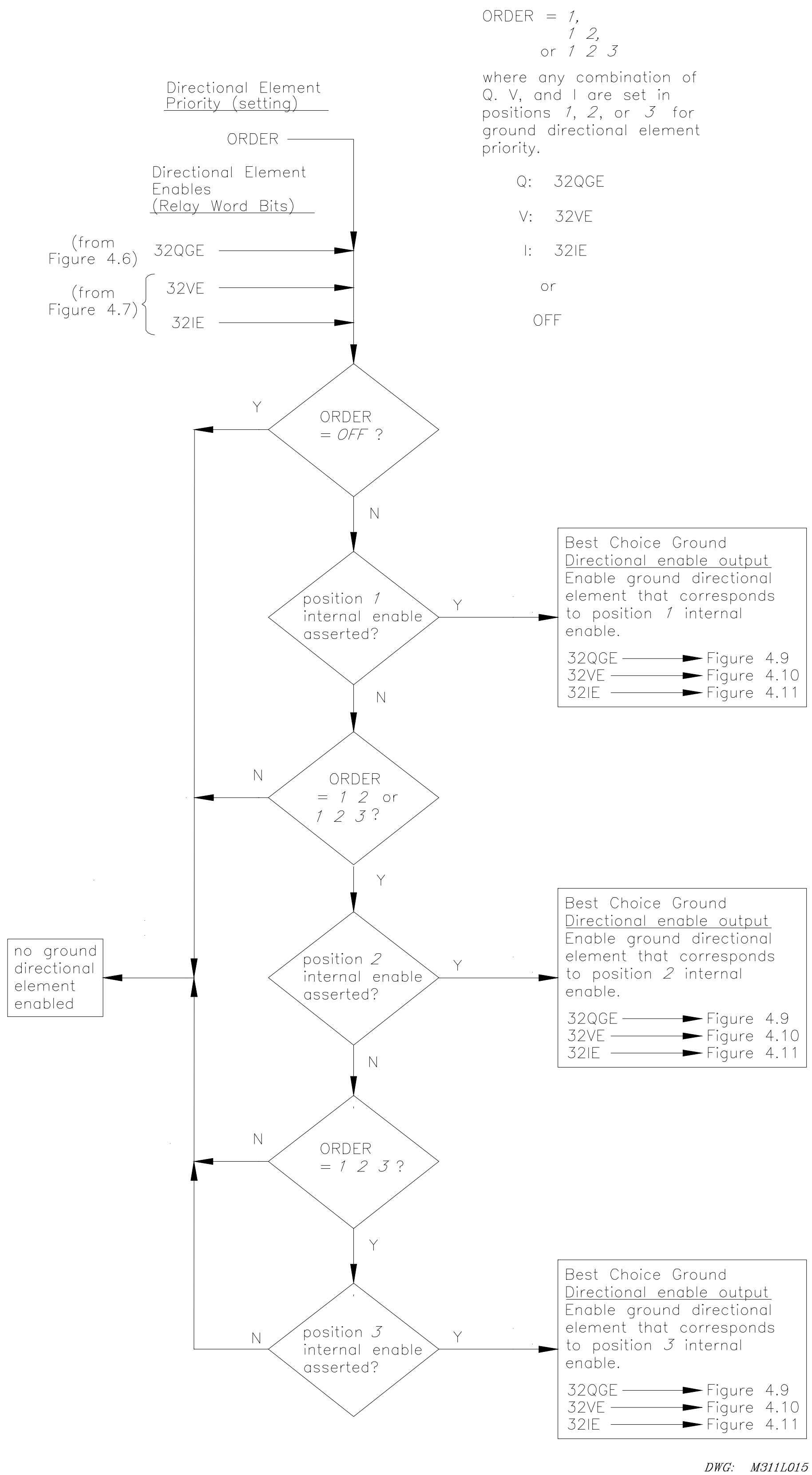
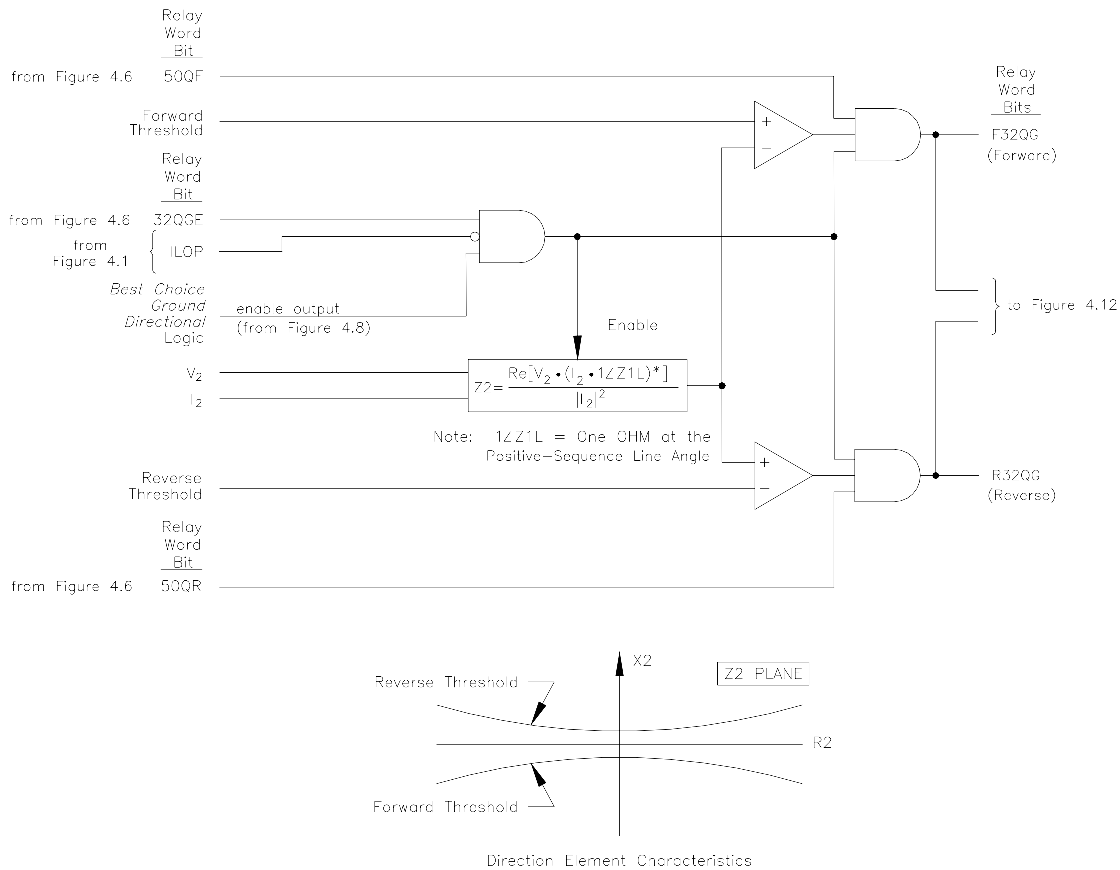


Figure 4.8: ***Best Choice Ground Directional*** **Logic**



Forward Threshold:

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

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

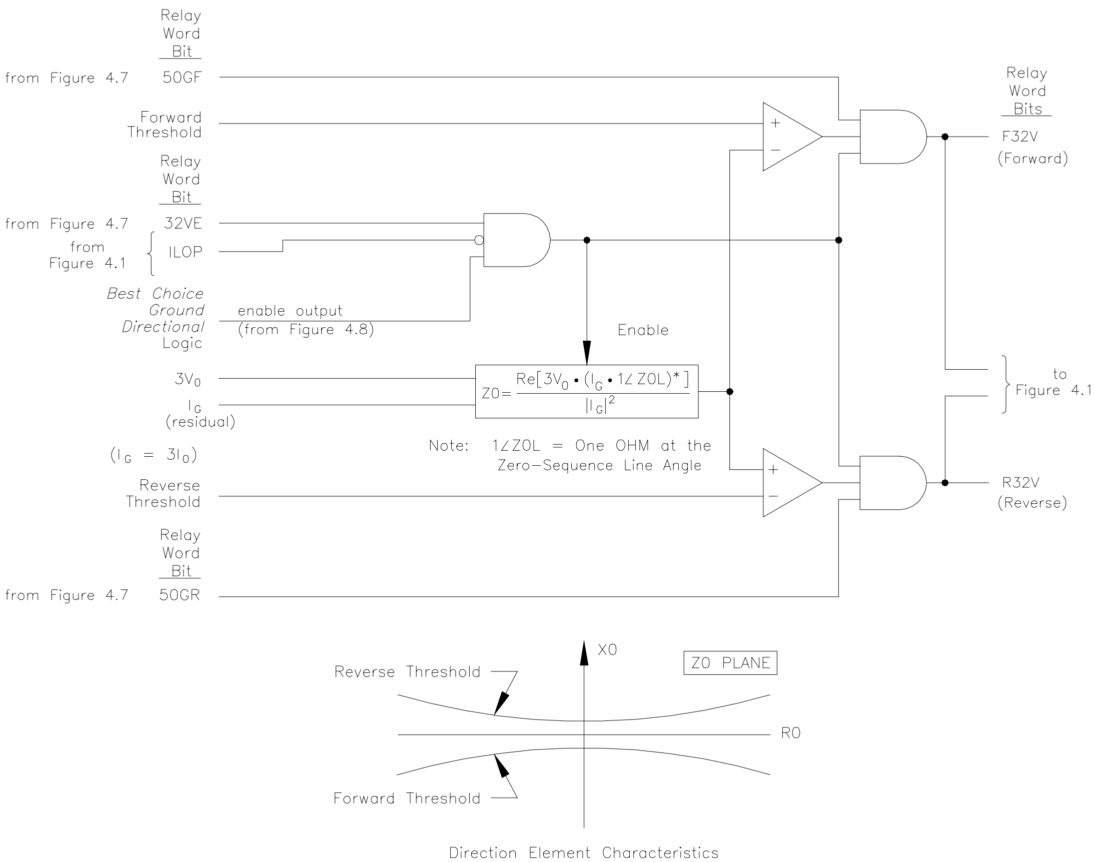
Reverse Threshold:

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

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

DWG: M311C056

Figure 4.9: Negative-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements



Forward Threshold:

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

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

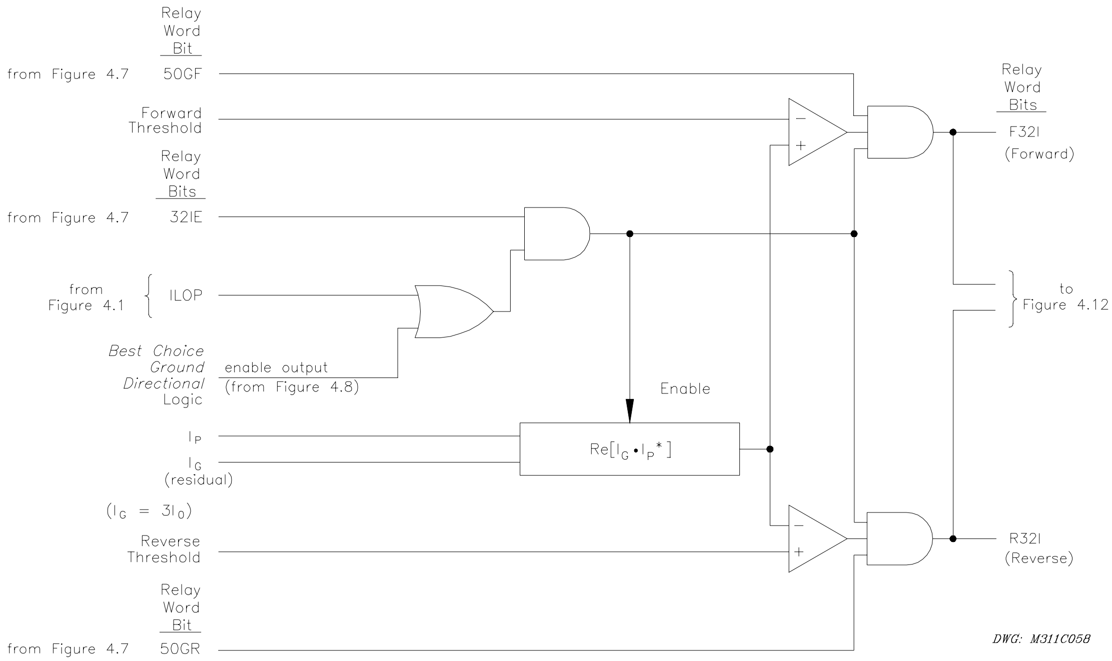
Reverse Threshold:

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

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

DWG: M311C057

Figure 4.10: Zero-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements



Forward Threshold

Forward Threshold = (channel I_P nominal rating) • (phase channels nominal rating) • $(0.05)^2$

Reverse Threshold

Reverse Threshold = −(channel I_P nominal rating) • (phase channels nominal rating) • $(0.05)^2$

Figure 4.11: Channel IP Current-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements

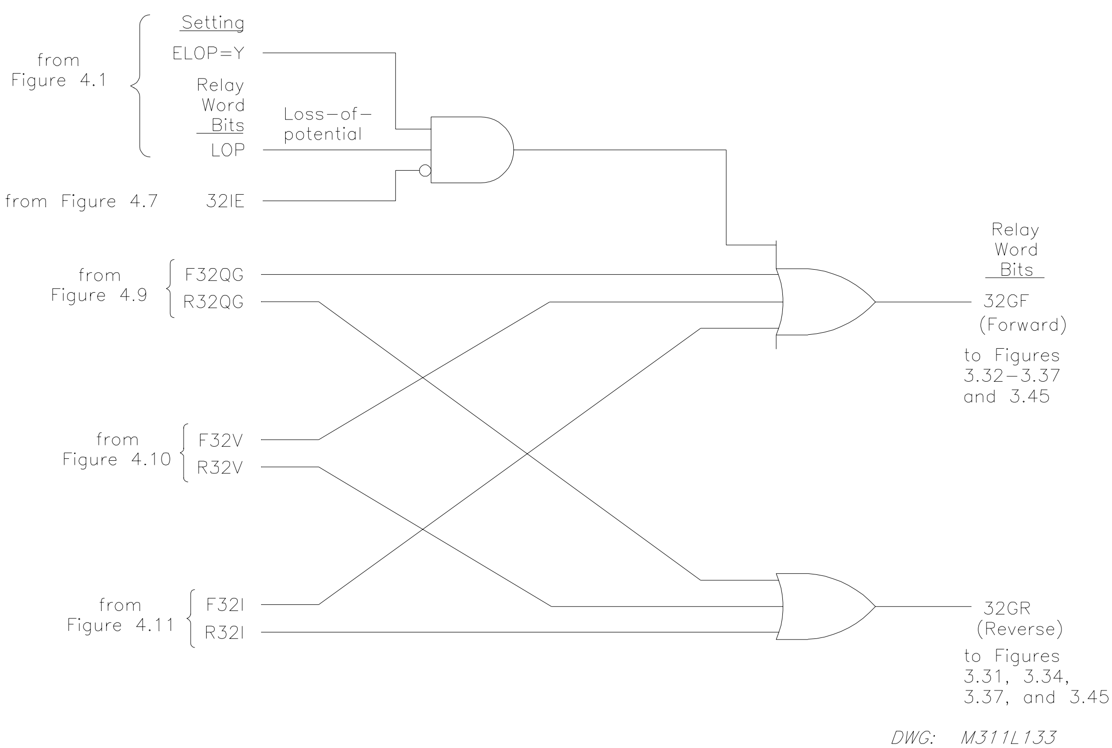


Figure 4.12: Ground Distance and Residual Ground Directional Logic

Directional Control for Phase Distance and Negative-Sequence Elements

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 the following subsection ***Directional Control Settings***.

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 4.13 gives an overview of how the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements are enabled and routed.

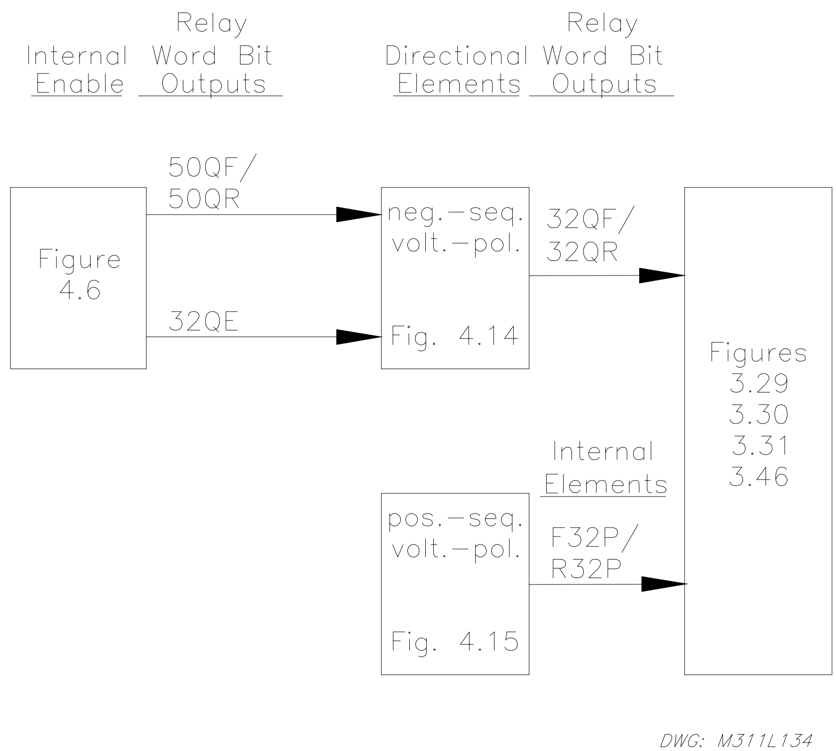


Figure 4.13: General Logic Flow of Directional Control for Negative-Sequence Phase Overcurrent and Phase Distance Elements

Internal Enables

Refer to Figure 4.6 and Figure 4.13.

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

The settings involved with 32QE in Figure 4.6 (e.g., setting a2) are explained in a following subsection ***Directional Control Settings***.

Directional Elements

Refer to Figure 4.13, Figure 4.14, and Figure 4.15.

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 4.14 and Figure 4.15).

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

The negative-sequence voltage-polarized directional element operates for unbalanced faults while the positive-sequence voltage-polarized directional element operates for three-phase faults.

Note in Figure 4.15 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 4.3).

Directional Element Routing

Refer to Figure 4.13 and Figure 4.14.

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,
- 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 4.1 and accompanying text for more information on loss-of-potential.

As shown in Figure 3.29 through Figure 3.31, ILOP also disables all phase distance elements.

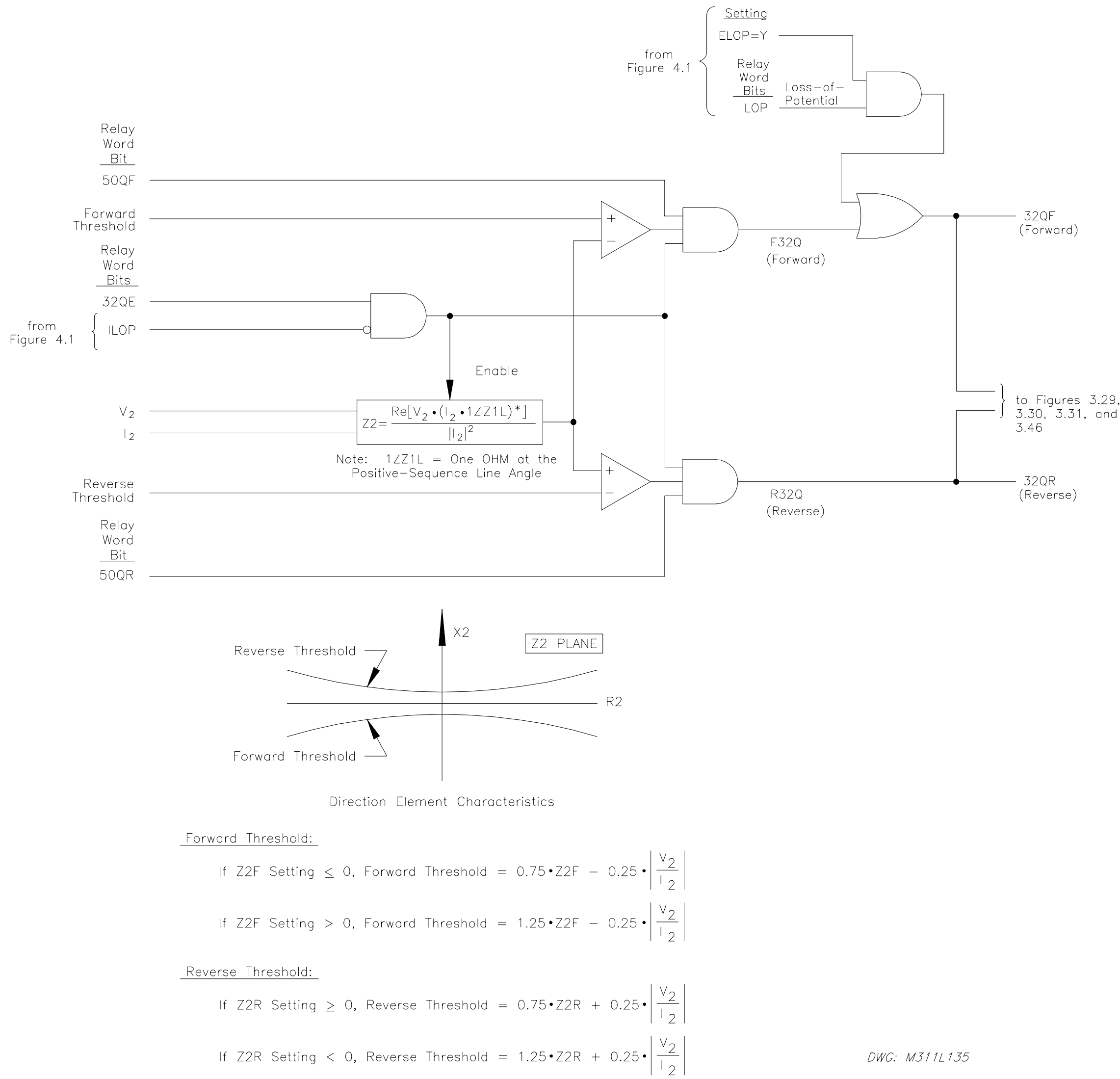


Figure 4.14: Negative-Sequence Voltage-Polarized Directional Element for Phase Distance and Negative-Sequence Elements

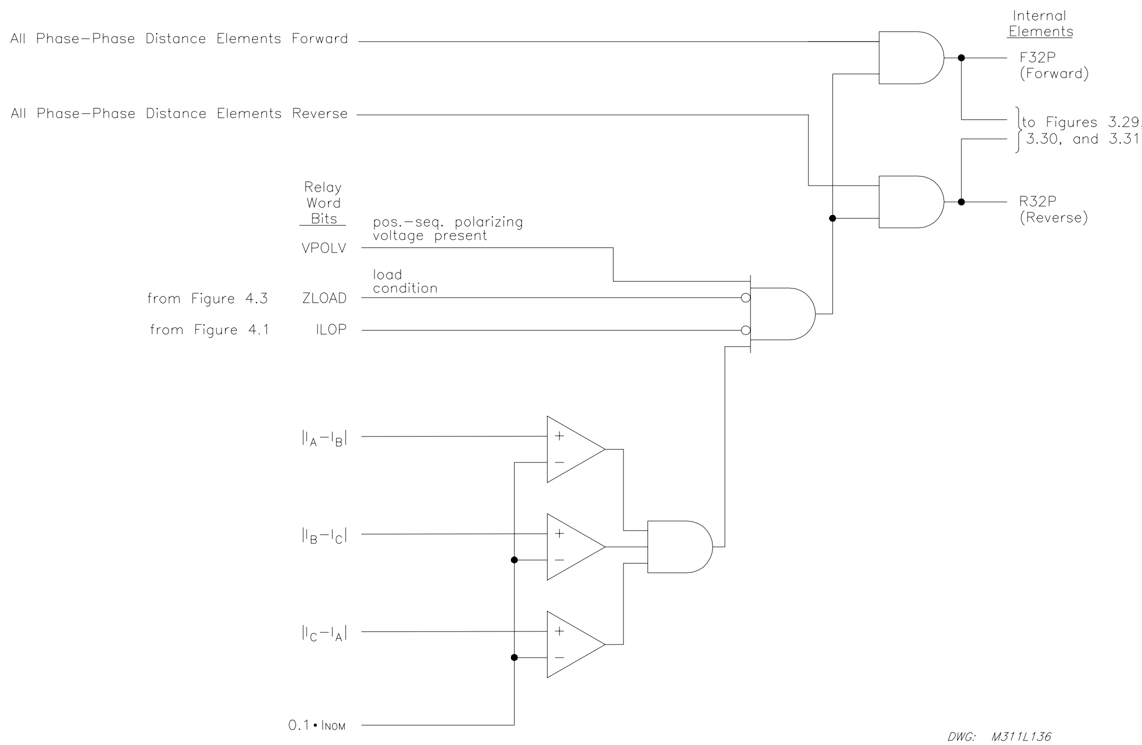


Figure 4.15: Positive-Sequence Voltage-Polarized Directional Element for Phase Distance Elements

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.

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 subsection.

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

Table 4.1: 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 (3.29) M1PT (3.34)	Z1G (3.32) Z1GT(3.39)	67G1 (3.45) 67G1T (3.45)	67Q1 (3.46) 67Q1T (3.46)
Forward	M2P (3.30) M2PT (3.34)	Z2G (3.33) Z2GT(3.39)	67G2 (3.45) 67G2T (3.45)	67Q2 (3.46) 67Q2T (3.46)
DIR3 = F or R	M3P (3.31) M3PT (3.34)	Z3G (3.34) Z3GT (3.39)	67G3 (3.45) 67G3T (3.45)	67Q3 (3.46) 67Q3T (3.46)
DIR4 = F or R	M4P (3.31) M4PT (3.34)	Z4G (3.34) Z4GT (3.39)	67G4 (3.45) 67G4T (3.45)	67Q4 (3.46) 67Q4T (3.46)

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* logic control. See Figure 4.8.

For example, if setting:

ORDER = QV

then the first listed directional element (Q = negative-sequence voltage-polarized directional element; see Figure 4.9) 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 4.10) 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 4.10) 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).

Note: If ground quadrilateral distance elements are used, the first entry in the ORDER setting should be as shown below:

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 4.9 and Figure 4.14).

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 (1A nominal).

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 4.6). 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 4.6). 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 4.6.

The a2 factor increases the security of the negative-sequence voltage-polarized directional elements. It keeps the elements from operating for negative-sequence current (system unbalance), which circulates due to line asymmetries, CT saturation during three-phase faults, etc.

a2 Set Automatically

If 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 ($|I_2| > 0.1 \cdot |I_1|$).

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

Setting Range:

0.10–1.20 (unitless)

Note the directional enable logic outputs in Figure 4.6:

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 4.9) to be enabled:

$$|I_2| > k2 \cdot |I_0|$$

This check assures that the relay uses the most robust analog quantities in making directional decisions for the ground distance and residual ground overcurrent elements.

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 4.7). 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 4.7). 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 4.7.

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 due to 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 4.10).

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 (5A nominal) or 0.5 Ω (1A 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 4.7.

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 Relay:

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 4.2: 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

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SECTION 5: TRIP AND TARGET LOGIC

INTRODUCTION

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 up to 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 5.2, when setting ESHT ≥ 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.

When high-speed tripping is enabled, Relay Word bit TRIP87 is also routed to the backup protection tripping logic in Figure 5.4. This triggers event reports and the target logic when a high-speed 87L trip occurs.

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*** in ***Section 9: Setting the Relay*** for a more detailed example of qualified 87L tripping. See ***Backup Protection Trips*** later in this section 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, Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements*** for more information about setting E87L.

The SEL-311L Relay 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

Set EDD = Y to qualify 87L tripping for up to two cycles with the local disturbance detector Relay Word bit DD. There are no other settings associated with the local disturbance detector. Make setting EDD = Y at all terminals where a weak-infeed or zero-infeed condition cannot occur. If a weak-infeed or zero-infeed condition can occur, set EDD = N. The disturbance detector output DD asserts for 10 cycles after the local I1 changes by more than 5 degrees or more than 2% of nominal current, or the local I0 changes by more than 5 degrees or more than 2% of nominal current.

Setting EDD = Y increases communications channel security. The 87L algorithms have excellent communications security that results in less than one unwanted trip per five hundred thousand channel noise bursts when setting EDD = N. When setting EDD = Y, the relay retains that security even if every noise burst results from an external detectable fault (an unlikely case). The security increases if some noise bursts do not result from an external fault (a more likely case).

The relay maintains excellent dependability by limiting disturbance detector qualification to 2 cycles maximum. The local disturbance detector does not qualify 87L direct transfer trips.

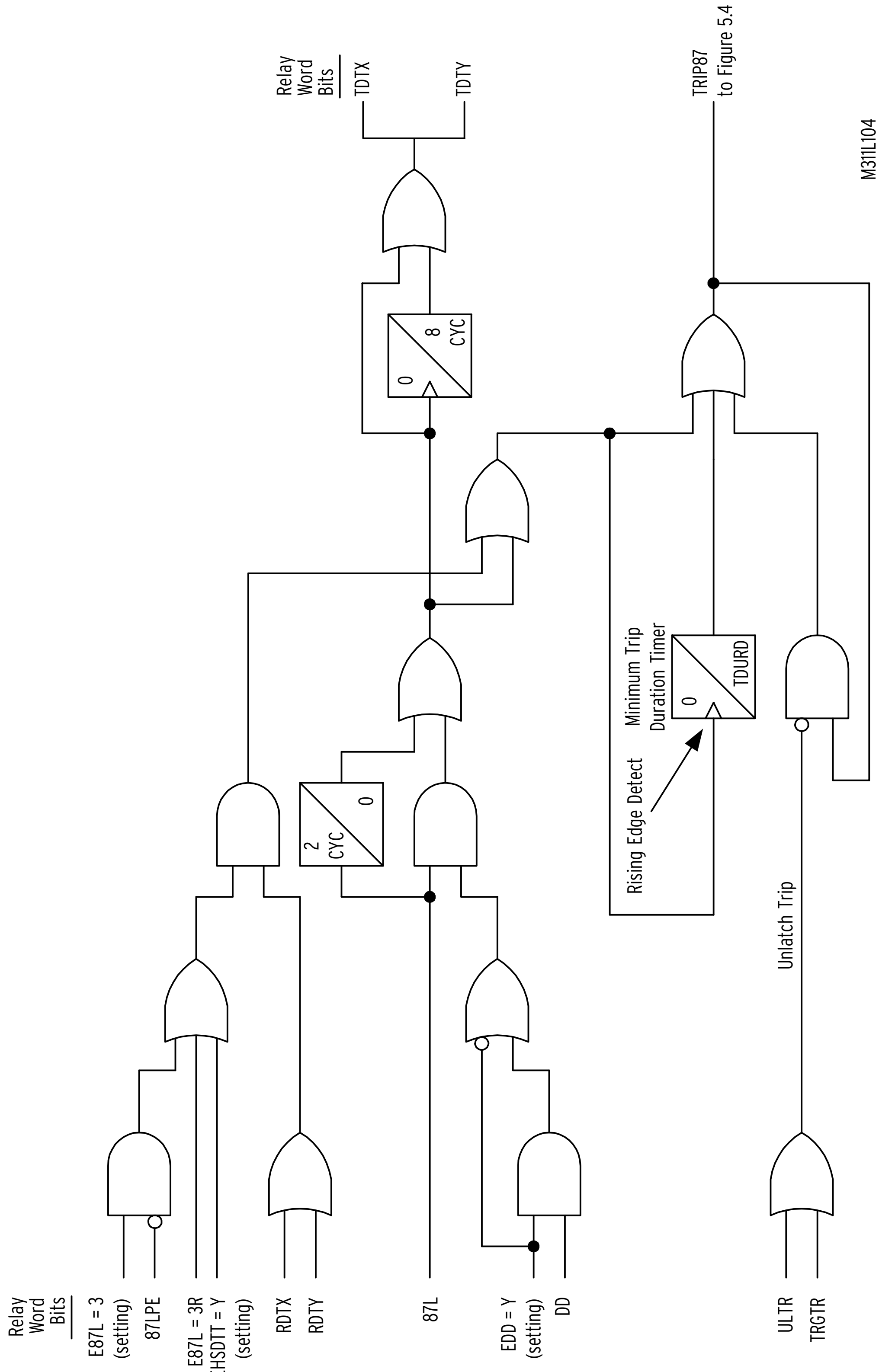

Figure 5.1: Line Current Differential Trip Logic With Direct Transfer Tripping, and Local Disturbance Detector Supervision

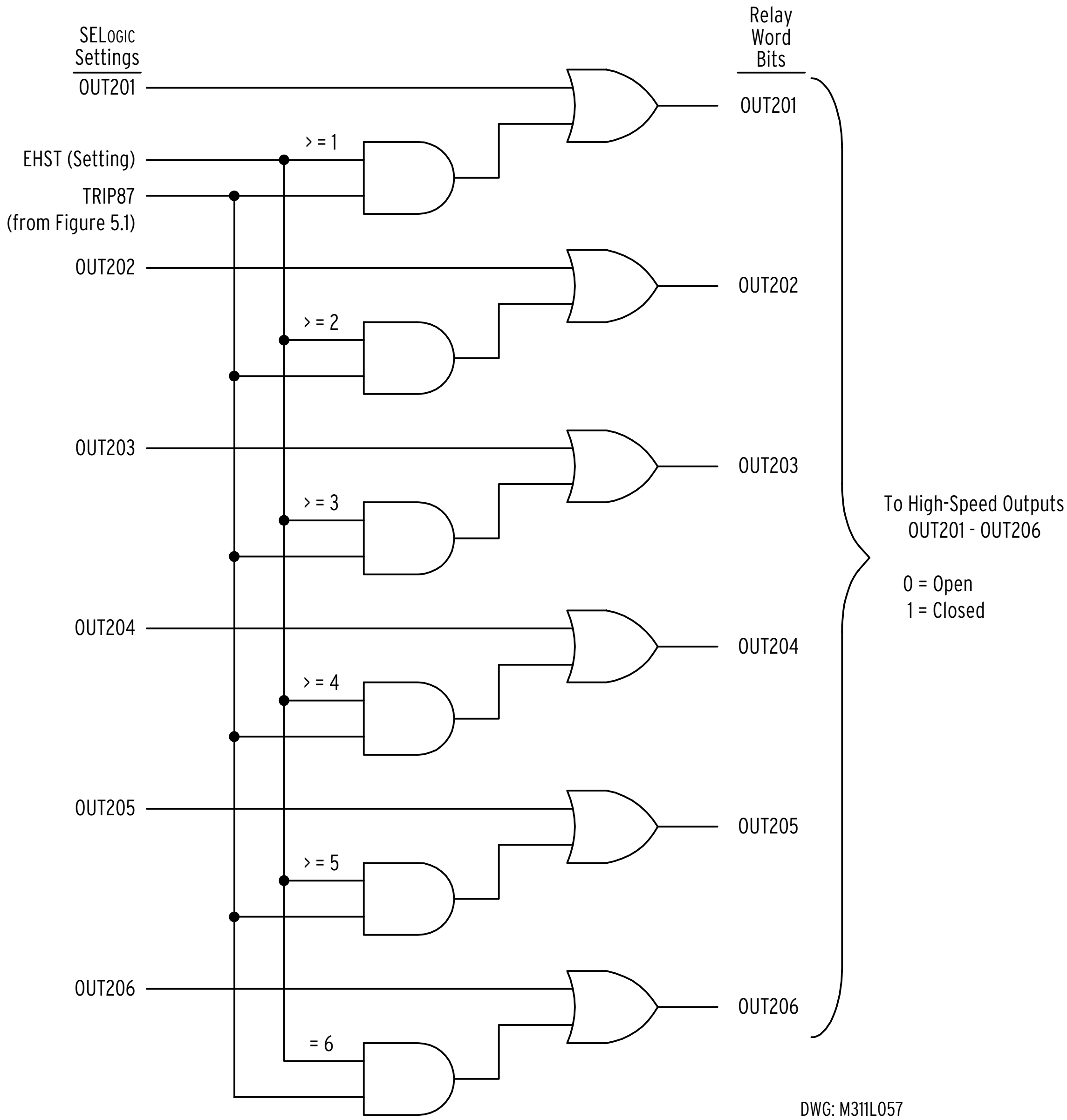

Figure 5.2: High-Speed Output Logic

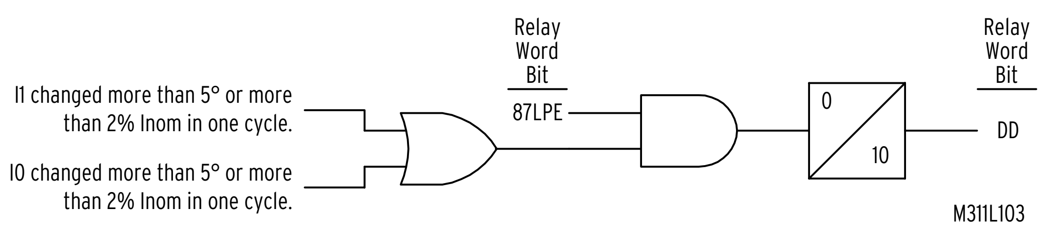

Figure 5.3: Local Disturbance Detector

Backup Protection Trips

The trip logic in Figure 5.4 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*** later in this section for more information on communications-assisted tripping.

DTT Direct Transfer Trip Conditions.

Note in Figure 5.4 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 discussion in the ***Front-Panel Target LEDs*** subsection at the end of this section).

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 (SOTF) Trip Logic*** on page 5-10 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 5.4 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 4–16,000 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 non-directional elements.

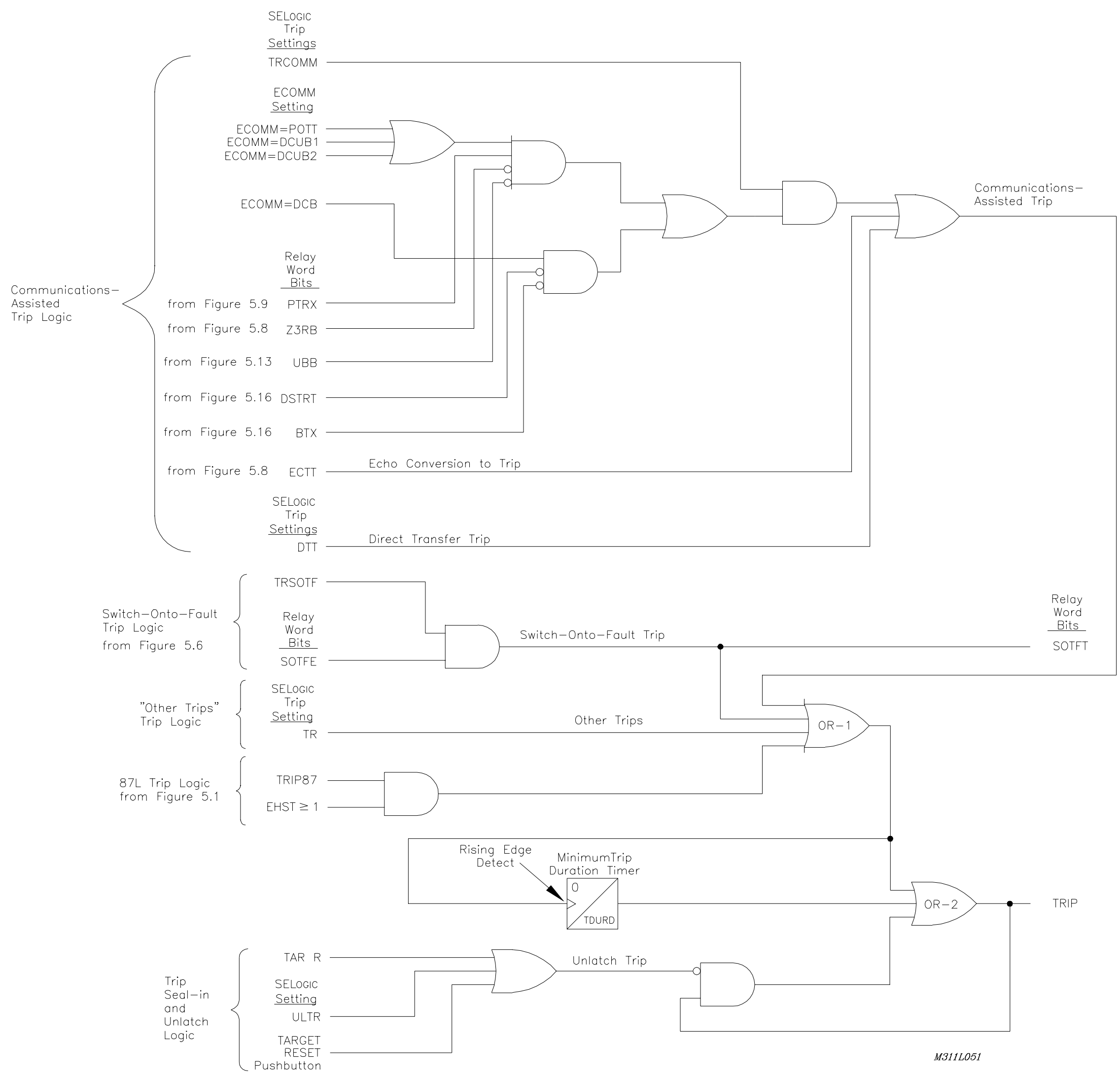

Figure 5.4: Trip Logic

In addition, when setting EHST ≥ 1, Relay Word bit TRIP asserts when any 87L element detects an internal fault.

Set Trip

Refer to Figure 5.4. All trip conditions:

- Communications-Assisted Trip, including Direct Transfer Trip
- Switch-Onto-Fault Trip
- Other High-Speed 87L 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 4 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)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** 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*** subsection at the end of this section.

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 5.4 deasserts to logical 0
- One of the following occurs:
  - SELOGIC control equation setting ULTR asserts to logical 1,
  - The front-panel TARGET RESET button is pressed,
  - Or the **TAR R** (Target Reset) command is executed via the serial port.

The front-panel TARGET RESET button 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 5.19 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 5.4 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: Setting the Relay*** 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)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** 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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***)

ULTR = !52A

Input IN101 has to be deenergized (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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***)
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 5.4 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 through 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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** for more information on programming output contacts.

Switch-Onto-Fault (SOTF) Trip Logic

Switch-Onto-Fault (SOTF) trip logic provides a programmable time window for selected elements to trip right after the circuit breaker closes. "Switch-onto-fault" implies that a circuit breaker is closed into an existing fault condition, such as when safety grounds are accidentally left attached to a line. If the circuit breaker is closed into such a condition, the resulting fault needs to be cleared right away and reclosing blocked. An instantaneous element is usually set to trip in the three-pole open (3PO) logic and the SOTF trip logic.

Refer to the switch-onto-fault trip logic in Figure 5.4 (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 5.5 and the following discussion describe the three-pole open (3PO) logic and the SOTF logic.

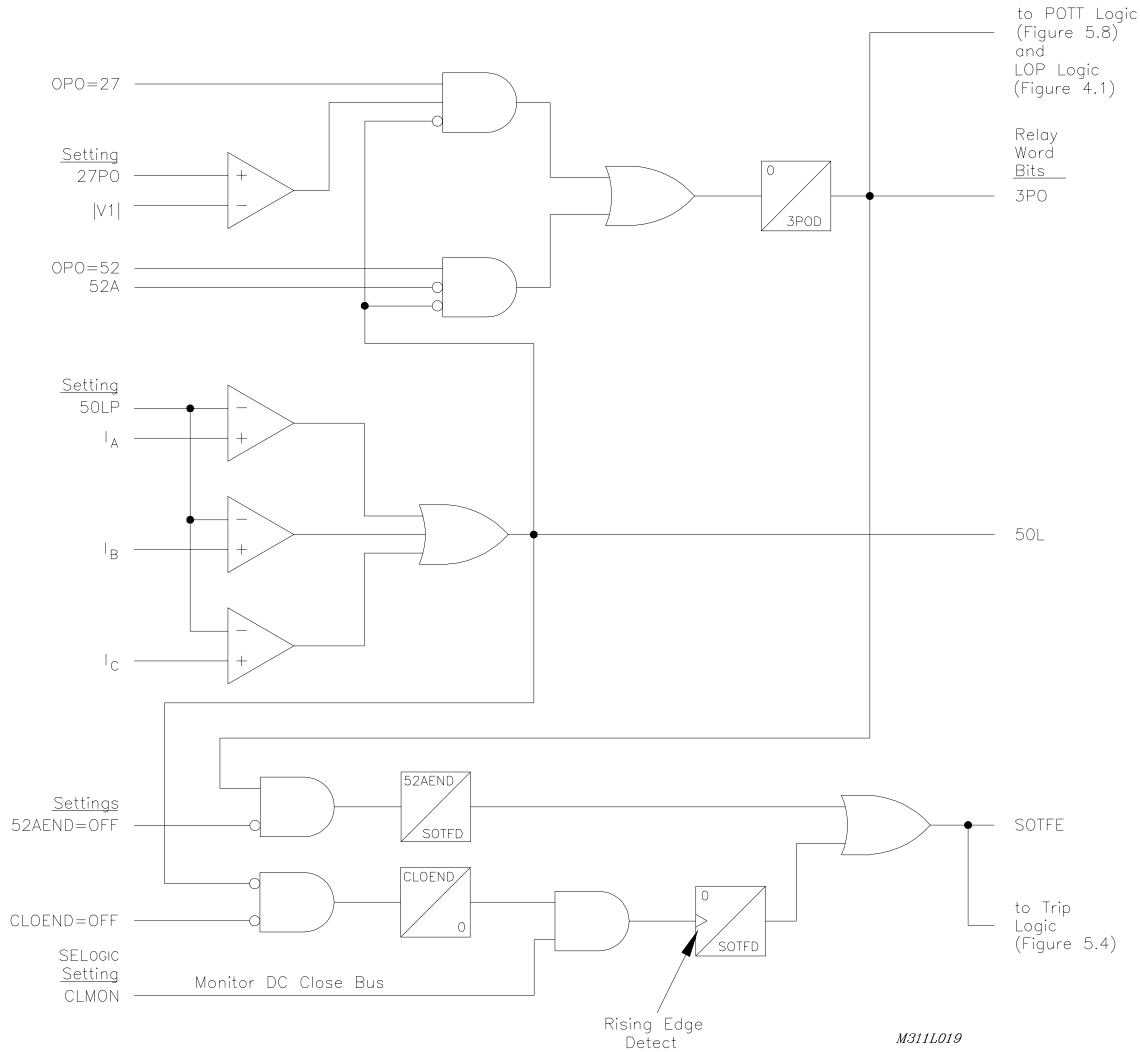

Figure 5.5: Three-Pole Open Logic (Top) and Switch-Onto-Fault Logic (Bottom)

Three-Pole Open Logic

Three-pole open (3PO) logic is the top half of Figure 5.5. It is not affected by enable setting ESOTF (see the settings sheets in ***Section 9: Setting the Relay***).

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 Relay 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 5.8), loss-of-potential (LOP) logic (see Figure 4.1), and line current differential protection logic (see Figure 3.17, Figure 3.18, and Figure 3.19).

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 5.4). 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 Relay 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 Relay (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 5.4—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 deenergized, 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 Relay includes communications-assisted tripping schemes that provide unit-protection for transmission lines with the help of communications. No external coordination devices are required.

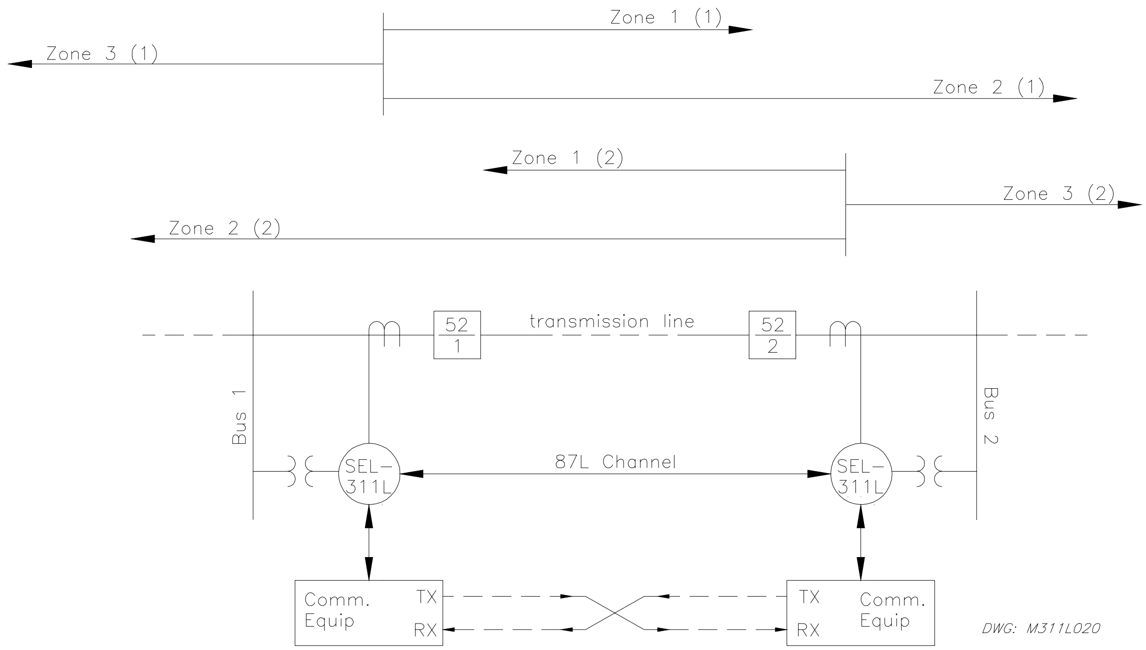

Figure 5.6: Communications-Assisted Tripping Scheme

Refer to Figure 5.6 and the top half of Figure 5.4.

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 5.6. Note that Zone 1 and Zone 2 are fixed in the forward direction.

See ***Directional Control Settings***, in ***Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic*** for more information on Zone/Level direction settings DIR3 and DIR4.

POTT, PUTT, DCUB, and DCB communications-assisted tripping schemes are explained in subsections that follow.

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 5.4). 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 5.16. 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 preceding subsection ***Switch-Onto-Fault (SOTF) Trip Logic***.

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 Relay are very similar to those in the SEL-321 Relay. Existing SEL-321 Relay application guides can also be used in setting up these schemes in the SEL-311L Relay. 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 (POTT) Logic

Enable the POTT logic by setting ECOMM = POTT. The POTT logic in Figure 5.8 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 Relay

Use the existing SEL-321 Relay POTT application guide (AG95-29) to help set up the SEL-311L Relay in a POTT scheme (see preceding subsection ***Communications-Assisted Trip Logic—General Overview*** for more setting comparison information on the SEL-321/SEL-311L Relays).

External Inputs

See ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 Relay (e.g., input IN104) is driven by a communications equipment receiver output (see Figure 5.10). 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 Relay (e.g., input IN104 and IN106) are driven by communications equipment receiver outputs (see Figure 5.11). Make SELOGIC control equation setting PT1 as follows:

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

SELOGIC control equation setting PT1 in Figure 5.7 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 5.8 (for echo keying).

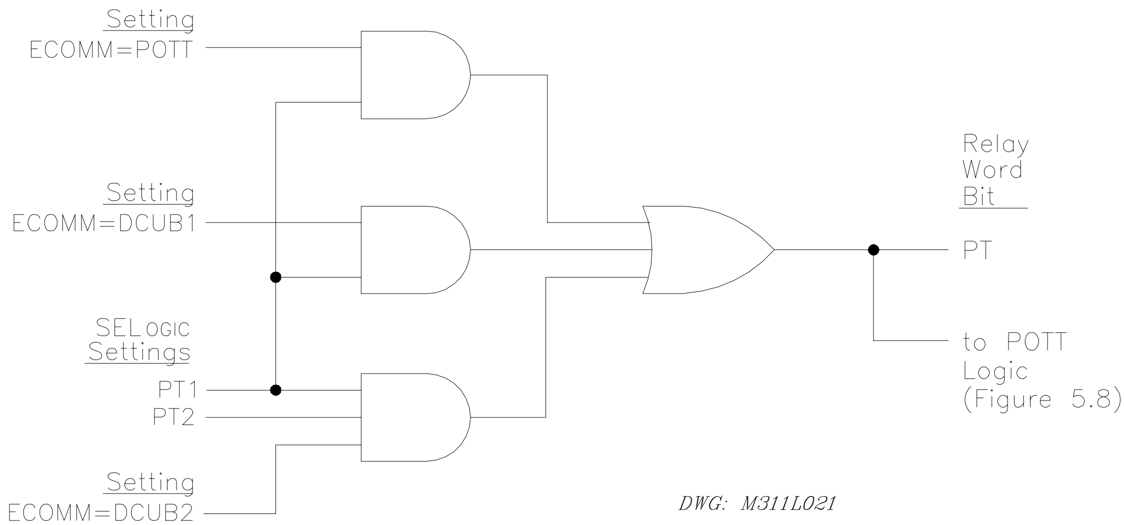

Figure 5.7: Permissive Input Logic Routing to POTT Logic

Also note that SELOGIC control equation setting PT1 in Figure 5.9 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 5.4.

Timer Settings

See ***Section 9: Setting the Relay*** for setting ranges.

Z3RBD—Zone (Level) 3 Reverse Block Delay

Current-reversal guard timer—typically set at 5 cycles.

EBLKD—Echo Block Delay

Prevents echoing of received PT for settable delay after dropout of local permissive elements in trip setting TRCOMM—typically set at 10 cycles. Set to OFF to defeat EBLKD.

ETDPU—Echo Time Delay Pickup

Sets minimum time requirement for received PT, before echo begins—typically set at 2 cycles. Set to OFF for no echo.

EDURD—Echo Duration

Limits echo duration, to prevent channel lockup—typically set at 4.0 cycles.

Logic Outputs

The following logic outputs can be tested by assigning them to output contacts. See ***Output Contacts*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 5.4 and the DCUB logic in Figure 5.12).

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 5.4).

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 Relay Weak-Infeed Logic

Enable the weak-infeed logic by setting EWFC = Y.

The SEL-311L Relay provides additional logic (see Figure 5.8) 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:

1. A permissive trip (PT) signal is received for ETDPU time.
2. A phase undervoltage or residual overvoltage element is picked up.
3. No reverse-looking elements are picked up.
4. 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 5.4) 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 5.10).

In a three-terminal line scheme, output contact OUT107 is set the same as OUT105 (see Figure 5.11):

OUT107 = KEY

EKEY—Echo Key Permissive Trip

Permissive trip signal keyed by Echo logic (used in testing).

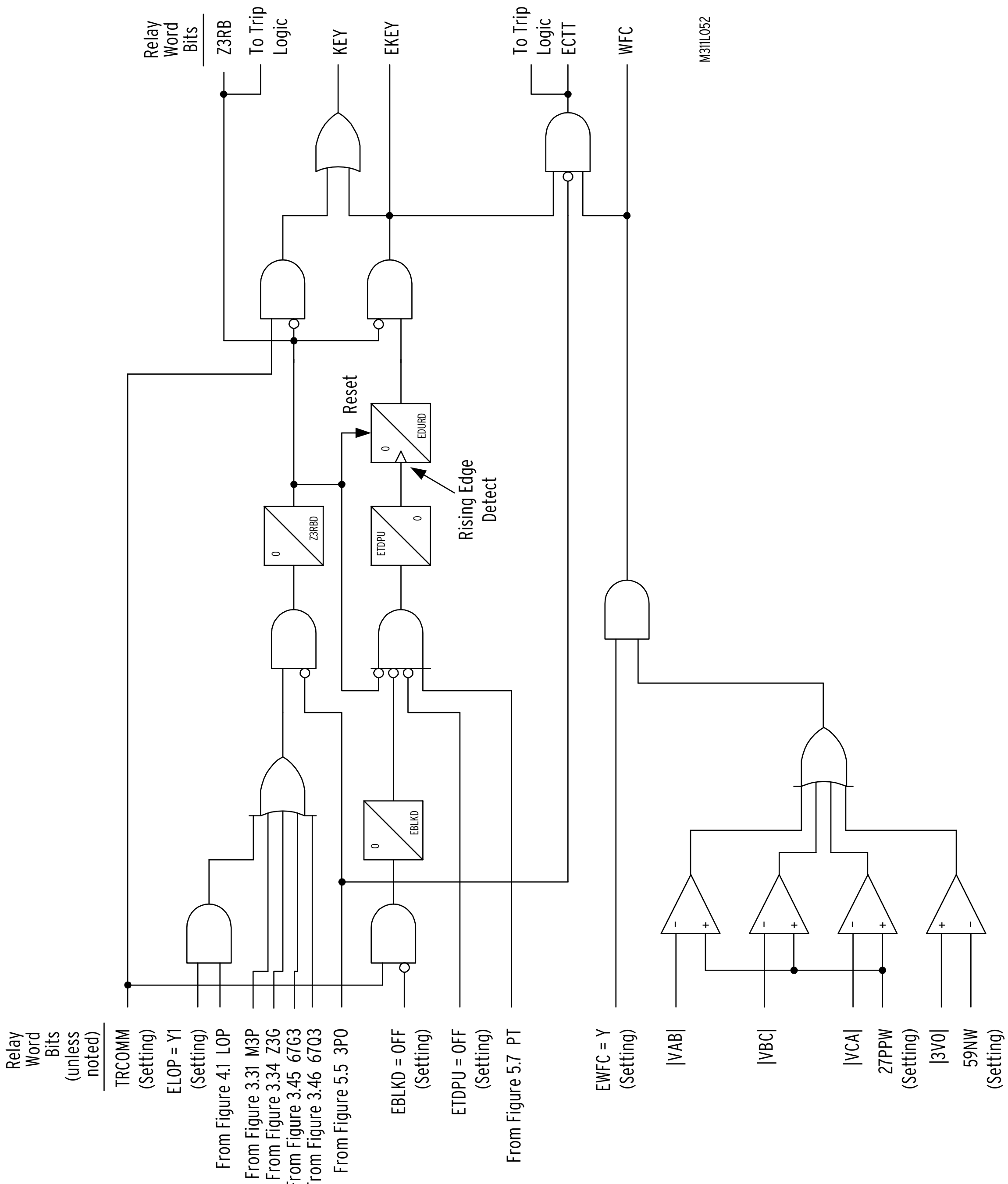

Figure 5.8: POTT Logic

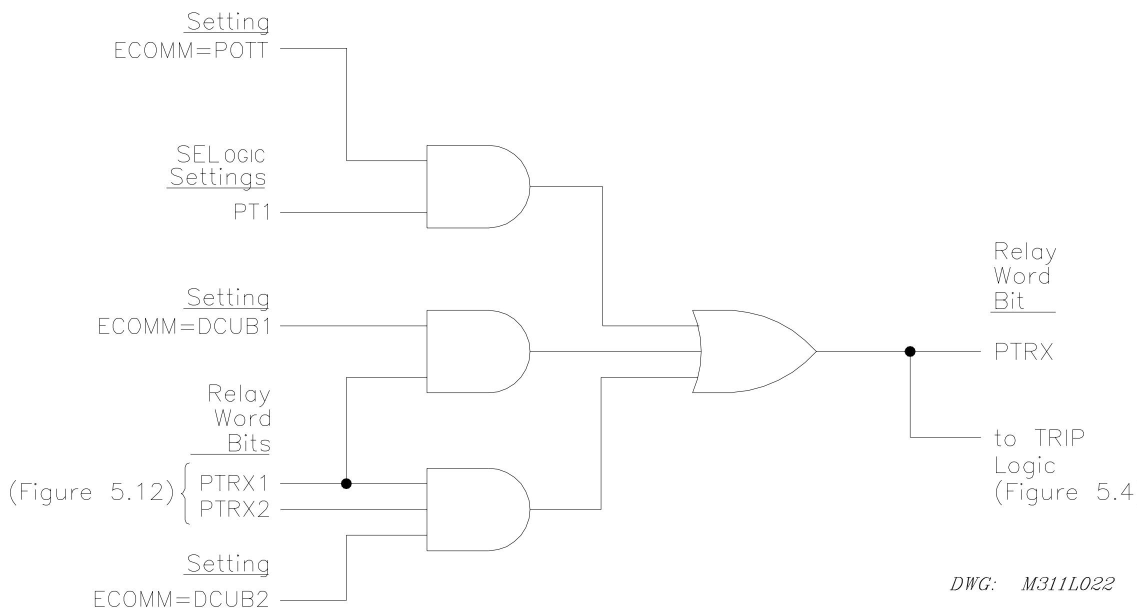

Figure 5.9: Permissive Input Logic Routing to Trip Logic

Variations for Permissive Underreaching Transfer Trip (PUTT) Scheme

Refer to Figure 5.6 and Figure 5.8. 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 5.10):

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 5.11).

Installation Variations

Figure 5.11 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 5.11. Then output contact OUT107 can be used for another function.

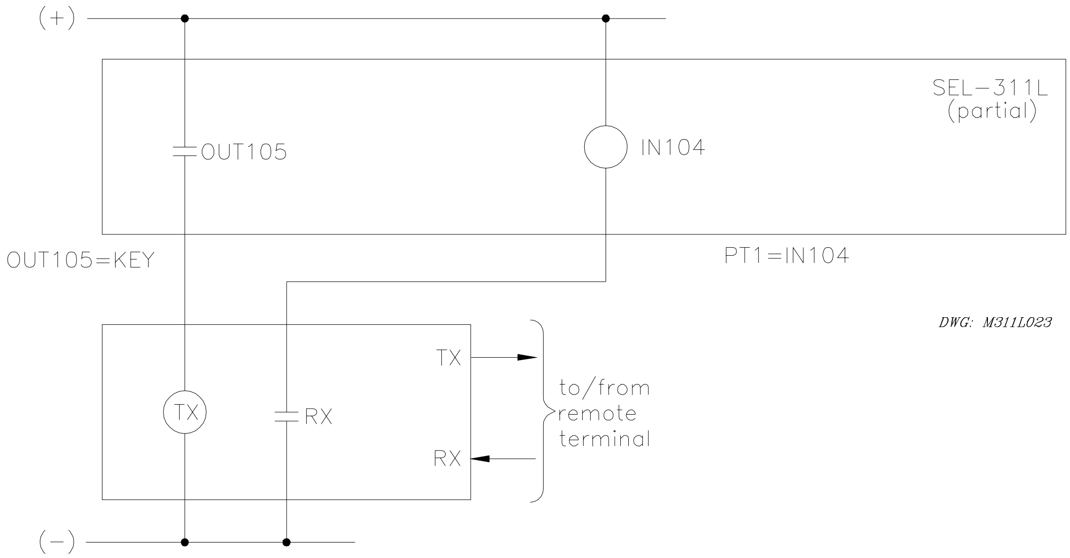

Figure 5.10: SEL-311L Relay Connections to Communications Equipment for a Two-Terminal Line POTT Scheme

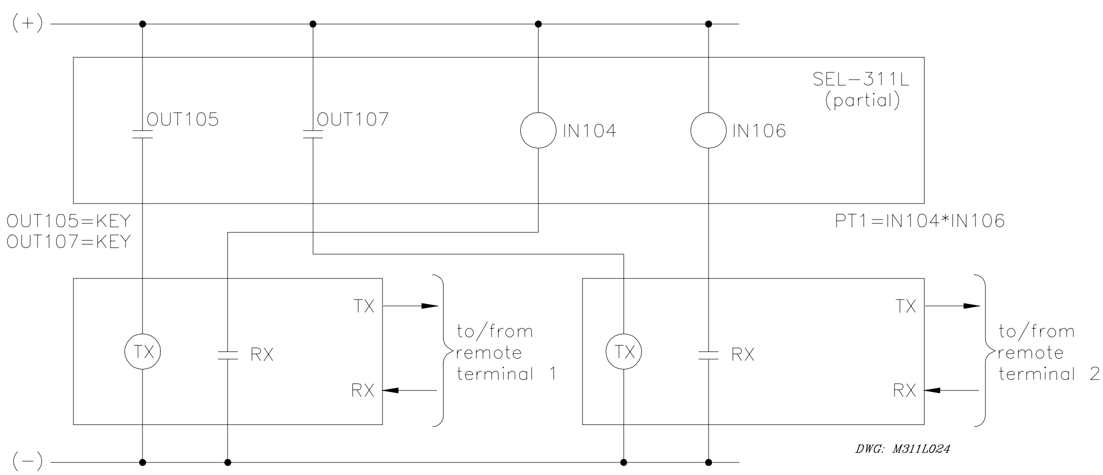

Figure 5.11: SEL-311L Relay Connections to Communications Equipment for a Three-Terminal Line POTT Scheme

DIRECTIONAL COMPARISON UNBLOCKING (DCUB) LOGIC

Enable the DCUB logic by setting ECOMM = DCUB1 or ECOMM = DCUB2. The DCUB logic in Figure 5.12 is an extension of the POTT logic in Figure 5.8. 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 5.12 takes in the loss-of-guard and permissive trip outputs from the communications receivers (see Figure 5.14 and Figure 5.15) and makes permissive (PTRX1/PTRX2) and unblocking block (UBB1/UBB2) logic output decisions.

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

Use the existing SEL-321 Relay DCUB application guide (AG96-19) to help set up the SEL-311L Relay in a DCUB scheme (see preceding subsection ***Communications-Assisted Trip Logic—General Overview*** for more setting comparison information on the SEL-321/SEL-311L Relays).

External Inputs

See ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 Relay (e.g., input IN104) is driven by a communications equipment receiver output (see Figure 5.14). 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 Relay (e.g., inputs IN104 and IN106) are driven by communications equipment receiver outputs (see Figure 5.15). 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 5.12 for “unblocking block” and “permissive trip receive” logic decisions.

As explained in the preceding POTT subsection, the SELOGIC control equation settings PT1 and PT2 in Figure 5.7 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 5.8 (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 Relay (e.g., input IN105) is driven by a communications equipment receiver output (see Figure 5.14). 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 Relay (e.g., input IN105 and IN103) are driven by communications equipment receiver outputs (see Figure 5.15). 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 5.12 for "unblocking block" and "permissive trip receive" logic decisions.

Timer Settings

See ***Section 9: Setting the Relay*** for setting ranges.

GARD1D—Guard-Present Delay

Sets minimum time requirement for reinstating permissive tripping following a loss-of-channel condition—typically set at 10 cycles. Channel 1 and 2 logic use separate timers but have this same delay setting.

UBDURD—DCUB Disable Delay

Prevents tripping by POTT logic after a settable time following a loss-of-channel condition—typically set at 9 cycles (150 ms). Channel 1 and 2 logic use separate timers but have this same delay setting.

UBEND—DCUB Duration Delay

Sets minimum time required to declare a loss-of-channel condition—typically set at 0.5 cycles. Channel 1 and 2 logic use separate timers but have this same delay setting.

Logic Outputs

The following logic outputs can be tested by assigning them to output contacts. See ***Output Contacts*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 5.13 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 5.4. When UBB asserts to logical 1, tripping is blocked.

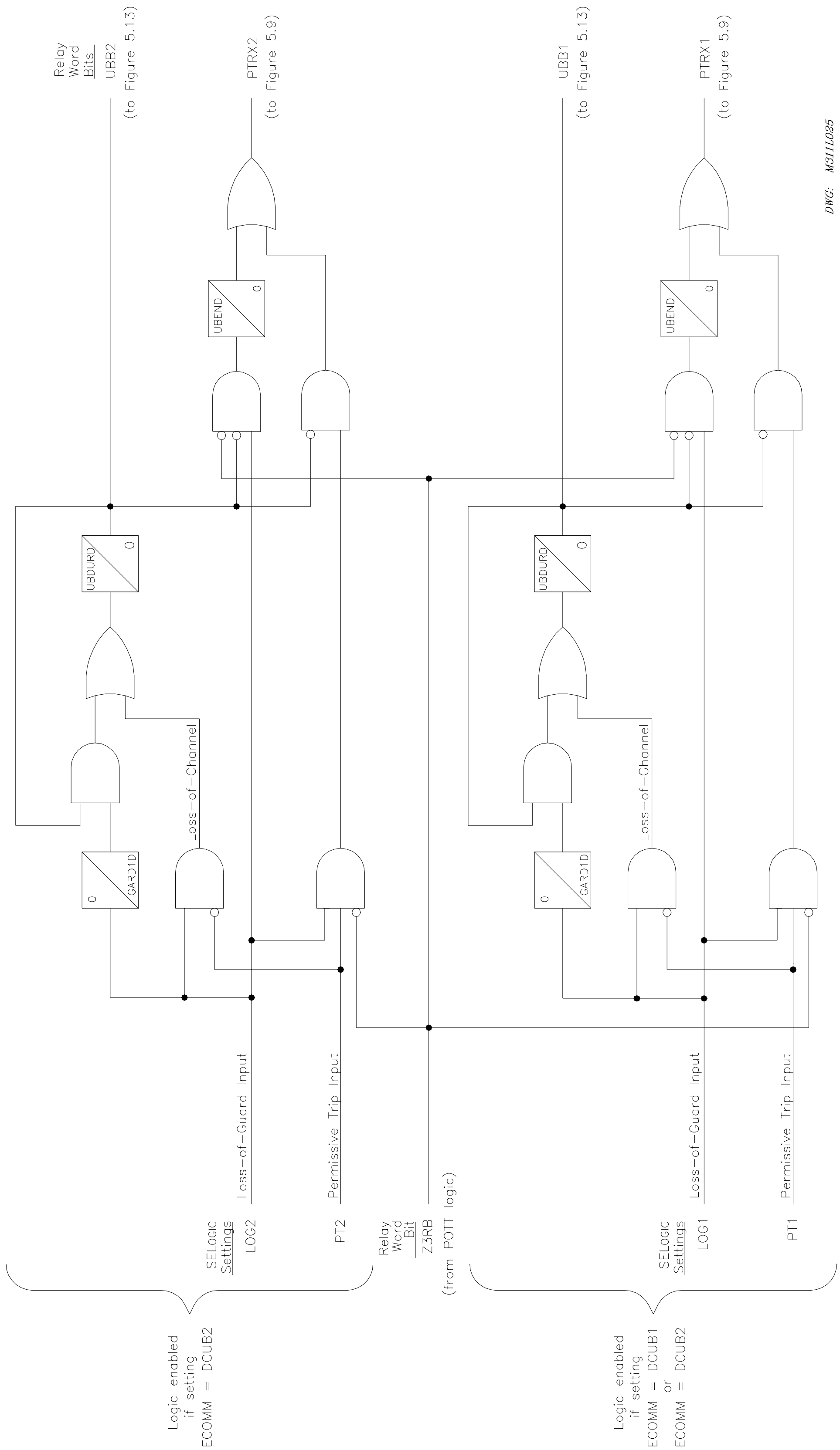

Figure 5.12: DCUB Logic

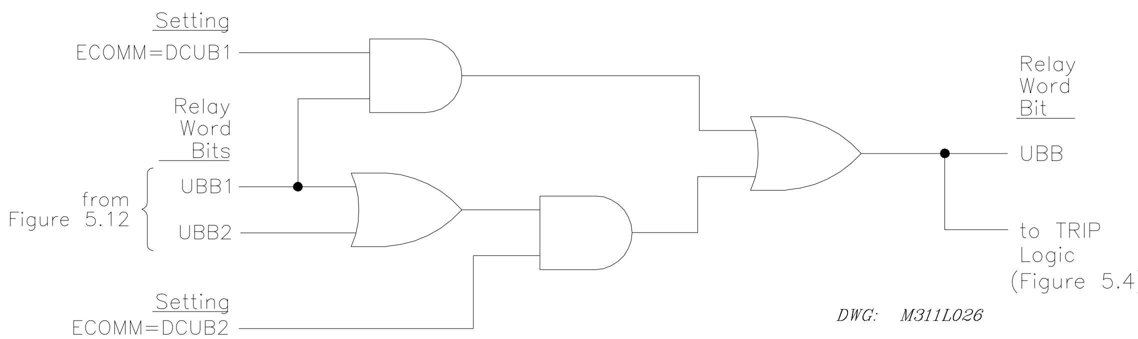

Figure 5.13: Unblocking Block Logic Routing to Trip Logic

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 5.9 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 5.4.

Installation Variations

Figure 5.15 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 5.15. Then output contact OUT107 can be used for another function.

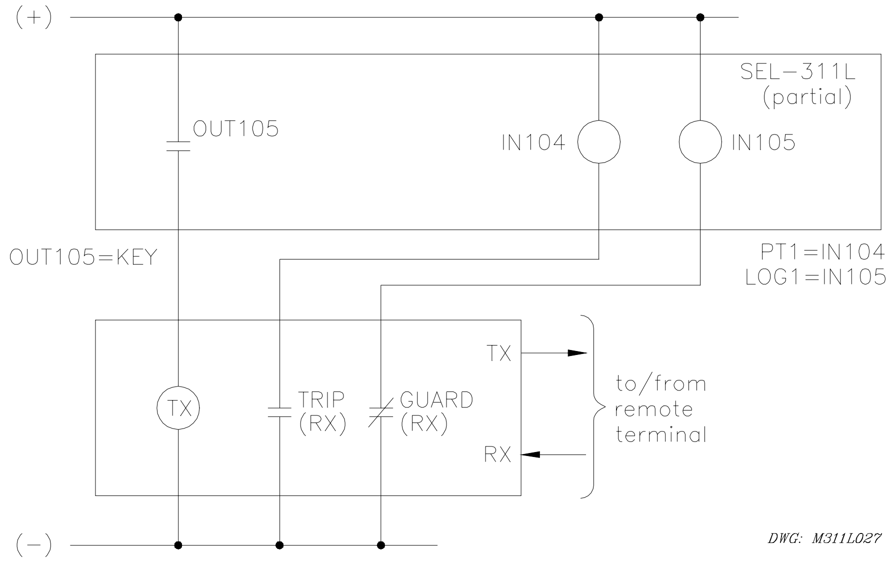

Figure 5.14: SEL-311L Relay Connections to Communications Equipment for a Two-Terminal Line DCUB Scheme (Setting ECOMM = DCUB1)

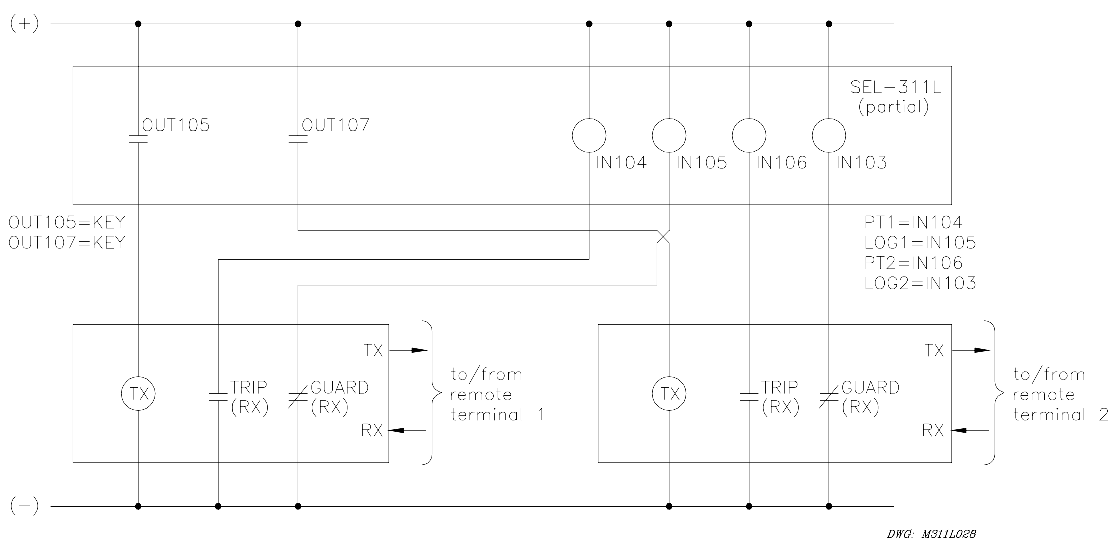

Figure 5.15: SEL-311L Relay Connections to Communications Equipment for a Three-Terminal Line DCUB Scheme (Setting ECOMM = DCUB2)

Directional Comparison Blocking (DCB) Logic

Enable the DCB logic by setting ECOMM = DCB. The DCB logic in Figure 5.16 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 Relay DCB Application Guide for the SEL-311L Relay

Use the existing SEL-321 Relay DCB application guide (AG93-06) to help set up the SEL-311L Relay in a DCB scheme (see preceding subsection ***Communications-Assisted Trip Logic—General Overview*** for more setting comparison information on the SEL-321/SEL-311L Relays).

External Inputs

See ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 Relay (e.g., input IN104) is driven by a communications equipment receiver output (see Figure 5.17). 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 Relay (e.g., input IN104 and IN106) are driven by communications equipment receiver outputs (see Figure 5.18). 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 5.16. The timer output, Relay Word bit BTX, is routed to the trip logic in Figure 5.4.

Timer Settings

See ***Section 9: Setting the Relay*** for setting ranges.

Z3XPU—Zone (Level) 3 Reverse Pickup Time Delay

Current-reversal guard pickup timer—typically set at 2 cycles.

Z3XD—Zone (Level) 3 Reverse Dropout Extension

Current-reversal guard dropout timer—typically set at 5 cycles.

BTXD—Block Trip Receive Extension

Sets reset time of block trip received condition (BTX) after the reset of block trip input BT.

21SD and 67SD—Zone 2 Short Delay

Carrier coordination delays for the output of Zone 2 overreaching distance elements 21SD and 67SD are typically set at 1 to 2 cycles.

Logic Outputs

The following logic outputs can be tested by assigning them to output contacts. See ***Output Contacts*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 5.17).

In a three-terminal line scheme, output contact OUT107 is set the same as OUT105 (see Figure 5.18):

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 5.17).

In a three-terminal line scheme, output contact OUT107 is set the same as OUT105 (see Figure 5.18):

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 5.17).

In a three-terminal line scheme, another output contact (e.g., OUT104) is set the same as OUT106 (see Figure 5.18):

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 5.16. The timer output (BTX) is routed to the trip logic in Figure 5.4.

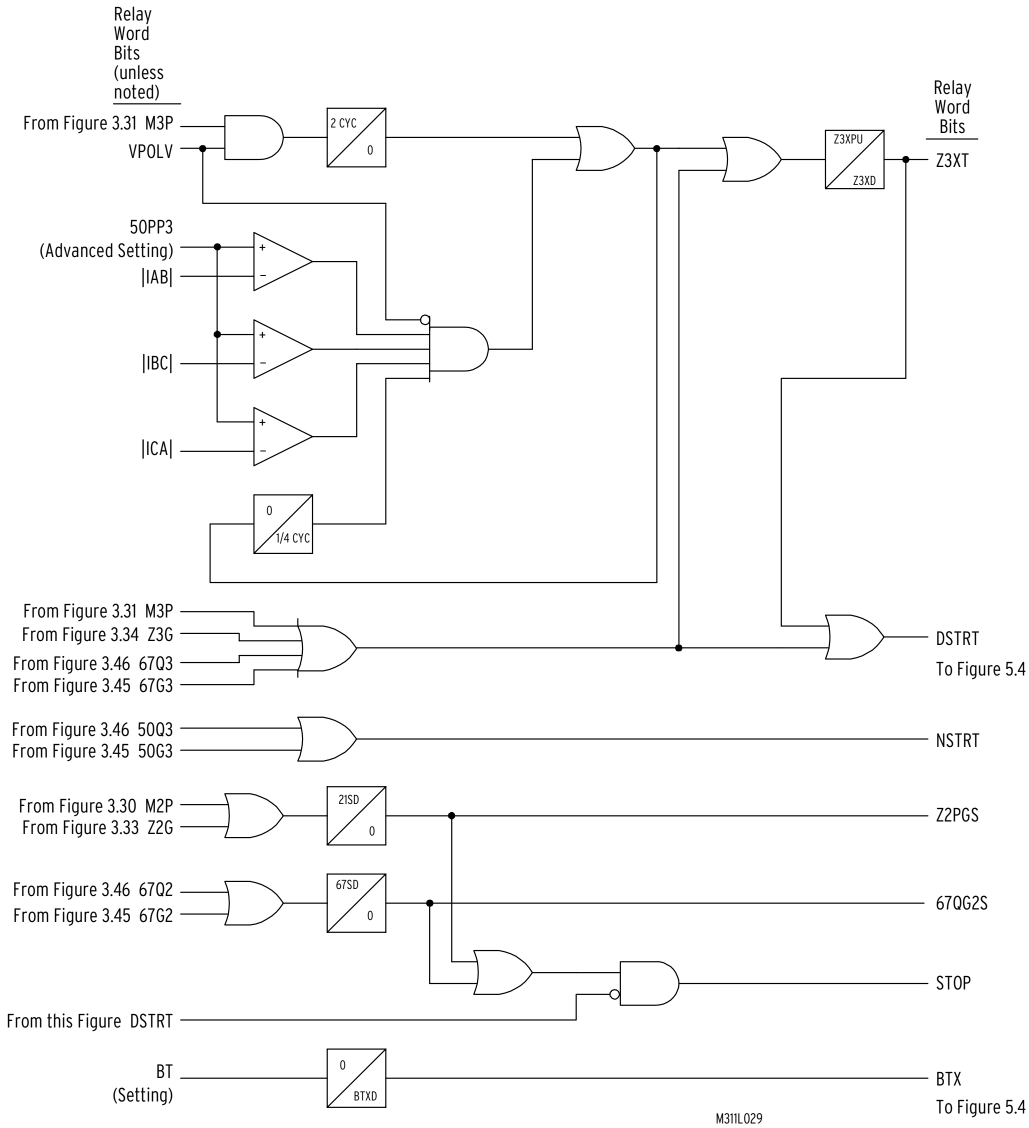

Figure 5.16: DCB Logic

Installation Variations

Figure 5.18 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 5.18. 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 5.18. Then output contact OUT104 can be used for another function.

