SEL-311B

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.

PM311B-01

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.	
20011205	Reissued entire manual to reflect the following changes: Updated Section 2 and Section 3 figure references throughout the manual. **Section 1:** – Added 220 V control input voltage specification to ***General Specifications***. – Updated Terminal Connections information in ***General Specifications***. **Section 2:** – Added Connectorized® rear-panel drawings. **Section 3:** – Added *Ground and Phase Distance Speed Curves* drawing. – Added ***Distance Element Operating Time Curves at Nominal Frequency*** section. **Section 7:** – Updated ***Input Debounce Timers*** section. – Added ***Displaying Time-Overcurrent Elements on the Rotating Default Display*** and following sections. – Added descriptions of the ELAT, ESV, and EDP settings. **Section 8:** – Modified breaker reset options to include the internal and external trips and currents in the ***Via Serial Port*** subsection in the ***View or Reset Breaker Monitor Information*** section. **Section 9:** – Updated ***Event Report Parameters*** section in the Settings Sheets. – Updated ***Optoisolated Input Timers*** section in the Settings Sheets. – Added ELAT and EDP settings in the ***Other Enable Settings*** section in the Settings Sheets.

Revision Date	Summary of Revisions
	Section 10: – Added **STA C** command information to ***Access Level 2 Commands*** in the Command Summary. **Section 12:** – Added 180-cycle event report information. Also updated the number of event reports that are maintained. – Updated *Output, Input, and Protection, and Control Element Event Report Columns* table. **Section 13:** – Added ***Ground Quadrilateral Distance Element Reactive Reach Test Using Three Voltage Sources and One Current Source*** section. – Added ***Ground Quadrilateral Distance Element Resistive Reach Test Using Three Voltage Sources and One Current Source*** section. **Section 14:** – Updated *SELOGIC Equivalent to SEL-221F Relay Word Bits* table. – Updated *SELOGIC Equivalent to SEL-221F-3 Relay Word Bits* table. **Appendix A:** – Updated firmware. **Appendix D:** – Updated ***A5C0 Relay Definition Block*** section. – Updated information in ***ID Message*** and ***DNA Message*** sections. **Appendix H:** – Updated *SEL-311B-Wye DNP Data Map* table. **Appendix J:** – Added ***Appendix J: Unsolicited Fast SER Protocol***.
20010625	**Section 3:** – Corrected Table 3.7. **Appendix A:** – Modified SEL-311 Relays to record consecutive event reports. – Modified the **SUM** command so that the Breaker Status reports the status from the last row of the event report.
20010518	**Appendix A:** – Improved overflow supervision for distance elements.

Revision Date	Summary of Revisions
20010124	Reissued entire manual to reflect the following changes: – Added cautions, warnings, and dangers in English and French to the reverse of the title page. **Section 1:** – Updated Relay Specifications format. – Added information on Tightening Torque in *General Specifications*. – Updated Power Supply information to include medium range Power Supply Specification. – Updated Output Contacts information. **Section 2:** – Updated Relay Dimensions drawing. – Added Product Safety Compliance paragraph. – Added Danger statement to *Accessing the Relay Circuit Boards* subsection. – Added Caution statement to the *Clock Battery* subsection. **Section 5:** – Corrected *Zone LED* subsection. **Section 8:** – Removed reference to NDEM and NDEMP in the *Demand Meter Settings* subsection. – Section 9 (Settings Sheets): – Updated formatting. **Section 10:** – Added Warning statement to change default passwords to private passwords at relay installation. **Appendix H:** – Updated first row of Table H.3. – Correctly identify binary output point 23 in the *Relay Summary Event Data* subsection.
20000818	New Manual Release.

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FIGURES

SECTION 1: INTRODUCTION AND SPECIFICATIONS

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

SEL-311B Relay Models

Instruction Manual Sections

Applications

AC/DC Connections

Communications Connections

General Specifications

SEL-311B Relay Models

This instruction manual covers all SEL-311B Relay models.

The SEL-311B Relay is available as a horizontal rack-mount unit, and as a horizontal or vertical panel-mount unit. The vertical relays use the same rear panels as the horizontal models in Figure 2.2 through Figure 2.4.

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-311B Relay, application connections, and the operation of circuit board jumpers. Figure 2.2 through Figure 2.4 show the SEL-311B Relay front and rear panels.

Section 3: Distance, Overcurrent, Voltage, and Synchronism Check Elements describes the operation of:

- Phase and ground distance elements (phase mho, ground mho, and Zone 1 extension)
- 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

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:

- General trip logic
- Switch-Onto-Fault trip logic
- Front-panel target LEDs

Most tripping applications (not requiring switch-onto-fault tripping) require only SELOGIC® control equation trip setting TR and unlatch trip setting ULTR in the general trip logic (see Figure 5.1).

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
- 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)
- Output contacts OUT101 through OUT107 and ALARM
- Rotating default displays and display points

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

- Breaker monitor
- Station dc monitor
- Demand and maximum/minimum 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-311B 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 = 221F, 221F3, 221C, 221-16, 2PG10)

Section 10: Serial Port Communications and Commands describes:

- 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-311B factory default relay settings.

Section 11: Front-Panel Interface describes the front-panel 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-, 60-, and 180-cycle event reports
- Event summaries
- Sequential events recorder (SER) report

Section 13: Testing and Troubleshooting describes:

- General testing philosophy, methods, and tools
- Relay self-tests and troubleshooting

Section 14: Application Settings for SEL-221 Series Relays

- Conversion guides for the SEL-221F, SEL-221F-3, SEL-221C, SEL-221-16, SEL-2PG10 relays
- Settings Sheets for the SEL-221F, SEL-221F-3, SEL-221C, SEL-221-16, SEL-2PG10 relays

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***
- ***Appendix I: MIRRORED BITS™ Communciations***
- ***Appendix J: SEL-311B Unsolicited SER Protocol***

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

APPLICATIONS

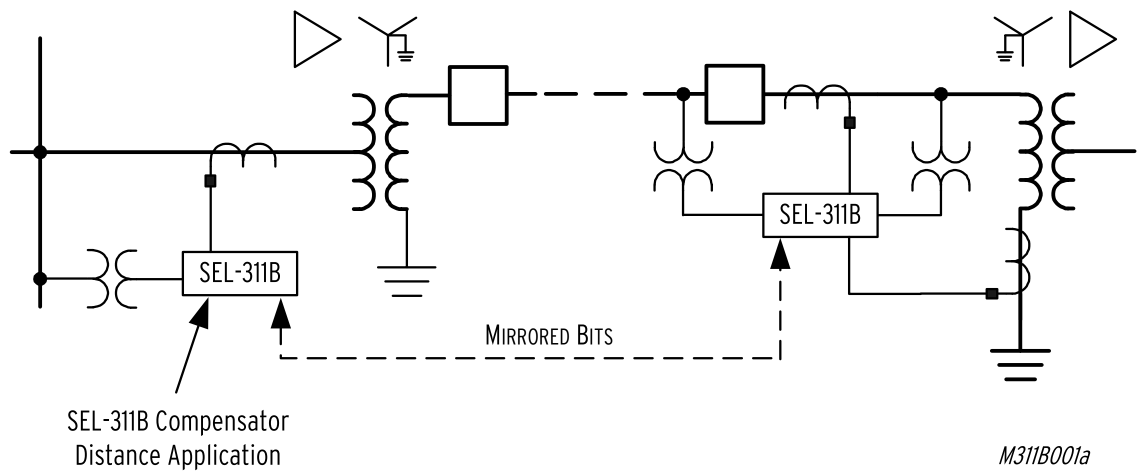

Figure 1.1: SEL-311B Relay Transmission Line Protection with MIRRORED BITS, Reclosing, and Synch Check

AC/DC CONNECTIONS

See ***General Specifications*** later in this section and ***Section 2: Installation*** for more information on hardware and connections.

Dual Terminal Labels:

For installation in systems with drawings designed for SEL-221 Relays, use the numeric terminal labels.

Section 14 describes how to easily set the SEL-311B to emulate the popular SEL-221 relays.

For installation in systems with drawings designed for SEL-311B Relays, use the alphanumeric terminal labels.

See Figure 2.2 through Figure 2.4 for rear-panel drawings.

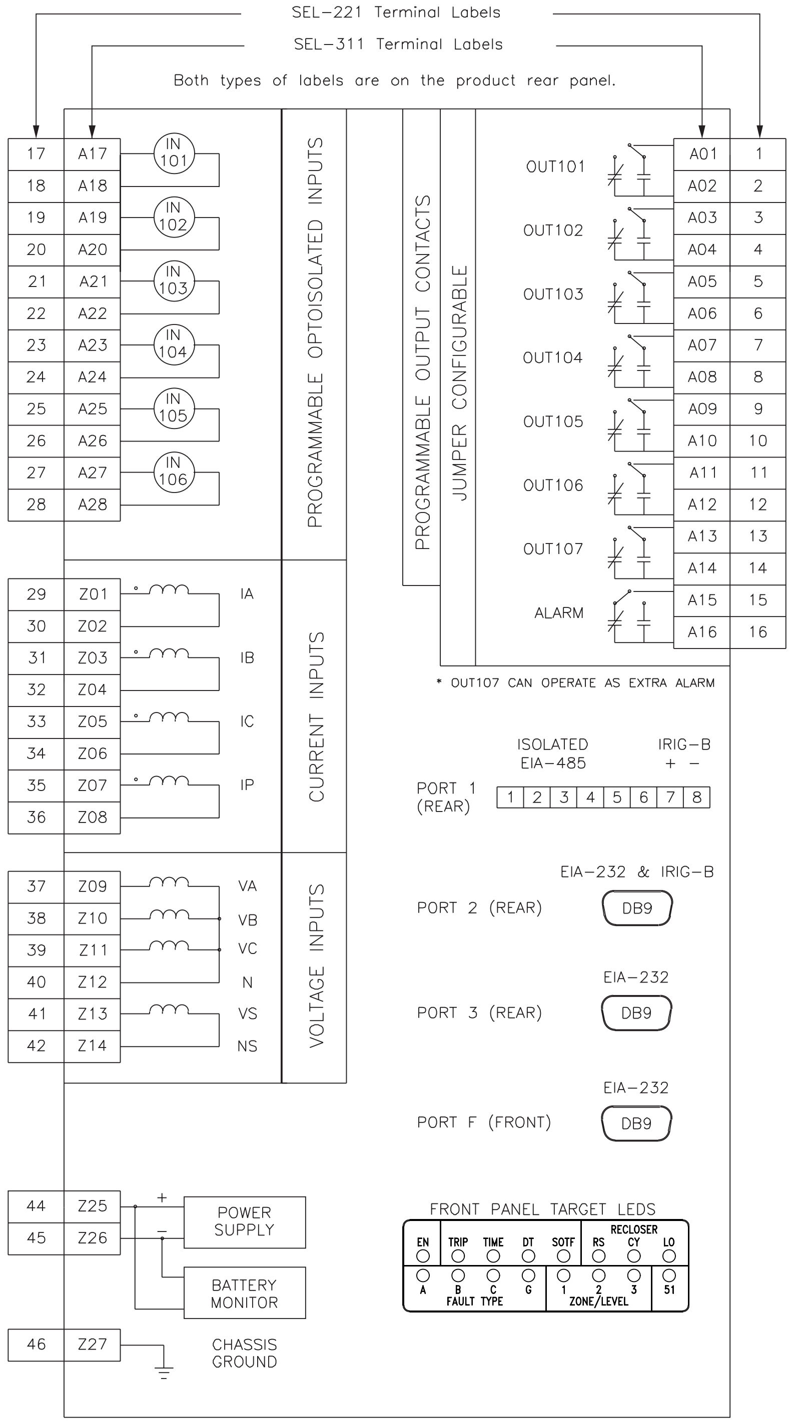

Figure 1.2: SEL-311B Relay Inputs, Outputs, and Communications Ports

Communications Connections

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

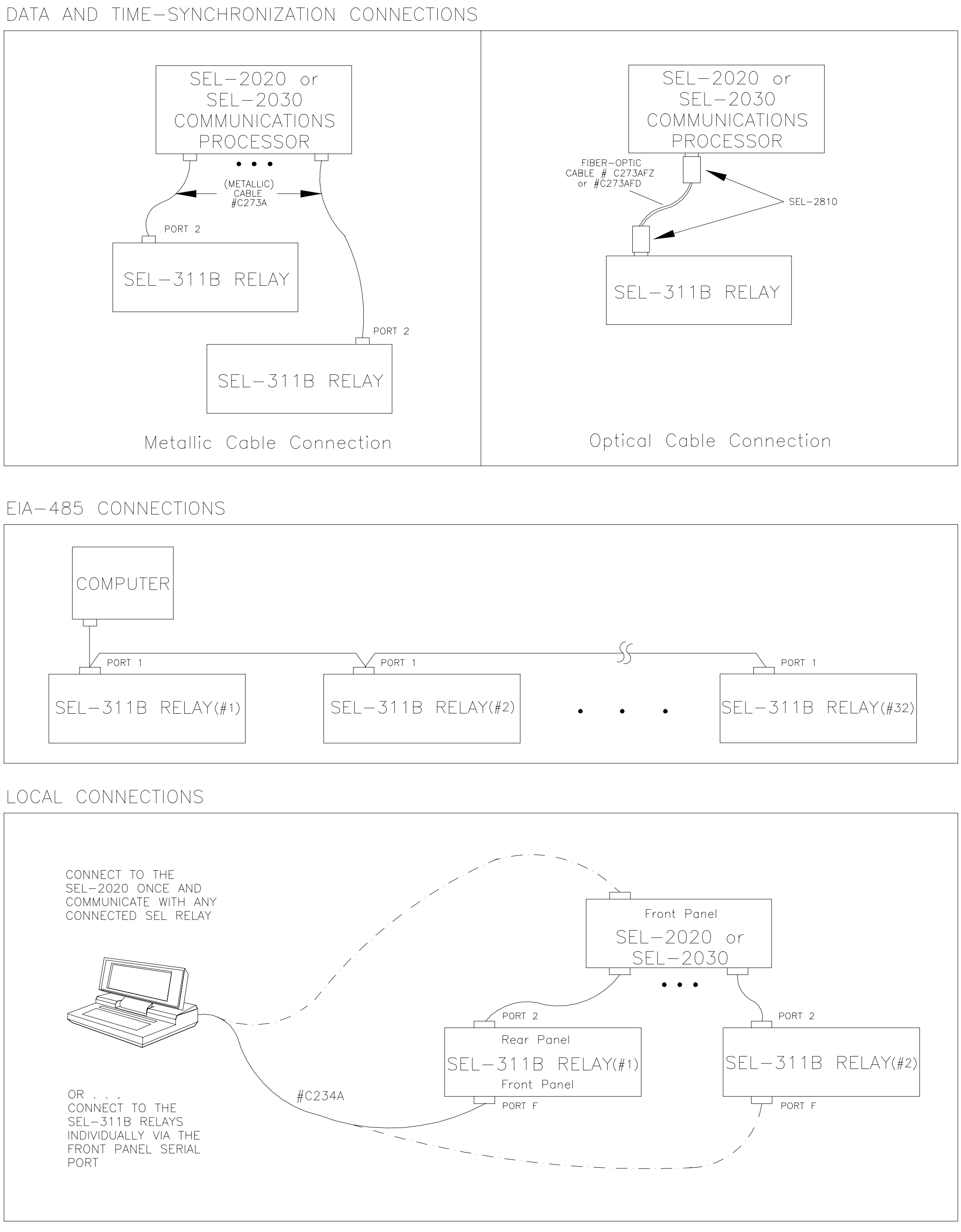

Figure 1.3: SEL-311B Relay Communications Connections Examples

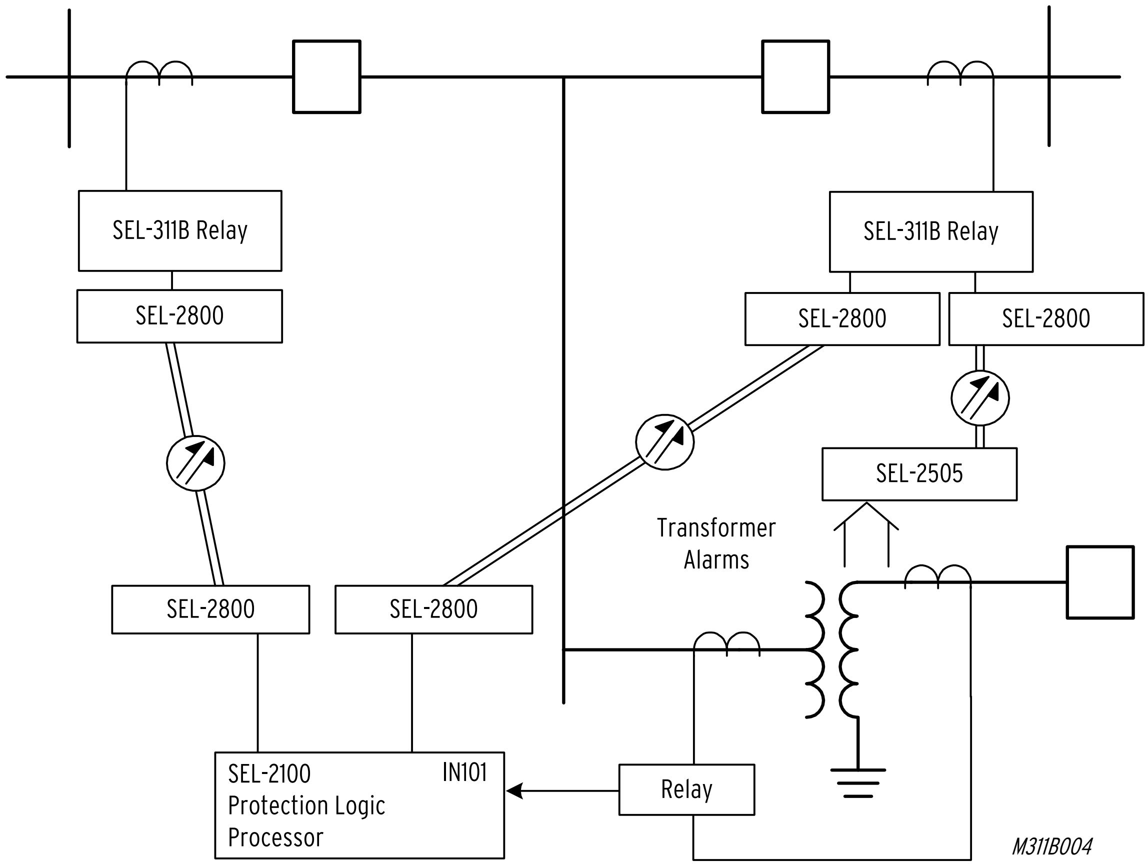

Figure 1.4: SEL-311B Relay Communications Connections Examples (Continued)

Relay Specifications

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

General Specifications

Terminal Connections:

Rear Screw-Terminal Tightening Torque

Terminal Block
- Minimum: 8-in-lb (0.9 Nm)
- Maximum: 12-in-lb (1.4 Nm)

Connectorized®
- Minimum: 4.4-in-lb (0.5 Nm)
- Maximum: 8.8-in-lb (1 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:

Rated: 125/250 Vdc or Vac
- Range: 85–350 Vdc or 85–264 Vac
- Burden: < 25 W

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

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

Output Contacts:

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

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.

Note: 220 Vdc optoisolated inputs are not available in the Connectorized version of the relay.

Routine Dielectric Test:

Voltage/Current inputs: 2500 Vac for 10 s
Power supply,
optoisolated inputs,
and output contacts: 3000 Vdc for 10 s

The following IEC 60255-5 Dielectric Tests–1977 are performed on all units with the CE mark:
- 2500 Vac for 10 seconds on analog inputs
- 3100 Vdc for 10 seconds on power supply, optoisolated inputs, and output contacts

Frequency and Rotation:

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

Note: V_A required for frequency tracking.

Communications Ports:

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

Time-Code Input:

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

Operating Temperature Range:

-40° to +85°C (-40° to +185°F)

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

Relay Weight:	2U Rack unit: 13 lbs. (5.92 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, Severity Level 4 (4000 V on power supply, 2000 V on inputs and outputs)
		Radiated Radio Frequency:	IEC 60255-22-3–1989; 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°
		Dry Heat:	IEC 60068-2-2–1974, Test Bd; 16 hr. @ +85°
		Damp Heat, Cyclic:	IEC 60068-2-30–1980, Test Db; 55°C, 6 cycles, 95% humidity
		Object Penetration:	IEC 60529–1989, IP30, IP54
		Vibration:	IEC 60255-21-1–1988, Class 1 IEC 60255-21-2–1988, Class 1 IEC 60255-21-3–1993, Class 2
	Safety		
		Impulse:	IEC 60255-5–1977, 0.5 J, 5000 V
Certifications:		ISO:	Relay is designed and manufactured using ISO 9001 certified quality program.
		UL Listed, CSA Certified, 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.

Protection and Control Processing 4 times per power system cycle.

Relay Element Settings Ranges and Accuracies

Metering Accuracy

Voltages	V_A, V_B, V_C, V_S:	±0.67 V secondary
Currents	I_A, I_B, I_C, I_P:	±0.05 A secondary (5 A nominal) ±0.01 A secondary (1 A nominal)

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
Other Timers:	0.00–16,000.00 cycles, 0.25-cycle steps
Pickup/dropout accuracy for all timers:	±0.25 cycle and ±0.1% of setting

Mho Phase Distance Elements

Zones 1–3 Impedance Reach

Setting Range:	OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal)
	Minimum sensitivity is controlled by the pickup of the supervising phase-to-phase overcurrent elements for each zone.
Accuracy:	±5% of setting at line angle for $30 \leq SIR \leq 60$ ±3% of setting at line angle for $SIR < 30$
Transient Overreach:	< 5% of setting plus steady state accuracy

Zones 1–3 Phase-to-Phase Current Fault Detectors (FD)

Setting Range:	0.5–170.00 A_{P-P} secondary, 0.01 A steps (5 A nominal) 0.1–34.00 A_{P-P} secondary, 0.01 A steps (1 A nominal)
Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:	< 5% of pickup
Max. Operating Time:	See pickup and reset time curves in Figure 3.14 and Figure 3.15

Mho and Quadrilateral Ground Distance Element

Zones 1–3 Impedance Reach

Mho Element Reach:	OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal)
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 1–3 Phase and Residual Current Fault Detectors (FD)

Setting Range:	0.5–100.00 A secondary, 0.01 A steps (5 A nominal) 0.1–20.00 A secondary, 0.01 A steps (1 A nominal)
Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:	< 5% of pickup
Max. Operating Time:	See pickup and reset time curves in Figure 3.14 and Figure 3.15

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 3.14 and Figure 3.15

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 (phase 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°

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FIGURES

SECTION 2: INSTALLATION

Relay Mounting

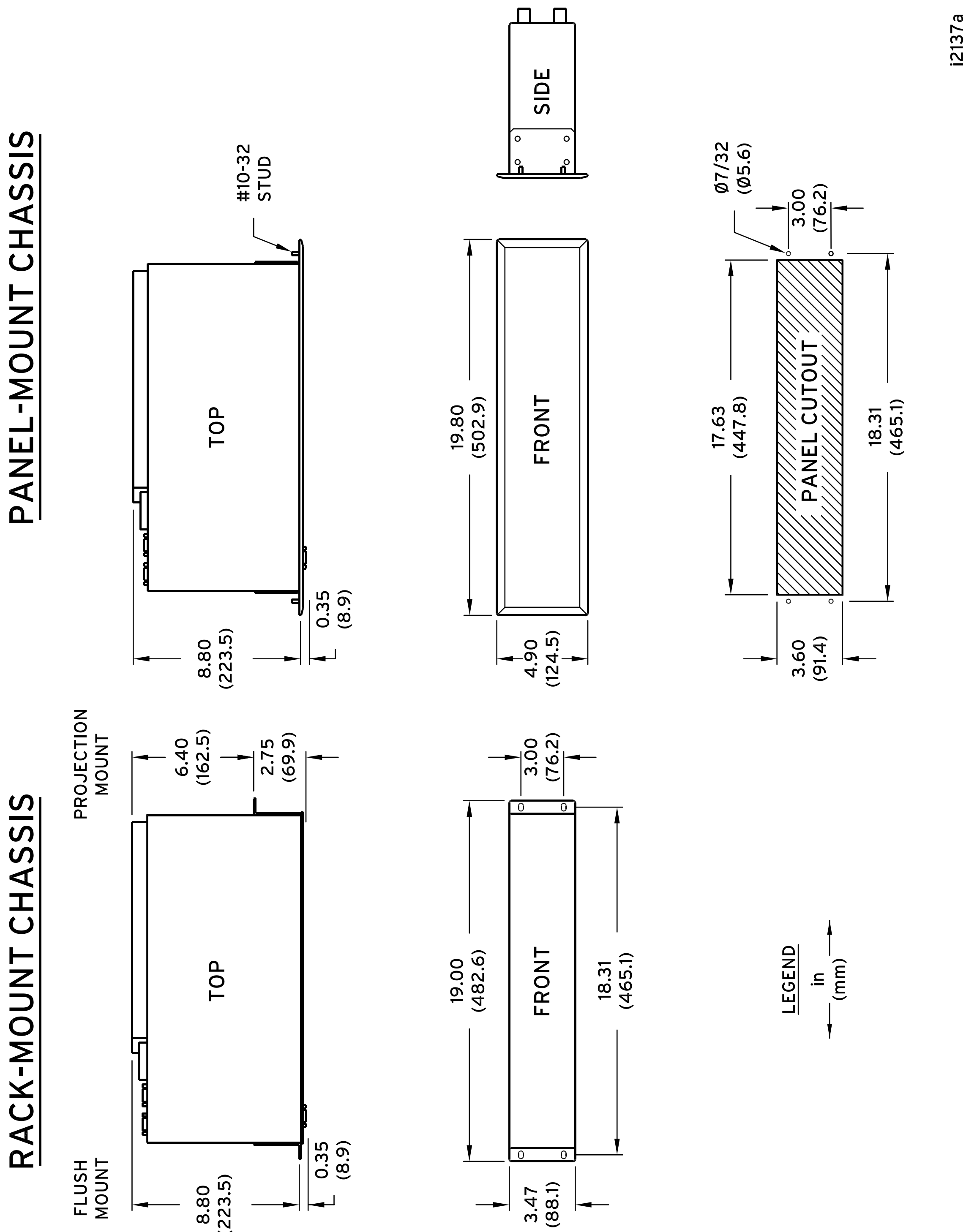


Figure 2.1: SEL-311B Relay Dimensions and Panel-Mount Cutout

Front- and Rear-Panel Diagrams

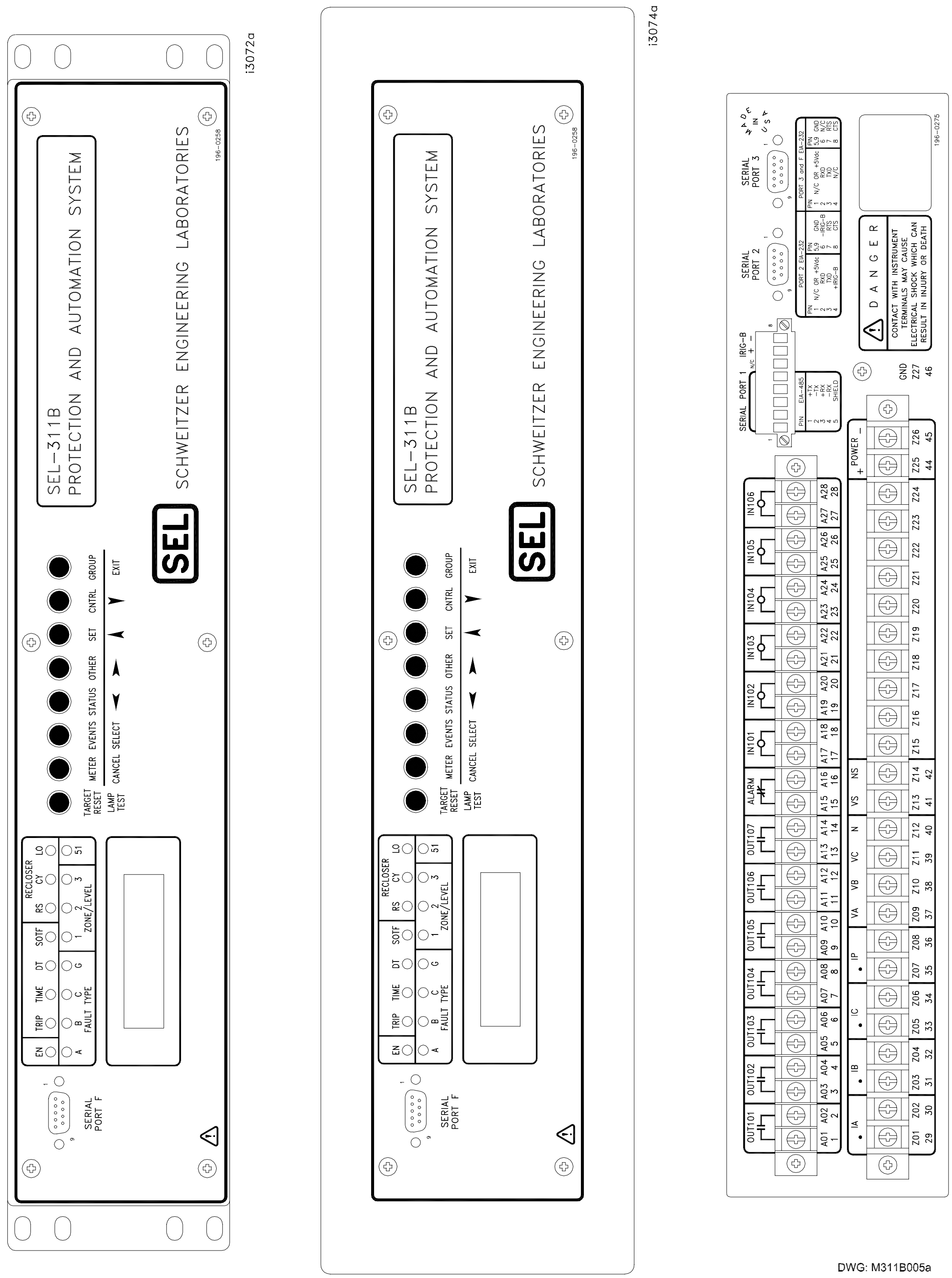


Figure 2.2: SEL-311B Relay Front- and Rear-Panel Drawings—Models 0311B00H2 (Rack) and 0311B0032 (Panel)

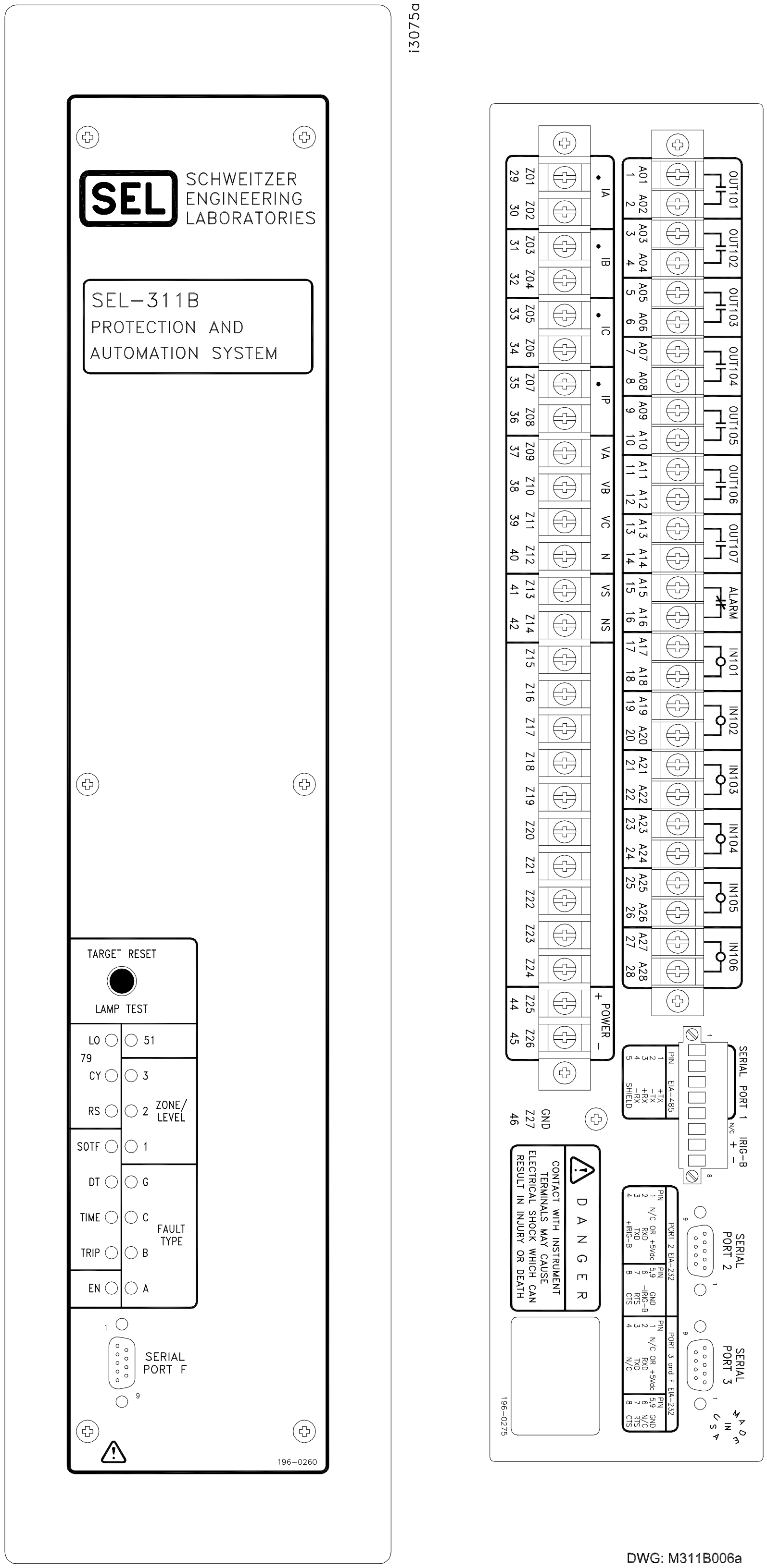


Figure 2.3: SEL-311B Relay Front- and Rear-Panel Drawings—Model 0311B0041

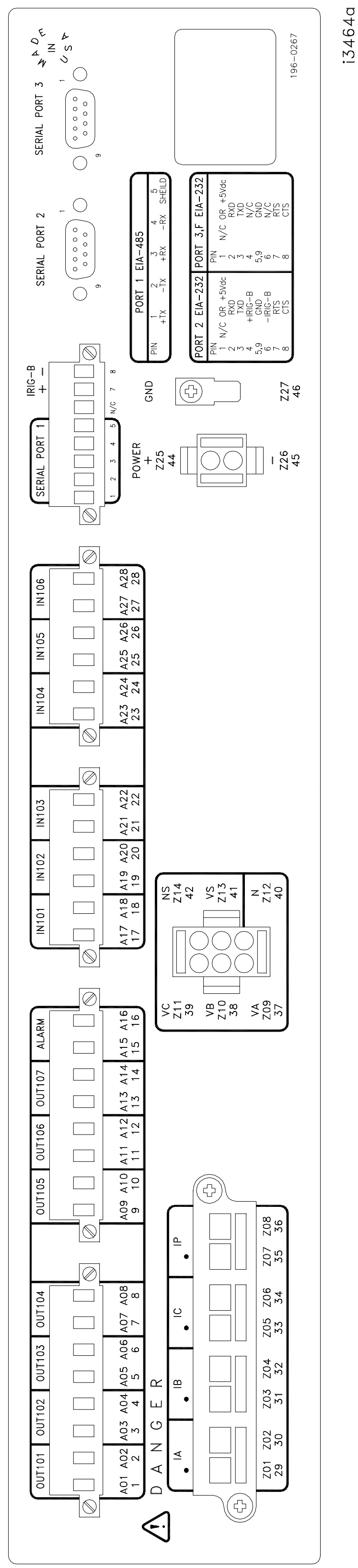


Figure 2.4: SEL-311B Relay Connectorized® Rear-Panel Drawing

Making Rear-Panel Connections

Refer to Figure 2.5 through Figure 2.7 for wiring examples of typical applications.

Tools: Phillips or slotted-tip screwdriver

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

Ground the relay chassis at terminal Z27.

Wire-Alike Screw Terminal Connections

All SEL-311B relays have SEL-221 wire-alike terminals. Both SEL-311B standard terminal numbers and SEL-221 terminal numbers are shown on the rear-panel wiring connections for those models. A properly programmed SEL-311B Relay may be installed in place of an SEL-221 Relay with no changes to the terminal numbers in a user's wiring diagram.

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

The contact outputs in the SEL-311B Relay are not polarity dependant. Refer to ***General Specifications*** in ***Section 1: Introduction and Specifications*** for contact output ratings.

Optoisolated Inputs

The optoisolated inputs in the SEL-311B Relay are not polarity dependent. With nominal control voltage applied, each optoisolated input draws approximately 4 mA of current. 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 2.5 through Figure 2.7 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 current inputs.

Potential Transformer Inputs

Note the signal labels (VA, VB, VC, N, VS, NS) on terminals Z09 through Z14. Figure 1.2 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 single-phase voltage inputs (i.e., VA-N, VB-N, VC-N, or VS-NS) can be connected to voltages up to 150 V continuous. Figure 2.5 through Figure 2.7 show examples of wye-connected voltages. System frequency is determined from the voltages connected to terminals VA-N.

Serial Ports

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

Serial Port 1 on all the SEL-311B 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 10.2; also see following discussion on IRIG-B time code input).

All EIA-232 ports accept 9-pin D-subminiature male connectors. Port 2 on all the SEL-311B Relay models includes the IRIG-B time-code signal input (see Table 10.1; also see following discussion on IRIG-B time-code input).

The pin definitions for all the ports are given on the relay rear panel and are detailed in Table 10.1 through Table 10.3 in ***Section 10: Serial Port Communications and Commands***.

Refer to Table 2.1 for a list of cables available from SEL for various communication applications. Refer to ***Section 10: Serial Port Communications and Commands*** for detailed cable diagrams for selected cables (cable diagrams precede Table 10.3).

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-311B 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 30 feet, SEL offers fiber-optic transceivers. The SEL-2800 family of transceivers provides fiber-optic links between devices for electrical isolation and long-distance signal transmission. Contact SEL for further information on these products.

Table 2.1: Communication Cables to Connect the SEL-311B Relay to Other Devices

SEL-311B 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*	Telenetics Modem, 5 Vdc Powered	C220*
all EIA-232 ports	Standard Modem, 25-Pin Female (DCE)	C222
all EIA-232 ports	RFL-9660	C245A
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 Telenetics Modem with +5 Vdc (0.5 A limit) from the SEL-311B Relay. See Figure 2.8 and Table 2.5.

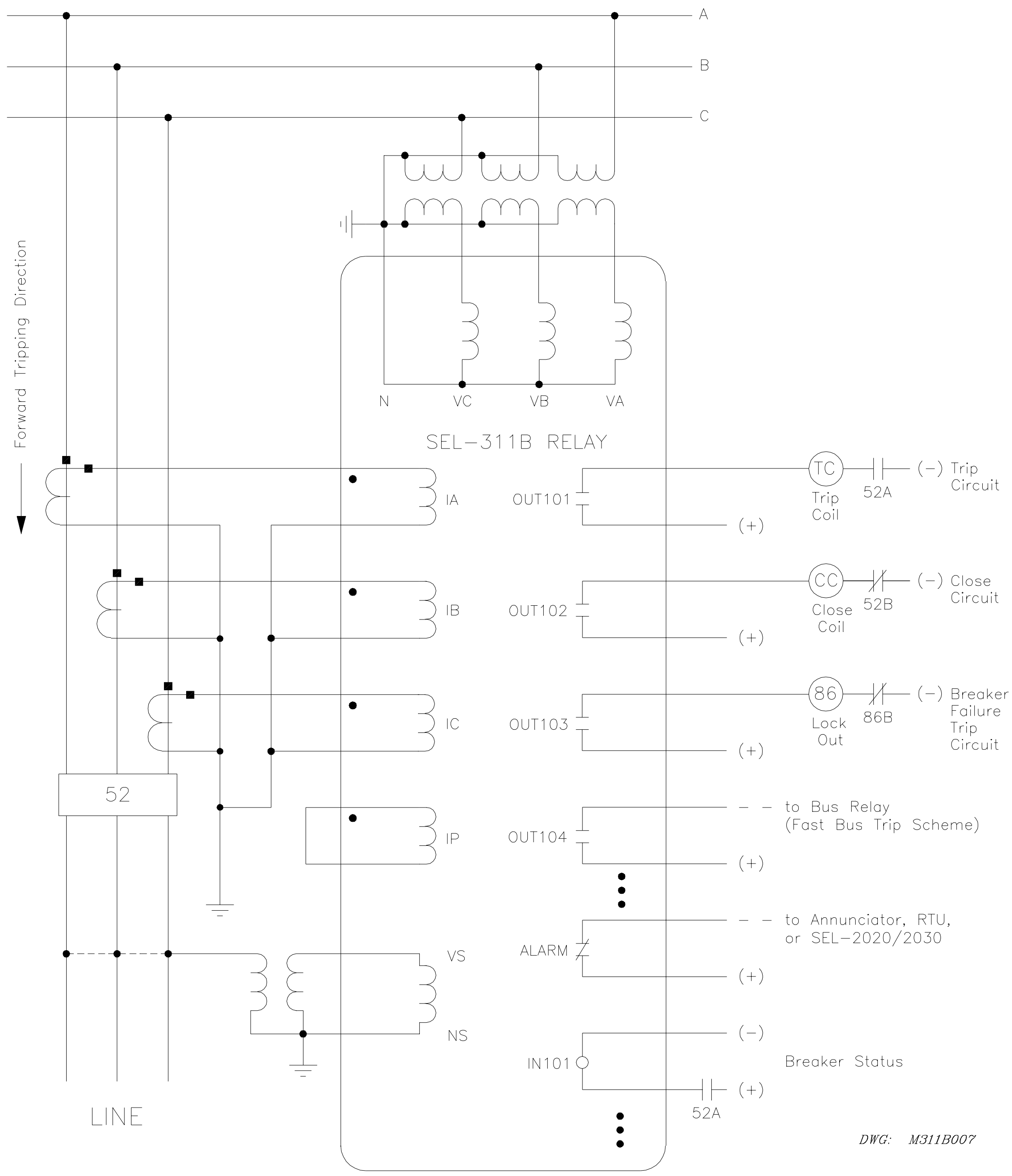
IRIG-B Time-Code Input

The SEL-311B Relay accepts a demodulated IRIG-B time signal to synchronize the relay internal clock with some external source.

A demodulated IRIG-B time code can be input into Serial Port 2 on any of the SEL-311B Relay models (see Table 10.1) by connecting Serial Port 2 of the SEL-311B Relay to an SEL-2020 with Cable C273A.

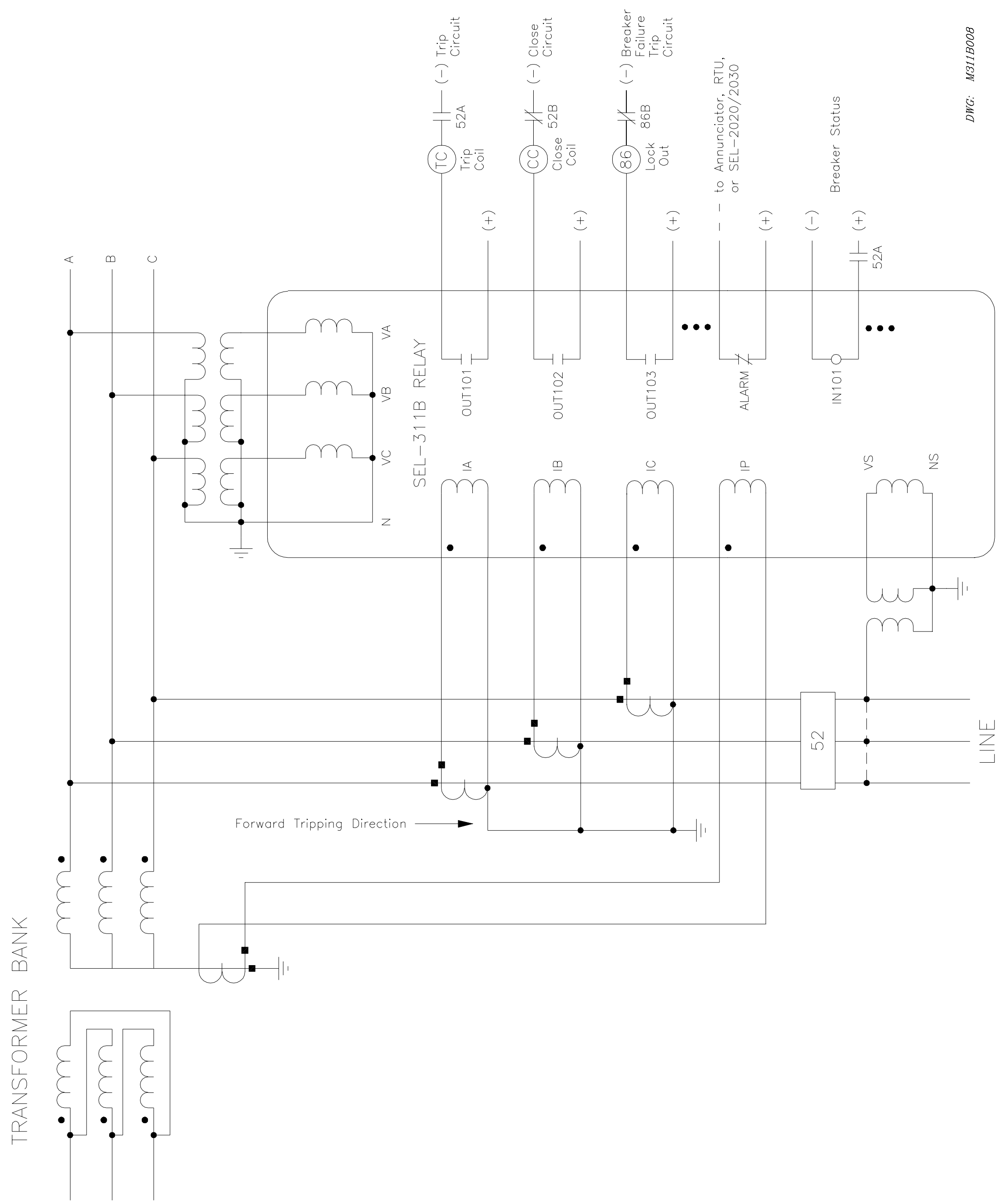
A demodulated IRIG-B time code can also be input into the connector for Serial Port 1 (see Table 10.2). If demodulated IRIG-B time code is input into this connector, it should not be input into Serial Port 2 and vice versa.

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



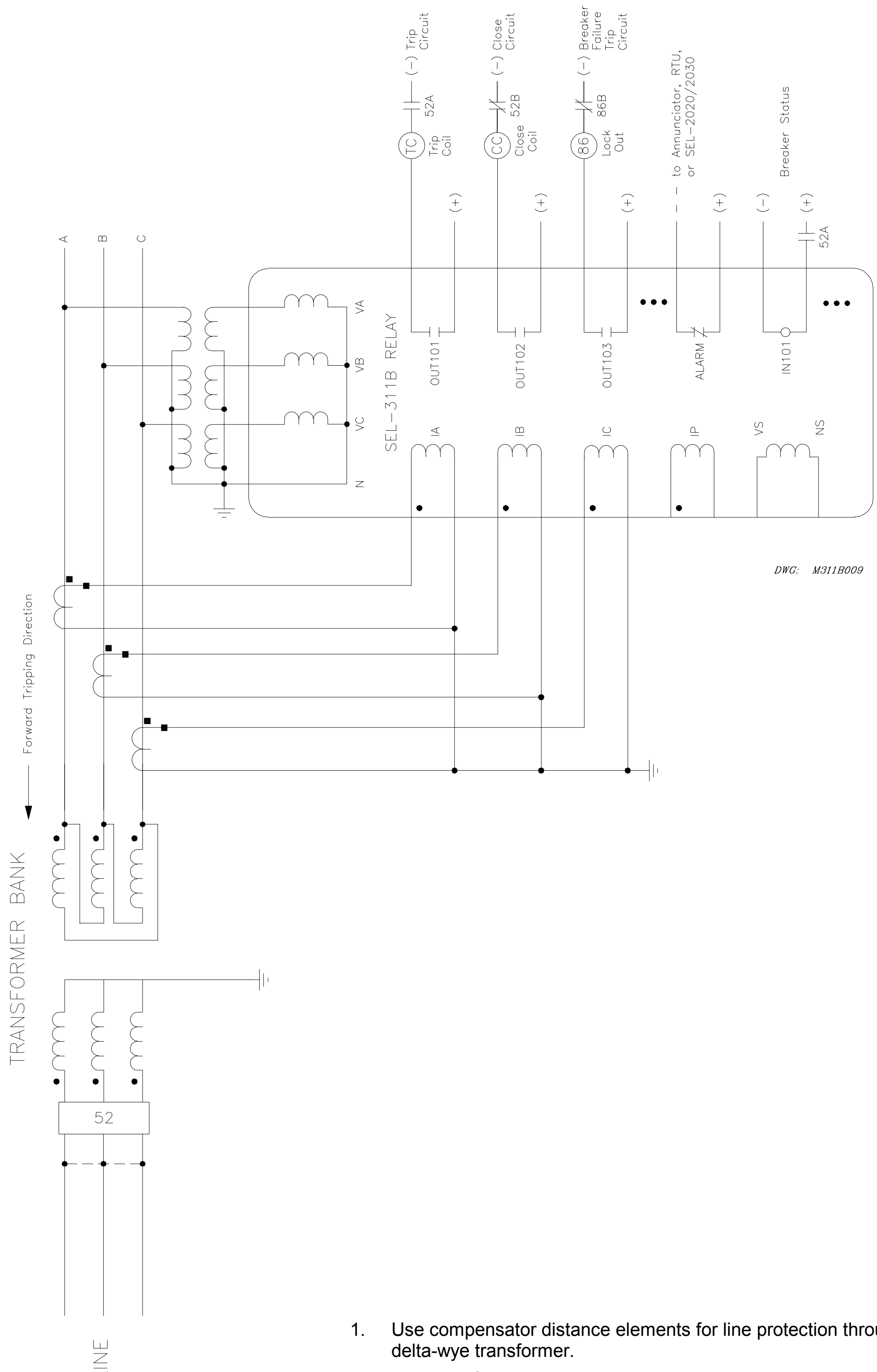
1. Voltage Channel VS is used in voltage and synchronism check elements and voltage metering.
2. Current Channel IP does not need to be connected. Channel IP provides current for current polarized directional elements.

Figure 2.5: SEL-311B Relay Provides Distance and Overcurrent Protection, Reclosing, and Synch Check for a Transmission Line



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 2.6: SEL-311B Relay Provides Distance and Overcurrent Protection, and Reclosing for a Transmission Line (Current-Polarization Source Connected to Channel IP)



1. Use compensator distance elements for line protection through a delta-wye transformer.
2. Voltage VS does not need to be connected.

Figure 2.7: SEL-311B Line Protection Through a Delta-Wye Transformer Using Compensator Distance Elements

CIRCUIT BOARD CONNECTIONS

Accessing the Relay Circuit Boards

To change circuit board jumpers or replace the clock battery, refer to Figure 2.8 and take the following steps:

1. Deenergize the relay.
2. Remove any cables connected to serial ports on the front and rear panels.
3. 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.

4. Disconnect circuit board cables as necessary to allow the main board and drawout tray to be removed. 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.
5. Grasp the drawout assembly of the main board and pull the assembly from the relay chassis.
6. Locate the jumper(s) or battery to be changed (refer to Figure 2.8). Make the desired changes. Note that the output contact jumpers are soldered in place.
7. When finished, slide the drawout assembly into the relay chassis. Reconnect the cables removed in step 4. Replace the relay front-panel cover.
8. Replace any cables previously connected to serial ports.
9. Reenergize the relay.

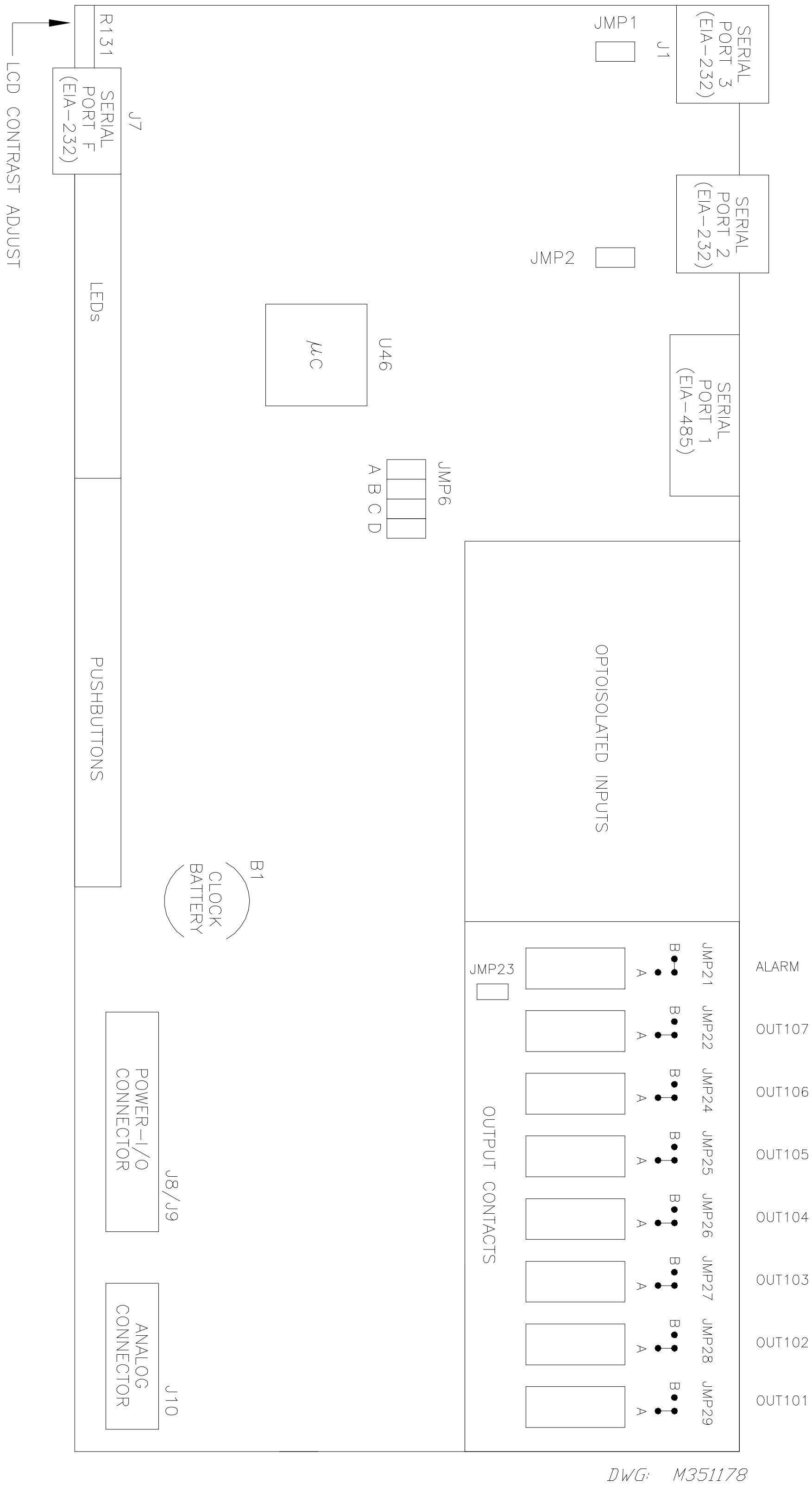


Figure 2.8: Jumper, Connector, and Major Component Locations on the SEL-311B Relay Main Board

Output Contact Jumpers

Table 2.2 shows the correspondence between output contact jumpers and the output contacts they control. Figure 2.8 shows 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 2.8, 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 for examples of output contact operation for different output contact types.

Table 2.2: Output Contact Jumpers and Corresponding Output Contacts

Output Contact Jumpers	Corresponding Output Contacts	Reference Figures
JMP21–JMP29 (but not JMP23)	ALARM–OUT101	Figure 2.8

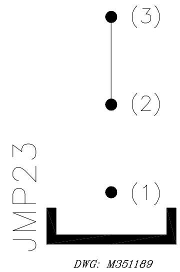
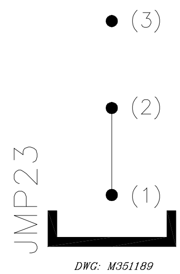
"Extra Alarm" Output Contact Control Jumper

All the SEL-311B Relays have dedicated alarm output contacts (labeled ALARM—see Figure 2.2 and Figure 2.3). 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 2.3).

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 2.3).

Table 2.3: 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 <u>standard relay shipment</u> (see Figure 7.26).
	"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 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 <u>opposite state</u> of the dedicated ALARM output contact in a <u>standard relay shipment</u>. 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 any output contact 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 2.4: 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: 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: Serial Port Communications and Commands***).

Note that JMP6 in Figure 2.8 has multiple jumpers A through D. Jumpers A and B are used (see Table 2.4). Since jumpers C and D are not used, the positions (ON or OFF) of jumpers C and D are of no consequence.

EIA-232 Serial Port Voltage Jumpers

The jumpers listed in Table 2.5 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 10.1 in ***Section 10: 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 2.5: EIA-232 Serial Port Voltage Jumper Positions for Standard Relay Shipments

EIA-232 Serial Port 2 (rear panel)	EIA-232 Serial Port 3 (rear panel)	Reference Figure
JMP2 = OFF	JMP1 = OFF	Figure 2.8

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 2.8 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: Serial Port Communications and Commands*** or ***Section 11: Front-Panel Interface***).

TABLE OF CONTENTS

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FIGURES

SECTION 3: DISTANCE, OVERCURRENT, VOLTAGE, AND SYNCHRONISM CHECK ELEMENTS

DISTANCE ELEMENTS

Phase Distance Elements

The SEL-311B Relay has three independent zones of mho phase distance protection. All zones are independently set. Zones 1 and 2 are fixed to operate in the forward direction only. Zone 3 can be set to operate either forward or reverse. 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-311B 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 12.3 and 12.4 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 $\mathrm{Im}(V_1 \bullet V_2^*)$.
- Test for $V_1 \bullet V_2^*$ balance point at $\theta_1 - \theta_2 = 90$ degrees by calculating $\cos(\theta_1 - \theta_2)$. In a digital relay, this is done by examining the sign (+ or -) of the real component of $V_1 \bullet V_2^*$, written $\mathrm{Re}(V_1 \bullet V_2^*)$.

Table 3.1 shows the 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 1 for the quantity "|Z|", which represents the relay reach at the balance point. This equation is in the form of a line drop-compensated voltage and a polarizing (reference) voltage.

$$0 = \mathrm{Re}\left[(Z \bullet I - V) \bullet (Vmem)^*\right] \qquad \text{Equation 1}$$

Table 3.1: Phase Distance Calculations

	Positive-Sequence Polarized Mho Element	Compensator-Distance Mho Element
Distance Calculation in a Digital Relay	$\lvert Z\rvert = \frac{\text{Re}(V_{AB} \bullet V_{AB}\text{mem})^*}{\text{Re}(1\angle Z \bullet I_{AB} \bullet V_{AB}^*\text{mem})}$ Phase A-B $\lvert Z\rvert = \frac{\text{Re}(V_{BC} \bullet V_{BC}\text{mem})^*}{\text{Re}(1\angle Z \bullet I_{BC} \bullet V_{BC}^*\text{mem})}$ Phase B-C $\lvert Z\rvert = \frac{\text{Re}(V_{CA} \bullet V_{CA}\text{mem})^*}{\text{Re}(1\angle Z \bullet I_{CA} \bullet V_{CA}^*\text{mem})}$ 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. Z = Replica line impedance at operating or balance point.

As mentioned previously, a digital relay mho element tests the angle between a line drop-compensated voltage and a polarizing (reference) voltage. Figure 3.1 through Figure 3.3 show the operating voltages "inside" positive-sequence polarized mho elements and compensator-distance mho elements. Note that V1mem is the polarizing voltage for the positive-sequence polarized mho element and (Z • I - V) is the line drop-compensated voltage. In the compensator distance phase-to-phase element, the polarizing voltage is the unfaulted phase-to-phase voltage, and the line drop-compensated voltage is the faulted phase-to-phase voltage. In the compensator distance three-phase element, the polarizing voltage is ($-jV_{AB}$ - 0.25 • $V_C$mem) and the line drop compensated voltage is (V_{AB} - Z • I_{AB}).

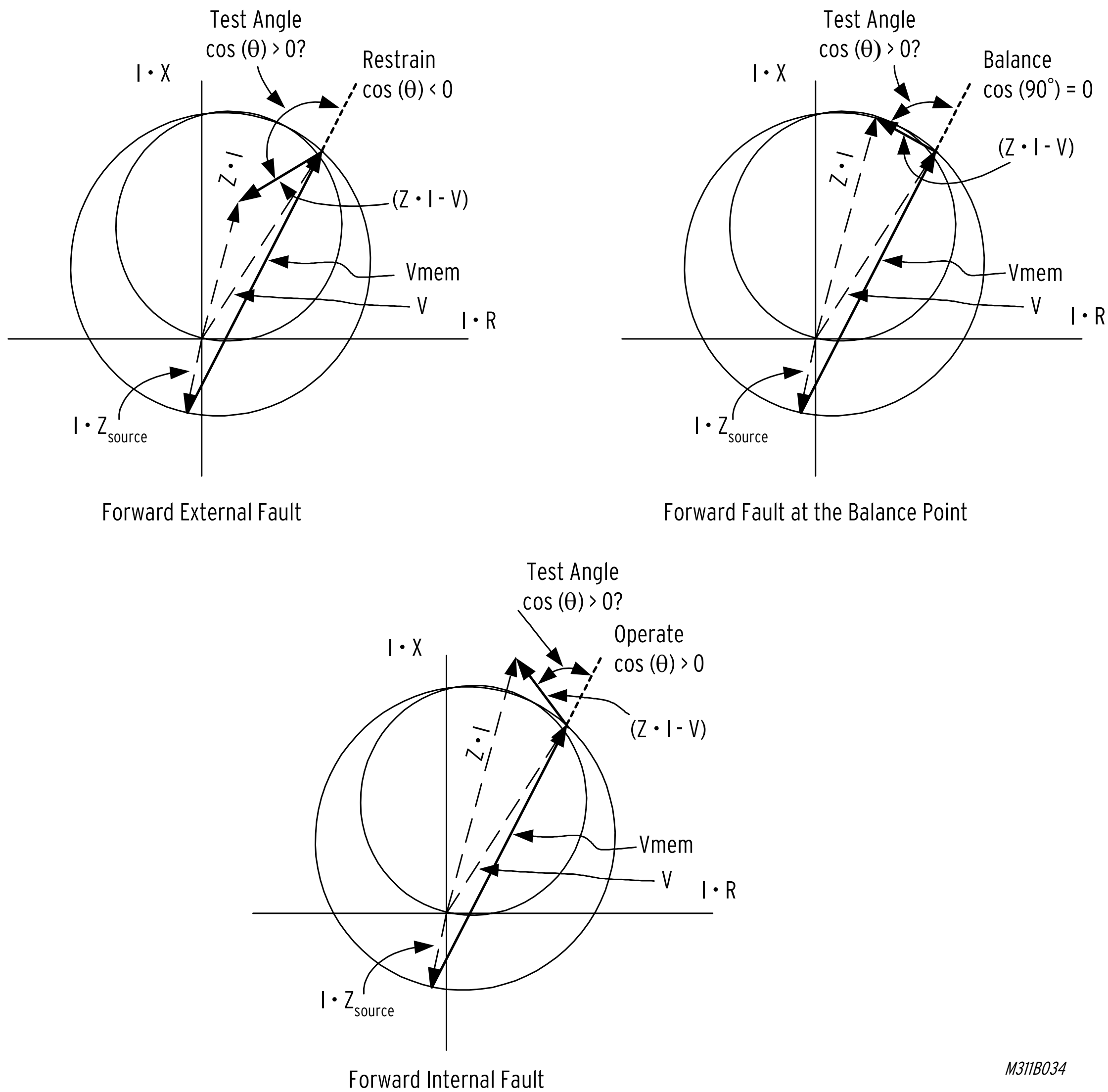


Figure 3.1: Positive-Sequence Polarized Mho Element

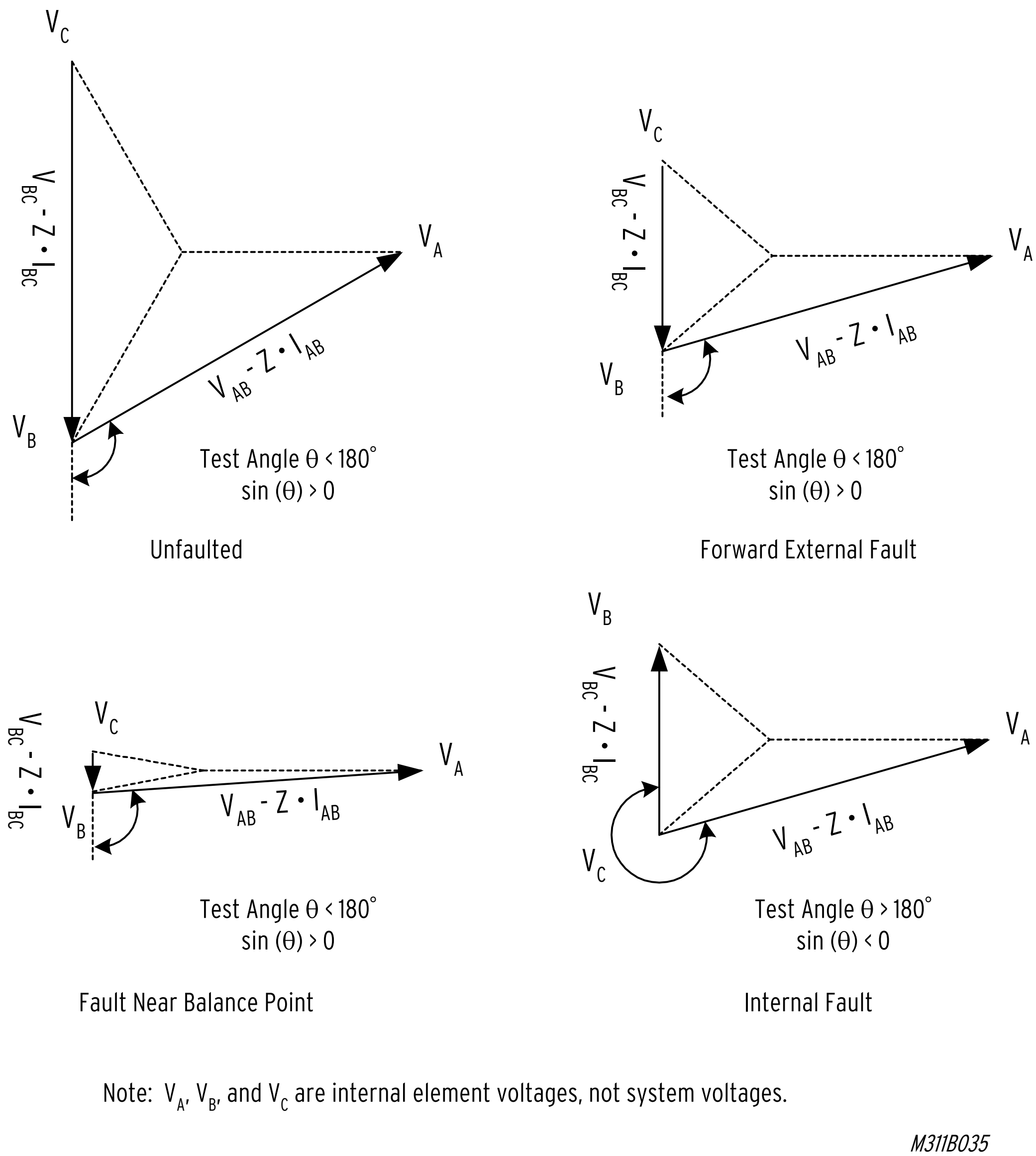


Figure 3.2: Compensator-Distance Phase-to-Phase Element Operation

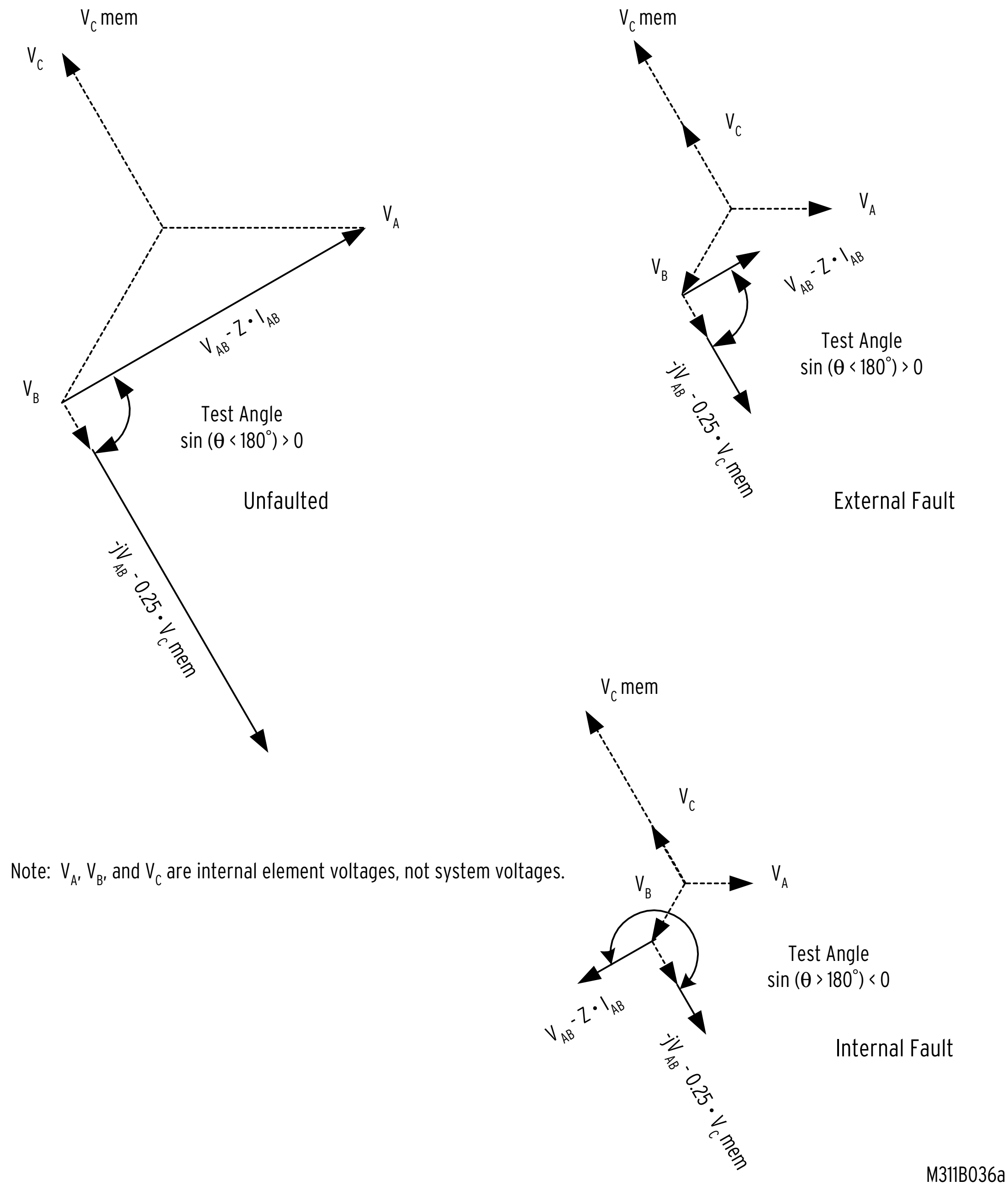


Figure 3.3: Compensator-Distance Three-Phase Element Operation

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

- A different phase-distance operating principle is desired for backup relaying.
- Protecting a transmission line through a delta-wye transformer. The compensator distance element reaches through a delta-wye transformer bank for phase-to-phase, phase-to-phase-to-ground, and three-phase faults. Calculate the total primary impedance as the sum of the per-unit transformer and line impedances, then convert from per-unit to actual primary impedance at the protected bus voltage. The

compensator distance element measures impedance through the transformer for all phase faults and will not overreach on ground faults. See ***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. The user selects 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 EADV = N and compensator distance elements are selected, E21MG is set to "N" and hidden. If EADV = Y, setting E21MG is visible and the user may apply ground distance relaying along with compensator distance phase relaying.

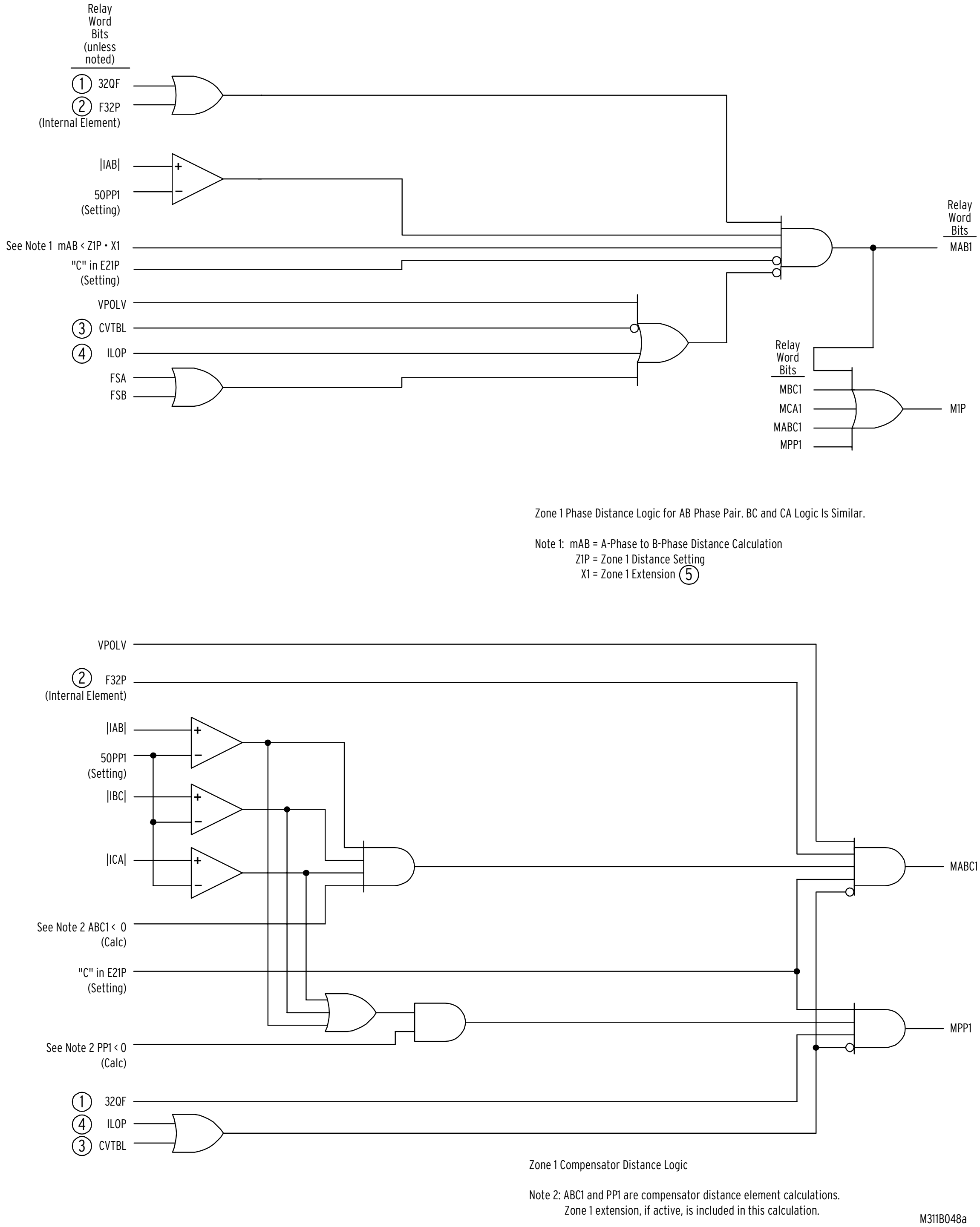
Mho Phase Distance Elements (Zones 1–3)

Enable Setting:	E21P (1–3, 1C–3C)
Setting range for Mho Phase Distance Elements (Z1P through Z3P):	OFF, 0.05 to 64 Ω sec, 0.01Ω steps (5 A nominal) OFF, 0.25 to 320 Ω sec, 0.01Ω 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 1–3)

Setting Range for Phase-to-Phase Current Fault Detectors (50PP1–50PP3): **Note:** If setting EADVS = N, settings 50PP2 and 50PP3 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 3.14 and Figure 3.15.

Mho Phase Distance Elements

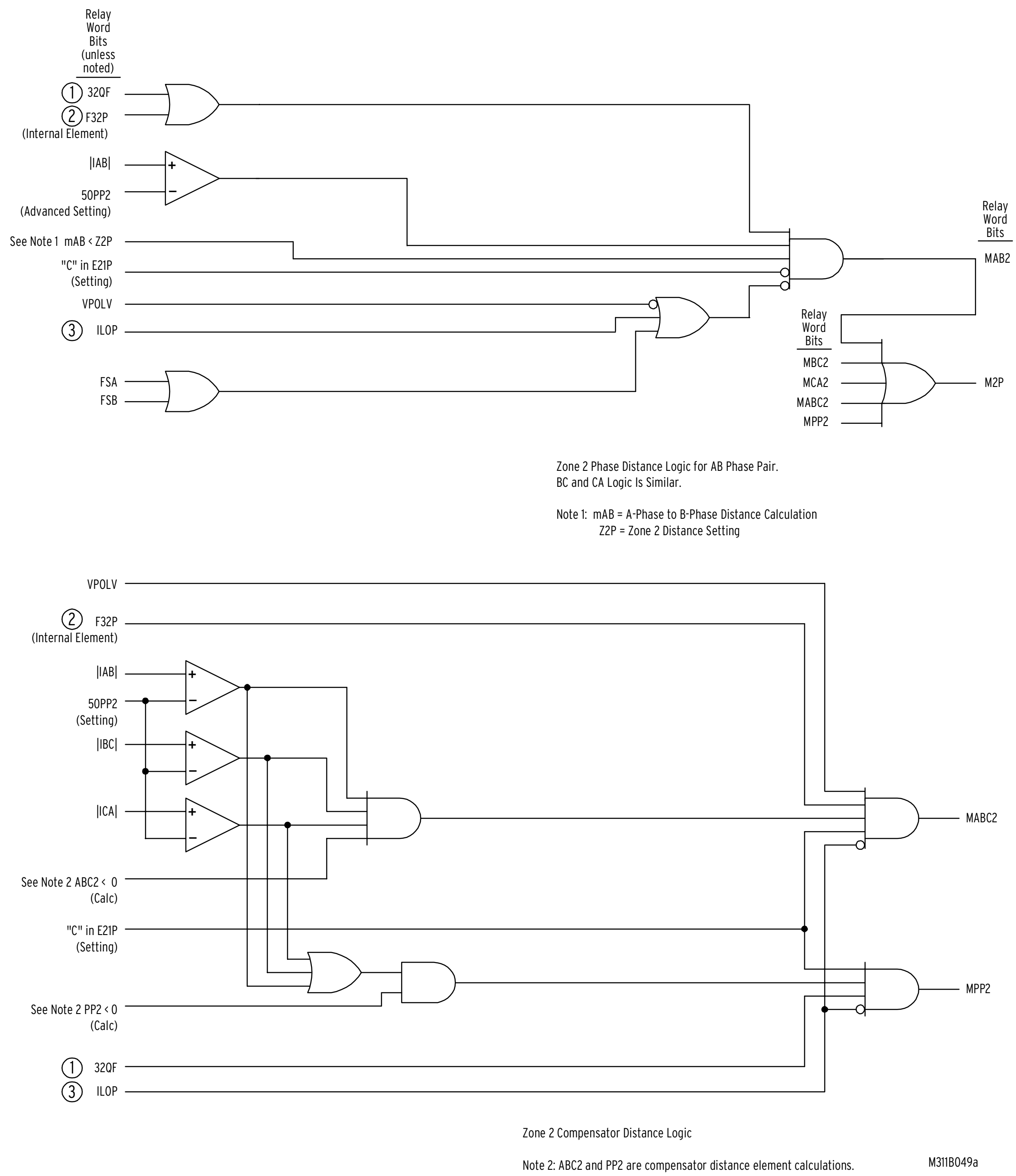


① From Figure 4.14 ④ From Figure 4.1

② From Figure 4.15 ⑤ From Figure 3.11

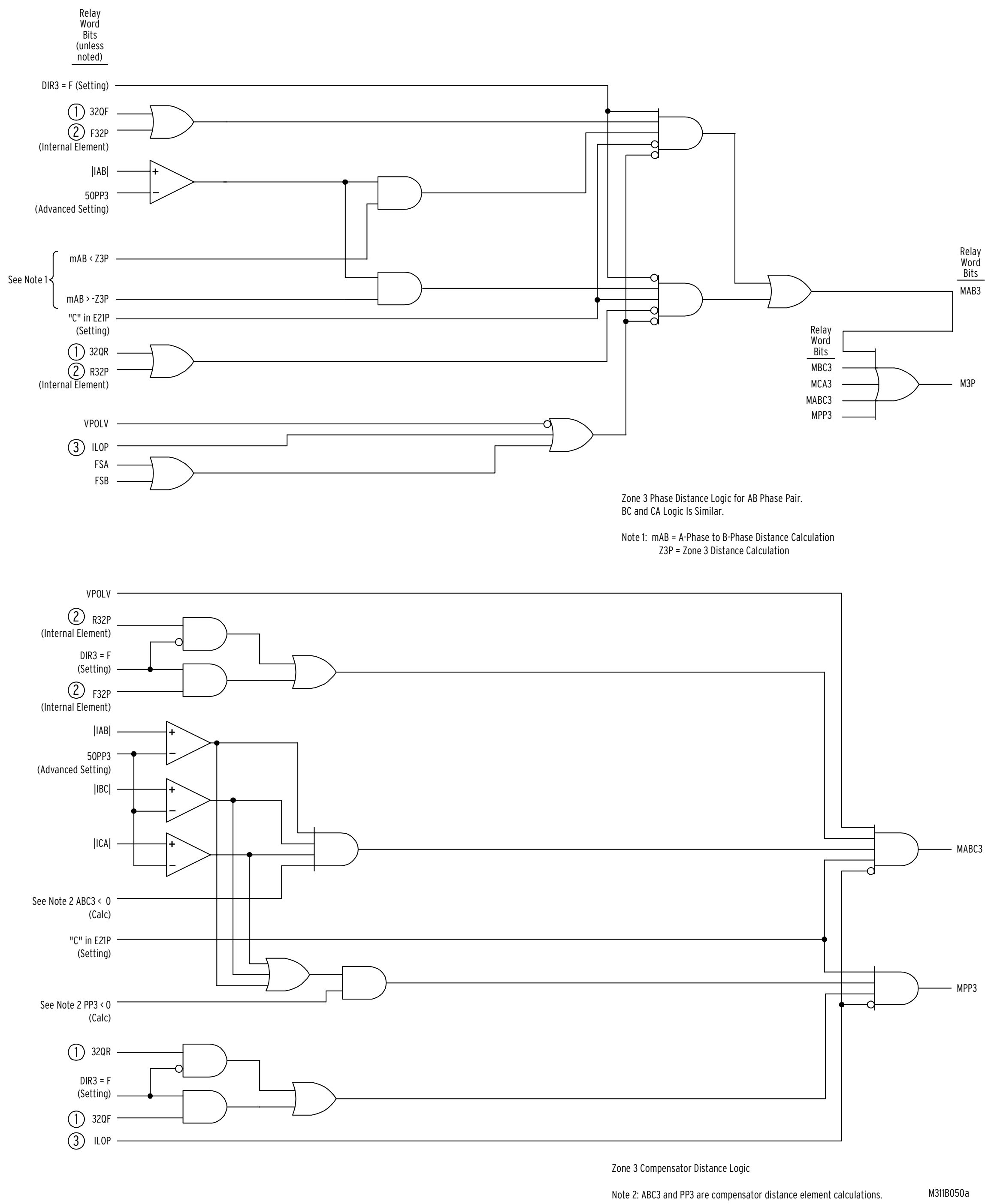
③ From Figure 4.2

Figure 3.4: Zone 1 Phase Distance Logic



① From Figure 4.14 ③ From Figure 4.1
② From Figure 4.15

Figure 3.5: Zone 2 Phase Distance Logic



① From Figure 4.14 ③ From Figure 4.1

② From Figure 4.15

Figure 3.6: Zone 3 Phase Distance Logic

Ground Distance Elements

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

Impedance Reach (Zones 1–3)

Enable Setting:	E21MG Mho Ground
Settings range for Mho elements (Z1MG through Z3MG):	OFF, 0.05 to 64 Ω sec, 0.01Ω steps (5 A nominal) OFF, 0.25 to 320 Ω sec, 0.01Ω steps (1 A nominal) Minimum sensitivity is controlled by the pickup of the supervising phase and residual overcurrent elements for each zone.
Accuracy:	±5% of setting at line angle for 30 ≤ SIR ≤ 60 ±3% of setting at line angle for SIR < 30
Transient Overreach:	< 5% of setting plus steady-state accuracy

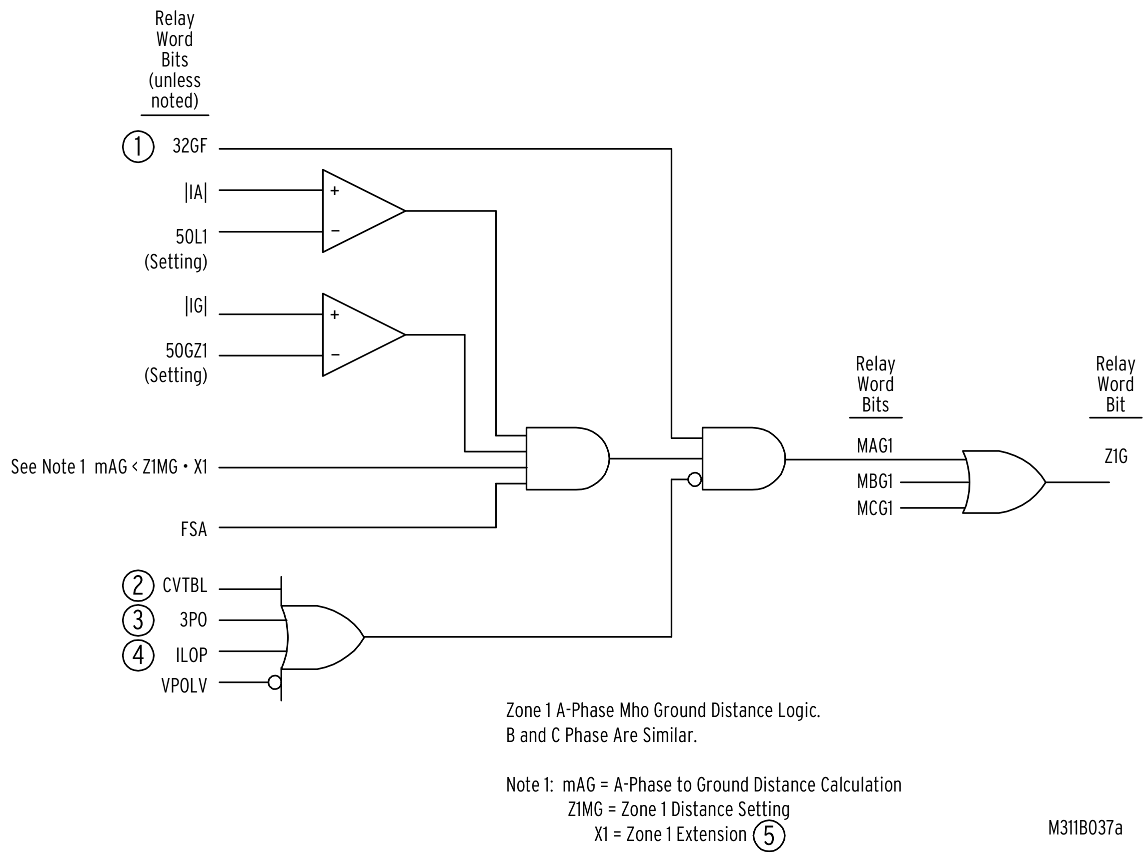
Phase and Residual Current Fault Detectors (Zones 1–3)

Setting Range for Phase and Residual Current Fault Detectors (50L1 through 50L3 and 50GZ1 through 50GZ3): **Note:** If EADVS = N, levels 2 and 3 fault detectors are set at their minimum values and are hidden.	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 3.14 and Figure 3.15.

