

SEL-311A

PROTECTION AND AUTOMATION SYSTEM

INSTRUCTION MANUAL

SCHWEITZER ENGINEERING LABORATORIES
2350 NE HOPKINS COURT
PULLMAN, WA USA 99163-5603
TEL: (509) 332-1890 FAX: (509) 332-7990



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.



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.



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.



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



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.



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.



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

The software (firmware), schematic drawings, relay commands, and relay messages are copyright protected by the United States Copyright Law and International Treaty provisions. All rights are reserved.

You may not copy, alter, disassemble, or reverse-engineer the software. You may not provide the software to any third party.

All brand or product names appearing in this document are the trademark or registered trademark of their respective holders.

Schweitzer Engineering Laboratories, SELlogic, Connectorized, Job Done, SEL-PROFILE, acSELERATOR, and **SEL** are registered trademarks of Schweitzer Engineering Laboratories, Inc.

The English language manual is the only approved SEL manual.

Copyright © SEL 2000, 2001 (All rights reserved) Printed in USA.

This product is covered by U.S. Patent Numbers: 5,041,737; 5,208,545; 5,317,472; 5,325,061; 5,349,490; 5,365,396; 5,367,426; 5,479,315; 5,515,227; 5,652,688; 5,694,281; 5,703,745; 5,790,418; 5,793,750; 5,883,578; 6,011,480; 6,028,754; and U.S. Patent(s) Pending, and Foreign Patent(s) Issued and Pending.

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

PM311A-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
<p>The <i>Manual Change Information</i> section has been created to begin a record of revisions to this manual. All changes will be recorded in this Summary of Revisions table.</p>	
20011205	<p>Reissued entire manual to reflect the following changes:</p> <p>Updated Section 2 and Section 3 figure references throughout the manual.</p> <p>Section 1:</p> <ul style="list-style-type: none"> – Added 220 V control input voltage specification to <i>General Specifications</i>. – Updated Terminal Connections information in <i>General Specifications</i>. <p>Section 2:</p> <ul style="list-style-type: none"> – Added Connectorized[®] rear-panel drawings. <p>Section 3:</p> <ul style="list-style-type: none"> – Added <i>Ground and Phase Distance Speed Curves</i> drawing. – Added <i>Distance Element Operating Time Curves at Nominal Frequency</i> section. <p>Section 7:</p> <ul style="list-style-type: none"> – Updated <i>Input Debounce Timers</i> section. – Added <i>Displaying Time-Overcurrent Elements on the Rotating Default Display</i> and following sections. – Added descriptions of the ELAT, ESV, and EDP settings. <p>Section 8:</p> <ul style="list-style-type: none"> – Modified breaker reset options to include the internal and external trips and currents in the <i>Via Serial Port</i> subsection in the <i>View or Reset Breaker Monitor Information</i> section. <p>Section 9:</p> <ul style="list-style-type: none"> – Updated <i>Event Report Parameters</i> section in the Settings Sheets. – Updated <i>Optoisolated Input Timers</i> section in the Settings Sheets. – Added ELAT and EDP settings in the <i>Other Enable Settings</i> section in the Settings Sheets.

Revision Date	Summary of Revisions
	<p>Section 10:</p> <ul style="list-style-type: none"> – Added STA C command information to <i>Access Level 2 Commands</i> in the Command Summary. <p>Section 12:</p> <ul style="list-style-type: none"> – Added 180-cycle event report information. Also updated the number of event reports that are maintained. – Updated <i>Output, Input, and Protection, and Control Element Event Report Columns</i> table. <p>Appendix A:</p> <ul style="list-style-type: none"> – Updated firmware. <p>Appendix D:</p> <ul style="list-style-type: none"> – Updated <i>A5C0 Relay Definition Block</i> section. – Updated information in <i>ID Message</i> and <i>DNA Message</i> sections. <p>Appendix G:</p> <ul style="list-style-type: none"> – Updated <i>SEL-311A-Wye DNP Data Map</i> table. <p>Appendix I:</p> <ul style="list-style-type: none"> – Added <i>Appendix I: Unsolicited Fast SER Protocol</i>.
20010625	<p>Appendix A:</p> <ul style="list-style-type: none"> – 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	<p>Appendix A:</p> <ul style="list-style-type: none"> – Improved overflow supervision for distance elements.
20010124	<p>Reissued entire manual to reflect the following changes:</p> <ul style="list-style-type: none"> – Added cautions, warnings, and dangers in English and French to the reverse of the title page. <p>Section 1:</p> <ul style="list-style-type: none"> – Updated Relay Specifications format. – Added information on Tightening Torque in <i>General Specifications</i>. – Updated Power Supply information to include medium range Power Supply Specification. – Updated Output Contacts information. <p>Section 2:</p> <ul style="list-style-type: none"> – Added Product Safety Compliance paragraph. – Added Danger statement to <i>Accessing the Relay Circuit Boards</i> subsection. – Added Caution statement to the <i>Clock Battery</i> subsection.

Revision Date	Summary of Revisions
	<p>Section 8:</p> <ul style="list-style-type: none"> – Removed reference to NDEMP in the <i>Demand Meter Settings</i> subsection. <p>Section 9 (Settings Sheets):</p> <ul style="list-style-type: none"> – Updated formatting. <p>Section 10:</p> <ul style="list-style-type: none"> – Added Warning statement to change default passwords to private passwords at relay installation. <p>Appendix G:</p> <ul style="list-style-type: none"> – Updated first row of Table G.3. – Correctly identify binary output point 23 in the <i>Relay Summary Event Data</i> subsection.
20000911	New Manual Release.

SEL-311A INSTRUCTION MANUAL

TABLE OF CONTENTS

SECTION 1:	INTRODUCTION AND SPECIFICATIONS
SECTION 2:	INSTALLATION
SECTION 3:	DISTANCE AND OVERCURRENT ELEMENTS
SECTION 4:	LOSS-OF-POTENTIAL, CCVT TRANSIENT DETECTION, LOAD-ENCROACHMENT, AND DIRECTIONAL ELEMENT LOGIC
SECTION 5:	TRIP AND TARGET LOGIC
SECTION 6:	CLOSE LOGIC
SECTION 7:	INPUTS, OUTPUTS, TIMERS, AND OTHER CONTROL LOGIC
SECTION 8:	BREAKER MONITOR AND METERING FUNCTIONS
SECTION 9:	SETTING THE RELAY
SECTION 10:	SERIAL PORT COMMUNICATIONS AND COMMANDS
SECTION 11:	FRONT-PANEL INTERFACE
SECTION 12:	STANDARD EVENT REPORTS AND SER
SECTION 13:	TESTING AND TROUBLESHOOTING
SECTION 14:	APPLICATION SETTINGS FOR SEL-2PG10 RELAYS
SECTION 15:	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 SELogic[®] Control Equations
	Appendix G: Distributed Network Protocol (DNP) 3.00
	Appendix H: MIRRORED BITS[™] Communications
	Appendix I: Unsolicited Fast SER Protocol
	SEL-311A RELAY COMMAND SUMMARY

TABLE OF CONTENTS

SECTION 1: INTRODUCTION AND SPECIFICATIONS	1-1
SEL-311A Relay Models	1-1
Instruction Manual Sections Overview	1-1
Applications	1-4
AC/DC Connections	1-4
Communications Connections	1-6
Relay Specifications	1-8
General Specifications	1-8
Processing Specifications	1-10
Relay Element Settings Ranges and Accuracies	1-11

FIGURES

Figure 1.1: SEL-311A Relay Transmission Line Protection with MIRRORING™	1-4
Figure 1.2: SEL-311A Relay Inputs, Outputs, and Communications	1-5
Figure 1.3: SEL-311A Relay Communications Connections Examples	1-6
Figure 1.4: SEL-311A Relay Communications Connections Examples (Continued)	1-7

SECTION 1: INTRODUCTION AND SPECIFICATIONS

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

- SEL-311A Relay Models
- Instruction Manual Sections
- Applications
- AC/DC Connections
- Communications Connections
- General Specifications

SEL-311A RELAY MODELS

This instruction manual covers SEL-311A Relay models.

A vertical SEL-311A Relay is available. The vertical relays use the same rear panels as the horizontal models. See 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-311A Relay, application connections, and the operation of circuit board jumpers. Figure 2.2 through Figure 2.4 show the SEL-311A Relay front and rear panels.

Section 3: *Distance and Overcurrent Elements* describes the operation of:

- Phase and ground distance elements (phase mho and ground mho)
- Instantaneous/definite-time overcurrent elements (phase and residual ground)
- Time-overcurrent elements (phase and residual ground)

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 Logic describes the close logic operation for:

- 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-311A 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 = 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-311A 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-2PG10 Relays

- Conversion guide for the SEL-2PG10 relays
- Settings Sheets for the 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 SELOGIC[®] Control Equations**
- **Appendix G: Distributed Network Protocol (DNP) 3.00**
- **Appendix H: MIRRORING BITS[™]**
- **Appendix I: SEL-311A Unsolicited SER Protocol**

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

APPLICATIONS

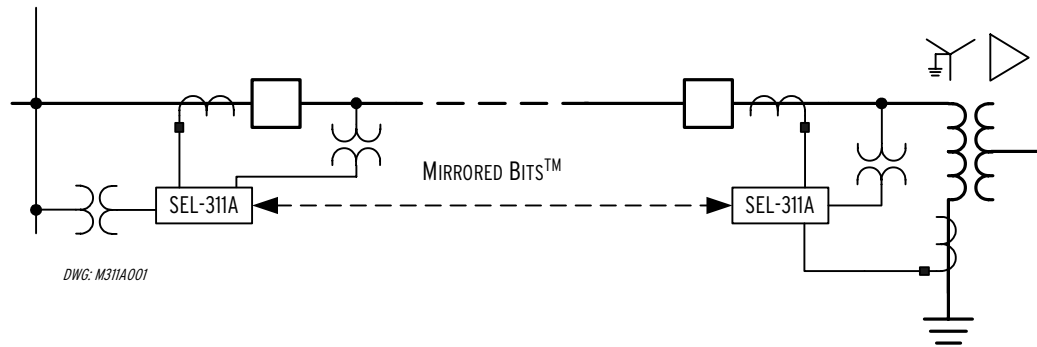


Figure 1.1: SEL-311A Relay Transmission Line Protection with MIRRORED BITS

AC/DC CONNECTIONS

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

Dual Terminal Labels:

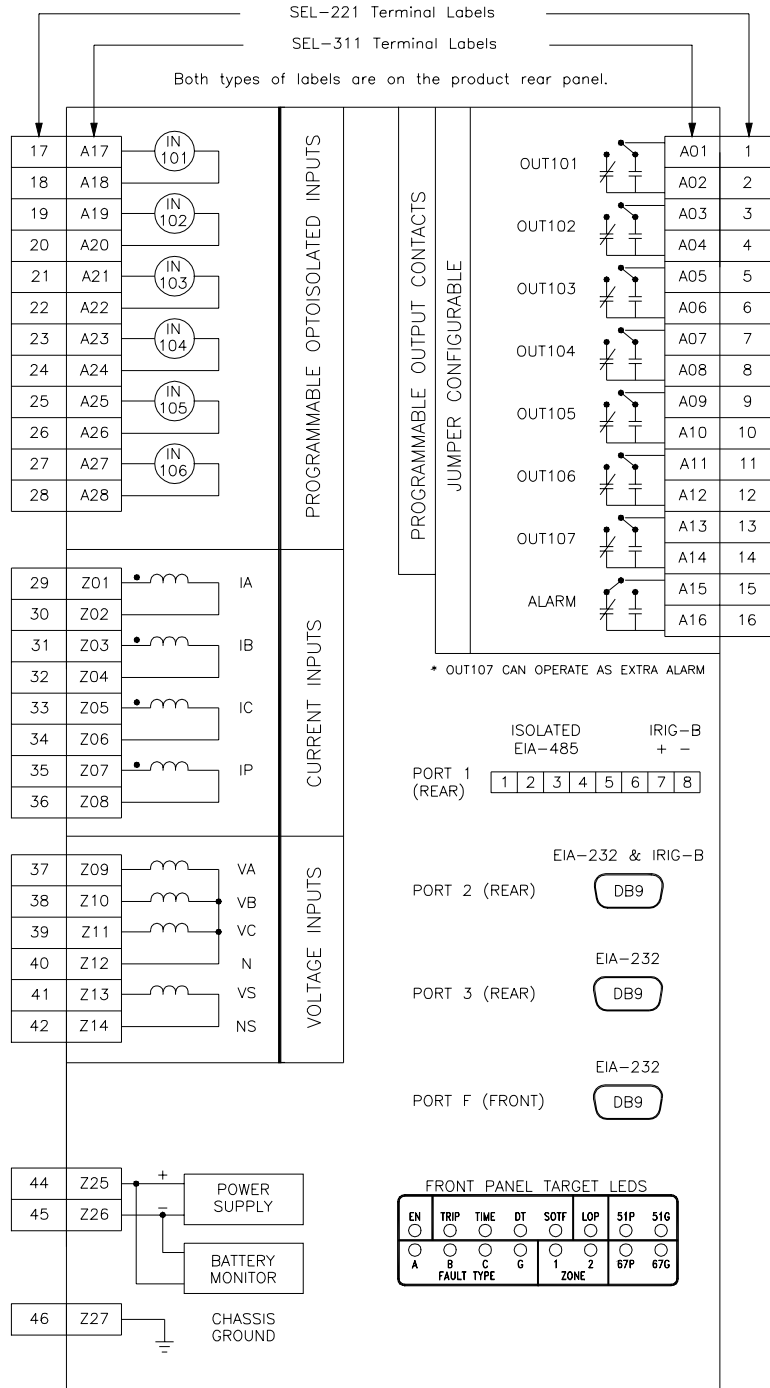
For installation in systems with drawings designed for SEL-221 Relays, use the numeric terminal labels.

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

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

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

Note: Terminals 41 and 42 are **not** used in the SEL-311A.



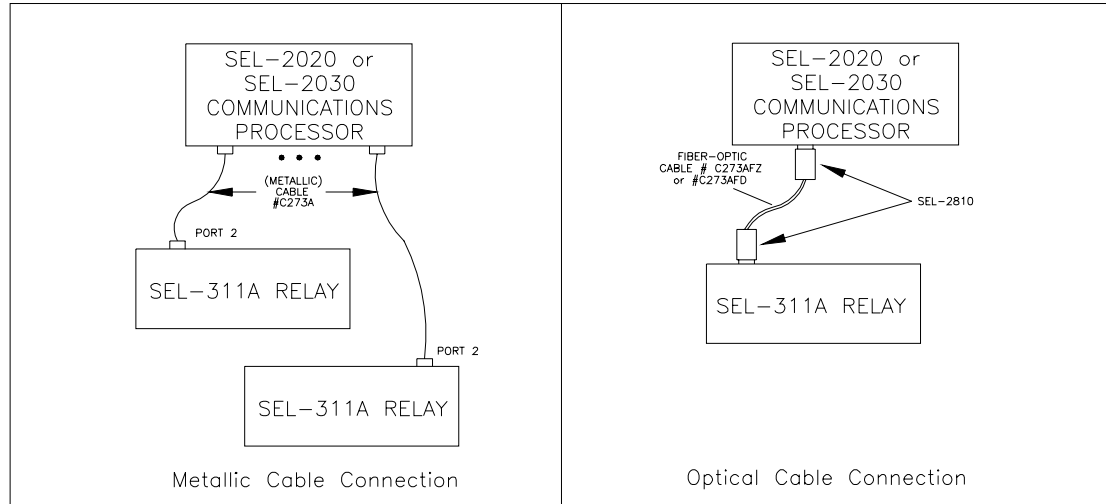
DWG: M311A002

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

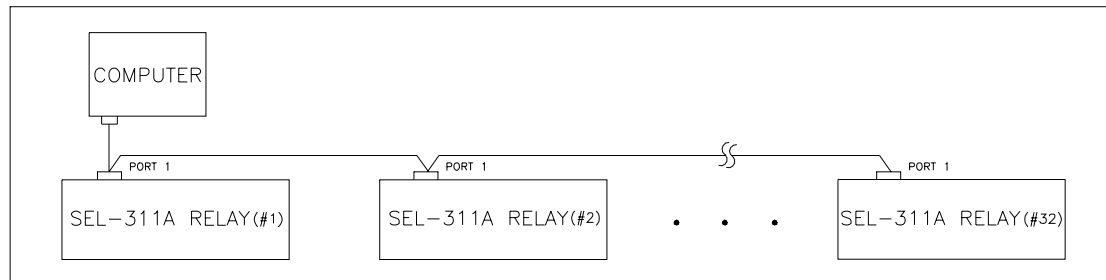
COMMUNICATIONS CONNECTIONS

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

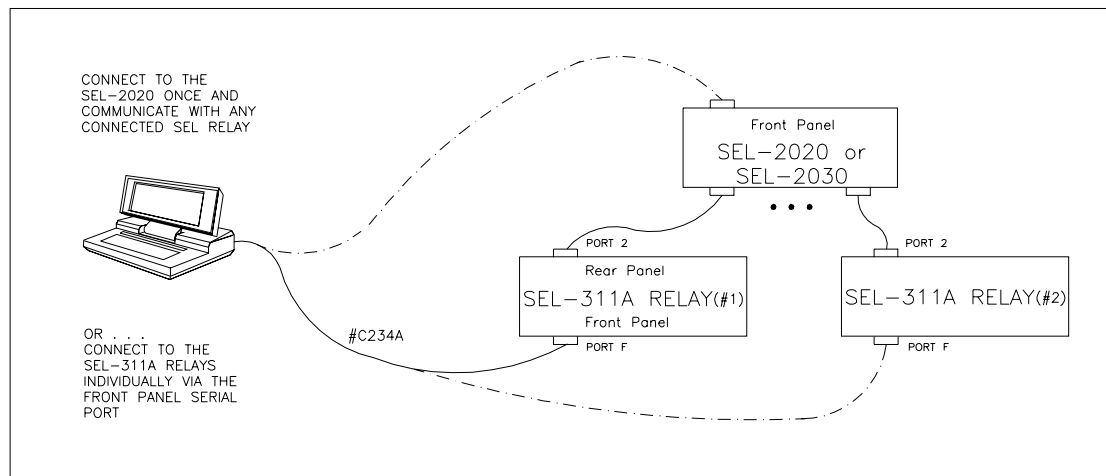
DATA AND TIME-SYNCHRONIZATION CONNECTIONS



EIA-485 CONNECTIONS



LOCAL CONNECTIONS



DWG: M311A003

Figure 1.3: SEL-311A Relay Communications Connections Examples

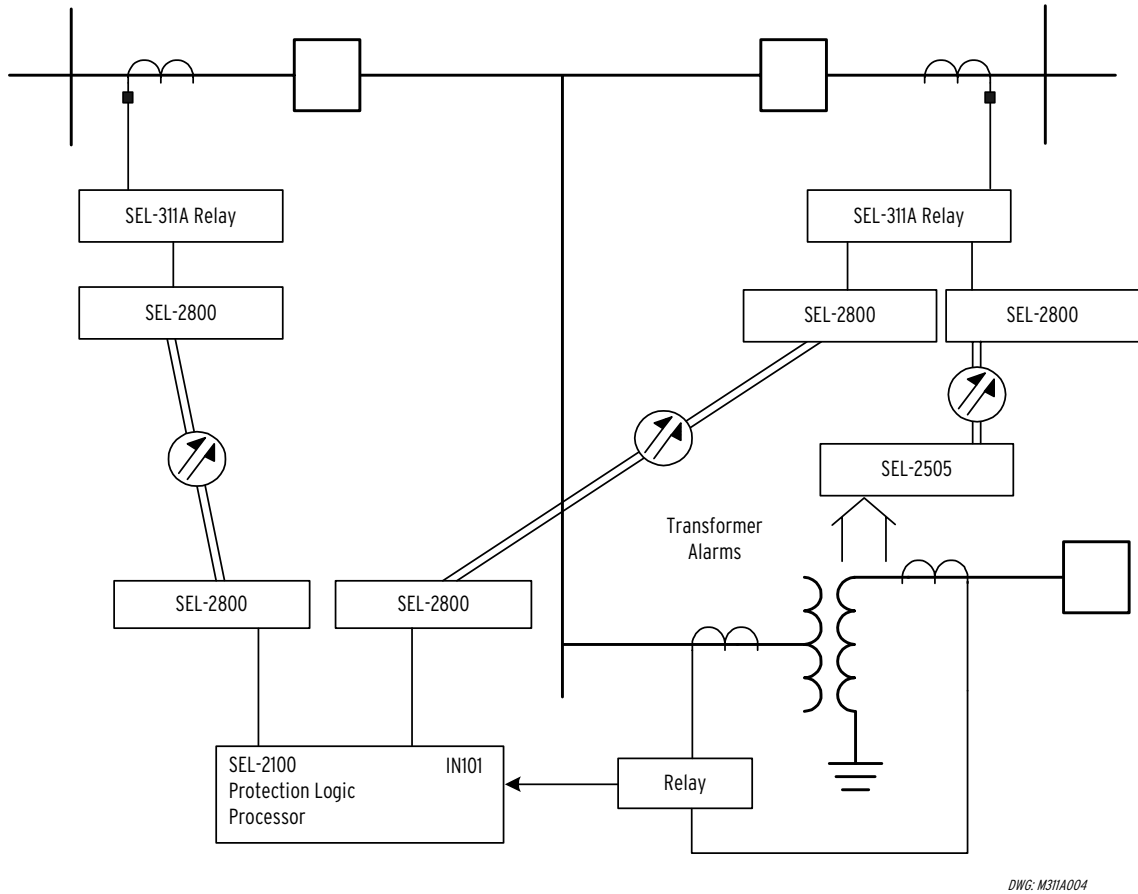


Figure 1.4: SEL-311A Relay Communications Connections Examples (Continued)

RELAY SPECIFICATIONS

Important: Do not use the following specification information to order an SEL-311A 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:	<p>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</p> <p>Note: Make per IEEE C37.90–1989; Breaking and Cyclic Capacity per IEC 60255-23–1994.</p>
Optoisolated Input Ratings:	<p>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</p> <p>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.</p> <p>Note: 220 Vdc optoisolated inputs are not available in the Connectorized version of the relay.</p>
Routine Dielectric Test:	<p>Voltage/Current inputs: 2500 Vac for 10 s Power supply, optoisolated inputs, and output contacts: 3000 Vdc for 10 s</p> <p>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</p>
Frequency and Rotation:	<p>System Frequency: 50 or 60 Hz Phase Rotation: ABC or ACB Frequency Tracking Range: 40.1–65 Hz</p> <p>Note: V_A required for frequency tracking.</p>
Communications Ports:	<p>EIA-232: 1 Front and 2 Rear EIA-485: 1 Rear, 2100 Vdc isolation Baud Rate: 300–38400</p>
Time-Code Input:	<p>Relay accepts demodulated IRIG-B time-code input at Port 2. Relay time is synchronized to within ±5 ms of time-source input.</p>
Operating Temperature Range:	<p>-40° to +85°C (-40° to +185°F)</p> <p>Note: LCD contrast impaired for temperatures below -20°C.</p>

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 :	± 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:	$\pm 2\%$ 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 $\pm 0.1\%$ of setting

Phase Distance Elements

Zones 1–2 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:	$\pm 5\%$ of setting at line angle for $30 \leq \text{SIR} \leq 60$ $\pm 3\%$ of setting at line angle for $\text{SIR} < 30$
Transient Overreach:	$< 5\%$ of setting plus steady state accuracy

Zones 1–2 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 $\pm 3\%$ of setting (5 A nominal) ± 0.01 A and $\pm 3\%$ of setting (1 A nominal)
Transient Overreach:	$< 5\%$ of pickup
Max. Operating Time:	See pickup and reset time curves in Figure 3.11 and Figure 3.12

Mho Ground Distance Element

Zones 1–2 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:	$\pm 5\%$ of setting at line angle for $30 \leq \text{SIR} \leq 60$ $\pm 3\%$ of setting at line angle for $\text{SIR} < 30$
Transient Overreach:	$< 5\%$ of setting plus steady state accuracy

Zones 1–2 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 $\pm 3\%$ of setting (5 A nominal) ± 0.01 A and $\pm 3\%$ of setting (1 A nominal)
Transient Overreach:	$< 5\%$ of pickup
Max. Operating Time:	See pickup and reset time curves in Figure 3.11 and Figure 3.12

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 $\pm 3\%$ of setting (5 A nominal) ± 0.01 A and $\pm 3\%$ 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 $\pm 0.1\%$ of setting
Max. Operating Time:	See pickup and reset time curves in Figure 3.11 and Figure 3.12

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 $\pm 3\%$ of setting (5 A nominal) ± 0.01 A and $\pm 3\%$ 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 $\pm 4\%$ of curve time for current between 2 and 30 multiples of pickup

TABLE OF CONTENTS

SECTION 2: INSTALLATION.....	2-1
Relay Mounting	2-1
Front- and Rear-Panel Diagrams	2-2
Making Rear-Panel Connections	2-5
Wire-Alike Screw Terminal Connections.....	2-5
Power Supply	2-5
Output Contacts	2-5
Optoisolated Inputs	2-5
Current Transformer Inputs	2-5
Potential Transformer Inputs	2-6
Serial Ports	2-6
IRIG-B Time-Code Input	2-7
SEL-311A Relay AC/DC Connection Diagrams for Various Applications.....	2-8
Circuit Board Connections	2-10
Accessing the Relay Circuit Boards	2-10
Output Contact Jumpers.....	2-12
“Extra Alarm” Output Contact Control Jumper	2-12
Password and Breaker Jumpers	2-13
EIA-232 Serial Port Voltage Jumpers.....	2-13
Clock Battery	2-14

TABLES

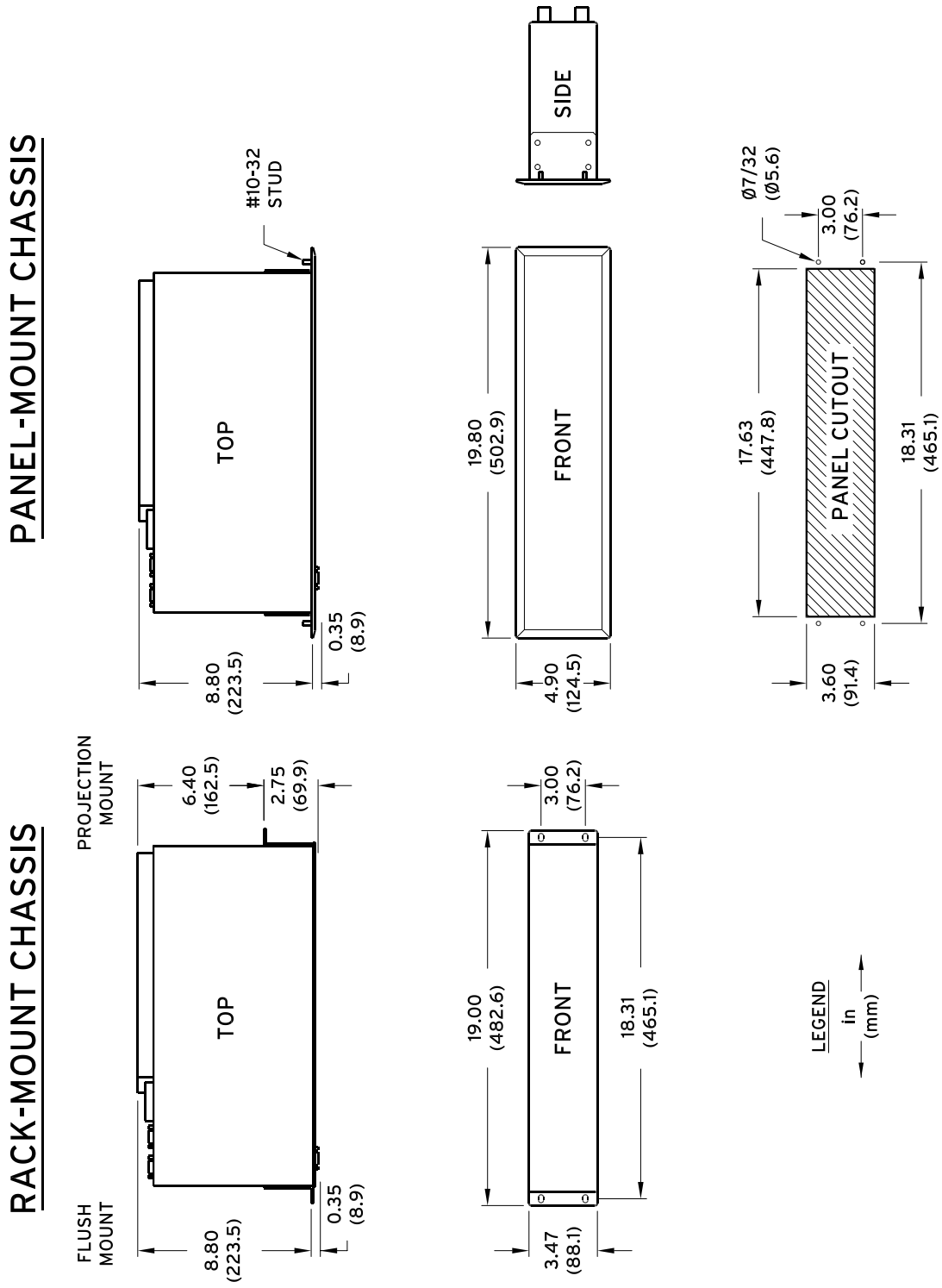
Table 2.1: Communication Cables to Connect the SEL-311A Relay to Other Devices	2-7
Table 2.2: Move Jumper JMP23 to Select Extra Alarm.....	2-12
Table 2.3: Password and Breaker Jumper Operation.....	2-13
Table 2.4: EIA-232 Serial Port Voltage Jumper Positions for Standard Relay Shipments.....	2-14

FIGURES

Figure 2.1: SEL-311A Relay Dimensions and Panel-Mount Cutout	2-1
Figure 2.2: SEL-311A Relay Front- and Rear-Panel Drawings (Horizontal).....	2-2
Figure 2.3: SEL-311A Relay Front- and Rear-Panel Drawings (Vertical).....	2-3
Figure 2.4: SEL-311A Relay Connectorized® Rear-Panel Drawing.....	2-4
Figure 2.5: SEL-311A Relay Provides Distance and Overcurrent Protection for a Transmission Line	2-8
Figure 2.6: SEL-311A Relay Provides Distance and Overcurrent Protection for a Transmission Line (Current-Polarization Source Connected to Channel IP).....	2-9
Figure 2.7: Jumper, Connector, and Major Component Locations on the SEL-311A Relay Main Board.....	2-11

SECTION 2: INSTALLATION

RELAY MOUNTING



i2137a

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

FRONT- AND REAR-PANEL DIAGRAMS

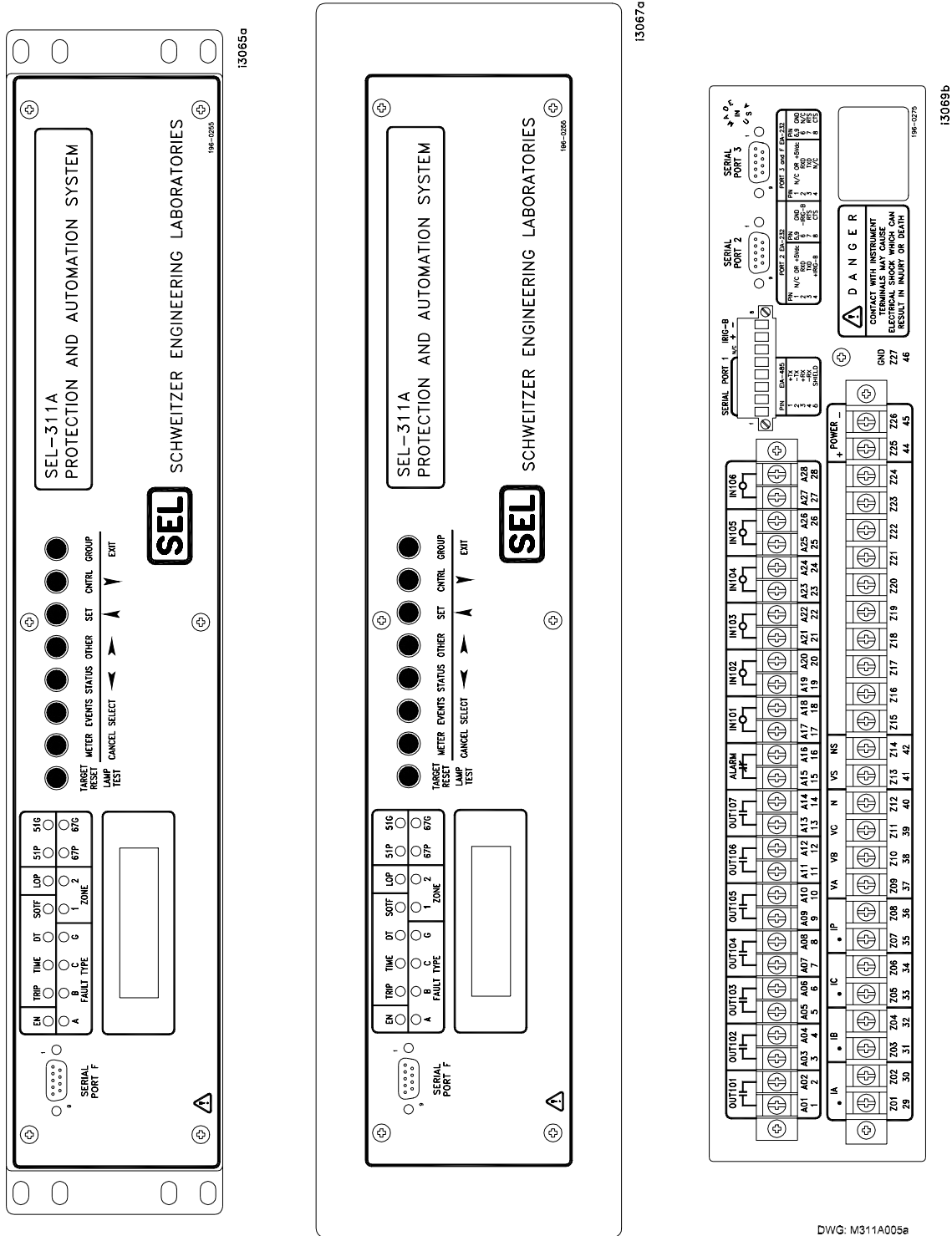


Figure 2.2: SEL-311A Relay Front- and Rear-Panel Drawings (Horizontal)

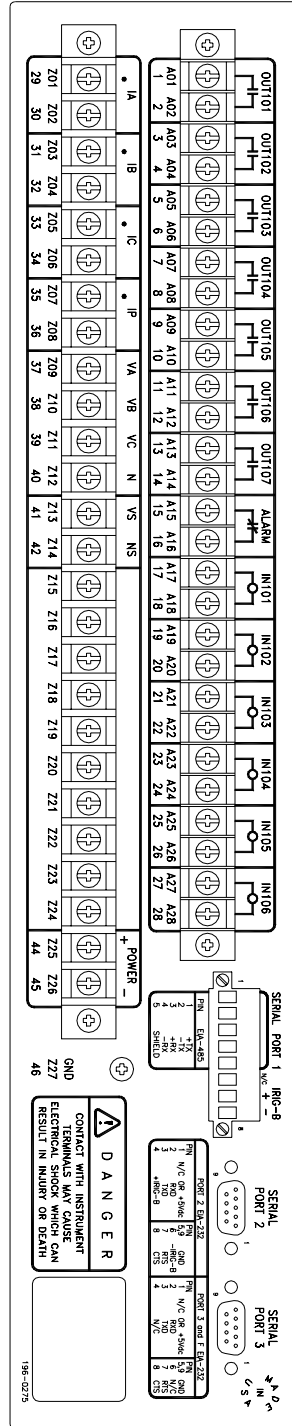
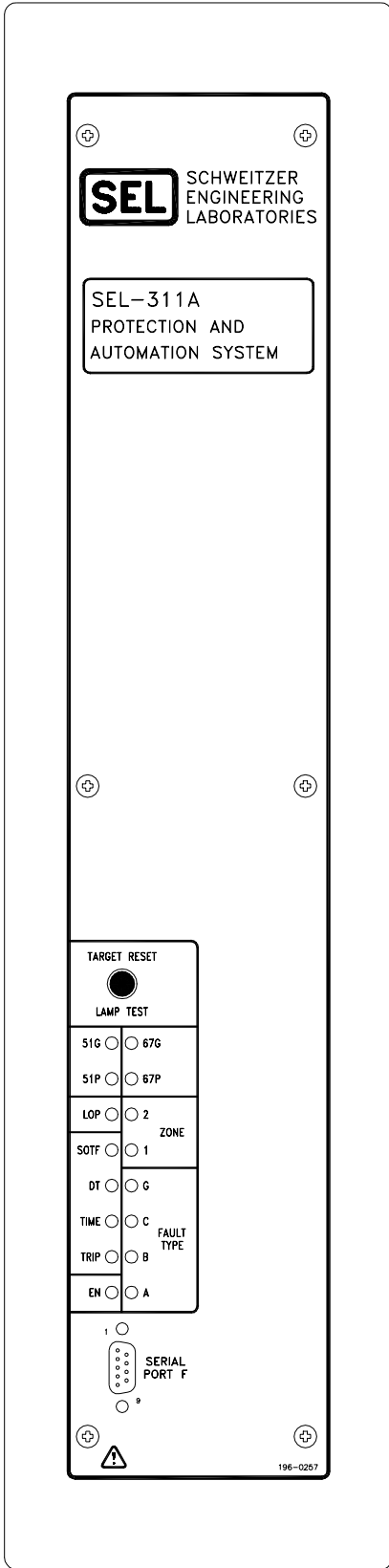
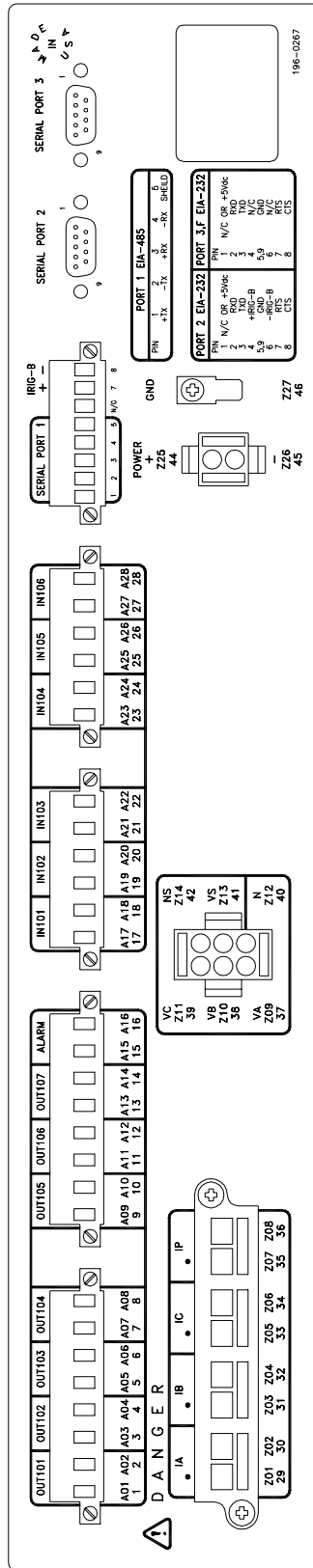


Figure 2.3: SEL-311A Relay Front- and Rear-Panel Drawings (Vertical)



i3464a

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

MAKING REAR-PANEL CONNECTIONS

Refer to Figure 2.5 and Figure 2.6 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-311A relays have SEL-221 wire-alike terminals. Both SEL-311A standard terminal numbers and SEL-221 terminal numbers are shown on the rear-panel wiring connections for those models.