Figure 5.18 also shows communications equipment RX (receive) output contacts from each remote terminal connected to separate inputs IN104 and IN106 on the SEL-311L Relay. 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 5.18. Then setting BT would be programmed as:

BT = IN104

and input IN106 can be used for another function.

In Figure 5.17 and Figure 5.18, 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.

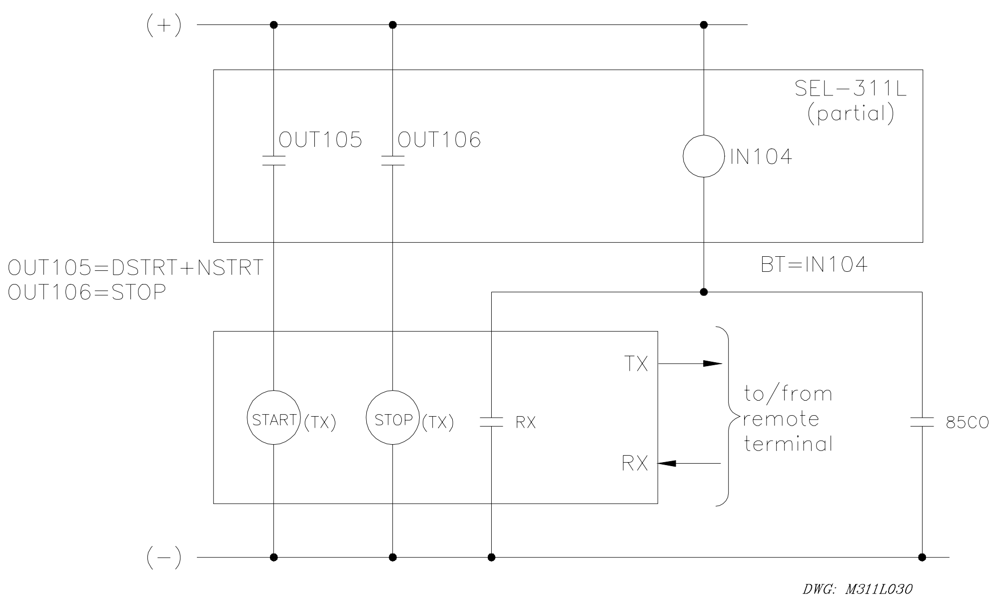

Figure 5.17: SEL-311L Relay Connections to Communications Equipment for a Two-Terminal Line DCB Scheme

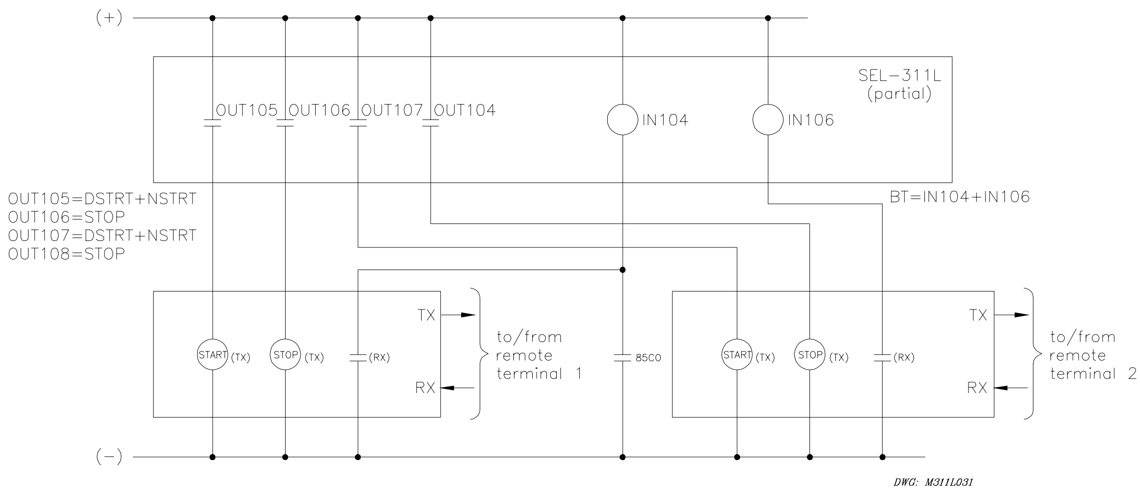

Figure 5.18: SEL-311L Relay Connections to Communications Equipment for a Three-Terminal Line DCB Scheme

Front-Panel Target LEDs

Table 5.1: SEL-311L Relay Front-Panel Target LED Definitions

LED Number	LED Label	Definition
1	EN	Relay Enabled—see subsection ***Relay Self-Tests*** in ***Section 13: Testing, Troubleshooting, and Commissioning***
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	Phase A involved in the fault
10	B	Phase B involved in the fault
11	C	Phase C involved in the fault
12	G	Ground is involved in the fault
13	1	Zone/Level 1 element picked up at time of trip

LED Number	LED Label	Definition
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 through 6 and 9 through 15 in Table 5.1 are updated and then latched for every new assertion (rising edge) of the TRIP Relay Word bit. The TRIP Relay Word bit is the output of the backup protection trip logic (see Figure 5.4). The TRIP Relay Word bit also asserts when setting EHST ≠ N and Relay Word bit TRIP87 asserts. The TRIP87 Relay Word bit is the output of the 87L trip logic (see Figure 5.1).

Further target LED information follows. Refer also to Figure 2.2, Figure 2.3, and Figure 2.4 in ***Section 2: Installation*** 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 through 6 and 9 through 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*** in ***Section 8: Breaker Monitor and Metering Functions***). 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 Relay is used without relaying potentials.

COMM Target LED

The COMM target LED illuminates at the rising edge of trip if the trip is the 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 5.4, 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 5.4).

For example, if the OPEN command or remote bit RB1 (see ***CON Command*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***) 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 if any overcurrent element (except 50L) 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" (Phase A) target LED is illuminated at the rising edge of trip if a protection element causes the trip and Phase A is involved in the fault (likewise for "B" [Phase B] and "C" [Phase C] target LEDs).

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 detected during the fault (M1P, M2P, M3P, Z1G, Z2G, Z3G, 50P1, 67P1, 67P2, 67P3, 67P4, 67G1, 67G2, 67G3, 67Q1, 67Q2, 67Q3).

87CH FAIL LED

The 87CH FAIL LED illuminates when the relay detects a problem with any active 87L Communications Channel. See ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** 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 through 6 and 9 through 15 in Table 5.1) are extinguished (unlatched).

Other Applications for the Target Reset Function

Refer to the bottom of Figure 5.4. 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 7.25 in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***. 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*** in ***Section 7*** and ***Section 11***, also):

SV8 = (SV8 + SV7T) * !TRGTR

DP3 = SV8

DP3_1 = BREAKER FAILURE

DP3_0 = (blank)

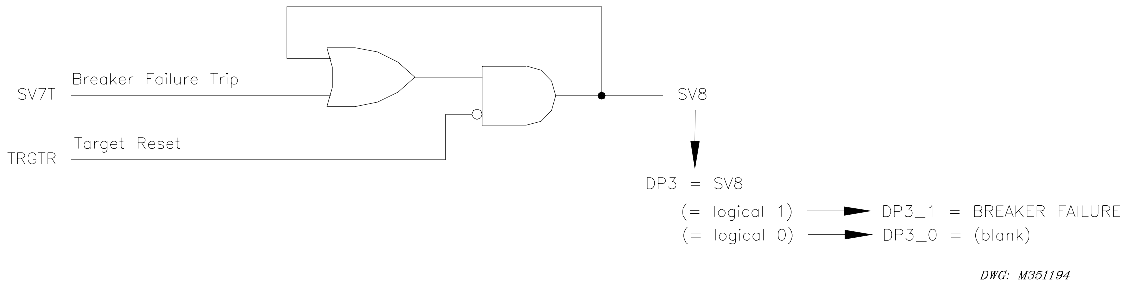

Figure 5.19: Seal-in of Breaker Failure Occurrence for Message Display

If a breaker failure trip has occurred, the momentary assertion of SV7T (breaker failure trip) will cause SV8 in Figure 5.19 to seal-in. Asserted SV8 in turn asserts DP3, causing the message:

```
BREAKER FAILURE
```

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.

TABLE OF CONTENTS

TABLES

FIGURES

SECTION 6: CLOSE AND RECLOSE LOGIC

OVERVIEW

This section is made up of three subsections:

Close Logic

This subsection describes the final logic that controls the close output contact (e.g., OUT103 = CLOSE). This output contact closes the circuit breaker for automatic reclosures and other 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 subsection is the only subsection that needs to be read in this section (particularly the description of SELOGIC® control equation setting CL).

Reclose Supervision Logic

This subsection 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

This subsection 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 subsections).

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 through 4 are the number of desired automatic reclosures.

Note: Setting E79 = N defeats the reclosing relay, but does not defeat the ability of the close logic described in the first subsection (Figure 6.1) to close the circuit breaker for other close conditions via SELOGIC control equation setting CL (e.g., manual close initiation via serial port or optoisolated inputs).

CLOSE LOGIC

The close logic in Figure 6.1 provides flexible circuit breaker closing/automatic reclosing with SELOGIC control equation settings:

52A	(breaker status)
CL	(close conditions, other than automatic reclosing)
ULCL	(unlatch close conditions, other than circuit breaker status, close failure, or reclose initiation)

and setting:

CFD	(Close Failure Time)

See the settings sheet in ***Section 9: Setting the Relay*** for setting ranges.

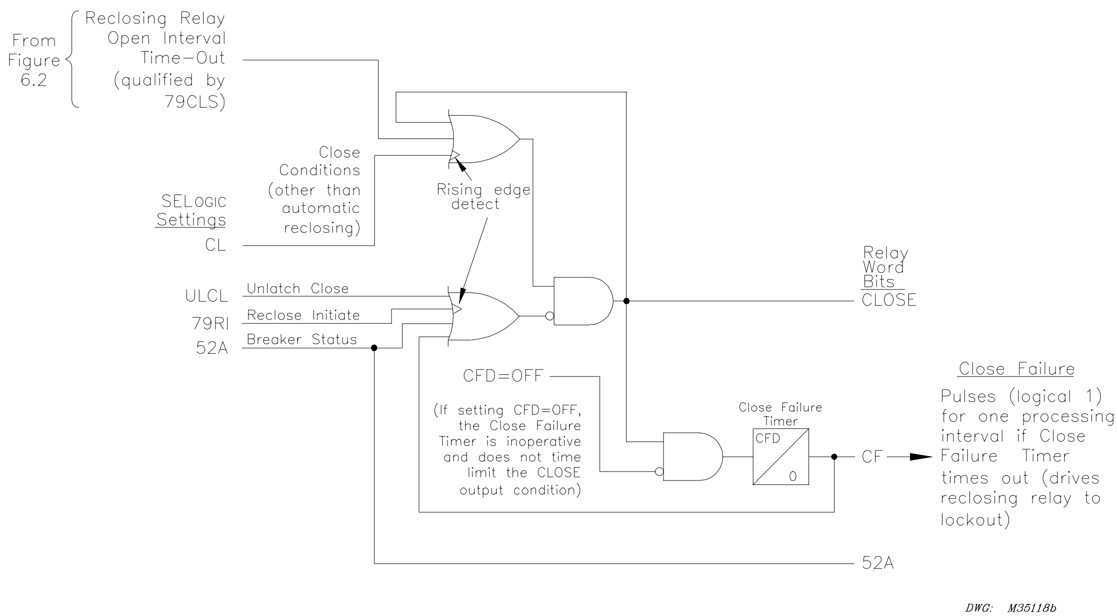

Figure 6.1: Close Logic

Set Close

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.
- And 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)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** 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: Setting the Relay*** 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 subsection), then SELOGIC control equation setting CL is the only logic input that can set the CLOSE Relay Word bit.

In SELOGIC control equation setting CL = CC, Relay Word bit CC asserts for execution of the CLOSE Command. See ***CLO Command (Close Breaker)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** 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 ***Trip Logic*** in ***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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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*** later in this section). 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 doesn't have to enter IN101 (for a 52a) or !IN101 (for a 52b). For example, refer to ***Rotating Default Display*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***. 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).

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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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.

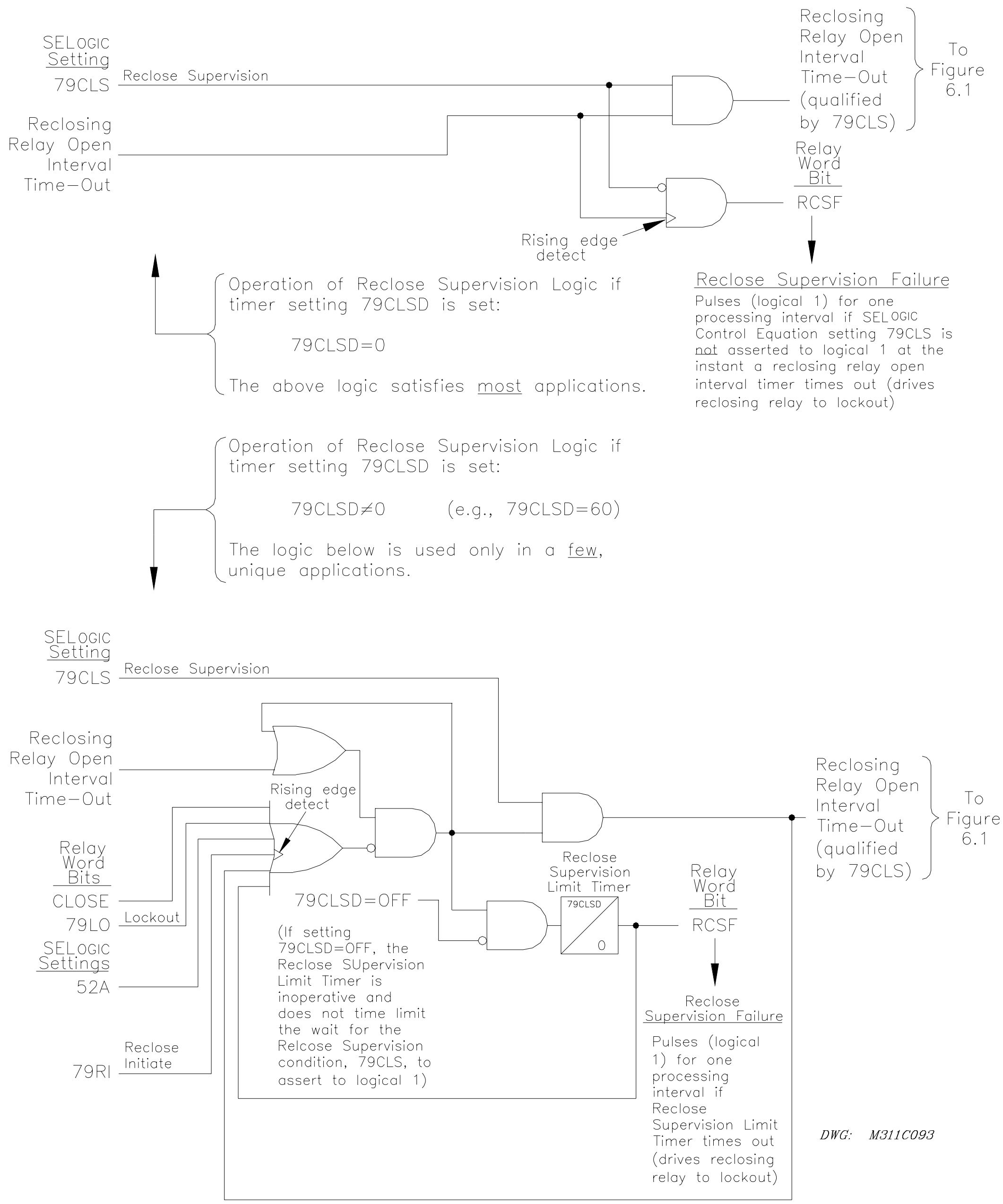

Figure 6.2: Reclose Supervision Logic (Following Open Interval Time-Out)

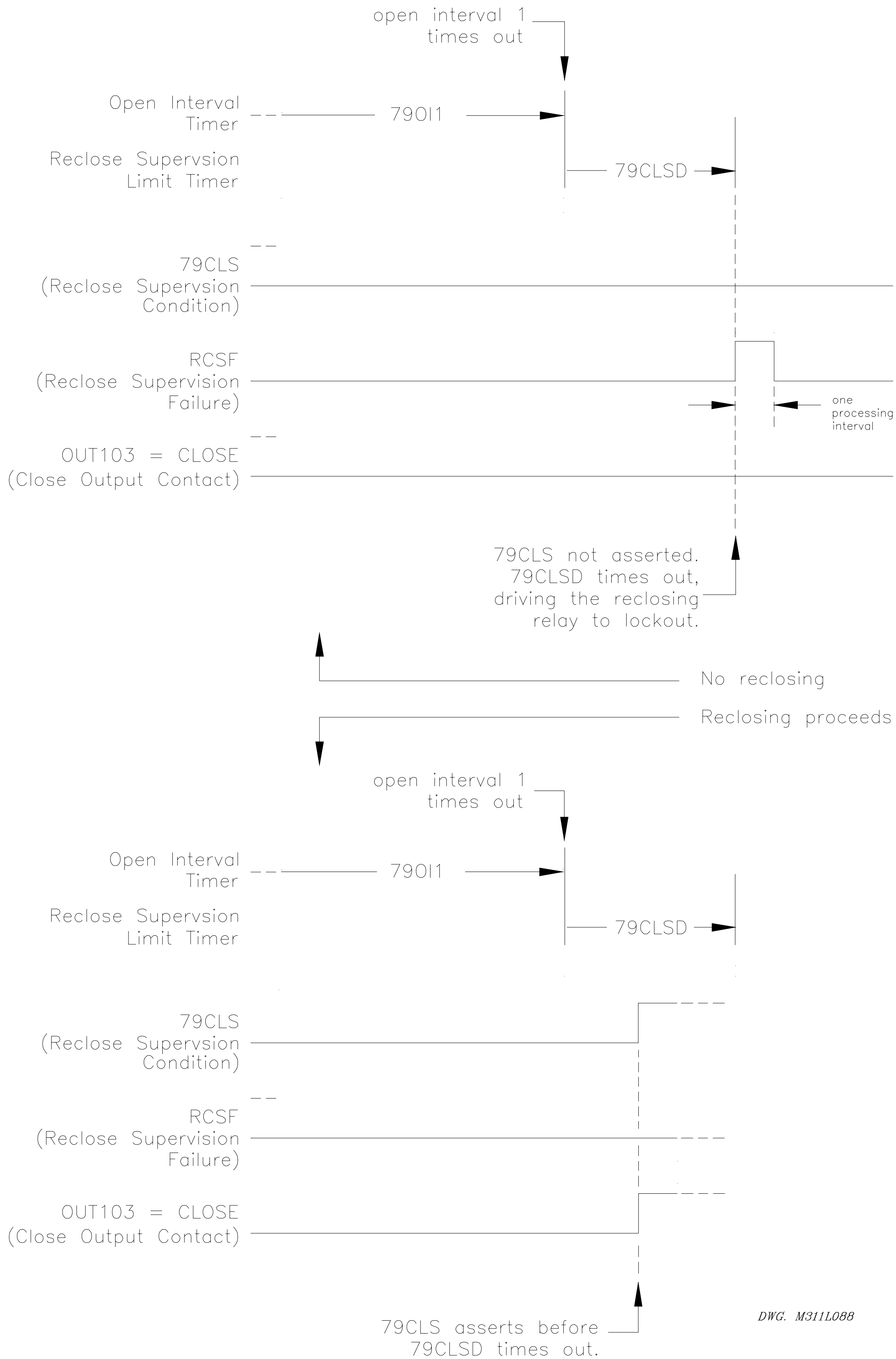

Figure 6.3: Reclose Supervision Limit Timer Operation (Refer to Bottom of Figure 6.2)

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: Setting the Relay*** 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*** and ***Additional Settings Example 1*** that follow in this subsection.

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*** that follows in this subsection.

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.

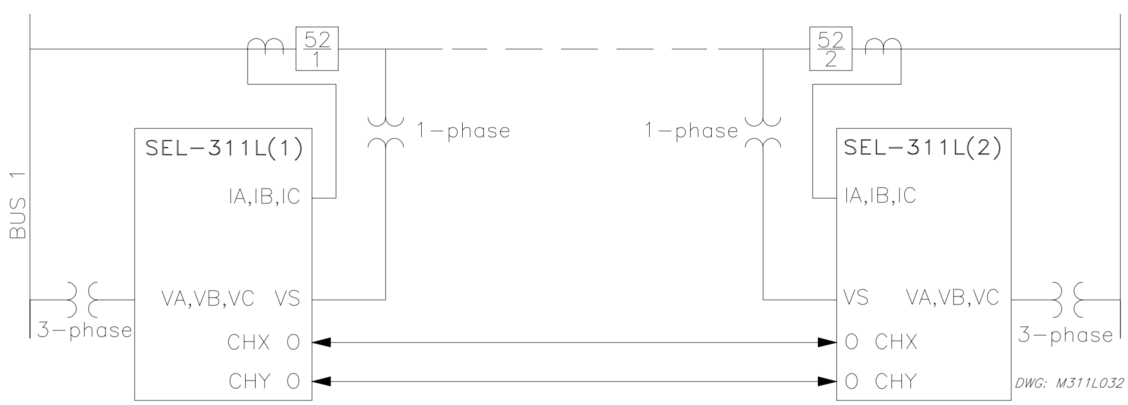

Figure 6.4: SEL-311L Relays in a Two-Terminal Application With Reclosing

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)*** in the following ***Reclosing Relay*** subsection.

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) Relay starts open interval timing after circuit breaker 52/1 at the remote end has reenergized the line. The SEL-311L(2) Relay 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) Relay open interval timing is stalled when the transmission line voltage and Bus 2 voltage are <u>not</u> in synchronism across open circuit breaker 52/2:

79STL = !25A1 [=NOT(25A1)]

Note: 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) Relay 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) Relay 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) Relay (see Figure 7.23 and Figure 7.24). Note the built-in 3-cycle qualification of the synchronism check voltages shown in Figure 3.53.

Additional Settings Example 2

Refer to subsection ***Synchronism Check Elements*** in ***Section 3: Line Current Differential, Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements***. 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.

In the above referenced subsection ***Synchronism Check Elements***, note item 3 under ***Synchronism Check Element Outputs***, 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 subsection 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. Up to 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*** that follows in this subsection).

Reclosing Relay States and General Operation

Figure 6.5 explains in general the different states of the reclosing relay and its operation.

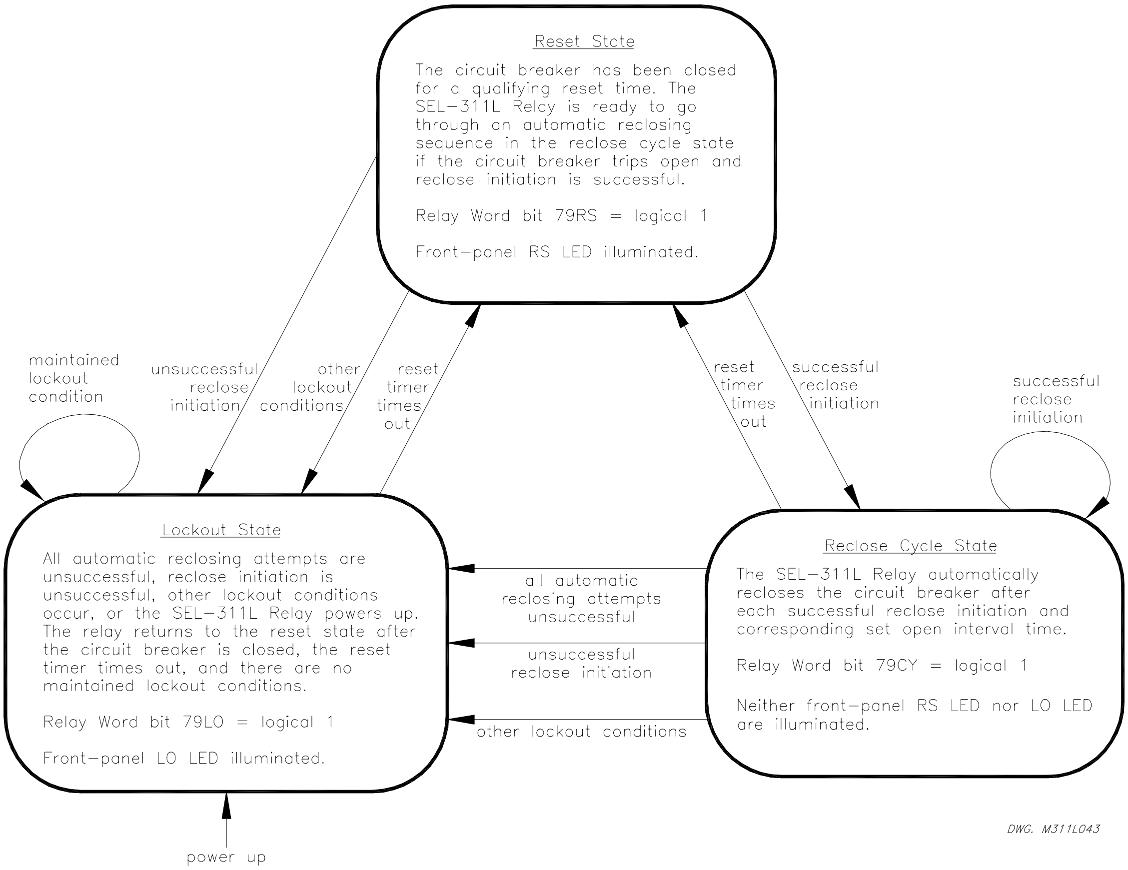

Figure 6.5: Reclosing Relay States and General Operation

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 <u>one</u> 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]*** later in this subsection).
- 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]*** later in this subsection).
- 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]*** later in this subsection).
- The Reclose Supervision Limit Timer (setting 79CLSD) times out (see Figure 6.2 and top of Figure 6.3).

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)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** for more information on the **OPE** command. Also, see ***Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively)*** later in this subsection.

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)

<u>Reclosing Relay States After a Settings or Setting Group Change</u>

If individual settings are changed for the active setting group <u>or</u> the active setting group is changed, <u>all</u> of the following occur:

- The reclosing relay remains in the state it was in before the settings change.
- The shot counter is driven to last shot (last shot corresponding to the new settings; see discussion on last shot that follows).
- The reset timer is loaded with reset time setting 79RSLD (see discussion on reset timing later in this section).

If the relay happened to be in the Reclose Cycle State and was timing on an open interval before the settings change, the relay would be in the Reclose Cycle State after the settings change, but the relay would immediately go to the Lockout State. This is because the breaker is open, and the relay is at last shot after the settings change, and thus no more automatic reclosures are available.

If the circuit breaker remains closed through the settings change, the reset timer times out on reset time setting 79RSLD after the settings change and goes to the Reset State (if it is not already in the Reset State), and the shot counter returns to shot = 0. If the relay happens to trip during this reset timing, the relay will immediately go to the Lockout State, because shot = last shot.

Defeat the Reclosing Relay

If any one of the following reclosing relay settings are made:

- Reclose enable setting E79 = N.
- Open Interval 1 time setting 79OI1 = 0.00.

then the reclosing relay is defeated, and no automatic reclosing can occur. These settings are explained later in this section. See also the settings sheets at the end of ***Section 9: Setting the Relay***.

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*** earlier in this section for more discussion on SELOGIC control equation settings 52A and CL. Also see ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 limit

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: Setting the Relay***.

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 time line in Figure 6.6.

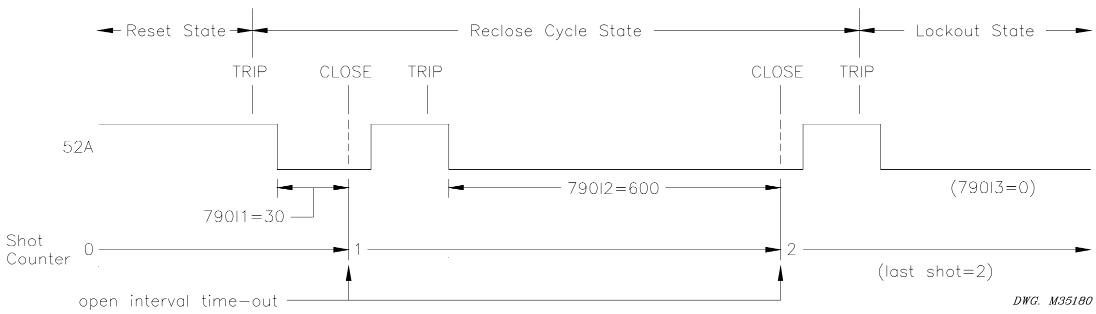

Figure 6.6: Reclosing Sequence From Reset to Lockout With Example Settings

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]*** later in this subsection).

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*** in ***Section 11: Front-Panel Interface***.

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*** earlier in this section for more discussion on SELOGIC control equation setting 52A. Also see ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 and Settings/Setting Group Changes*** earlier in this subsection).

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]*** later in this subsection).

Monitoring Open Interval and Reset Timing

Open interval and reset timing can be monitored with the following Relay Word bits:

Relay Word Bits	Definition
OPTMN	Indicates that the open interval timer is actively timing
RSTMN	Indicates that the reset timer is actively timing

If the open interval timer is actively timing, OPTMN asserts 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]*** later in this subsection).

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)*** later in this subsection.

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]*** earlier in this subsection). The shot counter resets back to shot = 0 when the reclosing relay returns to the Reset State.

Table 6.3: Shot Counter Correspondence to Relay Word Bits and Open Interval Times

Shot	Corresponding Relay Word Bit	Corresponding Open Interval
0	SH0	79OI1
1	SH1	79OI2
2	SH2	79OI3
3	SH3	79OI4
4	SH4	

When the shot counter is at a particular shot value (e.g., shot = 2), the corresponding Relay Word bit asserts to logical 1 (e.g., SH2 = logical 1).

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 6.4: 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

SELOGIC Control Equation Setting	Setting	Definition
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 subsection.

Reclose Initiate and Reclose Initiate Supervision Settings (79RI and 79RIS, Respectively)

The reclose initiate setting 79RI is a rising-edge detect setting. The reclose initiate supervision setting 79RIS supervises setting 79RI. When setting 79RI senses a rising edge (logical 0 to logical 1 transition), setting 79RIS has to be at logical 1 (79RIS = logical 1) in order for open interval timing to be initiated.

If 79RIS = logical 0 when setting 79RI senses a rising edge (logical 0 to logical 1 transition), the relay goes to the Lockout State.

Settings Example

With 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 auto-reclose cycle in order for the SEL-311L Relay to successfully initiate reclosing and start timing on the first open interval. The SEL-311L Relay 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 auto-reclose cycle, the SEL-311L Relay is in the reclose cycle state (79CY = logical 1) and the SEL-311L Relay 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 Relay 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 Relay calls for a trip), the SEL-311L Relay goes immediately to lockout.

Additional Settings Example

The preceding settings example initiates open interval timing on rising edge of the TRIP Relay or TRIP 87 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 in order 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 5.4 in ***Section 5: Trip and Target Logic***).

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 auto-reclose 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*** in the preceding setting 79RI [reclose initiation] discussion).

Then the drive-to-lockout condition overlaps reclose initiation and the SEL-311L Relay stays in lockout after the breaker trips open.

When 79DLS = logical 1, the reclosing relay goes to the last shot, if the shot counter is not at a shot value greater than or equal to the calculated last shot (see ***Reclosing Relay Shot Counter*** earlier in this subsection).

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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***). 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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** and ***Trip Logic*** in ***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 6.3). If the new shot is the "last shot," no open interval timing takes place, and the relay goes to the Lockout State if the circuit breaker is open (see ***Lockout State*** earlier in this subsection).

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 6.3). If the new shot turns out to be the "last shot," no open interval timing takes place, and the relay goes to the Lockout State if the circuit breaker is open (see ***Lockout State*** earlier in this subsection).

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*** earlier in this subsection).

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 6.5: 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 6.5, note that the open interval 1 time (setting 79OI1) is a short time, while the following open interval 2 time (setting 79OI2) is significantly longer. For a high magnitude fault (greater than the phase instantaneous overcurrent element 50P2 threshold), open interval 1 time is skipped, and open interval timing proceeds on the following open interval 2 time.

Once the shot is incremented to shot = 1, Relay Word bit SH0 = logical 0 and then setting 79SKP = logical 0, regardless of Relay Word bit 50P2.

Additional Settings Example 2

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*** earlier in this subsection).

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 = 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 Relay "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.

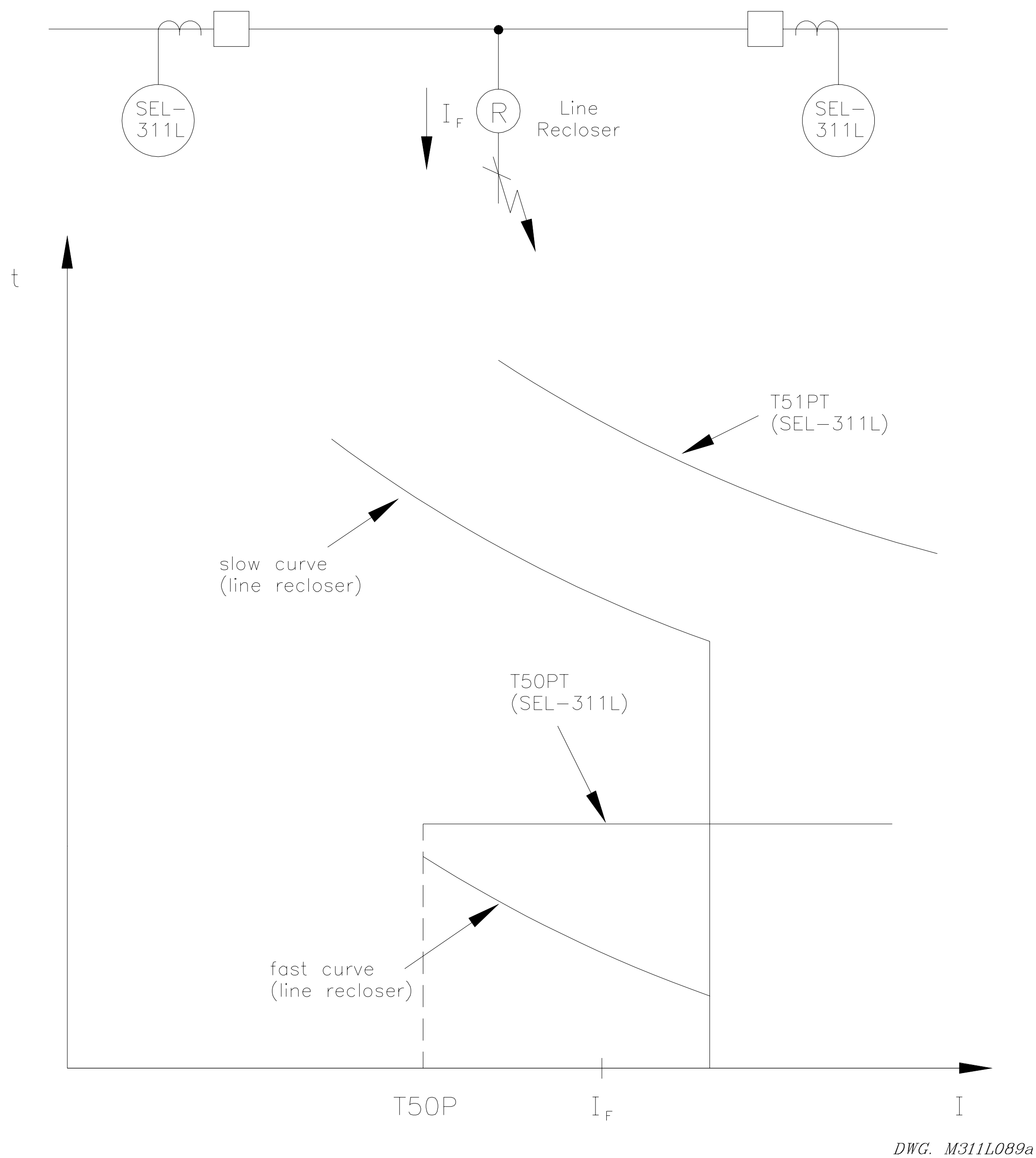

Figure 6.7: Sequence Coordination Between the SEL-311L Relay and a Line Recloser

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 Relay instantaneous/definite time-overcurrent element T50PT is coordinated with the line recloser fast curve. The SEL-311L Relay tapped load phase time-overcurrent element T51PT is coordinated with the line recloser slow curve.

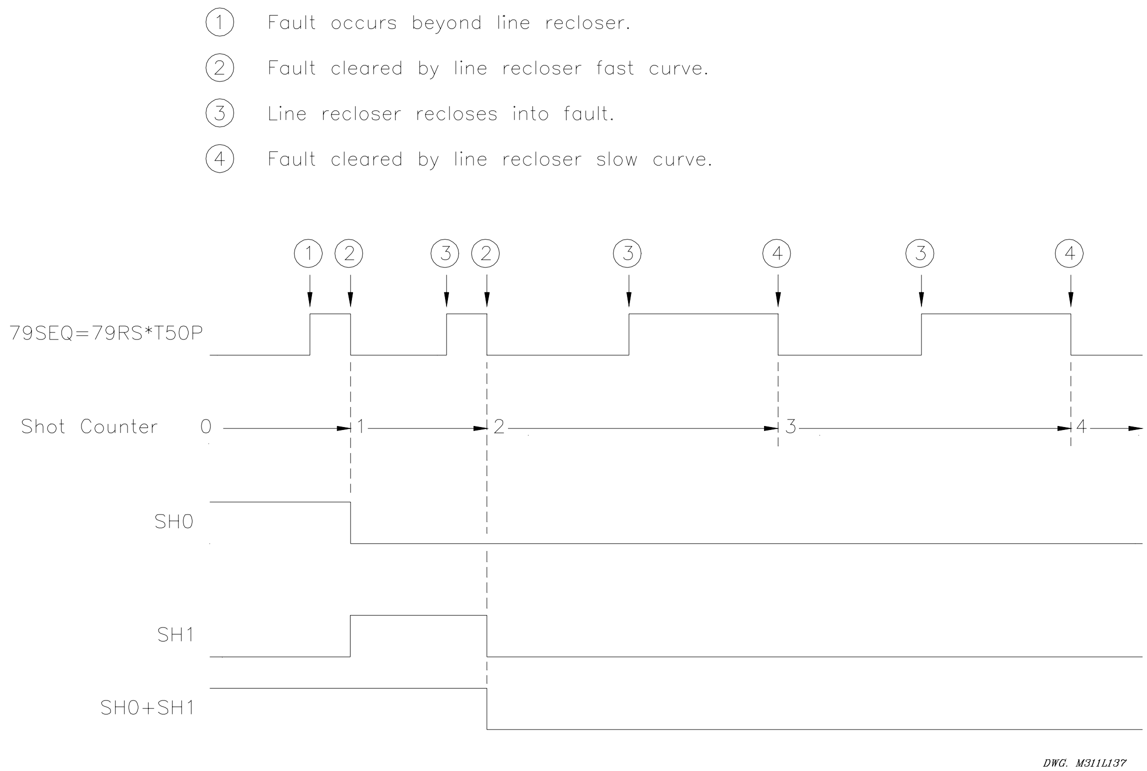

Figure 6.8: Operation of SEL-311L Relay Shot Counter for Sequence Coordination With Line Recloser (Additional Settings Example 1)

If the SEL-311L Relay is in the Reset State (79RS = logical 1) and then a permanent fault beyond the line recloser occurs (fault current I_F in Figure 6.7), the line recloser fast curve operates to clear the fault. The SEL-311L Relay 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 Relay 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

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.

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.

The following 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 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 Relay is set to operate once on T50PT and then twice on T51PT for faults between the SEL-311L Relay and the line recloser. This results in the following trip setting:

TR = T50PT * (SHO) + 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 Relay will increment all the way to shot = 4 (see Figure 6.8). If there is a coincident fault between the SEL-311L Relay and the line recloser, the SEL-311L Relay 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 Relay 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 I_F in Figure 6.7), the line recloser fast curve operates to clear the fault. The SEL-311L Relay 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 Relay cannot operate on its faster-set phase time-overcurrent element T50PT because the shot counter is at shot = 1 (SH0 = logical 0):

TR = T50PT * (SHO) + T51PT
= T50PT * (logical 0) + T51PT
= T51PT

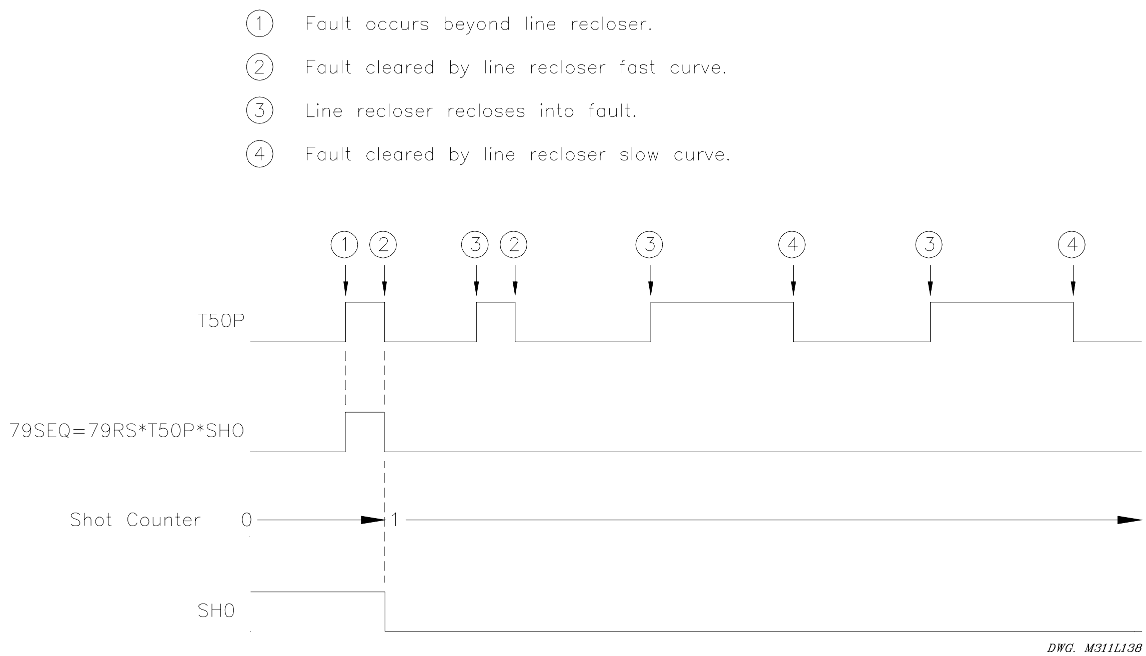

Figure 6.9: Operation of SEL-311L Relay Shot Counter for Sequence Coordination With Line Recloser (Additional Settings Example 2)

The line recloser continues to operate for the permanent fault beyond it, but the SEL-311L Relay 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 Relay and the line recloser, the SEL-311L Relay 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.

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TABLES

FIGURES

SECTION 7: INPUTS, OUTPUTS, TIMERS, AND OTHER CONTROL LOGIC

This section explains the settings and operation of:

Optoisolated inputs	IN101–IN106
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–OUT206
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: Setting the Relay*** for more information on Relay Word bits and SELOGIC control equation settings. See ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** for more information on viewing and making SELOGIC control equation settings (commands **SHO L** and **SET L**).

OPTOISOLATED INPUTS

Figure 7.1 shows the Relay Word bits that correspond to optoisolated inputs for the SEL-311L Relay. The figure shows examples of energized and deenergized 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 through Figure 2.5).

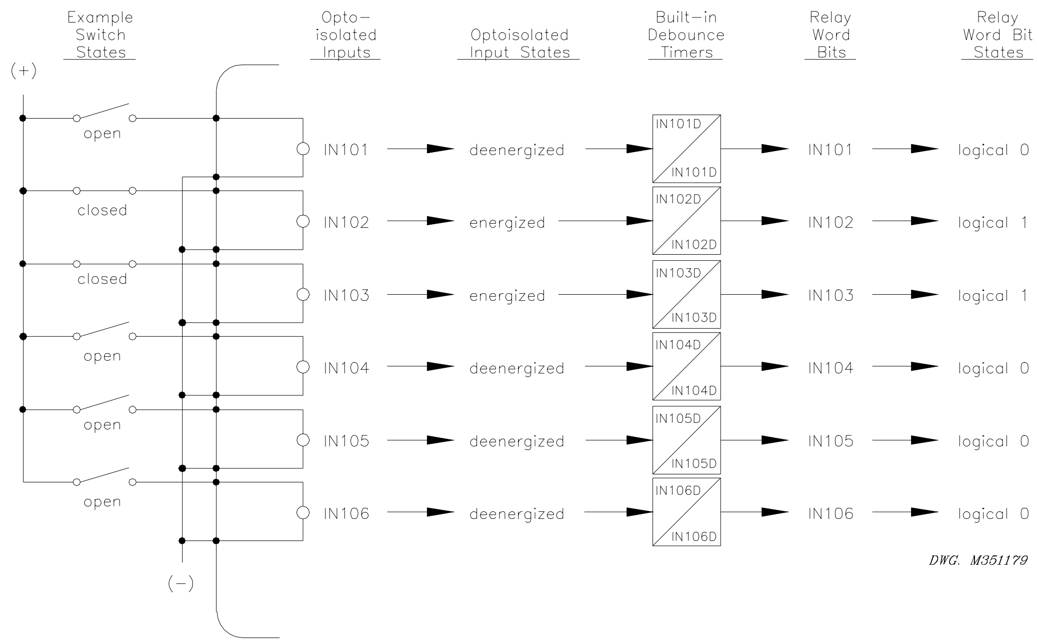


Figure 7.1: Example Operation of Optoisolated Inputs IN101 Through IN106

Input Debounce Timers

See Figure 7.1.

Each input has settable pickup/dropout timers (IN101D through IN106D) for input energization/deenergization 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 through IN106D are settable from 0.00 to 1.00 cycles. The relay takes the entered time setting and internally runs the timer at the nearest 1/16-cycle. For example, if setting IN105D = 0.80, internally the timer runs at the nearest 1/16-cycle: 13/16-cycles (13/16 = 0.8125).

For most applications, the input pickup/dropout debounce timers should be set in 1/4-cycle increments.

The relay updates Relay Word bits IN101 through IN106 every 1/4-cycle.

If more than 1 cycle of debounce is needed, use a SELOGIC control equation variable timer (see Figure 7.23 and Figure 7.24).

Input Functions

There are **no** optoisolated input settings such as:

IN101 =

IN102 =

Relay Word bits IN101 through IN106, used in SELOGIC control equations, represent the state of optoisolated inputs IN101 through IN106.

Settings Example 1

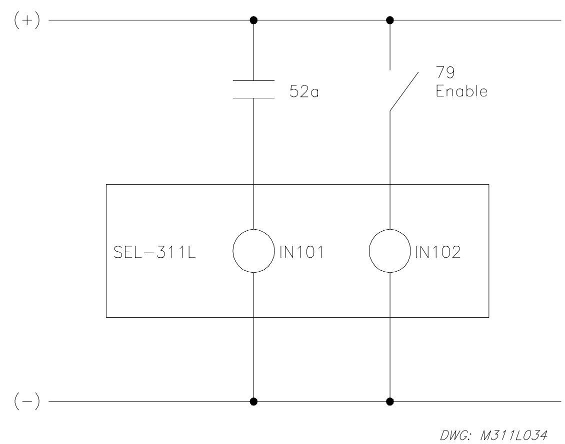


Figure 7.2: Circuit Breaker Auxiliary Contact and Reclose Enable Switch Connected to Optoisolated Inputs IN101 and IN102

The functions for inputs IN101 and IN102 (Figure 7.2) are described in the following discussions.

Input IN101

Relay Word bit IN101 (Figure 7.2) 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*** in ***Section 6: Close and Reclose Logic*** 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/deenergization 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 7.2) 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 deenergized 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/deenergization 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 using the front-panel keyboard/display (see ***Section 11: Front-Panel Interface***).

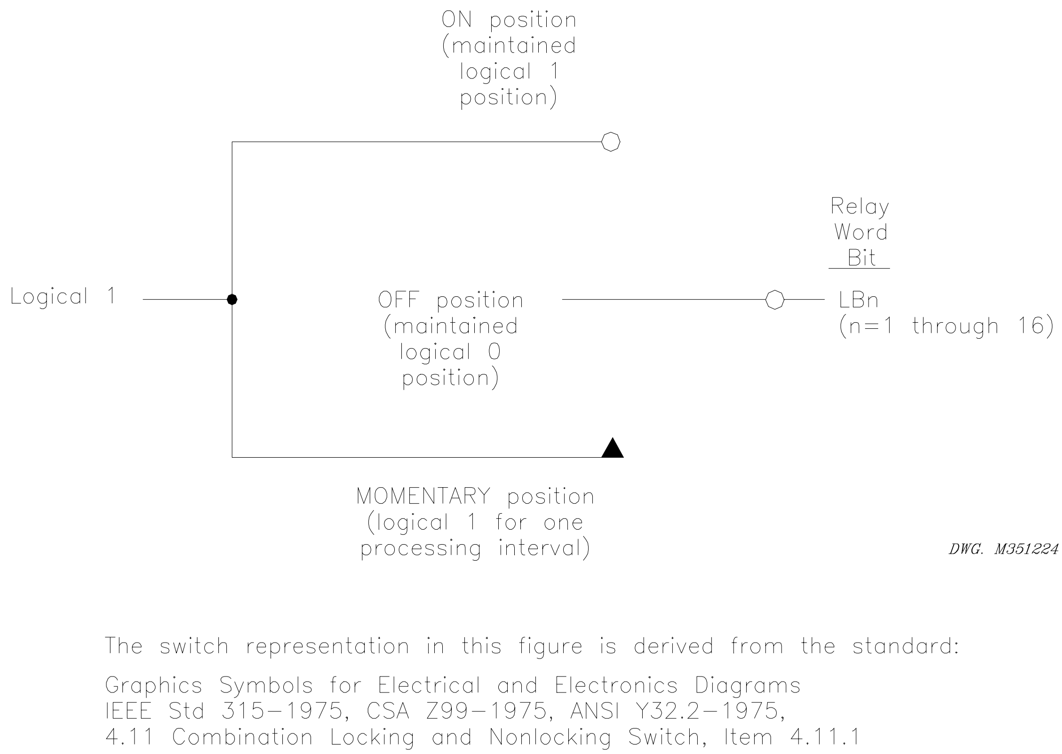


Figure 7.3: Local Control Switches Drive Local Bits LB1 Through LB16

The output of the local control switch in Figure 7.3 is a Relay Word bit LB*n* (*n* = 1 through 16), called a local bit. The local control switch logic in Figure 7.3 repeats for each local bit LB1 through 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 using the command **SET T**. View these settings using the serial port command **SHO T** (see ***Section 9: Setting the Relay*** and ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***).

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.

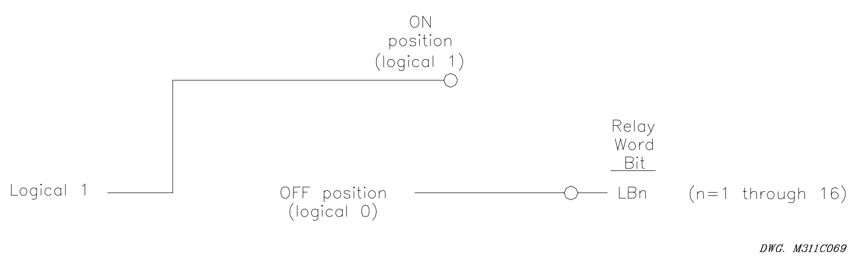


Figure 7.4: Local Control Switch Configured as an ON/OFF Switch

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).

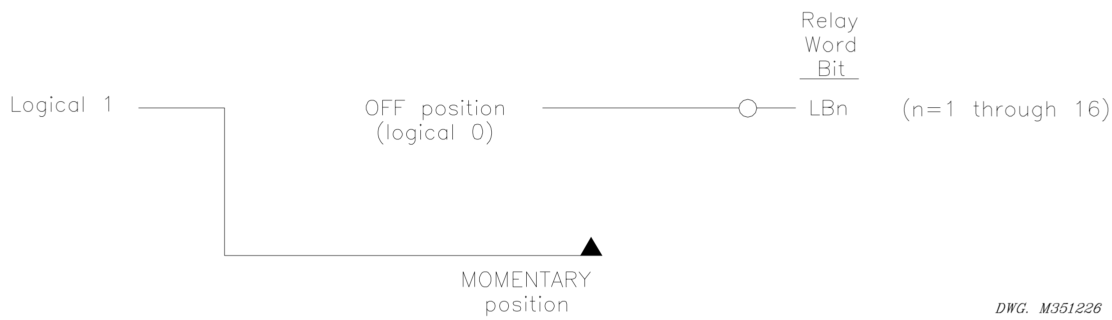


Figure 7.5: Local Control Switch Configured as an OFF/MOMENTARY Switch

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).

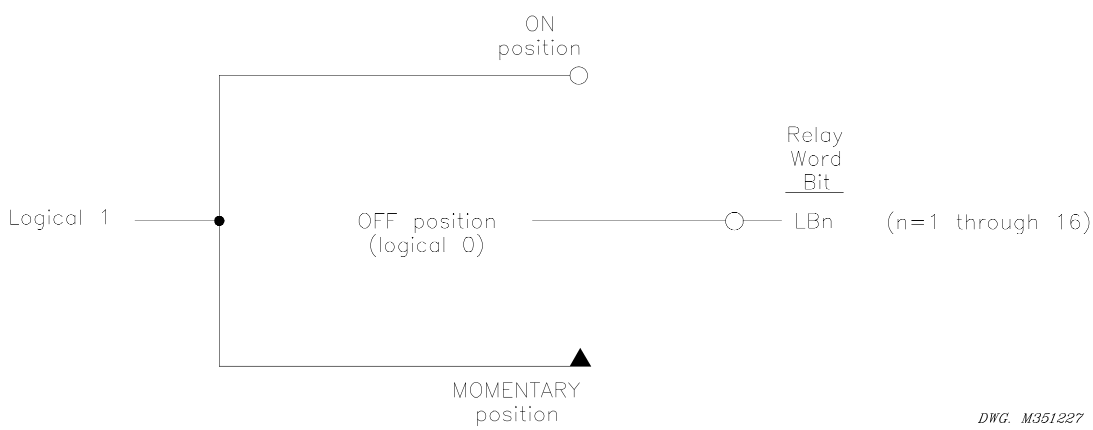


Figure 7.6: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

Table 7.2: Correspondence Between Local Control Switch Types and Required Label Settings

Local Switch Type	Label NLB*n*	Label CLB*n*	Label SLB*n*	Label PLB*n*
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: Setting the Relay***). The local bit associated with this disabled local control switch is then fixed at logical 0.

Settings Examples

Local bits LB3 and LB4 might be used for manual trip and close functions. Their corresponding local control switch position labels are set to configure the switches as OFF/MOMENTARY switches:

Local Bit	Label Settings	Function
LB3	NLB3 = MANUAL TRIP	trips breaker and drives reclosing relay to lockout
	CLB3 = RETURN	OFF position ("return" from MOMENTARY position)
	SLB3 =	ON position—not used (left "blank")
	PLB3 = TRIP	MOMENTARY position
LB4	NLB4 = MANUAL CLOSE	closes breaker, separate from automatic reclosing
	CLB4 = RETURN	OFF position ("return" from MOMENTARY position)
	SLB4 =	ON position—not used (left "blank")
	PLB3 = CLOSE	MOMENTARY position

Following Figure 7.7 and Figure 7.8 show local control switches with example settings.

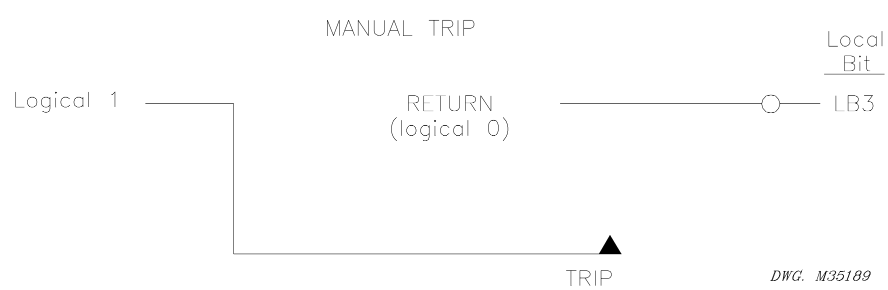


Figure 7.7: Configured Manual Trip Switch Drives Local Bit LB3

Local bit LB3 is set to trip in the following SELOGIC control equation trip setting (see Figure 5.1 in ***Section 5: Trip and Target Logic***):

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

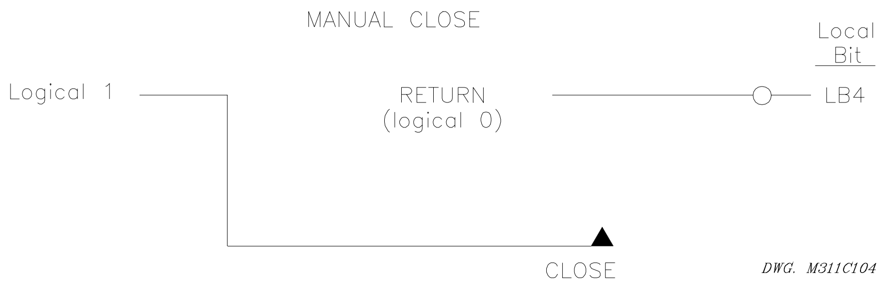


Figure 7.8: Configured Manual Close Switch Drives Local Bit LB4

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 in ***Section 6: Close and Reclose Logic***).

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 through 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 through LB16) are retained, much like in the preceding ***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)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***).

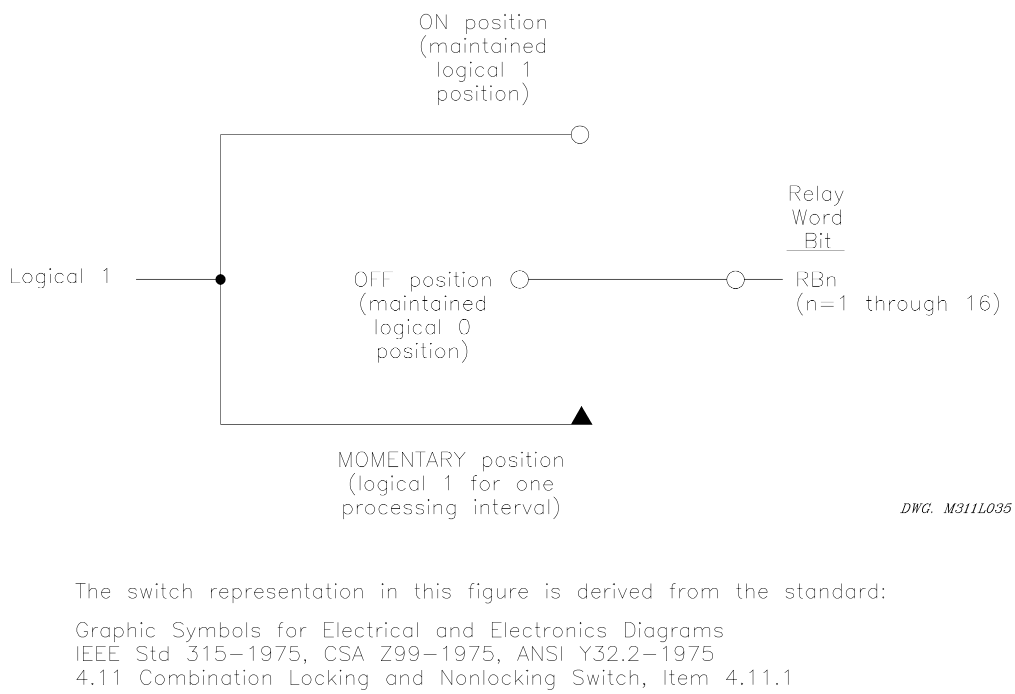


Figure 7.9: Remote Control Switches Drive Remote Bits RB1 Through RB16

The outputs of the remote control switches in Figure 7.9 are Relay Word bits RB*n* (*n* = 1 to 16), called remote bits. Use these remote bits in SELOGIC control equations.

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

ON	(logical 1)
OFF	(logical 0)
MOMENTARY	(logical 1 for one processing interval)

Remote Bit Application Ideas

With SELOGIC control equations, the remote bits can be used in applications similar to those that local bits are used in (see preceding local control switch discussion).

Also, remote bits can be used much as optoisolated inputs are used in operating latch control switches (see discussion following Figure 7.14). 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 through 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 through 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 Relay 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 deenergized 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 7.10). 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).

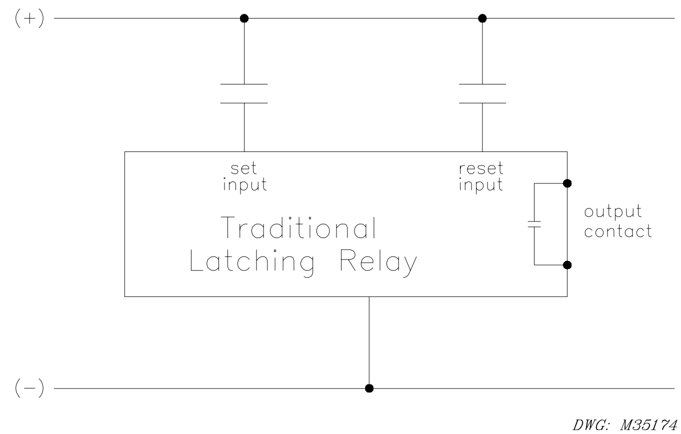


Figure 7.10: Traditional Latching Relay

The sixteen (16) latch control switches in the SEL-311L Relay provide latching relay type functions.

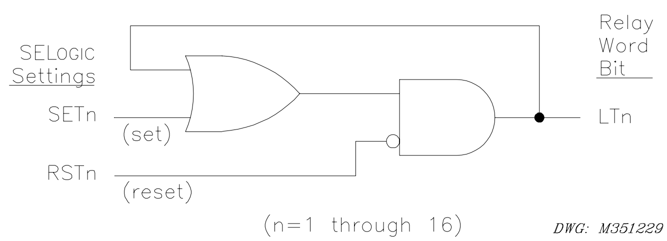


Figure 7.11: Latch Control Switches Drive Latch Bits LT1 Through LT16

The output of the latch control switch in Figure 7.11 is a Relay Word bit LT*n* (*n* = 1 through 16), called a latch bit. The latch control switch logic in Figure 7.11 repeats for each latch bit LT1 through LT16. Use these latch bits in SELOGIC control equations.

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

SET*n*	(set latch bit LT*n* to logical 1)
RST*n*	(reset latch bit LT*n* to logical 0)

If setting SET*n* asserts to logical 1, latch bit LT*n* asserts to logical 1. If setting RST*n* asserts to logical 1, latch bit LT*n* deasserts to logical 0. If both settings SET*n* and RST*n* assert to logical 1, setting RST*n* has priority and latch bit LT*n* deasserts to logical 0.

Latch Control Switch Application Ideas

Latch control switches can be used for such applications as:

- Reclosing relay enable/disable
- Ground relay enable/disable

Latch control switches can be applied to almost any control scheme. The following is an example of using a latch control switch to enable/disable the reclosing relay in the SEL-311L Relay.

Reclosing Relay Enable/Disable Setting Example

Use a latch control switch to enable/disable the reclosing relay in the SEL-311L Relay. 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.

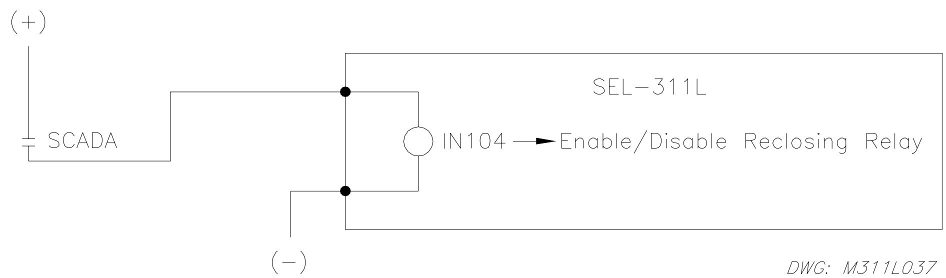


Figure 7.12: SCADA Contact Pulses Input IN104 to Enable/Disable Reclosing Relay

If the reclosing relay is enabled and the SCADA contact is pulsed, the reclosing relay is then disabled. If the SCADA contact is pulsed again, the reclosing relay is enabled again. The control operates in a cyclic manner:

pulse to enable ... pulse to disable ... pulse to enable ... pulse to disable ...

This reclosing relay logic is implemented in the following SELOGIC control equation settings and displayed in Figure 7.13.

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]

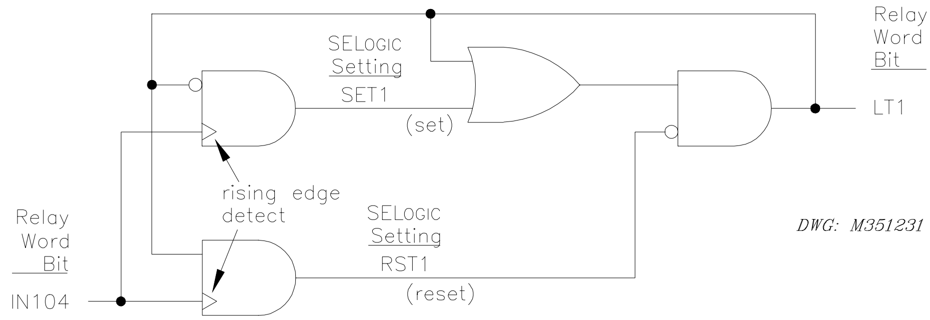


Figure 7.13: Latch Control Switch Controlled by a Single Input to Enable/Disable Reclosing

Note: Refer to preceding subsection ***Optoisolated Inputs*** 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 7.13 and associated SELOGIC control equations, keep in mind any time delay produced by the input pickup/dropout debounce timer IN104D.

Feedback Control

Note in Figure 7.13 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 7.13 and Figure 7.14.

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 7.13, 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 7.14), 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 7.14), 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 7.14) changes the state of the latch control switch just once.

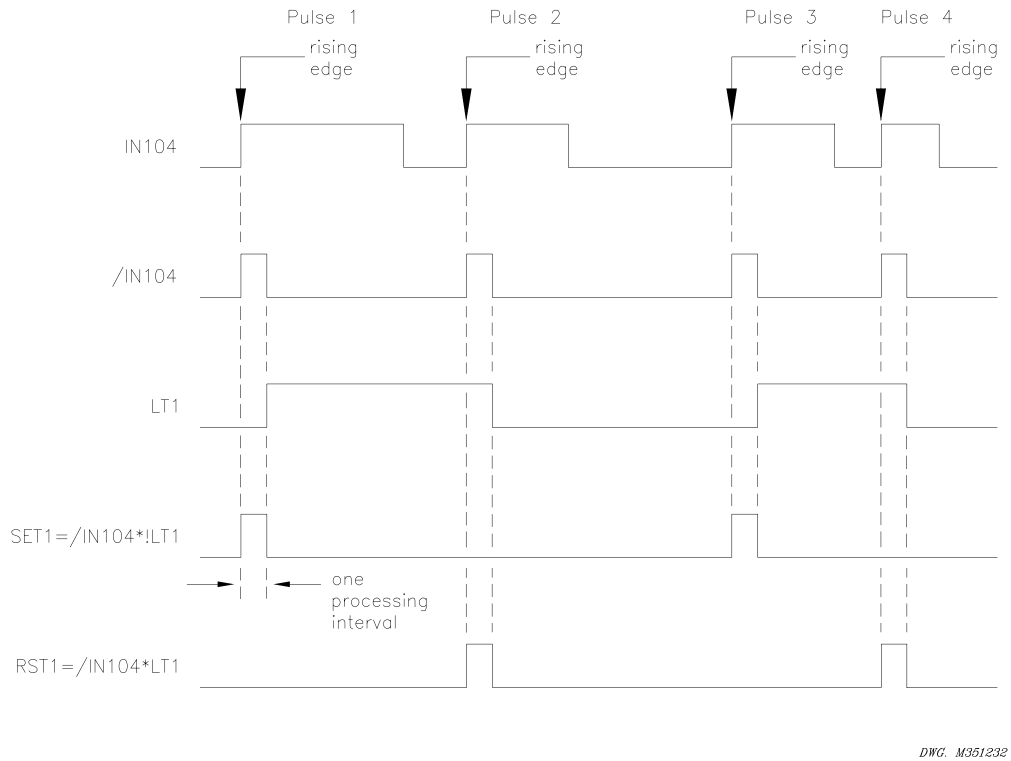


Figure 7.14: Latch Control Switch Operation Time Line

Use a Remote Bit Instead to Enable/Disable the Reclosing Relay

Use a remote bit to enable/disable the reclosing relay, instead of an optoisolated input. For example, substitute remote bit RB1 for optoisolated input IN104 in the settings accompanying Figure 7.13:

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 through RB16) are operated through the serial port. See Figure 7.9 and ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** 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 through 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 deenergized 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 through LT16) are retained, much like in the preceding "Power Loss" explanation.

If individual settings are changed for a setting group other than the active setting group, there is no interruption of the latch bits (the relay is not momentarily disabled).

If the individual settings change or active setting group change causes a change in SELOGIC control equation settings SET*n* or RST*n* (*n* = 1 through 16), the retained states of the latch bits can be changed, subject to the newly enabled settings SET*n* or RST*n*.

Reset Latch Bits for Active Setting Group Change

If desired, the latch bits can be reset to logical 0 right after a settings group change, using SELOGIC control equation setting RST*n* (*n* = 1 through 16). Relay Word bits SG1 through SG6 indicate the active setting Group 1 through 6, respectively (see Table 7.3).

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) + ...]

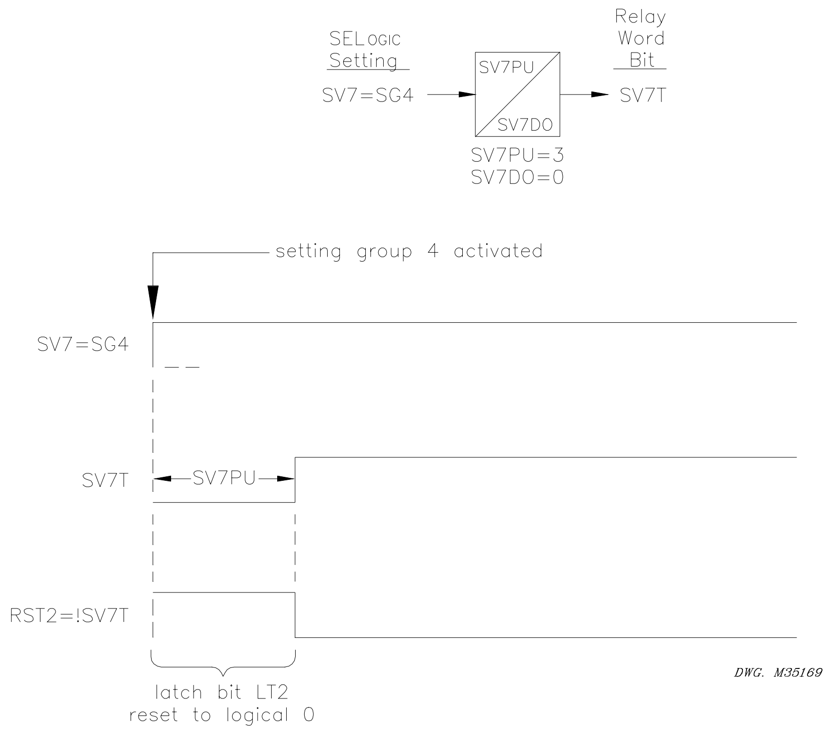


Figure 7.15: Time Line for Reset of Latch Bit LT2 After Active Setting Group Change

In Figure 7.15, 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.

Note: Make Latch Control Switch Settings with Care

The latch bit states are stored in nonvolatile memory so they can be retained during power loss, settings change, or active setting group change. The nonvolatile memory is rated for a finite number of "writes" for all cumulative latch bit state changes. Exceeding the limit can result in an 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 through 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 7.12 through Figure 7.14), 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 7.12 through Figure 7.14 that adds more security is a timer with pickup/dropout times set the same (see Figure 7.16 and Figure 7.17).

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).

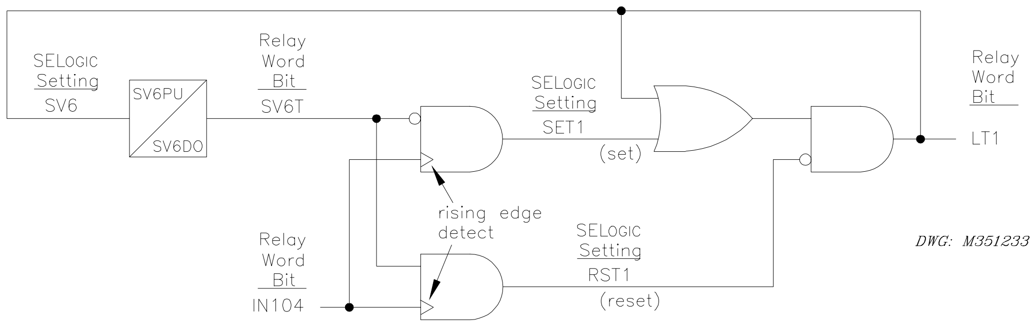


Figure 7.16: Latch Control Switch (With Time Delay Feedback) Controlled by a Single Input to Enable/Disable Reclosing

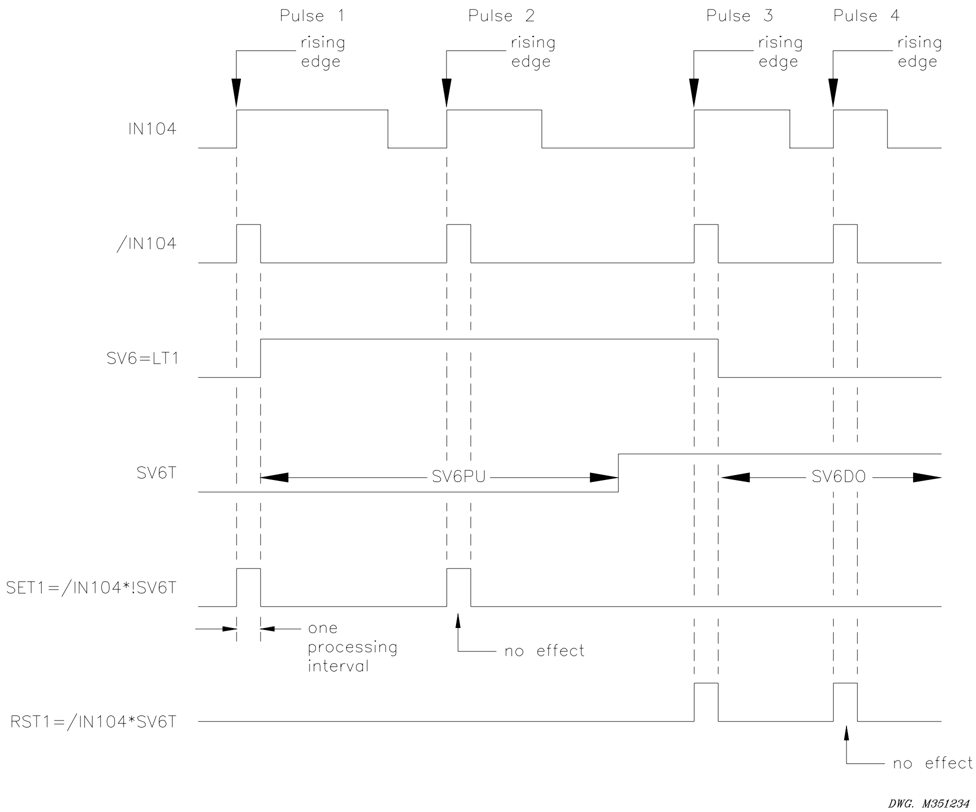


Figure 7.17: Latch Control Switch (With Time Delay Feedback) Operation Time Line

MULTIPLE SETTING GROUPS

The relay has six (6) independent setting groups. Each setting group has complete relay (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 through SG6 indicate the active setting group:

Table 7.3: Definitions for Active Setting Group Indication Relay Word Bits SG1 Through SG6

Relay Word bit	Definition
SG1	Indication that setting Group 1 is the active setting group
SG2	Indication that setting Group 2 is the active setting group
SG3	Indication that setting Group 3 is the active setting group
SG4	Indication that setting Group 4 is the active setting group
SG5	Indication that setting Group 5 is the active setting group
SG6	Indication that setting Group 6 is the active setting group

For example, if setting Group 4 is the active setting group, Relay Word bit SG4 asserts to logical 1, and the other Relay Word bits SG1, SG2, SG3, SG5, and SG6 are all deasserted to logical 0.

Selecting the Active Setting Group

The active setting group is selected with one of the following:

- SELOGIC control equation settings SS1 through SS6.
- The serial port **GROUP** command (see ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***).
- The front-panel GROUP pushbutton (see ***Section 11: Front-Panel Interface***).

SELOGIC control equation settings SS1 through 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 Through SS6

Each setting group has its own set of SELOGIC control equation settings SS1 through SS6.

Table 7.4: Definitions for Active Setting Group Switching SELOGIC Control Equation Settings SS1 Through SS6

Setting	Definition
SS1	go to (or remain in) setting Group 1
SS2	go to (or remain in) setting Group 2
SS3	go to (or remain in) setting Group 3
SS4	go to (or remain in) setting Group 4
SS5	go to (or remain in) setting Group 5
SS6	go to (or remain in) setting Group 6

The operation of these settings is explained with the following example:

Assume the active setting group starts out as setting Group 3. Corresponding Relay Word bit SG3 is asserted to logical 1 as an indication that setting Group 3 is the active setting group (see Table 7.3).

With setting Group 3 as the active setting group, setting SS3 has priority. If setting SS3 is asserted to logical 1, setting Group 3 remains the active setting group, regardless of the activity of settings SS1, SS2, SS4, SS5, and SS6. With settings SS1 through SS6 all deasserted to logical 0, setting Group 3 still remains the active setting group.

With setting Group 3 as the active setting group, if setting SS3 is deasserted to logical 0 and one of the other settings (e.g., setting SS5) asserts to logical 1, the relay switches from setting Group 3 as the active setting group to another setting group (e.g., setting Group 5) as the active setting group, after qualifying time setting TGR:

TGR Group Change Delay Setting (settable from 0.00 to 16000.00 cycles)

In this example, TGR qualifies the assertion of setting SS5 before it can change the active setting group.

Operation of Serial Port GROUP Command and Front-Panel GROUP Pushbutton

SELOGIC control equation settings SS1 through 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 through 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 through 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: Line Current Differential Communications and Serial Port Communications and Commands*** for more information on the serial port **GROUP** command. See ***Section 11: Front-Panel Interface*** for more information on the front-panel GROUP pushbutton.

Relay Disabled Momentarily During Active Setting Group Change

The relay is disabled for a **few seconds** while the relay is in the process of changing active setting groups. Relay elements, timers, and logic are reset, unless indicated otherwise in specific logic description (e.g., local bit [LB1 through LB16] and latch bit [LT1 through LT16] states are retained during a 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 Relay. In this example, optoisolated input IN105 on the relay is connected to a SCADA contact in Figure 7.18. 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.

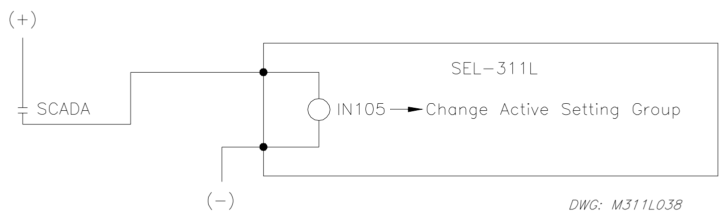


Figure 7.18: SCADA Contact Pulses Input IN105 to Switch Active Setting Group Between Setting Groups 1 and 4

If setting Group 1 is the active setting group and the SCADA contact is pulsed, setting Group 4 becomes the active setting group. If the SCADA contact is pulsed again, setting Group 1 becomes the active setting group again. The setting group control operates in a cyclical manner:

> pulse to activate setting Group 4 ... pulse to activate setting Group 1 ... pulse to activate setting Group 4 ... pulse to activate setting Group 1 ...

This logic is implemented in the SELOGIC control equation settings in Table 7.5.

Table 7.5: SELOGIC Control Equation Settings for Switching Active Setting Group Between Setting Groups 1 and 4

Setting Group 1	Setting Group 4
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 7.5 has logic output SV8T, shown in operation in Figure 7.19 for both setting Groups 1 and 4.

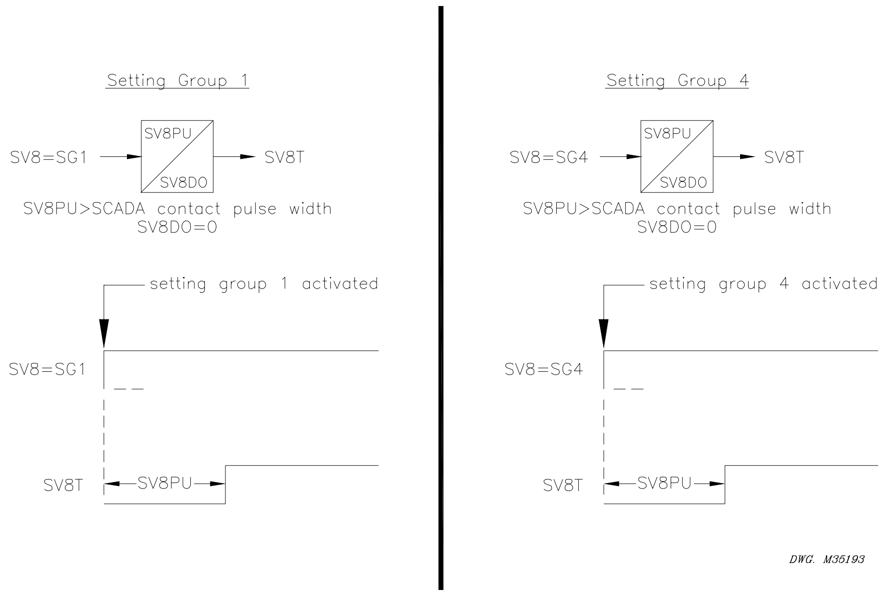


Figure 7.19: SELOGIC Control Equation Variable Timer SV8T Used in Setting Group Switching

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 7.18). 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 7.5 are explained in the following example.