Other Settings

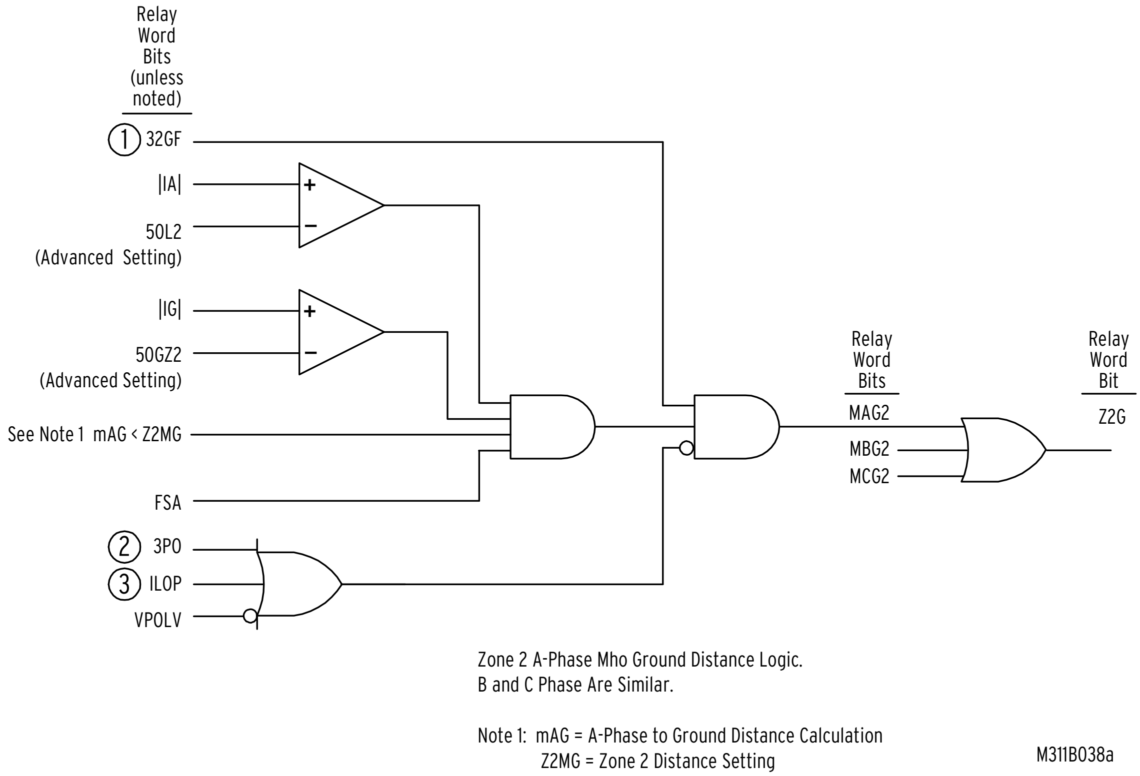
Settings range for zero sequence compensation (ZSC) factor magnitude:	k0M1 = 0.000–6.000 unitless (Zone 1) k0M = 0.000–6.000 unitless (Zone 2 and 3 advanced setting hidden and set to k0M1 when EADVS = N)
Settings range for zero sequence compensation (ZSC) factor angle:	k0A1 = -180.0 to +180.0 degrees (Zone 1) k0A = -180.0 to +180.0 degrees (Zone 2 and 3 advanced setting hidden and set to k0A1 when EADVS = N)

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



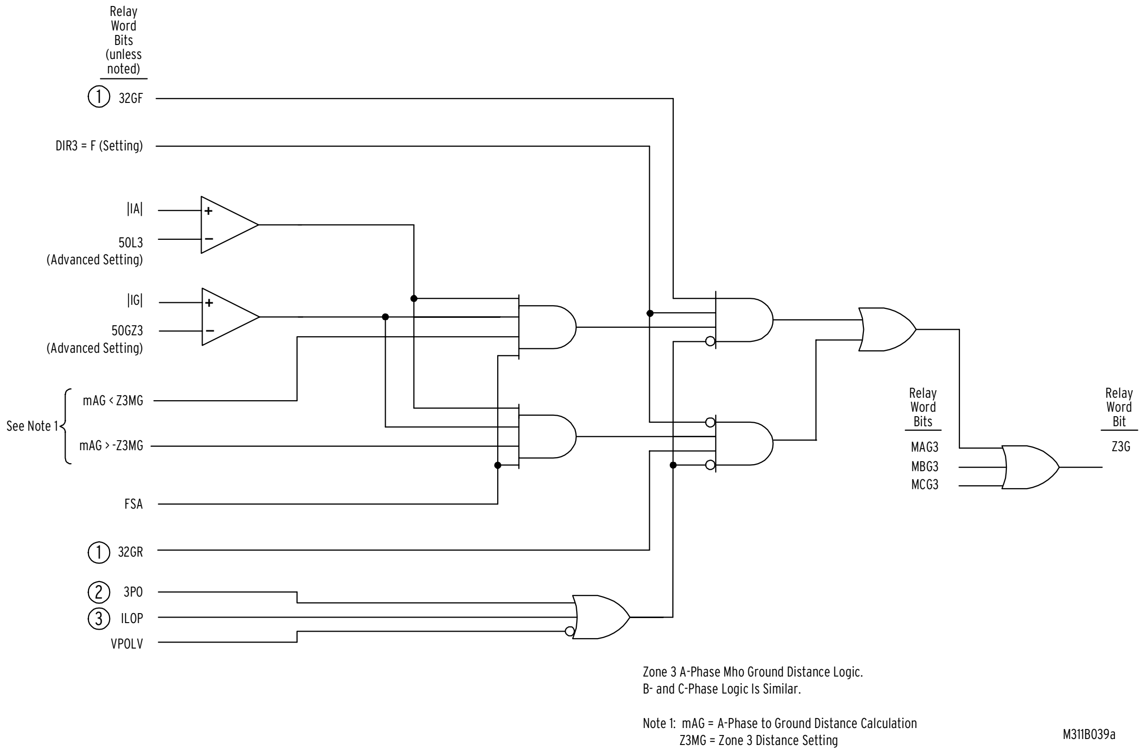
① From Figure 4.12 ④ From Figure 4.1
② From Figure 4.2 ⑤ From Figure 3.11
③ From Figure 5.3

Figure 3.7: Zone 1 Mho Ground Distance Logic



① From Figure 4.12 ③ From Figure 4.1
② From Figure 5.3

Figure 3.8: Zone 2 Mho Ground Distance Logic



① From Figure 4.12 ③ From Figure 4.1

② From Figure 5.3

Figure 3.9: Zone 3 Mho Ground Distance Logic

Distance Element Operating Time Curves at Nominal Frequency

Figure 3.10 shows operating times for the SEL-311B Relay distance elements. The diagrams show operating times at each test point. Operating times include output contact closure time.

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

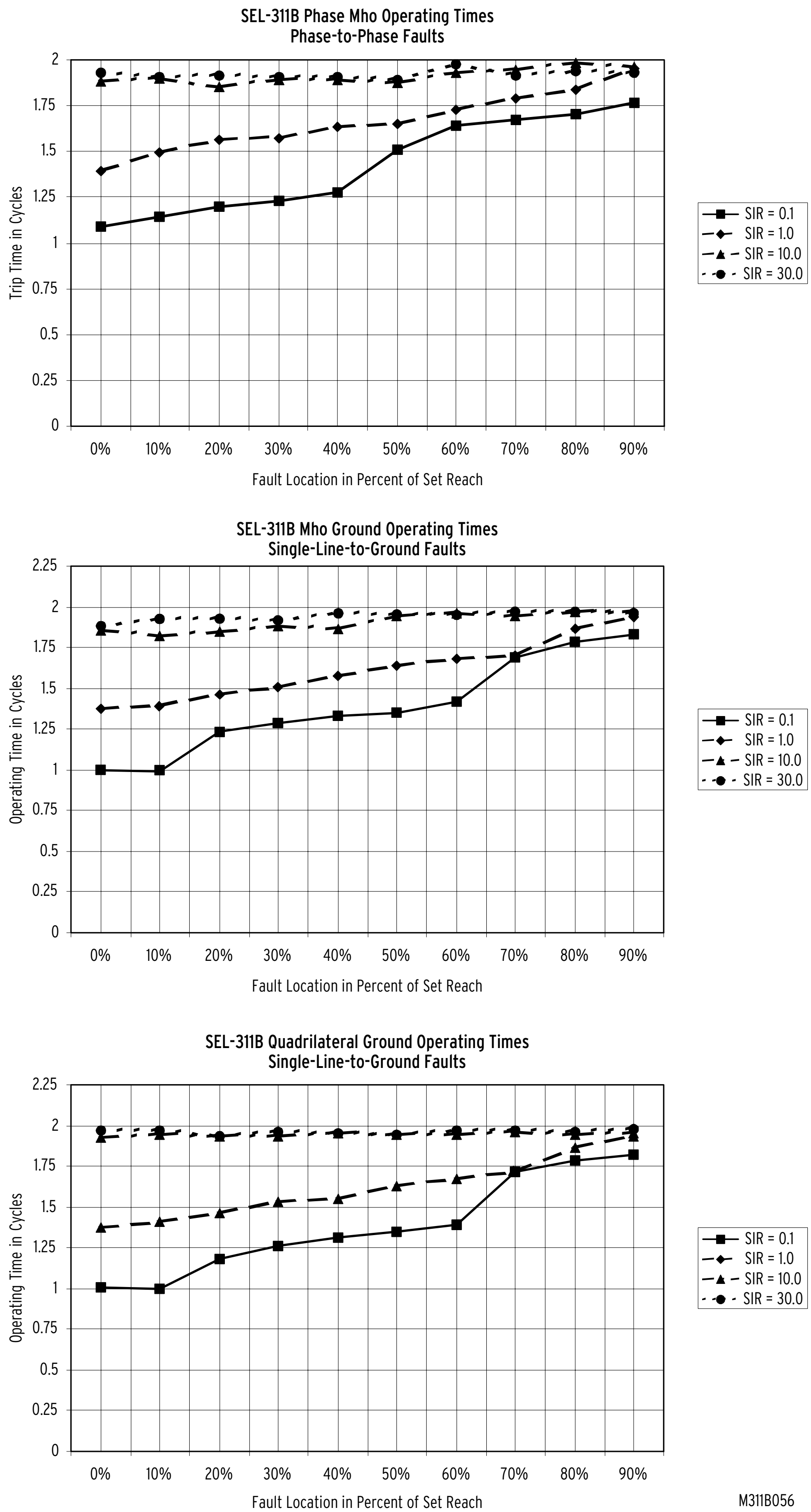


Figure 3.10: Ground and Phase Distance Speed Curves

Additional Distance Element Supervision

The SEL-311B 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.

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

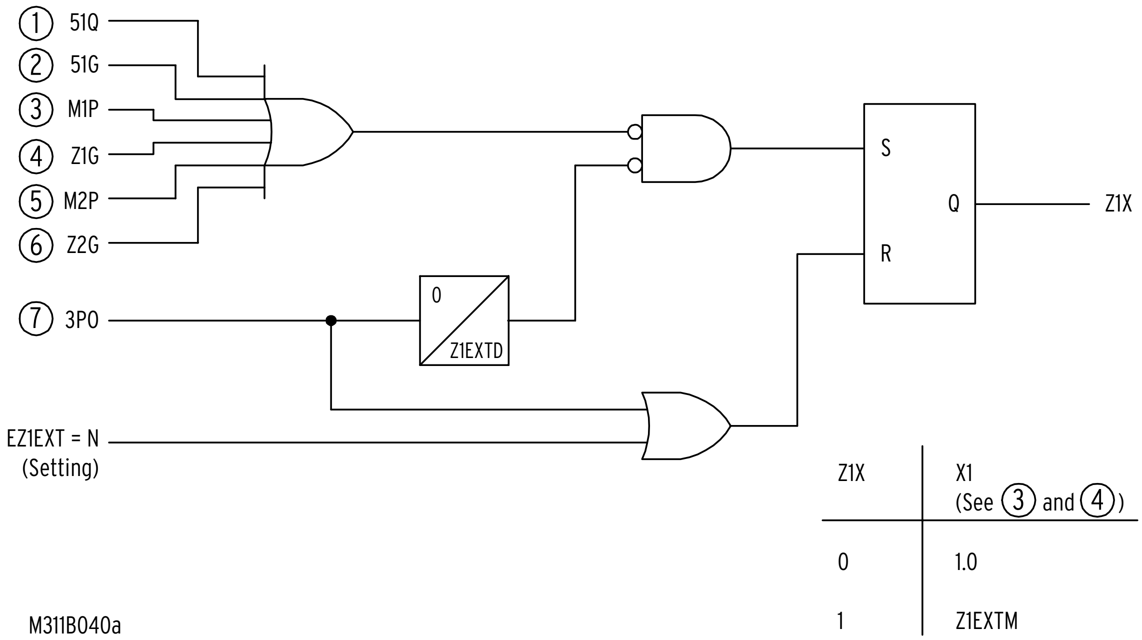
Zone 1 Extension

See Figure 3.11. 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.

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) must all be true or the SEL-311B will not allow the Z1EXTM setting.



① From Figure 3.20
② From Figure 3.19
③ From Figure 3.4
④ From Figure 3.7
⑤ From Figure 3.5
⑥ From Figure 3.8
⑦ From Figure 5.3

Figure 3.11: Zone 1 Extension Logic

Zone Time Delay Elements

The SEL-311B Relay supports two philosophies of zone timing: independent or common timing (see Figure 3.12). 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 Z3D
Independent Phase Timer Settings:	Z1PD through Z3PD
Independent Ground Timer Settings:	Z1GD through Z3GD
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

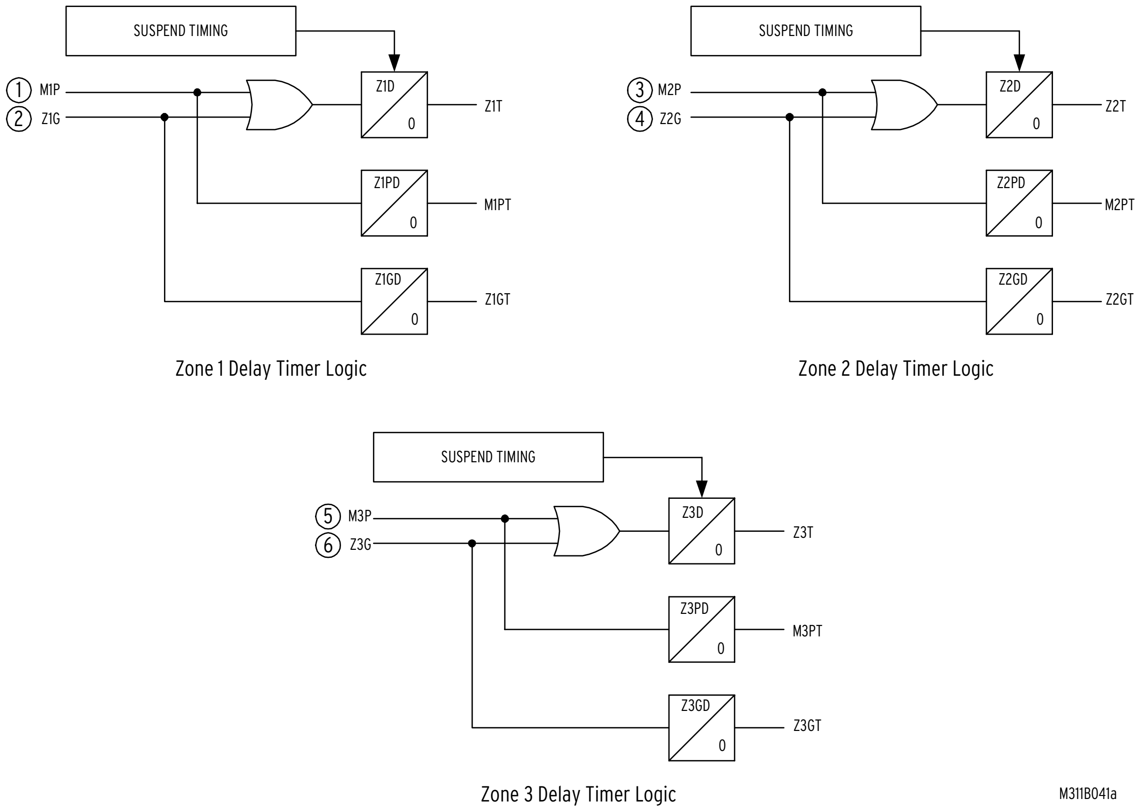
Select independent zone timing by using relay words M*n*PT and Z*n*GT (where *n* is the protection zone number) in the appropriate SELOGIC trip equation.

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 ϕG). If the timer expires, the suspension logic is blocked.



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

Figure 3.12: Zone Timing Elements

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 3.13.

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 3.13. 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 3.13 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 will display in an organized fashion in event reports (see Figure 3.13 and Table 12.3).

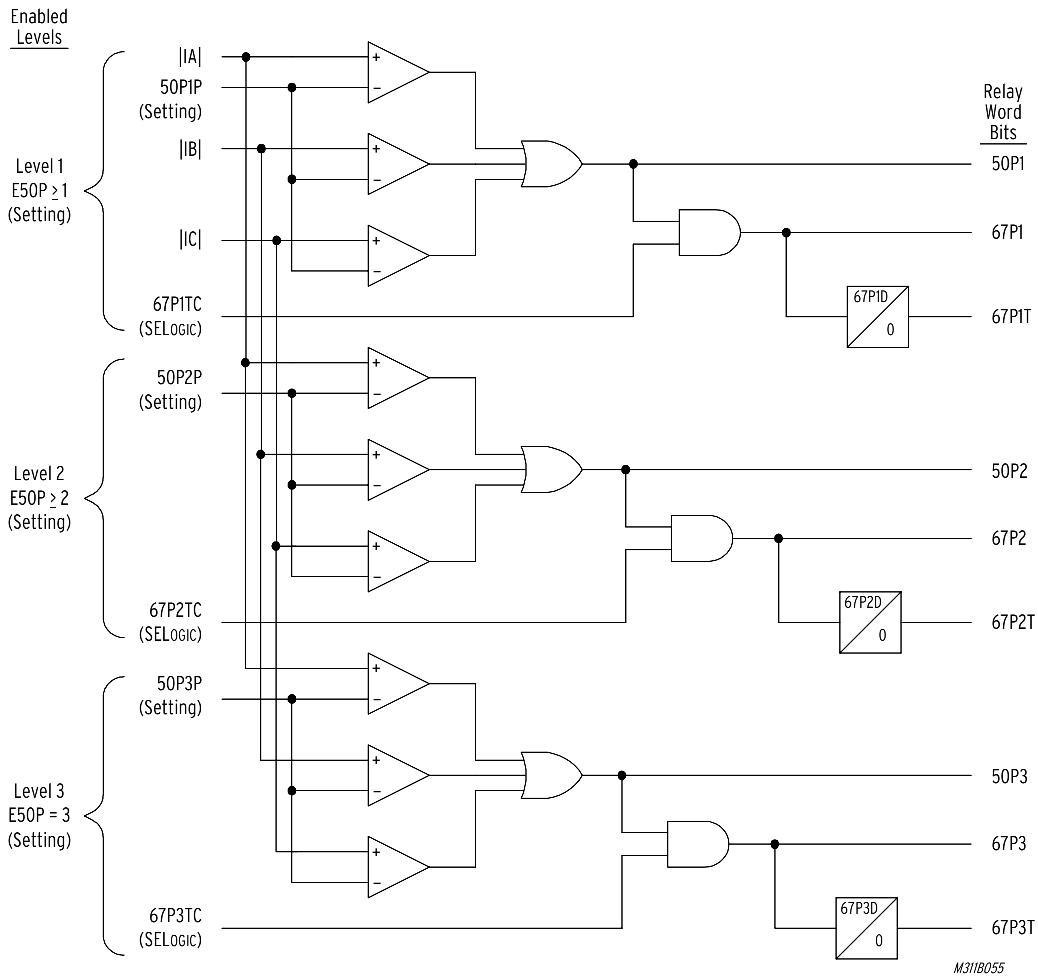


Figure 3.13: Levels 1 through 3 Phase Instantaneous/Definite-Time Overcurrent Elements

Torque Control

Levels 1 through 3 in Figure 3.13 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: 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 The 67P1/67P1T uses the Zone 2 phase distance element to provide forward directional control.

Other SELOGIC control equation torque control settings may be set to provide directional control. See ***Overcurrent Directional Control Provided by Torque Control Settings*** at the end of ***Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic***.

Pickup and Reset Time Curves

Figure 3.14 and Figure 3.15 show pickup and reset time curves applicable to all nondirectional instantaneous overcurrent elements in the SEL-311B 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. Output contact pickup/dropout time is typically 4 ms (0.25 cycle for a 60 Hz relay; 0.20 cycle for a 50 Hz relay).

If instantaneous overcurrent elements are made directional (with standard directional elements such as 32QF), the pickup time curve in Figure 3.14 is adjusted as follows:

multiples of pickup setting ≤ 4: add 0.25 cycle

multiples of pickup setting > 4: add 0.50 cycle

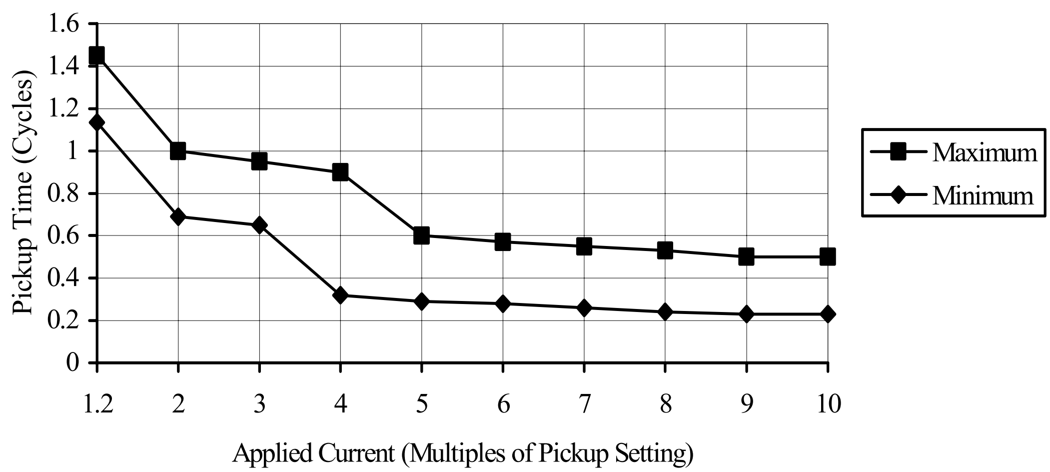


Figure 3.14: SEL-311B Relay Nondirectional Instantaneous Overcurrent Element Pickup Time Curve

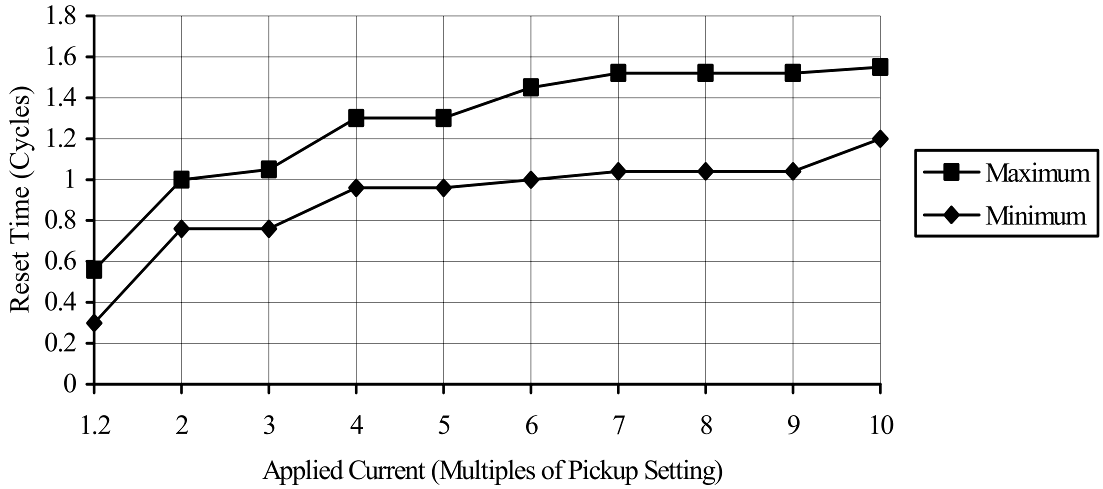


Figure 3.15: SEL-311B Relay Nondirectional Instantaneous Overcurrent Element Reset Time Curve

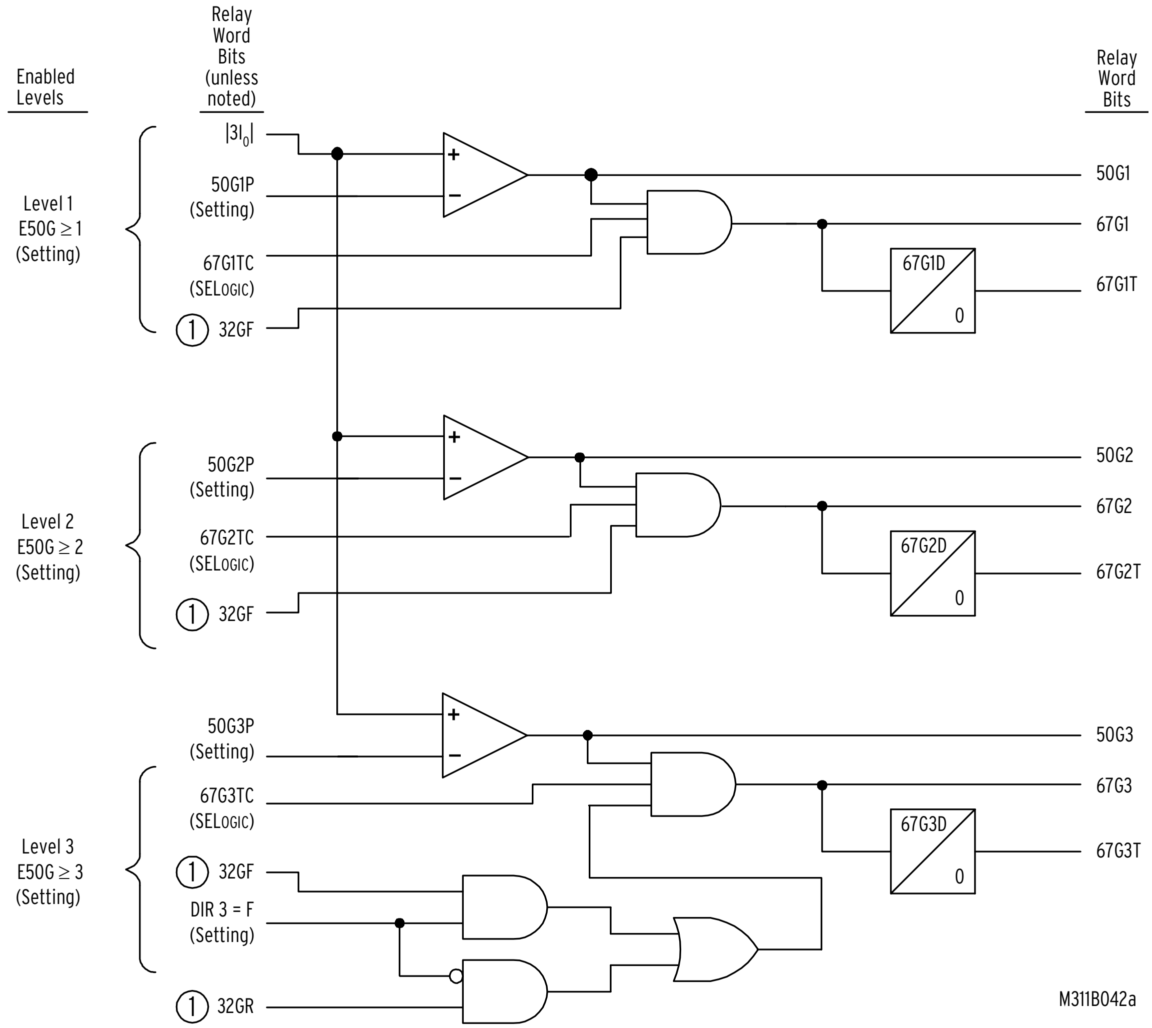
Residual Ground Instantaneous/Definite-Time Overcurrent Elements

Three 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 3.16.

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 3.16, follow the explanation given for Figure 3.13 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 3.16 Levels 1 and 2 67G*n* elements have their directional control fixed forward. Level 3 has 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.



① From Figure 4.12

Figure 3.16: Levels 1 Through 3 Residual Ground Instantaneous/Definite-Time Overcurrent Elements with Directional and Torque Control

Settings Ranges

Setting range for pickup settings 50G1P through 50G3P:

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 67G3D:

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 3.14 and Figure 3.15.

Negative-Sequence Instantaneous/Definite-Time Overcurrent Elements

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

Three 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 3.17.

To understand the operation of Figure 3.17, follow the explanation given for Figure 3.13 in the preceding ***Phase Instantaneous/Definite-Time Overcurrent Elements*** subsection, substituting negative-sequence current $3I_2$ [$3I_2 = I_A + a^2 \cdot I_B + a \cdot I_C$ (ABC rotation), $3I_2 = I_A + a^2 \cdot I_C + a \cdot I_B$ (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 3.17, Levels 1 and 2 67Q*n* elements have directional controls fixed forward. Level 3 has 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.

Settings Ranges

Settings range for pickup settings 50Q1P through 50Q3P:

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 67Q3D:

0.00–16000.00 cycles, in 0.25-cycle steps

Accuracy

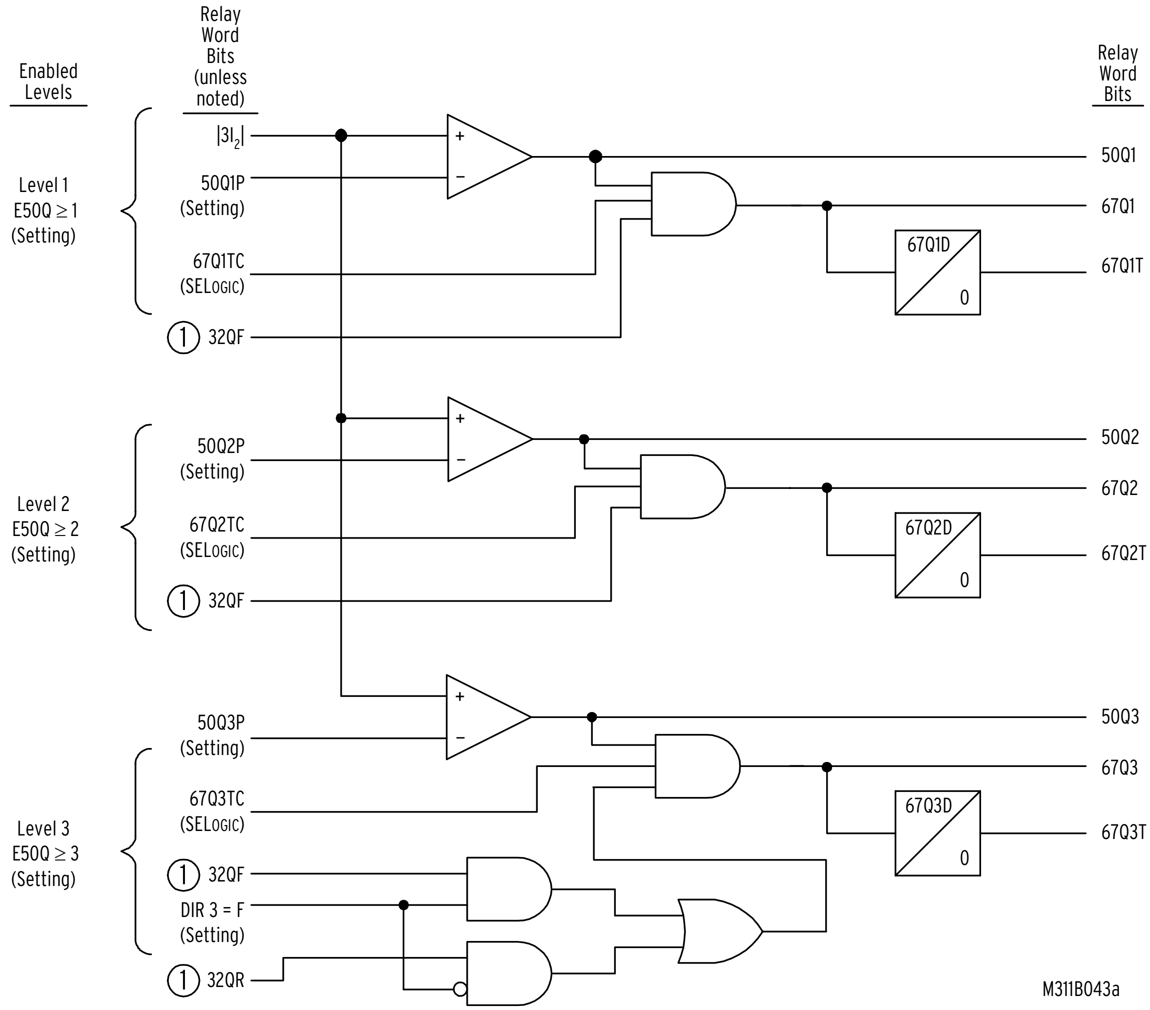
Pickup: ±0.05 A secondary and ±3% of setting (5 A nominal phase current inputs, IA, IB, IC)
±0.01 A secondary and ±3% of setting (1 A nominal phase current inputs, IA, IB, IC)

Timer: ±0.25 cycles and ±0.1% of setting

Transient Overreach: < 5% of setting

Pickup and Reset Time Curves

See Figure 3.14 and Figure 3.15.



① From Figure 4.12

Figure 3.17: Levels 1 Through 3 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 3.2: 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 3.18

51PT Element Settings Ranges

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

Table 3.3: 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.

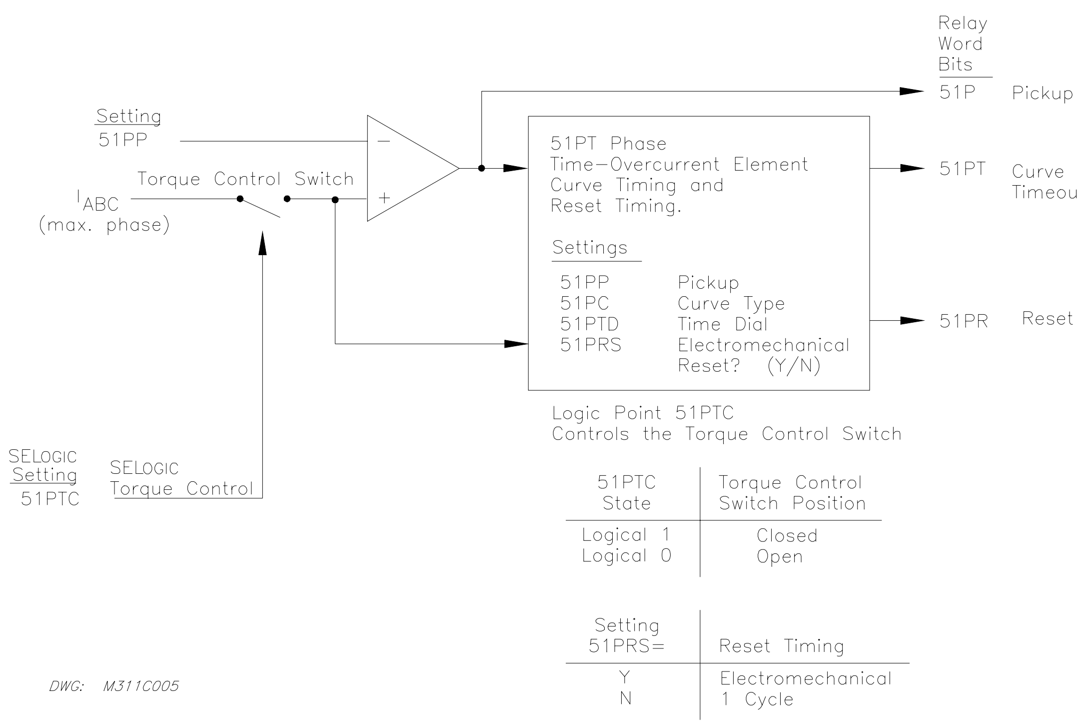


Figure 3.18: Phase Time-Overcurrent Element 51PT

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 3.18 are the Relay Word bits shown in Table 3.4.

Table 3.4: 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 3.18 compares the pickup setting (51PP) to the maximum phase current, I_{ABC}, if the Torque Control Switch is closed. I_{ABC} is also routed to the curve timing/reset timing functions. The Relay Word Bit logic outputs operate as follows with the Torque Control Switch closed:

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

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

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

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

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

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

= 0 (logical 0), if I_{ABC} ≤ 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 3.18 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 3.18.

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: 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. 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 3.18.

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 3.19, follow the explanation given for Figure 3.18 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.

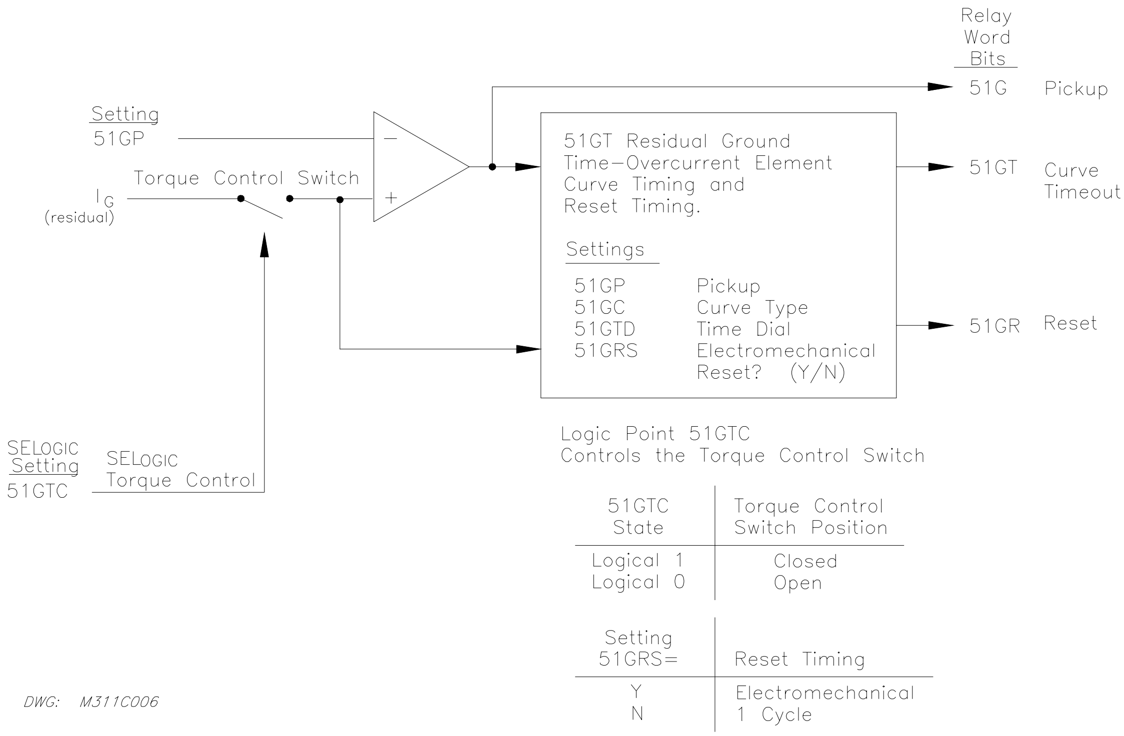


Figure 3.19: Residual Ground Time-Overcurrent Element 51GT

Settings Ranges

Table 3.5: 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.

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

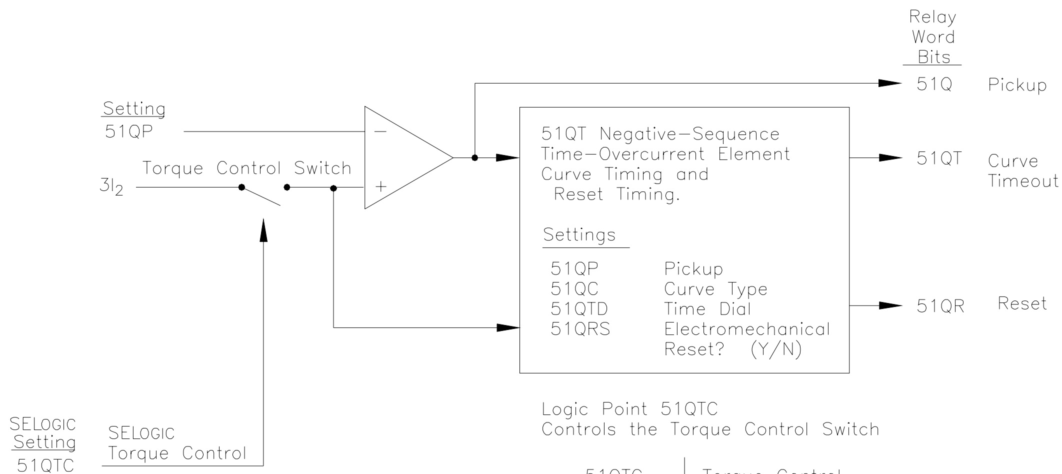
Accuracy

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 3.20, follow the explanation given for Figure 3.18 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.



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

Setting 51QRS=	Reset Timing
Y	Electromechanical
N	1 Cycle

Figure 3.20: Negative-Sequence Time-Overcurrent Element 51QT

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

Settings Ranges

Table 3.6: 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.

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-311B voltage elements by making the enable setting:

EVOLT = Y

Voltage Values

Voltage elements operate from the voltage values shown in Table 3.7.

Table 3.7: Voltage Values Used by Voltage Elements

Voltage	Description
V_A	A-phase voltage, from SEL-311B Relay rear-panel voltage input VA
V_B	B-phase voltage, from SEL-311B Relay rear-panel voltage input VB
V_C	C-phase voltage, from SEL-311B 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
V_S	Synchronism check voltage, from SEL-311B 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 3.8 and in Figure 3.23. These voltage elements are <u>independent</u> of the synchronism check elements, even though voltage V_S is used in both.

Voltage Element Settings

Table 3.8 lists available voltage elements and the corresponding voltage inputs and settings ranges for the SEL-311B Relay (see Figure 1.2 for voltage input connection).

Table 3.8: Voltage Elements Settings and Settings Ranges

Voltage Element (Relay Word bits)	Operating Voltage	Pickup Setting/Range	See Figure
27A	V_A	27P OFF, 0.00–150.00 V secondary	Figure 3.21
27B	V_B		
27C	V_C		
3P27	27A * 27B * 27C		
59A	V_A	59P OFF, 0.00–150.00 V secondary	
59B	V_B		
59C	V_C		
3P59	59A * 59B * 59C		
27AB	V_{AB}	27PP OFF, 0.00–260.00 V secondary	Figure 3.22
27BC	V_{BC}		
27CA	V_{CA}		
59AB	V_{AB}	59PP OFF, 0.00–260.00 V secondary	
59BC	V_{BC}		
59CA	V_{CA}		

Voltage Element (Relay Word bits)	Operating Voltage	Pickup Setting/Range	See Figure
27S	V_S	27SP 0.00–150.00 V secondary	Figure 3.23
59S	V_S	59SP 0.00–150.00 V secondary	

Accuracy

Pickup: ±1 V and ±5% of setting

Transient Overreach: < 5% of setting

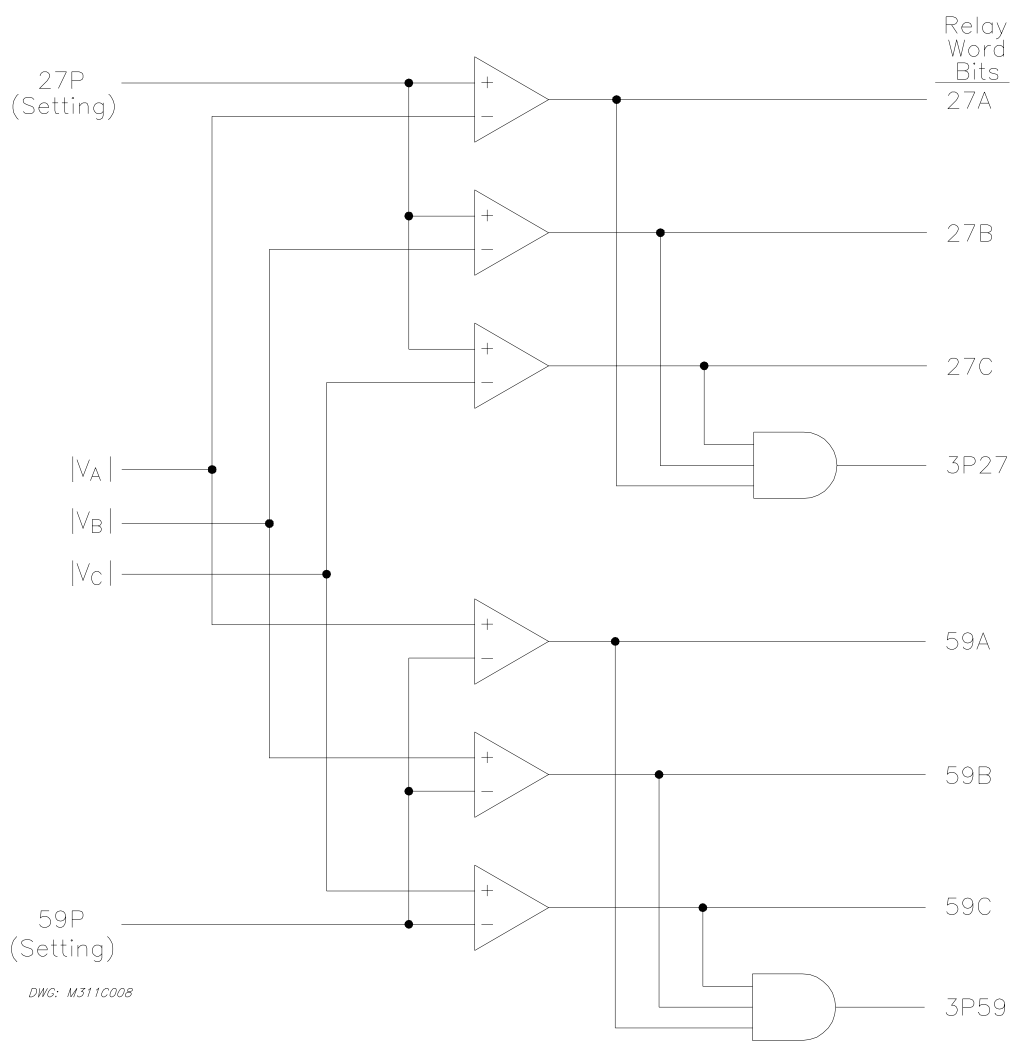


Figure 3.21: Single-Phase and Three-Phase Voltage Elements

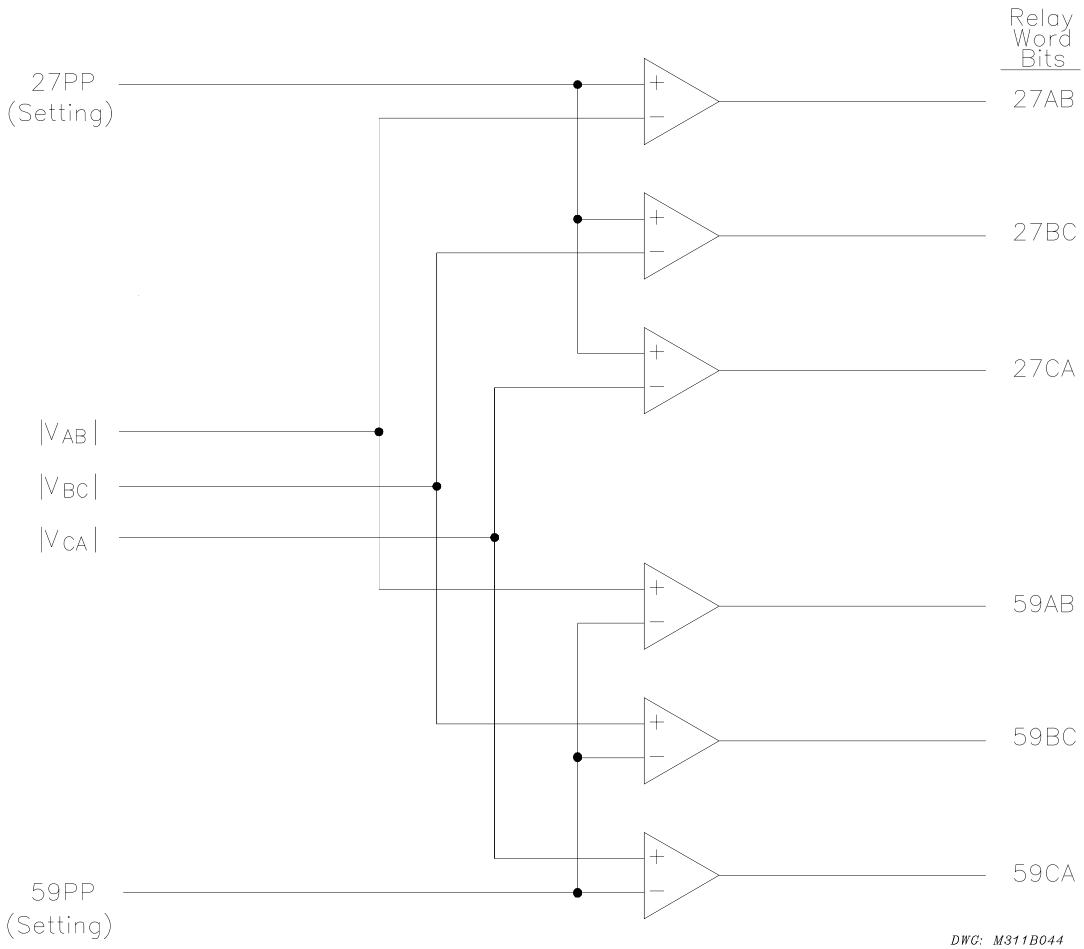


Figure 3.22: Phase-to-Phase Elements

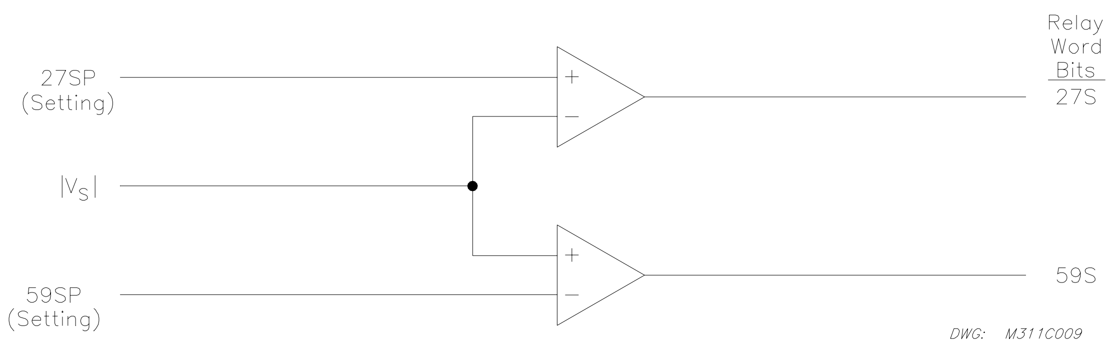


Figure 3.23: Channel V_S Voltage Elements

Voltage Element Operation

Note that the voltage elements in Table 3.8 and Figure 3.21 through Figure 3.23 are a combination of "undervoltage" (Device 27) and "overvoltage" (Device 59) type elements. Undervoltage elements (Device 27) assert when the operating voltage goes <u>below</u> the corresponding pickup setting. Overvoltage elements (Device 59) assert when the operating voltage goes <u>above</u> the corresponding pickup setting.

Undervoltage Element Operation Example

Refer to Figure 3.21 (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 3.21 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 3.21 (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 3.21 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 2.5 and Figure 2.6 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 3.24). They have separate angle settings (see Figure 3.25).

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 3.25.

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 not set to OFF. With TCLOSD not set to OFF, the synchronism check is performed as described in either the top or bottom of Figure 3.25, 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 3.25. 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 3.25. 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.

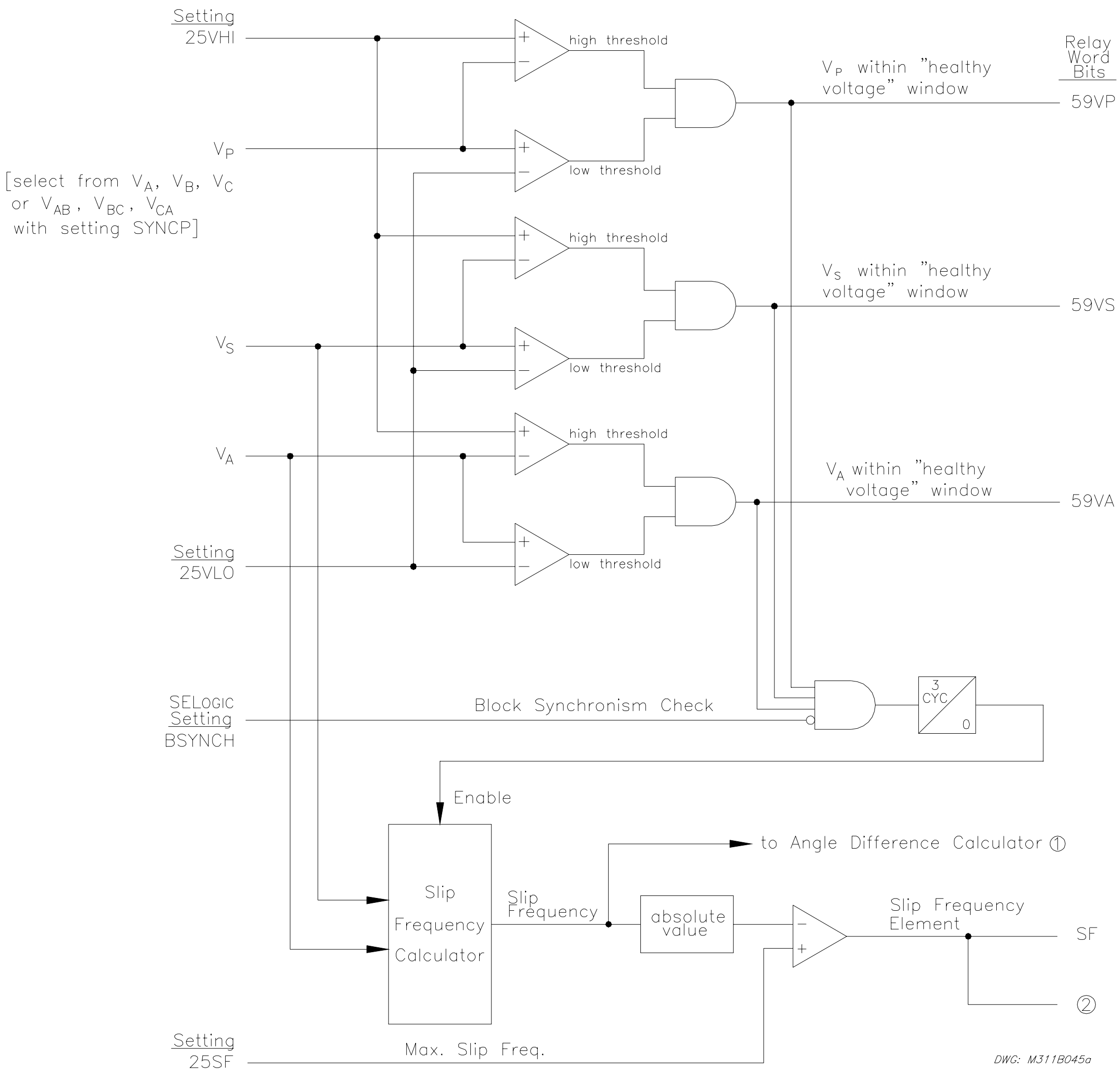
Synchronism Check Elements Settings

Table 3.9: 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

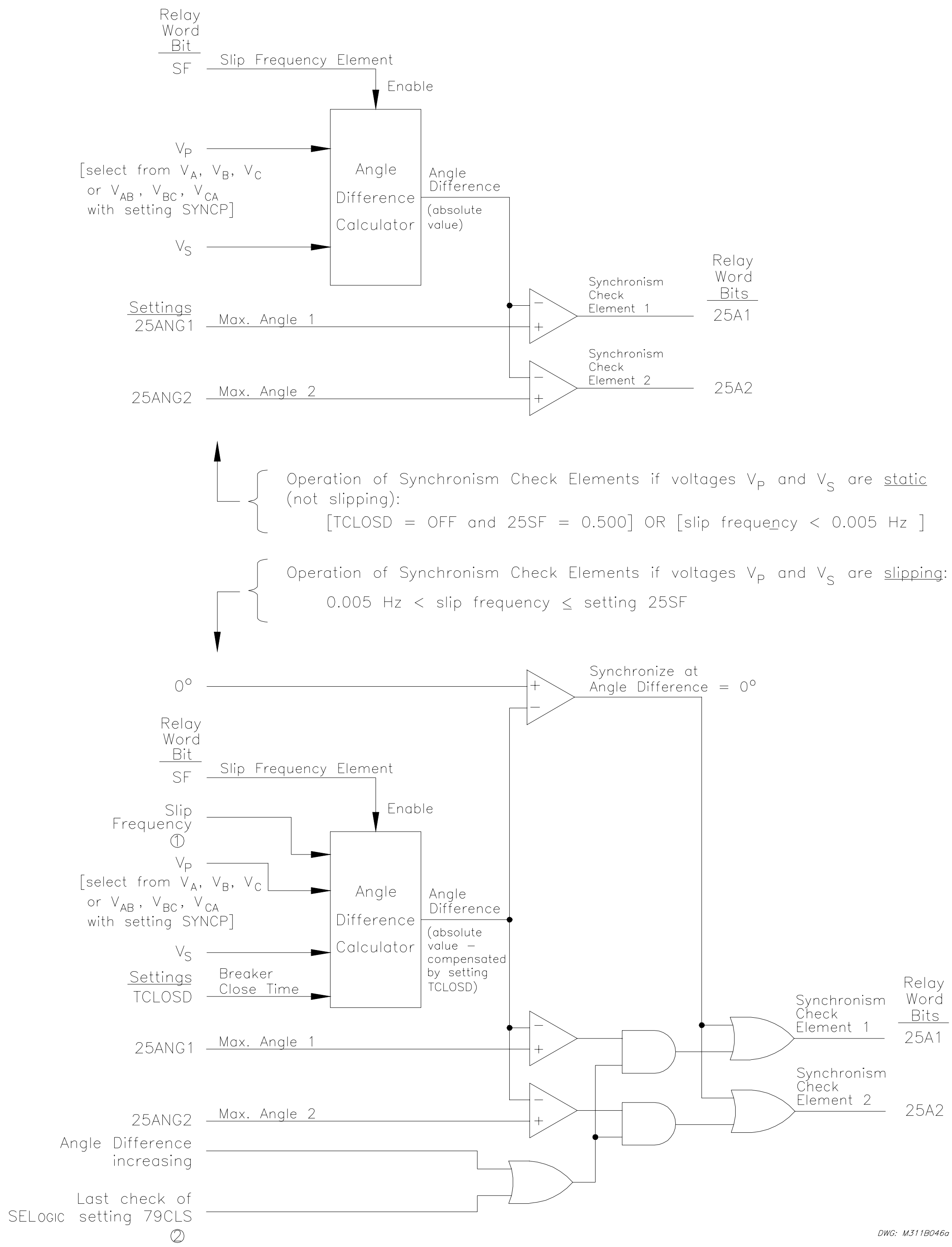
Accuracy

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



① See bottom of Figure 3.25 ② To Figure 3.25

Figure 3.24: Synchronism Check Voltage Window and Slip Frequency Elements



① From Figure 3.24 ② See Figure 6.2

Figure 3.25: 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-311B 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 1.2 and Figures 2.4 and 2.5).

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 3.24 and Figure 3.25.

Voltage Window

Refer to Figure 3.24.

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 3.24.

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 3.24.

The synchronism check element Slip Frequency Calculator in Figure 3.24 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	(in units of Hz = cycles/second) [determined from V_A]
f_S = frequency of voltage V_S	(in units of Hz = cycles/second)

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

For example, in Figure 3.24, 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 3.25 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 3.25.

If the slip frequency is less than or equal to 0.005 Hz or TCLOSD = OFF, the Angle Difference Calculator does <u>not</u> 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 3.25.

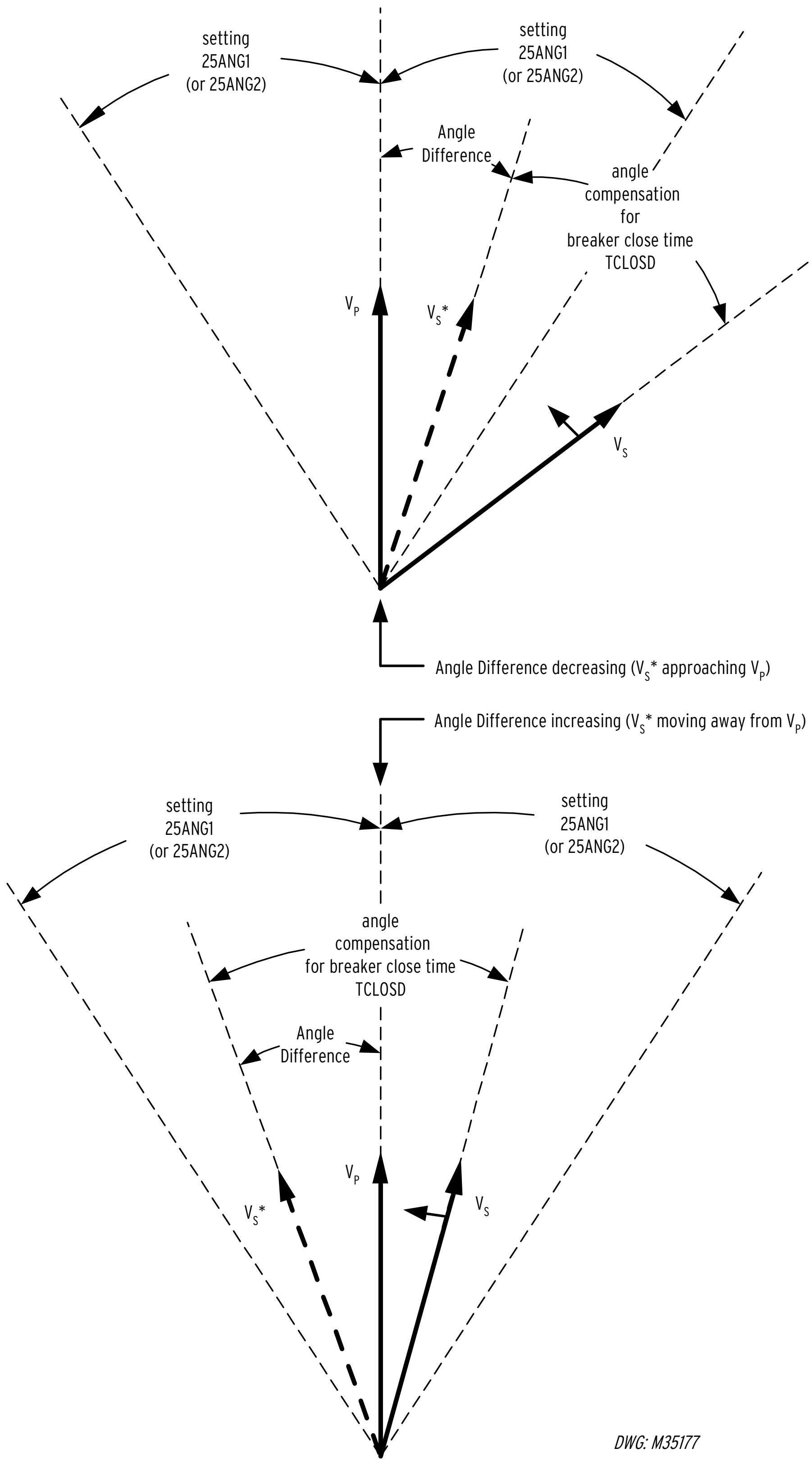


Figure 3.26: Angle Difference Between V_P and V_S Compensated by Breaker Close Time ($f_P < f_S$ and V_P Shown as Reference in This Example)

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 3.26). 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 3.25 and Figure 3.26.

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 3.26.

Note: The angle compensation in Figure 3.26 appears much greater than 6 degrees. Figure 3.26 is for general illustrative purposes only.

The top of Figure 3.26 shows the Angle Difference <u>decreasing</u>; 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 3.26 shows the Angle Difference <u>increasing</u>; 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 3.25) 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 3.25.

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 3.25. 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 3.26 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 3.26 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 3.26. 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 3.25 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).

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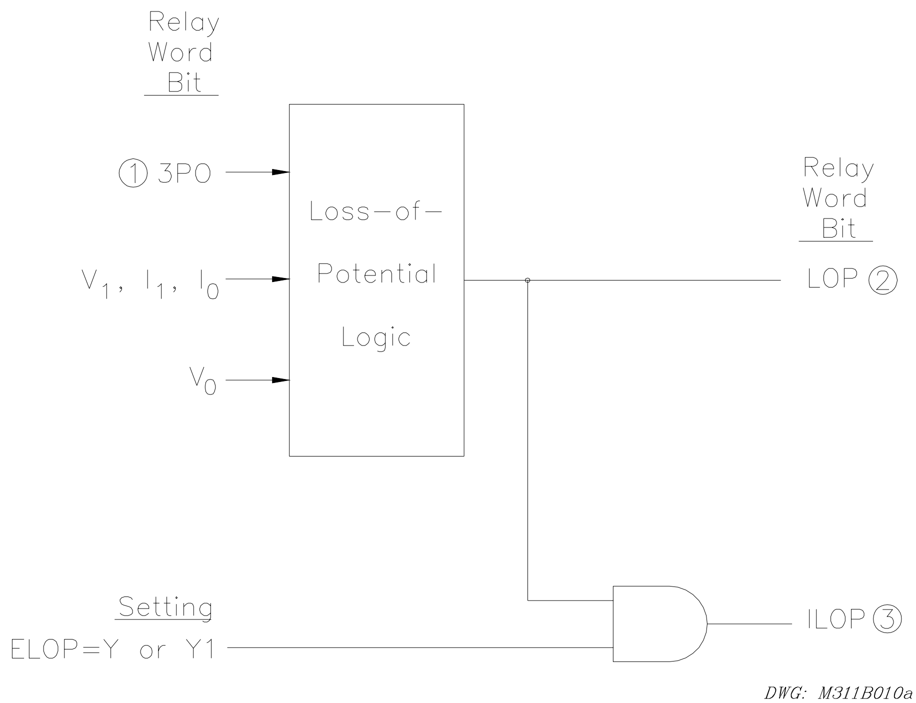
TABLES

FIGURES

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

Loss-of-Potential Logic

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



① From Figure 5.3
② To Figure 4.12
③ To Figure 3.4 through Figure 3.9, Figure 4.9 through Figure 4.11, Figure 4.14, and Figure 4.15

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 5.3)
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 V_1 returns above 50 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 (Figures 3.4 through 3.9).

LOP is disabled while 3PO is asserted (breaker open). If an input potential is 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.

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

SV1 = 3PO

OUT105 = !3P59 * SV1T + LOP

See Figure 3.22. 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 3.4 through Figure 3.9). 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.

Setting ELOP = Y

Additionally, if setting ELOP = Y and a loss-of-potential condition occurs (Relay Word bit LOP asserts to logical 1), overcurrent elements set direction forward are enabled (see Figure 4.12). These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

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).

CCVT Transient Detection Logic

The SEL-311B detects CCVT transients that may cause Zone 1 distance overreach. If CCVT transient blocking is enabled (setting ECCVT = Y), and the relay detects a high SIR during a Zone 1 fault, the relay delays tripping for up to 1.5 cycles, allowing the CCVT 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-311B 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.

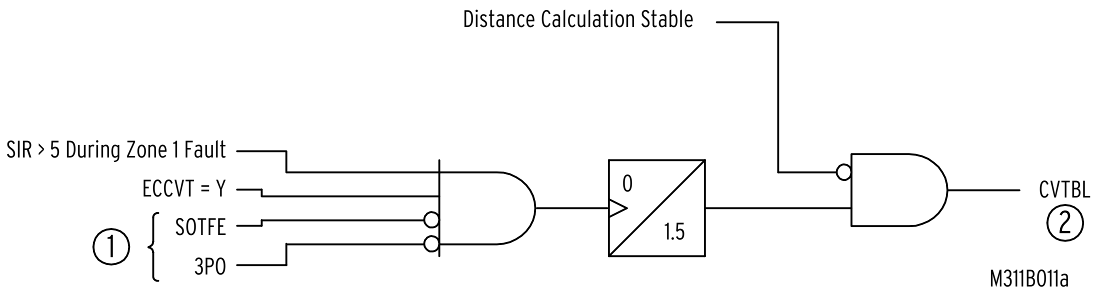
Consider using CCVT transient detection logic when you have either of the following conditions:

- 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***.



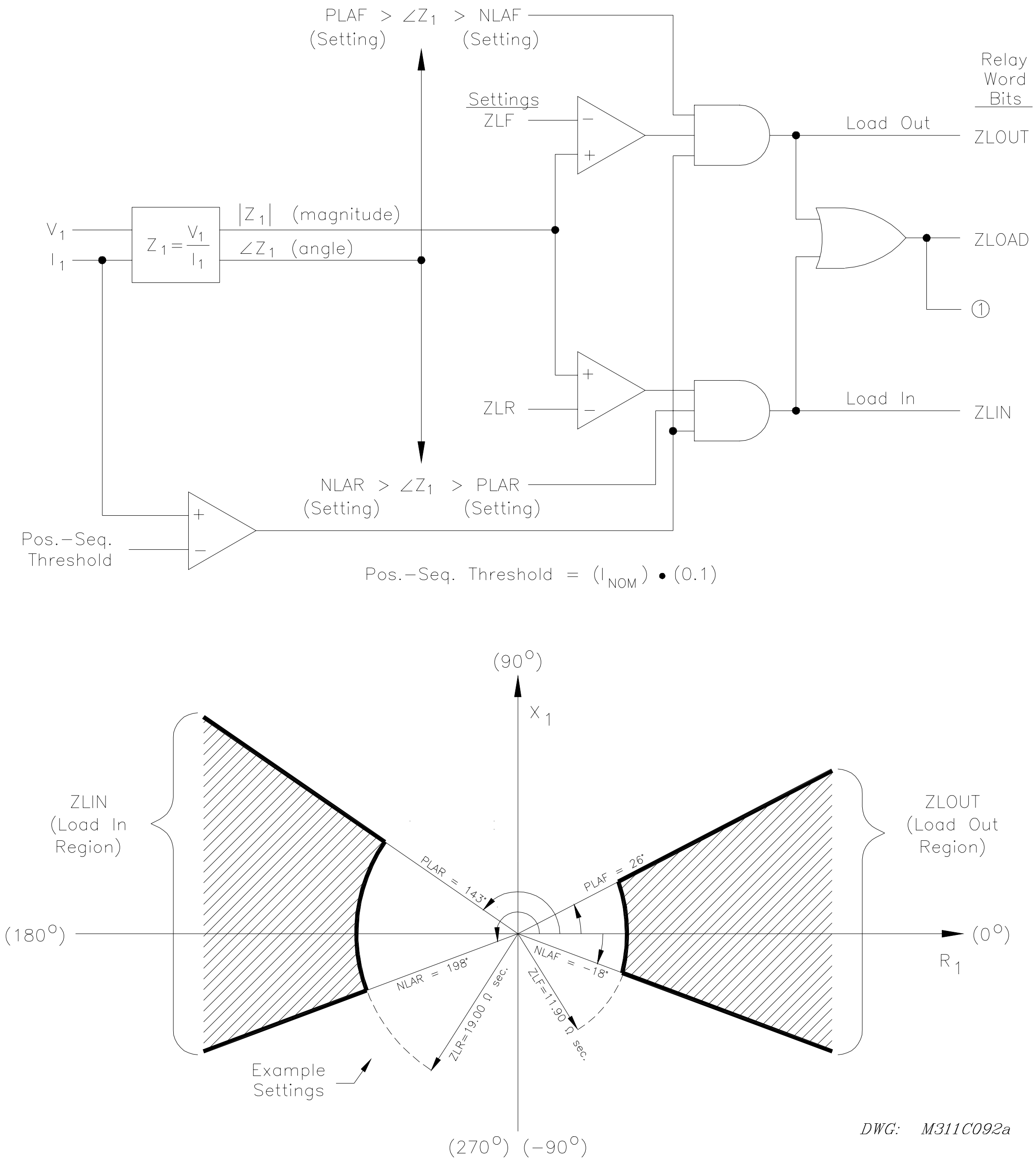
① From Figure 5.3 ② To Figure 3.4 and Figure 3.7

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).

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 M3P, will not operate without directional control. Set !ZLOAD in the phase overcurrent torque control equation to block phase overcurrent operation.



① To Figure 4.15

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:

$[(\text{line-line voltage in kV})^2 \bullet (\text{CT ratio})]/[(\text{3-phase load in MVA}) \bullet (\text{PT ratio})]$

Again, for the maximum forward load:

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

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

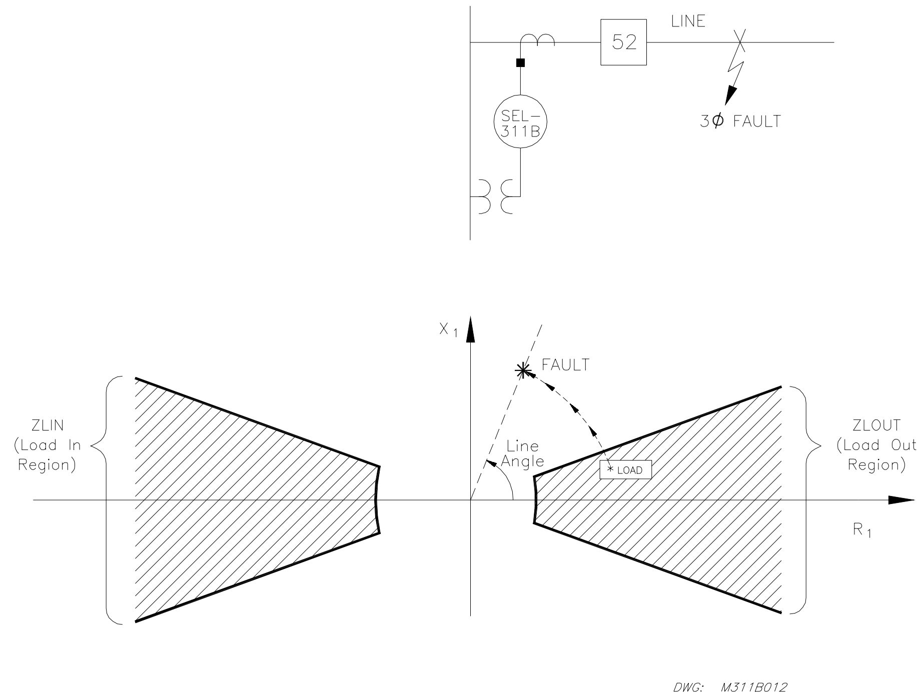


Figure 4.4: Migration of Apparent Positive-Sequence Impedance for a Fault Condition

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 3.18 in ***Section 3: Distance, 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-311B Relay

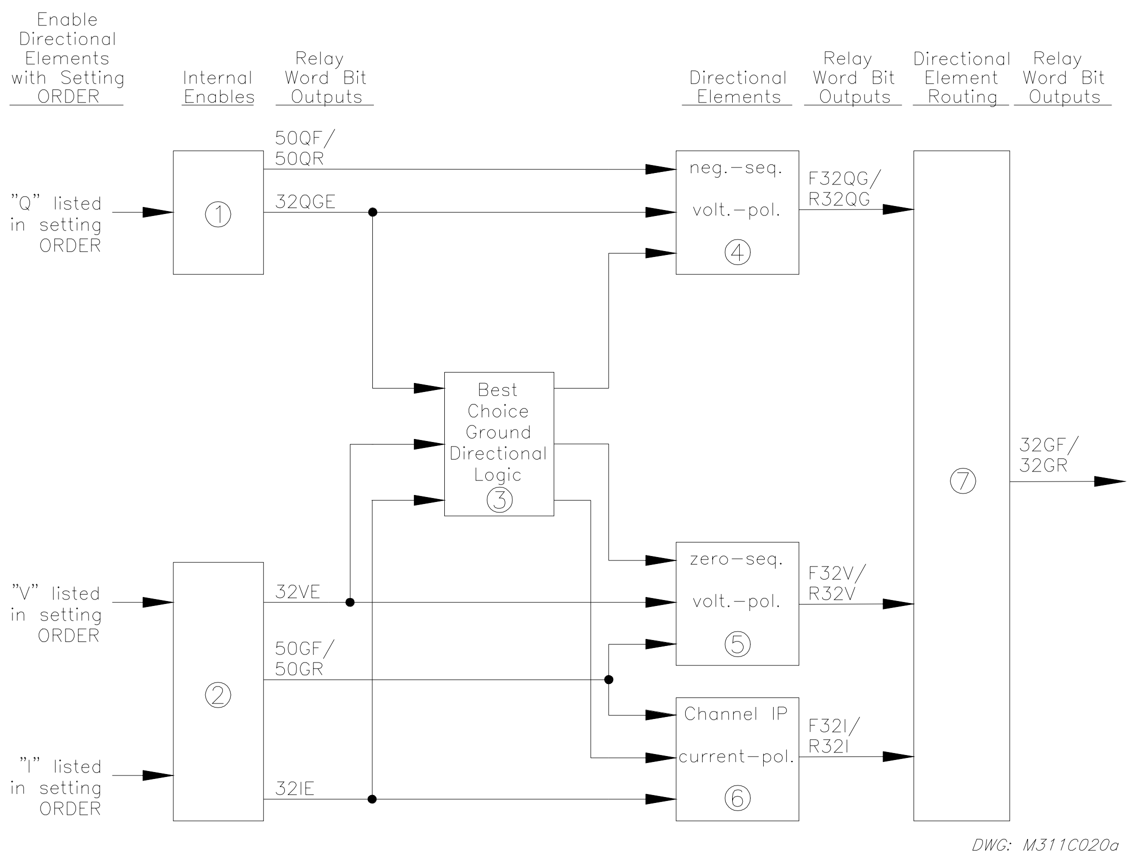
The load-encroachment logic and settings in the SEL-311B Relay are the same as those in the SEL-321 Relay. Refer to ***Application Guide 93-10: SEL-321 Relay Load-Encroachment Function Setting Guidelines*** for applying the load-encroachment logic in the SEL-311B Relay.

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***.

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



① Figure 4.6 ⑤ Figure 4.10
② Figure 4.7 ⑥ Figure 4.11
③ Figure 4.8 ⑦ Figure 4.12
④ Figure 4.9

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. Setting ORDER can be set with any combination of Q, V, and I. They have the following correspondence to the directional elements:

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***.

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:

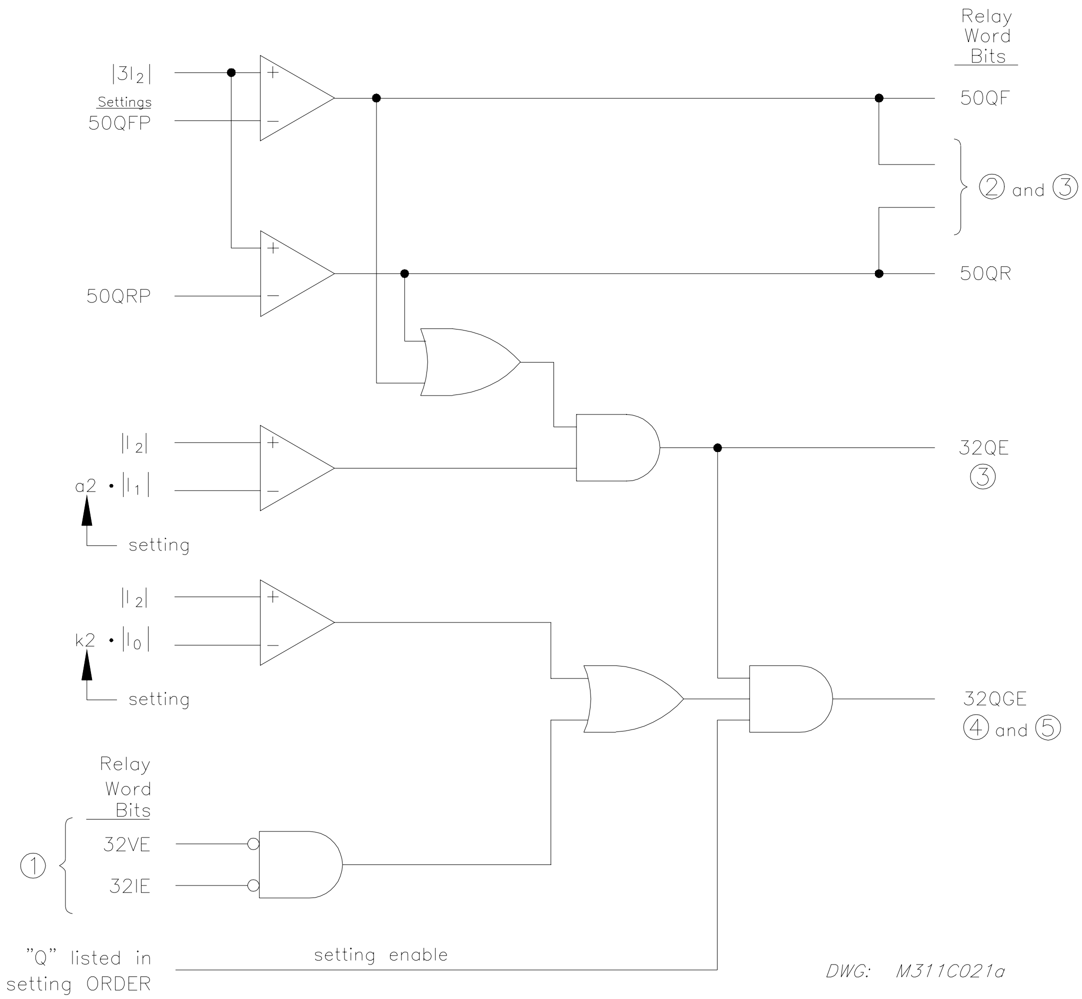
- enable setting ELOP = Y,
- a loss-of-potential condition occurs (Relay Word bit LOP asserts),
- and internal enable 32IE (for channel IP current-polarized directional element) is not asserted

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 3.7 through Figure 3.9, ILOP also disables all ground distance elements.