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 SEL-311A Relay can be ordered with standard output contacts only. Refer to *General Specifications* in *Section 1: Introduction and Specifications* for output contact ratings.

Standard output contacts are not polarity dependent.

Optoisolated Inputs

The optoisolated inputs in any of the SEL-311A Relay models (e.g., IN102) 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 and Figure 2.6 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) on terminals Z09 through Z12. Figure 1.2 shows the internal connection for terminals VA, VB, and VC. Terminals VS and NS are not used in the SEL-311A, although internal components are in place for future upgrades.

Wye-Connected Voltages

Any of the single-phase voltage inputs (i.e., VA-N, VB-N, or VC-N) can be connected to voltages up to 150 V continuous. Figure 2.5 shows an example 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-311A 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 the SEL-311A Relay 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-311A 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-311A Relay to Other Devices

SEL-311A 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-311A Relay. See Figure 2.7 and Table 2.4.

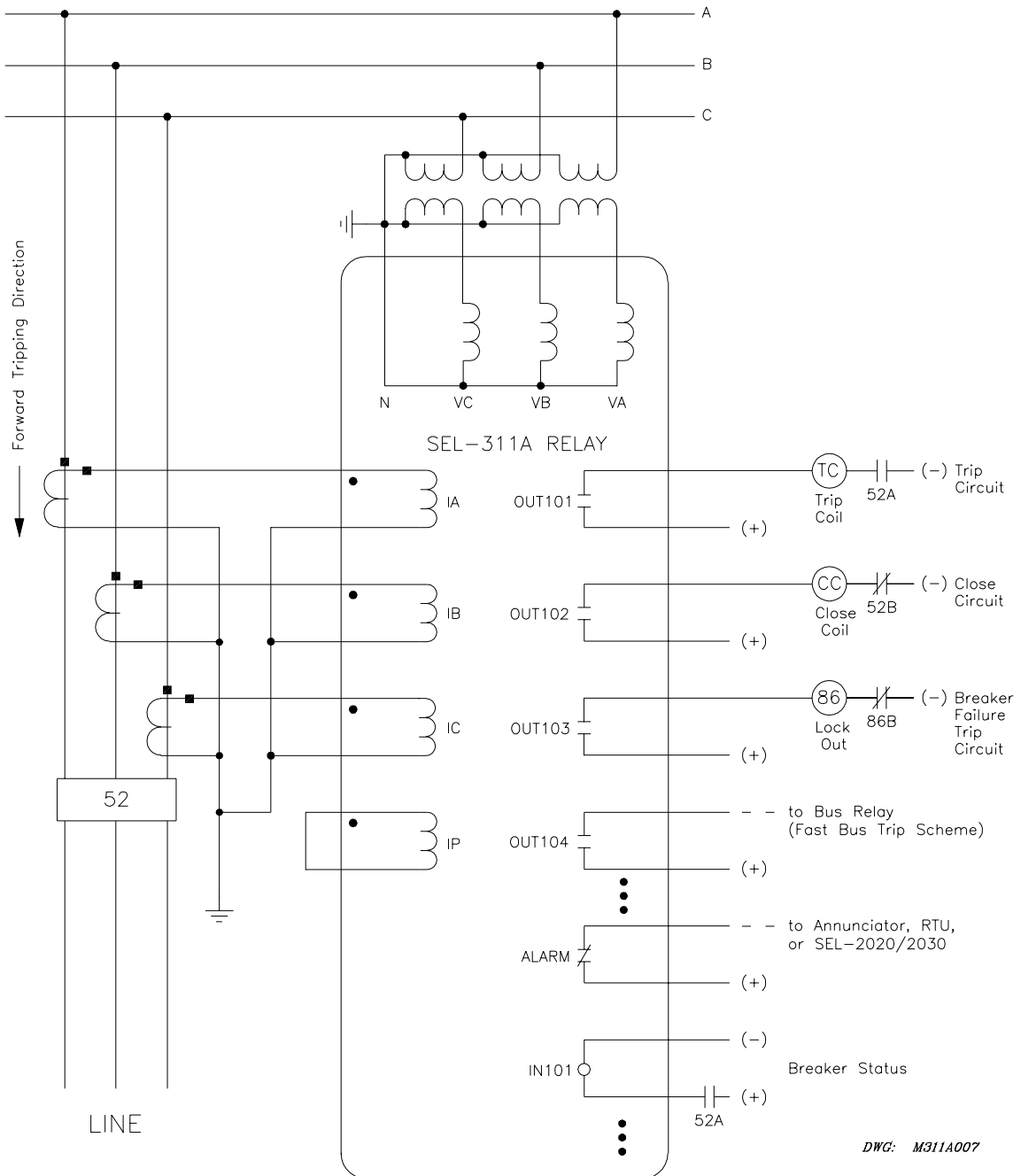
IRIG-B Time-Code Input

The SEL-311A 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-311A Relay models (see Table 10.1) by connecting Serial Port 2 of the SEL-311A Relay to an SEL-2020 with Cable C273A.

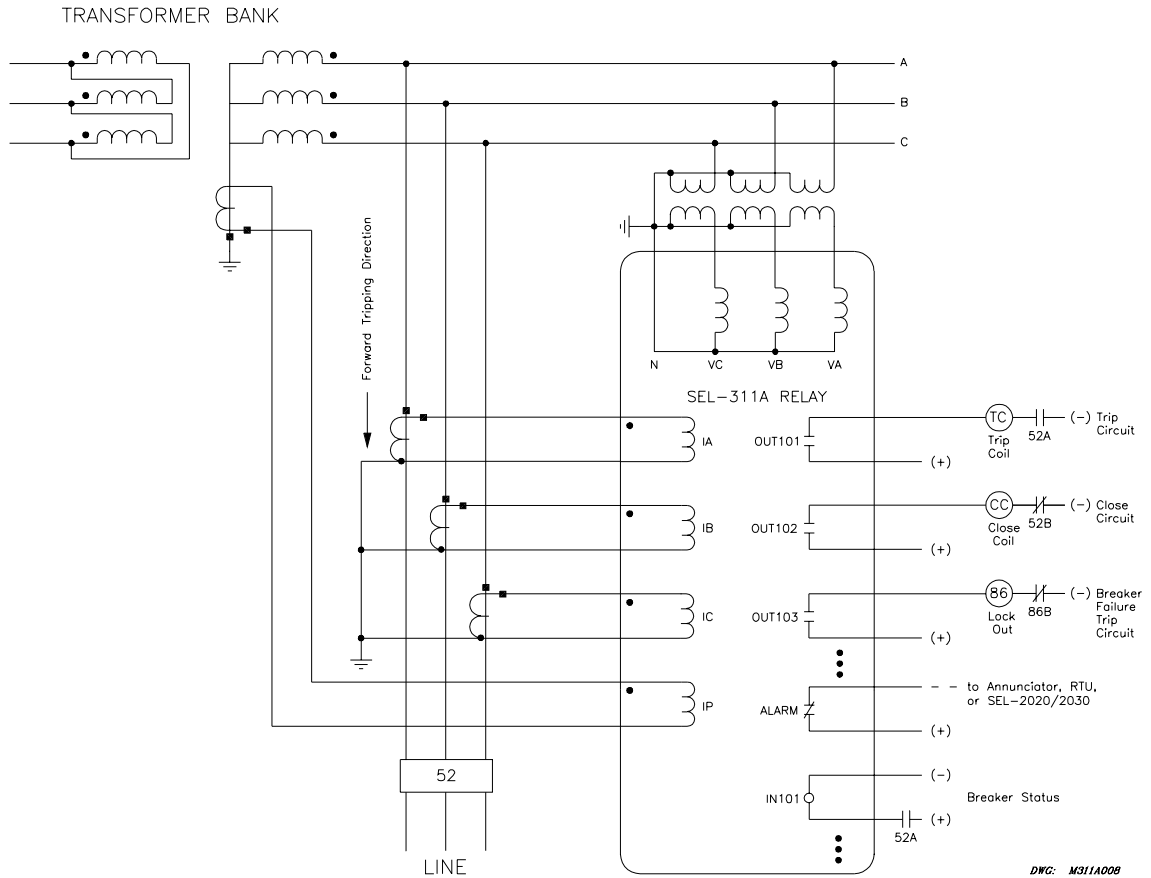
A demodulated IRIG-B time code can also be input into the connector for Serial Port 1 (see Table 10.2). If demodulated IRIG-B time code is input into this connector, it should not be input into Serial Port 2 and vice versa.

SEL-311A RELAY AC/DC CONNECTION DIAGRAMS FOR VARIOUS APPLICATIONS



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

Figure 2.5: SEL-311A Relay Provides Distance and Overcurrent Protection for a Transmission Line



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

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

CIRCUIT BOARD CONNECTIONS

Accessing the Relay Circuit Boards

To change circuit board jumpers or replace the clock battery, refer to Figure 2.7 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

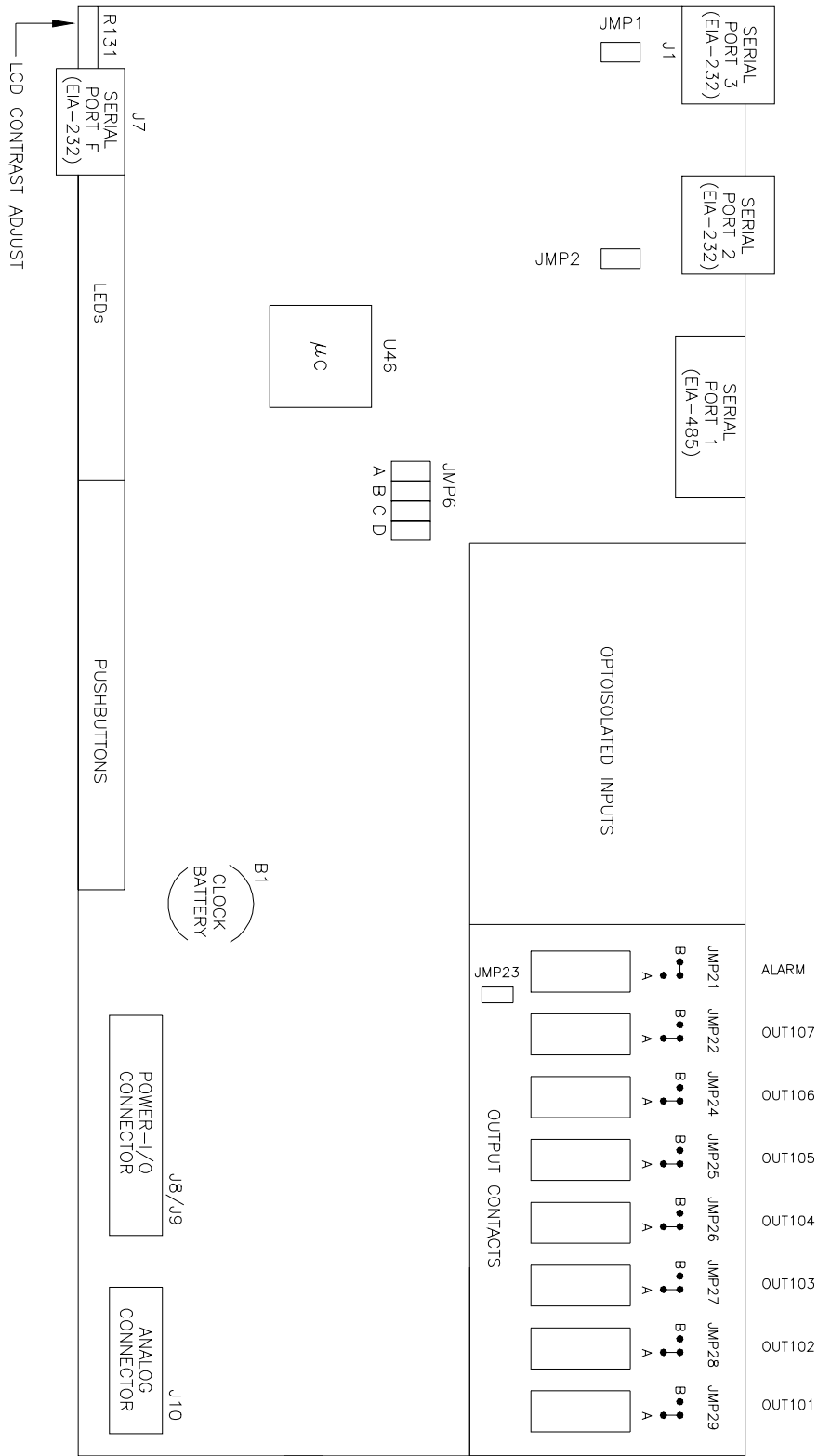
The relay contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with front or top cover removed, work surfaces and personnel must be properly grounded or equipment damage may result.



DANGER

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

4. Each circuit board corresponds to a row of rear-panel terminal blocks or connectors and is affixed to a drawout tray. The SEL-311A Relay has only a main board.
5. 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.
6. Grasp the drawout assembly of the main board and pull the assembly from the relay chassis.
7. Locate the jumper(s) or battery to be changed (refer to Figure 2.7). Make the desired changes. Note that the output contact jumpers are soldered in place.
8. When finished, slide the drawout assembly into the relay chassis. Reconnect the cables removed in step 5. Replace the relay front-panel cover.
9. Replace any cables previously connected to serial ports.
10. Reenergize the relay.



DWG: M351178

Figure 2.7: Jumper, Connector, and Major Component Locations on the SEL-311A Relay Main Board

Output Contact Jumpers

Jumpers JMP21–JMP29 (but not JMP23) correspond to contact outputs ALARM through OUT101. Figure 2.7 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 open when the associated SELOGIC equation is deasserted, and closed when the associated SELOGIC equation is asserted. 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 2.7, 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.

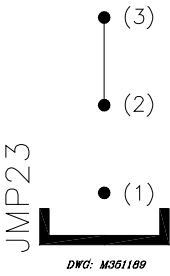
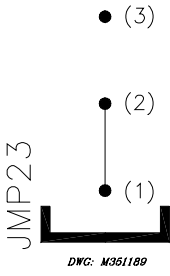
“Extra Alarm” Output Contact Control Jumper

All the SEL-311A 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 2.2).

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 2.2).

Table 2.2: Move Jumper JMP23 to Select Extra Alarm

Position	Output Contact OUT107 Operation
	<p>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).</p>
	<p>“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).</p>

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

The output contact type for 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 2.3: 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 <u>standard relay shipment</u> .
Breaker JMP6-B	ON (in place)	Enable serial port commands OPEN, CLOSE, and PULSE ² . These commands are disabled in a <u>standard relay shipment</u> .
	OFF (removed/not in place)	Disable serial port commands OPEN, CLOSE, and PULSE ² . These commands are disabled in a <u>standard relay shipment</u> .

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 2.7 has multiple jumpers A through D. Jumpers A and B are used (see Table 2.3). 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 2.4 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 2.4: 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 2.7

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 2.7 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

SECTION 3: DISTANCE AND OVERCURRENT ELEMENTS.....3-1

Distance Elements.....	3-1
Phase Distance Elements	3-1
Ground Distance Elements.....	3-8
Distance Element Operating Time Curves at Nominal Frequency	3-11
Additional Distance Element Supervision	3-12
Zone Time Delay Elements.....	3-13
Instantaneous/Definite-Time Overcurrent Elements.....	3-15
Phase Instantaneous/Definite-Time Overcurrent Elements	3-15
Residual Ground Instantaneous/Definite-Time Overcurrent Elements.....	3-17
Time-Overcurrent Elements.....	3-19
Phase Time-Overcurrent Elements	3-19
Residual Ground Time-Overcurrent Element	3-23

TABLES

Table 3.1: Phase Distance Calculations	3-2
Table 3.2: Available Phase Time-Overcurrent Elements.....	3-19
Table 3.3: Phase Time-Overcurrent Element (Maximum Phase) Settings	3-19
Table 3.4: Phase Time-Overcurrent Element (Maximum Phase) Logic Outputs	3-21
Table 3.5: Residual Ground Time-Overcurrent Element Settings	3-24

FIGURES

Figure 3.1: Positive-Sequence Polarized Mho Element.....	3-3
Figure 3.2: Compensator-Distance Phase-to-Phase Element Operation	3-4
Figure 3.3: Compensator-Distance Three-Phase Element Operation.....	3-5
Figure 3.4: Zone 1 Phase Distance Logic.....	3-7
Figure 3.5: Zone 2 Phase Distance Logic.....	3-8
Figure 3.6: Zone 1 Mho Ground Distance Logic	3-10
Figure 3.7: Zone 2 Mho Ground Distance Logic	3-11
Figure 3.8: Ground and Phase Distance Speed Curves	3-12
Figure 3.9: Zone Timing Elements	3-14
Figure 3.10: Phase Instantaneous/Definite-Time Overcurrent Elements	3-15
Figure 3.11: SEL-311A Relay Nondirectional Instantaneous Overcurrent Element Pickup Time Curve	3-17
Figure 3.12: SEL-311A Relay Nondirectional Instantaneous Overcurrent Element Reset Time Curve	3-17
Figure 3.13: Residual Ground Instantaneous/Definite-Time Overcurrent Elements with Directional and Torque Control	3-18
Figure 3.14: Phase Time-Overcurrent Element 51PT	3-20
Figure 3.15: Residual Ground Time-Overcurrent Element 51GT.....	3-24

SECTION 3: DISTANCE AND OVERCURRENT ELEMENTS

DISTANCE ELEMENTS

Phase Distance Elements

The SEL-311A Relay has two independent zones of mho phase distance protection. All zones are independently set. Zone 1 and 2 are fixed to operate in the forward direction only. 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-311A 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
 $V_1 \cdot (V_2 \text{ conjugate}) = V_1 \cdot V_2^* = [|V_1| \cdot |V_2|] \angle (\theta_1 - \theta_2)$
The angle between vector quantities $V_1 \cdot V_2^*$ is the test angle of the mho element.
- Test for $V_1 \cdot V_2^*$ 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 $V_1 \cdot V_2^*$, written $\text{Im}(V_1 \cdot V_2^*)$.
- Test for $V_1 \cdot V_2^*$ 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 $V_1 \cdot V_2^*$, written $\text{Re}(V_1 \cdot V_2^*)$.

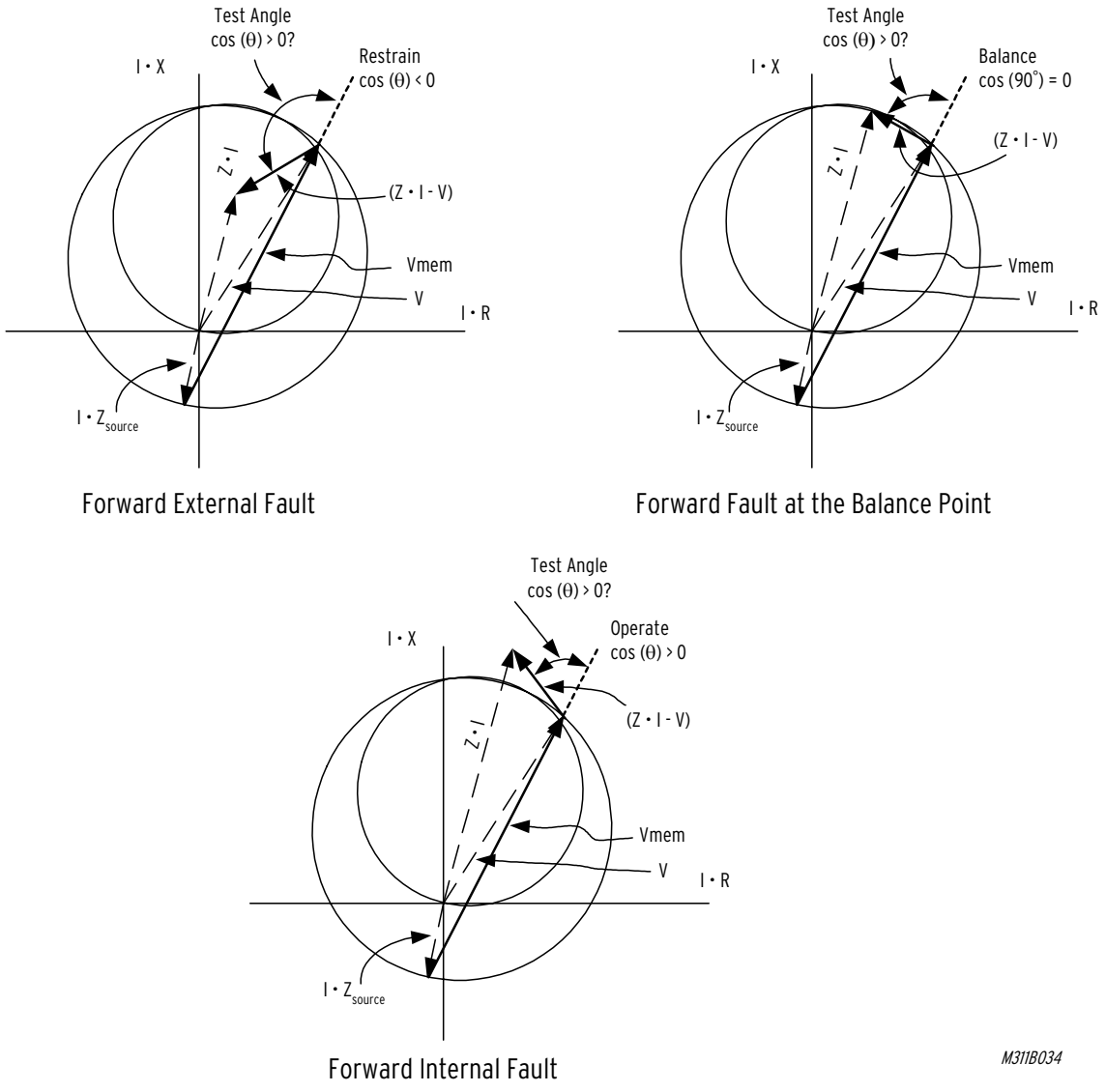
Table 3.1 shows the different calculations used for the positive-sequence polarized mho elements and compensator-distance mho elements. Notice that the positive-sequence polarized mho element equation is the solution of Equation 1 for the quantity “|Z|”, which represents the relay reach at the balance point. This equation is in the form of a line drop-compensated voltage and a polarizing (reference) voltage.

$$0 = \text{Re}[(Z \bullet I - V) \bullet V^* \text{ mem}] \quad \text{Equation 1}$$

Table 3.1: Phase Distance Calculations

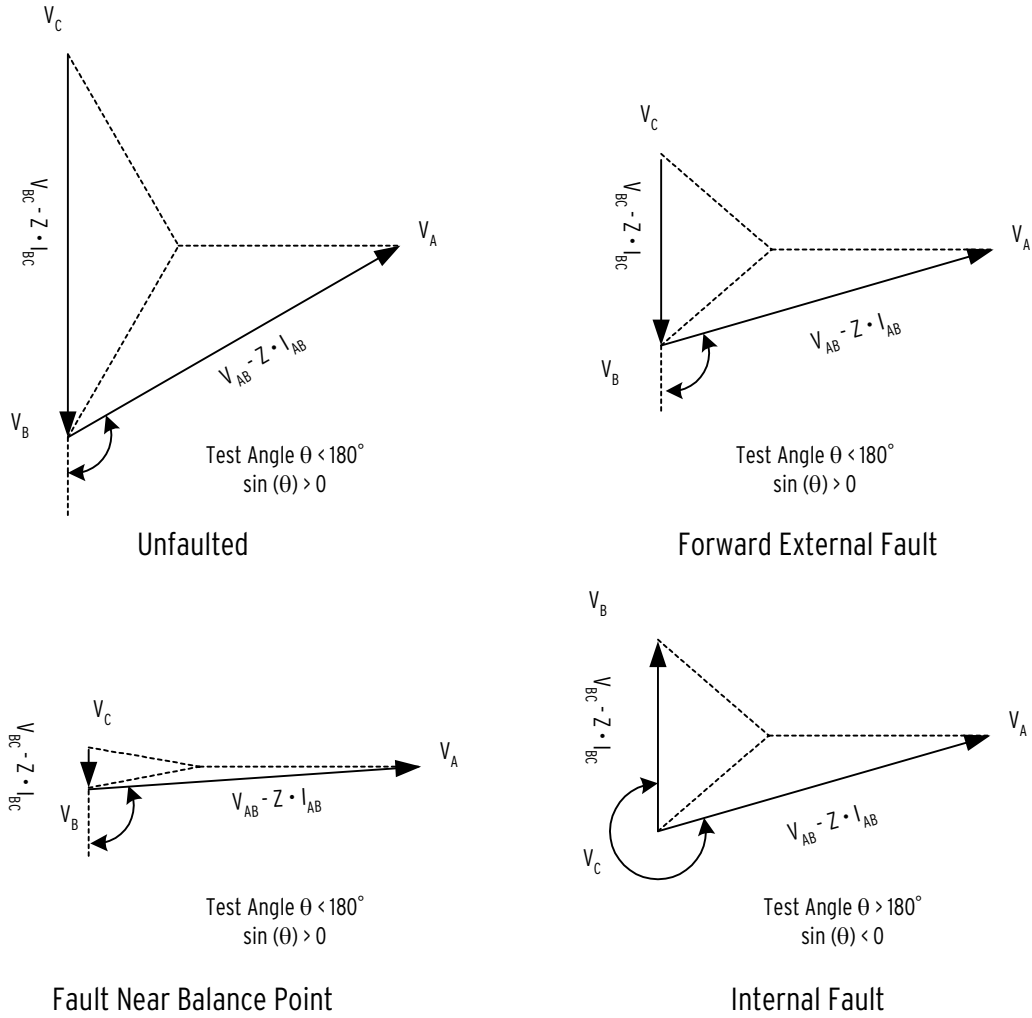
	Positive-Sequence Polarized Mho Element	Compensator-Distance Mho Element
Distance Calculation in a Digital Relay	$ Z = \frac{\text{Re}(V_{AB} \cdot V_{AB}^* \text{mem})}{\text{Re}(1 \angle Z \cdot I_{AB} \cdot V_{AB}^* \text{mem})}$ Phase A-B	$mPP = \text{Im}[(V_{AB} - Z \cdot I_{AB}) \cdot (V_{BC} - Z \cdot I_{BC})^*]$ Phase-to-Phase Element
	$ Z = \frac{\text{Re}(V_{BC} \cdot V_{BC}^* \text{mem})}{\text{Re}(1 \angle Z \cdot I_{BC} \cdot V_{BC}^* \text{mem})}$ Phase B-C	$mABC = \text{Im}[(V_{AB} - Z \cdot I_{AB}) \cdot (-jV_{AB} - 0.25 \cdot V_C \text{mem})^*]$ Three-Phase Element
	$ Z = \frac{\text{Re}(V_{CA} \cdot V_{CA}^* \text{mem})}{\text{Re}(1 \angle Z \cdot I_{CA} \cdot V_{CA}^* \text{mem})}$ Phase C-A	mPP = Phase-to-phase torque calculation. Positive torque restrains, negative torque operates. mABC = Three-phase torque calculation. Positive torque restrains, negative torque operates.
	Z = Impedance measurement at the line angle	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 $V_{1\text{mem}}$ is the polarizing voltage for the positive-sequence polarized mho element and $(Z \cdot I - V)$ is the line drop-compensated voltage. In the compensator distance phase-to-phase element, the polarizing voltage is the unfaulted phase-to-phase voltage, and the line drop-compensated voltage is the faulted phase-to-phase voltage. In the compensator distance three-phase element, the polarizing voltage is $(-jV_{AB} - 0.25 \cdot V_C \text{mem})$ and the line drop compensated voltage is $(V_{AB} - Z \cdot I_{AB})$.



M311B034

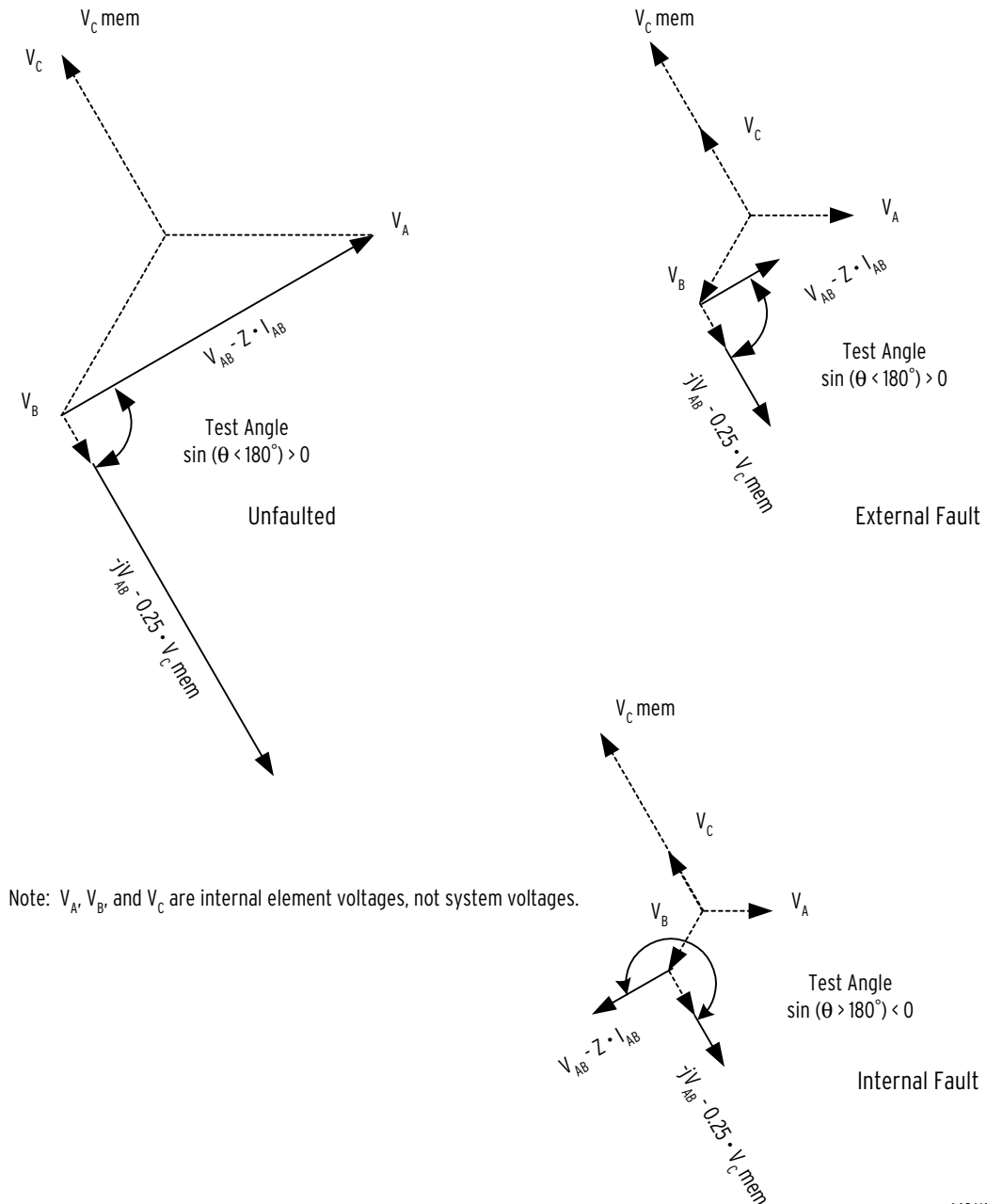
Figure 3.1: Positive-Sequence Polarized Mho Element



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

M311B035

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



M311B036a

Figure 3.3: Compensator-Distance Three-Phase Element Operation

Positive-sequence polarized and compensator distance 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).

$$79DTL = MABC2 * !MPP2 \dots$$

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_{Cmem} (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., 2C is two 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.

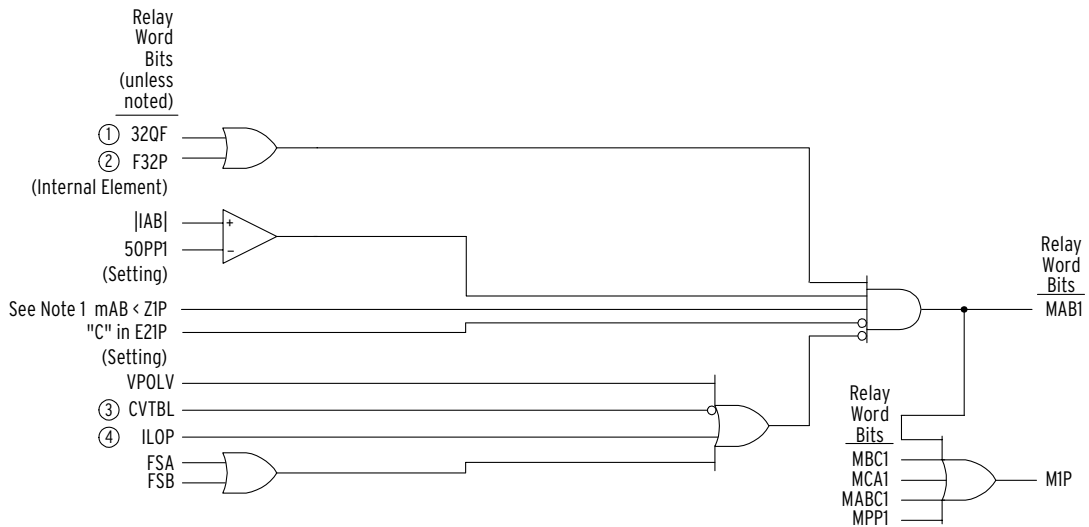
Mho Phase Distance Elements (Zones 1–2)

Enable Setting:	E21P (1–2, 1C–2C)
Setting range for Mho Phase Distance Elements (Z1P and Z2P):	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:	$\pm 5\%$ of setting at line angle for $30 \leq SIR \leq 60$ $\pm 3\%$ of setting at line angle for $SIR < 30$
Transient Overreach:	$< 5\%$ of setting plus steady state accuracy

Phase-to-Phase Current Fault Detectors (Zones 1–2)

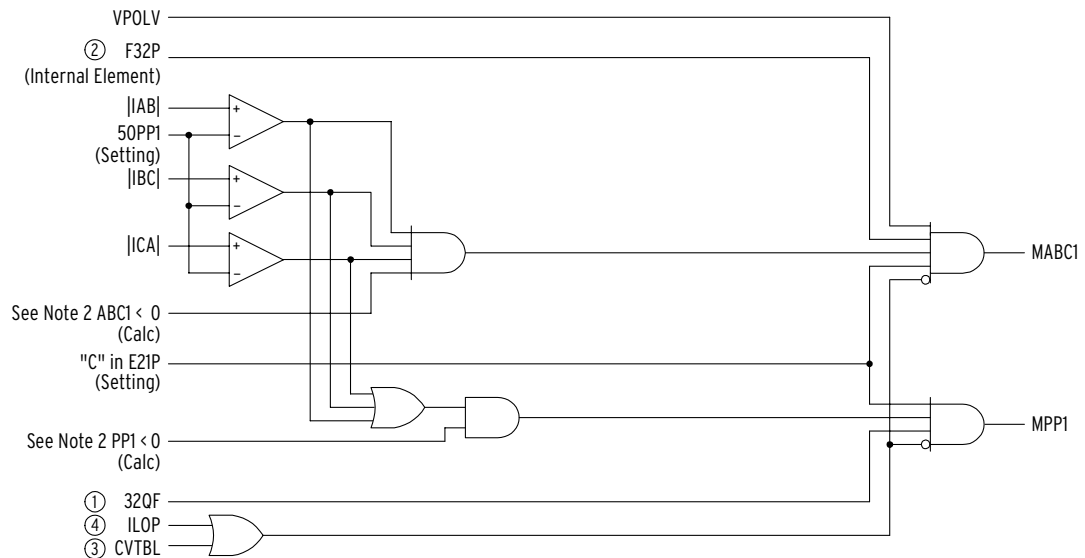
Setting Range for Phase-to-Phase Current Fault Detectors (50PP1 and 50PP2):	0.50–170.00 A_{p-p} secondary, 0.01 A steps (5 A nominal)
Note: If setting EADVS = N, settings 50PP2 is at minimum value and hidden.	0.10–34.00 A_{p-p} secondary, 0.01 A steps (1 A nominal)
Accuracy:	± 0.05 A and $\pm 3\%$ of setting (5 A nominal) ± 0.01 A and $\pm 3\%$ of setting (1 A nominal)
Transient Overreach:	$< 5\%$ of pickup
Max. Operating Time:	See pickup and reset time curves in Figure 3.11 and Figure 3.12.