Start Out in Setting Group 1

Refer to Figure 7.20.

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 7.20.

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 7.20 shows both setting Group 1 and setting Group 4 settings. The setting Group 1 settings (top of Figure 7.20) 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 7.20.

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).

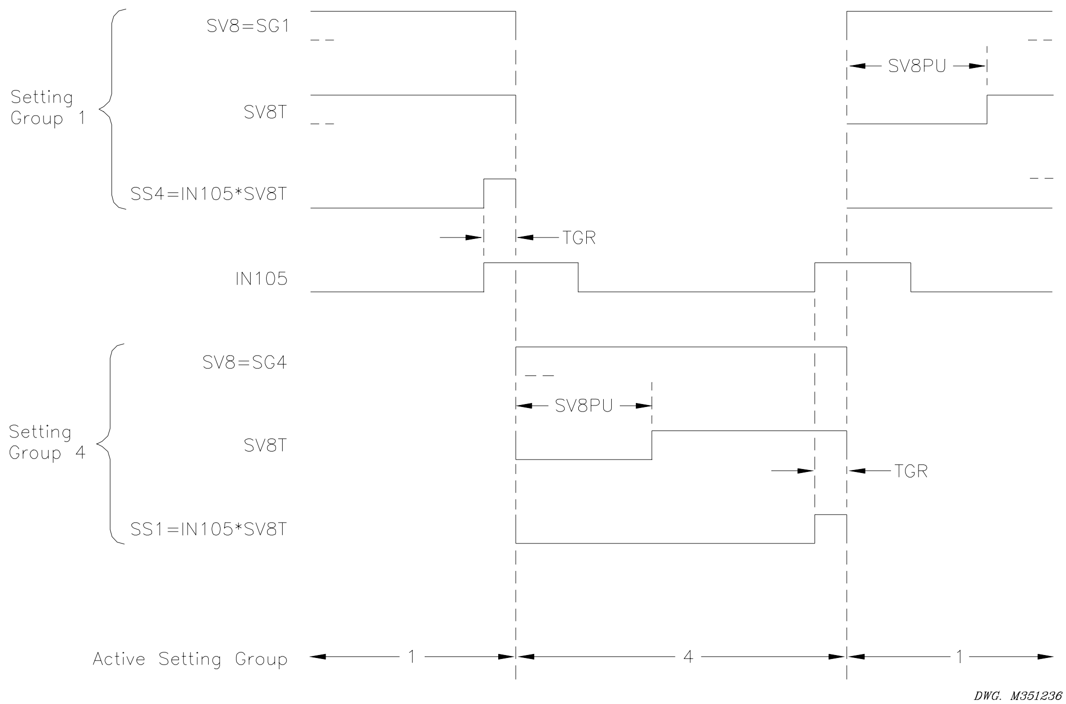


Figure 7.20: Active Setting Group Switching (With Single Input) Time Line

Active Setting Group Switching Example 2

Previous SEL relays (e.g., SEL-321 and SEL-251 Relays) have multiple settings groups controlled by the assertion of three optoisolated inputs (e.g., IN101, IN102, and IN103) in different combinations as shown in Table 7.6.

Table 7.6: Active Setting Group Switching Input Logic

Input States			Active
IN103	**IN102**	**IN101**	**Setting Group**
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 Relay can be programmed to operate similarly. Use three optoisolated inputs to switch between the six setting groups in the SEL-311L Relay. In this example, optoisolated inputs IN101, IN102, and IN103 on the relay are connected to a rotating selector switch in Figure 7.21.

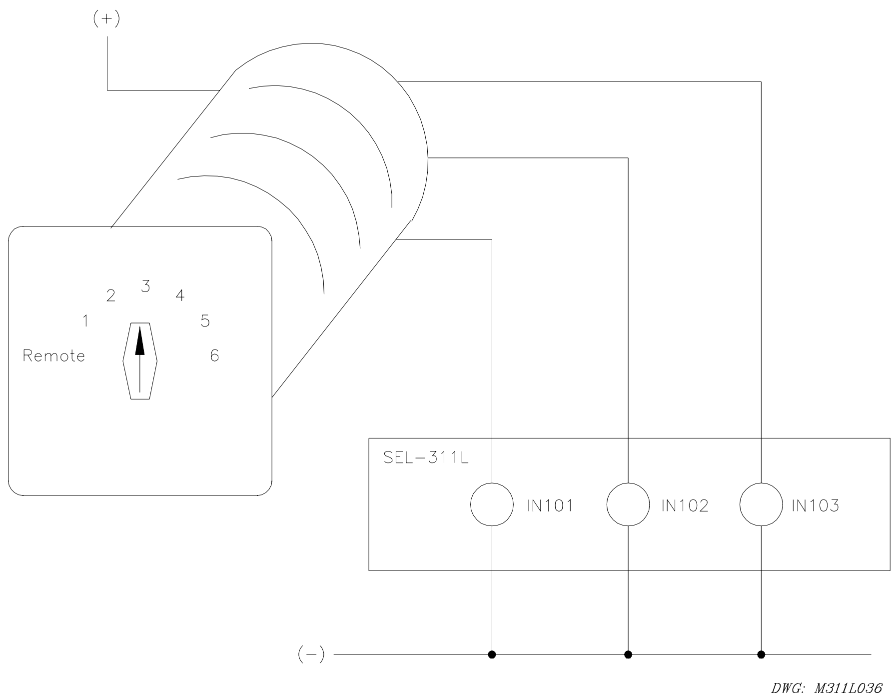


Figure 7.21: Rotating Selector Switch Connected to Inputs IN101, IN102, and IN103 for Active Setting Group Switching

The selector switch has multiple internal contacts arranged to assert inputs IN101, IN102, and IN103, dependent on the switch position. As shown in Table 7.7, when the selector switch is moved from one position to another, a different setting group is activated. The logic in Table 7.6 is implemented in the SELOGIC control equation settings in Table 7.7.

Table 7.7: SELOGIC Control Equation Settings for Rotating Selector Switch Active Setting Group Switching

SS1 = !IN103 * !IN102 * IN101	= NOT(IN103) * NOT(IN102) * IN101
SS2 = !IN103 * IN102 * !IN101	= NOT(IN103) * IN102 * NOT(IN101)
SS3 = !IN103 * IN102 * IN101	= NOT(IN103) * IN102 * IN101
SS4 = IN103 * !IN102 * !IN101	= IN103 * NOT(IN102) * NOT(IN101)
SS5 = IN103 * !IN102 * IN101	= IN103 * NOT(IN102) * IN101
SS6 = IN103 * IN102 * !IN101	= IN103 * IN102 * NOT(IN101)

The settings in Table 7.7 are made in each setting Group 1 through 6.

Selector Switch Starts Out in Position 3

Refer to Table 7.7 and Figure 7.22.

If the selector switch is in position 3 in Figure 7.21, setting Group 3 is the active setting group (Relay Word bit SG3 = logical 1). Inputs IN101 and IN102 are energized and IN103 is deenergized:

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 in order to change the active setting group to setting Group 4. For such a rotating selector switch application, qualifying time setting TGR is typically set at 180 to 300 cycles. Set TGR long enough to allow the selector switch to pass through intermediate positions without changing the active setting group, until the switch rests on the desired setting group position.

Selector Switch Switched to Position 5

Refer to Figure 7.22.

If the selector switch is rested on position 5 in Figure 7.21, 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 deenergized:

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 in order to change the active setting group to any one of these setting groups.

Selector Switch Now Rests on Position REMOTE

Refer to Figure 7.22.

If the selector switch is rested on position REMOTE, all inputs IN101, IN102, and IN103 are deenergized and all settings SS1 through SS6 in Table 7.7 are at logical 0. The last active setting group (Group 5 in this example) remains the active setting group (Relay Word bit SG5 = logical 1).

With settings SS1 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.

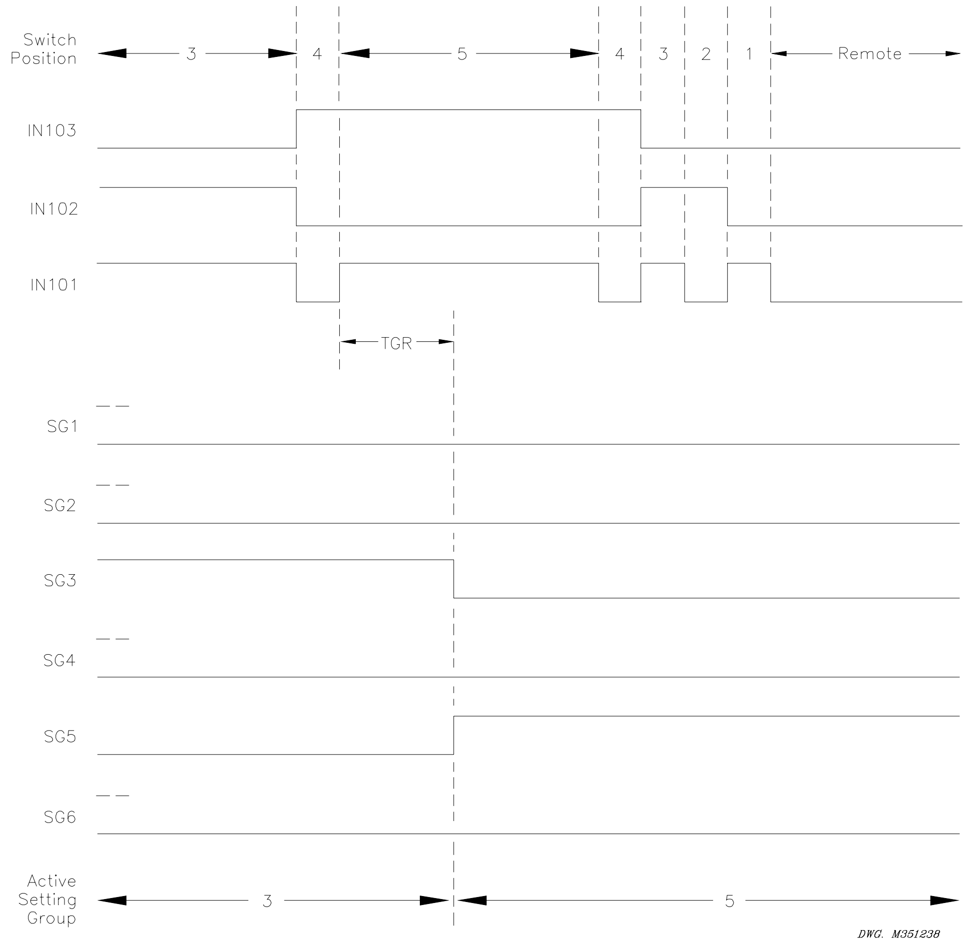


Figure 7.22: Active Setting Group Switching (With Rotating Selector Switch) Time Line

Active Setting Group Retained

Power Loss

The active setting group is retained if power to the relay is lost and then restored. If a particular setting group is active (e.g., setting Group 5) when power is lost, it comes back with the same setting group active when power is restored.

Settings Change

If individual settings are changed (for the active setting group or one of the other setting groups), the active setting group is retained, much like in the preceding ***Power Loss*** explanation.

If individual settings are changed for a setting group other than the active setting group, there is no interruption of the active setting group (the relay is not momentarily disabled).

If the individual settings change causes a change in one or more SELOGIC control equation settings SS1 through SS6, the active setting group can be changed, subject to the newly enabled SS1 through SS6 settings.

Note: Make Active Setting Group Switching Settings with Care

The active setting group is stored in nonvolatile memory so it can be retained during power loss or settings change. The nonvolatile memory is rated for a finite number of "writes" for all setting group changes. Exceeding the limit can result in an 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 through SS6 (see Table 7.4) be set with care. Settings SS1 through SS6 cannot result in continuous cyclical changing of the active setting group. Time setting TGR qualifies settings SS1 through SS6 before changing the active setting group. If optoisolated inputs IN101 through IN106 are used in settings SS1 through 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 7.23 and Figure 7.24.

Timers SV1T through SV6T in Figure 7.23 have a setting range of a little over 4.5 hours:

0.00–999999.00 cycles in 0.25-cycle increments

Timers SV7T through SV16T in Figure 7.24 have a setting range of almost 4.5 minutes:

0.00–16000.00 cycles in 0.25-cycle increments

These timer setting ranges apply to both pickup and dropout times (SV*n*PU and SV*n*DO, *n* = 1 through 16).

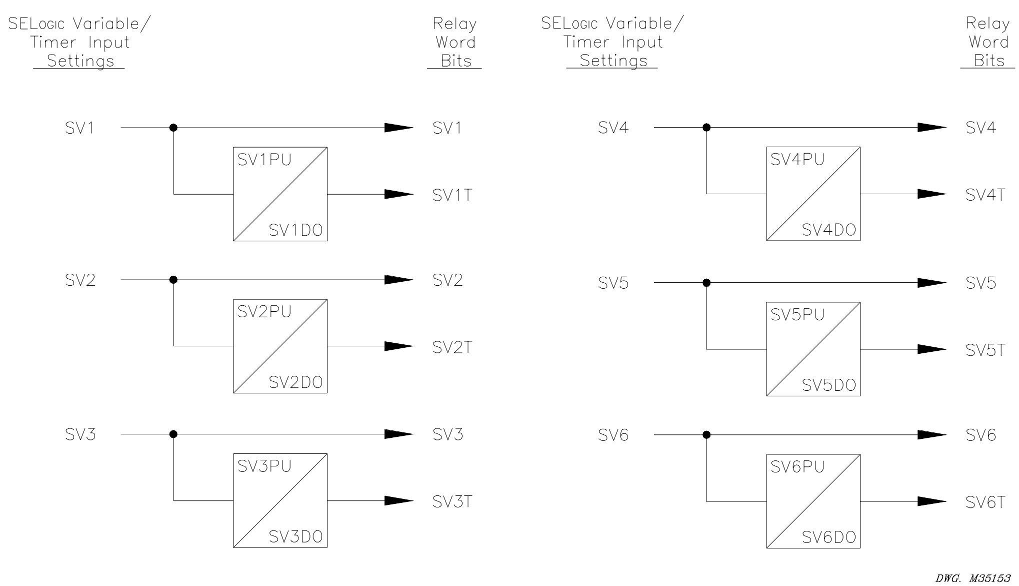


Figure 7.23: SELOGIC Control Equation Variables/Timers SV1/SV1T Through SV6/SV6T

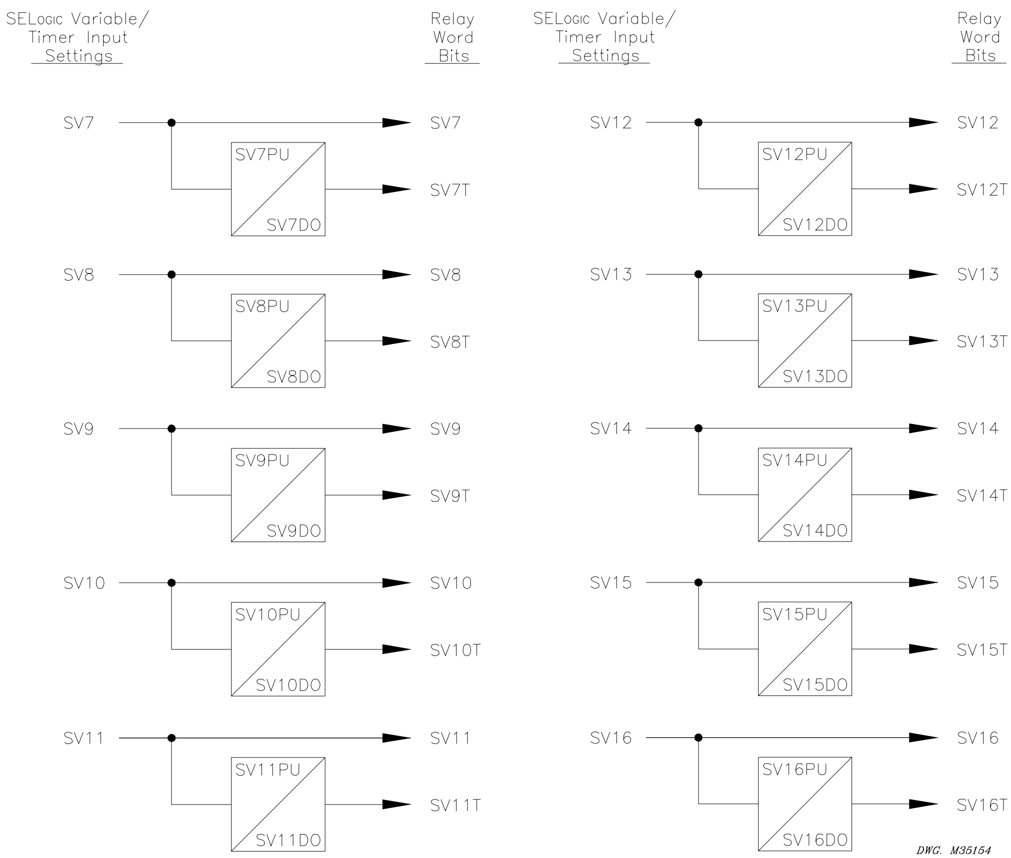


Figure 7.24: SELOGIC Control Equation Variables/Timers SV7/SV7T Through SV16/SV16T

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 7.25):

SV6 = IN101	(breaker failure initiate)
SV7 = (SV7 + IN101) * (50P1 + 50G1)	
OUT101 = SV6T	(retrip)
OUT102 = SV7T	(breaker failure trip)

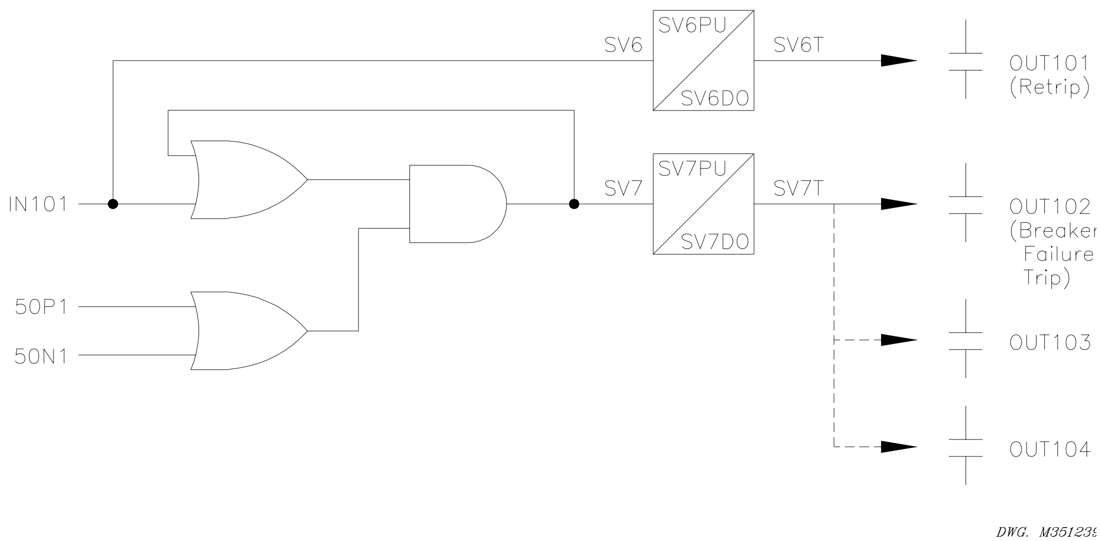


Figure 7.25: Dedicated Breaker Failure Scheme Created With SELOGIC Control Equation Variables/Timers

Note that the above SELOGIC control equation setting SV7 creates a seal-in logic circuit (as shown in Figure 7.25) 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 7.25 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 7.25 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 through 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 7.25 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 Relay contains two types of output contacts. The backup protection hardware controls contacts OUT101 through OUT107 independent of the line current differential hardware. Use outputs OUT101 through OUT107 for backup protection tripping, closing, and for control applications.

The line current differential hardware controls special high-speed contacts OUT201 through OUT206. Contacts OUT201 through OUT206 operate if both the backup protection hardware and the dedicated line current differential hardware are healthy. Use contacts OUT201 through 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 Through OUT107

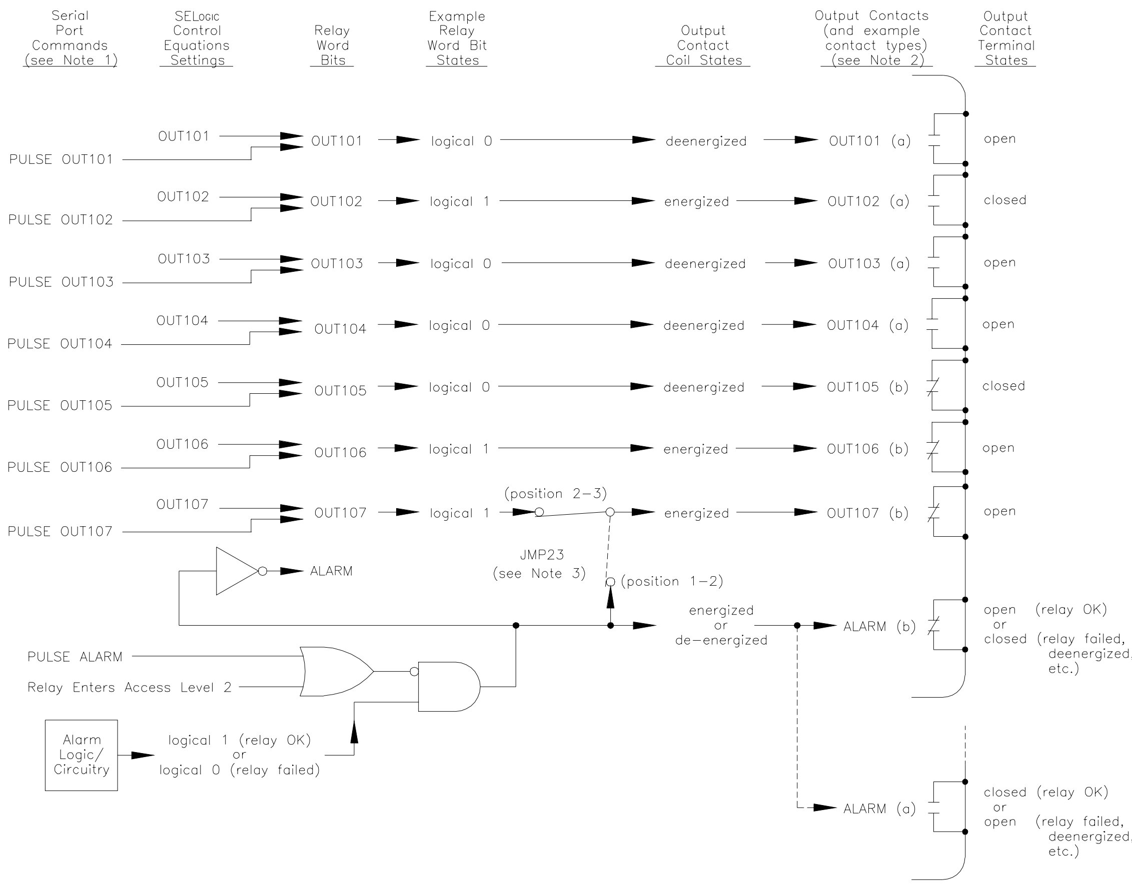
SELOGIC control equations OUT101 through OUT107 control contacts OUT101 through OUT107. When the SELOGIC control equation evaluates to logical 1 for one of these contacts, the relay closes normally open contacts (a), and opens normally closed contacts (b) as shown in Figure 7.26. The PULSE command also 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*** in ***Section 2: Installation***, for output contact type options.

Notice in Figure 7.26 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*** later in this section 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 through 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.



Note 1: PULSE command is also available via the front panel (CNTRL pushbutton, "output contact testing" option). Execution of the PULSE command results in a logical 1 input into the above logic (1−second default pulse width).

Note 2: Output contacts OUT101 through ALARM are configurable as "a" or "b" type output contacts. See Table 2.3 and Figure 2.14 for more information on selecting output contact type.

Note 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 2.4 for more information on jumper JMP23.

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Figure 7.26: Logic Flow for Example Output Contact Operation

High-Speed Output Contacts OUT201 Through OUT206

The SEL-311L Relay contains six special high-speed contacts, OUT201 through 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. OUT201 through OUT206 are rated to interrupt trip current, which helps avoid the added delay caused by tripping auxiliary relays.

Refer to Figure 7.27. Notice the OR gates that drive contacts OUT201 through OUT206. Control each of these contacts with the EHST (Enable High-Speed Trip) setting, OR with the associated SELOGIC control equation OUT201 through OUT206, OR with the PULSE command. Use setting EHST to achieve the fastest 87L tripping as shown in Table 7.8.

Table 7.8: Operate Time for Contacts OUT201–OUT206

OUT201 through 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 through OUT206	< 4 milliseconds
87L tripping via SELOGIC Control equations OUT201 through OUT206	< 11 milliseconds

Refer to the first row of Table 7.8. Line current differential protection via setting EHST is fastest because the same 87L hardware that performs 87L protection also controls contacts OUT201 through OUT206. The relay typically trips via setting EHST less than 1 cycle after an internal fault occurs.

Refer to the third row of Table 7.8. Use SELOGIC control equations OUT201 through OUT206 for line current differential protection only when qualifying the line current differential trip decision with SELOGIC as shown in section ***87L Protection Coordinated with Tapped Load Protection Example 4*** below.

The following subsections detail how and why to control contacts OUT201 through OUT206 using the control methods shown in Table 7.8 above. 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.

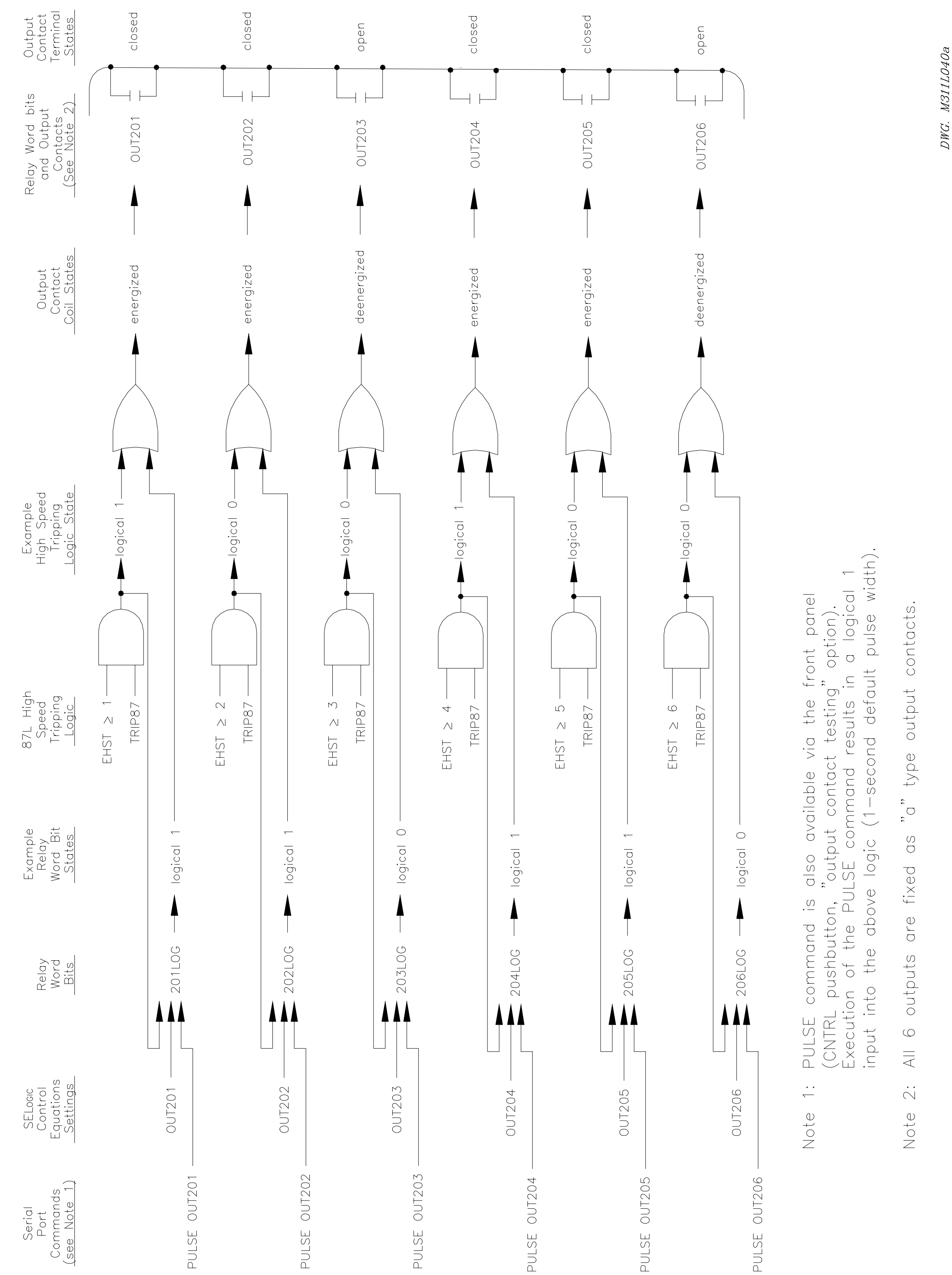


Figure 7.27: Logic Flow for Example Output Contact Operation—OUT201–OUT206

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 through 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 7.28. OUT201 through 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 = TRIP87L

OUT202 = TRIP87L

This does not change how the relay operates; it only serves as a reminder that OUT201 and OUT202 are trip contacts.

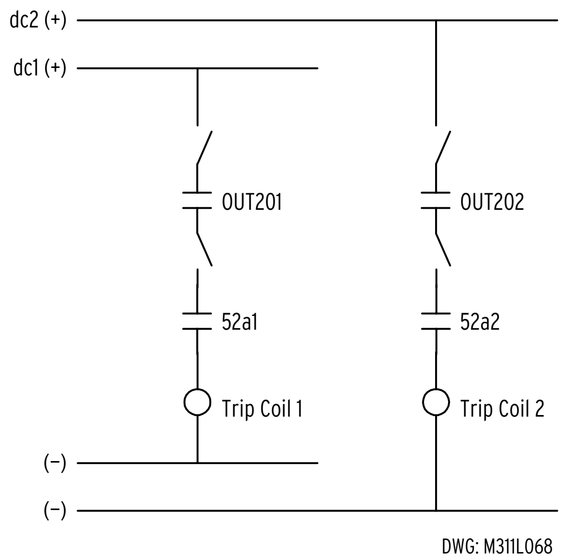


Figure 7.28: High-Speed Trip Contact Connections—Example 1

High-Speed 87L Tripping with Backup Protection Tripping—Example 2

Contacts OUT201 through 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 due to 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 + TRIP87L

OUT202 = TRIP + TRIP87L

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 7.28. 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 due to a problem in the line current differential hardware, use some of contacts OUT101 through 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 through 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 OUT102 in parallel with OUT202 as shown in Figure 7.29. Given the settings discussed above and the connections shown in Figure 7.29, the SEL-311L Relay responds to hardware problems in the following ways:

Problem: 87L communications channel problem.

Action: Switch to the hot standby channel if available, or switch to three-terminal protection mode 3R if appropriate. Assert Relay Word bits CHYAL or CHXAL (Channel Y Alarm or Channel X Alarm) as appropriate. Deassert Relay Word bit 87LPE as appropriate. Illuminate front-panel target 87CH FAIL.

Protection: 87L protection still available if hot standby channel is operable, or if three-terminal protection mode 3R is available. 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: Assert Relay Word 87HWAL (87L Hardware Alarm), deassert Relay Word bit 87LPE, illuminate 87CH FAIL front-panel target.

Protection: Backup protection still available via contacts OUT101 and OUT102.

Problem: Problem with backup protection hardware.

Action: Close ALARM contact, extinguish ENABLE front-panel target.

Protection: 87L and backup protection disabled.

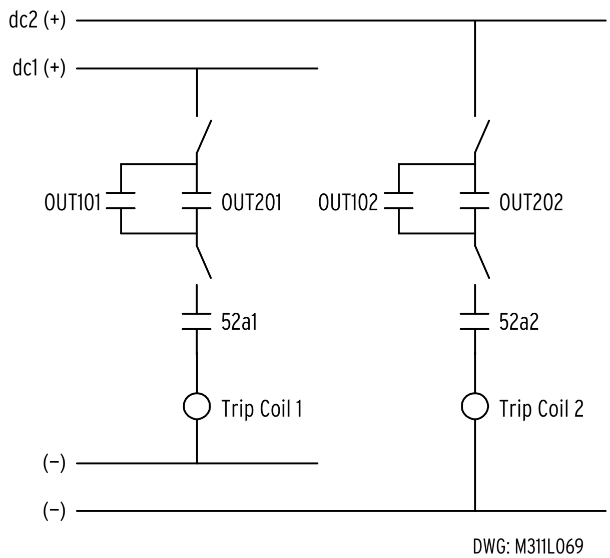


Figure 7.29: High-Speed Trip Contact Connections—Example 3

87L Tripping Coordinated with Tapped Load Protection—Example 4

The SEL-311L Relay 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 3.20 through Figure 3.25) elements and the integral four-shot reclosing relay to coordinate line current differential protection with tapped-load protection. For example, the system in Figure 7.30 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 auto-reclose. 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 Relay 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 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 7.28. Optionally include contacts OUT101 and OUT102 as shown in Figure 7.29 and set

OUT101 = TRIP

OUT102 = TRIP

See ***Settings Example: 230 kV Transmission Line With Tapped Load*** in ***Section 9: Setting the Relay*** for more information regarding coordination with tapped loads.

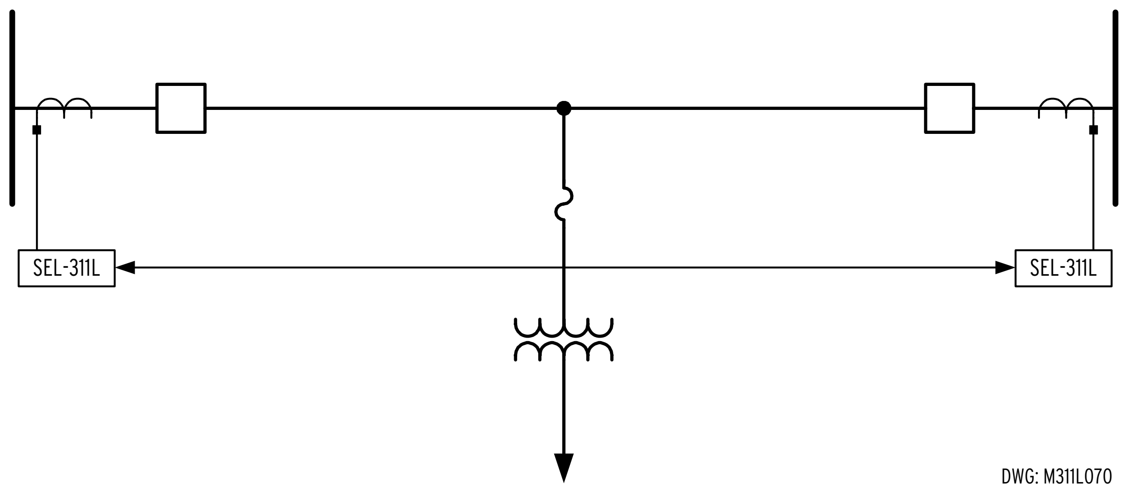


Figure 7.30: Typical Two-Terminal Application With Tapped Load

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% of nominal dc control voltage.

$$R_L \leq 500 \bullet T_{pu} \quad \text{Equation 7.1}$$

where:

R_L is the load resistance in kΩ.

T_{pu} is the minimum load response time, in milliseconds.

For example, a 125 V contact input on an SEL-311L Relay 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 over 30.

$$31 \leq 500 \bullet 2$$

$$31 \leq 1000$$

ALARM Output Contact and 87HWAL

Refer to Figure 7.26 and ***Relay Self-Tests*** in ***Section 13: Testing, Troubleshooting, and Commissioning***.

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 7.26. An “a” type output contact is open when the output contact coil is deenergized and closed when the output contact coil is energized. A “b” type output contact is closed when the output contact coil is deenergized 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 deenergized momentarily).

To verify ALARM output contact mechanical integrity, execute the serial port command **PULSE ALARM**. Execution of this command momentarily deenergizes the ALARM output contact coil.

Notice in Figure 7.26 that all possible combinations of ALARM output contact coil states (energized or deenergized) and output contact types (a or b) are demonstrated. See ***Output Contact Jumpers*** in ***Section 2: Installation*** 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 through 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 7.31 shows traditional indicating panel lights wired in parallel with SEL-311L Relay 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]

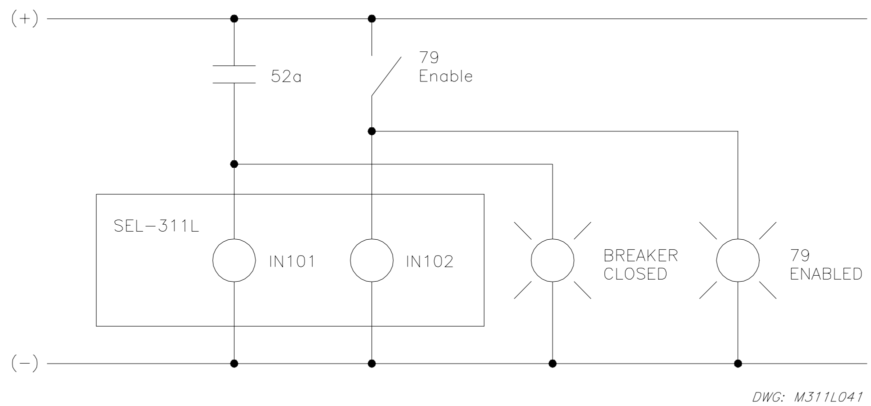


Figure 7.31: Traditional Panel Light Installations

Note that Figure 7.31 corresponds to Figure 7.2.

Reclosing Relay Status Indication

In Figure 7.31, the 79 ENABLED panel light illuminates when the “79 Enable” switch is closed. When the “79 Enable” switch is open, the 79 ENABLED panel light extinguishes, and it is understood that the reclosing relay is disabled.

Circuit Breaker Status Indication

In Figure 7.31, the BREAKER CLOSED panel light illuminates when the 52a circuit breaker auxiliary contact is closed. When the 52a circuit breaker auxiliary contact is open, the BREAKER CLOSED panel light extinguishes, and it is understood that the breaker is open.

Traditional Indicating Panel Lights Replaced with Rotating Default Display

The indicating panel lights are not needed if the rotating default display feature in the SEL-311L Relay is used. Figure 7.32 shows the elimination of the indicating panel lights by using the rotating default display.

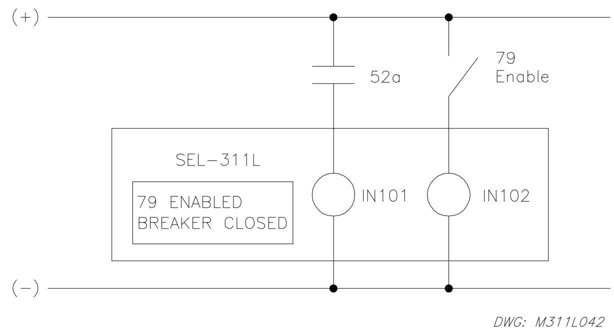


Figure 7.32: Rotating Default Display Replaces Traditional Panel Light Installations

There are sixteen (16) of these default displays available in the SEL-311L Relay. 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 through 16) controls the display of corresponding, complementary text settings:

DP*n*_1 (displayed when DP*n* = logical 1)

DP*n*_0 (displayed when DP*n* = logical 0)

Make each text setting through the serial port using the command **SET T**. View these text settings using the serial port command **SHO T** (see ***Section 9: Setting the Relay*** and ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***). These text settings are displayed on the SEL-311L Relay front-panel display on a time-variable rotation using Global setting SCROLD (see ***Rotating Default Display*** in ***Section 11: Front-Panel Interface*** for more specific operation information).

The following settings examples use optoisolated inputs IN101 and IN102 in the display points settings. Local bits (LB1 through LB4), latch bits (LT1 through LT4), remote bits (RB1 through RB8), setting group indicators (SG1 through 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 7.32 for the traditional indicating panel lights in Figure 7.31.

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 7.32, optoisolated input IN102 is energized to enable the reclosing relay, resulting in:

DP1 = IN102 = logical 1

This results in the display of corresponding text setting DP1_1 on the front-panel display:

```
79 ENABLED
```

Reclosing Relay Disabled

In Figure 7.32, optoisolated input IN102 is deenergized 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 7.32, 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 7.32, optoisolated input IN101 is deenergized 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 7.32)
DP2_1 = BREAKER CLOSED	(displays when DP2 = logical 1)
DP2_0 =	(blank)

Circuit Breaker Closed

In Figure 7.32, optoisolated input IN101 is energized when the 52a circuit breaker auxiliary contact is 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 7.32, optoisolated input IN101 is deenergized 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 Relay 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:

```
LINE 1204
```

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:

```
LINE 1204
```

Active Setting Group Switching Considerations

The SELOGIC control equation display point settings DP*n* (*n* = 1 through 16) are available separately in each setting group. The corresponding text settings DP*n*_1 and DP*n*_0 are made only once and used in all setting groups.

Refer to Figure 7.32 and the following 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 7.32, optoisolated input IN102 is energized to enable the reclosing relay, resulting in:

DP1 = IN102 = logical 1

This results in the display of corresponding text setting DP1_1 on the front-panel display:

```
79 ENABLED
```

Reclosing Relay Disabled

In Figure 7.32, optoisolated input IN102 is deenergized to disable the reclosing relay, resulting in:

DP1 = IN102 = logical 0

This results in the display of corresponding text setting DP1_0 on the front-panel display:

```
79 DISABLED
```

Now the active setting group is switched from setting Group 1 to 4.

Switch to Setting Group 4 as the Active Setting Group

When setting Group 4 is the active setting group, the reclosing relay is always disabled and optoisolated input IN102 has no control over the reclosing relay. The text settings cannot be changed (they are used in all setting groups), but the SELOGIC control equation settings can be changed:

SELOGIC control equation settings:

79DTL	= 1	(set directly to logical 1—reclosing relay permanently "driven-to-lockout")
DP1	= 0	(set directly to logical 0)

Text settings (remain the same for all setting groups):

DP1_1	= 79 ENABLED	(displayed when DP1 = logical 1)
DP1_0	= 79 DISABLED	(displayed when DP1 = logical 0)

Because SELOGIC control equation display point setting DP1 is always at logical 0, the corresponding text setting DP1_0 continually displays in the rotating default displays:

```
79 DISABLED
```

Additional Rotating Default Display Example

See Figure 5.20 and accompanying text in ***Section 5: Trip and Target Logic*** for an example of resetting a rotating default display with the TARGET RESET pushbutton.

TABLE OF CONTENTS

TABLES

FIGURES

SECTION 8: BREAKER MONITOR AND METERING FUNCTIONS

INTRODUCTION

The SEL-311L Relay monitoring functions include:

- Breaker Monitor
- Station DC Battery Monitor

The SEL-311L Relay metering functions include:

- Instantaneous Metering
- Demand Metering
- Energy Metering
- Maximum/Minimum Metering

This section explains these functions in detail.

BREAKER MONITOR

The breaker monitor in the SEL-311L Relay helps in scheduling circuit breaker maintenance. The breaker monitor is enabled with the enable setting:

EBMON = Y

The breaker monitor settings in Table 8.2 are available via the **SET G** and **SET L** commands (see Table 9.1 in ***Section 9: Setting the Relay*** and also the Settings Sheet at the end of ***Section 9***). Also refer to ***BRE Command (Breaker Monitor Data)*** and ***BRE n Command (Preload/Reset Breaker Wear)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***.

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 8.1: Breaker Maintenance Information for an Example Circuit Breaker

Current Interruption Level (kA)	Permissible Number of Close/Open Operations*
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

* The action of a circuit breaker closing and then later opening is counted as one close/open operation.

The breaker maintenance information in Table 8.1 is plotted in Figure 8.1.

Connect the plotted points in Figure 8.1 for a breaker maintenance curve. To estimate this breaker maintenance curve in the SEL-311L Relay breaker monitor, three set points are entered:

Set Point 1	maximum number of close/open operations with corresponding current interruption level.
Set Point 2	number of close/open operations that correspond to some midpoint current interruption level.
Set Point 3	number of close/open operations that correspond to the maximum current interruption level.

These three points are entered with the settings in Table 8.2.

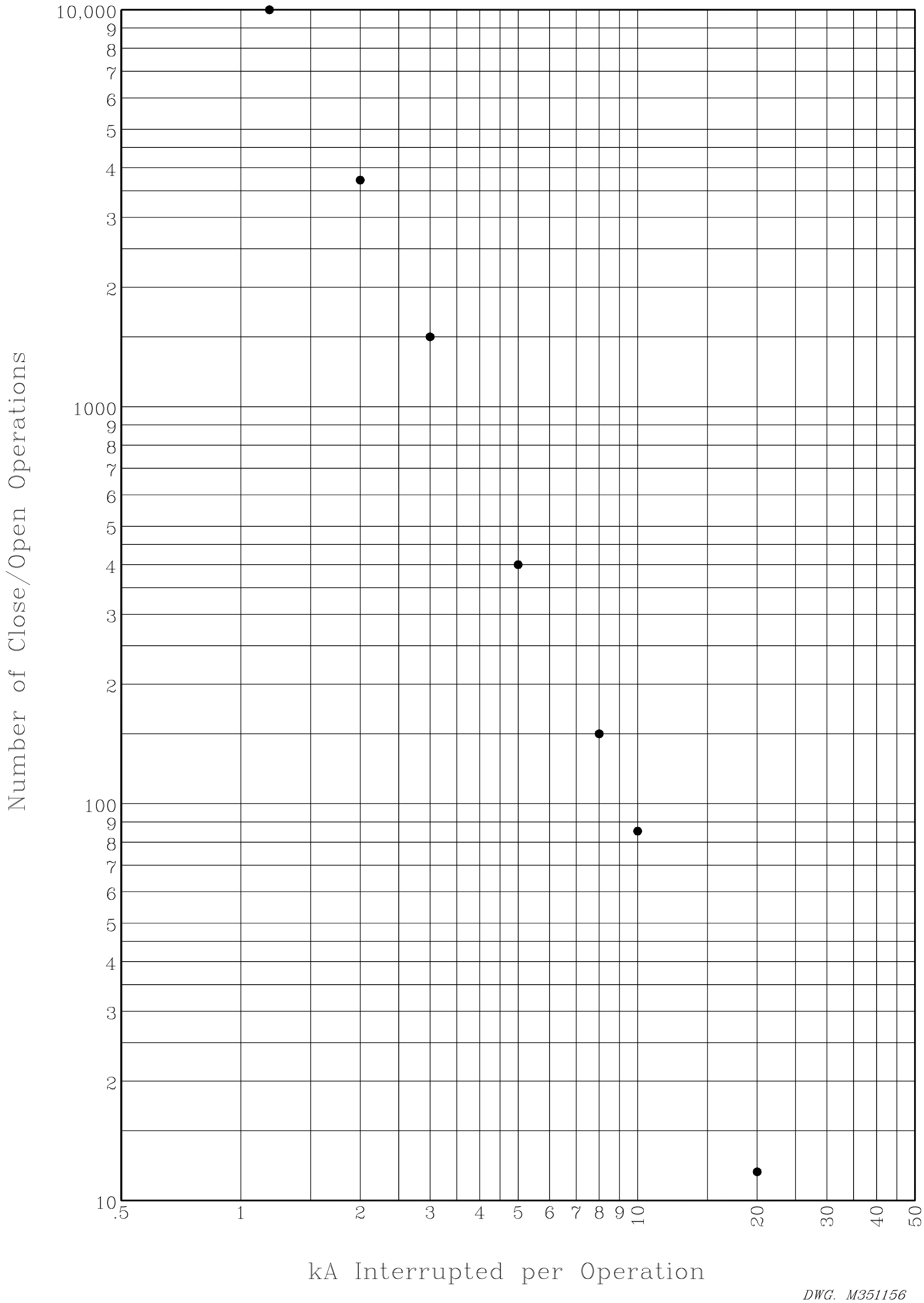


Figure 8.1: Plotted Breaker Maintenance Points for an Example Circuit Breaker

Breaker Monitor Setting Example

Table 8.2: Breaker Monitor Settings and Settings Ranges

Setting	Definition	Range
COSP1	Close/Open set point 1—maximum	0–65000 close/open operations
COSP2	Close/Open set point 2—middle	0–65000 close/open operations
COSP3	Close/Open set point 3—minimum	0–65000 close/open operations
KASP1*	kA Interrupted set point 1—minimum	0.00–999.00 kA in 0.01 kA steps
KASP2	kA Interrupted set point 1—middle	0.00–999.00 kA in 0.01 kA steps
KASP3*	kA Interrupted set point 1—maximum	0.00–999.00 kA in 0.01 kA steps
BKMON	SELOGIC® control equation breaker monitor initiation setting	Relay Word bits referenced in Tables 9.3 and 9.4

* The ratio of settings KASP3/KASP1 must be: 5 ≤ KASP3/KASP1 ≤ 100

The following settings are made from the breaker maintenance information in Table 8.1 and Figure 8.1:

COSP1 = 10000
COSP2 = 150
COSP3 = 12
KASP1 = 1.20
KASP2 = 8.00
KASP3 = 20.00

Figure 8.2 shows the resultant breaker maintenance curve.

Breaker Maintenance Curve Details

In Figure 8.2, note that set points KASP1, COSP1 and KASP3, COSP3 are set with breaker maintenance information from the two extremes in Table 8.1 and Figure 8.1.

In this example, set point KASP2, COSP2 happens to be from an in-between breaker maintenance point in the breaker maintenance information in Table 8.1 and Figure 8.1, but it doesn't have to be. Set point KASP2, COSP2 should be set to provide the best "curve-fit" with the plotted breaker maintenance points in Figure 8.1.

Each phase (A, B, and C) has its own breaker maintenance curve (like that in Figure 8.2), because the separate circuit breaker interrupting contacts for phases A, B, and C don't necessarily interrupt the same magnitude current (depending on fault type and loading).

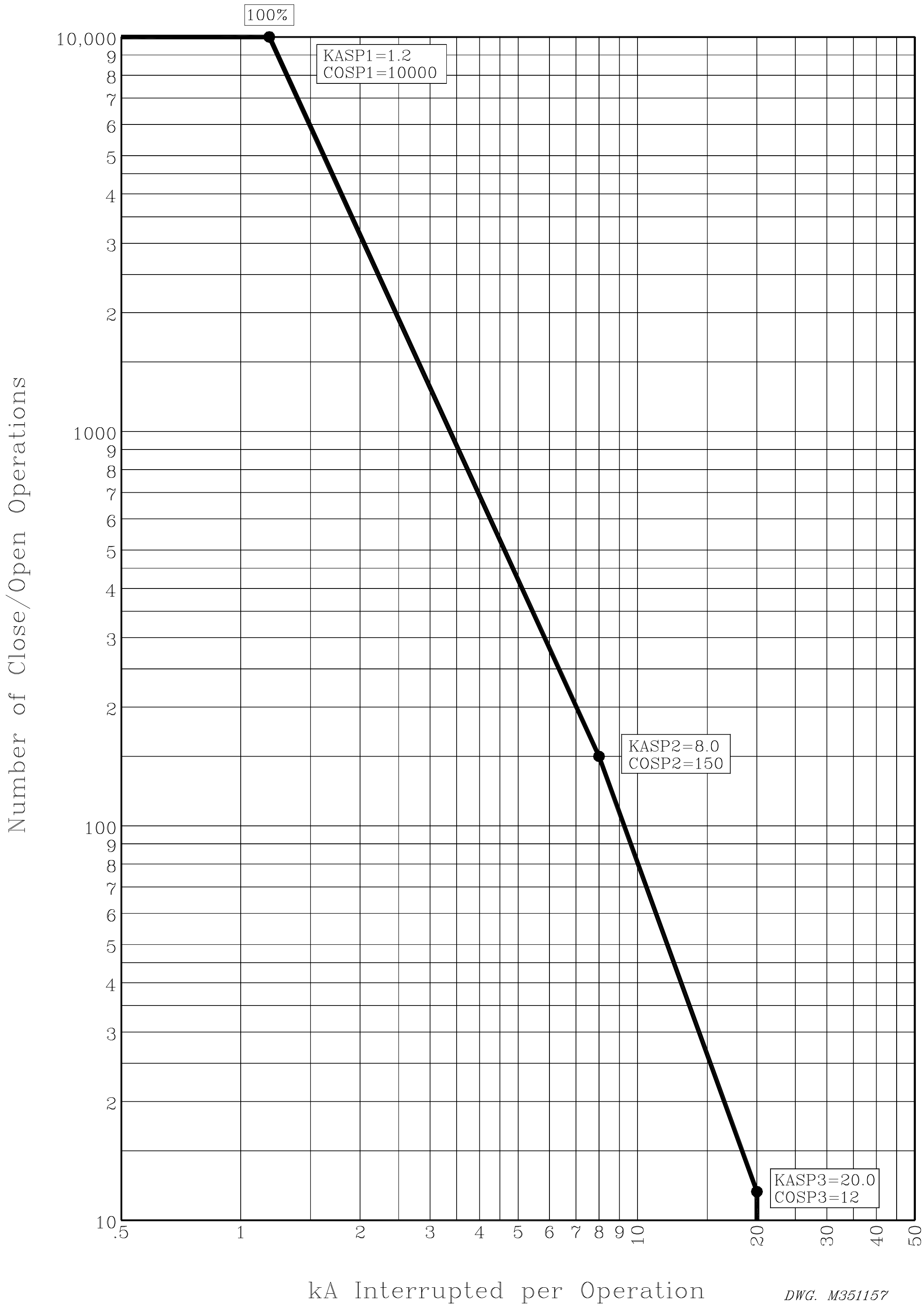


Figure 8.2: SEL-311L Relay Breaker Maintenance Curve for an Example Circuit Breaker

In Figure 8.2, 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 8.2 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]*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***).

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 Figures 5.1 and 5.4)

Refer to Figure 8.3. 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 8.3, the breaker monitor actually reads in the current values 1.5 cycles after the assertion of BKMON. This helps especially if an instantaneous trip occurs. The instantaneous element trips when the fault current reaches its pickup setting level. The fault current may still be "climbing" to its full value, after which it levels off. The 1.5-cycle delay reading the current values allows time for the fault current to level off.

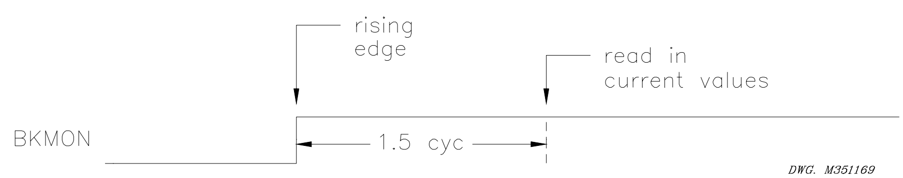


Figure 8.3: Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

See Figure 8.8 and accompanying text for more information on setting BKMON. The operation of the breaker monitor maintenance curve, when new current values are read in, is explained in the following example.

Breaker Monitor Operation Example

As stated earlier, each phase (A, B, and C) has its own breaker maintenance curve. For this example, presume that the interrupted current values occur on a single phase in Figure 8.4 through Figure 8.7. 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 8.4 through Figure 8.7) that the interrupted current in a given figure is the same magnitude for all the interruptions (e.g., in Figure 8.5, 2.5 kA is interrupted 290 times). This is not realistic, but helps in demonstrating the operation of the breaker maintenance curve and how it integrates for varying current levels.

0 Percent to 10 Percent Breaker Wear

Refer to Figure 8.4. 7.0 kA is interrupted 20 times, pushing the breaker maintenance curve from the 0 percent wear level to the 10 percent wear level.

Compare the 100 percent and 10 percent curves and note that for a given current value, the 10 percent curve has only 1/10 of the close/open operations of the 100 percent curve.

10 Percent to 25 Percent Breaker Wear

Refer to Figure 8.5. The current value changes from 7.0 kA to 2.5 kA. 2.5 kA is interrupted 290 times (290 close/open operations = 480 - 190), pushing the breaker maintenance curve from the 10 percent wear level to the 25 percent wear level.

Compare the 100 percent and 25 percent curves and note that for a given current value, the 25 percent curve has only 1/4 of the close/open operations of the 100 percent curve.

25 Percent to 50 Percent Breaker Wear

Refer to Figure 8.6. The current value changes from 2.5 kA to 12.0 kA. 12.0 kA is interrupted 11 times (11 close/open operations = 24 - 13), pushing the breaker maintenance curve from the 25 percent wear level to the 50 percent wear level.

Compare the 100 percent and 50 percent curves and note that for a given current value, the 50 percent curve has only 1/2 of the close/open operations of the 100 percent curve.

50 Percent to 100 Percent Breaker Wear

Refer to Figure 8.7. The current value changes from 12.0 kA to 1.5 kA. 1.5 kA is interrupted 3000 times (3000 close/open operations = 6000 - 3000), pushing the breaker maintenance curve from the 50 percent wear level to the 100 percent wear level.

When the breaker maintenance curve reaches 100 percent for a particular phase, the percentage wear remains at 100 percent (even if additional current is interrupted), until reset by the **BRE R** command (see ***View or Reset Breaker Monitor Information*** that follows later). Current and trip counts continue to be accumulated, until reset by the **BRE R** command.

Additionally, logic outputs assert for alarm or other control applications—see the following discussion.

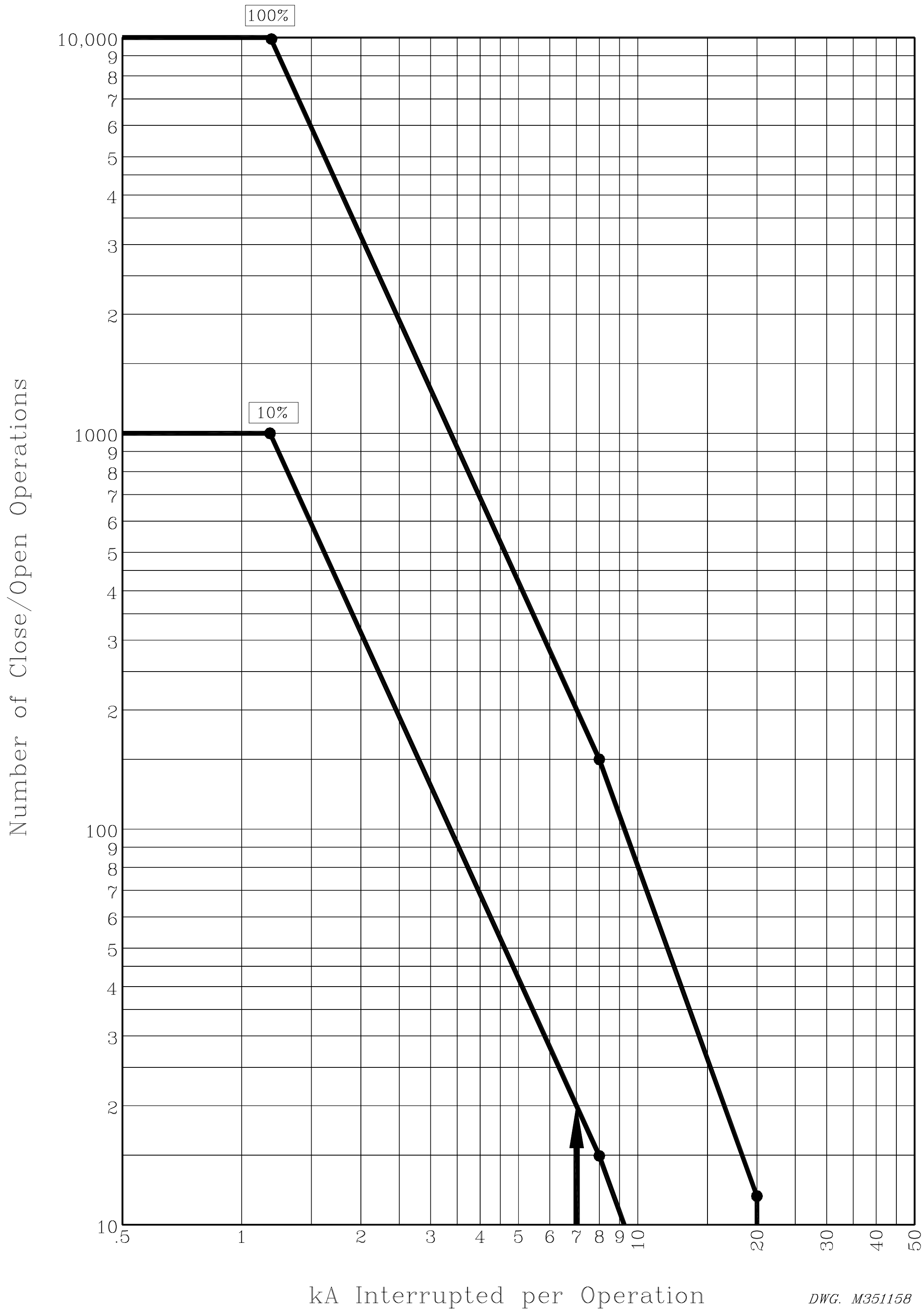


Figure 8.4: Breaker Monitor Accumulates 10 Percent Wear

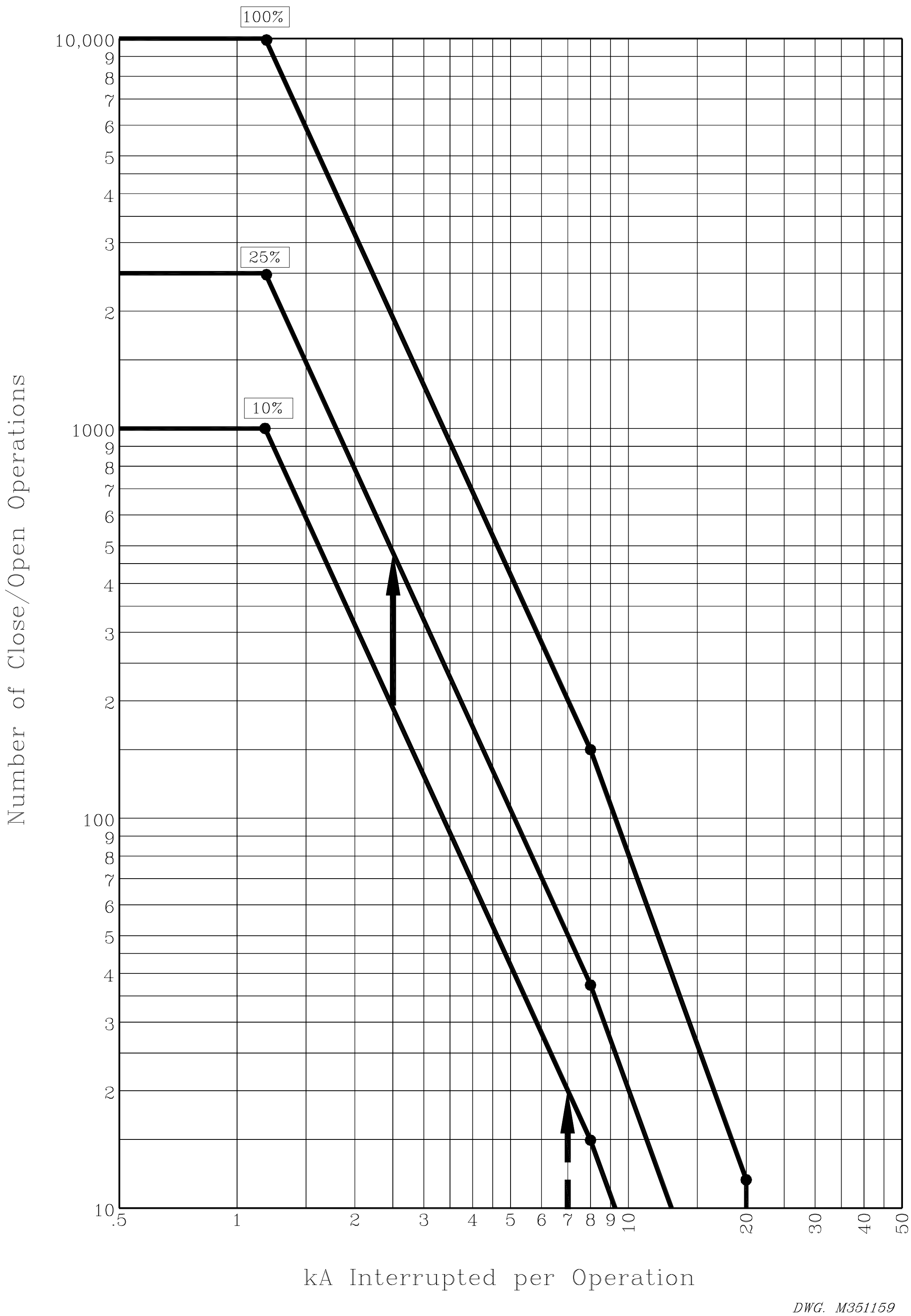


Figure 8.5: Breaker Monitor Accumulates 25 Percent Wear

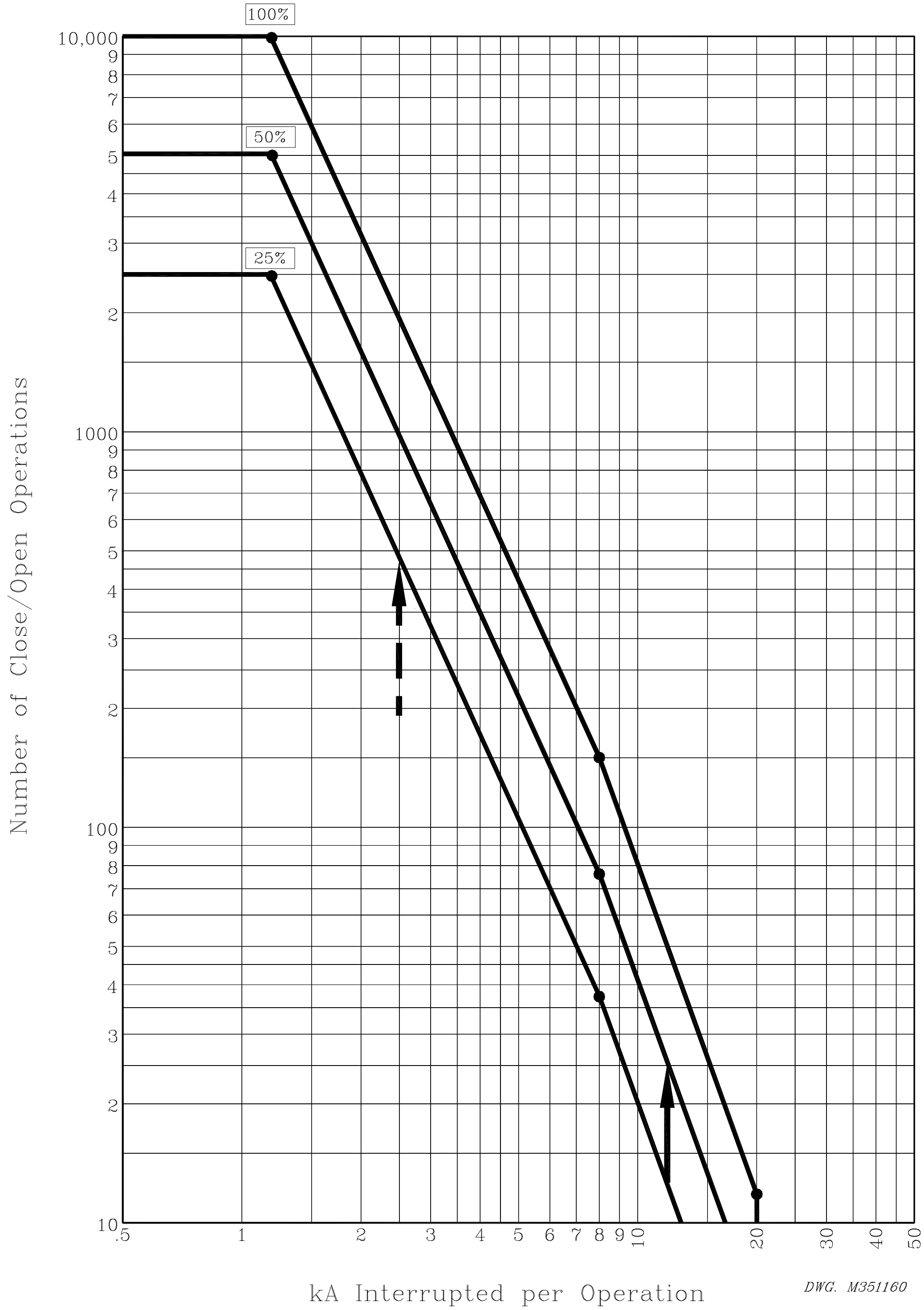


Figure 8.6: Breaker Monitor Accumulates 50 Percent Wear

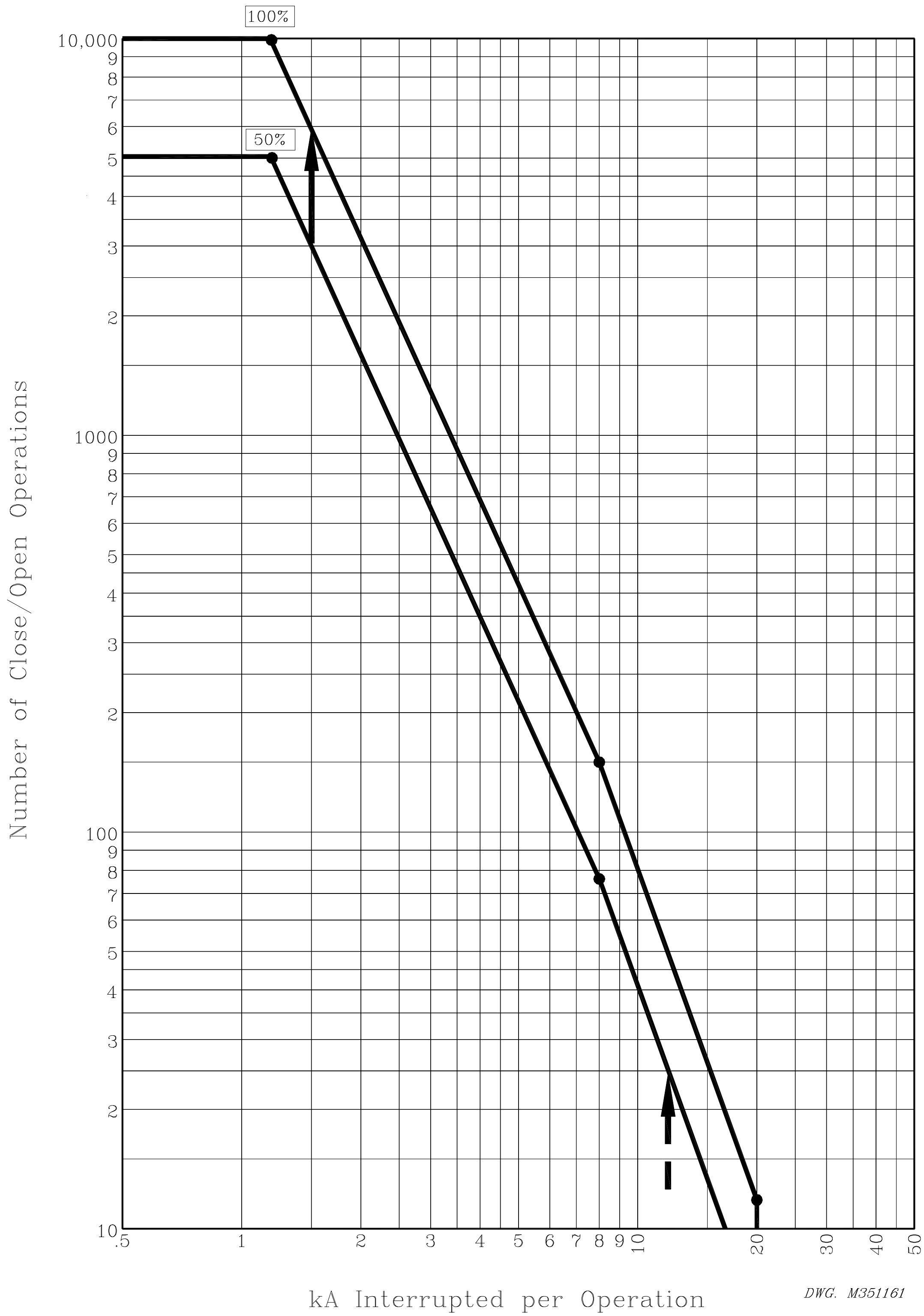


Figure 8.7: Breaker Monitor Accumulates 100 Percent Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100 percent wear level (see Figure 8.7), a corresponding Relay Word bit (BCWA, BCWB, or BCWC) asserts.

Relay Word Bits	Definition
BCWA	Phase A breaker contact wear has reached the 100 percent wear level
BCWB	Phase B breaker contact wear has reached the 100 percent wear level
BCWC	Phase C breaker contact wear has reached the 100 percent wear level
BCW	BCWA + BCWB + BCWC

Example Applications

These logic outputs can be used to alarm:

OUT105 = BCW

View or Reset Breaker Monitor Information

Accumulated breaker wear/operations data is retained if the relay loses power or the breaker monitor is disabled (setting EBMON = N). The accumulated data can only be reset if the **BRE R** command is executed (see the following discussion on the **BRE R** command).

Via Serial Port

See ***BRE Command (Breaker Monitor Data)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***. 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)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***. The **BRE W** command allows 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 in ***Section 11: Front-Panel Interface***.

Determination of Relay-Initiated Trips and Externally Initiated Trips

See ***BRE Command (Breaker Monitor Data)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***. 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 this data is determined by the status of the TRIP Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON operates.

Refer to Figure 8.3 and 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 5.4). 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 8.3 through Figure 8.7).

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 8.8. Output contact OUT101 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.

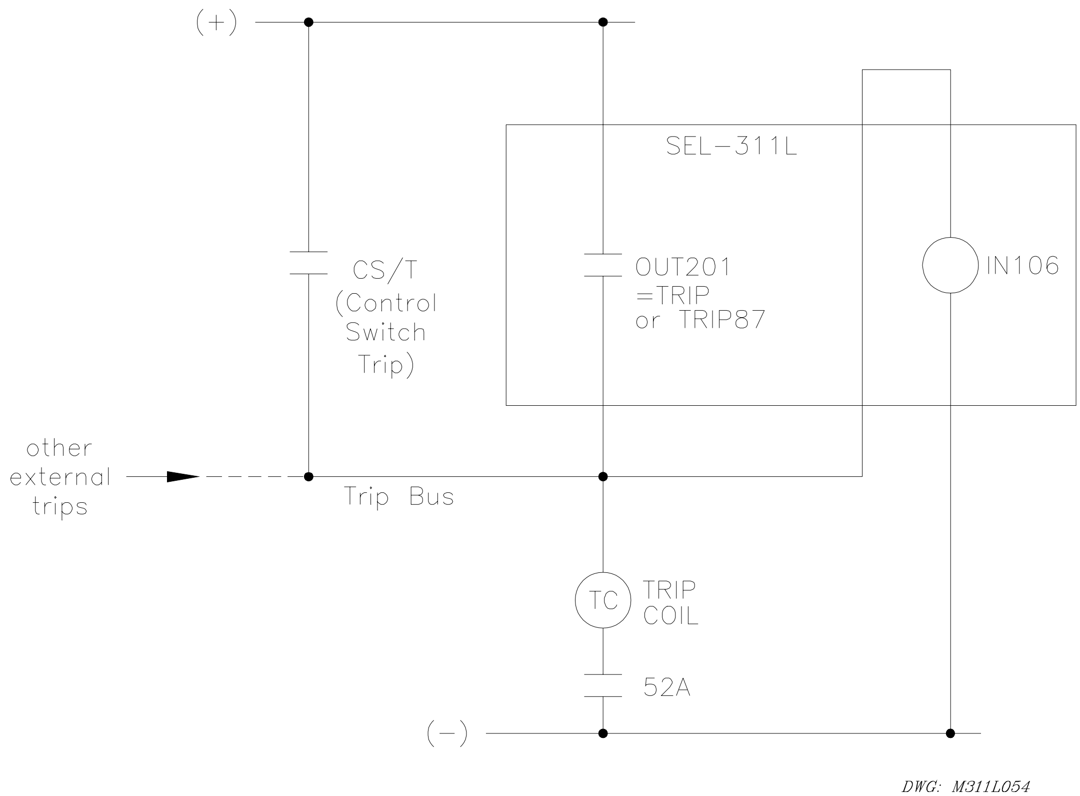


Figure 8.8: Input IN106 Connected to Trip Bus for Breaker Monitor Initiation

If the SELOGIC control equation breaker monitor initiation setting is set:

BKMON = IN106

then the SEL-311L Relay 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 assures 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 Relay 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 in ***Section 9: Setting the Relay*** and also Settings Sheet 6 in the back of ***Section 9***).

DC Under- and Overvoltage Elements

Refer to Figure 8.9. The station dc battery monitor compares the measured station battery voltage (Vdc) to the undervoltage (low) and overvoltage (high) pickups DCLOP and DCHIP. The setting range for pickup settings DCLOP and DCHIP is:

OFF, 20 to 300 Vdc, .01 Vdc increments

This range allows the SEL-311L Relay 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 Relay outside of the power supply limits listed in ***Section1: Introduction and Specifications***.

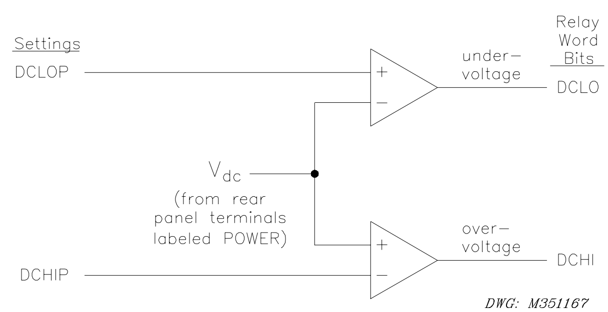


Figure 8.9: DC Under- and Overvoltage Elements

Logic outputs DCLO and DCHI in Figure 8.9 operate as follows:

DCLO = 1 (logical 1), if $V_{dc} \leq$ pickup setting DCLOP
= 0 (logical 0), if $V_{dc} >$ pickup setting DCLOP

DCHI = 1 (logical 1), if $V_{dc} \geq$ pickup setting DCHIP
= 0 (logical 0), if $V_{dc} <$ 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 8.10 shows the resultant dc voltage elements that can be created with SELOGIC control equations for these two setting cases. In these two examples, the resultant dc voltage elements are time-qualified by timer SV4T and then routed to output contact OUT106 for alarm purposes.

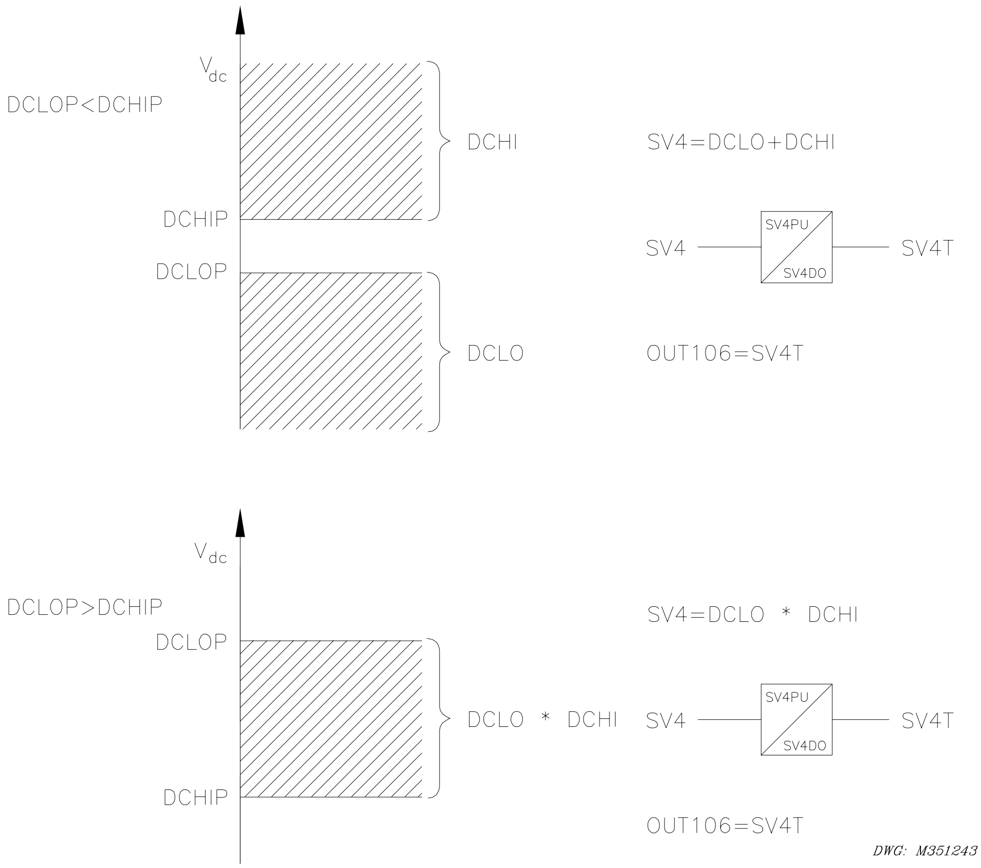


Figure 8.10: Create DC Voltage Elements With SELOGIC Control Equations

DCLO < DCHI (Top of Figure 8.10)

Output contact OUT106 asserts when:

$V_{dc} \leq$ DCLOP or $V_{dc} \geq$ DCHIP

Pickup settings DCLOP and DCHIP are set such that output contact OUT106 asserts when dc battery voltage goes below or above allowable limits.