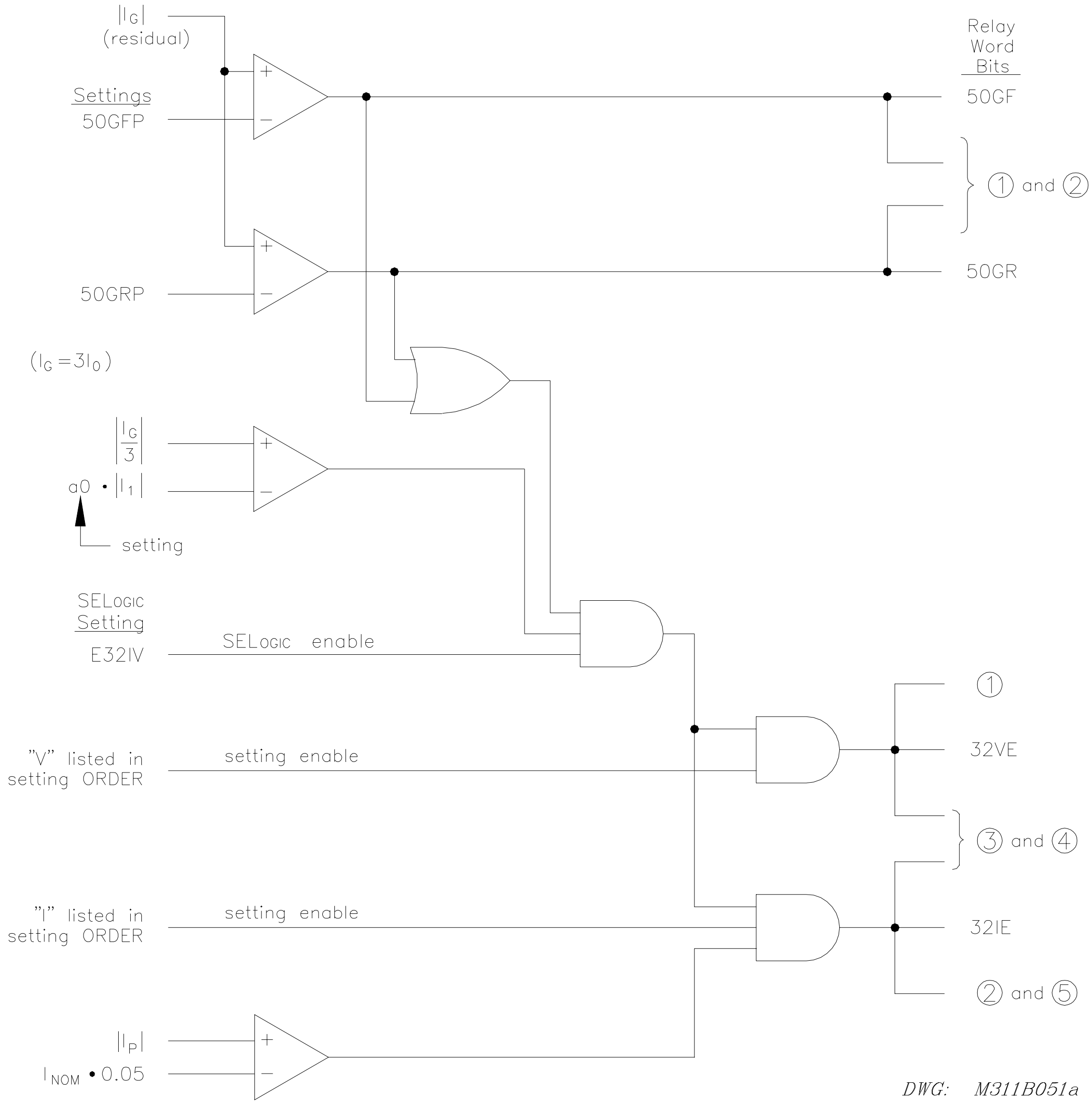


① From Figure 4.7 ④ To Figure 4.8

② To Figure 4.9 ⑤ To Figure 4.9

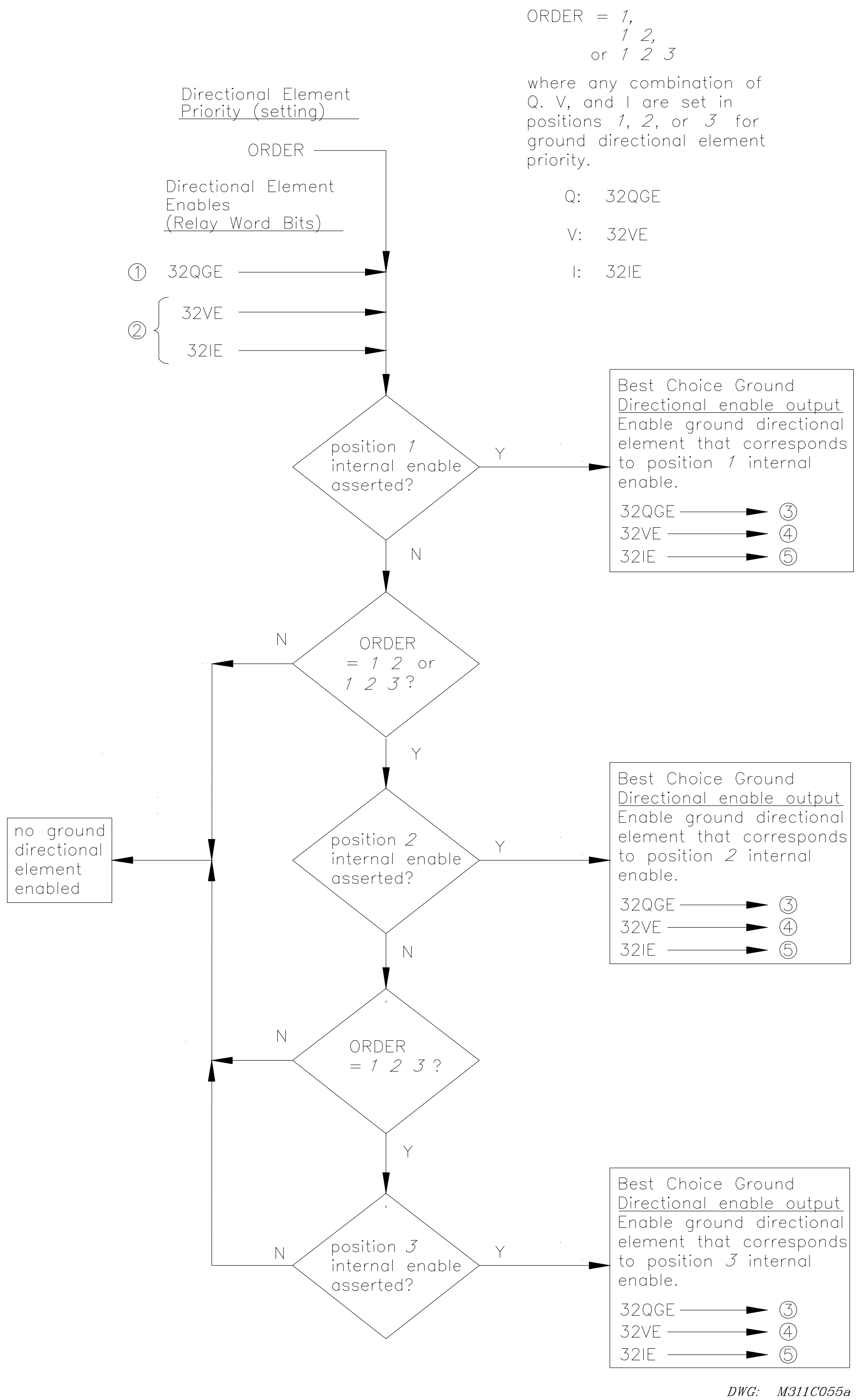
③ To Figure 4.14

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



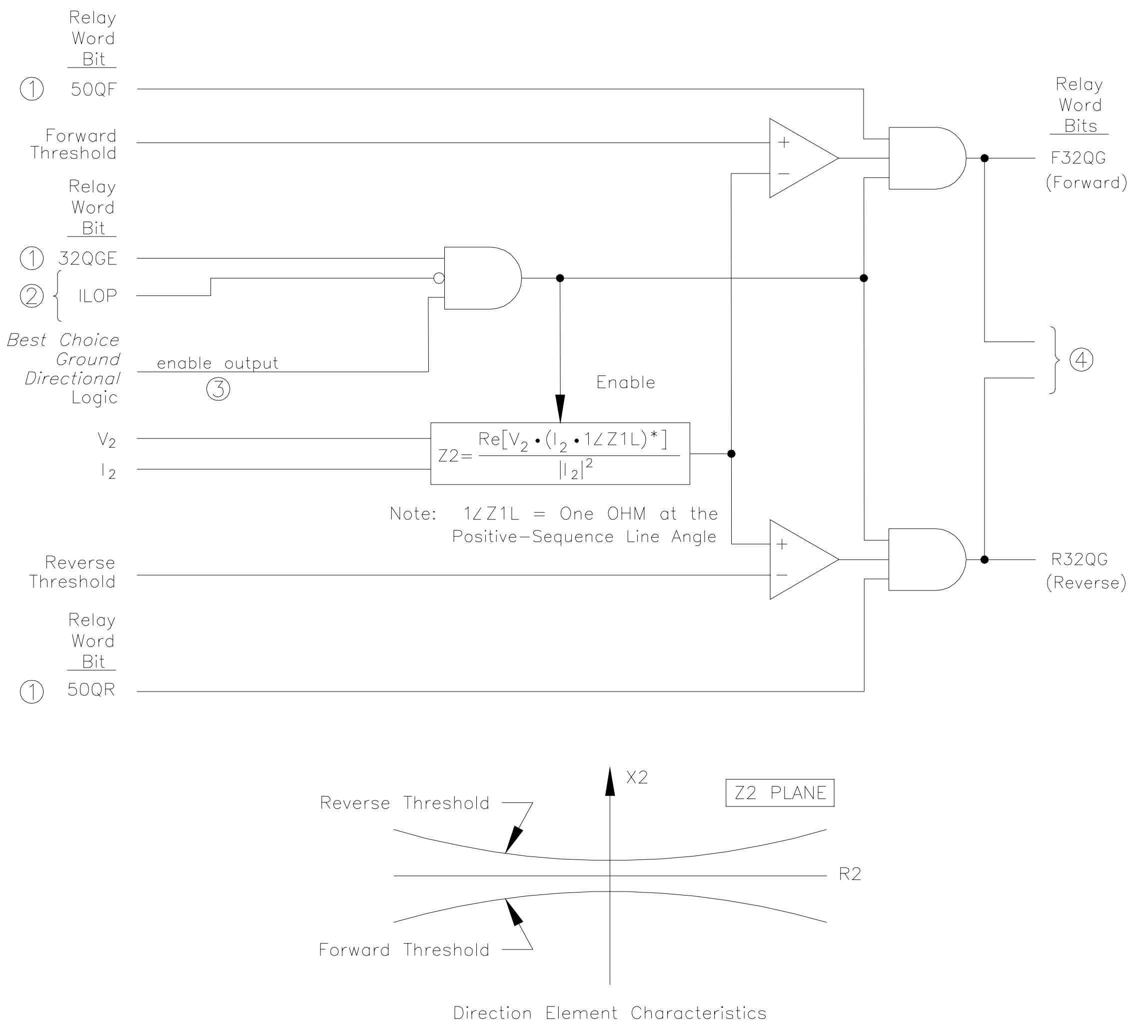
① To Figure 4.10
② To Figure 4.11
③ To Figure 4.6
④ To Figure 4.8
⑤ To Figure 4.12

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



① From Figure 4.6 ④ Figure 4.10
② From Figure 4.7 ⑤ Figure 4.12
③ Figure 4.9

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 $= 0.75 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

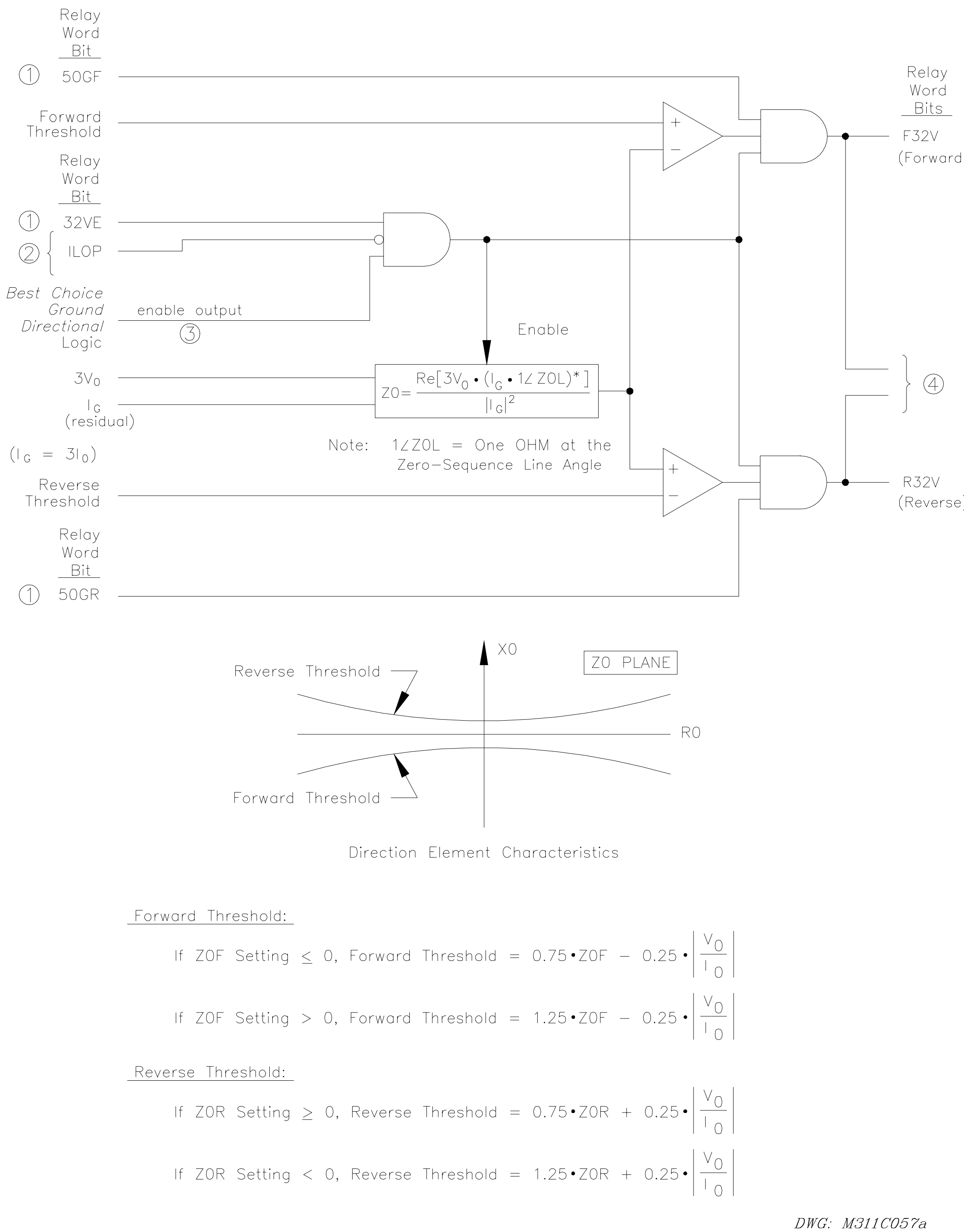
If Z2R Setting $<$ 0, Reverse Threshold $= 1.25 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

DWG: M311C056a

① From Figure 4.6 ③ From Figure 4.8

② From Figure 4.1 ④ To Figure 4.12

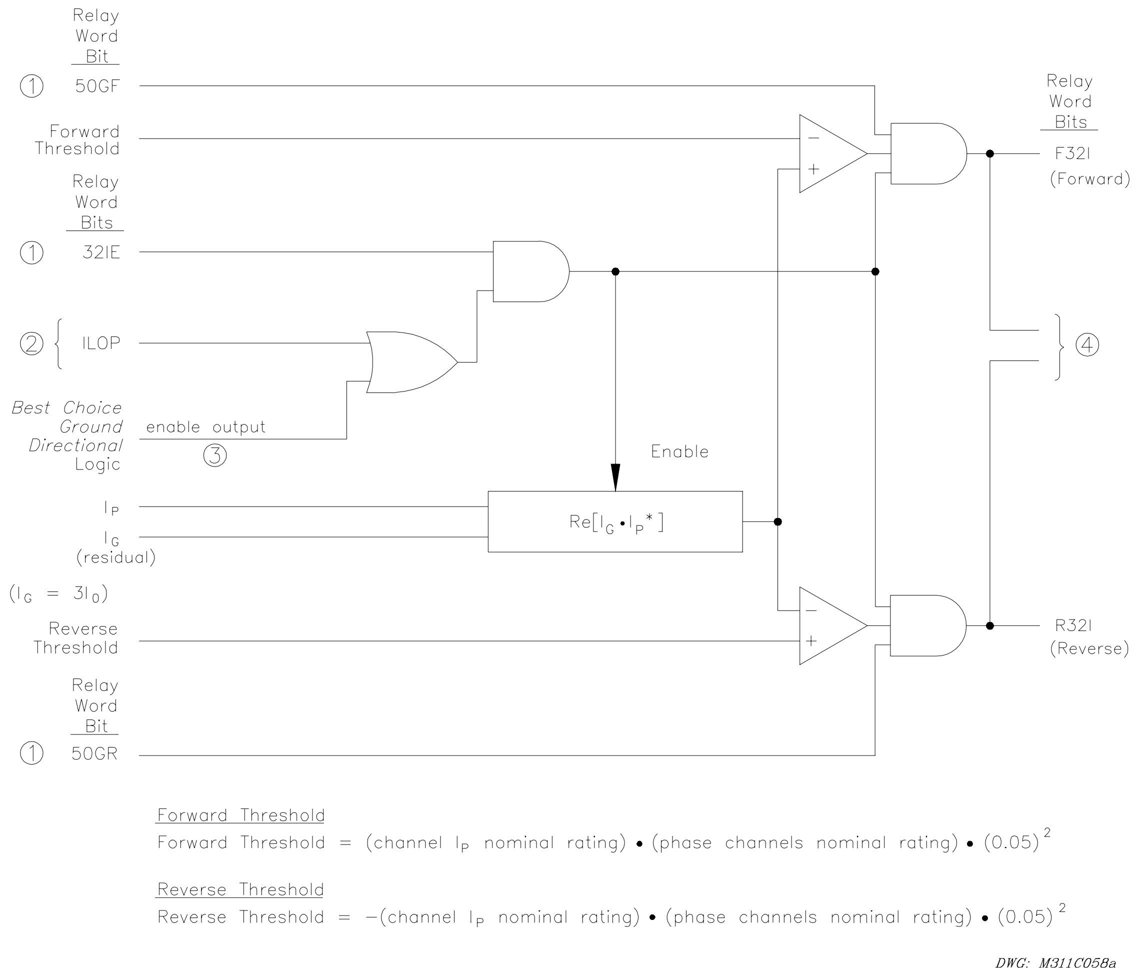
Figure 4.9: Negative-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements



① From Figure 4.7 ③ From Figure 4.8

② From Figure 4.1 ④ To Figure 4.12

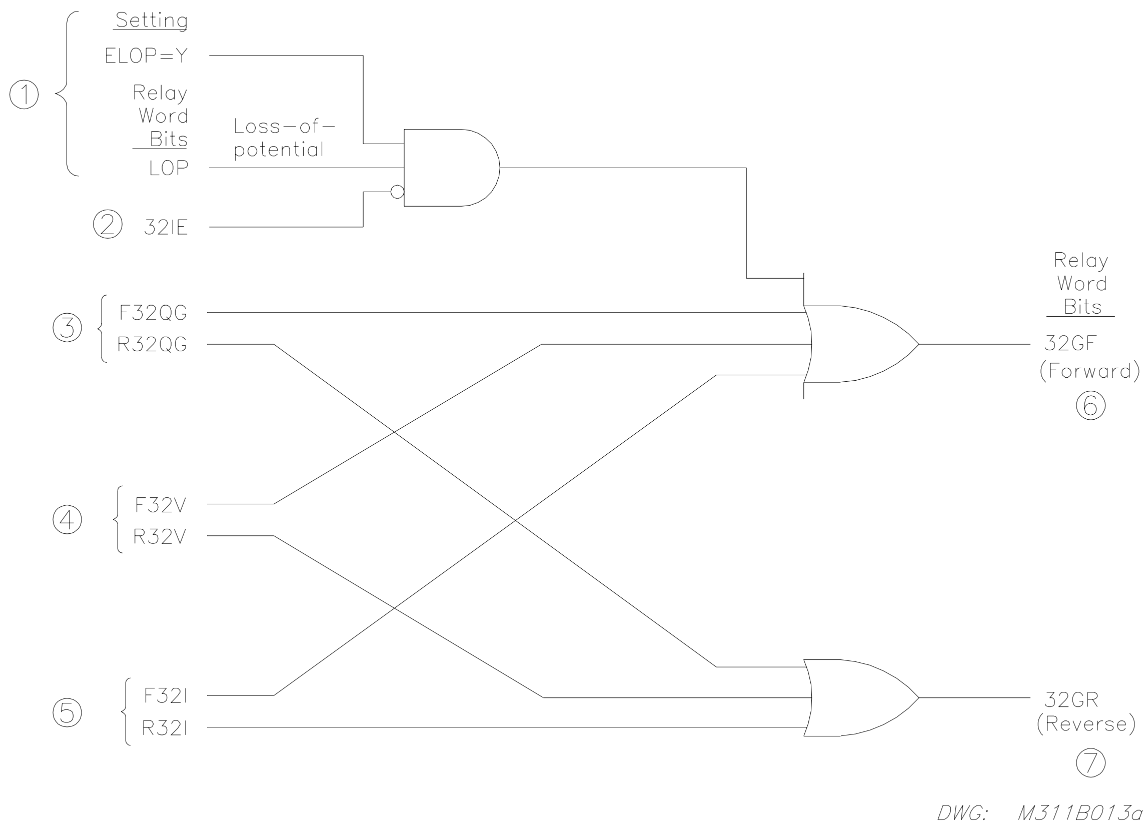
Figure 4.10: Zero-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements



① From Figure 4.7 ③ From Figure 4.8

② From Figure 4.1 ④ To Figure 4.12

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



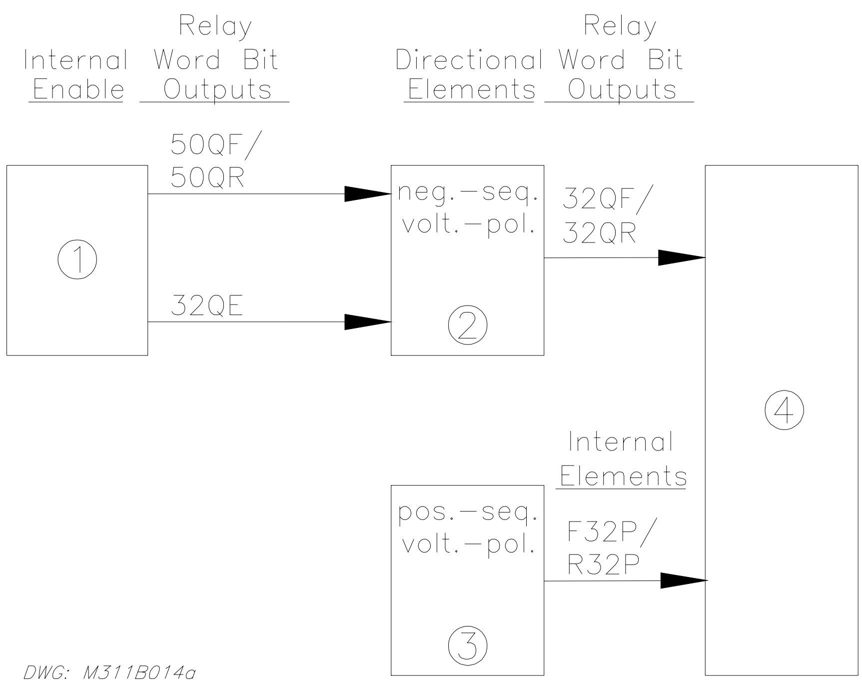
① From Figure 4.1
② From Figure 4.7
③ From Figure 4.9
④ From Figure 4.10
⑤ From Figure 4.11
⑥ To Figure 3.7 through Figure 3.9 and Figure 3.16
⑦ To Figure 3.9 and Figure 3.16

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.



① Figure 4.6 ③ Figure 4.15

② Figure 4.14 ④ Figure 3.4 through Figure 3.6 and Figure 3.17

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

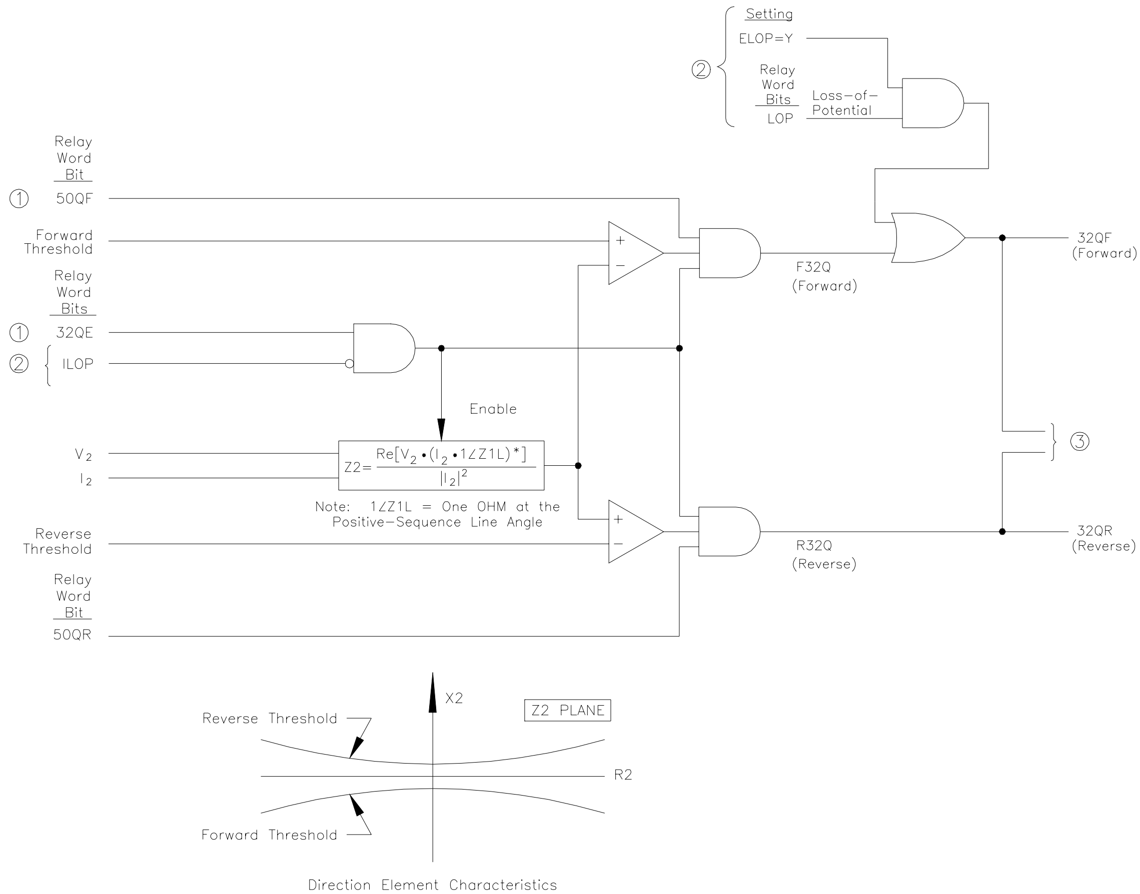
Note if both the following are true:

- 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 3.4 through Figure 3.9, ILOP also disables all distance elements.



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 $= 0.75 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

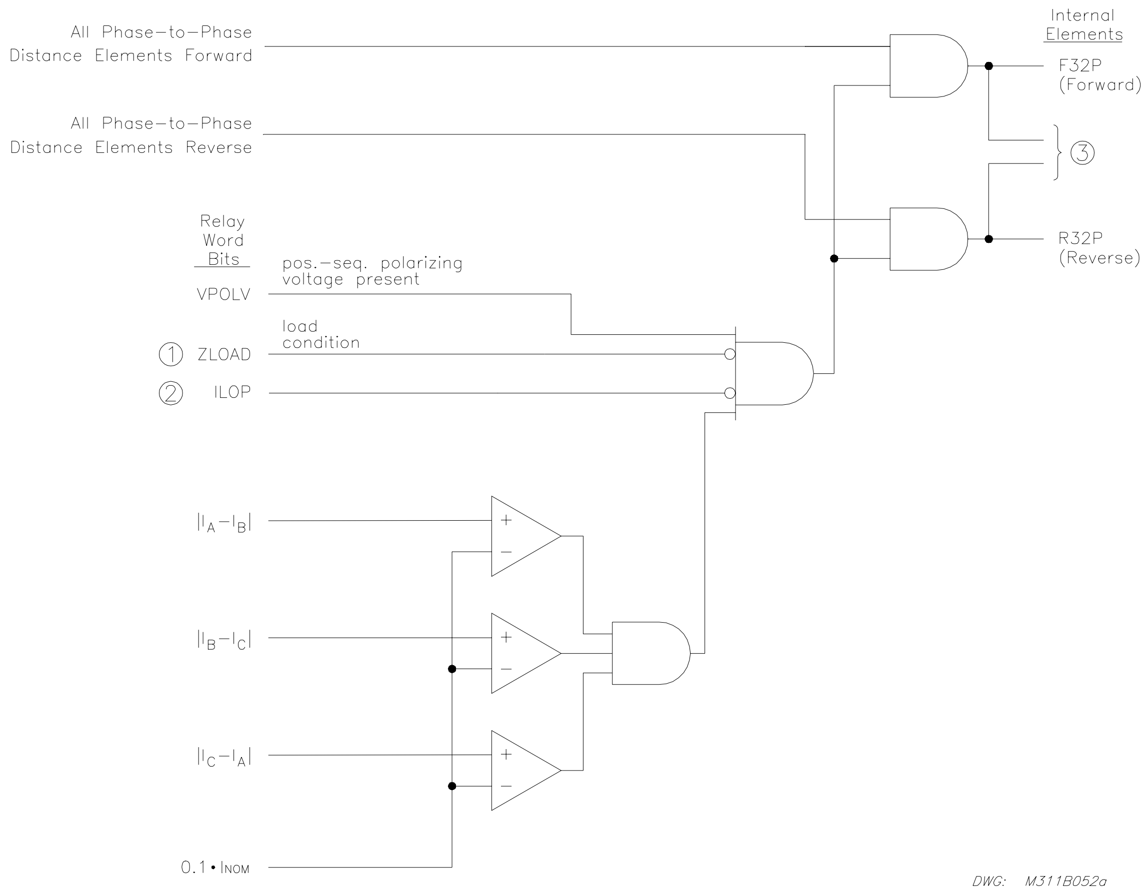
If Z2R Setting $<$ 0, Reverse Threshold $= 1.25 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

DWG: M311B015a

① From Figure 4.6 ③ To Figure 3.4 through Figure 3.6 and Figure 3.17

② From Figure 4.1

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



① From Figure 4.3 ③ To Figure 3.4 through Figure 3.6

② From Figure 4.1

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

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

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 (3.4) M1PT (3.11)	Z1G (3.7) Z1GT(3.11)	67G1 (3.15) 67G1T (3.15)	67Q1 (3.16) 67Q1T (3.16)
Forward	M2P (3.5) M2PT (3.11)	Z2G (3.8) Z2GT(3.11)	67G2 (3.15) 67G2T (3.15)	67Q2 (3.16) 67Q2T (3.16)
DIR3 = F or R	M3P (3.6) M3PT (3.11)	Z3G (3.9) Z3GT (3.11)	67G3 (3.15) 67G3T (3.15)	67Q3 (3.16) 67Q3T (3.16)

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

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).

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:

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

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-311B 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
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
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

TRIP LOGIC

The trip logic in Figure 5.1 provides flexible tripping with SELOGIC® control equation settings:

DTT Direct Transfer Trip Conditions.

Note in Figure 5.1 that setting DTT is unsupervised. Any element that asserts in setting DTT will cause Relay Word bit TRIP to assert to logical 1.

Although setting TR is also unsupervised, setting DTT is provided separately from setting TR for target LED purposes. (DT target LED on the front panel illuminates when DTT asserts to logical 1; see DT 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.

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 5-6 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 DTT or switch-onto-fault (setting TRSOTF) trip logic.

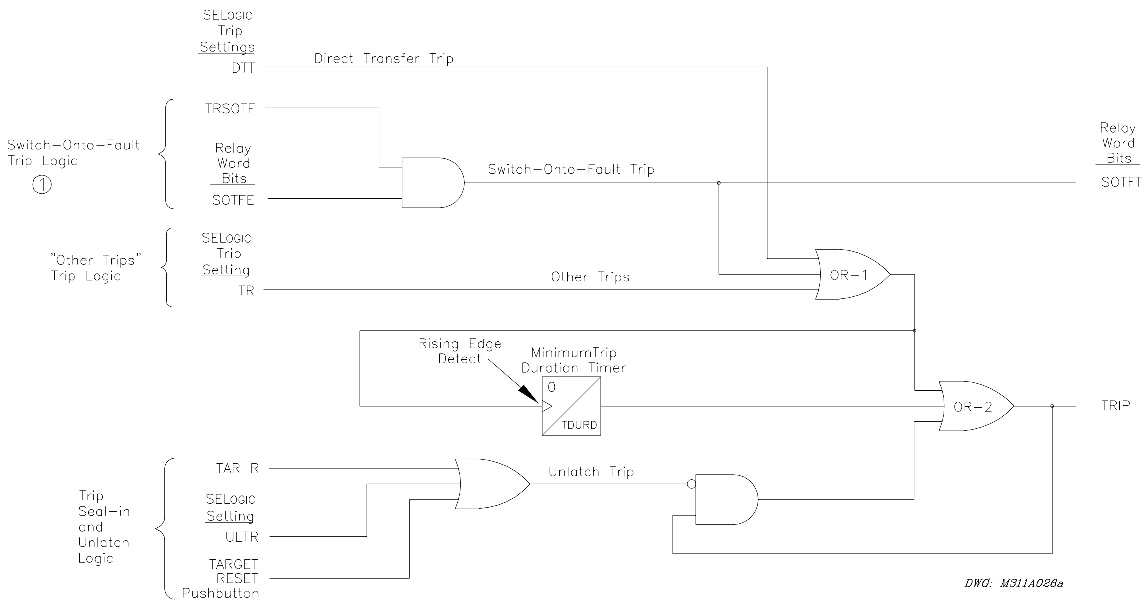
Note in Figure 5.1 that setting TR is unsupervised. Any element that asserts in setting TR will cause Relay Word bit TRIP to assert to logical 1.

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. See Figure 5.2.

More than one trip setting (or all three trip settings DTT, TRSOTF, and TR) can be set. For example, in a direct trip scheme, DTT is set with a direct trip contact input, 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.



① From Figure 5.3

Figure 5.1: Trip Logic

Set Trip

Refer to Figure 5.1. All trip conditions:

- Direct Transfer Trip
- Switch-Onto-Fault Trip
- Other Trips

are combined into OR-1 gate. The output of OR-1 gate asserts Relay Word bit TRIP to logical 1, regardless of other trip logic conditions. It also is routed into the Minimum Trip Duration Timer (setting TDURD).

As shown in the time line example in Figure 5.2, the Minimum Trip Duration Timer (with setting TDURD) outputs a logical 1 for a time duration of "TDURD" cycles any time it sees a rising edge on its input (logical 0 to logical 1 transition), if it is not already timing (timer is reset). The TDURD timer 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.

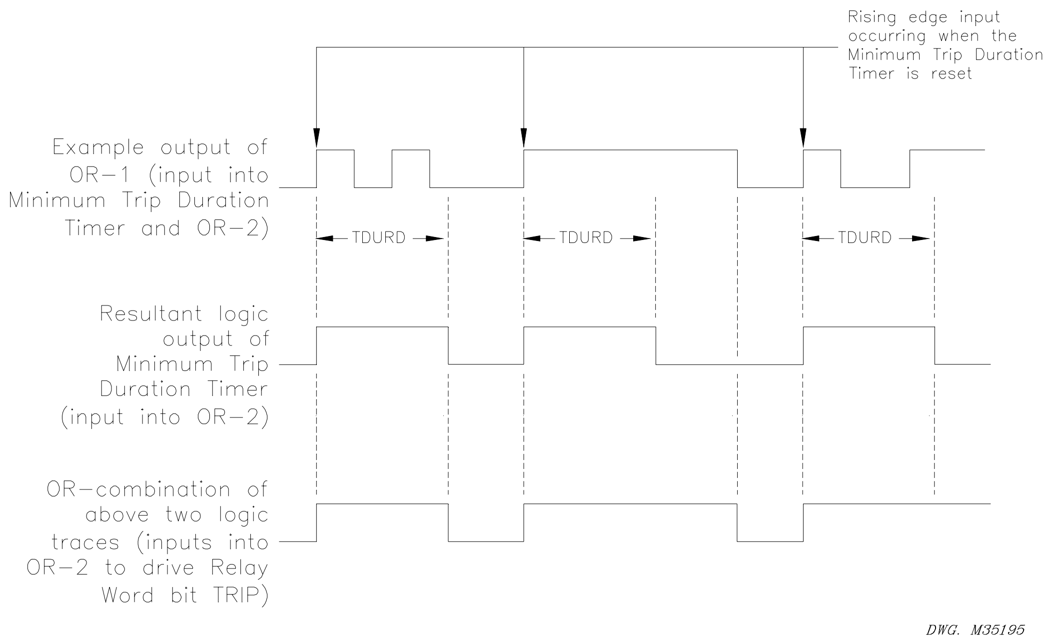


Figure 5.2: Minimum Trip Duration Timer Operation (See Bottom of Figure 5.1)

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: 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, Relay Word bit OC is entered in the SELOGIC control equation setting 79DTL (Drive-to-Lockout) in the factory settings. See the Note in the Lockout State discussion, following Table 6.1.

Unlatch Trip

Once Relay Word bit TRIP is asserted to logical 1, it remains asserted at logical 1 until all the following conditions come true:

- Minimum Trip Duration Timer stops timing (logic output of the TDURD timer goes to logical 0)
- Output of OR-1 gate in Figure 5.1 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 or the **TAR R** (Target Reset) serial port command is 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 instead.

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 5.4 and accompanying text for applications for Relay Word bit TRGTR.

Factory Settings Example (Using Setting TR)

In this example the DTT and "switch-onto-fault" trip logic at the top of Figure 5.1 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: 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 5.1 is routed to output contacts OUT101 and OUT102 with the following SELOGIC control equation settings:

OUT101 = TRIP

OUT102 = TRIP

If more than two TRIP output contacts are needed, program other output contacts with the TRIP Relay Word bit. Examples of uses for additional TRIP output contacts:

- 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.

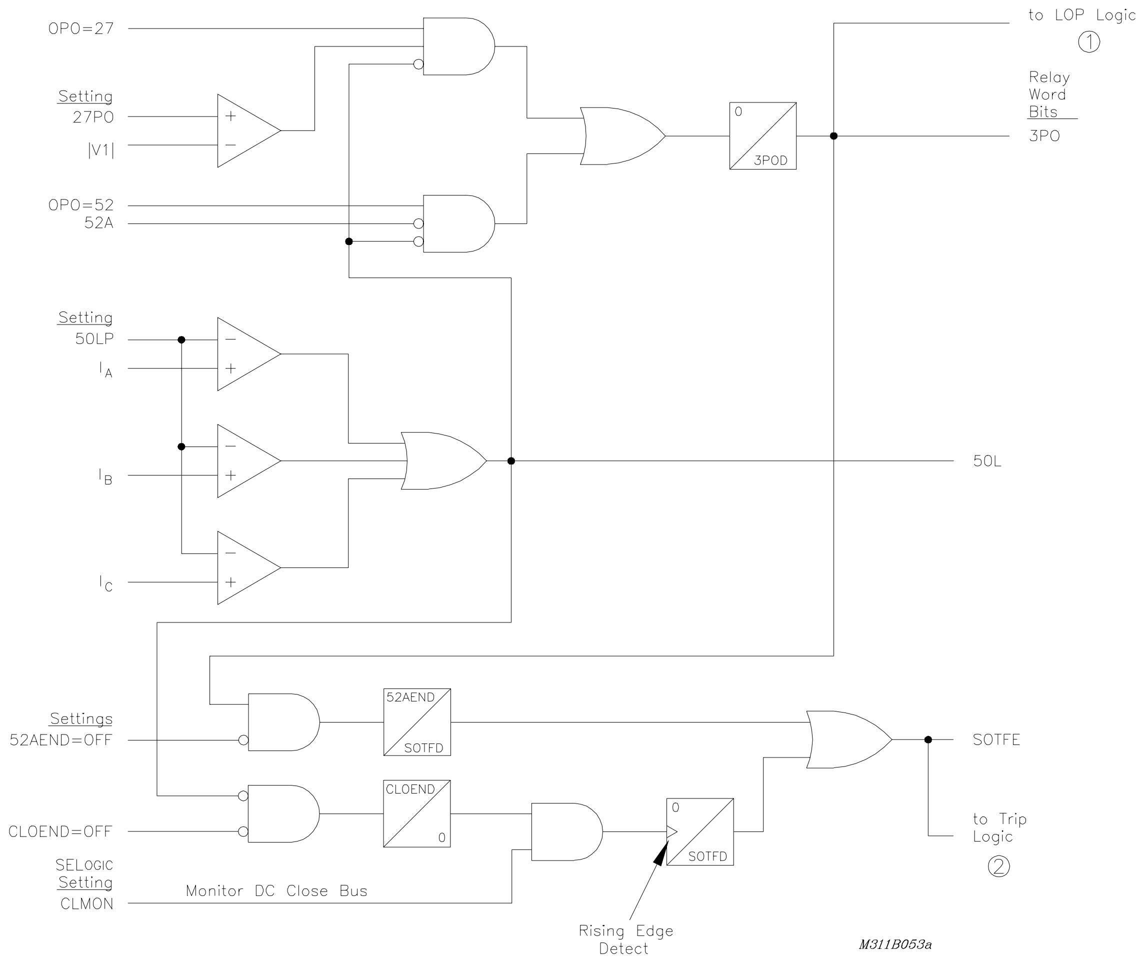
Switch-Onto-Fault (SOTF) Trip Logic

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. For example, suppose 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 5.1 (middle of figure). The SOTF trip logic permits tripping if both the following occur:

- An element asserts in SELOGIC control equation trip setting TRSOTF
- Relay Word bit SOTFE is asserted to logical 1

Relay Word bit SOTFE (the output of the SOTF logic) provides the effective time window for an element in trip setting TRSOTF (e.g., TRSOTF = 50P2) to trip after the circuit breaker closes. Figure 5.3 and the following discussion describe the three-pole open (3PO) logic and the SOTF logic.



① Figure 4.1 ② Figure 5.1

Figure 5.3: Three-Pole Open Logic (Top) and Switch-Onto-Fault Logic (Bottom)

Three-Pole Open Logic

Three-pole open (3PO) logic is the top half of Figure 5.3. It is not affected by enable setting ESOTF (see Settings Sheet 2 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)
- Positive-sequence voltage (|V1| < 27PO)

Select OPO = 52 if 3PO is determined by circuit breaker status. Select OPO = 27 if 3PO is determined by positive-sequence voltage.

If OPO = 52, <u>and</u> the circuit breaker is open (52A = logical 0) <u>and</u> 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)

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-311B 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)

Circuit Breaker Operated Switch-Onto-Fault Logic

Circuit breaker operated switch-onto-fault logic is enabled by making time setting 52AEND (52AEND ≠ OFF). Time setting 52AEND qualifies the three-pole open (3PO) condition and then asserts Relay Word bit SOTFE:

SOTFE = logical 1

Note that SOTFE is asserted when the circuit breaker is open. This allows elements set in the SELOGIC control equation trip setting TRSOTF to operate if a fault occurs when the circuit breaker is open (see Figure 5.1). In such a scenario (e.g., flashover inside the circuit breaker tank), the tripping via setting TRSOTF cannot help in tripping the circuit breaker (the circuit breaker is already open), but can initiate breaker failure protection, if a breaker failure scheme is implemented in the SEL-311B Relay or externally (see example in Figure 7.25).

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-311B 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 5.1—middle of figure). Time setting SOTFD is usually set around 30 cycles.

A SOTF trip illuminates the SOTF front-panel LED.

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.

Front-Panel Target LEDs

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

LED Number	LED Label	Definition
1	EN	Relay Enabled—see subsection ***Relay Self-Tests*** in ***Section 13: Testing and Troubleshooting***
2	TRIP	Indication that a trip occurred, by a protection or control element
3	TIME	Time delayed trip
4	DT	Direct trip
5	SOTF	Switch-onto-fault trip
6	RS	Recloser reset
7	CY	Recloser cycling
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 distance or residual ground element picked up at time of trip
13	1	Zone/Level 1 element picked up at time of trip
14	2	Zone/Level 2 element picked up at time of trip
15	3	Zone/Level 3 element picked up at time of trip
16	51	Time overcurrent element trip

Target LEDs numbered 2 through 5 and 9 through 16 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 trip logic (see Figure 5.1).

Further target LED information follows. Refer also to Figure 2.2 and Figure 2.3 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 trip (the new assertion of the TRIP Relay Word bit).

The TRIP target LED is especially helpful in providing front-panel indication for tripping that does not involve protection elements. If the trip is not a protection element generated trip, none of the target LEDs illuminate (3 through 5 and 9 through 16), 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.

DT Target LED

The DT target LED illuminates at the rising edge of trip if the trip is the result of SELOGIC control equation setting DTT (see Figure 5.1).

Use the DT 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 5.1).

For example, if the OPEN command or remote bit RB1 (see ***CON Command*** in ***Section 10: Serial Port Communications and Commands***) are used to trip via the serial port and they should illuminate the DT 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 DT 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 DT target LED to illuminate.

Many other variations of the above DTT settings examples are possible.

SOTF Target LED

The SOTF target LED illuminates at the rising edge of the TRIP Relay Word bit if the trip is the result of the SELOGIC control equation setting TRSOTF and associated switch-onto-fault trip logic (see Figure 5.3).

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.

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 a ground distance or residual ground overcurrent element causes the trip or was picked up and timing to trip.

Zone LED

Zone/Level LEDs illuminate for the lowest zone number detected during the fault (M1P, M2P, M3P, Z1G, Z2G, Z3G, 50P1, 67P1, 67P2, 67P3, 67G1, 67G2, 67G3, 67Q1, 67Q2, 67Q3).

51 Target LED

The 51 target LED illuminates at the rising edge of trip if a time-overcurrent element (51PT, 51GT, or 51QT) causes the trip.

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 5 and 9 through 16 in Table 5.1) are extinguished (unlatched).

Other Applications for the Target Reset Function

Refer to the bottom of Figure 5.1. 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)

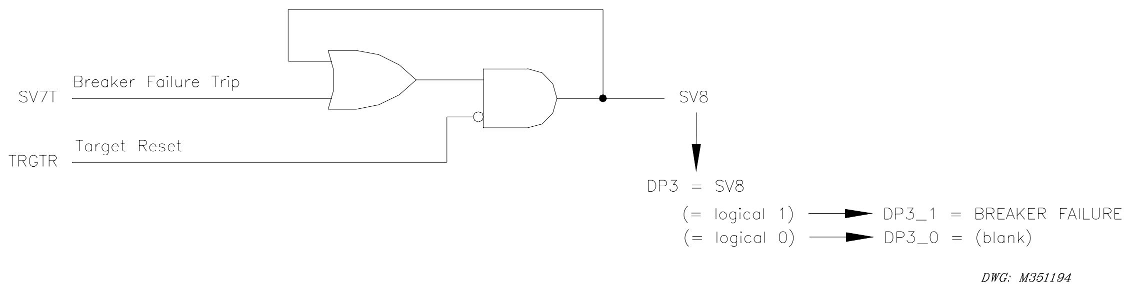


Figure 5.4: Seal-in of Breaker Failure Occurrence for Message Display

If a breaker failure trip has occurred, the momentary assertion of SV7T (breaker failure trip) will cause SV8 in Figure 5.4 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.

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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-311B 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. 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

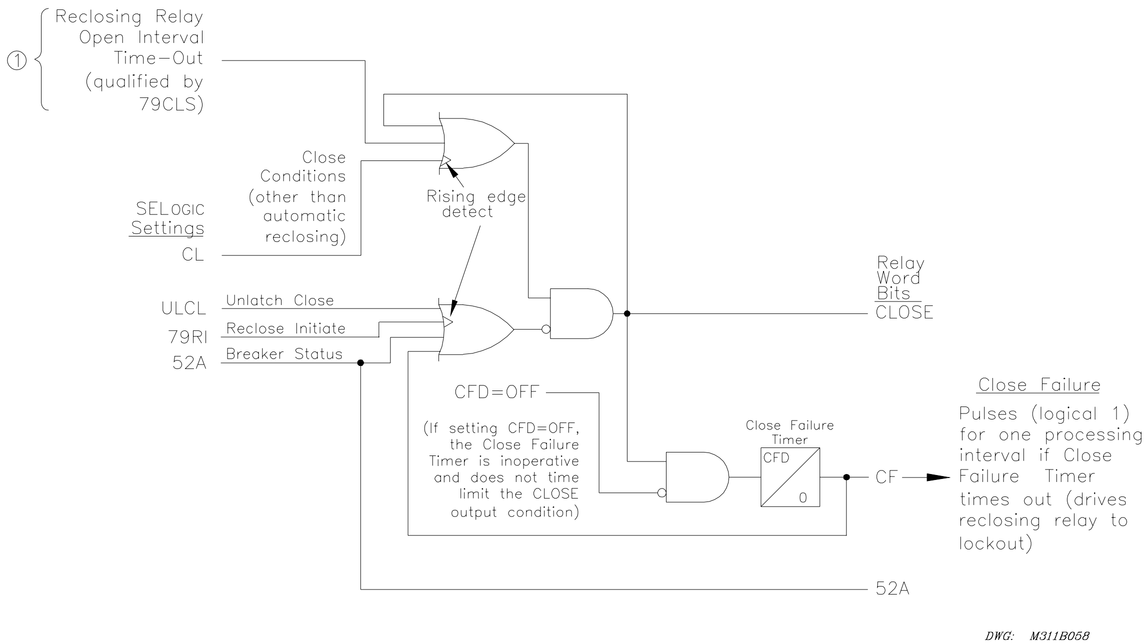
The close logic in Figure 6.1 provides flexible circuit breaker closing/automatic reclosing with SELOGIC control equation settings:

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.



① From Figure 6.2

Figure 6.1: Close Logic

Set Close

If <u>all</u> 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 included in the close logic in the factory settings:

CL = … + CC

Relay Word bit CC asserts for execution of the CLOSE Command. See ***CLO Command (Close Breaker)*** in ***Section 10: 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 setting is made:

CL = … + CC * IN106

With this setting, the CLOSE command can provide a close only if optoisolated input IN106 is asserted. This is just one CLOSE command supervision example—many variations are possible.

Unlatch Close

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

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

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: Serial Port Communications and Commands*** for more information on the CLOSE Command.

Unlatch Close

SELOGIC control equation setting ULCL is usually set with the TRIP Relay Word bit. This prevents the CLOSE Relay Word bit from being asserted any time the TRIP Relay Word bit is asserted (TRIP takes priority). See ***Trip Logic*** 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.

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. Also, the reclosing relay is defeated (see ***Reclosing Relay*** later in this section).

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

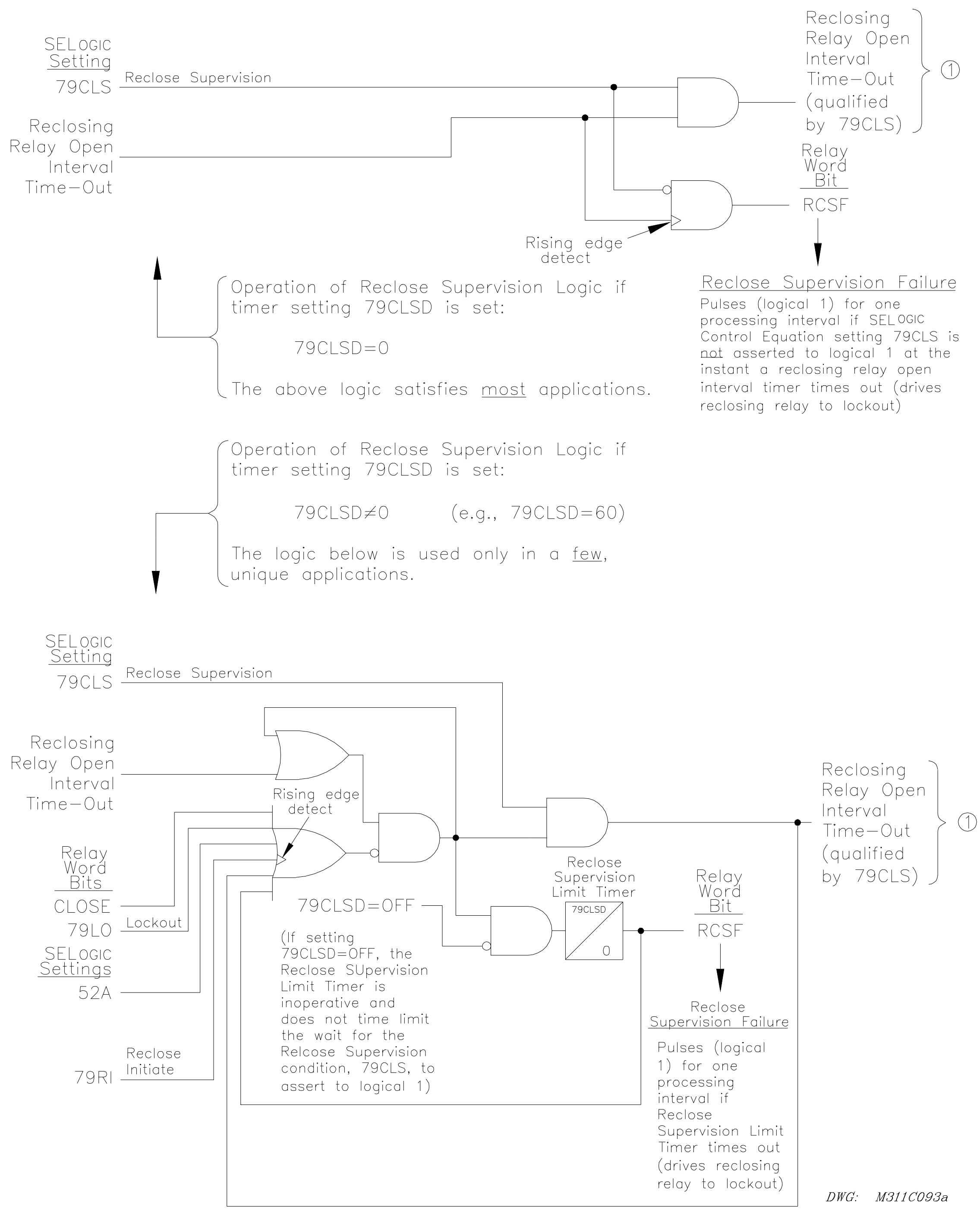
See ***Output Contacts*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** for more information on programming output contacts.

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.



① To Figure 6.1

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

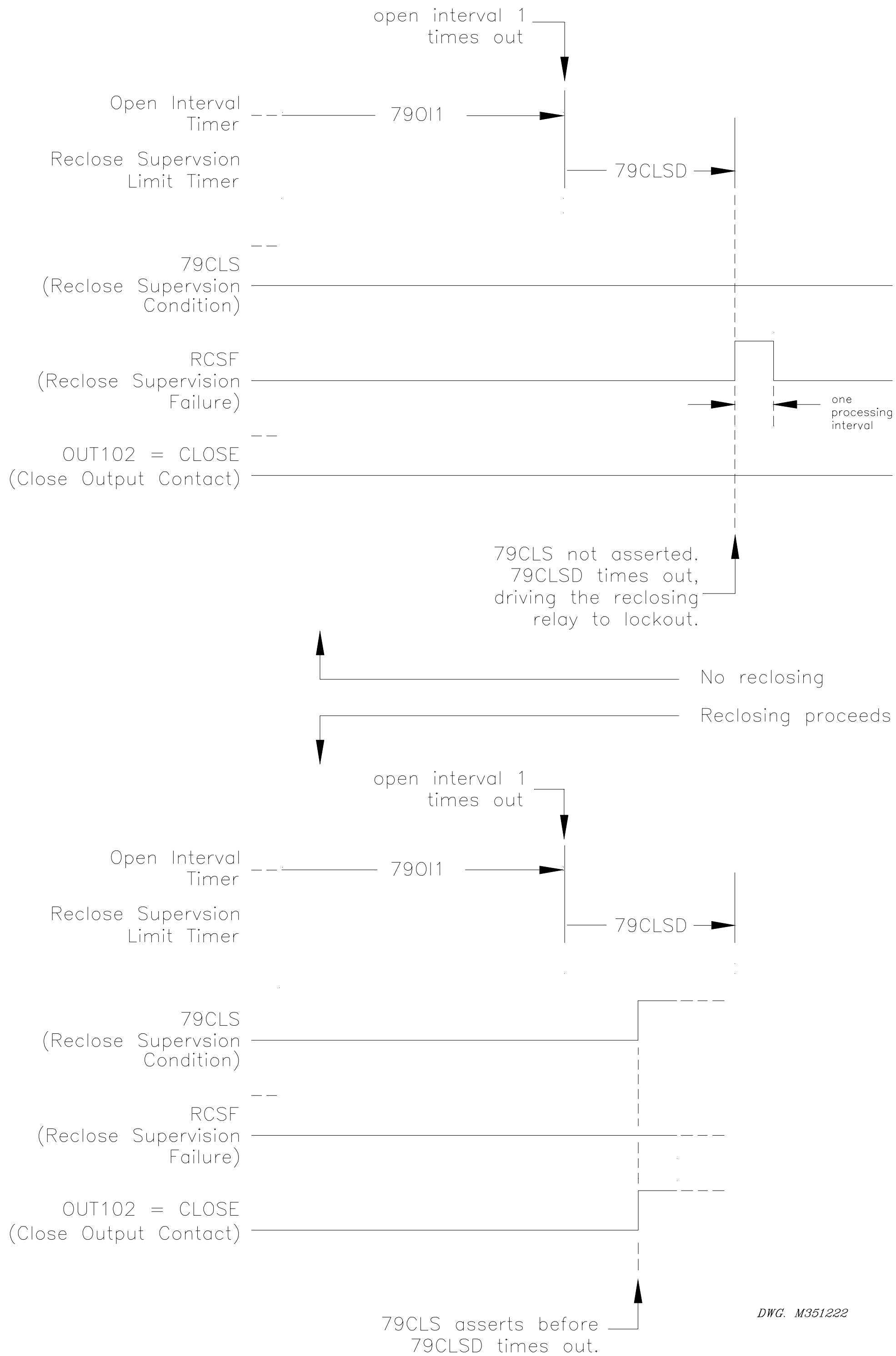


Figure 6.3: Reclose Supervision Limit Timer Operation (Refer to Bottom of Figure 6.2)

Settings and General Operation

Figure 6.2 contains the following SELOGIC control equation setting:

79CLS (reclose supervision conditions—checked after reclosing relay open interval time-out)

and setting:

79CLSD (Reclose Supervision Limit Time)

See the settings sheets at the end of ***Section 9: 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 <u>checked just once</u>.

If 79CLS is <u>asserted</u> 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 <u>deasserted</u> 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, the Reclose Supervision Limit Time setting is <u>not</u> 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 <u>checked for a time window</u> equal to setting 79CLSD.

If 79CLS <u>asserts</u> 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-311B 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-311B(1) Relay recloses circuit breaker 52/1 first, followed by the SEL-311B(2) Relay reclosing circuit breaker 52/2, after a synchronism check across circuit breaker 52/2.

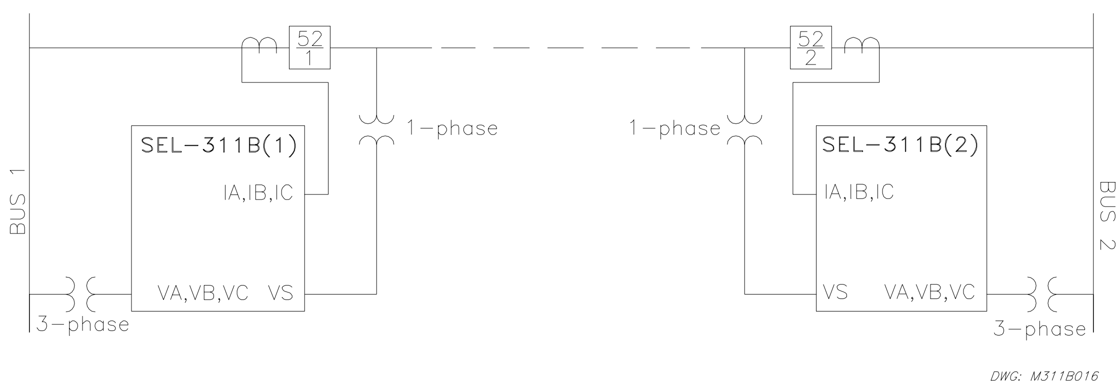


Figure 6.4: SEL-311B Relays Installed at Both Ends of a Transmission Line in a High-Speed Reclose Scheme

SEL-311B(1) Relay

Before allowing circuit breaker 52/1 to be reclosed after an open interval time-out, the SEL-311B(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-311B(2) Relay

The SEL-311B(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-311B(1) and SEL-311B(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-311B(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-311B(2) Relay starts open interval timing after circuit breaker 52/1 at the remote end has reenergized the line. The SEL-311B(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-311B(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-311B(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-311B(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-311B(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 3.24.

Additional Settings Example 2

Refer to subsection ***Synchronism Check Elements*** in ***Section 3: Distance, Overcurrent, Voltage, and Synchronism Check 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.

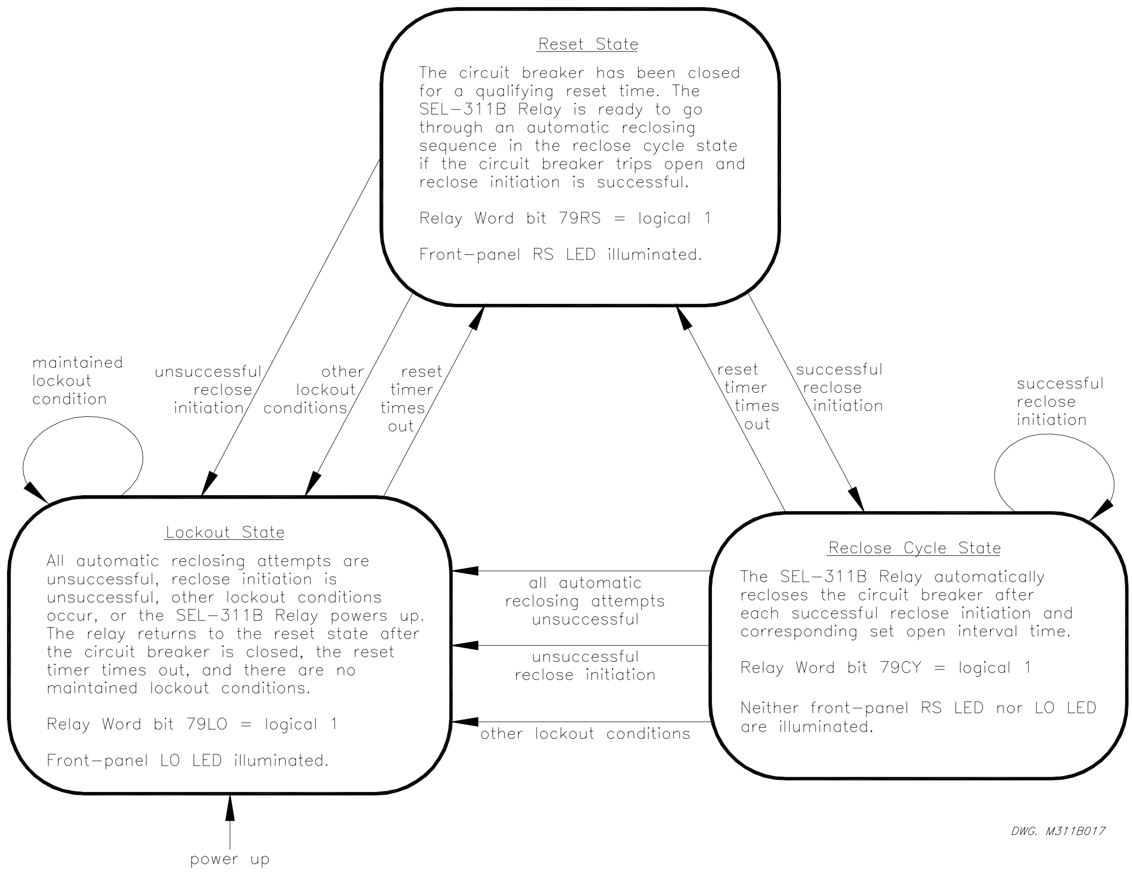


Figure 6.5: Reclosing Relay States and General Operation

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
Cycle	79RCY	CY
Lockout	79LO	LO

The reclosing relay is in one (and only one) of these states (listed in Table 6.1) at any time. When in reset or lockout, the corresponding Relay Word bit asserts to logical 1, and the LED illuminates. Automatic reclosing only takes place when the relay is in the Reclose Cycle State.

Lockout State

The reclosing relay goes to the Lockout State if any one of the following occurs:

- The shot counter is equal to or greater than the last shot at the time of reclose initiation (e.g., all automatic reclosing attempts are unsuccessful—see Figure 6.6).
- Reclose initiation is unsuccessful because of SELOGIC control equation setting 79RIS (see ***Reclose Initiate and Reclose Initiate Supervision Settings [79RI and 79RIS, Respectively]*** 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 is 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: 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 (reclose initiate)

79DTL = … + OC (drive-to-lockout)

Reclosing Relay States After a Settings or Setting Group Change

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

- The reclosing relay remains in the state it was in before the settings change.
- The shot counter is driven to last shot (last shot corresponding to the new settings; see discussion on last shot that follows).
- The reset timer is loaded with reset time setting 79RSLD (see 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, CY, and LO are all 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.

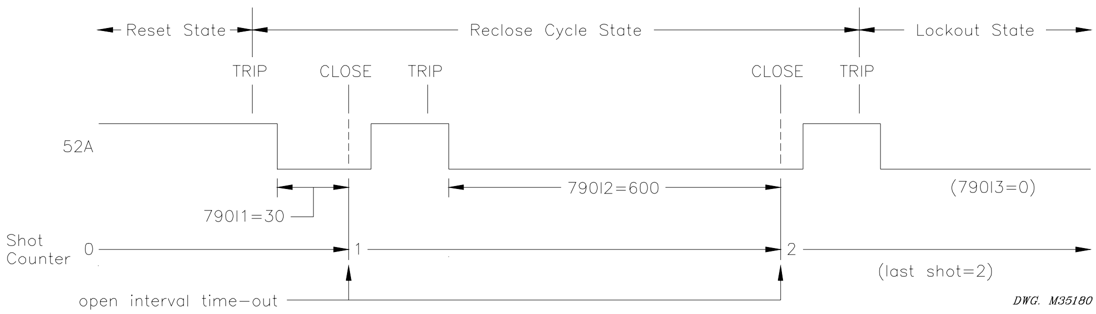


Figure 6.6: Reclosing Sequence From Reset to Lockout with Example Settings

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).

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	Reclose Initiate
79RIS	52A + 79CY	Reclose Initiate Supervision
79DTL	!IN102 + LB3	Drive-to-Lockout
79DLS	79LO	Drive-to-Last Shot
79SKP	0	Skip Shot
79STL	TRIP	Stall Open Interval Timing
79BRS	0	Block Reset Timing
79SEQ	0	Sequence Coordination
79CLS	1	Reclose Supervision

These example settings are discussed in detail in the remainder of this 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

79RIS = 52A + 79CY

the transition of the TRIP 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-311B to successfully initiate reclosing and start timing on the first open interval. The SEL-311B 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-311B is in the reclose cycle state (79CY = logical 1) and the SEL-311B 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-311B sees the circuit breaker close.

If a flashover occurs in a circuit breaker tank during an open interval (circuit breaker open and the SEL-311B calls for a trip), the SEL-311B goes immediately to lockout.

Additional Settings Example

The preceding settings example initiates open interval timing on rising edge of the TRIP Relay Word bit. The following is an example of reclose initiation on the opening of the circuit breaker.

Presume input IN101 is connected to a 52a circuit breaker auxiliary contact (52A = IN101).

With setting:

79RI = !52A

the transition of the 52A Relay Word bit from logical 1 to logical 0 (breaker opening) 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

the transition of the 52A Relay Word bit from logical 1 to logical 0 initiates open interval timing only if the TRIP Relay Word bit is at logical 1 (TRIP = logical 1). Thus, the TRIP Relay Word bit has to be asserted when the circuit breaker opens in order to initiate open interval timing. With a long enough setting of the Minimum Trip Duration Timer (TDURD), the TRIP Relay Word bit will still be asserted to logical 1 when the circuit breaker opens (see Figure 5.1 and Figure 5.2 in ***Section 5: Trip and Target Logic***).

If the TRIP Relay Word bit is at logical 0 (TRIP = 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-311B 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 <u>not</u> 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 <u>not</u> 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 + ...

Additional Settings Example 2

To drive the relay to the Lockout State for fault current above a certain level when tripping (e.g., level of phase instantaneous overcurrent element 50P3), make settings similar to the following:

79DTL = TRIP * 50P3 + ...

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

After successful reclose initiation, open interval timing does not start as long as the trip condition is present (Relay Word bit TRIP = logical 1). As discussed previously, if an open interval time has not yet started timing (79STL = logical 1 still), the 79SKP setting is still processed. Once the trip condition goes away (Relay Word bit TRIP = logical 0), open interval timing can proceed.

Additional Settings Example 1

With skip shot setting:

79SKP = 50P2 * SH0

if shot = 0 (Relay Word bit SH0 = logical 1) and phase current is above the phase instantaneous overcurrent element 50P2 threshold (Relay Word bit 50P2 = logical 1), at the instant of successful reclose initiation, the shot counter is incremented from shot = 0 to shot = 1. Then, open interval 1 time (setting 79OI1) is skipped, and the relay times on the open interval 2 time (setting 79OI2) instead.

Table 6.5: Open Interval Time 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

If the SEL-311B Relay is used on a line serving an independent power producer (cogenerator), the utility should not reclose into a line still energized by an islanded generator. To monitor line voltage and block reclosing, connect a line-side single-phase potential transformer to channel VS on the SEL-311B Relay as shown in Figure 6.7.

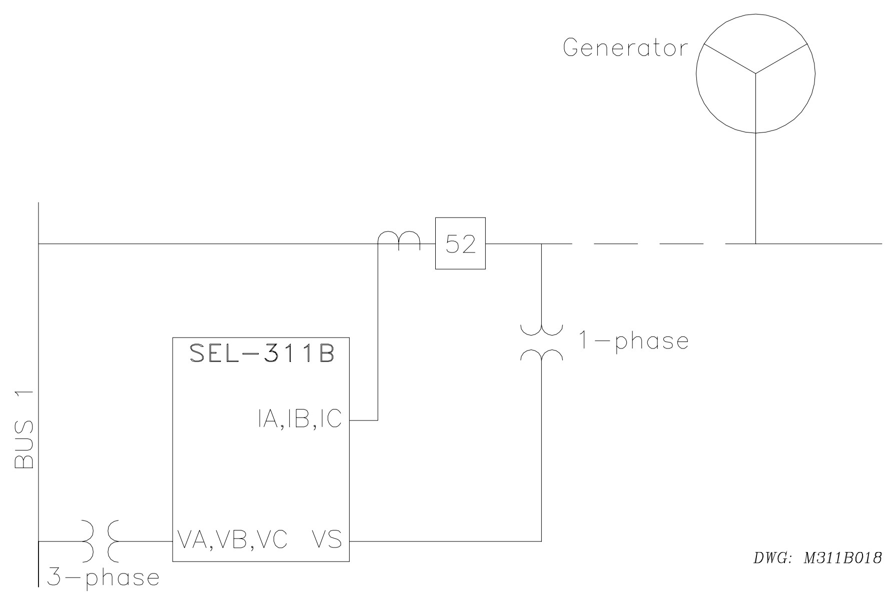


Figure 6.7: Reclose Blocking for Islanded Generator

If the line is energized, channel VS overvoltage element 59S1 can be set to assert. Make the following setting:

79STL = 59S1 + ...

If line voltage is present, Relay Word bit 59S1 asserts, stalling open interval timing (reclose block). If line voltage is not present, Relay Word bit 59S1 deasserts, allowing open interval timing to proceed (unless some other set condition stalls open interval timing).

Additional Settings Example 3

Refer to Figure 6.4 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 79SEQ setting is applicable to distribution applications, for transmission system applications set 79SEQ = 0. See the SEL-351 Instruction Manual for a description of setting 79SEQ.

TABLE OF CONTENTS

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
Rotating default displays	display points DP1–DP16

The above items are relay logic inputs and outputs. They are combined with the 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: 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 resultant Relay Word bits that follow corresponding optoisolated inputs for the SEL-311B 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 Figures 1.2, 2.2, and 2.3).

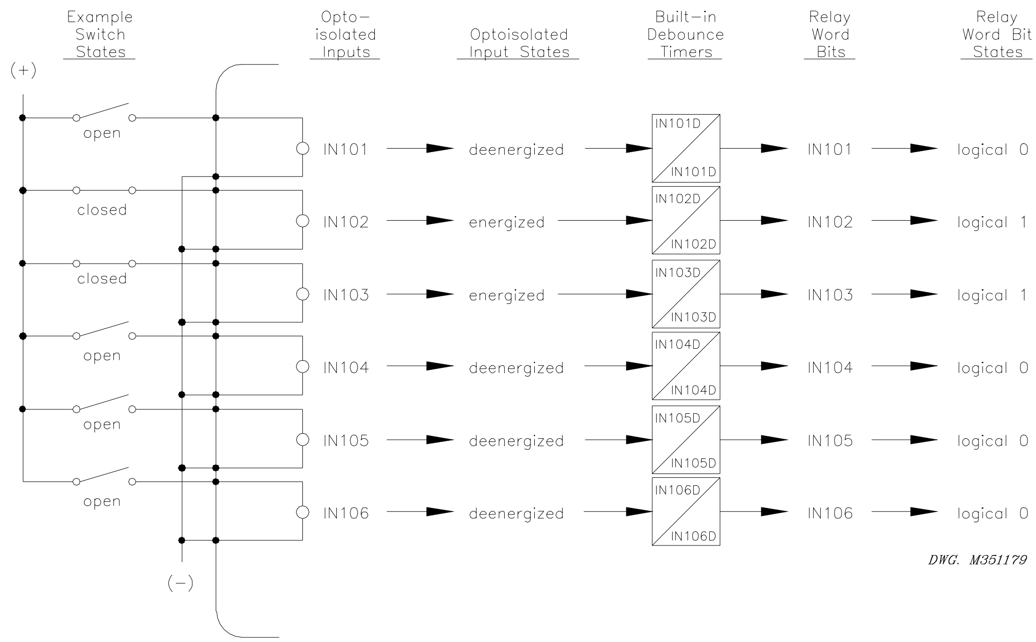


Figure 7.1: Example Operation of Optoisolated Inputs IN101 Through IN106

Input Debounce Timers

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 2.00 cycles. The relay takes the entered time setting and internally runs the timer at the nearest 1/8-cycle. For example, if setting IN105D = 0.80, internally the timer runs at the nearest 1/8-cycle: 13/16-cycles (6/8 = 0.75).

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

The relay processing interval is 1/4-cycle, so Relay Word bits IN101 through IN106 are updated every 1/4-cycle. The optoisolated input status may assert input debounce timer settings less than 1/4-cycle, because these timers run each 1/8-cycle. However, Relay Word bits IN101 through IN106 may not be available until the next 1/4-cycle relay processing interval.

If more than 21 cycles of debounce are needed, run Relay Word bit IN*n* (*n* = 101 through 106) through a SELOGIC control equation variable timer and use the output of the timer for input functions (see Figure 7.23 and Figure 7.24).

Input Functions

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

IN101 =
IN102 =

Optoisolated inputs IN101 through IN106 receive their function by how their corresponding Relay Word bits IN101 through IN106 are used in SELOGIC control equations.

Settings Example 1

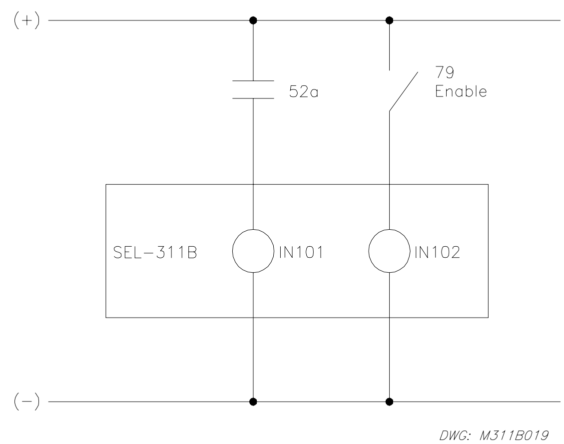


Figure 7.2: Circuit Breaker Auxiliary Contact and Reclose Enable Switch Connected to Optoisolated Inputs IN101 and IN102

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.

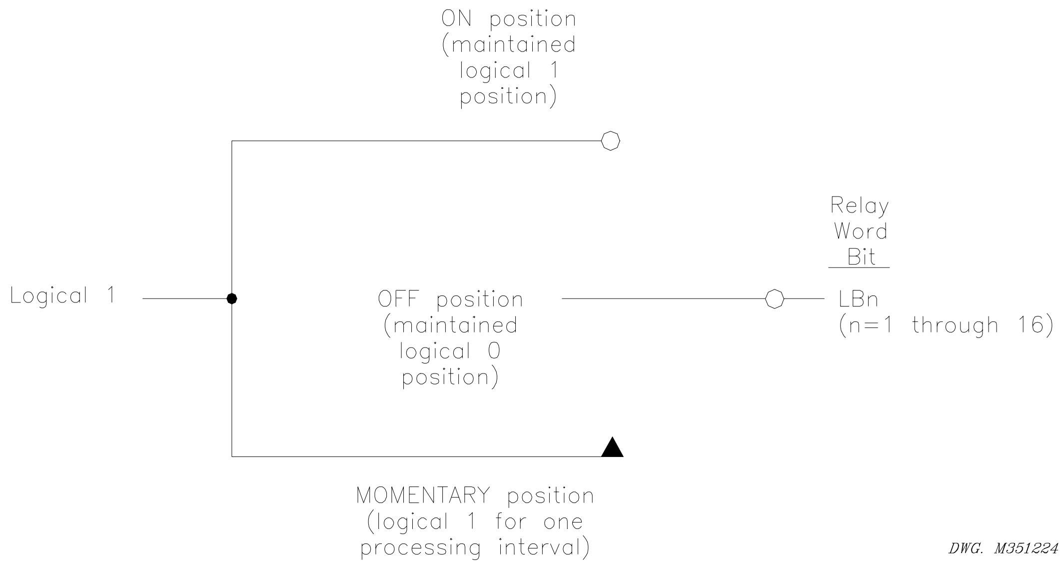
The pickup/dropout timer for input IN102 (IN102D) in this example might be set at:

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***).



The switch representation in this figure is derived from the standard:

Graphics Symbols for Electrical and Electronics Diagrams
IEEE Std 315–1975, CSA Z99–1975, ANSI Y32.2–1975,
4.11 Combination Locking and Nonlocking Switch, Item 4.11.1

Figure 7.3: 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.

Note: On SEL-311B Relays without an LCD, the Relay Word bits LB1–LB16 are always = logical 0. (Local bit control is not possible because there are no front-panel buttons or display on the relay.)

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 LBn	logical 1
OFF	CLB*n*	"Clear" Local bit LBn	logical 0
MOMENTARY	PLB*n*	"Pulse" Local bit LBn	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: 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.

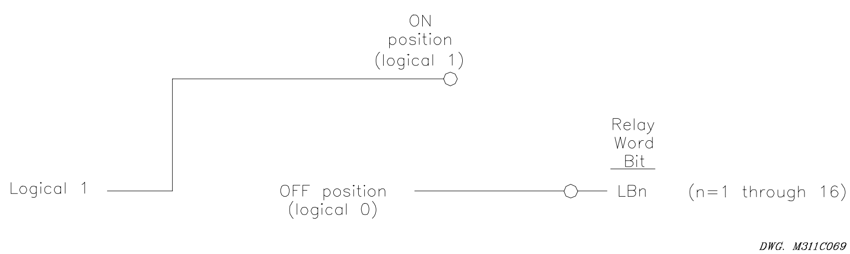


Figure 7.4: Local Control Switch Configured as an ON/OFF Switch

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).

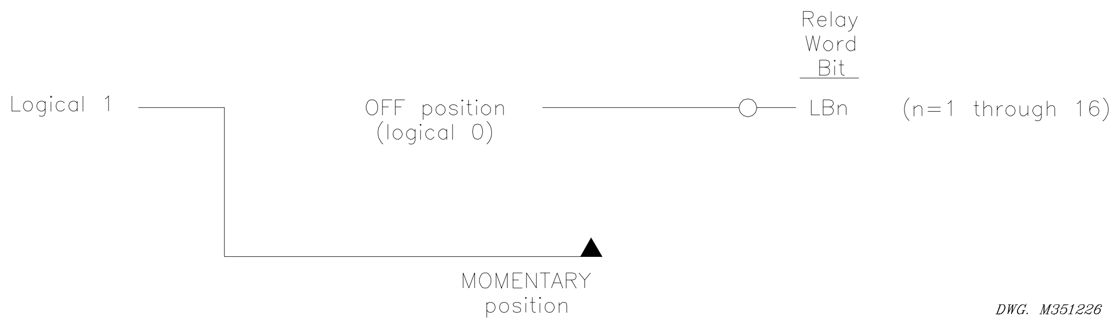


Figure 7.5: Local Control Switch Configured as an OFF/MOMENTARY Switch

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).

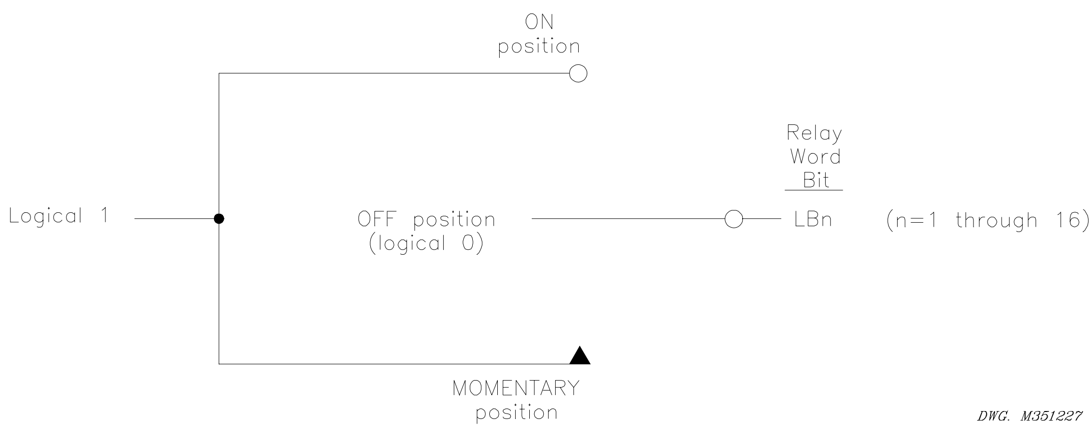


Figure 7.6: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

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

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

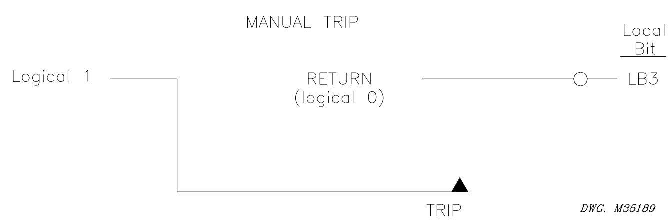


Figure 7.7: Configured Manual Trip Switch Drives Local Bit LB3

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

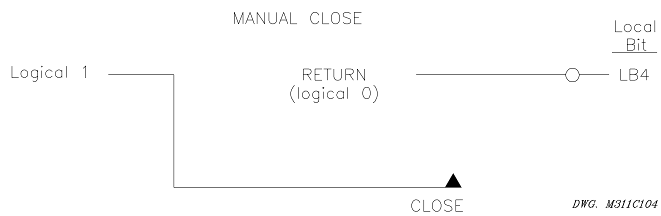


Figure 7.8: Configured Manual Close Switch Drives Local Bit LB4

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: Serial Port Communications and Commands***).

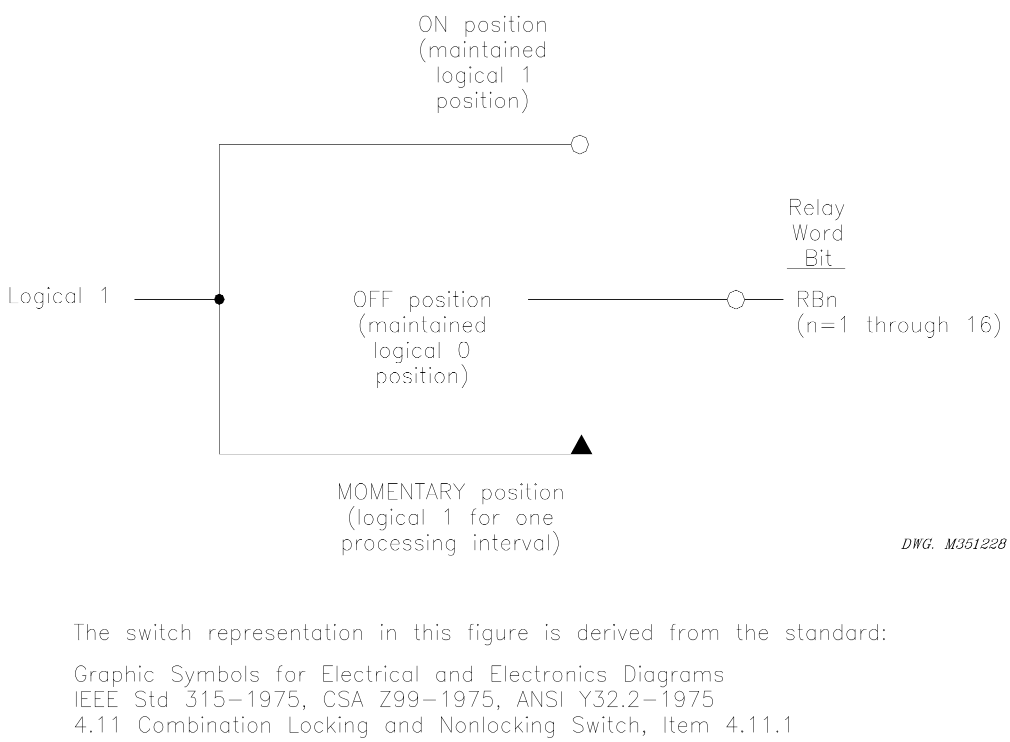


Figure 7.9: Remote Control Switches Drive Remote Bits RB1 Through RB16

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 switches are enabled using the ELAT setting. Set ELAT to the number of latch control switches that are desired (N, 1–16).

The latch control switch feature of this relay replaces latching relays. Traditional latching relays maintain their output contact state when set. The SEL-311B 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).

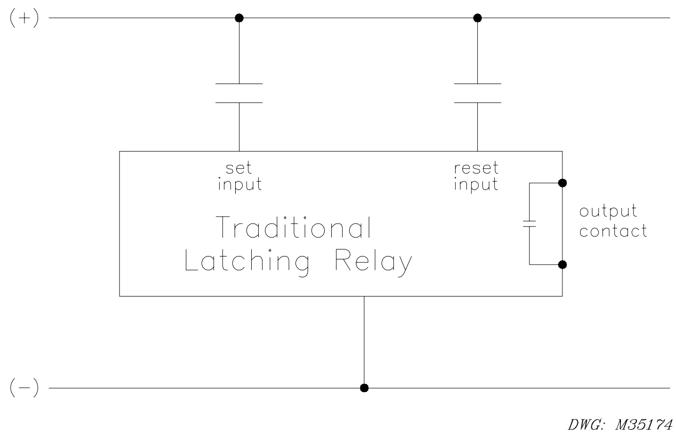


Figure 7.10: Traditional Latching Relay

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

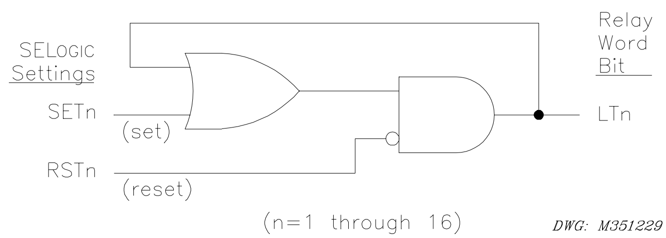


Figure 7.11: Latch Control Switches Drive Latch Bits LT1 Through LT16

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-311B Relay.

Reclosing Relay Enable/Disable Setting Example

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

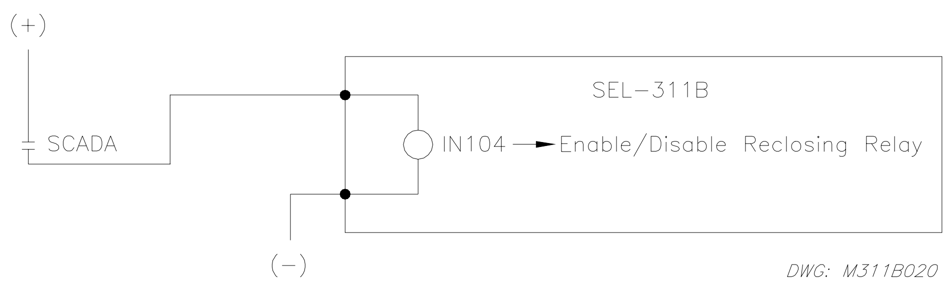


Figure 7.12: SCADA Contact Pulses Input IN104 to Enable/Disable Reclosing Relay

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]

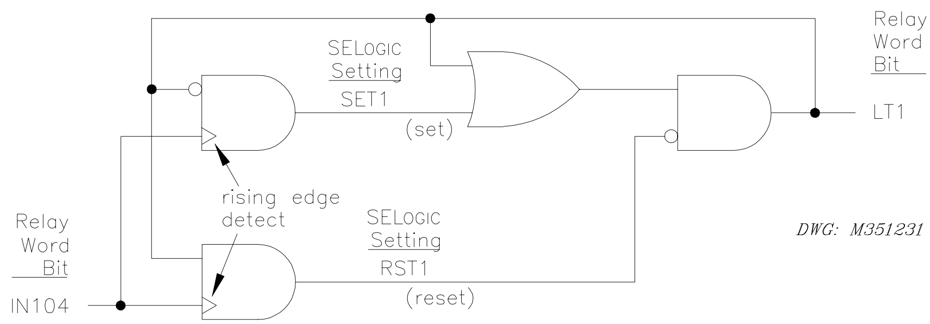


Figure 7.13: Latch Control Switch Controlled by a Single Input to Enable/Disable Reclosing

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.

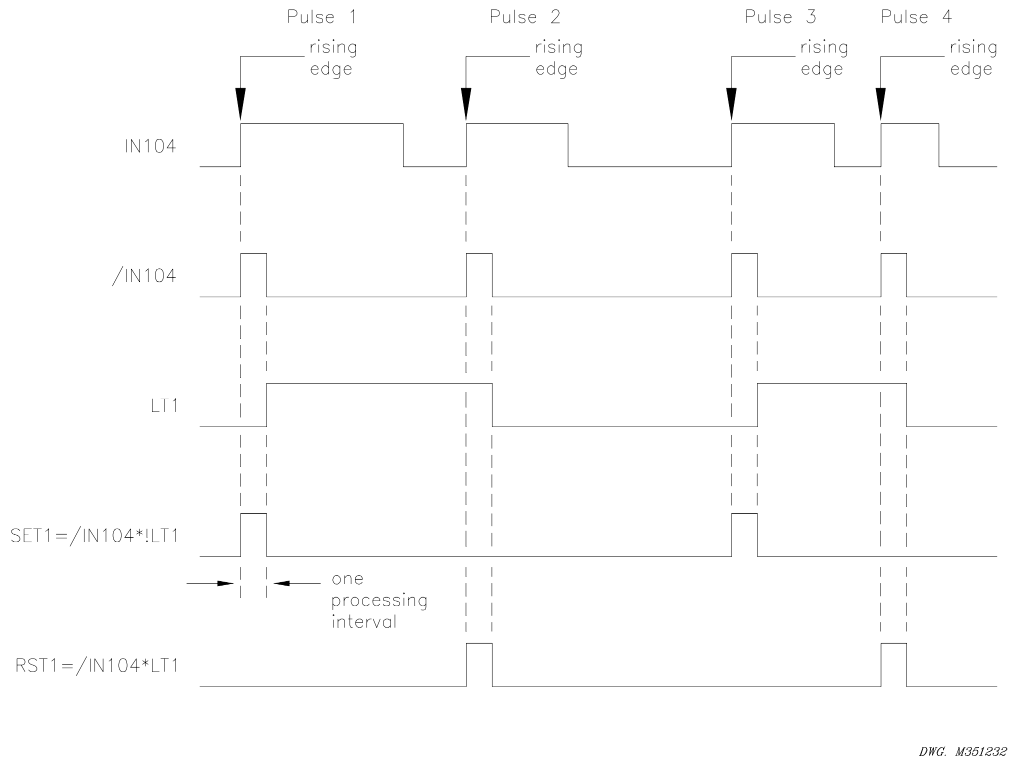


Figure 7.14: Latch Control Switch Operation Time Line

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: 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) + ...]

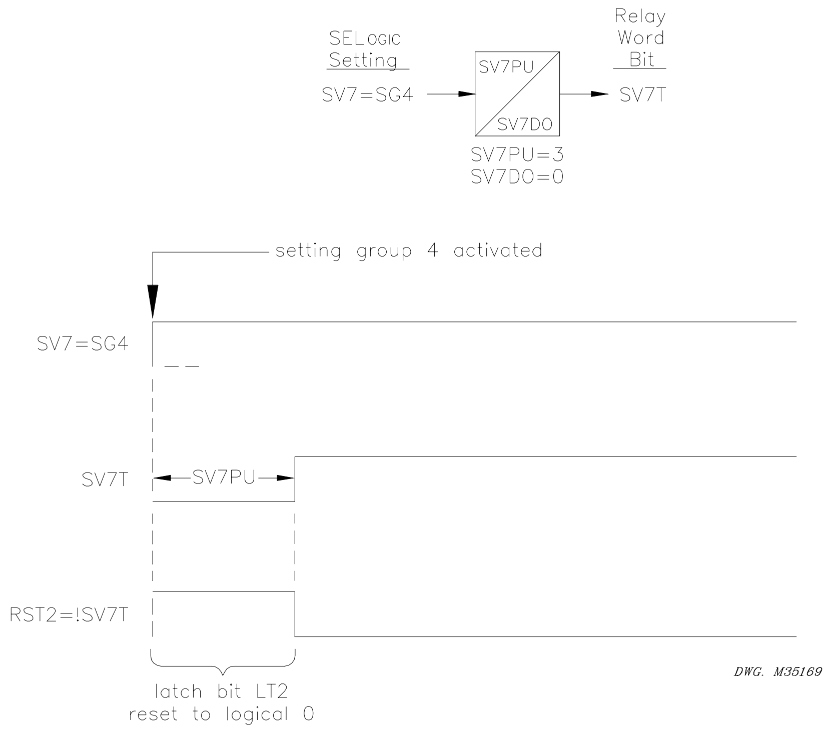


Figure 7.15: Time Line for Reset of Latch Bit LT2 After Active Setting Group Change

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).