Mho Phase Distance Elements



Zone 1 Phase Distance Logic for AB Phase Pair.
BC and CA Logic Is Similar.

Note 1: mAB = A-Phase to B-Phase Distance Calculation
 ZIP = Zone 1 Distance Setting



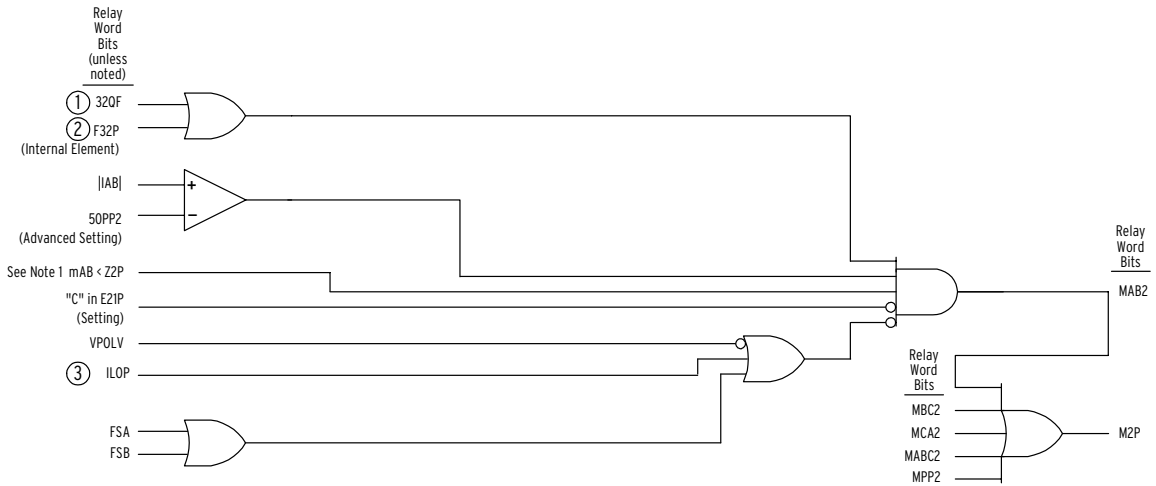
Zone 1 Compensator Distance Logic

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

DWG: M311A048a

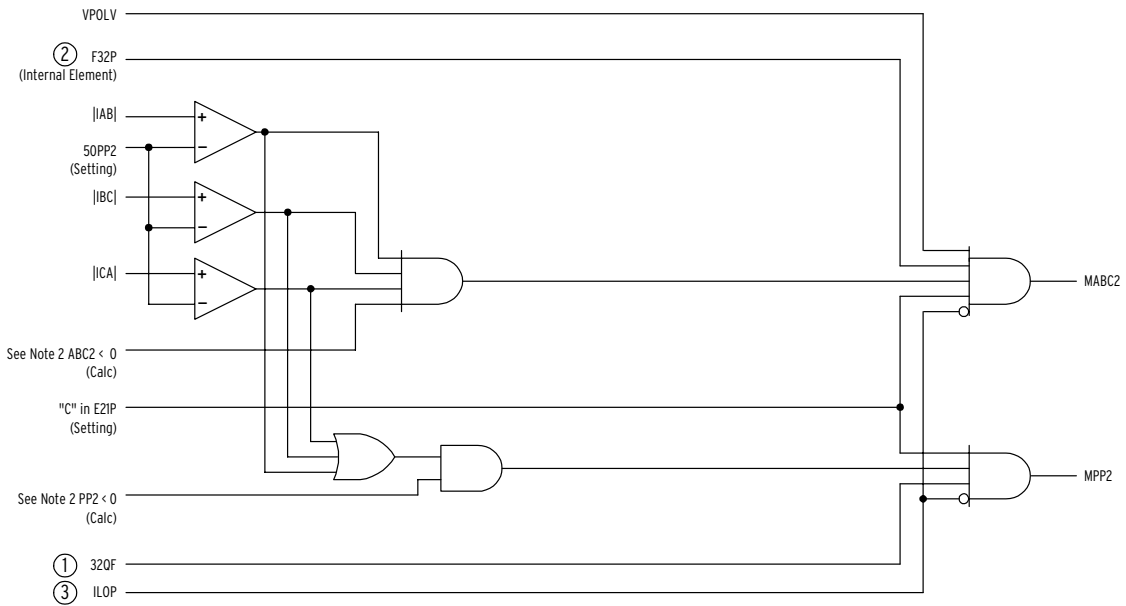
- ① From Figure 4.14 ③ From Figure 4.2
② From Figure 4.15 ④ From Figure 4.1

Figure 3.4: Zone 1 Phase Distance Logic



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

Note 1: $mAB = A\text{-Phase to B-Phase Distance Calculation}$
 $Z2P = \text{Zone 2 Distance Setting}$



Zone 2 Compensator Distance Logic

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

M311B049a

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

Figure 3.5: Zone 2 Phase Distance Logic

Ground Distance Elements

The SEL-311A Relay has two independent zones of mho ground distance protection. All zones are independently set. Zones 1 and 2 are forward direction only. The mho ground distance elements use positive-sequence voltage polarization for security and to create an expanded mho characteristic.

Impedance Reach (Zones 1–2)

Enable Setting:	E21MG Mho Ground
Settings range for Mho elements (Z1MG and Z2MG):	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

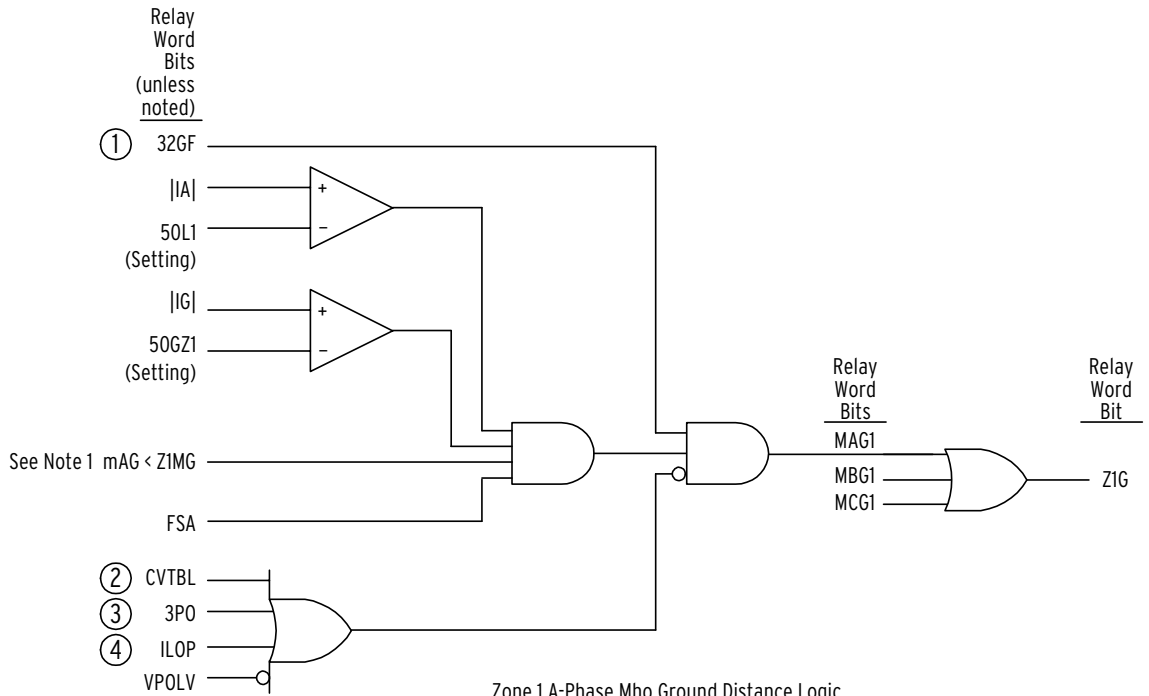
Phase and Residual Current Fault Detectors (Zones 1–2)

Setting Range for Phase and Residual Current Fault Detectors (50L1 and 50L2 and 50GZ1 and 50GZ2):	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)
Note: If EADVVS = N, level 2 fault detector is set at its minimum value and hidden.	
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 3.11 and Figure 3.12.

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 advanced setting hidden and set to k0M1 when EADVVS = N)
Settings range for zero sequence compensation (ZSC) factor angle:	k0A1 = -180.0 to +180.0 degrees (Zone 1) k0A = -180.0 to +180.0 degrees (Zone 2, 3, 4 advanced setting hidden and set to k0A1 when EADVVS = N)

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



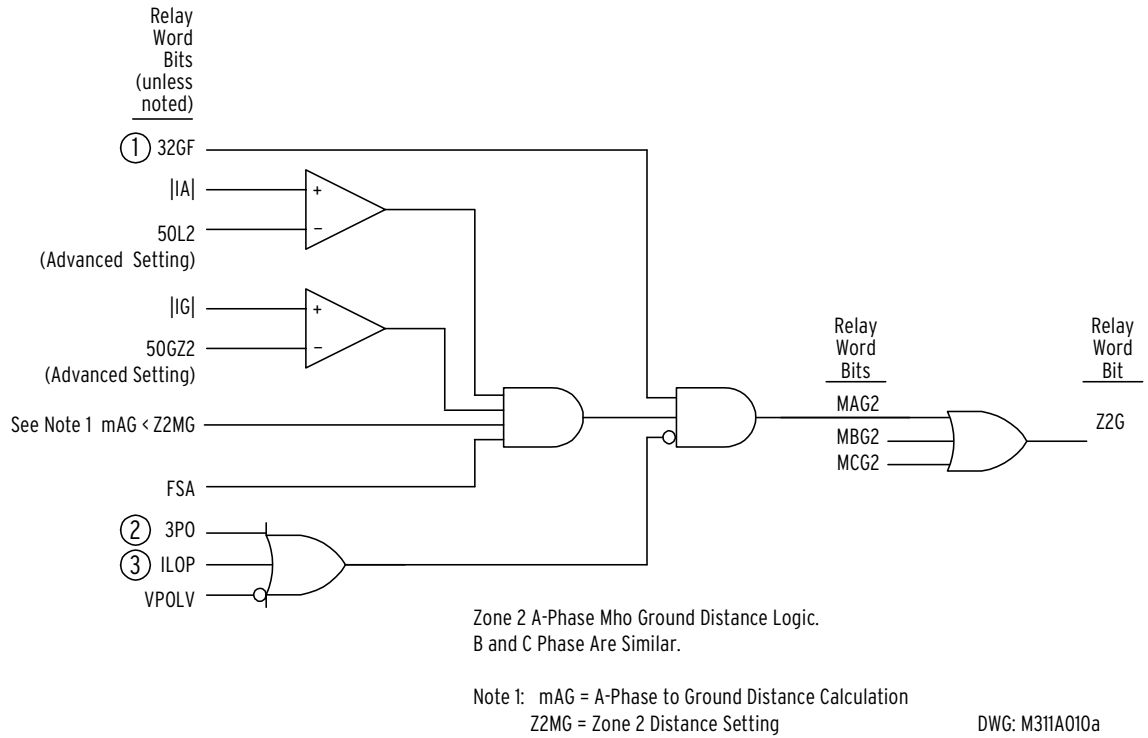
Zone 1 A-Phase Mho Ground Distance Logic.
B and C Phase Are Similar.

Note 1: mAG = A-Phase to Ground Distance Calculation
 $ZIMG$ = Zone 1 Distance Setting

DWG: M311A009a

- ① From Figure 4.12 ③ From Figure 5.3
② From Figure 4.2 ④ From Figure 4.1

Figure 3.6: Zone 1 Mho Ground Distance Logic



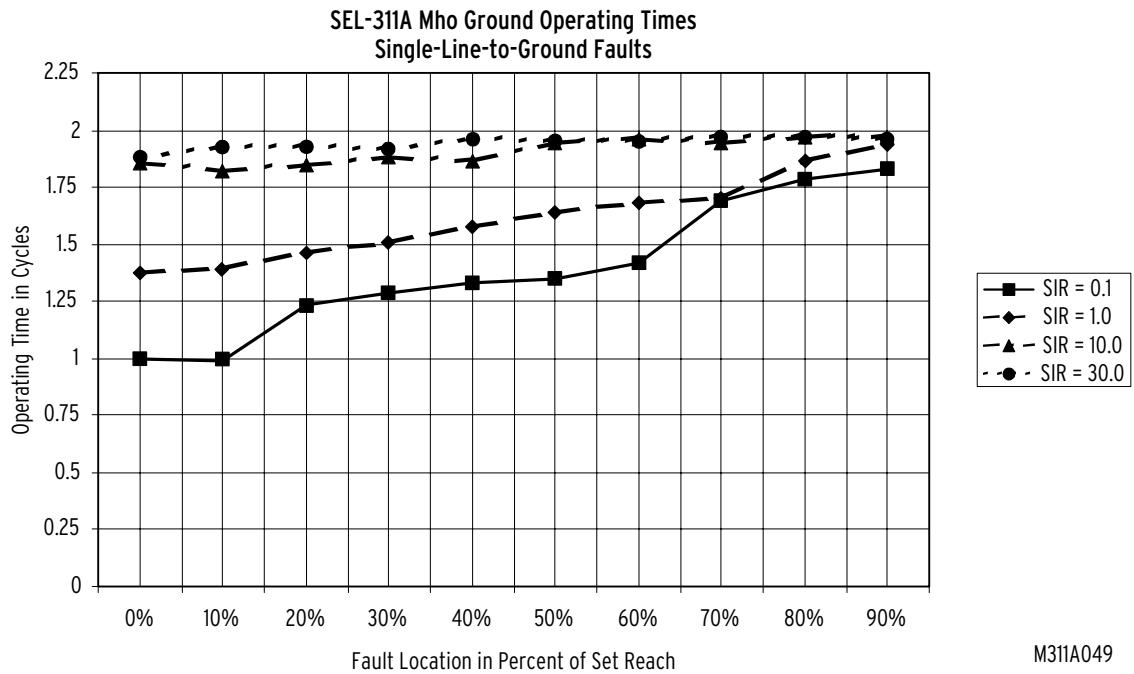
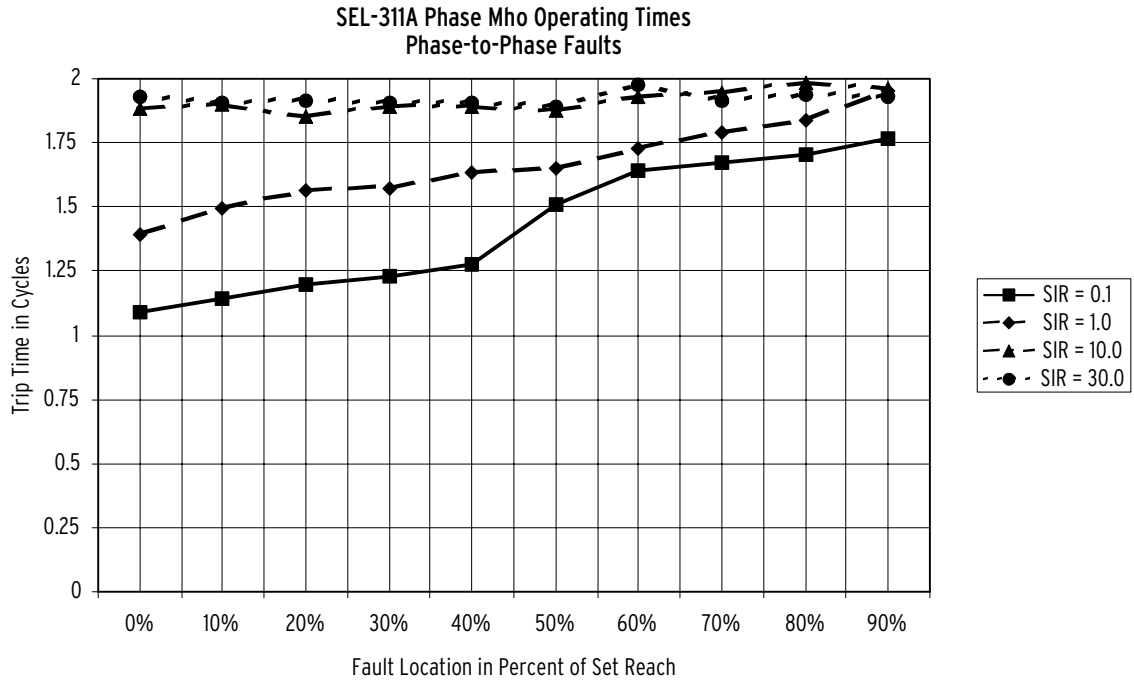
- ① From Figure 4.12 ③ From Figure 4.1
② From Figure 5.3

Figure 3.7: Zone 2 Mho Ground Distance Logic

Distance Element Operating Time Curves at Nominal Frequency

Figure 3.8 shows operating times for the SEL-311A 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.



M311A049

Figure 3.8: Ground and Phase Distance Speed Curves

Additional Distance Element Supervision

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

Phase and ground distance elements are supervised with Fault Identification Selection (FIDS) 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 Time Delay Elements

The SEL-311A Relay supports two philosophies of zone timing: independent or common timing (see Figure 3.9). 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 and Z2D
Independent Phase Timer Settings:	Z1PD and Z2PD
Independent Ground Timer Settings:	Z1GD and Z2GD
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

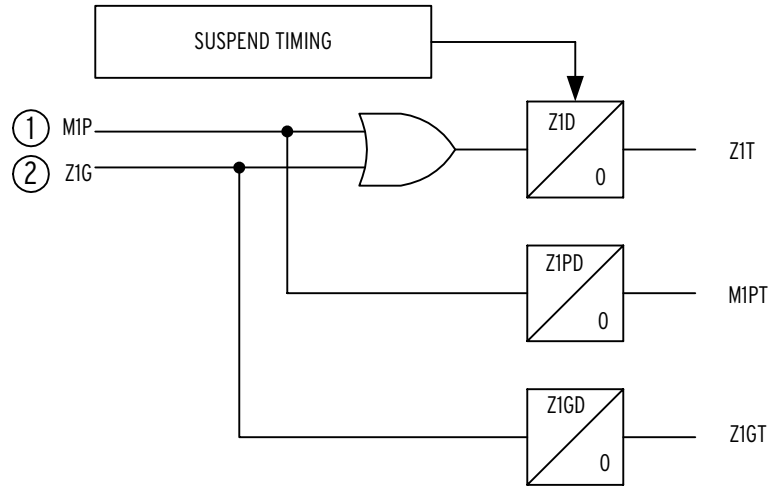
Select independent zone timing by using relay words $MnPT$ and $ZnGT$ (where n is the protection zone number) in the appropriate SELOGIC trip equation.

$$TR = M1P + Z1G + \mathbf{M2PT} + \mathbf{Z2GT} + 51GT$$

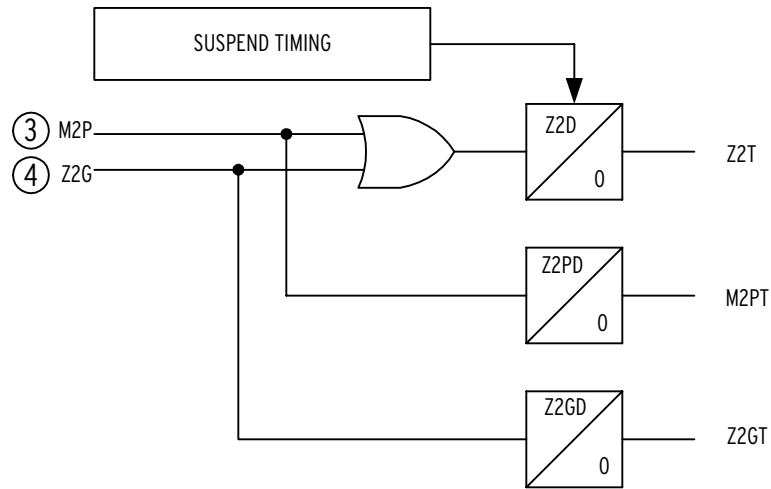
Select common zone timing by using relay words ZnT (where n is the protection zone number) in the appropriate SELOGIC trip equation.

$$TR = M1P + Z1G + \mathbf{Z2T} + 51GT$$

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., $\phi\phi$ to 3ϕ , SLG to $\phi\phi G$). If the timer expires, the suspension logic is blocked.



Zone 1 Delay Timer Logic



Zone 2 Delay Timer Logic

DWG: M311A011a

- ① From Figure 3.4
- ② From Figure 3.6
- ③ From Figure 3.5
- ④ From Figure 3.7

Figure 3.9: Zone Timing Elements

INSTANTANEOUS/DEFINITE-TIME OVERCURRENT ELEMENTS

Phase Instantaneous/Definite-Time Overcurrent Elements

One phase instantaneous/definite-time overcurrent element is available. It is enabled with the E50P enable setting, as shown in Figure 3.10.

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

Settings Ranges

Setting range for pickup setting 50P1P:

OFF, 0.25–100.00 A secondary (5 A nominal phase current inputs, I_A, I_B, I_C)
OFF, 0.05–20.00 A secondary (1 A nominal phase current inputs, I_A, I_B, I_C)

Setting range for definite-time setting 67P1D:

0.00–16000.00 cycles, in 0.25-cycle steps

Accuracy

Pickup: ± 0.05 A secondary and $\pm 3\%$ of setting (5 A nominal phase current inputs, I_A, I_B, I_C)
 ± 0.01 A secondary and $\pm 3\%$ of setting (1 A nominal phase current inputs, I_A, I_B, I_C)

Timer: ± 0.25 cycles and $\pm 0.1\%$ of setting

Transient Overreach: < 5% of setting

Pickup Operation

See the phase instantaneous/definite-time overcurrent element logic in Figure 3.10. The pickup setting is compared to the magnitudes of the individual phase currents I_A, I_B, and I_C. The logic outputs in Figure 3.10 are Relay Word bits and operate as follows:

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

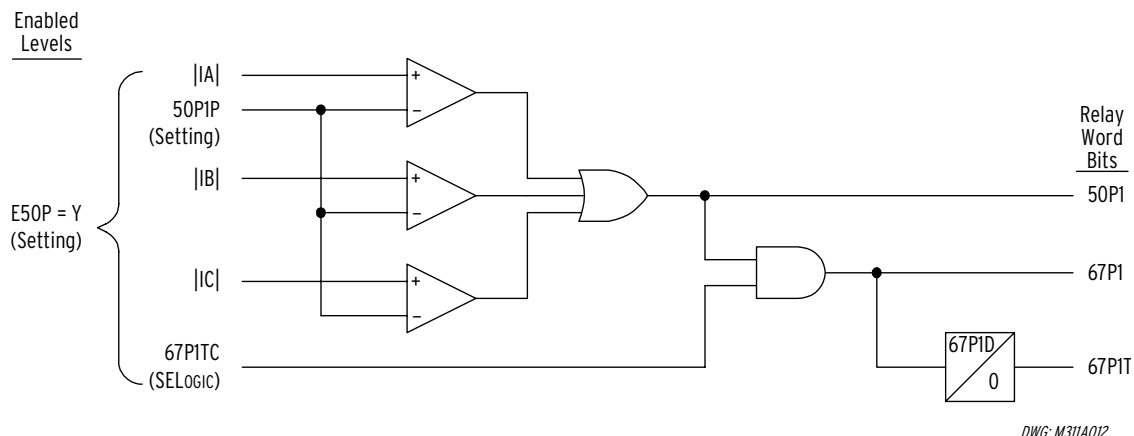


Figure 3.10: Phase Instantaneous/Definite-Time Overcurrent Elements

Torque Control

Setting 50P1P has corresponding SELOGIC control equation torque control setting 67P1TC. SELOGIC control equation torque control settings cannot be set directly to logical 0. The following are torque control setting examples for 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 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 Detection, Load-Encroachment, and Directional Element Logic***.

Pickup and Reset Time Curves

Figure 3.11 and Figure 3.12 show pickup and reset time curves applicable to all nondirectional instantaneous overcurrent elements in the SEL-311A 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 3.11 is adjusted as follows:

- multiples of pickup setting ≤ 4 : add 0.25 cycle
- multiples of pickup setting > 4 : add 0.50 cycle

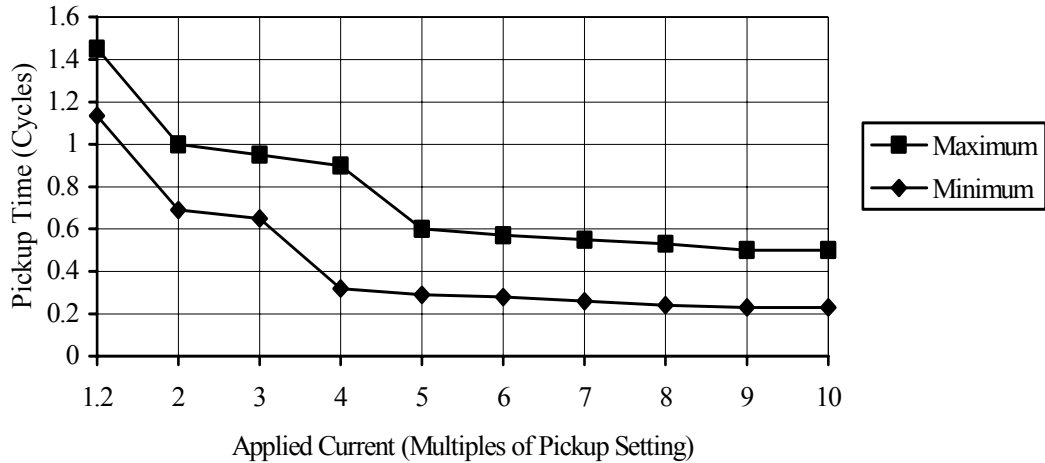


Figure 3.11: SEL-311A Relay Nondirectional Instantaneous Overcurrent Element Pickup Time Curve

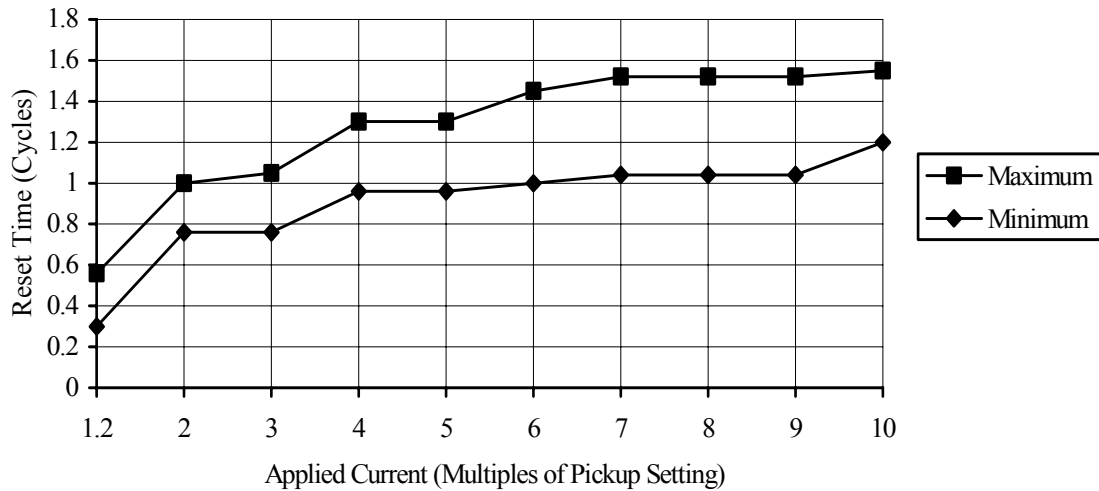


Figure 3.12: SEL-311A Relay Nondirectional Instantaneous Overcurrent Element Reset Time Curve

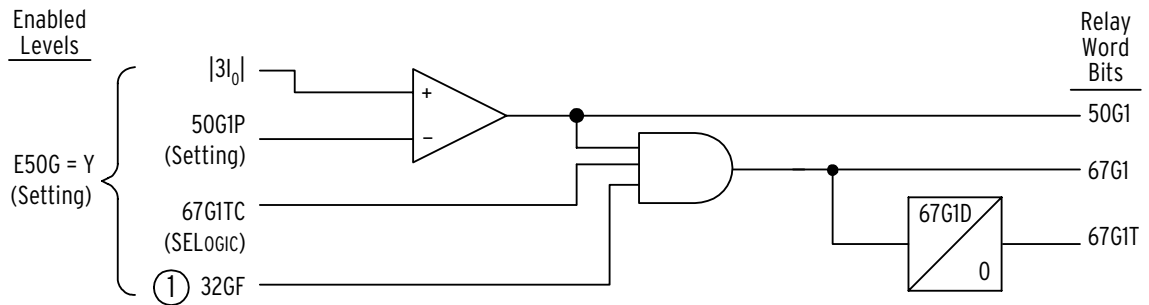
Residual Ground Instantaneous/Definite-Time Overcurrent Elements

One residual ground instantaneous/definite-time overcurrent element is available. It is enabled with the E50G enable setting, as shown in Figure 3.13.

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 3.13, follow the explanation given for Figure 3.10 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 3.13 the 67G1 element has its directional control fixed forward. 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.



DWG: M311A013a

① From Figure 4.12

Figure 3.13: Residual Ground Instantaneous/Definite-Time Overcurrent Elements with Directional and Torque Control

Settings Ranges

Setting range for pickup setting 50G1P:

- 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 setting 67G1D:

0.00–16000.00 cycles, in 0.25-cycle steps

Accuracy

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

Pickup and Reset Time Curves

See Figure 3.11 and Figure 3.12.

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 3.14

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.

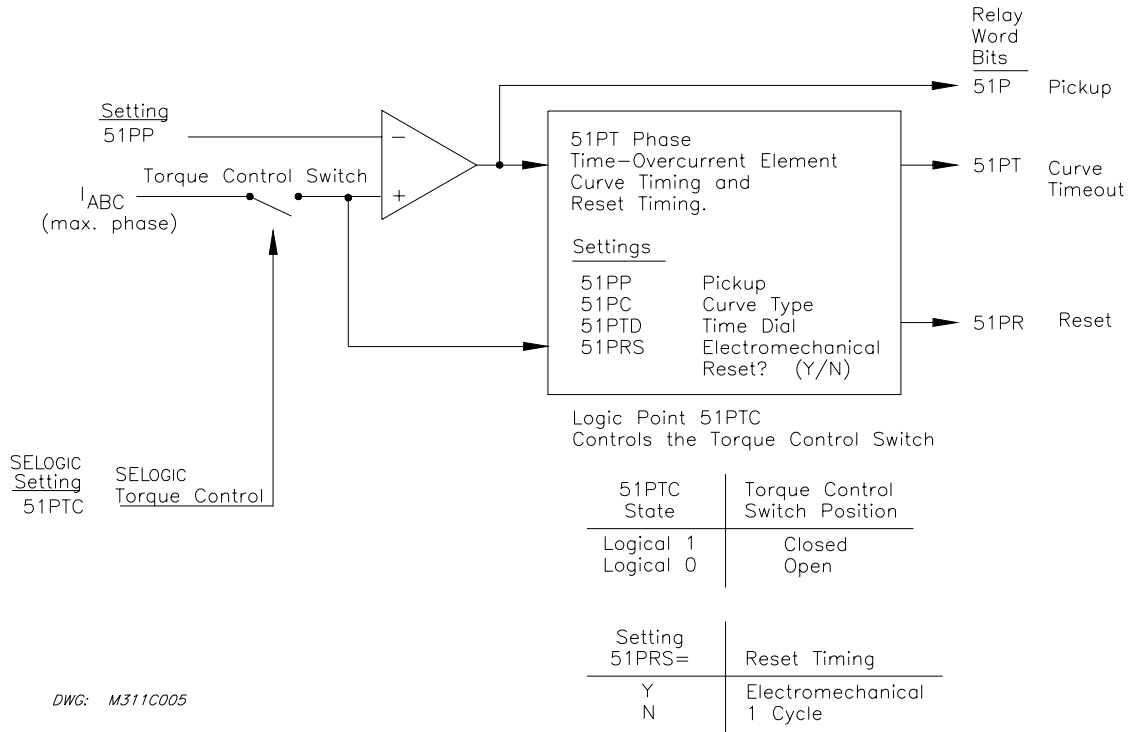


Figure 3.14: Phase Time-Overcurrent Element 51PT

Accuracy

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

Curve Timing: ± 1.50 cycles and $\pm 4\%$ of curve time for currents between (and including) 2 and 30 multiples of pickup

51PT Element Logic Outputs

The logic outputs in Figure 3.14 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 <i>Trip Logic</i> in <i>Section 5: Trip and Target Logic</i> .
51PT	Phase time-overcurrent element is timed out on its curve.	Tripping and other control applications. See <i>Trip Logic</i> in <i>Section 5: Trip and Target Logic</i> .
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 3.14 compares the pickup setting (51PP) to the maximum phase current, I_{ABC} , if the Torque Control Switch is closed. I_{ABC} is also routed to the curve timing/reset timing functions. The Relay Word Bit logic outputs operate as follows with the Torque Control Switch closed:

- 51P = 1 (logical 1), if $I_{ABC} >$ pickup setting 51PP and the phase time-overcurrent element is timing or is timed out on its curve
 = 0 (logical 0), if $I_{ABC} \leq$ pickup setting 51PP
- 51PT = 1 (logical 1), if $I_{ABC} >$ pickup setting 51PP and the phase time-overcurrent element is timed out on its curve
 = 0 (logical 0), if $I_{ABC} >$ pickup setting 51PP and the phase time-overcurrent element is timing, but not yet timed out on its curve
 = 0 (logical 0), if $I_{ABC} \leq$ pickup setting 51PP
- 51PR = 1 (logical 1), if $I_{ABC} \leq$ pickup setting 51PP and the phase time-overcurrent element is fully reset
 = 0 (logical 0), if $I_{ABC} \leq$ pickup setting 51PP and the phase time-overcurrent element is timing to reset (not yet fully reset)
 = 0 (logical 0), if $I_{ABC} >$ pickup setting 51PP and the phase time-overcurrent element is timing or is timed out on its curve

Torque Control Switch Open

If the Torque Control Switch in Figure 3.14 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:

$$I_{ABC} > \text{pickup setting } 51PP$$

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:

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

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 3.14.

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 3.14.

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 3.15, follow the explanation given for Figure 3.14 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.