If the relay loses power entirely (V_{dc} = 0 Vdc)

V_{dc} = < DCLOP

then output contact OUT106 should logically assert (according to top of Figure 8.10), but cannot because of the total loss of power (all output contacts deassert on total loss of power). Thus, the resultant dc voltage element at the bottom of Figure 8.10 would probably be a better choice—see following discussion.

DCLO > DCHI (Bottom of Figure 8.10)

Output contact OUT106 asserts when:

DCHIP ≤ V_{dc} ≤ 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 8.10), and this is surely what happens for a total loss of power (all output contacts deassert on total loss of power).

Output Contact Type Considerations ("a" or "b")

Refer to ***Output Contacts*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** (especially Note 2 in Figure 7.26). Consider the output contact type ("a" or "b") needed for output contact OUT106 in the bottom of Figure 8.10 (dc voltage alarm example).

If SELOGIC control equation setting OUT106 is asserted (OUT106 = SV4T = logical 1; dc voltage OK), the state of output contact OUT106 (according to contact type) is:

closed ("a" type output contact)
open ("b" type output contact)

If SELOGIC control equation setting OUT106 is deasserted (OUT106= SV4T = logical 0; dc voltage not OK), the state of output contact OUT106 (according to contact type) is:

open ("a" type output contact)
closed ("b" type output contact)

If the relay loses power entirely, all output contacts deassert, and the state of output contact OUT106 (according to contact type) is:

open ("a" type output contact)
closed ("b" type output contact)

Additional Application

Other than alarming, the dc voltage elements can be used to disable reclosing.

For example, if the station dc batteries have a problem and the station dc battery voltage is declining, drive the reclosing relay to lockout:

79DTL = !SV4T + ...   [= NOT(SV4T) + ...]

Timer output SV4T is from the bottom of Figure 8.10. When dc voltage falls below pickup DCHIP, timer output SV4T drops out (= logical 0), driving the relay to lockout:

79DTL = !SV4T + ... = NOT(SV4T) + ... = NOT(logical 0) + ... = logical 1

View Station DC Battery Voltage

Via Serial Port

See ***MET Command (Metering Data)***—Instantaneous Metering in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***. 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 in ***Section 11: Front-Panel Interface***.

Analyze Station DC Battery Voltage

See ***Standard 15/30/60-Cycle Event Reports*** in ***Section 12: Standard Event Reports and SER***. The station dc battery voltage is displayed in column Vdc in the example event report in Figure 12.4. 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 5.4). 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 8.8 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 Relay 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 8.10. 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 [SER] Report*** in ***Section 12: Standard Event Reports and SER***).

Operation of Station DC Battery Monitor When AC Voltage Is Powering the Relay

If the SEL-311L Relay 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 8.9 see the average of the sampled ac voltage powering the relay—which is very near zero volts (as displayed in column Vdc in event reports). Pickup settings DCLOP and DCHIP should be set off (DCLOP = OFF, DCHIP = OFF) since 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.

METERING

The SEL-311L Relay 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 since 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 13V secondary. If the A-phase voltage is 13V or less, the angles are referenced to the local A phase current.

INSTANTANEOUS METERING

The instantaneous metering in SEL-311L Relay 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 8.11: 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 Relay.

The current magnitude and angles listed under “Local” in Figure 8.11 are always reported since they pertain to the local relay.

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.

Figure 8.12 below 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 8.12: Instantaneous Meter Display for Local Quantities

Local Demand Metering

The SEL-311L Relay 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 8.3) are available via the **SET** command (see Settings Sheet at the end of ***Section 9***. Also refer to ***MET Command [Metering Data]***, MET D—Demand Metering in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***).

The SEL-311L Relay 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; $I_G = 3I_0 = I_A + I_B + I_C$)
	$3I_2$	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 8.13 shows the response of thermal and rolling demand meters to a step current input. The current input is at a magnitude of zero and then suddenly goes to an instantaneous level of 1.0 per unit (a “step”).

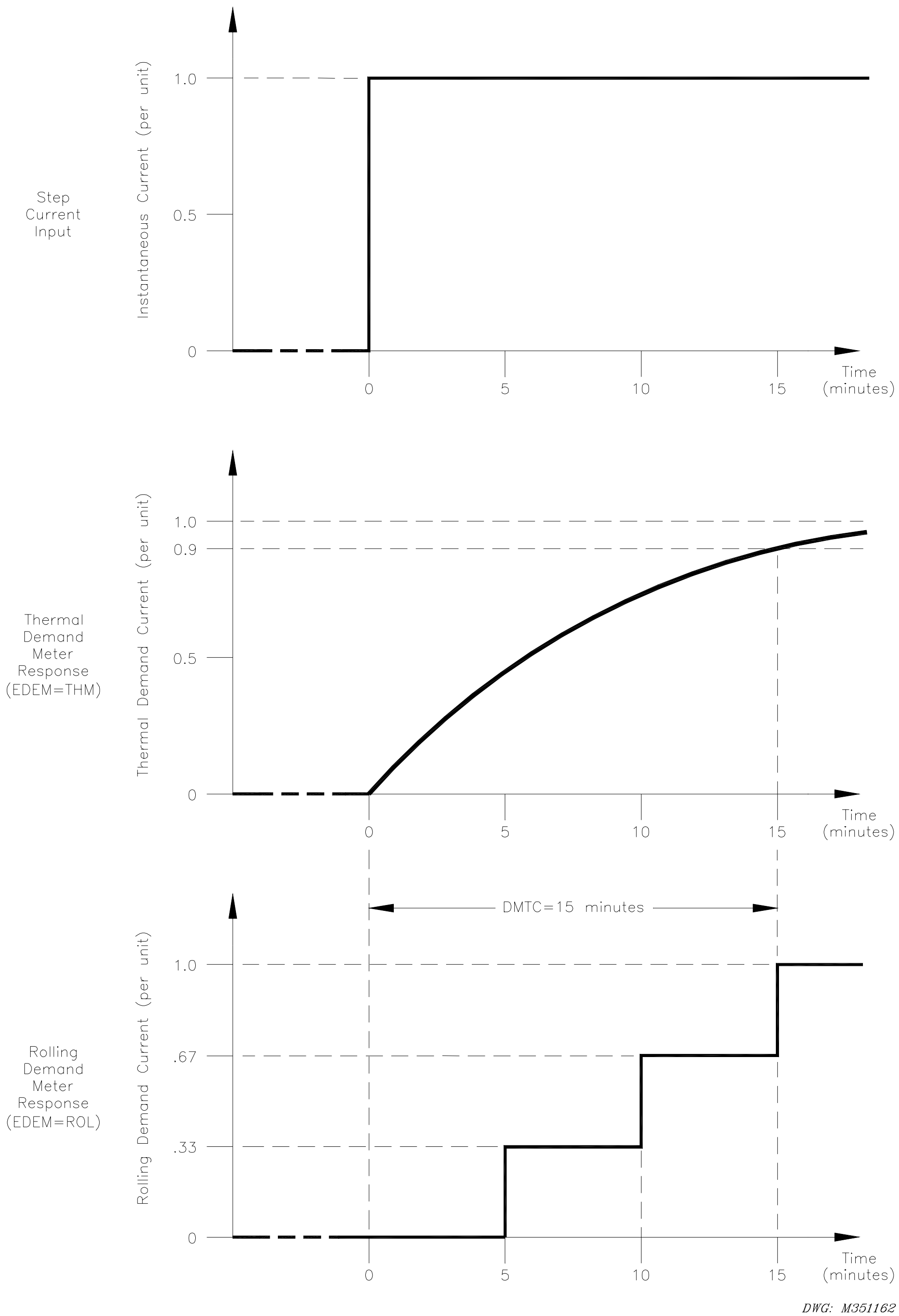


Figure 8.13: Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 Minutes)

Thermal Demand Meter Response (EDEM = THM)

The response of the thermal demand meter in Figure 8.13 (middle) to the step current input (top) is analogous to the parallel RC circuit in Figure 8.14.

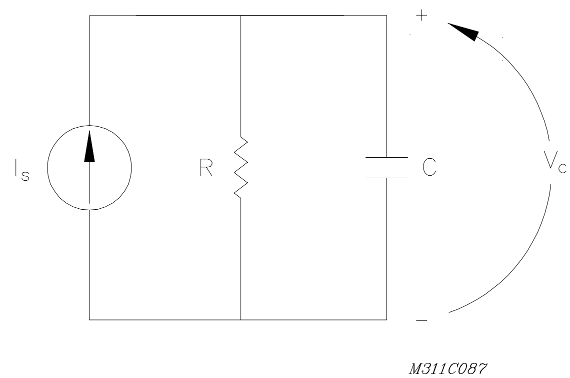


Figure 8.14: Current I_s Applied to Parallel RC Circuit

In the analogy:

Current I_s in Figure 8.14 corresponds to the step current input in Figure 8.13 (top).

Voltage V_c across the capacitor in Figure 8.14 corresponds to the response of the thermal demand meter in Figure 8.13 (middle).

If current I_s in Figure 8.14 has been at zero (I_s = 0.0 per unit) for some time, voltage V_c across the capacitor in Figure 8.14 is also at zero (V_c = 0.0 per unit). If 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 8.13 (middle) to the step current input (top).

In general, just as voltage V_c across the capacitor in Figure 8.14 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 8.3). Note in Figure 8.13, the thermal demand meter response (middle) is at 90 percent (0.9 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step current input is first applied.

The SEL-311L Relay updates thermal demand values approximately every 2 seconds.

Rolling Demand Meter Response (EDEM = ROL)

The response of the rolling demand meter in Figure 8.13 (bottom) to the step current input (top) is calculated with a sliding time-window arithmetic average calculation. The width of the sliding time-window is equal to the demand meter time constant setting DMTC (see Table 8.3). Note in Figure 8.13, the rolling demand meter response (bottom) is at 100 percent (1.0 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step current input is first applied.

The rolling demand meter integrates the applied signal (e.g., step current) input in 5-minute intervals. The integration is performed approximately every 2 seconds. The average value for an integrated 5-minute interval is derived and stored as a 5-minute total. The rolling demand meter then averages a number of the 5-minute totals to produce the rolling demand meter response. In the Figure 8.13 example, the rolling demand meter averages the three latest 5-minute totals because setting DMTC = 15 (15/5 = 3). The rolling demand meter response is updated every 5 minutes, after a new 5-minute total is calculated.

The following is a step-by-step calculation of the rolling demand response example in Figure 8.13 (bottom).

Time = 0 Minutes

Presume that the instantaneous current has been at zero for quite some time before "Time = 0 minutes" (or the demand meters were reset). The three 5-minute intervals in the sliding time-window at "Time = 0 minutes" each integrate into the following 5-minute totals:

5-Minute Totals	Corresponding 5-Minute Interval
0.0 per unit	-15 to -10 minutes
0.0 per unit	-10 to -5 minutes
0.0 per unit	-5 to 0 minutes
0.0 per unit	

Rolling demand meter response at "Time = 0 minutes" = 0.0/3 = 0.0 per unit

Time = 5 Minutes

The three 5-minute intervals in the sliding time-window at "Time = 5 minutes" each integrate into the following 5-minute totals:

5-Minute Totals	Corresponding 5-Minute Interval
0.0 per unit	-10 to -5 minutes
0.0 per unit	-5 to 0 minutes
1.0 per unit	0 to 5 minutes
1.0 per unit	

Rolling demand meter response at "Time = 5 minutes" = 1.0/3 = 0.33 per unit

Time = 10 Minutes

The three 5-minute intervals in the sliding time-window at "Time = 10 minutes" each integrate into the following 5-minute totals:

5-Minute Totals	Corresponding 5-Minute Interval
0.0 per unit	-5 to 0 minutes
1.0 per unit	0 to 5 minutes
1.0 per unit	5 to 10 minutes
2.0 per unit	

Rolling demand meter response at "Time = 10 minutes" = 2.0/3 = 0.67 per unit

Time = 15 Minutes

The three 5-minute intervals in the sliding time-window at "Time = 15 minutes" each integrate into the following 5-minute totals:

5-Minute Totals	Corresponding 5-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.

Table 8.3: 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

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 subsection.

The demand current pickup settings in Table 8.3 are applied to demand current meter outputs as shown in Figure 8.15. For example, when residual ground demand current $I_{G(DEM)}$ goes above corresponding demand pickup GDEMP, Relay Word bit GDEM asserts to logical 1. Use these demand current logic outputs (PDEM, GDEM, and QDEM) to alarm for high loading or unbalance conditions. Use in other schemes such as the following example.

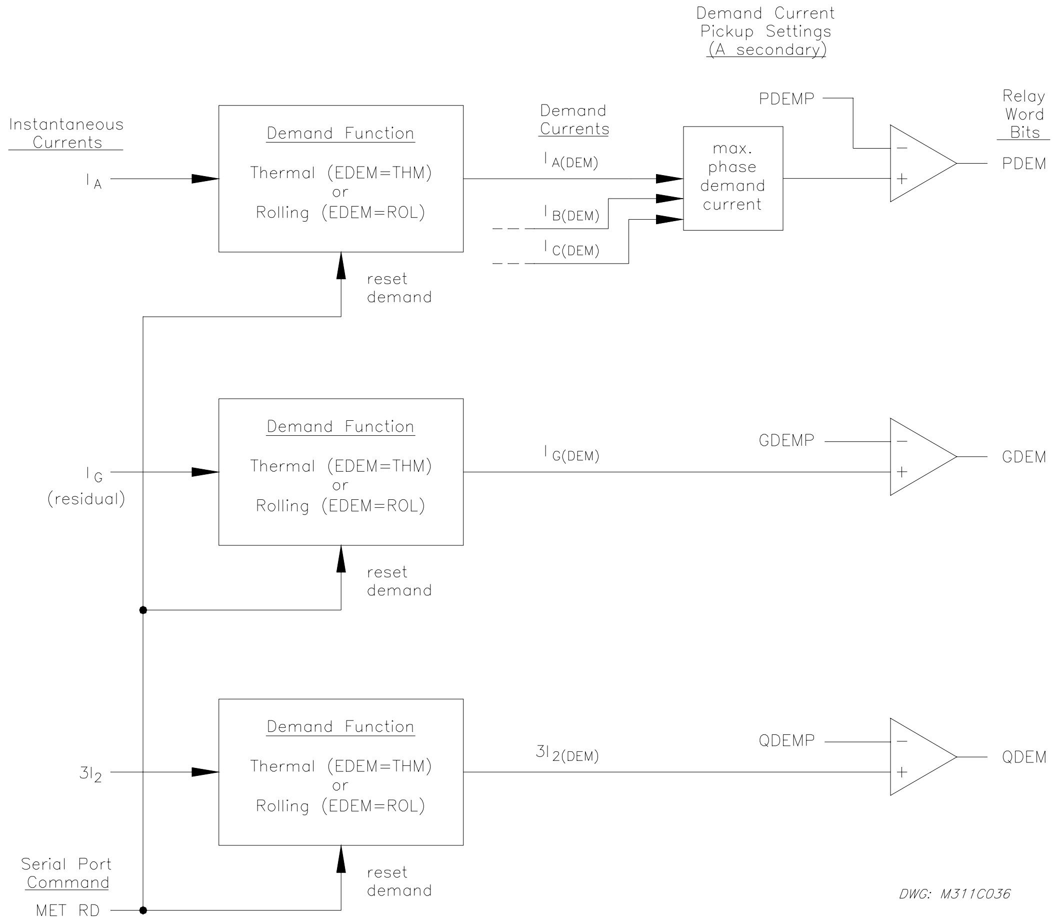


Figure 8.15: Demand Current Logic Outputs

Demand Current Logic Output Application—Raise Pickup for Unbalance Current

During times of high loading, the residual ground overcurrent elements can see relatively high unbalance current I_G ($I_G = 3I_0$). To avoid tripping on unbalance current I_G, use Relay Word bit GDEM to detect the residual ground (unbalance) demand current $I_{G(DEM)}$ and effectively raise the pickup of the residual ground time-overcurrent element 51GT. This is accomplished with the following settings from Table 8.3, pertinent residual ground overcurrent element settings, and SELOGIC control equation torque control setting 51GTC:

EDEM	=	THM
DMTC	=	5
GDEMP	=	1.0
51GP	=	1.50
50G2P	=	2.30
51GTC	=	!GDEM + GDEM * 50G2

Refer to Figure 8.15, Figure 8.16, and Figure 3.24.

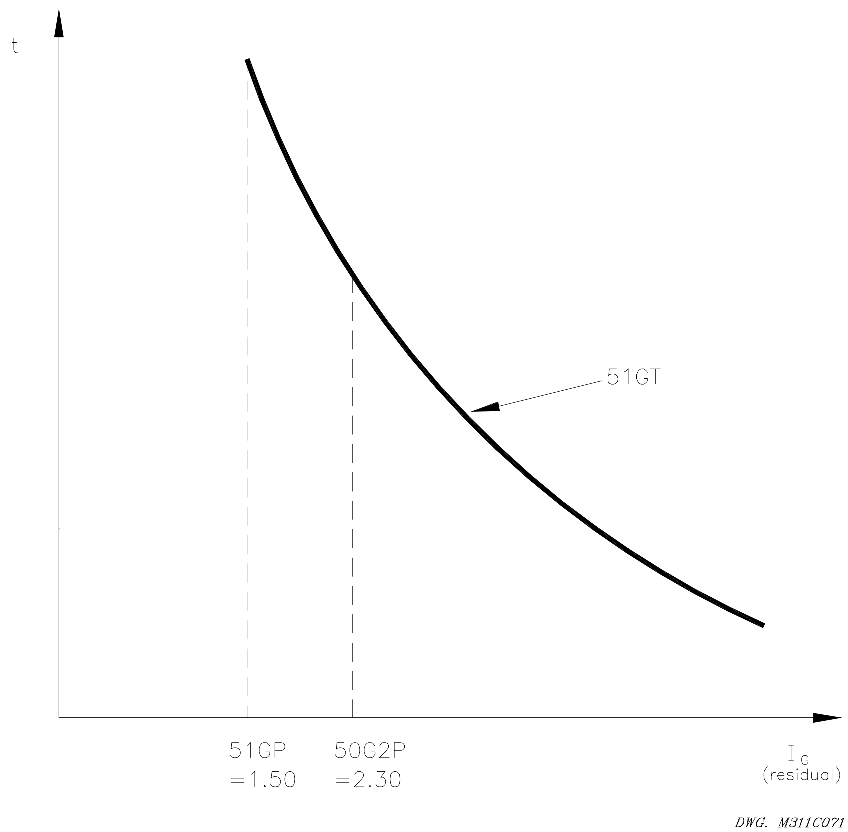


Figure 8.16: Raise Pickup of Residual Ground Time-Overcurrent Element for Unbalance Current

Residual Ground Demand Current Below Pickup GDEMP

When unbalance current I_G is low, unbalance demand current $I_{G(DEM)}$ is below corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM is deasserted to logical 0. This results in SELOGIC control equation torque control setting 51GTC being in the 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)***, MET D—Demand Metering in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***. 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 in ***Section 11: Front-Panel Interface***.

Demand Metering Updating and Storage

The SEL-311L Relay updates demand values approximately every 2 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 the following ***Maximum/Minimum Metering Updating and Storage*** subsection. It is not necessary to suspend demand metering during a fault since fault quantities will not significantly change demand quantities that are calculated using a minimum time constant of 5 minutes.

Local Energy Metering

View or Reset Energy Metering Information

Via Serial Port

See ***MET Command (Metering Data)***, MET E—Energy Metering in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***. 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 in ***Section 11: Front-Panel Interface***.

Energy Metering Updating and Storage

The SEL-311L Relay updates energy values approximately every 2 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)***, MET M—Maximum/Minimum Metering in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***. 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; $I_G = 3I_0 = I_A + I_B + I_C$)
	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 in ***Section 11: Front-Panel Interface***.

Maximum/Minimum Metering Updating and Storage

The SEL-311L Relay 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 1 minute after FAULT deasserts.
- The metering value is above the previous maximum or below the previous minimum for 2 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 Relay 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.

TABLE OF CONTENTS

TABLES

FIGURES

SECTION 9: SETTING THE RELAY

INTRODUCTION

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*
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).	1–15
SET L *m*	Logic	SELOGIC® control equations for settings group *m* (*m* = 1, 2, 3, 4, 5, 6).	16–21
SET G	Global	Battery and breaker monitors, optoisolated input debounce timers, etc.	22–23
SET R	SER	Sequential Events Recorder trigger conditions.	24
SET T	Text	Front-panel default display and local control text.	25–28
SET P *m*	Port	Serial port settings for Serial Port *m* (*m* = 1, 2, 3, or F).	29
SET X	Channel	Differential communications Channel X settings.	30
SET Y	Channel	Differential communications Channel Y settings.	30

* 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 (Showset)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***.

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 in ***Section 11: Front-Panel Interface*** 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/uppercase/brackets: **<ENTER>**.

See ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** 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). 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 7.26) and the EN LED extinguishes (see Table 5.1) while the relay is disabled. The relay is disabled for about 1 second. If Logic settings are changed for the active group, the relay can be disabled for up to 15 seconds.

If changes are made to the Relay or Logic settings for a setting group other than the active setting group (see Table 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 7.26), but the EN LED remains on (see Table 5.1) while the new settings are saved.

TIME-OVERCURRENT CURVES

The following information describes the curve timing for the curve and time dial settings made for the time-overcurrent elements (see Figure 3.47, 3.48 and 3.49 through Figure 3.24). The time-overcurrent relay curves in Figure 9.1 through Figure 9.5 conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays. Figure 9.6 through Figure 9.10 represent IEC defined relay curves.

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

U.S. Moderately Inverse Curve: U1

$tp = TD \bullet (0.0226 + 0.0104/(M^{0.02}-1))$

$tr = TD \bullet (1.08/(1-M^2))$

U.S. Inverse Curve: U2

$tp = TD \bullet (0.180 + 5.95/(M^2-1))$

$tr = TD \bullet (5.95/(1-M^2))$

U.S. Very Inverse Curve: U3

$tp = TD \bullet (0.0963 + 3.88/(M^2-1))$

$tr = TD \bullet (3.88/(1-M^2))$

U.S. Extremely Inverse Curve: U4

$tp = TD \bullet (0.0352 + 5.67/(M^2-1))$

$tr = TD \bullet (5.67/(1-M^2))$

U.S. Short-Time Inverse Curve: U5

$tp = TD \bullet (0.00262 + 0.00342/(M^{0.02}-1))$

$tr = TD \bullet (0.323/(1-M^2))$

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

$tp = TD \bullet (0.14/(M^{0.02}-1))$

$tr = TD \bullet (13.5/(1-M^2))$

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

$tp = TD \bullet (13.5/(M-1))$

$tr = TD \bullet (47.3/(1-M^2))$

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

$tp = TD \bullet (80.0/(M^2-1))$

$tr = TD \bullet (80.0/(1-M^2))$

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

$tp = TD \bullet (120.0/(M-1))$

$tr = TD \bullet (120.0/(1-M))$

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

$tp = TD \bullet (0.05/(M^{0.04}-1))$

$tr = TD \bullet (4.85/(1-M^2))$

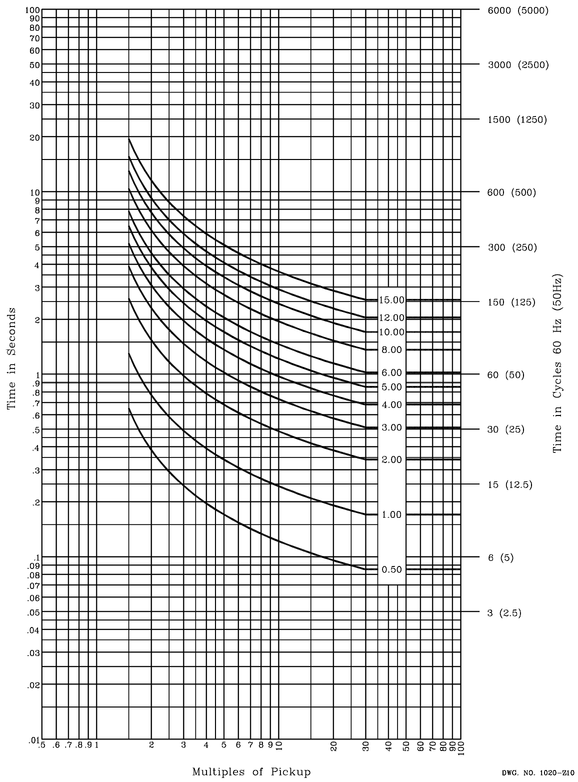


Figure 9.1: U.S. Moderately Inverse Curve: U1

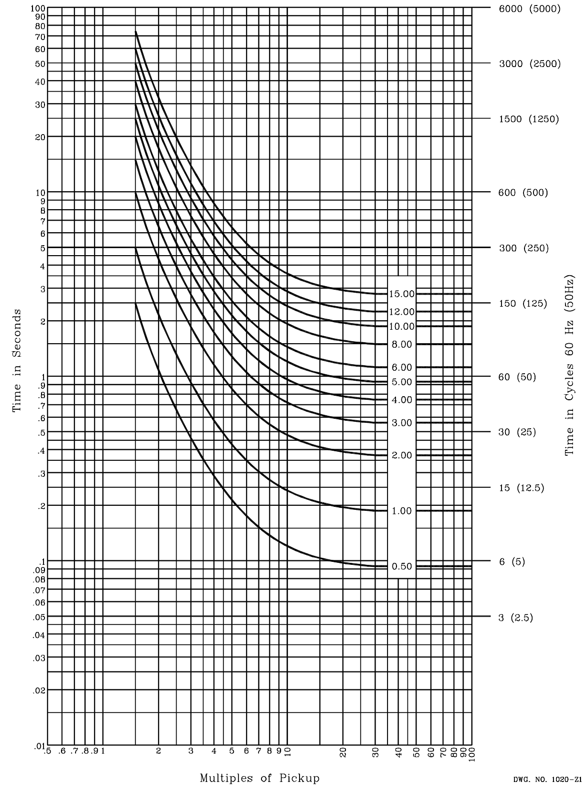


Figure 9.2: U.S. Inverse Curve: U2

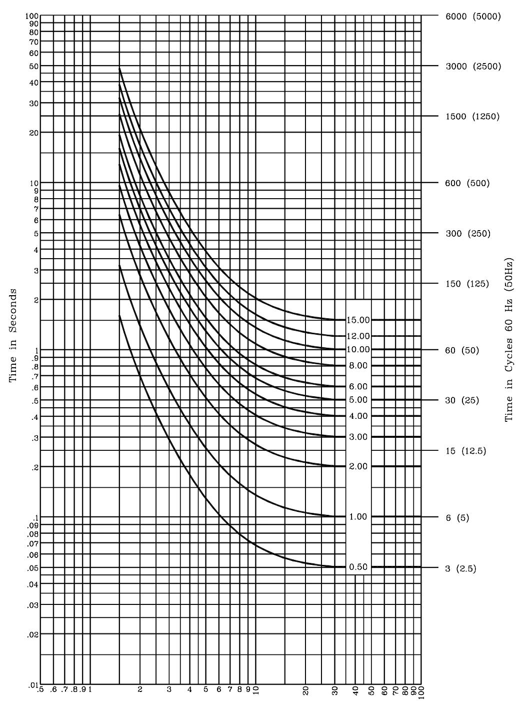


Figure 9.3: U.S. Very Inverse Curve: U3

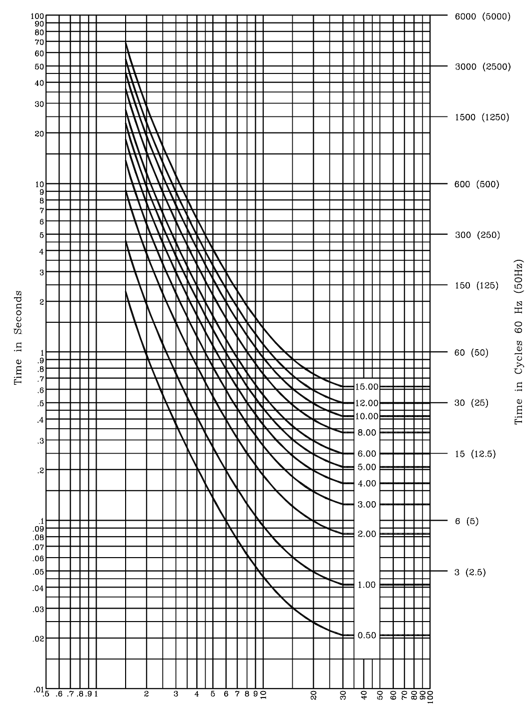


Figure 9.4: U.S. Extremely Inverse Curve: U4

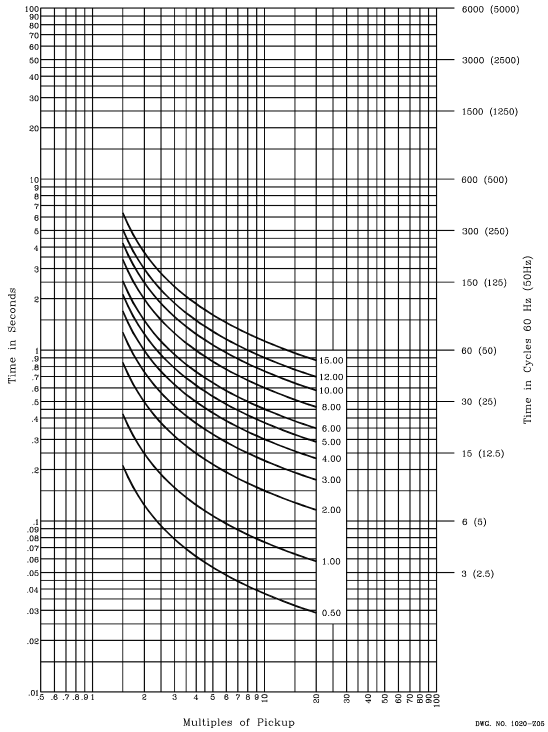


Figure 9.5: U.S. Short-Time Inverse Curve: U5

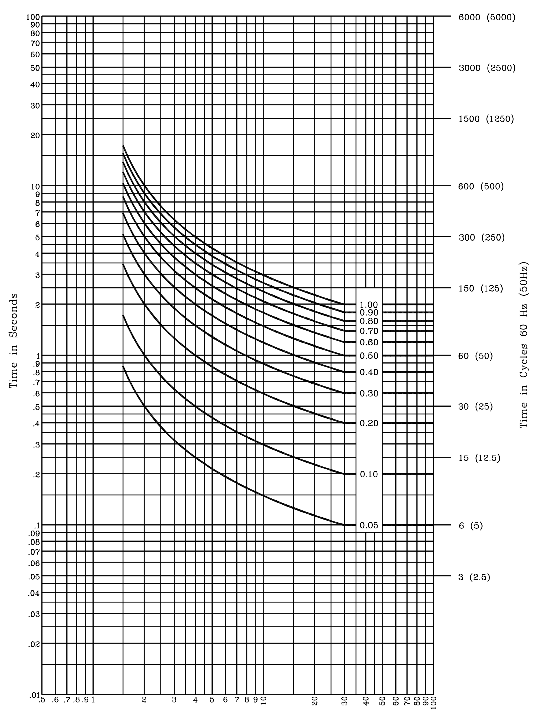


Figure 9.6: I.E.C. Class A Curve (Standard Inverse): C1

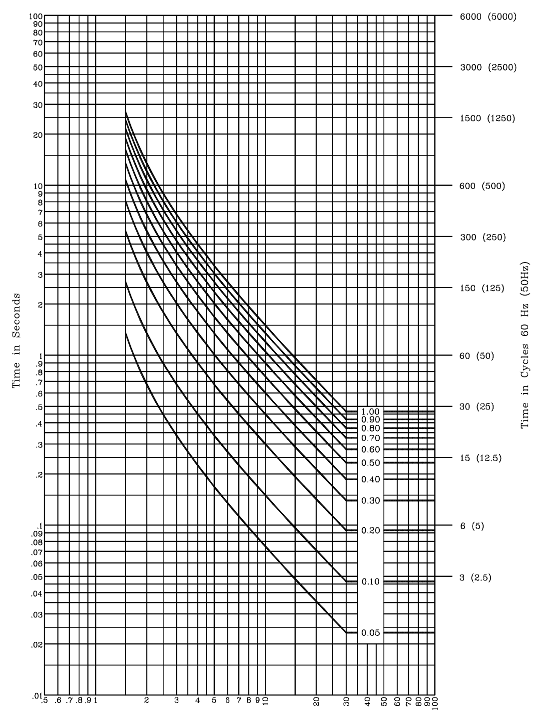


Figure 9.7: I.E.C. Class B Curve (Very Inverse): C2

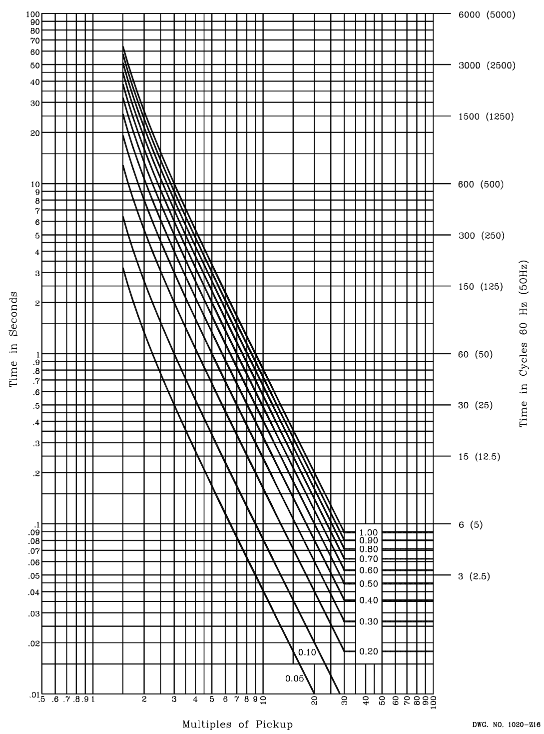


Figure 9.8: I.E.C. Class C Curve (Extremely Inverse): C3

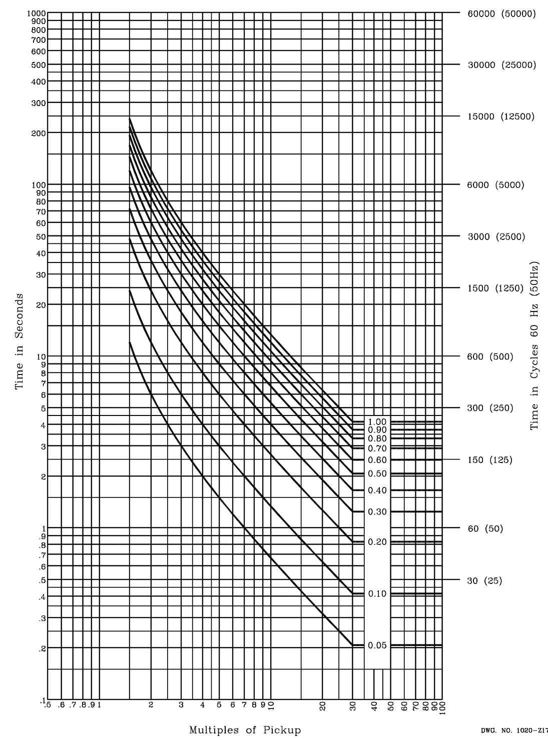


Figure 9.9: I.E.C. Long-Time Inverse Curve: C4

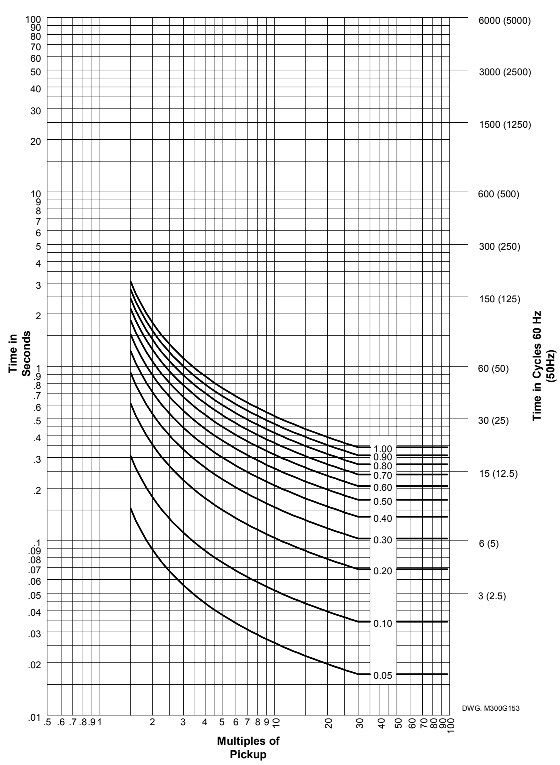


Figure 9.10: I.E.C. Short-Time Inverse Curve: C5

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*** through ***Section 8***. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). ***Appendix G: 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 [Target]*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***). Rows 0 and 1 are reserved for the display of the two front-panel target LED rows.

Table 9.3: SEL-311L Relay Word Bits

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	IN105	IN104	IN103	IN102	IN101
24.	ALARM	OUT107	OUT106	OUT105	OUT104	OUT103	OUT102	OUT101
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
30.	SF	25A1	25A2	RCSF	OPTMN	RSTMN	*	*
31.	79RS	79CY	79LO	SH0	SH1	SH2	SH3	SH4
32.	MAB4	MBC4	MCA4	MAG4	MBG4	MCG4	*	*

Row	Relay Word Bits							
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.	*	*	*	*	MPP3	MABC3	MPP4	MABC4
46.	*	*	*	*	*	*	*	*
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.	OUT201	OUT202	OUT203	OUT204	OUT205	OUT206	87LPE	DD
55.	FTABC	FTAG	FTBG	FTCG	FTAB	FTBC	FTCA	FTSE
56.	87L	87LA	87LB	87LC	87L2	87LG	CHYAL	CHXAL
57.	87LOPA	87LAE	R87LA	CTAA	PQ87LA	TRIP87	BXYZ2	BXYZG
58.	87LOPB	87LBE	R87LB	CTAB	PQ87LB	BXYZA	BXYZB	BXYZC
59.	87LOPC	87LCE	R87LC	CTAC	PQ87LC	T51PT	T50P	T50PT
60.	87LOP2	87L2E	R87L2	B87L2	PQ87L2	T51QT	T50Q	T50QT
61.	87LOPG	87LGE	R87LG	B87LG	PQ87LG	T51GT	T50G	T50GT
62.	RDTY	TDTY	TESTY	3POY	RDTX	TDTX	TESTX	3POX
63.	R4X	R3X	R2X	R1X	T4X	T3X	T2X	T1X
64.	R4Y	R3Y	R2Y	R1Y	T4Y	T3Y	T2Y	T1Y
65.	DBADY	AVAY	RBADY	ROKY	DBADX	AVAX	RBADX	ROKX
66.	50LA	50RA	50LB	50RB	50LC	50RC	50L2	50R2
67.	50LG	50RG	T51P	T51PR	T51G	T51GR	T51Q	T51QR

1. See Figure 7.1 for more information on the operation of optoisolated inputs IN101 through IN106.
2. All output contacts, except OUT201 through OUT206, can be “a” or “b” type contacts. See Figure 2.13 and Figure 7.26 for more information on the operation of output contacts OUT101 through OUT107 and ALARM. See Figure 2.13 and Figure 7.27 for more information on the operation of output contacts OUT201 through OUT206.

Table 9.4: Relay Word Bit Definitions for the SEL-311L

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	Phase A is involved in the fault (see Table 5.1)	
	B	Phase B is involved in the fault	
	C	Phase C 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 3.29)	Tripping, Control
	M1PT	Zone 1 phase distance, time delayed (see Figure 3.39)	
	Z1G	Zone 1 mho and/or quad. distance, instantaneous (see Figure 3.32)	
	Z1GT	Zone 1 ground distance, time delayed (see Figure 3.39)	
	M2P	Zone 2 phase distance, instantaneous (see Figure 3.30)	
	M2PT	Zone 2 phase distance, time delayed (see Figure 3.39)	
	Z2G	Zone 2 mho and/or quad. distance, instantaneous (see Figure 3.33)	
	Z2GT	Zone 2 ground distance, time delayed (see Figure 3.39)	

Row	Bit	Definition	Primary Application
3	Z1T	Zone 1 phase and/or ground distance, time delayed (see Figure 3.39)	
	Z2T	Zone 2 phase and/or ground distance, time delayed (see Figure 3.39)	
	50P1	Level 1 phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P1P; see Figure 3.42)	
	67P1	Level 1 torque controlled phase instantaneous overcurrent element (derived from 50P1; see Figure 3.42)	
	67P1T	Level 1 phase definite-time overcurrent element 67P1T timed out (derived from 67P1; see Figure 3.42)	
	50G1	Level 1 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G1P; see Figure 3.45)	
	67G1	Level 1 torque controlled residual ground instantaneous overcurrent element (derived from 50G1; see Figure 3.45)	
	67G1T	Level 1 residual ground definite-time overcurrent element 67G1T timed out (derived from 67G1; see Figure 3.45)	
4	51G	Residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see Figure 3.48)	Testing, Control
	51GT	Residual ground time-overcurrent element 51GT timed out (see Figure 3.48)	Tripping
	51GR	Residual ground time-overcurrent element 51GT reset (see Figure 3.48)	Testing
	LOP	Loss-of-potential (see Figure 4.1)	Testing, Special directional control schemes
	ILOP	Internal loss-of-potential (see Figure 4.1)	Distance directional control enable

Row	Bit	Definition	Primary Application
	ZLOAD	ZLOUT + ZLIN (see Figure 4.3)	Special phase overcurrent element control
	ZLOUT	Load encroachment “load out” element (see Figure 4.3)	
	ZLIN	Load encroachment “load in” element (see Figure 4.3)	
5	LB1	Local Bit 1 asserted (see Figure 7.3)	Local control via front panel—replacing traditional panel-mounted control switches
	LB2	Local Bit 2 asserted (see Figure 7.3)	
	LB3	Local Bit 3 asserted (see Figure 7.3)	
	LB4	Local Bit 4 asserted (see Figure 7.3)	
	LB5	Local Bit 5 asserted (see Figure 7.3)	
	LB6	Local Bit 6 asserted (see Figure 7.3)	
	LB7	Local Bit 7 asserted (see Figure 7.3)	
	LB8	Local Bit 8 asserted (see Figure 7.3)	
6	LB9	Local Bit 9 asserted (see Figure 7.3)	
	LB10	Local Bit 10 asserted (see Figure 7.3)	
	LB11	Local Bit 11 asserted (see Figure 7.3)	
	LB12	Local Bit 12 asserted (see Figure 7.3)	
	LB13	Local Bit 13 asserted (see Figure 7.3)	
	LB14	Local Bit 14 asserted (see Figure 7.3)	
	LB15	Local Bit 15 asserted (see Figure 7.3)	
	LB16	Local Bit 16 asserted (see Figure 7.3)	
7	RB1	Remote Bit 1 asserted (see Figure 7.9)	Remote control via serial port
	RB2	Remote Bit 2 asserted (see Figure 7.9)	
	RB3	Remote Bit 3 asserted (see Figure 7.9)	
	RB4	Remote Bit 4 asserted (see Figure 7.9)	
	RB5	Remote Bit 5 asserted (see Figure 7.9)	
	RB6	Remote Bit 6 asserted (see Figure 7.9)	
	RB7	Remote Bit 7 asserted (see Figure 7.9)	
	RB8	Remote Bit 8 asserted (see Figure 7.9)	

Row	Bit	Definition	Primary Application
8	RB9	Remote Bit 9 asserted (see Figure 7.9)	
	RB10	Remote Bit 10 asserted (see Figure 7.9)	
	RB11	Remote Bit 11 asserted (see Figure 7.9)	
	RB12	Remote Bit 12 asserted (see Figure 7.9)	
	RB13	Remote Bit 13 asserted (see Figure 7.9)	
	RB14	Remote Bit 14 asserted (see Figure 7.9)	
	RB15	Remote Bit 15 asserted (see Figure 7.9)	
	RB16	Remote Bit 16 asserted (see Figure 7.9)	
9	LT1	Latch Bit 1 asserted (see Figure 7.11)	Latched control –replacing traditional latching relays
	LT2	Latch Bit 2 asserted (see Figure 7.11)	
	LT3	Latch Bit 3 asserted (see Figure 7.11)	
	LT4	Latch Bit 4 asserted (see Figure 7.11)	
	LT5	Latch Bit 5 asserted (see Figure 7.11)	
	LT6	Latch Bit 6 asserted (see Figure 7.11)	
	LT7	Latch Bit 7 asserted (see Figure 7.11)	
	LT8	Latch Bit 8 asserted (see Figure 7.11)	
10	LT9	Latch Bit 9 asserted (see Figure 7.11)	
	LT10	Latch Bit 10 asserted (see Figure 7.11)	
	LT11	Latch Bit 11 asserted (see Figure 7.11)	
	LT12	Latch Bit 12 asserted (see Figure 7.11)	
	LT13	Latch Bit 13 asserted (see Figure 7.11)	
	LT14	Latch Bit 14 asserted (see Figure 7.11)	
	LT15	Latch Bit 15 asserted (see Figure 7.11)	
	LT16	Latch Bit 16 asserted (see Figure 7.11)	
11	SV1	SELOGIC control equation variable timer input SV1 asserted (see Figure 7.23)	Testing, Seal-in functions, etc. (see Figure 7.25)
	SV2	SELOGIC control equation variable timer input SV2 asserted (see Figure 7.23)	
	SV3	SELOGIC control equation variable timer input SV3 asserted (see Figure 7.23)	
	SV4	SELOGIC control equation variable timer input SV4 asserted (see Figure 7.23)	

Row	Bit	Definition	Primary Application
	SV1T	SELOGIC control equation variable timer output SV1T asserted (see Figure 7.23)	Control
	SV2T	SELOGIC control equation variable timer output SV2T asserted (see Figure 7.23)	
	SV3T	SELOGIC control equation variable timer output SV3T asserted (see Figure 7.23)	
	SV4T	SELOGIC control equation variable timer output SV4T asserted (see Figure 7.23)	
12	SV5	SELOGIC control equation variable timer input SV5 asserted (see Figure 7.23)	Testing, Seal-in functions, etc. (see Figure 7.25)
	SV6	SELOGIC control equation variable timer input SV6 asserted (see Figure 7.23)	
	SV7	SELOGIC control equation variable timer input SV7 asserted (see Figure 7.24)	
	SV8	SELOGIC control equation variable timer input SV8 asserted (see Figure 7.24)	
	SV5T	SELOGIC control equation variable timer output SV5T asserted (see Figure 7.23)	Control
	SV6T	SELOGIC control equation variable timer output SV6T asserted (see Figure 7.23)	
	SV7T	SELOGIC control equation variable timer output SV7T asserted (see Figure 7.24)	
	SV8T	SELOGIC control equation variable timer output SV8T asserted (see Figure 7.24)	
13	SV9	SELOGIC control equation variable timer input SV9 asserted (see Figure 7.24)	Testing, Seal-in functions, etc. (see Figure 7.25)
	SV10	SELOGIC control equation variable timer input SV10 asserted (see Figure 7.24)	
	SV11	SELOGIC control equation variable timer input SV11 asserted (see Figure 7.24)	
	SV12	SELOGIC control equation variable timer input SV12 asserted (see Figure 7.24)	

Row	Bit	Definition	Primary Application
	SV9T	SELOGIC control equation variable timer output SV9T asserted (see Figure 7.24)	Control
	SV10T	SELOGIC control equation variable timer output SV10T asserted (see Figure 7.24)	
	SV11T	SELOGIC control equation variable timer output SV11T asserted (see Figure 7.24)	
	SV12T	SELOGIC control equation variable timer output SV12T asserted (see Figure 7.24)	
14	SV13	SELOGIC control equation variable timer input SV13 asserted (see Figure 7.24)	Testing, Seal-in functions, etc. (see Figure 7.25)
	SV14	SELOGIC control equation variable timer input SV14 asserted (see Figure 7.24)	
	SV15	SELOGIC control equation variable timer input SV15 asserted (see Figure 7.24)	
	SV16	SELOGIC control equation variable timer input SV16 asserted (see Figure 7.24)	
	SV13T	SELOGIC control equation variable timer output SV13T asserted (see Figure 7.24)	Control
	SV14T	SELOGIC control equation variable timer output SV14T asserted (see Figure 7.24)	
	SV15T	SELOGIC control equation variable timer output SV15T asserted (see Figure 7.24)	
	SV16T	SELOGIC control equation variable timer output SV16T asserted (see Figure 7.24)	
15	MAB1	Mho AB phase distance zone 1, instantaneous (see Figure 3.29)	Testing
	MBC1	Mho BC phase distance zone 1, instantaneous (see Figure 3. 29)	
	MCA1	Mho CA phase distance zone 1, instantaneous (see Figure 3. 29)	
	MAB2	Mho AB phase distance zone 2 instantaneous (see Figure 3. 30)	
	MBC2	Mho BC phase distance zone 2, instantaneous (see Figure 3.30)	
	MCA2	Mho CA phase distance zone 2, instantaneous (see Figure 3.30)	
	CVTBL	CCVT transient blocking logic active (see Figure 4.2)	Indication, Testing
	SOTFT	Switch-onto-fault trip	

Row	Bit	Definition	Primary Application
16	MAG1	Mho ground distance A-phase, zone 1 (see Figure 3.32)	Testing
	MBG1	Mho ground distance B-phase, zone 1 (see Figure 3.32)	
	MCG1	Mho ground distance C-phase, zone 1 (see Figure 3.32)	
	MAG2	Mho ground distance A-phase, zone 2 (see Figure 3.33)	
	MBG2	Mho ground distance B-phase, zone 2 (see Figure 3.33)	
	MCG2	Mho ground distance C-phase, zone 2 (see Figure 3.33)	
	DCHI	Station dc battery instantaneous overvoltage element (see Figure 8.34)	Indication
	DCLO	Station dc battery instantaneous undervoltage element (see Figure 8.34)	
17	BCW	BCWA + BCWB + BCWC	
	BCWA	A-phase breaker contact wear has reached 100% wear level (see ***Breaker Monitor*** in ***Section 8***)	
	BCWB	B-phase breaker contact wear has reached 100% wear level (see ***Breaker Monitor*** in ***Section 8***)	
	BCWC	C-phase breaker contact wear has reached 100% wear level (see ***Breaker Monitor*** in ***Section 8***)	
	FIDEN	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	

Row	Bit	Definition	Primary Application
18	SG1	Setting group 1 active (see Table 7.3)	Indication
	SG2	Setting group 2 active (see Table 7.3)	
	SG3	Setting group 3 active (see Table 7.3)	
	SG4	Setting group 4 active (see Table 7.3)	
	SG5	Setting group 5 active (see Table 7.3)	
	SG6	Setting group 6 active (see Table 7.3)	
	OC	Asserts 1/4 cycle for Open Command execution (see ***OPE Command (Open Breaker)*** in ***Section 10***)	Control
	CC	Asserts 1/4 cycle for Close Command execution (see ***CLO Command (Close Breaker)*** in ***Section 10***)	
19	CLOSE	Close logic output asserted (see Figure 6.1)	Output contact assignment
	CF	Close failure condition (asserts for 1/4 cycle; see Figure 6.1)	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 (see Figure 5.1, Figure 5.4 and Figure 5.19)	
	52A	Circuit breaker status (asserts to logical 1 when circuit breaker is closed; see Figure 6.1)	
	3PO	Three pole open condition (see Figure 5.5)	
	SOTFE	Switch-onto-fault condition (see Figure 5.5)	
	VPOLV	Positive-sequence polarization voltage valid (see Figure 3.29 through Figure 3.37 and Figure 4.15)	Indication
	50L	Phase instantaneous overcurrent element for closed circuit breaker detection (any phase current above pickup setting 50LP; see Figure 5.5)	
20	PDEM	Phase demand current above pickup setting PDEMP (see Figure 8.15)	
	GDEM	Residual ground demand current above pickup setting GDEMP (see Figure 8.15)	
	QDEM	Negative-sequence demand current above pickup setting QDEMP (see Figure 8.15)	
	TRIP	Trip logic output asserted (see Figure 5.4)	Output contact assignment
	50QF	Forward direction negative-sequence overcurrent threshold exceeded (see Figure 4.5, Figure 4.6, and Figure 4.14)	Directional threshold

Row	Bit	Definition	Primary Application
	50QR	Reverse direction negative-sequence overcurrent threshold exceeded (see Figure 4.5, Figure 4.6, and Figure 4.14)	
	50GF	Forward direction residual ground overcurrent threshold exceeded (see Figure 4.5 and Figure 4.7)	
	50GR	Reverse direction residual ground overcurrent threshold exceeded (see Figure 4.5 and Figure 4.7)	
21	32QF	Forward directional control routed to phase-distance elements (see Figure 4.13 and Figure 4.14)	Directional control
	32QR	Reverse directional control routed to phase-distance elements (see Figure 4.13 and Figure 4.14)	
	32GF	Forward directional control routed to ground distance elements (see Figure 4.5 and Figure 4.12)	
	32GR	Reverse directional control routed to ground distance elements (see Figure 4.5 and Figure 4.12)	
	32VE	Enable for zero-sequence voltage-polarized directional element (see Figure 4.5 and Figure 4.7)	
	32QGE	Enable for negative-sequence voltage-polarized directional element (see Figure 4.5 and Figure 4.6)	
	32IE	Enable for channel IP current-polarized directional element (see Figure 4.5 and Figure 4.7)	
	32QE	Enable for negative-sequence voltage-polarized directional element (see Figure 4.13 and Figure 4.14)	
22	F32I	Forward channel IP current-polarized directional element (see Figure 4.5 and Figure 4.11)	
	R32I	Reverse channel IP current-polarized directional element (see Figure 4.5 and Figure 4.11)	
	F32Q	Forward negative-sequence voltage-polarized directional element (see Figure 4.14)	
	R32Q	Reverse negative-sequence voltage-polarized directional element (see Figure 4.14)	
	F32QG	Forward negative-sequence voltage-polarized directional element (see Figure 4.5 and Figure 4.9)	
	R32QG	Reverse negative-sequence voltage-polarized directional element (see Figure 4.5 and Figure 4.9)	
	F32V	Forward zero-sequence voltage-polarized directional element (see Figure 4.5 and Figure 4.10)	
	R32V	Reverse zero-sequence voltage-polarized directional element (see Figure 4.5 and Figure 4.10)	

Row	Bit	Definition	Primary Application
23	*		
	*		
	IN106	Optoisolated input IN106 asserted (see Figure 7.1)	Relay input status, Control via optoisolated inputs
	IN105	Optoisolated input IN105 asserted (see Figure 7.1)	
	IN104	Optoisolated input IN104 asserted (see Figure 7.1)	
	IN103	Optoisolated input IN103 asserted (see Figure 7.1)	
	IN102	Optoisolated input IN102 asserted (see Figure 7.1)	
	IN101	Optoisolated input IN101 asserted (see Figure 7.1)	
24	ALARM	ALARM output contact indicating that relay failed or PULSE ALARM command executed (see Figure 7.26)	Relay output status, Control
	OUT107	Output contact OUT107 asserted (see Figure 7.26)	
	OUT106	Output contact OUT106 asserted (see Figure 7.26)	
	OUT105	Output contact OUT105 asserted (see Figure 7.26)	
	OUT104	Output contact OUT104 asserted (see Figure 7.26)	
	OUT103	Output contact OUT103 asserted (see Figure 7.26)	
	OUT102	Output contact OUT102 asserted (see Figure 7.26)	
	OUT101	Output contact OUT101 asserted (see Figure 7.26)	
25	M3P	Zone 3 phase distance, instantaneous (see Figure 3.31)	Tripping, Control
	M3PT	Zone 3 phase distance, time delayed (see Figure 3.39)	
	Z3G	Zone 3 mho and/or quad. distance, instantaneous (see Figure 3.34)	
	Z3GT	Zone 3 ground distance, time delayed (see Figure 3.39)	
	M4P	Zone 4 phase distance, instantaneous (see Figure 3.31)	
	M4PT	Zone 4 phase distance, time delayed (see Figure 3.39)	
	Z4G	Zone 4 mho and/or quad. distance, instantaneous (see Figure 3.34)	
	Z4GT	Zone 4 ground distance, time delayed (see Figure 3.39)	

Row	Bit	Definition	Primary Application
26	Z3T	Zone 3 phase and/or ground distance, time delayed (see Figure 3.39)	
	Z4T	Zone 4 phase and/or ground distance, time delayed (see Figure 3.39)	
	50P2	Level 2 Phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P2P; see Figure 3.42)	
	67P2	Level 2 torque controlled phase instantaneous overcurrent element (derived from 50P2; see Figure 3.42)	
	67P2T	Level 2 phase definite-time overcurrent element 67P2T timed out (derived from 67P2; see Figure 3.42)	
	50P3	Level 3 Phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P3P; see Figure 3.42)	
	67P3	Level 3 torque controlled phase instantaneous overcurrent element (derived from 50P3; see Figure 3.42)	
	67P3T	Level 3 phase definite-time overcurrent element 67P3T timed out (derived from 67P3; see Figure 3.42)	
27	50G2	Level 2 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G2P; see Figure 3.45)	
	67G2	Level 2 torque controlled residual ground instantaneous overcurrent element (derived from 50G2; see Figure 3.45)	
	67G2T	Level 2 residual ground definite-time overcurrent element 67G2T timed out (derived from 67G2; see Figure 3.45)	
	50G3	Level 3 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G3P; see Figure 3.45)	
	67G3	Level 3 torque controlled residual ground instantaneous overcurrent element (derived from 50G3; see Figure 3.45)	
	67G3T	Level 3 residual ground definite-time overcurrent element 67G3T timed out (derived from 67G3; see Figure 3.45)	
	*		

Row	Bit	Definition	Primary Application
	*		
28	51P	Maximum phase current above pickup setting 51PP for phase time-overcurrent element 51PT (see Figure 3.47)	Testing, Control
	51PT	Phase time-overcurrent element 51PT timed out (see Figure 3.47)	Tripping
	51PR	Phase time-overcurrent element 51PT reset (see Figure 3.47)	Testing
	Z1X	Zone 1 extension element picked up (see Figure 3.38)	Indication
	59VA	Channel VA voltage window element (channel VA voltage between threshold settings 25VLO and 25VHI; see Figure 3.53)	
	MAB3	Mho AB phase distance zone 3 instantaneous (see Figure 3.31)	Testing
	MBC3	Mho BC phase distance zone 3, instantaneous (see Figure 3.31)	
	MCA3	Mho CA phase distance zone 3, instantaneous (see Figure 3.31)	
29	MAG3	Mho ground distance A-phase, zone 3 (see Figure 3.34)	
	MBG3	Mho ground distance B-phase, zone 3 (see Figure 3.34)	
	MCG3	Mho ground distance C-phase, zone 3 (see Figure 3.34)	
	27S	Channel VS instantaneous undervoltage element (channel VS voltage below pickup setting 27SP; see Figure 3.52)	
	59S	Channel VS instantaneous overvoltage element (channel VS voltage above pickup setting 59SP; see Figure 3.52)	
	*		
	59VP	Phase voltage window element (selected phase voltage [VP] between threshold settings 25VLO and 25VHI; see Figure 3.53)	
	59VS	Channel VS voltage window element (channel VS voltage between threshold settings 25VLO and 25VHI; see Figure 3.53)	
30	SF	Slip frequency between voltages VP and VS less than setting 25SF (see Figure 3.53)	

Row	Bit	Definition	Primary Application
	25A1	Synchronism check element (see Figure 3.54)	
	25A2	Synchronism check element (see Figure 3.54)	
	RCSF	Reclose supervision failure (asserts for 1/4 cycle; see Figure 6.2)	
	OPTMN	Open interval timer is timing (see ***Reclosing Relay*** in ***Section 6***)	
	RSTMN	Reset timer is timing (see ***Reclosing Relay*** in ***Section 6***)	
	*		
	*		
31	79RS	Reclosing relay in the Reset State (see Figure 6.5 and Table 6.1)	
	79CY	Reclosing relay in the Reclose Cycle State (see Figure 6.5)	
	79LO	Reclosing relay in the Lockout State (see Figure 6.5)	
	SH0	Reclosing relay shot counter = 0 (see Table 6.3)	
	SH1	Reclosing relay shot counter = 1 (see Table 6.3)	
	SH2	Reclosing relay shot counter = 2 (see Table 6.3)	
	SH3	Reclosing relay shot counter = 3 (see Table 6.3)	
	SH4	Reclosing relay shot counter = 4 (see Table 6.3)	
32	MAB4	Mho AB phase distance zone 4 instantaneous (see Figure 3.31)	
	MBC4	Mho BC phase distance zone 4, instantaneous (see Figure 3.31)	
	MCA4	Mho CA phase distance zone 4, instantaneous (see Figure 3.31)	
	MAG4	Mho ground distance A-phase, zone 4 (see Figure 3.34)	
	MBG4	Mho ground distance B-phase, zone 4 (see Figure 3.34)	
	MCG4	Mho ground distance C-phase, zone 4 (see Figure 3.34)	
	*		
	*		

Row	Bit	Definition	Primary Application
33	XAG1	Quadrilateral ground distance A-phase, zone 1 (see Figure 3.35)	
	XBG1	Quadrilateral ground distance B-phase, zone 1 (see Figure 3.35)	
	XCG1	Quadrilateral ground distance C-phase, zone 1 (see Figure 3.35)	
	XAG2	Quadrilateral ground distance A-phase, zone 2 (see Figure 3.36)	
	XBG2	Quadrilateral ground distance B-phase, zone 2 (see Figure 3.36)	
	XCG2	Quadrilateral ground distance C-phase, zone 2 (see Figure 3.36)	
	XAG3	Quadrilateral ground distance A-phase, zone 3 (see Figure 3.37)	
	XBG3	Quadrilateral ground distance B-phase, zone 3 (see Figure 3.37)	
34	XCG3	Quadrilateral ground distance C-phase, zone 3 (see Figure 3.37)	
	XAG4	Quadrilateral ground distance A-phase, zone 4 (see Figure 3.37)	
	XBG4	Quadrilateral ground distance B-phase, zone 4 (see Figure 3.37)	
	XCG4	Quadrilateral ground distance C-phase, zone 4 (see Figure 3.37)	
	OSTI	Out-of-step trip entering zone 5 (see Figure 3.41)	
	OSTO	Out-of-step trip leaving zone 5 (see Figure 3.41)	
	OST	Out-of-Step Trip Condition (see Figure 3.41)	Tripping
	50ABC	Positive-Sequence current above threshold to enable OOS logic (see Figure 3.40)	Indication

Row	Bit	Definition	Primary Application
35	X5ABC	Zone 5, out-of-step distance element, instantaneous (see Figure 3.40)	Testing
	X6ABC	Zone 6, out-of-step distance element, instantaneous (see Figure 3.40)	
	OSB	Out-of-step block condition declaration (see Figure 3.41)	
	OSB1	Out-of-step Block, Zone 1 (see Figure 3.41)	
	OSB2	Out-of-step Block, Zone 2 (see Figure 3.41)	
	OSB3	Out-of-step Block, Zone 3 (see Figure 3.41)	
	OSB4	Out-of-step Block, Zone 4 (see Figure 3.41)	
	UBOSB	Unblock out-of-step blocking (see Figure 3.40)	
36	50G4	Level 4 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G4P; see Figure 3.45)	Tripping
	67G4	Level 4 torque controlled residual ground instantaneous overcurrent element (derived from 50G4; see Figure 3.45)	
	67G4T	Level 4 residual ground definite-time overcurrent element 67G4T timed out (derived from 67G4; see Figure 3.45)	
	*		
	MPP1	Zone 1 phase-to-phase compensator distance element (see Figure 3.29)	
	MABC1	Zone 1 three-phase compensator distance element (see Figure 3.29)	
	MPP2	Zone 2 phase-to-phase compensator distance element (see Figure 3.30)	
	MABC2	Zone 2 three-phase compensator distance element (see Figure 3.30)	

Row	Bit	Definition	Primary Application
37	50Q1 [1]	Level 1 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q1P; see Figure 3.46)	
	67Q1	Level 1 torque controlled negative-sequence instantaneous overcurrent element (derived from 50Q1; see Figure 3.46)	
	67Q1T	Level 1 torque controlled negative-sequence definite-time overcurrent element 67Q1T timed out (derived from 67Q1; see Figure 3.46)	
	50Q2 [1]	Level 2 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q2P; see Figure 3.46)	
	67Q2	Level 2 torque controlled negative-sequence instantaneous overcurrent element (derived from 50Q2; see Figure 3.46)	
	67Q2T	Level 2 torque controlled negative-sequence definite-time overcurrent element 67Q2T timed out (derived from 67Q2; see Figure 3.46)	
	59N1	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N1P; see Figure 3.51)	
	59N2	Zero-sequence instantaneous overvoltage element (zero-sequence voltage above pickup setting 59N2P; see Figure 3.51)	
38	50Q3 [1]	Level 3 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q3P; see Figure 3.46)	
	67Q3	Level 3 torque controlled negative-sequence instantaneous overcurrent element (derived from 50Q3; see Figure 3.46)	
	67Q3T	Level 3 torque controlled negative-sequence definite-time overcurrent element 67Q3T timed out (derived from 67Q3; see Figure 3.46)	
	50Q4 [1]	Level 4 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q4P; see Figure 3.46)	
	67Q4	Level 4 torque controlled negative-sequence instantaneous overcurrent element (derived from 50Q4; see Figure 3.46)	
	67Q4T	Level 4 torque controlled negative-sequence definite-time overcurrent element 67Q4T timed out (derived from 67Q4; see Figure 3.46)	

Row	Bit	Definition	Primary Application
	59Q	Negative-sequence instantaneous overvoltage element (negative-sequence voltage above pickup setting 59QP; see Figure 3.51)	
	59V1	Positive-sequence instantaneous overvoltage element (positive-sequence voltage above pickup setting 59V1P; see Figure 3.51)	
39	51Q [1]	Negative-sequence current above pickup setting 51QP for negative-sequence time-overcurrent element 51QT (see Figure 3.49)	Testing, Control
	51QT	Negative-sequence time-overcurrent element 51QT timed out (see Figure 3.49)	Tripping
	51QR	Negative-sequence time-overcurrent element 51QT reset (see Figure 3.49)	Testing
	*		
	*		
	Z2PGS	Zone 2 phase and ground short delay element	DCB Logic
	67QG2S	Negative-sequence and residual directional overcurrent short delay element	See Figure 5.16
	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	
	Z3RB	Current reversal guard asserted	POTT Logic
	KEY	Transmit permissive trip signal	See Figure 5.8
	EKEY	Echo received permissive trip signal	
	ECTT	Echo conversion to trip signal	
41	PTRX	Permissive trip signal to Trip logic (see Figure 5.9)	
	UBB1	Unblocking block 1 from DCUB logic (see Figure 5.12)	
	UBB2	Unblocking block 2 from DCUB logic (see Figure 5.12)	
	UBB	Unblocking block to trip logic (see Figure 5.13)	
	WFC	Weak-infeed condition detected	
	PT	Permissive trip signal to POTT logic (see Figure 5.7)	

Row	Bit	Definition	Primary Application
	PTRX1	Permissive trip 2 signal from DCUB logic (see Figure 5.12)	
	PTRX2	Permissive trip 2 signal from DCUB logic (see Figure 5.12)	
42	27A	A-phase instantaneous undervoltage element (A-phase voltage below pickup setting 27P; see Figure 3.50)	Control
	27B	B-phase instantaneous undervoltage element (B-phase voltage below pickup setting 27P; see Figure 3.50)	
	27C	C-phase instantaneous undervoltage element (C-phase voltage below pickup setting 27P; see Figure 3.50)	
	59A	A-phase instantaneous overvoltage element (A-phase voltage above pickup setting 59P; see Figure 3.50)	
	59B	B-phase instantaneous overvoltage element (B-phase voltage above pickup setting 59P; see Figure 3.50)	
	59C	C-phase instantaneous overvoltage element (C-phase voltage above pickup setting 59P; see Figure 3.50)	
	3P27	27A * 27B * 27C (see Figure 3.50)	
	3P59	59A * 59B * 59C (see Figure 3.50)	
43	27AB	AB phase-to-phase instantaneous undervoltage element (AB phase-to-phase voltage below pickup setting 27PP; see Figure 3.51)	
	27BC	BC phase-to-phase instantaneous undervoltage element (BC phase-to-phase voltage below pickup setting 27PP; see Figure 3.51)	
	27CA	CA phase-to-phase instantaneous undervoltage element (CA phase-to-phase voltage below pickup setting 27PP; see Figure 3.51)	
	59AB	AB phase-to-phase instantaneous overvoltage element (AB phase-to-phase voltage above pickup setting 59PP; see Figure 3.51)	
	59BC	BC phase-to-phase instantaneous overvoltage element (BC phase-to-phase voltage above pickup setting 59PP; see Figure 3.51)	
	59CA	CA phase-to-phase instantaneous overvoltage element (CA phase-to-phase voltage above pickup setting 59PP; see Figure 3.51)	
	*		
	*		

Row	Bit	Definition	Primary Application
44	201LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1 (see Figure 7.27)	Testing
	202LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1 (see Figure 7.27)	
	203LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1 (see Figure 7.27)	
	204LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1 (see Figure 7.27)	
	205LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1 (see Figure 7.27)	
	206LOG	SELOGIC control equation OUT20*n* evaluates to Logical 1 (see Figure 7.27)	
	*		
	*		
45	*		Tripping
	*		
	*		
	*		
	MPP3	Zone 3 phase-to-phase compensator distance element (see Figure 3.31)	
	MABC3	Zone 3 three-phase compensator distance element (see Figure 3.31)	
	MPP4	Zone 4 phase-to-phase compensator distance element (see Figure 3.31)	
	MABC4	Zone 4 three-phase compensator distance element (see Figure 3.31)	
46	*		
	*		
	*		
	*		
	*		
	*		
	*		
	*		

Row	Bit	Definition	Primary Application
47	RMB8A	Channel A, received bit 8	Relay-to-relay communication (see ***Appendix I***)
	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	
	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	

Row	Bit	Definition	Primary Application
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; see Figure 3.57)	Testing
	81D2	Level 2 instantaneous frequency element (with corresponding pickup setting 81D2P; see Figure 3.57)	
	81D3	Level 3 instantaneous frequency element (with corresponding pickup setting 81D3P; see Figure 3.57)	
	81D4	Level 4 instantaneous frequency element (with corresponding pickup setting 81D4P; see Figure 3.57)	
	81D5	Level 5 instantaneous frequency element (with corresponding pickup setting 81D5P; see Figure 3.57)	
	81D6	Level 6 instantaneous frequency element (with corresponding pickup setting 81D6P; see Figure 3.57)	
	27B81	Undervoltage element for frequency element blocking (any phase voltage below pickup setting 27B81P; see Figure 3.56)	
	*		

Row	Bit	Definition	Primary Application
53	81D1T	Level 1 definite-time frequency element 81D1T timed out (derived from 81D1; see Figure 3.57)	Tripping, Control
	81D2T	Level 2 definite-time frequency element 81D2T timed out (derived from 81D2; see Figure 3.57)	
	81D3T	Level 3 definite-time frequency element 81D3T timed out (derived from 81D3; see Figure 3.57)	
	81D4T	Level 4 definite-time frequency element 81D4T timed out (derived from 81D4; see Figure 3.57)	
	81D5T	Level 5 definite-time frequency element 81D5T timed out (derived from 81D5; see Figure 3.57)	
	81D6T	Level 6 definite-time frequency element 81D6T timed out (derived from 81D6; see Figure 3.57)	
	87HWAL	Differential board self-test alarm	
	87BSY	Differential board self-test alarm	
54	OUT201	State of output contact OUT201 (see Figure 7.27)	
	OUT202	State of output contact OUT202 (see Figure 7.27)	
	OUT203	State of output contact OUT203 (see Figure 7.27)	
	OUT204	State of output contact OUT204 (see Figure 7.27)	
	OUT205	State of output contact OUT205 (see Figure 7.27)	
	OUT206	State of output contact OUT206 (see Figure 7.27)	
	87LPE	Enable phase differential calculation (see Figure 3.17, Figure 3.18, Figure 3.19, and Figure 5.1)	Testing
	DD	Disturbance detector (see Figure 5.1)	
55	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	

Row	Bit	Definition	Primary Application
56	87L	ORed combination of 87LA, 87LB, 87LC, 87L2, and 87LG (see Figure 3.17)	Testing, Control
	87LA	A-Phase differential trip output (see Figure 3.17)	
	87LB	B-Phase differential trip output (see Figure 3.17)	
	87LC	C-Phase differential trip output (see Figure 3.17)	
	87L2	Negative-sequence differential trip output (see Figure 3.18)	
	87LG	Zero-sequence differential trip output (see Figure 3.19)	
	CHYAL	Status of Channel X (see ***Section 10***)	Alarming
	CHXAL	Status of Channel Y (see ***Section 10***)	
57	87LOPA	A-Phase differential current enable level detector (see Figure 3.17)	Testing, Control
	87LAE	A-Phase differential calculation enable (see Figure 3.17)	
	R87LA	A-Phase restrain region detection output	
	CTAA	A-Phase CT alarm level detector (see Figure 3.17)	Alarming
	PQ87LA	Protection quality 87LA alarm (see Figure 3.17)	
	TRIP87	Line current differential trip logic output asserted (see Figure 5.1 and Figure 5.4)	Tripping
	BXYZ2	Negative-sequence CT saturation and outfeed block	Testing, Control
	BXYZG	Zero-sequence CT saturation and outfeed block	
58	87LOPB	B-Phase differential current enable level detector (see Figure 3.17)	
	87LBE	B-Phase differential calculation enable (see Figure 3.17)	
	R87LB	B-Phase restrain region detection output (see Figure 3.17)	
	CTAB	B-Phase CT alarm level detector (see Figure 3.17)	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	

Row	Bit	Definition	Primary Application
59	87LOPC	C-Phase differential current enable level detector (see Figure 3.17)	
	87LCE	C-Phase differential calculation enable (see Figure 3.17)	
	R87LC	C-Phase restrain region detection output (see Figure 3.17)	
	CTAC	C-Phase CT alarm level detector (see Figure 3.17)	Alarming
	PQ87LC	Protection quality 87LC alarm	
	T51PT	Tapped load phase time-overcurrent element T51PT timed out (see Figure 3.23)	Tripping
	T50P	Tapped load phase instantaneous overcurrent element above pickup setting T50P (see Figure 3.20)	
	T50PT	Delayed definite-time phase-overcurrent element timed out (see Figure 3.20)	
60	87LOP2	Negative-sequence current enable level detector (see Figure 3.18)	Testing, Control
	87L2E	Negative-sequence differential calculation enable (see Figure 3.18)	
	R87L2	Negative-sequence restrain region detection output (see Figure 3.18)	
	B87L2	Extended 87L2 block (see Figure 3.18)	
	PQ87L2	Protection quality 87L2 alarm	Alarming
	T51QT	Tapped load negative-sequence time-overcurrent element T51QT timed out (see Figure 3.25)	Tripping
	T50Q	Tapped load negative-sequence instantaneous overcurrent element above pickup setting T50QP (see Figure 3.22)	
	T50QT	Delayed definite-time negative-sequence overcurrent element timed out (see Figure 3.22)	
61	87LOPG	Zero-sequence current enable level detector (see Figure 3.19)	Testing, Control
	87LGE	Zero-sequence differential calculation enable (see Figure 3.19)	
	R87LG	Zero-sequence restrain region detection output (see Figure 3.19)	
	B87LG	Extended 87LG block (see Figure 3.19)	
	PQ87LG	Protection quality 87LG alarm	Alarming

Row	Bit	Definition	Primary Application
	T51GT	Tapped load residual time-overcurrent element T51GT timed out (see Figure 3.24)	Tripping
	T50G	Tapped load residual instantaneous overcurrent element above pickup setting T50GP (see Figure 3.21)	
	T50GT	Delayed definite-time residual overcurrent element timed out (see Figure 3.21)	
62	RDTY	Differential Channel Y receive direct trip (see Figure 5.1)	
	TDTY	Differential Channel Y transmit direct trip (see Figure 5.1)	
	TESTY	Differential Channel Y in test mode (see ***Section 10***)	Testing
	3POY	Differential Channel Y receive three pole open (see Figure 3.17)	
	RDTX	Differential Channel X receive direct trip (see Figure 5.1)	Tripping
	TDTX	Differential Channel X transmit direct trip (see Figure 5.1)	
	TESTX	Differential Channel X in test mode (see ***Section 10***)	Testing
	3POX	Differential Channel X receive three pole open (see Figure 3.17)	
63	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***)	
64	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***)	

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***)	
65	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***)	
66	50LA	Local A-phase overcurrent element output (see Figure 3.17)	Testing
	50RA	Remote A-phase overcurrent element output (see Figure 3.17)	
	50LB	Local B-phase overcurrent element output (see Figure 3.17)	
	50RB	Remote B-phase overcurrent element output (see Figure 3.17)	
	50LC	Local C-phase overcurrent element output (see Figure 3.17)	
	50RC	Remote C-phase overcurrent element output (see Figure 3.17)	
	50L2	Local 3I2 overcurrent element output (see Figure 3.18)	
	50R2	Remote 3I2 overcurrent element output (see Figure 3.18)	

Row	Bit	Definition	Primary Application
67	50LG	Local 3I0 overcurrent element output (see Figure 3.19)	
	50RG	Remote 3I0 overcurrent element output (see Figure 3.19)	
	T51P	Tapped load phase time overcurrent pickup (see Figure 3.23)	
	T51PR	Tapped load phase time overcurrent reset (see Figure 3.23)	
	T51G	Tapped load ground time overcurrent pickup (see Figure 3.24)	
	T51GR	Tapped load ground time overcurrent reset (see Figure 3.24)	
	T51Q	Tapped load negative-sequence time overcurrent pickup (see Figure 3.25)	
	T51QR	Tapped load negative-sequence time overcurrent reset (see Figure 3.25)	

[1] **IMPORTANT**: See ***Appendix F*** 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 Relay has two identifier labels: the Relay Identifier (RID) and the Terminal Identifier (TID). The Relay Identifier is typically used to identify the relay or the type of protection scheme. Typical terminal identifiers include an abbreviation of the substation name and line terminal.

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

RID and TID settings may include the following characters: 0–9, A–Z, #, &, @, -, /, ., space. These two settings cannot be made via the front-panel interface.

Current Transformer Ratios

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*** in ***Section 12: Standard Event Reports and SER***) and in automatically making directional element settings Z2F, Z2R, Z0F, and Z0R (see ***Settings Made Automatically*** in ***Section 4: Loss-of-Potential Logic, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic***). 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 through 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 Relay 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 in order to reduce the number of settings to be made for applications that may not require the full features of the SEL-311L Relay.

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 are selected. ***Section 14: Application Settings for SEL-311L Relays*** contains the settings sheets for APP = 87L, 87L21, and 87L21P. 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.

SETTINGS EXAMPLE: 230 KV TRANSMISSION LINE WITH TAPPED LOAD

Use the SEL-311L Relay to protect a transmission line with transformer tapped load. Figure 9.11 shows a 230 kV transmission line with SEL-311L Relay 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 Relay 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 assure 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 assure that zero-sequence quantities seen by the SEL-311L Relay 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 Relay and communications at the tap point even if no breaker is present. A third SEL-311L Relay provides high-speed, high-sensitivity, protection of the transmission line without overreaching for faults on the tap. This example considers two terminal protection only.