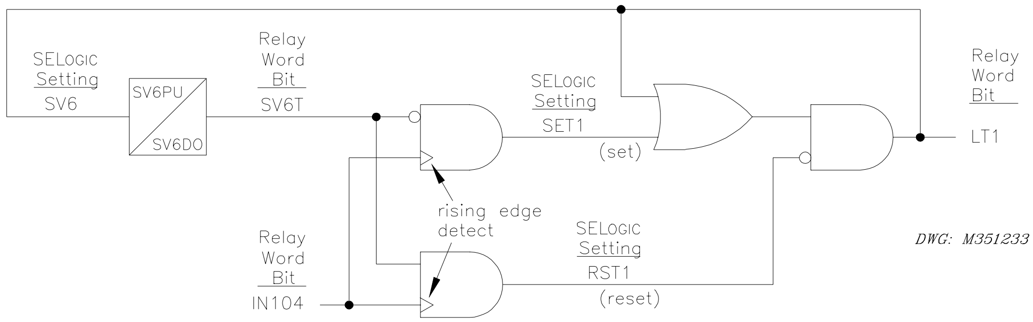


Figure 7.16: Latch Control Switch (with Time Delay Feedback) Controlled by a Single Input to Enable/Disable Reclosing

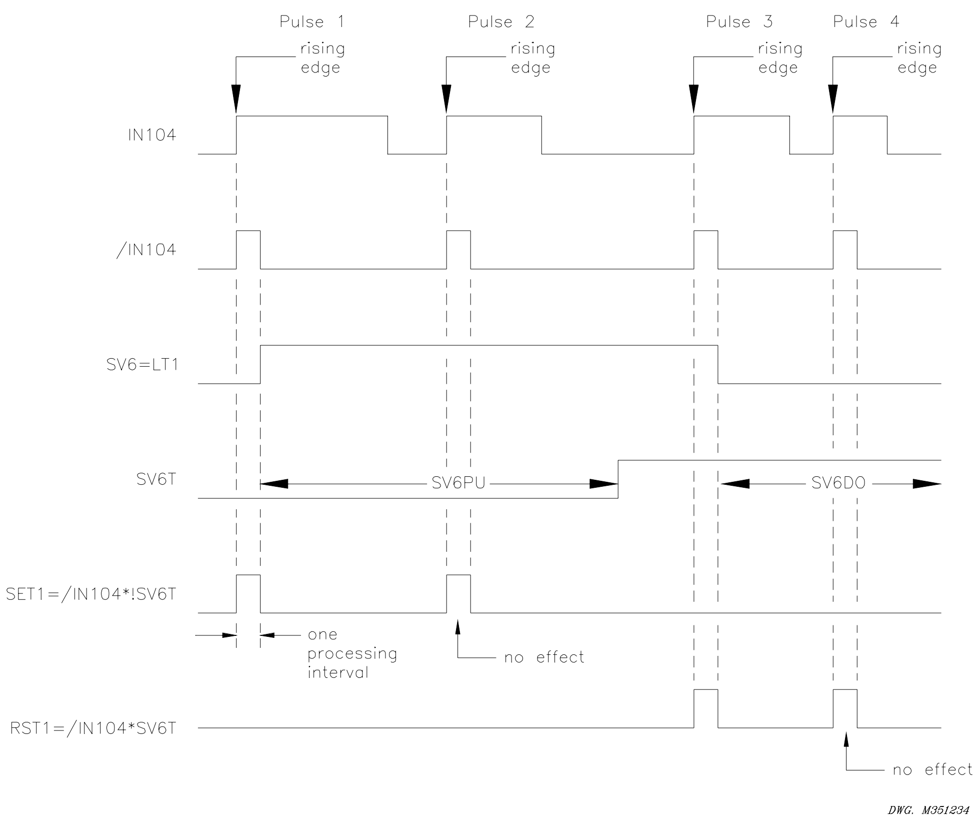


Figure 7.17: Latch Control Switch (with Time Delay Feedback) Operation Time Line

MULTIPLE SETTING GROUPS

The relay has six (6) independent setting groups. Each setting group has complete relay (distance, overcurrent, 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: 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: 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-311B 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.

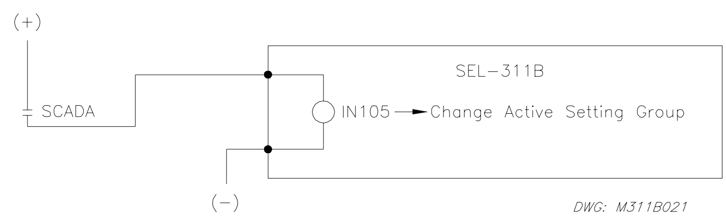


Figure 7.18: SCADA Contact Pulses Input IN105 to Switch Active Setting Group Between Setting Groups 1 and 4

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.

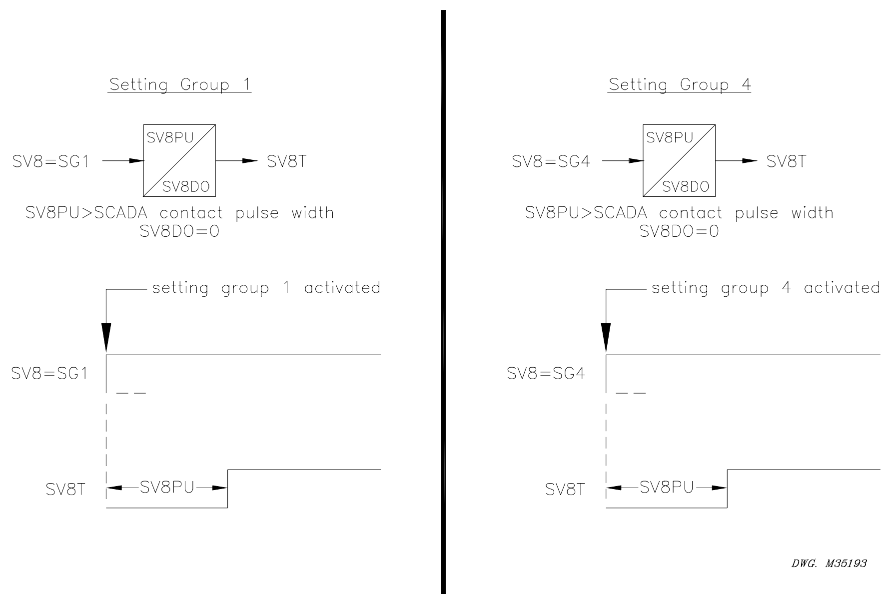


Figure 7.19: SELOGIC Control Equation Variable Timer SV8T Used in Setting Group Switching

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).

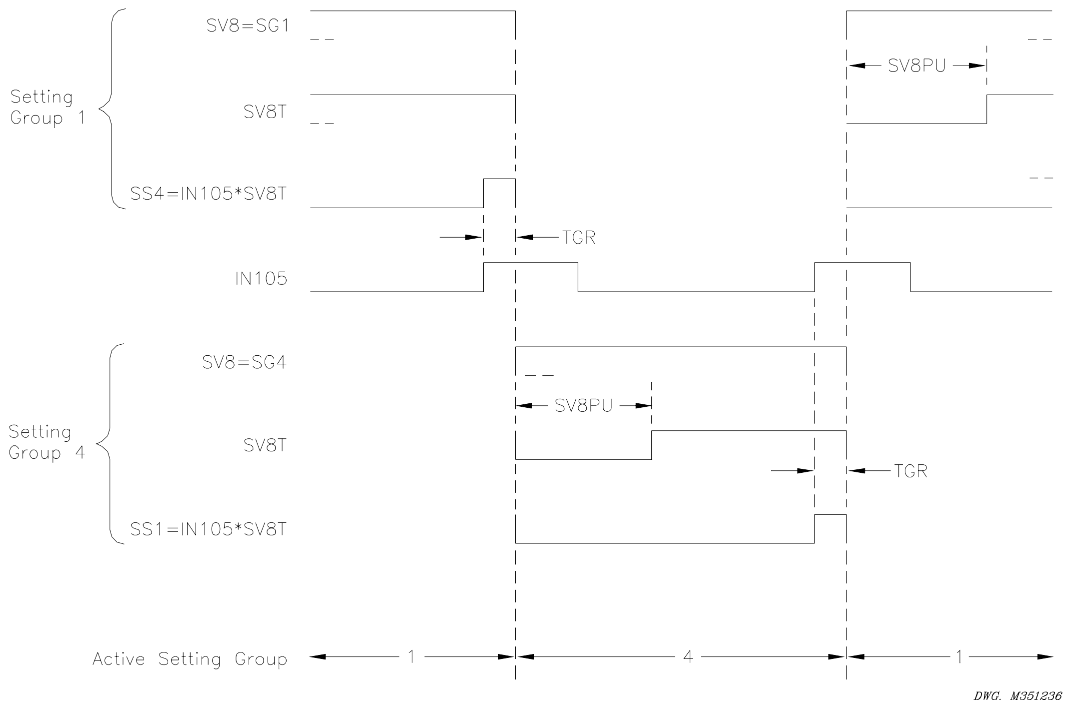


Figure 7.20: Active Setting Group Switching (with Single Input) Time Line

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

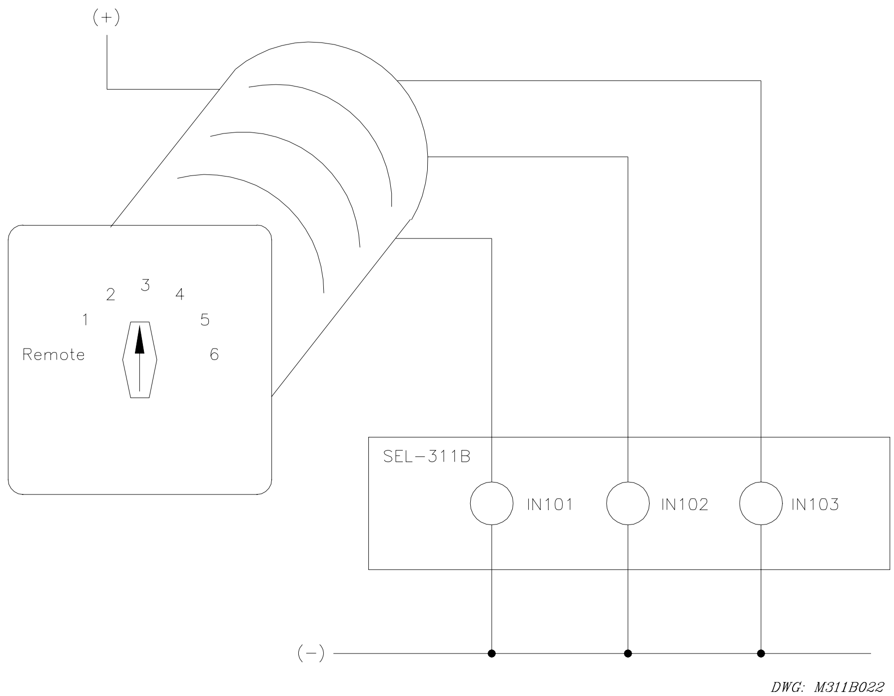


Figure 7.21: Rotating Selector Switch Connected to Inputs IN101, IN102, and IN103 for Active Setting Group Switching

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.

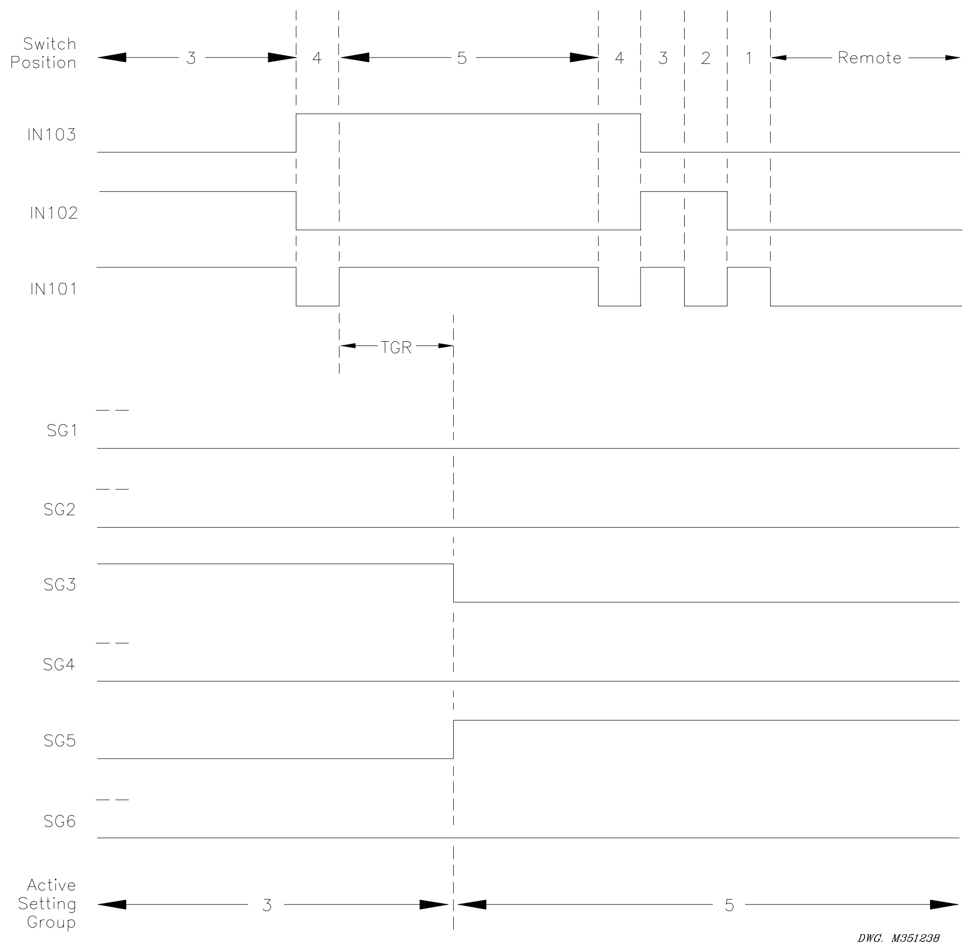


Figure 7.22: Active Setting Group Switching (with Rotating Selector Switch) Time Line

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

The SELOGIC control equation variables/timers are enabled using the ESV setting. Set ESV to the number of SELOGIC control equation variables/timers that are desired (N, 1–16).

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).

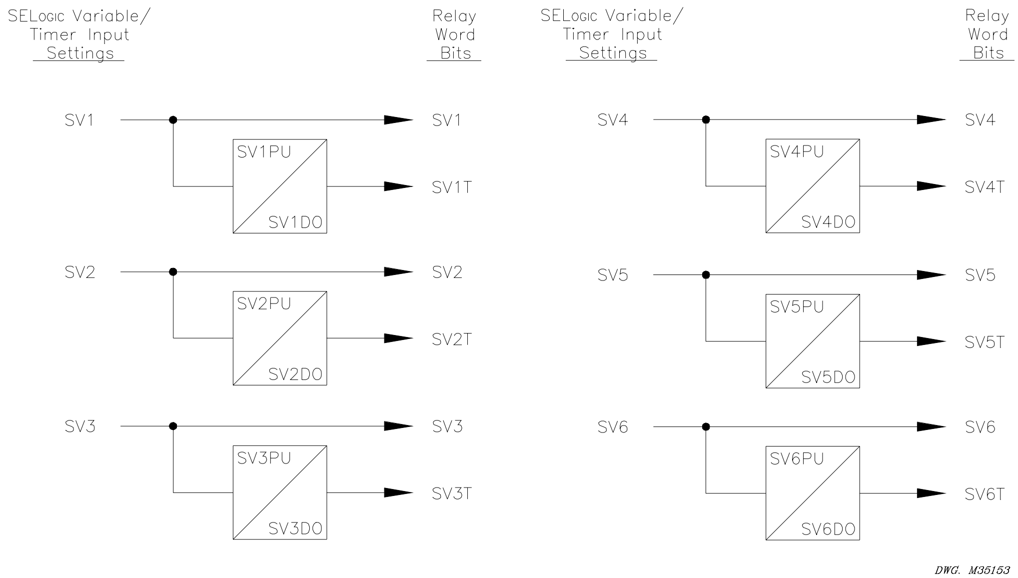


Figure 7.23: SELOGIC Control Equation Variables/Timers SV1/SV1T Through SV6/SV6T

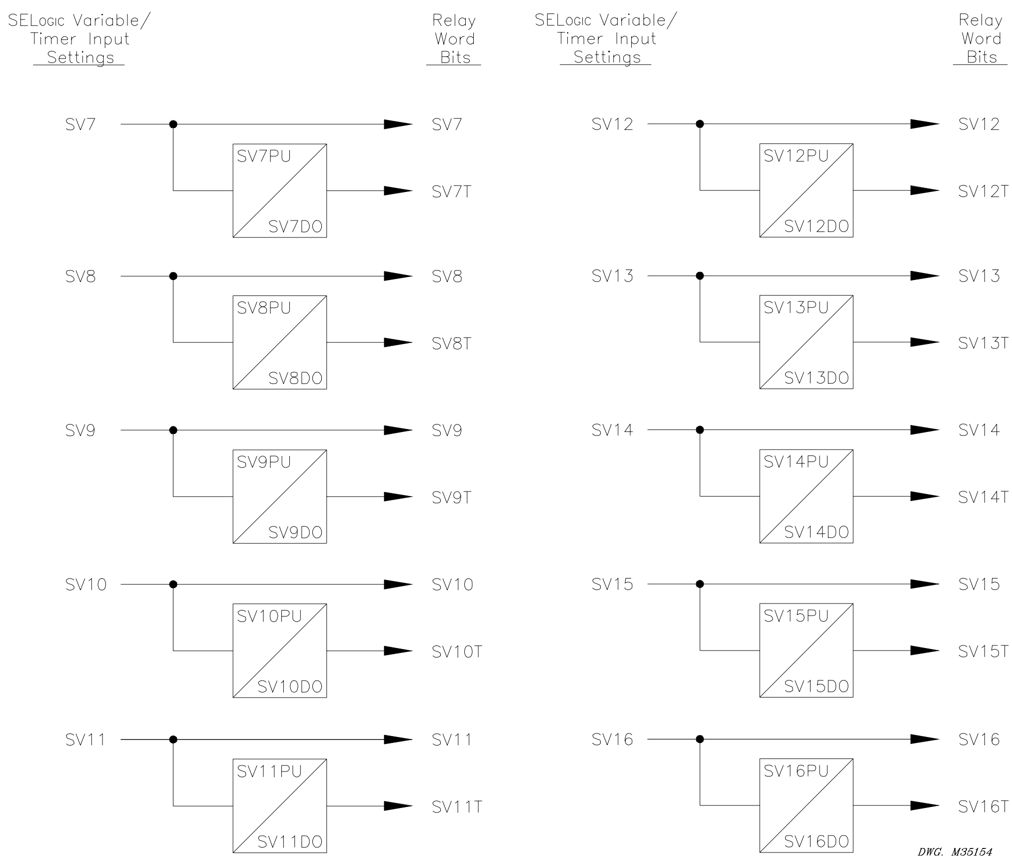


Figure 7.24: SELOGIC Control Equation Variables/Timers SV7/SV7T Through SV16/SV16T

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 = V1T

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)

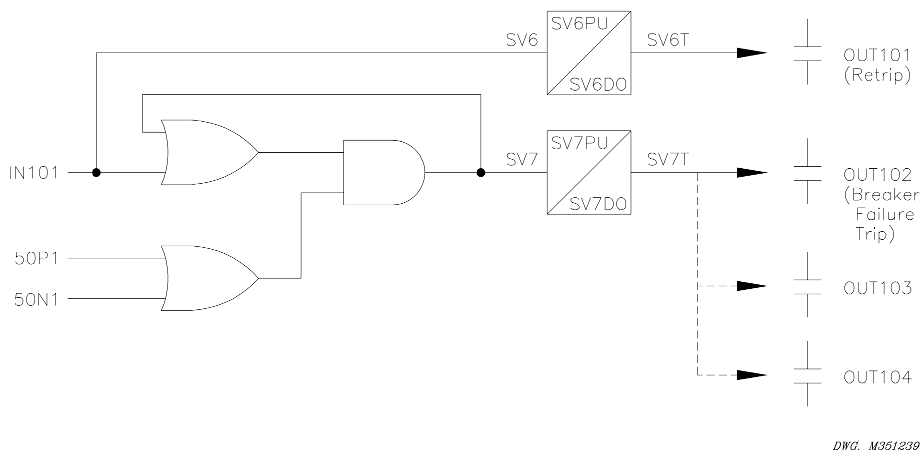


Figure 7.25: Dedicated Breaker Failure Scheme Created with SELOGIC Control Equation Variables/Timers

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:

SV = 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

Figure 7.26 shows the example operation of output contact Relay Word bits due to:

SELOGIC control equation operation

or

PULSE command execution

The output contact Relay Word bits in turn control the output contacts.

Alarm logic/circuitry controls the ALARM output contact (see Figure 7.26)

Factory Settings Example

In the factory SELOGIC control equation settings, three output contacts are used:

OUT101 = TRIP	(overcurrent tripping/manual tripping; see ***Section 5: Trip and Target Logic***)
OUT102 = TRIP	
OUT103 = CLOSE	(automatic reclosing/manual closing; see ***Section 6: Close and Reclose Logic***)
•	
•	
•	
OUT107 = 0	(output contact OUT107 not used—set equal to zero)

Operation of Output Contacts for Different Output Contact Types

Output Contacts OUT101 Through OUT107

Refer to Figure 7.26.

The execution of the serial port command **PULSE *n*** (*n* = OUT101 through OUT107) asserts the corresponding Relay Word bit (OUT101 through OUT107) to logical 1. The assertion of SELOGIC control equation setting OUT*m* (*m* = 101 through 107) to logical 1 also asserts the corresponding Relay Word bit OUT*m* (*m* = 101 through 107) to logical 1.

The assertion of Relay Word bit OUT*m* (*m* = 101 through 107) to logical 1 causes the energization of the corresponding output contact OUT*m* coil. Depending on the contact type (a or b), the output contact closes or opens as demonstrated in Figure 7.26. 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.

Notice in Figure 7.26 that all four possible combinations of 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.

Output contact pickup/dropout time is typically 4 ms.

ALARM Output Contact

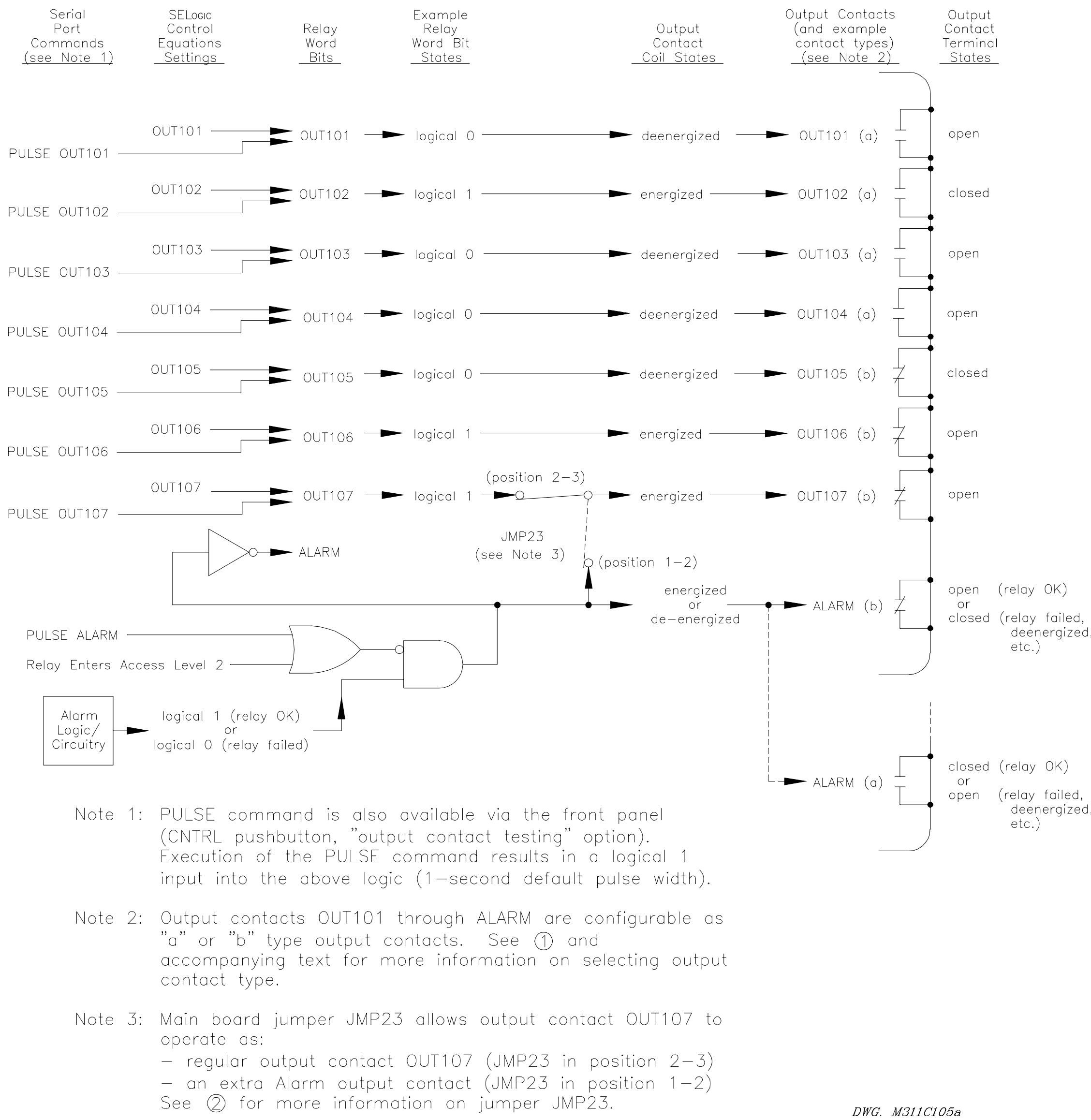
Refer to Figure 7.26 and ***Relay Self-Tests*** in ***Section 13: Testing and Troubleshooting***.

When the relay is operational, the ALARM output contact coil is energized. The alarm logic/circuitry keeps the ALARM output contact coil energized. Depending on the ALARM output contact type (a or b), the ALARM output contact closes or opens as demonstrated in Figure 7.26. 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.

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.

The Relay Word bit ALARM is deasserted to logical 0 when the relay is operational. When the serial port command **PULSE ALARM** is executed, the ALARM Relay Word bit momentarily asserts to logical 1. Also, when the relay enters Access Level 2, the ALARM Relay Word bit momentarily asserts to logical 1 (and the ALARM output contact coil is deenergized momentarily).

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.



① Table 2.2 ② Table 2.3

Figure 7.26: Logic Flow for Example Output Contact Operation

ROTATING DEFAULT DISPLAY (ONLY ON MODELS WITH LCD)

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 7.27 shows traditional indicating panel lights wired in parallel with SEL-311B 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]

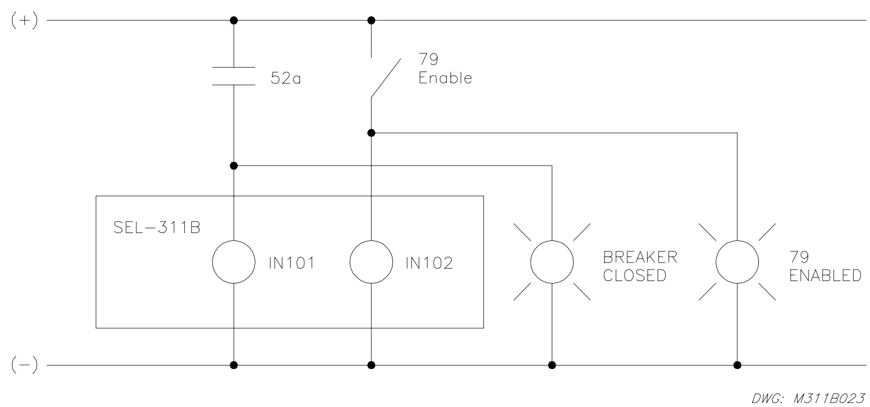


Figure 7.27: Traditional Panel Light Installations

Note that Figure 7.27 corresponds to Figure 7.2.

Reclosing Relay Status Indication

In Figure 7.27, 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 7.27, 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-311B Relay is used. Figure 7.28 shows the elimination of the indicating panel lights by using the rotating default display.

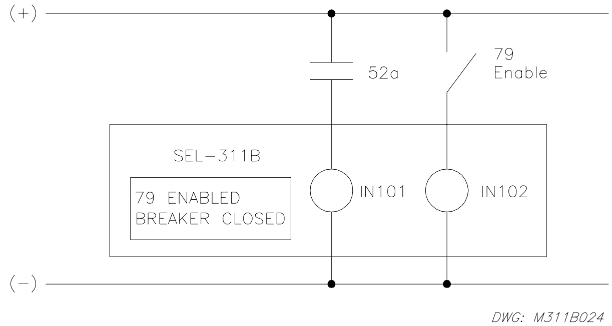


Figure 7.28: Rotating Default Display Replaces Traditional Panel Light Installations

There are sixteen (16) of these default displays available in the SEL-311B Relay. Each default display has two complementary screens (e.g., BREAKER CLOSED and BREAKER OPEN) available.

General Operation of Rotating Default Display Settings

The display settings are enabled using the EDP setting. Set EDP to the number of display settings that are desired (N, 1–16).

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: Serial Port Communications and Commands***). These text settings are displayed on the SEL-311B 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 7.28 for the traditional indicating panel lights in Figure 7.27.

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 7.28, 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 7.28, 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 7.28, 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 7.28, 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 7.28)
DP2_1	= BREAKER CLOSED	(displays when DP2 = logical 1)
DP2_0	=	(blank)

Circuit Breaker Closed

In Figure 7.28, 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 7.28, 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-311B 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 7.28 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 7.28, 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 7.28, 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 5.4 and accompanying text in ***Section 5: Trip and Target Logic*** for an example of resetting a rotating default display with the TARGET RESET pushbutton.

Displaying Time-Overcurrent Elements on the Rotating Default Display

The LCD can display the pickup settings for the time-overcurrent elements in primary units via a special character sequence in the display points equations. As with the previously described display points, the operator does not need to press any buttons to see this information.

To program a display point to show the pickup setting of a time-overcurrent element, first enter the two-character sequence "::" (double colon) followed by the name of the desired time-overcurrent element pickup settings for 51PP, 51GP, or 51QP.

For example with the factory default settings for 51PP and CTR, setting DP1_0 = ::51PP will display **1200.00 A pri**.

The relay calculates the value to display by multiplying the 51PP setting (6.00 A secondary) by the CTR setting (200), arriving at 1200.00 A primary. The relay displays the display point DP1_0 because the factory default SELOGIC control equation DP1 = 0 (logical 0).

The calculations for the remaining time-overcurrent elements are similar, except for 51GP which is multiplied by the CTRP setting.

If the display point setting does not match the format correctly, the relay will display the setting text string as it was actually entered, without substituting the time-overcurrent element setting value.

Displaying Time-Overcurrent Elements Example

This example demonstrates use of the rotating display to show time-overcurrent elements in primary units. This example will set the 51PP and 51GP to display in the rotating default display.

Set the following:

SET	SET T	SET L
CTR = 200	DP1_0 = PHASE TRIPS AT	DP1 = 0
CTRP = 200	DP2_0 = ::51PP	DP2 = 0
E51P = Y	DP3_0 = NEUTRAL TRIPS AT	DP3 = 0
E51G = Y	DP4_0 = ::51GP	DP4 = 0
51PP = 6		
51GP = 0.75		

Setting DP*n* = 0 and using the DP*n*_0 in the text settings allows the setting to permanently rotate in the display. The DP*n* logic equation can be set to control the text display—turning it on and off under certain conditions. With the relay set as shown above, the LCD will show the following:

```
PHASE TRIPS AT
  1200.00 A pri
```

then,

```
NEUTRAL TRIPS AT
   150.00 A pri
```

With the control string set on the even display points "DP2, DP4, DP6, …" and the description set on the odd display points "DP1, DP3, …" each screen the relay scrolls through will have a description with the value below it.

For additional format control for the setting elements only, use the following **SET T** control string:

Dpi_j = XXX;;[;]ABCDE;YYY

where:

- i is a number between 1 and 16, representing the 16 display points, and j is either 1 or 0 representing logic high or low, respectively.
- XXX is an optional pre-label. YYY is an optional post label that is preceded by a single semicolon (;) character. The label character count is the sum of the characters used in the pre and post labels.
- ABCDE is a relay setting variable from the table below.

SET T Setting Variable	Displays Relay Setting Value	Display Format/Resolution	Maximum Label Character Count
;;51PP	51PP	xxxxxxx.xx	6
;;51GP	51GP	xxxxxxx.xx	6
;;51QP	51QP	xxxxxxx.xx	6
;;;000	51PP	xxxxxxx	9
;;;001	51GP	xxxxxxx	9
;;;002	51QP	xxxxxxx	9

For example, setting DP1_0 = OC PU;;51PP;A will display:

```
OC PU    1200.00A
```

Or setting DP1_0 = OC PU;;;001;A will display:

```
OC PU    1200A
```

Displaying Metering Quantities on the Rotating Default Display

Display points can be programmed to display metering quantities automatically, making this information available without the use of pushbuttons. The values shown in Table 7.8 can be set to automatically display on the rotating LCD screen.

Table 7.8: Mnemonic Settings for Metering on the Rotating Default Display

Mnemonic	Display	Description
IA	I A = x . x x x A y y y °	IA input current
IB	I B = x . x x x A y y y °	IB input current
IC	I C = x . x x x A y y y °	IC input current
IP	I P = x . x x x A y y y °	IN input current
VA	V A = x . x x x K V y y y °	VA input voltage
VB	V B = x . x x x K V y y y °	VB input voltage
VC	V C = x . x x x K V y y y °	VC input voltage
VS	V S = x . x x x K V y y y °	VS input voltage
IG	I G = x . x x x A y y y °	IG = IA + IB + IC (residual)
3IO	3 I 0 = x . x x x A y y y °	3IO = IG (zero-sequence)
I1	I 1 = x . x x x A y y y °	positive-sequence current
3I2	3 I 2 = x . x x x A y y y °	negative-sequence current
3V0	3 V 0 = x . x x x K V y y y °	zero-sequence voltage
V1	V 1 = x . x x x K V y y y °	positive-sequence voltage
V2	V 2 = x . x x x K V y y y °	negative-sequence voltage
MWA	M W A = x x . x x x	A megawatts
MWB	M W B = x x . x x x	B megawatts
MWC	M W C = x x . x x x	C megawatts
MW3	M W 3 P = x x . x x x	three-phase megawatts
MVARA	M V A R A = x x . x x x	A megavars
MVARB	M V A R B = x x . x x x	B megavars
MVARC	M V A R C = x x . x x x	C megavars
MVAR3	M V A R 3 P = x x . x x x	three-phase megavars
PFA	P F A = x . x x L E A D	A power factor

Mnemonic	Display	Description
PFB	P F B = x . x x L A G	B power factor
PFC	P F C = x . x x L A G	C power factor
PF3	P F 3 P = x . x x L E A D	three-phase power factor
FREQ	F R Q = x x . x	system frequency from VA
VDC	V D C = x x x . x v	DC voltage
IADEM	I A D E M = x . x x x	IA demand current
IAPK	I A P E A K = x . x x x	IA peak current
IBDEM	I B D E M = x . x x x	IB demand current
IBPK	I B P E A K = x . x x x	IB peak current
ICDEM	I C D E M = x . x x x	IC demand current
ICPK	I C P E A K = x . x x x	IC peak current
IPDEM	I P D E M = x . x x x	IP demand current
IPPK	I P P E A K = x . x x x	IP peak current
3I2DEM	3 I 2 D E M = x . x x x	3I2 demand current
3I2PK	3 I 2 P E A K = x . x x x	3I2 peak current
MWADI	M W A I N D E M = x . x x x	A demand megawatts in
MWAPI	M W A I N P K = x . x x x	A peak megawatts in
MWBDI	M W B I N D E M = x . x x x	B demand megawatts in
MWBPI	M W B I N P K = x . x x x	B peak megawatts in
MWCDI	M W C I N D E M = x . x x x	C demand megawatts in
MWCPI	M W C I N P K = x . x x x	C peak megawatts in
MW3DI	M W 3 I N D E M = x . x x x	three-phase demand megawatts in
MW3PI	M W 3 I N P K = x . x x x	three-phase peak megawatts in
MVRADI	M V R A I D E M = x . x x x	A demand megavars in
MVRAPI	M V R A I P K = x . x x x	A peak megavars in
MVRBDI	M V R B I D E M = x . x x x	B demand megavars in
MVRBPI	M V R B I P K = x . x x x	B peak megavars in
MVRCDI	M V R C I D E M = x . x x x	C demand megavars in
MVRCPI	M V R C I P K = x . x x x	C peak megavars in
MVR3DI	M V R 3 I D E M = x . x x x	three-phase demand megavars in
MVR3PI	M V R 3 I P K = x . x x x	three-phase peak megavars in
MWADO	M W A O D E M = x . x x x	A demand megawatts out
MWAPO	M W A O P K = x . x x x	A peak megawatts out
MWBDO	M W B O D E M = x . x x x	B demand megawatts out
MWBPO	M W B O P K = x . x x x	B peak megawatts out
MWCDO	M W C O D E M = x . x x x	C demand megawatts out
MWCPO	M W C O P K = x . x x x	C peak megawatts out
MW3DO	M W 3 O D E M = x . x x x	three-phase demand megawatts out
MW3PO	M w 3 O P K = x . x x x	three-phase peak megawatts out
MVRADO	M V R A O D E M = x . x x x	A demand megavars out

Mnemonic	Display	Description
MVRAPO	M V R A O P K = x . x x x	A peak megavars out
MVRBDO	M V R B O D E M = x . x x x	B demand megavars out
MVRBPO	M V R B O P K = x . x x x	B peak megavars out
MVRCDO	M V R C O D E M = x . x x x	C demand megavars out
MVRCPO	M V R C O P K = x . x x x	C peak megavars out
MVR3DO	M V R 3 O D E M = x . x x x	three-phase demand megavars out
MVR3PO	M V R 3 O P K = x . x x x	three-phase peak megavars out
MWHAI	M W h A I N = x x . x x x	A megawatt-hours in
MWHAO	M W h A O U T = x x . x x x	A megawatt-hours out
MWHBI	M W h B I N = x x . x x x	B megawatt-hours in
MWHBO	M W h B O U T = x x . x x x	B megawatt-hours out
MWHCI	M W h C I N = x x . x x x	C megawatt-hours in
MWHCO	M W h C O U T = x x . x x x	C megawatt-hours out
MWH3I	M W h 3 I N = x x . x x x	three-phase megawatt-hours in
MWH3O	M W h 3 O U T = x x . x x x	three-phase megawatt-hours out
MVRHAI	M V A R h A I = x x . x x x	A megavar-hours in
MVRHAO	M V A R h A O = x x . x x x	A megavar-hours out
MVRHBI	M V A R h B I = x x . x x x	B megavar-hours in
MVRHBO	M V A R h B O = x x . x x x	B megavar-hours out
MVRHCI	M V A R h C I = x x . x x x	C megavar-hours in
MVRHCO	M V A R h C O = x x . x x x	C megavar-hours out
MVRH3I	M V A R h 3 I = x x . x x x	three-phase megavar-hours in
MVRH3O	M V A R h 3 O = x x . x x x	three-phase megavar-hours out

To program a display point to display one of the metering quantities above, first enter the two-character sequence "::" (double colon) followed by the name of the desired metering quantity (e.g., IA, VA, MW3, etc.).

If the display point setting does not match the format correctly, the relay will display the setting text string as it was actually entered, without substituting the metering value.

Displaying Metering Values Example

This example demonstrates use of the rotating display to show metering quantities automatically on the rotating default display. This example will set the MW3, MVAR3, PF3, and FREQ to display in the rotating default display.

Set the following:

SET T	SET L
DP1_0 = ::MW3	DP1 = 0
DP2_0 = ::MVAR3	DP2 = 0
DP3_0 = ::PF3	DP3 = 0
DP4_0 = ::FREQ	DP4 = 0

Setting DPn = 0 and using the DPn_0 in the text settings allows the setting to permanently rotate in the display. The DPn logic equation can be set to control the text display—turning it on and off under certain conditions. With the relay set as shown above, the LCD will show the following:

```
  MW 3P= XXXX.X
MVAR 3P= XXXX.X
```

then,

```
PF 3P=XX.XX XXXX
FRQ=XX.X
```

Displaying Breaker Monitor Output Information on the Rotating Default Display

Display points can be programmed to display breaker monitor output information automatically, making this information available without using pushbuttons. The values shown Table 7.9 in can be set to automatically display on the rotating LCD screen.

Table 7.9: Mnemonic Settings for Self-Check Status on the Rotating Default Display

Mnemonic	Display	Description
BRKDATE	RST DAT:mm/dd/yy	last reset date
BRKTIME	RST TIM:hh:mm:ss	last reset time
CTRLTR	CTRL TRIPS=xxxxx	internal trip count
OPSCNTR	OPS CNTR= xxxxx	internal trip count
CTRLIA	CTRL IA=xxxxx kA	internal trip Σ IA
CTRLIB	CTRL IB=xxxxx kA	internal trip Σ IB
CTRLIC	CTRL IC=xxxxx kA	internal trip Σ IC
EXTTR	EXT TRIPS= xxxxx	external trip count
EXTIA	EXT IA= xxxxx kA	external trip Σ IA
EXTIB	EXT IB= xxxxx kA	external trip Σ IB
EXTIC	EXT IC= xxxxx kA	external trip Σ IC
WEARA	WEAR A= yyy%	A phase wear monitor
WEARB	WEAR B= yyy%	B phase wear monitor
WEARC	WEAR C= yyy%	C phase wear monitor

To program a display point to display one of the Breaker Monitor outputs above, first enter the two-character sequence "::" (double colon) followed by the name of the desired breaker monitor output (e.g., EXTTR, CTRLTR, CTRLIA, etc.).

If the display point setting does not match the format correctly, the relay will display the setting text string as it was actually entered, without substituting the breaker monitor output value.

Displaying Breaker Monitor Outputs Example

This example demonstrates use of the rotating display to show metering quantities automatically on the rotating default display. This example will set the EXTTR CTRLTR, CTRLIA, EXTIA, and WEARA to display in the rotating default display.

Set the following:

SET T	SET L
DP1_0 = ::EXTTR	DP1 = 0
DP2_0 = ::CTRLTR	DP2 = 0
DP3_0 = ::CTRLIA	DP3 = 0
DP4_0 = ::EXTIA	DP4 = 0
DP5_0 = ::WEARA	DP5 = 0

Setting DP*n* = 0 and using the DP*n*_0 in the text settings allows the setting to permanently rotate in the display. The DP*n* logic equation can be set to control the text display—turning it on and off under certain conditions. With the relay set as shown above, the LCD will show the following:

```
EXT TRIPS=XXXXX
CTRL TRIPS=XXXXX
```

then,

```
CTRL IA=XXXXXX kA
EXT IA=XXXXXX kA
```

and then,

```
WEAR A=   XXX %
```

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TABLES

FIGURES

SECTION 8: BREAKER MONITOR AND METERING FUNCTIONS

INTRODUCTION

The SEL-311B Relay monitoring functions include:

- Breaker Monitor
- Station DC Battery Monitor

In addition to instantaneous metering, the SEL-311B Relay metering functions include:

- Demand Metering
- Energy Metering
- Maximum/Minimum Metering

This section explains these functions in detail.

BREAKER MONITOR

The breaker monitor in the SEL-311B 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 Settings Sheet 17 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: 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 <u>one</u> 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-311B Relay breaker monitor, three set points are entered:

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

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

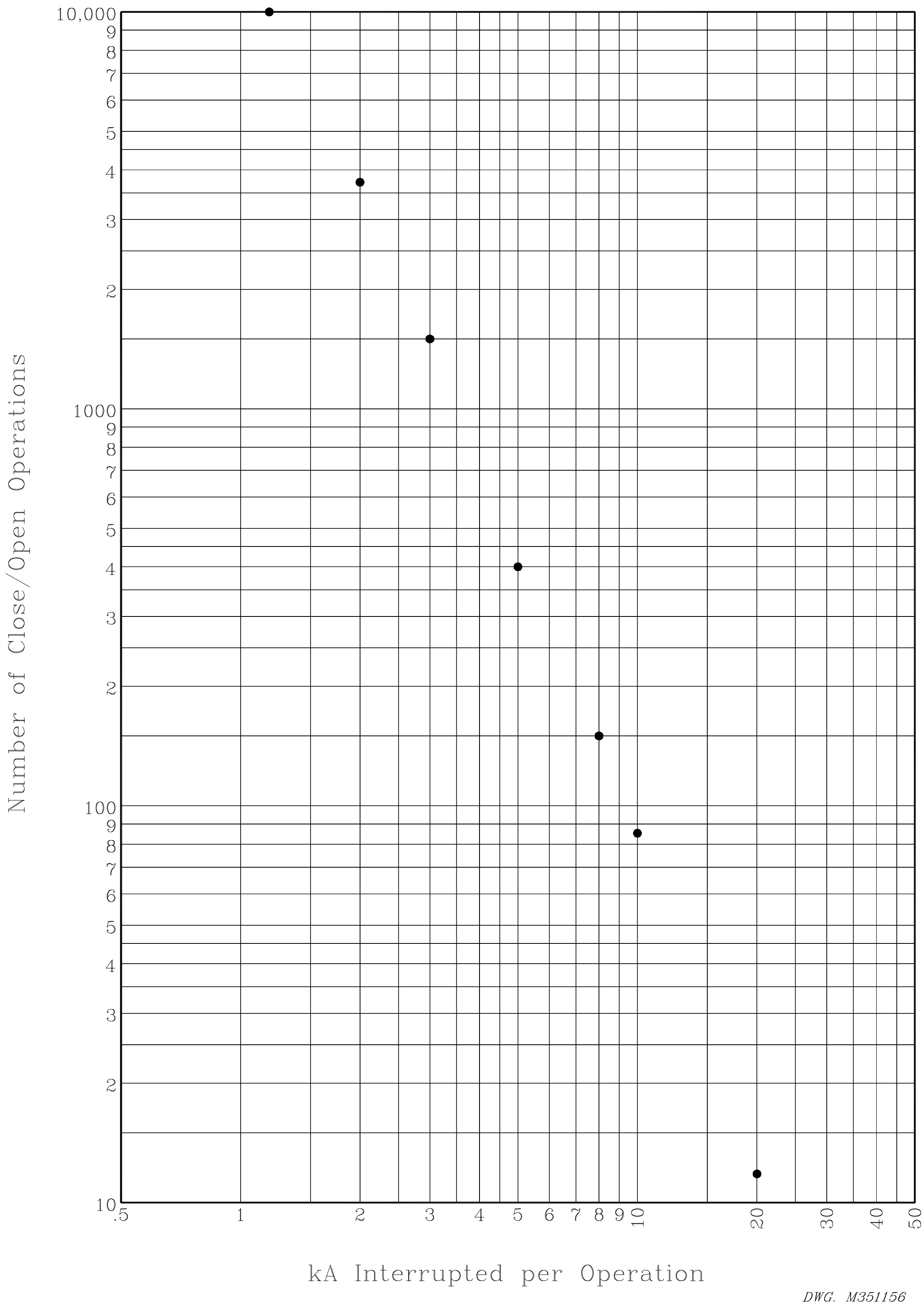

Figure 8.1: Plotted Breaker Maintenance Points for an Example Circuit Breaker

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: $5 \leq \text{KASP3/KASP1} \leq 100$

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).

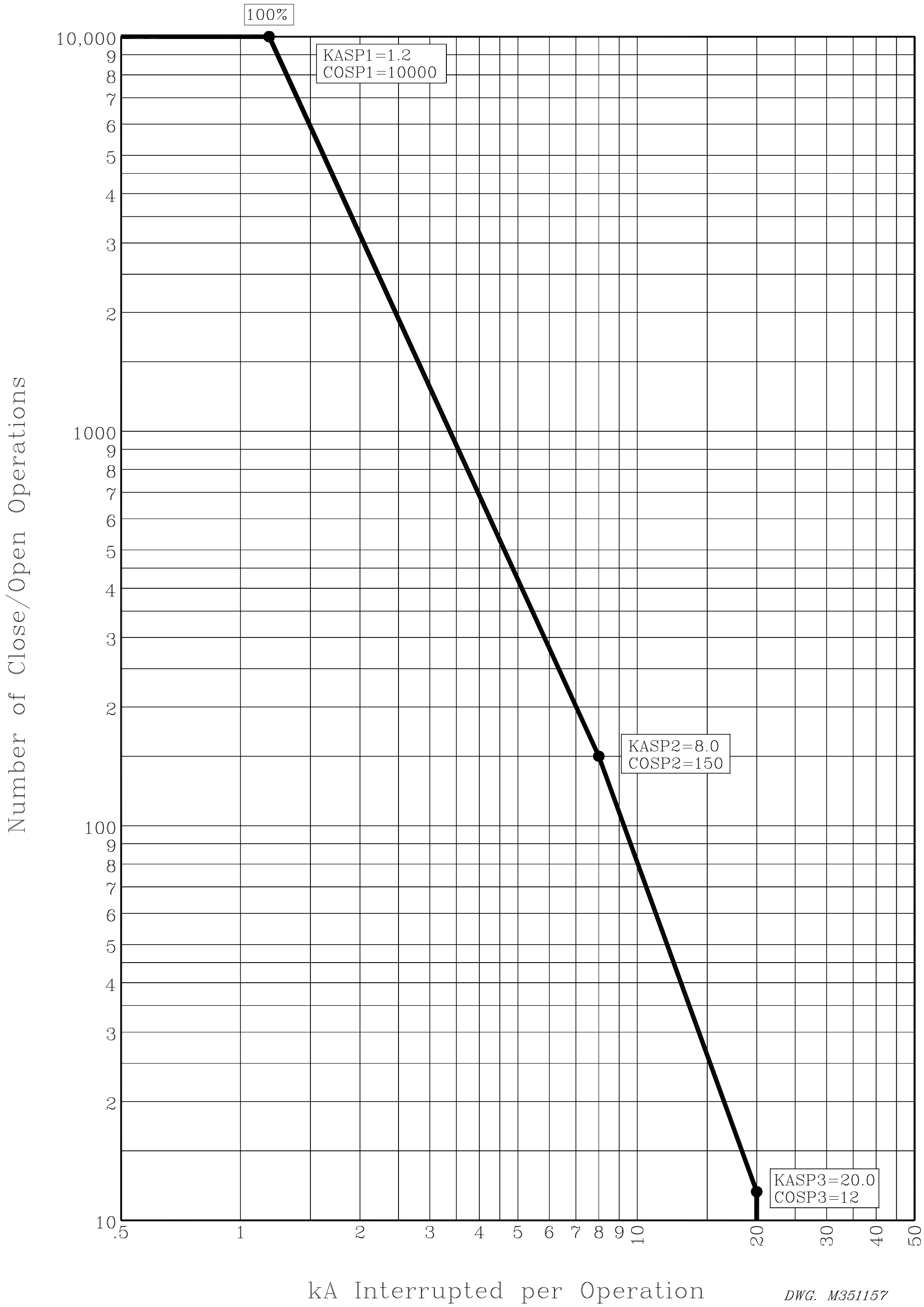

Figure 8.2: SEL-311B Relay Breaker Maintenance Curve for an Example Circuit Breaker

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: 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 Figure 5.1)

Refer to Figure 8.3. When BKMON asserts (Relay Word bit TRIP goes from logical 0 to logical 1), the breaker monitor reads in 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 on reading in the current values allows time for the fault current to level off.

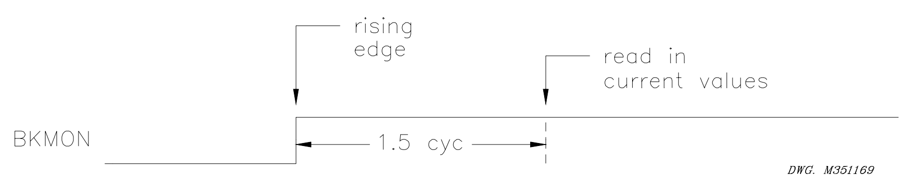

Figure 8.3: Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

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

Breaker Monitor Operation Example

As stated earlier, each phase (A, B, and C) has its own breaker maintenance curve. For this example, presume that the interrupted current values occur on a single phase in Figure 8.4 through Figure 8.7. Also, presume that the circuit breaker interrupting contacts have no wear at first (brand new or recent maintenance performed).

Note in the following four figures (Figure 8.4 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. Value 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. Value 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. Value 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. Value 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.

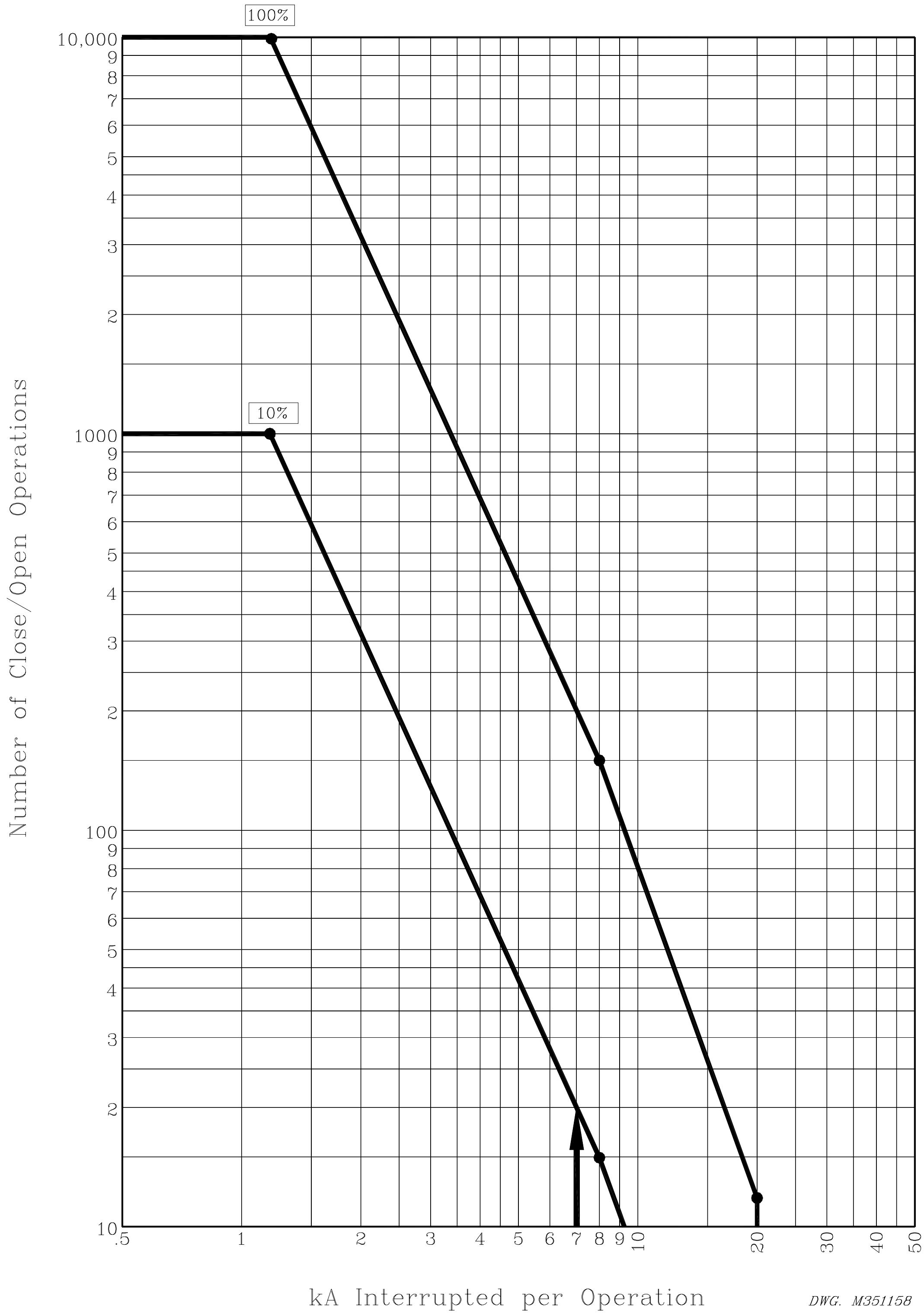

Figure 8.4: Breaker Monitor Accumulates 10 Percent Wear

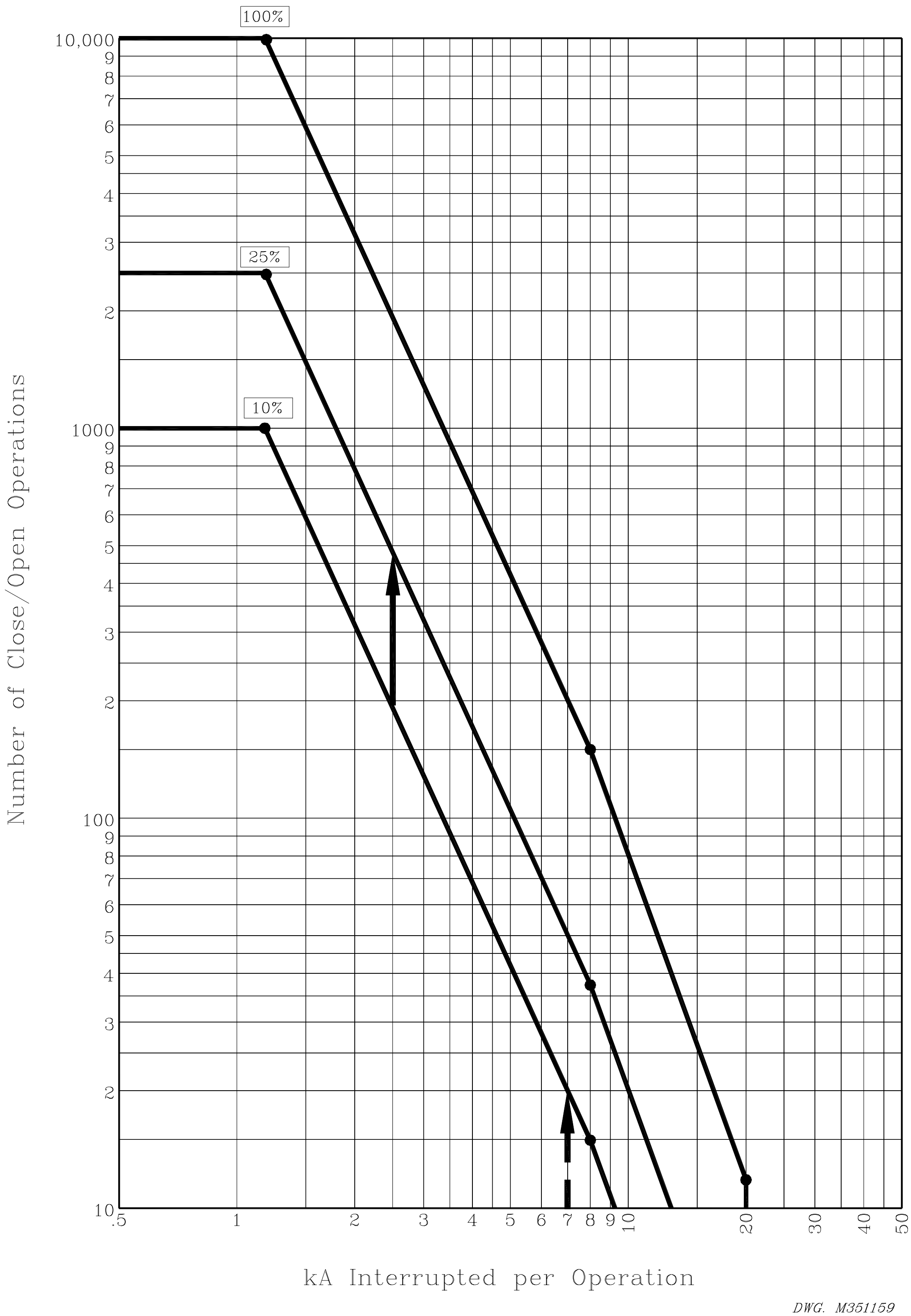

Figure 8.5: Breaker Monitor Accumulates 25 Percent Wear

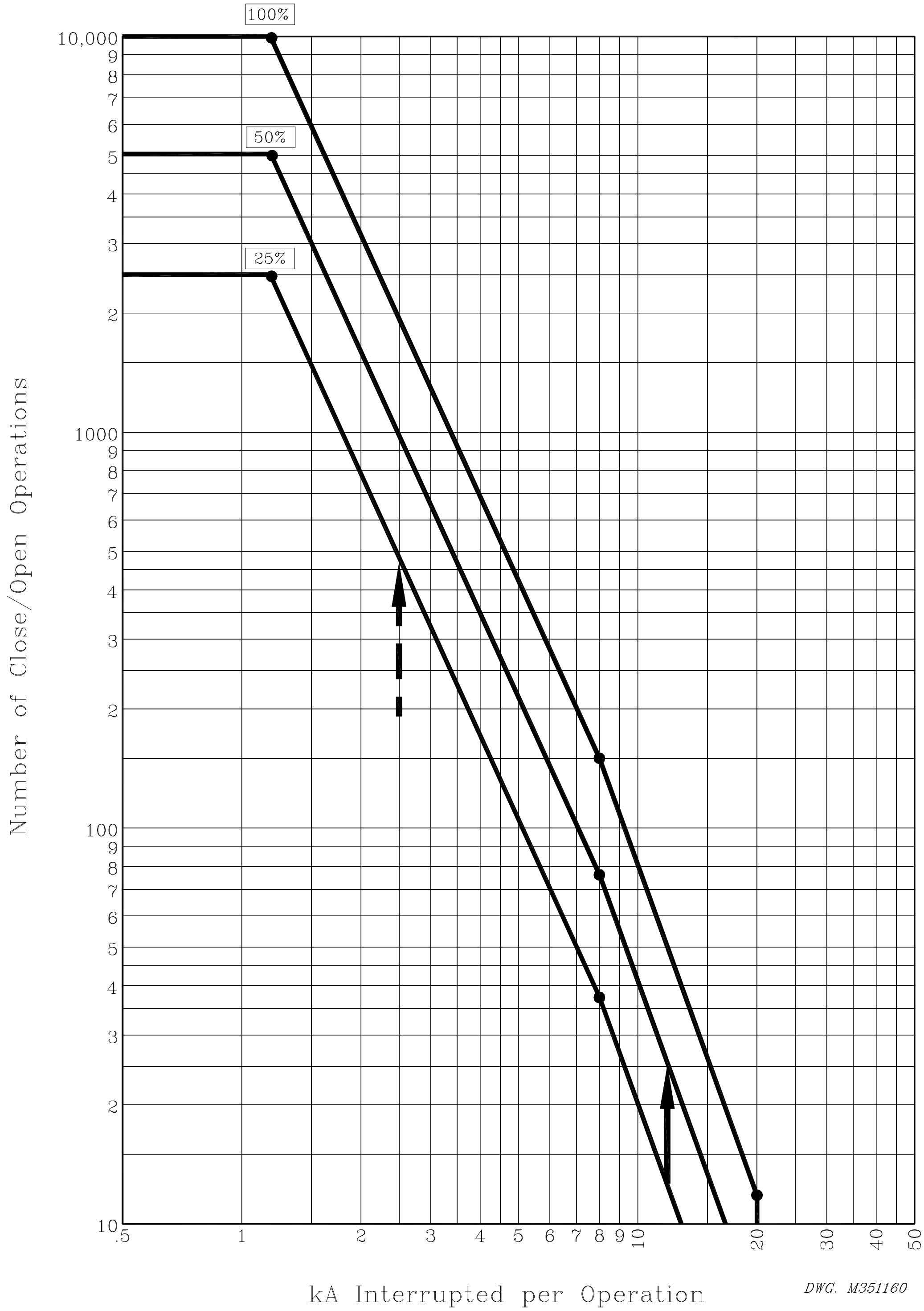

Figure 8.6: Breaker Monitor Accumulates 50 Percent Wear

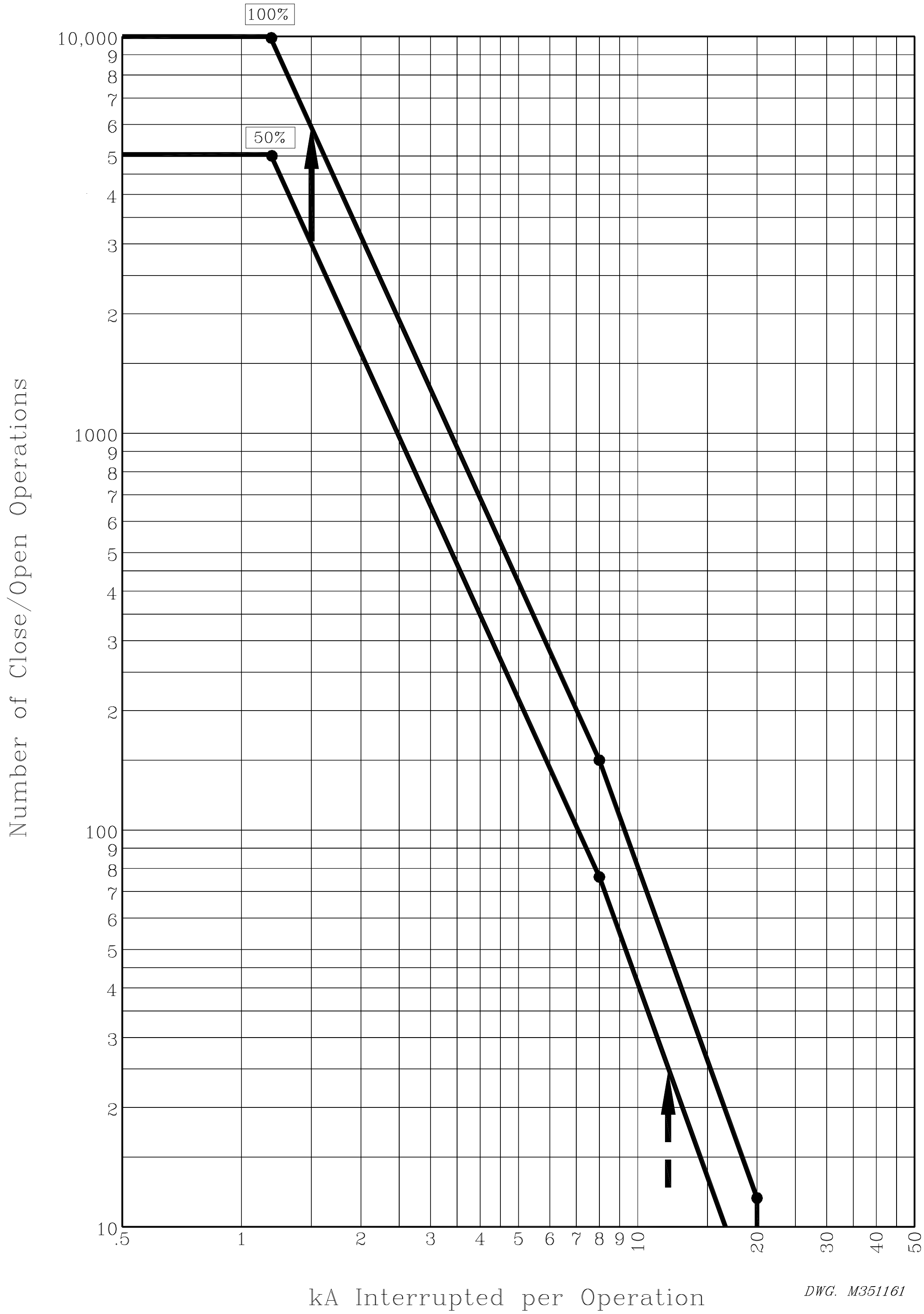

Figure 8.7: Breaker Monitor Accumulates 100 Percent Wear

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: 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: Serial Port Communications and Commands***. The **BRE W** command allows the internal trips and currents, the external trips and currents, and the percent breaker wear to be preloaded for each individual phase.

The **BRE R** command resets the accumulated values and the percent wear for all three phases. For example, if breaker contact wear has reached the 100 percent wear level for A-phase, the corresponding Relay Word bit BCWA asserts (BCWA = logical 1). Execution of the **BRE R** command resets the wear levels for all three phases back to 0 percent and consequently causes Relay Word bit BCWA to deassert (BCWA = logical 0).

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **BRE** and **BRE R** are also available via the front-panel OTHER pushbutton. See Figure 11.3 in ***Section 11: Front-Panel Interface***.

Determination of Relay-Initiated Trips and Externally Initiated Trips

See ***BRE Command (Breaker Monitor Data)*** in ***Section 10: 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 5.1). 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

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:

OUT101 = TRIP

Note that optoisolated input IN106 monitors the trip bus. If the trip bus is energized by output contact OUT101, an external control switch, or some other external trip, then IN106 is asserted.

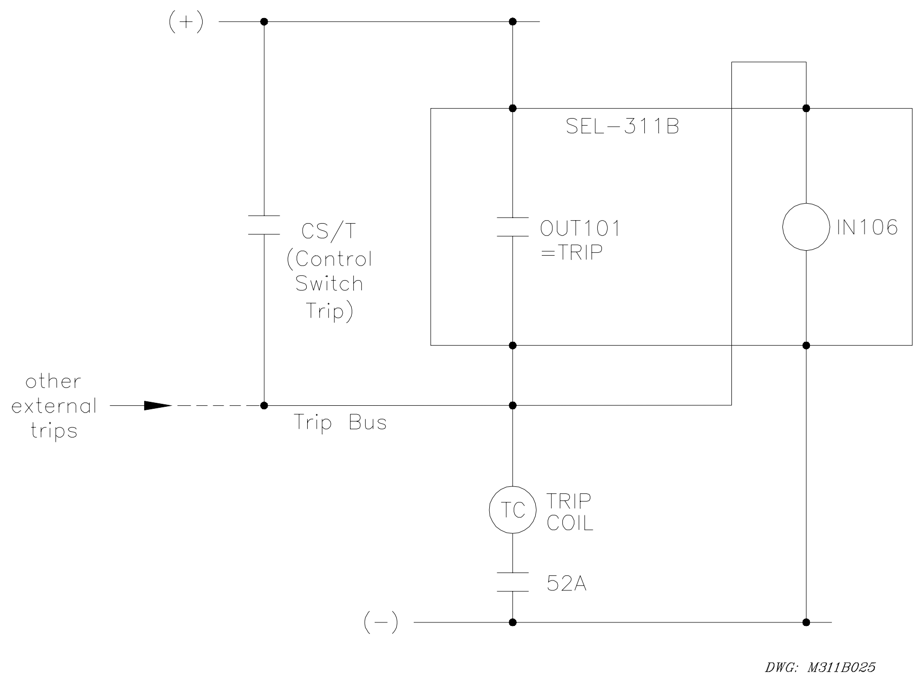

Figure 8.8: Input IN106 Connected to Trip Bus for Breaker Monitor Initiation

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

BKMON = IN106

then the SEL-311B Relay breaker monitor sees all trips.

If output contact OUT101 asserts, energizing the trip bus, the breaker monitor will deem it a relay-initiated trip. This is because when BKMON is newly asserted (input IN106 energized), the TRIP Relay Word bit is asserted. Thus, the current and trip count information is accumulated under relay-initiated trips (Rly Trips).

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-311B 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 1.2). 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 16 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:

20 to 300 Vdc, 1 Vdc increments

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

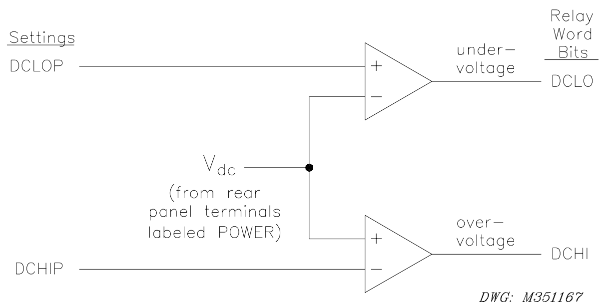

Figure 8.9: DC Under- and Overvoltage Elements

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.

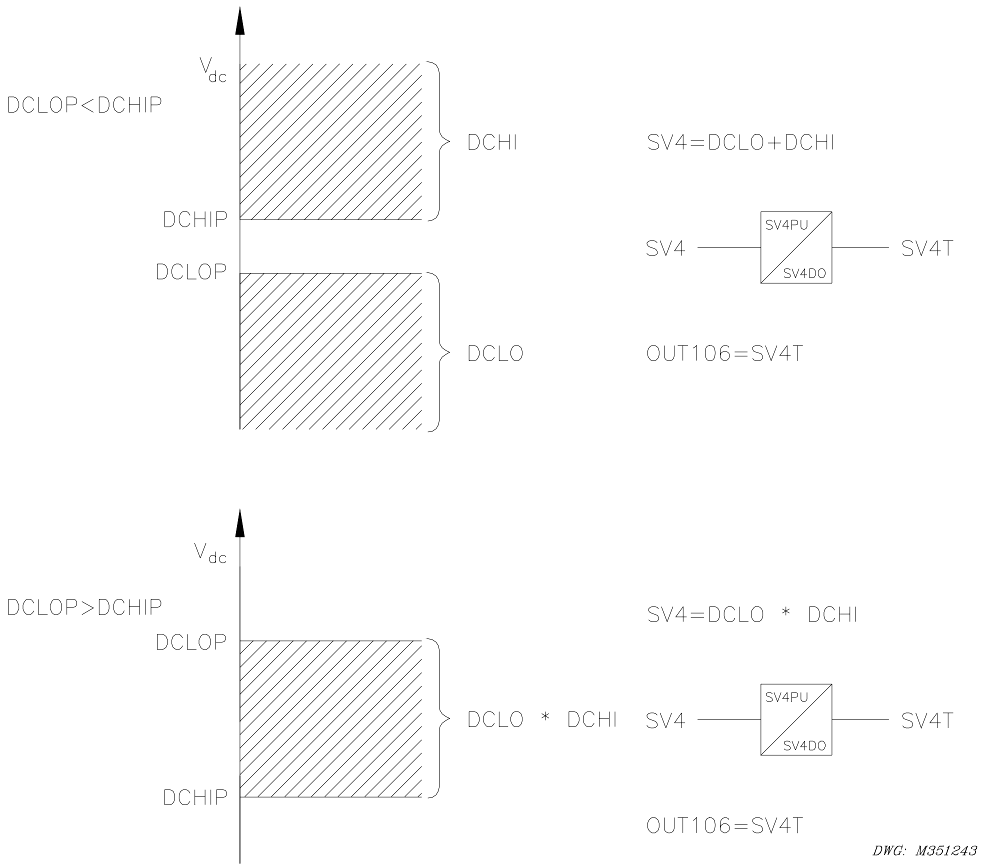

Figure 8.10: Create DC Voltage Elements with SELOGIC Control Equations

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:

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

Pickup settings DCLOP and DCHIP are set such that output contact OUT106 asserts when dc battery voltage stays between allowable limits.

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

V_{dc} = < DCHIP

then output contact OUT106 should logically deassert (according to bottom of Figure 8.10), 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***. 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 <u>not</u> 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: 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 12.2. Changes in station dc battery voltage for an event (e.g., circuit breaker tripping) can be observed. Use the **EVE** command to retrieve event reports as discussed in ***Section 12***.

Station DC Battery Voltage Dips During Circuit Breaker Tripping

Event reports are automatically generated when the TRIP Relay Word bit asserts (TRIP is the logic output of Figure 5.1). For example, output contact OUT101 is set to trip:

OUT101 = TRIP

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-311B 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-311B 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.

Demand Metering

The SEL-311B 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 Sheets 2 and 14 at the end of ***Section 9***. Also refer to ***MET Command [Metering Data]***, MET D—Demand Metering in ***Section 10: Serial Port Communications and Commands***).

The SEL-311B Relay provides 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	$MW_{A,B,C,3P}$	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 8.11 shows the response of thermal and rolling demand meters to a step current input. The current input is at a magnitude of zero and then suddenly goes to an instantaneous level of 1.0 per unit (a "step").

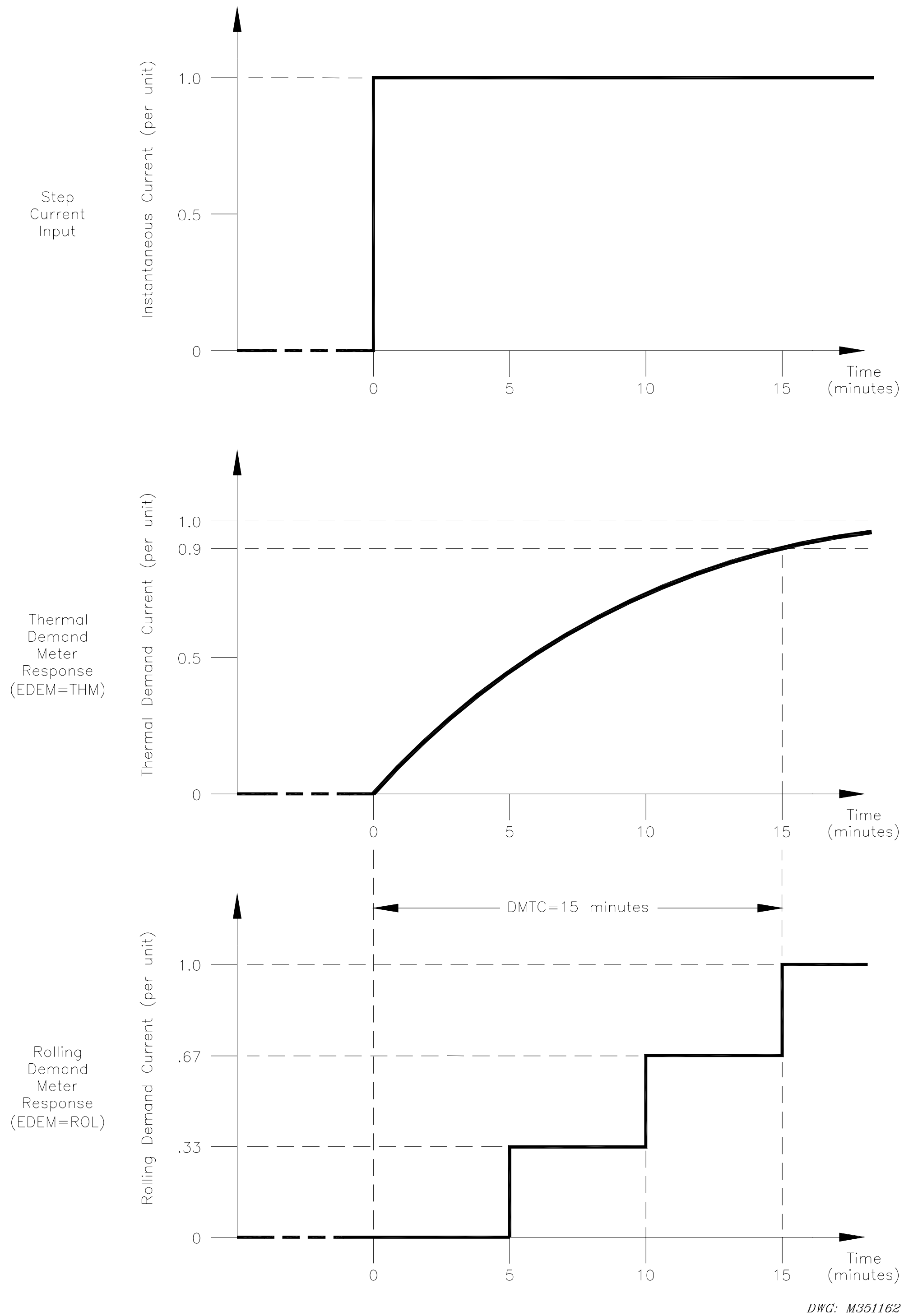

Figure 8.11: Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 Minutes)

Thermal Demand Meter Response (EDEM = THM)

The response of the thermal demand meter in Figure 8.11 (middle) to the step current input (top) is analogous to the parallel RC circuit in Figure 8.12.

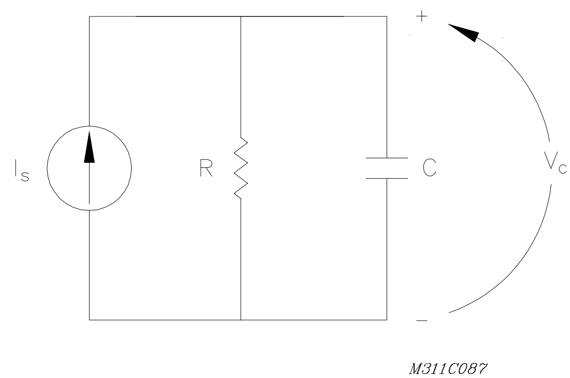

Figure 8.12: Current I_S Applied to Parallel RC Circuit

In the analogy:

Current I_S in Figure 8.12 corresponds to the step current input in Figure 8.11 (top).

Voltage V_C across the capacitor in Figure 8.12 corresponds to the response of the thermal demand meter in Figure 8.11 (middle).

If current I_S in Figure 8.12 has been at zero (I_S = 0.0 per unit) for some time, voltage V_C across the capacitor in Figure 8.12 is also at zero (V_C = 0.0 per unit). If 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 8.11 (middle) to the step current input (top).

In general, just as voltage V_C across the capacitor in Figure 8.12 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 8.11, the thermal demand meter response (middle) is at 90 percent (0.9 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step current input is first applied.

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

Rolling Demand Meter Response (EDEM = ROL)

The response of the rolling demand meter in Figure 8.11 (bottom) to the step current input (top) is calculated with a sliding time-window arithmetic average calculation. The width of the sliding time-window is equal to the demand meter time constant setting DMTC (see Table 8.3). Note in Figure 8.11, the rolling demand meter response (bottom) is at 100 percent (1.0 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step current input is first applied.

The rolling demand meter integrates the applied signal (e.g., step current) input in 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 8.11 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 8.11 (bottom).

Time = 0 Minutes

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

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

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

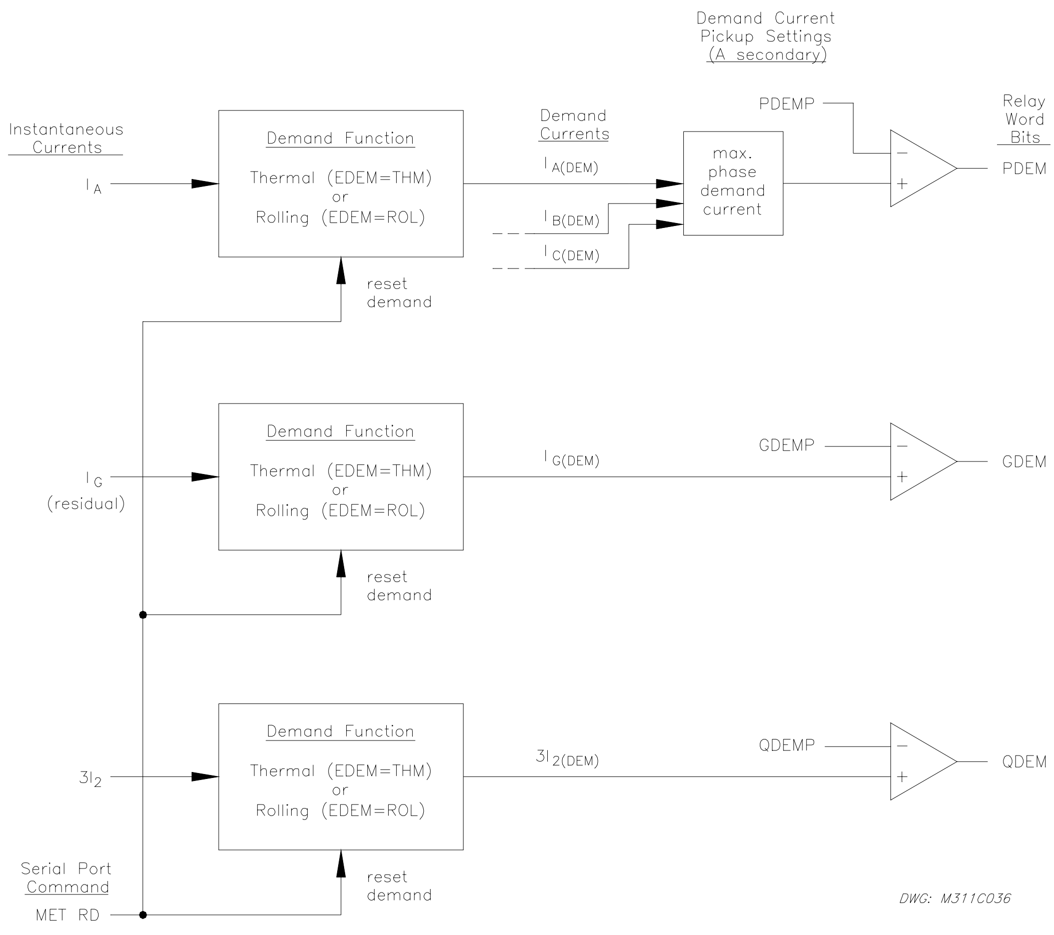

Figure 8.13: Demand Current Logic Outputs

Demand Current Logic Output Application—Raise Pickup for Unbalance Current

During times of high loading, the residual ground overcurrent elements can see relatively high unbalance current I_G ($I_G = 3I_0$). To avoid tripping on unbalance current I_G, use Relay Word bit GDEM to detect the residual ground (unbalance) demand current $I_{G(DEM)}$ and effectively raise the pickup of the residual ground time-overcurrent element 51GT. This is accomplished with the following settings from Table 8.3, 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 8.13, Figure 8.14, and Figure 3.19.

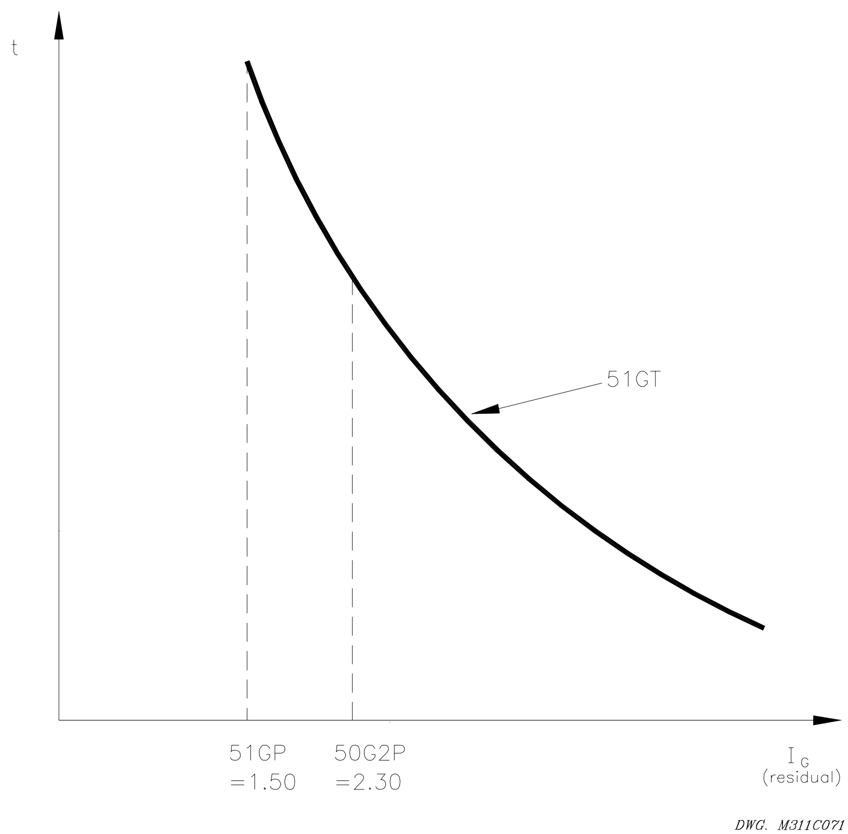

Figure 8.14: Raise Pickup of Residual Ground Time-Overcurrent Element for Unbalance Current

Residual Ground Demand Current Below Pickup GDEMP

When unbalance current I_G is low, unbalance demand current $I_{G(DEM)}$ is below corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM is deasserted to logical 0. This results in SELOGIC control equation torque control setting 51GTC being in the state:

51GTC = !GDEM + GDEM * 50G2 = NOT(GDEM) + GDEM * 50G2

= NOT(logical 0) + (logical 0) * 50G2 = logical 1

Thus, the residual ground time-overcurrent element 51GT operates on its standard pickup:

51GP = 1.50 A secondary

If a ground fault occurs, the residual ground time-overcurrent element 51GT operates with the sensitivity provided by pickup 51GP = 1.50 A secondary. The thermal demand meter, even with setting DMTC = 5 minutes, does not respond fast enough to the ground fault to make a change to the effective residual ground time-overcurrent element pickup—it remains at 1.50 A secondary. Demand meters respond to more "slow moving" general trends.

Residual Ground Demand Current Goes Above Pickup GDEMP

When unbalance current I_G increases, unbalance demand current $I_{G(DEM)}$ follows, going above corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM asserts to logical 1. This results in SELOGIC control equation torque control setting 51GTC being in the state:

51GTC = !GDEM + GDEM * 50G2 = NOT(GDEM) + GDEM * 50G2

= NOT(logical 1) + (logical 1) * 50G2 = logical 0 + 50G2 = 50G2

Thus, the residual ground time-overcurrent element 51GT operates with an effective, less-sensitive pickup:

50G2P = 2.30 A secondary

The reduced sensitivity keeps the residual ground time-overcurrent element 51GT from tripping on higher unbalance current I_G.

Residual Ground Demand Current Goes Below Pickup GDEMP Again

When unbalance current I_G decreases again, unbalance demand current $I_{G(DEM)}$ follows, going below corresponding demand pickup GDEMP = 1.00 A secondary, and Relay Word bit GDEM deasserts to logical 0. This results in SELOGIC control equation torque control setting 51GTC being in the state:

51GTC = !GDEM + GDEM * 50G2 = NOT(GDEM) + GDEM * 50G2

= NOT(logical 0) + (logical 0) * 50G2 = logical 1

Thus, the residual ground time-overcurrent element 51GT operates on its standard pickup again:

51GP = 1.50 A secondary

View or Reset Demand Metering Information

Via Serial Port

See ***MET Command (Metering Data)***, MET D—Demand Metering in ***Section 10: 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-311B 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.

Demand metering updating and 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*** subsection.

ENERGY METERING

View or Reset Energy Metering Information

Via Serial Port

See ***MET Command (Metering Data)***, MET E—Energy Metering in ***Section 10: 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-311B 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.

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: 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; $I_G = 3I_0 = I_A + I_B + I_C$)
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-311B 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.
- 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-311B 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.

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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	Distance, overcurrent and voltage elements, reclosing relay, timers, etc., for settings group *m* (*m* = 1, 2, 3, 4, 5, 6).	1–10
SET L *m*	Logic	SELOGIC® control equations for settings group *m* (*m* = 1, 2, 3, 4, 5, 6).	11–15
SET G	Global	Battery and breaker monitors, optoisolated input debounce timers, etc.	16–17
SET R	SER	Sequential Events Recorder trigger conditions.	18
SET T	Text	Front-panel default display and local control text.	19–22
SET P *m*	Port	Serial port settings for Serial Port *m* (*m* = 1, 2, 3, or F).	23

* 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**). See ***SHO Command (Showset)*** in ***Section 10: Serial Port Communications and Commands***.