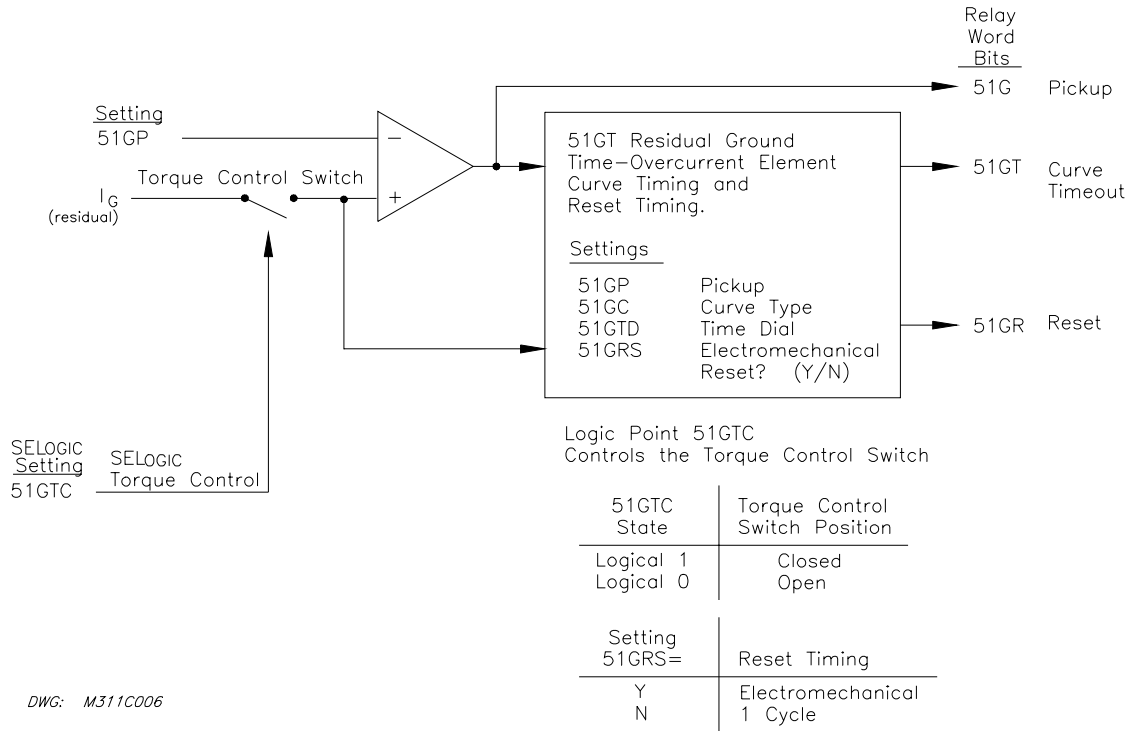


Figure 3.15: Residual Ground Time-Overcurrent Element 51GT

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 $\pm 3\%$ of setting (5 A nominal phase current inputs, IA, IB, IC)

± 0.01 A secondary and $\pm 3\%$ of setting (1 A nominal phase current inputs, IA, IB, IC)

Curve Timing: ± 1.50 cycles and $\pm 4\%$ of curve time for currents between (and including) 2 and 30 multiples of pickup

TABLE OF CONTENTS

SECTION 4: LOSS-OF-POTENTIAL, CCVT TRANSIENT DETECTION, LOAD-ENCROACHMENT, AND DIRECTIONAL ELEMENT LOGIC.....4-1

Loss-of-Potential Logic	4-1
Setting ELOP = Y or Y1	4-2
Setting ELOP = Y	4-2
Setting ELOP = N	4-2
CCVT Transient Detection Logic	4-2
Load-Encroachment Logic.....	4-3
Settings Ranges	4-5
Load-Encroachment Setting Example.....	4-5
Convert Power Factors to Equivalent Load Angles	4-6
Use SEL-321 Relay Application Guide for the SEL-311A Relay	4-8
Directional Control for Ground Distance and Residual Ground Overcurrent Elements.....	4-8
Directional Element Enables.....	4-10
Best Choice Ground Directional™ Logic.....	4-10
Directional Elements.....	4-10
Directional Element Routing.....	4-10
Directional Control for Phase Distance and Negative-Sequence Elements.....	4-18
Internal Enables.....	4-18
Directional Elements.....	4-19
Directional Element Routing.....	4-19
Directional Control Settings	4-21
Settings Made Automatically	4-21
Settings.....	4-22
E32IV—SELOGIC® Control Equation Enable	4-26
Overcurrent Directional Control Provided by Torque Control Settings	4-27

TABLES

Table 4.1: Elements Controlled by Zone/Level Direction Settings (Corresponding Overcurrent and Directional Element Figure Numbers in Parentheses).....	4-22
Table 4.2: Torque Control Settings and Elements	4-27

FIGURES

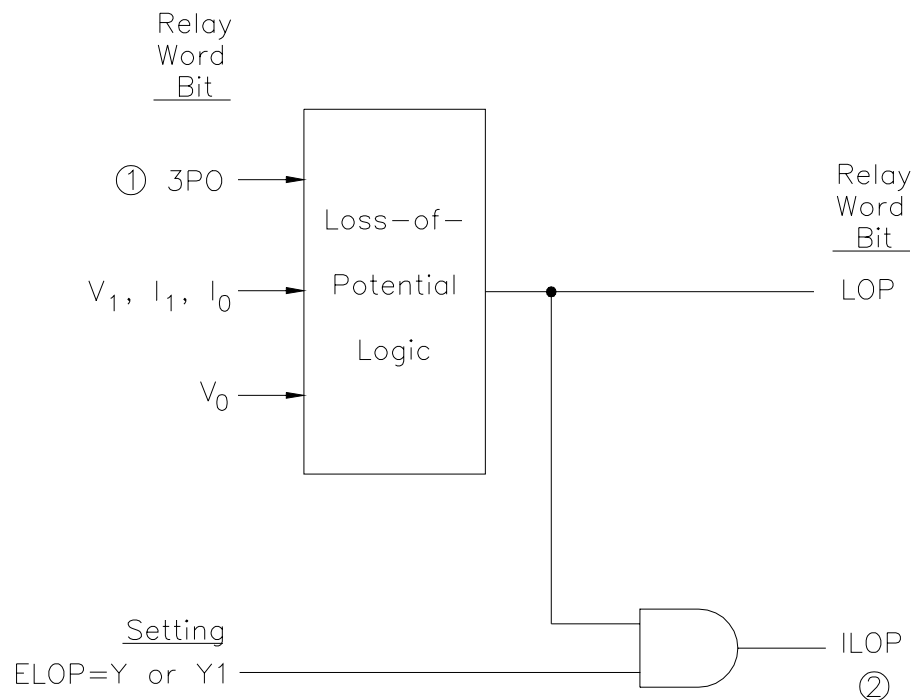
Figure 4.1: Loss-of-Potential Logic	4-1
Figure 4.2: CCVT Transient Blocking Logic.....	4-3
Figure 4.3: Load-Encroachment Logic with Example Settings	4-4
Figure 4.4: Migration of Apparent Positive-Sequence Impedance for a Fault Condition.....	4-7
Figure 4.5: General Logic Flow of Directional Control for Ground Distance and Residual Ground Overcurrent Elements.....	4-9
Figure 4.6: Internal Enables (32QE and 32QGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements.....	4-12

Figure 4.7: Internal Enables (32VE and 32IE) Logic for Zero-Sequence Voltage-Polarized and Channel IP Current-Polarized Directional Elements.....	4-13
Figure 4.8: Best Choice Ground Directional Logic	4-14
Figure 4.9: Negative-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements.....	4-15
Figure 4.10: Zero-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements.....	4-16
Figure 4.11: Channel IP Current-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements.....	4-17
Figure 4.12: Ground Distance and Residual Ground Directional Logic	4-17
Figure 4.13: General Logic Flow of Directional Control for Negative-Sequence Phase Overcurrent and Phase Distance Elements.....	4-18
Figure 4.14: Negative-Sequence Voltage-Polarized Directional Element for Phase Distance and Negative-Sequence Elements.....	4-20
Figure 4.15: Positive-Sequence Voltage-Polarized Directional Element for Phase Distance Elements.....	4-21

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.



DWG: M311A014a

- ① From Figure 5.3 ② To Figure 3.4 through Figure 3.7,
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 (Figure 3.4 through Figure 3.7).

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 3.7). 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).

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-311A 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-311A 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.

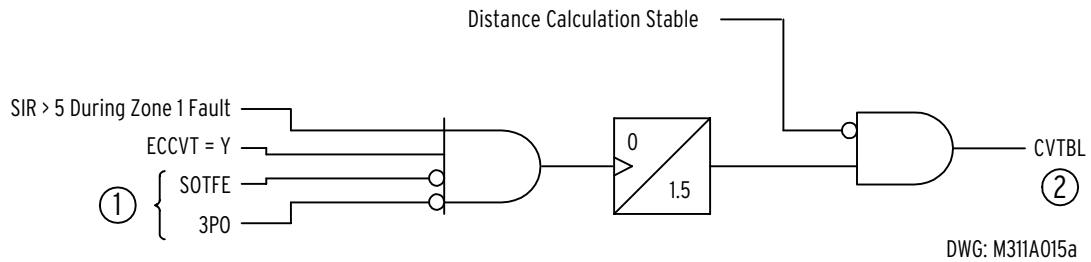
Consider using CCVT transient detection logic when you have either of the following conditions:

- 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*.



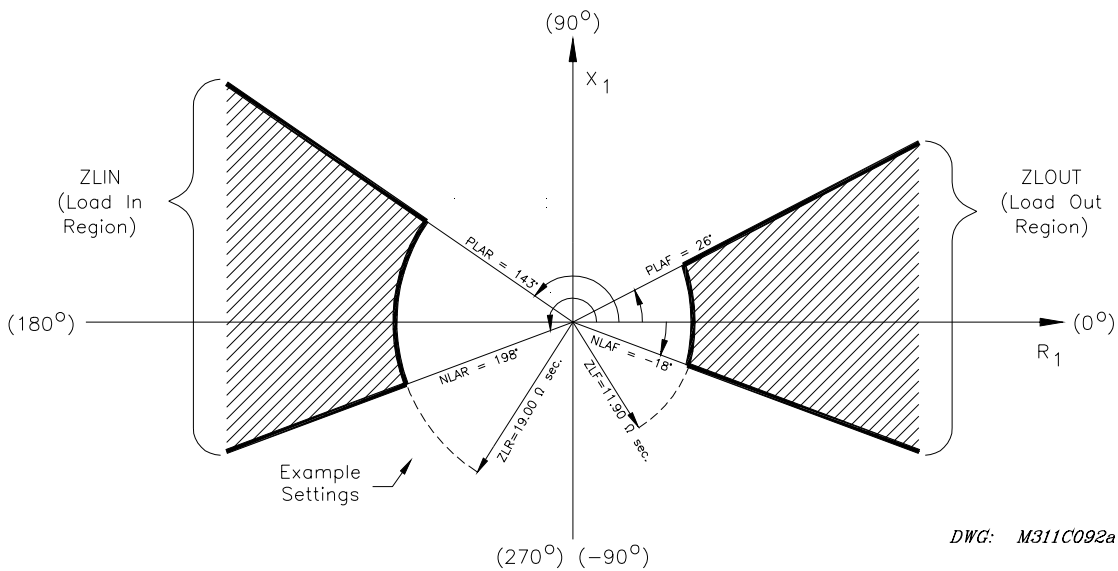
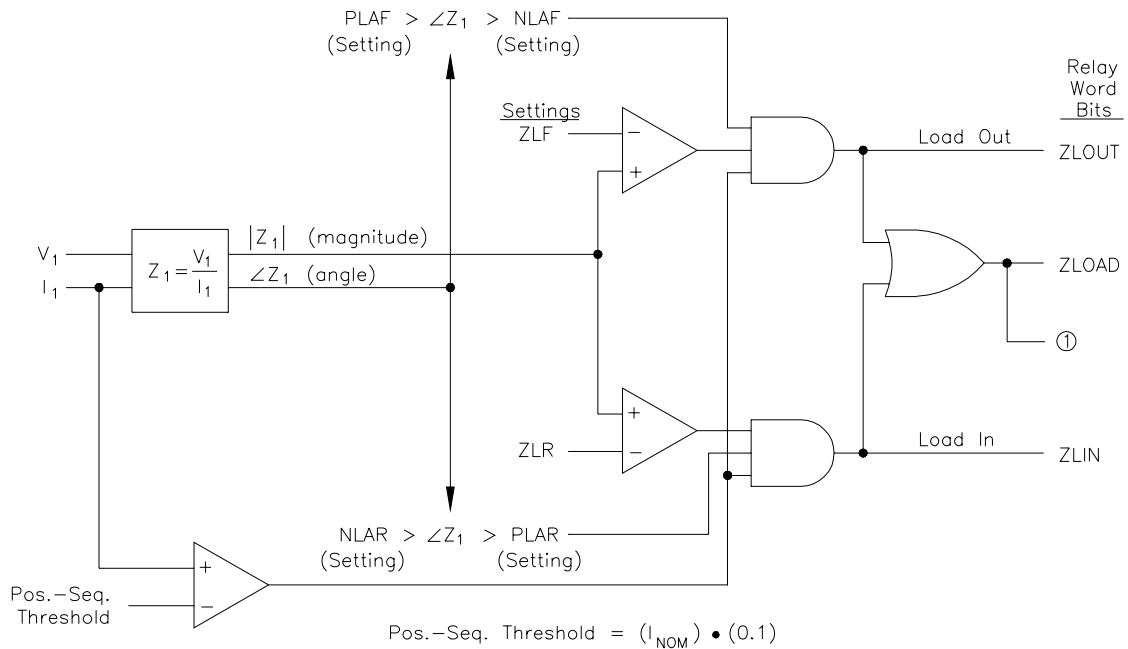
① From Figure 5.3 ② To Figure 3.4 and Figure 3.6

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 and M2P, 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:

$$800 \text{ MVA} \cdot (1/3) = 267 \text{ MVA per phase}$$

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

$$267 \text{ MVA} \cdot (1/132.8 \text{ kV}) \cdot (1000 \text{ kV/MV}) = 2010 \text{ A primary}$$

$$2010 \text{ A primary} \cdot (1/\text{CT ratio}) = 2010 \text{ A primary} \cdot (1 \text{ A secondary}/400 \text{ A primary}) \\ = 5.03 \text{ A secondary}$$

$$132.8 \text{ kV} \cdot (1000 \text{ V/kV}) = 132800 \text{ V primary}$$

$$132800 \text{ V primary} \cdot (1/\text{PT ratio}) = 132800 \text{ V primary} \cdot (1 \text{ V secondary}/2000 \text{ V primary}) \\ = 66.4 \text{ V secondary}$$

Now, calculate the equivalent secondary impedance:

$$66.4 \text{ V secondary} / 5.03 \text{ A secondary} = 13.2 \text{ } \Omega \text{ secondary}$$

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

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

Again, for the maximum forward load:

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

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

$$\text{ZLF} = 13.2 \text{ } \Omega \text{ secondary} \cdot 0.9 = 11.90 \text{ } \Omega \text{ secondary}$$

For the maximum reverse load:

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

Again, to provide a margin for setting ZLR:

$$\text{ZLR} = 21.1 \text{ } \Omega \text{ secondary} \cdot 0.9 = 19.00 \text{ } \Omega \text{ secondary}$$

Convert Power Factors to Equivalent Load Angles

The power factor (forward load) can vary from 0.90 lag to 0.95 lead.

$$\text{Setting PLAF} = \cos^{-1}(0.90) = 26^\circ$$

$$\text{Setting NLAF} = \cos^{-1}(0.95) = -18^\circ$$

The power factor (reverse load) can vary from 0.80 lag to 0.95 lead.

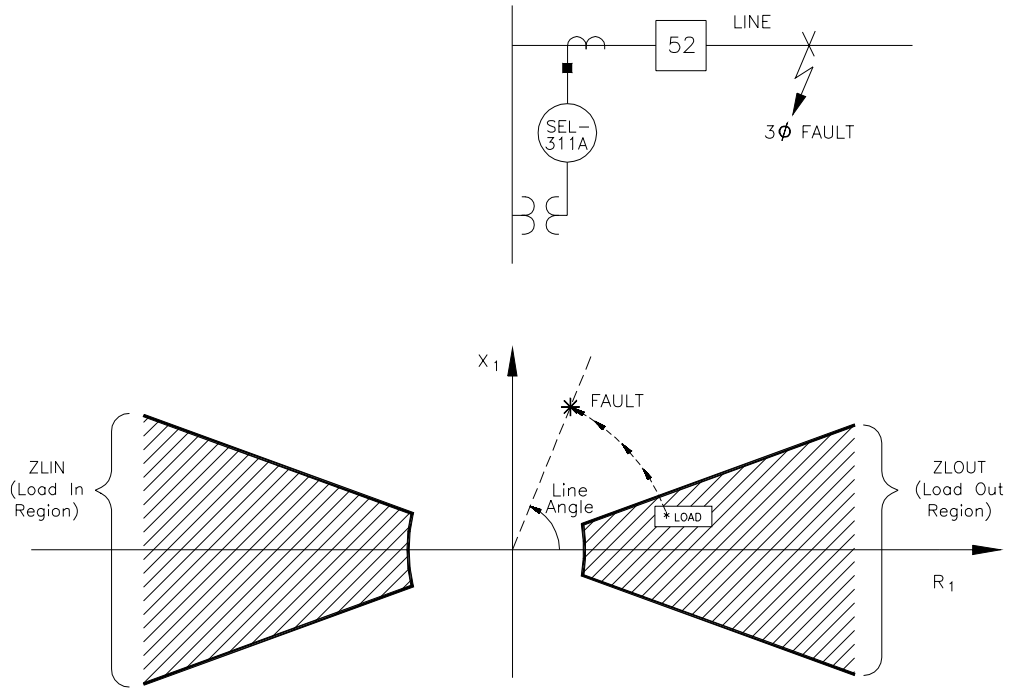
$$\text{Setting PLAR} = 180^\circ - \cos^{-1}(0.80) = 180^\circ - 37^\circ = 143^\circ$$

$$\text{Setting NLAR} = 180^\circ + \cos^{-1}(0.95) = 180^\circ + 18^\circ = 198^\circ$$

Apply Load-Encroachment Logic to a Phase Time-Overcurrent

Again, from Figure 4.3:

$$\text{ZLOAD} = \text{ZLOUT} + \text{ZLIN}$$



DWG: M311A047

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 within the ZLOAD area, resulting in:

$$ZLOAD = ZLOAD + ZLIN = \text{logical 1} + ZLIN = \text{logical 1}$$

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

$$ZLOAD = ZLOAD + ZLIN = \text{logical 0} + \text{logical 0} = \text{logical 0}$$

Refer to Figure 3.14 in **Section 3: Distance and Overcurrent Elements**. To prevent phase time-overcurrent element 51PT from operating for high load conditions, make the following SELLOGIC[®] control equation torque control setting:

$$51PTC = !ZLOAD$$

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

$$51PTC = !(\text{logical 1}) = \text{NOT}(\text{logical 1}) = \text{logical 0}$$

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

$$51PTC = !ZLOAD = !(\text{logical 0}) = \text{NOT}(\text{logical 0}) = \text{logical 1}$$

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

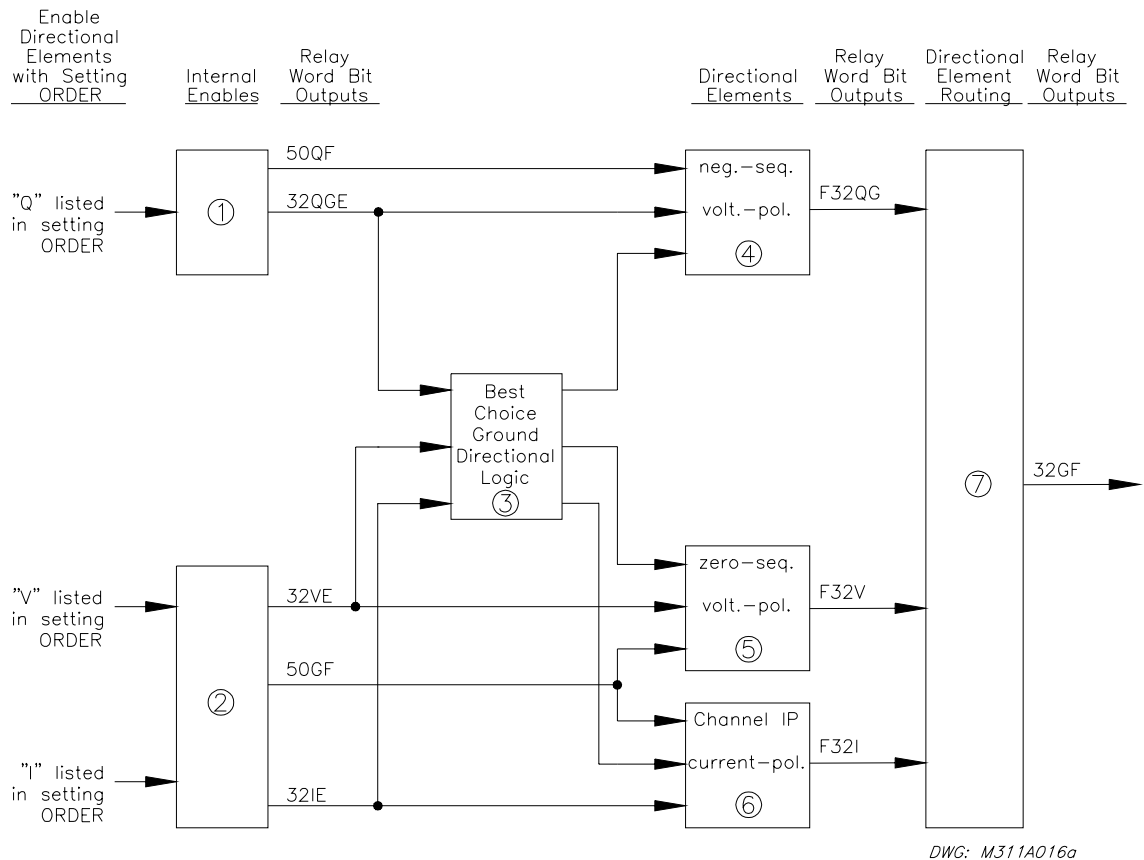
The load-encroachment logic and settings in the SEL-311A Relay are the same as those in the SEL-321 Relay. Refer to *Application Guide 93-10 (SEL-321 Relay Load-Encroachment Function Setting Guidelines)* for applying the load-encroachment logic in the SEL-311A Relay.

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

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.

Loss-of-Potential

Note in Figure 4.12 that if all the following are true:

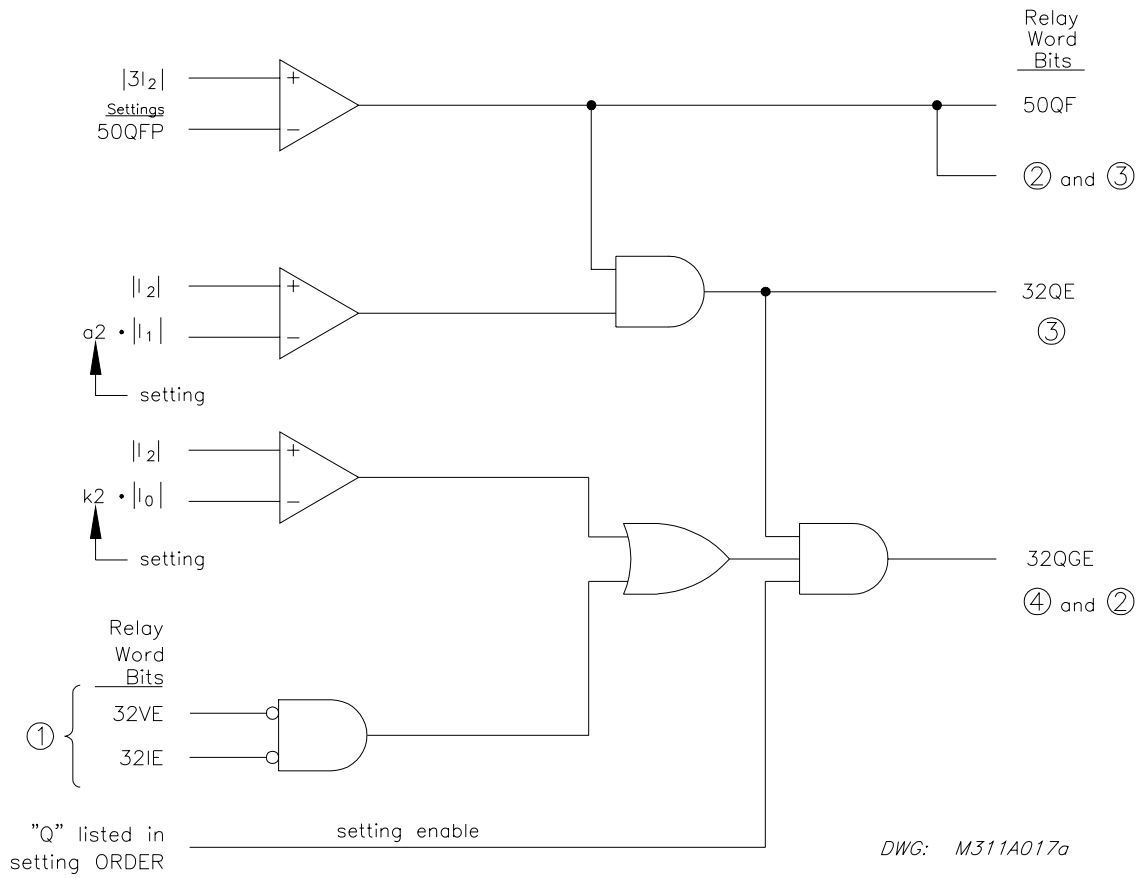
- enable setting ELOP = Y,
- a loss-of-potential condition occurs (Relay Word bit LOP asserts),
- and internal enable 32IE (for channel IP current-polarized directional element) is not asserted

then the forward logic point (Relay Word bit 32GF) asserts to logical 1, thus, enabling Levels 1 and 2 residual ground overcurrent elements. 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 3.6 and Figure 3.7, ILOP also disables all ground distance elements.



- ① From Figure 4.7
- ② To Figure 4.9
- ③ To Figure 4.14
- ④ To Figure 4.8

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

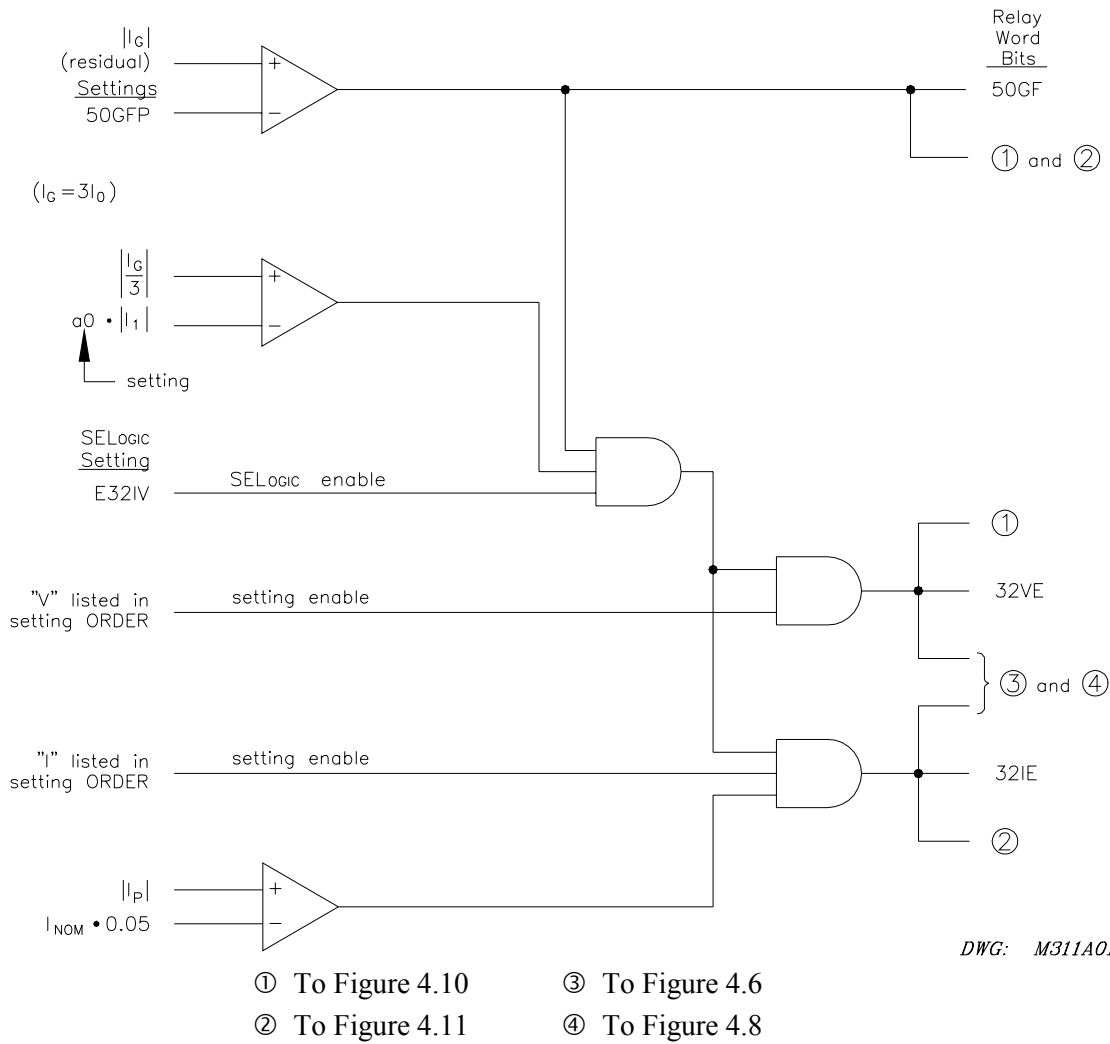
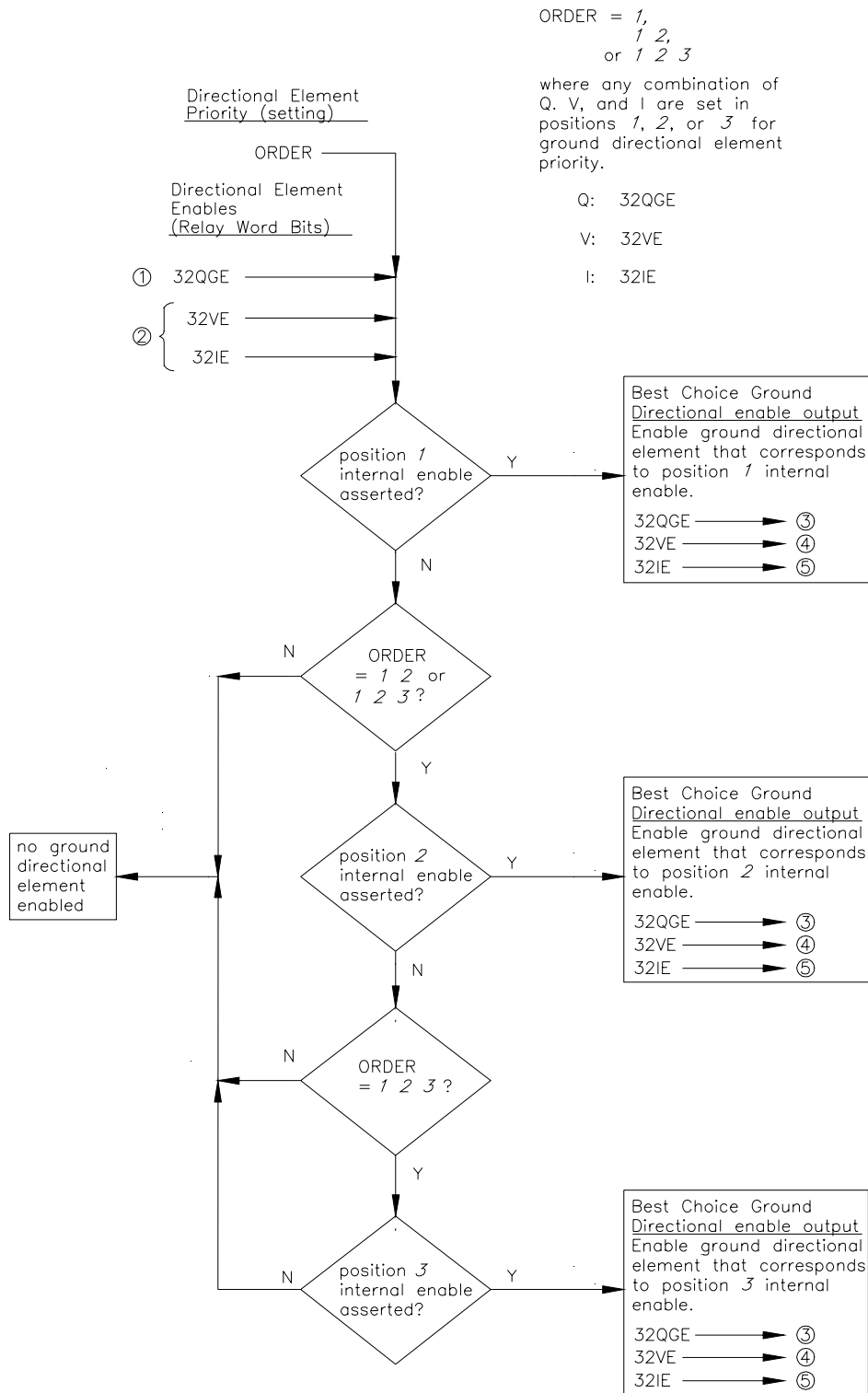


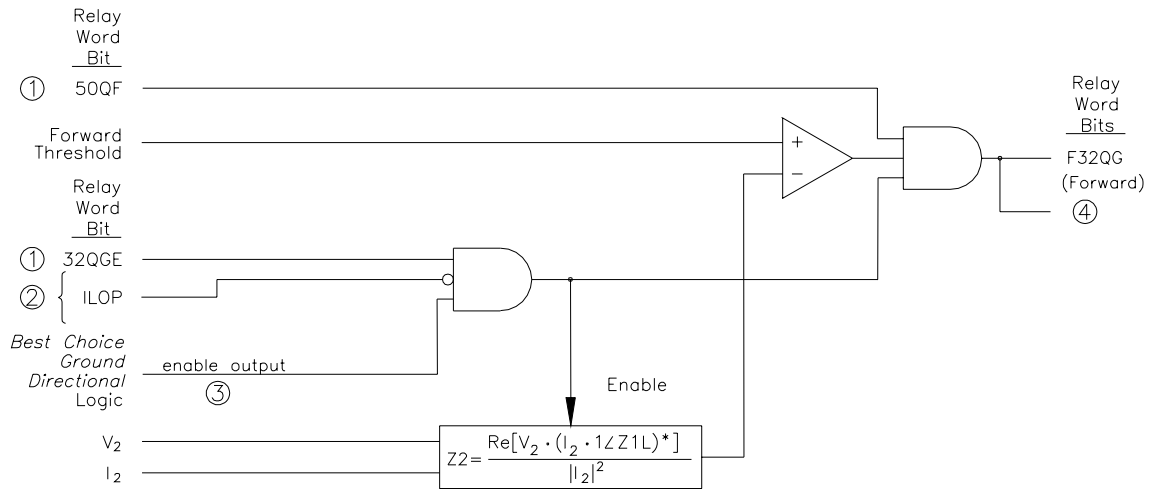
Figure 4.7: Internal Enables (32VE and 32IE) Logic for Zero-Sequence Voltage-Polarized and Channel IP Current-Polarized Directional Elements



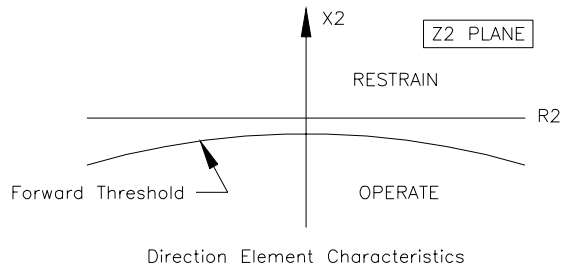
DWG: M311C055a

- ① From Figure 4.6
- ② From Figure 4.7
- ③ Figure 4.9
- ④ Figure 4.10
- ⑤ Figure 4.11

Figure 4.8: Best Choice Ground Directional Logic



Note: $1Z Z1L = \text{One OHM at the Positive-Sequence Line Angle}$



Forward Threshold:

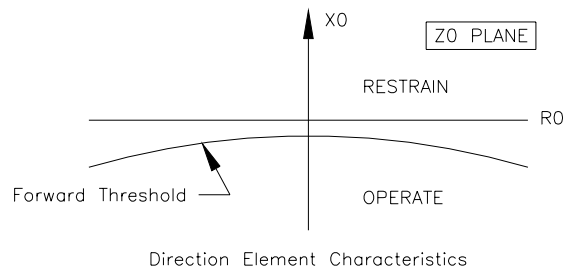
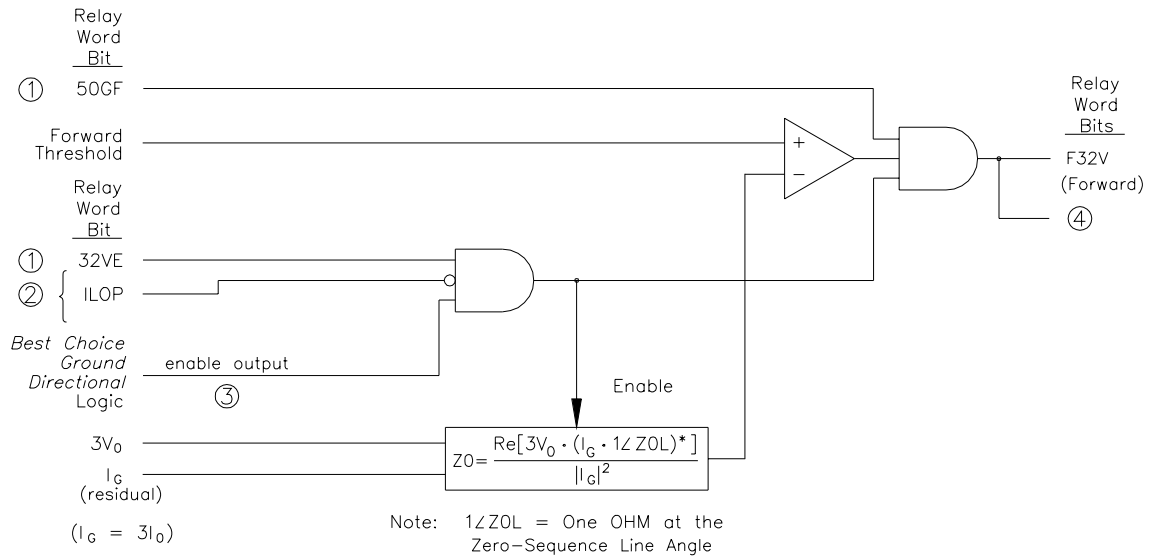
$$\text{If } Z2F \text{ Setting} \leq 0, \text{ Forward Threshold} = 0.75 \cdot Z2F - 0.25 \cdot \left| \frac{V_2}{I_2} \right|$$