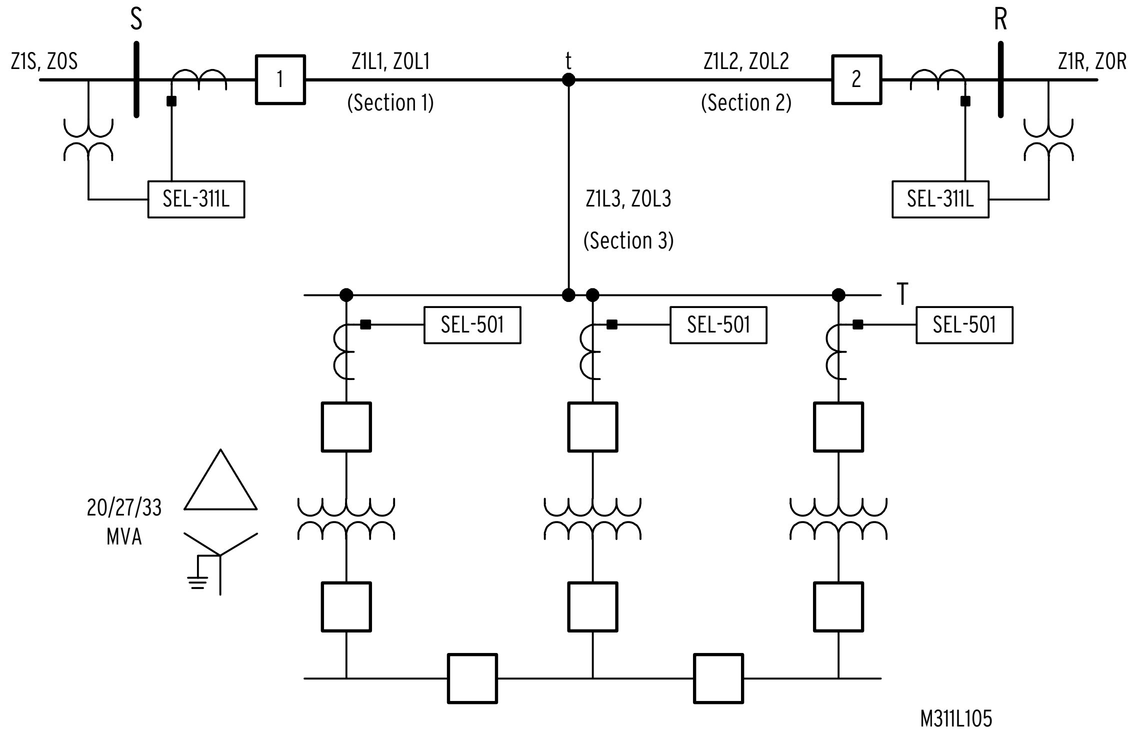


Figure 9.11: 230 kV Model Power System

Table 9.6: Model Power System Data

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) t–R (Section 2) t–T (Section 3)	 10 miles 10 miles 15 miles	
Line impedances Z1L1 = Z1L2 Z0L1 = Z0L2 Z1L3 Z0L3	 5.93 Ω ∠84.70° primary 19.33 Ω ∠73.00° primary 8.90 Ω ∠84.70° primary 28.00 Ω ∠73.00° primary	 0.71 Ω ∠84.70° secondary 2.32 Ω ∠73.00° secondary 1.07 Ω ∠84.70° secondary 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		

Parameter	Primary	Secondary
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	
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 imbalance	5%	

Convert the impedances to secondary ohms as follows:

$$k = \frac{CTR}{PTR} = 240/2000 = 0.12 \quad \text{Equation 9.1}$$

$$Z_{secondary} = k \bullet Z_{primary} \quad \text{Equation 9.2}$$

For example:

$$Z_{1L1\ (secondary)} = Z_{1L2\ (secondary)} = k \bullet Z_{1L1\ (primary)} = 0.12 \bullet (5.93\ \Omega\ \angle 84.7^\circ) = 0.71\ \Omega\ \angle 84.7^\circ$$

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 9.7: Primary Fault Study Data, as Seen by Terminal S (Differential Current in Parentheses)

Fault Location	Fault Type	I_A Amps	I_A ∠0	I_B Amps	I_B ∠0	I_C Amps	I_C ∠0	I_R Amps	I_R ∠0	Zf Apparent Impedance at Station S Amps	∠0
R	ABC	6081.0	-85.6	6081.0	154.4	6081.0	34.4	0		11.8	84.5
		(9874.6	-86.2)	(9874.6	153.8)	(9874.6	33.8)	(0)			
	AG	4654.9	-82.2	491.4	89.7	659.1	83.1	3538.9	-78.3	11.8	84.3
		(8442.2	-84.4)	(131.2	-134.1)	(132.9	83.3)	(8397.3	-84.9)		
	BC	103.9	-25.1	5311.6	-175.9	5221.1	4.7	0		11.8	84.5

Fault Location	Fault Type	I_A Amps	I_A ∠0	I_B Amps	I_B ∠0	I_C Amps	I_C ∠0	I_R Amps	I_R ∠0	Zf Apparent Impedance at Station S Amps	Zf Apparent Impedance at Station S ∠0
		(144.6	-25.3)	(8614.9	-176.4)	(8488.6	4.1)	(0)			
	BCG	525.9	-87	5769.9	166.3	5353.3	23.9	3081.3	102.8	11.8	84.5
		(118.6	-25.9)	(9501.4	161.0)	(9120.6	27.6)	(7311.9	96.3)		
T[1]	ABC	4694.1	-85.4	4694.1	154.6	4694.1	34.6	0		18.3	84.6
		(6521	-85.6)	6521	154.4)	(6521	34.4)	(0)			
	AG	3194.1	-79.4	70.3	144.5	204.7	84.6	2946.8	-79.2	18.3	83.8
		(4584.6	-80)	(128.3	-132.9)	(133.6	81.6)	(4535.5	-80.8)		
	BC	103.9	-25.1	4110.4	-175.8	4020.1	4.9	0		18.3	84.6
		(144.4	-25.3)	(5710.2	-176)	(5584.8	4.8)	(0)			
	BCG	143.5	-58.0	4428.6	169.2	4036.3	21.5	2252.4	103.3	18.3	84.6
		(119.1	-26.9)	(6174.0	167.9)	(5651.7	22.4)	(3466.9	101.8)		
T secondary	ABC	439.6	-81.9	439.6	158.1	439.6	38.1	0		292.1	81.8
		(609.8	-82.7)	(609.8	157.3)	(609.8	37.3)	(0)			
	AG	239.4	-98.9	103.9	-145.1	320.2	67.6	0		404.0	76.4
		(329.8	-100.3)	(144.4	-145.3)	(443.9	66.4)	(0)			
	BC	299.2	-31.4	439.6	158.1	152.7	-3.1	0		303.8	54.8
		(415.8	-32)	(609.8	157.3)	(210.6	-4.1)	(0)			
	BCG	317.7	-53.5	439.6	158.1	237.2	22.6	0		306.0	64.4
		(436.9	-54.4)	(609.8	157.3)	(330.9	21.2)	(0)			

[1] 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

Following is a filled out example setting sheet for this application.

Identifier Labels and Configuration Settings (See Settings Explanations)

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 due to 87L element assertion. Since 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.

CTR at terminal connected to Channel X (1–6000) CTR_X = 240

Enter the current transformer ratio used in the SEL-311L Relay 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.

$3I_2$ 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.

[(Max. Tap Load) • (Max. unbalance) • 1.25 margin] / CTR = 200 • 0.05 • 1.25 / 240 = 0.05 A

Note: 87LG element logic requires 5% 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.

(Max. Load + Line Charging) • 1.1 / CTR = 216 • 1.1 / 240 = 0.99 A

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*** for application considerations.

Excessive CT saturation will adversely affect differential operation. Calculate the relay burden limit at the highest fault current as follows:

$$ZB \le \frac{150 \bullet ZB_{PU}}{\left(1+\frac{X}{R}\right) \bullet IF_{PU}} = \frac{150 \bullet 8}{(1+19.1) \bullet \left(\frac{13279}{240 \bullet 5}\right)} = 5.42$$

where: ZB_{PU} is the per unit ct burden on its voltage class base,(e.g., 8 ohms for class C800)
IF_{PU} is the per unit secondary fault current on the nominal CT secondary current base.
X is the system source reactance
R is the system source resistance

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:

Pickup = Max. Load • 4.0 / CTR = 200 A • 4.0 / 240 = 3.33.

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

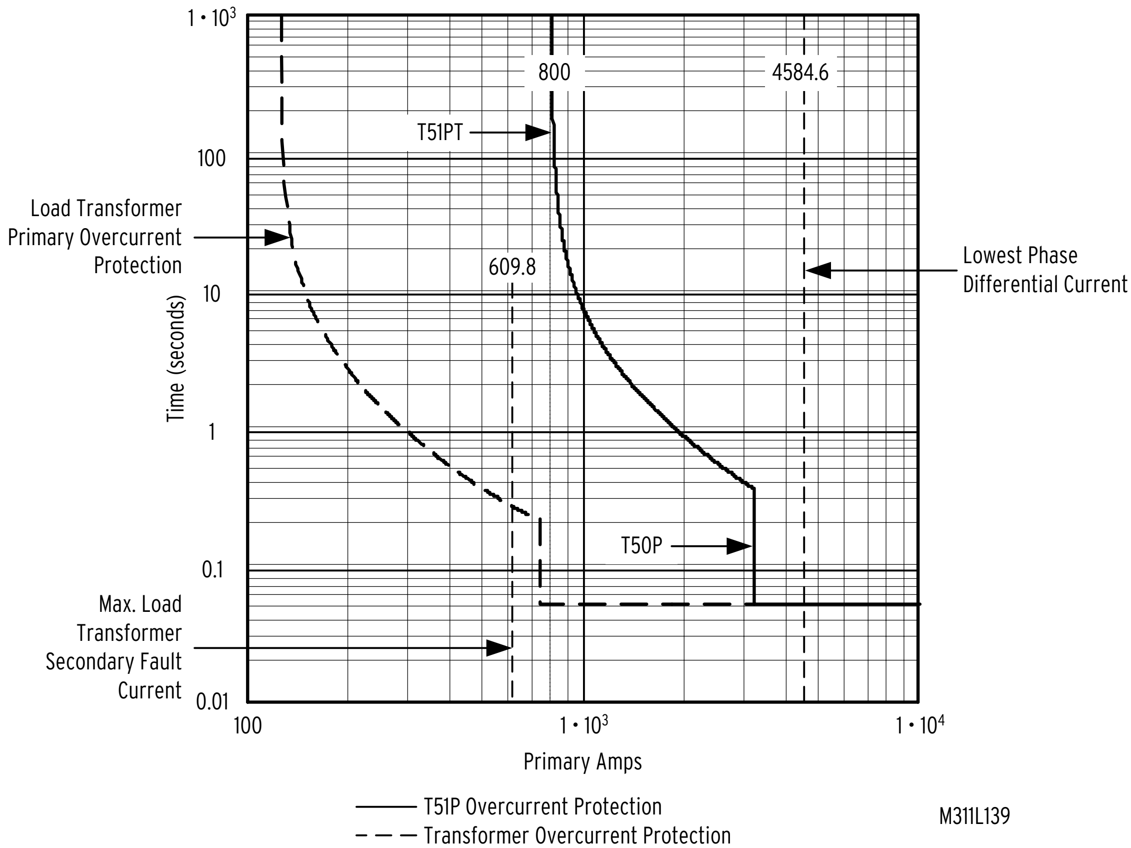
Use consistent overcurrent relay reset methods to avoid misoperation. All relays in this example use electromechanical reset emulation.

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 since 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 ft of cable versus miles of transmission line. A simultaneous operation of the transformer breaker and the line breakers is possible. Station T is reenergized 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. Pickup = (Station T HV fault + Station T LV fault) / (2 • CTR) = (4584.6 + 609.8 • 3.0) / (2 • 240) = 13.36 A.



Time delay (OFF, 0.00–16000.00 cycles) T50PD = OFF

No time delay is needed since 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

Since 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) • (CTR / PTR) = (66.4 / 2.0)• (2000 / 240) = 276.7 Ohms 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 = 7.22

Set the tapped-load ground overcurrent element with differential current. Since 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% 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—since 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 = OFF

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*)

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 assure 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 Figures 3.26–3.28) E21P = 3

Mho ground distance element zones (N, 1–4) (see Figures 3.29–3.31) E21MG = 3

Quadrilateral ground distance element zones (N, 1–4) (see Figures 3.32–3.34) 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 3.42) E50P = N

Residual ground element levels (N, 1–4) (see Figure 3.45) E50G = N

Negative-sequence element levels (N, 1–4) (see Figure 3.46) E50Q = N

Instantaneous overcurrent elements are not required in this application.

Time-Overcurrent Enable Settings

Phase element (Y, N) (see Figure 3.47) E51P = Y

Residual ground element (Y, N) (see Figure 3.48) E51G= Y

Negative-sequence element (Y, N) (see Figure 3.49) E51Q= N

Use 51PT and 51GT to provide backup protection for the protected 230 kV line.

Other Enable Settings

Directional control (Y, AUTO) E32 = AUTO
(see ***Directional Control Settings*** in ***Section 4***)

Enable *Best Choice Ground Directional*™ 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 3.41) 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 4.3) ELOAD = N

Load encroachment is not required in this example.

At maximum load, Zload = (67 / 4.58) = 14.6 Ohms which is much larger than distance element settings.

Set ELOAD = N to disable load-encroachment elements.

Switch-onto-fault (Y, N) (see Figure 5.5) 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. Since this example uses bus side relaying potentials, set ESOTF = N.

Voltage elements (Y, N) (see Figures 3.50, 3.51, 3.52, and 3.53) EVOLT = N

Voltage elements are not enabled in this example. Set EVOLT = N.

Synchronism check (Y, N) (see Figures 3.53 and 3.54) 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*** in ***Section 12***) EFLOC = Y

Fault location is enabled in this example. Set EFLOC = Y.

Loss-of-potential (Y, Y1, N) (see Figure 4.1) ELOP = Y1

Set ELOP = Y1 to disable all voltage polarized directional overcurrent elements and distance elements during a loss-of-potential.

Communications-assisted trip scheme (N, DCB, POTT, DCUB1, DCUB2) (see ***Communications-Assisted Trip Logic—General Overview*** in ***Section 5***) ECOMM = N

Reclosures (N, 1–4) (see ***Reclosing Relay*** in ***Section 6***) E79 = 1

Use single shot reclosing in this example. Set E79 = 1.

Zone 1 extension (Y, N) (see Figure 3.38) EZ1EXT = N

Zone 1 extension is not used. Set EZ1EXT = N.

CCVT transient detection (Y, N) (see Figure 4.2) 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 up to 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 Figures 7.24 and 7.25) ESV = N

Set ESV = N. No SELOGIC variables are required.

SELOGIC Latch Bits (N, 1–16) ELAT = N

Set ELAT = N. No latches are required.

SELOGIC Display Points (N, 1–16) EDP = 2

Use two display points in this example. Set EDP = 2.

Demand Metering (THM = Thermal; ROL = Rolling) (see Figure 8.13) 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 3.29) Z1P = 1.13

Set Z1P to 75–90% of distance from Station S to Station R.

Z1P = Z1MAG • 80% = 1.41 Ω • 0.8 = 1.13 Ω

Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.30) Z2P = 2.75

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 ohms 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-phase impedance at station T times a margin of 125%.

Z2P = 18.3 Ω • (CTR / PTR) • 1.25 = 2.75 Ω

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 3.31) Z3P = 1.76

Set Zone 3 to overreach Station R without reaching beyond Zone 1 protection of the next line. In this example, set Z4P to 125% • Z1MAG.

Z3P = Z1MAG • 1.25 = 1.41 Ω • 1.25 = 1.76 Ω

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 3.29) 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 3.32) Z1MG = 1.13

Set Z1MG to 75–90% of distance from Station S to Station R.

Z1MG = Z1MAG • 80% = 1.41 Ω • 0.8 = 1.13 Ω

Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.33) 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 ohms 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%.

Z2MG = 18.3 Ω • (CTR / PTR) • 1.25 = 2.75 Ω

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 3.34) 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 Figures 3.32 and 3.35)	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 Figures 3.32 and 3.35)	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* in *Section 3)*

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.

$$k01 = \frac{Z_{0L1} - Z_{1L1}}{3 \bullet Z_{1L1}} = \frac{4.64\angle 73.00° - 1.42\angle 84.7°}{3 \bullet 1.42\angle 84.7°} = 0.766\angle -16.74°$$

Mho Phase Distance Element Time Delays (See Figure 3.39)

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 3.39)

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 3.39)

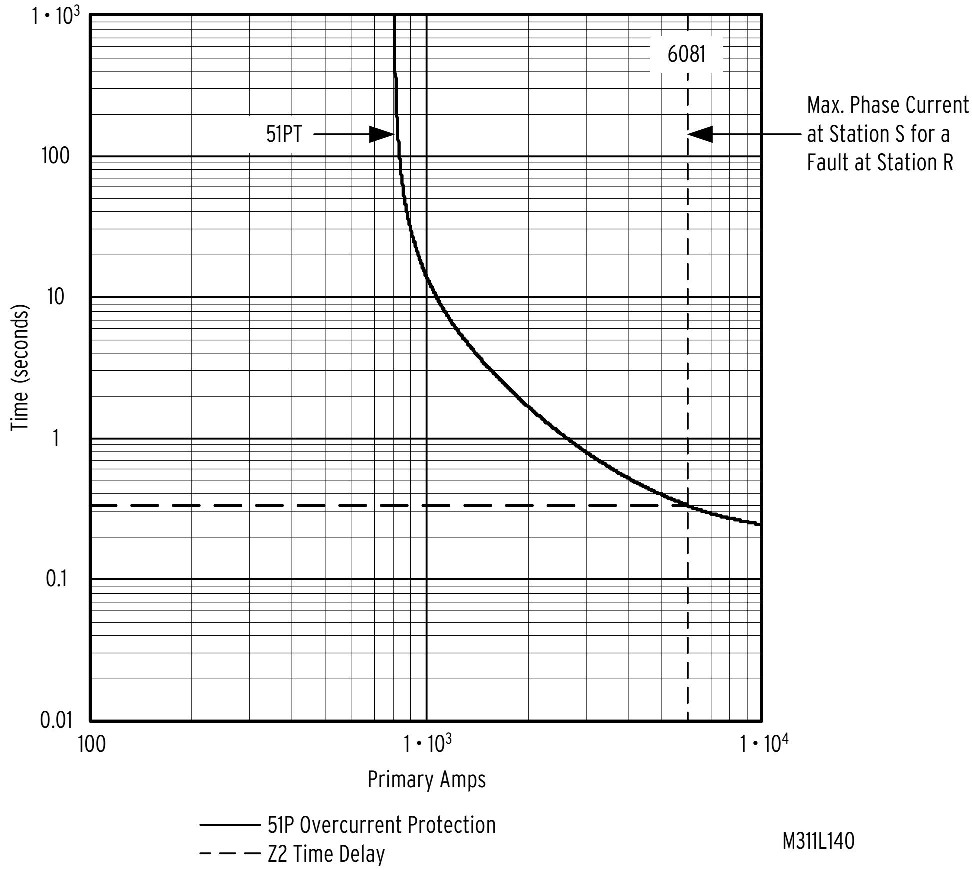
Zone 1 time delay (OFF, 0.00–16000.00 cycles)	Z1D = OFF
Zone 2 time delay (OFF, 0.00–16000.00 cycles)	Z2D = OFF
Zone 3 time delay (OFF, 0.00–16000.00 cycles)	Z3D = 20.0

Phase Time-Overcurrent Element (See Figure 3.47)

Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})	51PP = 3.33
Curve (U1–U5, C1–C5) (see Figures 9.1 through 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.



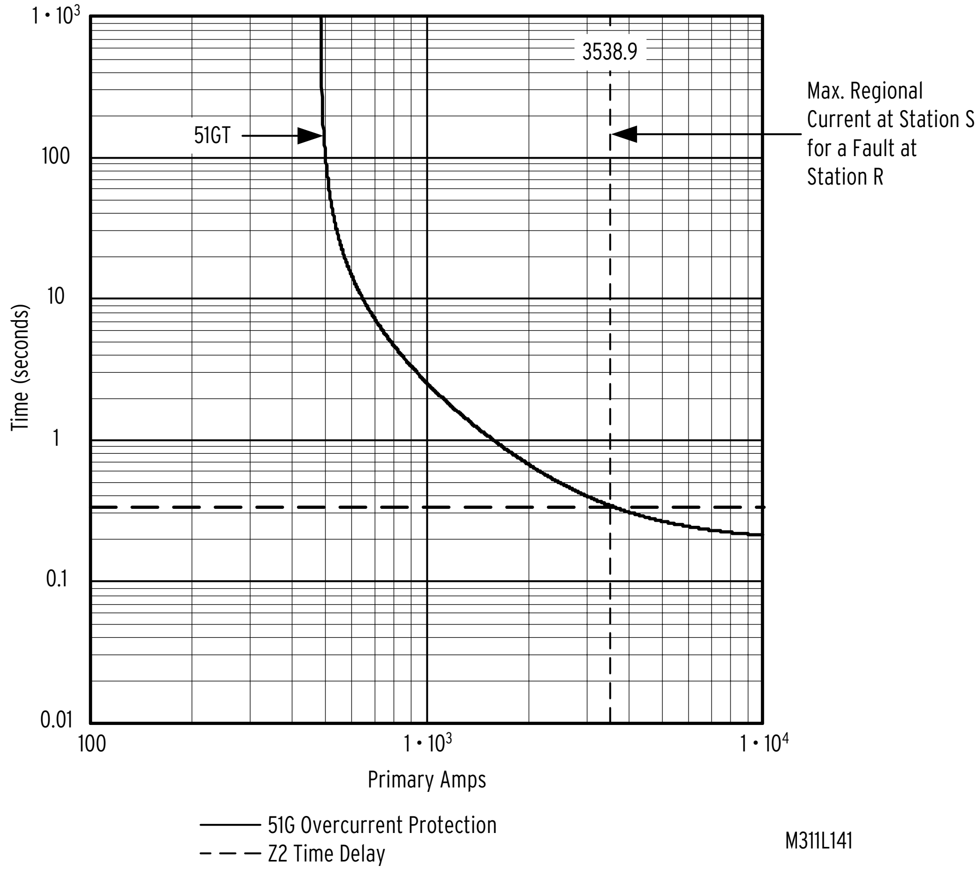
Residual Ground Time-Overcurrent Element (See Figure 3.48)

Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})	51GP = 2.0
Curve (U1–U5, C1–C5) (see Figures 9.1 through 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* in Section 4)

(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 Tables 6.2 and 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 = 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[1] is:

$$T_{MIN} = 10.5 + \frac{V_{LL}(kV)}{34.5} = 10.5 + \frac{230}{34.5} = 17.17 \text{ cycles}$$

Set both reset timers to 30 seconds or 1800 cycles.

[1] Power System Protection by P.M. Anderson; IEEE Press; 1999; pg 880.

Demand Metering Settings (See Figures 8.13 and 8.15)

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 (4.00–16000.00 cycles in 0.25-cycle steps) (see Figure 5.4)	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 5.5)	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 5.5)	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 between Stations S and R, and T. T50G provides instantaneous tripping between Stations S, R, and T. T51PT and T51GT provide time delayed tripping between 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 5.5, 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*** in ***Section 6: Close and Reclose Logic***.

Reclosing Relay Equations (See *Reclosing Relay* in *Section 6*)

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 3.47)	51PTC = M2P
Residual ground element (see Figure 3.48)	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 3.23)	T51PTC = 87LA + 87LB + 87LC
Ground inverse time (see Figure 3.24)	T51GTC = 87LG
Phase instantaneous (see Figure 3.20)	T50PTC = 87LA + 87LB + 87LC
Ground instantaneous (see Figure 3.21)	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 7.26)

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 7.27)

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* in *Sections 7* and *11*)

Display Point DP1	DP1 = 52A
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 + 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 ***Demand Metering*** and ***Maximum/Minimum Metering*** in ***Section 8***)	FAULT = T51P + T51G + M2P + Z2G
Block synchronism check elements (see Figure 3.53)	BSYNCH = 0
Close bus monitor (see Figure 5.5)	CLMON = 0
Breaker monitor initiation (see Figure 8.3)	BKMON = 0

Enable for zero-sequence voltage-polarized and channel IP current-polarized directional elements (see Figure 4.7)	E32IV = 1

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* in *Section 7* and *11*)

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* in *Section 11*)

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 SHEETS

The settings sheets that follow include the definition and input range for each setting in the relay. Refer to ***Relay Element Pickup Ranges and Accuracies*** in ***Section 1: Introduction and Specifications*** for information on 5 A nominal and 1 A nominal ordering options and how they influence overcurrent element setting ranges.

SETTINGS SHEET FOR THE SEL-311L RELAY (APP = 311L)
RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

Identifier Labels and Configuration Settings (See *Settings Explanations* in *Section 9*)

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, 311L)	APP = 311L

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 disturbance detect (Y, N)	EDD = ________
Tapped-load coordination (Y, N)	ETAP = ________
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 PCHAN = Y or EHSC = Y or E87L = 3:	
CTR at terminal connected to Channel Y (1–6000)	CTR_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* in *Section 9*)

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 Figures 3.26–3.28)	E21P = ________
Mho ground distance element zones (N, 1–4) (see Figures 3.29–3.31)	E21MG = ________
Quadrilateral ground distance element zones (N, 1–4) (see Figures 3.32–3.34)	E21XG = ________

Instantaneous/Definite-Time Overcurrent Enable Settings

Phase element levels (N, 1–3) (see Figure 3.42)	E50P = ________
Residual ground element levels (N, 1–4) (see Figure 3.45)	E50G = ________
Negative-sequence element levels (N, 1–4) (see Figure 3.46)	E50Q = ________

Time-Overcurrent Enable Settings

Phase element (Y, N) (see Figure 3.47)	E51P = ________
Residual ground element (Y, N) (see Figure 3.48)	E51G= ________
Negative-sequence element (Y, N) (see Figure 3.49)	E51Q= ________

Other Enable Settings

Directional control (Y, AUTO) (see ***Directional Control Settings*** in ***Section 4***)	E32 = ________
Out-of-Step (Y, N) (see Figure 3.41)	EOOS = ________
Load encroachment (Y, N) (see Figure 4.3)	ELOAD = ________
Switch-onto-fault (Y, N) (see Figure 5.5)	ESOTF = ________
Voltage elements (Y, N) (see Figures 3.50, 3.51, 3.52, and 3.53)	EVOLT = ________
Synchronism check (Y, N) (see Figures 3.53 and 3.54)	E25 = ________
Frequency Elements (N, 1–6)	E81 = ________
Fault location (Y, N) (see Table 12.1 and ***Fault Location*** in ***Section 12***)	EFLOC = ________
Loss-of-potential (Y, Y1, N) (see Figure 4.1)	ELOP = ________

Communications-assisted trip scheme (N, DCB, POTT, DCUB1, DCUB2) (see ***Communications-Assisted Trip Logic—General Overview*** in ***Section 5***)	ECOMM = ________
Reclosures (N, 1–4) (see ***Reclosing Relay*** in ***Section 6***)	E79 = ________
Zone 1 extension (Y, N) (see Figure 3.38)	EZ1EXT = ________
CCVT transient detection (Y, N) (see Figure 4.2)	ECCVT = ________
SELOGIC® control equation Variable Timers (N, 1–16) (see Figures 7.23 and 7.24)	ESV = ________
SELOGIC Latch Bits (N, 1–16)	ELAT = ________
SELOGIC Display Points (N, 1–16)	EDP = ________
Demand Metering (THM = Thermal; ROL = Rolling) (see Figure 8.13)	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 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.29)	Z1P = ________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.30)	Z2P = ________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.31)	Z3P = ________
Zone 4 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.31)	Z4P = ________

Mho Phase Distance Fault Detector Settings

Zone 1 phase-to-phase current FD (0.5–170.00 A secondary {5 A nom.}; 0.1–34.00 A secondary {1 A nom.}) (see Figure 3.29)	50PP1 = ________
∗Zone 2 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 3.30)	50PP2 = ________
∗Zone 3 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 3.31)	50PP3 = ________
∗Zone 4 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 3.31)	50PP4 = ________

Mho Ground Distance Elements

(Number of mho ground distance element settings dependent on preceding enable setting E21MG = 1–4.)

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.32) Z1MG = ________

Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.33) Z2MG = ________

Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.34) Z3MG = ________

Zone 4 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.34) Z4MG = ________

Quadrilateral Ground Distance Elements

(Number of quadrilateral ground distance element settings dependent on preceding enable setting E21XG = 1–4.)

Zone 1 reactance (OFF, 0.05–64.00 Ω secondary {5 A nom.}; OFF, 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.35) XG1 = ________

Zone 2 reactance (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.36) XG2 = ________

Zone 3 reactance (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.37) XG3 = ________

Zone 4 reactance (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.37) XG4 = ________

Zone 1 resistance (0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.}) (see Figure 3.35) RG1 = ________

Zone 2 resistance (0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.}) (see Figure 3.36) RG2 = ________

Zone 3 resistance (0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.}) (see Figure 3.37) RG3 = ________

Zone 4 resistance (0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.}) (see Figure 3.37) RG4 = ________

∗Quadrilateral ground polarizing quantity (I2, IG) (see Figures 3.35–3.37) XGPOL = ________

∗Non-homogenous correction angle (-45.0° to +45.0°) TANG = ________

Quadrilateral and Mho Ground Distance Fault Detector Settings

(Number of quadrilateral and mho ground distance element settings dependent on the larger of preceding enable settings E21MG = 1–4 or E21XG = 1–4.)

Zone 1 phase current FD (0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.}) (see Figures 3.32 and 3.35) — 50L1 = ____________

∗Zone 2 phase current FD (0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.}) (see Figures 3.33 and 3.36) — 50L2 = ____________

∗Zone 3 phase current FD (0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.}) (see Figures 3.34 and 3.37) — 50L3 = ____________

∗Zone 4 phase current FD (0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.}) (see Figures 3.34 and 3.37) — 50L4 = ____________

Zone 1 residual current FD (0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.}) (see Figures 3.32 and 3.35) — 50GZ1 = ___________

∗Zone 2 residual current FD (0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.}) (see Figures 3.33 and 3.36) — 50GZ2 = ___________

∗Zone 3 residual current FD (0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.}) (see Figures 3.34 and 3.37) — 50GZ3 = ___________

∗Zone 4 residual current FD (0.50–100.00 A secondary {5 A nom.}; 0.10–20.00 A secondary {1 A nom.}) (see Figures 3.34 and 3.37) — 50GZ4 = ___________

Zero Sequence Compensation (ZSC) Settings (see *Ground Distance Elements* in *Section 3)*

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) — k0M = _____________

∗Zone 2, 3, and 4 ZSC factor angle (-180.0° to +180.0°) — k0A = ______________

Mho Phase Distance Element Time Delays (See Figure 3.39)

(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 = ____________

∗ Indicates a setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.

Quadrilateral and Mho Ground Distance Element Time Delays (See Figure 3.39)

(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 3.39)

(Number of time delay element settings dependent on the larger of preceding enable settings E21P = 1–4 or 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 3.42)

(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 3.42)

(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 3.45)

(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 3.45)

(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 3.46)*

(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 3.46)*

(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 = ________

*** IMPORTANT**: See ***Appendix F*** for information on setting negative-sequence overcurrent elements.

Phase Time-Overcurrent Element (See Figure 3.47)

(Make the following settings if preceding enable setting E51P = Y.)

Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})	51PP = ________
Curve (U1–U5, C1–C5) (see Figures 9.1 through 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 3.48)

(Make the following settings if preceding enable setting E51G = Y.)

Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})	51GP = ________
Curve (U1–U5, C1–C5) (see Figures 9.1 through 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 3.49)*

(Make the following settings if preceding enable setting E51Q = Y.)

Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})	51QP = ________
Curve (U1–U5, C1–C5) (see Figures 9.1 through 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 = ________

* **IMPORTANT**: See ***Appendix F*** for information on setting negative-sequence overcurrent elements.

Out-of-Step Settings (See Figures 3.40 and 3.41)

(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 (-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 (-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 (-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 (-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)	UBOSBF = ______

∗ Indicates a setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.

Load-Encroachment Elements (See Figure 4.3)

(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* in Section 4)

(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 Figures 3.50, 3.51, and 3.52)

(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 Figures 3.53 and 3.54)

(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 Figures 3.56 and 3.57)

(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 Tables 6.2 and 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 = ___________

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 5.5)

(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 5.8)

(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 5.12)

(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 5.16)

(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 = ______

Zone 1 Extension Scheme Settings (See Figure 3.38)

(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 Figures 8.13 and 8.15)

(Make the following settings, whether preceding enable setting EDEM = THM or ROL.)

Time constant (5, 10, 15, 30, 60 minutes)	DMTC = ___________
Phase pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})	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 (4.00–16000.00 cycles in 0.25-cycle steps) (see Figure 5.4)	TDURD = _________
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 5.5)	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 5.5)	50LP = ____________

SELOGIC Control Equation Variable Timers (See Figures 7.23 and 7.24)

(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 (SERIAL PORT COMMAND SET L)

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 ***Sections 3*** through ***8***. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). ***Appendix G: Setting SELOGIC Control Equations*** gives SELOGIC control equation details, examples, and limitations.

Trip Logic Equations (See Figure 5.4)

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 Figures 5.7, 5.9, and 5.12)	PT1 = ________
Loss-of-guard 1 (used for ECOMM = DCUB1 or DCUB2; see Figure 5.12)	LOG1 = ________
Permissive trip 2 (used for ECOMM = DCUB2; see Figures 5.7 and 5.12)	PT2 = ________
Loss of guard 2 (used for ECOMM = DCUB2; see Figure 5.12)	LOG2 = ________
Block trip (used for ECOMM = DCB; see Figure 5.16)	BT = ________

Close Logic Equations (See Figure 6.1)

Circuit breaker status (used in Figure 5.5, also)	52A = ________
Close conditions (other than automatic reclosing or CLOSE command)	CL = ________
Unlatch close conditions	ULCL = ________

Reclosing Relay Equations (See *Reclosing Relay* in *Section 6*)

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 7.11)

Set Latch Bit LT1	SET1 = ________
Reset Latch Bit LT1	RST1 = ________
Set Latch Bit LT2	SET2 = ________
Reset Latch Bit LT2	RST2 = ________
Set Latch Bit LT3	SET3 = ________
Reset Latch Bit LT3	RST3 = ________
Set Latch Bit LT4	SET4 = ________
Reset Latch Bit LT4	RST4 = ________
Set Latch Bit LT5	SET5 = ________
Reset Latch Bit LT5	RST5 = ________
Set Latch Bit LT6	SET6 = ________
Reset latch Bit LT6	RST6 = ________
Set Latch Bit LT7	SET7 = ________
Reset Latch Bit LT7	RST7 = ________
Set Latch Bit LT8	SET8 = ________
Reset Latch Bit LT8	RST8 = ________
Set Latch Bit LT9	SET9 = ________
Reset Latch Bit LT9	RST9 = ________
Set Latch Bit LT10	SET10 = ________
Reset Latch Bit LT10	RST10 = ________
Set Latch Bit LT11	SET11 = ________
Reset Latch Bit LT11	RST11 = ________
Set Latch Bit LT12	SET12 = ________
Reset Latch Bit LT12	RST12 = ________
Set Latch Bit LT13	SET13 = ________
Reset Latch Bit LT13	RST13 = ________
Set Latch Bit LT14	SET14 = ________
Reset latch Bit LT14	RST14 = ________
Set Latch Bit LT15	SET15 = ________
Reset Latch Bit LT15	RST15 = ________
Set Latch Bit LT16	SET16 = ________
Reset Latch Bit LT16	RST16 = ________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements

[Note: torque control equation settings cannot be set directly to logical 0]

Level 1 phase (see Figure 3.42)	67P1TC = ____________
Level 2 phase (see Figure 3.42)	67P2TC = ____________
Level 3 phase (see Figure 3.42)	67P3TC = ____________
Level 1 residual ground (see Figure 3.45)	67G1TC = ____________
Level 2 residual ground (see Figure 3.45)	67G2TC = ____________
Level 3 residual ground (see Figure 3.45)	67G3TC = ____________
Level 4 residual ground (see Figure 3.45)	67G4TC = ____________
Level 1 negative-sequence (see Figure 3.46)	67Q1TC = ____________
Level 2 negative-sequence (see Figure 3.46)	67Q2TC = ____________
Level 3 negative-sequence (see Figure 3.46)	67Q3TC = ____________
Level 4 negative-sequence (see Figure 3.46)	67Q4TC = ____________

Torque Control Equations for Time-Overcurrent Elements

[Note: torque control equation settings cannot be set directly to logical 0]

Phase element (see Figure 3.47)	51PTC = ____________
Residual ground element (see Figure 3.48)	51GTC = ____________
Negative-sequence element (see Figure 3.49)	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 3.23)	T51PTC = ____________
Ground inverse time (see Figure 3.24)	T51GTC = ____________
Negative-sequence time (see Figure 3.25)	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 3.20)	T50PTC = ____________
Ground instantaneous (see Figure 3.21)	T50GTC = ____________
Negative-sequence instantaneous (see Figure 3.22)	T50QTC = ____________

SELOGIC Control Equation Variable Timer Input Equations (See Figures 7.23 and 7.24)

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 7.26)

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 7.27)

Output Contact OUT201	OUT201 = ____________
Output Contact OUT202	OUT202 = ____________
Output Contact OUT203	OUT203 = ____________
Output Contact OUT204	OUT204 = ____________
Output Contact OUT205	OUT205 = ____________
Output Contact OUT206	OUT206 = ____________

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

Display Point Equations (See *Rotating Default Display* in *Sections 7* and *11*)

Display Point DP1	DP1 = ________
Display Point DP2	DP2 = ________
Display Point DP3	DP3 = ________
Display Point DP4	DP4 = ________
Display Point DP5	DP5 = ________
Display Point DP6	DP6 = ________
Display Point DP7	DP7 = ________
Display Point DP8	DP8 = ________
Display Point DP9	DP9 = ________
Display Point DP10	DP10 = ________
Display Point DP11	DP11 = ________
Display Point DP12	DP12 = ________
Display Point DP13	DP13 = ________
Display Point DP14	DP14 = ________
Display Point DP15	DP15 = ________
Display Point DP16	DP16 = ________

Setting Group Selection Equations (See Table 7.4)

Select Setting Group 1	SS1 = ________
Select Setting Group 2	SS2 = ________
Select Setting Group 3	SS3 = ________
Select Setting Group 4	SS4 = ________
Select Setting Group 5	SS5 = ________
Select Setting Group 6	SS6 = ________

Other Equations

Event report trigger conditions (see ***Section 12***)	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 ***Demand Metering*** and ***Maximum/Minimum Metering*** in ***Section 8***)	FAULT = ________
Block synchronism check elements (see Figure 3.53)	BSYNCH = ________
Close bus monitor (see Figure 5.5)	CLMON = ________
Breaker monitor initiation (see Figure 8.3)	BKMON = ________
Enable for zero-sequence voltage-polarized and channel IP current-polarized directional elements (see Figure 4.7)	E32IV = ________

SETTINGS SHEET FOR THE SEL-311L RELAY (APP = 311L)
SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

MIRRORED BITS™ Transmit Equations (See *Appendix I*)

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 = ______________

Settings Group Change Delay (See *Multiple Setting Groups* in *Section 7*)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps) TGR = ____________

Power System Configuration and Date Format (See *Settings Explanations* in *Section 9*)

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 PRE = _____________

(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)

Station DC Battery Monitor (See Figures 8.9 and 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 (0.00–1.00 cycles in 0.25-cycle steps) IN101D = __________

Input IN102 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN102D = __________

Input IN103 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN103D = __________

Input IN104 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN104D = __________

Input IN105 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN105D = __________

Input IN106 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN106D = __________

Breaker Monitor Settings (See *Breaker Monitor* in *Section 8*)

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= ________

SEQUENTIAL EVENTS RECORDER SETTINGS (SERIAL PORT COMMAND SET R)

Sequential Events Recorder settings are comprised of three trigger lists. Each trigger list can include up to 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See ***Sequential Events Recorder (SER) Report*** in ***Section 12***.

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

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 Tables 7.1 and 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 = ________

Settings Sheet
for the SEL-311L Relay (APP = 311L)
Text Label Settings (Serial Port Command SET T)

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* in *Section 7* and *11*)

Display if DP1 = logical 1 (16 characters) DP1_1 = ________
Display if DP1 = logical 0 (16 characters) DP1_0 = ________

Display if DP2 = logical 1 (16 characters) DP2_1 = ________
Display if DP2 = logical 0 (16 characters) DP2_0 = ________

Display if DP3 = logical 1 (16 characters) DP3_1 = ________
Display if DP3 = logical 0 (16 characters) DP3_0 = ________

Display if DP4 = logical 1 (16 characters) DP4_1 = ________
Display if DP4 = logical 0 (16 characters) DP4_0 = ________

Display if DP5 = logical 1 (16 characters) DP5_1 = ________
Display if DP5 = logical 0 (16 characters) DP5_0 = ________

Display if DP6 = logical 1 (16 characters) DP6_1 = ________
Display if DP6 = logical 0 (16 characters) DP6_0 = ________

Display if DP7 = logical 1 (16 characters) DP7_1 = ________
Display if DP7 = logical 0 (16 characters) DP7_0 = ________

Display if DP8 = logical 1 (16 characters) DP8_1 = ________
Display if DP8 = logical 0 (16 characters) DP8_0 = ________

Display if DP9 = logical 1 (16 characters) DP9_1 = ________
Display if DP9 = logical 0 (16 characters) DP9_0 = ________

Display if DP10 = logical 1 (16 characters) DP10_1 = ________
Display if DP10 = logical 0 (16 characters) DP10_0 = ________

Display if DP11 = logical 1 (16 characters) DP11_1 = ________
Display if DP11 = logical 0 (16 characters) DP11_0 = ________

Display if DP12 = logical 1 (16 characters) DP12_1 = ________
Display if DP12 = logical 0 (16 characters) DP12_0 = ________

Display if DP13 = logical 1 (16 characters) DP13_1 = ________
Display if DP13 = logical 0 (16 characters) DP13_0 = ________

Display if DP14 = logical 1 (16 characters)	DP14_1 = ________________
Display if DP14 = logical 0 (16 characters)	DP14_0 = ________________
Display if DP15 = logical 1 (16 characters)	DP15_1 = ________________
Display if DP15 = logical 0 (16 characters)	DP15_0 = ________________
Display if DP16 = logical 1 (16 characters)	DP16_1 = ________________
Display if DP16 = logical 0 (16 characters)	DP16_0 = ________________

Reclosing Relay Labels (See *Functions Unique to the Front-Panel Interface* in *Section 11*)

Reclosing Relay Last Shot Label (14 char.)	79LL = ________________
Reclosing Relay Shot Counter Label (14 char.)	79SL = ________________

PORT SETTINGS (SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol Settings (See Below)

Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B) 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 H*** for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, or MB8B. Refer to ***Appendix I*** for details on MIRRORED BITS.

The following settings are used if PROTO = LMD.

LMD Prefix (@, #, $, %, &) PREFIX = ________

LMD Address (01–99) ADDR = ________

LMD Settling Time (0–30 seconds) SETTLE = ________

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) SPEED = ________

Data Bits (6, 7, 8) BITS = ________

Parity (O, E, N) {Odd, Even, None} PARITY = ________

Stop Bits (1, 2) STOP = ________

Other Port Settings (See Below)

Time-out (0–30 minutes) T_OUT = ________

DTA Meter Format (Y, N) DTA = ________

Send Auto Messages to Port (Y, N) AUTO = ________

Enable Hardware Handshaking (Y, N, MBT) RTSCTS = ________
(Refer to ***Appendix I*** for details on setting MBT.)

Fast Operate Enable (Y, N) FASTOP = ________

Other Port Settings 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.

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.

Set AUTO = Y to allow automatic messages at the serial port.

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.

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*** for the description of the SEL-311L Relay Fast Operate commands.

87L Channel X Configuration Settings

Channel X address check (Y, N)	EADDCX = ________
If EADDCX = Y	
Channel X transmit address (1–16)	TA_X = ____________
Channel X receive address (1–16)	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, N)	EADDCY = ________
If EADDCY = Y	
Channel Y transmit address (1–16)	TA_Y = ____________
Channel Y receive address (1–16)	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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FIGURES

SECTION 10: LINE CURRENT DIFFERENTIAL COMMUNICATIONS AND SERIAL PORT COMMUNICATIONS AND COMMANDS

INTRODUCTION

This section describes SEL-311L Relay line current differential communications, and also describes the serial communications used to set and interrogate the relay. The first part describes 87L communications, the 87L channel monitors, and settings related to 87L communications. The second part describes EIA-232 and EIA-485 serial communications used to set, control and interrogate the relay.

CURRENT DIFFERENTIAL COMMUNICATIONS, CHANNEL CONFIGURATION, AND CHANNEL MONITOR

Order the SEL-311L Relay with up to two line current differential interfaces. Each interface is factory configured as EIA-422, CCITT G.703, IEEE PC37.94 compliant multimode fiber, or 1300 nm direct fiber. When the SEL-311L Relay arrives, the channels are configured per your ordering options. Additional channel configuration settings optimize each channel interface to your particular applications. The following sections describe each interface, and also describe channel configuration settings particular to each interface type. After introducing each interface type, this section describes the channel monitor indicators and monitor settings applicable to all interface types.

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 Relay 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 2.2 for the EIA-422 cable appropriate to your application. All of the cables shown in Table 2.2 connect the shield at the multiplexer end only. The DB-25 connector pinout on the SEL-311L Relay is shown in Figure 2.6, and is per RS-530. Figure 2.6 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
RFL	IMUX	DS562I	MA406IA	RXICP = Normal TXICP = Normal	RC422 = F TC422 = R
Pulsar	FOCUS	64k	N/A	N/A	RC422 = R TC422 = R
Nortel	JMUX	Nx64 Unit 86464-01	86447-90	Transmit = INT ↑ Receive = INT ↑	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 Relay 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.

The EIA-422 standard is not well suited for back-to-back connections because an external clock must always be supplied. Figure 10.1 shows such a back-to-back connection with an external clock source. Notice that in a back-to-back connection, the clock source must drive four clock receivers—one each for transmit and receive clock on each relay. Set the clock polarity as shown in Figure 10.1 for a back-to-back connection.

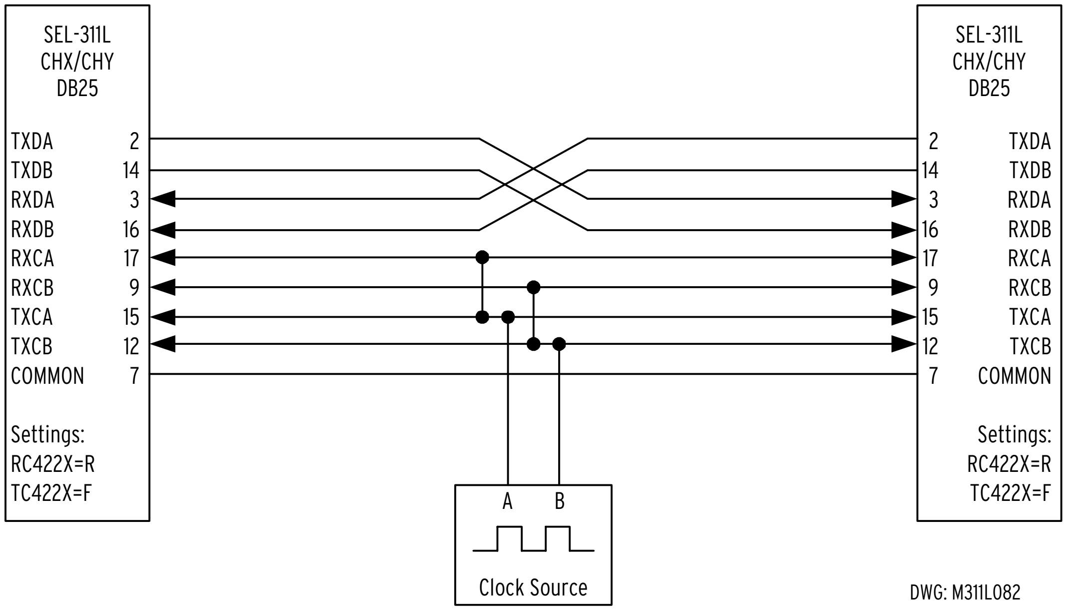


Figure 10.1: Back-to-Back EIA-422 Connection With External Clock Source

CCITT G.703 Codirectional Interface

The G.703 interface is transformer isolated from the chassis to 1500 V rms. Since 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 2.2 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 Relay and the direction of signal flow is shown in Figure 2.7.

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 2.7. 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.

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.

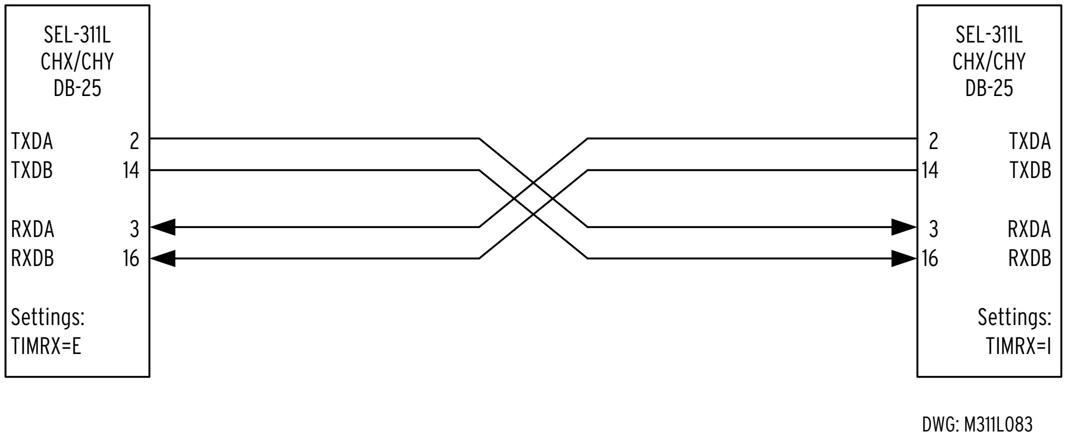


Figure 10.2: Back-to-Back CCITT G.703 Connection

IEEE Proposed Standard PC37.94 Multimode Fiber Optic Interface

IEEE Proposed Standard PC37.94 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, and also defines the physical interface (connectors, light wavelength, fiber type, etc.) ensuring that all PC37.94 compliant relays interface with all PC37.94 compliant multiplexers.

Connect the SEL-311L Relay to a PC37.94 compliant multiplexer as shown in Figure 2.8. 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 Relay to synchronize the transmit date rate to exactly match the receive data rate set by the multiplexer.

PC37.94 defines several troubleshooting aids, including a Yellow Alarm bit. At present, the SEL-311L Relay 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.

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-PC37.94 interface is suitable for distances up to 2 km, either between the relay and the multiplexer or directly between relays. For longer haul direct-fiber applications using either multimode or single-mode fiber, order the 1300 nm fiber-optic interface described next.

1300 nm Single-Mode or Multimode Fiber-Optic Interface

The 1300 nm Fiber-Optic Interface on the SEL-311L Relay utilizes eye-safe lasers and sensitive detectors to achieve 40 dB of system gain. This yields up to an 80 km link on a pair of 9 micron single-mode fibers (30 km for 62.5 micron multimode fibers). 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 2.9.

Even though the 1300 nm direct-fiber interface provided on the SEL-311L Relay 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 (three 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.

Dual Channel Applications

Order the SEL-311L Relay with combinations of up to 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	Channel Y
TIMRX = E	RC422Y = F
	TC422Y = R

Relay 2:

Channel X	Channel Y
TIMRX = I	RC422Y = F
	TC422Y = R

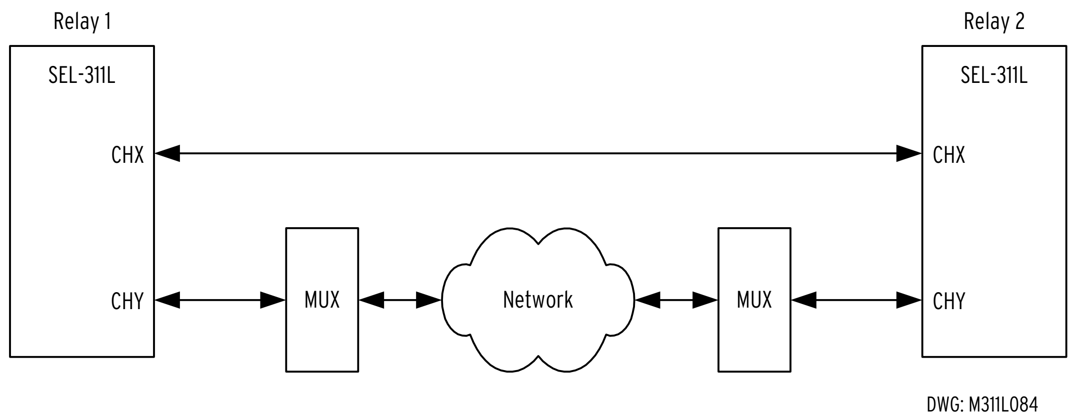


Figure 10.3: Typical Hot-Standby Connection Using Direct Fiber and Multiplexed EIA-422

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 Channel Monitors and Channel Problem Indicators Common to ALL 87L Channel Types

The relay indicates there is a problem with an 87L channel in several ways. The front-panel LED 87CH FAIL illuminates when the relay detects a problem on either Channel X or Channel Y. Rear panel TX/RX LEDs illuminate when the relay transmits and receives valid 87L packets from another SEL-311L Relay. In addition, several Relay Word bits per channel indicate channel health, and help determine the cause of channel problems. The collection of Relay Word bits, LEDs, and channel monitor reports collectively form the channel monitors. This section describes each of the channel problem indicators, and describes settings associated with them.

Section 13: Testing, Troubleshooting, and Commissioning describes how to use channel indicators to troubleshoot a channel problem.

Availability and Delay Monitor Drive Front Panel LED 87CH FAIL

The availability monitor detects channel degradation or failure by counting lost packets. A packed 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 effect 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 Relay connected to the network. For direct-fiber connections, set RA_X and TA_X uniquely for each SEL-311L Relay with a fiber pair in a bundle, or for each SEL-311L Relay with a fiber pair routed through a patch panel.

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)

Setting DBADXP (DBADYP for Channel Y) detects longer than expected channel delays. Such increased delays might be caused by channel re-routes 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. Ensure it 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 the same for Channel Y.

⚠ 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 Relay (35 milliseconds) can result in misoperation.

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.

Front-Panel LED 87LCH FAIL

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 Relay 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 which 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 is 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.

Loopback, End-to-End, and Back-to-Back Testing With the TST Command

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. 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.

  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
=>>
```

The **TST** command presents several options. The first 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 Relay hardware without external connections. Internal loopback connects the SEL-311L Relay transmitter 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 Relay. Loop the channel back at the SEL-311L Relay 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.

87L COMM 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 using the **COMM X** or **COMM Y** commands. Retrieve the entire report 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 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

=>>
```

Serial Port Communications and Commands

In addition to the differential communication channel(s) all SEL-311L Relay models have three EIA-232 ports (one front and two rear) and one rear EIA-485 port. The ports are useful for relay settings changes, interrogation, control, and data collection.

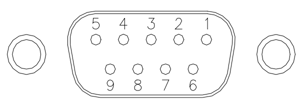
Connect the serial port to a computer serial port for local communications or to a modem for remote communications. Other devices useful for communications include the SEL-2020 and SEL-2030 Communications Processors, SEL-2505 Remote I/O Module, SEL-2100 Protection Logic Processor, and SEL-DTA2 Display Transducer Adapter. You can use a variety of terminal emulation programs on your personal computer to communicate with the relay. Examples of PC-based terminal emulation programs include CROSSTALK®, Microsoft® Windows® Terminal and HyperTerminal, Procomm® Plus, Relay/Gold, and SmartCOM. 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: Setting the Relay***) or the front-panel SET pushbutton (see ***Section 11: Front-Panel Interface***).

Port Connector and Communications Cables



(female chassis connector, as viewed from outside)

Figure 10.4: DB-9 Connector Pinout for EIA-232 Serial Ports

IRIG-B

Refer to Figure 1.5 and Figure 2.2 through 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 Relay models. This is easily handled by connecting Serial Port 2 of the SEL-311L Relay to an SEL-2020 with Cable C273A (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.

Table 10.2: Pinout Functions for EIA-232 Serial Ports 2, 3, and F

Pin	Port 2	Port 3	Port F
1	N/C or +5 Vdc[1]	N/C or +5 Vdc[1]	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

[1] See ***EIA-232 Serial Port Jumpers*** in ***Section 2: Installation***.

Table 10.3: 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

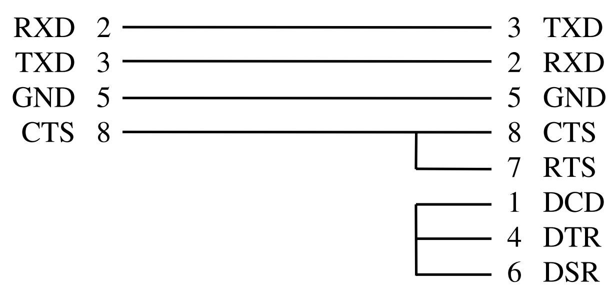
The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-311L Relay to other devices. SEL provides fiber-optic transceivers and cable for communications links with improved safety, noise immunity, and distance as compared to copper links. The equivalent 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

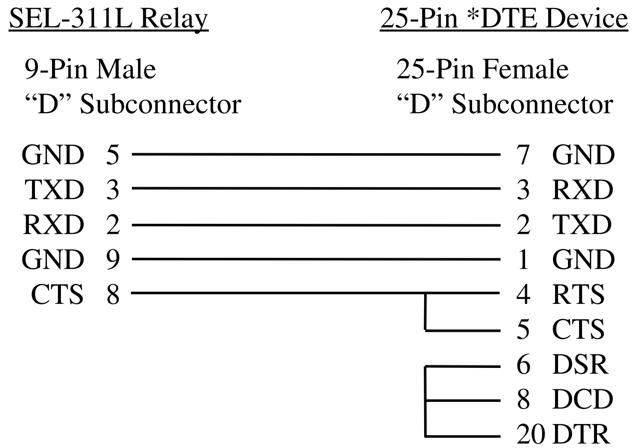
Cable C234A

SEL-311L Relay — 9-Pin Male "D" Subconnector

9-Pin *DTE Device — 9-Pin Female "D" Subconnector

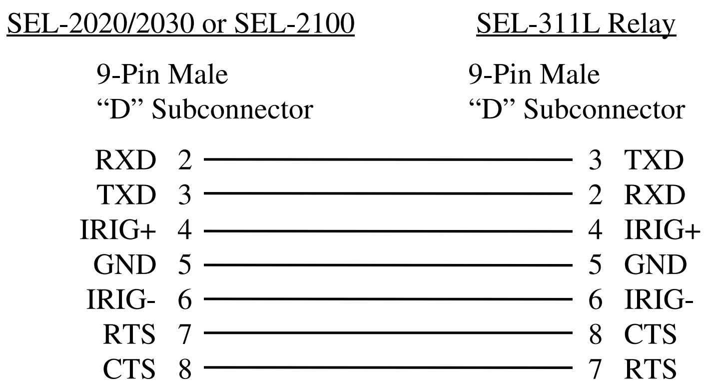


Cable C227A



SEL-311L to SEL-2020, SEL-2030, or SEL-2100

Cable C273A

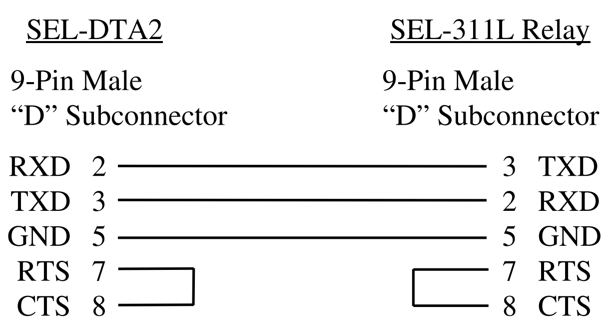


* DTE = Data Terminal Equipment (Computer, Terminal, Printer, etc.)

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

SEL-311L to SEL-DTA2

Cable C272A



SEL-311L to StarComm Modem, 5 Vdc Powered

Cable C220

StarComm Modem 25-Pin Male "D" Subconnector			SEL-311L Relay 9-Pin Male "D" Subconnector	
GND	7	—	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

Cable C222

SEL-311L Relay 9-Pin Male "D" Subconnector			**DCE Device 25-Pin Male "D" Subconnector	
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

Table 10.4: 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

For communications up to 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

Hardware Protocol

All EIA-232 serial ports support RTS/CTS hardware handshaking. RTS/CTS handshaking is not supported on the EIA-485 Serial Port 1.

To enable hardware handshaking, use the **SET P** command (or front-panel SET pushbutton) to set RTSCTS = Y. Disable hardware handshaking by setting RTSCTS = N.

If RTSCTS = N, the relay permanently asserts the RTS line.

If RTSCTS = Y, the relay deasserts RTS when it is unable to receive characters.

If RTSCTS = Y, the relay does not send characters until the CTS input is asserted.

Software Protocols

The SEL-311L Relay provides standard SEL protocols: SEL ASCII, SEL Distributed Port Switch Protocol (LMD), SEL Fast Meter, SEL Compressed ASCII, and MIRRORED BITS™. In addition, the relay provides Distributed Network Protocol (DNP) 3.00 as an ordering option. The relay activates protocols on a per-port basis. The SEL-311L Relay supports the SEL-DTA2 Display Transducer Adapter analog transducer function with the exception of relay status information. See ***Serial Port Command SET P*** in the Settings Sheets in ***Section 9: Setting the Relay***.

To select SEL ASCII protocol, set the port PROTO setting to SEL. To select SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD. To select DNP protocol, set PROTO = DNP.

SEL Fast Meter and SEL Compressed ASCII commands are active when PROTO is set to either SEL or LMD. The commands are not active when PROTO is set to DNP or MIRRORED BITS.

SEL ASCII Protocol

SEL ASCII protocol is designed for manual and automatic communications.

1. All commands received by the relay must be of the form:

   <command><CR> or <command><CRLF>

   A command transmitted to the relay should consist of the command followed by either a CR (carriage return) or a CRLF (carriage return and line feed). You may truncate commands to the first three characters. For example, **EVENT 1 <ENTER>** would become **EVE 1 <ENTER>**. Upper and lower case characters may be used without distinction, except in passwords.

   Note: The ENTER key on most keyboards is configured to send the ASCII character 13 (^M) for a carriage return. This manual instructs you to press the ENTER key after commands, which should send the proper ASCII code to the relay.

2. The relay transmits all messages in the following format:

   <STX><MESSAGE LINE 1><CRLF>
   <MESSAGE LINE 2><CRLF>
   •
   •
   •
   <LAST MESSAGE LINE><CRLF>< ETX>

   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:

XON:	**<CNTRL> Q**	(hold down the Control key and press Q)
XOFF:	**<CNTRL> S**	(hold down the Control key and press S)
CAN:	**<CNTRL> X**	(hold down the Control key and press X)

SEL Distributed Port Switch Protocol (LMD)

The SEL Distributed Port Switch Protocol (LMD) permits multiple SEL relays to share a common communications channel. The protocol is selected by setting the port setting PROTO = LMD. See ***Appendix C*** for more information on SEL Distributed Port Switch Protocol (LMD).

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 Compressed ASCII Protocol

SEL Compressed ASCII protocol provides compressed versions of some of the relay ASCII commands. The protocol is described in ***Appendix E***.

Distributed Network Protocol (DNP) 3.00

The relay provides Distributed Network Protocol (DNP) 3.00 slave support. DNP is an optional protocol and is described in ***Appendix H***.

MIRRORED BITS Communications

The SEL-311L Relay supports MIRRORED BITS relay-to-relay communications on two ports simultaneously. See ***Appendix I***.

SERIAL PORT AUTOMATIC MESSAGES

When the serial port AUTO setting is Y, the relay sends automatic messages to indicate specific conditions. The automatic messages are described in Table 10.5.

Table 10.5: Serial Port Automatic Messages

Condition	Description
Power Up	The relay sends a message containing the present date and time, Relay and Terminal Identifiers, and the Access Level 0 prompt when the relay is turned on.
Event Trigger	The relay sends an event summary each time an event report is triggered. See ***Section 12: Standard Event Reports and SER***.
Group Switch	The relay displays the active settings group after a group switch occurs. See ***GRO n Command*** (Group) in this section.
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*** (Status) in this section.

SEL-DTA Protocol

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 Relay supports the SEL-DTA2 Display Transducer Adapter analog transducer function with the exception of relay status information.

Using and Changing SEL-311L Relay Passwords

1. Connect to one of the serial ports on the SEL-311L Relay and open a connection.
2. Press a carriage return, **<ENTER>**, and verify that a "=" prompt is returned. The "=" indicates that you are in Access Level 0. If you do not get a "=" with each carriage return, then something is wrong with your connection. Terminate your serial connection, check your cable connections and your communications parameters, and restart your serial I/O connection.
3. To change passwords you need to move through Access Level 1 to Access Level 2. Type **ACC <ENTER>** to go to Access Level 1. The SEL-311L Relay will respond with:

    Password: ? @@@@@@

4. At the above prompt, enter your existing or default Level 1 password and press **<ENTER>**. The SEL-311L Relay will respond with the Level 1 access notification and the "=>" prompt indicating that you are in Access Level 1.
5. Type **2AC <ENTER>** to go to Access Level 2. The SEL-311L Relay will respond with the same password prompt that you saw for Level 1. At the password prompt, enter your existing or default Level 2 password and press **<ENTER>**. The SEL-311L Relay will respond with the Level 2 access notification and the "=>>" prompt indicating that you are in Access Level 2.
6. The **PAS** command is used to view and set passwords. Type **PAS <ENTER>** to see the existing passwords settings. Another form of the **PAS** command is used to set passwords. The command **PAS 1** followed by a password string is used to change the Level 1 password.

For example, **PAS 1 Ot3579 <ENTER>** sets "Ot3579" as the password for Access Level 1. Similarly, the command **PAS B** followed by a password will set the Level B password, and the command **PAS 2** followed by a password will set the Level 2 password.

7. After entering your new passwords use the **PAS** command to view the new settings. When setting your passwords be sure and choose "strong" passwords that cannot be guessed or broken with an automated password cracker. These passwords include special characters, upper and lower case letters, and numbers. They also form no recognizable names or words.

The following example demonstrates how to change your SEL-311L Relay passwords. It assumes the existing passwords are "BADPAS," "BRAKER," and "TOOEZY" for Access Levels 1, B, and 2, respectively. It changes the passwords to "Ot3579," "Bkr351," and "Ta2468," respectively. Your default factory password settings can be found under the ***Command Explanations*** subsection.

```
=ACC <ENTER>
Password: ? BADPAS <ENTER>

FEEDER 1          Date: 11/27/00    Time: 13:46:38.548      STATION A
Level 1

=>2AC <ENTER>
Password: ? TOOEZY <ENTER>

FEEDER 1          Date: 11/27/00    Time: 13:46:45.048      STATION A
Level 2

=>>PAS <ENTER>
1:BADPAS
B:BRAKER
2:TOOEZY

=>>PAS 1 Ot3579 <ENTER>
Set

=>>PAS B Bkr351 <ENTER>
Set

=>>PAS 2 Ta2468 <ENTER>
Set

=>>PAS <ENTER>
1:Ot3579
B:Bkr351
2:Ta2468

=>>QUIT
=
```

Serial Port Access Levels

Commands can be issued to the relay via the serial port to view metering values, change relay settings, etc. The available serial port commands are listed in Table 10.6. The commands can be accessed only from the corresponding access level as shown in Table 10.6. The access levels are:

Access Level 0	(the 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 access level; all Level B commands plus setting and test commands)

Note: In this manual, commands you type appear in bold/uppercase: **STATUS**. Computer keys you press appear in bold/uppercase/brackets: **<ENTER>**.

Access Level 0

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

```
=
```

This is referred to as Access Level 0. The only command that is available at Access Level 0 is the **ACC** command (see Table 10.6). Enter the **ACC** command at the Access Level 0 prompt:

=ACC <ENTER>

The **ACC** command takes the relay to Access Level 1 (see ***ACC, BAC, and 2AC Commands [Go to Access Level 1, B, or 2]*** in the ***Command Explanations*** subsection for more detail).

Access Level 1

When the relay is in Access Level 1, the relay sends the following prompt:

```
=>
```

Commands **2AC** through **TRI** in Table 10.6 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 10.6 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 10.6).

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 10.6 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 10.6).

Command Summary

Table 10.6 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 10.6. See ***Section 11: Front-Panel Interface*** 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 upper-case letters, but they can also be entered with lower-case letters.

Table 10.6: Serial Port Command Summary

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	
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	=>	GRO	Display active setting group number	GROUP
1	=>	HIS	Event summaries/histories	EVENTS
1	=>	IRI	Synchronize to IRIG-B	
1	=>	QUI	Quit to Access Level 0	
1	=>	MET	Differential metering data	METER
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	

Access Level	Prompt	Serial Port Command	Command Description	Corresponding Front-Panel Pushbutton
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
2	=>>	CON	Control remote bit	
2	=>>	COP	Copy setting group	
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	
2	=>>	VER	Display version and configuration information	

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: This is the RID setting (the relay is shipped with the default setting RID = SEL-311L; see ***Identifier Labels*** in ***Section 9: Setting the Relay***).

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*** in ***Section 9: Setting the Relay***).

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 ***Command Explanations*** subsection are in the same order as the commands listed in Table 10.6.

Command Explanations

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 10.6.

ACC moves from any access level to Access Level 1.

Password Requirements and Default Passwords

Passwords are required if the main board Password jumper is not in place (Password jumper = OFF). Passwords are not required if the main board Password jumper is in place (Password jumper = ON). Refer to Table 2.5 for Password jumper information. See ***PAS Command*** later in this section for more information on passwords.

The factory default passwords for Access Levels 1, B, and 2 are:

Access Level	Factory Default Password
1	OTTER
B	EDITH
2	TAIL

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

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, or Access Level B to Access Level 2 is much the same, with command **BAC** or **2AC** entered at the access level screen prompt. The relay closes the ALARM contact for one second after a successful Level B or Level 2 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 E: Compressed ASCII Commands***.

Access Level 1 Commands

2AC and BAC Commands

See previous discussion on passwords.

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*** in ***Access Level B Commands*** that follows in this section and ***Breaker Monitor*** in ***Section 8: Breaker Monitor and Metering Functions*** 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 E: Compressed ASCII Commands***.

CHIS Command

Display history in compressed ASCII format. For details on this and other Compressed ASCII commands see ***Appendix E: Compressed ASCII Commands***.

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 I: MIRRORED BITS***. 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 the previous subsection, ***87L COMM Report***, 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 only one MIRRORED BITS port is enabled, the channel specifier may be omitted. Use the L parameter to get a summary report, followed by a listing of the 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 up to 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 E: Compressed ASCII Commands***.

CSU Command

Display long summary event report in compressed ASCII format. For details on this and other Compressed ASCII commands see ***Appendix E: Compressed ASCII Commands***.

DAT Command (View/Change Date)

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

To set the date, type **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.

Note: After setting date or time, allow at least 60 seconds before powering down the relay or the new setting may be lost.

EVE Command (Event Reports)

Use the **EVE** command to view event reports. See ***Section 12: Standard Event Reports and SER*** for further details on retrieving event reports.

GRO Command (Display Active Setting Group Number)

Use the **GRO** command to display the active settings group number. See ***GRO n Command*** in ***Access Level B Commands*** that follows in this section and ***Multiple Setting Groups*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 10.7: 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:

- 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: Standard Event Reports and SER***.

For more information on event summaries, see ***SUM Command*** later in the section.

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.

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 A-phase 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.

```
=>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, $3I_2$, $3I_0$ V_1, V_2 $3V_0$	Positive-, negative-, and zero-sequence currents (A primary) Positive- and negative-sequence voltages (kV primary) 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 A-phase 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 Relay 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 Relay 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 ***Demand Metering*** in ***Section 8: Breaker Monitor and Metering Functions***.

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 Relay 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 ***Energy Metering*** in ***Section 8: Breaker Monitor and Metering Functions***.

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 Relay 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 using the **MET RM** command. All values will display RESET until new maximum/minimum values are recorded. For more information on maximum/minimum metering, see ***Maximum/Minimum Metering*** in ***Section 8: Breaker Monitor and Metering Functions***.

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*** for details on SEL Distributed Port Switch Protocol [LMD]).

SER Command (Sequential Events Recorder Report)

Use the **SER** command to view the Sequential Events Recorder report. For more information on SER reports, see ***Section 12: Standard Event Reports and SER***.

SHO Command (Show/View Settings)

Use the **SHO** command to view relay settings, SELOGIC control equations, global settings, serial port settings, sequential events recorder (SER) settings, and text label settings. Below are the **SHO** command options.

SHO *n*	Show relay settings. *n* specifies the setting group (1, 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.

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 Relay, 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   = N        ETAP  = 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

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     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
67P1TC=1
51GTC =1
51QTC =1
OUT101=TRIP
OUT102=TRIP
OUT103=CLOSE
OUT104=KEY
OUT105=0

Press RETURN to continue
OUT106=0
OUT107=87HWAL
OUT201=TRIP + TRIP87
OUT202=TRIP + TRIP87
OUT203=0
OUT204=0
OUT205=0
OUT206=0
DP1   =52A
DP2   =CHXAL
DP3   =CHYAL
SS1   =0
SS2   =0
SS3   =0
SS4   =0
SS5   =0
SS6   =0
ER    =/B87L2 + /M2P + /Z2G + /51G + /51Q + /50P1 + /LOP
FAULT =51G + 51Q + M2P + Z2G
BSYNCH=0

Press RETURN to continue
```

```
CLMON =0
E32IV =1

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
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,R87L2,R87LG,R87LA,R87LB,R87LC
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= N
RBADXP= 1        AVAXP = 10       DBADXP= 10
TIMRX = E

=>
```

```
=>SHO Y <ENTER>
EADDCY= N
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 Relay with wye-connected voltage inputs and no extra I/O board is shown:

```
=>STA <ENTER>

SEL-311L                          Date: 06/01/01    Time: 21:43:05.997
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311L-R100-V0-Z001001-D20010625       CID=BAFD

SELF TESTS

W=Warn    F=Fail

       IA      IB      IC      IP      VA      VB      VC      VS      MOF
OS     0       1       0       1       1       1       1      -0       1

       +5V_PS  +5V_REG -5V_REG +12V_PS -12V_PS +15V_PS -15V_PS
PS      4.91    4.98   -5.00    12.00  -12.05   14.80  -14.71

MB     TEMP    RAM     ROM     A/D     CR_RAM  EEPROM
        36.8   OK      OK      OK      OK      OK

87L    RAM     ROM     CHAN X  CHAN Y  FPGA    BOARD
       OK      OK      FAIL    N/A     OK      OK

 Relay Enabled       Line Current Differential Protection Disabled

=>
```

STA Command Row and Column Definitions

FID — FID is the firmware identifier string. It identifies the firmware revision.

CID — CID is the firmware checksum identifier.

OS — OS = Offset; displays measured dc offset voltages in millivolts for the current and voltage channels. The MOF (master) status is the dc offset in the A/D circuit when a grounded input is selected.

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), and EEPROM

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 hardware. FAIL indicates a problem.

BOARD Indicates the health of the dedicated 87L hardware. FAIL indicates a problem.

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 in order to capture transient out-of-tolerance conditions. To reset the self-test statuses, use the **STA C** command from Access Level 2:

=>>STA C <ENTER>

The relay responds:

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

If you select "N" or "n", the relay displays:

```
Canceled
```

and aborts the command.

If you select "Y", the relay displays:

```
Rebooting the relay
```

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

Refer to ***Section 13: Testing, Troubleshooting, and Commissioning*** 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*** below). 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 2 rows correspond to Table 10.8. All rows of the Relay Word are described in ***Section 9: Setting the Relay***.

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: Setting the Relay*** and ***Appendix G: 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 *n k*	Shows Relay Word row number *n* (0–67). *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 9.3 and Table 9.4. *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 5.4). Shows Relay Word Row 0.

Table 10.8: 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 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 since 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:

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

Note: After setting date or time, allow at least 60 seconds before powering down the relay or the new setting may be lost.

TRI Command (Trigger Event Report)

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

```
=>TRI <ENTER>
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: Standard Event Reports and SER*** for more information on event reports.

Recall this event summary with the **SUM** command.

Access Level B Commands

BRE *n* Command (Preload/Reset Breaker Wear)

Use the **BRE W** command to preload breaker wear. For example, to preload the breaker wear to 25 percent, 28 percent, and 24 percent for the respective phases, issue the command below.

```
==>BRE W <ENTER>
Breaker Wear Percent Preload

A-phase % = 1 ? 25 <ENTER>
B-phase % = 2 ? 28 <ENTER>
C-phase % = 3 ? 24 <ENTER>
Are you sure (Y/N) ? Y <ENTER>

SEL-311L                          Date: 04/13/01    Time: 13:49:33.253
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=  25 B=  28 C=  24

==>
```

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*** in ***Section 8: Breaker Monitor and Metering Functions*** 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 2.5). 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
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 through SS6 are asserted to logical 1, the active setting group may not be changed with the **GRO** command. SELOGIC control equations settings SS1 through SS6 have priority over the **GRO** command in active setting group control.

For example, assume setting Group 1 is the active setting group and the SS1 setting is asserted to logical 1 (e.g., SS1 = IN101 and optoisolated input IN101 is asserted). An attempt to change to setting Group 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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***.

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 5.4.

See the discussion following Figure 5.4 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 2.5). 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* is the output name (e.g. OUT101, OUT107, ALARM, OUT206—see Figure 7.26 and Figure 7.27).
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 2.5). 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 through OUT107 or OUT201 through OUT206 contacts are pulsed. The **PUL** command is primarily used for testing purposes.

Access Level 2 Commands

CON Command (Control Remote Bit)

The **CON** command is a two-step command that allows you to control Relay Word bits RB1 through 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 wish to perform (see Table 10.9).

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 10.9: SEL-311L Relay Control Subcommands

Subcommand	Description
SRB *n*	Set Remote Bit *n* ("ON" position)
CRB *n*	Clear Remote Bit *n* ("OFF" position)
PRB *n*	Pulse Remote Bit *n* for 1/4 cycle ("MOMENTARY" position)

See ***Remote Control Switches*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 I: MIRRORED BITS***. With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing will be wrong and ROK will be de-asserted. 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 is received.

The **LOO** command with just the channel specifier, enables looped-back mode on that channel for 5 minutes, while 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 looped-back 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 looped-back 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 (View/Change Passwords)

For details on the **PAS** command see ***Using and Changing SEL-311L Relay Passwords*** above.

SET Command (Change Settings)

The **SET** command allows the user to view or change the relay settings—see Table 9.1 in ***Section 9: Setting the Relay***.

TST Command (Differential Channel Testing)

The **TST** command is used for configuring the differential channels for testing. 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
```

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.

Note that 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.

```
=>>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.