SETTINGS CHANGES VIA THE FRONT PANEL

The relay front-panel SET pushbutton provides access to the Relay, Global, and Port settings only. Thus, the corresponding Relay, Global, and Port 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: 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, or P (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 or Text 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 Figures 3.17 through 3.19). The time-overcurrent relay curves in Figure 9.1 through Figure 9.10 conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

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

U.S. Moderately Inverse Curve: U1

$tp = TD \cdot (0.0226 + 0.0104/(M^{0.02}-1))$
$tr = TD \cdot (1.08/(1-M^2))$

U.S. Inverse Curve: U2

$tp = TD \cdot (0.180 + 5.95/(M^2-1))$
$tr = TD \cdot (5.95/(1-M^2))$

U.S. Very Inverse Curve: U3

$tp = TD \cdot (0.0963 + 3.88/(M^2-1))$
$tr = TD \cdot (3.88/(1-M^2))$

U.S. Extremely Inverse Curve: U4

$tp = TD \cdot (0.0352 + 5.67/(M^2-1))$
$tr = TD \cdot (5.67/(1-M^2))$

U.S. Short-Time Inverse Curve: U5

$tp = TD \cdot (0.00262 + 0.00342/(M^{0.02}-1))$
$tr = TD \cdot (0.323/(1-M^2))$

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

$tp = TD \cdot (0.14/(M^{0.02}-1))$
$tr = TD \cdot (13.5/(1-M^2))$

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

$tp = TD \cdot (13.5/(M-1))$
$tr = TD \cdot (47.3/(1-M^2))$

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

$tp = TD \cdot (80.0/(M^2-1))$
$tr = TD \cdot (80.0/(1-M^2))$

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

$tp = TD \cdot (120.0/(M-1))$
$tr = TD \cdot (120.0/(1-M))$

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

$tp = TD \cdot (0.05/(M^{0.04}-1))$
$tr = TD \cdot (4.85/(1-M^2))$

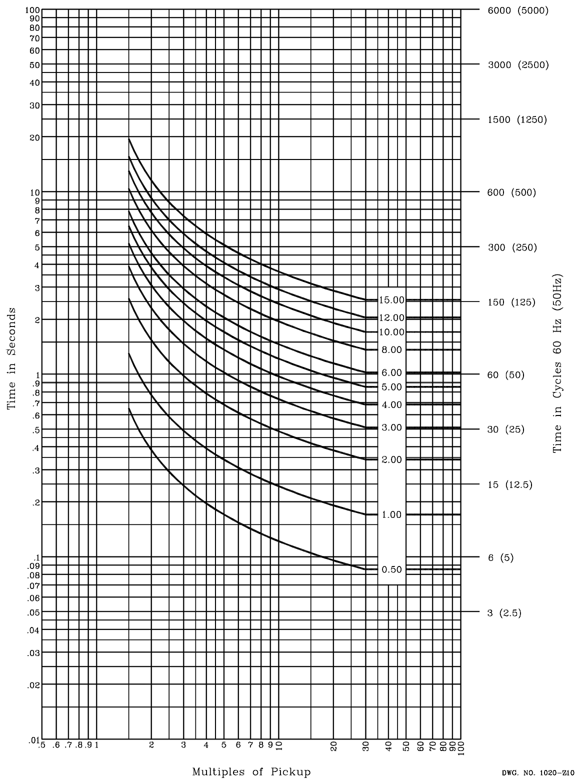

Figure 9.1: U.S. Moderately Inverse Curve: U1

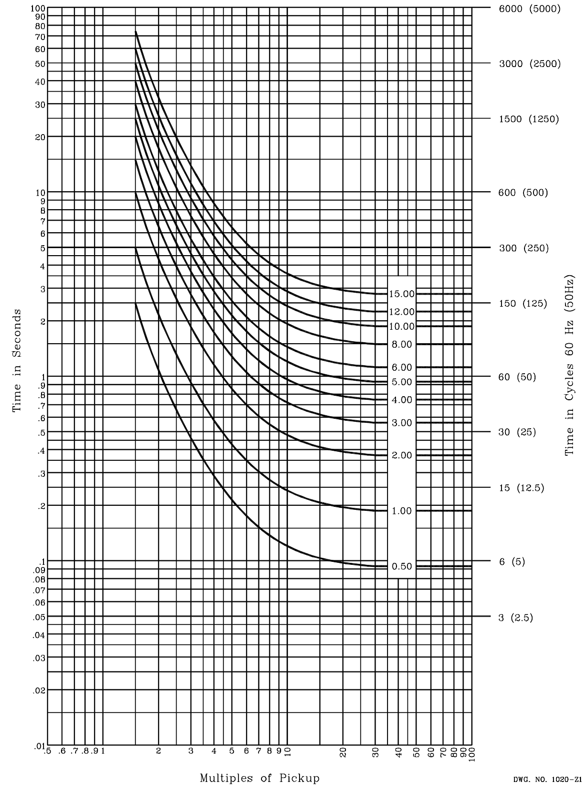

Figure 9.2: U.S. Inverse Curve: U2

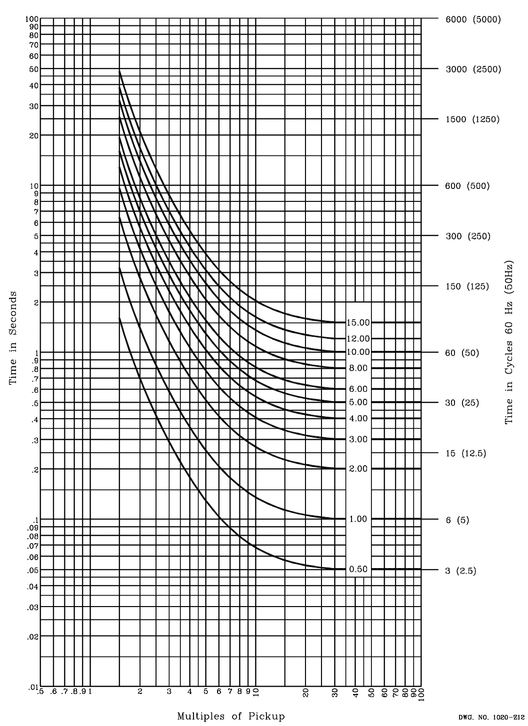

Figure 9.3: U.S. Very Inverse Curve: U3

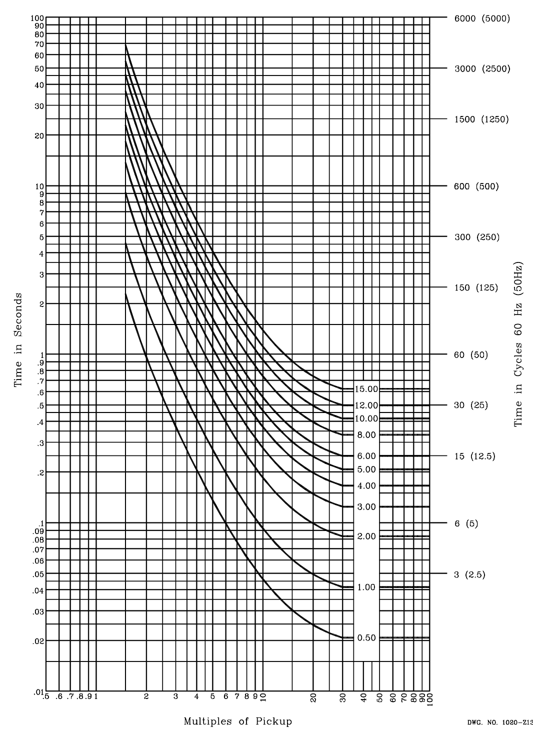

Figure 9.4: U.S. Extremely Inverse Curve: U4

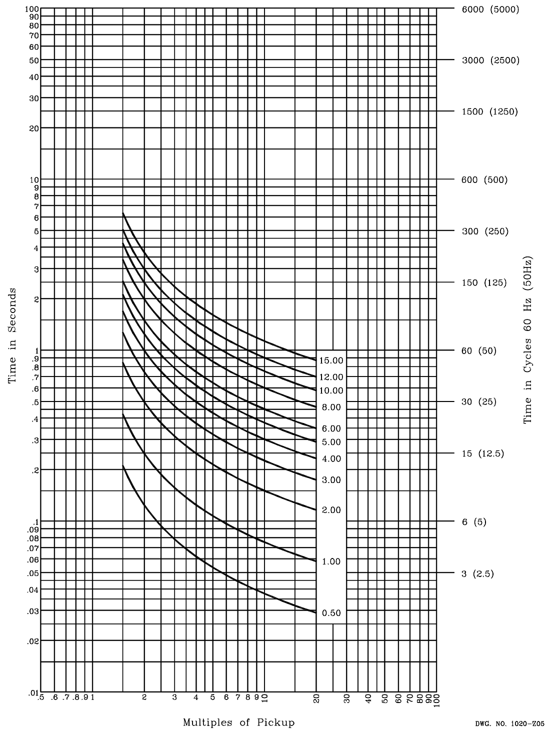

Figure 9.5: U.S. Short-Time Inverse Curve: U5

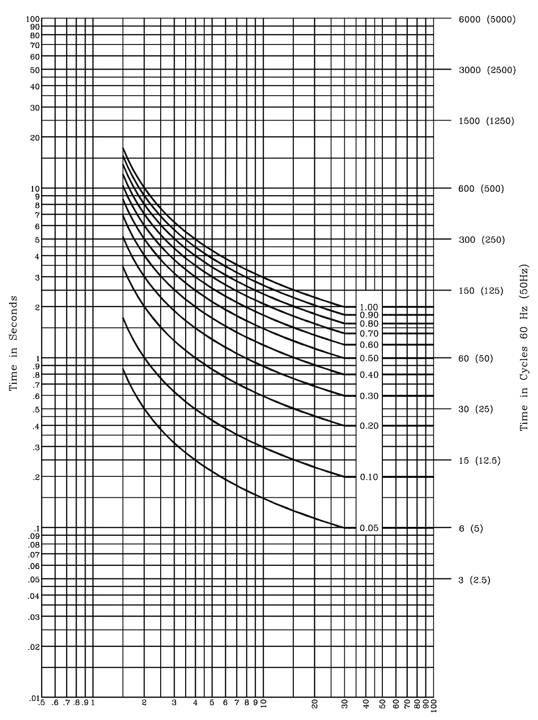

Figure 9.6: I.E.C. Class A Curve (Standard Inverse): C1

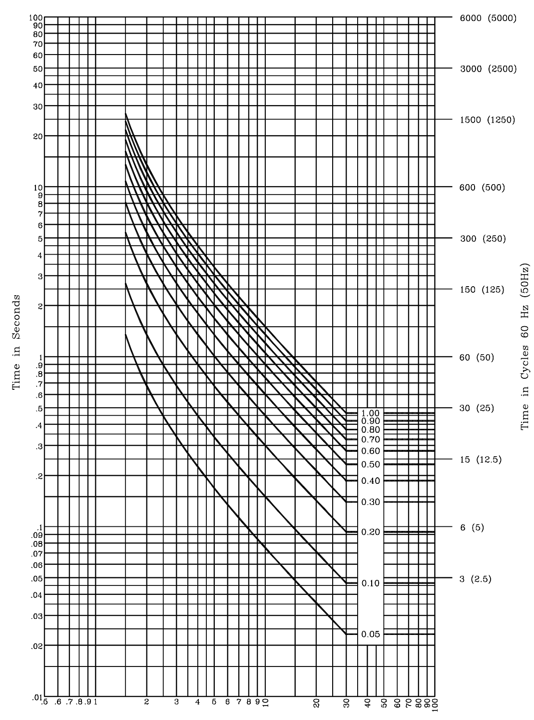

Figure 9.7: I.E.C. Class B Curve (Very Inverse): C2

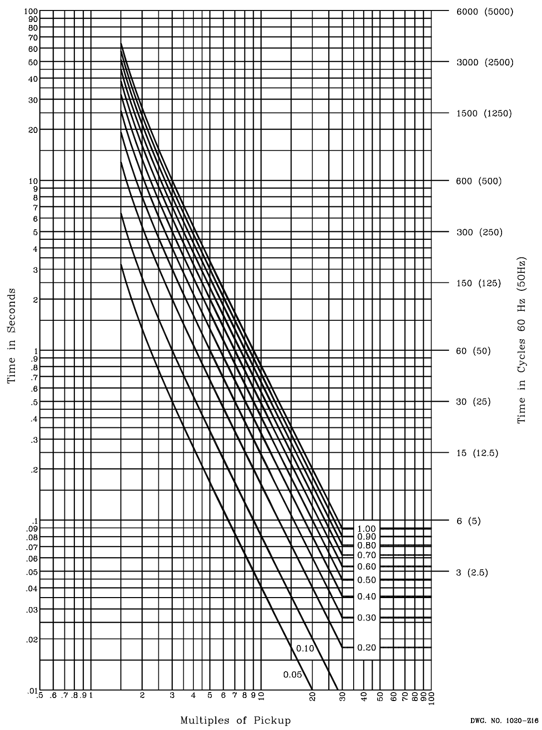

Figure 9.8: I.E.C. Class C Curve (Extremely Inverse): C3

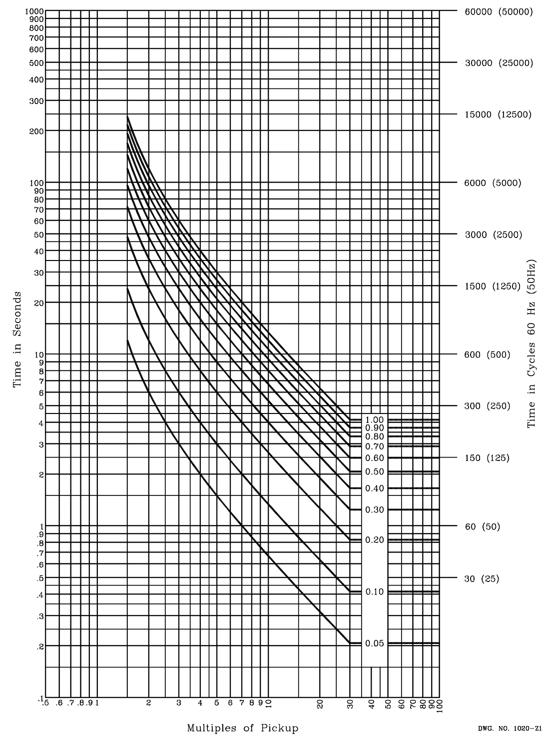

Figure 9.9: I.E.C. Long-Time Inverse Curve: C4

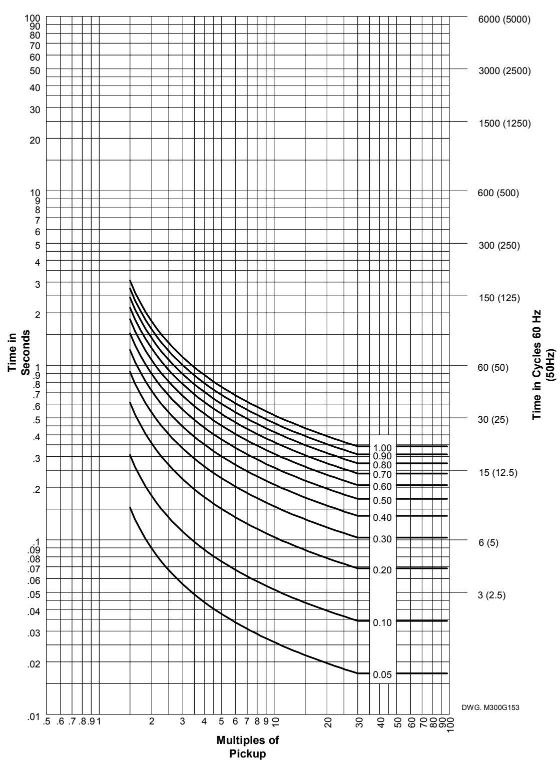

Figure 9.10: I.E.C. Short-Time Inverse Curve: C5

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: 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-311B Relay Word Bits

Row	Relay Word Bits							
0	EN	TRP	TIME	TARDT	SOTF	RCRS	RCCY	RCLO
1	A	B	C	G	ZONE1	ZONE2	ZONE3	51
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[1]
24	ALARM	OUT107	OUT106	OUT105	OUT104	OUT103	OUT102	OUT101[2]
25	M3P	M3PT	Z3G	Z3GT	*	*	*	*
26	Z3T	*	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	*	*	*	*	*	*	*	*
33	*	*	*	*	*	*	*	*

Row	Relay Word Bits							
34	*	*	*	*	*	*	*	*
35	*	*	*	*	*	*	*	*
36	*	*	*	*	MPP1	MABC1	MPP2	MABC2
37	50Q1	67Q1	67Q1T	50Q2	67Q2	67Q2T	*	*
38	50Q3	67Q3	67Q3T	*	*	*	*	*
39	51Q	51QT	51QR	*	*	*	*	*
40	*	*	*	*	*	*	*	*
41	*	*	*	*	*	*	*	*
42	27A	27B	27C	59A	59B	59C	3P27	3P59
43	27AB	27BC	27CA	59AB	59BC	59CA	*	*
44	*	*	*	*	*	*	*	*
45	*	*	*	*	MPP3	MABC3	*	*
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

1. See Figure 7.1 for more information on the operation of optoisolated inputs IN101 through IN106.
2. All output contacts can be "a" or "b" type contacts. See Figure 2.7 and Figure 7.26 for more information on the operation of output contacts OUT101 through ALARM.

Table 9.4: Relay Word Bit Definitions for the SEL-311B

Row	Bit	Definition	Primary Application
0	EN	Relay Enabled (see Table 5.1)	Target
	TRP	Relay Trip	
	TIME	Time Trip	
	TARDT	Direct Trip	
	SOTF	Switch-Onto-Fault Trip	
	RCRS	Recloser in Reset State	
	RCCY	Recloser in Cycle 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	

Row	Bit	Definition	Primary Application
	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	
	51	Time-Overcurrent Trip	
2	M1P	Zone 1 phase distance, instantaneous (see Figure 3.4)	Tripping, Control
	M1PT	Zone 1 phase distance, time delayed (see Figure 3.12)	
	Z1G	Zone 1 mho distance, instantaneous (see Figure 3.7)	
	Z1GT	Zone 1 ground distance, time delayed (see Figure 3.12)	
	M2P	Zone 2 phase distance, instantaneous (see Figure 3.5)	
	M2PT	Zone 2 phase distance, time delayed (see Figure 3.12)	
	Z2G	Zone 2 mho distance, instantaneous (see Figure 3.8)	
	Z2GT	Zone 2 ground distance, time delayed (see Figure 3.12)	
3	Z1T	Zone 1 phase and/or ground distance, time delayed (see Figure 3.12)	
	Z2T	Zone 2 phase and/or ground distance, time delayed (see Figure 3.12)	
	50P1	Level 1 phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P1P; see Figure 3.13)	
	67P1	Level 1 torque controlled phase instantaneous overcurrent element (derived from 50P1; see Figure 3.13)	
	67P1T	Level 1 phase definite-time overcurrent element 67P1T timed out (derived from 67P1; see Figure 3.13)	
	50G1	Level 1 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G1P; see Figure 3.16)	

Row	Bit	Definition	Primary Application
	67G1	Level 1 torque controlled residual ground instantaneous overcurrent element (derived from 50G1; see Figure 3.16)	
	67G1T	Level 1 residual ground definite-time overcurrent element 67G1T timed out (derived from 67G1; see Figure 3.16)	
4	51G	Residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see Figure 3.19)	Testing, Control
	51GT	Residual ground time-overcurrent element 51GT timed out (see Figure 3.19)	Tripping
	51GR	Residual ground time-overcurrent element 51GT reset (see Figure 3.16)	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
	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)	

Row	Bit	Definition	Primary Application
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)	
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)	

Row	Bit	Definition	Primary Application
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)	
	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)	

Row	Bit	Definition	Primary Application
	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)	
	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)	

Row	Bit	Definition	Primary Application
15	MAB1	Mho AB phase distance zone 1, instantaneous (see Figure 3.4)	Testing
	MBC1	Mho BC phase distance zone 1, instantaneous (see Figure 3.4)	
	MCA1	Mho CA phase distance zone 1, instantaneous (see Figure 3.4)	
	MAB2	Mho AB phase distance zone 2 instantaneous (see Figure 3.5)	
	MBC2	Mho BC phase distance zone 2, instantaneous (see Figure 3.5)	
	MCA2	Mho CA phase distance zone 2, instantaneous (see Figure 3.5)	
	CVTBL	CCVT transient blocking logic active (see Figure 4.5)	Indication, Testing
	SOTFT	Switch-onto-fault trip	
16	MAG1	Mho ground distance A-phase, zone 1 (see Figure 3.7)	Testing
	MBG1	Mho ground distance B-phase, zone 1 (see Figure 3.7)	
	MCG1	Mho ground distance C-phase, zone 1 (see Figure 3.7)	
	MAG2	Mho ground distance A-phase, zone 2 (see Figure 3.8)	
	MBG2	Mho ground distance B-phase, zone 2 (see Figure 3.8)	
	MCG2	Mho ground distance C-phase, zone 2 (see Figure 3.8)	
	DCHI	Station dc battery instantaneous overvoltage element (see Figure 8.9)	Indication
	DCLO	Station dc battery instantaneous undervoltage element (see Figure 8.9)	
17	BCW	BCWA + BCWB + BCWC	
	BCWA	A-phase breaker contact wear has reached 100% wear level (see ***Breaker Monitor*** in ***Section 8: Breaker Monitor and Metering Functions***)	
	BCWB	B-phase breaker contact wear has reached 100% wear level (see ***Breaker Monitor*** in ***Section 8: Breaker Monitor and Metering Functions***)	

Row	Bit	Definition	Primary Application
	BCWC	C-phase breaker contact wear has reached 100% wear level (see ***Breaker Monitor*** in ***Section 8: Breaker Monitor and Metering Functions***)	
	FIDEN	Fault Identification Logic Enabled	Internal control
	FSA	A-phase to ground or B-C phases to ground fault identification logic output used in distance element logic	
	FSB	B-phase to ground or A-C phases to ground fault identification logic output used in distance element logic	
	FSC	C-phase to ground or A-B phases to ground fault identification logic output used in distance element logic	
18	SG1	Setting group 1 active (see Table 7.3)	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: Serial Port Communications and Commands***)	Control
	CC	Asserts 1/4 cycle for Close Command execution (see ***CLO Command (Close Breaker)*** in ***Section 10: Serial Port Communications and Commands***)	
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 Figures 5.1 and 5.17)	
	52A	Circuit breaker status (asserts to logical 1 when circuit breaker is closed; see Figure 6.1)	
	3PO	Three pole open condition (see Figure 5.3)	
	SOTFE	Switch-onto-fault condition (see Figure 5.3)	

Row	Bit	Definition	Primary Application
	VPOLV	Positive-sequence polarization voltage valid (see Figures 3.4 through 3.9 and Figure 4.15)	Indication
	50L	Phase instantaneous overcurrent element for closed circuit breaker detection (any phase current above pickup setting 50LP; see Figure 5.3)	
20	PDEM	Phase demand current above pickup setting PDEMP (see Figure 8.13)	Indication
	GDEM	Residual ground demand current above pickup setting GDEMP (see Figure 8.13)	
	QDEM	Negative-sequence demand current above pickup setting QDEMP (see Figure 8.13)	
	TRIP	Trip logic output asserted (see Figure 5.1)	Output contact assignment
	50QF	Forward direction negative-sequence overcurrent threshold exceeded (see Figures 4.5, 4.6, and 4.14)	Directional threshold
	50QR	Reverse direction negative-sequence overcurrent threshold exceeded (see Figures 4.5, 4.6, and 4.14)	
	50GF	Forward direction residual ground overcurrent threshold exceeded (see Figures 4.5 and 4.7)	
	50GR	Reverse direction residual ground overcurrent threshold exceeded (see Figures 4.5 and 4.7)	
21	32QF	Forward directional control routed to phase-distance elements (see Figures 4.13 and 4.14)	Directional control
	32QR	Reverse directional control routed to phase-distance elements (see Figures 4.13 and 4.14)	
	32GF	Forward directional control routed to ground distance elements (see Figures 4.5 and 4.12)	
	32GR	Reverse directional control routed to ground distance elements (see Figures 4.5 and 4.12)	
	32VE	Enable for zero-sequence voltage-polarized directional element (see Figures 4.5 and 4.7)	
	32QGE	Enable for negative-sequence voltage-polarized directional element (see Figures 4.5 and 4.6)	
	32IE	Enable for channel IP current-polarized directional element (see Figures 4.5 and 4.7)	
	32QE	Enable for negative-sequence voltage-polarized directional element (see Figure 4.13 and Figure 4.14)	

Row	Bit	Definition	Primary Application
22	F32I	Forward channel IP current-polarized directional element (see Figures 4.5 and 4.11)	
	R32I	Reverse channel IP current-polarized directional element (see Figures 4.5 and 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 Figures 4.5 and 4.9)	
	R32QG	Reverse negative-sequence voltage-polarized directional element (see Figures 4.5 and 4.9)	
	F32V	Forward zero-sequence voltage-polarized directional element (see Figure 4.5 and 4.10)	
	R32V	Reverse zero-sequence voltage-polarized directional element (see Figure 4.5 and 4.10)	
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)	

Row	Bit	Definition	Primary Application
25	M3P	Zone 3 phase distance, instantaneous (see Figure 3.6)	Tripping, Control
	M3PT	Zone 3 phase distance, time delayed (see Figure 3.12)	
	Z3G	Zone 3 mho and/or quad. distance, instantaneous (see Figure 3.9)	
	Z3GT	Zone 3 ground distance, time delayed (see Figure 3.12)	
	*		
	*		
	*		
	*		
26	Z3T	Zone 3 phase and/or ground distance, time delayed (see Figure 3.12)	
	*		
	50P2	Level 2 Phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P2P; see Figure 3.13)	
	67P2	Level 2 torque controlled phase instantaneous overcurrent element (derived from 50P2; see Figure 3.13)	
	67P2T	Level 2 phase definite-time overcurrent element 67P2T timed out (derived from 67P2; see Figure 3.13)	
	50P3	Level 3 Phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P3P; see Figure 3.13)	
	67P3	Level 3 torque controlled phase instantaneous overcurrent element (derived from 50P3; see Figure 3.13)	
	67P3T	Level 3 phase definite-time overcurrent element 67P3T timed out (derived from 67P3; see Figure 3.13)	
27	50G2	Level 2 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G2P; see Figure 3.16)	
	67G2	Level 2 torque controlled residual ground instantaneous overcurrent element (derived from 50G2; see Figure 3.16)	

Row	Bit	Definition	Primary Application
	67G2T	Level 2 residual ground definite-time overcurrent element 67G2T timed out (derived from 67G2; see Figure 3.16)	
	50G3	Level 3 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G3P; see Figure 3.16)	
	67G3	Level 3 torque controlled residual ground instantaneous overcurrent element (derived from 50G3; see Figure 3.16)	
	67G3T	Level 3 residual ground definite-time overcurrent element 67G3T timed out (derived from 67G3; see Figure 3.16)	
	*		
	*		
28	51P	Maximum phase current above pickup setting 51PP for phase time-overcurrent element 51PT (see Figure 3.18)	Testing, Control
	51PT	Phase time-overcurrent element 51PT timed out (see Figure 3.18)	Tripping
	51PR	Phase time-overcurrent element 51PT reset (see Figure 3.18)	Testing
	Z1X	Zone 1 extension element picked up (see Figure 3.11)	Indication
	59VA	Channel VA voltage window element (channel VA voltage between threshold settings 25VLO and 25VHI; see Figure 3.24)	
	MAB3	Mho AB phase distance zone 3 instantaneous (see Figure 3.6)	Testing
	MBC3	Mho BC phase distance zone 3, instantaneous (see Figure 3.6)	
	MCA3	Mho CA phase distance zone 3, instantaneous (see Figure 3.6)	
29	MAG3	Mho ground distance A-phase, zone 3 (see Figure 3.9)	
	MBG3	Mho ground distance B-phase, zone 3 (see Figure 3.9)	
	MCG3	Mho ground distance C-phase, zone 3 (see Figure 3.9)	

Row	Bit	Definition	Primary Application
	27S	Channel VS instantaneous undervoltage element (channel VS voltage below pickup setting 27SP; see Figure 3.23)	Testing
	59S	Channel VS instantaneous overvoltage element (channel VS voltage above pickup setting 59SP; see Figure 3.23)	
	*		
	59VP	Phase voltage window element (selected phase voltage [VP] between threshold settings 25VLO and 25VHI; see Figure 3.24)	
	59VS	Channel VS voltage window element (channel VS voltage between threshold settings 25VLO and 25VHI; see Figure 3.24)	
30	SF	Slip frequency between voltages VP and VS less than setting 25SF (see Figure 3.24)	
	25A1	Synchronism check element (see Figure 3.25)	
	25A2	Synchronism check element (see Figure 3.25)	
	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: Close and Reclose Logic***)	
	RSTMN	Reset timer is timing (see ***Reclosing Relay* in *Section 6: Close and Reclose Logic***)	
	*		
	*		
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)	

Row	Bit	Definition	Primary Application
32–35	*		
36	*		
	*		
	*		
	*		
	MPP1	Zone 1 phase-to-phase compensator distance element (see Figure 3.4)	
	MABC1	Zone 1 three-phase compensator distance element (see Figure 3.4)	
	MPP2	Zone 2 phase-to-phase compensator distance element (see Figure 3.5)	
	MABC2	Zone 2 three-phase compensator distance element (see Figure 3.5)	
37	50Q1**	Level 1 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q1P; see Figure 3.17)	Tripping
	67Q1	Level 1 torque controlled negative-sequence instantaneous overcurrent element (derived from 50Q1; see Figure 3.17)	
	67Q1T	Level 1 torque controlled negative-sequence definite-time overcurrent element 67Q1T timed out (derived from 67Q1; see Figure 3.17)	
	50Q2**	Level 2 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q2P; see Figure 3.17)	
	67Q2	Level 2 torque controlled negative-sequence instantaneous overcurrent element (derived from 50Q2; see Figure 3.17)	
	67Q2T	Level 2 torque controlled negative-sequence definite-time overcurrent element 67Q2T timed out (derived from 67Q2; see Figure 3.17)	
	*		
	*		

Row	Bit	Definition	Primary Application
38	50Q3**	Level 3 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q3P; see Figure 3.17)	
	67Q3	Level 3 torque controlled negative-sequence instantaneous overcurrent element (derived from 50Q3; see Figure 3.17)	
	67Q3T	Level 3 torque controlled negative-sequence definite-time overcurrent element 67Q3T timed out (derived from 67Q3; see Figure 3.17)	
	*		
	*		
	*		
	*		
	*		
39	51Q**	Negative-sequence current above pickup setting 51QP for negative-sequence time-overcurrent element 51QT (see Figure 3.20)	Testing, Control
	51QT	Negative-sequence time-overcurrent element 51QT timed out (see Figure 3.20)	Tripping
	51QR	Negative-sequence time-overcurrent element 51QT reset (see Figure 3.20)	Testing
	*	Not used	
	*	Not used	
	*		
	*		
	*		
40–41	*		
42	27A	A-phase instantaneous undervoltage element (A-phase voltage below pickup setting 27P; see Figure 3.21)	Control
	27B	B-phase instantaneous undervoltage element (B-phase voltage below pickup setting 27P; see Figure 3.21)	
	27C	C-phase instantaneous undervoltage element (C-phase voltage below pickup setting 27P; see Figure 3.21)	

Row	Bit	Definition	Primary Application
	59A	A-phase instantaneous overvoltage element (A-phase voltage above pickup setting 59P; see Figure 3.21)	
	59B	B-phase instantaneous overvoltage element (B-phase voltage above pickup setting 59P; see Figure 3.21)	
	59C	C-phase instantaneous overvoltage element (C-phase voltage above pickup setting 59P; see Figure 3.21)	
	3P27	27A * 27B * 27C (see Figure 3.21)	
	3P59	59A * 59B * 59C (see Figure 3.21)	
43	27AB	AB phase-to-phase instantaneous undervoltage element (AB phase-to-phase voltage below pickup setting 27PP; see Figure 3.22)	
	27BC	BC phase-to-phase instantaneous undervoltage element (BC phase-to-phase voltage below pickup setting 27PP; see Figure 3.22)	
	27CA	CA phase-to-phase instantaneous undervoltage element (CA phase-to-phase voltage below pickup setting 27PP; see Figure 3.22)	
	59AB	AB phase-to-phase instantaneous overvoltage element (AB phase-to-phase voltage above pickup setting 59PP; see Figure 3.22)	
	59BC	BC phase-to-phase instantaneous overvoltage element (BC phase-to-phase voltage above pickup setting 59PP; see Figure 3.22)	
	59CA	CA phase-to-phase instantaneous overvoltage element (CA phase-to-phase voltage above pickup setting 59PP; see Figure 3.22)	
	*		
	*		
44	*		
45	*		
	*		
	*		
	*		
	MPP3	Zone 3 phase-to-phase compensator distance element (see Figure 3.6)	
	MABC3	Zone 3 three-phase compensator distance element (see Figure 3.6)	

Row	Bit	Definition	Primary Application
	*		
	*		
46	*		
47	RMB8A	Channel A, received bit 8	Relay-to-relay communication (see ***Appendix I: Mirrored Bits***)
	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	

Row	Bit	Definition	Primary Application
50	TMB8B	Channel B, transmit bit 8	
	TMB7B	Channel B, transmit bit 7	
	TMB6B	Channel B, transmit bit 6	
	TMB5B	Channel B, transmit bit 5	
	TMB4B	Channel B, transmit bit 4	
	TMB3B	Channel B, transmit bit 3	
	TMB2B	Channel B, transmit bit 2	
	TMB1B	Channel B, transmit bit 1	
51	LBOKB	Channel B, received data OK in loop back mode	
	CBADB	Channel B, channel unavailability over threshold	
	RBADB	Channel B, outage duration over threshold	
	ROKB	Channel B, received data OK	
	LBOKA	Channel A, received data OK in loop back mode	
	CBADA	Channel A, channel unavailability over threshold	
	RBADA	Channel A, outage duration over threshold	
	ROKA	Channel A, received data OK	

** **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

Refer to Settings Sheet 1.

The SEL-311B 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

Refer to Settings Sheet 1.

Phase and polarizing current transformer ratios are set independently.

Line Settings

Refer to Settings Sheet 1.

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

Refer to Settings Sheets 1, 2, and 17.

The enable settings on Settings Sheets 1 and 2 (E21P through EADVS) control the settings that follow, through Sheet 10. Enable setting, EBMON, on Settings Sheet 17 controls the settings that immediately follow it. This helps limit the number of settings that need to be made.

Each setting subgroup on Settings Sheets 2 through 10 has a reference back to the controlling enable setting. For example, the residual time-overcurrent element settings on Sheet 5 (settings 51GP through 51GRS) are controlled by enable setting E51G.

Other System Parameters

Refer to Settings Sheet 16.

The global settings NFREQ and PHROT allow you to configure the SEL-311B 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.

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-311B RELAY

RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

Identifier Labels (See *Settings Explanations* in *Section 9*)

Relay Identifier (30 characters) RID = ______________________

Terminal Identifier (30 characters) TID = ______________________

Current and Potential Transformer Ratios (See *Settings Explanations* in *Section 9*)

Phase (IA, IB, IC) Current Transformer Ratio (1–6000) CTR = __________

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 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 = __________

Application Settings (See *Section 14*)

Application (311B, 221F, 221F3, 221C, 221-16, 2PG10) APP = __________

Distance Settings

Mho phase distance element zones (N, 1–3, 1C–3C) (see Figures 3.4–3.6) E21P = __________

Mho ground distance element zones (N, 1–3) (see Figures 3.7–3.9) E21MG = __________

Instantaneous/Definite-Time Overcurrent Enable Settings

Phase element levels (N, 1–3) (see Figure 3.13) E50P = __________

Residual ground element levels (N, 1–3) (see Figure 3.16) E50G = __________

Negative-sequence element levels (N, 1–3) (see Figure 3.17) E50Q = __________

Time-Overcurrent Enable Settings

Phase element (Y, N) (see Figure 3.18) E51P = __________

Residual ground element (Y, N) (see Figure 3.19) E51G= __________

Negative-sequence element (Y, N) (see Figure 3.20) E51Q= __________

Other Enable Settings

Directional control (Y, AUTO) (see ***Directional Control Settings*** in ***Section 4***)	E32 = __________
Load encroachment (Y, N) (see Figure 4.3)	ELOAD = __________
Switch-onto-fault (Y, N) (see Figure 5.3)	ESOTF = __________
Voltage elements (Y, N) (see Figures 3.21, 3.22, 3.23, and 3.24)	EVOLT = __________
Synchronism check (Y, N) (see Figures 3.24 and 3.25)	E25 = __________
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 = __________
Reclosures (N, 1–4) (see ***Reclosing Relay*** in ***Section 6***)	E79 = __________
Zone 1 extension (Y, N) (see Figure 3.11)	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) (Set ELAT = N if no latches are required.)	ELAT = __________
SELOGIC display points (N, 1–16) (Set EDP = N if no latches are required.)	EDP = __________
Demand Metering (THM = Thermal; ROL = Rolling) (see Figure 8.11)	EDEM = __________
Advanced settings (Y, N)	EADVS = __________

Phase Distance Elements

(Number of mho phase distance element settings dependent on preceding enable setting E21P = 1–3, 1C–3C.)

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.3)	Z1P = __________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.4)	Z2P = __________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.5)	Z3P = __________

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 3.3)	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 3.4)	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 3.5)	50PP3 = __________

∗ Indicates a setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.

Mho Ground Distance Elements

(Number of mho ground distance element settings dependent on preceding enable setting E21MG = 1–3.)

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.7)	Z1MG = ________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.8)	Z2MG = ________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.9)	Z3MG = ________

Mho Ground Distance Fault Detector Settings

(Number of mho ground distance element settings dependent on the preceding enable settings E21MG = 1–3.)

Zone 1 phase current FD (0.5–100.00 A secondary{5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figure 3.7)	50L1 = ________
∗Zone 2 phase current FD (0.5–100.00 A secondary{5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figure 3.8)	50L2 = ________
∗Zone 3 phase current FD (0.5–100.00 A secondary{5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figure 3.9)	50L3 = ________
Zone 1 residual current FD (0.5–100.00 A secondary{5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figure 3.7)	50GZ1 = ________
∗Zone 2 residual current FD (0.5–100.00 A secondary{5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figure 3.8)	50GZ2 = ________
∗Zone 3 residual current FD (0.5–100.00 A secondary{5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figure 3.9)	50GZ3 = ________

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 and 3 ZSC factor magnitude (0.000–6.000 unitless)	k0M = ________
∗Zones 2 and 3 ZSC factor angle (-180.0° to +180.0°)	k0A = ________

Phase Distance Element Time Delays (See Figure 3.12)

(Number of mho phase distance element time delay settings dependent on preceding enable setting E21P = 1–3, 1C–3C.)

Zone 1 time delay (OFF, 0–16000 cycles)	Z1PD = ________
Zone 2 time delay (OFF, 0–16000 cycles)	Z2PD = ________
Zone 3 time delay (OFF, 0–16000 cycles)	Z3PD = ________

Mho Ground Distance Element Time Delays (See Figure 3.12)

(Number of time delay element settings dependent on the preceding enable settings E21MG = 1–3.)

Zone 1 time delay (OFF, 0–16000 cycles)	Z1GD = ________
Zone 2 time delay (OFF, 0–16000 cycles)	Z2GD = ________
Zone 3 time delay (OFF, 0–16000 cycles)	Z3GD = ________

Common Phase/Ground Distance Element Time Delay (See Figure 3.12)

(Number of time delay element settings dependent on the larger of preceding enable settings E21P = 1–3, 1C–3C or E21MG = 1–3.)

Zone 1 time delay (OFF, 0–16000 cycles)	Z1D = ________
Zone 2 time delay (OFF, 0–16000 cycles)	Z2D = ________
Zone 3 time delay (OFF, 0–16000 cycles)	Z3D = ________

Phase Inst./Def.-Time Overcurrent Elements (See Figure 3.13)

(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 3.13)

(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 3.16)

(Number of residual ground element pickup settings dependent on preceding enable setting E50G = 1–3.)

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 3.16)

(Number of residual ground element time delay settings dependent on preceding enable setting E50G = 1–3.)

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 = ___________

Negative-Sequence Inst./Def.-Time Overcurrent Elements (See Figure 3.17)*

(Number of negative-sequence element time delay settings dependent on preceding enable setting E50Q = 1–3)

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 = ___________

Negative-Sequence Definite-Time Overcurrent Element Time Delay (See Figure 3.17)*

(Number of negative-sequence element time delay settings dependent on preceding enable setting E50Q = 1–3.)

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 = ___________

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

Phase Time-Overcurrent Element (See Figure 3.18)

(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 3.19)

(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 3.20)*

(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.

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 Directional Control

Zone/Level 3 direction: Forward, Reverse (F, R)	DIR3 = ________

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 = ________

(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 3.21, 3.22, and 3.23)

(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 = __________

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 3.24 and 3.25)

(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 = __________

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 5.3)

(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 = __________

Zone 1 Extension Scheme Settings (See Figure 3.11)

(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 8.11 and 8.13)

(Make the following settings, whether preceding enable setting EDEM = THM or ROL.)

Time constant (5, 10, 15, 30, 60 minutes)	DMTC = __________
Phase pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})	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 5.1)	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 5.3)	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 5.3)	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 = __________

* Indicates a setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.

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 5.1)

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 5.3, 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 3.13)	67P1TC = ________________
Level 2 phase (see Figure 3.13)	67P2TC = ________________
Level 3 phase (see Figure 3.13)	67P3TC = ________________
Level 1 residual ground (see Figure 3.16)	67G1TC = ________________
Level 2 residual ground (see Figure 3.16)	67G2TC = ________________
Level 3 residual ground (see Figure 3.16)	67G3TC = ________________
Level 1 negative-sequence (see Figure 3.17)	67Q1TC = ________________
Level 2 negative-sequence (see Figure 3.17)	67Q2TC = ________________
Level 3 negative-sequence (see Figure 3.17)	67Q3TC = ________________

Torque Control Equations for Time-Overcurrent Elements

[Note: torque control equation settings cannot be set directly to logical 0]

Phase (see Figure 3.18)	51PTC = ____________
Residual Ground (see Figure 3.19)	51GTC = ____________
Negative-Sequence (see Figure 3.20)	51QTC = ____________

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 = ____________

Display Point Equations (See *Rotating Default Display* in *Section 7* and *11*)

Display Point DP1	DP1 = ____________
Display Point DP2	DP2 = ____________
Display Point DP3	DP3 = ____________
Display Point DP4	DP4 = ____________

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

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 3.24)	BSYNCH = ______________
Close bus monitor (see Figure 5.3)	CLMON = ______________
Breaker monitor initiation (see Figure 8.3)	BKMON = ______________
Enable for zero-sequence voltage-polarized and channel IP current-polarized directional elements (see Figure 4.7)	E32IV = ______________

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 = ______________

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

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 = ______________________

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, 180 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)
(1–179 cycles in 1-cycle steps for LER = 180)

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 (See Figure 7.1)

Input IN101 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN101D = __________

Input IN102 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN102D = __________

Input IN103 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN103D = __________

Input IN104 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN104D = __________

Input IN105 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN105D = __________

Input IN106 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN106D = __________

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-311B RELAY
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 = ____________

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-311B Relay
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 *Sections 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 = ________________

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-311 Relay Fast Operate commands.

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TABLES

FIGURES

SECTION 10: SERIAL PORT COMMUNICATIONS AND COMMANDS

INTRODUCTION

All SEL-311B Relay models have three EIA-232 ports (one front and two rear) and one rear EIA-485 port.

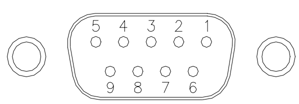
Connect the serial port to a computer serial port for local communications or to a modem for remote communications. Other devices useful for communications include the SEL-2020 and SEL-2030 Communications Processors, SEL-2505 Remote I/O Module, SEL-2100 Protection Logic Processor, and SEL-DTA2 Display 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.

PORT CONNECTOR AND COMMUNICATIONS CABLES



(female chassis connector, as viewed from outside)

Figure 10.1: DB-9 Connector Pinout for EIA-232 Serial Ports

IRIG-B

Refer to Figures 1.2, 2.2, and 2.3. Note that demodulated IRIG-B time code can be input into Serial Port 1 or Serial Port 2 on any of the SEL-311B Relay models. This is easily handled by connecting Serial Port 2 of the SEL-311B 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 10.1: 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 10.2: 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-311B 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-311B to Computer

Cable C234A

SEL-311B Relay 9-Pin Male “D” Subconnector	9-Pin *DTE Device 9-Pin Female “D” Subconnector
RXD 2	3 TXD
TXD 3	2 RXD
GND 5	5 GND
CTS 8	8 CTS
	7 RTS
	1 DCD
	4 DTR
	6 DSR

Cable C227A

SEL-311B Relay 9-Pin Male “D” Subconnector	25-Pin *DTE Device 25-Pin Female “D” Subconnector
GND 5	7 GND
TXD 3	3 RXD
RXD 2	2 TXD
GND 9	1 GND
CTS 8	4 RTS
	5 CTS
	6 DSR
	8 DCD
	20 DTR

SEL-311B to Modem or Other DCE

Cable C222

SEL-311B 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

SEL-311B to SEL-2020, SEL-2030, or SEL-2100

Cable C273A

SEL-2020/2030 or SEL-2100 9-Pin Male "D" Subconnector			SEL-311B Relay 9-Pin Male "D" Subconnector	
RXD	2	—	3	TXD
TXD	3	—	2	RXD
IRIG+	4	—	4	IRIG+
GND	5	—	5	GND
IRIG-	6	—	6	IRIG-
RTS	7	—	8	CTS
CTS	8	—	7	RTS

* DTE = Data Terminal Equipment (Computer, Terminal, Printer, etc.)
** DCE = Data Communications Equipment (Modem, etc.)

SEL-311B to SEL-DTA2

Cable C272A

SEL-DTA2 9-Pin Male "D" Subconnector			SEL-311B Relay 9-Pin Male "D" Subconnector	
RXD	2	—	3	TXD
TXD	3	—	2	RXD
GND	5	—	5	GND
RTS	7		7	RTS
CTS	8		8	CTS

SEL-311B to SEL-PRTU

Cable C231

SEL-PRTU 9-Pin Male Round Conxall			SEL-311B Relay 9-Pin Male "D" Subconnector	
GND	1	—	5	GND
TXD	2	—	2	RXD
RXD	4	—	3	TXD
CTS	5	—	7	RTS
+12	7	—	8	CTS
GND	9	—	9	GND

Table 10.3: 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-311B 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-311B Relay is compatible with the SEL-DTA2 Display Transducer Adapter. See Settings Sheet 23 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-311B 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 10.4.

Table 10.4: 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 DTA setting is Y, the AUTO setting is hidden and forced to Y. With DTA set to Y, the SEL-311B Relay is compatible with the SEL-DTA2 Display Transducer Adapter.

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 10.5. The commands can be accessed only from the corresponding access level as shown in Table 10.5. The access levels are:

Access Level 0 (the lowest access level)

Access Level 1

Access Level B

Access Level 2 (the highest access level)

Note: In this manual, commands you type appear in bold/uppercase: **OTTER**. 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 10.5). 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 10.5 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 10.5 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 10.5).

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 10.5 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 10.5).

Command Summary

Table 10.5 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 10.5. 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 10.5: Serial Port Command Summary

Access Level	Prompt	Serial Port Command	Command Description	Corresponding Front-Panel Pushbutton
0	=	ACC	Go to Access Level 1	
0	=	QUI	Quit to Access Level 0	
1	=>	2AC	Go to Access Level 2	
1	=>	BAC	Go to Access Level B	
1	=>	BRE	Breaker monitor data	OTHER
1	=>	COM	MIRRORED BITS communications statistics	
1	=>	DAT	View/change date	OTHER
1	=>	EVE	Event reports	
1	=>	GRO	Display active setting group number	GROUP
1	=>	HIS	Event summaries/histories	EVENTS
1	=>	INI	Display I/O configuration	
1	=>	IRI	Synchronize to IRIG-B	
1	=>	MET	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	
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	=>>	LOO	Loopback	
2	=>>	PAS	View/change passwords	SET
2	=>>	SET	Change settings	SET
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-311B                      Date: 08/18/00    Time: 16:15:39.372
EXAMPLE: BUS B, BREAKER 3
```

The definitions are:

SEL-311B:	This is the RID setting (the relay is shipped with the default setting RID =SEL-311B; see ***Identifier Labels*** in ***Section 9: Setting the Relay***).
BUS B, BREAKER 3:	This is the TID setting (the relay is shipped with the default setting TID = 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 10.5.

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 10.5.

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 2.4 for Password jumper information. See ***PAS Command (View/Change Passwords)*** explanation 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 is shipped with the default Access Level 1 password "OTTER". Enter the default password:

Password: ? **OTTER <ENTER>**

The relay responds:

```
SEL-311B                          Date: 08/18/00    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-311B                         Date: 08/18/00    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.

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-311B                         Date: 08/20/00    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 08/18/00 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.

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** command with the channel parameter (A or B).

```
=>COM A <ENTER>

SEL-311B                          Date: 08/22/00    Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311B-R100-V0-Z001001-D20000818       CID=F30B
Summary for Mirrored Bits channel A

For 08/18/00 18:36:09.279 to 08/21/00 18:36:11.746

    Total failures      1                  Last error  Relay Disabled
    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                  Loopback     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 L <ENTER>

SEL-311B                          Date: 08/22/00    Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311B-R100-V0-Z001001-D20000818       CID=F30B
Summary for Mirrored Bits channel A

For 08/18/00 17:18:12.993 to 08/21/00 18:37:36.123

    Total failures      4                  Last error  Relay Disabled
    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                  Loopback     0
    Bad Re-Sync         0

    Failure                Recovery
#   Date     Time          Date     Time          Duration  Cause
1   08/18/00 18:36:09.279  08/18/00 18:37:36.114     2.835  Relay Disabled
2   08/19/00 13:18:09.236  08/19/00 13:18:09.736     0.499  Parity error
3   08/20/00 11:43:35.547  08/20/00 11:43:35.637     0.089  Underrun
4   08/21/00 17:18:12.993  08/21/00 17:18:13.115     0.121  Relay Disabled

=>
```

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 10 L <ENTER>**. To select lines 10 through 20 of the COMM records for display in the report, type **COM 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 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 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 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 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.

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 August 1, 2000, enter when DATE_F = MDY:

```
=>DAT 8/1/00 <ENTER>
08/01/00
=>
```

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-311B                          Date: 08/22/00    Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

#     DATE      TIME      EVENT   LOCAT  CURR  FREQ GRP SHOT TARGETS

1  08/19/00 08:33:00.365 TRIG  $$$$$$$     1 60.00  3    2
2  08/20/00 20:32:58.361 ER    $$$$$$$   231 60.00  2    2
3  08/21/00 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 10.6: 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 DT SOTF 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-311B                      Date: 08/18/00    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)

The **MET** commands provide access to the relay metering data. Metered quantities include phase voltages and currents, sequence component voltages and currents, power, frequency, substation battery voltage, energy, demand, and maximum/minimum logging of selected quantities. To make the extensive amount of meter information manageable, the relay divides the displayed information into four groups: Instantaneous, Demand, Energy, and Maximum/Minimum.

MET *k*—Instantaneous Metering

The **MET *k*** command displays instantaneous magnitudes (and angles if applicable) of the following quantities:

Currents	$I_{A,B,C,P}$	Input currents (A primary)
	I_G	Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C,S}$	Wye-connected voltage inputs (kV primary)
Power	$MW_{A,B,C}$	Single-phase megawatts
	MW_{3P}	Three-phase megawatts
	$MVAR_{A,B,C}$	Single- and three-phase megavars
	$MVAR_{3P}$	Three-phase megavars
Power Factor	$PF_{A,B,C,3P}$	Single- and three-phase power factor; leading or lagging
Sequence	I_1, $3I_2$, $3I_0$	Positive-, negative-, and zero-sequence currents (A primary)
	V_1, V_2	Positive- and negative-sequence voltages (kV primary)
	$3V_0$	Zero-sequence voltage (kV primary)
Frequency	FREQ (Hz)	Instantaneous power system frequency (measured on voltage channel VA)
Station DC	VDC (V)	Voltage at POWER terminals (input into station battery monitor)

The angles are referenced to the A-phase voltage if it is greater than 13 V secondary; otherwise, the angles are referenced to A-phase current. The angles range from -179.99 to 180.00 degrees.

To view instantaneous metering values, enter the command:

=>**MET *k* <ENTER>**

where *k* is an optional parameter to specify the number of times (1–32767) to repeat the meter display. If *k* is not specified, the meter report is displayed once. The output from an SEL-311B Relay is shown:

```
=>MET <ENTER>

SEL-311B                          Date: 08/18/00    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-311B Relay is shown:

```
=>MET D <ENTER>

SEL-311B                          Date: 08/22/00    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 08/18/00 15:31:51.238   LAST PEAK RESET 008/18/00 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-311B Relay is shown:

```
=>MET E <ENTER>

SEL-311B                 Date: 08/22/00    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 08/18/00 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-311B Relay is shown:

```
=>MET M <ENTER>

SEL-311B                          Date: 08/22/00    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3
           Max    Date      Time             Min    Date      Time
IA(A)      196.8  08/10/00  15:00:42.574     30.0  08/10/00  14:51:02.391
IB(A)      195.0  08/10/00  15:05:19.558     31.8  08/10/00  14:50:55.536
IC(A)      200.4  08/10/00  15:00:42.578     52.2  08/10/00  14:51:02.332
IP(A)       42.6  08/10/00  14:51:02.328     42.6  08/10/00  14:51:02.328
IG(A)       42.0  08/10/00  14:50:55.294     42.0  08/10/00  14:50:55.294
VA(kV)      11.7  08/10/00  15:01:01.576      3.4  08/10/00  15:00:42.545
VB(kV)      11.7  08/10/00  15:00:42.937      2.4  08/10/00  15:00:42.541
VC(kV)      11.7  08/10/00  15:00:42.578      3.1  08/10/00  15:00:42.545
VS(kV)      11.7  08/10/00  15:01:01.576      3.4  08/10/00  15:00:42.545
MW3P         6.9  08/10/00  15:00:44.095      0.4  08/10/00  15:00:42.545
MVAR3P       1.0  08/10/00  15:00:42.578      0.1  08/10/00  15:00:42.545
LAST RESET 08/18/00 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-311B                    Date: 08/18/00    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 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.

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-311B Relay showing all the **factory default settings**.

```
=>SHO <ENTER>
Group 1

Group Settings:
RID   =SEL-311B                       TID   =EXAMPLE: BUS B, BREAKER 3
CTR   = 200
CTRP  = 200      PTR   = 2000.00  PTRS  = 2000.00
Z1MAG = 7.80     Z1ANG = 84.00
Z0MAG = 24.80    Z0ANG = 81.50    LL    = 100.00   APP   = 311B
E21P  = 3        E21MG = 3
E50P  = 1        E50G  = N        E50Q  = N
E51P  = N        E51G  = Y        E51Q  = Y
E32   = AUTO     ELOAD = Y        ESOTF = Y
EVOLT = N        E25   = N        EFLOC = Y
ELOP  = Y        E79   = N        EZ1EXT= N
ECCVT = N        ESV   = N        ELAT  = 16       EDP   = 16
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
50L1  = 0.50

Press RETURN to continue
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
ORDER = QVI
CLOEND= OFF      52AEND= 10.00    SOTFD = 30.00
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
TRSOTF=M2P + Z2G + 50P1
DTT   =0
ULTR  =!(50L + 51G)
52A   =IN101
CL    =CC
ULCL  =TRIP
SET1  =0
RST1  =0
SET2  =0
RST2  =0
SET3  =0
RST3  =0
SET4  =0
RST4  =0
SET5  =0
RST5  =0

Press RETURN to continue
SET6  =0
RST6  =0
SET7  =0
RST7  =0
SET8  =0
RST8  =0
SET9  =0
RST9  =0
SET10 =0
RST10 =0
SET11 =0
RST11 =0
SET12 =0
RST12 =0
SET13 =0
RST13 =0
SET14 =0
RST14 =0
SET15 =0
RST15 =0

Press RETURN to continue
SET16 =0
RST16 =0
67P1TC=1
51GTC =1
51QTC =1
OUT101=TRIP
OUT102=TRIP
OUT103=CLOSE
OUT104=0
OUT105=0
OUT106=0
OUT107=0
DP1   =52A
DP2   =0
DP3   =0
DP4   =0
DP5   =0
DP6   =0
DP7   =0
DP8   =0
```

```
Press RETURN to continue
DP9   =0
DP10  =0
DP11  =0
DP12  =0
DP13  =0
DP14  =0
DP15  =0
DP16  =0
SS1   =0
SS2   =0
SS3   =0
SS4   =0
SS5   =0
SS6   =0
ER    =/M2P + /Z2G + /51G + /51Q + /50P1 + /LOP
FAULT =51G + 51Q + M2P + Z2G
BSYNCH=0
CLMON =0
E32IV =1

=>
```

```
=>SHO G <ENTER>

Global Settings:
TGR   = 180.00   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  = Y        RTSCTS= N        FASTOP= N

=>
```

```
=>SHO R <ENTER>

Sequential Events Recorder trigger lists:
SER1  =M1P,Z1G,M2P,Z2G,M3P,Z3G,51G,51Q,50P1
SER2  =IN101,IN102,OUT101,OUT102,OUT103,LOP
SER3  =0

=>
```

```
=>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 =                 DP2_0 =
DP3_1 =                 DP3_0 =
DP4_1 =                 DP4_0 =
DP5_1 =                 DP5_0 =
DP6_1 =                 DP6_0 =
DP7_1 =                 DP7_0 =
DP8_1 =                 DP8_0 =
DP9_1 =                 DP9_0 =
DP10_1=                 DP10_0=
DP11_1=                 DP11_0=
DP12_1=                 DP12_0=
DP13_1=                 DP13_0=
DP14_1=                 DP14_0=
DP15_1=                 DP15_0=
DP16_1=                 DP16_0=
79LL  =              79SL  =

=>
```

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-311B Relay with wye-connected voltage inputs and no extra I/O board is shown:

```
=>STA <ENTER>

SEL-311B                          Date: 08/18/00    Time: 16:46:08.998
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311B-R100-V0-Z001001-D20000818       CID=F30B

SELF TESTS

W=Warn    F=Fail

       IA      IB      IC      IP      VA      VB      VC      VS      MOF
OS     1       0       0      -1       1      -1       1       0      -1

       +5V_PS  +5V_REG -5V_REG +12V_PS -12V_PS +15V_PS -15V_PS
PS      4.92    4.98   -5.02    11.87  -11.98   14.89  -14.95

       TEMP    RAM     ROM     A/D     CR_RAM  EEPROM  IO_BRD
        28.1   OK      OK      OK      OK      OK      N/A

Relay Enabled

=>
```

STA Command Row and Column Definitions

FID FID is the firmware identifier string. It identifies the firmware revision.

CID CID is the firmware checksum identifier.

OS OS = Offset; displays measured dc offset voltages in millivolts for the current and voltage channels. The MOF (master) status is the dc offset in the A/D circuit when a grounded input is selected.

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.

IO_BRD N/A

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 and Troubleshooting*** for self-test thresholds (in Table 13.1) 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 10.7. 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* (0–51). *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, DT, SOTF, 51, A, B, C, G, Zone 1, Zone 2, and Zone 3. Unlatches the trip logic for testing purposes (see Figure 5.1). Shows Relay Word Row 0.

Table 10.7: SEL-311B Relay Word and Its Correspondence to TAR Command

TAR 0 (Front-Panel LEDs)	EN	TRIP	TIME	TARDT	SOTF	RS	CY	LO
TAR 1 (Front-Panel LEDs)	A	B	C	G	ZONE1	ZONE2	ZONE3	51

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-311B                          Date: 08/18/00    Time: 10:12:45.627
EXAMPLE: BUS B, BREAKER 3

Event: TRIG      Location: $$$$$$$             Trip Time: --:--:--.---
#: 00002  Shot:    Freq:  60.00  Group: 1     Close Time: --:--:--.---
Targets:                                                    Breaker: Open

PreFault:     IA     IB     IC     IP     IG    3I2       VA       VB       VC
MAG(A/kV)    200    199    199      1      2      0  131.420  131.560  131.460
ANG(DEG)    0.25-120.22 119.50  85.96  40.96   5.96     0.00  -120.14   119.87
Fault:
MAG(A/kV)    200    199    199      1      2      0  131.420  131.560  131.460
ANG(DEG)    0.25-120.22 119.50  85.96  40.96   5.96     0.00  -120.14   119.87

                                                 L C R     L C R
                                                 B B B R   B B B R
                                                 O A A O   O A A O
                                                 K D D K   K D D K
MB:8->1    RMBA      TMBA      RMBB      TMBB    A A A A   B B B B

  TRIG  00000000  00000000  00000000  00000000   0 0 0 0   0 0 0 0
  TRIP  00000000  00000000  00000000  00000000   0 0 0 0   0 0 0 0

=>
```

See ***Section 12: Standard Event Reports and SER*** for more information on event reports.

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 monitor data.

```
==>BRE W <ENTER>
Breaker Wear Preload

Internal Trips (0-65000)          ITRIP   =     0      ? 11 <ENTER>
Internal Current (0.00-99999 kA)  IA      = 0.00       ? 40.7 <ENTER>
                                  IB      = 0.00       ? 40.8 <ENTER>
                                  IC      = 0.00       ? 40.8 <ENTER>

External Trips (0-65000)          EXTRIP  =     0      ? 3 <ENTER>
External Current (0.00-99999 kA)  IA      = 0.00       ? 0.8 <ENTER>
                                  IB      = 0.00       ? 0.9 <ENTER>
                                  IC      = 0.00       ? 1.1 <ENTER>

Percent Wear (0-100%)             A-phase = 0          ? 25 <ENTER>
                                  B-phase = 0          ? 28 <ENTER>
                                  C-phase = 0          ? 24 <ENTER>
Are you sure (Y/N) ? Y <ENTER>
```

```
SEL-311B                          Date: 09/24/01    Time: 12:22:21.506
EXAMPLE: BUS B, BREAKER 3

Rly Trips=     11
 IA=     40.7 IB=     40.7 IC=     40.7 kA

Ext Trips=      3
 IA=      0.8 IB=      0.8 IC=      1.1 kA

Percent wear: A=  25 B=  28 C=  24

LAST RESET 00/00/00 00:00:00
==>
```

Use the **BRE R** command to reset the breaker monitor:

```
==>BRE R <ENTER>

Reset Trip Counters and Accumulated Currents/Wear
Are you sure (Y/N) ? Y <ENTER>

SEL-311B                          Date: 08/22/00    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 08/18/00 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 2.4). 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 *n*** command changes the active setting group to setting Group *n*. To change to settings Group 2, enter the following:

```
==>GRO 2 <ENTER>
Change to Group 2
Are you sure (Y/N) ? Y <ENTER>
 Changing
Active Group = 2
==>
```

The relay switches to Group 2 and pulses the ALARM contact. If the serial port AUTO setting = Y, the relay sends the group switch report:

```
==>
SEL-311B                          Date: 08/18/00    Time: 10:12:45.627
EXAMPLE: BUS B, BREAKER 3

Active Group = 2
==>
```

If any of the SELOGIC control equation settings SS1 through SS6 are asserted to logical 1, the active setting group may not be change with the **GRO** command. SELOGIC control equations settings SS1 through SS6 have priority over the **GRO** command in active setting group control.

For example, assume setting Group 1 is the active setting group and the SS1 setting is asserted to logical 1 (e.g., SS1 = IN101 and optoisolated input IN101 is asserted). An attempt to change to setting Group 2 with the **GRO 2** command will not be accepted:

```
==>GRO 2 <ENTER>
No group change (see manual)
Active Group = 1
==>
```

For more information on setting group selection, see ***Multiple Setting Groups*** 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 5.1.

See the discussion following Figure 5.2 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 2.4). 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—see Figure 7.26.
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 2.4). 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 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 (see Rows 7 and 8 in Table 9.3). 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 10.8).

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 10.8: SEL-311B 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 (Loopback)

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
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)

PAS allows you to inspect or change existing passwords. To inspect passwords, type:

```
=>>PAS <ENTER>
1:OTTER
B:EDITH
2:TAIL
=>>
```

The above listings are the **factory default passwords** for Access Levels 1, B, and 2. To change the password for Access Level 1 to BIKE, enter the following:

```
=>>PAS 1 BIKE <ENTER>
Set
=>>
```

After entering new passwords, type **PAS <ENTER>** to inspect them. Make sure they are what you intended, and record the new passwords.

Passwords may include up to six characters. Valid characters consist of: 'A-Z', 'a-z', '0-9', '-', and '.'. Upper- and lower-case letters are treated as different characters. Examples of valid, distinct passwords include:

OTTER otter Ot3456 TAIL 123456 12345. 12345-

If the passwords are lost or you wish to operate the relay without password protection, put the main board Password jumper in place (Password jumper = ON). Refer to Table 2.4 for Password jumper information.

If you wish to disable password protection for a specific access level (even if Password jumper is not in place [Password jumper = OFF]), simply set the password to DISABLE. For example, **PAS 1 DISABLE** disables password protection for Level 1.

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***.

SEL-311B Relay Command Summary

Access Level 0 Command	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.
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).
COM *p* L	Show a long format communications summary report for all events on MIRRORED BITS™ Channel *p*.
COM *p n*	Show a communications summary for latest *n* events on MIRRORED BITS Channel *p*.
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS Channel *p*.
COM *p d1*	Show a communications summary report for events occurring on date *d1* on MIRRORED BITS Channel *p*.
COM *p d1 d2*	Show a communications summary report for events occurring between dates *d1* and *d2* on MIRRORED BITS Channel *p*. Entry of dates is dependent on the Date Format setting DATE_F (=MDY or YMD).
COM C *p*	Clears the communications summary report for Channel *p*.
DAT	Show date.
DAT m/d/y	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT y/m/d	Enter date in this manner if Date Format setting DATE_F = YMD.
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 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.
INI	Displays input/output contact information.
INI T	Displays I/O contact information and I/O board type.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET *k*	Display instantaneous metering data. 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 51, display row n. If *n* is an element name (e.g., 50P1) 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) 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*.
LOO	Set MIRRORED BITS port to loopback.
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.
STA C	Resets self-test warnings/failures and reboots relay.
VER	Displays version and configuration information.

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FIGURES

SECTION 11: FRONT-PANEL INTERFACE (ONLY ON MODELS WITH LCD)

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.

Note: This section only applies to SEL-311B Relay models with an LCD. Disregard this section for relays ordered with Targets Only (no LCD).

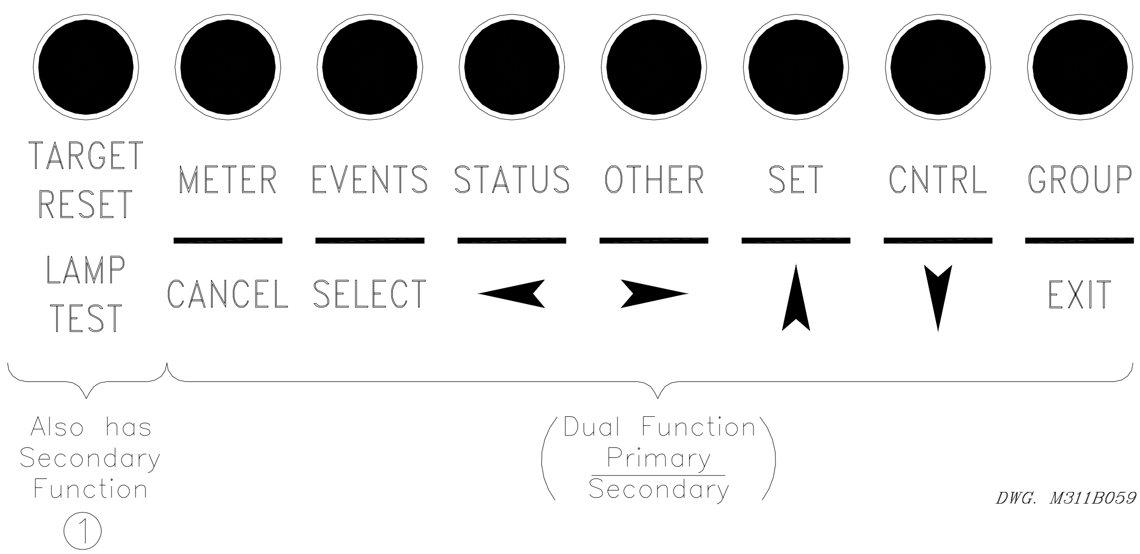
FRONT-PANEL PUSHBUTTON OPERATION

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 (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 Settings Sheet 16 at the end of ***Section 9: Setting the Relay***; the relay is shipped with FP_TO = 15 minutes).



① See Figure 11.4

Figure 11.1: SEL-311B 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: 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***.

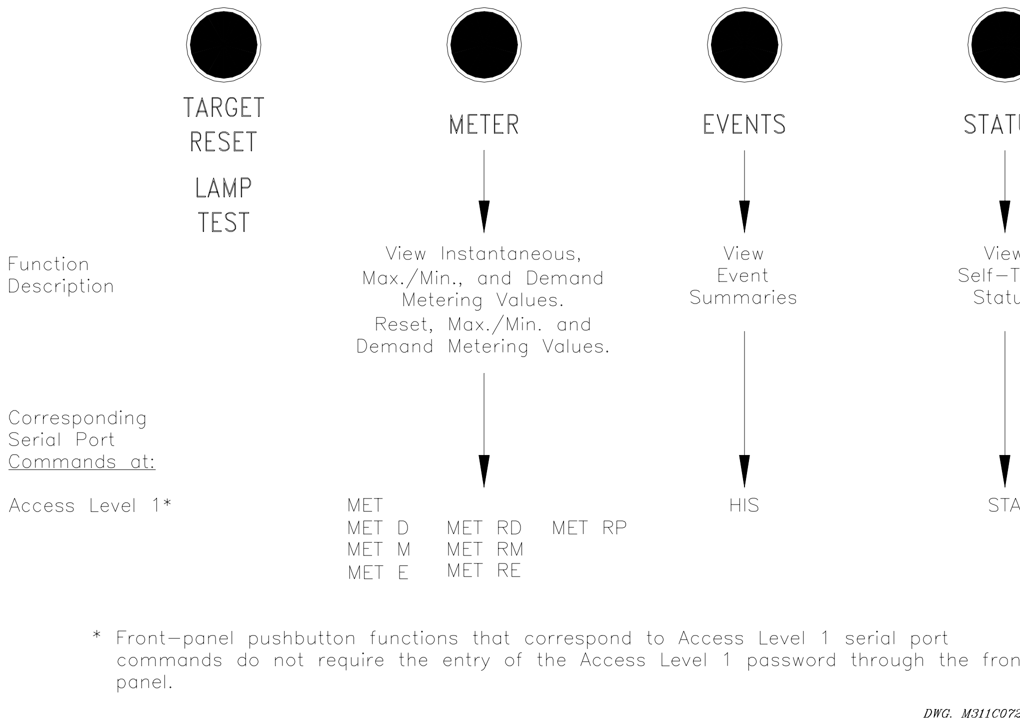


Figure 11.2: SEL-311B Relay Front-Panel Pushbuttons—Primary Functions

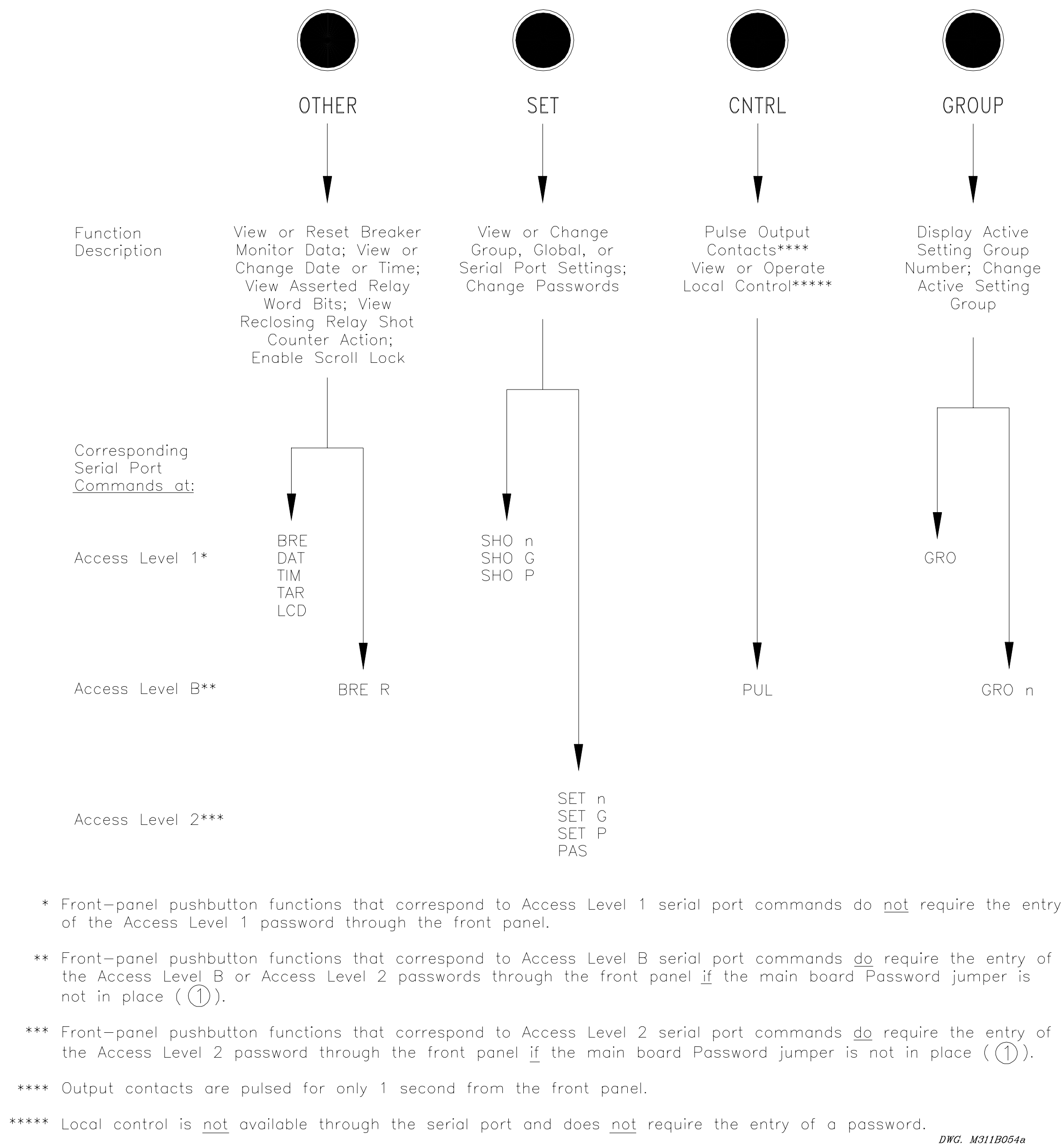
Front-Panel Password Security

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 more information on 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.

The factory default passwords for Access Level 1, B, and 2 are:

Access Level	Factory Default Password
1	OTTER
B	EDITH
2	TAIL



① See Table 2.4

Figure 11.3: SEL-311B 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).

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).

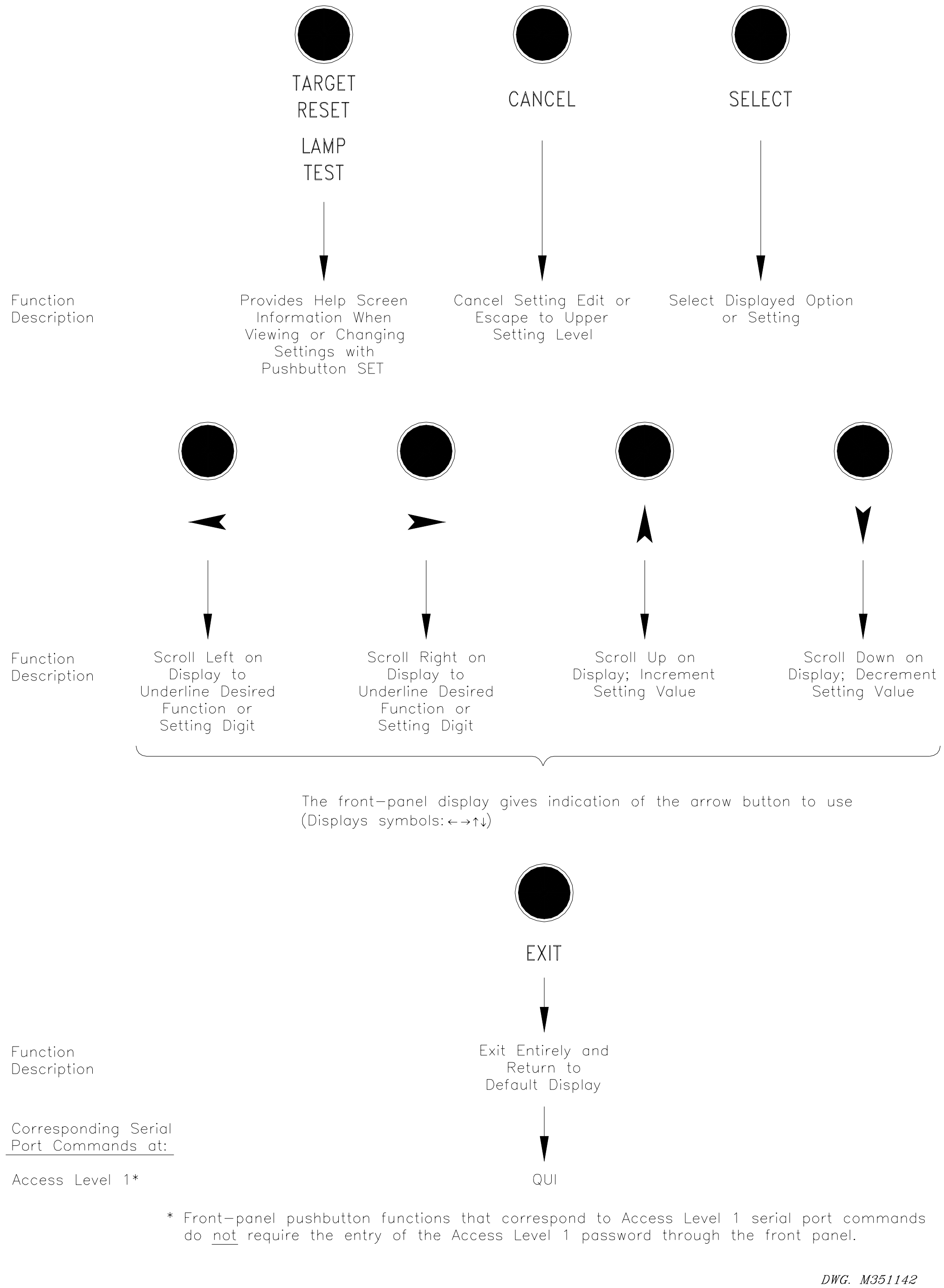


Figure 11.4: SEL-311B Relay Front-Panel Pushbuttons—Secondary Functions

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 the reclosing relay doesn’t exist (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: 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 (front-panel CY LED illuminated). 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 Rows 5 and 6 in Table 9.3 and Table 9.4).

Local control can emulate the following switch types in Figure 11.5 through Figure 11.7.

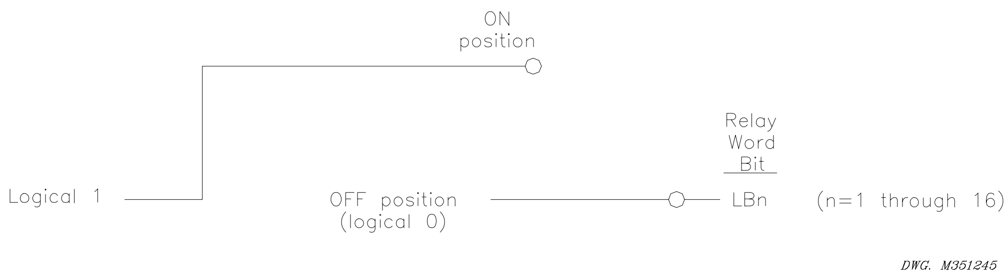


Figure 11.5: Local Control Switch Configured as an ON/OFF Switch

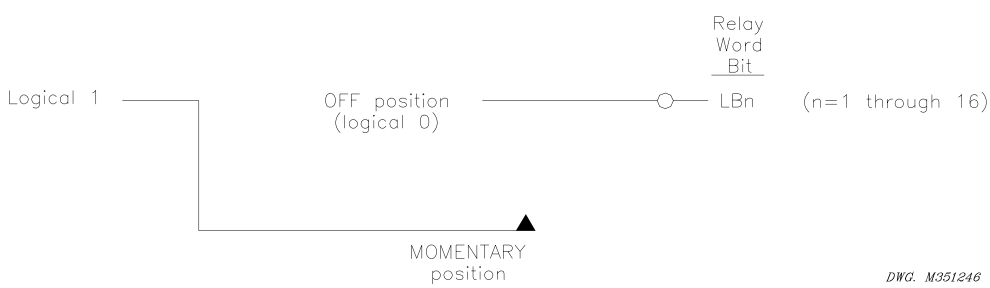


Figure 11.6: Local Control Switch Configured as an OFF/MOMENTARY Switch

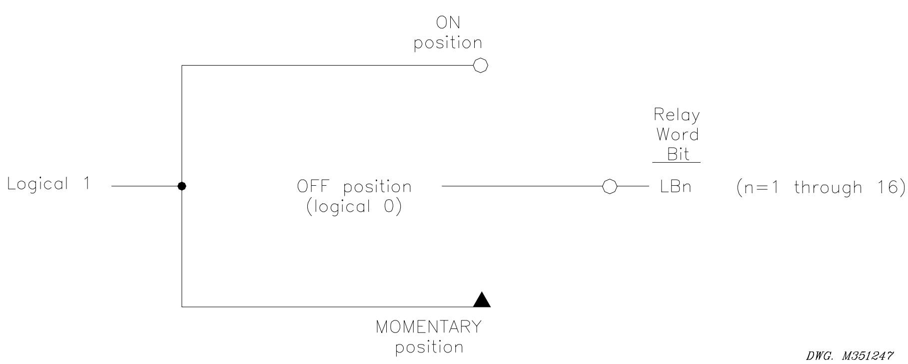


Figure 11.7: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

Local control switches are created by making corresponding switch position label settings. These text label settings are set with the **SET T** command or viewed with the **SHO T** command via the serial port (see ***Section 9: Setting the Relay*** and ***SHO Command [Show/View Settings]*** in ***Section 10: 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.