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

DWG: M311A019a

- 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



Forward Threshold:

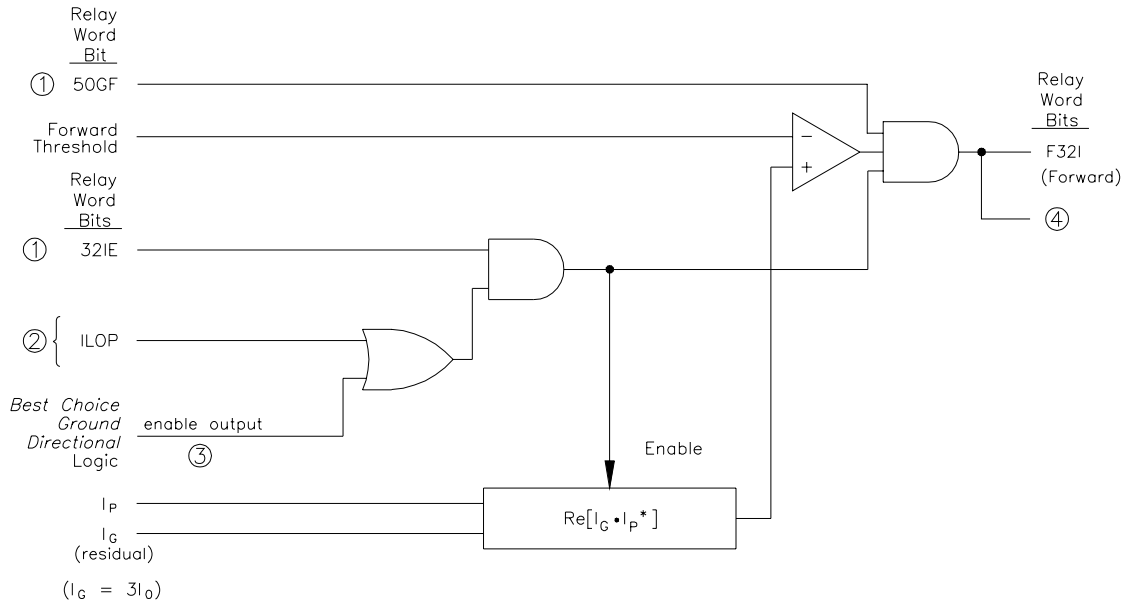
$$\text{If } Z0F \text{ Setting} \leq 0, \text{ Forward Threshold} = 0.75 \cdot Z0F - 0.25 \cdot \left| \frac{V_0}{I_0} \right|$$

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

DWG: M311A020a

- 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



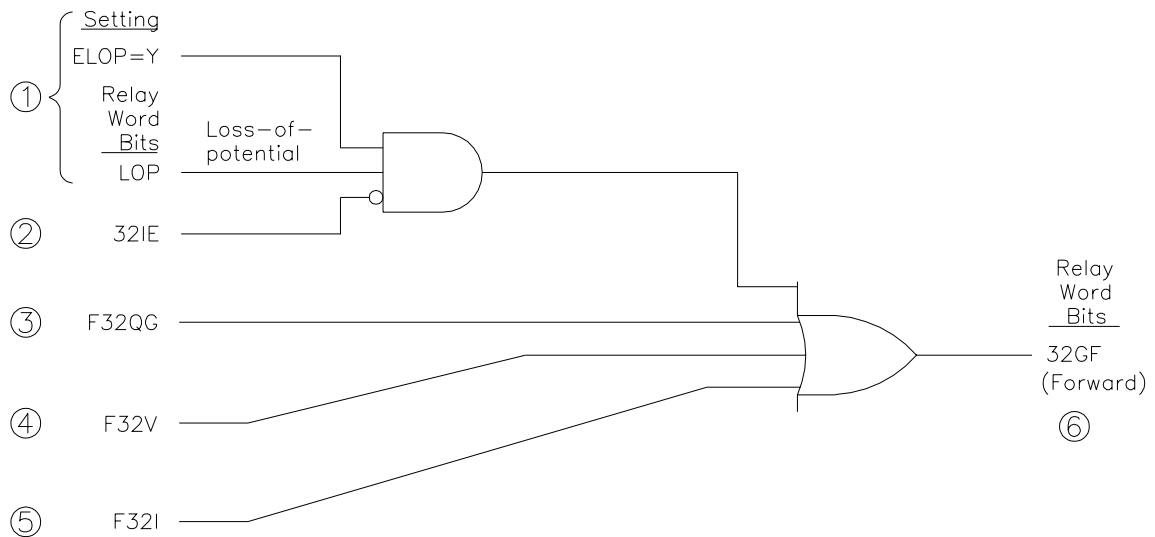
Forward Threshold

$$\text{Forward Threshold} = (\text{channel } I_p \text{ nominal rating}) \cdot (\text{phase channels nominal rating}) \cdot (0.05)^2$$

DWG: M311A021a

- 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



DWG: M311A022a

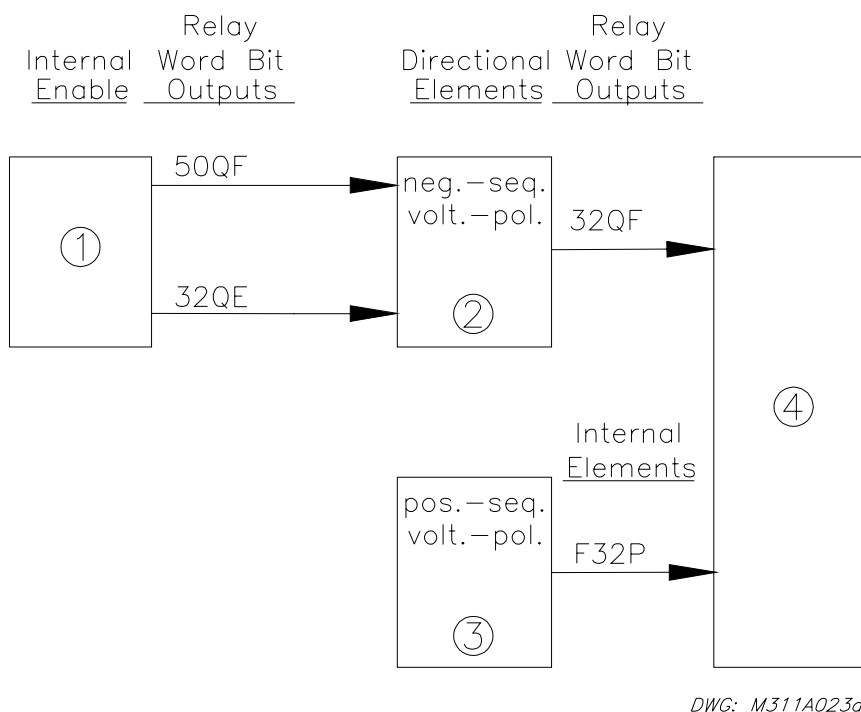
- ① From Figure 4.1 ⑤ From Figure 4.11
 ② From Figure 4.7 ⑥ To Figure 3.6, Figure 3.7
 ③ From Figure 4.9 and Figure 3.13
 ④ From Figure 4.10

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 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
- ② Figure 4.14
- ③ Figure 4.15
- ④ Figure 3.4 and Figure 3.5

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). The negative-sequence voltage-polarized directional element operates for unbalanced faults while the positive-sequence voltage-polarized directional element operates for three-phase faults. Refer to Figure 4.1 and accompanying text for more information on loss-of-potential.

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) logic point.

Loss-of-Potential

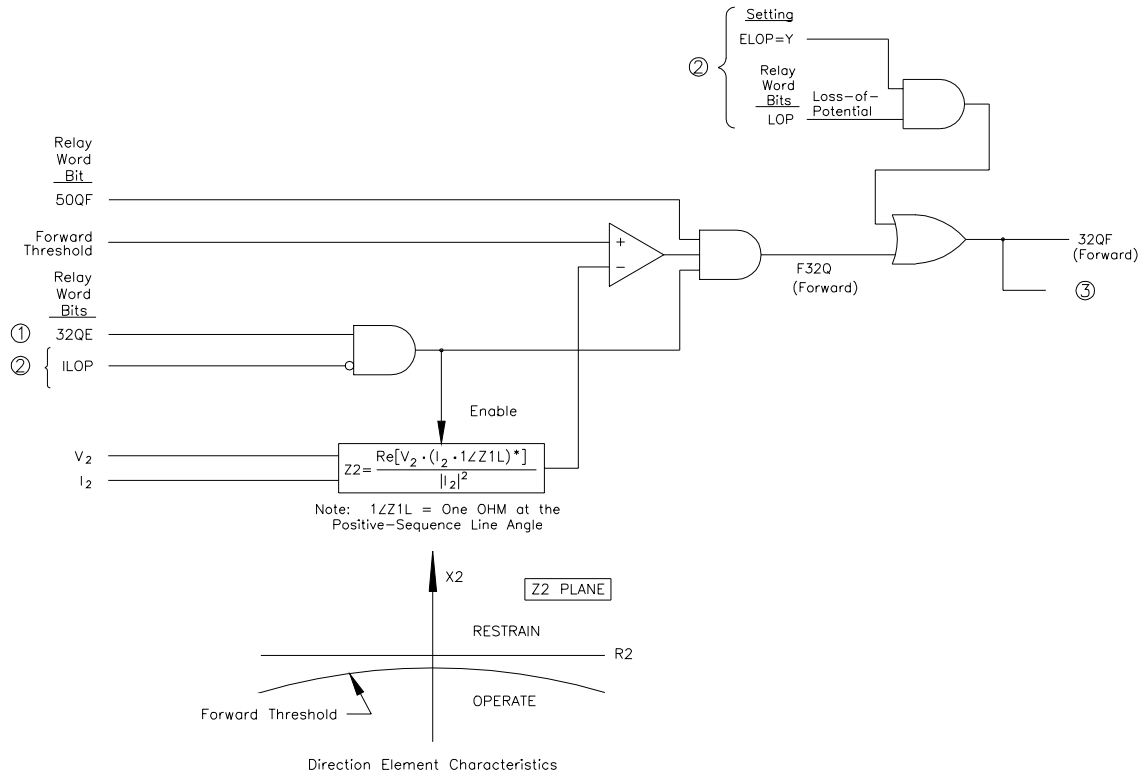
Note if both the following are true:

- 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 and Figure 3.5, ILOP also disables all phase distance elements.



Forward Threshold:

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

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

DWG: M311A024

- ① From Figure 4.6
- ② From Figure 4.1
- ③ From Figure 3.4 and Figure 3.5

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

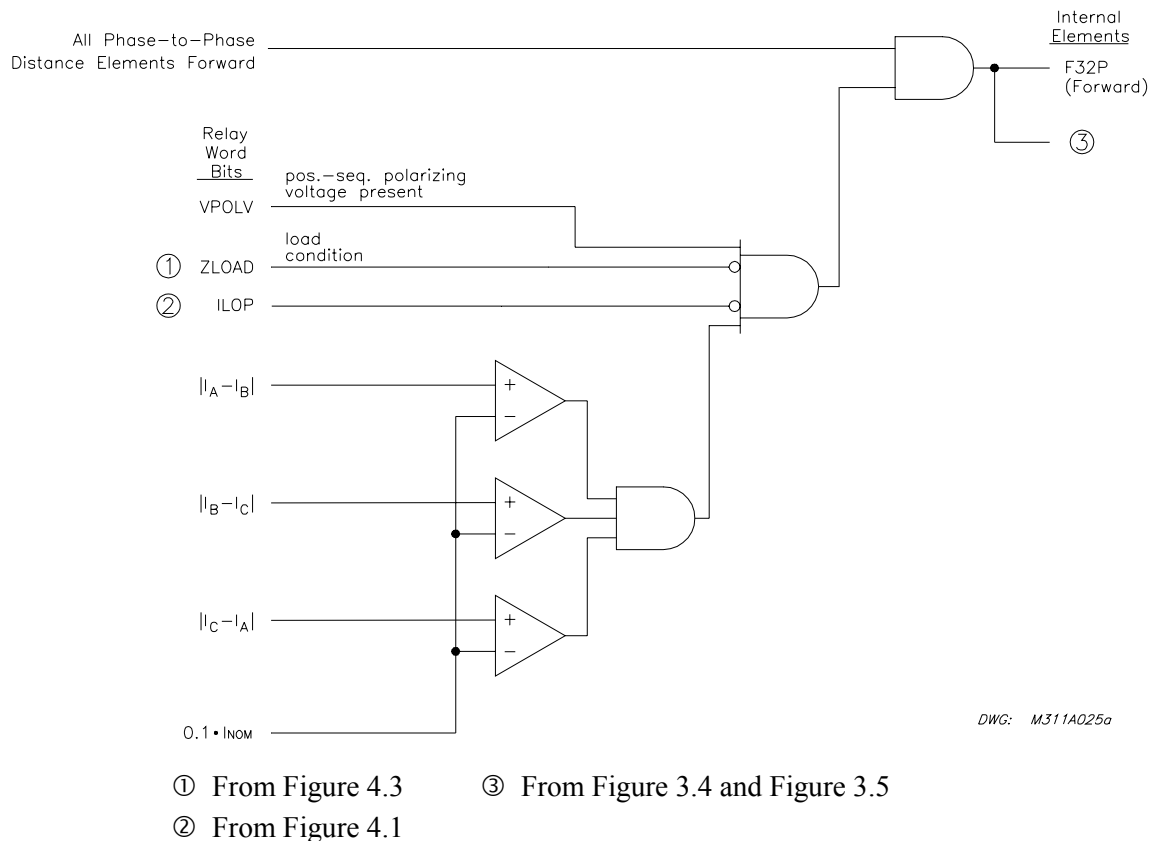


Figure 4.15: Positive-Sequence Voltage-Polarized Directional Element for Phase Distance Elements

DIRECTIONAL CONTROL SETTINGS

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

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

Settings Made Automatically

If the directional control enable setting E32 is set:

E32 = AUTO

then the following directional control settings are calculated and set automatically:

Z2F, 50QFP, a2, k2, 50GFP, a0, and Z0F

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 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.

Table 4.1 shows the elements that are directionally controlled.

**Table 4.1: Elements Controlled by Zone/Level Direction Settings
(Corresponding Overcurrent and Directional Element Figure Numbers in Parentheses)**

Phase Distance	Ground Distance	Residual Ground
M1P (3.4)	Z1G (3.6)	67G1 (3.12)
M1PT (3.8)	Z1GT (3.8)	67G1T (3.12)
M2P (3.5)	Z2G (3.7)	
M2PT (3.8)	Z2GT (3.8)	

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:

$$\text{ORDER} = \text{QV}$$

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:

$$\text{ORDER} = \text{V}$$

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

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 is used to calculate the Forward Threshold for the negative-sequence voltage-polarized directional elements (see Figure 4.9 and Figure 4.14).

If configuration setting E32 = Y, setting Z2F (negative-sequence impedance) is calculated by the user and entered by the user.

Z2F Set Automatically

If configuration setting E32 = AUTO, setting Z2F (negative-sequence impedance) is calculated automatically, using the positive-sequence line impedance magnitude setting Z1MAG as follows:

$$Z2F = Z1MAG/2 \quad (\Omega \text{ secondary})$$

50QFP–Forward 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.

50QFP Set Automatically

If configuration setting E32 = AUTO, setting 50QFP is set automatically at:

50QFP = 0.50 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)

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

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 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:

$$|I_2| > k \bullet |I_0|$$

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

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 setting 50GFP is 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.

50GFP Set Automatically

If configuration setting E32 = AUTO, setting 50GFP is set automatically at:

50GFP = 0.50 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)

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

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 setting Z0F is not made or displayed.

Z0F is used to calculate the Forward Threshold for the zero-sequence voltage-polarized directional elements (see Figure 4.10).

If configuration setting E32 = Y, settings Z0F (zero-sequence impedance) is calculated by the user and entered by the user.

Z0F Set Automatically

If configuration setting E32 = AUTO, setting Z0F (zero-sequence impedance) is calculated automatically, using the zero-sequence line impedance magnitude setting Z0MAG as follows:

$$Z0F = Z0MAG/2 \quad (\Omega \text{ secondary})$$

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:

$$E32IV = 1 \quad (\text{numeral } 1)$$

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-311A Relay:

$$E32IV = IN106 \quad (52a \text{ connected to optoisolated input IN106})$$

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
67G1TC	67G1/67G1T	Forward and Torque Control
51PTC	51P/51PT	Torque Control
51GTC	51G/51GT	Torque Control

TABLE OF CONTENTS

SECTION 5: TRIP AND TARGET LOGIC	5-1
Trip Logic	5-1
Set Trip	5-2
Unlatch Trip	5-3
Factory Settings Example (Using Setting TR).....	5-4
Additional Settings Examples.....	5-5
Program an Output Contact for Tripping.....	5-5
Switch-Onto-Fault (SOTF) Trip Logic.....	5-6
Three-Pole Open Logic.....	5-7
Circuit Breaker Operated Switch-Onto-Fault Logic.....	5-8
Close Bus Operated Switch-Onto-Fault Logic	5-9
Switch-Onto-Fault Logic Output (SOTFE)	5-9
Switch-Onto-Fault Trip Logic Trip Setting (TRSOTF)	5-9
Front-Panel Target LEDs.....	5-10
Additional Target LED Information	5-10
Target Reset/Lamp Test Front-Panel Pushbutton.....	5-12

TABLES

Table 5.1: SEL-311A Relay Front-Panel Target LED Definitions	5-10
--	------

FIGURES

Figure 5.1: Trip Logic.....	5-2
Figure 5.2: Minimum Trip Duration Timer Operation (See Bottom of Figure 5.1).....	5-3
Figure 5.3: Three-Pole Open Logic (Top) and Switch-Onto-Fault Logic (Bottom).....	5-7
Figure 5.4: Seal-in of Breaker Failure Occurrence for Message Display.....	5-13

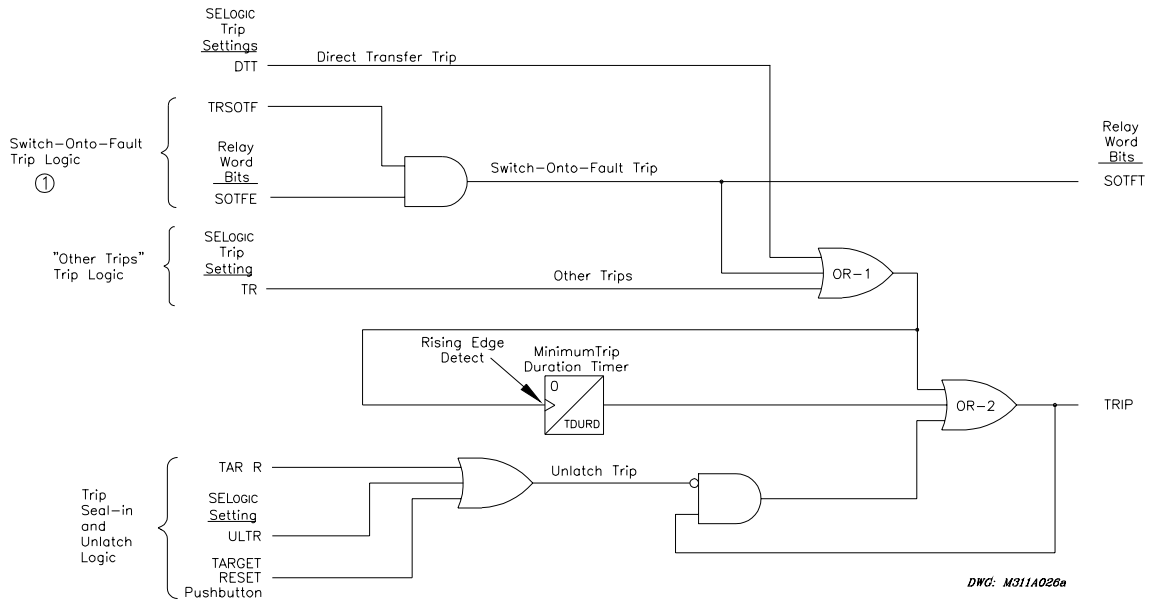
SECTION 5: TRIP AND TARGET LOGIC

TRIP LOGIC

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

DTT	<p>Direct Transfer Trip Conditions.</p> <p>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.</p> <p>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 <i>Front-Panel Target LEDs</i> subsection at the end of this section).</p> <p>Typical settings for DTT are:</p> <p style="text-align: center;">DTT = IN106 or DTT = RMB1A</p> <p>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.</p>
TRSOTF	<p>Switch-Onto-Fault Trip Conditions.</p> <p>Setting TRSOTF is supervised by the switch-onto-fault condition SOTFE. See <i>Switch-Onto-Fault (SOTF) Trip Logic</i> on page 5-6 for more information on switch-onto-fault logic.</p>
TR	<p>Other Trip Conditions.</p> <p>Setting TR is the SELOGIC control equation trip setting most often used if tripping does not involve communications-assisted (setting DTT) or switch-onto-fault (setting TRSOTF) trip logic.</p> <p>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.</p>
ULTR	<p>Unlatch Trip Conditions.</p>
TDURD	<p>Minimum Trip Duration Time.</p> <p>This timer establishes the <u>minimum</u> 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.</p>

More than one trip setting (or all three trip settings DTT, TRSOTF, and TR) can be set. For example, 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

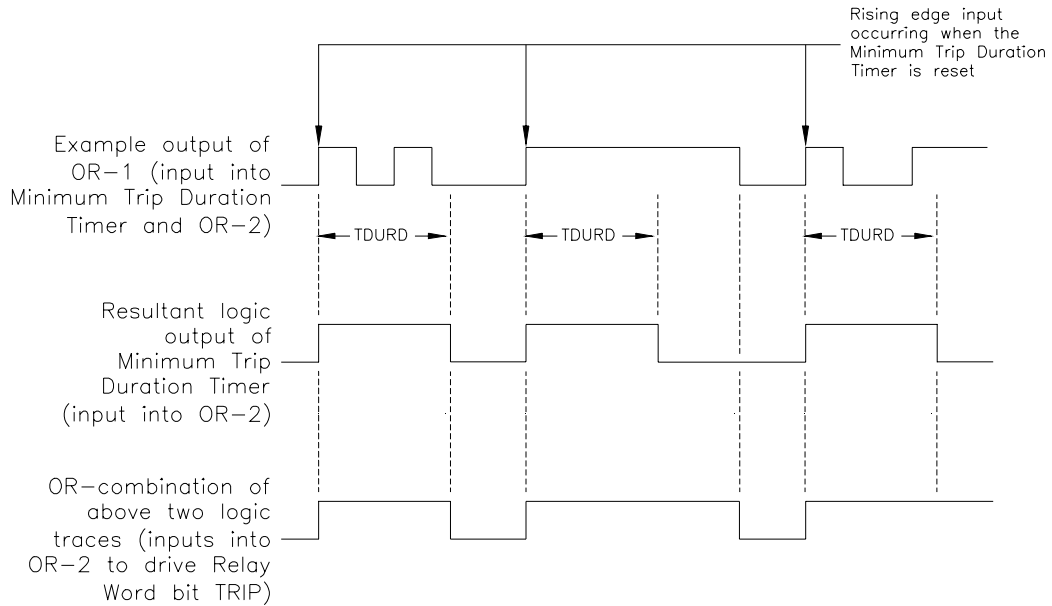
Refer to Figure 5.1. All trip conditions:

- 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.



DWG. M35195

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:

$$TR = \dots + OC$$

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:

$$TR = \dots + OC * IN105$$

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.

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 “switch-onto-fault” trip logic at the top of Figure 5.1 is 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:

$$\begin{aligned} \text{TR} &= \text{M1P} + \text{Z1G} + \text{M2PT} + \text{Z2GT} + \text{51GT} + \text{OC} && \text{(trip conditions)} \\ \text{ULTR} &= \text{!(50L} + \text{51G)} && \text{(unlatch trip conditions)} \end{aligned}$$

The factory setting for the Minimum Trip Duration Timer setting is:

$$\text{TDURD} = 9.000 \text{ cycles}$$

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

Set Trip

In SELOGIC control equation setting $\text{TR} = \text{M1P} + \text{Z1G} + \text{M2PT} + \text{Z2GT} + \text{51GT} + \text{OC}$:

- Distance elements M1P, M2PT, Z1G, and Z2GT and time-overcurrent element 51GT trip directly. Time-overcurrent and definite-time overcurrent elements can be torque controlled (e.g., element 51GT is torque controlled by SELOGIC control equation setting 51GTC). 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 $\text{TDURD} = 9.000$ 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.

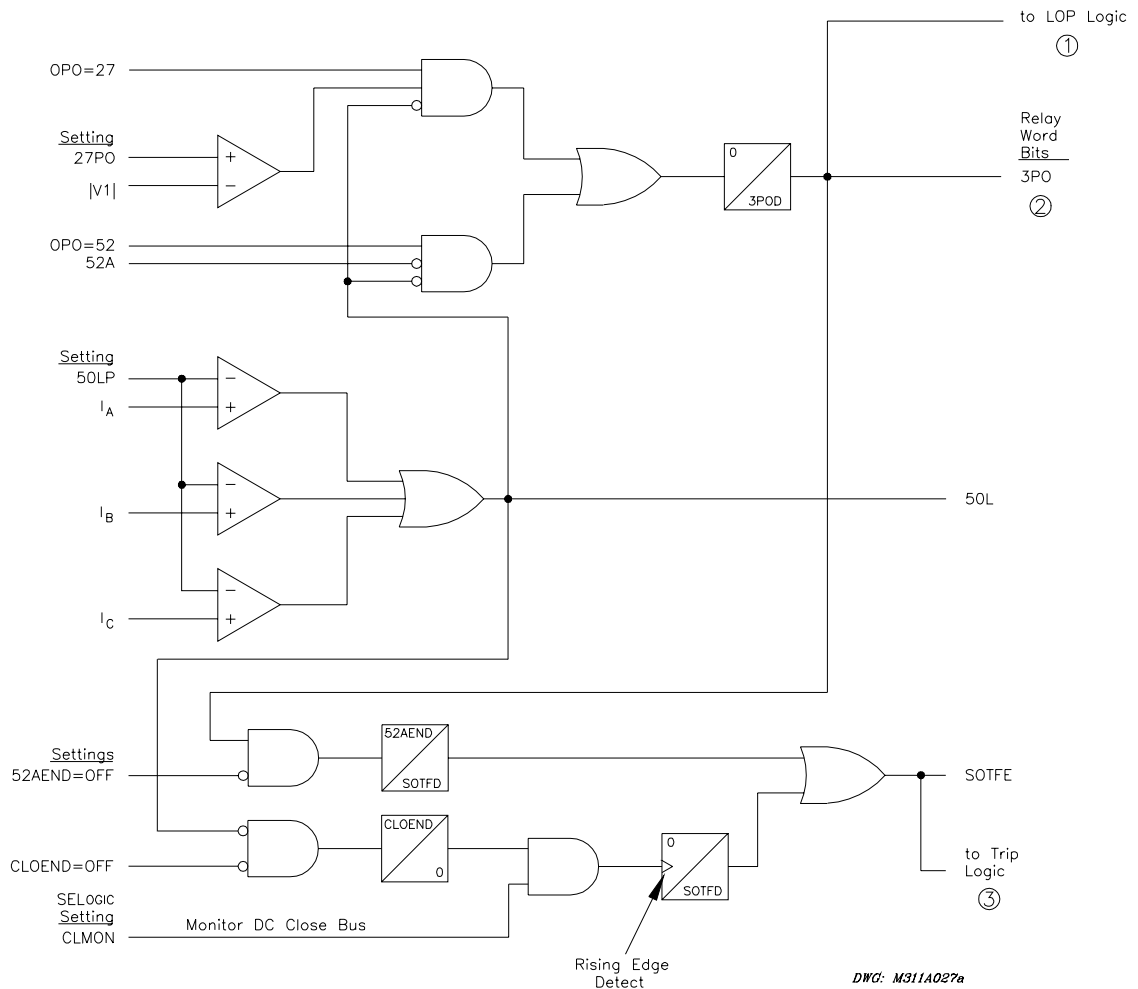
SWITCH-ONTO-FAULT (SOTF) TRIP LOGIC

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

③ Figure 5.1

② To Figure 3.6 and Figure 3.7

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 1 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, and the circuit breaker is open (52A = logical 0) and current is below phase pickup 50LP (50L = logical 0), then the three-pole open (3PO) condition is true:

3PO = logical 1 (circuit breaker open)

If OPO = 27, and |V1| is less than setting 27PO, and current is below phase pickup 50LP (50L = logical 0), then the three-pole open (3PO) condition is true:

3PO = logical 1 (circuit breaker open)

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-311A Relay and OPO = 52, SELOGIC control equation setting 52A may be set:

52A = 0 (numeral 0)

With SELOGIC control equation setting 52A continually at logical 0, 3PO logic is controlled solely by load detection element 50L. Phase pickup 50LP is set below load current levels.

When the circuit breaker is open, Relay Word bit 50L drops out (= logical 0) and the 3PO condition asserts:

3PO = logical 1 (circuit breaker open)

When the circuit breaker is closed, Relay Word bit 50L picks up (= logical 0; current above phase pickup 50LP) and the 3PO condition deasserts after the 3POD dropout time:

3PO = logical 0 (circuit breaker closed)

Note that the 3PO condition is also routed to the loss-of-potential (LOP) logic (see Figure 4.1).

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-311A 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-311A 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:

$$\text{CLMON} = \text{IN105}$$

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-311A Relay Front-Panel Target LED Definitions

LED Number	LED Label	Definition
1	EN	Relay Enabled—see subsection <i>Relay Self-Tests</i> in <i>Section 13: Testing and Troubleshooting</i>
2	TRIP	Indication that a trip occurred, by a protection or control element
3	TIME	Time delayed trip
4	DT	Direct transfer trip (DTT)
5	SOTF	Switch-onto-fault trip
6	LOP	Loss-of-potential
7	51P	Phase time-overcurrent trip
8	51G	Ground time-overcurrent element trip
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	67P	Phase instantaneous torque-controlled element picked up at time of trip
16	67G	Forward directional ground instantaneous torque-controlled element picked up at time of trip

Target LEDs numbered 2 through 5 and 7 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 7 through 16), but the TRIP target LED still illuminates. Thus, tripping via the front-panel local control (local bits) or serial port (remote bits or OPEN command) 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., $FAULT = 51G + M2P + Z2G$) 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 DT (see Figure 5.1).

Use the DT target LED to **indicate direct 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, they should illuminate the DT target LED. Set them in SELOGIC control equation setting DTT:

$$DTT = \dots + OC + RB1$$

Additionally, if SCADA asserts optoisolated input IN104 to trip, it should illuminate the DT target LED. Set it in SELOGIC control equation setting DTT also:

$$DTT = \dots + IN104 + \dots$$

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).

LOP Target LEDs

If LOP Relay Word bit asserts (see Figure 4.1 in *Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic*), target LED LOP illuminates and remains illuminated until LOP deasserts.

51P Target LED

The 51P target LED illuminates at the rising edge of trip if time-overcurrent element 51PT causes the trip.

51G Target LED

The 51G target LED illuminates at the rising edge of trip if time-overcurrent element 51GT causes the trip.

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, Z1G, Z2G, 67G1).

67 Target LED

A 67 target LED (67P, 67G) illuminates at the rising edge of trip if any of the following elements causes the trip or was picked up at the time of trip: 67P1, 67G1, 67P1T, or 67G1T.

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 7 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):

$$SV8 = (SV8 + SV7T) * !TRGTR$$

$$DP3 = SV8$$

$$DP3_1 = \text{BREAKER FAILURE}$$

$$DP3_0 = \text{(blank)}$$

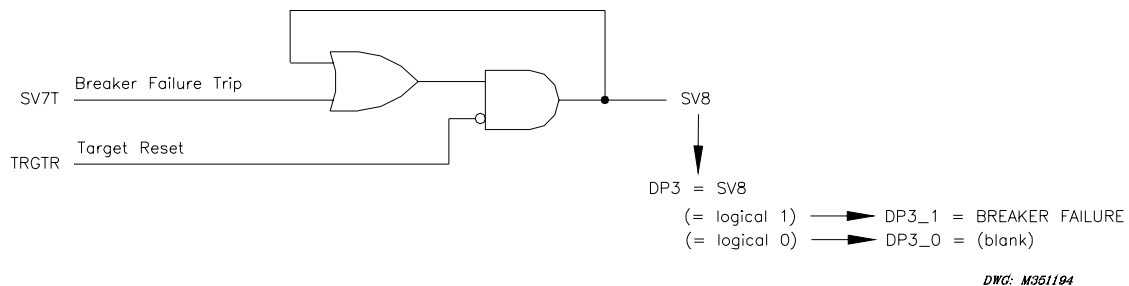


Figure 5.4: Seal-in of Breaker Failure Occurrence for Message Display

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.

TABLE OF CONTENTS

SECTION 6: CLOSE LOGIC	6-1
Close Logic	6-1
Set Close	6-2
Unlatch Close	6-2
Factory Settings Example	6-2
Defeat the Close Logic	6-3
Circuit Breaker Status	6-3
Program an Output Contact for Closing	6-4

FIGURES

Figure 6.1: Close Logic	6-1
-------------------------------	-----

SECTION 6: CLOSE LOGIC

CLOSE LOGIC

This section describes the final logic that controls the close output contact (e.g., OUT103 = CLOSE). This output contact closes the circuit breaker for other close conditions (e.g., manual close initiation via serial port or optoisolated inputs).

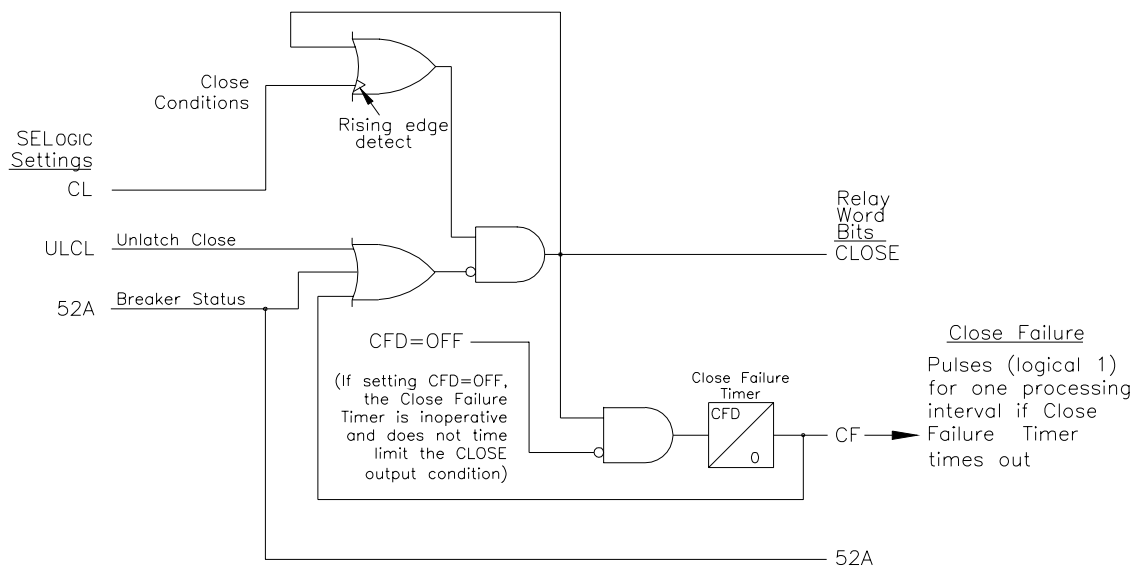
The close logic in Figure 6.1 provides flexible circuit breaker closing with SELOGIC control equation settings:

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

and setting:

- CFD (Close Failure Time)

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



DWG: M311A028

Figure 6.1: Close Logic

Set Close

If all the following are true:

- The unlatch close condition is not asserted (ULCL = logical 0).
- The circuit breaker is open (52A = logical 0).
- 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 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:

$$CL = \dots + CC$$

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:

$$CL = \dots + CC * IN106$$

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 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:

$$\begin{aligned} 52A &= IN101 \\ CL &= CC \\ ULCL &= TRIP \end{aligned}$$

The factory setting for the Close Failure Timer setting is:

$$CFD = 60.00 \text{ cycles}$$

See the settings sheets at the end of ***Section 9: Setting the Relay*** for setting ranges.

Set Close

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.