  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
=>>
```

SEL-311L Relay Command Summary

Access Level 0 Commands

The only thing that can be done at Access level 0 is to go to Access Level 1. The screen prompt is: =

ACC — Enter Access Level 1. If the main board password jumper is not in place, the relay prompts for entry of the Access Level 1 password in order to enter Access Level 1.

CAS — Compressed ASCII configuration data

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 Access Level 2. If the main board password jumper is not in place, the relay prompts for entry of the Access Level 2 password in order to enter Access Level 2.

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 Sx Ly L R C] — Compressed event report (parameters in [ ] are optional)

where:
- *n* — event number (1–41 if LER = 15; 1–22 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 15 if not specified
- L — 16 samples per cycle; overridden by the S*x* parameter, if present
- R — specifies raw (unfiltered) data; defaults to 16 samples per cycle unless overridden by the S*x* parameter. Defaults to 16 cycles in length unless overridden with the L*y* parameter.
- C — specifies 16 samples per cycle, 15-cycle length

CHIS — Compressed history

COM *p* L — Show a long format communications summary report for all events on MIRRORED BITS™ or Differential Channel *p*.

COM *p n* — Show a communications summary for latest *n* events on MIRRORED BITS or Differential Channel *p*.

COM *p m n* — Show a communications summary report for events *n* through *m* on MIRRORED BITS or Differential Channel *p*.

COM *p d1* — Show a communications summary report for events occurring on date *d1* on MIRRORED BITS or Differential Channel *p*.

COM *p d1 d2* — Show a communications summary report for events occurring between dates *d1* and *d2* on MIRRORED BITS or Differential Channel *p*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).

COM C *p* — Clears the communications summary report for Channel *p*.

CST — Compressed status report

CSU — Compressed event summary

DAT — Set / Show relay 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 — Set / Show DNP map

EVE *n* — Show event report number *n* with 1/4-cycle resolution.

EVE L *n* — Show event report number *n* with 1/16-cycle resolution.

EVE R *n* — Show raw event report number *n* with 1/16-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 Analytic Assistant.

GRO — Display active group number.

HIS *n*	Show brief summary of the *n* latest event reports.
HIS C	Clear the brief summary and corresponding event reports.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET *k*	Display instantaneous metering data (currents and alpha plane) for local and remote terminals. 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.
QUI	Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) protocol connection. Available in all access levels.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER *m n*	Show rows *m* through *n* in the Sequential Events Recorder (SER) event report.
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 C	Clears the Sequential Events Recorder (SER).
SHO *n*	Show relay settings (overcurrent, reclosing, timers, etc.) for Group *n*.
SHO L *n*	Show SELOGIC® control equation settings for Group *n*.
SHO G	Show global settings.
SHO P *n*	Show Port *n* settings.
SHO R	Show Sequential Events Recorder (SER) settings.
SHO T	Show text label settings.
STA	Show relay self-test status.
SUM	Show newest event summary.
SUM A	Acknowledge oldest even summary.
SUM N	View oldest unacknowledged event report.
SUM N [A]	Display or acknowledge event summary number “N”.
TAR R	Reset the front-panel tripping targets.
TAR *n k*	Display Relay Word row. If *n* = 0 through 45, display row *n*. If *n* is an element name (e.g., 50G1) display the row containing element *n*. Enter *k* for repeat count.
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	Trigger an event report.

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. See the Note in the ***Set Close*** discussion, following Figure 6.1 for more information concerning the CLO command.
GRO *n*	Change active group to Group *n*.
OPE	Open the circuit breaker. See the Note following Figure 5.2 and the Note in the ***Lockout State*** discussion, following Table 6.1 for more information concerning the OPE command.
PUL *n k*	Pulse output contact *n* (OUT101–OUT107, ALARM, OUT201–OUT212) for *k* (1–30) seconds. Parameter *n* must be specified; *k* defaults to 1 if not specified.

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: =>>
CON *n*	Control Remote Bit RB*n* (Remote Bit *n*; *n* = 1 through 8). Execute CON *n* and the relay responds: CONTROL RB*n*. Then reply with one of the following: SRB *n* set Remote Bit *n* (assert RB*n*). CRB *n* clear Remote Bit *n* (deassert RB*n*). PRB *n* pulse Remote Bit *n* (assert RB*n* for 1/4 cycle).
COP *m n*	Copy relay and logic settings from Group *m* to Group *n*.
L_D	Load new firmware
LOO	Set MIRRORED BITS port to loop back.
PAS	Show existing Access Level 1, B, and 2 passwords.
PAS 1 xxxxxx	Change Access Level 1 password to xxxxxx.
PAS B xxxxxx	Change Access Level B password to xxxxxx.
PAS 2 xxxxxx	Change Access Level 2 password to xxxxxx.
SET *n*	Change relay settings (overcurrent, reclosing, timers, etc.) for Group *n*.
SET L *n*	Change SELOGIC control equation settings for Group *n*.
SET G	Change global settings.
SET P *n*	Change Port *n* settings.
SET R	Change Sequential Events Recorder (SER) settings.
SET T	Change text label settings.
SET {X, Y}	Change differential channel parameters
STA C	Resets self-test warnings/failures and reboots relay.
TST {chn}	Test the differential communication channel 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.
VER	Displays version and configuration information.

TABLE OF CONTENTS

FIGURES

SECTION 11: FRONT-PANEL INTERFACE

INTRODUCTION

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: Setting the Relay***; the relay is shipped with FP_TO = 15 minutes).

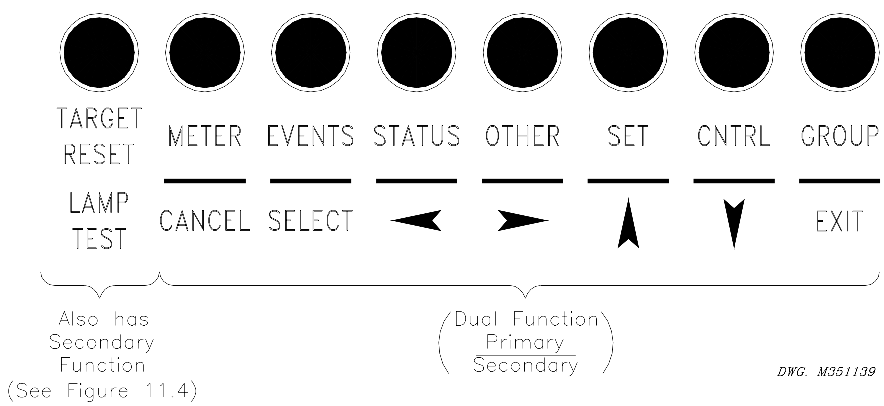


Figure 11.1: SEL-311L Relay Front-Panel Pushbuttons—Overview

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 10.5 in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***. For example, to get more information on the metering values available via the front-panel METER pushbutton, refer to the ***MET Command (Metering Data)*** in ***Section 10***.

Some of the front-panel primary functions do not have serial port command equivalents. These are discussed in the following subsection ***Functions Unique to the Front-Panel Interface***.

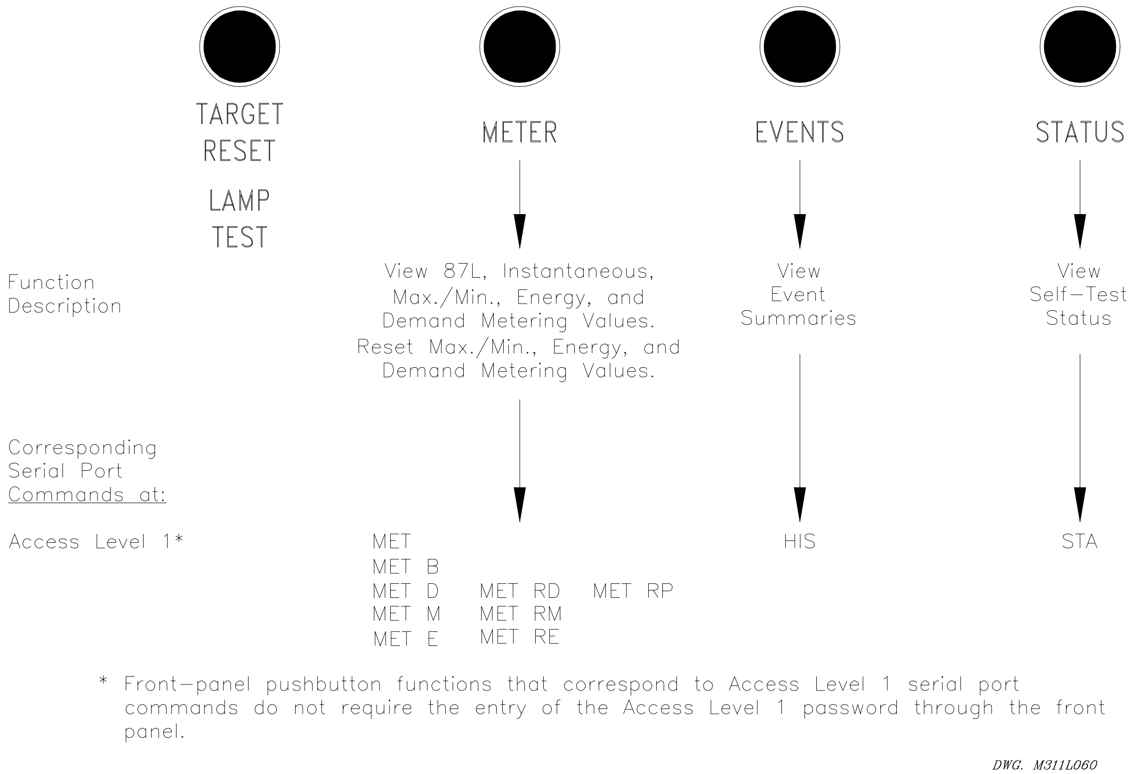
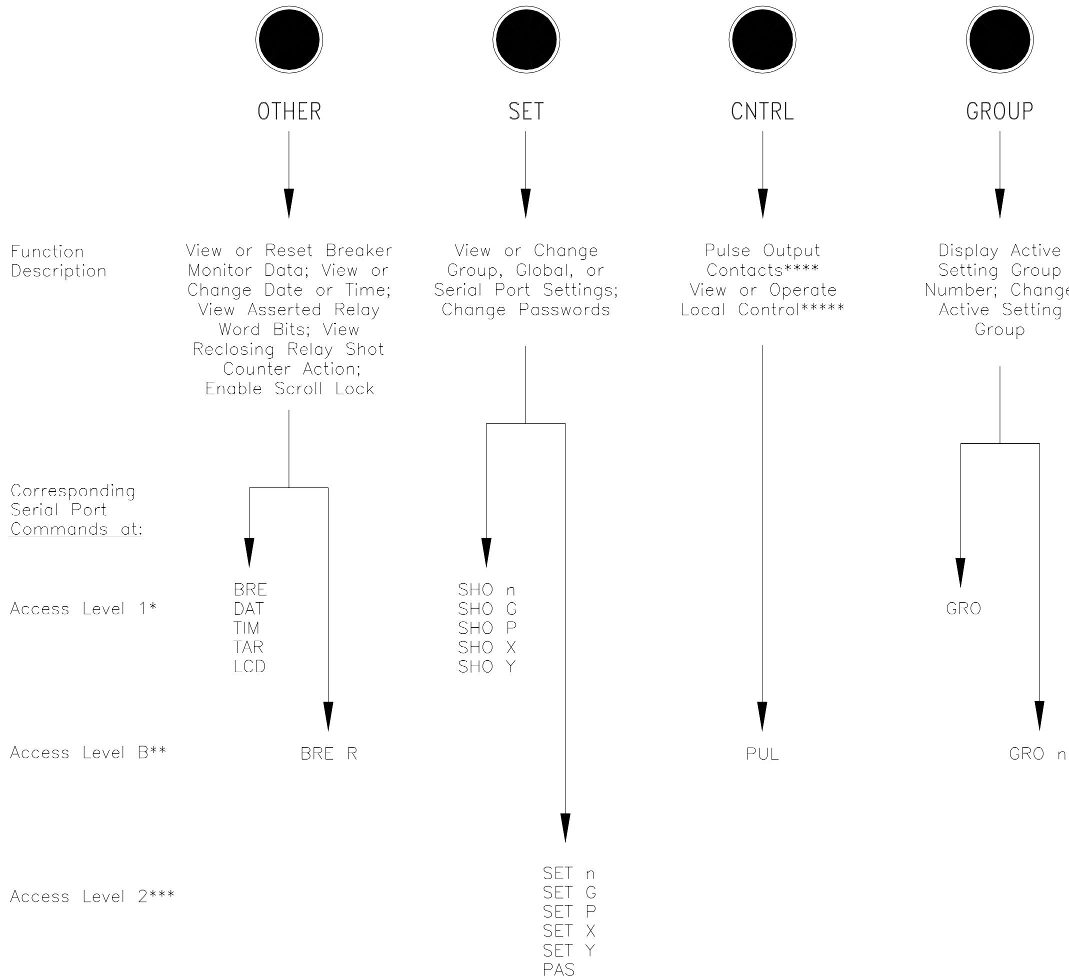


Figure 11.2: SEL-311L Relay Front-Panel Pushbuttons—Primary Functions

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 (View/Change Password)*** in ***Section 10*** 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.



* 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.

** 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 2.5).

*** 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 2.5).

**** Output contacts are pulsed for only 1 second from the front panel.

***** Local control is not available through the serial port and does not require the entry of a password.

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Figure 11.3: SEL-311L Relay 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).

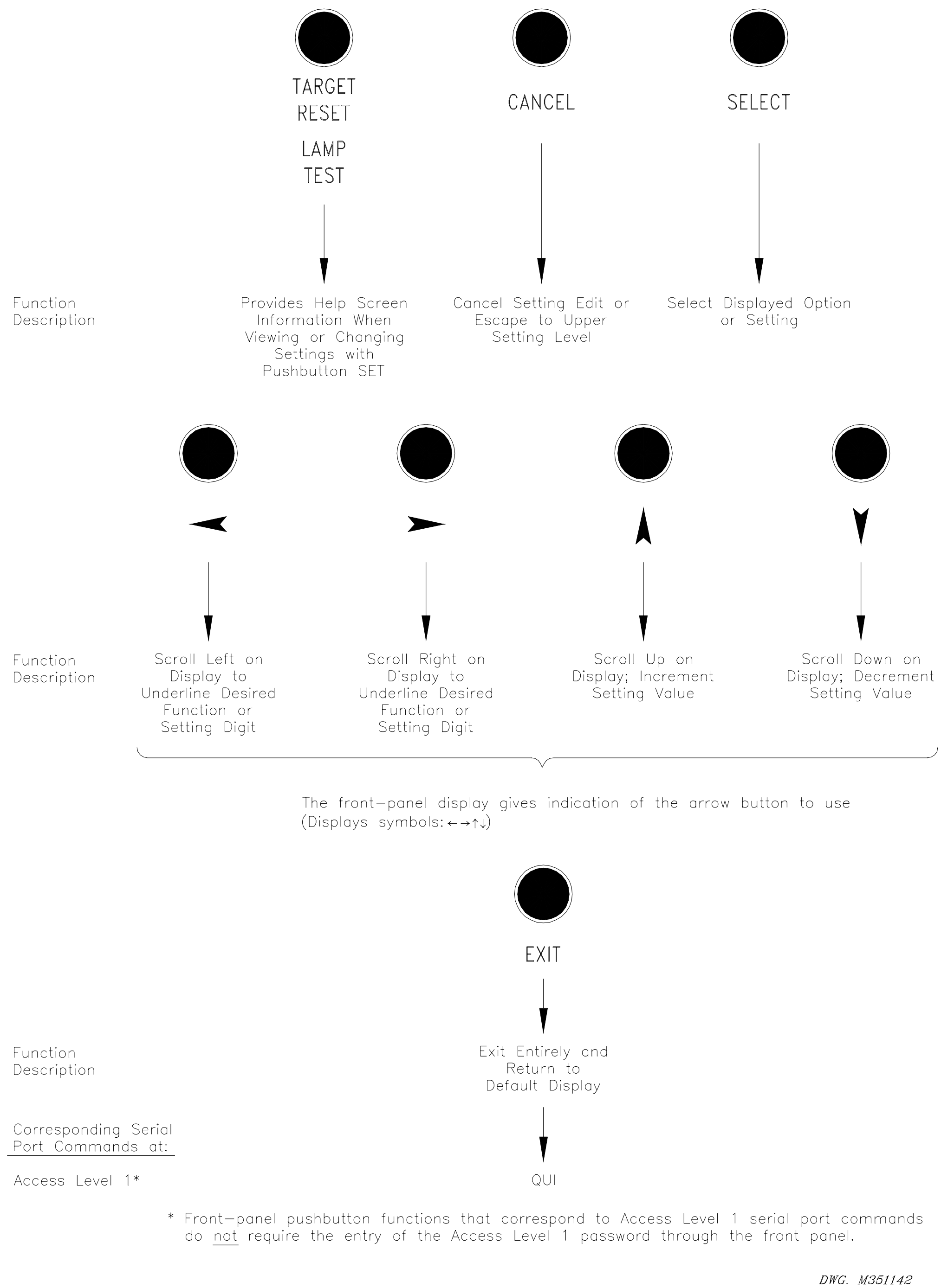


Figure 11.4: SEL-311L Relay Front-Panel Pushbuttons—Secondary Functions

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 = 2)

If reclosing functions are disabled (see ***Reclosing Relay*** in ***Section 6: Close and Reclose Logic***), 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 79LL nor 79SL are 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: Setting the Relay*** and ***SHO Command [Show/View Settings]*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***).

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 = 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 through LB16. These local bits are available as Relay Word bits and are used in SELOGIC® control equations (see Tables 9.3 and 9.4).

Local control can emulate the switch types shown in Figure 11.5 through Figure 11.7.

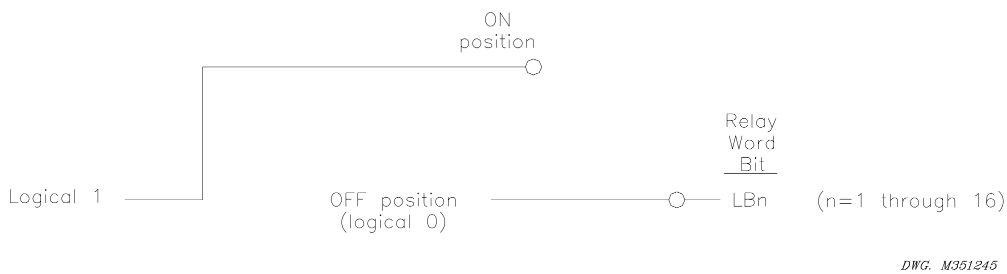


Figure 11.5: Local Control Switch Configured as an ON/OFF Switch

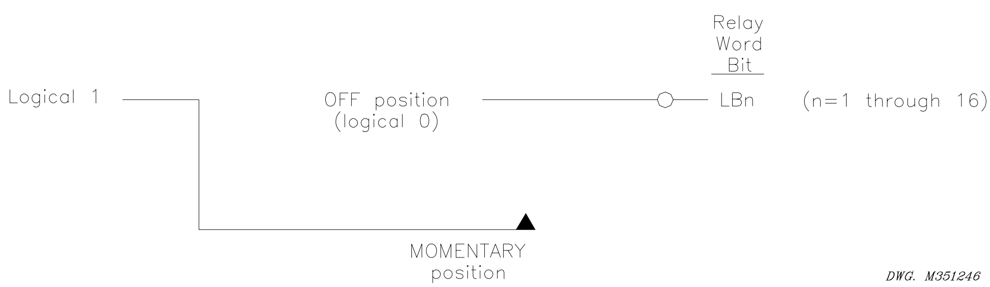


Figure 11.6: Local Control Switch Configured as an OFF/MOMENTARY Switch

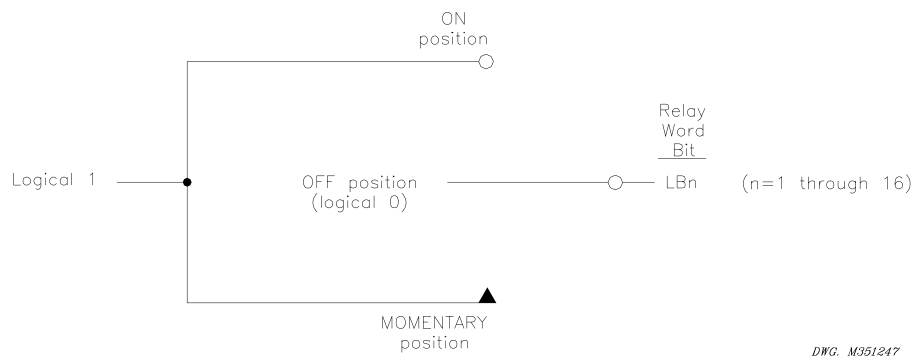


Figure 11.7: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

Local control switches are created by making corresponding switch position label settings. These text label settings are set with the **SET T** command or viewed with the **SHO T** command via the serial port (see ***Section 9: Setting the Relay*** and ***SHO Command [Show/View Settings]*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***). See ***Local Control Switches*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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
```

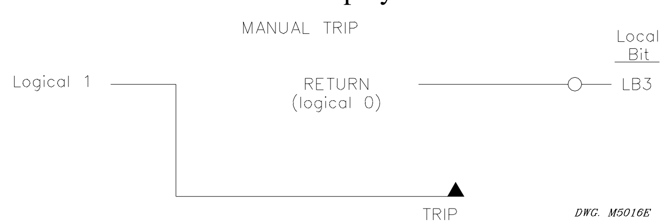
Assume the following settings:

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

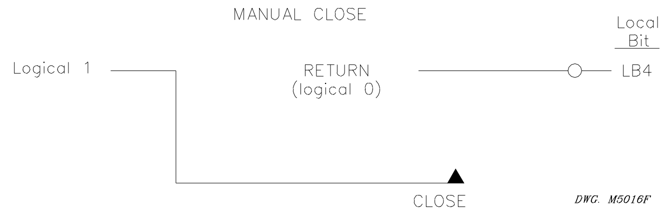
Press the CNTRL pushbutton, and the first set local control switch displays

```
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:

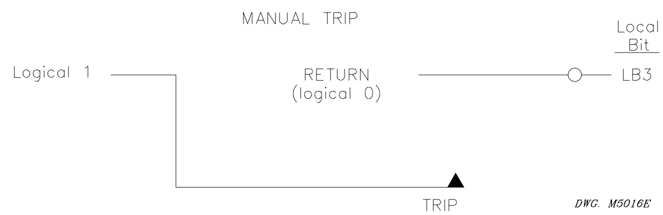
```
Output Contact ←→
Testing
```

This front-panel function provides the same function as the serial port **PUL** command (see Figure 11.3).

Operate Local Control (with Example Settings)

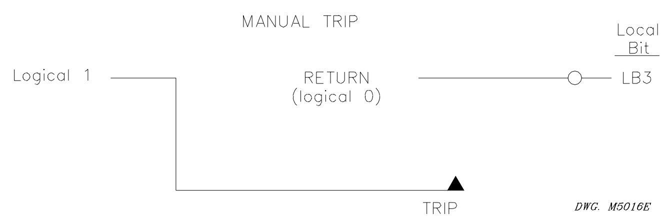
Press the right arrow pushbutton, and scroll back to the first set local control switch in the example settings:

```
MANUAL TRIP   ←→
Position: RETURN
```



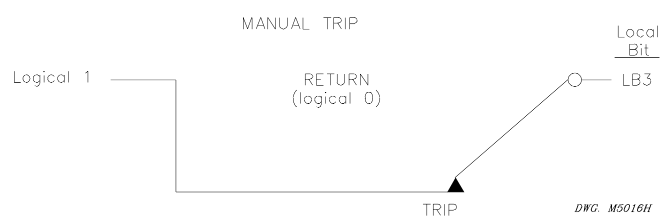
Press the SELECT pushbutton, and the operate option for the displayed local control switch displays:

```
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:

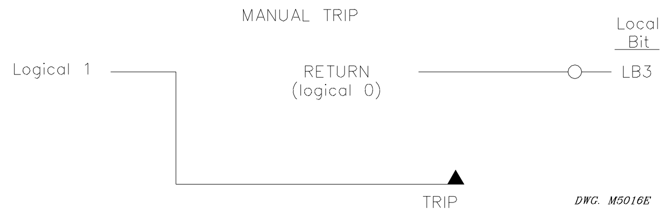
```
MANUAL TRIP
Position: TRIP
```



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 2 seconds (long enough to be seen), and then it returns to the RETURN position:

```
MANUAL TRIP   ←→
Position: RETURN
```



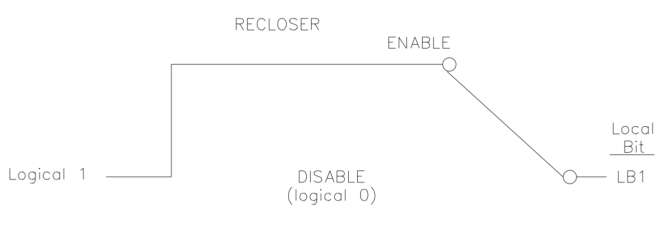
The MANUAL CLOSE switch is an OFF/MOMENTARY type switch, like the MANUAL TRIP switch, and operates similarly.

See ***Local Control Switches*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 Deenergized

Local bit states are stored in nonvolatile memory, so when power to the relay is turned off, the local bit states are retained.

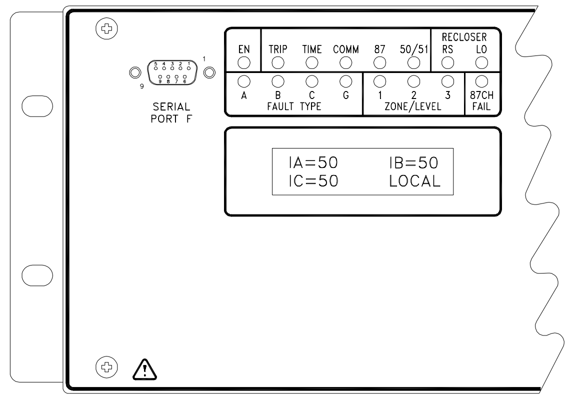
For example, suppose the local control switch with local bit output LB1 is configured as an ON/OFF type switch (see Figure 11.5). Additionally, suppose it is used to enable/disable reclosing. If local bit LB1 is at logical 1, reclosing is enabled:



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 Amps) 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.



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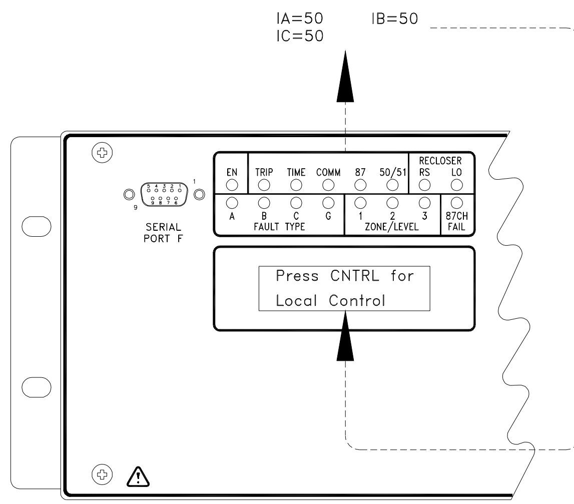
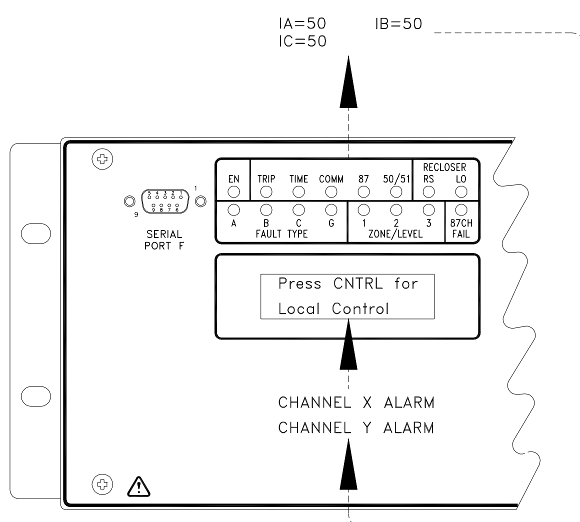
The "Press CNTRL for Local Control" message displays in rotation (display time = SCROLD) with the default metering screen if at least one local control switch is operational. It is a reminder of how to access the local control function. See the preceding discussion in this section and ***Local Control Switches*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** for more information on local control.



DWG: M311L062

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).



DWG: M311L063

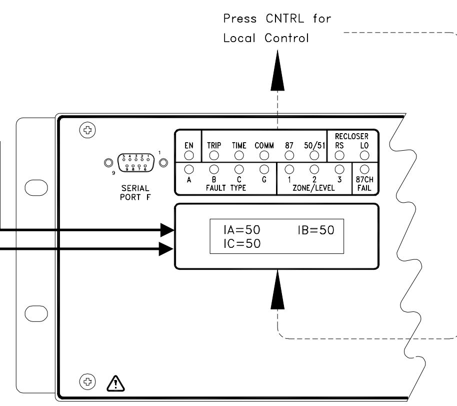
The following table and figures demonstrate the correspondence between changing display point states (e.g., DP2 and DP3) and enabled display point labels (DP2_1/DP2_0 and DP3_1/DP3_0, respectively). The display time is equal to global setting SCROLD for each screen.

The display point example settings are:

DP2 = CHXAL (alarm condition on Channel X)
DP3 = CHYAL (alarm condition on Channel Y)

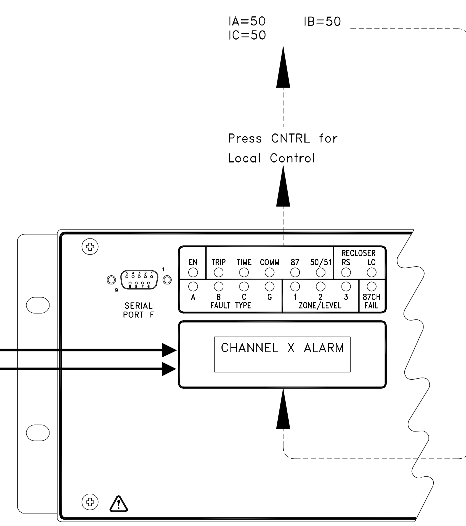
Display Points 2 and 3 are used to help diagnostics when the 87CH FAIL LED illuminates.

Display Points (SELOGIC Control Equation Settings)	Example Display Point States	Display Point Label Settings
		DP2_1 = CHANNEL X ALARM
DP2 = CHXAL	= logical 0	DP2_0 = NA
		DP3_1 = CHANNEL Y ALARM
DP3 = CHYAL	= logical 0	DP3_0 = NA



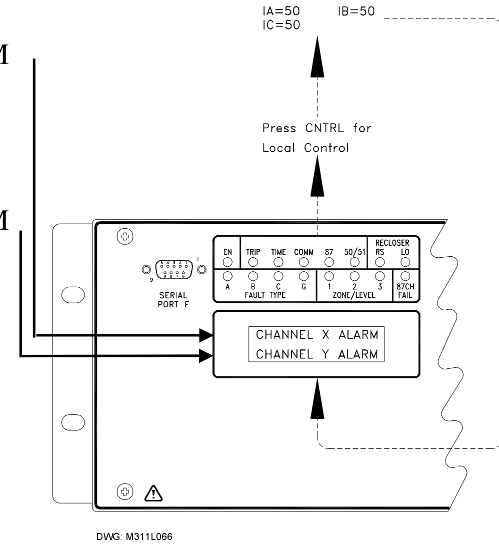
DWG: M311L064

Display Points (SELOGIC Control Equation Settings)	Example Display Point States	Display Point Label Settings
DP2 = CHXAL	= logical 1	DP2_1 = CHANNEL X ALARM
		DP2_0 = NA
		DP3_1 = CHANNEL Y ALARM
DP3 = CHYAL	= logical 0	DP3_0 = NA

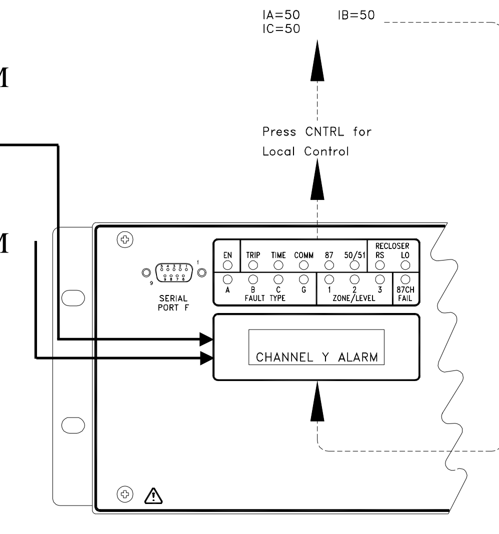


DWG: M311L065

Display Points (SELOGIC Control Equation Settings)	Example Display Point States	Display Point Label Settings
DP2 = CHXAL	= logical 1	DP2_1 = CHANNEL X ALARM
		DP2_0 = NA
DP3 = CHYAL	= logical 1	DP3_1 = CHANNEL Y ALARM
		DP3_0 = NA



Display Points (SELOGIC Control Equation Settings)	Example Display Point States	Display Point Label Settings
		DP2_1 = CHANNEL X ALARM
DP2 = CHXAL	= logical 0	DP2_0 = NA
DP3 = CHYAL	= logical 1	DP3_1 = CHANNEL Y ALARM
		DP3_0 = NA



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: Setting the Relay*** and ***SHO Command [Show/View***

Settings] in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***).

For more detailed information on the logic behind the rotating default display, see ***Rotating Default Display*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***.

Scroll Lock Control of Front Panel LCD

The rotating default display can be locked on a single screen. (See ***Rotating Default Display*** in ***Section 7: Inputs, Output, Timers, and Other Control Logic***). Access the scroll lock control with the OTHER push-button.

```
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 8 seconds for 1 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 1 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 5.19 and accompanying text in ***Section 5: Trip and Target Logic*** for an example of resetting a rotating default display with the TARGET RESET pushbutton.

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SECTION 12: STANDARD EVENT REPORTS AND SER

INTRODUCTION

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 Relay 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-one 15-cycle, twenty-two 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 12.4 for an example standard 15-cycle backup event report and Figure 12.5 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 12.8 for an example SER report.

STANDARD 15/30/60-CYCLE EVENT REPORTS

See Figure 12.4 and Figure 12.5 for example event reports (**Note**: Figure 12.4 and Figure 12.5 are on multiple pages).

Event Report Length (Settings LER and PRE)

The SEL-311L Relay 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 in ***Section 9: Setting the Relay*** 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
- Programmable SELOGIC® control equation setting ER asserts
- **TRI** (Trigger Event Reports) serial port command executed
- Output contacts OUT101–OUT107 and OUT201–OUT206 pulsed via the serial port or front-panel **PUL** (Pulse output contact) command

Relay Word Bit TRIP

Refer to Figure 5.4. If Relay Word bits 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).

TRIP87 also asserts Relay Word bit TRIP when high-speed tripping is enabled (EHST ≥ 1).

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 Relay 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 3.42).
51Q	Negative-sequence current above pickup setting 51QP for negative-sequence time-overcurrent element 51QT (see Figure 3.43).
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 G: 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 G.2 in ***Appendix G: 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 or OUT201–OUT206 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: Line Current Differential Communications and Serial Port Communications and Commands*** and ***Section 11: Front-Panel Interface*** (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 12.4.

Figure 12.1 corresponds to the full-length standard 15-cycle event reports in Figure 12.4 and Figure 12.5. (**Note**: Figure 12.4 and Figure 12.5 are on multiple pages.)

```
=>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 the table below. Note the correspondence to the preceding event report triggering conditions (see ***Standard Event Report Triggering*** in this section).

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 in ***Section 9: Setting the Relay*** 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: Line Current Differential Communications and Serial Communications and Commands***.

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

The relay reports the targets at the rising edge of TRIP and TRIP87. The targets include ZONE/LEVEL 1–3; TIME; COMM; 87; and 50/51. If there is no rising edge of TRIP in the report, the Targets field is blank. See ***Front-Panel Target LEDs*** in ***Section 5: Trip and Target Logic***.

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 is 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**]

where:

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. The SEL-5601 Analytic Assistant 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.

Below are example **EVE** commands.

Serial Port Command	**Description**
EVE	Display the most recent event report at 1/4-cycle resolution.
EVE 2	Display the second event report at 1/4-cycle resolution.
EVE S16 L10	Display 10 cycles of the most recent report at 1/16-cycle resolution.
EVE C 2	Display the second report in Compressed ASCII format at 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”

Compressed ASCII Event Reports

The SEL-311L Relay provides compressed ASCII event reports to facilitate event report storage and display. The SEL-2020 Communications Processor and the SEL-5601 Analytic Assistant software 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. Figure 12.2 and Figure 12.3 show screen captures of the Alpha plane plots for internal and external faults using the SEL-5601 Analytical Assistant software.

See the CEVENT command discussion in ***Appendix E: Compressed ASCII Commands*** for further information.

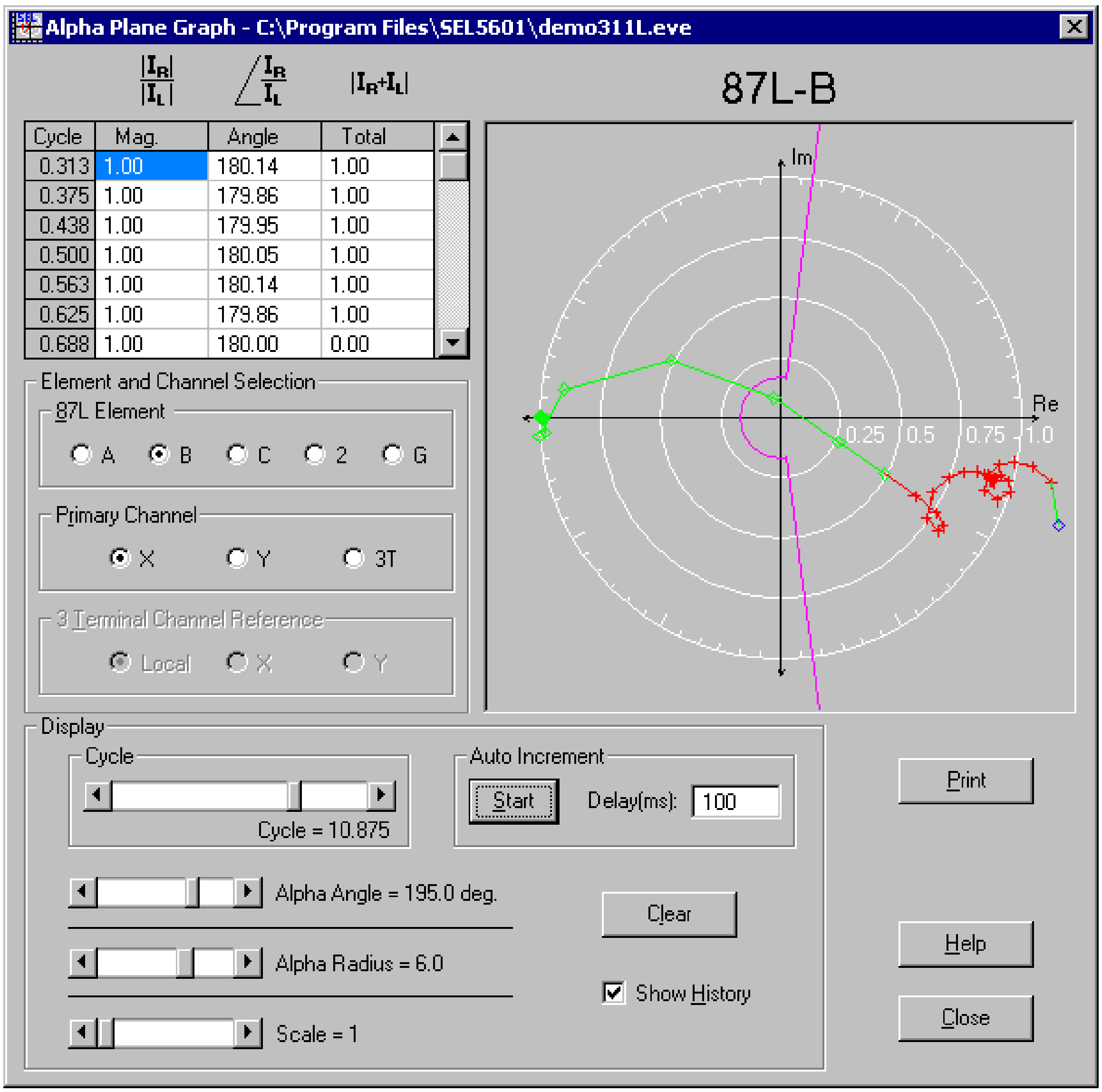

Figure 12.2: Internal Fault

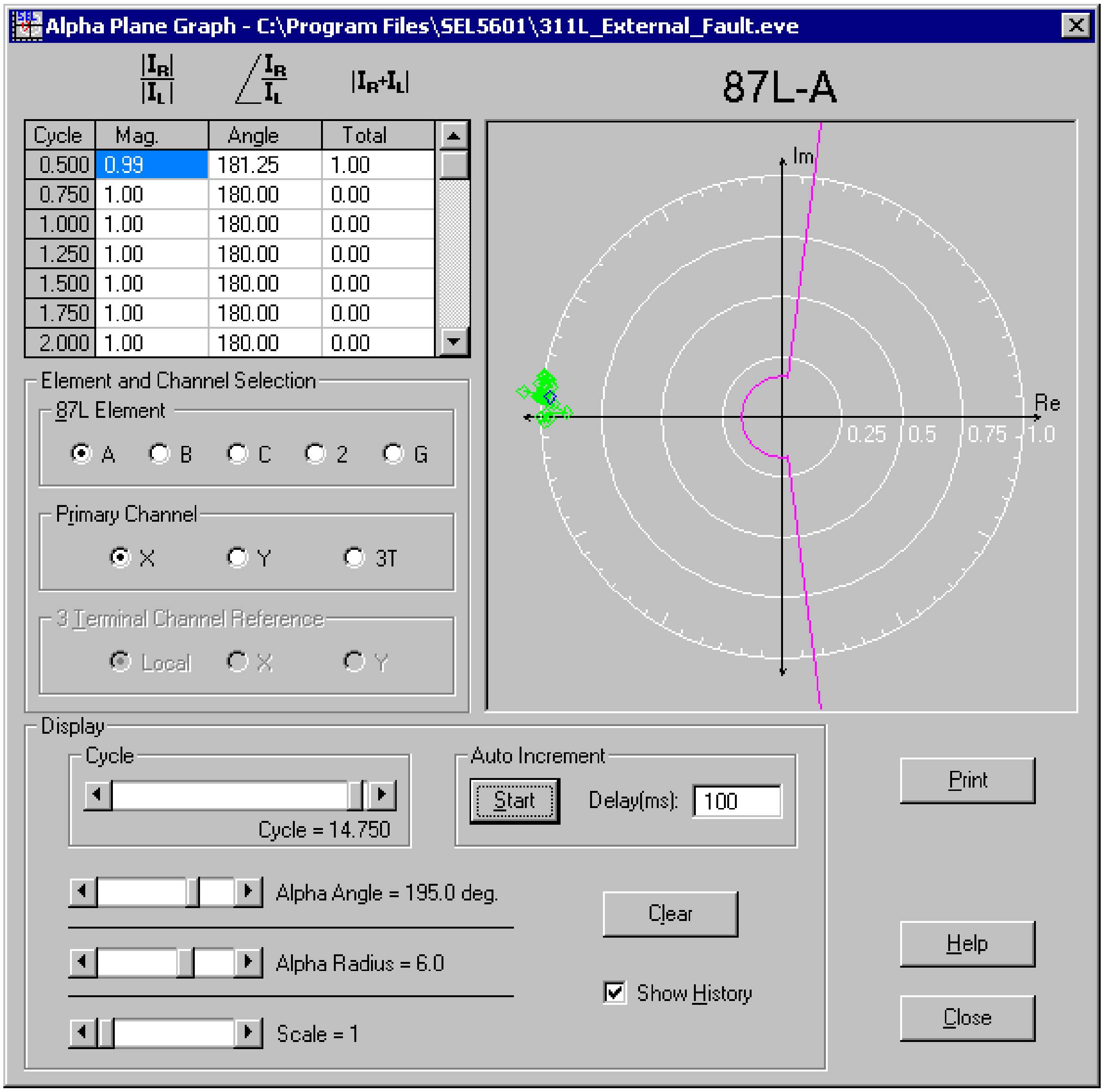

Figure 12.3: External Fault

Filtered and Unfiltered Event Reports

The SEL-311L Relay 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 in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***).

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: Line Current Differential Communications and Serial Port Communications and Commands*** 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 12.4 to view event report columns (**Note**: Figure 12.4 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 12.2 summarizes the backup event report current, voltage, and frequency columns.

Table 12.2: Standard Event Report Current, Voltage, and Frequency Columns (Backup Protection)

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 $IG = 3I_0 = IA + IB + IC$ (primary A)
VA	Voltage measured by channel VA (primary kV)
VB	Voltage measured by channel VB (primary kV)
VC	Voltage measured by channel VC (primary kV)
VS	Voltage measured by channel VS (primary kV)
V1Mem	Positive-sequence memory voltage (primary kV)
FREQ	Frequency of Channel VA
Vdc	Voltage measured at power input terminals Z25 and Z26 (Vdc)

Note that the ac values change from positive to negative in Figure 12.4, indicating the sinusoidal nature of the waveforms.

Other figures help in understanding the information available in the event report current or voltage columns:

Figure 12.6 shows how event report current column data relates to the actual sampled waveform and RMS values.

Figure 12.7 shows how event report column data can be converted to phasor RMS values.

Output, Input, Protection, and Control Columns

Table 12.3 and Table 12.6 summarize the event report output, input, protection, and control columns for backup and differential protection, respectively. See Table 9.4 in ***Section 9: Setting the Relay*** for more information on the Relay Word bits shown in Table 12.3, Table 12.4, and Table 12.6.

Table 12.3: Output, Input, Protection, and Control Element Event Report Columns (Backup Protection)

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
All columns		.	Element/input/output not picked up or not asserted, unless otherwise stated.
ZAB[1]	MAB1	1	If Zone 1 AB phase-phase distance element (MAB1) set
	MAB2	2	If Zone 2 AB phase-phase distance element (MAB2) set, not ZAB1
	MAB3	3	If Zone 3 AB phase-phase distance element (MAB3) set, not ZAB1 or ZAB2
	MAB4	4	If Zone 4 AB phase-phase distance element (MAB4) set, not ZAB1 or ZAB2 or ZAB3
ZPP[2]	MPP1	1	If Zone 1 phase-phase distance element (MPP1) set
	MPP2	2	If Zone 2 phase-phase distance element (MPP2) set, not ZPP1
	MPP3	3	If Zone 3 phase-phase distance element (MPP2) set, not ZPP1 or ZPP2
	MPP4	4	If Zone 4 phase-phase distance element (MPP4) set, not ZPP1, ZPP2, or ZPP3

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
ZBC[1]	MBC1	1	If Zone 1 BC phase-phase distance element (MBC1) set
	MBC2	2	If Zone 2 BC phase-phase distance element (MBC2) set, not ZBC1
	MBC3	3	If Zone 3 BC phase-phase distance element (MBC3) set, not ZBC1 or ZBC2
	MBC4	4	If Zone 4 BC phase-phase distance element (MBC4) set, not ZBC1 or ZBC2 or ZBC3
Z3P[2]	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[1]	MCA1	1	If Zone 1 CA phase-phase distance element (MCA1) set
	MCA2	2	If Zone 2 CA phase-phase distance element (MCA2) set, not ZCA1
	MCA3	3	If Zone 3 CA phase-phase distance element (MCA3) set, not ZCA1 or ZCA2
	MCA4	4	If Zone 4 CA phase-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

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
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

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
50G 1 2	50G1, 50G2	1	50G1 asserted
		2	50G2 asserted
		b	both 50G1 and 50G2 asserted
50G 3 4	50G3, 50G4	3	50G3 asserted
		4	50G4 asserted
		b	both 50G3 and 50G4 asserted
50Q 1 2	50Q1, 50Q2	1	50Q1 asserted
		2	50Q2 asserted
		b	both 50Q1 and 50Q2 asserted
50Q 3 4	50Q3, 50Q4	3	50Q3 asserted
		4	50Q4 asserted
		b	both 50Q3 and 50Q4 asserted
32 Q	F32Q	Q	Forward negative-sequence directional element F32Q picked up.
	R32Q	q	Reverse negative-sequence directional element R32Q picked up.
32 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

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
67G 1 2	67G1, 67G2	1	67G1 asserted
		2	67G2 asserted
		b	both 67G1 and 67G2 asserted
67G 3 4	67G3, 67G4	3	67G3 asserted
		4	67G4 asserted
		b	both 67G3 and 67G4 asserted
67Q 1 2	67Q1, 67Q2	1	67Q1 asserted
		2	67Q2 asserted
		b	both 67Q1 and 67Q2 asserted
67Q 3 4	67Q3, 67Q4	3	67Q3 asserted
		4	67Q4 asserted
		b	both 67Q3 and 67Q4 asserted
DM P Q	PDEM, QDEM	P	Phase demand ammeter element PDEM picked up.
		Q	Negative-sequence demand ammeter element QDEM picked up.
		b	Both PDEM and QDEM picked up.
DM G	GDEM	*	Residual ground demand ammeter element GDEM picked up.
27 P	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.

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.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
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.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
81 5 6	81D5, 81D6	5	Level 5 instantaneous frequency element asserted.
		6	Level 6 instantaneous frequency element asserted.
		b	Level 5 and 6 instantaneous frequency elements asserted.
79	RCSF, CF, 79RS, 79CY, 79LO	.	Reclosing relay nonexistent.
		S	Reclose supervision failure condition (RCSF asserts for only 1/4 cycle).
		F	Close failure condition (CF asserts for only 1/4 cycle).
		R	Reclosing relay in Reset State (79RS).
		C	Reclosing relay in Reclose Cycle State (79CY).
		L	Reclosing relay in Lockout State (79LO).
Time	OPTMN, RSTMN	o	Recloser open interval timer is timing.
		r	Recloser reset interval timer is timing.
Shot	SH0, SH1, SH2 SH3, SH4	.	Reclosing relay nonexistent.
		0	shot = 0 (SH0).
		1	shot = 1 (SH1).
		2	shot = 2 (SH2).
		3	shot = 3 (SH3).
		4	shot = 4 (SH4).
Zld	ZLIN, ZLOUT	i	Load encroachment “load in” element ZLIN picked up.
		o	Load encroachment “load out” element ZLOUT picked up.
LOP	LOP	*	Loss-of-potential element LOP picked up.
Vdc	DCHI, DCLO	H	Station battery instantaneous overvoltage element DCHI picked up.
		L	Station battery instantaneous undervoltage element DCLO picked up.
		b	Both DCHI and DCLO asserted.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
**Out1 1 2	OUT101, OUT102	1	Output contact OUT101 asserted.
		2	Output contact OUT102 asserted.
		b	Both OUT101 and OUT102 asserted.
**Out1 3 4	OUT103, OUT104	3	Output contact OUT103 asserted.
		4	Output contact OUT104 asserted.
		b	Both OUT103 and OUT104 asserted.
**Out1 5 6	OUT105, OUT106	5	Output contact OUT105 asserted.
		6	Output contact OUT106 asserted.
		b	Both OUT105 and OUT106 asserted.
**Out1 7 A	OUT107, ALARM	7	Output contact OUT107 asserted.
		A	Output contact ALARM asserted.
		b	Both OUT107 and ALARM asserted.
Out2 1 2	OUT201, OUT202	1	Output contact OUT201 asserted.
		2	Output contact OUT202 asserted.
		b	Both OUT201 and OUT202 asserted.
Out2 3 4	OUT203, OUT204	3	Output contact OUT203 asserted.
		4	Output contact OUT204 asserted.
		b	Both OUT203 and OUT204 asserted.
Out2 5 6	OUT205, OUT206	5	Output contact OUT205 asserted.
		6	Output contact OUT206 asserted.
		b	Both OUT205 and OUT206 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.
			Both IN105 and IN106 asserted.

** Output contacts can be A or B type contacts (see Table 2.4 and Figure 7.26 through Figure 7.27).

[1] This column is visible only when positive-sequence, polarized phase mho elements are enabled (E21P does not contain “C”).

[2] This column is visible only when compensator distance mho elements are enabled (E21P contains “C”).

Table 12.4: Communication Elements Event Report Columns (Backup Protection)

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	Permissive trip 1 signal from DCUB logic PTRX1 asserted.
		2	Permissive trip 2 signal from DCUB logic PTRX2 asserted.
		b	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	Unblocking block 1 from DCUB logic UBB1 asserted.
		2	Unblocking block 2 from DCUB logic UBB2 asserted.
		b	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.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
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.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
TMB B 1 2	TMB1B, TMB2B	1	MIRRORED BITS channel B transmit bit 1 TMB1B asserted.
		2	MIRRORED BITS channel B transmit bit 2 bit TMB2B asserted.
		b	Both TMB1B and TMB2B asserted.
TMB B 3 4	TMB3B, TMB4B	3	MIRRORED BITS channel B transmit bit 3 TMB3B asserted.
		4	MIRRORED BITS channel B transmit bit 4 TMB4B asserted.
		b	Both TMB3B and TMB4B asserted.
TMB B 5 6	TMB5B, TMB6B	5	MIRRORED BITS channel B transmit bit 5 TMB5B asserted.
		6	MIRRORED BITS channel B transmit bit 6 TMB6B asserted.
		b	Both TMB5B and TMB6B asserted.
TMB B 7 8	TMB7B, TMB8B	7	MIRRORED BITS channel B transmit bit 7 TMB7B asserted.
		8	MIRRORED BITS channel B transmit bit 8 TMB8B asserted.
		b	Both TMB7B and TMB8B asserted.
RMB B 1 2	RMB1B, RMB2B	1	MIRRORED BITS channel B receive bit 1 RMB1B asserted.
		2	MIRRORED BITS channel B receive bit 2 RMB2B asserted.
		b	Both RMB1B and RMB2B asserted.
RMB B 3 4	RMB3B, RMB4B	3	MIRRORED BITS channel B receive bit 3 RMB3B asserted.
		4	MIRRORED BITS channel B receive bit 4 RMB4B asserted.
		b	Both RMB3B and RMB4B asserted.
RMB B 5 6	RMB5B, RMB6B	5	MIRRORED BITS channel B receive bit 5 RMB5B asserted.
		6	MIRRORED BITS channel B receive bit 6 RMB6B asserted.
		b	Both RMB5B and RMB6B asserted.
RMB B 7 8	RMB7B, RMB8B	7	MIRRORED BITS channel B receive bit 7 RMB7B asserted.
		8	MIRRORED BITS channel B receive bit 8 RMB8B asserted.
		b	Both RMB7B and RMB8B asserted.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
ROK	ROKA, ROKB	A	MIRRORED BITS channel A receive OK ROKA asserted.
		B	MIRRORED BITS channel B receive OK ROKB asserted.
		b	Both ROKA and ROKB asserted.
RBAD	RBADA, RBADB	A	MIRRORED BITS channel A extended. outage RBADA asserted.
		B	MIRRORED BITS channel B extended outage RBADB asserted.
		b	Both RBADA and RBADB asserted.
CBAD	CBADA, CBADB	A	MIRRORED BITS channel A unavailability CBADA asserted.
		B	MIRRORED BITS channel B unavailability CBADB asserted.
		b	Both CBADA and CBADB asserted.
LBOK	LBOKA, LBOKB	A	MIRRORED BITS channel A loop back OK LBOKA asserted.
		B	MIRRORED BITS channel A loop back OK LBOKB asserted.
		b	Both LBOKA and LBOKB asserted.
OC	OC, CC	o	**OPE** (Open) command executed.
		c	**CLO** (Close) command executed.
Lcl RW 5	LB1–LB8	00–FF **Hex	Hex value of Relay Word 5, LB1–LB8, Local Bits
Lcl RW 6	LB9–LB16	00–FF **Hex	Hex value of Relay Word 6, LB9–LB16, Local Bits
Rem RW 7	RB1–RB8	00–FF **Hex	Hex value of Relay Word 7, RB1–RB8, Remote Bits
Rem RW 8	RB9–RB16	00–FF **Hex	Hex value of Relay Word 8, RB9–RB16, Remote Bits
Ltch RW 9	LT1–LT8	00–FF **Hex	Hex value of Relay Word 9, LT1–LT8, Latch Bits
Ltch RW 10	LT9–LT16	00–FF **Hex	Hex value of Relay Word 10, LT9–LT16, Latch Bits

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
SELOGIC			
1	SV1, SV1T	p	SELOGIC control equation variable timer input SV_ asserted; timer timing on pickup time; timer output SV_T not asserted.
2	SV2, SV2T		
3	SV3, SV3T		
4	SV4, SV4T		
5	SV5, SV5T	T	SELOGIC control equation variable timer input SV_ asserted; timer timed out on pickup time; timer output SV_T asserted.
6	SV6, SV6T		
7	SV7, SV7T		
8	SV8, SV8T		
9	SV9, SV9T		
10	SV10, SV10T	d	SELOGIC control equation variable timer input SV_ not asserted; timer previously timed out on pickup time; timer output SV_T remains asserted while timer timing on dropout time.
11	SV11, SV11T		
12	SV12, SV12T		
13	SV13, SV13T		
14	SV14, SV14T		
15	SV15, SV15T		
16	SV16, SV16T		

** 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 12.4 also corresponds to the example sequential events recorder (SER) report in Figure 12.8. The boxed numbers in Figure 12.4 correspond to the SER row numbers in Figure 12.8. The row explanations follow Figure 12.8.

In Figure 12.4, 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 12.4 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: 06/15/01    Time: 10:25:24.810
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311L-R100-V0-Z001001-D20010625       CID=396E


      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

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 In1
ABCABC O O     1 1313  V 1 1313 P   P  P 1  9S 71357mo 10d 1357 135  135
BCAGGG S L PGQ 232424 QI 232424 QG PPSPPSQN VFAB2469et dPc 246A 246  246
[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 ...... .. ...... .. ..  16 13  ....... ... .... ...  ... >
[5]
...... . V .pp ...... QQ ...... .. ........ .......... ... .... ...  ...
.2.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...
.1.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...
.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..  ...
```

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[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..  ...
[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..  ...
[11]
.2.... . V .pp ...... QQ ...... .. ........ .......... ... b4.. b..  ...
...... . V .pp ...... QQ ...... .. ........ .......... ... b... b..  ...
...... . 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]
...... . V .r. ...... .. ...... .. ........ .......... ... b... b..  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... b..  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... b..  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... ...  ...
[15]
...... . V .r. ...... .. ...... .. ........ .......... ... .... ...  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... ...  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... ...  ...
...... . V .r. ...... .. ...... .. ........ .......... ... .... ...  ...

Communication Elements                    Control Elements

 S  PZ EE   ZDNS  TMB  RMB  TMB  RMB  RRCL   Lcl   Rem   Ltch  SELogic
30  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 ................
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.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
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[3]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
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[4]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
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.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
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[5]
.. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
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[6]
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[7]
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[13]
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[15]
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*. ........ ..... .... .... .... .... .... . 00 00 00 00 00 00 ................
```

4

```
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   = N        ETAP  = 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
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
EBMON = N

=>
```

Figure 12.4: Example Standard 15-Cycle Event Report 1/4 Cycle Resolution (Backup Protection)

Table 12.5: Standard Event Report Current and Frequency Columns (Line Current Differential)

Column Heading		Definition
Local	IA	Local Phase A current
	IB	Local Phase B current
	IC	Local Phase C 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 Phase A terminal currents.
	IB	Sum of all Phase B terminal currents.
	IC	Sum of all Phase C terminal currents.
FREQ		Frequency measured by the relay

Table 12.6: Output, Input and Protection, and Control Element Event Report Columns (Line Current Differential)

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

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
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
		1	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
		1	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
		1	Tap load time-overcurrent negative seq element timing to reset after having timed out (not electromechanical reset)
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

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
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

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

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
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
Out2 5 6	OUT205, OUT206	1	OUT205 asserted
		2	OUT206 asserted
		b	Both OUT205 and OUT206 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

EXAMPLE STANDARD 15-CYCLE EVENT REPORT (DIFFERENTIAL PROTECTION)

The following example standard 15-cycle event report in Figure 12.5 also corresponds to the example sequential events recorder (SER) report in Figure 12.8. The boxed numbers in Figure 12.5 correspond to the SER row numbers in Figure 12.8. The row explanations follow Figure 12.8.

```
=>EVE <ENTER>

SEL-311L                          Date: 06/15/01    Time: 10:25:24.810
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311L-R100-V0-Z001001-D20010625       CID=396E

                  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
```

Figures 12.6 and 12.7

```
[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
[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 In1
             101010      77           DD D O 1357 135  135
ABCG2L ABCG2 PPGGQQ ABCE G2 1234 1234 TT D K 246A 246  246
[1]
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
[2]
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
[3]
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
[4]
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...
...... ***.. ...... .... .. .... .... .. * X .... ...  ...>
[5]
...... ***.. ...... ...* .. .... .... .. * X .... ...  ...
.**..* *.... ...... .*** .. .... .... .b * X b4.. b..  ...
.**.** *.... ...... .**. .. .... .... .b * X b4.. b..  ...
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...
```

15 14 21 22 23 18 20 19 17

```
[6]
.**.** *.... ...... .**. .. .... .... 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]
.**.** *.... ...... .**. .. .... .... Xb * X b4.. b..  ...
.**.** *.... ...... .**. .. .... .... Xb * X b... b..  ...
.**.** *.... ...... .**. .. .... .... Xb * X b... b..  ...
.*..** *.... ...... .*.* .. .... .... Xb * X b... b..  ...
[12]
....** *.... ...... .*** .. .... .... Xb * X b... b..  ...
....** ..... ...... .... .. .... .... Xb * X b... b..  ...
...... ..... ...... .... .. .... .... Xb * X b... b..  ...
...... ..... ...... .... .. .... .... Xb * X b... b..  ...
[13]
...... ..... ...... .... .. .... .... Xb * X b... b..  ...
...... ..... ...... .... .. .... .... Xb * X b... b..  ...
...... ..... ...... .... .. .... .... X. * X b... b..  ...
...... ..... ...... .... .. .... .... .. * X b... b..  ...
[14]
...... ..... ...... .... .. .... .... .. * X b... b..  ...
...... ..... ...... .... .. .... .... .. * X .... b..  ...
...... ..... ...... .... .. .... .... .. * X .... b..  ...
...... ..... ...... .... .. .... .... .. * 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   = N        ETAP  = 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
```

```
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
EBMON = N

=>
```

Figure 12.5: Example Standard 15-Cycle Event Report 1/4 Cycle Resolution (Differential Protection)

Figure 12.6 and Figure 12.7 look in detail at 1 cycle of B-phase total current (column Total IB) identified in Figure 12.5. Figure 12.6 shows how the event report ac current column data relates to the actual filtered waveform and RMS values. Figure 12.7 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 12.4 and Figure 12.5. Notice that the currents decrease to about zero 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 1/2 cycle plus channel delay by the data alignment processing algorithms.

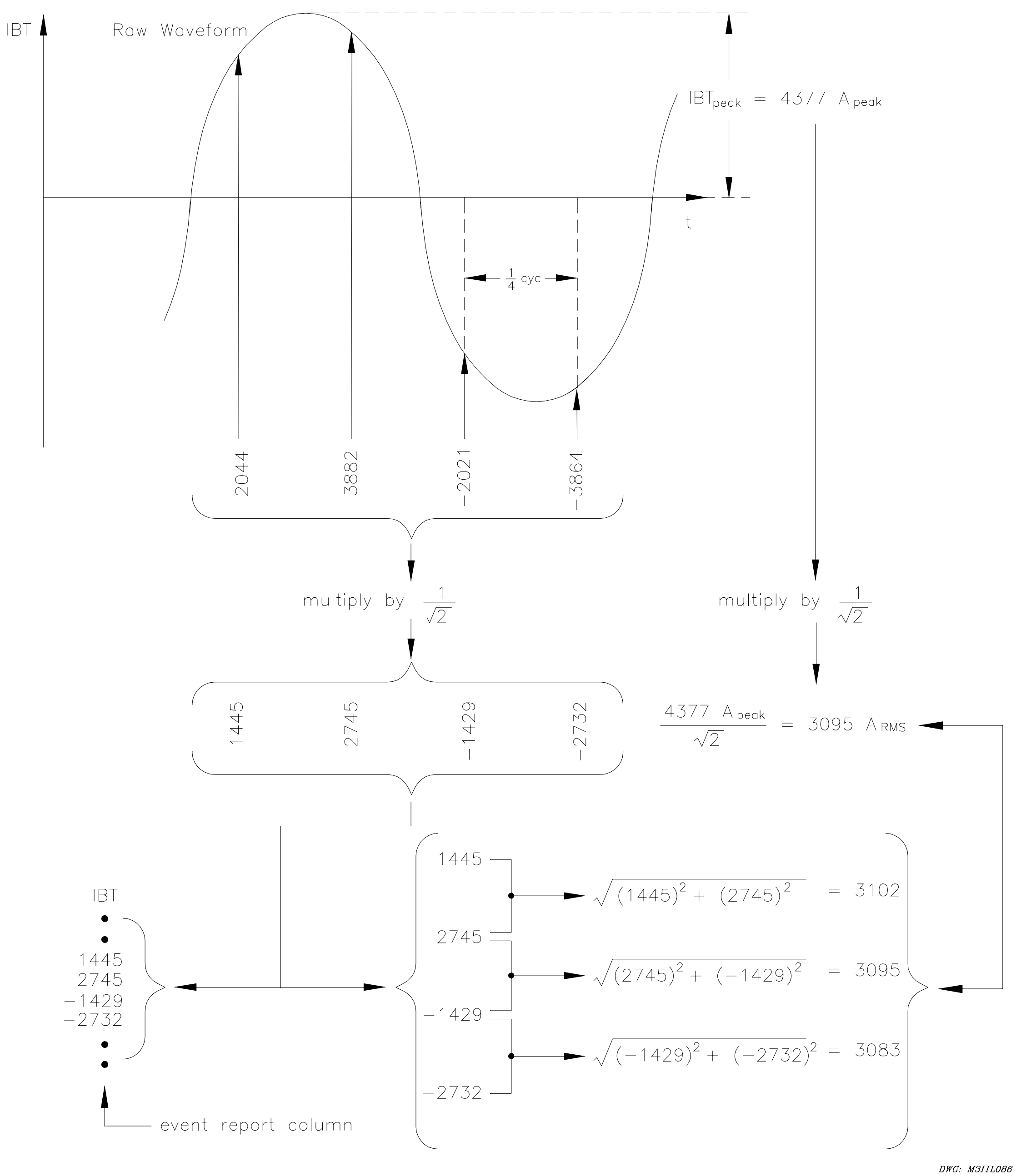

Figure 12.6: Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In Figure 12.6, note that any two rows of current data from the event report in Figure 12.5, 1/4 cycle apart, can be used to calculate RMS current values.

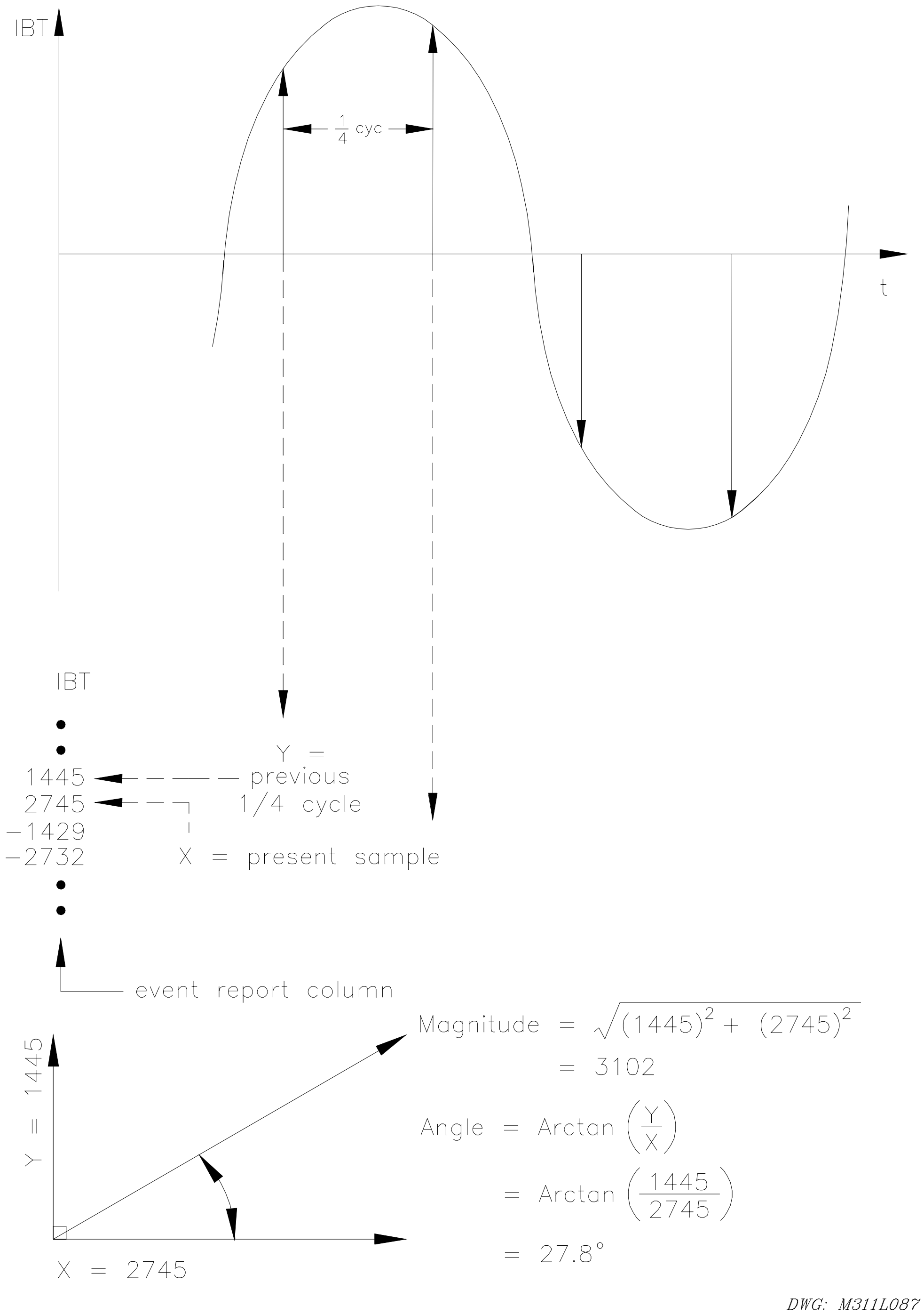

Figure 12.7: Derivation of Phasor RMS Current Values From Event Report Current Values

In Figure 12.7, note that two rows of current data from the event report in Figure 12.5, 1/4 cycle apart, can be used to calculate phasor RMS current values. In Figure 12.7, at the present sample, the phasor RMS current value is:

IBT = 3102 A $\angle$ 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 (SER) REPORT

See Figure 12.8 for an example SER report.

SER Triggering

The relay triggers (generates) an entry in the SER report for a change of state of any one of the elements listed in the SER1, SER2, and SER3 trigger settings. The factory default settings are:

SER1 = 87L, 87L2, 87LG, 87LA, 87LB, 87LC, R87L2, R87LG, R87LA, R87LB, R87LC

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 9.4. 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 power up or 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 up to 24 element names in each of the SER settings via the **SET R** command. See Tables 9.3 and 9.4 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: Setting the Relay***. 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 up to 72 elements in the SER (24 in each of SER1, SER2, and SER3).

Retrieving SER Reports

The relay saves the latest 512 rows of the SER in nonvolatile memory. Row 1 is the most recently triggered row, and row 512 is the oldest. View the SER report by date or SER row number as outlined in the examples below.

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 Sequential Events Recorder (SER) Report

An example sequential events recorder (SER) report is shown in Figure 12.8.

```
=>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

30    06/15/01  10:25:24.709  R87L2              Asserted
29    06/15/01  10:25:24.711  R87LC              Asserted
28    06/15/01  10:25:24.711  R87L2              Deasserted
27    06/15/01  10:25:24.713  R87LB              Asserted
26    06/15/01  10:25:24.713  R87L2              Asserted
25    06/15/01  10:25:24.714  R87LA              Asserted
24    06/15/01  10:25:24.726  R87L2              Deasserted
23    06/15/01  10:25:24.728  R87L2              Asserted
22    06/15/01  10:25:24.730  R87L2              Deasserted
21    06/15/01  10:25:24.812  R87LC              Deasserted
20    06/15/01  10:25:24.813  R87LB              Deasserted
19    06/15/01  10:25:24.816  TRIP87             Asserted
18    06/15/01  10:25:24.816  87LC               Asserted
17    06/15/01  10:25:24.816  87L                Asserted
16    06/15/01  10:25:24.819  87LB               Asserted
15    06/15/01  10:25:24.818  M2P                Asserted
14    06/15/01  10:25:24.818  TRIP               Asserted
13    06/15/01  10:25:24.818  KEY                Asserted
12    06/15/01  10:25:24.822  87L2               Asserted
11    06/15/01  10:25:24.823  M1P                Asserted
10    06/15/01  10:25:24.914  M1P                Deasserted
9     06/15/01  10:25:24.918  M2P                Deasserted
8     06/15/01  10:25:24.918  KEY                Deasserted
7     06/15/01  10:25:24.924  87LC               Deasserted
6     06/15/01  10:25:24.925  87LB               Deasserted
5     06/15/01  10:25:24.930  R87LA              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 12.8: Example Sequential Events Recorder (SER) Event Report

Give special attention to the time stamps associated with SER 16 and 15. SER 16 has an “older” time stamp than SER 15. 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 12.8 are explained in the following text, numbered in correspondence to the **#** column. The boxed, numbered comments in Figure 12.4 and Figure 12.5 also correspond to the **#** column numbers in Figure 12.8.

SER Row No.	Explanation
22, 21, 20	B-phase, C-phase, and negative-sequence differential restraints deassert during inception of the fault.
19, 18, 17	Differential element 87LC asserts which calls for a differential trip, TRIP87. 87L which is 87LA + 87LB + 87LC + 87L2 + 87LG also asserts.
16	B-phase differential element 87LB asserts.
15	The Zone 2 distance element M2P asserts.
14	TRIP asserts.
13	The POTT scheme asserts Relay Word bit KEY which closes OUT104.
12	Negative-sequence differential element 87L2 asserts.
11	The Zone 1 distance element M1P asserts.
10–3	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 12.5) with OUT101 = TRIP and OUT201 = TRIP + TRIP87. In Figure 12.5, 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 Through OUT206*** in ***Section 7: Input, Output, Timers, and Other Control Logic*** for an in-depth explanation of the TRIP and TRIP87 logic.

TABLE OF CONTENTS

SECTION 13: TESTING, TROUBLESHOOTING, AND COMMISSIONING 13-1

TABLES

FIGURES

SECTION 13: TESTING, TROUBLESHOOTING, AND COMMISSIONING

Introduction

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, and maintenance testing. 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

When: When qualifying a relay model to be used on the utility system.

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.

What to test: All protection elements and logic functions critical to the intended application.

SEL performs detailed acceptance testing on all new relay models and versions. We are certain the relays we ship meet their published specifications. It is important for you to perform acceptance testing on a relay if you are unfamiliar with its operating theory, protection scheme logic, or settings. This helps ensure the accuracy and correctness of the relay settings when you issue them.

Commissioning Testing

When: When installing a new protection system.

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.

What to test: All connected or monitored inputs and outputs, polarity and phase rotation of ac connections, simple check of protection elements.

SEL performs a complete functional check and calibration of each relay before it is shipped. This helps ensure that you receive a relay that operates correctly and accurately. Commissioning tests should verify that the relay is properly connected to the power system and all auxiliary equipment. Verify control signal inputs and outputs. Check breaker auxiliary inputs, SCADA control inputs, and monitoring outputs. Use an ac connection check to verify that the relay current and voltage inputs are of the proper magnitude and phase rotation.

Brief fault tests ensure that the relay settings are correct. It is not necessary to test every relay element, timer, and function in these tests.

At commissioning time, use the relay METER command to verify the ac current and voltage magnitude and phase rotation. Use the PULSE command to verify relay output contact operation. Use the TARGET command to verify optoisolated input operation.

Maintenance Testing

When: At regularly scheduled intervals or when there is an indication of a problem with the relay or system.

Goals:
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.

What to test: Anything not shown to have operated during an actual fault within the past maintenance interval.

SEL relays use extensive self-testing capabilities and feature detailed metering and event reporting functions that lower the utility dependence on routine maintenance testing.

Use the SEL relay reporting functions as maintenance tools. Periodically verify that the relay is making correct and accurate current and voltage measurements by comparing the relay METER output to other meter readings on that line. Review relay event reports in detail after each fault. Using the event report current, voltage, and relay element data, you can determine that the relay protection elements are operating properly. Using the event report input and output data, you can determine that the relay is asserting outputs at the correct instants 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

The following features assist you during relay testing.

MET and MET B Commands	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: Line Current Differential Communications and Serial Port Communications and Commands*** and ***Section 11: Front-Panel Interface***.
TST Command	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. **Note that 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.**
EVENT Command	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: Standard Event Reports and SER***.
SUM Command	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: Standard Event Reports and SER*** for more information on the event summary.
SER Command	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: Standard Event Reports and SER***.

TARGET Command	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: Line Current Differential Communications and Serial Port Communications and Commands*** and ***Section 11: Front-Panel Interface.***
PULSE Command	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: Line Current Differential Communications and Serial Port Communications and Commands***.

Low-Level Test Interface

The SEL-311L Relay 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 or 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).

You can test the relay processing module 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.

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

You can test the input module two different ways:

1. Measure the outputs from the input module with an accurate voltmeter (measure signal pin to GND pin), and compare the readings to accurate instruments in the relay input circuits, or
2. Replace the ribbon cable, press the front-panel **{METER}** button, and compare the relay readings to other accurate instruments in the relay input circuits.

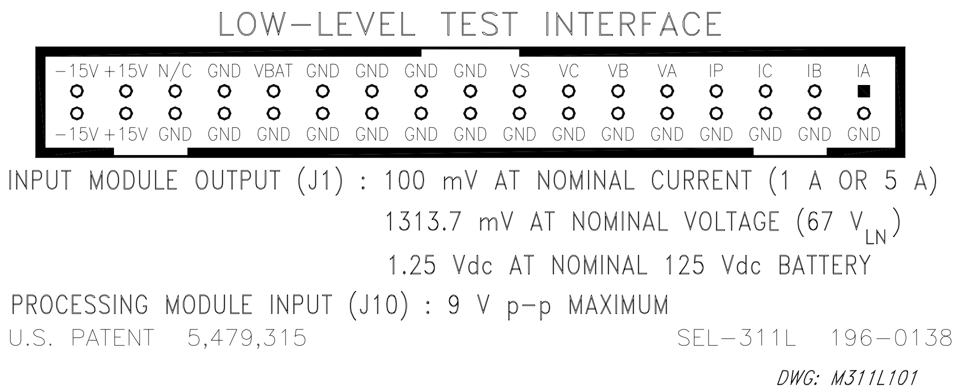

Figure 13.1: Low-Level Test Interface

Test Methods

Test the pickup and dropout of relay elements using one of three methods: target command indication, output contact closure, or sequential events recorder (SER).

The examples below show the settings necessary to route the phase time-overcurrent element 51PT to the output contacts and the SER. The 51PT element, like many in the SEL-311L Relay, 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 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. To display the state of the 51PT element on the front-panel display, press the OTHER pushbutton, cursor to the TAR option, and press SELECT. Press the up arrow pushbutton until TAR 28 is displayed on the top row of the LCD. The bottom row of the LCD displays all elements asserted in Relay Word Row 28. The relay maps the state of the elements in Relay Word Row 28 on the bottom row of LEDs. The 51PT element state is reflected on the LED labeled B. See Table 9.4 for the correspondence between the Relay Word elements and the **TAR** command.

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: Line Current Differential Communications and Serial Port Communications and Commands*** and ***Section 11: Front-Panel Interface*** 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 through OUT206 for Model 0311L00x) to the element under test. The available elements are the Relay Word bits referenced in Table 9.4.

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: Setting the Relay***. 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 through SER3). See ***Section 12: Standard Event Reports and SER***.

To test the phase time-overcurrent element 51PT with the SER, make the following setting:

SER1 = 51P, 51PT

Element 51P asserts when phase current is above the pickup of the phase time-overcurrent element. Element 51PT asserts when the phase time-overcurrent element times out. The assertion and deassertion of these elements is time-stamped in the SER report. Use this method to verify timing associated with time-overcurrent elements, reclosing relay operation, etc. Do not forget to reenter the correct relay settings when you are ready to place the relay in service.

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 prefault load current, then switch to an internal or external fault. Since the SEL-311L Relay 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 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 through OUT206 using setting EHST. The tests used symmetrical fault currents only, so they can be easily reproduced.

The SEL-5601 produces Alpha plane plots from SEL-311L Relay compressed event reports. The Alpha plane plot gives a quick visual indication that is especially useful for evaluating 87L element security. See Figure 3.9.

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 is deasserted indicating that the Alpha plane ratio falls outside the restraint region, and the operate element is asserted indicating 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 Relay.

The test procedure outlined below assumes factory default settings of:

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 Relay 87L Element Test Procedure

Purpose: Test the accuracy of phase and negative sequence 87L elements. Test the ground 87L element using an identical procedure.

Test Outline: Test the phase 87L element accuracy for A-phase (B- and C-phase optional), then test the negative-sequence 87L element accuracy. (Detailed test procedure follows.)

I: Test Phase 87L Element Accuracy

Test the phase operate element 87LOPA. To test the operate element, apply a low-current internal three-phase fault, then increase the difference current until the relay trips.

Test the phase restraint element R87LA. 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. Increase the magnitude of the currents at the remote relay until the restraint bit R87LA asserts. Continue to increase the magnitude of the remote currents until restraint bit R87LA deasserts. Repeat with various phase angles applied between local and remote currents. Finally, apply an internal fault with equal current at each relay. 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.

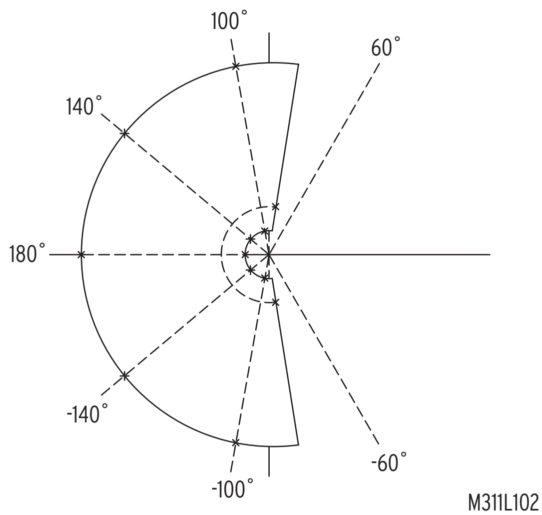

Figure 13.2: Alpha Plane Element Accuracy Test Points

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.

II: Test Negative-Sequence 87L Element Accuracy

Test the negative-sequence operate element 87LOP2. To test the negative sequence operate element, apply a low-grade internal three-phase fault. Then increase one phase current (creating negative-sequence current at one end) until the relay trips. 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. 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. Then increase the remote current until the R87L2 asserts in the local relay. Continue to increase the remote current until R87L2 deasserts. Finally, apply an internal ground fault with equal current at each relay. 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.
- SEL cable C234A

Test Setup:

1. Ensure the relay is set appropriately.
2. Connect three-phase secondary injection current sources or low-level test sources to the relays.
3. Connect the PC to the relays with an SEL C234A cable, and establish communications.

Test Procedure: The following procedure assumes Inom = 5 A. If Inom = 1 A, adjust the applied currents and pickup settings accordingly.

I: Phase 87L Element Tests

1. Make settings 87L2P = OFF, 87LGP = OFF, 87LPP = 6.0.
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

3. Increase IA in the remote relay at 0 degrees until the relay trips. Record the remote A-phase current which causes the relay to trip. Ensure it is within the range indicated.

   3.4 A < _________ < 3.6 A

4. Return A-phase current to 2.5 A, and repeat with the B- and C-phase currents if desired. Expect similar results.
5. Apply the following currents:

   Local Relay: IA = 2.33 A ∠0 degrees

   Remote Relay: IA = 0 A ∠180 degrees

6. 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. Ensure bit R87LA is deasserted.
7. Increase the remote A-phase current at 180 degrees until the R87LA bit solidly asserts. Record the remote A-phase current required to solidly assert R87LA in Table 13.1. Ensure it is within the expected range indicated.

Table 13.1: 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

8. Apply the following currents:

   Local Relay: IA = 2.33 A ∠0 degrees

   Remote Relay: IA = 13 A ∠180 degrees*

   * The SEL-311L Relay is rated to withstand 3 • Inom indefinitely.

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. Ensure bit R87LA is asserted.

10. Increase the remote A-phase current at 180 degrees until the R87LA bit is no longer solidly asserted (until it begins to deassert). Record the remote A-phase current required to begin to deassert R87LA in Table 13.2. Ensure it is within the expected range indicated in the table.

11. Repeat Steps 5 though 10 above for each remote current angle shown in Table 13.1 and Table 13.2.

Table 13.2: 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

12. Apply the following currents:

    Local Relay: IA = 5 A ∠0 degrees

    Remote Relay: IA = 5 A ∠0 degrees

13. 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. Ensure bit R87LA is deasserted.

14. Increase the angle of the remote IA from zero until Relay Word bit R87LA is solidly asserted. Record the angle of IA required to solidly assert R87LA. Ensure it is within the range expected:

    80 degrees < _________ < 85 degrees

15. Decrease the angle of the remote IA from zero (more negative) until Relay Word bit R87LA is solidly asserted. Record the angle of IA required to solidly assert R87LA. Ensure it is within the range expected:

    -85 degrees < _________ < -80 degrees

II: Negative-Sequence 87L Element Tests

1. Make settings 87L2P = 0.5, 87LGP = OFF, 87LPP = OFF.

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

3. Increase IA in the remote relay at 0 degrees until the relay trips. Record the remote A-phase current which causes the relay to trip. Ensure it is within the range indicated.

    1.19 A < __________ < 1.31 A

4. Return the remote relay A-phase current to 0.75 A, and repeat with the B- and C-phase currents if desired. Expect similar results.

5. Apply the following currents:

    Local Relay: IA = 2.33 A ∠0 degrees

    Remote Relay: IA = 0 A ∠180 degrees

6. 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. Ensure bit R87L2 is deasserted.

7. Increase the remote A-phase current at 180 degrees until the R87L2 bit solidly asserts. Record the remote A-phase current required to solidly assert R87L2 in Table 13.3. Ensure it is within the expected range indicated.

Table 13.3: 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

8. Apply the following currents:

   Local Relay: IA = 2.33 A ∠0 degrees

   Remote Relay: IA = 13 A ∠180 degrees*

   * The SEL-311L Relay is rated to withstand 3 • Inom indefinitely.

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. Ensure bit R87L2 is asserted.

10. Decrease the remote A-phase current at 180 degrees until the R87L2 bit is no longer solidly asserted (until it begins to deassert). Record the remote A-phase current required to begin to deassert R87L2 in Table 13.4. Ensure it is within the expected range indicated.

11. Repeat Steps 5 though 10 above for each remote current angle shown in Table 13.3 and Table 13.4.

Table 13.4: 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

12. Apply the following currents:

    Local Relay: IA = 5 A ∠0 degrees

    Remote Relay: IA = 5 A ∠0 degrees

13. 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. Ensure bit R87L2 is deasserted.

14. Increase the angle on the remote IA from zero until Relay Word bit R87L2 is solidly asserted. Record the angle of IA required to solidly assert R87L2. Ensure it is within the range expected:

    80 degrees < _________ < 85 degrees

15. Decrease the angle on the remote IA from zero (more negative) until Relay Word bit R87L2 is solidly asserted. Record the angle of IA required to solidly assert R87LA. Ensure it 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 13.5):

- Protection Disabled: The relay disables overcurrent elements and trip/close logic. All output contacts are deenergized. The EN front-panel LED is extinguished.
- ALARM Output: The ALARM output contact signals an alarm condition by going to its deenergized state. If the ALARM output contact is a B contact (normally closed), it closes for an alarm condition or if the relay is deenergized. If the ALARM output contact is an A contact (normally open), it opens for an alarm condition or if the relay is deenergized. 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 deenergizes 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.

Use the serial port STATUS command or front-panel STATUS pushbutton to view relay self-test status.

Table 13.5: Relay Self-Tests

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	

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
TEMP	Warning Failure	-40° C +85° C -50° C +100° C	No Yes	 Latched	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.
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 Channel Monitors*** description in ***Section 10***.
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.

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
The following self-tests are performed by dedicated circuitry in the microprocessor and the SEL-311L Relay main board. Failures in these tests shut down the microprocessor and are not shown in the STATUS report.					
Micro-processor Crystal	Failure		Yes	Latched	The relay monitors the micro-processor crystal. If the crystal fails, the relay displays "CLOCK STOPPED" on the LCD display. The test runs continuously.
Micro-processor	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***.

1. Measure and record the power supply voltage at the power input terminals.
2. Check to see that the power is on. Do not turn the relay off.
3. Measure and record the voltage at all control inputs.
4. 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 deenergized. Check to see if the ALARM contact is closed.
2. LCD contrast is out of adjustment. Use the steps below to adjust the contrast.
   a) Remove the relay front panel by removing the six front-panel screws.
   b) Press any front-panel button. The relay should turn on the LCD back lighting.
   c) Locate the contrast adjust potentiometer adjacent to the serial port connector.
   d) Use a small screwdriver to adjust the potentiometer.
   e) Replace the relay front panel.

Relay Does Not Respond to Commands From Device Connected to Serial Port

1. Ensure that the communications device is connected to the relay.
2. Verify relay or communications device baud rate setting and other communications parameters. Check for a cabling error.
3. Relay serial port may have received an XOFF, halting communications. Type **<CTRL>Q** to send relay an XON and restart communications.
4. Relay may be set to LMD protocol, which requires an address to turn on the serial port. View the port setting 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 Faults

1. Verify that the 87CH FAIL front-panel LED is extinguished.
2. Verify that the relay is properly set.
3. Verify that the test source is properly set.
4. Verify that the test connections are correct using the **MET** command.
5. Ensure that the analog input cable between transformer secondary and main board is not loose or defective.
6. Inspect the relay self-test status with the **STA** command or with the front-panel STATUS button.

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 up to 15 seconds to extinguish after the problem is resolved.

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. If only one channel interface is in use, but the relay is equipped with two channel interfaces, ensure setting PCHAN selects the intended channel.

b. 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.

c. Inspect the channel settings 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.

2. Determine if there is channel delay problem.

   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. 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.

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 3.b.

   i. 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 3.a.ii.

   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 indicate Address Error if the address settings in both relays are not correct.

   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. Wait a few minutes and issue the COMM X or COMM Y commands 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.

   For EIA-422 interfaces, ensure clock polarity settings TC422X, RC422X, TC422Y, or RC422Y are correct for the connected DCE.

   For other interfaces, ensure settings TIMRX or TIMRY are correct. If channel X is connected to a multiplexer, or to any DCE, verify that setting TIMRX = E. If channel X is connected directly to another relay, ensure TIMRX = E in one relay, and TIMRX = I in the other relay. Likewise ensure setting TIMRY is correct for channel Y.

   If the problem persists, the communications link is probably noisy, or unreliable.

ii. If the RX LED is extinguished, the local relay is not receiving valid packets from the remote relay.

   Verify setting E87L is not OFF. If E87L is 2 or 3R, and the relay is equipped with two channel interfaces, verify PCHAN selects the appropriate primary channel. If E87L is 2 and the relay is equipped with two channel interfaces, verify hot-standby enable setting EHSC = Y if appropriate.

   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 is has the proper pinout. For an EIA-422 interface, verify 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 2.6 and Figure 2.7 for connector pinouts.

   For fiber interfaces, swap the transmit and receive fibers at the rear panel of the relay. 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 Proposed Standard PC37.94 interface.

   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 leaves the remote relay does not arrive at the local relay.

b. 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.

4. If the problem persists, contact the factory for assistance.

Relay Calibration

The SEL-311L Relay is factory-calibrated. If you suspect that the relay is out of calibration, please contact the factory.

Factory Assistance

The employee-owners of Schweitzer Engineering Laboratories are dedicated to making electric power safer, more reliable, and more economical.

We appreciate your interest in SEL products, and we are committed to making sure you are satisfied. If you have any questions, please contact us at:

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SECTION 14: APPLICATION SETTINGS FOR SEL-311L RELAYS

INTRODUCTION

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).

APPLICATION SETTING 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 communications channel failure. No potentials are required by the relay in this application.

When APP = 87L, the SEL-311L:

1. Configures itself as full-function differential relay. All differential and tapped load settings are available.
2. Enables two phase-overcurrent and two ground-overcurrent elements:
   - 50P—instantaneous/definite-time phase-overcurrent element (E50P = 1)
   - 50G—instantaneous/definite-time ground-overcurrent element (E50G = 1)
   - 51P—inverse-time phase-overcurrent element (E51P = Y)
   - 51G—inverse-time ground-overcurrent element (E51G = Y)
3. Hides settings for:
   - Polarizing (IPOL) CT Ratio (CTRP)
   - Phase (VA, VB, VC) PT Ratio (PTR)
   - Synchronism Voltage (VS) PT Ratio (PTRS)
   - Positive-Sequence Line Impedance Magnitude (Z1MAG)
   - Positive-Sequence Line Impedance Angle (Z1ANG)
   - Zero-Sequence Line Impedance Magnitude (Z0MAG)
   - Zero-Sequence Line Impedance Angle (Z0ANG)
   - Line Length (LL)
   - Directional control (E32 = AUTO)
   - SELOGIC® variables (ESV = 1)
   - SELOGIC Display points (EDP = 3)
   - Demand metering (EDEM = THM)

4. Disables and hides settings for:
    - Mho phase distance elements (E21P = N)
    - Mho ground distance elements (E21MG = N)
    - Quadrilateral ground distance elements (E21XG = N)
    - 50Q—instantaneous/definite-time negative-sequence overcurrent elements (E50Q = N)
    - 51Q—inverse-time negative-sequence overcurrent elements (E51Q = N)
    - Out-of-step elements (EOOS = N)
    - Load-encroachment elements (ELOAD = N)
    - Switch-onto-fault (ESOTF = N)
    - Voltage elements (EVOLT = N)
    - Synchronism check elements (E25 = N)
    - Frequency elements (E81 = N)
    - Fault locator (EFLOC = N)
    - Loss-of-potential (ELOP = N)
    - Communications-assisted trip schemes (ECOMM = N)
    - Reclosing (E79 = N)
    - CCVT transient protection (ECCVT = N)
    - SELOGIC Latch bits (ELAT = N)
    - Advanced settings (EADVS = N)
    - Ground directional element priority (ORDER = OFF)
5. Changes default SELOGIC control equations to:
    - TR = 67P1T + 67G1T + 51PT + 51GT + OC
    - 67P1TC = !87LPE + 87HWAL
    - 67G1TC = !87LPE + 87HWAL
    - 51PTC = !87LPE + 87HWAL
    - 51GTC = !87LPE + 87HWAL
    - T51QTC* = 87L
    - T50PTC* = 87L
    - T50GTC* = 87L
    - T50QTC* = 87L
    - ER = /B87L2 + /50P1 + /50G1 + /51P + /51G

    * **Note:** These settings are visible when T50 and T51 functions are enabled.

6. Makes no changes to:
    - Global settings
    - Port settings
    - Text settings
    - SER settings
    - Differential Channel X settings
    - Differential 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 = 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   = N        ETAP  = 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    =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
ER    =/B87L2 + /50P1 + /50G1 + /51P + /51G

T1X   =0
T2X   =0
T1Y   =0
T2Y   =0
=>>
```

Settings Sheet for the SEL-311L Relay (APP = 87L)
Relay Settings (Serial Port Command SET and Front Panel)

Identifier Labels and Configuration Settings (See *Settings Explanations* in *Section 9*)

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, 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 disturbance detect (Y, N) EDD = ________

Tapped-load coordination (Y, N) ETAP = ________

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 PCHAN = Y or EHSC = Y or E87L = 3:

CTR at terminal connected to Channel Y (1–6000) CTR_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 3.42)

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 3.42)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) 67P1D = ________

Residual Ground Inst./Def.-Time Overcurrent Elements (See Figure 3.45)

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 3.45)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) 67G1D = ________

Phase Time-Overcurrent Element (See Figure 3.47)

Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}) 51PP = ________

Curve (U1–U5, C1–C5) (see Figures 9.1 through 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 3.48)

Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}) 51GP = ________

Curve (U1–U5, C1–C5) (see Figures 9.1 through 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 = ________

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

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 ***Sections 3*** through ***8***. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). ***Appendix G: Setting SELOGIC Control Equations*** gives SELOGIC control equation details, examples, and limitations.