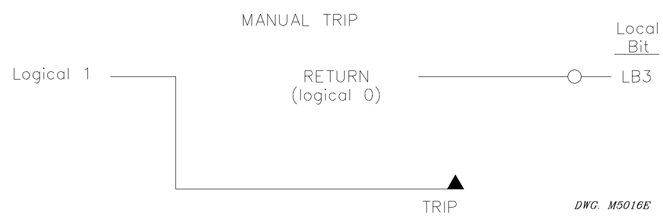
```
Press CNTRL for
Local Control
```

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

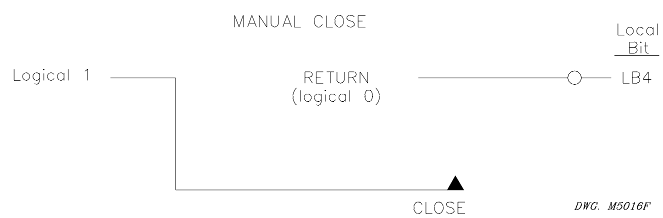
Press the CNTRL pushbutton, and the first set local control switch displays

```
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:

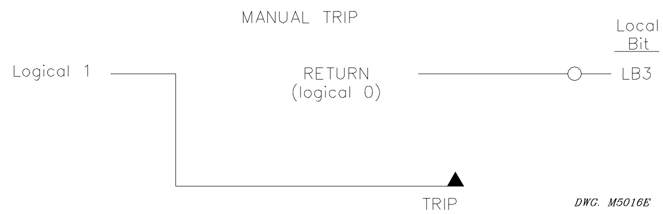
```
Output Contact ←→
Testing
```

This front-panel function provides the same function as the serial port **PUL** command (see Figure 11.3).

Operate Local Control (with Example Settings)

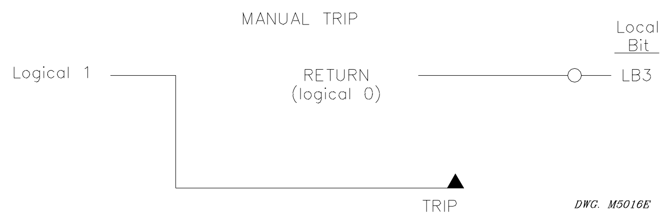
Press the right arrow pushbutton, and scroll back to the first set local control switch in the example settings:

```
MANUAL TRIP   ←→
Position:  RETURN
```



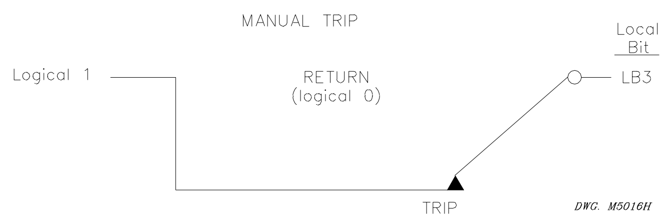
Press the SELECT pushbutton, and the operate option for the displayed local control switch displays:

```
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:

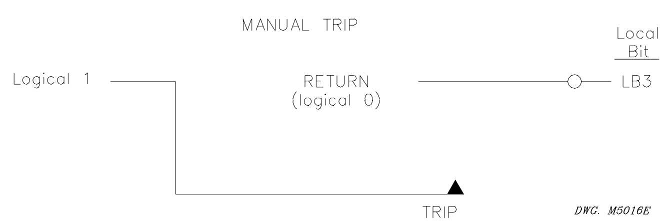
```
MANUAL TRIP
Position:  TRIP
```



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
```



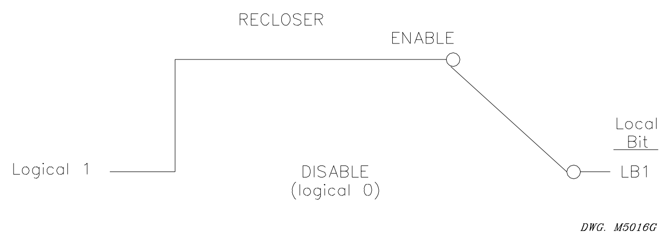
The MANUAL CLOSE switch is an OFF/MOMENTARY type switch, like the MANUAL TRIP switch, and operates similarly.

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.

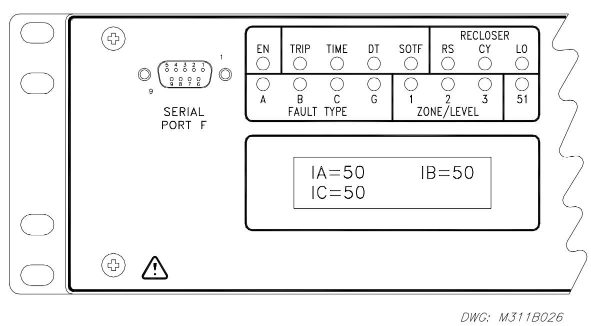
For example, suppose the local control switch with local bit output LB1 is configured as an ON/OFF type switch (see Figure 11.5). Additionally, suppose it is used to enable/disable reclosing. If local bit LB1 is at logical 1, reclosing is enabled:



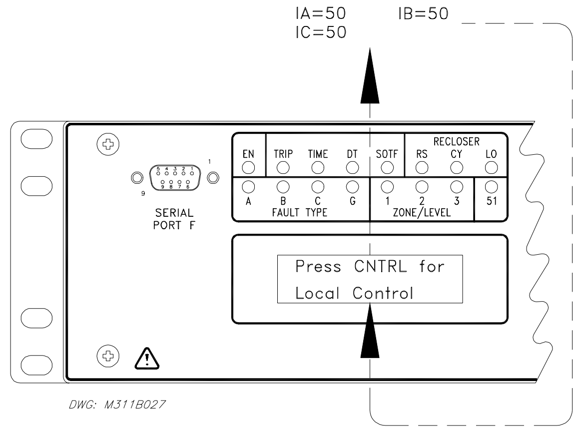
If power to the relay is turned off and then turned on again, local bit LB1 remains at logical 1, and reclosing is still enabled. This is akin to a traditional panel, where enabling/disabling of reclosing and other functions is accomplished by panel-mounted switches. If dc control voltage to the panel is lost and then restored again, the switch positions are still in place. If the reclosing switch is in the enable position (switch closed) before the power outage, it will be in the same position after the outage when power is restored.

ROTATING DEFAULT DISPLAY

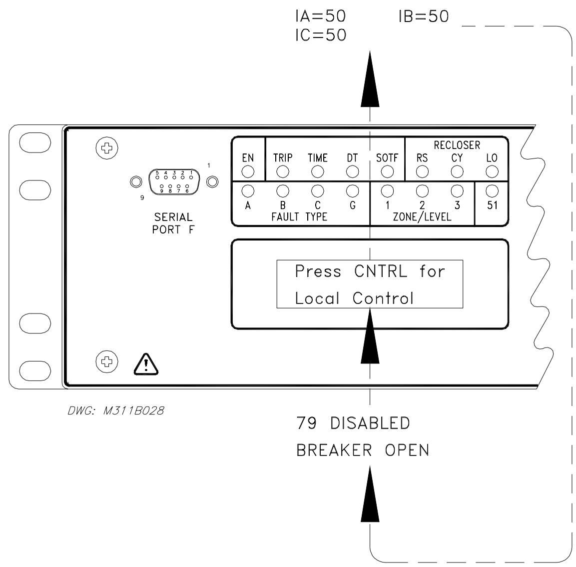
The channel IA, IB, and IC current values (in primary amps) display continually if no local control is operational (i.e., no corresponding switch position label settings were made) and no display point labels are enabled for display.



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.



If display point labels (e.g., “79 DISABLED” and “BREAKER OPEN”) are enabled for display, they also enter into the display rotation (display time = SCROLD).

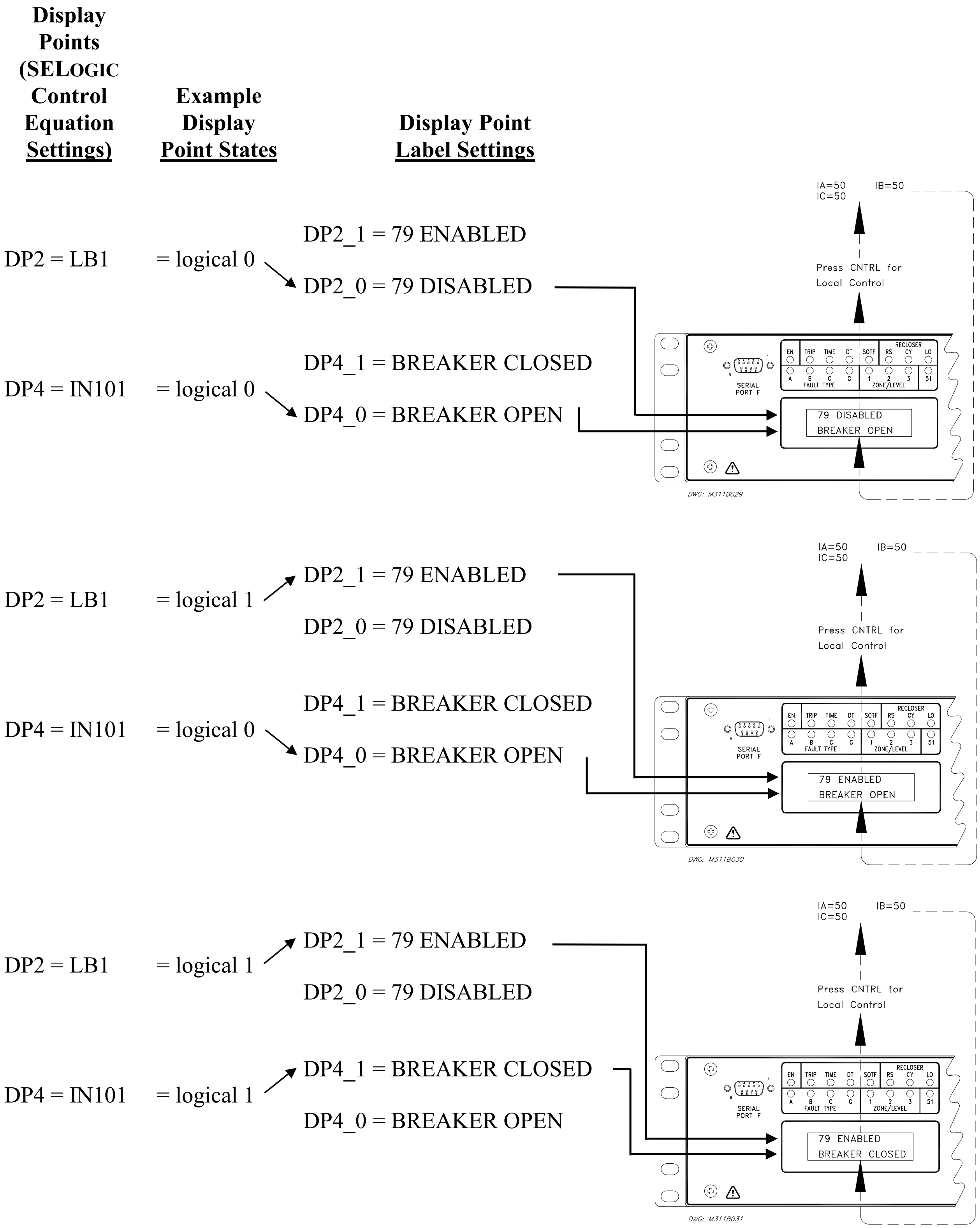


The following table and figures demonstrate the correspondence between changing display point states (e.g., DP2 and DP4) and enabled display point labels (DP2_1/DP2_0 and DP4_1/DP4_0, respectively). The display time is equal to global setting SCROLD for each screen.

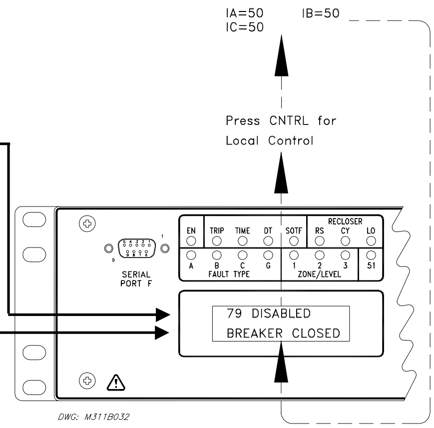
The display point example settings are:

DP2 = LB1 (local bit LB1)
DP4 = IN101 (optoisolated input IN101)

Local bit LB1 is used as a recloser enable/disable. Optoisolated input IN101 is used as a circuit breaker status input (a 52a circuit breaker auxiliary contact is connected to input IN101; see ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers and Other Control Logic***).


Display Points (SELOGIC Control Equation Settings)
Example Display Point States
Display Point Label Settings
DP2 = LB1
= logical 0
DP2_1 = 79 ENABLED
DP2_0 = 79 DISABLED
DP4 = IN101
= logical 0
DP4_1 = BREAKER CLOSED
DP4_0 = BREAKER OPEN
IA=50 IB=50
IC=50
Press CNTRL for
Local Control
79 DISABLED
BREAKER OPEN
SERIAL PORT F
DWG: M311B029
DP2 = LB1
= logical 1
DP2_1 = 79 ENABLED
DP2_0 = 79 DISABLED
DP4 = IN101
= logical 0
DP4_1 = BREAKER CLOSED
DP4_0 = BREAKER OPEN
IA=50 IB=50
IC=50
Press CNTRL for
Local Control
79 ENABLED
BREAKER OPEN
SERIAL PORT F
DWG: M311B030
DP2 = LB1
= logical 1
DP2_1 = 79 ENABLED
DP2_0 = 79 DISABLED
DP4 = IN101
= logical 1
DP4_1 = BREAKER CLOSED
DP4_0 = BREAKER OPEN
IA=50 IB=50
IC=50
Press CNTRL for
Local Control
79 ENABLED
BREAKER CLOSED
SERIAL PORT F
DWG: M311B031

Display Points (SELOGIC Control Equation Settings)	Example Display Point States	Display Point Label Settings
DP2 = LB1	= logical 0	DP2_1 = 79 ENABLED DP2_0 = 79 DISABLED
DP4 = IN101	= logical 1	DP4_1 = BREAKER CLOSED DP4_0 = BREAKER OPEN



In the preceding example, only two display points (DP2 and DP4) 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: 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 5.4 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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TABLES

FIGURES

SECTION 12: STANDARD EVENT REPORTS AND SER

INTRODUCTION

The SEL-311B Relay offers two styles of event reports:

- Standard 15/30/60/180-cycle oscillographic event reports.
- Sequential events recorder (SER) report.

The standard event reports contain date, time, current, voltage, frequency, relay element, optoisolated input, output contact, and fault location information.

The relay generates (triggers) standard 15/30/60/180-cycle event reports by both fixed and programmable conditions. These reports show information for 15, 30, 60, or 180 continuous cycles. At least forty-three 15-cycle, twenty-five 30-cycle, thirteen 60-cycle, or four 180-cycle reports are maintained; if more reports are triggered, the latest event report overwrites the oldest event report. See Figure 12.2 for an example standard 15-cycle 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 12.5 for an example SER report.

STANDARD 15/30/60/180-CYCLE EVENT REPORTS

See Figure 12.2 for an example event report (**Note**: Figure 12.2 is on multiple pages).

Event Report Length (Settings LER and PRE)

The SEL-311B Relay provides user-programmable event report length and pre-fault length. Event report length is 15, 30, 60, or 180 cycles. Pre-fault length ranges from 1 to 179 cycles. Pre-fault length is the first part of the event report that precedes the event report triggering point.

Set the event report length with the **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 Sheet 16 in ***Section 9: Setting the Relay*** for instructions on setting the LER and PRE settings.

Changing the LER setting will erase all events stored in nonvolatile memory. Changing the PRE setting has no effect on the nonvolatile reports.

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 through OUT107 pulsed via the serial port or front-panel **PUL** (Pulse Output Contact) command

Relay Word Bit TRIP

Refer to Figure 5.1. If Relay Word bit TRIP asserts to logical 1, an event report is automatically generated. Thus, any condition that causes a trip does not have to be entered in SELOGIC control equation setting ER. For example, SELOGIC control equation trip setting TR is unsupervised. Any trip condition that asserts in setting TR causes the TRIP Relay Word bit to assert immediately. The Relay Word bit TRIP asserts, and an event report is automatically generated.

Relay Word bit TRIP (in Figure 5.1) is usually assigned to an output contact for tripping a circuit breaker (e.g., SELOGIC control equation setting OUT101 = TRIP).

Programmable SELOGIC Control Equation Setting ER

The programmable SELOGIC control equation event report trigger setting ER is set to trigger standard event reports for conditions other than trip conditions. When setting ER sees a logical 0 to logical 1 transition, it generates an event report (if the SEL-311B Relay is not already generating a report that encompasses the new transition). The factory setting is:

ER = /M2P + /Z2G + /51G + /51Q + /50P1 + /LOP

The elements in this example setting are:

M2P	Zone 2 phase-distance element asserted (see Figure 3.5).
Z2G	Zone 2 ground-distance element asserted. (see Figure 3.8).
51G	Residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see Figure 3.19).
51Q	Negative-sequence current above pickup setting 51QP for negative-sequence time-overcurrent element 51QT (see Figure 3.20).
50P1	Phase current above pickup setting 50P1P for phase overcurrent element 50P1 (see Figure 3.13).
LOP	Loss of potential (LOP) asserts (see Figure 4.1).

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:

ER = ... + /51G + ... = logical 1 (for one processing interval)

Even though the 51G pickup indicator will remain asserted for the duration of the ground fault, the rising edge operator / in front of 51G (/51G) causes setting ER to be asserted for only one processing interval. 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 contact OUT101 through OUT107 asserts via the **PUL** command, the relay triggers a standard event report. The **PUL** command is available at the serial port and the relay front-panel CNTRL pushbutton.

See ***Section 10: 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.
- MIRRORED BITS™ status if MIRRORED BITS are enabled.

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 12.2.

Figure 12.1 corresponds to the full-length standard 15-cycle event report in Figure 12.2. (**Note**: Figure 12.2 is on multiple pages.)

```
=>>

SEL-311B                          Date: 08/18/00    Time: 08:53:34.926
EXAMPLE: BUS B, BREAKER 3

Event: BCG T     Location:   48.84             Trip Time: 08:53:34.930
#: 00008  Shot:    Freq:  60.01  Group: 1     Close Time: --:--:--.---
Targets: ZONE1                                                  Breaker: Closed

PreFault:     IA     IB     IC     IP     IG    3I2       VA       VB       VC
MAG(A/kV)    199    200    201      0      2      0  131.500  131.610  131.730
ANG(DEG)   -0.04-120.27 120.04  59.15 149.15 165.15     0.00  -120.03   119.94
Fault:
MAG(A/kV)    200   2478   2480      0    212   4294  131.570  113.930  113.980
ANG(DEG)   -0.46-172.34   6.65  59.15 -11.30  94.15     0.73  -123.36   124.67
                                                 L C R     L C R
                                                 B B B R   B B B R
                                                 O A A O   O A A O
                                                 K D D K   K D D K
MB:8->1    RMBA      TMBA      RMBB      TMBB    A A A A   B B B B

  TRIG  00000000  00000000  00000000  00000000   0 0 0 0   0 0 0 0
  TRIP  00000000  00000000  00000000  00000000   0 0 0 0   0 0 0 0

=>>
```

Figure 12.1: Example Event Summary

The relay sends event summaries to all serial ports with setting 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 (fault locator could not operate successfully to determine the phase involvement, so just TRIP is displayed).
ER	SELOGIC control equation setting ER. Phase involvement is indeterminate.
TRIG	Execution of TRIGGER command.
PULSE	Execution of PULSE command.

The event type designations AG through CAG in Table 12.1 are only entered in the "Event:" field if the fault locator operates successfully. If the fault locator does not operate successfully, just TRIP or ER is displayed.

Fault Location

The relay reports the fault location if setting EFLOC = 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 ***Line Settings*** and corresponding Settings Sheet 1 in ***Section 9: Setting the Relay*** for information on the line parameter settings.

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.

(Event Summary Number)

Unique event identifier of the event summary found in the **HIS E** command. See ***Section 10: Serial Communications and Commands***.

Shot

Reclosing Shot Count at trigger time. See ***Section 6: Close and Reclose Logic***.

Frequency

Sampling frequency at trigger time.

Group

Active settings group at trigger time.

Targets

The relay reports the targets at the rising edge of TRIP. The targets include: ZONE/LEVEL 1–3; TIME; DT; SOTF; and 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 are stored in nonvolatile memory. Each event report includes five sections:

- Current, voltage, station battery, and V1Mem
- Protection elements, contact outputs, and optoisolated inputs
- MIRRORED BITS and SELOGIC control equation elements
- Event summary
- Group, SELOGIC control equations, and global settings

Use the **EVE** command to retrieve the reports. There are several options to customize the report format. The general command format is:

EVE [*n* S*x* L*y* L R A D 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 contact I/O elements) of the event is displayed.
C	Display the report in Compressed ASCII format.
M	Specifies only that the communication elements section of the event is 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 contact I/O 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.

If an event report is requested that does not exist, the relay responds:

"Invalid Event"

Compressed ASCII Event Reports

The SEL-311B 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 CEVENT (**CEV**) command to display compressed ASCII event reports. See the CEVENT command discussion in ***Appendix E: Compressed ASCII Commands*** for further information.

Filtered and Unfiltered Event Reports

The SEL-311B 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**). Use the unfiltered event reports to observe:

- Power system harmonics on channels IA, IB, IC, IP, VA, VB, VC, VS
- Decaying dc offset during fault conditions on IA, IB, IC
- 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 Figures 7.1 and 7.2 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: Serial Port Communications and Commands*** for more information on the **HIS** (Event Summaries/History) command.

Standard Event Report Column Definitions

Refer to the example event report in Figure 12.2 to view event report columns (**Note**: Figure 12.2 is on multiple pages). This example event report displays rows of information each 1/4 cycle and was retrieved with the **EVE** command.

The columns contain ac current, ac voltage, station dc battery voltage, and directional polarizing voltage, V1Mem.

Current, Voltage, and Frequency Columns

Table 12.2 summarizes the event report current, voltage, and frequency columns.

Note that the ac values change from plus to minus (-) values in Figure 12.2, indicating the sinusoidal nature of the waveforms.

Other figures help in understanding the information available in the event report current columns:

Figure 12.3: shows how event report current column data relates to the actual sampled current waveform and RMS current values.

Figure 12.4: shows how event report current column data can be converted to phasor RMS current values.

Table 12.2: Standard Event Report Current, Voltage, and Frequency Columns

Column Heading	Definition
IA	Current measured by channel IA (primary A)
IB	Current measured by channel IB (primary A)
IC	Current measured by channel IC (primary A)
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)
Vdc	Voltage measured at power input terminals Z25 and Z26 (Vdc)
V1Mem	Positive-sequence memory voltage (primary kV)

Output, Input, Protection, and Control Columns

Table 12.3 summarizes the event report output, input, protection, and control columns. See Tables 9.3 and 9.4 in ***Section 9: Setting the Relay*** for more information on the Relay Word bits shown in Table 12.3.

Table 12.3: Output, Input, and Protection, and Control Element Event Report Columns

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
Z PP[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
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
Z 3P[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
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

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
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
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
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
VPOL	VPOLV	V	VPOLV asserted
51 P	51P, 51PT, 51PR	p	Time-overcurrent element picked up and timing
51 G	51G, 51GT, 51GR	T	Time-overcurrent element timed out
51 Q	51Q, 51QT, 51QR	r	Time-overcurrent element timing to reset
		1	Time-overcurrent element timing to reset after having timed out (when element reset is set for 1 cycle, not electromechanical reset)
50P 1 2	50P1, 50P2	1	50P1 asserted
		2	50P2 asserted
		b	both 50P1 and 50P2 asserted
50P 3	50P3	3	50P3 asserted
50G 1 2	50G1, 50G2	1	50G1 asserted
		2	50G2 asserted
		b	both 50G1 and 50G2 asserted
50G 3	50G3	3	50G3 asserted
50Q 1 2	50Q1, 50Q2	1	50Q1 asserted
		2	50Q2 asserted
		b	both 50Q1 and 50Q2 asserted
50Q 3	50Q3	3	50Q3 asserted

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
32 Q	F32Q	Q	Forward negative-sequence directional element F32Q picked up.
	R32Q	q	Reverse negative-sequence directional element R32Q picked up.
32 QVI	F32QG	Q	Forward negative-sequence ground directional element F32Q picked up.
	R32QG	q	Reverse negative-sequence ground directional element R32Q picked up.
	F32V	V	Forward zero-sequence ground directional element F32V picked up.
	R32V	v	Reverse zero-sequence ground directional element R32V picked up.
	F32I	I	Forward current polarized ground directional element F32I picked up.
	R32I	i	Reverse current polarized ground directional element R32I picked up.
67P 1 2	67P1, 67P2	1	67P1 asserted
		2	67P2 asserted
		b	both 67P1 and 67P2 asserted
67P 3	67P3	3	67P3 asserted
67G 1 2	67G1, 67G2	1	67G1 asserted
		2	67G2 asserted
		b	both 67G1 and 67G2 asserted
67G 3	67G3	3	67G3 asserted
67Q 1 2	67Q1, 67Q2	1	67Q1 asserted
		2	67Q2 asserted
		b	both 67Q1 and 67Q2 asserted
67Q 3	67Q3	3	67Q3 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.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
27 P	27A, 27B, 27C	A	A-phase instantaneous undervoltage element 27A picked up.
		B	B-phase instantaneous undervoltage element 27B picked up.
		C	C-phase instantaneous undervoltage element 27C picked up.
		a	27A and 27B elements picked up.
		b	27B and 27C elements picked up.
		c	27C and 27A elements picked up.
		3	27A, 27B, and 27C elements picked up.
27 PP	27AB, 27BC, 27CA	A	AB phase-to-phase instantaneous undervoltage element 27AB picked up.
		B	BC phase-to-phase instantaneous undervoltage element 27BC picked up.
		C	CA phase-to-phase instantaneous undervoltage element 27CA picked up.
		a	27AB and 27CA elements picked up.
		b	27AB and 27BC elements picked up.
		c	27BC and 27CA elements picked up.
		3	27AB, 27BC and 27CA elements picked up.
27 S	27S	*	Channel VS instantaneous undervoltage element 27S picked up.
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.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
59 PP	59AB, 59BC, 59CA	A	AB phase-to-phase instantaneous overvoltage element 59AB picked up.
		B	BC phase-to-phase instantaneous overvoltage element 59BC picked up.
		C	CA phase-to-phase instantaneous overvoltage element 59CA picked up.
		a	59AB and 59CA elements picked up.
		b	59AB and 59BC elements picked up.
		c	59BC and 59CA elements picked up.
		3	59AB, 59BC and 59CA elements picked up.
59 S	59S	*	VS instantaneous overvoltage element 59S picked up.
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.
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).

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
Time	OPTMN, RSTMN	o r	Recloser open interval timer is timing. Recloser reset interval timer is timing.
Shot	SH0, SH1, SH2 SH3, SH4	. 0 1 2 3 4	Reclosing relay nonexistent. shot = 0 (SH0). shot = 1 (SH1). shot = 2 (SH2). shot = 3 (SH3). shot = 4 (SH4).
Zld	ZLIN, ZLOUT	i o	Load encroachment “load in” element ZLIN picked up. Load encroachment “load out” element ZLOUT picked up.
LOP	LOP	*	Loss-of-potential element LOP picked up.
Vdc	DCHI, DCLO	H L b	Station battery instantaneous overvoltage element DCHI picked up. Station battery instantaneous undervoltage element DCLO picked up. Both DCHI and DCLO asserted.
**Out1 1 2	OUT101, OUT102	1 2 b	Output contact OUT101 asserted. Output contact OUT102 asserted. Both OUT101 and OUT102 asserted.
**Out1 3 4	OUT103, OUT104	3 4 b	Output contact OUT103 asserted. Output contact OUT104 asserted. Both OUT103 and OUT104 asserted.
**Out1 5 6	OUT105, OUT106	5 6 b	Output contact OUT105 asserted. Output contact OUT106 asserted. Both OUT105 and OUT106 asserted.
**Out1 7 A	OUT107, ALARM	7 A b	Output contact OUT107 asserted. Output contact ALARM asserted. Both OUT107 and ALARM asserted.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
In1 1 2	IN101, IN102	1 2 b	Optoisolated input IN101 asserted. Optoisolated input IN102 asserted. Both IN101 and IN102 asserted.
In1 3 4	IN103, IN104	3 4 b	Optoisolated input IN103 asserted. Optoisolated input IN104 asserted. Both IN103 and IN104 asserted.
In1 5 6	IN105, IN106	5 6	Optoisolated input IN105 asserted. Optoisolated input IN106 asserted. Both IN105 and IN106 asserted.

** Output contacts can be A or B type contacts (see Table 2.2 and Figure 7.26).

[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

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.
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.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
TMB A 7 8	TMB7A, TMB8A	7	MIRRORED BITS channel A transmit bit 7 TMB7A asserted.
		8	MIRRORED BITS channel A transmit bit 8 TMB8A asserted.
		b	Both TMB7A and TMB8A asserted.
RMB A 1 2	RMB1A, RMB2A	1	MIRRORED BITS channel A receive bit 1 RMB1A asserted.
		2	MIRRORED BITS channel A receive bit 2 RMB2A asserted.
		b	Both RMB1A and RMB2A asserted.
RMB A 3 4	RMB3A, RMB4A	3	MIRRORED BITS channel A receive bit 3 RMB3A asserted.
		4	MIRRORED BITS channel A receive bit 4 RMB4A asserted.
		b	Both RMB3A and RMB4A asserted.
RMB A 5 6	RMB5A, RMB6A	5	MIRRORED BITS channel A receive bit 5 RMB5A asserted.
		6	MIRRORED BITS channel A receive bit 6 RMB6A asserted.
		b	Both RMB5A and RMB6A asserted.
RMB A 7 8	RMB7A, RMB8A	7	MIRRORED BITS channel A receive bit 7 RMB7A asserted.
		8	MIRRORED BITS channel A receive bit 8 RMB8A asserted.
		b	Both RMB7A and RMB8A asserted.
TMB B 1 2	TMB1B, TMB2B	1	MIRRORED BITS channel B transmit bit 1 TMB1B asserted.
		2	MIRRORED BITS channel B transmit bit 2 bit TMB2B asserted.
		b	Both TMB1B and TMB2B asserted.
TMB B 3 4	TMB3B, TMB4B	3	MIRRORED BITS channel B transmit bit 3 TMB3B asserted.
		4	MIRRORED BITS channel B transmit bit 4 TMB4B asserted.
		b	Both TMB3B and TMB4B asserted.
TMB B 5 6	TMB5B, TMB6B	5	MIRRORED BITS channel B transmit bit 5 TMB5B asserted.
		6	MIRRORED BITS channel B transmit bit 6 TMB6B asserted.
		b	Both TMB5B and TMB6B asserted.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
TMB B 7 8	TMB7B, TMB8B	7 8 b	MIRRORED BITS channel B transmit bit 7 TMB7B asserted. MIRRORED BITS channel B transmit bit 8 TMB8B asserted. Both TMB7B and TMB8B asserted.
RMB B 1 2	RMB1B, RMB2B	1 2 b	MIRRORED BITS channel B receive bit 1 RMB1B asserted. MIRRORED BITS channel B receive bit 2 RMB2B asserted. Both RMB1B and RMB2B asserted.
RMB B 3 4	RMB3B, RMB4B	3 4 b	MIRRORED BITS channel B receive bit 3 RMB3B asserted. MIRRORED BITS channel B receive bit 4 RMB4B asserted. Both RMB3B and RMB4B asserted.
RMB B 5 6	RMB5B, RMB6B	5 6 b	MIRRORED BITS channel B receive bit 5 RMB5B asserted. MIRRORED BITS channel B receive bit 6 RMB6B asserted. Both RMB5B and RMB6B asserted.
RMB B 7 8	RMB7B, RMB8B	7 8 b	MIRRORED BITS channel B receive bit 7 RMB7B asserted. MIRRORED BITS channel B receive bit 8 RMB8B asserted. Both RMB7B and RMB8B asserted.
ROK	ROKA, ROKB	A B b	MIRRORED BITS channel A receive OK ROKA asserted. MIRRORED BITS channel B receive OK ROKB asserted. Both ROKA and ROKB asserted.
RBAD	RBADA, RBADB	A B b	MIRRORED BITS channel A extended. outage RBADA asserted. MIRRORED BITS channel B extended outage RBADB asserted. Both RBADA and RBADB asserted.
CBAD	CBADA, CBADB	A B b	MIRRORED BITS channel A unavailability CBADA asserted. MIRRORED BITS channel B unavailability CBADB asserted. Both CBADA and CBADB asserted.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
LBOK	LBOKA, LBOKB	A B b	MIRRORED BITS channel A loopback OK LBOKA asserted. MIRRORED BITS channel A loopback OK LBOKB asserted. Both LBOKA and LBOKB asserted.
OC	OC, CC	o c	**OPE** (Open) command executed. **CLO** (Close) command executed.
Lcl RW 5	LB1–LB8	00–FF **Hex	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
SELOGIC 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	 SV1, SV1T SV2, SV2T SV3, SV3T SV4, SV4T SV5, SV5T SV6, SV6T SV7, SV7T SV8, SV8T SV9, SV9T SV10, SV10T SV11, SV11T SV12, SV12T SV13, SV13T SV14, SV14T SV15, SV15T SV16, SV16T	p T d	SELOGIC control equation variable timer input SV_ asserted; timer timing on pickup time; timer output SV_T not asserted. SELOGIC control equation variable timer input SV_ asserted; timer timed out on pickup time; timer output SV_T asserted. SELOGIC control equation variable timer input SV_ not asserted; timer previously timed out on pickup time; timer output SV_T remains asserted while timer timing on dropout time.

** 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

The following example standard 15-cycle event report in Figure 12.2 also corresponds to the example sequential events recorder (SER) report in Figure 12.5. The boxed numbers in Figure 12.2 correspond to the SER row numbers in Figure 12.5. The row explanations follow Figure 12.5.

In Figure 12.2, 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 12.2 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 <ENTER>

SEL-311B                          Date: 08/18/00    Time: 08:53:34.926
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311B-R100-V0-Z001001-D20000818      CID=F30B


       Currents (Amps Pri)            Voltages (kV Pri)             V1
     IA     IB     IC     IP     IG     VA     VB     VC     VS Vdc    Mem
[1]
    102   -200     98      0      0   67.4 -131.6   64.3   67.4  24   67.1
    171      2   -176      0     -3  112.9    1.9 -115.0  113.2  24  113.2
   -103    199    -99     -1     -3  -67.5  131.6  -64.2  -67.5  24  -67.2
   -173     -3    174      0     -2 -112.9   -2.0  115.0 -113.2  24 -113.1
[2]
    102   -200     97      0     -1   67.6 -131.6   64.1   67.6  24   67.3
    171      2   -175     -1     -2  112.8    2.0 -115.1  113.1  24  113.1
   -103    199    -98      0     -2  -67.7  131.6  -64.0  -67.7  24  -67.4
   -172     -3    175     -1      0 -112.8   -2.1  115.1 -113.1  24 -113.0
[3]
    102   -201     97      0     -2   67.8 -131.6   63.9   67.8  24   67.5
    171      2   -176     -1     -3  112.7    2.2 -115.2  113.0  24  113.0
   -104    200    -97     -1     -1  -67.9  131.6  -63.9  -67.9  24  -67.5
   -172     -4    175      0     -1 -112.6   -2.4  115.2 -112.9  24 -112.9
[4]
    103   -270    165      0     -2   68.0 -130.8   63.0   68.0  24   67.6
    171   -686    576     -1     61  112.6    3.2 -114.7  112.9  24  112.7
   -104    936   -867     -1    -35  -68.1  121.8  -55.0  -68.1  24  -67.7
   -172   1661  -1653      0   -164 -112.5    0.9  108.8 -112.8  24 -111.2>
[5]
    103  -1532   1499      0     70   68.2 -113.8   47.9   68.2  24   67.0
    171  -1948   1976     -1    199  112.5   -5.6 -103.5  112.8  24  109.0
   -104   1531  -1500      0    -73  -68.3  113.8  -47.8  -68.3  24  -65.7
   -171   1945  -1975      0   -201 -112.4    5.5  103.5 -112.7  24 -107.3
[6]
    104  -1533   1500     -1     71   68.4 -113.8   47.7   68.3  24   64.8
    170  -1945   1973      0    198  112.4   -5.4 -103.6  112.7  24  106.1
   -105   1533  -1503     -1    -75  -68.4  113.8  -47.7  -68.4  24  -64.2
   -172   1944  -1973     -1   -201 -112.4    5.3  103.6 -112.6  24 -105.1
[7]
    104  -1536   1504      0     72   68.5 -113.8   47.5   68.5  24   63.7
    171  -1944   1971      0    198  112.3   -5.3 -103.6  112.6  24  104.4
   -105   1538  -1507     -1    -74  -68.6  113.8  -47.5  -68.6  24  -63.3
   -171   1940  -1970      0   -201 -112.2    5.1  103.7 -112.5  24 -103.8
[8]
    104  -1539   1506     -1     71   68.7 -113.8   47.4   68.7  24   63.1
    170  -1941   1968     -1    197  112.2   -5.1 -103.7  112.4  24  103.4
   -105   1540  -1509     -1    -74  -68.8  113.8  -47.3  -68.8  24  -63.0
   -171   1939  -1968      0   -200 -112.1    5.0  103.7 -112.4  24 -103.0
[9]
    104  -1543   1510      0     71   68.9 -113.8   47.2   68.9  24   62.9*
    170  -1938   1965     -1    197  112.0   -4.9 -103.8  112.3  24  102.7
   -106   1543  -1513     -1    -76  -69.0  113.8  -47.2  -69.0  24  -62.8
   -171   1936  -1964      0   -199 -112.0    4.8  103.8 -112.3  24 -102.5
[10]
    105  -1546   1513      0     72   69.1 -113.9   47.1   69.1  24   62.8
    158  -1803   1835      0    190  111.9   -4.4 -104.3  112.2  24  102.4
   -105   1446  -1429     -1    -88  -69.2  119.6  -52.8  -69.2  24  -62.9
    -73    827   -847     -1    -93 -111.9    0.1  110.4 -112.2  24 -103.1
[11]
     51   -673    671      0     49   69.2 -128.5   60.4   69.2  24   63.7
     -1      7     -8      0     -2  111.8    4.0 -116.0  112.1  24  105.0
     -1     -1      0     -1     -2  -69.3  131.6  -62.3  -69.3  24  -65.1
      0     -1     -1      0     -2 -111.8   -4.1  116.0 -112.1  24 -106.7
```

see Figure 12.1

firmware identifier

firmware checksum identifier

one cycle of data

See Figure 12.3 and Figure 12.4 for details on this one cycle of Phase B (Channel IB) current.

```
[12]
      0      0     -1      0     -1   69.4 -131.6   62.2   69.4  24   66.2
     -1      0      0      0     -1  111.7    4.2 -116.1  112.0  24  108.0
      0     -1      0     -1     -1  -69.5  131.6  -62.2  -69.5  24  -67.0
      0     -1     -1      0     -2 -111.7   -4.3  116.1 -111.9  24 -108.9
[13]
     -1      0      0      0     -1   69.6 -131.6   62.1   69.6  24   67.6
     -1      0      0     -1     -1  111.6    4.4 -116.2  111.9  24  109.6
      0     -1      0     -1     -1  -69.7  131.6  -62.0  -69.7  24  -68.1
      0     -1      0      0     -1 -111.5   -4.5  116.2 -111.8  24 -110.1
[14]
      0      0      0      0      0   69.8 -131.6   61.9   69.8  24   68.5
     -1     -1     -1      0     -3  111.4    4.6 -116.3  111.7  24  110.5
      0     -1      0      0     -1  -69.9  131.6  -61.8  -69.9  24  -68.9
      0      0     -1     -1     -1 -111.4   -4.7  116.3 -111.7  24 -110.8
[15]
     -1      0      0      0     -1   70.0 -131.6   61.7   70.0  24   69.1
     -1      0      0      0     -1  111.3    4.8 -116.4  111.6  24  110.9
      0     -1     -1     -1     -2  -70.1  131.5  -61.6  -70.1  24  -69.3
      0     -1      0     -1     -1 -111.3   -4.9  116.4 -111.6  24 -111.1

Protection and Contact I/O Elements

21     V 51  50     32 67     Dm 27  59
ZZZZZZ P     P G Q   Q P G Q           255 TSih ZLV Out1 In1
ABCABC O     1 1 1   V 1 1 1  P   P   P  9S  7mo lOd 1357 135
BCAGGG L PGQ 232323 QI 232323 QG PPS PPS VFA 9et dPc 246A 246
[1]
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
[2]
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
[3]
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
[4]                              11 10
...... V ... ...... .. ...... .. ... ... ... ... o.. .... 1..
...... V ... ...... .. ...... .. ... ... ... ... ... .... 1..
...... V ..p ...... QQ ...... .. ... ... ... ... ... .... 1..
...... V .pp ...... QQ ...... .. ... ... ... ... ... .... 1..>
[5]                     13                                          9 8
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... 12 ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
[6]
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
[7]
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
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[8]
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
[9]
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
[10]
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.1.... V .pp 1..... QQ 1..... .. ... ... ... ... ... b4.. 1..
.2.... V .rp ...... QQ ...... .. ... ... ... ... ... b4.. 1..
[11]
...... V .rp ...... QQ ...... .. ... ... ... ... ... b... ...
...... V .rp ...... QQ ...... .. ... ... ... ... o.. b... ...
...... V .rp ...... QQ ...... .. ... ... ... ... ... b... ...
...... V .rr ...... .. ...... .. ... ... ... ... ... b... ...
[12]
...... V .rr ...... .. ...... .. ... ... ... ... ... b... ...
...... V .rr ...... .. ...... .. ... ... ... ... ... b... ...
...... V .rr ...... .. ...... .. ... ... ... ... ... b... ...
...... V .r. ...... .. ...... .. ... ... ... ... ... b... ...
[13]
...... V .r. ...... .. ...... .. ... ... ... ... ... b... ...
...... V .r. ...... .. ...... .. ... ... ... ... ... b... ...
...... V .r. ...... .. ...... .. ... ... ... ... ... b... ...
...... V .r. ...... .. ...... .. ... ... ... ... ... b... ...
[14]
...... V .r. ...... .. ...... .. ... ... ... ... ... .... ...
...... V .r. ...... .. ...... .. ... ... ... ... ... .... ...
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[15]
...... V .r. ...... .. ...... .. ... ... ... ... ... .... ...
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...... V .r. ...... .. ...... .. ... ... ... ... ... .... ...

Communication Elements

 S TMB  RMB  TMB  RMB  RRCL   Lcl   Rem   Ltch  SELogic
30 A    A    B    B    OBBB
PT 1357 1357 1357 1357 KAAO O RW RW RW RW RW RW          1111111
OF 2468 2468 2468 2468  DDK C  5  6  7  8  9 10 1234567890123456
[1]
.. .... .... .... .... .... . 00 00 00 00 40 00 ................
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[3]
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[4]
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[14]
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[15]
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*. .... .... .... .... .... . 00 00 00 00 40 00 ................

Event: BCG T  Location:   48.84  Shot:    Frequency:  60.01
Targets: ZONE1
Currents (A Pri), ABCPGQ:    200  2478  2480     0   212  4294
```

```
Group 1
Group Settings:
RID   =SEL-311B                       TID   =EXAMPLE: BUS B, BREAKER 3
CTR   = 200
CTRP  = 200      PTR   = 2000.00  PTRS  = 2000.00
Z1MAG = 7.80     Z1ANG = 84.00
Z0MAG = 24.80    Z0ANG = 81.50    LL    = 100.00   APP   = 311B
E21P  = 3        E21MG = 3
E50P  = 1        E50G  = N        E50Q  = N
E51P  = N        E51G  = Y        E51Q  = Y
E32   = AUTO     ELOAD = Y        ESOTF = Y
EVOLT = N        E25   = N        EFLOC = Y
ELOP  = Y        E79   = N        EZ1EXT= N
ECCVT = N        ESV   = N        ELAT  = 16       EDP   = 16
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
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
ORDER = QVI
CLOEND= OFF      52AEND= 10.00    SOTFD = 30.00
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
TRSOTF=M2P + Z2G + 50P1
DTT   =0
ULTR  =!(50L + 51G)
52A   =IN101
CL    =CC
ULCL  =TRIP
SET1  =0
RST1  =0
SET2  =0
RST2  =0
SET3  =0
RST3  =0
SET4  =0
RST4  =0
SET5  =0
RST5  =0
SET6  =0
RST6  =0
SET7  =0
RST7  =0
SET8  =0
RST8  =0
SET9  =0
RST9  =0
```

```
SET10 =0
RST10 =0
SET11 =0
RST11 =0
SET12 =0
RST12 =0
SET13 =0
RST13 =0
SET14 =0
RST14 =0
SET15 =0
RST15 =0
SET16 =0
RST16 =0
67P1TC=1
51GTC =1
51QTC =1
OUT101=TRIP
OUT102=TRIP
OUT103=CLOSE
OUT104=0
OUT105=0
OUT106=0
OUT107=0
DP1   =52A
DP2   =0
DP3   =0
DP4   =0
DP5   =0
DP6   =0
DP7   =0
DP8   =0
DP9   =0
DP10  =0
DP11  =0
DP12  =0
DP13  =0
DP14  =0
DP15  =0
DP16  =0
SS1   =0
SS2   =0
SS3   =0
SS4   =0
SS5   =0
SS6   =0
ER    =/M2P + /Z2G + /51G + /51Q + /50P1 + /LOP
FAULT =51G + 51Q + M2P + Z2G
BSYNCH=0
CLMON =0
E32IV =1


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 12.2: Example Standard 15-Cycle Event Report 1/4 Cycle Resolution

Figure 12.3 and Figure 12.4 look in detail at 1 cycle of B-phase current (channel IB) identified in Figure 12.2. Figure 12.3 shows how the event report ac current column data relates to the actual sampled waveform and RMS values. Figure 12.4 shows how the event report current column data can be converted to phasor RMS values. Voltages are processed similarly.

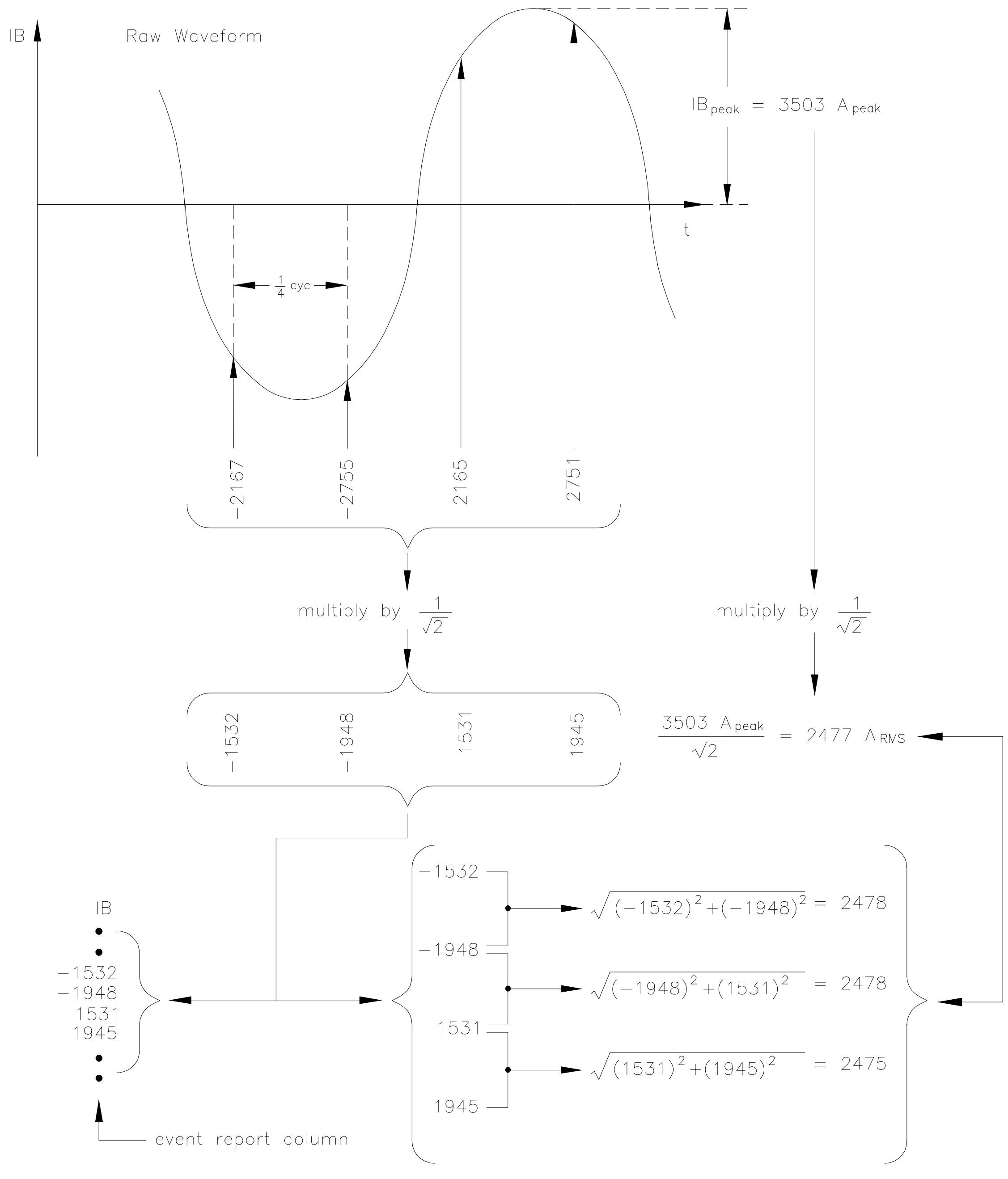

Figure 12.3: Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In Figure 12.3, note that any two rows of current data from the event report in Figure 12.2, 1/4 cycle apart, can be used to calculate RMS current values.

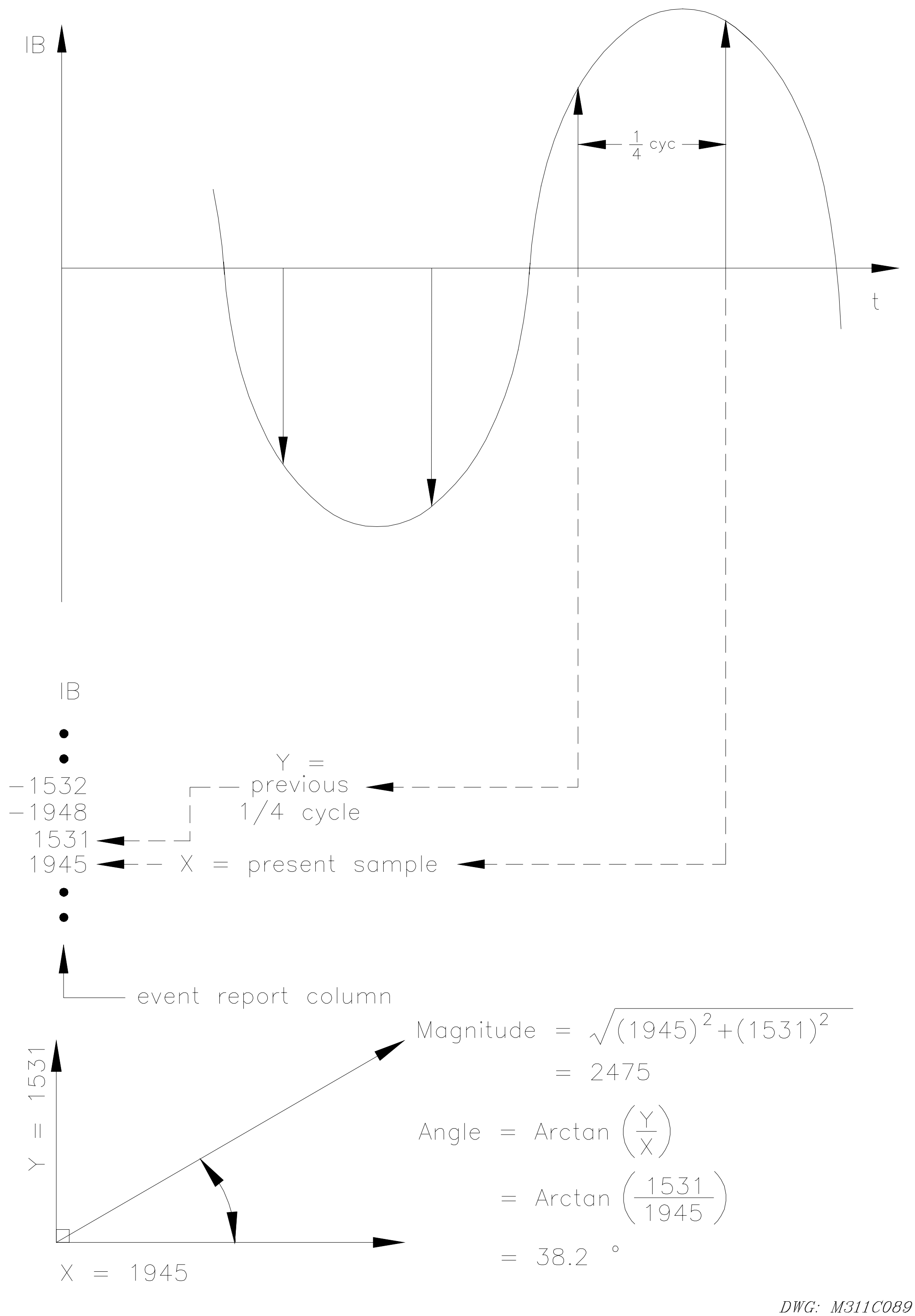

Figure 12.4: Derivation of Phasor RMS Current Values From Event Report Current Values

In Figure 12.4, note that two rows of current data from the event report in Figure 12.2, 1/4 cycle apart, can be used to calculate phasor RMS current values. In Figure 12.4, at the present sample, the phasor RMS current value is:

IB = 2475 A $\angle$ 38.2°

The present sample (IB = 1945 A) is a real RMS current value that relates to the phasor RMS current value:

2475 A * cos(38.2°) = 1945 A

Sequential Events Recorder (SER) Report

See Figure 12.5 for an example SER report.

SER Triggering

The relay triggers (generates) an entry in the SER report for a change of state of any one of the elements listed in the SER1, SER2, and SER3 trigger settings. The factory default settings are:

SER1 = M1P, Z1G, M2P, Z2G, M3P, Z3G, 51G, 51Q, 50P1
SER2 = IN101, IN102, OUT101, OUT102, OUT103, OUT104, LOP
SER3 = 0

The elements are Relay Word bits referenced in Table 9.4. The relay monitors each element in the SER lists every 1/4 cycle. If an element changes state, the relay time-tags the changes in the SER. For example, setting SER1 contains 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 Sheet 18 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

The following example sequential events recorder (SER) report in Figure 12.5 also corresponds to the example standard 15-cycle event report in Figure 12.2.

```
=>>SER <ENTER>

SEL-311B                          Date: 08/20/00    Time: 08:56:47.400
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311B-R100-V0-Z001001-D20000818       CID=F30B

#     DATE      TIME           ELEMENT            STATE

14    08/19/00  08:53:34.083   IN101              Asserted
13    08/19/00  08:53:34.926   51G                Asserted
12    08/19/00  08:53:34.930   50P1               Asserted
11    08/19/00  08:53:34.930   M2P                Asserted
10    08/19/00  08:53:34.930   M1P                Asserted
9     08/19/00  08:53:34.930   OUT101             Asserted
8     08/19/00  08:53:34.930   OUT102             Asserted
7     08/19/00  08:53:35.026   50P1               Deasserted
6     08/19/00  08:53:35.026   M1P                Deasserted
5     08/19/00  08:53:35.026   51G                Deasserted
4     08/19/00  08:53:35.030   M2P                Deasserted
3     08/19/00  08:53:35.030   IN101              Deasserted
2     08/19/00  08:53:35.079   OUT101             Deasserted
1     08/19/00  08:53:35.079   OUT102             Deasserted

=>>
```

Figure 12.5: Example Sequential Events Recorder (SER) Event Report

The SER event report rows in Figure 12.5 are explained in the following text, numbered in correspondence to the # column. The boxed, numbered comments in Figure 12.2 also correspond to the # column numbers in Figure 12.5. The SER event report in Figure 12.5 may contain records of events that occurred before and after the standard event report in Figure 12.2

SER Row No.	Explanation
14	IN101 is asserted when the circuit breaker closes. Related Setting: 52A = IN101
13	Time-overcurrent element 51G asserts.
12	Instantaneous-overcurrent element 50P1 asserts.
11	Phase-distance element M2P asserts.
10	Phase-distance element M1P asserts. This is an instantaneous trip condition. Related setting: TR =M1P + Z1G + M2PT + Z2GT + 51GT + 51QT
9, 8	Outputs OUT101 and OUT102 assert. Related setting: OUT101 = TRIP OUT102 = TRIP
7, 6, 5, 4	Elements 50P1, M1P, 51G, and M2P deassert as the circuit breaker opens
3	IN101 is deasserts when the circuit breaker opens. Related Setting: 52A = IN101
2, 1	Outputs OUT101 and OUT102 deassert.

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SECTION 13: TESTING AND TROUBLESHOOTING

Introduction

This section provides guidelines for determining and establishing test routines for the SEL-311B 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 to 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.

METER Command	The METER (**MET**) command shows the ac currents and voltages (magnitude and phase angle) presented to the relay in primary values. In addition, the command shows power system frequency (FREQ) and the voltage input to the relay power supply terminals (VDC). Compare these quantities against other devices of known accuracy. The METER command is available at the serial ports and front-panel display. See ***Section 10: Serial Port Communications and Commands*** and ***Section 11: Front-Panel Interface***.
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: 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: Serial Port Communications and Commands***.

Low-Level Test Interface

The SEL-311B 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.

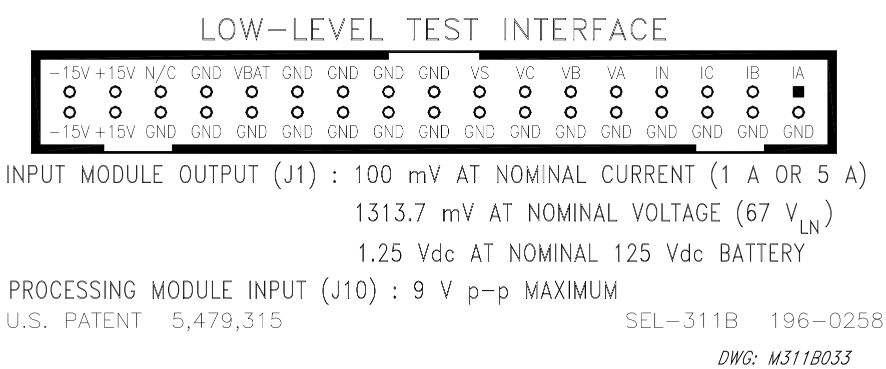

Figure 13.1: Low-Level Test Interface

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-311B 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 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 9.3 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: 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 OUT107) to the element under test. The available elements are the Relay Word bits referenced in Table 9.3 and 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.

Relay Testing

Use this section as a guide to test overcurrent, distance, and negative-sequence directional elements in the SEL-311A, SEL-311B, and SEL-311C Relays. Note that the SEL-311A has two zones, the SEL-311B has three zones, and the SEL-311C has four zones. Settings E21P, E21MG, and E21XG will need to be set to "2" instead of "3" when testing the SEL-311A.

Equipment Required

The following equipment is necessary for initial checkout.

1. Source of control power.
2. Source of three-phase voltages and at least two currents.
3. Ohmmeter or contact opening/closing sensing device.

Checkout Procedure

Step 1. Purpose: Be sure you received the relay in satisfactory condition.

Method: Inspect the instrument for physical damage such as dents or rattles.

Step 2. Purpose: Refer to the Relay Part Number and Hardware Identification Sticker on the relay rear panel to verify the power supply voltage, dc control voltage, and nominal ac signal magnitudes appropriate for the relay under test.

Method: Refer to the information sticker on the rear panel of the relay.

The Power options include 24 volts dc, 48 volts dc, and 250 volts ac/dc. Refer to the sticker attached to your relay to determine the magnitude of voltage you should apply to the relay power supply input terminals. The voltage source should be capable of providing 12 watts continuously at the rated voltage.

The Logic Input options include 24 volts dc, 48 volts dc, 110 volts dc, 125 volts dc, 220 volts dc, and 250 volts dc. To assert a relay logic input, apply dc voltage to the relay input terminals. Refer to the sticker attached to your relay to determine the magnitude of voltage you should apply to the relay logic inputs. Approximately four milliamps of current flow when rated voltage is applied to a relay logic input.

The V/phase specification indicates the nominal ac voltage that the relay is designed to measure. This voltage is specified from line to neutral and assumes a standard 4-wire wye ac voltage connection. This relay is configured to accept 67 volts ac, line to neutral. The relay measures other ac voltage magnitudes accurately, as defined in ***Section 1: Introduction and Specifications***.

The Amps specification indicates the nominal ac current (1 A or 5 A) that the relay is designed to measure. The relay measures other ac current magnitudes accurately, as defined in ***Section 1: Introduction and Specifications***.

Step 3. Purpose: Connect power supply voltage to the relay.

Method: Connect a frame ground to terminal marked GND on the rear panel and connect a voltage source to the terminals marked + and -. Polarity is unimportant. Relays equipped with 125 or 250 V power supplies may be powered from a 115 Vac wall receptacle for testing. In the final installation, we recommend that the relay receive control power from the station dc battery. This helps prevent loss of relay event reports stored in volatile memory if station ac service is lost.

Step 4. Purpose: Apply power supply voltage to the relay and access the relay via the optional LCD front panel.

Method: Turn on the voltage source connected to the relay power supply inputs If you are using a battery simulator as the relay power supply voltage source, be sure the simulator voltage level is stabilized.

The relay front panel Enable target (EN) should illuminate. **EN** should appear in the relay LCD screen.

The relay output labeled ALARM is typically configured as a normally closed (form “b”) contact and closes to indicate loss of dc power to the relay, failure of a relay self-test, and several other functions. With power applied to the relay and the relay turned on, the ALARM contacts open.

If the Enable LED does not illuminate or **EN** does not appear on the relay LCD screen, turn off the power and refer to Relay Troubleshooting later in this section.

Step 5. Purpose: Perform a front panel LED test and check LCD screen contrast.

Method: Press the **TARGET RESET** button to perform an LED lamp test. During the lamp test, the relay illuminates all 16 front panel LEDs for about one second. The relay also turns on the LCD back lighting. If the LCD contrast is poor, refer to the Troubleshooting Procedure in this section for steps to adjust it.

Step 6. Purpose: Verify the relay self-test status.

Method: Press the front panel **STATUS** button. The message **STATUS: OK** should appear on the relay LCD screen. Use the Up and Down arrow buttons to view the results of specific relay self-tests. Press the front panel **EXIT** button to exit the STATUS display.

Step 7. Purpose: Connect voltage and current sources to the relay.

Method: Turn relay power off. If three voltage sources and three current sources are available, connect the sources to the relay as shown in Figure 13.2. If three voltage sources and two current sources are available, connect them as shown in Figure 13.4. Apply 67 volts per phase (line-to-neutral) in positive-sequence rotation. Apply 2.0 amps per phase, in phase with the applied phase voltages.

Step 8. Purpose: Verify correct voltage and current connections and levels.

Method: Turn relay power on. Press the front panel **METER** button. Use the arrow keys to examine the METER data. The relay displays the measurements of the voltages and currents applied in Step 7. With applied voltages of 67 volts per phase and a potential transformer ratio of 2000:1, the displayed line-to-neutral voltages should be 134 kV. With applied currents of 2.0 A per phase and a current transformer ratio of 200:1, the displayed line-to-neutral currents should be 400 A. All line-to-line quantities should be balanced, differing from the line-to-neutral measurements by a factor of 1.73. Real power P should be approximately 160.1 MW; reactive power Q should be approximately 0 MVAR.

If you inadvertently switched a pair of voltages or currents, the MW reading should be approximately zero. It is important to remember this when commissioning the relay using system voltages and currents.

Step 9. Purpose: Use the front panel setting feature to adjust a relay setting.

Method: The following steps are required to change a relay setting from the SEL-311B Relay front panel:

1. Enter Access Level 2 using the appropriate password.
2. Execute the **SET** command.
3. Select the setting to change.
4. Make and accept the setting change.

Press the front panel button labeled **SET**. Using the arrow keys, move the cursor to the menu item **PASS**. Press the button labled **SELECT**. Using the arrow keys, move the cursor to the menu item **2AC**. Press the button labled **SELECT**. This instructs the relay to execute the **2ACCESS** command.

In order to enter Access Level 2, you must enter the correct password. Refer to ***Section 10*** for discussion about passwords. The relay displays a list of characters to build the password from. Use the Up or Down arrow button to select the first letter. Use the arrow buttons to select the remaing letters. The blank character precedes the second letter of the password.

When the lower line of the display reads the following (where “XYZ” represents the current password):

```
PASSWORD: XYZ
```

press the **SELECT** button to enter Access Level 2. The relay then resumes the default display.

Press the button labeled **SET**. The display shows:

```
GROUP    GLOBAL
PORT     PASS
```

Press **SELECT**. Use the Down arrow button to enter the number 1, then press **SELECT** again. Use the Left arrow button to selct the menu item **SET**, then press **SELECT** again.

Note: The SEL-311B Relays includes six setting groups. While you are testing this relay, it is important to change settings in the group that is active. If you change settings in an inactive setting group, the relay performance will not change. The relay is shipped with Setting Group 1 active. You may change the active group by executing the **GROUP** command from the relay front panel or from a terminal connected to a relay serial port. You must enter the Breaker Access Level or Access Level 2 to change the active group.

Press the Down arrow button repeatedly, until the upper line of the display reads:

```
LL = 100.00
```

Press **SELECT**. Use the left, right, up and down arrow keys to change the setting to:

```
LL = 99.00
```

Press **SELECT**. Press **EXIT**. Press **SELECT** (YES) to save the new settings.

Step 10. Purpose: Test the fault locator.

Method: Test the fault locator using the voltages and currents in Table 13.1. These voltages and currents were obtained for various locations and fault types assuming a radial line with a source impedance of 0.2 times the total 100 mile line impedance.

Note: To simplify this step, apply dc voltage to the IN1 input. The relay recognizes the asserted input when applied dc voltage is approximately equal to the Logic Input voltage rating shown on the relay identification sticker. Input IN1 is programmed to monitor the breaker auxiliary contact, 52A. Energize the IN1 input for the duration of this step to block the Switch-Onto-Fault logic from operating. If dc voltage source is not available, set ESOTF = N in the relay settings.

Run ground fault tests using the test source connections shown in Figure 13.2, Figure 13.3, or Figure 13.5. Run phase-to-phase fault tests using the test source connections shown in Figure 13.1, Figure 13.3, or Figure 13.6.

Table 13.1: Fault Locator Test Values

Location	Type	VA	VB	VC	IA	IB	IC	Units
75 miles	AG	52.89 0.00	69.97 -124.30	70.34 124.10	5.24 -82.40	0.00 0.00	0.00 0.00	V or A Degrees
	BC	67.00 0.00	56.75 -126.20	56.75 126.20	0.00 0.00	7.83 -174.00	7.83 6.00	V or A Degrees
85 miles	AG	54.24 0.00	69.67 -123.90	70.00 123.70	4.74 -82.40	0.00 0.00	0.00 0.00	V or A Degrees
	BC	67.00 0.00	57.69 -125.50	57.69 125.50	0.00 0.00	7.08 -174.00	7.08 6.00	V or A Degrees

Faults at 75 miles are within Zone 1, since the Zone 1 reach setting is 80% of the 100-mile line positive-sequence impedance (see Z1P, Z1MG, and XG1 in the settings). Faults at 85 miles are beyond Zone 1, but within Zone 2.

Faults listed in Table 13.1 cause certain combinations of output contacts to close and front panel LEDs to illuminate. You may use the front panel LCD functions to examine the short form fault data following each test. Table 13.2 shows the expected results.

Table 13.2: Output Contact and Target LED Results

Location	Type	Output Relays	Target LEDs
75 miles	AG	OUT1, OUT2, OUT4	INST, Zone 1, A, G
75 miles	BC	OUT1, OUT2, OUT4	INST, Zone 1, B, C
85 miles	AG	OUT1, OUT2, OUT4	TIME, Zone 2, A, G
85 miles	BC	OUT1, OUT2, OUT4	TIME, Zone 2, B, C

Output Contact Explanation

The OUT1 and OUT2 are set to close for trips. The relay is set to trip instantaneously for Zone 1 faults, with a short time delay for Zone 2 faults, and by operation of the residual and negative-sequence time-overcurrent elements. OUT4 is set to close for assertion of the KEY element. The KEY element is used in Permissive Overreaching Transfer Tripping protection schemes to send the permissive signal to the remote end. The SEL-311B Relay asserts the KEY element when overreaching Zone 2 elements pick up, if other conditions permit. (Note: The POTT scheme is not available in the SEL-311B and SEL-311A Relays.)

Target LED Explanation

The TRIP target illuminates at the rising edge of trip(the new assertion of the TRIP Relay Word bit).

The TIME target illuminates at the rising edge of trip if the SELOGIC control equation FAULT has been asserted for more than 3 cycles.

The Zone targets indicate the zone or level of the element that caused the trip. The A, B, C, and G targets indicate the phase involvement.

The COMM and SOTF targets indicate when the trip occurred as part of a Communications-based operation or a Switch-Onto-Fault operation, respectively.

Section 5: Trip and Target Logic includes detailed information regarding operation of the relay targets.

Front Panel LCD Explanation

The relay generates an event report for each fault. To see the summary event report for the last fault, press the **EVENT** button on the relay front panel and use the Up, Down, Left, and Right arrow buttons to review the information presented there.

If a new fault occurs while you are reviewing the fault data, press the **EXIT** button, then the **EVENT** button to review the new data.

You may review the long form event report for each fault using a terminal connected to one of the relay serial ports. Each event report is a record of the currents, voltages, relay element states, and logic input and contact output states. See ***Section 12: Standard Event Reports and SER*** for further details on the retrieval and analysis of event reports saved by this relay.

TEST SETUP

Test Source Connections

Each relay element test requires that ac voltage and/or current signals be applied to the relay. The figures and text below describe the test source connections required for relay protection element tests.

Three Voltage Source and Three Current Source Connections

Figure 13.2 shows connections to use when three voltage sources and three current sources are available. Any protective element may be tested and any fault type simulated using these connections.

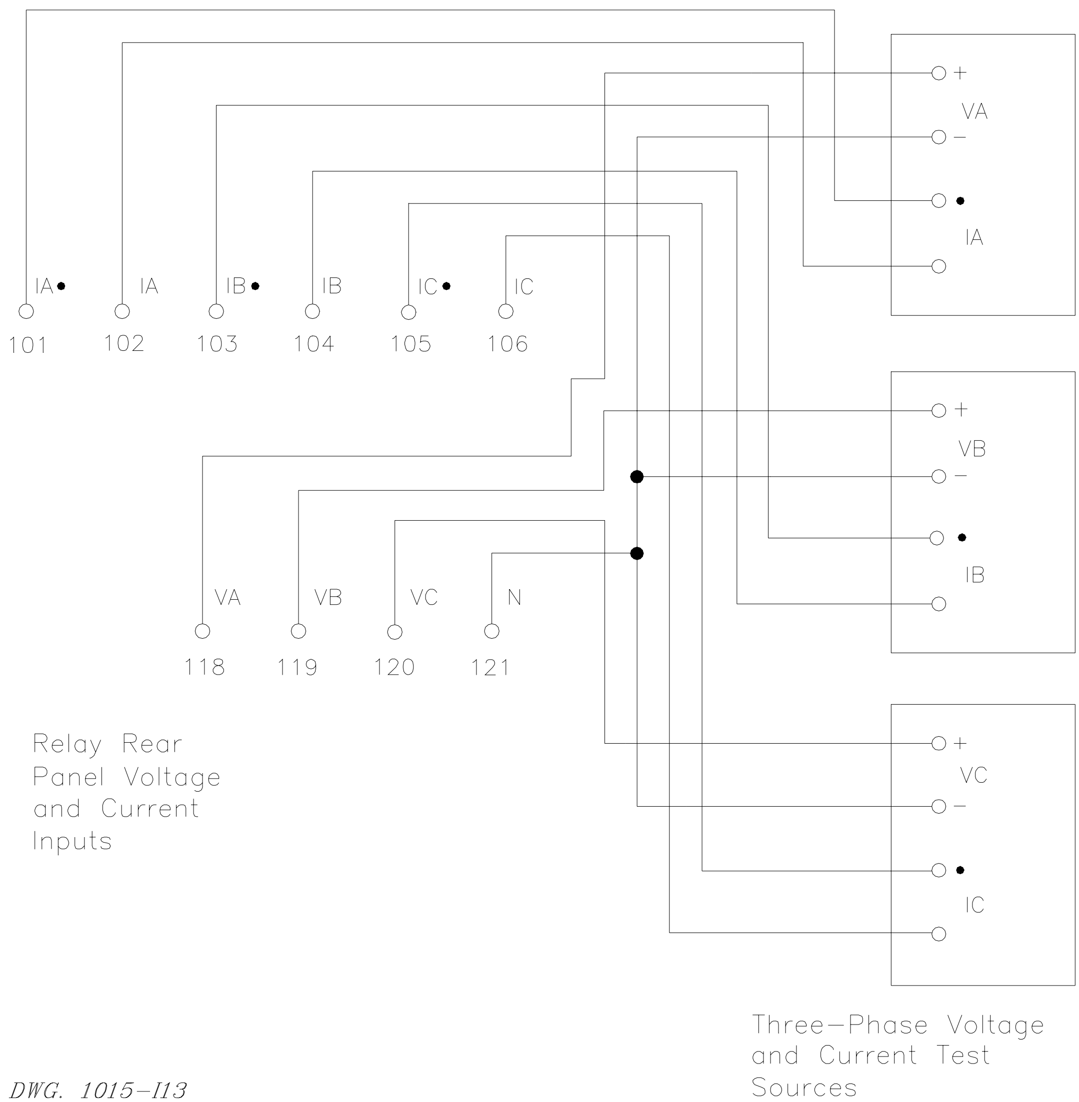

Figure 13.2: Three Voltage Source and Three Current Source Test Connections

Three Voltage Source and Two Current Source Connections

Figure 13.3 and Figure 13.4 show connections to use when three voltage sources and two current sources are available. Phase-to-phase, phase-ground, and two-phase-ground faults may be simulated using the connections shown in Figure 13.3. Three-phase faults may be simulated using the connections shown in Figure 13.4.

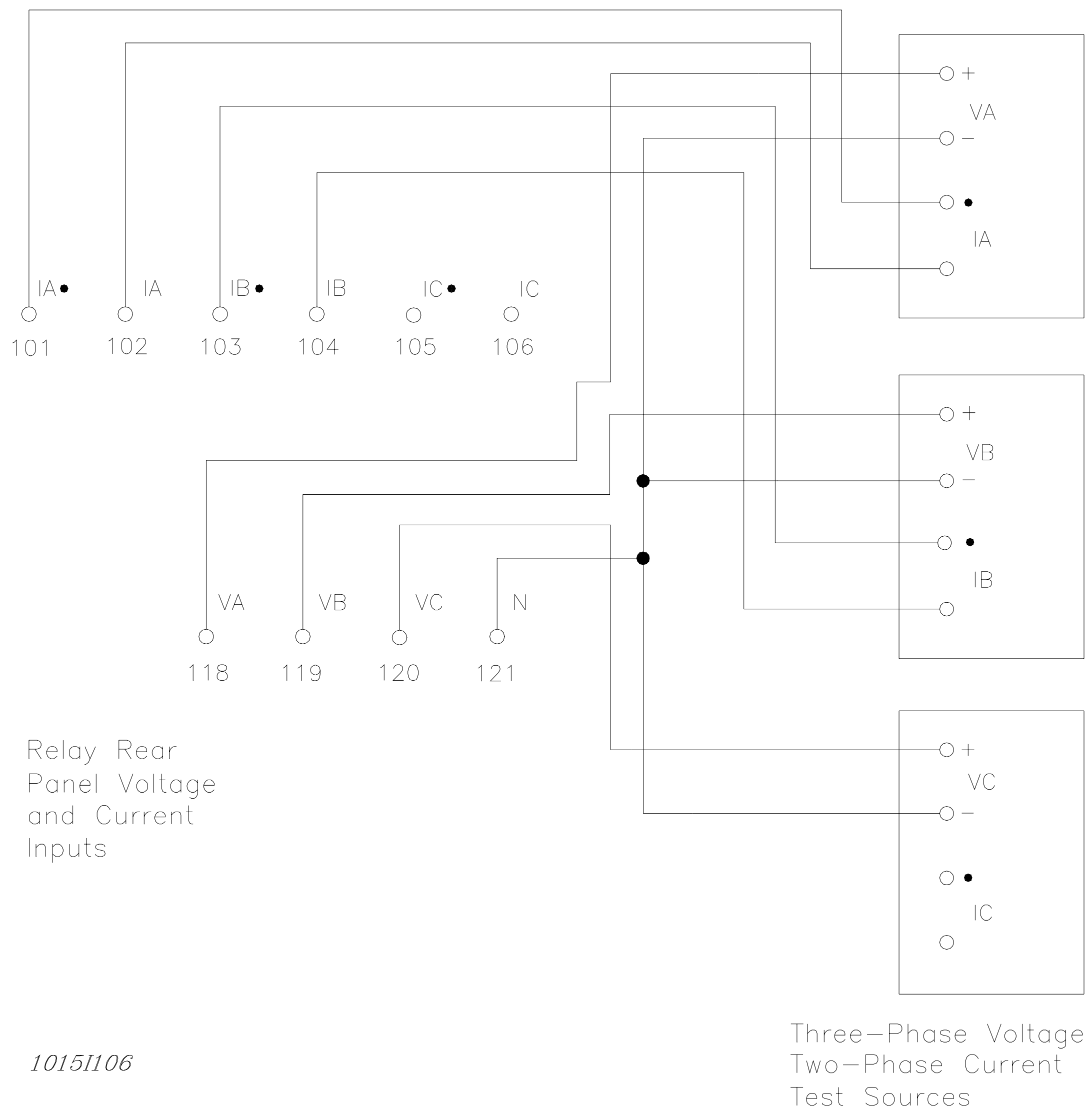

Figure 13.3: Phase-to-Phase, Phase-to-Ground, and Two-Phase-to-Ground Fault Test Connections Using Two Current Sources

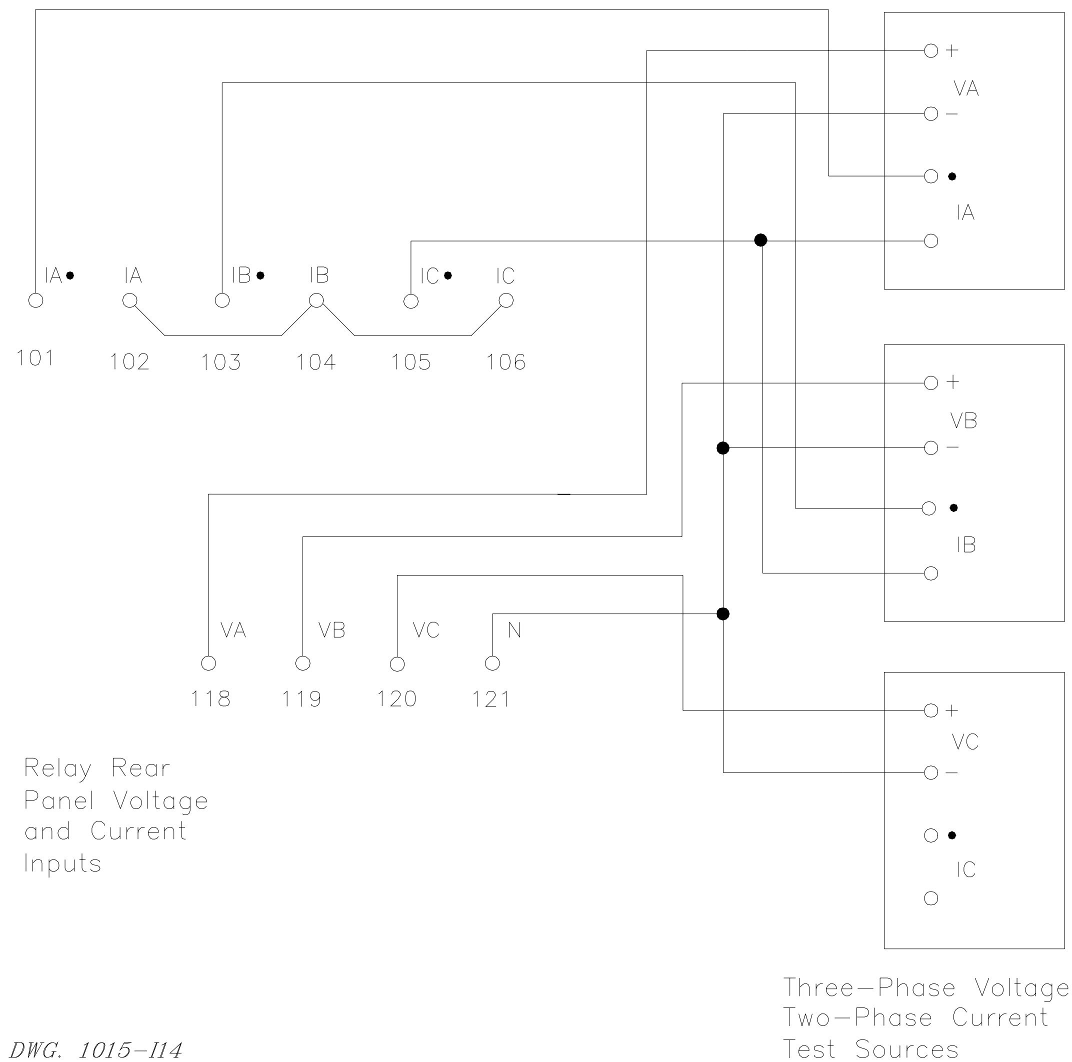

Figure 13.4: Three-Phase Fault and METER Test Connections Using Two Current Sources

Three Voltage Source and One Current Source Connections

Figure 13.5 and Figure 13.6 show connections to use when three voltage sources and a single current source are available. Phase-ground faults may be simulated using the connections shown in Figure 13.5. Phase-to-phase faults may be simulated using the connections shown in Figure 13.6.

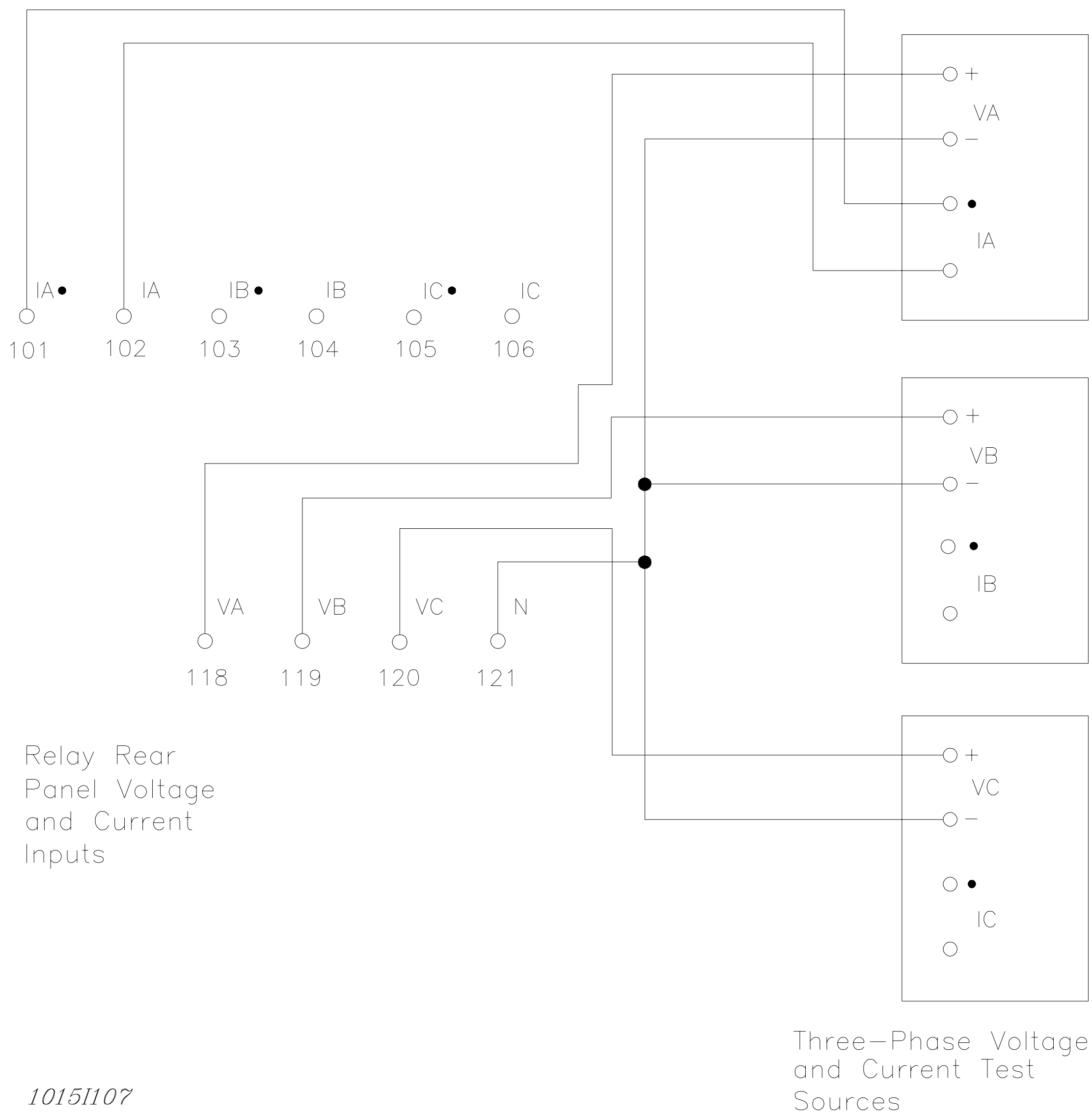

Figure 13.5: Phase-to-Ground Fault Test Connections Using a Single Current Source

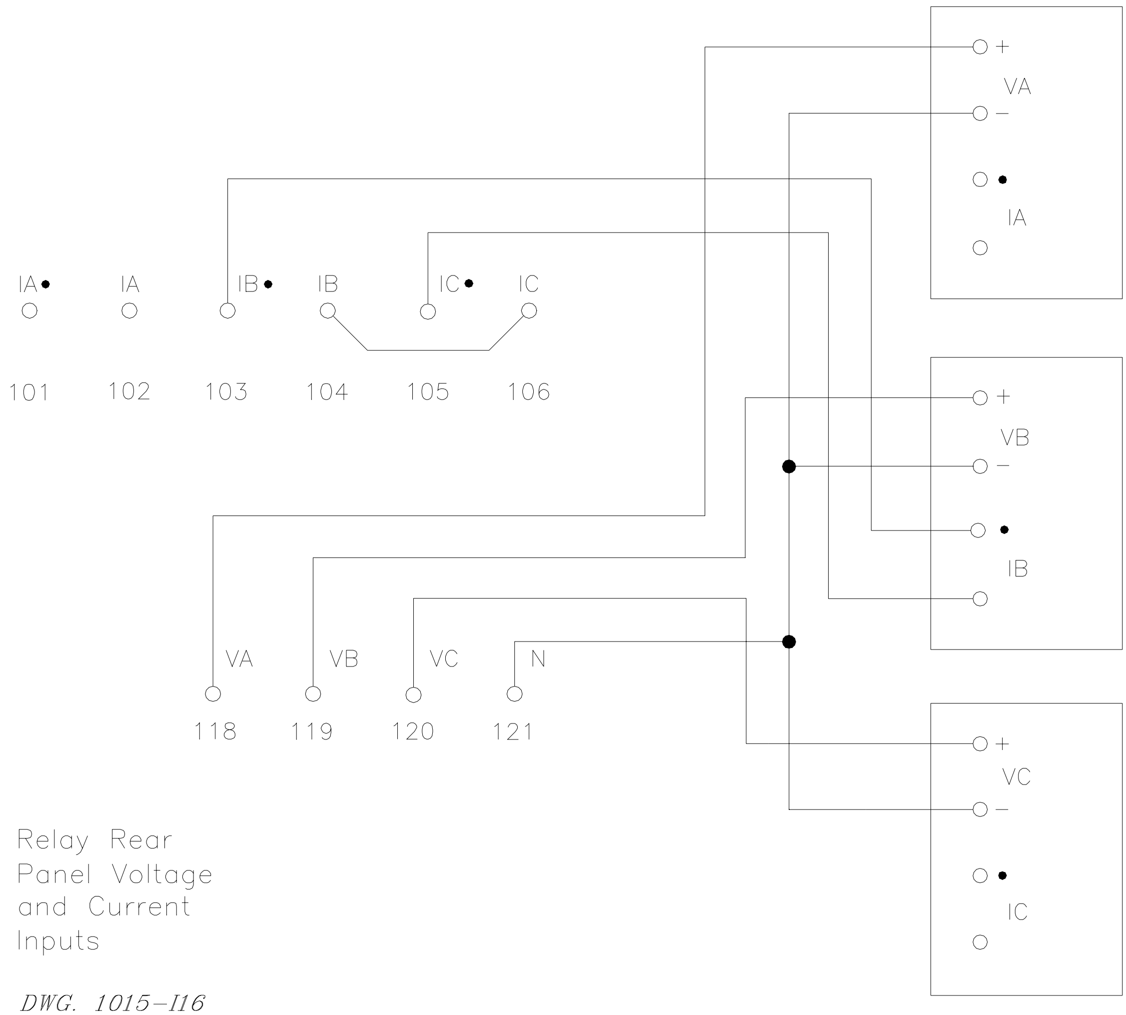

Figure 13.6: Phase-to-Phase Fault Test Connections Using a Single Current Source

Serial Communication Equipment Connections

A terminal or PC with communications software is necessary to make SELOGIC control equations setting changes and examine relay event reports. We recommend using a terminal during relay testing. Figure 13.7 shows typical connections between a computer and the SEL-311B Relay Port F. Complete details regarding serial communications with the relay may be found in ***Section 10: Serial Port Communications and Commands***.

⚠ WARNING

Use only serial communications cables manufactured by SEL or built to SEL specifications with the SEL-311B Relay. Damage to the relay or your communication equipment may result from the use of incorrect communication connections.

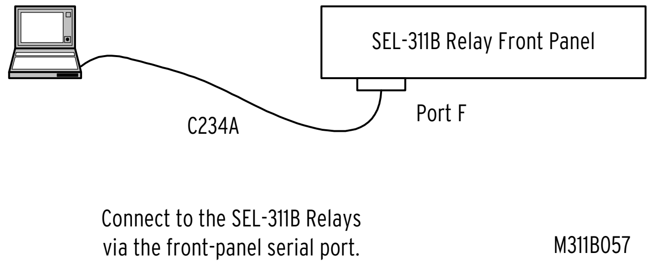

Figure 13.7: Communications Connections Between the SEL-311B Relay and a Terminal

Test Procedures

This section includes outline test procedures for overcurrent, directional, phase distance, and ground distance elements included in the SEL-311B Relay. The procedures are general, so that they may be applied to any specific element or zone.

Overcurrent Elements

The SEL-311B Relay includes phase, residual, negative-sequence, and positive-sequence overcurrent elements. The type of overcurrent element under test determines the test connections required. Some elements are supervised by directional elements or distance elements.

The steps necessary to perform an overcurrent element test are shown below.

Step 1. Select element under test. Briefly review the specifications for the element under test. If the element under test is supervised by other conditions, be sure that you understand the inputs necessary to satisfy the supervisory conditions, and the overcurrent condition.

Step 2. Verify the element setting by executing the **SHOWSET** command via a terminal connected to a relay serial port, or by examining the relay settings via the front panel LCD display using the Access Level 2 **SET** command.

Step 3. Select the method used to indicate assertion of the element under test. Typically, this is accomplished by monitoring an output contact programmed to indicate only the condition under test.

Step 4. Make test source connections. If an unsupervised, single-phase overcurrent element, such as the 50P1 element, is being tested, a single current source is all that is required to perform the test. If a directionally supervised negative-sequence overcurrent element is to be tested, voltage-sources are also required to satisfy the directional supervision conditions.

Make test source connections based upon the requirements of the test and the availability of sources. Figure 13.2 through Figure 13.6 illustrate the various source connections you may use.

Step 5. Determine the signals required to operate the element. For unsupervised elements, simply use the following equations. Fulfilling the requirements of the supervisory conditions may be more complicated. Refer to the test procedures appropriate to the supervising element for details.

Step 6. Apply the test signals.

Step 7. Monitor the output contact assigned to indicate the state of the element under test to ensure that the element asserts. Review the event reports to ensure that supervisory conditions and the element under test asserted appropriately.

Calculating Overcurrent Element Test Quantities

The SEL-311B Relay is equipped with several different types of overcurrent elements. Each has a specific purpose and a slightly different method of testing. The types of overcurrent elements, the signals they operate from, and the elements of that type are listed below.

Element Type	Operates based upon the magnitude of:	Relay Elements
Phase	A-phase or B-phase or C-phase current. Test using single-phase current.	50P1, 50P2, 50P3
Residual	Residual current: $I_R = I_A + I_B + I_C$. Test using single-phase current.	50G1, 50G2, 50G3, 50G4, 50GF, 50GR
Negative-Sequence	$3 \bullet I_2 = (I_A + a^2 \bullet I_B + a \bullet I_C)$ Test using single-phase current.	50Q1, 50Q2, 50Q3, 50Q4, 50QF, 50QR
Positive-Sequence	$I_1 = 1/3\ (I_A + a \bullet I_B + a^2 \bullet I_C)$ Test using three-phase or single-phase current.	50ABC

Overcurrent Element Test Examples

Examples below illustrate the test methods used for several elements.

Single-Phase Overcurrent Element: 50P1

Note: The steps taken in the example test for the 50P1 nondirectional phase overcurrent element may be applied to test the 50P2 and 50P3 nondirectional phase overcurrent element as well as the residual and negative-sequence overcurrent elements 50G1, 50G2, 50G3, 50G4, 50GF, 50GR, 50Q1, 50Q2, 50Q3, 50Q4, 50QF, and 50QR.

Step 1. Execute the **SHOWSET** command and verify the relay setting for the 50P1 overcurrent element. The example relay settings set the 50P1 element to pick up at 11.25 amps, secondary.

Step 2. Select an output contact to indicate operation of the 50P1 overcurrent element. In this example we use the OUT106 output.

From Access Level 2, execute the **SET L n** command to configure output OUT106 to close for assertion of the 50P1 overcurrent element.