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:

$$\text{OUT103} = \text{CLOSE}$$

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

TABLE OF CONTENTS

SECTION 7: INPUTS, OUTPUTS, TIMERS, AND OTHER CONTROL LOGIC 7-1

Optoisolated Inputs	7-1
Input Debounce Timers.....	7-2
Input Functions	7-3
Settings Example 1	7-3
Local Control Switches.....	7-5
Local Control Switch Types	7-6
Settings Examples.....	7-8
Additional Local Control Switch Application Ideas.....	7-9
Local Control Switch States Retained	7-9
Remote Control Switches	7-10
Remote Bit Application Ideas.....	7-10
Remote Bit States Not Retained When Power Is Lost.....	7-11
Remote Bit States Retained When Settings Changed or Active Setting Group Changed.....	7-11
Latch Control Switches.....	7-11
Latch Control Switch Application Ideas.....	7-13
Circuit Breaker Closing Enable/Disable Setting Example	7-13
Latch Control Switch States Retained	7-16
Reset Latch Bits for Active Setting Group Change	7-17
Note: Make Latch Control Switch Settings with Care	7-17
Multiple Setting Groups	7-20
Active Setting Group Indication	7-20
Selecting the Active Setting Group.....	7-20
Operation of SELOGIC [®] Control Equation Settings SS1 Through SS6.....	7-21
Operation of Serial Port GROUP Command and Front-Panel GROUP Pushbutton	7-21
Relay Disabled Momentarily During Active Setting Group Change	7-22
Active Setting Group Switching Example 1	7-22
Active Setting Group Switching Example 2	7-25
Active Setting Group Retained	7-28
Note: Make Active Setting Group Switching Settings with Care.....	7-29
SELOGIC Control Equation Variables/Timers	7-29
Settings Example	7-30
Additional Settings Example 1	7-31
Additional Settings Example 2	7-32
Timers Reset When Power Is Lost, Settings Are Changed, or Active Setting Group Is Changed.....	7-32
Output Contacts	7-32
Factory Settings Example	7-33
Operation of Output Contacts for Different Output Contact Types	7-33
Rotating Default Display (Only on Models with LCD)	7-35
Traditional Indicating Panel Lights	7-35
Traditional Indicating Panel Lights Replaced with Rotating Default Display	7-35

General Operation of Rotating Default Display Settings	7-36
Settings Examples	7-36
Additional Settings Examples	7-38
Active Setting Group Switching Considerations	7-39
Additional Rotating Default Display Example	7-41
Displaying Time-Overcurrent Elements on the Rotating Default Display	7-41
Displaying Time-Overcurrent Elements Example	7-42
Displaying Metering Quantities on the Rotating Default Display	7-43
Displaying Metering Values Example	7-45
Displaying Breaker Monitor Output Information on the Rotating Default Display	7-46
Displaying Breaker Monitor Outputs Example	7-47

TABLES

Table 7.1: Correspondence Between Local Control Switch Positions and Label Settings	7-6
Table 7.2: Correspondence Between Local Control Switch Types and Required Label Settings	7-7
Table 7.3: Definitions for Active Setting Group Indication Relay Word Bits SG1 Through SG6	7-20
Table 7.4: Definitions for Active Setting Group Switching SELOGIC Control Equation Settings SS1 Through SS6	7-21
Table 7.5: SELOGIC Control Equation Settings for Switching Active Setting Group Between Setting Groups 1 and 4	7-23
Table 7.6: Active Setting Group Switching Input Logic	7-25
Table 7.7: SELOGIC Control Equation Settings for Rotating Selector Switch Active Setting Group Switching	7-26
Table 7.8: Mnemonic Settings for Metering on the Rotating Default Display	7-43
Table 7.9: Mnemonic Settings for Self-Check Status on the Rotating Default Display	7-46

FIGURES

Figure 7.1: Example Operation of Optoisolated Inputs IN101 Through IN106	7-2
Figure 7.2: Circuit Breaker Auxiliary Contact and Close Enable Switch Connected to Optoisolated Inputs IN101 and IN102	7-3
Figure 7.3: Local Control Switches Drive Local Bits LB1 Through LB16	7-5
Figure 7.4: Local Control Switch Configured as an ON/OFF Switch	7-6
Figure 7.5: Local Control Switch Configured as an OFF/MOMENTARY Switch	7-7
Figure 7.6: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch	7-7
Figure 7.7: Configured Manual Trip Switch Drives Local Bit LB3	7-8
Figure 7.8: Configured Manual Close Switch Drives Local Bit LB4	7-8
Figure 7.9: Remote Control Switches Drive Remote Bits RB1 Through RB16	7-10
Figure 7.10: Traditional Latching Relay	7-12
Figure 7.11: Latch Control Switches Drive Latch Bits LT1 Through LT16	7-12
Figure 7.12: Pushbutton Contact Pulses Input IN104 to Enable/Disable Circuit Breaker Closing	7-13
Figure 7.13: Latch Control Switch Controlled by a Single Input to Enable/Disable Circuit Breaker Closing	7-14
Figure 7.14: Latch Control Switch Operation Time Line	7-16
Figure 7.15: Time Line for Reset of Latch Bit LT2 After Active Setting Group Change	7-17
Figure 7.16: Latch Control Switch (with Time Delay Feedback) Controlled by a Single Input to Enable/Disable Circuit Breaker Closing	7-18

Figure 7.17: Latch Control Switch (with Time Delay Feedback) Operation Time Line.....	7-19
Figure 7.18: SCADA Contact Pulses Input IN105 to Switch Active Setting Group Between Setting Groups 1 and 4.....	7-22
Figure 7.19: SELOGIC Control Equation Variable Timer SV8T Used in Setting Group Switching.....	7-23
Figure 7.20: Active Setting Group Switching (with Single Input) Time Line.....	7-25
Figure 7.21: Rotating Selector Switch Connected to Inputs IN101, IN102, and IN103 for Active Setting Group Switching.....	7-26
Figure 7.22: Active Setting Group Switching (with Rotating Selector Switch) Time Line.....	7-28
Figure 7.23: SELOGIC Control Equation Variables/Timers SV1/SV1T Through SV6/SV6T.....	7-29
Figure 7.24: SELOGIC Control Equation Variables/Timers SV7/SV7T Through SV16/SV16T.....	7-30
Figure 7.25: Dedicated Breaker Failure Scheme Created with SELOGIC Control Equation Variables/Timers.....	7-31
Figure 7.26: Logic Flow for Example Output Contact Operation.....	7-34
Figure 7.27: Traditional Panel Light Installations.....	7-35
Figure 7.28: Rotating Default Display Replaces Traditional Panel Light Installations.....	7-36

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, and voltage 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 different SEL-311A Relay models. The figures show examples of energized and deenergized optoisolated inputs and corresponding Relay Word bit states. To assert an input, apply rated control voltage to the appropriate terminal pair (see Figure 1.2 and Figures 2.2 and 2.3).

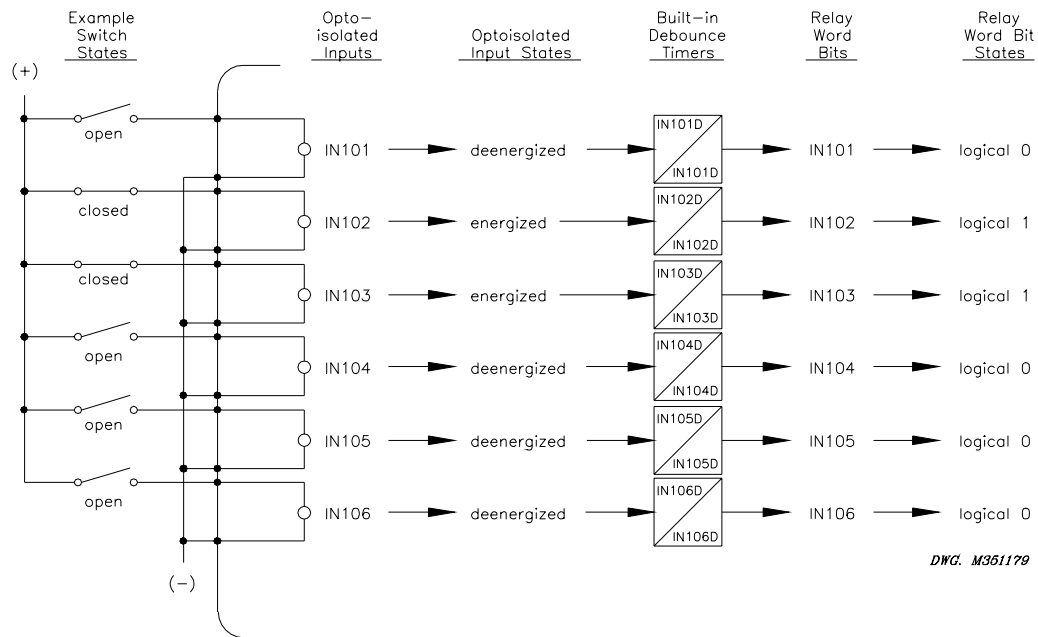


Figure 7.1: Example Operation of Optoisolated Inputs IN101 Through IN106

Input Debounce Timers

See Figure 7.1.

Each input has settable pickup/dropout timers (IN101D through IN106D) for input energization/deenergization debounce. Note that a given time setting (e.g., IN101D = 0.50) is applied to both the pickup and dropout time for the corresponding input.

Time settings IN101D through IN106D are settable from 0.00 to 2.00 cycles. The relay takes the entered time setting and internally runs the timer at the nearest 1/8-cycle. For example, if setting IN105D = 0.80, internally the timer runs at the nearest 1/8-cycle: 6/8-cycles ($6/8 = 0.75$).

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

The relay 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 2 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

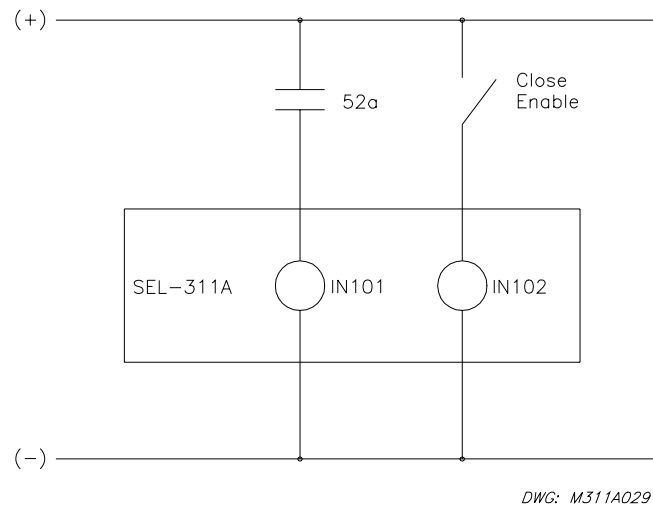


Figure 7.2: Circuit Breaker Auxiliary Contact and Close Enable Switch Connected to Optoisolated Inputs IN101 and IN102

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 Logic** for more information on SELOGIC control equation setting 52A.

The pickup/dropout timer for input IN101 (IN101D) might be set at:

$$\text{IN101D} = 0.75 \text{ cycles}$$

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 to block all breaker close operations:

$$\text{CL} = \text{IN102} * (\text{CC} + \dots)$$

Connect input IN102 to a close enable switch.

When the close enable switch is open, input IN102 is deenergized and the SELOGIC equation CLOSE is blocked:

$$\text{CL} = \text{IN102} * (\text{CC} + \dots) = (\text{logical } 0) * (\text{CC} + \dots) = \text{logical } 0, \text{ CLOSE DISABLED}$$

When the close enable switch is closed, input IN102 is energized and the SELOGIC equation CL enabled:

$$\text{CL} = \text{IN102} * (\text{CC} + \dots) = (\text{logical } 1) * (\text{CC} + \dots) = \text{logical } 1, \text{ CLOSE ENABLED}$$

See **Section 6: Close Logic** for more information on SELOGIC control equation setting CL.

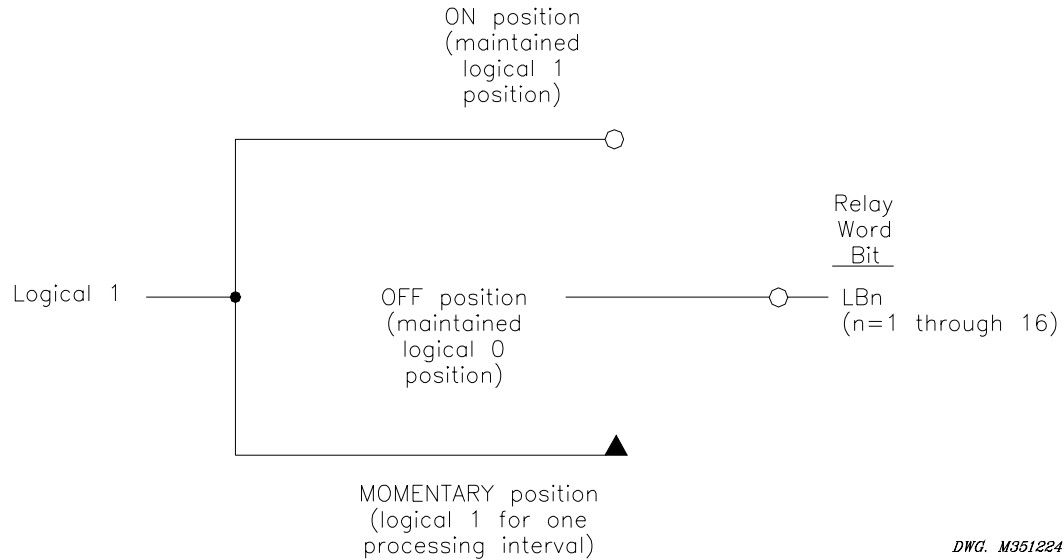
The pickup/dropout timer for input IN102 (IN102D) in this example might be set at:

$$\text{IN102D} = 1.00 \text{ cycle}$$

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-311A 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 LB n	logical 1
OFF	CLB n	“Clear” Local bit LB n	logical 0
MOMENTARY	PLB n	“Pulse” Local bit LB n	logical 1 for one processing interval

Note the first setting in Table 7.1 (NLB n) is the overall switch name setting. Make each label setting through the serial port using the command **SET T**. View these settings using the serial port command **SHO T** (see *Section 9: Setting the Relay* and *Section 10: 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.

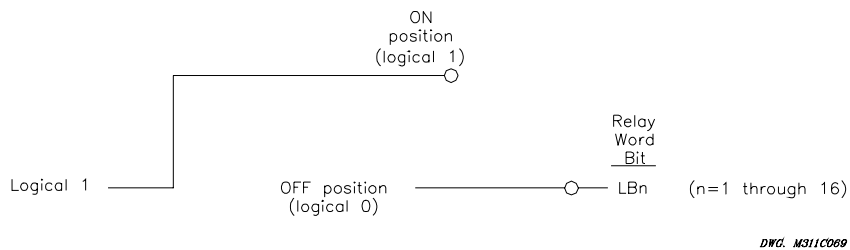


Figure 7.4: Local Control Switch Configured as an ON/OFF Switch

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).

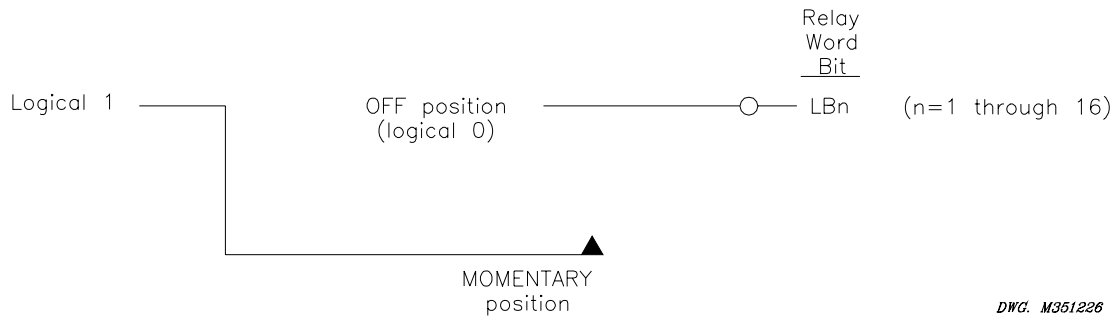


Figure 7.5: Local Control Switch Configured as an OFF/MOMENTARY Switch

ON/OFF/MOMENTARY Switch

The local bit LB_n :

is in either the ON ($LB_n = \text{logical 1}$) or OFF ($LB_n = \text{logical 0}$) position

or

is in the OFF ($LB_n = \text{logical 0}$) position and pulses to the MOMENTARY ($LB_n = \text{logical 1}$) position for one processing interval (1/4 cycle).

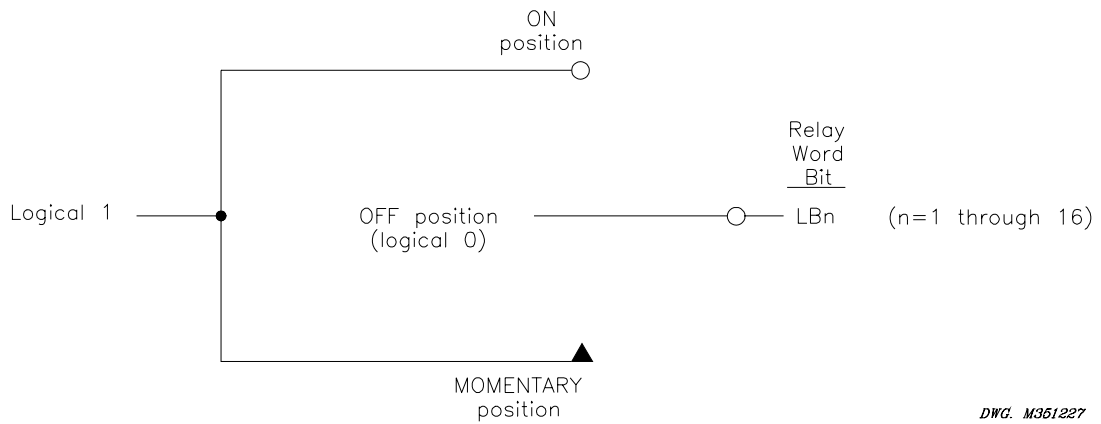


Figure 7.6: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

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:

<u>Local Bit</u>	<u>Label Settings</u>	<u>Function</u>
LB3	NLB3 = MANUAL TRIP	trips breaker
	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
	CLB4 = RETURN	OFF position (“return” from MOMENTARY position)
	SLB4 =	ON position—not used (left “blank”)
	PLB4 = CLOSE	MOMENTARY position

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

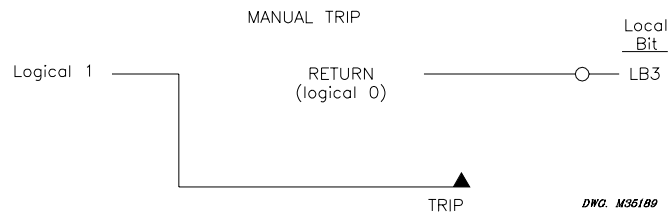


Figure 7.7: Configured Manual Trip Switch Drives Local Bit LB3

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

$$TR = \dots + LB3 + \dots$$

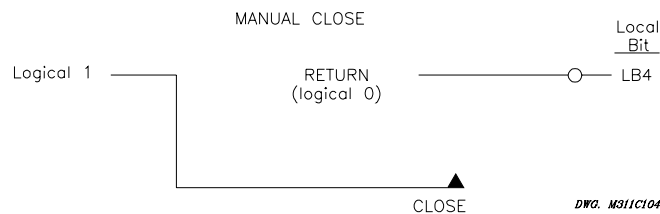


Figure 7.8: Configured Manual Close Switch Drives Local Bit LB4

Local bit LB4 is set to close the circuit breaker in the following SELOGIC control equation setting:

$$CL = \dots + LB4 + \dots$$

SELOGIC control equation setting CL is for close conditions, other than serial port **CLOSE** command (see Figure 6.1 in *Section 6: Close 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 ground relay enable/disable or remote control supervision.

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

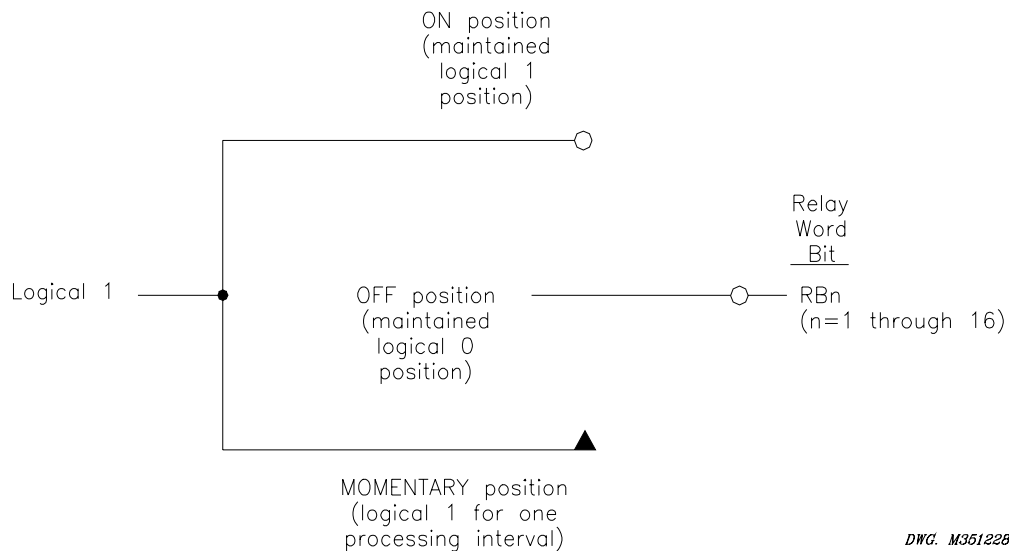
If settings are changed (for the active setting group or one of the other setting groups) or the active setting group is changed, the states of the local bits (Relay Word bits LB1 through LB16) are retained, much like in the preceding *Power Loss* explanation.

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*).



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

Graphic 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 7.9: 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-311A 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).

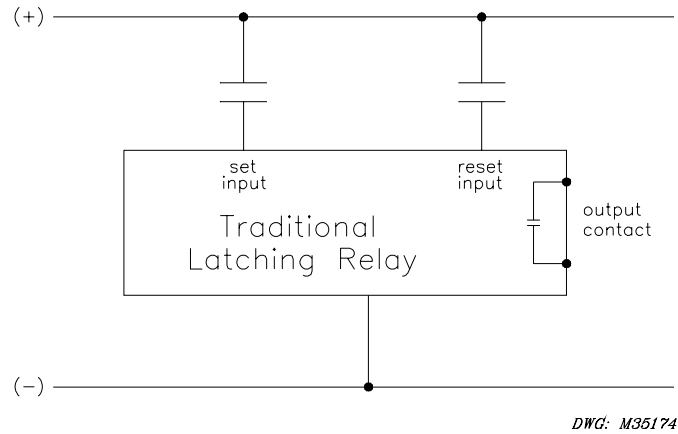


Figure 7.10: Traditional Latching Relay

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

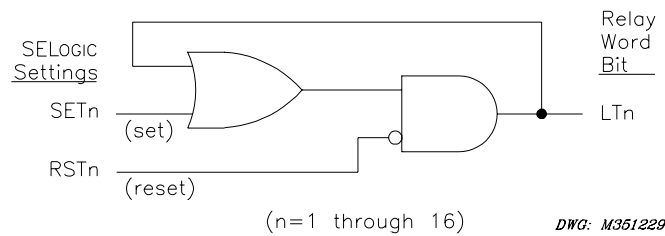


Figure 7.11: Latch Control Switches Drive Latch Bits LT1 Through LT16

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:

- Circuit breaker closing 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 circuit breaker closing in the SEL-311A Relay. This is used to prevent the circuit breaker from being closed remotely during line or breaker maintenance.

Circuit Breaker Closing Enable/Disable Setting Example

Use a local pushbutton to enable/disable the circuit breaker closing in the SEL-311A Relay. In this example, a contact is connected to optoisolated input IN104. Each pulse of the pushbutton contact changes the state of the close enable. The pushbutton contact is not maintained, just pulsed to enable/disable the circuit breaker closing.

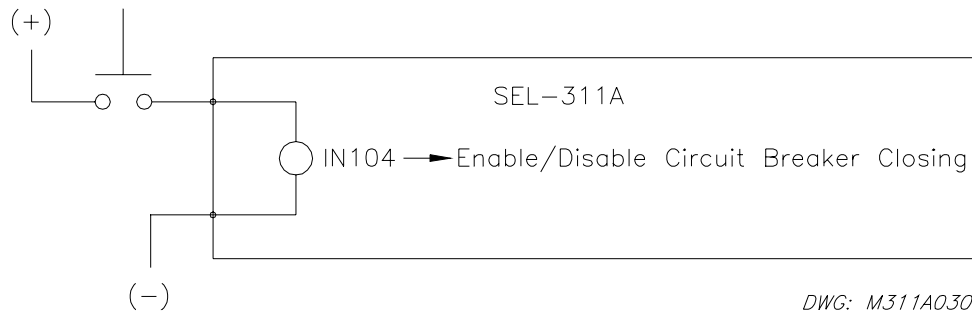


Figure 7.12: Pushbutton Contact Pulses Input IN104 to Enable/Disable Circuit Breaker Closing

If the circuit breaker closing is enabled and the pushbutton contact is pulsed, circuit breaker closing is then disabled. If the pushbutton contact is pulsed again, circuit breaker closing is enabled again. The control operates in a cyclic manner:

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

This circuit breaker closing 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]

CL = LT1 * (CC + ...) [= (LT1); enable **CLOSE** command]

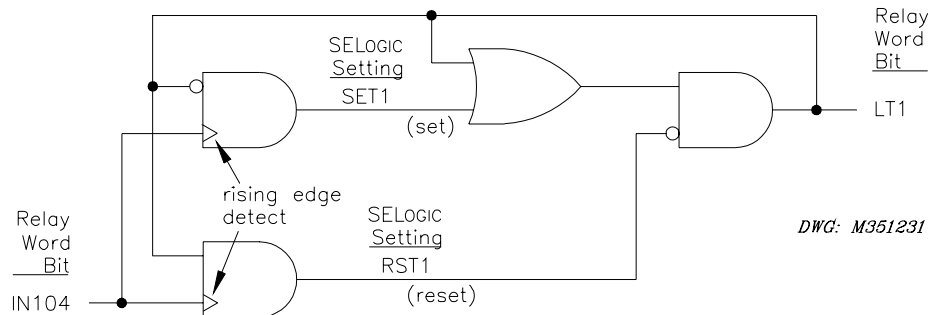


Figure 7.13: Latch Control Switch Controlled by a Single Input to Enable/Disable Circuit Breaker Closing

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):

$$\begin{aligned} \text{SET1} &= /IN104 * !LT1 = /IN104 * \text{NOT}(LT1) = /IN104 * \text{NOT}(\text{logical } 0) \\ &= /IN104 = \text{rising edge of input IN104} \end{aligned}$$

$$\begin{aligned} \text{RST1} &= /IN104 * LT1 = /IN104 * (\text{logical } 0) \\ &= \text{logical } 0 \end{aligned}$$

If latch bit LT1 = logical 1, input IN104 is routed to setting RST1 (reset latch bit LT1):

$$\begin{aligned} \text{SET1} &= /IN104 * !LT1 = /IN104 * \text{NOT}(LT1) = /IN104 * \text{NOT}(\text{logical } 1) = \\ &= /IN104 * (\text{logical } 0) \\ &= \text{logical } 0 \end{aligned}$$

$$\begin{aligned} \text{RST1} &= /IN104 * LT1 = /IN104 * (\text{logical } 1) \\ &= /IN104 = \text{rising edge of input IN104} \end{aligned}$$

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 pushbutton 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 pushbutton 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

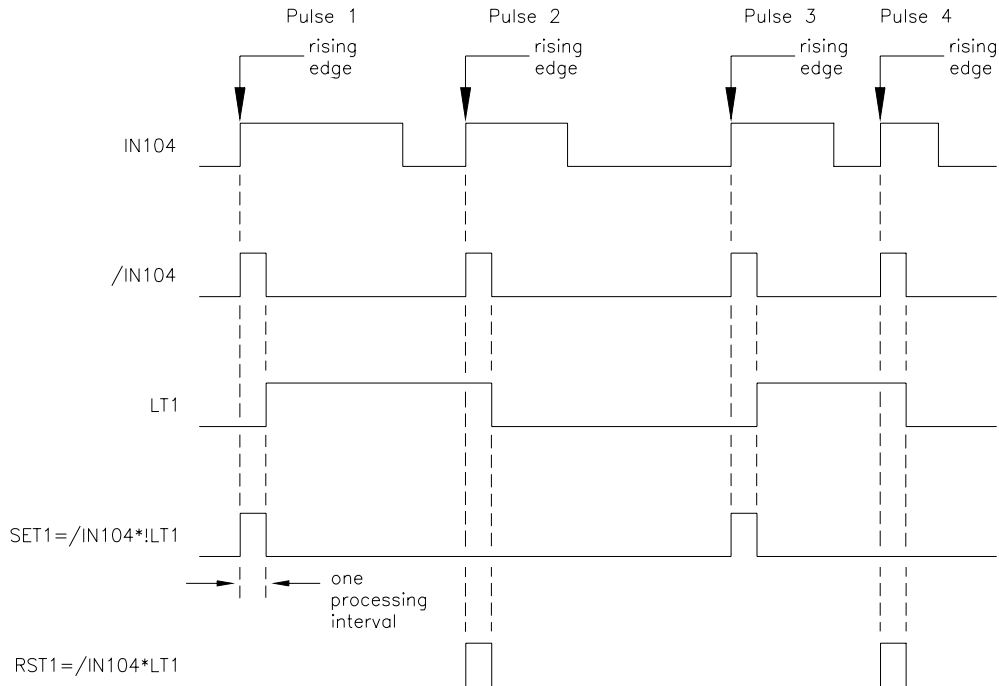
the next processing interval.

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 pushbutton contact.

If the pushbutton 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.



DWG. M351232

Figure 7.14: Latch Control Switch Operation Time Line

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:

$$SV7 = SG4$$

$$RST2 = !SV7T + \dots \quad [= \text{NOT}(SV7T) + \dots]$$

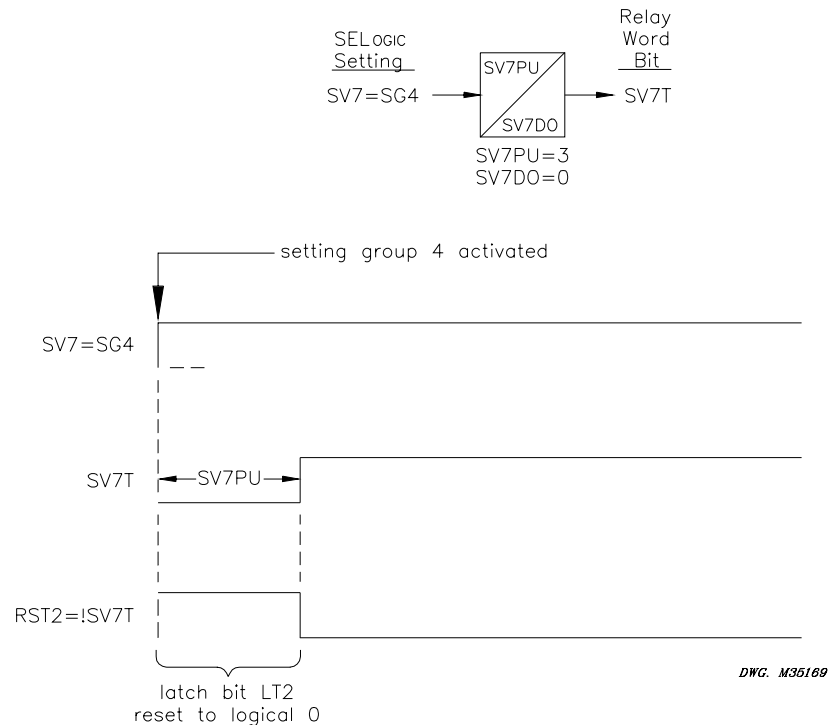


Figure 7.15: Time Line for Reset of Latch Bit LT2 After Active Setting Group Change

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 circuit breaker closing enable/disable example application (Figure 7.12 through Figure 7.14), the pushbutton 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 pushbutton 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).

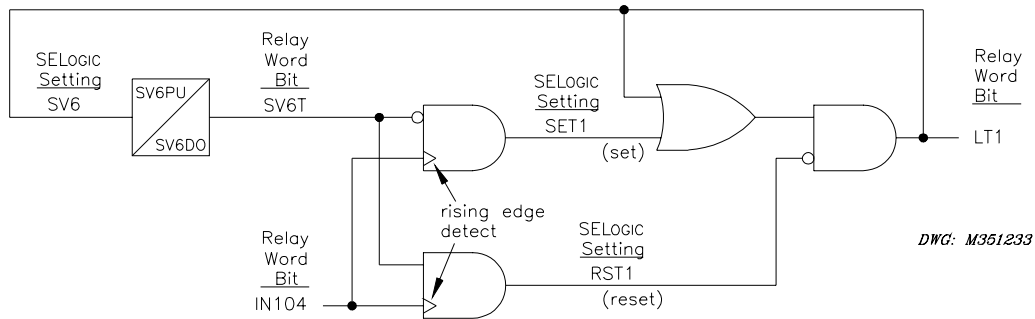


Figure 7.16: Latch Control Switch (with Time Delay Feedback) Controlled by a Single Input to Enable/Disable Circuit Breaker Closing

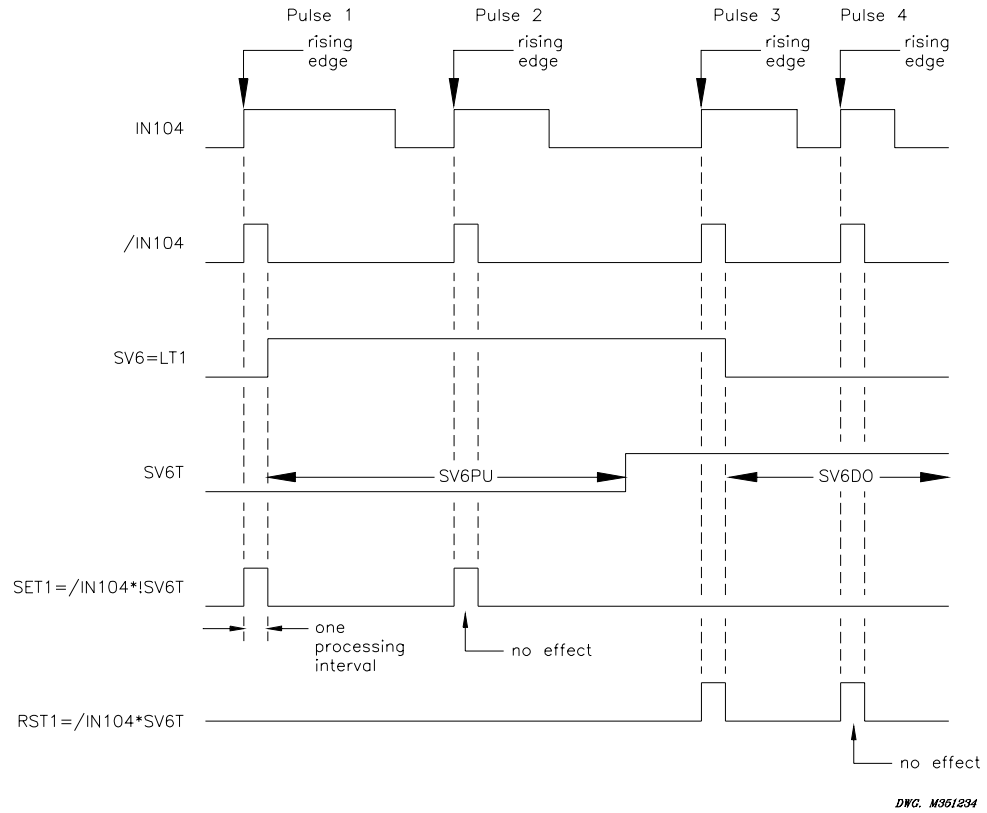


Figure 7.17: Latch Control Switch (with Time Delay Feedback) Operation Time Line

MULTIPLE SETTING GROUPS

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

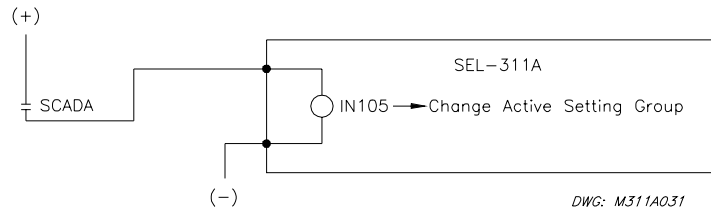


Figure 7.18: SCADA Contact Pulses Input IN105 to Switch Active Setting Group Between Setting Groups 1 and 4

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.

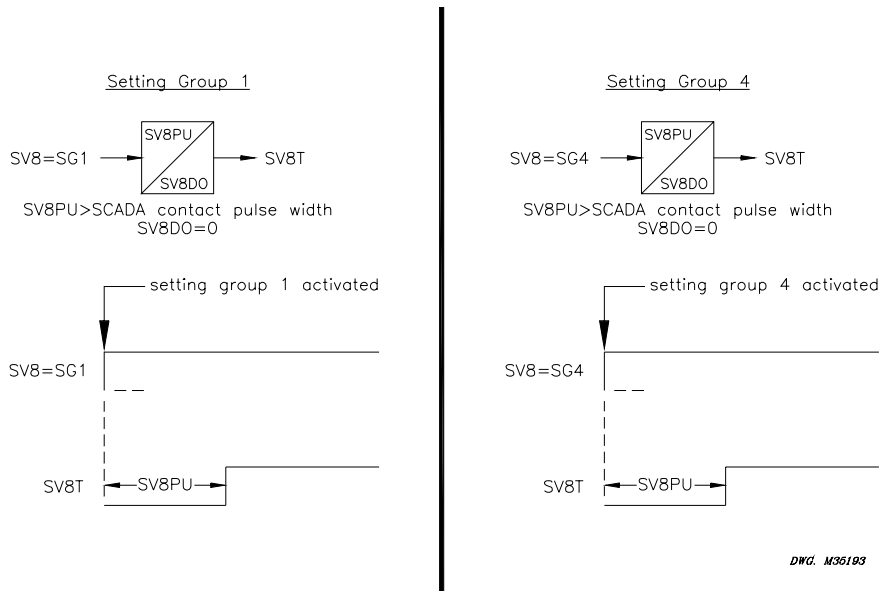


Figure 7.19: SELOGIC Control Equation Variable Timer SV8T Used in Setting Group Switching

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).