Trip Logic Equations (See Figure 5.4)

Direct trip conditions TR = ______________________________

Unlatch trip conditions ULTR = ______________________________

Close Logic Equations (See Figure 6.1)

Circuit breaker status (used in Figure 5.5, 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 3.42) 67P1TC = ______________________________

Level 1 residual ground (see Figure 3.45) 67G1TC = ______________________________

Torque Control Equations for Time-Overcurrent Elements

[Note: torque control equation settings cannot be set directly to logical 0]

Phase element (see Figure 3.47) 51PTC = ______________________________

Residual ground element (see Figure 3.48) 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 3.23) T51PTC = ______________________________

Ground inverse time (see Figure 3.24) T51GTC = ______________________________

Negative-sequence time (see Figure 3.25) 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 3.20) T50PTC = ______________________________

Ground instantaneous (see Figure 3.21) T50GTC = ______________________________

Negative-sequence instantaneous (see Figure 3.22) T50QTC = ______________________________

Output Contact Equations (See Figure 7.26)

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 7.27)

Output Contact OUT201	OUT201 = ________
Output Contact OUT202	OUT202 = ________
Output Contact OUT203	OUT203 = ________
Output Contact OUT204	OUT204 = ________
Output Contact OUT205	OUT205 = ________
Output Contact OUT206	OUT206 = ________

Other Equations

Event report trigger conditions (see ***Section 12***)	ER = ________

Mirrored Bits™ Transmit Equations (See *Appendix I*)

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 Y, transmit bit 1	T1Y = ________________
Channel Y, transmit bit 2	T2Y = ________________

Settings Group Change Delay (See *Multiple Setting Groups* in *Section 7*)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps) TGR = ____________

Power System Configuration and Date Format (See *Settings Explanations* in *Section 9*)

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 PRE = _____________
(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)

Station DC Battery Monitor (See Figures 8.9 and 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 (0.00–1.00 cycles in 0.25-cycle steps) IN101D = __________

Input IN102 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN102D = __________

Input IN103 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN103D = __________

Input IN104 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN104D = __________

Input IN105 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN105D = __________

Input IN106 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN106D = __________

Breaker Monitor Settings (See *Breaker Monitor* in *Section 8*)

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= ________

SEQUENTIAL EVENTS RECORDER SETTINGS (SERIAL PORT COMMAND SET R)

Sequential Events Recorder settings are comprised of three trigger lists. Each trigger list can include up to 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See ***Sequential Events Recorder (SER) Report*** in ***Section 12***.

SER Trigger List 1 SER1 = ________________

SER Trigger List 2 SER2 = ________________

SER Trigger List 3 SER3 = ________________

Settings Sheet
for the SEL-311L Relay (APP = 87L)
Text Label Settings (Serial Port Command SET T)

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

Local Bit Labels (See Tables 7.1 and 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 = ______________________

Settings Sheet for the SEL-311L Relay (APP = 87L)
Text Label Settings (Serial Port Command SET T)

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* in *Section 7* and *11*)

Display if DP1 = logical 1 (16 characters) DP1_1 = ________________
Display if DP1 = logical 0 (16 characters) DP1_0 = ________________

Display if DP2 = logical 1 (16 characters) DP2_1 = ________________
Display if DP2 = logical 0 (16 characters) DP2_0 = ________________

Display if DP3 = logical 1 (16 characters) DP3_1 = ________________
Display if DP3 = logical 0 (16 characters) DP3_0 = ________________

Display if DP4 = logical 1 (16 characters) DP4_1 = ________________
Display if DP4 = logical 0 (16 characters) DP4_0 = ________________

Display if DP5 = logical 1 (16 characters) DP5_1 = ________________
Display if DP5 = logical 0 (16 characters) DP5_0 = ________________

Display if DP6 = logical 1 (16 characters) DP6_1 = ________________
Display if DP6 = logical 0 (16 characters) DP6_0 = ________________

Display if DP7 = logical 1 (16 characters) DP7_1 = ________________
Display if DP7 = logical 0 (16 characters) DP7_0 = ________________

Display if DP8 = logical 1 (16 characters) DP8_1 = ________________
Display if DP8 = logical 0 (16 characters) DP8_0 = ________________

Display if DP9 = logical 1 (16 characters) DP9_1 = ________________
Display if DP9 = logical 0 (16 characters) DP9_0 = ________________

Display if DP10 = logical 1 (16 characters) DP10_1 = ________________
Display if DP10 = logical 0 (16 characters) DP10_0 = ________________

Display if DP11 = logical 1 (16 characters) DP11_1 = ________________
Display if DP11 = logical 0 (16 characters) DP11_0 = ________________

Display if DP12 = logical 1 (16 characters) DP12_1 = ________________
Display if DP12 = logical 0 (16 characters) DP12_0 = ________________

Display if DP13 = logical 1 (16 characters) DP13_1 = ________________
Display if DP13 = logical 0 (16 characters) DP13_0 = ________________

Display if DP14 = logical 1 (16 characters) DP14_1 = ____________________
Display if DP14 = logical 0 (16 characters) DP14_0 = ____________________

Display if DP15 = logical 1 (16 characters) DP15_1 = ____________________
Display if DP15 = logical 0 (16 characters) DP15_0 = ____________________

Display if DP16 = logical 1 (16 characters) DP16_1 = ____________________
Display if DP16 = logical 0 (16 characters) DP16_0 = ____________________

Reclosing Relay Labels (See *Functions Unique to the Front-Panel Interface* in *Section 11*)

Reclosing Relay Last Shot Label (14 char.) 79LL = ____________________
Reclosing Relay Shot Counter Label (14 char.) 79SL = ____________________

Protocol Settings (See Below)

Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B) 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 H*** for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, or MB8B. Refer to ***Appendix I*** for details on MIRRORED BITS.

The following settings are used if PROTO = LMD.

LMD Prefix (@, #, $, %, &) PREFIX = ________

LMD Address (01–99) ADDR = ________

LMD Settling Time (0–30 seconds) SETTLE = ________

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) SPEED = ________

Data Bits (6, 7, 8) BITS = ________

Parity (O, E, N) {Odd, Even, None} PARITY = ________

Stop Bits (1, 2) STOP = ________

Other Port Settings (See Below)

Time-out (0–30 minutes) T_OUT = ________

DTA Meter Format (Y, N) DTA = ________

Send Auto Messages to Port (Y, N) AUTO = ________

Enable Hardware Handshaking (Y, N, MBT) RTSCTS = ________
(Refer to ***Appendix I*** for details on setting MBT.)

Fast Operate Enable (Y, N) FASTOP = ________

Other Port Settings 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.

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.

Set AUTO = Y to allow automatic messages at the serial port.

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.

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*** for the description of the SEL-311L Relay Fast Operate commands.

87L Channel X Configuration Settings

Channel X address check (Y, N)	EADDCX = ________
If EADDCX = Y	
Channel X transmit address (1–16)	TA_X = ___________
Channel X receive address (1–16)	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, N)	EADDCY = ________
If EADDCY = Y	
Channel Y transmit address (1–16)	TA_Y = ___________
Channel Y receive address (1–16)	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 = _________

Application Setting 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 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* = 3, E21MG* = 3).
3. Enables overcurrent elements:
   - 50P—instantaneous/definite-time phase-overcurrent element (E50P* = 1)
   - 50G—instantaneous/definite-time ground-overcurrent element (E50G* = 1)
   - 51G—inverse-time ground-overcurrent element (E51G* = Y)

   * **Note:** These settings are hidden.
4. Displays the enable settings for:
   - Loss-of-potential (ELOP = Y1)
   - Reclosing (E79 = N)
   - CCVT transient protection (ECCVT = N)
   - SELOGIC variables (ESV = N)
   - SELOGIC Latch bits (ELAT = N)
   - SELOGIC Display points (EDP = 3)

5. Hides settings for:
   - Directional control (E32 = AUTO)
   - Switch-onto-fault (ESOTF = Y)
   - Fault locator (EFLOC = Y)
   - Demand metering (EDEM = THM)
   - Phase-mho and ground-mho overcurrent fault detectors
     - (50PPn = 0.5), (50Ln = 0.5), (50GZn = 0.5), (5 A nominal) (n = 1, 2, 3)
     - (50PPn = 0.1), (50Ln = 0.1), (50GZn = 0.1), (1 A nominal)
6. Disables and hides settings for:
   - Quadrilateral ground distance elements (E21XG = N)
   - 50Q—instantaneous/definite-time negative-sequence overcurrent elements (E50Q = N)
   - 51P—inverse-time phase-overcurrent element (E51P = N)
   - 51Q—inverse-time negative-sequence overcurrent elements (E51Q = N)
   - Out-of-step elements (EOOS = N)
   - Load-encroachment elements (ELOAD = N)
   - Voltage elements (EVOLT = N)
   - Synchronism check elements (E25 = N)
   - Frequency elements (E81 = N)
   - Communications-assisted trip schemes (ECOMM = N)
   - Advanced settings (EADVS = N)
7. Automatically calculates:
   - Directional settings. See ***Settings Made Automatically*** in ***Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic***.
   - Zero-sequence compensation factors (k0M1, k0A1, k0M, k0A) as

$$\text{k0M1}\angle\text{k0A1} = \text{k0M}\angle\text{k0A} = \frac{(\text{Z0MAG}\angle\text{Z0ANG} - \text{Z1MAG}\angle\text{Z1ANG})}{3 \bullet \text{Z1MAG}\angle\text{Z1ANG}}$$

8. Changes default SELOGIC control equations to:
   - TR = M1P + Z1G + M2PT + Z2GT + 67G1T + 51GT + OC
   - 51GTC = 32GF
   - T51PTC** = 87L
   - T51GTC** = 87L
   - T51QTC** = 87L

- T50PTC** = 87L
- T50GTC** = 87L
- T50QTC** = 87L
- ER = /B87L2 + /M2P + /Z2G + /51G + /50P1 + /LOP
- FAULT = 87L + M2P + Z2G + 51G

** **Note:** These settings are visible when T50 and T51 functions are enabled.

9. Makes no changes to:
   - Global settings
   - Port settings
   - Text settings
   - SER settings
   - 87 communications Channel X settings
   - 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-311L 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   = N         ETAP  = 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    =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
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
T1X   =0

Press RETURN to continue
T2X   =0
T1Y   =0
T2Y   =0

=>>
```

SETTINGS SHEET FOR THE SEL-311L RELAY (APP = 87L21)
RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

Identifier Labels and Configuration Settings (See *Settings Explanations* in *Section 9*)

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, 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 disturbance detect (Y, N)	EDD = ________
Tapped-load coordination (Y, N)	ETAP = ________
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 PCHAN = Y or EHSC = Y or E87L = 3:	
CTR at terminal connected to Channel Y (1–6000)	CTR_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* in *Section 9*)

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 4.1)	ELOP = ________
Reclosures (N, 1–4) (see ***Reclosing Relay*** in ***Section 6***)	E79 = ________
CCVT transient detection (Y, N) (see Figure 4.2)	ECCVT = ________
SELOGIC® control equation Variable Timers (N, 1–16) (see Figures 7.23 and 7.24)	ESV = ________
SELOGIC Latch Bits (N, 1–16)	ELAT = ________
SELOGIC Display Points (N, 1–16)	EDP = ________

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 3.29)	Z1P = ________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.30)	Z2P = ________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.31)	Z3P = ________

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 3.32)	Z1MG = ________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.33)	Z2MG = ________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.34)	Z3MG = ________

Mho Phase Distance Element Time Delays (See Figure 3.39)

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 3.39)

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 3.39)

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 3.42)

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 3.42)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) 67P1D = ____________

Residual Ground Inst./Def.-Time Overcurrent Elements (See Figure 3.45)

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 3.45)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) 67G1D = ____________

Residual Ground Time-Overcurrent Element (See Figure 3.48)

Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}) 51GP = ____________
Curve (U1–U5, C1–C5) (see Figures 9.1 through 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 Tables 6.2 and 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 = ___________
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 5.5)

(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 = __________

Other Settings

Minimum trip duration time (4.00–16000.00 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 Figures 7.23 and 7.24)

(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 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 ***Sections 3*** through ***8***. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). ***Appendix G: Setting SELOGIC Control Equations*** gives SELOGIC control equation details, examples, and limitations.

Trip Logic Equations (See Figure 5.4)

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 5.5, also)	52A = ____________
Close conditions (other than automatic reclosing or CLOSE command)	CL = ____________
Unlatch close conditions	ULCL = ____________

Reclosing Relay Equations (See *Reclosing Relay* in *Section 6*)

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 7.11)

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 = ____________

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

Set Latch Bit LT6	SET6 = ____________
Reset latch Bit LT6	RST6 = ____________
Set Latch Bit LT7	SET7 = ____________
Reset Latch Bit LT7	RST7 = ____________
Set Latch Bit LT8	SET8 = ____________
Reset Latch Bit LT8	RST8 = ____________
Set Latch Bit LT9	SET9 = ____________
Reset Latch Bit LT9	RST9 = ____________
Set Latch Bit LT10	SET10 = ____________
Reset Latch Bit LT10	RST10 = ____________
Set Latch Bit LT11	SET11 = ____________
Reset Latch Bit LT11	RST11 = ____________
Set Latch Bit LT12	SET12 = ____________
Reset Latch Bit LT12	RST12 = ____________
Set Latch Bit LT13	SET13 = ____________
Reset Latch Bit LT13	RST13 = ____________
Set Latch Bit LT14	SET14 = ____________
Reset latch Bit LT14	RST14 = ____________
Set Latch Bit LT15	SET15 = ____________
Reset Latch Bit LT15	RST15 = ____________
Set Latch Bit LT16	SET16 = ____________
Reset Latch Bit LT16	RST16 = ____________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements

[Note: torque control equation settings cannot be set directly to logical 0]

Level 1 phase (see Figure 3.42)	67P1TC = ____________
Level 1 residual ground (see Figure 3.45)	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 3.48)	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 3.23)	T51PTC = ____________
Ground inverse time (see Figure 3.24)	T51GTC = ____________
Negative-sequence time (see Figure 3.25)	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 3.20)	T50PTC = ____________________
Ground instantaneous (see Figure 3.21)	T50GTC = ____________________
Negative-sequence instantaneous (see Figure 3.22)	T50QTC = ____________________

SELOGIC Control Equation Variable Timer Input Equations (See Figures 7.23 and 7.24)

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 7.26)

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 7.27)

Output Contact OUT201	OUT201 = ______________
Output Contact OUT202	OUT202 = ______________
Output Contact OUT203	OUT203 = ______________
Output Contact OUT204	OUT204 = ______________
Output Contact OUT205	OUT205 = ______________
Output Contact OUT206	OUT206 = ______________

Display Point Equations (See *Rotating Default Display* in *Sections 7* and *11*)

Display Point DP1	DP1 = ______________
Display Point DP2	DP2 = ______________
Display Point DP3	DP3 = ______________
Display Point DP4	DP4 = ______________
Display Point DP5	DP5 = ______________
Display Point DP6	DP6 = ______________
Display Point DP7	DP7 = ______________
Display Point DP8	DP8 = ______________
Display Point DP9	DP9 = ______________
Display Point DP10	DP10 = ______________
Display Point DP11	DP11 = ______________
Display Point DP12	DP12 = ______________
Display Point DP13	DP13 = ______________
Display Point DP14	DP14 = ______________
Display Point DP15	DP15 = ______________
Display Point DP16	DP16 = ______________

Setting Group Selection Equations (See Table 7.4)

Select Setting Group 1	SS1 = ______________
Select Setting Group 2	SS2 = ______________
Select Setting Group 3	SS3 = ______________
Select Setting Group 4	SS4 = ______________
Select Setting Group 5	SS5 = ______________
Select Setting Group 6	SS6 = ______________

Other Equations

Event report trigger conditions (see ***Section 12***)	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 ***Demand Metering*** and ***Maximum/Minimum Metering*** in ***Section 8***)	FAULT = ________________
Breaker monitor initiation (see Figure 8.3)	BKMON = ________________

MIRRORED BITS™ Transmit Equations (See *Appendix I*)

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 Y, transmit bit 1	T1Y = ________________
Channel Y, transmit bit 2	T2Y = ________________

Settings Sheet for the SEL-311L Relay (APP = 87L21)

Global Settings (Serial Port Command SET G and Front Panel)

Settings Group Change Delay (See *Multiple Setting Groups* in *Section 7*)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps) TGR = ____________

Power System Configuration and Date Format (See *Settings Explanations* in *Section 9*)

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 PRE = _____________

(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)

Station DC Battery Monitor (See Figures 8.9 and 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 (0.00–1.00 cycles in 0.25-cycle steps) IN101D = __________

Input IN102 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN102D = __________

Input IN103 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN103D = __________

Input IN104 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN104D = __________

Input IN105 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN105D = __________

Input IN106 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN106D = __________

Breaker Monitor Settings (See *Breaker Monitor* in *Section 8*)

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= ___________

Sequential Events Recorder Settings (Serial Port Command SET R)

Sequential Events Recorder settings are comprised of three trigger lists. Each trigger list can include up to 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See ***Sequential Events Recorder (SER) Report*** in ***Section 12***.

SER Trigger List 1 SER1 = ______________________________

SER Trigger List 2 SER2 = ______________________________

SER Trigger List 3 SER3 = ______________________________

Settings Sheet for the SEL-311L Relay (APP = 87L21)
Text Label Settings (Serial Port Command SET T)

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

Local Bit Labels (See Tables 7.1 and 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 = ________

SETTINGS SHEET FOR THE SEL-311L RELAY (APP = 87L21)

TEXT LABEL SETTINGS (SERIAL PORT COMMAND SET T)

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 = ________

SETTINGS SHEET FOR THE SEL-311L RELAY (APP = 87L21)
TEXT LABEL SETTINGS (SERIAL PORT COMMAND SET T)

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* in *Section 7* and *11*)

Display if DP1 = logical 1 (16 characters)	DP1_1 = ________
Display if DP1 = logical 0 (16 characters)	DP1_0 = ________
Display if DP2 = logical 1 (16 characters)	DP2_1 = ________
Display if DP2 = logical 0 (16 characters)	DP2_0 = ________
Display if DP3 = logical 1 (16 characters)	DP3_1 = ________
Display if DP3 = logical 0 (16 characters)	DP3_0 = ________
Display if DP4 = logical 1 (16 characters)	DP4_1 = ________
Display if DP4 = logical 0 (16 characters)	DP4_0 = ________
Display if DP5 = logical 1 (16 characters)	DP5_1 = ________
Display if DP5 = logical 0 (16 characters)	DP5_0 = ________
Display if DP6 = logical 1 (16 characters)	DP6_1 = ________
Display if DP6 = logical 0 (16 characters)	DP6_0 = ________
Display if DP7 = logical 1 (16 characters)	DP7_1 = ________
Display if DP7 = logical 0 (16 characters)	DP7_0 = ________
Display if DP8 = logical 1 (16 characters)	DP8_1 = ________
Display if DP8 = logical 0 (16 characters)	DP8_0 = ________
Display if DP9 = logical 1 (16 characters)	DP9_1 = ________
Display if DP9 = logical 0 (16 characters)	DP9_0 = ________
Display if DP10 = logical 1 (16 characters)	DP10_1 = ________
Display if DP10 = logical 0 (16 characters)	DP10_0 = ________
Display if DP11 = logical 1 (16 characters)	DP11_1 = ________
Display if DP11 = logical 0 (16 characters)	DP11_0 = ________
Display if DP12 = logical 1 (16 characters)	DP12_1 = ________
Display if DP12 = logical 0 (16 characters)	DP12_0 = ________
Display if DP13 = logical 1 (16 characters)	DP13_1 = ________
Display if DP13 = logical 0 (16 characters)	DP13_0 = ________

Display if DP14 = logical 1 (16 characters) DP14_1 = ________________________________
Display if DP14 = logical 0 (16 characters) DP14_0 = ________________________________

Display if DP15 = logical 1 (16 characters) DP15_1 = ________________________________
Display if DP15 = logical 0 (16 characters) DP15_0 = ________________________________

Display if DP16 = logical 1 (16 characters) DP16_1 = ________________________________
Display if DP16 = logical 0 (16 characters) DP16_0 = ________________________________

Reclosing Relay Labels (See *Functions Unique to the Front-Panel Interface* in *Section 11*)

Reclosing Relay Last Shot Label (14 char.) 79LL = ________________________________
Reclosing Relay Shot Counter Label (14 char.) 79SL = ________________________________

Protocol Settings (See Below)

Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B) 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 H*** for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, or MB8B. Refer to ***Appendix I*** for details on MIRRORED BITS.

The following settings are used if PROTO = LMD.

LMD Prefix (@, #, $, %, &) PREFIX = ________________

LMD Address (01–99) ADDR = ________________

LMD Settling Time (0–30 seconds) SETTLE = ________________

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) SPEED = ________________

Data Bits (6, 7, 8) BITS = ________________

Parity (O, E, N) {Odd, Even, None} PARITY = ________________

Stop Bits (1, 2) STOP = ________________

Other Port Settings (See Below)

Time-out (0–30 minutes) T_OUT = ________________

DTA Meter Format (Y, N) DTA = ________________

Send Auto Messages to Port (Y, N) AUTO = ________________

Enable Hardware Handshaking (Y, N, MBT) RTSCTS = ________________
(Refer to ***Appendix I*** for details on setting MBT.)

Fast Operate Enable (Y, N) FASTOP = ________________

Other Port Settings 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.

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.

Set AUTO = Y to allow automatic messages at the serial port.

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.

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*** for the description of the SEL-311L Relay Fast Operate commands.

87L Channel X Configuration Settings

Channel X address check (Y, N)	EADDCX = ________
If EADDCX = Y	
Channel X transmit address (1–16)	TA_X = ___________
Channel X receive address (1–16)	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, N)	EADDCY = ________
If EADDCY = Y	
Channel Y transmit address (1–16)	TA_Y = ___________
Channel Y receive address (1–16)	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 = __________

Application Setting 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 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)
3. Enables one phase-overcurrent and four ground-overcurrent elements:
   - 50P—instantaneous/definite-time phase-overcurrent element (E50P* = 1)
   - 50G1-3—instantaneous/definite-time ground-overcurrent element (E50G* = 3)
   - 51G—inverse-time ground-overcurrent element (E51G* = Y)

* **Note:** These settings are hidden.

4. Displays the enable settings for:
   - Loss-of-potential (ELOP = Y1)
   - Communications-assisted trip schemes (ECOMM = N)
   - Reclosing (E79 = N)
   - CCVT transient protection (ECCVT = N)
   - SELOGIC variables (ESV = N)
   - SELOGIC Latch bits (ELAT = N)
   - SELOGIC Display points (EDP = 3)

5. Hides settings for:
   - Directional control (E32 = AUTO)
   - Switch-onto-fault (ESOTF = Y)
   - Fault locator (EFLOC = Y)
   - Demand metering (EDEM = THM)
   - Phase-mho and ground-mho overcurrent fault detectors
     - (50PPn = 0.5), (50Ln = 0.5), (50GZn = 0.5), (5 A nominal) (n = 1, 2, 3)
     - (50PPn = 0.1), (50Ln = 0.1), (50GZn = 0.1), (1 A nominal)
6. Disables and hides settings for:
   - Quadrilateral ground distance elements (E21XG = N)
   - 50Q—instantaneous/definite-time negative-sequence overcurrent elements (E50Q = N)
   - 51P—inverse-time phase-overcurrent element (E51P = N)
   - 51Q—inverse-time negative-sequence overcurrent elements (E51Q = N)
   - Out-of-step elements (EOOS = N)
   - Load-encroachment elements (ELOAD = N)
   - Voltage elements (EVOLT = N)
   - Synchronism check elements (E25 = N)
   - Frequency elements (E81 = N)
   - Advanced settings (EADVS = N)
7. Automatically calculates:
   - Directional settings. See ***Settings Made Automatically*** in ***Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic***.
   - Zero-sequence compensation factors (k0M1, k0A1, k0M, k0A) as

$$k0M1 \angle k0A1 = k0M \angle k0A = \frac{(Z0MAG \angle Z0ANG - Z1MAG \angle Z1ANG)}{3 \bullet Z1MAG \angle Z1ANG}$$

8. Changes default SELOGIC control equations to:
   - TR = M1P + Z1G + M2PT + Z2GT + 67G2T + 51GT + OC
   - TRCOMM = M2P +Z2G + 67G2 (Visible when ECOMM ≠ N)
   - 51GTC = 32GF
   - T51PTC** = 87L
   - T51GTC** = 87L
   - T51QTC** = 87L

- T50PTC** = 87L
- T50GTC** = 87L
- T50QTC** = 87L
- ER = /B87L2 + /M2P + /Z2G + /51G + /50P1 + /LOP
- FAULT = 87L + M2P + Z2G + 51G

** **Note:** These settings are visible when T50 and T51 functions are enabled.

9. Makes no changes to:
   - Global settings
   - Port settings
   - Text settings
   - SER settings
   - 87 communications Channel X settings
   - 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 = 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
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
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

T1X   =0

Press RETURN to continue
T2X   =0
T1Y   =0
T2Y   =0

=>>
```

SETTINGS SHEET FOR THE SEL-311L RELAY (APP = 87L21P)
RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

Identifier Labels and Configuration Settings (See *Settings Explanations* in *Section 9*)

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, 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 disturbance detect (Y, N)	EDD = ________
Tapped-load coordination (Y, N)	ETAP = ________
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 PCHAN = Y or EHSC = Y or E87L = 3:	
CTR at terminal connected to Channel Y (1–6000)	CTR_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* in *Section 9*)

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 4.1)	ELOP = ____________
Communications-assisted trip scheme (N, DCB, POTT, DCUB1, DCUB2) (see ***Communications-Assisted Trip Logic—General Overview*** in ***Section 5***)	ECOMM = _________
Reclosures (N, 1–4) (see ***Reclosing Relay*** in ***Section 6***)	E79 = ______________
CCVT transient detection (Y, N) (see Figure 4.2)	ECCVT = __________
SELOGIC® control equation Variable Timers (N, 1–16) (see Figures 7.23 and 7.24)	ESV = _____________
SELOGIC Latch Bits (N, 1–16)	ELAT = ___________
SELOGIC Display Points (N, 1–16)	EDP = _____________

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 3.29)	Z1P = _____________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.30)	Z2P = _____________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.31)	Z3P = _____________
Zone 4 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.31)	Z4P = _____________

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 3.32) Z1MG = ___________

Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.33) Z2MG = ___________

Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.34) Z3MG = ___________

Zone 4 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.34) Z4MG = ___________

Mho Phase Distance Element Time Delays (See Figure 3.39)

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 3.39)

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 3.39)

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 3.42)

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 3.42)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) 67P1D = ___________

Residual Ground Inst./Def.-Time Overcurrent Elements (See Figure 3.45)

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 3.45)

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 3.48)

Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})	51GP = ____________
Curve (U1–U5, C1–C5) (see Figures 9.1 through 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 Tables 6.2 and 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 = ____________
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 5.5)

(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 5.8)

(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 5.12)

(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 5.16)

(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 = ____________

Other Settings

Minimum trip duration time (4.00–16000.00 cycles in 0.25-cycle steps) (see Figure 5.4)	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 Figures 7.23 and 7.24)

(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 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 ***Sections 3*** through ***8***. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). ***Appendix G: Setting SELOGIC Control Equations*** gives SELOGIC control equation details, examples, and limitations.

Trip Logic Equations (See Figure 5.4)

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 Figures 5.7, 5.9, and 5.12)	PT1 = ________________
Loss-of-guard 1 (used for ECOMM = DCUB1 or DCUB2; see Figure 5.12)	LOG1 = ________________
Permissive trip 2 (used for ECOMM = DCUB2; see Figures 5.7 and 5.12)	PT2 = ________________
Loss of guard 2 (used for ECOMM = DCUB2; see Figure 5.12)	LOG2 = ________________
Block trip (used for ECOMM = DCB; see Figure 5.16)	BT = ________________

Close Logic Equations (See Figure 6.1)

Circuit breaker status (used in Figure 5.5, also)	52A = ________________
Close conditions (other than automatic reclosing or CLOSE command)	CL = ________________
Unlatch close conditions	ULCL = ________________

Reclosing Relay Equations (See *Reclosing Relay* in *Section 6*)

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 7.11)

Set Latch Bit LT1	SET1 = ________
Reset Latch Bit LT1	RST1 = ________
Set Latch Bit LT2	SET2 = ________
Reset Latch Bit LT2	RST2 = ________
Set Latch Bit LT3	SET3 = ________
Reset Latch Bit LT3	RST3 = ________
Set Latch Bit LT4	SET4 = ________
Reset Latch Bit LT4	RST4 = ________
Set Latch Bit LT5	SET5 = ________
Reset Latch Bit LT5	RST5 = ________
Set Latch Bit LT6	SET6 = ________
Reset latch Bit LT6	RST6 = ________
Set Latch Bit LT7	SET7 = ________
Reset Latch Bit LT7	RST7 = ________
Set Latch Bit LT8	SET8 = ________
Reset Latch Bit LT8	RST8 = ________
Set Latch Bit LT9	SET9 = ________
Reset Latch Bit LT9	RST9 = ________
Set Latch Bit LT10	SET10 = ________
Reset Latch Bit LT10	RST10 = ________
Set Latch Bit LT11	SET11 = ________
Reset Latch Bit LT11	RST11 = ________
Set Latch Bit LT12	SET12 = ________
Reset Latch Bit LT12	RST12 = ________
Set Latch Bit LT13	SET13 = ________
Reset Latch Bit LT13	RST13 = ________
Set Latch Bit LT14	SET14 = ________
Reset latch Bit LT14	RST14 = ________
Set Latch Bit LT15	SET15 = ________
Reset Latch Bit LT15	RST15 = ________
Set Latch Bit LT16	SET16 = ________
Reset Latch Bit LT16	RST16 = ________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements

[Note: torque control equation settings cannot be set directly to logical 0]

Level 1 phase (see Figure 3.42) 67P1TC = ____________________________
Level 1 residual ground (see Figure 3.45) 67G1TC = ____________________________
Level 2 residual ground (see Figure 3.45) 67G2TC = ____________________________
Level 3 residual ground (see Figure 3.45) 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 3.48) 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 3.23) T51PTC = ____________________________
Ground inverse time (see Figure 3.24) T51GTC = ____________________________
Negative-sequence time (see Figure 3.25) 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 3.20) T50PTC = ____________________________
Ground instantaneous (see Figure 3.21) T50GTC = ____________________________
Negative-sequence instantaneous (see Figure 3.22) T50QTC = ____________________________

SELOGIC Control Equation Variable Timer Input Equations (See Figures 7.23 and 7.24)

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 7.26)

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 7.27)

Output Contact OUT201 OUT201 = __________________________
Output Contact OUT202 OUT202 = __________________________
Output Contact OUT203 OUT203 = __________________________
Output Contact OUT204 OUT204 = __________________________
Output Contact OUT205 OUT205 = __________________________
Output Contact OUT206 OUT206 = __________________________

Display Point Equations (See *Rotating Default Display* in *Sections 7* and *11*)

Display Point DP1 DP1 = ______________________________
Display Point DP2 DP2 = ______________________________
Display Point DP3 DP3 = ______________________________
Display Point DP4 DP4 = ______________________________
Display Point DP5 DP5 = ______________________________
Display Point DP6 DP6 = ______________________________
Display Point DP7 DP7 = ______________________________
Display Point DP8 DP8 = ______________________________
Display Point DP9 DP9 = ______________________________
Display Point DP10 DP10 = ____________________________
Display Point DP11 DP11 = ____________________________
Display Point DP12 DP12 = ____________________________
Display Point DP13 DP13 = ____________________________
Display Point DP14 DP14 = ____________________________
Display Point DP15 DP15 = ____________________________
Display Point DP16 DP16 = ____________________________

Setting Group Selection Equations (See Table 7.4)

Select Setting Group 1	SS1 = ________________
Select Setting Group 2	SS2 = ________________
Select Setting Group 3	SS3 = ________________
Select Setting Group 4	SS4 = ________________
Select Setting Group 5	SS5 = ________________
Select Setting Group 6	SS6 = ________________

Other Equations

Event report trigger conditions (see ***Section 12***)	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 ***Demand Metering*** and ***Maximum/Minimum Metering*** in ***Section 8***)	FAULT = ________________
Breaker monitor initiation (see Figure 8.3)	BKMON = ________________

MIRRORED BITS™ Transmit Equations (See *Appendix I*)

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 Y, transmit bit 1	T1Y = ________________
Channel Y, transmit bit 2	T2Y = ________________

Settings Group Change Delay (See *Multiple Setting Groups* in *Section 7*)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps) TGR = ____________

Power System Configuration and Date Format (See *Settings Explanations* in *Section 9*)

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 PRE = _____________
(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)

Station DC Battery Monitor (See Figures 8.9 and 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 (0.00–1.00 cycles in 0.25-cycle steps) IN101D = __________

Input IN102 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN102D = __________

Input IN103 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN103D = __________

Input IN104 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN104D = __________

Input IN105 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN105D = __________

Input IN106 debounce time (0.00–1.00 cycles in 0.25-cycle steps) IN106D = __________

Breaker Monitor Settings (See *Breaker Monitor* in *Section 8*)

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= __________

SEQUENTIAL EVENTS RECORDER SETTINGS (SERIAL PORT COMMAND SET R)

Sequential Events Recorder settings are comprised of three trigger lists. Each trigger list can include up to 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See ***Sequential Events Recorder (SER) Report*** in ***Section 12***.

SER Trigger List 1 SER1 = ______________________________

SER Trigger List 2 SER2 = ______________________________

SER Trigger List 3 SER3 = ______________________________

Settings Sheet for the SEL-311L Relay (APP = 87L21P)
Text Label Settings (Serial Port Command SET T)

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

Local Bit Labels (See Tables 7.1 and 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 = ________

Settings Sheet for the SEL-311L Relay (APP = 87L21P)
Text Label Settings (Serial Port Command SET T)

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 = ________

Settings Sheet for the SEL-311L Relay (APP = 87L21P)
Text Label Settings (Serial Port Command SET T)

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* in *Section 7* and *11*)

Display if DP1 = logical 1 (16 characters)	DP1_1 = ________________
Display if DP1 = logical 0 (16 characters)	DP1_0 = ________________
Display if DP2 = logical 1 (16 characters)	DP2_1 = ________________
Display if DP2 = logical 0 (16 characters)	DP2_0 = ________________
Display if DP3 = logical 1 (16 characters)	DP3_1 = ________________
Display if DP3 = logical 0 (16 characters)	DP3_0 = ________________
Display if DP4 = logical 1 (16 characters)	DP4_1 = ________________
Display if DP4 = logical 0 (16 characters)	DP4_0 = ________________
Display if DP5 = logical 1 (16 characters)	DP5_1 = ________________
Display if DP5 = logical 0 (16 characters)	DP5_0 = ________________
Display if DP6 = logical 1 (16 characters)	DP6_1 = ________________
Display if DP6 = logical 0 (16 characters)	DP6_0 = ________________
Display if DP7 = logical 1 (16 characters)	DP7_1 = ________________
Display if DP7 = logical 0 (16 characters)	DP7_0 = ________________
Display if DP8 = logical 1 (16 characters)	DP8_1 = ________________
Display if DP8 = logical 0 (16 characters)	DP8_0 = ________________
Display if DP9 = logical 1 (16 characters)	DP9_1 = ________________
Display if DP9 = logical 0 (16 characters)	DP9_0 = ________________
Display if DP10 = logical 1 (16 characters)	DP10_1 = ________________
Display if DP10 = logical 0 (16 characters)	DP10_0 = ________________
Display if DP11 = logical 1 (16 characters)	DP11_1 = ________________
Display if DP11 = logical 0 (16 characters)	DP11_0 = ________________
Display if DP12 = logical 1 (16 characters)	DP12_1 = ________________
Display if DP12 = logical 0 (16 characters)	DP12_0 = ________________
Display if DP13 = logical 1 (16 characters)	DP13_1 = ________________
Display if DP13 = logical 0 (16 characters)	DP13_0 = ________________

Display if DP14 = logical 1 (16 characters) DP14_1 = ________________________________
Display if DP14 = logical 0 (16 characters) DP14_0 = ________________________________

Display if DP15 = logical 1 (16 characters) DP15_1 = ________________________________
Display if DP15 = logical 0 (16 characters) DP15_0 = ________________________________

Display if DP16 = logical 1 (16 characters) DP16_1 = ________________________________
Display if DP16 = logical 0 (16 characters) DP16_0 = ________________________________

Reclosing Relay Labels (See *Functions Unique to the Front-Panel Interface* in *Section 11*)

Reclosing Relay Last Shot Label (14 char.) 79LL = ________________________________
Reclosing Relay Shot Counter Label (14 char.) 79SL = ________________________________

Protocol Settings (See Below)

Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B) 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 H*** for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, or MB8B. Refer to ***Appendix I*** for details on MIRRORED BITS.

The following settings are used if PROTO = LMD.

LMD Prefix (@, #, $, %, &) PREFIX = ________________________

LMD Address (01–99) ADDR = ________________________

LMD Settling Time (0–30 seconds) SETTLE = ________________________

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) SPEED = ________________________

Data Bits (6, 7, 8) BITS = ________________________

Parity (O, E, N) {Odd, Even, None} PARITY = ________________________

Stop Bits (1, 2) STOP = ________________________

Other Port Settings (See Below)

Time-out (0–30 minutes) T_OUT = ________________________

DTA Meter Format (Y, N) DTA = ________________________

Send Auto Messages to Port (Y, N) AUTO = ________________________

Enable Hardware Handshaking (Y, N, MBT) RTSCTS = ________________________
(Refer to ***Appendix I*** for details on setting MBT.)

Fast Operate Enable (Y, N) FASTOP = ________________________

Other Port Settings 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.

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.

Set AUTO = Y to allow automatic messages at the serial port.

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.

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*** for the description of the SEL-311L Relay Fast Operate commands.

87L Channel X Configuration Settings

Channel X address check (Y, N) EADDCX = ________

If EADDCX = Y

Channel X transmit address (1–16) TA_X = ________

Channel X receive address (1–16) 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, N) EADDCY = ________

If EADDCY = Y

Channel Y transmit address (1–16) TA_Y = ________

Channel Y receive address (1–16) 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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TABLES

FIGURES

APPENDIX A: FIRMWARE VERSIONS

This manual covers SEL-311L Relays that contain firmware bearing the following part numbers and revision numbers (most recent firmware listed at top):

Firmware Part/Revision No.	Description of Firmware
SEL-311L-R103-V0-Z001001-D20011109	This firmware differs from the original as follows: – Correct local control bits operation. – Z1GT replaced with Z2GT in TR equation for 87L21 applications. – Fixed INT87 counter overflow.
SEL-311L-R102-V0-Z001001-D20010820	This firmware differs from the original as follows: – Internal changes to improve EIA-422 clock detection.
SEL-311L-R101-V0-Z001001-D20010717	This firmware differs from the original as follows: – Correct unused CT scaling issue.
SEL-311L-R100-V0-Z001001-D20010625	Original Version SEL-311L; standard features.

To find the firmware revision number in your relay, view the status report using the serial port STATUS (**STA**) command or the front-panel STATUS pushbutton. The status report displays the firmware revision as shown below:

FID=**SEL-311L-R100-V0-Z001001-D20010625**

The SEL-311L Relay provides a means of interpreting Firmware Identification Data (FID). 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[RD]

Where:

[RN] = Revision Number (e.g., 100)
[VS] = Version Specification
[ES] = External Software Version (e.g., 001001)
[RD] = Release Date (e.g., YYYYMMDD=20010625)

APPENDIX B: FIRMWARE UPGRADE INSTRUCTIONS

Firmware (Flash) Upgrade Instructions

SEL may occasionally offer firmware upgrades to improve the performance of your relay. The SEL-311L Relay stores firmware in Flash memory; therefore, changing physical components is not necessary. A firmware loader program called SELBOOT resides in the SEL-311L Relay. These instructions give a step-by-step procedure to upgrade the relay firmware by downloading a file from a personal computer to the relay via a serial port.

Important Note Regarding Settings

The firmware upgrade procedure may result in lost relay settings due to the addition of new features and changes in the way memory is used. It is imperative to have a copy of the original relay settings available in case they need to be re-entered. Carefully following these upgrade instructions will minimize the chance of inadvertently losing relay settings.

The communications processor (SEL-2020 or SEL-2030) will need to be re-autoconfigured for the port connected to a relay that has been firmware upgraded. Failure to do so may cause automatic data collection failure if the communication processor's power is cycled.

Required Equipment

- Personal computer.
- Terminal emulation software that supports XMODEM/CRC protocol (e.g., CROSSTALK®, Microsoft® Windows® Terminal and HyperTerminal, Procomm® Plus, Relay/Gold, or SmartCOM).
- Serial communications cable (SEL-234A or equivalent).
- Disk containing firmware upgrade file.

Upgrade Procedure

The instructions below assume you have a working knowledge of your personal computer terminal emulation software. In particular, you must be able to modify your serial communications parameters (baud rate, data bits, parity, etc.), disable any hardware or software flow control in your computer terminal emulation software, select transfer protocol (i.e., XMODEM/CRC), and transfer files (e.g., send and receive binary files).

1. If the relay is in service, disable its control functions.

   Note: If the SEL-311L Relay contains History (HIS) data, Event (EVE) data, Metering (MET) data, or Sequential Events Recorder (SER) data that you want to retain, you must retrieve this data prior to performing the firmware upgrade, because all of these data sets may be erased in the upgrade procedure.

2. Connect the personal computer to the relay serial port 2, 3, or F, and enter Access Level 2 by issuing the **ACC** and **2AC** commands.

3. Execute the Show Calibration (**SHO C**) command to retrieve the relay calibration settings. Record the displayed settings (or save them to a computer file) for possible reentry after the firmware upgrade.

   If you do not already have copies of the Global, Group, Logic, Port, SER channel, and Text label settings, use the SEL-5010 Settings Assistant or the following Show commands to retrieve the necessary settings: **SHO G**, **SHO 1**, **SHO L 1**, **SHO 2**, **SHO L 2**, **SHO 3**, **SHO L 3**, **SHO 4**, **SHO L 4**, **SHO 5**, **SHO L 5**, **SHO 6**, **SHO L 6**, **SHO P 1**, **SHO P 2**, **SHO P 3**, **SHO P F**, **SHO R**, **SHO T**, **SHO X**, and **SHO Y**.

   Issue the Password (**PAS**) command and save the original password settings in case they are needed later.

   Normally, the relay will preserve the settings during the firmware upgrade. However, depending on the firmware version that was previously installed and the use of relay memory, this cannot be ensured. Saving settings is always recommended.

4. Set your communication connection to the highest possible baud rate. The relay will support speeds up to 38,400 baud. Use the **SET P** command to change the SPEED setting to the desired baud rate.

5. Issue the **L_D <ENTER>** command to the relay (L underscore D ENTER) to start the SELBOOT program.

6. Type **Y <ENTER>** to the "Disable relay to send or receive firmware (Y/N)?" prompt and **Y <ENTER>** to the "Are you sure (Y/N)?" prompt. The relay will send (Relay Disabled) and will then send the SELBOOT prompt !> after a few seconds.

   Note: SELBOOT does not echo nonalphabetic characters as the first character of a line. This may make it appear that the relay is not functioning properly.

7. Make a copy of the firmware currently in the relay. This is recommended in case the new firmware download is unsuccessful. To make a backup of the firmware, you will need approximately 2 MB of free disk space. The procedure takes approximately 11 minutes at 38,400 baud.

   Issue the Send (**SEN**) command to the relay to initiate the firmware transfer from the relay to your computer. No activity will be seen on the PC screen, because the relay is waiting for the PC to request the first XMODEM data packet. Select the "Receive File" function with the XMODEM protocol in your terminal emulation software. Give the file a unique name to clearly identify the firmware version (e.g., 311L_R200.S19). After the transfer, the relay will respond: "Download completed successfully!"

   Note: Upgrade firmware shipped on a 2 MB floppy disk contains a self-extracting zip file with the file extension "EXE". Run this "EXE" file to extract a file with the extension "S19". This "S19" file is the firmware that must be downloaded to the relay.

8. Begin the transfer of the new firmware to the relay by issuing the Receive (**REC**) command to instruct the relay to receive new firmware.

9. The relay will ask if you are sure you want to erase the existing firmware. Type **Y** to erase the existing firmware and load new firmware, or just **<ENTER>** to abort.

10. The relay then prompts you to press a key and begin the transfer. Press a key (e.g., **<ENTER>**).

    Note: The relay will display one or more "C" characters as it waits for your PC Terminal Emulation program to send the new firmware. If you do not start the transfer quickly enough (within about 18 seconds), it may time out and respond "Remote system is not responding." If this happens, begin again in Step 8, above.

11. Start the file transfer by selecting the "Send File" function in your terminal emulation software. Use the XMODEM or 1k-XMODEM (fastest) protocol and send the file that contains the new firmware (e.g., Relay.S19).

    Note: If the relay power fails during a firmware receive after the old firmware is erased, the relay will restart in SELboot, but the baud rate will default to 2400 baud. (If this happens, connect to the relay at 2400 baud and type BAUD 38400 at the SELboot prompt. The firmware receive can be started again at Step 8.)

    The file transfer takes approximately 9 minutes at 38,400 baud using the 1k-XMODEM protocol. After the transfer completes, the relay will reboot and return to Access Level 0. The following screen capture shows the entire process.

```
=>>L_D <ENTER>
Disable relay to send or receive firmware (Y/N) ? Y <ENTER>
Are you sure (Y/N) ? Y <ENTER>
Relay Disabled
!>SEN <ENTER>
Download completed successfully!

!>REC <ENTER>
Caution! -  This command erases the relay's firmware.
If you erase the firmware, new firmware must be loaded into the relay
before it can be put back into service.

Are you sure you wish to erase the existing firmware? (Y/N) Y
Erasing
Erase successful
Press any key to begin transfer, then start transfer at the PC <ENTER>

Upload completed successfully. Attempting a restart
```

If the restart is not successful, the relay will either send "Restart unsuccessful. Use the REC command to reinstall firmware," or "Program is invalid." Or the relay will be totally unresponsive, with no local LCD display. In the first or second case, attempt to reload firmware from Step 8. In the third case (relay is unresponsive), contact the factory.

12. The relay illuminates the EN front-panel LED if the original relay settings were retained through the download. If the EN LED is illuminated, proceed to Step 13; otherwise, the relay may display various self-test failures because of changes in the way memory is used.

    Press **<ENTER>** to see if the Level 0 prompt "=" appears on your terminal screen. If the relay does not display the Level 0 prompt, the Relay baud rate has changed back to the factory default of 2400 baud; go to self-test failure: CR_RAM and EEPROM, Step 12a. If the relay does display the Level 0 prompt, go to Step 12b.

    Self-test failure: CR_RAM and EEPROM

    a. Set your communications software settings to 2400 baud, 8 data bits, 1 stop bit. Now enter Access Level 2 by issuing the **ACC** and **2AC** commands, (the factory default passwords will be in effect: OTTER for level 1, TAIL for level 2).

    b. Issue the Restore Settings (**R_S**) command to restore the factory default settings in the relay. This takes about two minutes, then the EN LED will illuminate.

       Note: If the relay asks for a part number to be entered, use the number from the label on the firmware diskette, or from the new part number sticker (if supplied).

    c. Enter Access Level 2 by issuing the **ACC** and **2AC** commands, (the factory default passwords will be in effect: OTTER for level 1, TAIL for level 2).

    d. Restore the original settings as necessary, using the SEL-5010 Settings Assistant, or with each of the following commands: **SET G**, **SET 1**, **SET L 1**, **SET 2**, **SET L 2**, **SET 3**, **SET L 3**, **SET 4**, **SET L 4**, **SET 5**, **SET L 5**, **SET 6**, **SET L 6**, **SET P 1**, **SET P 2**, **SET P 3**, **SET P F**, **SET R**, **SET X**, **SET Y**.

    e. Set the original relay passwords saved in Step 3 via the **PAS** command.

       For example, **PAS 1:APPLE <ENTER>** sets the level 1 password to APPLE. Use a similar format for **PAS B** and **PAS 2**. The **PAS** command is case-sensitive, so the lower and upper case letters are treated differently.

    If there are still any FAIL codes on the Relay LCD, see ***Section 13: Testing, Troubleshooting, and Commissioning.***

13. Verify the calibration settings by issuing the **SHO C** command. If the settings do not match the settings recorded in Step 3, reissue the settings with the **SET C** command.

14. Issue the Version (**VER**) command and check the part number from the label on the firmware diskette against the part number on the screen. If they match, go to Step 15; otherwise, type **PAR <ENTER>** and type the number from the diskette label and press **<ENTER>**. If the relay reinitializes after saving the changes, go to Access Level 2.

15. Execute the Status (**STA**) command to verify that all relay self-test parameters are within tolerance, and that the relay is enabled.

16. Apply current and voltage signals to the relay. Issue the **MET** command; verify that the current and voltage signals are correct. Issue the Trigger (**TRI**) and Event (**EVE**) commands. Verify that the current and voltage signals are correct in the event report.

The relay is now ready for your commissioning procedure.

APPENDIX C: SEL DISTRIBUTED PORT SWITCH PROTOCOL

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 multidrop network do not have the same prefix setting.

Note: You can use the front-panel SET pushbutton to change the port settings to return to SEL protocol.

APPENDIX D: CONFIGURATION, FAST METER, AND FAST OPERATE COMMANDS

INTRODUCTION

SEL relays have two separate data streams that share the same serial port. The human data communications with the relay consist of ASCII character commands and reports that are intelligible to humans using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a event report) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to exploit this feature. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

SEL Application Guide AG95-10: Configuration and Fast Meter Messages is a comprehensive description of the SEL binary messages. Below is a description of the messages provided in the SEL-311L Relay.

MESSAGE LISTS

Binary Message List

Request to Relay (hex)	Response From Relay
A5C0	Relay Definition Block
A5C1	Fast Meter Configuration Block
A5D1	Fast Meter Data Block
A5C2	Demand Fast Meter Configuration Block
A5D2	Demand Fast Meter Data Message
A5C3	Peak Demand Fast Meter Configuration Block
A5D3	Peak Demand Fast Meter Data Message
A5B9	Fast Meter Status Acknowledge
A5CE	Fast Operate Configuration Block
A5E0	Fast Operate Remote Bit Control
A5E3	Fast Operate Breaker Control
A5CD	Fast Operate Reset Definition Block
A5ED	Fast Operate Reset Command

ASCII Configuration Message List

Request to Relay (ASCII)	Response From Relay
ID	ASCII Firmware ID String and Terminal ID Setting (TID)
DNA	ASCII Names of Relay Word bits
BNA	ASCII Names of bits in the A5B9 Status Byte
SNS	ASCII Names of strings in SER settings

MESSAGE DEFINITIONS

A5C0 Relay Definition Block

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

Data	Description
A5C0	Command
34	Message length (52)
04	Support SEL, LMD, DNP 3.00, and R6 SEL protocols
03	Support Fast Meter, fast demand, and fast peak
03	Status flag for Warn, Fail, Group, or Settings change
A5C1	Fast Meter configuration
A5D1	Fast Meter message
A5C2	Fast demand configuration
A5D2	Fast demand message
A5C3	Fast peak configuration
A5D3	Fast peak message
0004	Settings change bit
A5C100000000	Reconfigure Fast Meter on settings change
0004	Settings change bit
A5C200000000	Reconfigure demand Fast Meter on settings change
0004	Settings change bit
A5C300000000	Reconfigure peak demand Fast Meter on settings change
0100	SEL protocol has Fast Operate
0101	LMD protocol has Fast Operate
0005	DNP 3.00
0006	R6 SEL (relay-to-relay) MIRRORED BITS protocol
00	Reserved
xx	Checksum

A5C1 Fast Meter Configuration Block

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

Data	Description
A5C1	Fast Meter command
DE	Length
01	One status flag byte
00	Scale factors in Fast Meter message
00	# of scale factors
13	# of analog input channels
02	# of samples per channel
44	# of digital banks
01	One calculation block
0004	Analog channel offset
009C	Time stamp offset
00A4	Digital offset
494100000000	Analog channel name (IA)
01	Analog channel type (float)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (HEX)
494200000000	Analog channel name (IB)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494300000000	Analog channel name (IC)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
495000000000	Analog channel name (IP)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564100000000	Analog channel name (VA)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564200000000	Analog channel name (VB)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564300000000	Analog channel name (VC)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
565300000000	Analog channel name (VS)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message

465245510000	Analog channel name (FREQ)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
564241540000	Analog channel name (VBAT)
01	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494158000000	Analog channel name (IAX)
01	Analog channel type (FLOAT)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494258000000	Analog channel name (IBX)
01	Analog channel type (FLOAT)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494358000000	Analog channel name (ICX)
01	Analog channel type (FLOAT)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494159000000	Analog channel name (IAY)
01	Analog channel type (FLOAT)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494259000000	Analog channel name (IBY)
01	Analog channel type (FLOAT)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494359000000	Analog channel name (ICY)
01	Analog channel type (FLOAT)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494154000000	Analog channel name (IAT) (T for Total)
01	Analog channel type (FLOAT)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494254000000	Analog channel name (IBT)
01	Analog channel type (FLOAT)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494354000000	Analog channel name (ICT)
01	Analog channel type (FLOAT)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
00	Line Configuration (0-ABC, 1-ACB)
00	Standard Power Calculations
FFFF	No Deskew angle
FFFF	No Rs compensation (-1)
FFFF	No Xs compensation (-1)

00	IA channel index
01	IB channel index
02	IC channel index
04	VA channel index
05	VB channel index
06	VC channel index
00	Reserved
checksum	1-byte checksum of all preceding bytes

A5D1 Fast Meter Data Block

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

Data	Description
A5D1	Command
0xEA	Length
1 byte	1 Status Byte
152 bytes	X and Y components of: IA, IB, IC, IP, VA, VB, VC, VS, Freq, Vbatt, IAX, IBX, ICX, IAY, IBY, ICY, IAT, IBT, ICT in 4-byte IEEE FPS
8 bytes	Time stamp
68 bytes	59 Digital banks: TAR0–TAR68
1 byte	Reserved
checksum	1-byte checksum of all preceding bytes

A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages

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

Data	Description
A5C2 or A5C3	Command; Demand (A5C2) or Peak Demand (A5C3)
E4	Length
01	# of status flag bytes
00	Scale factors in meter message
00	# of scale factors
15	# of analog input channels
01	# of samples per channel
00	# of digital banks
00	# of calculation blocks
0004	Analog channel offset
00AC	Time stamp offset
FFFF	Digital offset
494100000000	Analog channel name (IA)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)

494200000000	Analog channel name (IB)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
494300000000	Analog channel name (IC)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
494700000000	Analog channel name (IG)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
334932000000	Analog channel name (3I2)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
50412B000000	Analog channel name (PA+)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
50422B000000	Analog channel name (PB+)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
50432B000000	Analog channel name (PC+)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
50332B000000	Analog channel name (P3+)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
51412B000000	Analog channel name (QA+)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
51422B000000	Analog channel name (QB+)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
51432B000000	Analog channel name (QC+)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
51332B000000	Analog channel name (Q3+)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)

50412D000000	Analog channel name (PA-)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
50422D000000	Analog channel name (PB-)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
50432D000000	Analog channel name (PC-)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
50332D000000	Analog channel name (P3-)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
51412D000000	Analog channel name (QA-)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
51422D000000	Analog channel name (QB-)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
51432D000000	Analog channel name (QC-)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
51332D000000	Analog channel name (Q3-)
02	Analog channel type (Double)
FF	Scale factor type
0000	Scale factor offset in Fast Meter message (Hex)
00	Reserved
checksum	1-byte checksum of preceding bytes

A5D2/A5D3 Demand/Peak Demand Fast Meter Message

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

A5D2 or A5D3	Command
B6	Length
1 byte	1 Status Byte
168-bytes	Demand: IA, IB, IC, IG, 3I2, MWA I, MWB I, MWC I, MW3PI, MVA I, MVB I, MVC I, MV3PI, MWA O, MWB O, MWC O, MW3PO, MVA O, MVB O, MVC O, MV3PO in 8-byte IEEE FPS
8 bytes	Time stamp
1 byte	Reserved
1 byte	1-byte checksum of all preceding bytes

A5B9 Fast Meter Status Acknowledge Message

In response to the A5B9 request, the relay clears the Fast Meter (message A5D1) Status Byte. The SEL-311L Relay Status Byte contains one active bit, STSET (bit 4). The bit is set on power up and on settings changes. If the STSET bit is set, the external device should request the A5C1, A5C2, and A5C3 messages. The external device can then determine if the scale factors or line configuration parameters have been modified.

A5CE Fast Operate Configuration Block

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

Data	Description
A5CE	Command
3C	Length
01	Support 1 circuit breaker
0010	Support 16 remote bit set/clear commands
0100	Allow remote bit pulse commands
31	Operate code, open breaker 1
11	Operate code, close breaker 1
00	Operate code, clear remote bit RB1
20	Operate code, set remote bit RB1
40	Operate code, pulse remote bit RB1
01	Operate code, clear remote bit RB2
21	Operate code, set remote bit RB2
41	Operate code, pulse remote bit RB2
02	Operate code, clear remote bit RB3
22	Operate code, set remote bit RB3
42	Operate code, pulse remote bit RB3
03	Operate code, clear remote bit RB4
23	Operate code, set remote bit RB4
43	Operate code, pulse remote bit RB4
04	Operate code, clear remote bit RB5
24	Operate code, set remote bit RB5
44	Operate code, pulse remote bit RB5
05	Operate code, clear remote bit RB6
25	Operate code, set remote bit RB6
45	Operate code, pulse remote bit RB6
06	Operate code, clear remote bit RB7
26	Operate code, set remote bit RB7
46	Operate code, pulse remote bit RB7
07	Operate code, clear remote bit RB8
27	Operate code, set remote bit RB8
47	Operate code, pulse remote bit RB8
08	Operate code, clear remote bit RB9
28	Operate code, set remote bit RB9
48	Operate code, pulse remote bit RB9
09	Operate code, clear remote bit RB10
29	Operate code, set remote bit RB10

49	Operate code, pulse remote bit RB10
0A	Operate code, clear remote bit RB11
2A	Operate code, set remote bit RB11
4A	Operate code, pulse remote bit RB11
0B	Operate code, clear remote bit RB12
2B	Operate code, set remote bit RB12
4B	Operate code, pulse remote bit RB12
0C	Operate code, clear remote bit RB13
2C	Operate code, set remote bit RB13
4C	Operate code, pulse remote bit RB13
0D	Operate code, clear remote bit RB14
2D	Operate code, set remote bit RB14
4D	Operate code, pulse remote bit RB14
0E	Operate code, clear remote bit RB15
2E	Operate code, set remote bit RB15
4E	Operate code, pulse remote bit RB15
0F	Operate code, clear remote bit RB16
2F	Operate code, set remote bit RB16
4F	Operate code, pulse remote bit RB16
00	Reserved
checksum	1-byte checksum of all preceding bytes

A5E0 Fast Operate Remote Bit Control

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

Data	Description
A5E0	Command
06	Length
1 byte	Operate code: 00–0F clear remote bit RB1–RB16 20–2F set remote bit RB1–RB16 40–4F pulse remote bit for RB1–RB16 for one processing interval
1 byte	Operate validation: 4 · Operate code + 1
checksum	1-byte checksum of preceding bytes

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

1. The Operate code is valid.
2. The Operate validation = 4 · Operate code + 1.
3. The message checksum is valid.
4. The FASTOP port setting is set to Y.
5. The relay is enabled.

Remote bit set and clear operations are latched by the relay. Remote bit pulse operations assert the remote bit for one processing interval (1/4 cycle).

It is common practice to route remote bits to output contacts to provide remote control of the relay outputs. If you wish to pulse an output contact closed for a specific duration, SEL recommends using the remote bit pulse command and SELOGIC® control equations to provide secure and accurate contact control. The remote device sends the remote bit pulse command; the relay controls the timing of the output contact assertion. You can use any remote bit (RB1 through RB16), and any SELOGIC control equation timer (SV1 through SV16) to control any of the output contacts (OUT101 through OUT107 and OUT201 through OUT206). For example, to pulse output contact OUT104 for 30 cycles with Remote Bit RB4 and SELOGIC control equation timer SV4, issue the following relay settings:

via the **SET L** command,

SV4 = RB4	SV4 input is RB4
OUT104 = SV4T	route SV4 timer output to OUT104

via the **SET** command,

SV4PU = 0	SV4 pickup time = 0
SV4DO = 30	SV4 dropout time is 30 cycles

To pulse the contact, send the A5E006430DDB command to the relay.

A5E3 Fast Operate Breaker Control

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

Data	Description
A5E3	Command
06	Length
1 byte	Operate code: 31—OPEN breaker 11—CLOSE breaker
1 byte	Operate Validation: 4 · Operate code + 1
checksum	1-byte checksum of preceding bytes

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

1. Conditions 1-5 defined in the A5E0 message are true.
2. The breaker jumper (JMP2B) is in place on the SEL-311L Relay main board.

A5CD Fast Operate Reset Definition Block

In response to an A5CD request, the relay sends the configuration block for the Fast Operate Reset message:

Data	Description
A5CD	Command
0E	Message length
01	The number of Fast Operate reset codes supported
00	Reserved for future use
	Per Fast Operate reset code, repeat:
00	Fast Operate reset code (e.g., “00” for target reset)
54415220520000	Fast Operate reset description string (e.g., “TAR R”)
xx	Checksum

A5ED Fast Operate Reset Command

The Fast Operate Reset commands take the following form:

Data	Description
A5ED	Command
06	Message Length—always 6
00	Operate Code (e.g., “00” for target reset, “TAR R”)
01	Operate Validation—(4 + Operate Code) + 1
xx	Checksum

ID Message

In response to the ID command, the relay sends the firmware ID and relay TID setting as described below.

<STX>
"FID=SEL-311L-Rrrr-V0-Zzzzzzz-Dyyyymmdd","aaaa"<CR><LF>
"CID=cccc","aaaa"<CR><LF>
"DEVID=[TID SETTING]","aaaa"<CR><LF>
"DEVCODE=50","aaaa"<CR><LF>
"PARTNO=[PARTNO SETTING]","aaaa"<CR><LF>
"CONFIG=bbbbbb","aaaa"<CR><LF><ETX>

where: rrr is the firmware revision.
zzzzzz is settings and protocol version numbers.
cccc is the 4-digit firmware checksum.
yyyy is the 4-digit year code.
mm is the 2 digit month code.
dd is the 2-digit day code.
bbbbbb is the 6-digit configuration code.
aaaa is an ASCII representation of the 2-byte checksum for each line.

The ID message is available from Access Level 1 and higher.

DNA Message

In response to the **DNA** command, the relay sends names of the Relay Word bits transmitted in the A5D1 message. The first name is associated with the MSB, the last name with the LSB. These names are listed in the Relay Word Bits table for the appropriate model in ***Section 9: Setting the Relay*** of this manual. The **DNA** command is available from Access Level 1 and higher.

The DNA message is:

<STX>
"EN","TRP","TIME","COMM","87","50_51","RCRS","RCLO","0B67"<CR>
"A","B","C","G","ZONE1","ZONE2","ZONE3","87CHFAIL","0AED"<CR>
"M1P","M1PT","Z1G","Z1GT","M2P","M2PT","Z2G","Z2GT","0B54"<CR>
"Z1T","Z2T","50P1","67P1","67P1T","50G1","67G1","67G1T","0B50"<CR>
"51G","51GT","51GR","LOP","ILOP","ZLOAD","ZLOUT","ZLIN","0CA1"<CR>
"LB1","LB2","LB3","LB4","LB5","LB6","LB7","LB8","0994"<CR>
"LB9","LB10","LB11","LB12","LB13","LB14","LB15","LB16","0AE5"<CR>
"RB1","RB2","RB3","RB4","RB5","RB6","RB7","RB8","09C4"<CR>
"RB9","RB10","RB11","RB12","RB13","RB14","RB15","RB16","0B15"<CR>
"LT1","LT2","LT3","LT4","LT5","LT6","LT7","LT8","0A24"<CR>
"LT9","LT10","LT11","LT12","LT13","LT14","LT15","LT16","0B75"<CR>
"SV1","SV2","SV3","SV4","SV1T","SV2T","SV3T","SV4T","0BAC"<CR>
"SV5","SV6","SV7","SV8","SV5T","SV6T","SV7T","SV8T","0BCC"<CR>
"SV9","SV10","SV11","SV12","SV9T","SV10T","SV11T","SV12T","0CD6"<CR>
"SV13","SV14","SV15","SV16","SV13T","SV14T","SV15T","SV16T","0D44"<CR>
"MAB1","MBC1","MCA1","MAB2","MBC2","MCA2","CVTBL","SOTFT","0C9A"<CR>
"MAG1","MBG1","MCG1","MAG2","MBG2","MCG2","DCHI","DCLO","0BE7"<CR>
"BCW","BCWA","BCWB","BCWC","FIDEN","FSA","FSB","FSC","0BAD"<CR>
"SG1","SG2","SG3","SG4","SG5","SG6","OC","CC","0969"<CR>
"CLOSE","CF","TRGTR","52A","3PO","SOTFE","VPOLV","50L","0C55"<CR>
"PDEM","GDEM","QDEM","TRIP","50QF","50QR","50GF","50GR","0C1D"<CR>
"32QF","32QR","32GF","32GR","32VE","32QGE","32IE","32QE","0BA4"<CR>
"F32I","R32I","F32Q","R32Q","F32QG","R32QG","F32V","R32V","0C18"<CR>
"*","*","IN106","IN105","IN104","IN103","IN102","IN101","0AD9"<CR>
"ALARM","OUT107","OUT106","OUT105","OUT104","OUT103","OUT102","OUT101",
"0FC8"<CR>
"M3P","M3PT","Z3G","Z3GT","M4P","M4PT","Z4G","Z4GT","0B64"<CR>
"Z3T","Z4T","50P2","67P2","67P2T","50P3","67P3","67P3T","0B78"<CR>
"50G2","67G2","67G2T","50G3","67G3","67G3T","*","*","09D3"<CR>
"51P","51PT","51PR","Z1X","59VA","MAB3","MBC3","MCA3","0B3C"<CR>
"MAG3","MBG3","MCG3","27S","59S","*","59VP","59VS","0A6D"<CR>
"SF","25A1","25A2","RCSF","OPTMN","RSTMN","*","*","0A70"<CR>
"79RS","79CY","79LO","SH0","SH1","SH2","SH3","SH4","0AAD"<CR>
"MAB4","MBC4","MCA4","MAG4","MBG4","MCG4","*","*","0A01"<CR>
"XAG1","XBG1","XCG1","XAG2","XBG2","XCG2","XAG3","XBG3","0C16"<CR>
"XCG3","XAG4","XBG4","XCG4","OSTI","OSTO","OST","50ABC","0C79"<CR>
"X5ABC","X6ABC","OSB","OSB1","OSB2","OSB3","OSB4","UBOSB","0CE0"<CR>
"50G4","67G4","67G4T","*","MPP1","MABC1","MPP2","MABC2","0B74"<CR>
"50Q1","67Q1","67Q1T","50Q2","67Q2","67Q2T","59N1","59N2","0B90"<CR>

"50Q3","67Q3","67Q3T","50Q4","67Q4","67Q4T","59Q","59V1","0B75"<CR>
"51Q","51QT","51QR","*","*","Z2PGS","67QG2S","BTX","0A8D"<CR>
"Z3XT","DSTRT","NSTRT","STOP","Z3RB","KEY","EKEY","ECTT","0D93"<CR>
"PTRX","UBB1","UBB2","UBB","WFC","PT","PTRX1","PTRX2","0C3F"<CR>
"27A","27B","27C","59A","59B","59C","3P27","3P59","096E"<CR>
"27AB","27BC","27CA","59AB","59BC","59CA","*","*","0971"<CR>
"201LOG","202LOG","203LOG","204LOG","205LOG","206LOG","*","*","0CA1"<CR>
"*","*","*","*","MPP3","MABC3","MPP4","MABC4","08F6"<CR>
"*","*","*","*","*","*","*","*","04D0"<CR>
"RMB8A","RMB7A","RMB6A","RMB5A","RMB4A","RMB3A","RMB2A","RMB1A","0E34"
<CR>
"TMB8A","TMB7A","TMB6A","TMB5A","TMB4A","TMB3A","TMB2A","TMB1A","0E44"
<CR>
"RMB8B","RMB7B","RMB6B","RMB5B","RMB4B","RMB3B","RMB2B","RMB1B","0E3C"
<CR>
"TMB8B","TMB7B","TMB6B","TMB5B","TMB4B","TMB3B","TMB2B","TMB1B","0E4C"
<CR>
"LBOKB","CBADB","RBADB","ROKB","LBOKA","CBADA","RBADA","ROKA","0DFA"
<CR>
"81D1","81D2","81D3","81D4","81D5","81D6","27B81","*","0A01"<CR>
"81D1T","81D2T","81D3T","81D4T","81D5T","81D6T","87HWAL","87BSY","0DB3"<CR>
"OUT201","OUT202","OUT203","OUT204","OUT205","OUT206","87LPE","DD","0EA9"
<CR>
"FTABC","FTAG","FTBG","FTCG","FTAB","FTBC","FTCA","FTSE","0CD5"<CR>
"87L","87LA","87LB","87LC","87L2","87LG","CHYAL","CHXAL","0C02"<CR>
"87LOPA","87LAE","R87LA","CTAA","PQ87LA","TRIP87","BXYZ2","BXYZG","0F21"
<CR>
"87LOPB","87LBE","R87LB","CTAB","PQ87LB","BXYZA","BXYZB","BXYZC","0F12"
<CR>
"87LOPC","87LCE","R87LC","CTAC","PQ87LC","T51PT","T50P","T50PT","0E2E"<CR>
"87LOP2","87L2E","R87L2","B87L2","PQ87L2","T51QT","T50Q","T50QT","0E01"<CR>
"87LOPG","87LGE","R87LG","B87LG","PQ87LG","T51GT","T50G","T50GT","0E4C"<CR>
"RDTY","TDTY","TESTY","3POY","RDTX","TDTX","TESTX","3POX","0E14"<CR>
"R4X","R3X","R2X","R1X","T4X","T3X","T2X","T1X","0A6C"<CR>
"R4Y","R3Y","R2Y","R1Y","T4Y","T3Y","T2Y","T1Y","0A74"<CR>
"DBADY","AVAY","RBADY","ROKY","DBADX","AVAX","RBADX","ROKX","0E14"
<CR>
"50LA","50RA","50LB","50RB","50LC","50RC","50L2","50R2","0B10"<CR>
"50LG","50RG","T51P","T51PR","T51G","T51GR","T51Q","T51QR","0C98"<CR><ETX>

where <STX> is the STX character (02).
<ETX> is the ETX character (03).
the last field in each line is the 4-byte ASCII hex representation of the checksum for the line.
"*" indicates an unused bit location.

Messages for other relay models may be derived from the appropriate tables in ***Section 9: Setting the Relay*** of this manual, using the above format.

BNA Message

In response to the **BNA** command, the relay sends names of the bits transmitted in the Status Byte in the A5D1 message. The first name is the MSB, the last name is the LSB. The BNA message is:

<STX>"*","*","*","STSET","*","*","*","*","yyyy"<ETX>

where: "yyyy" is the 4-byte ASCII representation of the checksum.
"*" indicates an unused bit location.

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

SNS Message

In response to the **SNS** command, the relay sends the name string of the SER (SER1 SER2 SER3) settings. **SNS** command is available at Access Level 1.

The relay responds to the **SNS** command with the name string in the SER settings. The name string starts with SER1, followed by SER2 and SER3.

For example: If SER1 = 50G1 OUT101; SER2 = 67P1T; SER3 = OUT102 52A; the name string will be "50G1","OUT101","67P1T","OUT102","52A".

If there are more than eight settings in SER, the SNS message will have several rows. Each row will have eight strings, followed by the checksum and cartridge return. The last row may have fewer than eight strings.