```
=>>SET L 1 OUT106 <ENTER>
SELogic group 1

OUT106  =0

 ? 50P1 <ENTER>
OUT107  =0

? END <ENTER>
```

After you type **END <ENTER>** to end the set procedure, the relay displays the current logic settings. You must continue to type **<ENTER>** to review the full group of logic settings. At the prompt, type **Y <ENTER>** to accept those settings.

Connect output OUT106 to the sense input of your test set, an ohmmeter, or some other contact sensing device.

Step 3. Connect a single current source to a phase current input of the relay. Refer to the current connections shown in Figure 13.6 as an example.

Step 4. Because the 50P1 overcurrent element operates based upon the magnitude of any single-phase current, the 50P1 element asserts when any phase current exceeds 11.25 amps.

Step 5. Turn on the current test source and slowly increase the magnitude of current applied until the 50P1 element asserts, causing OUT106 to close. This should occur when current applied is approximately 11.25 amps.

Note: As you perform this test, other protection elements may assert, causing the relay to close other output contacts and assert relay targets. This is normal and is not a cause for concern.

Negative-Sequence Directional Element

The SEL-311B Relay includes phase (F32Q and R32Q) and ground (F32QG and R32QG) directional elements that operates based upon the calculated magnitude and angle of negative-sequence impedance applied to the relay. There are two methods of testing these elements. The first, using a single voltage and current, and the second using three voltages and one current. Examples of both methods are provided below following an explanation of the equations that define the element.

Negative-Sequence Directional Element Based Upon Negative-Sequence Impedance

The SEL-311B Relay calculates the magnitude and angle of negative-sequence voltage and current applied to the relay. From that information, the relay calculates the magnitude of negative-sequence impedance that lies collinear to the line positive-sequence impedance. The equation defining that function is shown below:

$$Z2c = \frac{\mathrm{Re}[V_2 \bullet (1 \angle Z1ANG° \bullet I_2)^*]}{|I_2|^2} \qquad \text{Equation 13.1}$$

Where: Re indicates the real part of the term in brackets, for instance Re[A + jB] = A
* indicates the complex conjugate of the expression in parentheses, (A + jB)* = (A - jB).

The result of Equation 13.1 is an impedance magnitude value that varies with the magnitude and angle of applied current. An example illustrates this operation.

Consider the result of applying the following voltage and current signals to Equation 13.1:

$$\angle Z1ANG = 90°$$
$$V_2 = 10 \angle 180° \text{ volts, secondary}$$
$$I_2 = 2 \angle -90° \text{ amps, secondary}$$

$$Z2c = \frac{\mathrm{Re}[10 \angle 180° \bullet (1 \angle 90° \bullet 2 \angle \text{-}90°)^*]}{|2|^2}$$

$$Z2c = \frac{\text{- 20 ohms}}{4}$$

$$Z2c = \text{-5 ohms}$$

Coincidentally, these voltage and current signals could represent a forward single line-ground fault on a system with a 90° impedance angle. Normally, a forward fault results in a negative Z2c value.

Here is an example for a reverse single line-ground fault.

$$\angle Z1ANG = 90°$$
$$V_2 = 10 \angle 180° \text{ volts, secondary}$$
$$I_2 = 2 \angle 90° \text{ amps, secondary}$$

$$Z2c = \frac{\mathrm{Re}[10 \angle 180° \bullet (1 \angle 90° \bullet 2 \angle +90°)^*]}{|2|^2}$$

$$Z2c = \frac{\text{20 ohms}}{4}$$

$$Z2c = \text{5 ohms}$$

Notice that the result of Equation 13.1 is positive for a reverse fault and negative for a forward fault. This result is consistent with actual behavior on the power system.

The relay determines fault direction by comparing the result of Equation 13.1 to forward and reverse impedance thresholds that are dependent upon the Z2F and Z2R relay settings and the magnitude of negative-sequence voltage divided by the magnitude of negative-sequence current.

When Z2c is less than the forward Z2 threshold, Z2FT, the fault is in the forward direction, so the relay sets the F32Q and F32QG elements, if other supervisory conditions permit. When Z2c is greater than the reverse Z2 threshold, Z2RT, the fault is in the reverse direction, so the relay sets the R32Q and R32QG elements, if other supervisory conditions permit.

The forward directional threshold is calculated using Equation 13.2 when Z2F is negative or Equation 13.3 when Z2F is positive.

When Z2F ≤ 0:

$$Z2FT = 0.75 \bullet Z2F - 0.25 \bullet Z2m \qquad \text{Equation 13.2}$$

When Z2F > 0:

$$Z2FT = 1.25 \bullet Z2F - 0.25 \bullet Z2m \qquad \text{Equation 13.3}$$

Where:

$$Z2m = \frac{|V_2|}{|I_2|}$$

The reverse directional threshold is calculated using Equation 13.4 when Z2R is positive or Equation 13.5 when Z2R is negative.

When Z2R ≥ 0:

$$Z2RT = 0.75 \bullet Z2R + 0.25 \bullet Z2m \qquad \text{Equation 13.4}$$

When Z2R < 0:

$$Z2RT = 1.25 \bullet Z2R + 0.25 \bullet Z2m \qquad \text{Equation 13.5}$$

The threshold equations have a unique property. When Z2m = │Z2R│, Z2RT = Z2R and when Z2m = │Z2F│, Z2FT = Z2F. This property is used to simplify the test procedures outlined on the following pages.

It is possible to create test conditions for a Z2c that lies between the forward and reverse thresholds. In this case the relay does not set the F32Q, F32QG, R32Q, or R32QG elements. While these conditions can be contrived in the lab, correct Z2F and Z2R settings prevent this from occurring for real power system faults.

Settings for both Z2F and Z2R may be either positive or negative, depending upon the constraints of the relay application.

Negative-Sequence Directional Element Supervisory Conditions

There are a number of supervisory conditions that must be fulfilled before the relay asserts the negative-sequence directional elements. These supervisory conditions are described below:

Magnitude of $3I_2$

The SEL-311B Relay uses the 50QF and 50QR negative-sequence overcurrent elements to supervise operation of the directional element. If the magnitude of applied $3I_2$ is not greater than the 50QFP setting, the F32Q and F32QG elements do not assert to indicate direction. If the magnitude of $3I_2$ applied is not greater than the 50QRP setting, the R32Q and R32QG elements do not assert.

Magnitude Comparison of Positive-Sequence Current to Negative-Sequence Current

The relay multiplies the measured positive-sequence current (I_1) magnitude by the a2 setting, then compares the result to the measured magnitude of negative-sequence current (I_2). The magnitude of I_2 must be greater than the magnitude of I_1 multiplied by a2 for the directional elements (F32Q, F32QG, R32Q or R32QG) to operate.

Relay word bit 32QE asserts when both the $3I_2$ magnitude condition and the magnitude comparison of positive-sequence current to negative-sequence current are satisfied. This relay word bit supervises the F32Q and R32Q elements. The F32QG and R32QG elements require further supervision.

Magnitude Comparison of Zero-Sequence Current to Negative-Sequence Current

The relay multiplies the measured zero-sequence current (I_1) magnitude by the k2 setting, then compares the result to the measured magnitude of negative-sequence current (I_2). The magnitude of I_2 must be greater than the magnitude of I_0 multiplied by k2 for the directional elements F32QG or R32QG to operate.

Loss-of-Potential Supervision

If ELOP = Y or Y1 the relay supervises the directional logic using the Internal Loss-of-Potential condition (ILOP). If ELOP = Y the relay sets the 32QF element and disables F32Q, F32QG, R32Q, and R32QG when a loss-of-potential is detected, regardless of other signals applied to the relay. If you test the directional logic using single voltage and current sources, set ELOP = N to simplify the test.

Negative-Sequence Directional Element Test Using Single Voltage and Current Sources

Step 1. Execute the **SHOWSET** command and verify the following relay settings: Z1MAG, Z1ANG, Z2F, 50QF, Z2R, 50QR, and a2. The example relay settings use the following settings: Z1MAG = 7.8 Ω, Z1ANG = 83.97°, Z2F = 0.77 Ω; 50QF = 0.5 amps secondary; Z2R = 5.45 Ω; 50QR = 0.5 amps secondary; a2 = 0.07, k2 = 0.2

Execute the **SET** command and change the example ELOP setting from Y to N.

Step 2. Select output contacts to indicate operation of the F32Q and R32Q elements. In this example we use the OUT106 and OUT107 outputs.

From Access Level 2, execute the **SET L n** command to configure Output 6 and Output 7 to close for assertion of the F32Q and R32Q elements, respectively.

```
=>>SET L 1 OUT106 <ENTER>
SELogic group 1
   OUT106  =0

 ? F32Q <ENTER>
OUT107  =0
    ? R32Q <ENTER>
DP1  =52A
    ? END <ENTER>
```

After you type **END <ENTER>** to end the set procedure, the relay displays the current logic settings. At the prompt, type **Y <ENTER>** to accept those settings.

Connect outputs OUT106 and OUT107 to the sense input of your test set, an ohmmeter, or some other contact sensing device.

Step 3. Connect the voltage source to the A-phase to neutral relay voltage input. Connect the current source to the A-phase relay current input. Refer to the A-phase voltage and current connections shown in Figure 13.5 as an example. The B-phase and C-phase voltage connections are not required for this test.

Step 4. As described above, the relay 32Q element operates based upon the magnitude and angle of negative-sequence voltages and currents. You can calculate the magnitude and angle of V_2 and I_2, given the magnitude and angle of each of the phase quantities using the equations below.

$$V_2 = \tfrac{1}{3} \bullet \left(V_A + a^2 \bullet V_B + a \bullet V_c\right)$$
$$I_2 = \tfrac{1}{3} \bullet \left(I_A + a^2 \bullet I_B + a \bullet I_C\right)$$

Using single-phase signals simplifies the V_2 and I_2 calculations.

$$V_B = V_C = 0 \text{ volts}$$
$$I_B = I_C = 0 \text{ amps}$$
$$V_2 = \tfrac{1}{3} \bullet (V_A)$$
$$I_2 = \tfrac{1}{3} \bullet (I_A)$$

Assume that you apply a test voltage $V_A = 18.0 \angle 180°$ volts secondary.

$$V_2 = \tfrac{1}{3} \bullet (18.0 \angle 180°) \text{ volts}$$
$$V_2 = 6.0 \angle 180° \text{ volts}$$

Determine the test angle of A-phase current from the Z1ANG relay setting. Equation 13.1 yields a positive result when I_2 lags V_2 by the angle of Z1ANG°. Equation 13.1 yields a negative result when I_2 leads V_2 by (180° - ∠Z1ANG°).

We are testing for positive values of Z2c, so I_2 should lag V_2 by Z1ANG.

Assuming that $V_A = 18.0 \angle 180°$ volts, the angle of I_A for this test should be 96°.

Determine the magnitude of A-phase current where Z2 equals Z2R or Z2F using Equation 13.6:

$$|I_A| = 3 \bullet (|V_2| / |Z_2|) \qquad \text{Equation 13.6}$$

For Z2R = 5.45 Ω:

$$|I_A| = 3 \bullet (6.0 \text{ volts}/5.45 \text{ ohms})$$
$$|I_A| = 3.3 \text{ amps}$$

Calculate Z2m:

$$Z2m = \frac{|V_2|}{|I_2|}$$
$$Z2m = \frac{6.0V}{1.1A}$$
$$Z2m = 5.45 \text{ ohms}$$

Because Z2R is positive, use Equation 13.4 to calculate Z2RT.

$$Z2RT = 0.75 \bullet Z2R + 0.25 \bullet Z2m$$
$$Z2RT = 0.75 \bullet (5.45) + 0.25 \bullet (5.45)$$
$$Z2RT = 5.45 \text{ ohms}$$

The R32Q element asserts when Z2c applied is greater than Z2RT. As the magnitude of I_A is increased, the magnitudes of Z2c and Z2m decrease. For magnitudes of I_A less than 3.3 amps, R32Q asserts, given the other test quantities. For I_A magnitudes greater than 3.3 amps, Z2c is less than Z2RT, so R32Q deasserts.

For Z2F = 0.77 Ω:

$$|I_A| = 3 \bullet (6.0 \text{ volts}/0.77 \text{ ohms})$$
$$|I_A| = 23.4 \text{ amps}$$

Calculate Z2m:

$$Z2m = \frac{|V_2|}{|I_2|}$$
$$Z2m = \frac{6.0V}{7.8A}$$
$$Z2m = 0.77 \text{ ohms}$$

Because Z2F is positive, use Equation 13.3 to calculate Z2FT.

$$Z2FT = 1.25 \bullet Z2F - 0.25 \bullet Z2m$$
$$Z2FT = 1.25 \bullet (0.77) - 0.25 \bullet (0.77)$$
$$Z2FT = 0.77 \text{ ohms}$$

The F32Q element asserts when Z2c is less than Z2FT. As the magnitude of I_A is increased, the magnitudes of Z2c and Z2m decrease. For magnitudes of I_A less than 23.4 amps, F32Q should not assert, given the other test quantities. For I_A magnitudes greater than 23.4 amps, Z2c applied is less than Z2FT, so F32Q asserts.

Step 5. Turn on the voltage source.

Apply $V_A = 18.0 \text{ V} \angle 180°$ $I_A = 0.0 \text{ A} \angle 96°$.

Slowly increase the magnitude of I_A, without varying the phase angle.

The relay R32Q element asserts, closing OUT107 when $|I_A| = 0.5$ amps. This indicates that Z2c applied is greater than Z2RT, $3I_2$ is greater than 50QR, and I_2 is greater than $a2 \cdot I_1$, where a2 is the relay setting.

Continue to increase the magnitude of I_A. R32Q deasserts when $|I_A| = 3.3$ amps, indicating that Z2c is now less than Z2RT. F32Q asserts, closing OUT106 when $|I_A| = 23.4$ amps, indicating that Z2c is less than Z2FT.

Verify the performance described above by calculating Z2c using Equation 13.1 and the test quantities listed above.

For $V_A = 18.0\ V \angle 180°, I_A = 3.3\ A \angle 96°$:

$$\begin{aligned} V_2 &= 6.0 \angle 180° \\ I_2 &= 1.10 \\ 1 \angle Z1ANG° &= 1 \angle 83.97° \end{aligned}$$

$$Z2c = \frac{Re[V_2 \bullet (1 \angle Z1ANG° \bullet I_2)^*]}{|I_2|^2}$$

$$Z2c = \frac{Re[6 \angle 180° \bullet (1 \angle 83.97° \bullet 1.10 \angle 96°)^*]}{|1.10|^2} \qquad \text{Equation 13.1}$$

$$Z2c = \frac{6.6 \text{ ohms}}{1.21}$$

$$Z2c = 5.45 \text{ ohms} = Z2RT \text{ when } Z2m = 5.45 \text{ ohms}$$

For $V_A = 18.0\ V \angle 180°, I_A = 23.4\ A \angle 96°,$ and using the equation above:

$$\begin{aligned} V_2 &= 6.0\ V \angle 180° \\ I_2 &= 7.80 \\ 1 \angle Z1ANG° &= 1 \angle 83.97° \end{aligned}$$

$$Z2c = \frac{Re[6 \angle 180° \bullet (1 \angle 83.97° \bullet 7.80 \angle 96°)^*]}{|7.80|^2}$$

$$Z2c = \frac{46.8 \text{ ohms}}{60.84}$$

$$Z2c = 0.77 \text{ ohms} = Z2FT \text{ when } Z2m = 0.77 \text{ ohms}$$

Note: As you perform this test, other protection elements may assert, causing the relay to close other output contacts and assert relay targets. This is normal and is not a cause for concern.

Negative-Sequence Directional Element Test Using Three Voltage Sources and One Current Source

Step 1. Execute the **SHOWSET** command and verify the following relay settings: Z1MAG, Z1ANG, Z2F, 50QF, Z2R, 50QR, and a2. The example relay settings use the following settings: Z1MAG = 7.8 Ω, Z1ANG = 83.97°, Z2F = 0.77 Ω; 50QF = 0.5 amps secondary; Z2R = 5.45 Ω; 50QR = 0.5 amps secondary; a2 = 0.07, k2 = 0.2

Execute the **SET** command and change the example ELOP setting from Y to N.

Step 2. Select output contacts to indicate operation of the F32Q and R32Q elements. In this example we use the OUT106 and OUT107 outputs.

From Access Level 2, execute the **SET L n** command to configure Output 6 and Output 7 to close for assertion of the F32Q and R32Q elements, respectively.

```
=>>SET L 1 OUT106 <ENTER>
SELogic group 1
   OUT106  =0

 ? F32Q <ENTER>
OUT107  =0
    ? R32Q <ENTER>
DP1  =52A
    ? END <ENTER>
```

After you type **END <ENTER>** to end the set procedure, the relay displays the current logic settings. At the prompt, type **Y <ENTER>** to accept those settings.

Connect outputs OUT106 and OUT107 to the sense input of your test set, an ohmmeter, or some other contact sensing device.

Step 3. Connect the three voltage sources and one current source to the relay as shown in Figure 13.5.

Step 4. As described above, the relay 32Q elements operate based upon the magnitude and angle of negative-sequence voltages and currents. You can calculate the magnitude and angle of V2 and I2, given the magnitude and angle of each of the phase quantities using the equations below.

$$V_2 = \tfrac{1}{3}\cdot\left(V_A + a^2 \cdot V_B + a \cdot V_C\right)$$
$$I_2 = \tfrac{1}{3}\cdot\left(I_A + a^2 \cdot I_B + a \cdot I_C\right)$$

Using a single-phase current source simplifies the I_2 calculation.

$$I_B = I_C = 0 \text{ amps}$$
$$I_2 = \tfrac{1}{3} \bullet (I_A)$$

Assume that you apply the following test voltages:

$$V_A = 49.0 \text{ V } \angle 0°$$
$$V_B = 67.0 \text{ V } \angle -120°$$
$$V_C = 67.0 \text{ V } \angle 120°$$

$$V_2 = \tfrac{1}{3} \bullet \left(49.0 \angle 0° + 1 \angle 240° \bullet 67 \angle -120° + 1 \angle 120° \bullet 67 \angle 120°\right) \text{ volts}$$

$$V_2 = \tfrac{1}{3} \bullet \left(49.0 \angle 0° + 67 \angle 120° + 67 \angle -120°\right) \text{ volts}$$
$$V_2 = 6.0 \angle 180° \text{ volts}$$

Determine the test angle of A-phase current from the Z1ANG relay setting. For Equation 13.1 to yield a positive result, I_A, hence I_2, should lag V_2 by the angle of Z1ANG. For Equation 13.1 to yield a negative result, I_A should lead V_2 by (180° - ∠Z1ANG°).

When you apply the voltage signals shown above, V_2 is 180° out of phase from V_A. Take this into account, and calculate the angle of I_A with respect to the angle of V_A.

Equation 13.1 yields a positive result when I_A leads V_A by (180° - ∠Z1ANG°). Equation 13.1 yields a negative result when I_A lags V_A by ∠Z1ANG°.

We are testing for positive values of Z2c, so I_A should lead V_A by (180° - ∠Z1ANG°). Assuming that V_A = 49.0 ∠0° volts, the angle of I_A for this test should be 96°.

Calculate the magnitude of A-phase current where Z2c equals Z2RT or Z2FT using Equation 13.6:

$$|I_A| = 3 \bullet (|V_2| / |Z_2|) \qquad \text{Equation 13.6}$$

For Z2R = 5.45 Ω:

$$|I_A| = 3 \bullet (6.0 \text{ volts}/5.45 \text{ ohms})$$
$$|I_A| = 3.3 \text{ amps}$$

Calculate Z2m:

$$Z2m = \frac{|V_2|}{|I_2|}$$
$$Z2m = \frac{6.0 \text{ V}}{1.1 \text{ A}}$$
$$Z2m = 5.45 \text{ ohms}$$

Because Z2R is positive, use Equation 13.4 to calculate Z2RT.

$$Z2RT = 0.75 \bullet Z2R + 0.25 \bullet Z2m$$
$$Z2RT = 0.75 \bullet (5.45) + 0.25 \bullet (5.45)$$
$$Z2RT = 5.45 \text{ ohms}$$

The R32Q element asserts when Z2c applied is greater than Z2RT. As the magnitude of I_A is increased, the magnitudes of Z2c and Z2m decrease. For magnitudes of I_A less than 3.3 amps, R32Q asserts, given the other test quantities. For I_A magnitudes greater than 3.3 amps, Z2c is less than Z2RT, so R32Q deasserts.

For Z2F = 0.77 Ω:

$$|I_A| = 3 \bullet (6.0 \text{ volts}/0.77 \text{ ohms})$$
$$|I_A| = 23.4 \text{ amps}$$

Calculate Z2m:

$$Z2m = \frac{|V_2|}{|I_2|}$$
$$Z2m = \frac{6.0 \text{ V}}{7.8 \text{ A}}$$
$$Z2m = 0.77 \text{ ohms}$$

Because Z2F is positive, use Equation 13.3 to calculate Z2FT.

$$Z2FT = 1.25 \bullet Z2F - 0.25 \bullet Z2m$$
$$Z2FT = 1.25 \bullet (0.77) - 0.25 \bullet (0.77)$$
$$Z2FT = 0.77 \text{ ohms}$$

The F32Q element asserts when Z2c is less than Z2FT. As the magnitude of I_A is increased, the magnitudes of Z2c and Z2m decrease. For magnitudes of I_A less than 23.4 amps, F32Q should not assert, given the other test quantities. For I_A magnitudes greater than 23.4 amps, Z2c applied is less than Z2FT, so F32Q asserts.

Step 5. Turn on the voltage sources.

Apply:

$$V_A = 49.0 \text{ V } \angle 0°$$
$$V_B = 67.0 \text{ V } \angle -120°$$
$$V_C = 67.0 \text{ V } \angle 120°$$
$$I_A = 0.0 \text{ A } \angle 96°$$

Slowly increase the magnitude of I_A, without varying the phase angle.

The relay R32Q element asserts, closing OUT107 when $|I_A| = 0.5$ amps. This indicates that Z2c applied is greater than Z2RT, $3I_2$ is greater than 50QR, and I_2 is greater than $a2 \cdot I_1$, where a2 is the relay setting.

Continue to increase the magnitude of I_A. R32Q deasserts when $|I_A| = 3.3$ amps, indicating that Z2c is now less than Z2RT. F32Q asserts, closing OUT106 when $|I_A| = 23.4$ amps, indicating that Z2c is less than Z2FT.

Verify that the relay operated properly by calculating Z2c using Equation 13.1 and the test quantities listed below.

For:

$$I_A = 3.30 \text{ A } \angle 96°$$
$$V_A = 49.0 \text{ V } \angle 0°$$
$$V_B = 67.0 \text{ V } \angle -120°$$
$$V_C = 67.0 \text{ V } \angle 120°$$

$$V_2 = 6.0 \text{ V } \angle 180°$$
$$I_2 = 1.10$$
$$1\angle Z1ANG° = 1 \angle 83.97°$$

$$Z2c = \frac{\mathrm{Re}\left[V_2 \bullet (1 \angle Z1ANG° \bullet I_2)^*\right]}{|I_2|^2}$$
$$Z2c = \frac{\mathrm{Re}\left[6 \angle 180° \bullet (1 \angle 83.97° \bullet 1.10 \angle 96°)^*\right]}{|1.10|^2} \quad \text{Equation 13.1}$$
$$Z2c = \frac{6.6 \text{ ohms}}{1.21}$$
$$Z2c = 5.45 \text{ ohms} = Z2RT \text{ when } Z2m = 5.45 \text{ ohms}$$

For:

$$
\begin{aligned}
I_A &= 23.4\ \text{A}\ \angle 96^\circ \\
V_A &= 49.0\ \text{V}\ \angle 0^\circ \\
V_B &= 67.0\ \text{V}\ \angle -120^\circ \\
V_C &= 67.0\ \text{V}\ \angle 120^\circ
\end{aligned}
$$

$$
\begin{aligned}
V_2 &= 6.0\ \text{V}\ \angle 180^\circ \\
I_2 &= 7.80 \\
1\ \angle \text{Z1ANG}^\circ &= 1\ \angle 83.97^\circ
\end{aligned}
$$

$$
\begin{aligned}
\text{Z2c} &= \frac{\text{Re}\left[6\ \angle 180^\circ \bullet \left(1\ \angle 83.97^\circ \bullet 7.80\ \angle 96^\circ\right)^*\right]}{|7.80|^2} \\
\text{Z2c} &= \frac{46.8\ \text{ohms}}{60.84} \\
\text{Z2c} &= 0.77\ \text{ohms} = \text{Z2F when Z2m} = 0.77\ \text{ohms}
\end{aligned}
$$

Note: As you perform this test, other protection elements may assert, causing the relay to close other output contacts and assert relay targets. This is normal and is not a cause for concern.

Phase Mho Distance Elements

The SEL-311B Relay includes up to four zones of mho phase distance protection. Enable the number of phase distance zones you would like to apply using the E21P setting. Zones 1 and 2 are fixed forward. Zones 3 and 4 may be set forward or reverse. The reach and direction of each zone is independent from the other zones. When a zone of phase distance protection is set to reach in one direction, the ground distance elements associated with that zone must be set to reach in the same direction. Reach is set in secondary ohms. The phase distance element maximum reach angle is always equal to the angle of Z1ANG.

Each zone has an instantaneous indication. For example, the M3P element asserts without intentional time delay for A-B, B-C, or C-A faults within the Zone 3 characteristic. All zones also include time-delayed indication through elements M1PT, M2PT, M3PT, and M4PT. In addition, the relay provides an instantaneous indication for each individual phase-to-phase distance element. For example, the MAB1, MAB2, MAB3, and MAB4 elements provide instantaneous indication of A-B phase faults in each zone.

For general testing, use the instantaneous and time delayed elements that respond to any phase-to-phase fault within a given zone such as M1P, M2P, etc. You can record more detailed and specific test results using the instantaneous element associated with the faulted phase pair and zone under test.

Phase Distance Element Supervisory Conditions

There are a number of supervisory conditions that must be fulfilled before the relay allows a phase distance element to pick up. These supervisory conditions are described below.

Phase-to-Phase Nondirectional Overcurrent Element, 50PPn

Each phase-to-phase distance element is supervised by a nondirectional phase-to-phase overcurrent element. For example, the relay cannot assert the Zone 3 A-B phase-to-phase distance element if the vector difference between A-phase current and B-phase current is less than the 50PP3 setting. You may set 50PPn, but the operation of the 50PPn element is internal to the phase-to-phase distance element and may not be observed directly.

Directional Elements

The phase distance protection function is supervised by the negative-sequence directional and three-phase directional elements to provide improved directional security. Forward-reaching phase distance elements may not assert unless a 32QF or F32P element is asserted. Reverse-reaching phase distance elements may not assert unless a 32QR or R32P element is asserted. Relay word bits F32P and R32P are internal to the relay and may not be used or observed directly.

Loss-of-Potential Logic

If ELOP = Y or Y1, the relay supervises the phase distance element logic using the Internal Loss-of-Potential condition (ILOP). When ELOP = Y or Y1 the relay disables the phase distance elements when a loss-of-potential is detected, regardless of other signals applied to the relay. If you test the phase distance elements using low voltage signals, set ELOP = N to simplify the test.

Load-Encroachment Logic

The relay includes Load-Encroachment logic to help prevent the relay phase distance elements from operating improperly under heavy load conditions. Forward and reverse load regions are defined using impedance and angle settings. The relay calculates the positive-sequence impedance. If the calculated impedance falls within the set load area, the phase distance elements are blocked from operating. This may result in a phase distance element characteristic that appears to have a bow tie shaped section missing near the area of the resistive axis. Double-check the relay Load-Encroachment logic settings if your test results appear incorrect near the resistive axis.

Out-of-Step Blocking Logic

The relay includes Out-of-Step Tripping and Blocking logic that operates based on the Zone 5 and Zone 6 positive-sequence impedance zones and several timers. If you suspect that the Out-of-Step logic is blocking operation of a phase distance element under test, check the relay settings associated with the Out-of-Step function and review the relay event report.

Phase Distance Element Test Using Three Voltage Sources and One Current Source

Note: This test refers directly to the Zone 2 phase distance element, but may be applied to any other forward-reaching phase-to-phase distance element zone. To test reverse-reaching zones, simply add 180° to the calculated test current phase angle. Verify correct operation of the 32QR element for the test voltage and current signals using Equation 13.1 in the Negative-Sequence Directional Element Test Procedure.

Step 1. Execute the **SHOWSET** command and verify the following relay settings: Z1MAG, Z1ANG, PMHOZ, Z2P, 50PP2, Z2F, and 50QF. The example relay settings use the following settings: Z1MAG = 7.8; Z1ANG = 83.97°; PMHOZ = 3; Z2P = 9.36 Ω; 50PP2 = 2.22; Z2F = 0.77 Ω; 50QF = 0.5 amps secondary.

Execute the **SET** command and change the example ELOP setting from Y to N. This prevents the relay Loss-of-Potential logic from blocking operation of the relay distance elements.

Step 2. Select an output contact to indicate operation of the M2P element. In this example we use the OUT106 output.

From Access Level 2, execute the **SET L n** command to configure Output 6 to close for assertion of the M2P element.

```
=>>SET L 1 OUT106 <ENTER>
SELogic group 1
OUT106  =0
 ? M2P <ENTER>
OUT107  =0
 ? END <ENTER>
```

After you type **END <ENTER>** to end the set procedure, the relay displays the current logic settings. Type **Y <ENTER>** to accept those settings.

Connect output OUT106 to the sense input of your test set, an ohmmeter, or some other contact sensing device.

Step 3. Connect the voltage sources to the relay A-phase, B-phase, and C-phase voltage inputs. Connect the current source to the relay B-phase and C-phase current inputs. Refer to the voltage and current connections shown in Figure 13.6 as an example.

Step 4. Select the magnitude of the test signals, I_{BC}, V_B, and V_C.

Table 13.3 summarizes the test quantities for the Zone 2 B-C phase distance element based upon the example relay settings.

Table 13.3: Test Quantities for Zone 2 Phase Distance Element

Test Voltages	Test Current
$V_A = 67 \angle 0°$ volts	$I_{TEST} = 2.5 \angle -173.97°$ amps
$V_B = 46.8 \angle -150°$ volts	
$V_C = 46.8 \angle 150°$ volts	

The following text describes a hand calculation method you may use to calculate relay distance element voltage and current test signals. If you do not wish to review this information, go to Step 5.

The relay phase distance elements operate based upon the magnitude of applied phase-to-phase impedance. The impedance calculation is also supervised by the functions described. To effectively test the distance elements, select voltage and current test signals that fulfill the impedance and supervisory requirements of the relay settings, but are within the ability of the voltage and current test sources to produce accurately.

The Zone 2 phase distance element is forward-reaching. Thus, it is supervised by the forward directional element 32QF, as well as the 50PP2 phase-to-phase overcurrent elements. For the distance element to assert, the applied phase-to-phase current must exceed the 50PP2 setting and applied $3I_2$ must exceed the 50QF setting.

The 50PP overcurrent elements operate based upon the magnitude of the vector difference between any two phase currents. Using the current connections shown in Figure 13.6, the magnitude of I_{BC} is twice the magnitude of the applied current. This is illustrated by the following equations.

$$\begin{aligned} I_{TEST} &= I_B = -I_C \\ I_{BC} &= I_B - I_C \\ I_{BC} &= 2 \bullet I_B \\ I_{BC} &= 2 \bullet I_{TEST} \end{aligned}$$

With a 50PP2 setting of 2.22 amps, 50PP2 picks up when I_{TEST} is greater than 1.11 amps.

The 50QF negative-sequence overcurrent element operates based upon the magnitude of $3I_2$ applied. Using the current connections shown in Figure 13.6, we can calculate the magnitude of $3I_2$ applied based upon the magnitude of I_{TEST}.

$$\begin{aligned} I_2 &= \tfrac{1}{3} \bullet \left(I_A + a^2 \bullet I_B + a \bullet I_C\right) \\ 3 \bullet I_2 &= \left(I_A + a^2 \bullet I_B + a \bullet I_C\right) \\ I_A &= 0 \text{ and } I_C = -I_B \text{, so:} \\ 3 \bullet I_2 &= \left(a^2 \bullet I_B - a \bullet I_B\right) \\ 3 \bullet I_2 &= I_B \bullet \left(a^2 - a\right) \\ 3 \bullet I_2 &= I_B \bullet (1.732 \angle -90°) \end{aligned}$$

Because the 50QF element operates based upon magnitude only, the equation above is simplified.

$$|3 \bullet I_2| = |I_{TEST}| \bullet 1.732$$

With a 50QF setting of 0.5 amps, 50QF picks up when I_{TEST} is greater than 0.288 amps.

In this example, select $|I_{TEST}|$ = 2.5 amps, thus I_{BC} = 5.0 amps and $3I_2$ = 4.33 amps. This selection fulfills the supervisory overcurrent conditions described above.

The reach of the distance element under test is defined by the element setting. In this case Z2P = 9.36 secondary ohms.

Calculate the magnitude of V_{BC} using Equation 13.7.

$$|V_{BC}| = |I_{BC}| \bullet |Z_{BC}|$$
$$|V_{BC}| = |5.0| \bullet |9.36| \qquad \text{Equation 13.7}$$
$$|V_{BC}| = 46.8 \text{ volts secondary}$$

Refer to Figure 13.8 and use the equations below to calculate the magnitude and angle of V_B and V_C based upon the magnitude of V_{BC} calculated above.

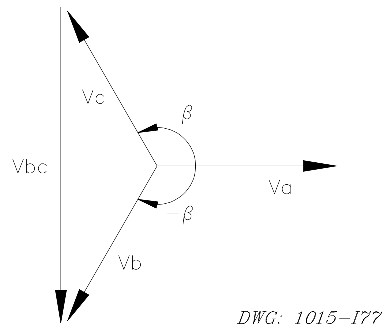

Figure 13.8: Phase Distance Element Test Voltage Signals

When the magnitude of V_{BC} calculated above lies between 67 and 35 volts, use β = 150° and $|V_B| = |V_C| = |V_{BC}|$.

When the magnitude of V_{BC} calculated above is greater than 67 volts, use $|V_B| = |V_C| = 67$ V. Calculate the angle β using Equation 13.8.

When the magnitude of V_{BC} calculated above is less than 35 volts, use $|V_B| = |V_C| = 35$ V. Calculate the angle β using Equation 13.8.

$$\beta = 180° - a\sin\left[|V_{BC}|/(2 \bullet |V_C|)\right] \deg \qquad \text{Equation 13.8}$$

Select $V_A = 67 \angle 0°$ volts. For the Zone 2 B-C element test, based upon the example settings, the magnitude of V_{BC} equals 46.8 volts. From the equations above, select the following test voltage magnitudes and angles.

$$V_A = 67.0 \angle 0° \text{ volts}$$
$$V_B = 46.8 \angle -150° \text{ volts}$$
$$V_C = 46.8 \angle 150° \text{ volts}$$

The phase distance element maximum reach is measured when faulted phase-to-phase current lags faulted phase-to-phase voltage by the distance element maximum torque angle. In the SEL-311B Relay, the phase distance element maximum torque angle is defined by the angle of the relay Z1ANG setting.

For the example relay settings, I_{BC} should lag V_{BC} by 83.97°. Based upon the test voltages selected above, V_{BC} lags V_A by 90°, so I_{BC} should lag V_A by 173.97°.

As stated above, the phase distance elements are supervised by the negative-sequence directional element. It is important to check the negative-sequence quantities applied and verify that the 32QF element should assert allowing the forward-reaching distance element to operate. We can calculate the magnitude and angle of negative-sequence voltage and current applied for the test quantities listed above. We can then calculate the negative-sequence impedance, Z2c, applied using Equation 13.1 and compare Z2c to the Z2FT threshold which is a function of the Z2F setting and Z2m.

$$V_2 = \tfrac{1}{3} \cdot \left(V_A + a^2 \cdot V_B + a \cdot V_C\right)$$
$$I_2 = \tfrac{1}{3} \cdot \left(I_A + a^2 \cdot I_B + a \cdot I_C\right)$$

$$Z2c = \frac{\mathrm{Re}\left[V_2 \cdot (1 \angle Z1ANG° \cdot I_2)^*\right]}{|I_2|^2} \qquad \text{Equation 13.1}$$

$$Z2m = \frac{|V_2|}{|I_2|}$$

$$Z2FT = 1.25 \cdot Z2F - 0.25 \cdot Z2m \qquad \text{Equation 13.3}$$

Taking the test signals from Table 13.3.

$$V_A = 67.0\ V\angle 0°\ \text{volts}$$
$$V_B = 46.8\ V\angle -150°\ \text{volts}$$
$$V_C = 46.8\ V\angle 150°\ \text{volts}$$

$$V_2 = \tfrac{1}{3} \cdot (67.0\ \angle 0° + 1\ \angle 240° \cdot 46.8\ \angle -150° + 1\ \angle 120° \cdot 46.8\ \angle 150°)\ \text{volts}$$
$$V_2 = 22.3\ \angle 0°\ \text{volts}$$

Due to the test connections used, $I_B = -I_C = I_{TEST}$.

$$I_A = 0.0\ A\ \angle 0°$$
$$I_B = 2.5\ A\ \angle -173.97°$$
$$I_C = 2.5\ A\ \angle 6.03°$$

$$I_2 = \tfrac{1}{3} \cdot (0.0\ \angle 0° + 1\ \angle 240° \cdot 2.5\ \angle -173.97° + 1\ \angle 120° \cdot 2.5\ \angle 6.03°)\ \text{amps}$$
$$I_2 = 1.44\ \angle 96.03°\ \text{amps}$$

Using Equation 13.1 to calculate Z2c, the result is:

$$Z2c = -15.47\ \text{ohms}$$

$$Z2m = 15.47\ \text{ohms}$$
$$Z2FT = 1.25 \cdot (0.77) - 0.25 \cdot (15.47)$$
$$Z2FT = -2.91\ \text{ohms}$$

The Z2FT threshold is -2.91 Ω. Z2c applied (-15.47 Ω) is less than the Z2FT threshold based upon the Z2F setting (0.77 Ω) and Z2m (15.47 Ω), therefore, the 32QF element asserts when these signals are applied. If Z2c applied is greater than the Z2FT threshold, select new test current and voltages using the steps outlined above.

Step 5. Turn on the voltage sources. Apply V_A, V_B, and V_C at the magnitudes and angles listed in Table 13.3. Turn on the current test source. Set the current angle to -174°.

Slowly increase the magnitude of current applied until the M2P element asserts, causing OUT106 to close. This should occur when current applied is approximately 2.5 amps.

With these signals applied, the relay measures B-C phase impedance defined by the equation:

$$Z_{BC} = \frac{V_{BC}}{2 \cdot I_{TEST}} \text{ ohms, sec} \qquad \text{Equation 13.9}$$

You may wish to test the distance element characteristic at impedance angles other than the line positive-sequence impedance angle. To do this, you must adjust the magnitude and angle of I_{TEST} from the values shown in Table 13.3. As an example, calculate the current signal necessary to test the distance element at an angle of 38.97°.

First, the new desired impedance angle (38.97°) is 45° less than the original test impedance angle (83.97°). Add 45° to the angle of I_{TEST1}.

$$\angle I_{TEST2} = \angle I_{TEST1} + 45°$$
$$\angle I_{TEST2} = -173.97° + 45°$$
$$\angle I_{TEST2} = -128.97°$$

Calculate the magnitude of I_{TEST2} using Equation 13.10.

$$|I_{TEST2}| = \frac{|I_{TEST1}|}{\cos(\text{Line Impedance Angle} - \text{New Test Impedance Angle})} \text{ amps, sec}$$

$$|I_{TEST2}| = \frac{2.5}{\cos(83.97° - 38.97°)} \text{ amps}$$

$$|I_{TEST2}| = \frac{2.5}{\cos(45°)} \text{ amps} \qquad \text{Equation 13.10}$$

$$|I_{TEST2}| = 3.54 \text{ amps}$$

Note: As you perform this test, other protection elements may assert, causing the relay to close other output contacts and assert relay targets. This is normal and is not a cause for concern

Ground Mho Distance Elements

The SEL-311B Relay includes up to four zones of mho ground distance protection. Enable the number of ground distance zones you would like to apply using the E21MG setting. Zones 1 and 2 are fixed forward. Zones 3 and 4 may be set forward or reverse. The reach and direction of each zone is independent from the other zones. When a zone of phase distance protection is set to reach in one direction, the ground distance elements associated with that zone must be set to reach in the same direction. Reach is set in secondary ohms. The angle of maximum reach of the ground distance elements is defined by the Z1ANG setting and the zero-sequence current compensation factor for the zone under test.

Each zone has an instantaneous indication. For example, the Z3G element asserts without intentional time delay for A-G, B-G, and C-G faults within the Zone 3 mho or quadrilateral characteristic. All zones include time delayed indication through elements Z1GT, Z2GT, Z3GT, and Z4GT. In addition, each individual phase-ground distance element provides an instantaneous indication for each zone. For example, the MAG1, MAG2, MAG3, and MAG4 elements provide instantaneous indication of A-G ground faults in each zone.

For general testing, use the instantaneous and time delayed elements that respond to any phase-ground fault within a given zone such as Z1G, Z2G, etc. You can record more detailed and specific test results using the instantaneous element associated with the faulted phase and zone under test.

There are a number of supervisory conditions that must be fulfilled before the relay allows a ground distance element to pick up. These supervisory conditions are described below.

Ground Distance Element Supervisory Conditions

Note: Unless otherwise indicated, all of the supervisory conditions listed below apply to the ground mho and ground quadrilateral distance elements.

Phase and Ground Nondirectional Overcurrent Elements, 50Ln and 50GZn

Each zone ground distance element is supervised by two nondirectional overcurrent elements, 50GZn and 50Ln, where n indicates the zone associated with the overcurrent element. For example, the relay may assert the Zone 3 A-ground distance element only if the A-phase current is greater than the 50L3 setting and the residual current is greater than the 50GZ3 setting.

Ground Directional Element

The ground distance protection function is supervised by the ground directional element to provide improved directional security. Forward-reaching distance elements may not assert unless the 32GF element is asserted. Reverse-reaching distance elements may not assert unless the 32GR element is asserted. See **Directional Control for Ground Distance and Residual Ground Overcurrent Elements** in ***Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic*** for a complete description of ground directional elements.

Loss-of-Potential Logic

If ELOP = Y or Y1, the relay supervises the ground distance element logic using the Internal Loss-of-Potential condition (ILOP). When ELOP = Y or Y1, the relay disables the ground distance elements when a loss-of-potential is detected, regardless of other signals applied to the relay. If you test the ground distance elements using low voltage signals, set ELOP = N to simplify the test.

Pole Open Logic

If significant pole-scatter occurs when a circuit breaker closes, sensitive ground distance elements may operate undesirably due to the unbalanced signals applied. The SEL-311B Relay disables the ground distance elements during Three-Pole Open conditions and for a short, settable time after the breaker closes. The time is set by the 3POD time delay settings. To simplify distance element tests, apply control voltage to any inputs assigned to perform the 52 auxiliary functions.

Ground Mho Distance Element Test Using Three Voltage Sources and One Current Source

Note: This test refers directly to the Zone 2 ground mho distance element, but may be applied to any other forward-reaching ground mho distance element zone. To test reverse-reaching zones, simply add 180° to the calculated test current phase angle. Verify correct operation of the 32GR element for the test voltage and current signals using Equation 13.1 in the Negative-Sequence Directional Element Test Procedure.

Step 1. Execute the **SHOWSET** command and verify the following relay settings: Z1MAG, Z1ANG, E21MG, E32, Z2MG, 50L2, 50GZ2, k0M1, k0A1, ORDER, Z2F, and 50QF. The example relay settings use the following settings: Z1MAG = 7.8; Z1ANG = 83.97°; E21G = 3; E32 = Y; Z2MG = 9.36 Ω; 50L2 = 0.50; 50GZ2 = 0.50; k0M = 0.726; k0A = -3.69; ORDER = Q; Z2F = 0.77 Ω; 50QF = 0.5 amps secondary.

Execute the **SET** command and change the following settings. Change E21XG to N and ELOP from Y to N. Changing the E21XG setting prevents the relay ground quadrilateral distance elements from interfering with the test. Changing the ELOP setting prevents the Loss-of-Potential logic from blocking operation of the relay distance elements if the test signals fulfill Loss-of-Potential conditions.

Step 2. Select an output contact to indicate operation of the Z2G element. In this example we use the OUT106 output.

From Access Level 2, execute the **SET L n** command to configure Output 6 to close for assertion of the Z2G element.

```
=>>SET L 1 OUT106 <ENTER>
SELogic group 1

OUT106  =0

 ? Z2G <ENTER>
OUT107  =0

 ? END <ENTER>
```

After you type **END <ENTER>** to end the set procedure, the relay displays the current logic settings. Type **Y <ENTER>** to accept those settings.

Connect output OUT106 to the sense input of your test set, an ohmmeter, or some other contact sensing device.

Step 3. Connect the voltage sources to the A-phase, B-phase, and C-phase to neutral relay voltage inputs. Connect the current source to the A-phase relay current input. Refer to the voltage and current connections shown in Figure 13.5 as an example.

Step 4. Select the magnitude of the test signals, I_A and V_A.

Table 13.4 summarizes the test quantities for the Zone 2 A-G ground distance element based upon the example relay settings.

Table 13.4: Test Quantities for Zone 2 Ground Mho Distance Element

Test Voltages	Test Current
$V_A = 40.4 \angle 0°$ volts	$I_{TEST} = 2.5 \angle -82.42°$ amps
$V_B = 67.0 \angle -120°$ volts	
$V_C = 67.0 \angle 120°$ volts	

The following text describes a hand calculation method you may use to calculate relay distance element voltage and current test signals. If you do not wish to review this information, go to Step 5.

The relay ground distance elements operate based upon the magnitude of applied phase-ground impedance. The impedance calculation is supervised by the functions described. To effectively test the distance elements, select test signals that fulfill the impedance and supervisory requirements of the relay, but are within the ability of the test sources to produce accurately.

The Zone 2 ground distance element is forward reaching. Thus, it is supervised by the forward directional element 32GF, as well as the 50L2 and 50GZ2 phase and residual overcurrent elements. Applied phase current must exceed the 50L2 setting, applied residual current must exceed the 50GZ2 setting, and applied $3I_2$ must exceed the 50QF setting.

The 50L overcurrent elements operate based upon the magnitude of the phase current. Using the current connections shown in Figure 13.5, the magnitude of I_A is equal to the magnitude of the applied test current. With a 50L2 setting of 0.50 amps, 50L2 picks up when I_{TEST} is greater than 0.90 amps.

The 50GZ overcurrent elements operate based upon the magnitude of the residual current. Using the current connections shown in Figure 13.5, the magnitude of I_R is equal to the magnitude of the applied test current, I_A. With a 50GZ2 setting of 0.50 amps, 50G2 picks up when I_{TEST} is greater than 0.50 amps.

The 50QF negative-sequence overcurrent element operates based upon the magnitude of $3I_2$ applied. Using the current connections shown in Figure 13.5, we can calculate the magnitude of $3I_2$ applied based upon the magnitude of I_{TEST}.

$$
\begin{aligned}
I_2 &= \tfrac{1}{3} \cdot \left(I_A + a^2 \cdot I_B + a \cdot I_C\right) \\
3 \cdot I_2 &= \left(I_A + a^2 \cdot I_B + a \cdot I_C\right) \\
I_A &= I_{TEST} \text{ and } I_B = I_C = 0, \text{ so:} \\
3 \cdot I_2 &= I_{TEST}
\end{aligned}
$$

With a 50QF setting of 0.5 amps, 50QF picks up when I_{TEST} is greater than 0.5 amps.

Select the magnitude of I_A greater than the 50L2, 50GZ2, and 50QF settings, but less than the maximum current output capability of the current test source.

In this example, select $|I_{TEST}|$ = 2.5 amps. This selection fulfills the supervisory overcurrent conditions described above.

The reach of the distance element under test in secondary ohms is defined by the element setting. In this case Z2MG = 9.36 Ω. The impedance measured by the relay for a ground fault is determined by the faulted phase voltage, faulted phase current, and the residual current multiplied by the zero-sequence current compensation factor, k0. The SEL-311B Relay uses k0M1 and k0A1 settings to define the zero-sequence current compensation factor for Zone 1 ground distance elements. When the advanced user settings are not enabled (EADVS = N), the remaining zone settings, k0M and k0A, follow k0M1 and k0A1. The impedance measured by the relay ground mho distance element for a Zone 2 fault is defined by the following equation:

$$
Z_{AG} = \frac{V_A}{I_A + k0 \cdot I_R} \qquad \text{Equation 13.11}
$$

Where: $k0 = k0M \angle k0A°$

For a fault on a radial system and when testing a ground distance element using a single current source, $I_A = I_R$. In this case, Equation 13.11 can be simplified:

$$
Z_{AG} = \frac{V_A}{I_A \cdot (1 + k0)} \qquad \text{Equation 13.12}
$$

If we multiply both sides of Equation 13.12 by the quantity (1 + k0), the result is the impedance applied by the A-phase test signals, V_A and I_A.

$$
Z_{AG} \cdot (1 + k0) = \frac{V_A}{I_A} \qquad \text{Equation 13.13}
$$

Since we are testing the Zone 2 mho ground distance element, the intended value of Z_{AG} = Z2MG = 9.36 Ω. The angle of Z2MG is equal to the angle of positive-sequence impedance, Z1ANG.

Because the element under test is not a Zone 1 element, the k0 value is defined by the relay settings k0M and k0A. When you test the relay Zone 1 ground elements, use k01M and k01A to define the magnitude and angle of k0.

Calculate the value of $Z_{AG} \cdot (1 + k0)$ based upon the information above.

$$Z_{AG} \cdot (1 + k0) = Z_{TEST} = Z2MG \cdot (1 + k0M \angle k0A) \qquad \text{Equation 13.14}$$

$$Z_{TEST} = 9.36 \angle 83.97° \cdot (1 + 0.726 \angle -3.69°)$$
$$Z_{TEST} = 9.36 \angle 83.97° \cdot (1.725 \angle -1.55°)$$
$$Z_{TEST} = 16.15 \angle 82.42°$$

I_A must lag V_A by the angle of Z_{TEST} to check the maximum reach of the element under test. With V_A applied at an angle of 0°, the angle of I_A is:

$$I_A = 2.5 \angle -82.42°$$

Calculate the magnitude of V_A using Equation 13.15

$$V_A = I_A \cdot Z_{TEST}$$
$$V_A = 2.5 \angle -82.42° \cdot 16.15 \angle 82.42° \qquad \text{Equation 13.15}$$
$$V_A = 40.4 \angle 0.0° \text{ volts secondary}$$

Select $V_B = 67 \angle -120°$ volts and $V_C = 67 \angle 120°$ volts.

With the above settings, the ground distance elements are supervised by the negative-sequence directional element. It is important to check the negative-sequence quantities applied and verify that the 32GF element should assert allowing the forward-reaching distance element to operate. Calculate the magnitude and angle of negative-sequence voltage and current applied for the test quantities listed above. Then calculate the negative-sequence impedance, Z2c, applied using Equation 13.1 and compare Z2c to the Z2FT threshold that is a function of the Z2F setting and Z2m.

$$V_2 = \tfrac{1}{3} \cdot (V_A + a^2 \cdot V_B + a \cdot V_C)$$
$$I_2 = \tfrac{1}{3} \cdot (I_A + a^2 \cdot I_B + a \cdot I_C)$$

$$Z2c = \frac{\operatorname{Re}[V_2 \cdot (1 \angle Z1ANG° \cdot I_2)^*]}{|I_2|^2} \qquad \text{Equation 13.1}$$

$$Z2m = \frac{|V_2|}{|I_2|}$$

$$Z2FT = 1.25 \cdot Z2F - 0.25 \cdot Z2m$$

Taking the test signals from Table 13.4.

$$V_A = 40.4\ V\angle 0°$$
$$V_B = 67.0\ V\angle -120°$$
$$V_C = 67.0\ V\angle 120°$$

$$V_2 = \tfrac{1}{3} \cdot (40.4 \angle 0° + 1 \angle 240° \cdot 67.0 \angle -120° + 1 \angle 120° \cdot 67.0 \angle 120°) \text{ volts}$$
$$V_2 = 8.88 \angle 180° \text{ volts}$$

$$
\begin{aligned}
I_A &= 2.5\ \angle -82.42^\circ \\
I_B &= 0.0\ \angle 0.0^\circ \\
I_C &= 0.0\ \angle 0.0^\circ
\end{aligned}
$$

$$
\begin{aligned}
I_2 &= \tfrac{1}{3}\cdot\left(2.5\ \angle -82.42^\circ\right)\ \text{amps} \\
I_2 &= 0.83\ \angle -82.42^\circ\ \text{amps}
\end{aligned}
$$

Using Equation 13.1 to calculate Z2, the result is:

$$
\begin{aligned}
\text{Z2c} &= -10.66\ \text{ohms} \\
\text{Z2m} &= 15.47\ \text{ohms} \\
\text{Z2FT} &= 1.25\cdot(0.77) - 0.25\cdot(15.47) \\
\text{Z2FT} &= -2.91\ \text{ohms}
\end{aligned}
$$

The relay example Z2F setting is 0.77 Ω. Z2c applied (-10.66 Ω) is less than the Z2FT threshold (-2.91 Ω), therefore, the 32GF element asserts when these signals are applied. If Z2c applied is greater than the Z2FT threshold, select new test current and voltages using the steps outlined above.

Step 5. Turn on the voltage sources. Apply V_A, V_B, and V_C at the magnitudes and angles listed in Table 13.4. Turn on the current test source. Set the current angle to -82°. Slowly increase the magnitude of current applied until the Z2G element asserts, causing OUT106 to close. This occurs when current applied is approximately 2.5 amps.

You may wish to test the distance element characteristic at impedance angles other than the line positive-sequence impedance angle. To do this, you must adjust the magnitude and angle of I_{TEST} from the values shown in Table 13.4. As an example, calculate the current signal necessary to test the distance element at an angle of 38.97°.

First, the new desired impedance angle (38.97°) is 45° less than the original test impedance angle (83.97°). Add 45° to the angle of I_{TEST1}.

$$
\begin{aligned}
\angle I_{TEST2} &= \angle I_{TEST1} + 45^\circ \\
\angle I_{TEST2} &= -173.97^\circ + 45^\circ \\
\angle I_{TEST2} &= -128.97^\circ
\end{aligned}
$$

Calculate the magnitude of I_{TEST2} using Equation 13.10.

$$
\begin{aligned}
\left|I_{TEST2}\right| &= \frac{\left|I_{TEST1}\right|}{\cos(\text{Line Impedance Angle} - \text{New Test Impedance Angle})}\ \text{amps, sec} \\
\left|I_{TEST2}\right| &= \frac{2.5}{\cos(83.97^\circ - 38.97^\circ)}\ \text{amps} \\
\left|I_{TEST2}\right| &= \frac{2.5}{\cos(45^\circ)}\ \text{amps} \qquad \text{Equation 13.10} \\
\left|I_{TEST2}\right| &= 3.54\ \text{amps}
\end{aligned}
$$

Note: As you perform this test, other protection elements may assert, causing the relay to close other output contacts and assert relay targets. This is normal and is not a cause for concern.

Troubleshooting Test Results

The following information is intended to help you troubleshoot relay tests if the relay does not perform as you expected.

Symptom:	What to check:
Incorrect Targets	• Check the relay event report. Determine the asserted elements at the instant the TRIP output was asserted. • Verify the ac connections by plotting currents and voltages from event report data. • Verify the TR, TRCOMM, and TRSOTF settings to ensure the appropriate elements are enabled to trip. • Verify the ULTR setting. If a trip occurs and does not unlatch following clearance of the fault, new faults do not generate new targets. You may need to turn off ac current applied to the relay, deassert 52A inputs, or press the Target Reset button.
Incorrect Tripping	• Check the current and voltage connections by applying small signals to the connected current and voltage inputs. Trigger an event report using the **TRIGGER** command. Plot the magnitude and angle of measured currents and voltages. • Check the TR, TRCOMM, and TRSOTF settings to determine which elements are enabled to trip. • Check the output logic equation settings to determine which outputs are enabled to trip. • Check the settings of elements that are enabled to trip. • Check the settings of elements that supervise elements that are enabled to trip.
Incorrect Distance Element Characteristic Shape	• Check the voltage and current connections by applying small signals to the connected current and voltage inputs. Trigger an event report using the **TRIGGER** command. Plot the magnitude and angle of measured currents and voltages. • Verify the distance element settings, including Zone 1 Extension logic settings. • Verify the supervisory overcurrent element settings which apply to the element under test: 50PP overcurrent elements supervise the phase distance elements; 50GZ and 50L overcurrent elements supervise the ground mho and quadrilateral distance elements. • Verify the directional element settings. 32QF supervises forward-reaching phase and ground distance elements. 32QR supervises reverse-reaching phase and ground distance elements.

Symptom:	What to check:
	• Verify the Loss-of-Potential (LOP) logic and element settings. If ELOP = Y or Y1, the relay blocks operation of the distance elements when LOP conditions are detected. • The Load-Encroachment function blocks operation of the relay phase distance elements if measured positive-sequence impedance is within a defined load characteristic. Verify your Load-Encroachment logic settings and review event report data to determine if this function is interfering with your phase distance element test.
Incorrect Contact Operation	• Check the logic equation settings to determine which elements are enabled to operate the contact. • Check the event report to determine which elements asserted during the event. • Check the connections and test signals to ensure that the appropriate signals were applied to cause the element under test to assert.

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 protection 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).
- 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	
TEMP	Warning	-40° C +85° C	No		Measures the temperature at the A/D voltage reference every 10 seconds.
	Failure	-50° C +100° C	Yes	Latched	

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
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.
The following self-tests are performed by dedicated circuitry in the microprocessor and the SEL-311B 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 microprocessor 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 “CPU ERROR” 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 relay is properly set.
2. Verify that the test source is properly set.
3. Verify that the test connections are correct.
4. Ensure that the analog input cable between transformer secondary and main board is not loose or defective.
5. Inspect the relay self-test status with the **STA** command or with the front-panel STATUS button.

Relay Calibration

The SEL-311B Relay is factory-calibrated. If you suspect that the relay is out of calibration, please contact the factory.

Factory Assistance

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

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA USA 99163-5603
Tel: (509) 332-1890
Fax: (509) 332-7990
Internet: www.selinc.com

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SECTION 14: APPLICATION SETTINGS FOR SEL-221 SERIES RELAYS

SEL-221F TO SEL-311B SETTINGS CONVERSION GUIDE

Set APP = 221F in the SEL-311B to configure the relay to closely approximate the features, performance, and settings of an SEL-221F. When APP = 221F, the SEL-311B:

1. Configures itself as a phase and ground distance relay with ground directional overcurrent elements, reclosing, and synchronism check functions.
2. Configures contact inputs and outputs to emulate those in an SEL-221F.
3. Presents the user only with those settings associated with SEL-221F type features.
4. Automatically calculates all other settings required to simulate an SEL-221F.

If additional capability is needed (e.g., MIRRORED BITS™ or SELOGIC® control equations) the relay may be returned to the setting APP = 311B to make all of the SEL-311B settings visible. It is important to remember that changing from APP = 311B to APP = 221F changes settings in the relay. Changing from APP = 221F to APP = 311B makes more SEL-311B settings visible, but does not change any other settings. If SEL-311B functions are used after setting APP is changed from 221F to 311B, do not change setting APP back to 221F.

As described above, when setting APP = 221F, the user is presented only with SEL-311B settings associated with the features found in an SEL-221F. This section explains how to make those remaining SEL-311B settings directly from the settings used in an SEL-221F.

There are mainly two kinds of settings in the SEL-311B. Relay settings are settings for protective elements. SELOGIC settings are Boolean expressions used to customize the logic of the SEL-311B. To set the SEL-311B to emulate an SEL-221F, follow these four steps:

1. Turn on the SEL-221F application setting by making setting APP = 221F. See ***Application Settings*** below.
2. Convert the appropriate SEL-221F settings to SEL-311B settings using the simple equations shown in Table 14.1. Be sure to convert from primary quantities (SEL-221F settings) to secondary quantities (SEL-311B settings). See ***Convert SEL-221F Primary Quantities to SEL-311B Secondary Quantities*** below.
3. For each Mask Logic setting in the SEL-221F shown in Table 14.2, create an equivalent SELOGIC control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.3.
4. Test the relay to verify intended performance.

The remainder of this section shows how to perform steps 1 through 3 above, and also gives an example of step 3.

Application Settings

From Access Level 2, set the SEL-311B application setting to “221F” as shown below:

```
=>>SET APP TERSE <ENTER>

Line Parameter Settings:

Application (311B,221F,221F3,221C,221-16,2PG10)   APP   = 311B      ? 221F <ENTER>

Enable Settings:

Fault Location(Y,N)                               EFLOC = Y         ? END <ENTER>
Save Changes(Y/N)? Y <ENTER>
Settings saved
=>>
```

Convert SEL-221F Primary Quantities to SEL-311B Secondary Quantities

All SEL-221F current settings must be converted from primary to secondary amps to be used in the SEL-311B. Divide the SEL-221F current setting by the current transformer ratio setting (CTR) to make the change.

SEL-221F impedance settings must be converted from percent of primary line impedance to secondary impedance in ohms. For example, the Zone 1 distance setting in the SEL-311B (Z1P) is calculated as

$$Z1P = \frac{Z1\%}{100} \cdot Z1MAG$$

where: Z1% is the SEL-221F distance reach setting.

Z1MAG is the SEL-311B positive-sequence line impedance setting in secondary ohms.

Z1P is the SEL-311B Zone 1 reach setting in secondary ohms.

Convert SEL-221F Relay Settings to SEL-311B Relay Settings

Table 14.1 shows all the SEL-311B Relay settings that must be entered for the relay to perform protection similar to the SEL-221F when APP = 221F. Calculate each SEL-311B Relay setting from the corresponding SEL-221F Relay setting using the formula shown. Instruction manual references are to subsection headings rather than to section headings.

Please carefully note the difference between the SEL-311B and SEL-221F in the implementation of certain protection and logic schemes. For example, reclosing and synchronism check settings do not correspond exactly between the two relays. Always thoroughly test logic schemes to be sure they operate as intended.

Table 14.1: SEL-311B Settings Calculated From SEL-221F Settings

SEL-311B Relay Setting	Calculated from SEL-221F Settings	SEL-311B Instruction Manual Section	SEL-221F Instruction Manual Section
RID TID	None = ID		Section 3—Set
CTR CTRP PTR PTRS	= CTR = CTR = PTR = SPTR	Section 9—Settings Sheets	Section 5—Current and Potential Transformer Ratio Selection
Z1MAG Z1ANG Z0MAG Z0ANG LL	$= \sqrt{(R1^2 + X1^2)} \cdot \left[\frac{CTR}{PTR}\right]$ $= \text{Arc}\tan\left[\frac{X1}{R1}\right]$ (degrees) = MTA $= \sqrt{(R0^2 + X0^2)} \cdot \left[\frac{CTR}{PTR}\right]$ $= \text{Arc}\tan\left[\frac{X0}{R0}\right]$ (degrees) = LL	Section 9—Settings Sheets	Section 5—R1, X1, R0, X0, and Line Length (LL)
APP	None		
ELOP N Y	= LOPE = N = Y	Section 4—Loss of Potential	Section 5—Loss-of-Potential (LOP) Enable Setting (LOPE)
Z1P Z1MG Z2P Z2MG Z3P Z3MG	$= \frac{Z1\%}{100} \cdot Z1MAG$ $= \frac{Z2\%}{100} \cdot Z1MAG$ $= \frac{Z3\%}{100} \cdot Z1MAG$ where Z1MAG $= \sqrt{\left(R1^2 + X1^2\right)}\left[\frac{CTR}{PTR}\right]$	Section 3—Phase Distance Elements	Section 5—Zone 1 Reach Setting (Z1%) Section 5—Zone 2 Reach Setting (Z2%) Section 5—Zone 3 Reach Setting (Z3%) **Note:** Z1MAG is an SEL-311B setting

SEL-311B Relay Setting	Calculated from SEL-221F Settings	SEL-311B Instruction Manual Section	SEL-221F Instruction Manual Section
Z2PD	= Z2DP	Section 3—Zone Time Delay Elements	Section 5—Zone 2 Phase and Ground Distance
Z2GD	= Z2DG		Section 5—Time Delays (Z2DP, Z2DG)
Z3D	= Z3D		Section 5—Zone 3 Phase and Ground Time Delay (Z3D)
50P1P	= 50H / CTR	Section 5—Switch-Onto-Fault (SOTF) Trip Logic	Section 5—High Set Phase Overcurrent Element Setting
50G1P	= 67NP / CTR	Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements	Section 5—67NP Residual Overcurrent Settings (67NP, 67NTC)
N/A (67G1TC = 1)	= 67NTC (In the SEL-311B, 50G1P is fixed forward)		
51GP	= 51NP / CTR	Section 3—Residual Ground Time-Overcurrent Element	Section 5—Residual Time-Overcurrent Settings (51NP, 51NC, 51NTD, 51NTC)
51GC	= 51NC		
U1*	= 1		
U2	= 2		
U3	= 3		
U4	= 4		
51GTD	= 51NTD		
51GTC	= 51NTC (51GTC is an SEL-311B SELOGIC setting)		
(= 1	= N)		
(= 32GF	= Y)		

SEL-311B Relay Setting	Calculated from SEL-221F Settings	SEL-311B Instruction Manual Section	SEL-221F Instruction Manual Section
25VLO 25VHI 25SF 25ANG1 25ANG2 SYNCP TCLOSD	= 27VLO • (1000 / SPTR) = 59VHI • (1000 / SPTR) None None None SYNCP None	Section 4—Synchronism Check Element Settings	Section 5—Synchronism Checking Function
79OI1 79RSD 79RSLD	= 79OI1 = 79RS = 79RS	Section 6—Close and Reclose Logic	Section 5—Reclose Logic
52AEND SOTFD	= 52BT (Pickup) = 52BT (Dropout)	Section 5—Switch-Onto-Fault (SOTF) Trip Logic	Section 5—52BT Setting (52BT) And Switch-Onto-Fault Protection
TDURD	= TDUR	Section 4—Unlatch Trip	Section 5—Trip Duration Timer (TDUR)
SV1PU SV1DO	= A1TP = A1TD	Section 7—SELOGIC control equation Variables/Timers	Section 2—Miscellaneous Timers
SV2PU SV2DO	= VCT None	Section 3—Voltage Elements Section 7—Latch Control Switches	

* Curve U1 in the SEL-311B is slightly different from curve 1 in the SEL-221F. Time dial adjustments may be necessary.

Note: SEL-311B phase-to-phase fault detector settings (50PP1, 50PP2, 50PP3) are set to their minimum values and hidden. This corresponds to SEL-221F setting 50P.

SEL-311B phase-to-ground and residual fault detector settings (50L1, 50L2, 50L3, 50GZ1, 50GZ2, and 50GZ3) are set to their minimum values and hidden. This corresponds to SEL-221F setting 50NG

SEL-221F function "Remote End Just Opened" (REJO) is not implemented in the SEL-311B.

Convert SEL-221F Output Mask Logic Settings to SELOGIC Control Equations

See ***Programmable Output Contact Mask Settings*** in ***Section 5: Applications*** in the SEL-221F Instruction Manual for a description of output masks. In the SEL-311B, output masks are replaced by SELOGIC control equations as shown below:

Table 14.2: SEL-311B SELOGIC Equation Equivalent to Each SEL-221F Mask Logic Setting

SEL-221F Settings Mask	SEL-311B SELOGIC Equations
MTU	TR
MPT	SV3 (DTT)
MTB	SV4 (DTT)
MTO	TRSOTF
MA1	OUT104
MA2	OUT105
MA3	OUT106
MA4	OUT107
MRI	79RI
MRC	79DTL

Table 14.3 shows all SEL-221F Relay Word bits, and an approximate equivalent SEL-311B SELOGIC expression, when setting APP = 221F in the SEL-311B. Table 14.2 shows each SEL-221F Mask Logic Setting and the equivalent SEL-311B SELOGIC control equation. To convert a SEL-221F Mask Logic Setting to a SELOGIC control equation, logically OR each appropriate SEL-221F Relay Word bit equivalent expression (Table 14.3) and enter the resultant expression in the related SELOGIC control equation (Table 14.2).

Table 14.3: SELOGIC Equivalent to SEL-221F Relay Word Bits

SEL-221F Relay Word Bit	Equivalent SEL-311B SELOGIC Expression
Z1P	M1P
Z1G	Z1G
Z2PT	M2PT
Z2GT	Z2GT
Z3	M3P + M3G
Z3T	Z3T
3P21	M3P * !32QF
32Q	32GF + 32QF
67N	67G1
51NP	51G
51NT	51GT
50NG	None
50P	None
50H	50P1
IN1	IN101
REJO	None
LOP	ILOP
52BT	SOTFE
27S	!59VS
27P	!59VP
59S	59VS
59P	59VP
SSC	25A1
VSC (LSDP) (LPDS)	SV2T (59VS * !59VP * !50L) (59VP * !59VS * !50L)

For example, the factory default setting for MRC in the SEL-221F is shown in Table 14.4. From Table 14.2, the equivalent SEL-311B SELOGIC control equation to MRC is 79DTL. Constructing the logical OR of the equivalent of each element selected in the MRC mask from Table 14.3 gives:

79DTL = Z3T + 51GT

Include the open command OC:

79DTL = Z3T + 51GT + OC

This is the default SELOGIC control equation for 79DTL when APP = 221F.

When setting APP = 221F, the SEL-311B automatically sets the following SELOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-221F to customize the relay logic.

Table 14.4: Default SEL-221F Mask Logic Setting for MRC

Z1P 0	Z1G 0	Z2PT 0	Z2GT 0	Z3 0	Z3T 1	3P21 0	32Q 0
67N 0	51NP 0	51NT 1	50NG 0	50P 0	50H 0	IN1 0	REJO 0
LOP 0	52BT 0	27S 0	27P 0	59S 0	59P 0	SSC 0	VSC 0

Default Tripping Logic Equations

TR = M1P + Z1G + M2PT + Z2GT + Z3T + 67G1 + 51GT + OC

TRSOTF = M1P + Z1G + M2PT + Z2GT + M3P + Z3G + Z3T + 67G1 + 51GT + 50P1

DTT = IN101 + SV3 * IN102 + SV4 * !IN103

Default Reclose Logic Equations

79RI = M1P + Z1G + M2PT + Z2GT + 67G1

79DTL = Z3T + 51GT + OC

Default Output Contact Logic Equations

OUT101 = TRIP

OUT102 = TRIP

OUT103 = CLOSE

OUT104 = SV1T

OUT105 = SV2T

OUT106 = M1P + Z1G + M2PT + Z2GT + 67G1

OUT107 = Z3T + 51GT

SELOGIC Variables Equations

SV1 = 25A1

SV2 = 59VP * !59VS * !50L * LT1 + 59VS * !59VP * !50L * LT2

SV3 = M3P + Z3G

SV4 = 0

SELOGIC Latch Equations

The SELOGIC latch equations emulate the SEL-221F setting PSVC for settings P, S, and E.

Table 14.5: SEL-221F Setting PSVC for Settings P, S, and E

SEL-311B Relay Word Bit	PSVC = S (Default)	PSVC = P	PSVC = E
SET1	= 0	= 1	= 1
RST1	= 1	= 0	= 0
SET2	= 1	= 0	= 1
RST2	= 0	= 1	= 0

The following contact input assignments are made automatically by the SEL-311B when setting APP = 221F. These assignments cannot be changed unless setting APP is changed back to APP = 311B.

Default Contact Input Functions

IN101 = Programmable Input (Direct Trip)

IN102 = PT (Permit trip)

IN103 = BT (Block trip)

IN104 = CL (Close breaker)

IN105 = 52A

IN106 = EXT (External event report trigger)

SEL-311B SETTINGS SHEET
APPLICATION SETTING 221F

Identifier Labels (See *Settings Explanations* in *Section 9*)

Relay Identifier (30 characters)	RID = ________
Terminal Identifier (30 characters)	TID = ________

Current and Potential Transformer Ratios (See *Settings Explanations* in *Section 9*)

Phase (IA, IB, IC) Current Transformer Ratio (1–6000)	CTR = ________
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 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 = ________
Application (311B, 221F, 221F3, 221C, 221-16, 2PG10)	APP = **221F**
Loss-of-Potential (Y, Y1, N) (see Figure 4.1)	ELOP = ________

Phase Distance Elements (See *Settings Explanations* in *Section 3*)

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.4)	Z1P = ________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.5)	Z2P = ________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.6)	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 3.7)	Z1MG = ________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.8)	Z2MG = ________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.9)	Z3MG = ________

Phase and Ground Distance Element Time Delays (See *Settings Explanations* in *Section 3*)

Zone 2 phase distance time delay (OFF, 0–16000 cycles)	Z2PD = ___________
Zone 2 ground distance time delay (OFF, 0–16000 cycles)	Z2GD = ___________
Zone 3 time delay (OFF, 0–16000 cycles)	Z3D = ___________

Phase Inst./Def.-Time Overcurrent Element (See Figure 3.13)

Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})	50P1P = ___________

Residual Ground Inst./Def.-Time Overcurrent Element (See Figure 3.16)

Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})	50G1P = ___________

Residual Ground Time-Overcurrent Element (See Figure 3.19)

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 = ___________

Synchronism Check Elements (See Figures 3.24 and 3.25)

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 = ___________

Reclosing Relay (See Tables 6.2 and 6.3)

Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps)	79OI1 = ___________
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 = ___________

Switch-Onto-Fault (See Figure 5.3)

52 A 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) TDURD = ________

SELOGIC Control Equation Variable Timers (See Figure 7.23)

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 = ________

Trip Logic Equations (See Figure 5.1)

Direct trip conditions TR = ________
Switch-onto-fault trip conditions TRSOTF = ________
Direct transfer trip conditions DTT = ________

Reclosing Relay Equations (See *Reclosing Relay* in *Section 6*)

Reclose initiate 79RI = ________
Drive-to-lockout 79DTL = ________

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 = ________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements

[Note: torque control equation settings cannot be set directly to logical 0]

Level 1 residual ground (see Figure 3.16) 67G1TC = ________
Residual Ground (see Figure 3.19) 51GTC = ________

SELOGIC Control Equation Variable Timer Input Equations (See Figure 7.23)

SELOGIC Control Equation Variable SV1 SV1 = ________
SELOGIC Control Equation Variable SV2 SV2 = ________
SELOGIC Control Equation Variable SV3 SV3 = ________
SELOGIC Control Equation Variable SV4 SV4 = ________

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 = ____________

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. Do not use MIRRORED BITS (MB*x*) protocol in Application Settings. Refer to ***Appendix C*** for details on the LMD protocol.

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 = ________
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-311B Relay Fast Operate commands.

Power System Configuration (See *Settings Explanations* in *Section 9*)

Phase rotation (ABC, ACB) PHROT = __________

SEL-221F-3 TO SEL-311B SETTINGS CONVERSION GUIDE

Set APP = 221F3 in the SEL-311B to configure the relay to closely approximate the features, performance, and settings of an SEL-221F-3. When APP = 221F3, the SEL-311B:

1. Configures itself as a phase and ground distance relay with ground directional overcurrent elements, reclosing, and synchronism check functions.
2. Configures contact inputs and outputs to emulate those in an SEL-221F-3.
3. Presents the user only with those settings associated with SEL-221F-3 type features.
4. Automatically calculates all other settings required to simulate an SEL-221F-3.

If additional capability is needed (e.g., MIRRORED BITS or SELOGIC control equations) the relay may be returned to the setting APP = 311B to make all of the SEL-311B settings visible. It is important to remember that changing from APP = 311B to APP = 221F3 changes settings in the relay. Changing from APP = 221F3 to APP = 311B makes more SEL-311B settings visible, but does not change any other settings. If SEL-311B functions are used after setting APP is changed from 221F3 to 311B, do not change setting APP back to 221F3.

As described above, when setting APP = 221F3, the user is presented only with SEL-311B settings associated with the features found in an SEL-221F-3. This section explains how to make those remaining SEL-311B settings directly from the settings used in an SEL-221F-3.

There are mainly two kinds of settings in the SEL-311B. Relay settings are settings for protective elements. SELOGIC settings are Boolean expressions used to customize the logic of the SEL-311B. To set the SEL-311B to emulate an SEL-221F-3, follow these four steps:

1. Turn on the SEL-221F-3 application setting by making setting APP = 221F3. See ***Application Settings*** below.
2. Convert the appropriate SEL-221F settings to SEL-311B settings using the simple equations shown in Table 14.6. Be sure to convert from primary quantities (SEL-221F-3 settings) to secondary quantities (SEL-311B settings). See ***Convert SEL-221F-3 Primary Quantities to SEL-311B Secondary Quantities*** below.
3. For each Mask Logic setting in the SEL-***221F-3*** shown in Table 14.7, create an equivalent SELOGIC control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.8.
4. Test the relay to verify intended performance.

The remainder of this section shows how to perform steps 1 through 3 above, and also gives an example of step 3.

Application Settings

From Access Level 2, set the SEL-311B application setting to “221F3” as shown below:

```
=>>SET APP TERSE <ENTER>

Line Parameter Settings:

Application (311B,221F,221F3,221C,221-16,2PG10)   APP   = 311B      ? 221F3 <ENTER>

Enable Settings:

Fault Location(Y,N)                               EFLOC = Y         ? END <ENTER>
Save Changes(Y/N)? Y <ENTER>
Settings saved
=>>
```

Convert SEL-221F-3 Primary Quantities to SEL-311B Secondary Quantities

All SEL-221F-3 current settings must be converted from primary to secondary amps to be used in the SEL-311B. Divide the SEL-221F-3 current setting by the current transformer ratio setting (CTR) to make the change.

SEL-221F-3 impedance settings must be converted from percent of primary line impedance to secondary impedance in ohms. For example, the Zone 1 distance setting in the SEL-311B (Z1P) is calculated as

$$Z1P = \frac{Z1\%}{100} \cdot Z1MAG$$

where: Z1% is the SEL-221F-3 distance reach setting.

Z1MAG is the SEL-311B positive-sequence line impedance setting in secondary ohms.

Z1P is the SEL-311B Zone 1 reach setting in secondary ohms.

Convert SEL-221F-3 Relay Settings to SEL-311B Relay Settings

Table 14.6 shows all the SEL-311B Relay settings that must be entered for the relay to perform protection similar to the SEL-221F-3 when APP = 221F3. Calculate each SEL-311B Relay setting from the corresponding SEL-221F-3 Relay setting using the formula shown. Instruction manual references are to sub-section headings rather than to section headings.

Please carefully note the difference between the SEL-311B and SEL-221F-3 in the implementation of certain protection and logic schemes. For example, reclosing and synchronism check settings do not correspond exactly between the two relays. Always thoroughly test logic schemes to be sure they operate as intended.

Table 14.6: SEL-311B Settings Calculated From SEL-221F-3 Settings

SEL-311B Relay Setting	Calculated from SEL-221F-3 Settings	SEL-311B Instruction Manual Section	SEL-221F-3 Instruction Manual Section
RID TID	None = ID		Section 3—Set
CTR CTRP PTR PTRS	= CTR = CTR = PTR = SPTR	Section 9—Settings Sheets	Section 5—Current and Potential Transformer Ratio Selection
Z1MAG Z1ANG Z0MAG Z0ANG LL	$= \sqrt{(R1^2 + X1^2)} \cdot \left[\frac{CTR}{PTR}\right]$ $= \text{Arc}\tan\left[\frac{X1}{R1}\right]$ (degrees) = MTA $= \sqrt{(R0^2 + X0^2)} \cdot \left[\frac{CTR}{PTR}\right]$ $= \text{Arc}\tan\left[\frac{X0}{R0}\right]$ (degrees) = LL	Section 9—Settings Sheets	Section 5—R1, X1, R0, X0, and Line Length (LL)
APP	None		
ELOP N Y	= LOPE = N = Y	Section 4—Loss of Potential	Section 5—Loss-of-Potential (LOP) Enable Setting (LOPE)
Z1P Z1MG Z2P Z2MG Z3P Z3MG	$= \frac{Z1\%}{100} \cdot Z1MAG$ $= \frac{Z2\%}{100} \cdot Z1MAG$ $= \frac{Z3\%}{100} \cdot Z1MAG$ where Z1MAG $= \sqrt{(R1^2 + X1^2)}\left[\frac{CTR}{PTR}\right]$	Section 3—Phase Distance Elements	Section 5—Zone 1 Reach Setting (Z1%) Section 5—Zone 2 Reach Setting (Z2%) Section 5—Zone 3 Reach Setting (Z3%) **Note:** Z1MAG is an SEL-311B setting

SEL-311B Relay Setting	Calculated from SEL-221F-3 Settings	SEL-311B Instruction Manual Section	SEL-221F-3 Instruction Manual Section
Z2PD Z2GD Z3D	= Z2DP = Z2DG = Z3D	Section 3—Zone Time Delay Elements	Section 5—Zone 2 Phase and Ground Distance Time Delays (Z2DP, Z2DG) Section 5—Zone 3 Phase and Ground Time Delay (Z3D)
50P1P 50P2P	= 50H / CTR None: Breaker failure phase overcurrent pickup.	Section 5—Switch-Onto-Fault (SOTF) Trip Logic	Section 5—High Set Phase Overcurrent Element Setting
50G1P N/A (67G1TC = 1) 50G2P	= 67NP / CTR = 67NTC (In the SEL-311B, 50G1P is fixed forward) None: Breaker failure residual overcurrent pickup.	Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements	Section 5—67NP Residual Overcurrent Settings (67NP, 67NTC)
51GP 51GC U1* U2 U3 U4 51GTD 51GTC (= 1 (= 32GF	= 51NP / CTR = 51NC = 1 = 2 = 3 = 4 = 51NTD = 51NTC (51GTC is an SEL-311B SELOGIC setting) = N) = Y)	Section 3—Residual Ground Time-Overcurrent Element	Section 5—Residual Time-Overcurrent Settings (51NP, 51NC, 51NTD, 51NTC)

SEL-311B Relay Setting	Calculated from SEL-221F-3 Settings	SEL-311B Instruction Manual Section	SEL-221F-3 Instruction Manual Section
25VLO 25VHI 25SF 25ANG1 25ANG2 SYNCP TCLOSD	= 27VLO • (1000 / SPTR) = 59VHI • (1000 / SPTR) None None None SYNCP None	Section 4—Synchronism Check Element Settings	Section 5—Synchronism Checking Function
79OI1 79RSD 79RSLD	= 79OI1 = 79RS = 79RS	Section 6—Close and Reclose Logic	Section 5—Reclose Logic
52AEND SOTFD	= 52BT (Pickup) = 52BT (Dropout)	Section 5—Switch-Onto-Fault (SOTF) Trip Logic	Section 5—52BT Setting (52BT) And Switch-Onto-Fault Protection
TDURD	= TDUR	Section 4—Unlatch Trip	Section 5—Trip Duration Timer (TDUR)
SV1PU SV1DO	= BFTD None	Section 3—Inst./Def.-Time-Overcurrent Elements Section 7—Latch Control Switches	Section 2—Breaker Failure Features of the SEL-221-3/121F-3 and 221F-4 Relays
SV2PU SV2DO	VCT None	Section 3—Voltage Elements Section 7—Latch Control Switches	

* Curve U1 in the SEL-311B is slightly different from curve 1 in the SEL-221F-3. Time dial adjustments may be necessary.

Note: SEL-311B phase-to-phase fault detector settings (50PP1, 50PP2, 50PP3) are set to their minimum values and hidden. This corresponds to SEL-221F-3 setting 50P.

SEL-311B phase-to-ground and residual fault detector settings (50L1, 50L2, 50L3, 50GZ1, 50GZ2, and 50GZ3) are set to their minimum values and hidden. This corresponds to SEL-221F-3 setting 50NG

SEL-221F-3 function "Remote End Just Opened" (REJO) is not implemented in the SEL-311B.

Convert SEL-221F-3 Output Mask Logic Settings to SELOGIC Control Equations

See ***Programmable Output Contact Mask Settings*** in ***Section 5: Applications*** in the SEL-221F-3 Instruction Manual for a description of output masks. In the SEL-311B, output masks are replaced by SELOGIC control equations as shown below:

Table 14.7: SEL-311B SELOGIC Equation Equivalent to Each SEL-221F-3 Mask Logic Setting

SEL-221F-3 Settings Mask	SEL-311B SELOGIC Equations
MTU	TR
MPT	SV3 (DTT)
MTB	SV4 (DTT)
MTO	TRSOTF
MA1	OUT104
MA2	OUT105
MA3	OUT106
MA4	OUT107
MRI	79RI
MRC	79DTL

Table 14.8 shows all SEL-221F-3 Relay Word bits, and an approximate equivalent SEL-311B SELOGIC expression, when setting APP = 221F3 in the SEL-311B. Table 14.7 shows each SEL-221F-3 Mask Logic Setting and the equivalent SEL-311B SELOGIC control equation. To convert a SEL-221F-3 Mask Logic Setting to a SELOGIC control equation, logically OR each appropriate SEL-221F-3 Relay Word bit equivalent expression (Table 14.8) and enter the resultant expression in the related SELOGIC control equation (Table 14.7).

Table 14.8: SELOGIC Equivalent to SEL-221F-3 Relay Word Bits

SEL-221F-3 Relay Word Bit	Equivalent SEL-311B SELOGIC Expression
Z1P	M1P
Z1G	Z1G
Z2PT	M2PT
Z2GT	Z2GT
Z3	M3P + M3G

SEL-221F-3 Relay Word Bit	Equivalent SEL-311B SELOGIC Expression
Z3T	Z3T
3P21	M3P * !32QF
32Q	32GF + 32QF
67N	67G1
51NP	51G
51NT	51GT
50NG	None
50P	None
50H	50P1
IN1	IN101
REJO	None
LOP	ILOP
BFT	SV1T
27S	!59VS
27P	!59VP
59S	59VS
59P	59VP
SSC	25A1
VSC (LSDP) (LPDS)	SV2T (59VS * !59VP * !50L) (59VP * !59VS * !50L)

For example, the factory default setting for MRC in the SEL-221F-3 is shown in Table 14.9. From Table 14.7, the equivalent SEL-311B SELOGIC control equation to MRC is 79DTL. Constructing the logical OR of the equivalent of each element selected in the MRC mask from Table 14.8 gives:

79DTL = Z3T + 51GT

Include the open command OC:

79DTL = Z3T + 51GT + OC

This is the default SELOGIC control equation for 79DTL when APP = 221F3.

When setting APP = 221F3, the SEL-311B automatically sets the following SELOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-221F-3 to customize the relay logic.

Table 14.9: Default SEL-221F-3 Mask Logic Setting for MRC

Z1P 0	Z1G 0	Z2PT 0	Z2GT 0	Z3 0	Z3T 1	3P21 0	32Q 0
67N 0	51NP 0	51NT 1	50NG 0	50P 0	50H 0	IN1 0	REJO 0
LOP 0	BFT 0	27S 0	27P 0	59S 0	59P 0	SSC 0	VSC 0

Default Tripping Logic Equations

TR = M1P + Z1G + M2PT + Z2GT + Z3T + 67G1 + 51GT + OC

TRSOTF = M1P + Z1G + M2PT + Z2GT + M3P + Z3G + Z3T + 67G1 + 51GT + 50P1

DTT = IN101 + SV3 * IN102 + SV4 * !IN103

Default Reclose Logic Equations

79RI = M1P + Z1G + M2PT + Z2GT + 67G1

79DTL = Z3T + 51GT + OC

Default Output Contact Logic Equations

OUT101 = TRIP

OUT102 = TRIP

OUT103 = CLOSE

OUT104 = 25A1

OUT105 = SV4T

OUT106 = M1P + Z1G + M2PT + Z2GT + 67G1

OUT107 = Z3T + 51GT

SELOGIC Variables Equations

SV1 = (LT3 * IN101 + TRIP) * (50P2 + 50G2) * !SV5

SV2 = 59VP * !59VS * !50L * LT1 + 59VS * !59VP * !50L * LT2

SV3 = M3P + Z3G

SV4 = 0

SV5 = (OC + SV5) * TRIP

SELOGIC Latch Equations

The SELOGIC latch equations SET1 and SET 2 emulate the SEL-221F-3 setting PSVC for settings S, P, and E.

Table 14.10: SEL-221F-3 Setting PSVC for Settings S, P, and E

SEL-311B Relay Word Bit	PSVC = S (Default)	PSVC = P	PSVC = E
SET1	= 0	= 1	= 1
RST1	= 1	= 0	= 0
SET2	= 1	= 0	= 0
RST2	= 0	= 1	= 1

The SELOGIC latch equation SET3 emulates the SEL-221F-3 setting BFIN1.

Table 14.11: SEL-221F-3 Setting BFIN1

SEL-311B Relay Word Bit	BFIN1 = N (Default)	BFIN1 = Y
SET3	= 0	= 1
RST3	= 1	= 0

The following contact input assignments are made automatically by the SEL-311B when setting APP = 221F3. These assignments cannot be changed unless setting APP is changed back to APP = 311B.

Default Contact Input Functions

IN101 = Programmable Input (Direct Trip)

IN102 = PT (Permit trip)

IN103 = BT (Block trip)

IN104 = CL (Close breaker)

IN105 = 52A

IN106 = EXT (External event report trigger)

SEL-311B Settings Sheet
Application Setting 221F-3

Identifier Labels (See *Settings Explanations* in *Section 9*)

Relay Identifier (30 characters)	RID = ________
Terminal Identifier (30 characters)	TID = ________

Current and Potential Transformer Ratios (See *Settings Explanations* in *Section 9*)

Phase (IA, IB, IC) Current Transformer Ratio (1–6000)	CTR = ________
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 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 = ________
Application (311B, 221F, 221F3, 221C, 221-16, 2PG10)	APP = **221F3**
Loss-of-Potential (Y, Y1, N) (see Figure 4.1)	ELOP = ________

Phase Distance Elements (See *Settings Explanations* in *Section 3*)

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.4)	Z1P = ________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.5)	Z2P = ________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.6)	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 3.7)	Z1MG = ________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.8)	Z2MG = ________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.9)	Z3MG = ________

Phase and Ground Distance Element Time Delays (See *Settings Explanations* in *Section 3*)

Zone 2 phase distance time delay (OFF, 0–16000 cycles)	Z2PD = ________
Zone 2 ground distance time delay (OFF, 0–16000 cycles)	Z2GD = ________
Zone 3 time delay (OFF, 0–16000 cycles)	Z3D = ________

Phase Inst./Def.-Time Overcurrent Element (See Figure 3.13)

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 = ________

Residual Ground Inst./Def.-Time Overcurrent Elements (See Figure 3.16)

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 = ________

Residual Ground Time-Overcurrent Element (See Figure 3.19)

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 = ________

Synchronism Check Elements (See Figures 3.24 and 3.25)

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 = ________

Reclosing Relay (See Tables 6.2 and 6.3)

Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps)	79OI1 = ________
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 = ________

Switch-Onto-Fault (See Figure 5.3)

52 A 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) TDURD = ________

SELOGIC Control Equation Variable Timers (See Figure 7.23)

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 = ________

Trip Logic Equations (See Figure 5.1)

Direct trip conditions TR = ________________________
Switch-onto-fault trip conditions TRSOTF = ________________________
Direct transfer trip conditions DTT = ________________________

Reclosing Relay Equations (See *Reclosing Relay* in *Section 6*)

Reclose initiate 79RI = ________________________
Drive-to-lockout 79DTL = ________________________

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 = ________________________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements

[Note: torque control equation settings cannot be set directly to logical 0]

Level 1 residual ground (see Figure 3.16) 67G1TC = ________________________
Residual Ground (see Figure 3.19) 51GTC = ________________________

SELOGIC Control Equation Variable Timer Input Equations (See Figure 7.23)

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 = ______________________

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 = ___________________

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. Do not use MIRRORED BITS (MB*x*) protocol in Application Settings. Refer to ***Appendix C*** for details on the LMD protocol.

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 = ________
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-311B Relay Fast Operate commands.

Power System Configuration (See *Settings Explanations* in *Section 9*)

Phase rotation (ABC, ACB)	PHROT = ________

SEL-221C TO SEL-311B SETTINGS CONVERSION GUIDE

Set APP = 221C in the SEL-311B to configure the relay to closely approximate the features, performance, and settings of an SEL-221C. When APP = 221C, the SEL-311B:

1. Configures itself as a phase distance and phase and ground directional overcurrent relay with voltage supervised reclosing.
2. Configures contact inputs and contact outputs to emulate those in an SEL-221C.
3. Presents the user only with those settings associated with SEL-221C type features.
4. Automatically calculates all other settings required to simulate an SEL-221C.

If additional capability is needed (e.g., MIRRORED BITS or SELOGIC control equations) the relay may be returned to the setting APP = 311B to make all of the SEL-311B settings visible. It is important to remember that changing from APP = 311B to APP = 221C changes settings in the SEL-311B. Changing from APP = 221C to APP = 311B makes more SEL-311B settings visible, but does not change any other settings. If SEL-311B functions are used after setting APP is changed from 221C to 311B, do not change setting APP back to 221C.

As described above, when setting APP = 221C, the user is presented only with SEL-311B settings associated with the features found in an SEL-221C. This section explains how to make those remaining SEL-311B settings directly from the settings used in an SEL-221C.

There are mainly two kinds of settings in the SEL-311B, relay settings and SELOGIC settings. Relay settings are settings for protective elements. SELOGIC settings are Boolean expressions used to customize the logic of the SEL-311B. To set the SEL-311B to emulate an SEL-221C, follow these four steps:

1. Turn on the SEL-221C application setting by making setting APP = 221C. See ***Application Settings*** below.
2. Convert the appropriate SEL-221C settings to SEL-311B settings using the simple equations shown in Table 14.12. Be sure to convert from primary quantities (SEL-221C settings) to secondary quantities (SEL-311B settings). See ***Convert SEL-221C Primary Quantities to SEL-311B Secondary Quantities*** below.
3. For each Mask Logic setting in the SEL-221C shown in Table 14.13, create an equivalent SELOGIC control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.14.
4. Test the relay to verify intended performance.

The remainder of this section shows how to perform steps 1 through 3 above, and also gives an example of step 3.

Application Settings

From Access Level 2, set the SEL-311B application setting to "221C" as shown below:

```
=>>SET APP TERSE <ENTER>

Line Parameter Settings:

Application (311B,221F,221F3,221C,221-16,2PG10)   APP   = 311B      ? 221C <ENTER>

Enable Settings:

Fault Location(Y,N)                               EFLOC = Y         ? END <ENTER>
Save Changes(Y/N)? Y <ENTER>
Settings saved
=>>
```

Convert SEL-221C Primary Quantities to SEL-311B Secondary Quantities

All SEL-221C current settings must be converted from primary to secondary amps to be used in the SEL-311B. Divide the SEL-221C current setting by the current transformer ratio setting (CTR) to make the change.

SEL-221C impedance settings must be converted from percent of primary line impedance to secondary impedance in ohms. For example, the Zone 1 distance setting in the SEL-311B (Z1P) is calculated as

$$Z1P = \frac{Z1\%}{100} \cdot Z1MAG$$

where: Z1% is the SEL-221C distance reach setting.

Z1MAG is the SEL-311B positive-sequence line impedance setting in secondary ohms.

Z1P is the SEL-311B Zone 1 reach setting in secondary ohms.

Convert SEL-221C Relay Settings to SEL-311B Relay Settings

Table 14.12 shows all the SEL-311B Relay settings that must be entered for the relay to perform protection similar to the SEL-221C when APP = 221C. Calculate each SEL-311B Relay setting from SEL-221C Relay settings using the formula shown. Instruction manual references are to subsection headings rather than to section headings.

Table 14.12: SEL-311B Settings Calculated From SEL-221C Settings

SEL-311B Relay Setting	Calculated from SEL-221C Settings	SEL-311B Instruction Manual Section	SEL-221C Instruction Manual Section
RID TID	None = ID	Section 9—Settings Sheets	Section 3—Set n
CTR CTRP PTR PTRS	= CTR = CTR = PTR = PTR	Section 9—Settings Sheets	Section 5—Current and Potential Transformer Ratio Selection
Z1MAG Z1ANG Z0MAG Z0ANG LL	$= \sqrt{(R1^2 + X1^2)} \cdot \left[\frac{CTR}{PTR}\right]$ $= \text{Arc tan}\left[\frac{X1}{R1}\right]$ (degrees) = MTA $= \sqrt{(R0^2 + X0^2)} \cdot \left[\frac{CTR}{PTR}\right]$ $= \text{Arc tan}\left[\frac{X0}{R0}\right]$ (degrees) = LL	Section 9—Settings Sheets Section 9—Settings Sheets	Section 5—R1, X1, R0, X0, and Line Length
APP EFLOC ELOP N Y	None = LOCAT = LOPE = N = Y	Section 9—Settings Sheets Section 4—Loss of Potential	Section 2—Fault Location Section 5—Loss-of-Potential (LOP) Enable Setting (LOPE)

SEL-311B Relay Setting	Calculated from SEL-221C Settings	SEL-311B Instruction Manual Section	SEL-221C Instruction Manual Section
Z1P Z2P Z3P	$= \frac{Z1\%}{100} \bullet Z1MAG$ $= \frac{Z2\%}{100} \bullet Z1MAG$ $= \frac{Z3\%}{100} \bullet Z1MAG$ where $Z1MAG = \sqrt{\left(R1^2 + X1^2\right)}\left[\frac{CTR}{PTR}\right]$	Section 3—Phase Distance Elements	Section 2—Distance Elements **Note:** Z1MAG is an SEL-311B setting
Z3PD 50P1P 50P2P	= Z3DP = 50H / CTR = 50M / CTR	Section 3—Zone Time Delay Elements Section 5—Switch-Onto-Fault (SOTF) Trip Logic Section 4—Loss-of-Potential Logic	Section 5—Zone 3 Distance Element Timer Section 5—High Set Phase Overcurrent Setting Section 5—Medium Set Phase Overcurrent Setting (50M)
50G1P 50G2P 50G3P	= 50N1P / CTR = 50N2P / CTR = 50N3P / CTR	Section 3—Inst./Def.-Time Overcurrent Elements	Section 5—Residual Overcurrent Setting (50N1P) Section 5—Residual Overcurrent Setting (50N2P) Section 5—Residual Overcurrent Setting (50N3P)
67G2D 67G3D	= Z2DG = Z3DG	Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements	Section 5—Choice of Zones 1, 2, and 3 Residual Overcurrent Pickup Settings

SEL-311B Relay Setting	Calculated from SEL-221C Settings	SEL-311B Instruction Manual Section	SEL-221C Instruction Manual Section
51PP 51PC U1* U2 U3 U4 51TD	= 51PP / CTR = 51PC = 1 = 2 = 3 = 4 51PTD	Section 3—Phase Time-Overcurrent Element	Section 5—Phase Time-Overcurrent Settings (51PP, 51PC, 51PTD)
51GP 51GC U1* U2 U3 U4 51GTD 51GTC (= 1 (= 32GF	= 51NP / CTR = 51NC = 1 = 2 = 3 = 4 = 51NTD = 51NTC = N) = Y)	Section 3—Residual Ground Time-Overcurrent Element	Section 5—Residual Time-Overcurrent Settings (51PP, 51PC, 51PTD, 51NTC)
DIR3	= ZONE 3	Section 4—Directional Control Settings	Section 5—Zone 3 Direction Setting
ORDER Q V I	= 32QE = 32VE = 32IE	Section 4—Directional Control for Ground Distance and Residual Ground Overcurrent Elements	Section 2—Functional Description—Directional Elements
27P 59P 27PP 59PP	$= (59N \bullet 1000) / (\sqrt{3} \bullet PTR)$ $= (47PXD \bullet 1000) / (\sqrt{3} \bullet PTR)$ = 47PXD · 1000 / PTR = 47PXL · 1000 / PTR	Section 3—Voltage Elements	Section 2—Reclosing Relay

SEL-311B Relay Setting	Calculated from SEL-221C Settings	SEL-311B Instruction Manual Section	SEL-221C Instruction Manual Section
79OI1 79OI2 79OI3 79RSD 79RSLD	= 79OI1 = 79OI2 = 79OI3 None (SEL-221C setting 79RS serves a slightly different purpose.) None	Section 6—Close and Reclose Logic Section 6—Reclosing Relay Timer Settings	Section 2—Reclosing Relay
52AEND SOTFD	= 52BT (Pickup) = 52BT (Dropout)	Section 5—Switch-Onto-Fault (SOTF) Trip Logic	Section 5—52BT Setting (52BT) and Switch-Onto-Fault Protection
TDURD	= TDUR	Section 4—Unlatch Trip	Section 5—Trip Duration Timer (TDUR)
SV1PU	= 50MFD		Section 5—Medium Set Overcurrent Setting (50M)
SV9DO	= VCT		Section 2—Reclosing Relay

* Curve U1 in the SEL-311B is slightly different from curve 1 in the SEL-221C. Time dial adjustments may be necessary.

Note: SEL-311B phase-to-phase fault detector settings 50PP1, 50PP2, and 50PP3 are set to 0.1 * I_{NOM} and are hidden. This corresponds to SEL-221C setting 50L.

Convert SEL-221C Output Mask Logic Settings to SELOGIC Control Equations

See ***Programmable Output Contact Mask Settings*** in ***Section 5: Applications*** in the SEL-221C Instruction Manual for a description of output masks. In the SEL-311B, output masks are replaced by SELOGIC control equations as shown below:

Table 14.13: SEL-311B SELOGIC Equation Equivalent to Each SEL-221C Mask Logic Setting

SEL-221C Settings Mask	SEL-311B SELOGIC Equations
MTU	TR
MPT	SV2 (DTT)
MTB	SV3 (DTT)
MTO	TRSOTF
MA1	OUT104
MA2	OUT105
MA3	OUT106
MA4	OUT107
MRI	79RI
MRC	79DTL

Table 14.14 shows all SEL-221C Relay Word bits, and an approximate equivalent SEL-311B SELOGIC expression, when setting APP = 221C in the SEL-311B. Table 14.13 shows each SEL-221C Mask Logic Setting and the equivalent SEL-311B SELOGIC control equation. To convert a SEL-221C Mask Logic Setting to a SELOGIC control equation, logically OR each appropriate SEL-221C Relay Word bit equivalent expression (Table 14.14) and enter the resultant expression in the related SELOGIC control equation listed in Table 14.13.

Table 14.14: SELOGIC Equivalent to SEL-221C Relay Word Bits

SEL-221C Relay Word Bit	Equivalent SEL-311B SELOGIC Expression
51PT	51PT
1ABC	MABC1
2ABC	MABC2
3ABC	MABC3
51PP	51P
50H	50P1
50L	None (Phase-Phase Current Fault Detector Setting 50PP1)

SEL-221C Relay Word Bit	Equivalent SEL-311B SELOGIC Expression
LOP	ILOP
51NT	51GT
67N1	67G1
67N2	67G2
67N3	67G3
51NP	51G
Z1P	MPP1
Z2P	MPP2
Z3P	MPP3
DF	32GF
DR	32GR
Z2GT	67G2T
Z3GT	67G3T
50MF	SV1T (SV1 = 50P2 * ILOP)
RC	None (SELOGIC equation 79DTL)
RI	None (SELOGIC equation 79RI)
Z3PT	M3PT
50M	50P2
TRIP	TRIP or OUT101 or OUT102
TC	OC
DT	IN101
52BT	SOTFE
59N	59N1

For example, the factory default setting for MTU in the SEL-221C is shown in Table 14.15. From Table 14.13, the equivalent SEL-311B SELOGIC control equation to MTU is TR. Constructing the logical OR of the equivalent of each element selected in the MTU mask from Table 14.14 gives:

TR = 51PT + MABC1 + 51GT + 67G1 + MPP1 + 67G2T + 67G3T + M3PT + OC + IN101

Since IN101 (DT) is also included in the DTT tripping logic equation, it can be eliminated from the TR equation. Also, MABC1 + MPP1 can be replaced by M1P. Therefore, the TR equation becomes:

TR = M1P + M3PT + 67G1 + 67G2T + 67G3T + 51PT + 51GT + OC

which is the default SELOGIC control equation for TR when APP = 221C.

When setting APP = 221C, the SEL-311B automatically sets the following SELOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-221C to customize the relay logic.

Table 14.15: Default SEL-221C Mask Logic Setting for MTU

51PT 1	1ABC 1	2ABC 0	3ABC 0	51PP 0	50H 0	50L 0	LOP 0
51NT 1	67N1 1	67N2 0	67N3 0	51NP 0	Z1P 1	Z2P 0	Z3P 0
DF 0	DR 0	Z2GT 1	Z3GT 1	50MF 0	RC 0	RI 0	Z3PT 1
50M 0	TRIP 0	TC 1	DT 1	52BT 0	59N 0	0	0

Default Tripping Logic Equations

TR = M1P + M3PT + 67G1 + 67G2T + 67G3T + 51PT + 51GT + OC

TRSOTF = M1P + M2P + M3P + 67G1 + 67G2 + 67G3 + 51PT + 51GT + 50P1

DTT = IN101 + SV2 * IN102 + SV3 * !IN103

Default Reclose Logic Equations

79RI = MPP1 + 67G1

79DTL = MABC1 + MABC2 + MABC3 + M3PT + 50P1 + 51PT + 51GT + 67G2T + 67G3T + OC + IN101 + **SV13**

Note: SELOGIC variable SV13 must be in the 79DTL equation for the correct operation of voltage supervised reclosing.

Default Output Contact Logic Equations

OUT101	=	TRIP	
OUT102	=	TRIP	
OUT103	=	CLOSE	
OUT104	=	M2P + 67G2	(Reserved for MA1)
OUT105	=	51PT + 51GT	(Reserved for MA2)
OUT106	=	MPP1 + 67G1	(Reserved for MA3)
OUT107	=	LOP	(Reserved for MA4)

SELOGIC Variables Equations

SV1	=	50P2 * ILOP	
SV2	=	0	(Reserved for MPT)
SV3	=	0	(Reserved for MBT)
SV4	=	1	(Reserved for DLC)
SV5	=	0	(Reserved for LLC)
SV6	=	1	(Reserved for CVC)
SV7	=	1	(Reserved for VSA)

WARNING

Do not set SV4 (DLC) and SV5 (LLC) equal to a logical 1 at the same time. This is an illegal condition in the SEL-221C, and will cause misoperation of voltage supervised reclosing!

Figure 14.1 shows the implementation of SEL-221C voltage supervised reclosing in the SEL-311B. These settings are made automatically by the SEL-311B when setting APP = 221C. These assignments cannot be changed unless setting APP is changed back to APP = 311B.

SELOGIC variables SV4–SV7 are used for SEL-221C settings DLC, LLC, CVC, and VSA. SELOGIC variables SV13 must be entered into the 79DTL equation or voltage supervised reclosing will misoperate. It is recommended that, after making voltage supervised reclosing settings, the reclosing should be tested to verify intended performance.

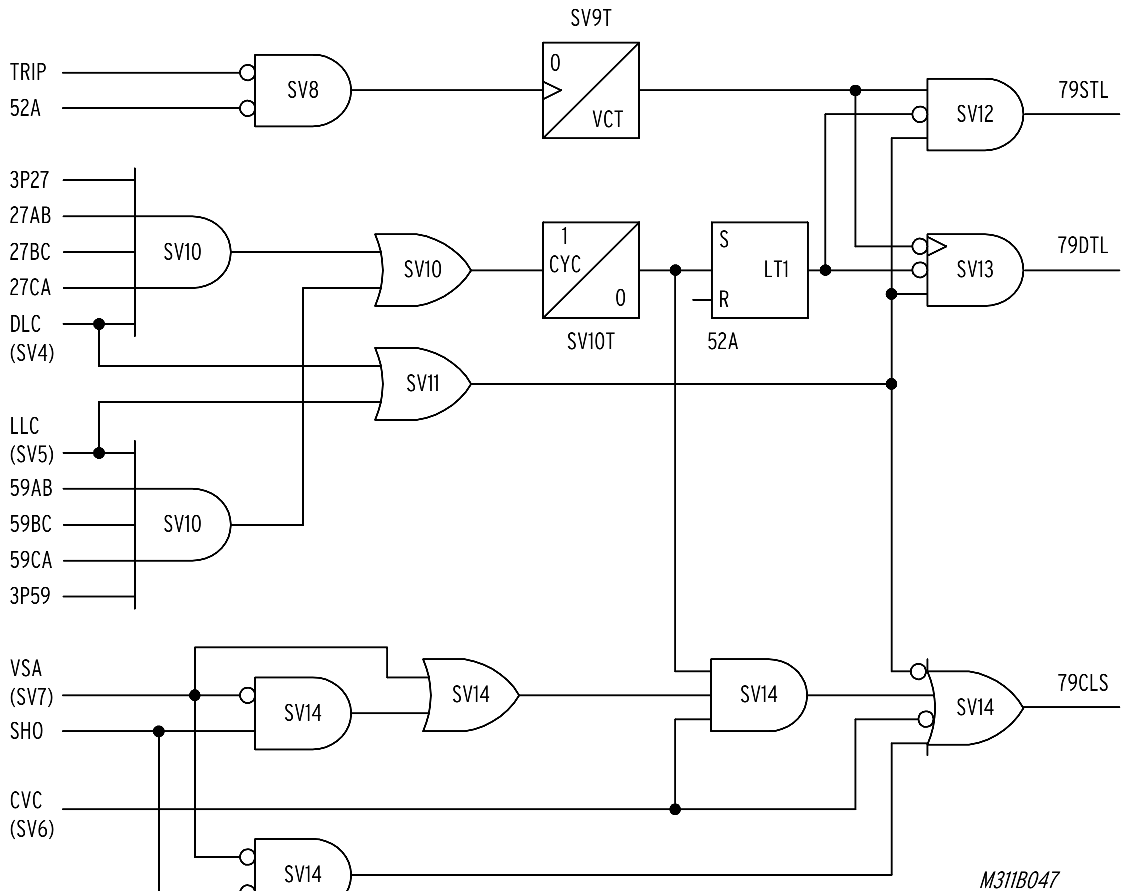

Figure 14.1: Voltage Supervised Reclosing Logic

The following contact input assignments are made automatically by the SEL-311B when setting APP = 221C. These assignments cannot be changed unless setting APP is changed back to APP = 311B.

Default Input Logic Equations

IN101	=	DT - DIRECT TRIP
IN102	=	PT - PERMIT TO TRIP
IN103	=	BT - BLOCK TRIP
IN104	=	DC - DIRECT CLOSE
IN105	=	52A
IN106	=	ET - EXTERNAL EVENT TRIGGER

SEL-311B SETTINGS SHEET
APPLICATION SETTING 221C

Identifier Labels (See *Settings Explanations* in *Section 9*)

Relay Identifier (30 characters)	RID = ______________________
Terminal Identifier (30 characters)	TID = ______________________

Current and Potential Transformer Ratios (See *Settings Explanations* in *Section 9*)

Phase (IA, IB, IC) Current Transformer Ratio (1–6000)	CTR = __________
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 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 = __________
Application (311B, 221F, 221F3, 221C, 221-16, 2PG10)	APP = **221C**
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 = __________

Mho Phase Distance Elements (See *Settings Explanations* in *Section 3*)

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.4)	Z1P = __________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.5)	Z2P = __________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.6)	Z3P = __________

Mho Phase Distance Element Time Delays (See *Settings Explanations* in *Section 3*)

Zone 3 time delay (OFF, 0–16000 cycles)	Z3PD = __________

Phase Inst./Def.-Time Overcurrent Elements (See Figure 3.13)

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 = __________

Residual Ground Inst./Def.-Time Overcurrent Elements (See Figure 3.16)

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 3.18)

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 = __________

Phase Time-Overcurrent Element (See Figure 3.18)

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 = __________

Residual Ground Time-Overcurrent Element (See Figure 3.19)

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 = __________

Zone/Level 3 and 4 Directional Control

Zone/Level 3 direction: Forward, Reverse (F, R)	DIR3 = __________

Directional Elements (See *Directional Control Settings* in *Section 4*)

Ground directional element priority: combination of Q, V, or I	ORDER = __________

Voltage Elements (See Figures 3.21 and 3.22)

(Make the following settings if preceding enable setting EVOLT = Y.)

Phase undervoltage pickup (OFF, 0.00–150.00 V secondary)	27P = __________
Phase overvoltage pickup (OFF, 0.00–150.00 V secondary)	59P = __________
Phase-to-phase undervoltage pickup (OFF, 0.00–260.00 V secondary)	27PP = __________
Phase-to-phase overvoltage pickup (OFF, 0.00–260.00 V secondary)	59PP = __________

Reclosing Relay (See Tables 6.2 and 6.3)

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 = ____________
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 = __________

Switch-Onto-Fault (See Figure 5.3)

52 A 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)	TDURD = _________

SELOGIC Control Equation Variable Timers (See Figures 7.23 and 7.24)

(SELOGIC control equation settings consist of Relay Word bits [see Table 9.4] and SELOGIC control.)

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 = __________
SV9 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps)	SV9DO = __________

Trip Logic Equations (See Figure 5.1)

Direct trip conditions	TR = ______________________________
Switch-onto-fault trip conditions	TRSOTF = __________________________
Direct transfer trip conditions	DTT = _____________________________

Reclosing Relay Equations (See *Reclosing Relay* in *Section 6*)

Reclose initiate	79RI = _____________________________
Drive-to-lockout	79DTL = ___________________________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements

[Note: torque control equation settings cannot be set directly to logical 0]

Residual Ground (see Figure 3.19)	51GTC = ___________________________

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 = ____________________

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 = ____________________

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. Do not use MIRRORED BITS (MB*x*) protocol in Application Settings. Refer to ***Appendix C*** for details on the LMD protocol.

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 = ________
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-311B Relay Fast Operate commands.

Power System Configuration (See *Settings Explanations* in *Section 9*)

Phase rotation (ABC, ACB)	PHROT = ________

SEL-221-16 TO SEL-311B SETTINGS CONVERSION GUIDE

Set APP = 221-16 in the SEL-311B to configure the relay to closely approximate the features, performance, and settings of an SEL-221-16. When APP = 221-16, the SEL-311B:

1. Configures itself as a phase and ground distance relay with ground directional overcurrent elements, and reclosing functions.
2. Configures contact inputs and outputs to emulate those in an SEL-221-16.
3. Presents the user only with those settings associated with SEL-221-16 type features.
4. Automatically calculates all other settings required to simulate an SEL-221-16.

If additional capability is needed (e.g., MIRRORED BITS or SELOGIC control equations) the relay may be returned to the setting APP = 311B to make all of the SEL-311B settings visible. It is important to remember that changing from APP = 311B to APP = 221-16 changes settings in the relay. Changing from APP = 221-16 to APP = 311B makes more SEL-311B settings visible, but does not change any other settings. If SEL-311B functions are used after setting APP is changed from 221-16 to 311B, do not change setting APP back to 221-16.

As described above, when setting APP = 221-16, the user is presented only with SEL-311B settings associated with the features found in an SEL-221-16. This section explains how to make those remaining SEL-311B settings directly from the settings used in an SEL-221-16.

There are mainly two kinds of settings in the SEL-311B, relay settings and SELOGIC settings. Relay settings are settings for protective elements. SELOGIC settings are Boolean expressions used to customize the logic of the SEL-311B. To set the SEL-311B to emulate an SEL-221-16, follow these four steps:

1. Turn on the SEL-221-16 application setting by making setting APP = 221-16. See ***Application Settings*** below.
2. Convert the appropriate SEL-221-16 settings to SEL-311B settings using the simple equations shown in Table 14.16. Be sure to convert from primary quantities (SEL-221-16 settings) to secondary quantities (SEL-311B settings). See ***Convert SEL-221-16 Primary Quantities to SEL-311B Secondary Quantities*** below.
3. For each Mask Logic setting in the SEL-221-16 shown in Table 14.17, create an equivalent SELOGIC control equation using the logical OR of each Relay Word bit (Table 14.18) asserted in the mask.
4. Test the relay to verify intended performance.

The remainder of this section shows how to perform steps 1 through 3 above, and also gives an example of step 3.

Application Settings

From Access Level 2, set the SEL-311B application setting to “221-16” as shown below:

```
=>>SET APP TERSE <ENTER>

Line Parameter Settings:

Application (311B,221F,221F3,221C,221-16,2PG10)   APP   = 311B      ? 221-16 <ENTER>

Enable Settings:

Fault Location(Y,N)                               EFLOC = Y         ? END <ENTER>
Save Changes(Y/N)? Y <ENTER>
Settings saved
=>>
```

Convert SEL-221-16 Primary Quantities to SEL-311B Secondary Quantities

All SEL-221-16 current settings must be converted from primary to secondary amps to be used in the SEL-311B. Divide the SEL-221-16 current setting by the current transformer ratio setting (CTR) to make the change.

SEL-221-16 impedance settings must be converted from percent of primary line impedance to secondary impedance in ohms. For example, the Zone 1 distance setting in the SEL-311B (Z1P) is calculated as

$$Z1P = \frac{Z1\%}{100} \cdot Z1MAG$$

where: Z1% is the SEL-221-16 distance reach setting.

Z1MAG is the SEL-311B positive-sequence line impedance setting in secondary ohms.

Z1P is the SEL-311B Zone 1 reach setting in secondary ohms.

Convert SEL-221-16 Relay Settings to SEL-311B Relay Settings

Table 14.16 shows all the SEL-311B Relay settings that must be entered for the relay to perform protection similar to the SEL-221-16 when APP = 221-16. Calculate each SEL-311B Relay setting from the corresponding SEL-221-16 Relay setting using the formula shown. Instruction manual references are to subsection headings rather than to section headings.

Please carefully note the difference between the SEL-311B and SEL-221-16 in the implementation of certain protection and logic schemes. For example, reclosing settings do not correspond exactly between the two relays. Always thoroughly test logic schemes to be sure they operate as intended.

Table 14.16: SEL-311B Settings Calculated From SEL-221-16 Settings

SEL-311B Relay Setting	Calculated from SEL-221-16 Settings	SEL-311B Instruction Manual Section	SEL-221-16 Instruction Manual Section
RID TID	None = ID		Section 3—Set
CTR CTRP PTR PTRS	= CTR = CTR = PTR = PTR	Section 9—Settings Sheets	Section 5—Current and Potential Transformer Ratio Selection
Z1MAG Z1ANG Z0MAG Z0ANG LL	$= \sqrt{(\mathrm{R1}^2 + \mathrm{X1}^2)} \cdot \left[\frac{\mathrm{CTR}}{\mathrm{PTR}}\right]$ $= \mathrm{Arc\,tan}\left[\frac{\mathrm{X1}}{\mathrm{R1}}\right](\mathrm{degrees}) = \mathrm{MTA}$ $= \sqrt{(\mathrm{R0}^2 + \mathrm{X0}^2)} \cdot \left[\frac{\mathrm{CTR}}{\mathrm{PTR}}\right]$ $= \mathrm{Arc\,tan}\left[\frac{\mathrm{X0}}{\mathrm{R0}}\right](\mathrm{degrees})$ = LL	Section 9—Settings Sheets	Section 5—R1, X1, R0, X0, and Line Length (LL)
APP (=221-16)	None		
ELOP N Y	= LOPE = N = Y	Section 4—Loss of Potential	Section 5—Loss-of-Potential (LOP) Enable Setting (LOPE)
Z1P Z1MG Z2P Z2MG Z3P Z3MG	$= \frac{Z1\%}{100} \cdot Z1MAG$ $= \frac{Z2\%}{100} \cdot Z1MAG$ $= \frac{Z3\%}{100} \cdot Z1MAG$ where Z1MAG $= \sqrt{\left(R1^2 + X1^2\right)}\left[\frac{CTR}{PTR}\right]$	Section 3—Phase Distance Elements	Section 5—Zone 1 Reach Setting (Z1%) Section 5—Zone 2 Reach Setting (Z2%) Section 5—Zone 3 Reach Setting (Z3%) **Note:** Z1MAG is an SEL-311B setting

SEL-311B Relay Setting	Calculated from SEL-221-16 Settings	SEL-311B Instruction Manual Section	SEL-221-16 Instruction Manual Section
Z2PD Z2GD Z3D	= Z2DP = Z2DG = Z3D	Section 3—Zone Time Delay Elements	Section 5—Zone 2 Phase and Ground Distance Time Delays (Z2DP, Z2DG) Section 5—Zone 3 Phase and Ground Time Delay (Z3D)
50P1P 50G1P N/A (67G1TC = 1)	= 50H / CTR = 67NP / CTR = 67NTC (In the SEL-311B, 50G1P is fixed forward)	Section 5—Switch-Onto-Fault (SOTF) Trip Logic Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements	Section 5—High Set Phase Overcurrent Element Setting Section 5—67NP Residual Overcurrent Settings (67NP, 67NTC)
51GP 51GC U1* U2 U3 U4 51GTD 51GTC (= 1 (= 32GF	= 51NP / CTR = 51NC = 1 = 2 = 3 = 4 = 51NTD = 51NTC (51GTC is an SEL-311B SELOGIC setting) = N) = Y)	Section 3—Residual Ground Time-Overcurrent Element	Section 5—Residual Time-Overcurrent Settings (51NP, 51NC, 51NTD, 51NTC)
79OI1 79RSD 79RSLD	= 79OI1 = 79RS = 79RS	Section 6—Close and Reclose Logic	Section 5—Reclose Logic

SEL-311B Relay Setting	Calculated from SEL-221-16 Settings	SEL-311B Instruction Manual Section	SEL-221-16 Instruction Manual Section
52AEND SOTFD	= 52BT (Pickup) = 52BT (Dropout)	Section 5—Switch-Onto-Fault (SOTF) Trip Logic	Section 5—52BT Setting (52BT) And Switch-Onto-Fault Protection
TDURD	= TDUR	Section 4—Unlatch Trip	Section 5—Trip Duration Timer (TDUR)
SV1PU SV1DO	= A1TP = A1TD	Section 7—SELOGIC control equation Variables/Timers	Section 2—Miscellaneous Timers

* Curve U1 in the SEL-311B is slightly different from curve 1 in the SEL-221-16. Time dial adjustments may be necessary.

Note: SEL-311B phase-to-phase fault detector settings (50PP1, 50PP2, 50PP3) are set to their minimum values and hidden. This corresponds to SEL-221-16 setting 50P.

SEL-311B phase-to-ground and residual fault detector settings (50L1, 50L2, 50L3, 50GZ1, 50GZ2, and 50GZ3) are set to their minimum values and hidden. This corresponds to SEL-221-16 setting 50NG

SEL-221-16 function “Remote End Just Opened” (REJO) is not implemented in the SEL-311B.

Convert SEL-221-16 Output Mask Logic Settings to SELOGIC Control Equations

See ***Programmable Output Contact Mask Settings*** in ***Section 5: Applications*** in the SEL-221-16 Instruction Manual for a description of output masks. In the SEL-311B, output masks are replaced by SELOGIC control equations as shown below:

Table 14.17: SEL-311B SELOGIC Equation Equivalent to Each SEL-221-16 Mask Logic Setting

SEL-221-16 Settings Mask	SEL-311B SELOGIC Equations
MTU	TR
MPT	None
MTB	None
MTO	TRSOTF
MA1	OUT104
MA2	OUT105

SEL-221-16 Settings Mask	SEL-311B SELOGIC Equations
MA3	OUT106
MA4	OUT107
MRI	79RI
MRC	79DTL

Table 14.18 shows all SEL-221-16 Relay Word bits, and an approximate equivalent SEL-311B SELOGIC expression, when setting APP = 221-16 in the SEL-311B. Table 14.17 shows each SEL-221-16 Mask Logic Setting and the equivalent SEL-311B SELOGIC control equation. To convert a SEL-221-16 Mask Logic Setting to a SELOGIC control equation, logically OR each appropriate SEL-221-16 Relay Word bit equivalent expression (Table 14.18) and enter the resultant expression in the related SELOGIC control equation (Table 14.17).

Table 14.18: SELOGIC Equivalent to SEL-221-16 Relay Word Bits

SEL-221-16 Relay Word Bit	Equivalent SEL-311B SELOGIC Expression
Z1P	M1P
Z1G	Z1G
Z2PT	M2PT
Z2GT	Z2GT
Z3	M3P + M3G
Z3T	Z3T
3P21	M3P * !32QF
32Q	32GF + 32QF
67N	67G1
51NP	51G
51NT	51GT
50NG	None
50P	None
50H	50P1
IN1	IN101
REJO	None
LOP	ILOP
TRIP	TRIP

For example, the factory default setting for MRC in the SEL-221-16 is shown in Table 14.19. From Table 14.17, the equivalent SEL-311B SELOGIC control equation to MRC is 79DTL.

Constructing the logical OR of the equivalent of each element selected in the MRC mask from Table 14.18 gives:

79DTL = Z3T + 51GT

Include the open command OC:

79DTL = Z3T + 51GT + OC

This is the default SELOGIC control equation for 79DTL when APP = 221-16.

When setting APP = 221-16, the SEL-311B automatically sets the following SELOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-221-16 to customize the relay logic.

Table 14.19: Default SEL-221-16 Mask Logic Setting for MRC

Z1P 0	Z1G 0	Z2PT 0	Z2GT 0	Z3 0	Z3T 1	3P21 0	32Q 0
67N 0	51NP 0	51NT 1	50NG 0	50P 0	50H 0	IN1 0	REJO 0
LOP 0	TRIP 0						

Default Tripping Logic Equations

TR = M1P + Z1G + M2PT + Z2GT + Z3T + 67G1 + 51GT + OC

TRSOTF = M1P + Z1G + M2PT + Z2GT + M3P + Z3G + Z3T + 67G1 + 51GT + 50P1

Default Reclose Logic Equations

79RI = M1P + Z1G + M2PT + Z2GT + 67G1

79DTL = Z3T + 51GT + OC

SELOGIC Torque Control Equations

51GTC = M2P (Setting 51NTC = 1)

SELOGIC Variables Equations

SV1 = 0 (Reserved for MA1)

Default Contact Input Functions

311 Input	221-16 Label	Function
IN101	IN1	Monitor
IN102	PT	Monitor
IN103	BT	Monitor
IN104	DC	Monitor
IN105	52A	Circuit Breaker Aux. Contact
IN106	ET	External Event Report Trigger

Default Output Contact Logic Equations

OUT101	=	TRIP	
OUT102	=	TRIP	
OUT103	=	CLOSE	
OUT104	=	0	(Reserved for MA1)
OUT105	=	0	(Reserved for MA2)
OUT106	=	M1P + Z1G + M2PT + Z2GT + 67G1	(Reserved for MA3)
OUT107	=	Z3T + 51GT	(Reserved for MA4)

SEL-311B SETTINGS SHEET APPLICATION SETTING 221-16

Identifier Labels (See *Settings Explanations* in *Section 9*)

Relay Identifier (30 characters)	RID = ______
Terminal Identifier (30 characters)	TID = ______

Current and Potential Transformer Ratios (See *Settings Explanations* in *Section 9*)

Phase (IA, IB, IC) Current Transformer Ratio (1–6000)	CTR = ______
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 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 = ______
Application (311B, 221F, 221F3, 221C, 221-16, 2PG10)	APP = **221-16**
Loss-of-Potential (Y, Y1, N) (see Figure 4.1)	ELOP = ______

Phase Distance Elements (See *Settings Explanations* in *Section 3*)

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (See Figure 3.4)	Z1P = ______
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (See Figure 3.5)	Z2P = ______
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (See Figure 3.6)	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 3.7)	Z1MG = ______
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.8)	Z2MG = ______
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.9)	Z3MG = ______

Phase and Ground Distance Element Time Delays (See *Settings Explanations* in *Section 3*)

Zone 2 phase distance time delay (OFF, 0–16000 cycles) Z2PD = ________
Zone 2 ground distance time delay (OFF, 0–16000 cycles) Z2GD = ________
Zone 3 time delay (OFF, 0–16000 cycles) Z3D = ________

Phase Inst./Def.-Time Overcurrent Element (See Figure 3.13)

Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}) 50P1P = ________

Residual Ground Inst./Def.-Time Overcurrent Element (See Figure 3.16)

Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}) 50G1P = ________

Residual Ground Time-Overcurrent Element (See Figure 3.19)

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 = ________

Reclosing Relay (See Tables 6.2 and 6.3)

Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI1 = ________
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 = ________

Switch-Onto-Fault (See Figure 5.3)

52 A 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) TDURD = ________

SELogic Control Equation Variable Timers (See Figure 7.23)

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 = ________

Trip Logic Equations (See Figure 5.1)

Direct trip conditions TR = ________________________
Switch-onto-fault trip conditions TRSOTF = ________________________

Reclosing Relay Equations (See *Reclosing Relay* in *Section 6*)

Reclose initiate	79RI = ____________________________
Drive-to-lockout	79DTL = ____________________________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements

[Note: torque control equation settings cannot be set directly to logical 0]

Level 1 residual ground (see Figure 3.16)	67G1TC = ___________________________
Residual Ground (see Figure 3.19)	51GTC = ____________________________

SELOGIC Control Equation Variable Timer Input Equations (See Figure 7.23)

SELOGIC Control Equation Variable SV1	SV1 = ______________________________

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 = ___________________________

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. Do not use MIRRORED BITS (MB*x*) protocol in Application Settings. Refer to ***Appendix C*** for details on the LMD protocol.

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 = __________
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-311B Relay Fast Operate commands.

Power System Configuration (See *Settings Explanations* in *Section 9*)

Phase rotation (ABC, ACB)	PHROT = __________

SEL-2PG10 TO SEL-311B SETTINGS CONVERSION GUIDE

Set APP = 2PG10 in the SEL-311B to configure the relay to closely approximate the features, performance, and settings of an SEL-2PG10. When APP = 2PG10, the SEL-311B:

1. Configures itself as a phase distance relay with ground directional overcurrent elements.
2. Configures contact inputs and outputs to emulate those in an SEL-2PG10.
3. Presents the user only with those settings associated with SEL-2PG10 type features.
4. Automatically calculates all other settings required to simulate an SEL-2PG10.

If additional capability is needed (e.g., MIRRORED BITS or SELOGIC control equations) the relay may be returned to the setting APP = 311B to make all of the SEL-311B settings visible. It is important to remember that changing from APP = 311B to APP = 2PG10 changes settings in the relay. Changing from APP = 2PG10 to APP = 311B makes more SEL-311B settings visible, but does not change any other settings. If SEL-311B functions are used after setting APP is changed from 2PG10 to 311B, do not change setting APP back to 2PG10.

As described above, when setting APP = 2PG10, the user is presented only with SEL-311B settings associated with the features found in an SEL-2PG10. This section explains how to make those remaining SEL-311B settings directly from the settings used in an SEL-2PG10.

There are mainly two kinds of settings in the SEL-311B, relay settings and SELOGIC settings. Relay settings are settings for protective elements. SELOGIC settings are Boolean expressions used to customize the logic of the SEL-311B. To set the SEL-311B to emulate an SEL-2PG10, follow these four steps:

1. Turn on the SEL-2PG10 application setting by making setting APP = 2PG10. See ***Application Settings*** below.
2. Convert the appropriate SEL-2PG10 settings to SEL-311B settings using the simple equations shown in Table 14.20. Be sure to convert from primary quantities (SEL-2PG10 settings) to secondary quantities (SEL-311B settings). See ***Convert SEL-2PG10 Primary Quantities to SEL-311B Secondary Quantities*** below.
3. For each Mask Logic setting in the SEL-2PG10 shown in Table 14.21, create an equivalent SELOGIC control equation using the logical OR of each Relay Word bit (Table 14.22) asserted in the mask.
4. Test the relay to verify intended performance.

The remainder of this section shows how to perform steps 1 through 3 above, and also gives an example of step 3.

Application Settings

From Access Level 2, set the SEL-311B application setting to "2PG10" as shown below:

```
=>>SET APP TERSE <ENTER>

Line Parameter Settings:

Application (311B,221F,221F3,221C,221-16,2PG10)   APP   = 311B      ? 2PG10 <ENTER>

Enable Settings:

Fault Location(Y,N)                               EFLOC = Y         ? END <ENTER>
Save Changes(Y/N)? Y <ENTER>
Settings saved
=>>
```

Convert SEL-2PG10 Primary Quantities to SEL-311B Secondary Quantities

All SEL-2PG10 current settings must be converted from primary to secondary amps to be used in the SEL-311B. Divide the SEL-2PG10 current setting by the current transformer ratio setting (CTR) to make the change.

SEL-2PG10 impedance settings must be converted from percent of primary line impedance to secondary impedance in ohms. For example, the Zone 1 distance setting in the SEL-311B (Z1P) is calculated as

$$Z1P = \frac{Z1\%}{100} \cdot Z1MAG$$

where: Z1% is the SEL-2PG10 distance reach setting.

Z1MAG is the SEL-311B positive-sequence line impedance setting in secondary ohms.

Z1P is the SEL-311B Zone 1 reach setting in secondary ohms.

Convert SEL-2PG10 Relay Settings to SEL-311B Relay Settings

Table 14.20 shows all the SEL-311B Relay settings that must be entered for the relay to perform protection similar to the SEL-2PG10 when APP = 2PG10. Calculate each SEL-311B Relay setting from the corresponding SEL-2PG10 Relay setting using the formula shown. Instruction manual references are to subsection headings rather than to section headings.

Please carefully note the difference between the SEL-311B and SEL-2PG10 in the implementation of certain protection and logic schemes. Always thoroughly test logic schemes to be sure they operate as intended.

Table 14.20: SEL-311B Settings Calculated From SEL-2PG10 Settings

SEL-311B Relay Setting	Calculated from SEL-2PG10 Settings	SEL-311B Instruction Manual Section	SEL-2PG10 Instruction Manual Section
RID TID	None = ID		Section 4—Set
CTR CTRP PTR PTRS	= CTR = CTR = PTR = SPTR	Section 9—Settings Sheets	
Z1MAG Z1ANG Z0MAG Z0ANG LL	$= \sqrt{(R1^2 + X1^2)} \cdot \left[\frac{CTR}{PTR}\right]$ $= \text{Arc}\tan\left[\frac{X1}{R1}\right]\text{(degrees)} = \text{MTA}$ $= \sqrt{(R0^2 + X0^2)} \cdot \left[\frac{CTR}{PTR}\right]$ $= \text{Arc}\tan\left[\frac{X0}{R0}\right]\text{(degrees)}$ = LL	Section 9—Settings Sheets	
APP Z1P	None $= \frac{Z\%}{100} \cdot Z1MAG$ where $\text{Z1MAG} = \sqrt{\left(R1^2 + X1^2\right)}\left[\frac{CTR}{PTR}\right]$	Section 3—Phase Distance Elements	
Z1PD	= PTMR	Section 3—Zone Time Delay Elements	
50G1P (SV1 = 50G1 67G1D SV1T	= 67NIP / CTR = 67NIP Non-directional) = GTMR (Directional) = GTMR (Non-directional)	Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements	

SEL-311B Relay Setting	Calculated from SEL-2PG10 Settings	SEL-311B Instruction Manual Section	SEL-2PG10 Instruction Manual Section
51GP	= 67NP / CTR	Section 3—Residual Ground Time-Overcurrent Element	
51GC	= 67NC		
U1*	= 1		
U2	= 2		
U3	= 3		
U4	= 4		
51GTD	= 67NTD		
51GTC	= 67NC (51GTC is an SEL-311B SELOGIC setting)		
(= 1	= Non-Directional)		
(= 32GF	= Torque Controlled)		
ORDER		Section 4—Directional Control for Ground Distance and Residual Ground Overcurrent Elements	
Q	= 32QE		
V	= 32VE		
I	= 32IE		

* Curve U1 in the SEL-311B is slightly different from curve 1 in the SEL-2PG10. Time dial adjustments may be necessary.

Note: SEL-311B phase-to-phase fault detector setting (50PP1) is set to its minimum value and hidden. This corresponds to SEL-2PG10 setting 50L.

Convert SEL-2PG10 Output Mask Logic Settings to SELOGIC Control Equations

See ***Access Level 2 Commands*** in ***Section 4: Commands and Serial Communications*** in the SEL-2PG10 Instruction Manual for a description of output masks. In the SEL-311B, output masks are replaced by SELOGIC control equations as shown below:

Table 14.21: SEL-311B SELOGIC Equation Equivalent to Each SEL-2PG10 Mask Logic Setting

SEL-2PG10 Settings Mask	SEL-311B SELOGIC Equations
MT	TR
MA1	OUT101
MA2	OUT102

SEL-2PG10 Settings Mask	SEL-311B SELOGIC Equations
MA3	OUT103
MA4	OUT104
MA5	OUT105

Table 14.22 shows all SEL-2PG10 Relay Word bits, and an approximate equivalent SEL-311B SELOGIC expression, when setting APP = 2PG10 in the SEL-311B. Table 14.21 shows each SEL-2PG10 Mask Logic Setting and the equivalent SEL-311B SELOGIC control equation. To convert a SEL-2PG10 Mask Logic Setting to a SELOGIC control equation, logically OR each appropriate SEL-2PG10 Relay Word bit equivalent expression (Table 14.22) and enter the resultant expression in the related SELOGIC control equation (Table 14.21).

Table 14.22: SELOGIC Equivalent to SEL-2PG10 Relay Word Bits

SEL-2PG10 Relay Word Bit	Equivalent SEL-311B SELOGIC Expression
50L	None
ZABC	MABC1
ZP	MPP1
ZPT	M1PT
67NP	51G
67NT	51GT
67NI	67G1 (Directional) 50G1 (Non-directional)
67DT	67G1T (Directional) SVIT (Non-directional)

For example, the factory default setting for MT in the SEL-2PG10 is shown in Table 14.23. From Table 14.21, the equivalent SEL-311B SELOGIC control equation to MT is TR. Constructing the logical OR of the equivalent of each element selected in the MT mask from Table 14.22 gives:

TR = MABC1 + MPP1 + 51GT + 67G1T

Include the open command OC:

TR = MABC1 + MPP1 + 51GT + 67G1T + OC

This is the default SELOGIC control equation for TR when APP = 2PG10.

When setting APP = 2PG10, the SEL-311B automatically sets the following SELOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-2PG10 to customize the relay logic.

Table 14.23: Default SEL-2PG10 Mask Logic Setting for MT

50L	ZABC	ZP	ZPT	67NP	67NT	67NI	67DT
0	1	1	0	0	1	1	0

Default Tripping Logic Equations

TR = MABC1 + MPP1 + 51GT + 67G1T + OC

SELOGIC Torque Control Equations

51GTC = M2P (Setting 51NTC = 1)

SELOGIC Variables Equations

SV1 = 0 (Reserved for non-directional instantaneous overcurrent timer)

Default Contact Input Functions

311 Input	2PG10 Label	Function
IN101	ET1	External Trigger 1
IN102	ET2	External Trigger 2
IN103	E1	Monitor 1
IN104	E2	Monitor 2
IN105	E3	Monitor 3
IN106	52A	Circuit breaker auxiliary contact

Default Output Contact Logic Equations

OUT101 = TRIP

OUT102 = TRIP

OUT103 = MABC1 (Reserved for A1)

OUT104 = MPP1 (Reserved for A2)

OUT105 = 51G (Reserved for A3)

OUT106 = 51GT (Reserved for A4)

OUT107 = 67G1T (Reserved for A5)

SEL-311B SETTINGS SHEET
APPLICATION SETTING 2PG10

Identifier Labels (See *Settings Explanations* in *Section 9*)

Relay Identifier (30 characters)	RID = ________
Terminal Identifier (30 characters)	TID = ________

Current and Potential Transformer Ratios (See *Settings Explanations* in *Section 9*)

Phase (IA, IB, IC) Current Transformer Ratio (1–6000)	CTR = ________
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 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 = ________
Application (311B, 221F, 221F3, 221C, 221-16, 2PG10)	APP = **2PG10**

Mho Phase Distance Elements (See *Settings Explanations* in *Section 3*)

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.})	Z1P = ________

Mho Phase Distance Element Time Delays (See *Settings Explanations* in *Section 3*)

Zone 1 time delay (OFF, 0–16000 cycles)	Z1PD = ________

Residual Ground Inst./Def.-Time Overcurrent Element (See Figure 3.16)

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 3.16)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps)	67G1D = ________

Residual Ground Time-Overcurrent Element (See Figure 3.19)

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 = ________

Directional Elements (See *Directional Control Settings* in *Section 4*)

Ground directional element priority: combination of Q, V, or I ORDER = ________

SELOGIC Control Equation Variable Timers (See Figure 7.23)

(SELOGIC control equation settings consist of Relay Word bits [see Table 9.4] and SELOGIC control.)

SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) SV1PU = ________

Trip Logic Equations (See Figure 5.1)

Direct trip conditions TR = ________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements

[Note: torque control equation settings cannot be set directly to logical 0]

Residual Ground (see Figure 3.19) 51GTC = ________

SELOGIC Control Equation Variable Timer Input Equations (See Figure 7.23)

SELOGIC Control Equation Variable SV1 SV1 = ________

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 = ________

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. Do not use MIRRORED BITS (MB*x*) protocol in Application Settings. Refer to ***Appendix C*** for details on the LMD protocol.

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 = ________
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-311B Relay Fast Operate commands.

Power System Configuration (See *Settings Explanations* in *Section 9*)

Phase rotation (ABC, ACB)	PHROT = ________

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APPENDIX A: FIRMWARE VERSIONS

This manual covers SEL-311B 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-311B-R103-V0-Z002002-D20011205	This firmware differs from the original as follows: – Added 180-cycle event report option. – Modified input debounce time. – Modified rotating display to include settings values. – Added ELAT and EDP settings. – Modified breaker reset (**BRE W**) option. – Added **STA C** command. – Added Fast SER.
SEL-311B-R102-V0-Z001001-D20010625	This firmware differs from the original as follows: – Modified SEL-311 Relays to record consecutive event reports. – Modified the **SUM** command so that the Breaker Status reports the status from the last row of the event report.
SEL-311B-R101-V0-Z001001-D20010518	This firmware differs from the original as follows: – Improved overflow supervision for distance elements.
SEL-311B-R100-V0-Z001001-D20000818	Original Version – SEL-311B; 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-311B-R100-V0-Z001001-D20000818**

APPENDIX B: FIRMWARE UPGRADE INSTRUCTIONS

FIRMWARE (FLASH) UPGRADE INSTRUCTIONS

SEL may occasionally offer firmware upgrades to improve the performance of your relay. The SEL-311B Relay stores firmware in Flash memory; therefore, changing physical components is not necessary. A firmware loader program called SELBOOT resides in the SEL-311B 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.

REQUIRED EQUIPMENT

- Personal computer.
- Terminal emulation software that supports XMODEM/CRC protocol (e.g., CROSSTALK®, Microsoft® Windows® Terminal and HyperTerminal, Procomm® Plus, Relay/Gold, and 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-311B 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. (Disconnect any other serial port connections.)

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, 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**, and **SHO T**.

   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 when just the **<ENTER>** key is pressed on the connected PC, even though everything is OK.

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 2.3 MB of free disk space. The procedure takes approximately 6 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., 311B_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 6 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 <ENTER>
Erasing
Erase successful
Press any key to begin transfer, then start transfer at the PC <ENTER>

Upload completed successfully. Attempting a restart
```

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.

If this occurs, press **<ENTER>** to see if the level 0 prompt " = " appears on your terminal screen. If it does, enter Access Level 2 by issuing the **ACC** and **2AC** commands and proceed to self-test failure: IO_BRD, Step 12a.

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, EEPROM, and IO_BRD, Step 12e.

Self-test failure: IO_BRD

a. Issue the Initialize (**INI**) command to reinitialize the I/O Board(s). If this command is not available, go to Step 12e.

b. Answer **Y <ENTER>** to the question: "Are the new I/O board(s) correct (Y/N)" After about one minute, the EN LED will illuminate. The original relay settings have been retained, but should be checked for accuracy.

c. Enter Access Level 2 by issuing the **ACC** and **2AC** commands. Go to Step 13.

Self-test failure: CR_RAM, EEPROM, and IO_BRD

d. 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).

e. 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).

f. 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).

g. 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**.

h. 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 and Troubleshooting.***

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 bits 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-311B 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 (74)
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 FM on settings change
0004	Settings change bit
A5C300000000	Reconfigure peak demand FM on settings change
0300	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
84	Length
01	One status flag byte
00	Scale factors in Fast Meter message
00	No scale factors
0A	# of analog input channels
02	# of samples per channel
36	# of digital banks
01	One calculation block
0004	Analog channel offset
0054	Time stamp offset
005C	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
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
94	Length
1 byte	1 Status Byte
80 bytes	X and Y components of: IA, IB, IC, IP, VA, VB, VC, VS, Freq and Vbatt in 4-byte IEEE FPS
8 bytes	Time stamp
54 bytes	54 Digital banks: TAR0–TAR53
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
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494200000000	Analog channel name (IB)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494300000000	Analog channel name (IC)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
494700000000	Analog channel name (IG)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
334932000000	Analog channel name (3I2)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50412B000000	Analog channel name (PA+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50422B000000	Analog channel name (PB+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50432B000000	Analog channel name (PC+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50332B000000	Analog channel name (P3+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51412B000000	Analog channel name (QA+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51422B000000	Analog channel name (QB+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message

51432B000000	Analog channel name (QC+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51332B000000	Analog channel name (Q3+)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50412D000000	Analog channel name (PA-)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50422D000000	Analog channel name (PB-)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50432D000000	Analog channel name (PC-)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
50332D000000	Analog channel name (P3-)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51412D000000	Analog channel name (QA-)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51422D000000	Analog channel name (QB-)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51432D000000	Analog channel name (QC-)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
51332D000000	Analog channel name (Q3-)
02	Analog channel type
FF	Scale factor type
0000	Scale factor offset in Fast Meter message
00	Reserved
checksum	1-byte checksum of preceding bytes

A5D2/A5D3 Demand/Peak Demand Fast Meter Message

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

Data	Description
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-311B 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 OUT108). 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-311B 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 following information described below.

<STX>"FID=SEL-311B-Rrrr-Vv-Zzzzzzz-Dyyyymmdd","aaaa"<CR><LF>
"CID=cccc","aaaa"<CR><LF>
"DEVID=[TID SETTING]","aaaa"<CR><LF>
"DEVCODE=47","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.
FID is the Firmware identification string.
CID is the 4 digit hexadecimal checksum of the firmware.
DEVID is the text from the Relay Identification (RID) setting.
DEVCODE is the MODBUS Device ID Code for the SEL-311B.
PARTNO is the part number that matches the Model Option Table number.
CONFIG is configuration string used for SEL internal use only.

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","TARDT","SOTF","RCRS","RCCY","RCLO","0C8E"
"A","B","C","G","ZONE1","ZONE2","ZONE3","51","093D"
"M1P","M1PT","Z1G","Z1GT","M2P","M2PT","Z2G","Z2GT","0B54"
"Z1T","Z2T","50P1","67P1","67P1T","50G1","67G1","67G1T","0B50"
"51G","51GT","51GR","LOP","ILOP","ZLOAD","ZLOUT","ZLIN","0CA1"
"LB1","LB2","LB3","LB4","LB5","LB6","LB7","LB8","0994"
"LB9","LB10","LB11","LB12","LB13","LB14","LB15","LB16","0AE5"
"RB1","RB2","RB3","RB4","RB5","RB6","RB7","RB8","09C4"
"RB9","RB10","RB11","RB12","RB13","RB14","RB15","RB16","0B15"
"LT1","LT2","LT3","LT4","LT5","LT6","LT7","LT8","0A24"
"LT9","LT10","LT11","LT12","LT13","LT14","LT15","LT16","0B75"
"SV1","SV2","SV3","SV4","SV1T","SV2T","SV3T","SV4T","0BAC"

```
"SV5","SV6","SV7","SV8","SV5T","SV6T","SV7T","SV8T","0BCC"
"SV9","SV10","SV11","SV12","SV9T","SV10T","SV11T","SV12T","0CD6"
"SV13","SV14","SV15","SV16","SV13T","SV14T","SV15T","SV16T","0D44"
"MAB1","MBC1","MCA1","MAB2","MBC2","MCA2","CVTBL","SOTFT","0C9A"
"MAG1","MBG1","MCG1","MAG2","MBG2","MCG2","DCHI","DCLO","0BE7"
"BCW","BCWA","BCWB","BCWC","FIDEN","FSA","FSB","FSC","0BAD"
"SG1","SG2","SG3","SG4","SG5","SG6","OC","CC","0969"
"CLOSE","CF","TRGTR","52A","3PO","SOTFE","VPOLV","50L","0C55"
"PDEM","GDEM","QDEM","TRIP","50QF","50QR","50GF","50GR","0C1D"
"32QF","32QR","32GF","32GR","32VE","32QGE","32IE","32QE","0BA4"
"F32I","R32I","F32Q","R32Q","F32QG","R32QG","F32V","R32V","0C18"
"*","*","IN106","IN105","IN104","IN103","IN102","IN101","0AD9"
"ALARM","OUT107","OUT106","OUT105","OUT104","OUT103","OUT102","OUT101","0FC8"
"M3P","M3PT","Z3G","Z3GT","*","*","*","*","0818"
"Z3T","*","50P2","67P2","67P2T","50P3","67P3","67P3T","0AC0"
"50G2","67G2","67G2T","50G3","67G3","67G3T","*","*","09D3"
"51P","51PT","51PR","Z1X","59VA","MAB3","MBC3","MCA3","0B3C"
"MAG3","MBG3","MCG3","27S","59S","*","59VP","59VS","0A6D"
"SF","25A1","25A2","RCSF","OPTMN","RSTMN","*","*","0A70"
"79RS","79CY","79LO","SH0","SH1","SH2","SH3","SH4","0AAD"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","MPP1","MABC1","MPP2","MABC2","08EE"
"50Q1","67Q1","67Q1T","50Q2","67Q2","67Q2T","*","*","0A09"
"50Q3","67Q3","67Q3T","*","*","*","*","*","0771"
"51Q","51QT","51QR","*","*","*","*","*","071D"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"27A","27B","27C","59A","59B","59C","3P27","3P59","096E"
"27AB","27BC","27CA","59AB","59BC","59CA","*","*","0971"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","MPP3","MABC3","*","*","06E2"
"*","*","*","*","*","*","*","*","04D0"
"RMB8A","RMB7A","RMB6A","RMB5A","RMB4A","RMB3A","RMB2A","RMB1A","0E34"
"TMB8A","TMB7A","TMB6A","TMB5A","TMB4A","TMB3A","TMB2A","TMB1A","0E44"
"RMB8B","RMB7B","RMB6B","RMB5B","RMB4B","RMB3B","RMB2B","RMB1B","0E3C"
"TMB8B","TMB7B","TMB6B","TMB5B","TMB4B","TMB3B","TMB2B","TMB1B","0E4C"
"LBOKB","CBADB","RBADB","ROKB","LBOKA","CBADA","RBADA","ROKA","0DFA"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"<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","*","*","*","*","0639"<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-311B 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-311B 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-311B 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 data for an external computer to extract data from other compressed ASCII commands. To obtain the configuration message for the compressed ASCII commands available in an SEL relay, type:

CAS <CR>

The relay sends:

<STX>"CAS",n,"yyyy"<CR>
"COMMAND 1",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-311B

Display the SEL-311B 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>
"23H","IA","IB","IC","IP","VA","VB","VC","VS","MOF","+5V_PS","+5V_REG",
"-5V_REG","+12V_PS","-12V_PS","+15V_PS","-15V_PS","TEMP","RAM","ROM","A/D",
"CR_RAM","EEPROM","IO_BRD","271F"<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","1789"<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","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>
"14H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IP","IG","3I2","1B59"<CR>
"1D","F","I","I","I","6S","F","I","22S","I","I","I","I","I","I","0BAB"<CR>
"13H","IA","IB","IC","IP","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","V1MEM","VDC",
"TRIG","***Names of elements in the relay word separated by spaces***","YYYY"<CR>
"60D","I","I","I","I","I","F","F","F","F","I","F","2S","104S","0B4B"<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>
"14H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IP","IG","3I2","1B59"<CR>
"1D","F","I","I","I","6S","F","I","22S","I","I","I","I","I","I","0BAB"<CR>
"13H","IA","IB","IC","IP","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","V1MEM","VDC",
"TRIG","***Names of elements in the relay word separated by spaces***","YYYY"<CR>
"240D","I","I","I","I","I","F","F","F","F","I","F","2S","104S","0B7B"<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>
"14H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"SHOT","TARGETS","IA","IB","IC","IP","IG","3I2","1B59"<CR>
"1D","F","I","I","I","6S","F","I","22S","I","I","I","I","I","I","0BAB"<CR>
"13H","IA","IB","IC","IP","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)","V1MEM","VDC",
"TRIG","***Names of elements in the relay word separated by spaces***","YYYY"<CR>
"256D","I","I","I","I","I","F","F","F","F","I","F","2S","104S","0B82"<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>
"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 LBOKB CBADB RBADB ROKB LBOKA CBADA RBADA ROKA","3D5A"<CR>
"2D","1S","10S","02FE"<CR>
<ETX>

"YYYY" 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-311B

Display status data in compressed ASCII format by sending:

CST <CR>

The relay sends:

<STX>"FID","yyyy"<CR>
"***Relay FID string***","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"IA","IB","IC","IP","VA","VB","VC","VS","MOF","+5V_PS","+5V_REG",
"-5V_REG","+12V_PS","-12V_PS","+15V_PS","-15V_PS",
"TEMP","RAM","ROM","A/D","CR_RAM","EEPROM","IO_BRD","yyyy"<CR>
,"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",”xxxx”,"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-311B

Display history data in compressed ASCII format by sending:

CHI <CR>

The relay sends:

<STX>"FID","yyyy"<CR>
"***Relay FID string***","yyyy"<CR>
"REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC",
"EVENT","LOCATION","CURR","FREQ","GROUP","SHOT","TARGETS","EVE_ID",
"yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,xxxx,xxxx,xxxx,xxxx,
"xxxx","xxxx","yyyy"<CR><ETX>

(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-311B

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 from 1 to 44 if LER = 15, 1 to 23 if LER = 30, 1 to 11 if LER = 60, or 1 to 4 if LER = 180; defaults to 1 if not specified.

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 Ly 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.

<STX>"FID","yyyy"<CR>
"***Relay FID string***","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT",
"LOCATION","SHOT","TARGETS","IA","IB","IC","IP","IG","3I2","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,xxxx,"xxxx",xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
"yyyy"<CR>
"IA","IB","IC","IP","IG","VAkV","VBkV","VCkV","VSkV","V1MEM","VDC","TRIG",
"***Names of elements in the relay word separated by spaces*** ","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,z,"***HEX-ASCII Relay Word***","yyyy"<CR>
"***Analog and digital data repeated for each row of event report***"
"SETTINGS","yyyy"<CR>
"***Relay group, global, and logic settings as displayed with the showset command (surrounded by quotes)***","yyyy"<CR><ETX>

where: "xxxx" are the data values corresponding to the line labels.
"yyyy" is the 4-byte hex ASCII representation of the checksum.
"FREQ" is the power system frequency at the trigger instant.
"SAM/CYC_A" is the number of analog data samples per cycle (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-311B.

"EN TRP TIME TARDT SOTF RCRS RCCY RCLO A B C G ZONE1 ZONE2 ZONE3 51 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 * * * * Z3T * 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 * MPP1 MABC1 MPP2 MABC2 50Q1 67Q1 67Q1T 50Q2 67Q2 67Q2T * * 50Q3 67Q3 67Q3T * * * * * 51Q 51QT 51QR * 27A 27B 27C 59A 59B 59C 3P27 3P59 27AB 27BC 27CA 59AB 59BC 59CA * * * * * * * * * * * * * * MPP3 MABC3 * * * * * * * * * * RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A TMB8A TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A RMB8B RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B TMB7B TMB6B TMB5B TMB4B TMB3B TMB2B TMB1B LBOKB CBADB RBADB ROKB LBOKA CBADA RBADA ROKA ","yyyy"

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:

100000049249000000000000000000000000000002000000000000000000000000240000800000
C0000100000000000000000000000000

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).

CSU Command—SEL-311B

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>
"FID=SEL-311B-R100-V0-Z001001-D20000818","08F7"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"<CR>
11,10,1999,10,39,4,614,"046F"<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>
"TRIG",$$$$$$$,10,39,4,614,15, , 59.99,1, , , , , ,Open,"0AE9"<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>
199,0.06,198,-120.53,201,119.91,1,105.04,4,105.04,14,-44.96,131.490,0.00,131.540,-120.06,
131.640,119.95,"13EB"<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>
200,0.31,199,-120.24,200,120.16,0,-29.96,2,105.04,0,-0.96,131.470,0.04,131.540,-120.02,
131.630,119.98,"1368"<CR>
"TRIG","RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A TMB8A
TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A RMB8B RMB7B RMB6B
RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B TMB7B TMB6B TMB5B TMB4B
TMB3B TMB2B TMB1B LBOKB CBADB RBADB ROKB LBOKA CBADA RBADA
ROKA","3C70"<CR>
">","0000000006","0304"<CR>
"*","0000000006","02F0"
```

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 50Q3 and 67Q1 through 67Q3 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 67Q3T 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 3.17 for more information on negative-sequence instantaneous and definite-time overcurrent elements.

SETTING NEGATIVE-SEQUENCE TIME-OVERCURRENT ELEMENTS

Negative-sequence time-overcurrent element 51QT should not be set to trip directly when it is set with a low time-dial setting 51QTD, **that results in curve times below 3 cycles** (see curves in 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 3.20 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)

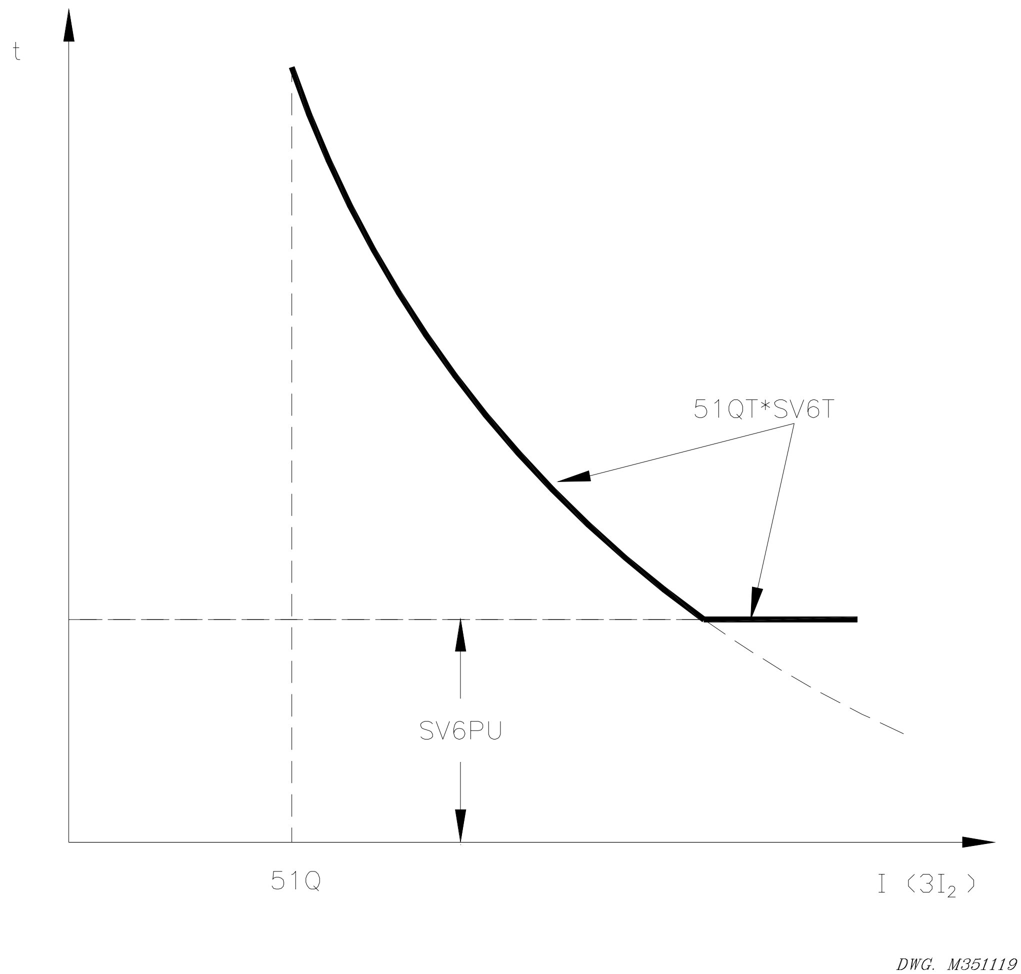

Figure F.1: Minimum Response Time Added to a Negative-Sequence Time-Overcurrent Element 51QT

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 Settings Sheets 11 through 15 in the back of ***Section 9***). See ***SHO command (Show/View Settings)*** in ***Section 10: Serial Port Communications and Commands*** for a list of the factory settings included in a standard shipment of a SEL-311B 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 3.18 in ***Section 3: Distance, Overcurrent, Voltage and Synchronism Check***. Read the text that accompanies Figure 3.18 (Table 3.4 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-311B 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 3.18)
- 51G — Maximum residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see Figure 3.19)
- 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.

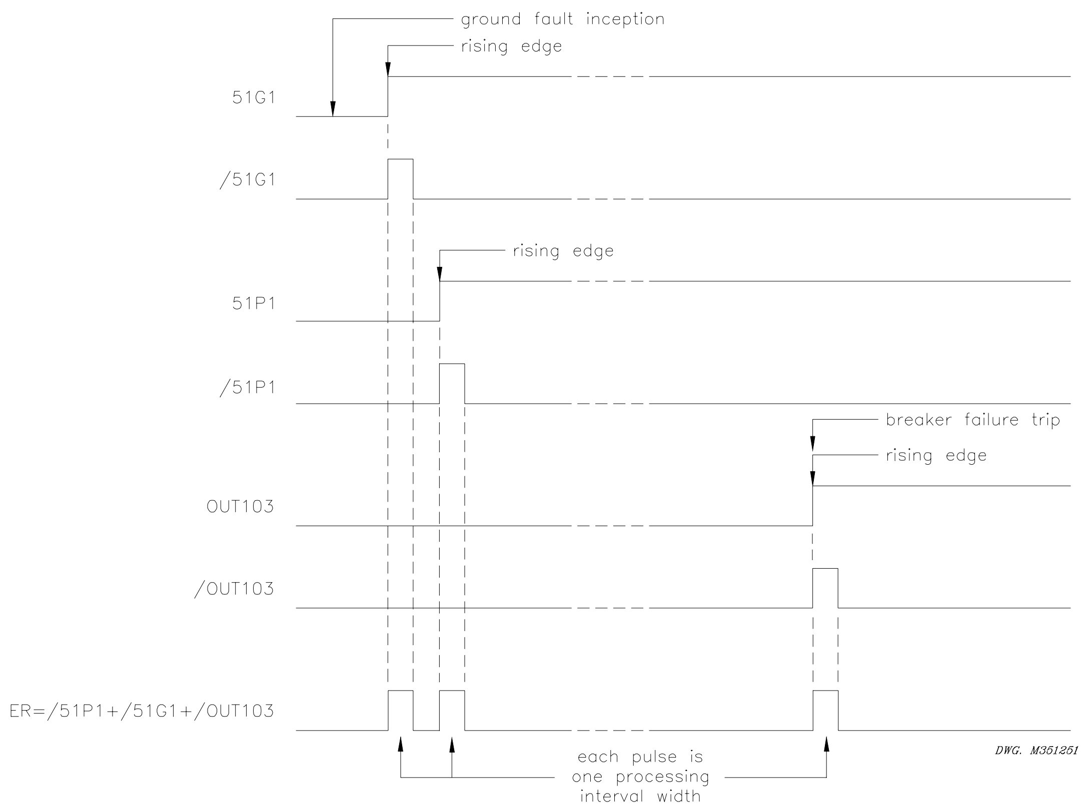

Figure G.1: Result of Rising Edge Operators on Individual Elements in Setting ER

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 overcurrent element:

ER = ... + \50G1

This allows recovery from an overcurrent condition to be observed. Figure G.2 demonstrates the action of the falling edge operator \ on the overcurrent element 50G1 in setting ER.

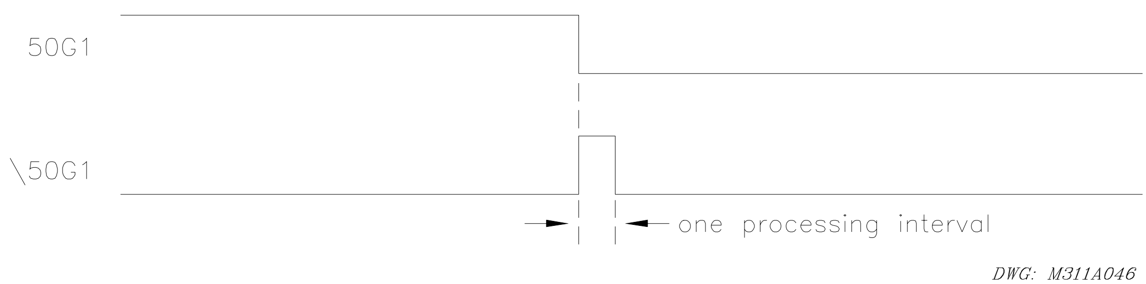

Figure G.2: Result of Falling Edge Operator on a Deasserting Out-of-Step Blocking Element

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., DTT = 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: 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 Settings Sheets 11 through 15 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-311B Relay, these are all set directly to logical 1. See these factory settings in ***SHO Command (Show/View Settings)*** in ***Section 10: 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 3.19 in ***Section 3: Distance, Overcurrent, Voltage, and Synchronism Check 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-311B 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 elements and logic (and corresponding SELOGIC control equation settings and resultant Relay Word bits) are processed in a predetermined order. They are processed every quarter-cycle (1/4-cycle), and the Relay Word bit states (logical 1 or logical 0) are updated with each quarter-cycle pass. Thus, the relay-processing interval is 1/4-cycle. Once a Relay Word bit is asserted, it retains the state (logical 1 or logical 0) until it is updated again in the next processing interval. Logical outputs of SELOGIC control equations may be delayed by 1/4-cycle due to relay element processing order.

APPENDIX H: DISTRIBUTED NETWORK PROTOCOL (DNP) 3.00

OVERVIEW

The SEL-311 family of relays are available with the option to support Distributed Network Protocol (DNP) 3.00 L2 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-311B 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-311B 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-311B 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-311B 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-311B 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-311B decides to transmit on the DNP link, it has to wait if the physical connection is in use. The SEL-311B 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-311B 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-311B 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.
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:

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)	
Vendor Name: **Schweitzer Engineering Laboratories, Inc.**	
Device Name: **SEL-311B**	
Highest DNP Level Supported: For Requests **Level 2** For Responses **Level 2**	Device Function: ☐ Master ☑ Slave
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>	

Maximum Data Link Frame Size (octets): Transmitted 292 Received (must be 292)	Maximum Application Fragment Size (octets): Transmitted 2048 (if >2048, must be configurable) Received 2048 (must be >249)
Maximum Data Link Re-tries: ☐ None ☐ Fixed at ____ ☑ Configurable, range 0 to 15	Maximum Application Layer Re-tries: ☑ 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.

<table>
<tr><th colspan="2">FILL OUT THE FOLLOWING ITEM FOR MASTER DEVICES ONLY:</th></tr>
<tr><td colspan="2">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)</td></tr>
<tr><th colspan="2">FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY</th></tr>
<tr><td>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)</td><td>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)</td></tr>
<tr><td>Sends Unsolicited Responses:
☐ Never
☑ Configurable (attach explanation)
☐ Only certain objects
☐ Sometimes (attach explanation)
☑ ENABLE/DISABLE UNSOLICITED
Function codes supported</td><td>Sends Static Data in Unsolicited Responses:
☑ Never
☐ When Device Restarts
☐ When Status Flags Change
No other options are permitted.</td></tr>
<tr><td>Default Counter Object/Variation:
☐ No Counters Reported
☐ Configurable (attach explanation)
☑ Default object 20
☐ Default variation 6
☐ Point-by-point list attached</td><td>Counters Roll Over at:
☐ No Counters Reported
☐ Configurable (attach explanation)
☑ 16 Bits
☐ 32 Bits
☐ Other Value ______________
☐ Point-by-point list attached</td></tr>
<tr><td colspan="2">Sends Multi-Fragment Responses: ☐ Yes ☑ No</td></tr>
</table>

In all cases within the device profile that an item is configurable, it is controlled by SEL-311B settings.

Object Table

The supported object, function, and qualifier code combinations are given by the following object table.

Table H.2: SEL-311B 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		
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				

Object			Request (supported)		Response (may generate)	
Obj	*default Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)
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				
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				

Object			Request (supported)		Response (may generate)	
Obj	*default Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)
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				
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				

Object			Request (supported)		Response (may generate)	
Obj	*default Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)
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-311B has a slightly different data map. The following is the default object map supported by the SEL-311B wye-connected PTs (FID = SEL-311B-Rxxx-VM-Dxxxxxxxx).

Table H.3: SEL-311B-Wye DNP Data Map

DNP Object Type	Index	Description
01,02	000–499	Relay Word, where 51 is 0 and LBOKB is 415.
01,02	500–999	Relay Word from the SER, encoded same as inputs 000–499 with 500 added.
01,02	1000–1015	Relay front-panel targets, where 1015 is A, 1008 is 51, 1007 is EN and 1000 is RCL0.
01,02	1016–1019	Power factor leading for A-, B-, C-, and 3-phase.
01,02	1020	Relay Disabled.
01,02	1021	Relay diagnostic failure.
01,02	1022	Relay diagnostic warning.
01,02	1023	New relay event available.
01,02	1024	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.

DNP Object Type	Index	Description
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.
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	IG 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.

DNP Object Type	Index	Description
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.
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).
40,41	00	Active settings group.

Binary inputs (objects 1 and 2) are supported as defined by the previous table. Binary inputs 0–499 and 1000–1023 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 500–999 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 0–499 group. Only points that are actually in the SER list (**SET R**) will generate events in the 500–999 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 and 16–21 (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 (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) 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 in the following table.

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 23. 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 DTT, etc. The SEL-311B 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-311B.

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-311B talking to another SEL-311B 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-311B. 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-311B, 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-311B will delay a bit by 1/4 cycle, because the SEL-311B 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 loop back mode has been enabled. If loop back is not enabled, the node deasserts ROK*x* and transmits the attention message with its TX_ID included. If loop back 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.

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 COMM 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-311B
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 311B 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: UNSOLICITED FAST SER PROTOCOL

INTRODUCTION

This appendix describes special binary Sequential Events Recorder (Fast SER) messages that are not included in ***Section 10: Serial Port Communications and Commands*** of the instruction manual. Devices with embedded processing capability can use these messages to enable and accept unsolicited Fast SER messages from the SEL-311B Relay.

SEL relays and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible to people using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information, and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data. To exploit this feature, the device connected to the other end of the link requires software that uses the separate data streams. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

MAKE SEQUENTIAL EVENTS RECORDER (SER) SETTINGS WITH CARE

The relay triggers a row in the Sequential Events Recorder (SER) event report for any change of state in any one of the elements listed in the SER1, SER2, or SER3 trigger settings. Nonvolatile memory is used to store the latest 512 rows of the SER event report so they can be retained during power loss. The nonvolatile memory is rated for a finite number of “writes.” Exceeding the limit can result in an EEPROM self-test failure. <u>An average of four state changes per minute can be made for a 25-year relay service life</u>.

RECOMMENDED MESSAGE USAGE

Use the following sequence of commands to enable unsolicited Fast SER messaging in the SEL-311B Relay:

1. On initial connection, send the SNS command to retrieve and store the ASCII names for the digital I/O points assigned to trigger SER records. The order of the ASCII names matches the point indices in the unsolicited Fast SER messages. Send the “Enable Unsolicited Data Transfer” message to enable the SEL-311B Relay to transmit unsolicited Fast SER messages.
2. When SER records are triggered in the SEL-311B, the relay responds with an unsolicited Fast SER message. If this message has a valid checksum, it must be acknowledged by sending an acknowledge message with the same response number as contained in the original message. The relay will wait approximately 100 ms to 500 ms to receive an acknowledge message, at which time the relay will resend the same unsolicited Fast SER message with the same response number.

3. Upon receiving an acknowledge message with a matching response number, the relay increments the response number, and continues to send and seek acknowledgment for Fast SER messages, if additional SER records are available. When the response number reaches three it wraps around to zero on the next increment.

Functions and Function Codes

In the messages shown below, all numbers are in hexadecimal unless otherwise noted.

01—Function Code: Enable Unsolicited Data Transfer, Sent From Master to Relay

Upon power-up, the SEL-311B Relay disables it own unsolicited transmissions. This function enables the SEL-311B Relay to begin sending unsolicited data to the device which sent the enable message, if the SEL-311B has such data to transfer. The message format for function code 01 is shown below.

Data	Description
A546	Message header
12	Message length in bytes (18 decimal)
0000000000	Five bytes reserved for future use as a routing address
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
01	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 00, 01...).
18	Function to enable (18—unsolicited Fast SER messages)
0000	Reserved for future use as function code data
nn	Maximum number of SER records per message, 01–20 hex
cccc	Two byte CRC-16 check code for message

The SEL-311B Relay verifies the message by checking the header, length, function code, and enabled function code against the expected values. It also checks the entire message against the CRC-16 field. If any of the checks fail, except the function code or the function to enable, the message is ignored.

If an acknowledge is requested as indicated by the least significant bit of the status byte, the relay transmits an acknowledge message with the same response number received in the enable message.

The “nn” field is used to set the maximum number of SER records per message. The relay checks for SER records approximately every 500 ms. If there are new records available, the relay immediately creates a new Fast SER message and transmits it. If there are more than “nn” new records available, or if the first and last record are separated by more than 16 seconds, the relay will break the transmission into multiple messages so that no message contains more than “nn” records, and the first and last record of each message are separated by no more than 16 seconds.

If the function to enable is not 18 or the function code is not recognized, the relay responds with an acknowledge message containing a response code 01 (function code unrecognized), and no functions are enabled. If the SER triggers are disabled (SER1, SER2, and SER3 are all set to NA), the Fast SER messages are still enabled, but the only SER records generated are due to settings changes, and power being applied to the relay. If the SER1, SER2, or SER3 settings are subsequently changed to any non-NA value and SER entries are triggered, Fast SER messages will be generated with the new SER records.

02—Function Code: Disable Unsolicited Data Transfer, Sent From Master to Relay

This function disables the SEL-311B Relay from transferring Fast SER data. The message format for function code 02 is shown below.

Data	Description
A546	Message header
10	Message length (16 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
02	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
18	Function to disable (18 = Unsolicited Fast SER)
00	Reserved for future use as function code data
cccc	Two byte CRC-16 check code for message

The SEL-311B Relay verifies the message by checking the header, length, function code, and disabled function code against the expected values, and checks the entire message against the CRC-16 field. If any of the checks fail, except the function code or the function to disable, the message is ignored.

If an acknowledge is requested as indicated by the least significant bit of the status byte, the relay transmits an acknowledge message with the same response number received in the enable message.

If the function to disable is not 18 or the function code is not recognized, the relay responds with an acknowledge message containing the response code 01 (function code unrecognized) and no functions are disabled.

18—Function: Unsolicited Fast SER Response, Sent From Relay to Master

The function 18 is used for the transmission of unsolicited Sequential Events Recorder (Fast SER) data from the SEL-311B Relay. This function code is also passed as data in the “Enable Unsolicited Data Transfer” and the “Disable Unsolicited Data Transfer” messages to indicate which type of Fast SER data should be enabled or disabled. The message format for function code 18 is shown below.

Data	Description
A546	Message header
ZZ	Message length (Up to 34 + 4 · nn decimal, where nn is the maximum number of SER records allowed per message as indicated in the "Enable Unsolicited Data Transfer" message.)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status Byte (01 = need acknowledgment; 03 = settings changed and need acknowledgment. If YY=03, the master should re-read the SNS data because the element index list may have changed.)
18	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
00000000	Four bytes reserved for future use as a return routing address.
dddd	Two-byte day of year (1–366)
yyyy	Two-byte, four-digit year (e.g., 1999 or 07CF hex)
mmmmmmmm	Four-byte time of day in milliseconds since midnight
XX	1st element index (match with the response to the SNS command; 00 for 1st element, 01 for second element, and so on)
uuuuuu	Three-byte time tag offset of 1st element in microseconds since time indicated in the time of day field.
XX	2nd element index
uuuuuu	Three-byte time tag offset of 2nd element in microseconds since time indicated in the time of day field.
•	
•	
•	
xx	last element index
uuuuuu	Three-byte time tag offset of last element in microseconds since time indicated in the time of day field.
FFFFFFFE	Four-byte end-of-records flag
ssssssss	Packed four-byte element status for up to 32 elements (LSB for the 1st element)
cccc	Two-byte CRC-16 checkcode for message

If the relay determines that SER records have been lost, it sends a message with the following format:

Data	Description
A546	Message header
22	Message length (34 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status Byte (01 = need acknowledgement; 03 = settings changed and need acknowledgement)
18	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 00, 01, ...)
00000000	Four bytes reserved for future use as a return routing address.
dddd	Two-byte day of year (1–366) of overflow message generation
yyyy	Two-byte, four-digit year (e.g., 1999 or 07CF hex) of overflow message generation.
mmmmmmmm	Four-byte time of day in milliseconds since midnight
FFFFFFFE	Four-byte end-of-records flag
00000000	Element status (unused)
cccc	Two byte CRC-16 checkcode for message

Acknowledge Message Sent from Master to Relay, and from Relay to Master

The acknowledge message is constructed and transmitted for every received message which contains a status byte with the LSB set (except another acknowledge message), and which passes all other checks, including the CRC. The acknowledge message format is shown below.

Data	Description
A546	Message header
0E	Message length (14 decimal)
0000000000	Five bytes reserved for future use as a routing address.
00	Status byte (always 00)
XX	Function code, echo of acknowledged function code with MSB set.
RR	Response code (see below)
XX	Response number (XX = 00, 01, 02, 03, 00, 01, ...) must match response number from message being acknowledged.)
cccc	Two byte CRC-16 checkcode for message

The SEL-311B supports the following response codes:

RR	Response
00	Success.
01	Function code not recognized.

Examples

1. Successful acknowledge for "Enable Unsolicited Data Transfer" message from a relay with at least one of SER1, SER2, or SER3 not set to NA:

   A5 46 0E 00 00 00 00 00 00 81 00 XX cc cc

   (XX is as same as the Response Number in the "Enable Unsolicited Data Transfer" message to which it responds)

2. Unsuccessful acknowledge for "Enable Unsolicited Data Transfer" message from a relay with all of SER1, SER2, and SER3 set to NA:

   A5 46 0E 00 00 00 00 00 00 81 02 XX cc cc

   (XX is as same as the response number in the "Enable Unsolicited Data Transfer" message to which it responds.)

3. Disable Unsolicited Data Transfer message, acknowledge requested:

   A5 46 10 00 00 00 00 00 01 02 C0 XX 18 00 cc cc

   (XX = 0, 1, 2, 3)

4. Successful acknowledge from the relay for the "Disable Unsolicited Data Transfer" message:

   A5 46 0E 00 00 00 00 00 00 82 00 XX cc cc

   (XX is as same as the response number in the "Disable Unsolicited Data Transfer" message to which it responds.)

5. Successful acknowledge message from the master for a Fast SER message:

   A5 46 0E 00 00 00 00 00 00 98 00 XX cccc

   (XX is as same as the response number in the Fast SER message to which it responds.)

Notes:

Once the relay receives an acknowledge with response code 00 from the master, it will clear the settings changed bit (bit 1) in its status byte, if that bit is asserted, and it will clear the settings changed bit in Fast Meter, if that bit is asserted.

An element index of FE indicates that the SER record is due to power up. An element index of FF indicates that the SER record is due to setting change. An element index of FD indicates that the element identified in this SER record is no longer in the SER trigger settings.

When the relay sends an SER message packet, it will put a sequential number (0, 1, 2, 3, 0, 1, ...) into the response number. If the relay does not receive an acknowledge from the master before approximately 500 mS, the relay will resend the same message packet with the same response number until it receives an acknowledge message with that response number. For the next SER message, the relay will increment the response number (it will wrap around to zero from three).

A single SER message packet from the relay can have a maximum number 32 records and the data may span a time period of no more than 16 seconds. The master may limit the number records in a packet with the third byte of function code data in the “Enable Unsolicited Data Transfer” message (function code 01). The relay may generate a Fast SER packet that with less than the requested number of records, if the record time stamps span more than 16 seconds.

The relay always requests acknowledgment in Fast SER messages (LSB of the status byte is set).

Fast SER messages can be enabled on multiple ports simultaneously.

SEL-311B Relay Command Summary

Access Level 0 Command	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.
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).
COM *p* L	Show a long format communications summary report for all events on MIRRORED BITS™ Channel *p*.
COM *p n*	Show a communications summary for latest *n* events on MIRRORED BITS Channel *p*.
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS Channel *p*.
COM *p d1*	Show a communications summary report for events occurring on date *d1* on MIRRORED BITS Channel *p*.
COM *p d1 d2*	Show a communications summary report for events occurring between dates *d1* and *d2* on MIRRORED BITS Channel *p*. Entry of dates is dependent on the Date Format setting DATE_F (=MDY or YMD).
COM C *p*	Clears the communications summary report for Channel *p*.
DAT	Show date.
DAT m/d/y	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT y/m/d	Enter date in this manner if Date Format setting DATE_F = YMD.
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 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.
INI	Displays input/output contact information.
INI T	Displays I/O contact information and I/O board type.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET *k*	Display instantaneous metering data. 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 51, display row n. If *n* is an element name (e.g., 50P1) 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) 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*.
LOO	Set MIRRORED BITS port to loopback.
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.
STA C	Resets self-test warnings/failures and reboots relay.
VER	Displays version and configuration information.