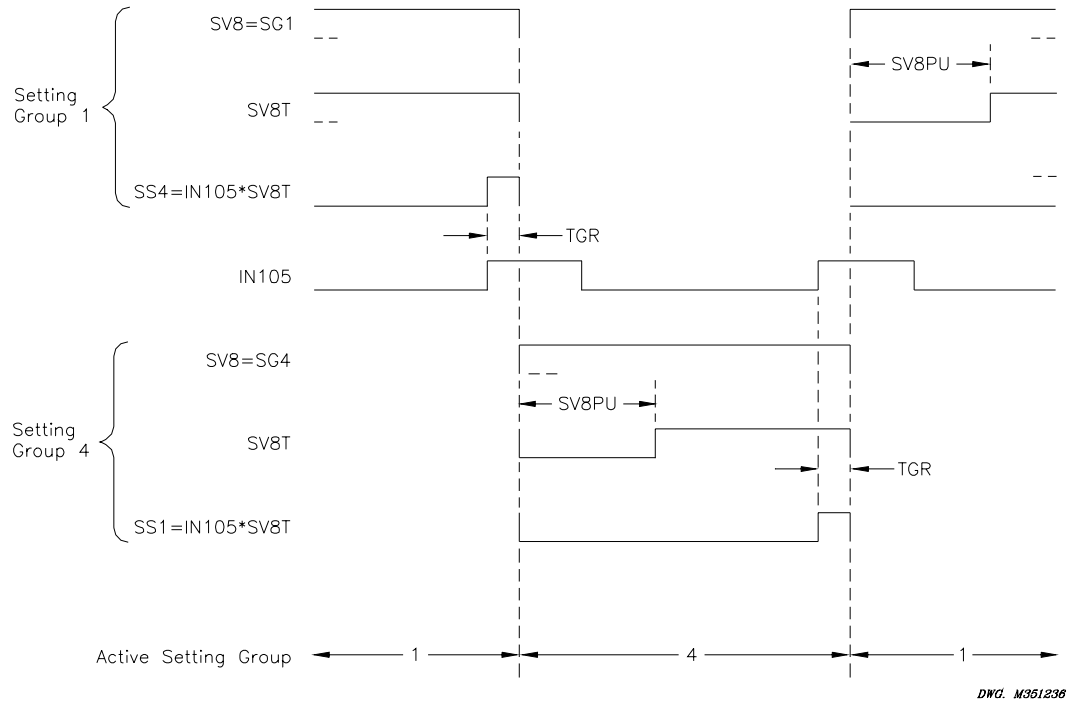


Figure 7.20: Active Setting Group Switching (with Single Input) Time Line

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

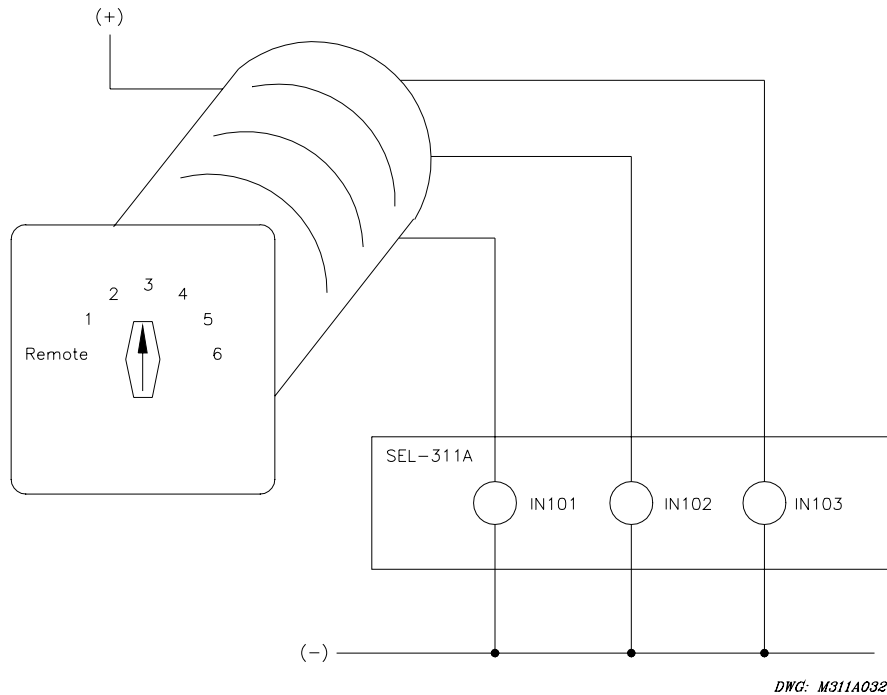


Figure 7.21: Rotating Selector Switch Connected to Inputs IN101, IN102, and IN103 for Active Setting Group Switching

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:

$$\begin{aligned}SS3 &= !IN103 * IN102 * IN101 = \text{NOT}(IN103) * IN102 * IN101 \\ &= \text{NOT}(\text{logical } 0) * \text{logical } 1 * \text{logical } 1 = \text{logical } 1\end{aligned}$$

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:

$$\begin{aligned}SS4 &= IN103 * !IN102 * !IN101 = IN103 * \text{NOT}(IN102) * \text{NOT}(IN101) \\ &= \text{logical } 1 * \text{NOT}(\text{logical } 0) * \text{NOT}(\text{logical } 0) = \text{logical } 1\end{aligned}$$

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:

$$\begin{aligned}SS5 &= IN103 * !IN102 * IN101 = IN103 * \text{NOT}(IN102) * IN101 \\ &= \text{logical } 1 * \text{NOT}(\text{logical } 0) * \text{logical } 1 = \text{logical } 1\end{aligned}$$

To get from position 5 to position REMOTE on the selector switch, the switch passes through the positions 4, 3, 2, and 1. The switch is only briefly in these positions, but not long enough to be qualified by time setting TGR in order to change the active setting group to any one of these setting groups.

Selector Switch Now Rests on Position REMOTE

Refer to Figure 7.22.

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.

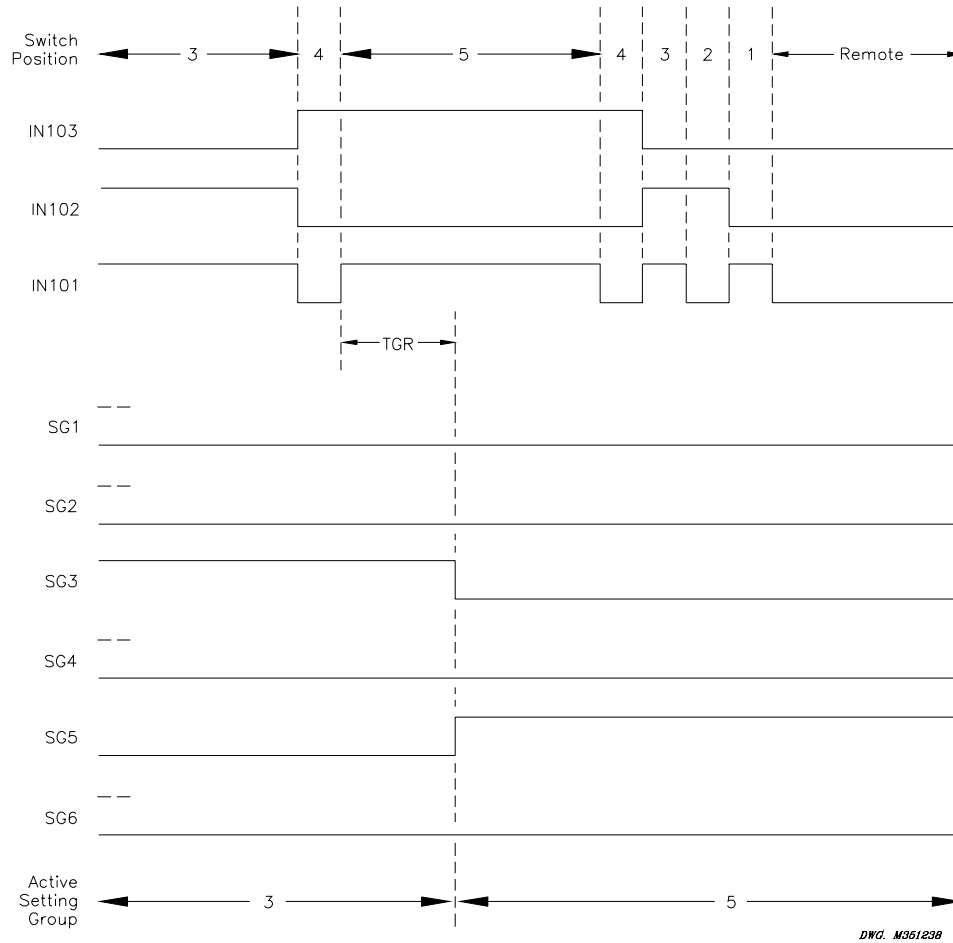


Figure 7.22: Active Setting Group Switching (with Rotating Selector Switch) Time Line

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).

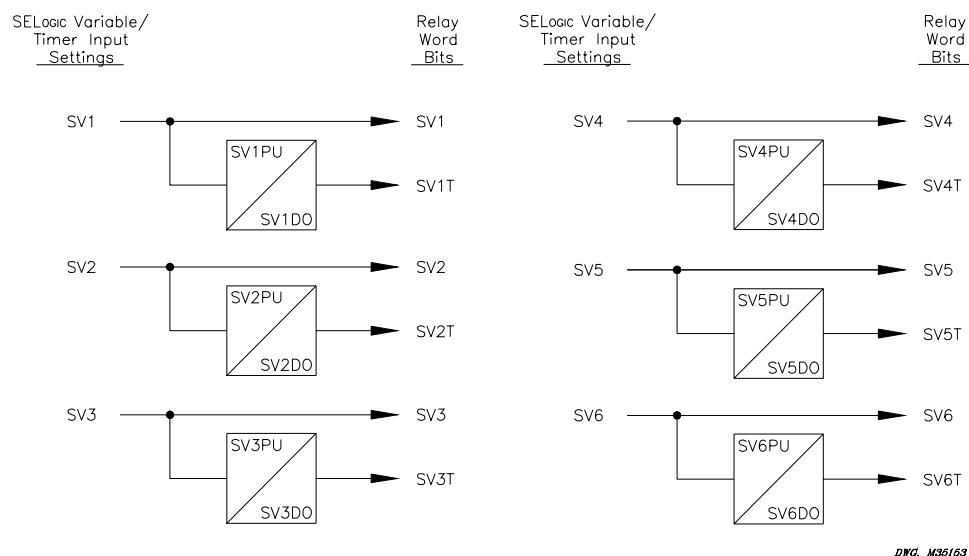


Figure 7.23: SELOGIC Control Equation Variables/Timers SV1/SV1T Through SV6/SV6T

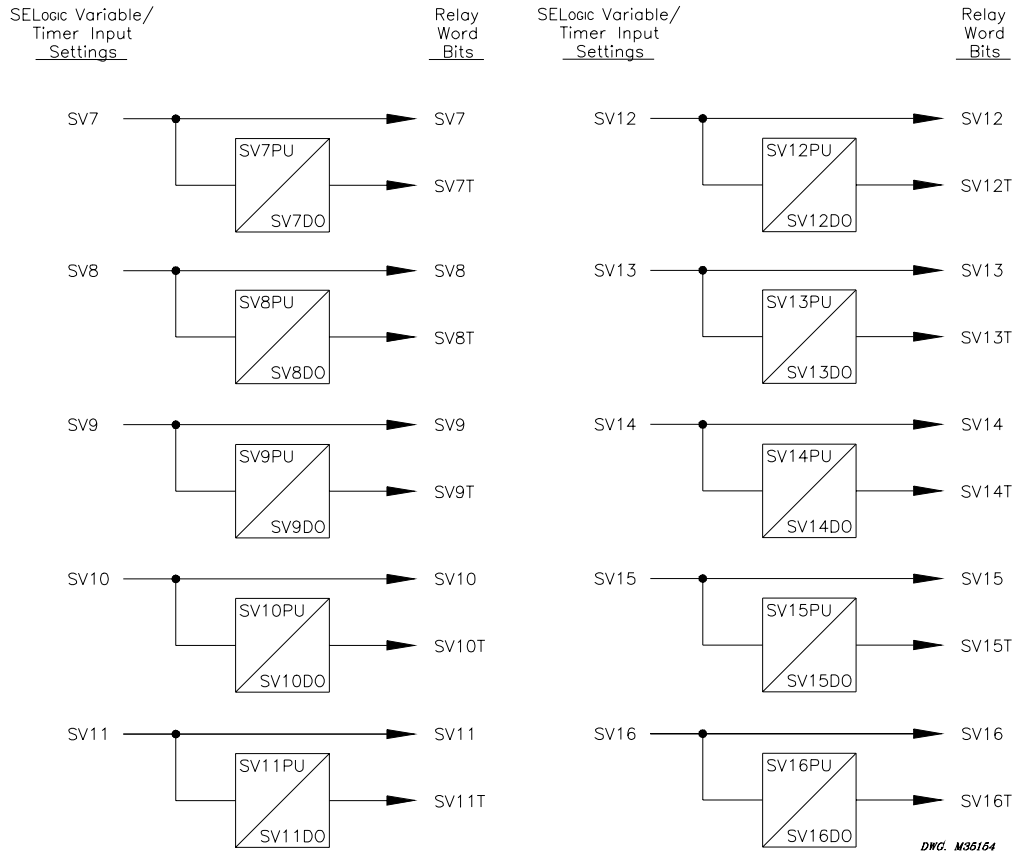


Figure 7.24: SELOGIC Control Equation Variables/Timers SV7/SV7T Through SV16/SV16T

Settings Example

In the SELOGIC control equation settings, a SELOGIC control equation timer may be used for a simple breaker failure scheme:

$$SV1 = TRIP$$

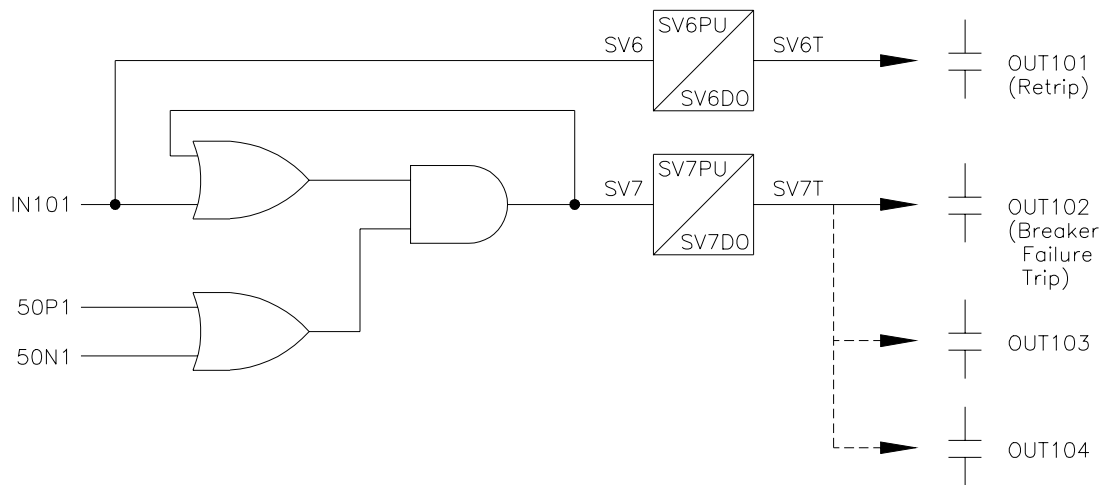
The TRIP Relay Word bit is run through a timer for breaker failure timing. Timer pickup setting SV1PU is set to the breaker failure time (SV1PU = 12 cycles). Timer dropout setting SV1DO is set for a 2-cycle dropout (SV1DO = 2 cycles). The output of the timer (Relay Word bit SV1T) operates output contact OUT103.

$$OUT103 = SV1T$$

Additional Settings Example 1

Another application idea is dedicated breaker failure protection (see Figure 7.25):

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



DWG. M351239

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):

$$\text{SV7} = \underbrace{(\text{SV7} + \text{IN101})}_{\text{seal-in}} * (\text{50P1} + \text{50G1})$$

Optoisolated input IN101 functions as a breaker failure initiate input. Phase instantaneous overcurrent element 50P1 and residual ground instantaneous overcurrent element 50G1 function as fault detectors.

Timer pickup setting SV6PU provides retrip delay, if desired (can be set to zero). Timer dropout setting SV6DO holds the retrip output (output contact OUT101) closed for extra time if needed after the breaker failure initiate signal (IN101) goes away.

Timer pickup setting SV7PU provides breaker failure timing. Timer dropout setting SV7DO holds the breaker failure trip output (output contact OUT102) closed for extra time if needed after the breaker failure logic unlatches (fault detectors 50P1 and 50G1 dropout).

Note that Figure 7.25 suggests the option of having output contacts OUT103 and OUT104 operate as additional breaker failure trip outputs. This is done by making the following SELOGIC control equation settings:

OUT103 = SV7T (breaker failure trip)
OUT104 = SV7T (breaker failure trip)

Additional Settings Example 2

The seal-in logic circuit in the dedicated breaker failure scheme in Figure 7.25 can be removed by changing the SELOGIC control equation setting SV7 to:

$$SV7 = IN101 * (50P1 + 50G1)$$

If the seal-in logic circuit is removed, optoisolated input IN101 (breaker failure initiate) has to be continually asserted for a breaker failure time-out.

Timers Reset When Power Is Lost, Settings Are Changed, or Active Setting Group Is Changed

If power is lost to the relay, settings are changed (for the active setting group), or the active setting group is changed, the SELOGIC control equation variables/timers are reset. Relay Word bits SV n and SV n T ($n = 1$ through 16) are reset to logical 0 and corresponding timer settings SV n PU and SV n DO load up again after power restoration, settings change, or active setting group switch.

Preceding Figure 7.25 shows an effective seal-in logic circuit, created by use of Relay Word bit SV7 (SELOGIC control equation variable SV7) in SELOGIC control equation SV7:

$$SV7 = \underbrace{(SV7 + IN101)} * (50P1 + 50G1)$$

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 operation examples 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, four 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 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** ($n = \text{OUT101 through OUT107}$) asserts the corresponding Relay Word bit (OUT101 through OUT107) to logical 1. The assertion of SELOGIC control equation setting OUT_m ($m = 101 \text{ through } 107$) to logical 1 also asserts the corresponding Relay Word bit OUT_m ($m = 101 \text{ through } 107$) to logical 1.

The assertion of Relay Word bit OUT_m ($m = 101 \text{ through } 107$) 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

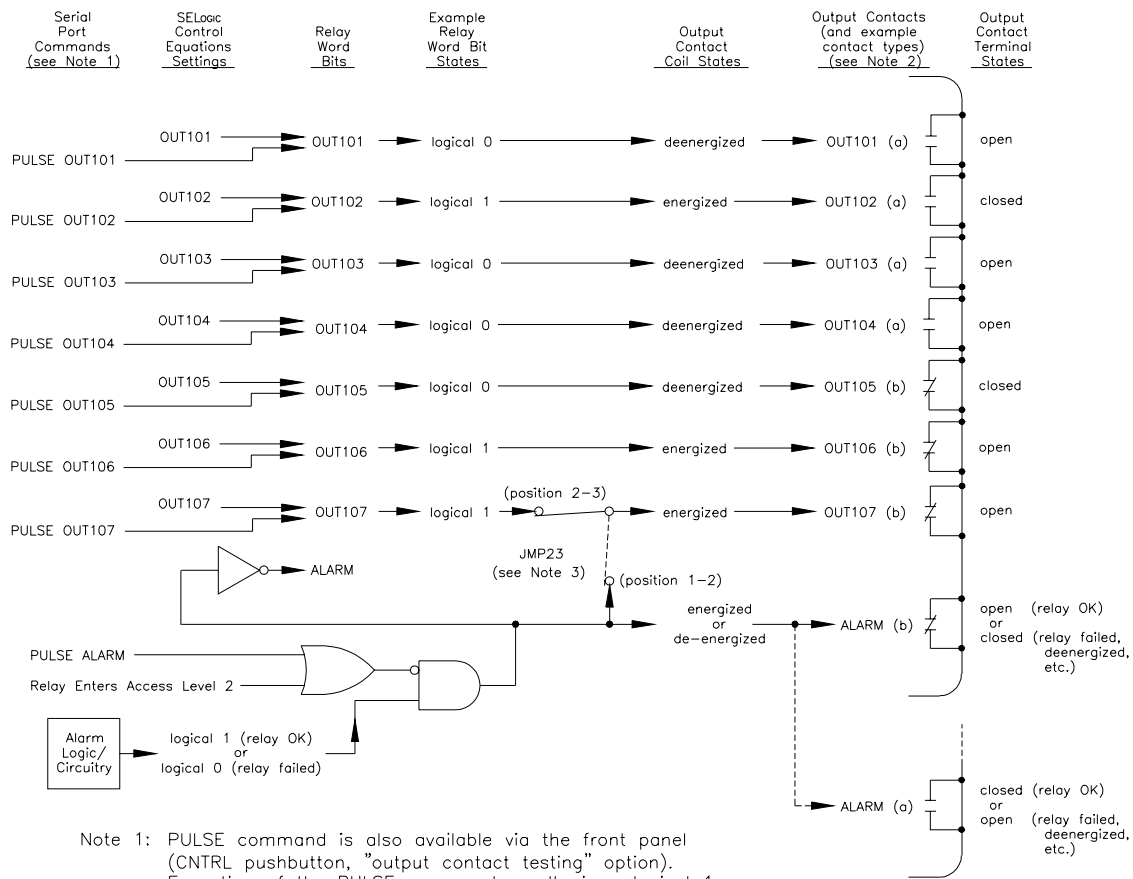
Refer to Figure 7.26 and *Relay Self-Tests* in *Section 13: Testing and Troubleshooting*.

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.



- Note 1: PULSE command is also available via the front panel (CNTRL pushbutton, "output contact testing" option). Execution of the PULSE command results in a logical 1 input into the above logic (1-second default pulse width).
- Note 2: Output contacts OUT101 through ALARM are configurable as "a" or "b" type output contacts. See ① and accompanying text for more information on selecting output contact type.
- Note 3: Main board jumper JMP23 allows output contact OUT107 to operate as:
 - regular output contact OUT107 (JMP23 in position 2-3)
 - an extra Alarm output contact (JMP23 in position 1-2)
 See ② for more information on jumper JMP23.

DWG. M311C105a

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.

Traditional Indicating Panel Lights

Figure 7.27 shows traditional indicating panel lights wired in parallel with SEL-311A Relay optoisolated inputs. Input IN101 provides circuit breaker status to the relay via the following SELOGIC control equation settings:

$$\begin{aligned} 52A &= \text{IN101} \\ \text{CL} &= \text{IN102} * (\text{CC} + \dots) \end{aligned}$$

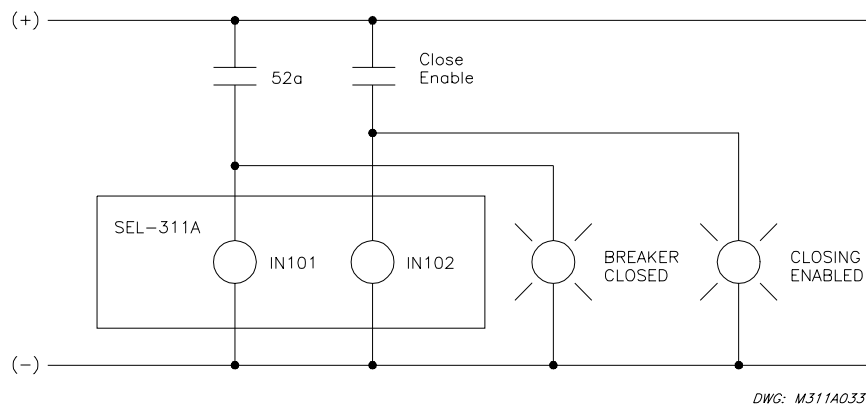


Figure 7.27: Traditional Panel Light Installations

Note that Figure 7.27 corresponds to Figure 7.2.

Circuit Breaker Closing Enabled Indication

In Figure 7.27, the CLOSING ENABLED panel light illuminates when the “Close Enable” switch is closed. When the “Close Enable” switch is open, the CLOSING ENABLED panel light extinguishes, and it is understood that the circuit breaker closing 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-311A Relay is used. Figure 7.28 shows the elimination of the indicating panel lights by using the rotating default display.

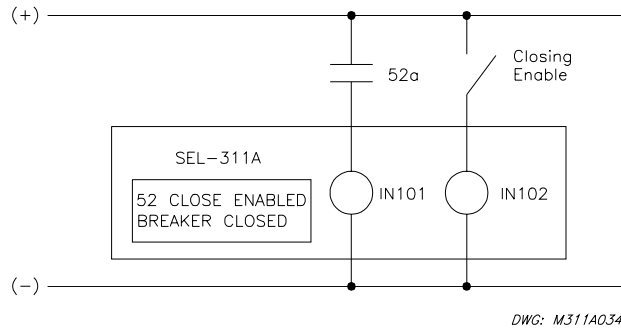


Figure 7.28: Rotating Default Display Replaces Traditional Panel Light Installations

There are sixteen (16) of these default displays available in the SEL-311A 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 DPn ($n = 1$ through 16) controls the display of corresponding, complementary text settings:

DPn_1	(displayed when $DPn = \text{logical } 1$)
DPn_0	(displayed when $DPn = \text{logical } 0$)

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-311A Relay front-panel display on a time-variable rotation using Global setting SCROLL (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 DPn .

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 = 52 CLOSE ENABLED

DP1_0 = 52 CLS DISABLED

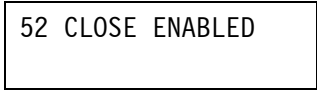
Display point setting DP1 controls the display of the text settings.

Circuit Breaker Closing Enabled

In Figure 7.28, optoisolated input IN102 is energized to enable the circuit breaker closing, resulting in:

DP1 = IN102 = logical 1

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



52 CLOSE ENABLED

Circuit Breaker Closing Disabled

In Figure 7.28, optoisolated input IN102 is deenergized to disable the circuit breaker closing, resulting in:

DP1 = IN102 = logical 0

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



52 CLS 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:

$$DP2 = IN101 = \text{logical 0}$$

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-311A 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 circuit breaker closing enable/disable switch with the following settings:

SELOGIC control equation settings:

$$CL = IN102 * (CC + \dots)$$

$$DP1 = IN102$$

Text settings:

DP1_1 = 52 CLOSE ENABLED (displayed when DP1 = logical 1)

DP1_0 = 52 CLS DISABLED (displayed when DP1 = logical 0)

Circuit Breaker Closing Enabled

In Figure 7.28, optoisolated input IN102 is energized to enable the circuit breaker closing, resulting in:

$$DP1 = IN102 = \text{logical 1}$$

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

52 CLOSE ENABLED

Circuit Breaker Closing Disabled

In Figure 7.28, optoisolated input IN102 is deenergized to disable the circuit breaker closing, resulting in:

$$DP1 = IN102 = \text{logical 0}$$

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

52 CLS 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 circuit breaker closing is always disabled and optoisolated input IN102 has no control over the circuit breaker closing. 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:

CL = 0 (set directly to logical 1—circuit breaker closing disabled)

DP1 = 0 (set directly to logical 0)

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

DP1_1 = 52 CLOSE ENABLED (displayed when DP1 = logical 1)

DP1_0 = 52 CLS 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:

52 CLS 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 or 51GP.

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
:::000	51PP	xxxxxxx	9
:::001	51GP	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
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	MW A = x x . x x x	A megawatts
MWB	MW B = x x . x x x	B megawatts
MWC	MW C = x x . x x x	C megawatts

Mnemonic	Display	Description
MW3	MW 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
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

Mnemonic	Display	Description
MWBPO	MWB O P K = x . x x x	B peak megawatts out
MWCDO	MWC O D E M = x . x x x	C demand megawatts out
MWCPO	MWC O P K = x . x x x	C peak megawatts out
MW3DO	MW 3 O D E M = x . x x x	three-phase demand megawatts out
MW3PO	Mw 3 O P K = x . x x x	three-phase peak megawatts out
MVRADO	MV R A O D E M = x . x x x	A demand megavars out
MVRAPO	MV R A O P K = x . x x x	A peak megavars out
MVRBDO	MV R B O D E M = x . x x x	B demand megavars out
MVRBPO	MV R B O P K = x . x x x	B peak megavars out
MVRCDO	MV R C O D E M = x . x x x	C demand megavars out
MVRCPO	MV R C O P K = x . x x x	C peak megavars out
MVR3DO	MV R 3 O D E M = x . x x x	three-phase demand megavars out
MVR3PO	MV R 3 O P K = x . x x x	three-phase peak megavars out
MWHAI	MW h A I N = x x . x x x	A megawatt-hours in
MWHAO	MW h A O U T = x x . x x x	A megawatt-hours out
MWHBI	MW h B I N = x x . x x x	B megawatt-hours in
MWHBO	MW h B O U T = x x . x x x	B megawatt-hours out
MWHCI	MW h C I N = x x . x x x	C megawatt-hours in
MWHCO	MW h C O U T = x x . x x x	C megawatt-hours out
MWH3I	MW h 3 I N = x x . x x x	three-phase megawatt-hours in
MWH3O	MW h 3 O U T = x x . x x x	three-phase megawatt-hours out
MVRHAI	MV A R h A I = x x . x x x	A megavar-hours in
MVRHAO	MV A R h A O = x x . x x x	A megavar-hours out
MVRHBI	MV A R h B I = x x . x x x	B megavar-hours in
MVRHBO	MV A R h B O = x x . x x x	B megavar-hours out
MVRHCI	MV A R h C I = x x . x x x	C megavar-hours in
MVRHCO	MV A R h C O = x x . x x x	C megavar-hours out
MVRH3I	MV A R h 3 I = x x . x x x	three-phase megavar-hours in
MVRH3O	MV 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

DP1_0 = ::MW3
 DP2_0 = ::MVAR3
 DP3_0 = ::PF3
 DP4_0 = ::FREQ

SET L

DP1 = 0
 DP2 = 0
 DP3 = 0
 DP4 = 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:

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	R S T D A T : m m / d d / y y	last reset date
BRKTIME	R S T T I M : h h : m m : s s	last reset time
CTRLTR	C T R L T R I P S = x x x x x	internal trip count
OPSCNTR	O P S C N T R = x x x x x	internal trip count
CTRLIA	C T R L I A = x x x x x k A	internal trip Σ IA
CTRLIB	C T R L I B = x x x x x k A	internal trip Σ IB
CTRLIC	C T R L I C = x x x x x k A	internal trip Σ IC
EXTTR	E X T T R I P S = x x x x x	external trip count
EXTIA	E X T I A = x x x x x k A	external trip Σ IA
EXTIB	E X T I B = x x x x x k A	external trip Σ IB
EXTIC	E X T I C = x x x x x k A	external trip Σ IC
WEARA	W E A R A = y y y %	A phase wear monitor
WEARB	W E A R B = y y y %	B phase wear monitor
WEARC	W E A R C = y y y %	C phase wear monitor

To program a display point to display one of the Breaker Monitor outputs above, first enter the two-character sequence “:.” (double colon) followed by the name of the desired breaker monitor output (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 %

TABLE OF CONTENTS

SECTION 8: BREAKER MONITOR AND METERING FUNCTIONS ...8-1

Introduction.....	8-1
Breaker Monitor.....	8-1
Breaker Monitor Setting Example	8-4
Breaker Monitor Operation Example.....	8-6
Breaker Monitor Output.....	8-12
View or Reset Breaker Monitor Information.....	8-12
Determination of Relay-Initiated Trips and Externally Initiated Trips	8-13
Station DC Battery Monitor.....	8-14
DC Under- and Overvoltage Elements	8-15
Create Desired Logic for DC Under- and Overvoltage Alarming	8-15
View Station DC Battery Voltage	8-17
Analyze Station DC Battery Voltage.....	8-18
Operation of Station DC Battery Monitor When AC Voltage Is Powering the Relay	8-19
Demand Metering	8-19
Comparison of Thermal and Rolling Demand Meters.....	8-20
Demand Meter Settings.....	8-23
Demand Current Logic Output Application—Raise Pickup for Unbalance Current	8-24
View or Reset Demand Metering Information	8-27
Demand Metering Updating and Storage.....	8-27
Energy Metering	8-27
View or Reset Energy Metering Information	8-27
Energy Metering Updating and Storage.....	8-28
Maximum/Minimum Metering	8-28
View or Reset Maximum/Minimum Metering Information	8-28
Maximum/Minimum Metering Updating and Storage	8-29

TABLES

Table 8.1: Breaker Maintenance Information for an Example Circuit Breaker	8-2
Table 8.2: Breaker Monitor Settings and Settings Ranges	8-4
Table 8.3: Demand Meter Settings and Settings Range	8-23

FIGURES

Figure 8.1: Plotted Breaker Maintenance Points for an Example Circuit Breaker	8-3
Figure 8.2: SEL-311A Relay Breaker Maintenance Curve for an Example Circuit Breaker	8-5
Figure 8.3: Operation of SELOGIC [®] Control Equation Breaker Monitor Initiation Setting	8-6
Figure 8.4: Breaker Monitor Accumulates 10 Percent Wear.....	8-8
Figure 8.5: Breaker Monitor Accumulates 25 Percent Wear.....	8-9
Figure 8.6: Breaker Monitor Accumulates 50 Percent Wear.....	8-10
Figure 8.7: Breaker Monitor Accumulates 100 Percent Wear.....	8-11
Figure 8.8: Input IN106 Connected to Trip Bus for Breaker Monitor Initiation	8-14

Figure 8.9: DC Under- and Overvoltage Elements	8-15
Figure 8.10: Create DC Voltage Elements with SELOGIC Control Equations	8-16
Figure 8.11: Response of Thermal and Rolling Demand Meters to a Step Input (setting DMTC = 15 minutes).....	8-20
Figure 8.12: Current I_s Applied to Parallel RC Circuit	8-21
Figure 8.13: Demand Current Logic Outputs	8-24
Figure 8.14: Raise Pickup of Residual Ground Time-Overcurrent Element for Unbalance Current	8-25

SECTION 8: BREAKER MONITOR AND METERING FUNCTIONS

INTRODUCTION

The SEL-311A Relay monitoring functions include:

- Breaker Monitor
- Station DC Battery Monitor

In addition to instantaneous metering, the SEL-311A 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-311A 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 13 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

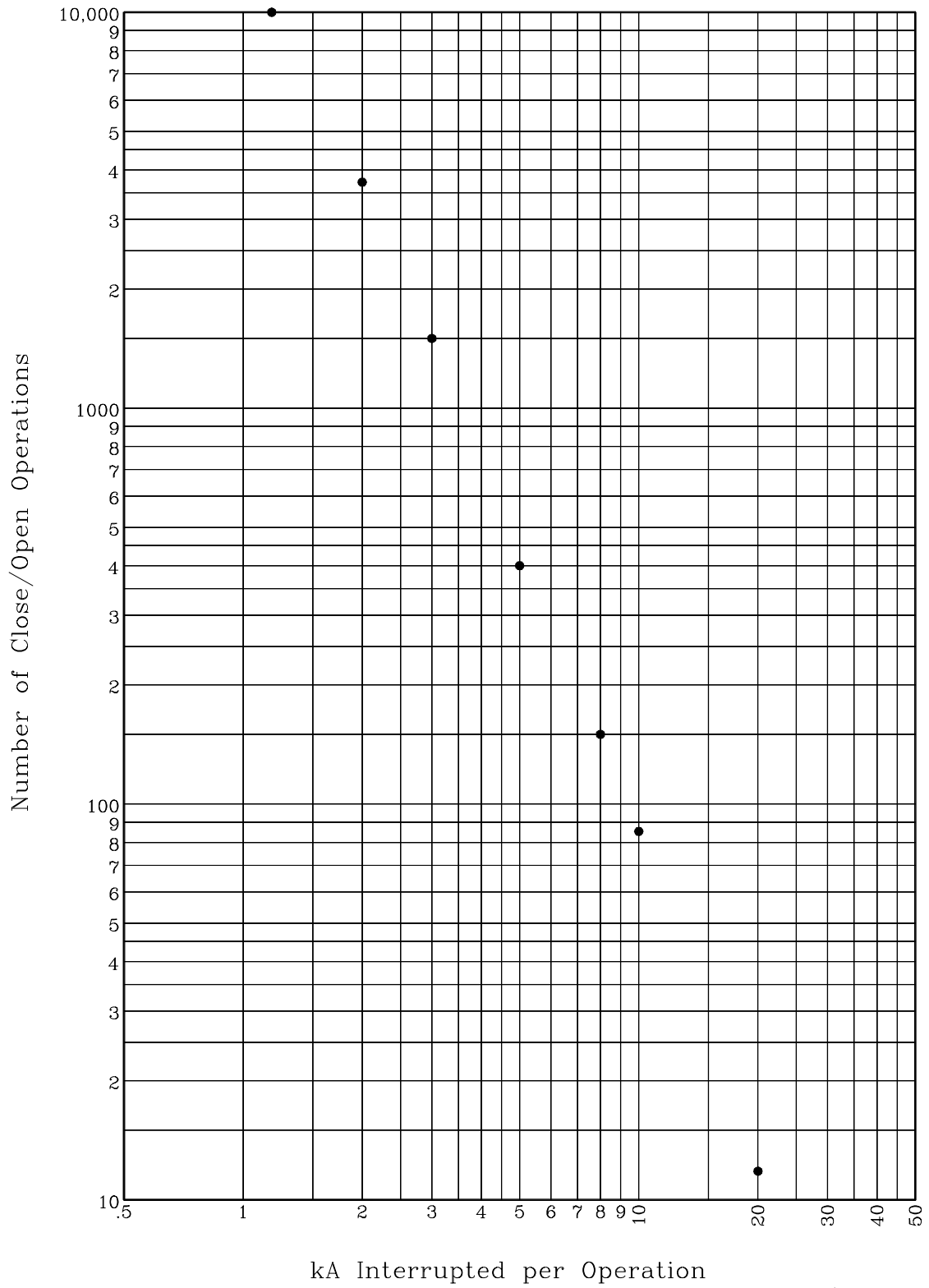
* The action of a circuit breaker closing and then later opening is counted as one close/open operation.