SNS message for the SEL-311L Relay is:

<STX>"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR>
"xxxx","xxxx","xxxx","yyyy"<CR><ETX>

where: "xxxx" is a string from the settings in SER (SER1, SER2 and SER3)
"yyyy" is the 4-byte ASCII representation of the checksum

APPENDIX E: COMPRESSED ASCII COMMANDS

INTRODUCTION

The SEL-311L Relay provides compressed ASCII versions of some of the relay's ASCII commands. The compressed ASCII commands allow an external device to obtain data from the relay, in a format which directly imports into spreadsheet or database programs, and which can be validated with a checksum.

The SEL-311L Relay provides the following compressed ASCII commands:

Command	Description
CASCII	Configuration message
CSTATUS	Status message
CHISTORY	History message
CEVENT	Event message
CSUMMARY	Event summary message

CASCII COMMAND—GENERAL FORMAT

The compressed ASCII configuration message provides the format information in all the compressed ASCII commands. This facilitates an external computer extracting data using other compressed ASCII commands. To obtain the configuration message for the compressed ASCII commands available in an SEL relay, type:

CAS <CR>

The relay sends:

```
<STX>"CAS",n,"yyyy"<CR>
"COMMAND 1",ll,"yyyy"<CR>
"#H","xxxxx","xxxxx",......,"xxxxx","yyyy"<CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR>
"COMMAND 2",ll,"yyyy"<CR>
"#h","ddd","ddd",......,"ddd","yyyy"<CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR>
    •
    •
    •
"COMMAND n",ll,"yyyy"<CR>
"#H","xxxxx","xxxxx",......,"xxxxx","yyyy"<CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR><ETX>
```

where: n is the number of compressed ASCII command descriptions to follow.

COMMAND is the ASCII name for the compressed ASCII command as sent by the requesting device. The naming convention for the compressed ASCII commands is a 'C' preceding the typical command. For example, CSTATUS (abbreviated to **CST**) is the compressed STATUS command.

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

"#H" identifies a header line to precede one or more data lines; '#' is the number of subsequent ASCII names. For example, “21H” identifies a header line with 21 ASCII labels.

"#h" identifies a header line to precede one or more data lines; '#' is the number of subsequent format fields. For example, “8h” identifies a header line with 8 format fields.

"xxxxx" is an ASCII name for corresponding data on following data lines. Maximum ASCII name width is 10 characters.

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

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

I	Integer data
F	Floating point data
mS	String of maximum m characters (e.g., 10S for a 10 character string)

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

A compressed ASCII command may require multiple header and data configuration lines.

If a compressed ASCII request is made for data that are not available, (e.g. the history buffer is empty or invalid event request), the relay responds with the following message:

<STX>"No Data Available","0668"<CR><ETX>

CASCII Command—SEL-311L

Display the SEL-311L Relay compressed ASCII configuration message by sending:

CAS <CR>

The relay sends:

<STX>
"**CAS**",6,"01A9"<CR>
"**CST**",1,"01B7"<CR>
"1H","FID","022C"<CR>
"1D","45S","0211"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0BB9"<CR>
"1D","I","I","I","I","I","I","I","05F4"<CR>
"28H","IA","IB","IC","IP","VA","VB","VC","VS","MOF","+5V_PS","+5V_REG","-5V_REG",
"+12V_PS","-12V_PS","+15V_PS","-15V_PS","MBTEMP","MBRAM","MBROM","MBA/D",
"MBCR_RAM","MBEEPROM","87LRAM","87LROM","CHANX","CHANY","87LFPGA",
"87LBOARD","3504"<CR>
"1D","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S",
"9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","1C75"<CR>
"**CHI**",1,"01A1"<CR>

"1H","FID","022C"<CR>
"1D","45S","0211"<CR>
"16H","REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT",
"LOCATION","CURR","FREQ","GROUP","SHOT","TARGETS","EVE_ID","1EF8"<CR>
"44D","I","I","I","I","I","I","I","I","6S","F","I","F","I","I","22S","I","0D54"<CR>
"**CEV**",1,"01AB"<CR>
"1H","FID","022C"<CR>
"1D","45S","0211"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0BB9"<CR>
"1D","I","I","I","I","I","I","I","05F4"<CR>
"23H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IP","IG","3I2","IAL","IBL","ICL","IAX","IBX","ICX",
"IAY","IBY","ICY","2723"<CR>
"1D","F","I","I","I","6S","F","I","22S","I","I","I","I","I","I","I","I","I","I","I","I","I","I","I",
"122C"<CR>
"26H","IA","IB","IC","IP","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","V1MEM","FREQ",
"VDC","IAL","IBL","ICL","IAX","IBX","ICX","IAY","IBY","ICY","IAT","IBT","ICT",
"TRIG","***Names of elements in the relay word separated by spaces***” ,"A42C"<CR>
"60D","I","I","I","I","I","F","F","F","F","F","F","I","I","I","I","I","I","I","I","I","I","I","I","I",
"2S","136S","14B2"<CR>
"**CEV C**",1,"020E"<CR>
"1H","FID","022C"<CR>
"1D","45S","0211"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0BB9"<CR>
"1D","I","I","I","I","I","I","I","05F4"<CR>
"23H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IP","IG","3I2","IAL","IBL","ICL","IAX","IBX","ICX",
"IAY","IBY","ICY","2723"<CR>
"1D","F","I","I","I","6S","F","I","22S","I","I","I","I","I","I","I","I","I","I","I","I","I","I","I",
"122C"<CR>
"26H","IA","IB","IC","IP","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","V1MEM","FREQ",
"VDC","IAL","IBL","ICL","IAX","IBX","ICX","IAY","IBY","ICY","IAT","IBT","ICT",
"TRIG","***Names of elements in the relay word separated by spaces***","A42C"<CR>
"240D","I","I","I","I","I","F","F","F","F","F","F","I","I","I","I","I","I","I","I","I","I","I","I","I",
"2S","136S","14E2"<CR>
"**CEV R**",1,"021D"<CR>
"1H","FID","022C"<CR>
"1D","45S","0211"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0BB9"<CR>
"1D","I","I","I","I","I","I","I","05F4"<CR>
"23H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IP","IG","3I2","IAL","IBL","ICL","IAX","IBX","ICX",
"IAY","IBY","ICY","2723"<CR>
"1D","F","I","I","I","6S","F","I","22S","I","I","I","I","I","I","I","I","I","I","I","I","I","I","I",
"122C"<CR>
"26H","IA","IB","IC","IP","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","V1MEM","FREQ",
"VDC","IAL","IBL","ICL","IAX","IBX","ICX","IAY","IBY","ICY","IAT","IBT","ICT",
"TRIG","***Names of elements in the relay word separated by spaces***","A42C"<CR>

"256D","I","I","I","I","I","F","F","F","F","F","F","I","I","I","I","I","I","I","I","I","I","I","I",
"2S","136S","14E9"<CR>
"**CSU**",1,"01B8"<CR>
"1H","FID","022C"<CR>
"1D","45S","0211"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0BB9"<CR>
"1D","I","I","I","I","I","I","I","05F4"<CR>
"16H","EVENT","LOCATION","HOUR_T","MIN_T","SEC_T","MSEC_T","EVENT_ID",
"SHOT","FREQ","GROUP","HOUR_C","MIN_C","SEC_C","MSEC_C","TARGETS",
"BREAKER","2415"<CR>
"1D","6S","F","I","I","I","I","I","I","F","I","I","I","I","I","22S","6S","0D5D"<CR>
"24H","IAL_PF","IAL_DEG_PF","IBL_PF","IBL_DEG_PF","ICL_PF","ICL_DEG_PF",
"3I2L_PF","3I2L_DEG_PF","IAX_PF","IAX_DEG_PF","IBX_PF","IBX_DEG_PF","ICX_PF",
"ICX_DEG_PF","3I2X_PF","3I2X_DEG_PF","IAY_PF","IAY_DEG_PF","IBY_PF",
"IBY_DEG_PF","ICY_PF","ICY_DEG_PF","3I2Y_PF","3I2Y_DEG_PF","468C"<CR>
"1D","I","F","I","F","I","F","I","F","I","F","I","F","I","F","I","F","I","F","I","F","I","F","I","F",
"1219"<CR>
"24H","IAL","IAL_DEG","IBL","IBL_DEG","ICL","ICL_DEG","3I2L","3I2L_DEG","IAX",
"IAX_DEG","IBX","IBX_DEG","ICX","ICX_DEG","3I2X","3I2X_DEG","IAY","IAY_DEG",
"IBY","IBY_DEG","ICY","ICY_DEG","3I2Y","3I2Y_DEG","2F94"<CR>
"1D","I","F","I","F","I","F","I","F","I","F","I","F","I","F","I","F","I","F","I","F","I","F","I","F",
"1219"<CR>
"18H","IA_PF","IA_DEG_PF","IB_PF","IB_DEG_PF","IC_PF","IC_DEG_PF","IP_PF",
"IP_DEG_PF","IG_PF","IG_DEG_PF","3I2_PF","3I2_DEG_PF","VA_PF","VA_DEG_PF",
"VB_PF","VB_DEG_PF","VC_PF","VC_DEG_PF","2F62"<CR>
"1D","I","F","I","F","I","F","I","F","I","F","I","F","F","F","F","F","F","F","0DC3"<CR>
"18H","IA","IA_DEG","IB","IB_DEG","IC","IC_DEG","IP","IP_DEG","IG","IG_DEG","3I2",
"3I2_DEG","VA","VA_DEG","VB","VB_DEG","VC","VC_DEG","1E28"<CR>
"1D","I","F","I","F","I","F","I","F","I","F","I","F","F","F","F","F","F","F","0DC3"<CR>
"2H","TRIG","RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A TMB8A
TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A RMB8B RMB7B RMB6B
RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B TMB7B TMB6B TMB5B TMB4B
TMB3B TMB2B TMB1B R4X R3X R2X R1X T4X T3X T2X T1X R4Y R3Y R2Y R1Y T4Y
T3Y T2Y T1Y ROKY ROKX ROKB ROKA","4724"<CR>
"2D","1S","11S","02FF"<CR>
<ETX>

The last field is the 4-byte hex ASCII representation of the checksum. See ***CEVENT Command*** for the definition of the "***Names of elements in the relay word separated by spaces***" field.

CSTATUS COMMAND—SEL-311L

Display status data in compressed ASCII format by sending:

CST <CR>

The relay sends:

<STX>
"FID","0143"<CR>
"***Relay FID string***","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"IA","IB","IC","IP","VA","VB","VC","VS","MOF","+5V_PS","+5V_REG","-5V_REG",
"+12V_PS","-12V_PS","+15V_PS","-15V_PS","MBTEMP","MBRAM","MBROM","MBA/D",
"MBCR_RAM","MBEEPROM","87LRAM","87LROM","CHANX","CHANY","87LFPGA",
"87LBOARD","33E2"<CR>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","xxxx","xxxx","yyyy"<CR><ETX>

where: "xxxx" are the data values corresponding to the first line labels and
"yyyy" is the 4-byte hex ASCII representation of the checksum.

CHISTORY COMMAND—SEL-311L

Display history data in compressed ASCII format by sending:

CHI <CR>

The relay sends:

<STX>"FID","0143"<CR>
"Relay FID string","yyyy"<CR>
"REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC",
"EVENT","LOCATION","CURR","FREQ","GROUP","SHOT","TARGETS","EVE_ID",
"1DD9"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,xxxx,xxxx,xxxx,xxxx,
"xxxx","xxxx",yyyy"<CR><ETX>

(the last line is then repeated for each record)

where: "xxxx" are the data values corresponding to the first line labels and
"yyyy" is the 4-byte hex ASCII representation of the checksum.

If the history buffer is empty, the relay responds:

<STX>"No Data Available","0668"<CR><ETX>

CEVENT COMMAND—SEL-311L

Display event report in compressed ASCII format by sending:

CEV [*n* S*x* L*y* L R C] (parameters in [ ] are optional)

where: *n* event number (1–41 if LER = 15; 1–22 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 15 if not specified

L 16 samples per cycle; overridden by the S*x* parameter, if present

R specifies raw (unfiltered) data; defaults to 16 samples per cycle unless overridden by the S*x* parameter. Defaults to 16 cycles in length unless overridden with the L*y* parameter.

C specifies 16 samples per cycle, 15-cycle length

The relay responds to the **CEV** command with the nth event report as shown below. Items in ***bold italics*** will be replaced with the actual relay data.

The compressed ASCII reports contain both backup and differential protection information.

<STX>"FID","0143"<CR>
"***Relay FID string***","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT",
"LOCATION","SHOT","TARGETS","IA","IB","IC","IP","IG","3I2","IAL","IBL","ICL","IAX",
"IBX","ICX","IAY","IBY","ICY","2606"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,xxxx,"xxxx",xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"IA","IB","IC","IP","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","V1MEM","FREQ",
"VDC","IAL","IBL","ICL","IAX","IBX","ICX","IAY","IBY","ICY","IAT","IBT","ICT",
"TRIG","***Names of elements in the relay word separated by spaces*** ","A30C"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,z,"***HEX-ASCII Relay Word***","yyyy"<CR>
"***Analog and digital data repeated for each row of event report***"
"SETTINGS","yyyy"<CR>
"***Relay group, logic, and global settings as displayed with the showset command (surrounded by quotes)***","yyyy"<CR><ETX>

where: "xxxx" are the data values corresponding to the line labels.
"yyyy" is the 4-byte hex ASCII representation of the checksum.
"FREQ" is the power system frequency at the trigger instant.
"SAM/CYC_A" is the number of analog data samples per cycle (4 or 16).
"SAM/CYC_D" is the number of digital data samples per cycle (4 or 16).
"NUM_OF_CYC" is the number of cycles of data in the event report.
"EVENT" is the event type.

"LOCATION" is the fault location.
"SHOT" is the recloser shot counter.
"TARGETS" are the front-panel tripping targets.
"IA", "IB", "IC", "IP", "IG", "3I2" is the fault current.
"TRIG" refers to the trigger record.
z is “>” for the trigger row, “*” for the fault current row and empty for all others. If the trigger row and fault current row are the same, both characters are included (e.g., “>*”).
"HEX-ASCII Relay Word" is the hex ASCII format of the relay word. The first element in the relay word is the most significant bit in the first character.

If samples per cycle are specified as 16, the analog data are displayed at 1/16-cycle intervals and digital data at 1/4-cycle intervals. The digital data are displayed as a series of hex ASCII characters. The relay displays digital data only when they are available. When no data are available, the relay sends only the comma delimiter in the digital data field.

If the specified event does not exist, the relay responds:

<STX>"No Data Available","0668"<CR><ETX>

The “***Names of elements in the relay word separated by spaces***” field is shown below for the SEL-311L Relay.

"EN TRP TIME COMM 87 50_51 RCRS RCLO A B C G ZONE1 ZONE2 ZONE3 87CHFAIL M1P M1PT Z1G Z1GT M2P M2PT Z2G Z2GT Z1T Z2T 50P1 67P1 67P1T 50G1 67G1 67G1T 51G 51GT 51GR LOP ILOP ZLOAD ZLOUT ZLIN LB1 LB2 LB3 LB4 LB5 LB6 LB7 LB8 LB9 LB10 LB11 LB12 LB13 LB14 LB15 LB16 RB1 RB2 RB3 RB4 RB5 RB6 RB7 RB8 RB9 RB10 RB11 RB12 RB13 RB14 RB15 RB16 LT1 LT2 LT3 LT4 LT5 LT6 LT7 LT8 LT9 LT10 LT11 LT12 LT13 LT14 LT15 LT16 SV1 SV2 SV3 SV4 SV1T SV2T SV3T SV4T SV5 SV6 SV7 SV8 SV5T SV6T SV7T SV8T SV9 SV10 SV11 SV12 SV9T SV10T SV11T SV12T SV13 SV14 SV15 SV16 SV13T SV14T SV15T SV16T MAB1 MBC1 MCA1 MAB2 MBC2 MCA2 CVTBL SOTFT MAG1 MBG1 MCG1 MAG2 MBG2 MCG2 DCHI DCLO BCW BCWA BCWB BCWC FIDEN FSA FSB FSC SG1 SG2 SG3 SG4 SG5 SG6 OC CC CLOSE CF TRGTR 52A 3PO SOTFE VPOLV 50L PDEM GDEM QDEM TRIP 50QF 50QR 50GF 50GR 32QF 32QR 32GF 32GR 32VE 32QGE 32IE 32QE F32I R32I F32Q R32Q F32QG R32QG F32V R32V * * IN106 IN105 IN104 IN103 IN102 IN101 ALARM OUT107 OUT106 OUT105 OUT104 OUT103 OUT102 OUT101 M3P M3PT Z3G Z3GT M4P M4PT Z4G Z4GT Z3T Z4T 50P2 67P2 67P2T 50P3 67P3 67P3T 50G2 67G2 67G2T 50G3 67G3 67G3T * * 51P 51PT 51PR Z1X 59VA MAB3 MBC3 MCA3 MAG3 MBG3 MCG3 27S 59S * 59VP 59VS SF 25A1 25A2 RCSF OPTMN RSTMN * * 79RS 79CY 79LO SH0 SH1 SH2 SH3 SH4 MAB4 MBC4 MCA4 MAG4 MBG4 MCG4 * * XAG1 XBG1 XCG1 XAG2 XBG2 XCG2 XAG3 XBG3 XCG3 XAG4 XBG4 XCG4 OSTI OSTO OST 50ABC X5ABC X6ABC OSB OSB1 OSB2 OSB3 OSB4 UBOSB 50G4 67G4 67G4T * MPP1 MABC1 MPP2 MABC2 50Q1 67Q1 67Q1T 50Q2 67Q2 67Q2T 59N1 59N2 50Q3 67Q3 67Q3T 50Q4 67Q4 67Q4T 59Q 59V1 51Q 51QT 51QR * * Z2PGS 67QG2S BTX Z3XT DSTRT NSTRT STOP Z3RB KEY EKEY ECTT PTRX UBB1 UBB2 UBB WFC PT PTRX1 PTRX2 27A 27B 27C 59A 59B 59C 3P27 3P59 27AB 27BC 27CA 59AB 59BC 59CA * * 201LOG 202LOG 203LOG 204LOG 205LOG 206LOG * * * * * * MPP3 MABC3 MPP4 MABC4 * * * * * * * * RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A TMB8A TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A RMB8B RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B TMB7B TMB6B TMB5B TMB4B TMB3B TMB2B TMB1B LBOKB CBADB RBADB ROKB

LBOKA CBADA RBADA ROKA 81D1 81D2 81D3 81D4 81D5 81D6 27B81 * 81D1T 81D2T 81D3T 81D4T 81D5T 81D6T 87HWAL 87BSY OUT201 OUT202 OUT203 OUT204 OUT205 OUT206 87LPE DD FTABC FTAG FTBG FTCG FTAB FTBC FTCA FTSE 87L 87LA 87LB 87LC 87L2 87LG CHYAL CHXAL 87LOPA 87LAE R87LA CTAA PQ87LA TRIP87 BXYZ2 BXYZG 87LOPB 87LBE R87LB CTAB PQ87LB BXYZA BXYZB BXYZC 87LOPC 87LCE R87LC CTAC PQ87LC T51PT T50P T50PT 87LOP2 87L2E R87L2 B87L2 PQ87L2 T51QT T50Q T50QT 87LOPG 87LGE R87LG B87LG PQ87LG T51GT T50G T50GT RDTY TDTY TESTY 3POY RDTX TDTX TESTX 3POX R4X R3X R2X R1X T4X T3X T2X T1X R4Y R3Y R2Y R1Y T4Y T3Y T2Y T1Y DBADY AVAY RBADY ROKY DBADX AVAX RBADX ROKX 50LA 50RA 50LB 50RB 50LC 50RC 50L2 50R2 50LG 50RG T51P T51PR T51G T51GR T51Q T51QR ","A30C"

These names are listed in the Relay Word Bits table for the appropriate model of relay in ***Section 9: Setting the Relay*** of this manual. Lists for other relay models may be derived from the appropriate tables in ***Section 9***, using the above format.

A typical ***HEX-ASCII Relay Word*** is shown below:

1000000492490000000000000000000000000020000000000000000000000024000080 0000C000010000000000000000000000000

Each bit in the ***HEX-ASCII Relay Word*** reflects the status of a Relay Word bit. The order of the labels in the "***Names of elements in the relay word separated by spaces"*** field matches the order of the ***HEX-ASCII Relay Word***. In the example above, the first two bytes in the ***HEX-ASCII Relay Word*** are "10". In binary, this evaluates to 00010000. Mapping the labels to the bits yields:

Labels	Z1T	Z2T	50P1	67P1	67P1T	50G1	67G1	67G1T
Bits	0	0	0	1	0	0	0	0

In this example, the 67P1 element is asserted (logical 1); all others are deasserted (logical 0).

CSUMMARY Command—SEL-311L

Display long summary event report in compressed ASCII format by sending:

CSU [N[EXT]] [TERSE]

CSU [[ACK] | [TERSE]] [*n*]

where:

No parameters	Output the newest chronological event summary
ACK	Acknowledge the oldest unacknowledged event report summary available on this port, or if a number is supplied, acknowledge the specified summary.
N[EXT]	View oldest unacknowledged event report
n	Display (or acknowledge if ACK present) event summary with this corresponding number in the **HIS E** command.
TERSE	Do not display label headers.

The relay responds to the **CSU** command with the nth long summary event report as shown in the example below:

<STX>"FID","0143"<CR>
"***Relay FID string***","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"EVENT","LOCATION","HOUR_T","MIN_T","SEC_T","MSEC_T",
"EVENT_ID","SHOT","FREQ","GROUP","HOUR_C","MIN_C","SEC_C","MSEC_C",
"TARGETS","BREAKER","22F6"<CR>
"xxxx",xxxx,xx,xx,xx,xxx,xxxxx,x,xxxx,x,xx,xx,xx,xxx,"xxxx",x,"yyyy"<CR>
"IAL_PF","IAL_DEG_PF","IBL_PF","IBL_DEG_PF","ICL_PF","ICL_DEG_PF","3I2L_PF",
"3I2L_DEG_PF","IAX_PF","IAX_DEG_PF","IBX_PF","IBX_DEG_PF","ICX_PF",
"ICX_DEG_PF","3I2X_PF","3I2X_DEG_PF","IAY_PF","IAY_DEG_PF","IBY_PF",
"IBY_DEG_PF","ICY_PF","ICY_DEG_PF","3I2Y_PF","3I2Y_DEG_PF",”456E”<CR>
xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,
xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,"yyyy"<CR>
"IAL","IAL_DEG","IBL","IBL_DEG","ICL","ICL_DEG","3I2L","3I2L_DEG","IAX",
"IAX_DEG","IBX","IBX_DEG","ICX","ICX_DEG","3I2X","3I2X_DEG","IAY","IAY_DEG",
"IBY","IBY_DEG","ICY","ICY_DEG","3I2Y","3I2Y_DEG",”2E76”<CR>
xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,
xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,"yyyy"<CR>
"IA_PF","IA_DEG_PF","IB_PF","IB_DEG_PF","IC_PF","IC_DEG_PF","IP_PF",
"IP_DEG_PF","IG_PF","IG_DEG_PF","3I2_PF","3I2_DEG_PF","VA_PF","VA_DEG_PF",
"VB_PF","VB_DEG_PF","VC_PF","VC_DEG_PF","2E41"<CR>
xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx.xx,
xxxx.xx,xxxx.xx,xxxx.xx,xxxx.xx,xxxx.xx,"yyyy"<CR>
"IA","IA_DEG","IB","IB_DEG","IC","IC_DEG","IP",
"IP_DEG","IG","IG_DEG","3I2","3I2_DEG","VA","VA_DEG","VB","VB_DEG","VC",
"VC_DEG","1D07"<CR>
xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx,xxxx.xx,xxxx.xx,
xxxx.xx,xxxx.xx,xxxx.xx,xxxx.xx,xxxx.xx,"yyyy"<CR>
"zzzz","RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A TMB8A
TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A RMB8B RMB7B RMB6B
RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B TMB7B TMB6B TMB5B TMB4B
TMB3B TMB2B TMB1B R4X R3X R2X R1X T4X T3X T2X T1X R4Y R3Y R2Y R1Y T4Y
T3Y T2Y T1Y ROKY ROKX ROKB ROKA","yyyy"<CR>
">","yyyyyyyyyyy","yyyy"<CR>
"*","yyyyyyyyyyy","yyyy"<CR>
<ETX>

where: "zzzz" is TRIP or TRIG, depending on event type.

If the specified event does not exist, the relay responds:

<STX>"No Data Available","067F"<CR><ETX>

APPENDIX F: SETTING NEGATIVE-SEQUENCE OVERCURRENT ELEMENTS

SETTING NEGATIVE-SEQUENCE DEFINITE-TIME OVERCURRENT ELEMENTS

Negative-sequence instantaneous overcurrent elements 50Q1 through 50Q4 and 67Q1 through 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 through 67Q4T with at least 1.5 cycles of time delay (transient condition lasts less than 1.5 cycles). For example, make time delay setting:

67Q1D = 1.50

for negative-sequence definite-time overcurrent element 67Q1T. Refer to Figure 3.46 for more information on negative-sequence instantaneous and definite-time overcurrent elements.

Continue reading in ***Coordinating Negative-Sequence Overcurrent Elements*** in this appendix for guidelines on coordinating negative-sequence definite-time overcurrent elements and a following coordination example. The coordination example 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 Figures 9.1 through 9.10 in ***Section 9: Setting the Relay***). This is because negative-sequence current can transiently appear when a circuit breaker is closed and balanced load current suddenly appears. Refer to Figure 3.49 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)

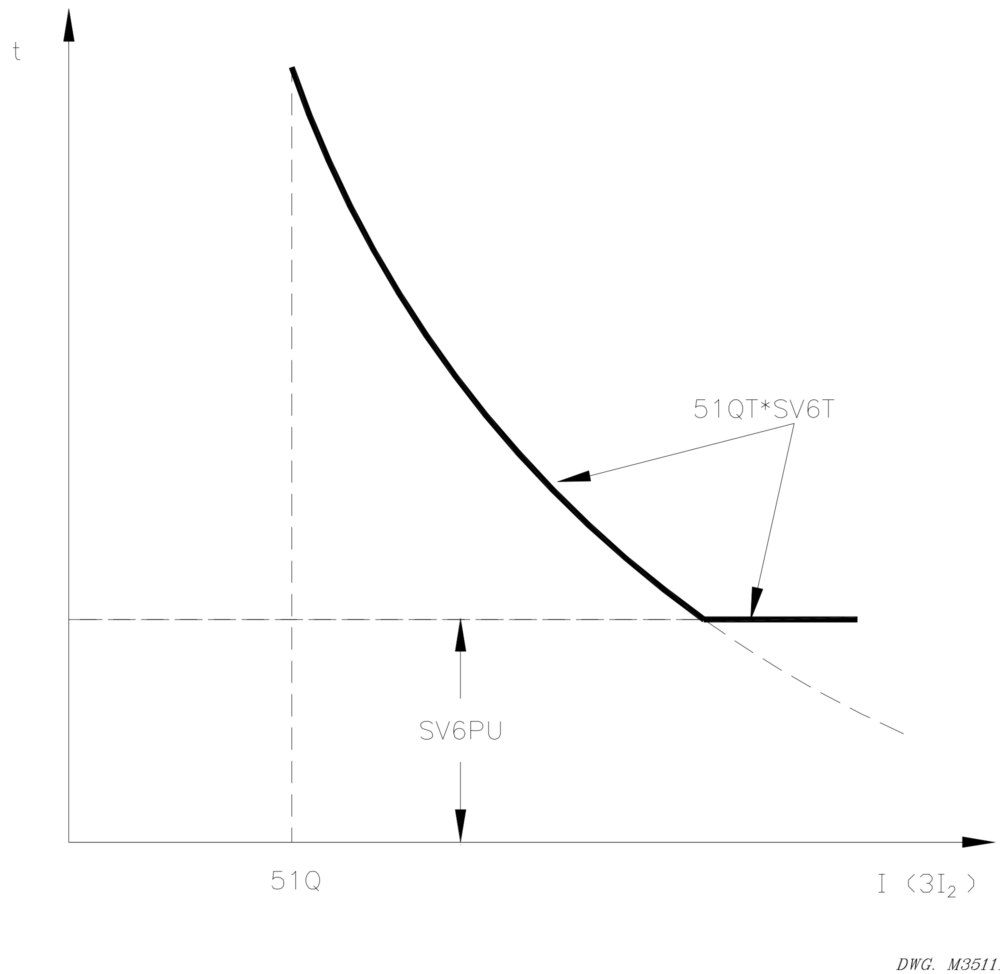


Figure F.1: Minimum Response Time Added to a Negative-Sequence Time-Overcurrent Element 51QT

Other Negative-Sequence Overcurrent Element References

A. F. Elneweihi, E. O. Schweitzer, M. W. Feltis, "Negative-Sequence Overcurrent Element Application and Coordination in Distribution Protection," IEEE Transactions on Power Delivery, Volume 8, Number 3, July 1993, pp. 915-924.

This IEEE paper is the source of the coordination guidelines and example given in this appendix. The paper also contains analyses of system unbalances and faults and the negative-sequence current generated by such conditions.

A. F. Elneweihi, "Useful Applications for Negative-Sequence Overcurrent Relaying," 22nd Annual Western Protective Relay Conference, Spokane, Washington, October 24-26, 1995.

This conference paper gives many good application examples for negative-sequence overcurrent elements. The focus is on the transmission system, where negative-sequence overcurrent elements provide better sensitivity than zero-sequence overcurrent elements in detecting some single-line-to-ground faults.

APPENDIX G: SETTING SELOGIC® CONTROL EQUATIONS

SELOGIC® control equations combine relay protection and control elements with logic operators to create custom protection and control schemes. This appendix shows how to set the protection and control elements (Relay Word bits) in the SELOGIC control equations.

Additional SELOGIC control equation setting details are available in ***Section 9: Setting the Relay*** (see also the Settings Sheets in the back of ***Section 9***). See ***SHO command (Show/View Settings)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** for a list of the factory settings included in a standard shipment of a 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) or 0 (logical 0)

Logical 1 represents an element being picked up, timed out, or otherwise asserted.

Logical 0 represents an element being dropped out or otherwise deasserted.

Complete listings of Relay Word bits and their descriptions are referenced in Tables 9.3 and 9.4 in ***Section 9: Setting the Relay***.

Relay Word Bit Operation Example—Phase Time-Overcurrent Element 51PT

As an example of protection element operation via the logic output of Relay Word bits, a phase time-overcurrent element is examined. Refer to phase time-overcurrent element 51PT in Figure 3.47 in ***Section 3: Line Current Differential, Distance, Out of Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements***. Read the text that accompanies Figure 3.47 (Table 3.8 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 subsection.

SELOGIC CONTROL EQUATIONS

Many of the protection and control element logic inputs shown in the various figures in ***Section 3*** through ***Section 8*** are SELOGIC control equations (labeled "SELOGIC Settings" in most of the Figures). SELOGIC control equations are set with combinations of Relay Word bits to accomplish such functions as:

- tripping circuit breakers
- assigning functions to optoisolated inputs
- operating output contacts
- torque-controlling overcurrent elements
- switching active setting groups
- enabling/disabling reclosing

Traditional or advanced custom schemes can be created with SELOGIC control equations.

SELOGIC Control Equation Operators

SELOGIC control equation settings use logic similar to Boolean algebra logic, combining Relay Word bits together using one or more of the six SELOGIC control equation operators listed in Table G.1.

Table G.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 G.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 of NOT Operator ! Applied to Single Element

The internal circuit breaker status logic in the SEL-311L Relay operates on 52a circuit breaker auxiliary contact logic. The SELOGIC control equation circuit breaker status setting is labeled 52A. See ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** and ***Close Logic*** in ***Section 6: Close and Reclose Logic*** 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 deenergized [IN101 = 0 (logical 0)]:

52A = !IN101 = NOT(IN101) = NOT(0) = 1

Thus, the SELOGIC control equation circuit breaker status setting 52A sees a closed circuit breaker.

With a 52b contact connected, if the circuit breaker is open, the 52b contact is closed and input IN101 is energized [IN101 = 1 (logical 1)]:

52A = !IN101 = NOT(IN101) = NOT(1) = 0

Thus, the SELOGIC control equation circuit breaker status setting 52A sees an open circuit breaker.

Example of NOT Operator ! Applied to Multiple Elements (Within Parentheses)

The SELOGIC control equation trip unlatch setting is set as follows:

ULTR = !(50L + 51G)

Refer also to ***Trip Logic*** in ***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 3.22)

51G Maximum residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see Figure 3.23)

OUT103 Output contact OUT103 is set as a breaker failure trip output (see Output Contacts in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***)

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 G.1 demonstrates the action of the rising edge operator / on the individual elements in setting ER.

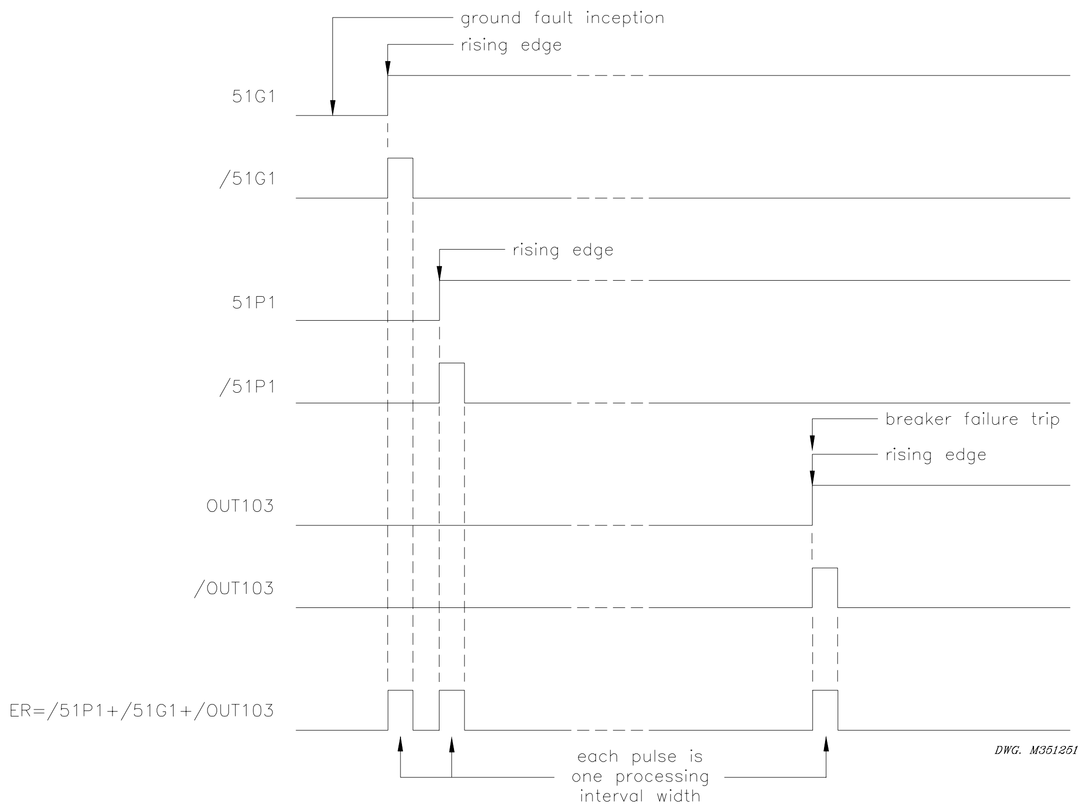


Figure G.1: Result of Rising Edge Operators on Individual Elements in Setting ER

Note in Figure G.1 that setting ER sees three separate rising edges, due to 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 G.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 G.2 demonstrates the action of the falling edge operator \ on the out-of-step blocking element in setting ER.

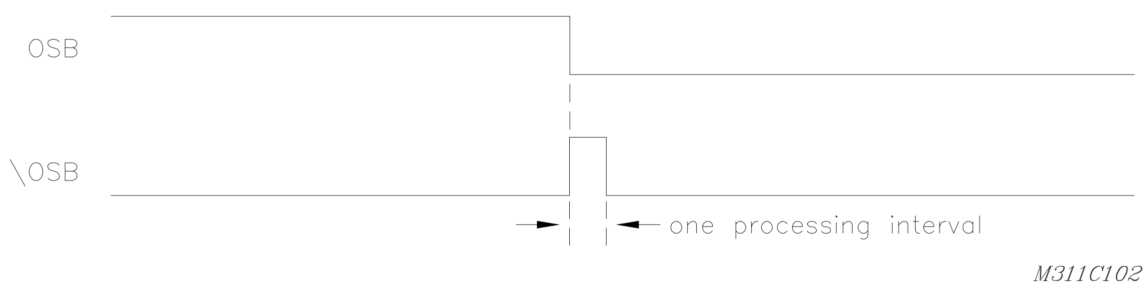


Figure G.2: Result of Falling Edge Operator on a Deasserting Out-of-Step Blocking Element

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

SELOGIC control equations can be set directly to:

1 (logical 1) or 0 (logical 0)

instead of with Relay Word bits. If a SELOGIC control equation setting is set directly to 1, it is always "asserted/on/enabled." If a SELOGIC control equation setting is set equal to 0, it is always "deasserted/off/disabled."

Note: SELOGIC control equation torque control settings (e.g., 67P1TC, 51P1TC) cannot be set directly to logical 0.

Under the ***SHO Command (Show/View Settings)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***, 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 at the end of ***Section 9: Setting the Relay***) 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 a SEL-311L Relay, these are all set directly to logical 1. See these factory settings in ***SHO Command (Show/View Settings)*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands***.

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 3.21 in ***Section 3: Line Current Differential, Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements*** 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 G.1. If this limit must be exceeded, use a SELOGIC control equation variable (SELOGIC control equation settings SV1 through 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 through 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 Relay 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 H: DISTRIBUTED NETWORK PROTOCOL (DNP) 3.00 LEVEL 2

OVERVIEW

The SEL-311L family of relays are available with the option to support Distributed Network Protocol (DNP) 3.00 Level 2 Slave protocol. This includes access to metering data, protection elements (Relay Word), contact I/O, targets, sequential events recorder, breaker monitor, relay summary event reports, settings groups, and time synchronization. The SEL-311L Relay supports DNP point remapping.

CONFIGURATION

To configure a port for DNP, set the port PROTO setting to DNP. Although DNP may be selected on any of the available ports, DNP may not be enabled on more than one port at a time. The following information is required to configure a port for DNP operation:

Label	Description	Default
SPEED	Baud rate (300–38400)	2400
DNPADR	DNP Address (0–65534)	0
ECLASS	Class for event data (0–3)	2
TIMERQ	Time-set request interval (0–32767 min.)	0
DECPLA	Currents scaling (0–3 decimal places)	1
DECPLV	Voltages scaling (0–3 decimal places)	1
DECPLM	Miscellaneous data scaling (0–3 decimal places)	1
STIMEO	Select/operate time-out (0–30 sec.)	1.0
DRETRY	Data link retries (0–15)	3
DTIMEO	Data link time-out (0–5 sec.)	1
MINDLY	Minimum time from DCD to Tx (0–1 sec.)	0.05
MAXDLY	Maximum time from DCD to Tx (0–1 sec.)	0.10
PREDLY	Settle time from RTS on to Tx (OFF, 0–30 sec.)	0
PSTDLY	Settle time after Tx to RTS off (0–30 sec.)	0
ANADB	Analog reporting dead band (0–32767 counts)	100
UNSOL	Enable Unsolicited reporting (Y, N)	N
PUNSOL	Enable Unsolicited reporting at power-up (Y, N)	N
REPADR	DNP Address to report to (0–65534)	0
NUMEVE	Number of events to transmit on (1–200)	10
AGEEVE	Age of oldest event to transmit on (0–60 sec.)	2.0
UTIMEO	Unsolicited confirmation timeout (0–50 sec.)	2

The RTS signal may be used to control an external transceiver. The CTS signal is used as a DCD input, indicating when the medium is in use. Transmissions are only initiated if DCD is de-asserted. When DCD drops, the next pending outgoing message may be sent once an idle time is satisfied. This idle time is randomly selected between the minimum and maximum allowed idle times (i.e., MAXDLY and MINDLY). In addition, the SEL-311L Relay monitors received data and treats receipt of data as a DCD indication. This allows RTS to be looped back to CTS in cases where the external transceiver does not support DCD. When the SEL-311L

Relay transmits a DNP message, it delays transmitting after asserting RTS by at least the time in the PREDLY setting. After transmitting the last byte of the message, the SEL-311L Relay delays for at least PSTDLY milliseconds before deasserting RTS. If the PSTDLY time delay is in progress (RTS still high) following a transmission, and another transmission is initiated, the SEL-311L Relay transmits the message without completing the PSTDLY delay and without any preceding PREDLY delay. The RTS/CTS handshaking may be completely disabled by setting PREDLY to OFF. In this case, RTS is forced high and CTS is ignored, with only received characters acting as a DCD indication. The timing is the same as above, but PREDLY functions as if it was set to 0, and RTS is not actually deasserted after the PSTDLY time delay expires.

Data-Link Operation

It is necessary to make two important decisions about the data-link layer operation. One is how to handle data-link confirmation, the other is how to handle data-link access. If a highly reliable communications link exists, the data-link access can be disabled altogether, which significantly reduces communications overhead. Otherwise, it is necessary to enable confirmation and determine how many retries to allow and what the data-link time-out should be. The noisier the communications channel, the more likely a message will be corrupted. Thus, the number of retries should be set higher on noisy channels. Set the data-link time-out long enough to allow for the worst-case response of the master plus transmission time. When the SEL-311L Relay decides to transmit on the DNP link, it has to wait if the physical connection is in use. The SEL-311L Relay monitors physical connections by using CTS input (treated as a Data Carrier Detect) and monitoring character receipt. Once the physical link goes idle, as indicated by CTS being deasserted and no characters being received, the SEL-311L Relay will wait a configurable amount of time before beginning a transmission. This hold-off time will be a random value between the MINDLY and MAXDLY setting values. The hold-off time is random, which prevents multiple devices waiting to communicate on the network from continually colliding.

Data Access Method

Based on the capabilities of the system, it is necessary to determine which method is desired to retrieve data on the DNP connection. The following table summarizes the main options, listed from least to most efficient, and corresponding key related settings are indicated.

Table H.1: Data Access Methods

Data Retrieval Method	Description	Relevant SEL-311L Settings
Polled Static	The master polls for static (Class 0) data only.	Set ECLASS = 0, Set UNSOL = N.
Polled Report-by-Exception	The master polls frequently for event data and occasionally for static data.	Set ECLASS to a non-zero value, Set UNSOL = N.

Data Retrieval Method	Description	Relevant SEL-311L Settings
Unsolicited Report-by-Exception	The slave devices send unsolicited event data to the master and the master occasionally sends integrity polls for static data.	Set ECLASS to a non-zero value, Set UNSOL = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent.
Quiescent	The master never polls and relies on unsolicited reports only.	Set ECLASS to a non-zero value, Set UNSOL = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent.

Device Profile

The following is the device profile as specified in the ***DNP 3.00 Subset Definitions*** document:

<table>
<tr><td colspan="2">DNP 3.00
DEVICE PROFILE DOCUMENT
This document must be accompanied by a table having the following headings:
Object Group | Request Function Codes | Response Function Codes
Object Variation | Request Qualifiers | Response Qualifiers
Object Name (optional)</td></tr>
<tr><td colspan="2">Vendor Name: Schweitzer Engineering Laboratories, Inc.</td></tr>
<tr><td colspan="2">Device Name: SEL-311L</td></tr>
<tr><td>Highest DNP Level Supported:
For Requests Level 2
For Responses Level 2</td><td>Device Function:
❐ Master ☑ Slave</td></tr>
<tr><td colspan="2">Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

<u>Supports enabling and disabling of unsolicited reports on a class basis.</u></td></tr>
<tr><td>Maximum Data Link Frame Size (octets):

Transmitted <u>292</u>

Received (must be 292)</td><td>Maximum Application Fragment Size (octets):

Transmitted <u>2048</u> (if >2048, must be configurable)

Received <u>2048</u> (must be >249)</td></tr>
</table>

Maximum Data Link Re-tries:	Maximum Application Layer Re-tries:
❒ None ❒ Fixed at ____________ ☑ Configurable, range _0_ to _15_	☑ None ❒ Configurable, range _____ to (Fixed is not permitted)

Requires Data Link Layer Confirmation:

❒ Never
❒ Always
❒ Sometimes If 'Sometimes', when? ____________
☑ Configurable If 'Configurable', how? _by settings._

Requires Application Layer Confirmation:

❒ Never
❒ Always (not recommended)
☑ When reporting Event Data (Slave devices only)
❒ When sending multi-fragment responses (Slave devices only)
❒ Sometimes If 'Sometimes', when? ____________
❒ Configurable If 'Configurable', how? ____________

Timeouts while waiting for:

Data Link Confirm	❒ None	❒ Fixed at _____	❒ Variable	☑ Configurable
Complete Appl. Fragment	☑ None	❒ Fixed at _____	❒ Variable	❒ Configurable
Application Confirm	❒ None	❒ Fixed at _____	❒ Variable	☑ Configurable
Complete Appl. Response	☑ None	❒ Fixed at _____	❒ Variable	❒ Configurable

Others ____________

Attach explanation if 'Variable' or 'Configurable' was checked for any timeout.

Sends/Executes Control Operations:

WRITE Binary Outputs	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
SELECT/OPERATE	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
DIRECT OPERATE	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
DIRECT OPERATE—NO ACK	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
Count > 1	☑ Never	❒ Always	❒ Sometimes	❒ Configurable
Pulse On	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
Pulse Off	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
Latch On	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
Latch Off	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
Queue	☑ Never	❒ Always	❒ Sometimes	❒ Configurable
Clear Queue	☑ Never	❒ Always	❒ Sometimes	❒ Configurable

Attach explanation if 'Sometimes' or 'Configurable' was checked for any operation.

FILL OUT THE FOLLOWING ITEM FOR MASTER DEVICES ONLY:

Expects Binary Input Change Events:

❒ Either time-tagged or non-time-tagged for a single event
❒ Both time-tagged and non-time-tagged for a single event
❒ Configurable (attach explanation)

FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY	
Reports Binary Input Change Events when no specific variation requested: ❒ Never ☑ Only time-tagged ❒ Only non-time-tagged ❒ Configurable to send both, one or the other (attach explanation)	Reports time-tagged Binary Input Change Events when no specific variation requested: ❒ Never ☑ Binary Input Change With Time ❒ Binary Input Change With Relative Time ❒ Configurable (attach explanation)
Sends Unsolicited Responses: ❒ Never ☑ Configurable (attach explanation) ❒ Only certain objects ❒ Sometimes (attach explanation) ☑ ENABLE/DISABLE UNSOLICITED Function codes supported	Sends Static Data in Unsolicited Responses: ☑ Never ❒ When Device Restarts ❒ When Status Flags Change No other options are permitted.
Default Counter Object/Variation: ❒ No Counters Reported ❒ Configurable (attach explanation) ☑ Default object 20 ❒ Default variation 6 ❒ Point-by-point list attached	Counters Roll Over at: ❒ No Counters Reported ❒ Configurable (attach explanation) ☑ 16 Bits ❒ 32 Bits ❒ Other Value ______________ ❒ Point-by-point list attached
Sends Multi-Fragment Responses: ❒ Yes ☑ No	

In all cases within the device profile that an item is configurable, it is controlled by SEL-311L Relay settings.

Object Table

The supported object, function, and qualifier code combinations are given by the following object table.

Table H.2: SEL-311L DNP Object Table

Object			Request (supported)		Response (may generate)	
Obj	*default Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)
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*	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		

Object			Request (supported)		Response (may generate)	
Obj	*default Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)
2	1	Binary Input Change without Time	1	6,7,8	129	17,28
2	2*	Binary Input Change with Time	1	6,7,8	129,130	17,28
2	3	Binary Input Change with Relative Time	1	6,7,8	129	17,28
10	0	Binary Output—All Variations	1	0,1,6,7,8		
10	1	Binary Output				
10	2*	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
20	6*	16-Bit Binary Counter without Flag	1	0,1,6,7,8	129	0,1,7,8
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*	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				

Object			Request (supported)		Response (may generate)	
Obj	*default Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)
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
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*	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				
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*	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				

Object			Request (supported)		Response (may generate)	
Obj	*default Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)
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*	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				
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				
		No object	13,14,23			

Data Map

Each version of the SEL-311L Relay has a slightly different data map. The following is the default object map supported by the SEL-311L Relay wye-connected PTs (FID = SEL-311L-Rxxx-VM-Dxxxxxxxx).

Table H.3: SEL-311L-Wye DNP Data Map

DNP Object Type	Index	Description
01,02	000–599	Relay Word, where RCLO is 0 and 50LG is 543.
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 87CHFAIL, 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, 01	IA magnitude and angle.

DNP Object Type	Index	Description
30,32	02, 03	IB magnitude and angle.
30,32	04, 05	IC magnitude and angle.
30,32	06, 07	IP magnitude and angle.
30,32	08, 09	VA magnitude (kV) and angle.
30,32	10, 11	VB magnitude (kV) and angle.
30,32	12, 13	VC magnitude (kV) and angle.
30,32	14, 15	VS magnitude (kV) and angle.
30,32	16, 17	3I0 magnitude and angle.
30,32	18, 19	I1 magnitude and angle.
30,32	20, 21	3I2 magnitude and angle.
30,32	22, 23	3V0 magnitude (kV) and angle.
30,32	24, 25	V1 magnitude (kV) and angle.
30,32	26, 27	V2 magnitude (kV) and angle.
30,32	28–31	MW A-, B-, C-, and 3-phase.
30,32	32–35	MVAR A-, B-, C-, and 3-phase.
30,32	36–39	Power factor A-, B-, C-, and 3-phase.
30,32	40	Frequency.
30,32	41	VDC.
30,32	42, 43	A-phase MWhr in and out.
30,32	44, 45	B-phase MWhr in and out.
30,32	46, 47	C-phase MWhr in and out.
30,32	48, 49	3-phase MWhr in and out.
30,32	50, 51	A-phase MVARhr in and out.
30,32	52, 53	B-phase MVARhr in and out.
30,32	54, 55	C-phase MVARhr in and out.
30,32	56, 57	3-phase MVARhr in and out.
30,32	58–62	Demand IA, IB, IC, IG, and 3I2 magnitudes.
30,32	63–66	A-, B-, C-, and 3-phase demand MW in.
30,32	67–70	A-, B-, C-, and 3-phase demand MVAR in.
30,32	71–74	A-, B-, C-, and 3-phase demand MW out.
30,32	75–78	A-, B-, C-, and 3-phase demand MVAR out.
30,32	79–83	Peak demand IA, IB, IC, IG, and 3I2 magnitudes.
30,32	84–87	A-, B-, C-, and 3-phase peak demand MW in.
30,32	88–91	A-, B-, C-, and 3-phase peak demand MVAR in.

DNP Object Type	Index	Description
30,32	92–95	A-, B-, C-, and 3-phase peak demand MW out.
30,32	96–99	A-, B-, C-, and 3-phase peak demand MVAR out.
30,32	100–102	Breaker contact wear percentage (A, B, C).
30	103	Fault type (see table for definition).
30	104	Fault location.
30	105	Fault current.
30	106	Fault frequency.
30	107	Fault settings group.
30	108	Fault recloser shot counter.
30	109–111	Fault time in DNP format (high, middle, and low 16 bits).
30,32	112, 113	IAX magnitude and angle.
30,32	114, 115	IBX magnitude and angle.
30,32	116, 117	ICX magnitude and angle.
30,32	118, 119	3I0X magnitude and angle.
30,32	120, 121	I1X magnitude and angle.
30,32	122, 123	3I2X magnitude and angle.
30,32	124, 125	IAY magnitude and angle.
30,32	126, 127	IBY magnitude and angle.
30,32	128, 129	ICY magnitude and angle.
30,32	130, 131	3I0Y magnitude and angle.
30,32	132, 133	I1Y magnitude and angle.
30,32	134, 135	3I2Y magnitude and angle.
30,32	136, 137	IAT magnitude and angle.
30,32	138, 139	IBT magnitude and angle.
30,32	140, 141	ICT magnitude and angle.
30,32	142, 143	3I0T magnitude and angle.
30,32	144, 145	I1T magnitude and angle.
30,32	146, 147	3I2T magnitude and angle.
40,41	00	Active settings group.

Note: For 112 to 147, when values to be returned invalid the value (float), 0x7F800000 will be returned.

Binary inputs (objects 1 and 2) are supported as defined by the previous table. Binary inputs 0–599 and 1200–1223 are scanned approximately once per second to generate events. When time is reported with these event objects, it is the time at which the scanner observed the bit change. This may be significantly delayed from when the original source changed and should not be used for sequence-of-events determination.

In order to determine an element's point index, consult the Relay Word Bits table in ***Section 9: Setting the Relay.*** Locate the element in question in the table and note the Relay Word row number. From that row number, subtract the row number of the first Relay Word row (usually 2) and multiply that result by 8. This is the index of the right-most element of the Relay Word row of the element in question. Count over to the original element and add that to get the point index. Binary Inputs 600–1199 are derived from the Sequential Events Recorder (SER) and carry the time stamp of actual occurrence. Static reads from these inputs will show the same data as a read from the corresponding index in the 0–599 group. Only points that are actually in the SER list (SET R) will generate events in the 600–1199 group.

Analog Inputs (objects 30 and 32) are supported as defined by the preceding table. The values are reported in primary units. Analog inputs 28–35, 42–57, 63–78, 84–102, and 104 are further scaled according to the DECPLM setting (e.g., if DECPLM is 3, then the value is multiplied by 1000). Analog inputs 58–62, 79–83, and the even-numbered points in 0–7, 16–21, and 112–146 (current magnitudes) are scaled according to the DECPLA setting. The even-numbered points in 8–15 and 22–27 (voltage magnitudes) are scaled according to the DECPLV setting. Analog inputs 36–41, 106, and the odd-numbered points in 0–27 and 113–147 (angles) are scaled by 100. The remaining analogs are not scaled.

Event-class messages are generated whenever an input changes beyond the value given by the ANADB setting. The dead-band check is done after any scaling is applied. The angles (the odd numbered points in 0–27 and 113–147) will only generate an event if, in addition to their dead-band check, the corresponding magnitude (the preceding point) contains a value greater than the value given by the ANADB setting. Analog inputs are scanned at approximately a 1-second rate, except for analogs 103–111. During a scan, all events generated will use the time the scan was initiated. Analogs 103–111 are derived from the history queue data for the most recently read fault and do not generate event messages. Analog 103 is a 16-bit composite value, where the upper byte is defined as follows:

Value	Event Cause
1	Trigger command
2	Pulse command
4	Trip element
8	ER element

And the lower byte is defined as follows:

Value	Fault Type
0	Indeterminate
1	A-Phase
2	B-Phase
4	C-Phase
8	Ground

The lower byte may contain any combination of the above bits (e.g., a 6 is a B to C fault and a 9 is an A to Ground fault). If Analog 103 is 0, fault information has not been read and the related analogs (104–111) do not contain valid data.

Control Relay Output Blocks (object 12, variation 1) are supported. The control relays correspond to the remote bits and other functions, as shown above. The Trip/Close bits take precedence over the control field. The control field is interpreted as follows:

Index	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
0-15	Set	Clear	Set	Clear	Pulse	Clear
16-23	Pulse	Do nothing	Pulse	Do nothing	Pulse	Do nothing
24	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1
25	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3
26	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5
27	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7
28	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9
29	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11
30	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13
31	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15
32	Pulse CC	Pulse OC	Pulse CC	Pulse OC	Pulse CC	Pulse OC

The Status field is used exactly as defined. All other fields are ignored. A pulse operation asserts a point for a single processing interval. Caution should be exercised with multiple remote bit pulses in a single message (i.e., point count > 1), as this may result in some of the pulse commands being ignored and returning an already active status.

Analog Outputs (objects 40 and 41) are supported as defined by the preceding table. Flags returned with object 40 responses are always set to 0. The Control Status field of object 41 requests is ignored. If the value written to index 0 is outside of the range 1 through 6, the relay will not accept the value and will return a hardware error status.

Relay Summary Event Data

Whenever there is unread relay event summary data (fault data), binary input point 1023 will be set. In order to load the next available relay event summary, the master should pulse binary output point 15. This will cause the event summary analogs (points 103–111) to be loaded with information from the next oldest relay event summary. Since the summary data is stored in a first-in, first-out manner, loading the next event will cause the data from the previous load to be discarded. The event summary analogs will retain this information until the next event is loaded. If no further event summaries are available, attempting to load the next event will cause the event type analog (point 103) to be set to 0.

Point Remapping

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 analogs (30 and 32) and the other for the binaries (1 and 2). The indices correspond to those given by the relay's default DNP data map. The order in which they 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 1025 binaries and 112 analogs 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 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 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 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>
==>
```

SETTINGS SHEET—DNP PORT—SET P

Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B)	PROTO	=	DNP
Baud rate (300,600,1200,2400,4800,9600,19200,38400)	SPEED	=	
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 dead band, counts (0–32767)	ANADB	=	
Allow Unsolicited Reporting (Y/N)	UNSOL	=	
Enable unsolicited messages on power-up (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	=	

APPENDIX I: MIRRORED BITS™ COMMUNICATIONS

OVERVIEW

MIRRORED BITS is a direct relay-to-relay communications protocol that allows protective relays to exchange information quickly and securely, and with minimal expense. The information exchanged can facilitate remote control, remote sensing, or communications-assisted protection schemes such as POTT, DCB, etc. The SEL-311L Relay supports two MIRRORED BITS channels, differentiated by the channel specifiers A and B. Bits transmitted are called TMB1*x* through TMB8*x*, where *x* is the channel specifier (e.g., A or B), and are controlled by the corresponding SELOGIC control equations. Bits received are called RMB1*x* through RMB8*x* and are usable as inputs to any SELOGIC control equations. Channel status bits are called ROK*x*, RBAD*x*, CBAD*x* and LBOK*x* and are also usable as inputs to any SELOGIC control equations. Further channel status information is available via the **COM** command.

Important: Do not connect an unconfigured port to a MIRRORED BITS device. Otherwise the relay will appear to be locked up. Configure the port first, then connect the device.

OPERATION

Message Transmission

All messages are transmitted without idle bits between characters. Idle bits are allowed between messages.

- At 4800 baud, one message is transmitted each 1/2-power system cycle.
- At 9600 baud, one message is transmitted each 1/4-power system cycle.
- At 19200 and 38400 baud, one message is transmitted each 1/8-power system cycle for the SEL-321 and 1/4 power system cycle for the SEL-311L Relay.

Message Decoding and Integrity Checks

The relay will deassert a user-accessible flag per channel (hereafter called ROK*x*) upon failing any of the following received-data checks:

- Parity, framing, or overrun errors.
- Receive data redundancy error.
- Receive message identification error.
- No message received in the time three messages have been sent.

While ROK*x* is not asserted, the relay will prevent new data from being transferred to the pickup dropout security counters described later. Instead, the relay will send one of the following user selectable values (hereafter called default values) to the security counter inputs:

- 1
- 0
- The last valid value

The user will be allowed to select one of the default values for each RMB.

Enter the synchronization process described below.

The relay will assert ROK*x* only after successful synchronization as described below and two consecutive messages pass all of the data checks described above. After ROK*x* is reasserted, received data may be delayed while passing through the security counters described below.

Transfer of received data to RMB1*x*–RMB8*x* is supervised by eight user-programmable pickup/dropout security counters settable from 1 (allow every occurrence to pass) to 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 it is set in counts of received messages instead of time. An SEL-311L Relay talking to another SEL-311L Relay 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. Things get a little more complicated when two relays of different processing rates are connected via MIRRORED BITS, such as a SEL-321 talking to a SEL-311L Relay. The SEL-321 processes power system information each 1/8 power system cycle, but processes the pickup/dropout security counters as messages are received. Since the SEL-321 is receiving messages from the SEL-311L Relay, it will receive a message per 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 Relay will delay a bit by 1/4 cycle, because the SEL-311L Relay is receiving new MIRRORED BITS messages each 1/8 cycle from the SEL-321.

Synchronization

When a node detects a communications error, it deasserts ROK*x* and transmits an attention message, which includes its TX_ID setting.

When a node receives an attention message, it checks to see if its TX_ID is included.

If its own TX_ID is included and at least one other TX_ID is included, the node transmits data.

If its own TX_ID is not included, the node deasserts ROK*x*, includes its TX_ID in the attention message, and transmits the new attention message.

If its own TX_ID is the only TX_ID included, the relay assumes the message is corrupted unless the loopback mode has been enabled. If loopback is not enabled, the node deasserts ROK*x* and transmits the attention message with its TX_ID included. If loopback is enabled, the relay transmits data.

In summary, when a node detects an error, it transmits attention until it receives an attention with its own TX_ID 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 will eventually be received by the originating node. It will then be killed, and data transmission will resume. This method of synchronization allows the relays to reliably determine which byte is the first byte of the message. It also forces mis-synchronized UARTs to become re-synchronized. On the down side, this method takes down the entire loop for a receive error at any node in the loop. This decreases availability and makes one-way communications impossible.

Loopback Testing

Use the **LOO** command to enable loopback testing.

While in loopback mode, ROK*x* is deasserted, and another user-accessible flag, LBOK*x* will assert and deassert based on the received data checks.

See ***LOO Command*** in ***Section 10: Line Current Differential Communications and Serial Port Communications and Commands*** for more information.

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 will contain at least the following fields:

- Dropout Time/Date
- Pickup Time/Date
- Time elapsed during dropout
- Reason for dropout (See Message Decoding and Integrity Checks)

Use the **COM** command to generate a long or summary report of the communications errors.

There is only a single record for each outage, but an outage can evolve. For example, the initial cause could be a data disagreement, but the outage can be perpetuated by framing errors. 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 exceeds a user-settable threshold, the relay will assert a user-accessible flag, hereafter called RBAD*x*. Note: The user will typically combine RBAD*x* with other alarm conditions using SELOGIC control equations.

When channel unavailability exceeds a user-settable threshold, the relay will assert a user accessible flag, hereafter called CBAD*x*. Note: The user will typically combine CBAD*x* with other alarm conditions using SELOGIC control equations.

MIRRORED BITS PROTOCOL FOR THE PULSAR 9600 BAUD MODEM

The user indicates that a Pulsar MBT modem is to be used by responding "MBT" to the RTS/CTS setting prompt. When the user selects MBT, the baud rate setting will be limited 9600 baud.

The MIRRORED BITS protocol compatible with the Pulsar MBT-9600 modem is identical to the standard MIRRORED BITS protocol with the following exceptions:

The relay injects a delay (idle time) between messages. The length of the delay is one relay processing interval. Note: An idle processing interval guarantees at least 19 idle bits at 9600 baud in an SEL-321 Relay with the system frequency at 65 Hz.

The relay resets RTS (to a negative voltage at the EIA-232 connector) for MIRRORED BITS communications using this specification. The relay sets RTS (to a positive voltage at the EIA-232 connector) for MIRRORED BITS communications using the R6 or original R version of MIRRORED BITS.

SETTINGS

```
protocol (SEL,LMD,MBA,MBB)                       PROTO = MBA  ?
```

Set PROTO = MBA to enable the MIRRORED BITS protocol channel A on this port. Set PROTO = MBB to enable the MIRRORED BITS protocol channel B on this port. For the remainder of this section, PROTO = MBA is assumed.

```
baud rate (300-38400)                            SPEED = 9600   ?
```

Use the SPEED setting to control the rate at which the MIRRORED BITS messages are transmitted, in power system cycles (~), based on the following table:

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

```
enable hardware handshaking (Y,N,MBT)            RTSCTS= N     ?
```

Use the MBT option if you are using a Pulsar MBT 9600 baud modem. With this option 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's RTS signal to determine whether the new or old MIRRORED BITS protocol is in use.

```
Mirrored Bits Receive bad pickup (1-10000 sec)   RBADPU= 60     ?
```

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.

```
Mirrored Bits Channel bad pickup (1-10000 10E-6) CBADPU= 1000   ?
```

Use the CBADPU setting to determine the ratio of channel down time 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 in the 321 or 311L manuals for a description of the COMM records.

```
Mirrored Bits transmit identifier(1-4)         TX_ID = 1      ?
Mirrored Bits receive identifier(1-4)          RX_ID = 2      ?
```

Set the RX_ID of the local relay to match the TX_ID 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:

	TX_ID	**RX_ID**
Relay X	1	3
Relay Y	2	1
Relay Z	3	2

```
Mirrored Bits receive default state (string of 1s, 0s or Xs)
       87654321
RXDFLT=00000X11
     ?
```

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 Xs, for RMB1A–RMB8A, where X represents the most recently received valid value.

```
Mirrored Bits RMB_ Debounce PU msgs (1-8)    RMB1PU= 1      ?
Mirrored Bits RMB_ Debounce DO msgs (1-8)    RMB1DO= 1      ?
Mirrored Bits RMB_ Debounce PU msgs (1-8)    RMB2PU= 1      ?
Mirrored Bits RMB_ Debounce DO msgs (1-8)    RMB2DO= 1      ?
Mirrored Bits RMB_ Debounce PU msgs (1-8)    RMB3PU= 1      ?
Mirrored Bits RMB_ Debounce DO msgs (1-8)    RMB3DO= 1      ?
Mirrored Bits RMB_ Debounce PU msgs (1-8)    RMB4PU= 1      ?
Mirrored Bits RMB_ Debounce DO msgs (1-8)    RMB4DO= 1      ?
Mirrored Bits RMB_ Debounce PU msgs (1-8)    RMB5PU= 1      ?
Mirrored Bits RMB_ Debounce DO msgs (1-8)    RMB5DO= 1      ?
Mirrored Bits RMB_ Debounce PU msgs (1-8)    RMB6PU= 1      ?
Mirrored Bits RMB_ Debounce DO msgs (1-8)    RMB6DO= 1      ?
Mirrored Bits RMB_ Debounce PU msgs (1-8)    RMB7PU= 1      ?
Mirrored Bits RMB_ Debounce DO msgs (1-8)    RMB7DO= 1      ?
Mirrored Bits RMB_ Debounce PU msgs (1-8)    RMB8PU= 1      ?
Mirrored Bits RMB_ Debounce DO msgs (1-8)    RMB8DO= 1      ?
```

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.

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.

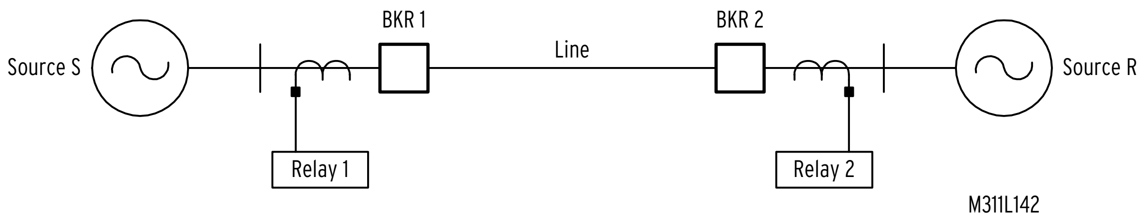
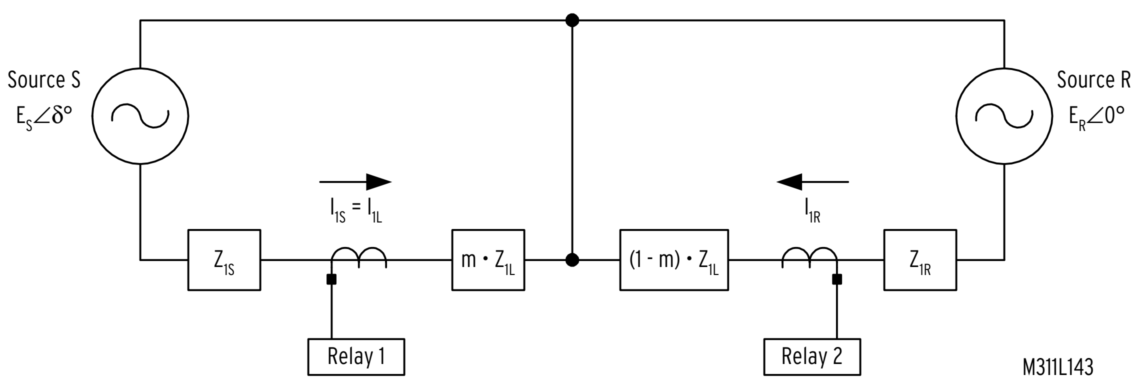


Figure J.1: Example System Single Line



Z1S = Source S Positive-Sequence Impedance

Z1R = Source R Positive-Sequence Impedance

Z1L = Line Positive-Sequence Impedance

m = Per-unit distance from Breaker 1 (BKR 1)

I1S = Positive-Sequence current measured by Relay 1 (local relay current, I_{1L}, for our example)

I1R = 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 effect 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.

$$I_{1S} = \frac{E_S \angle \delta°}{Z_{1S} + mZ_{1L}} \qquad \text{Equation J.1}$$

$$I_{1R} = \frac{E_R \angle 0°}{Z_{1R} + (1 - m) \bullet Z_{1L}} \qquad \text{Equation J.2}$$

$$\frac{I_{1R}}{I_{1S}} = \frac{I_{AR}}{I_{AL}} = \frac{E_R \angle 0°}{E_S \angle \delta°} \bullet \frac{[Z_{1S} + m \bullet Z_{1L}]}{[Z_{1R} + (1 - m) \bullet Z_{1L}]} \qquad \text{Equation J.3}$$

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 $\delta = 0°$. In our default settings, we assumed $\delta = 10°$. 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 non-homogeneous, 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 non-homogeneous angle difference can add with the angle difference caused by $\delta = 10°$. If the $\angle Z_{1S}$ is 10° greater than $\angle Z_{1R}$ for the fault at m = 0, the non-homogenous 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 that 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 restrain 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

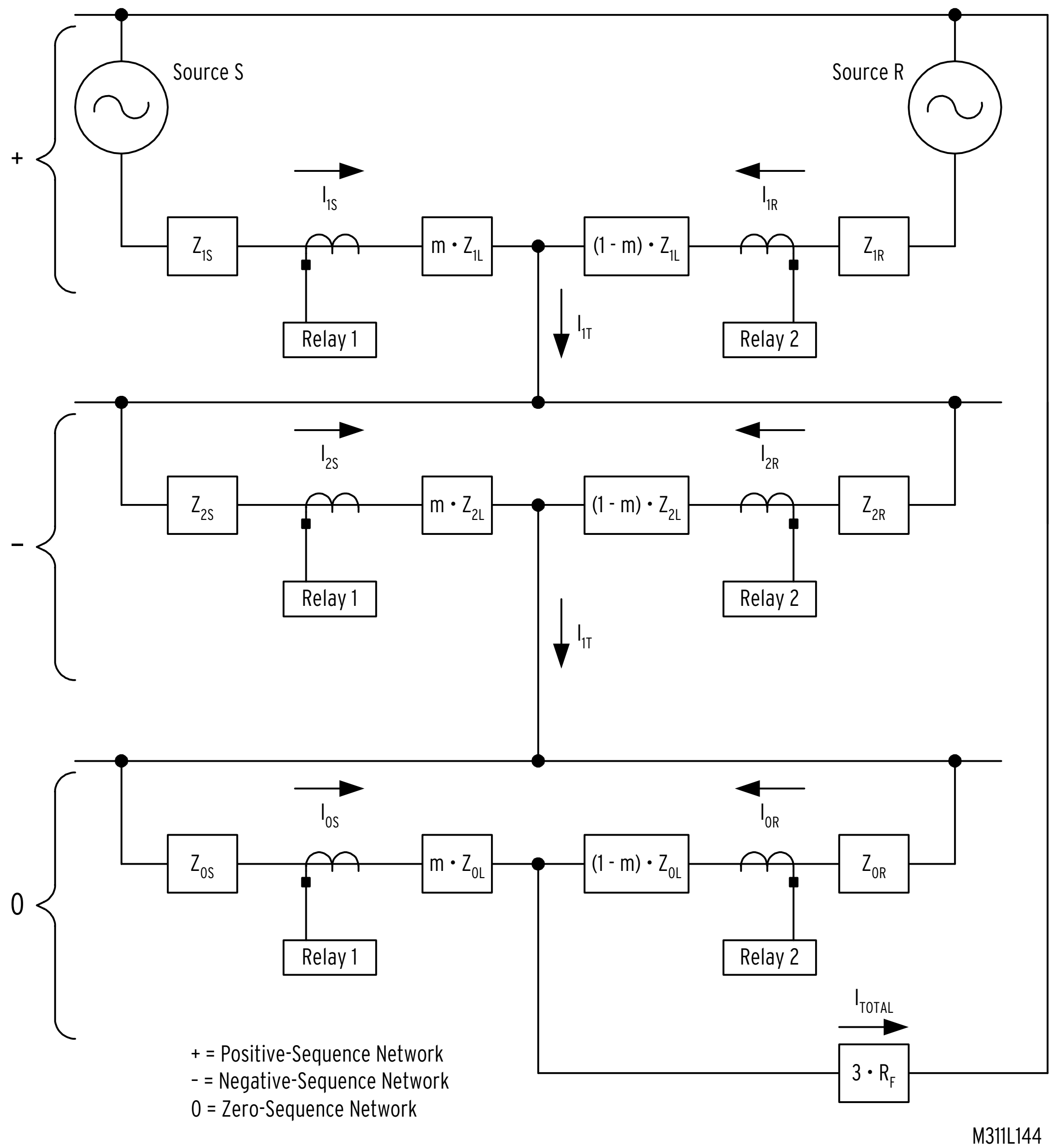


Figure J.3: Sequence Connection Diagram for an A-Phase Ground Fault

Summary

System non-homogeneity 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

Example 1: 500 kV OH Transmission Line: 100 Miles of Single 1113 MCM Conductor

$I = 2 \bullet \pi \bullet f \bullet C \bullet V_{L-N}$ [A per-phase per mile]

Equation J.7

$C = \frac{0.0388}{\log_{10}(D_{EQ} / r)} l$ [μF]

Equation J.8

where:

D_{EQ}[1] = 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)

[1] Assuming a conductor spacing of 50 ft between the conductors of a horizontal line configuration (D_{EQ} = 63 ft).

@ 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

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.

Example 2: 15 kV Underground Cable: 5 Miles

$C = \frac{0.0169 \bullet n \bullet k}{G} l$ [μF]

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-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.

Ground Fault Resistance Coverage With 87L2P = 0.5 A

In both examples, setting 87L2P = 0.5 A secondary allows ground fault resistance coverage up to:

$$R_F = \frac{66.4\ \text{V}}{0.5\ \text{A}} = 132.8\ \Omega\ \text{secondary}^2$$

[2] Assumes load current less than 1/3 of nominal secondary current. See Figure 3.8 for ground fault resistance coverage with more load current.

APPENDIX K: SEL-5030 ACSELERATOR™

INTRODUCTION

The SEL-5030 ACSELERATOR is an easy-to-use yet powerful tool to help get the most out of your SEL-311L Relay.

Using the SEL-5030 ACSELERATOR, you will be able to:

- Create, test, and manage settings with a Windows® interface.
- Visually design SELOGIC® control equations with a powerful Logic Editor.
- Verify SELOGIC control equations with an integrated Logic Simulator.
- Analyze power system events from SEL relays with integrated Waveform and Harmonic Analysis tools.
- Communicate with SEL devices via an HMI interface with integrated Meter and Control functions.
- Create, manage, copy, merge, and read relay settings with a settings database manager.

This document gives instructions for installing the SEL-5030 ACSELERATOR. A Quick Tour guide is available as part of the online help. After installation, the Quick Tour will show how to create a circuit breaker (CB) simulator. The CB simulator is useful for testing and evaluation.

Note: Like all SEL relay products, the SEL-311L can also be set and operated by a simple ASCII terminal.

ACSELERATOR SYSTEM REQUIREMENTS

CPU: Pentium class (recommended 90 MHz or faster)

Operating System: Windows 95/98 with 16 MB ram (32 MB ram recommended)
Windows NT4 SP3 or later with 32 MB ram (64 MB ram recommended)
Windows 2000 with 64 MB ram

Disk Space: 25 Mb

Communications: EIA-232 serial port for communicating with the relay

CD drive: required for installation

INSTALLATION

Note: Your PC must be restarted after the installation for the changes to take effect.

To install the ACSELERATOR software, perform the following steps.

1. Close all other software applications on your PC.
2. Insert the ACSELERATOR software CD into your PC's CD-ROM drive. The installation program should start automatically. If the install program does not start, select Run from the windows start menu and type in the following command **D:\SETUP** (substitute D:\ with your PC's CD-ROM drive letter).
3. Follow the steps that appear on the screen. The installation program will perform all the necessary steps to load the ACSELERATOR software onto your PC.

It is necessary to have the correct comctl32.dll file installed on your computer in order to see the toolbar buttons. If you do not see the toolbar buttons, run the 40ComUpd.exe, located in the install directory. This file will install the proper windows system drivers.

STARTING ACSELERATOR

You can start ACSELERATOR the following ways:

1. Double-click the ACSELERATOR icon if you have a desktop shortcut.
2. Choose "Programs | SEL Applications" and select the ACSELERATOR icon to start the program.

SEL-311L Relay Command Summary

Access Level 0 Commands	The only thing that can be done at Access level 0 is to go to Access Level 1. The screen prompt is: =
ACC	Enter Access Level 1. If the main board password jumper is not in place, the relay prompts for entry of the Access Level 1 password in order to enter Access Level 1.
CAS	Compressed ASCII configuration data
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 Access Level 2. If the main board password jumper is not in place, the relay prompts for entry of the Access Level 2 password in order to enter Access Level 2.
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 Sx Ly L R C]	Compressed event report (parameters in [ ] are optional) where: *n* event number (1–41 if LER = 15; 1–22 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 15 if not specified L 16 samples per cycle; overridden by the S*x* parameter, if present R specifies raw (unfiltered) data; defaults to 16 samples per cycle unless overridden by the S*x* parameter. Defaults to 16 cycles in length unless overridden with the L*y* parameter. C specifies 16 samples per cycle, 15-cycle length
CHIS	Compressed history
COM *p* L	Show a long format communications summary report for all events on MIRRORED BITS™ or Differential Channel *p*.
COM *p n*	Show a communications summary for latest *n* events on MIRRORED BITS or Differential Channel *p*.
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS or Differential Channel *p*.
COM *p d1*	Show a communications summary report for events occurring on date *d1* on MIRRORED BITS or Differential Channel *p*.
COM *p d1 d2*	Show a communications summary report for events occurring between dates *d1* and *d2* on MIRRORED BITS or Differential Channel *p*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
COM C *p*	Clears the communications summary report for Channel *p*.
CST	Compressed status report
CSU	Compressed event summary
DAT	Set / Show relay 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	Set / Show DNP map
EVE *n*	Show event report number *n* with 1/4-cycle resolution.
EVE L *n*	Show event report number *n* with 1/16-cycle resolution.
EVE R *n*	Show raw event report number *n* with 1/16-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 Analytic Assistant.
GRO	Display active group number.

HIS *n*	Show brief summary of the *n* latest event reports.
HIS C	Clear the brief summary and corresponding event reports.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET *k*	Display instantaneous metering data (currents and alpha plane) for local and remote terminals. 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.
QUI	Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) protocol connection. Available in all access levels.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER *m n*	Show rows *m* through *n* in the Sequential Events Recorder (SER) event report.
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 C	Clears the Sequential Events Recorder (SER).
SHO *n*	Show relay settings (overcurrent, reclosing, timers, etc.) for Group *n*.
SHO L *n*	Show SELOGIC® control equation settings for Group *n*.
SHO G	Show global settings.
SHO P *n*	Show Port *n* settings.
SHO R	Show Sequential Events Recorder (SER) settings.
SHO T	Show text label settings.
STA	Show relay self-test status.
SUM	Show newest event summary.
SUM A	Acknowledge oldest even summary.
SUM N	View oldest unacknowledged event report.
SUM N [A]	Display or acknowledge event summary number "N".
TAR R	Reset the front-panel tripping targets.
TAR *n k*	Display Relay Word row. If *n* = 0 through 45, display row *n*. If *n* is an element name (e.g., 50G1) display the row containing element *n*. Enter *k* for repeat count.
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	Trigger an event report.

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. See the Note in the ***Set Close*** discussion, following Figure 6.1 for more information concerning the CLO command.
GRO *n*	Change active group to Group *n*.
OPE	Open the circuit breaker. See the Note following Figure 5.2 and the Note in the ***Lockout State*** discussion, following Table 6.1 for more information concerning the OPE command.
PUL *n k*	Pulse output contact *n* (OUT101–OUT107, ALARM, OUT201–OUT212) for *k* (1–30) seconds. Parameter *n* must be specified; *k* defaults to 1 if not specified.

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: =>>
CON *n*	Control Remote Bit RB*n* (Remote Bit *n*; *n* = 1 through 8). Execute CON *n* and the relay responds: CONTROL RB*n*. Then reply with one of the following: SRB *n* set Remote Bit *n* (assert RB*n*). CRB *n* clear Remote Bit *n* (deassert RB*n*). PRB *n* pulse Remote Bit *n* (assert RB*n* for 1/4 cycle).
COP *m n*	Copy relay and logic settings from Group *m* to Group *n*.
L_D	Load new firmware
LOO	Set MIRRORED BITS port to loop back.
PAS	Show existing Access Level 1, B, and 2 passwords.
PAS 1 xxxxxx	Change Access Level 1 password to xxxxxx.
PAS B xxxxxx	Change Access Level B password to xxxxxx.
PAS 2 xxxxxx	Change Access Level 2 password to xxxxxx.
SET *n*	Change relay settings (overcurrent, reclosing, timers, etc.) for Group *n*.
SET L *n*	Change SELOGIC control equation settings for Group *n*.
SET G	Change global settings.
SET P *n*	Change Port *n* settings.
SET R	Change Sequential Events Recorder (SER) settings.
SET T	Change text label settings.
SET {X, Y}	Change differential channel parameters
STA C	Resets self-test warnings/failures and reboots relay.
TST {chn}	Test the differential communication channel 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.
VER	Displays version and configuration information.