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

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

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

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



DWG. M351156

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 Table 9.3 and Table 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).

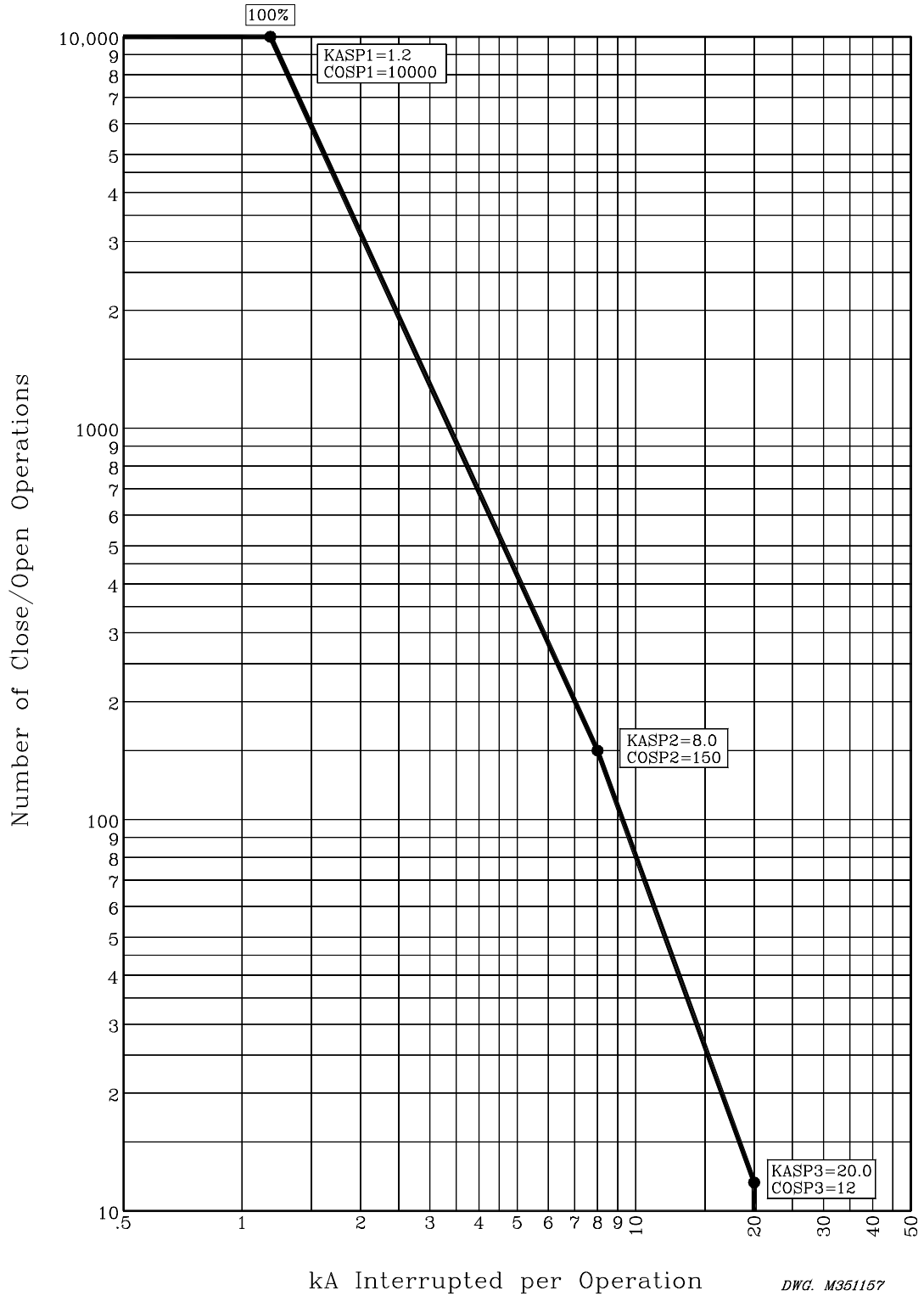


Figure 8.2: SEL-311A Relay Breaker Maintenance Curve for an Example Circuit Breaker

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.

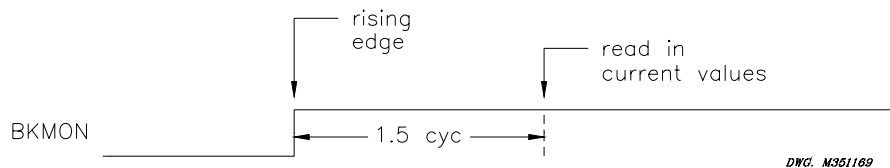


Figure 8.3: Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

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. 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.

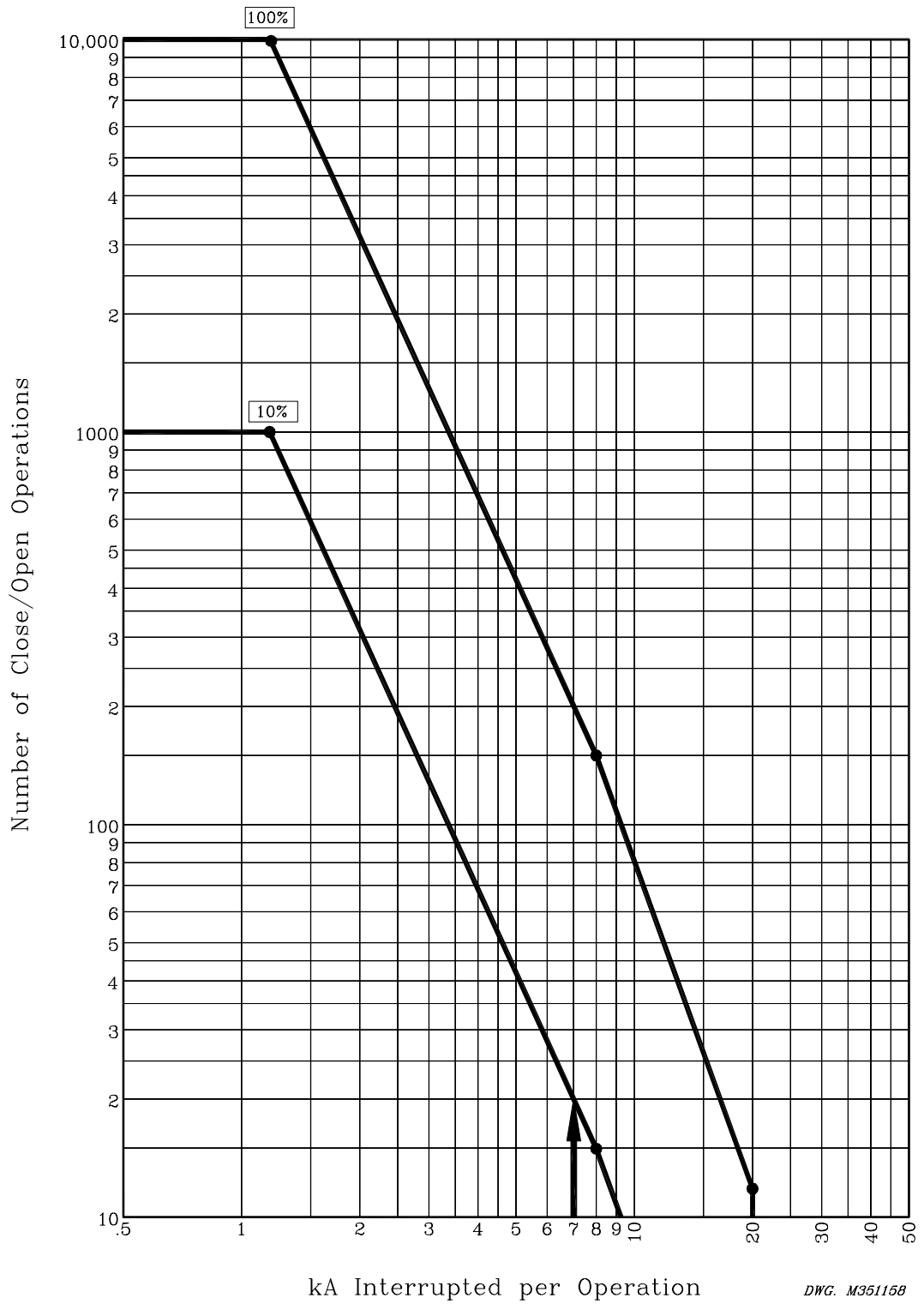
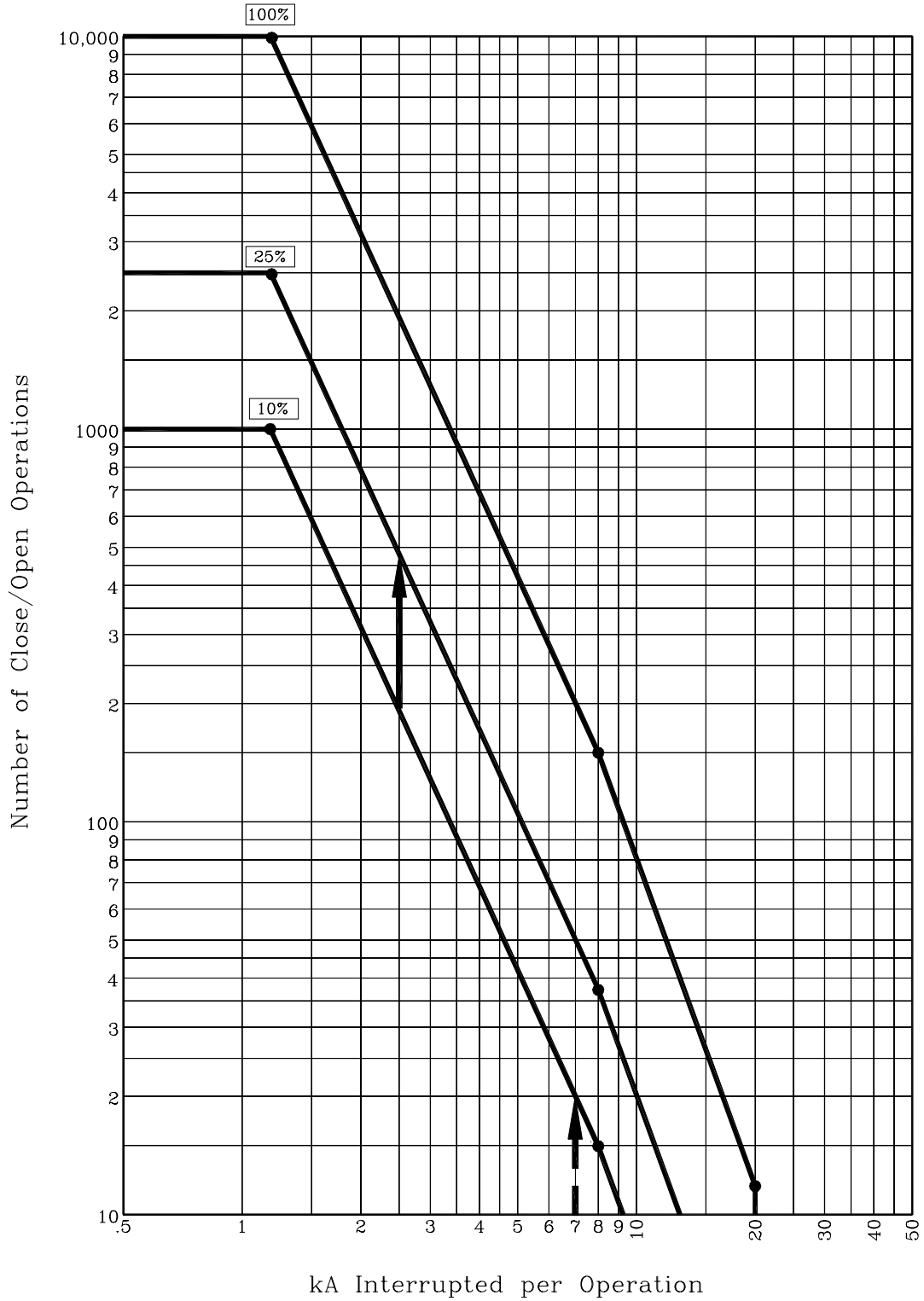


Figure 8.4: Breaker Monitor Accumulates 10 Percent Wear



DWG. M361159

Figure 8.5: Breaker Monitor Accumulates 25 Percent Wear

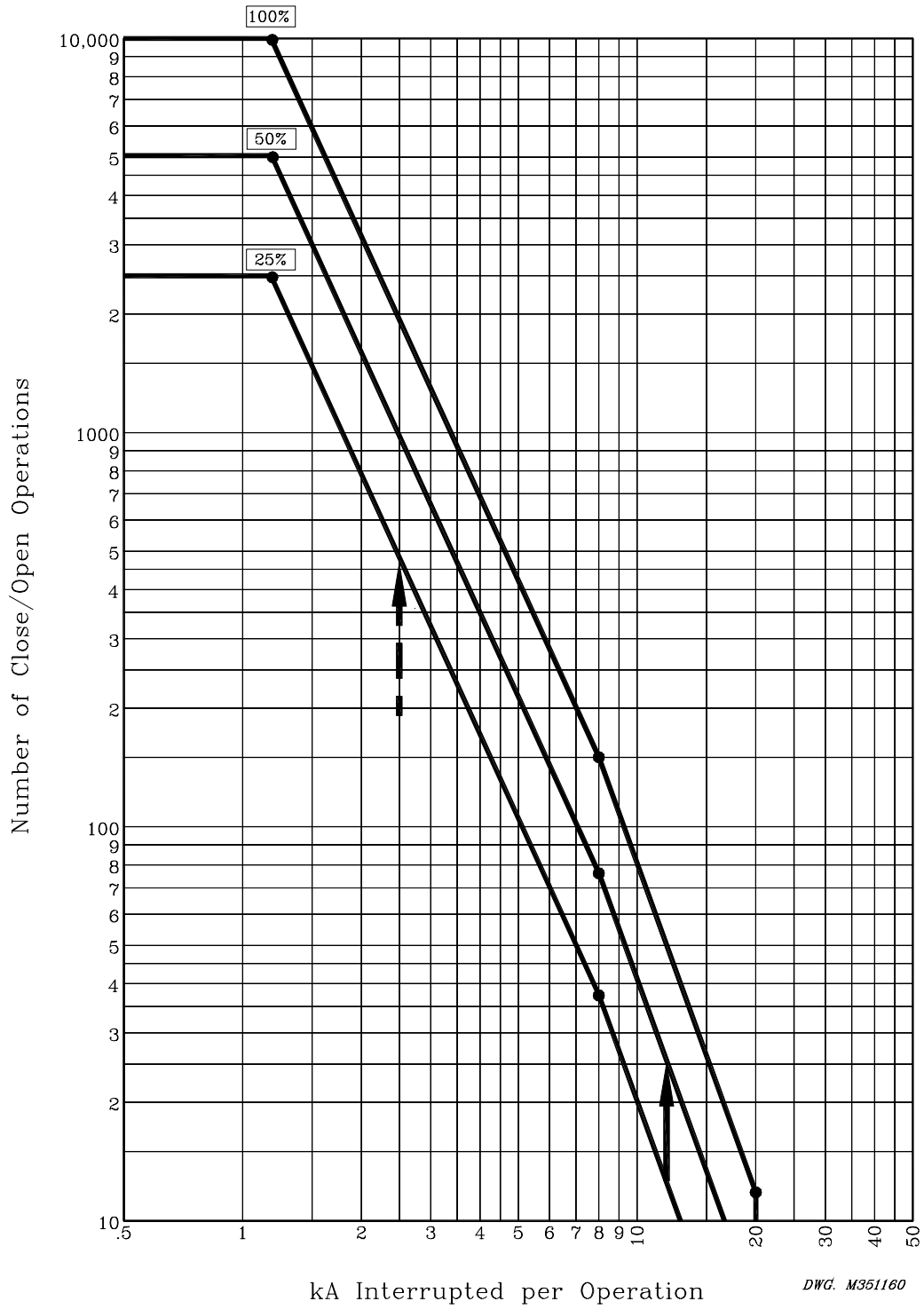


Figure 8.6: Breaker Monitor Accumulates 50 Percent Wear

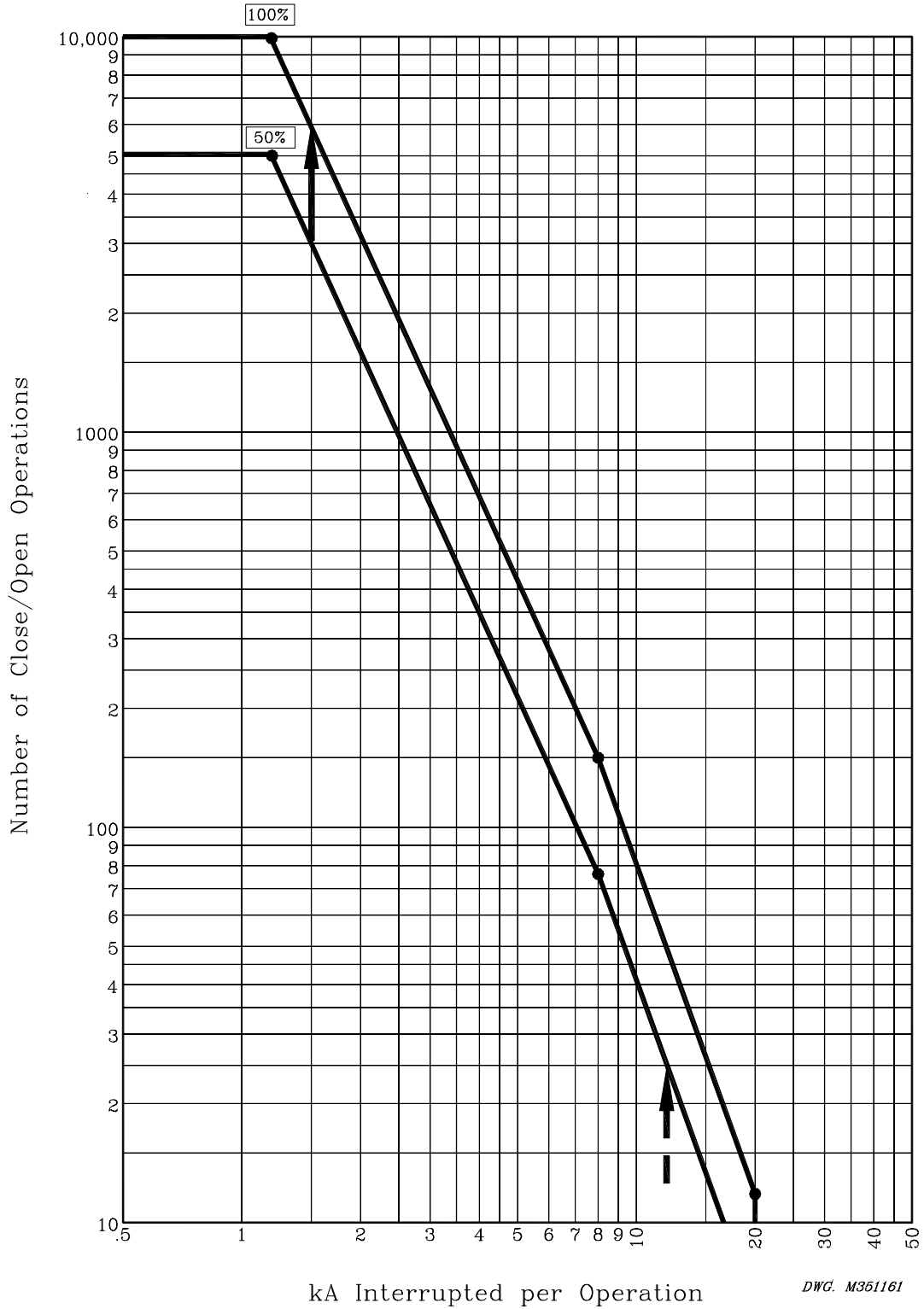


Figure 8.7: Breaker Monitor Accumulates 100 Percent Wear

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.

<u>Relay Word Bits</u>	<u>Definition</u>
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:

$$\text{BKMON} = \text{TRIP}$$

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:

$$\text{OUT101} = \text{TRIP}$$

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.

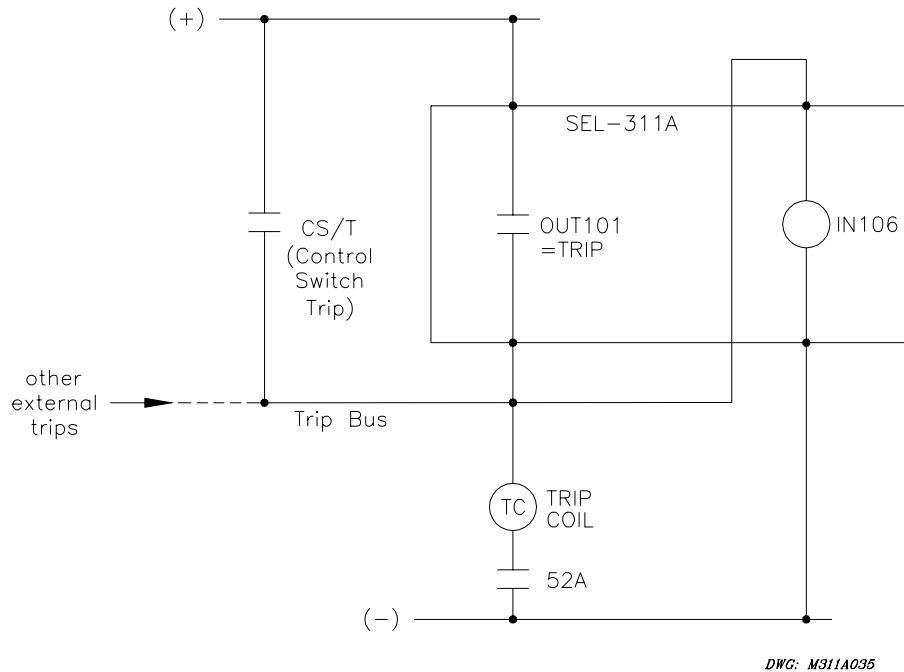


Figure 8.8: Input IN106 Connected to Trip Bus for Breaker Monitor Initiation

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

$$\text{BKMON} = \text{IN106}$$

then the SEL-311A 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-311A 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 12 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 (V_{dc}) to the undervoltage (low) and overvoltage (high) pickups DCLOP and DCHIP. The setting range for pickup settings DCLOP and DCHIP is:

OFF, 20 to 300 Vdc, 1 Vdc increments

This range allows the SEL-311A 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-311A Relay outside of the power supply limits listed in **Section 1: Introduction and Specifications**.

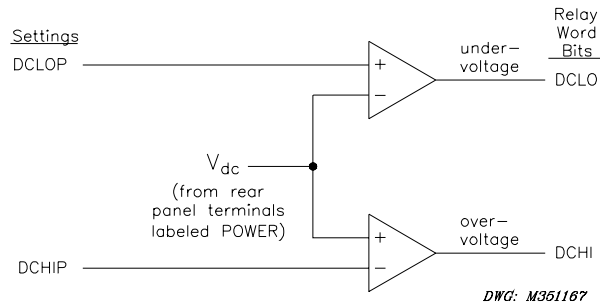


Figure 8.9: DC Under- and Overvoltage Elements

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.

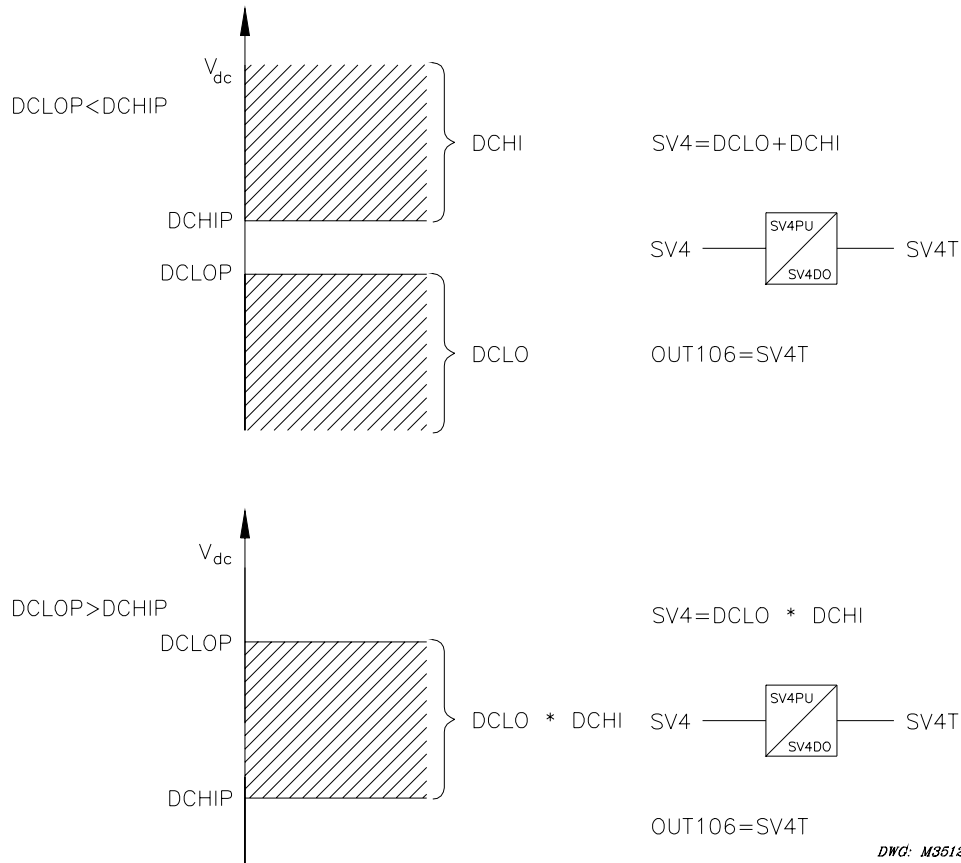


Figure 8.10: Create DC Voltage Elements with SELOGIC Control Equations

DCLO < DCHI (Top of Figure 8.10)

Output contact OUT106 asserts when:

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

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* (especially Note 2 in Figure 7.26). Consider the output contact type (“a” or “b”) needed for output contact OUT106 in the bottom of Figure 8.10 (dc voltage alarm example).

If SELOGIC control equation setting OUT106 is asserted ($OUT106 = SV4T = \text{logical } 1$; 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 ($OUT106 = SV4T = \text{logical } 0$; dc voltage not OK), the state of output contact OUT106 (according to contact type) is:

open (“a” type output contact)

closed (“b” type output contact)

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

open (“a” type output contact)

closed (“b” type output contact)

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-311A 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:

$$ER = \backslash SV4T + \dots$$

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-311A 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 ac voltage powers the relay, 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-311A Relay offers the choice between two types of demand metering, settable with the enable setting:

EDEM = THM (Thermal Demand Meter)

or

EDEM = ROL (Rolling Demand Meter)

The demand metering settings (in Table 8.3) are available via the **SET** command (see Settings Sheet 2 and 11 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-311A 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”).

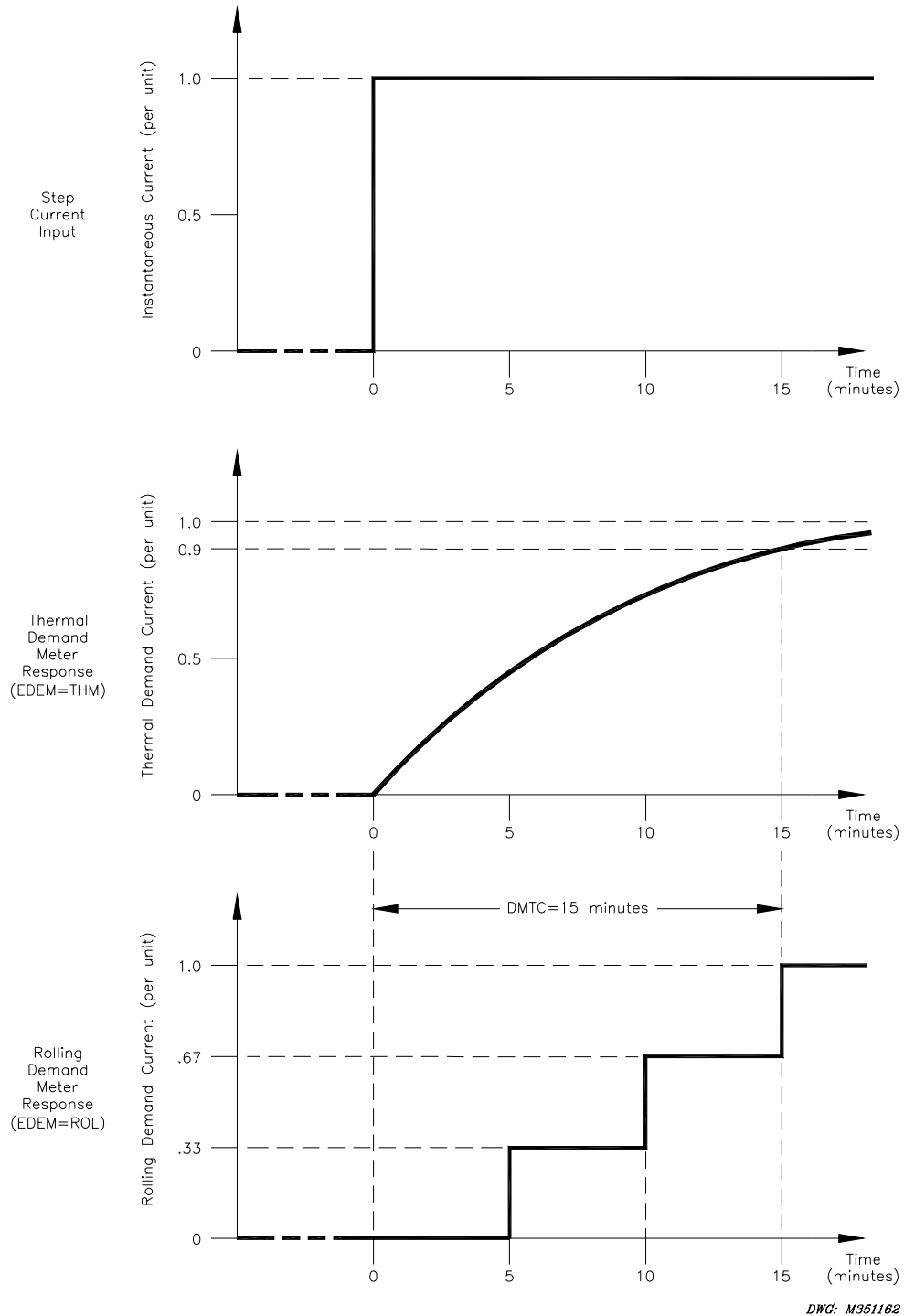


Figure 8.11: Response of Thermal and Rolling Demand Meters to a Step Input (setting DMTC = 15 minutes)

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.

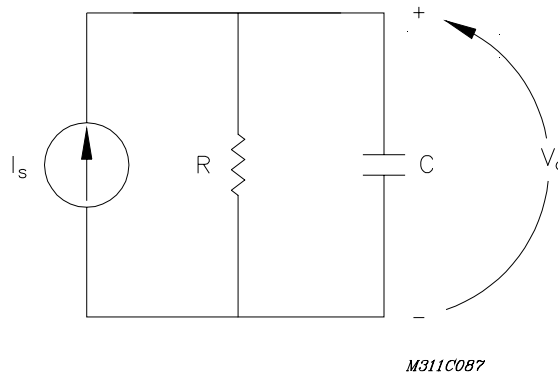


Figure 8.12: Current I_s Applied to Parallel RC Circuit

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-311A 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:

<u>5-Minute Totals</u>	<u>Corresponding 5-Minute Interval</u>
0.0 per unit	-15 to -10 minutes
0.0 per unit	-10 to -5 minutes
<u>0.0 per unit</u>	-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:

<u>5-Minute Totals</u>	<u>Corresponding 5-Minute Interval</u>
0.0 per unit	-10 to -5 minutes
0.0 per unit	-5 to 0 minutes
<u>1.0 per unit</u>	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:

<u>5-Minute Totals</u>	<u>Corresponding 5-Minute Interval</u>
0.0 per unit	-5 to 0 minutes
1.0 per unit	0 to 5 minutes
<u>1.0 per unit</u>	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:

<u>5-Minute Totals</u>	<u>Corresponding 5-Minute Interval</u>
1.0 per unit	0 to 5 minutes
1.0 per unit	5 to 10 minutes
<u>1.0 per unit</u>	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.

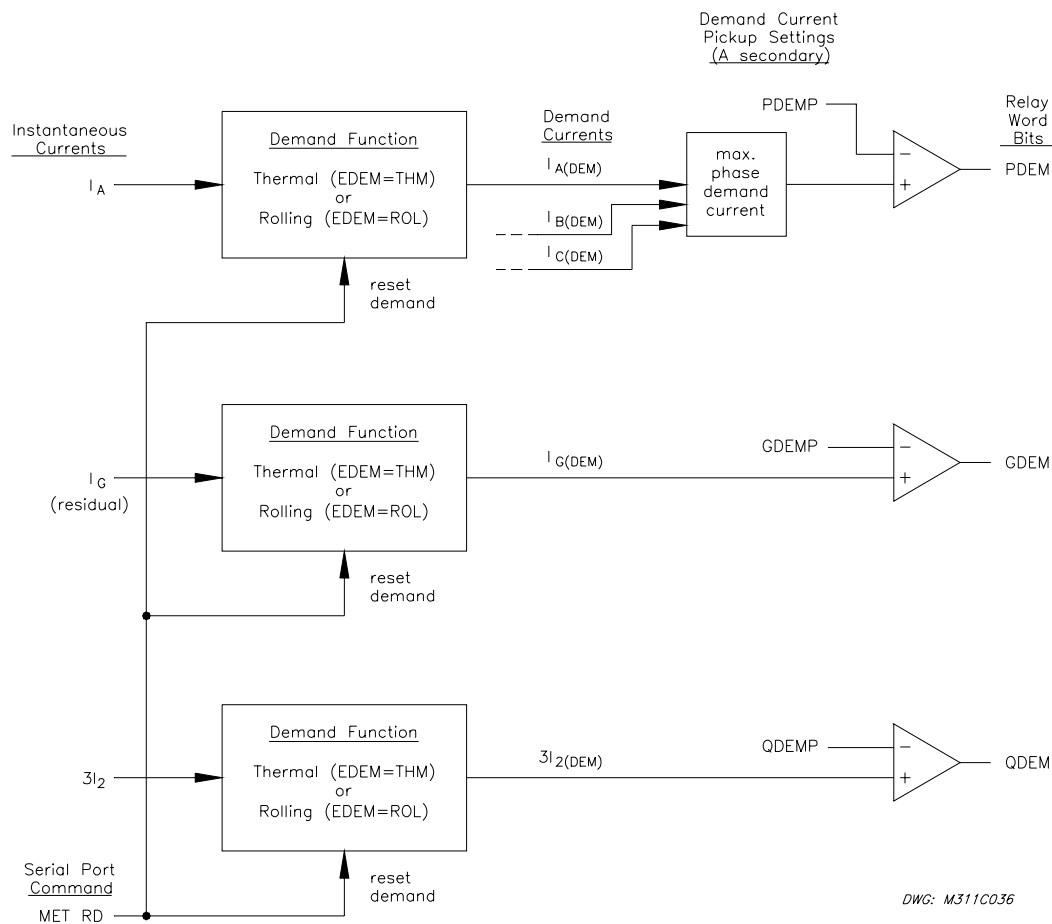


Figure 8.13: Demand Current Logic Outputs

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 SELLOGIC control equation torque control setting $51GTC$:

EDEM = THM
DMTC = 5

$$\begin{aligned} \text{GDEMP} &= 1.0 \\ 51\text{GP} &= 1.50 \\ 50\text{G1P} &= 2.30 \\ 51\text{GTC} &= \text{!GDEM} + \text{GDEM} * 50\text{G2} \end{aligned}$$

Refer to Figure 8.13, Figure 8.14, and Figure 3.15.

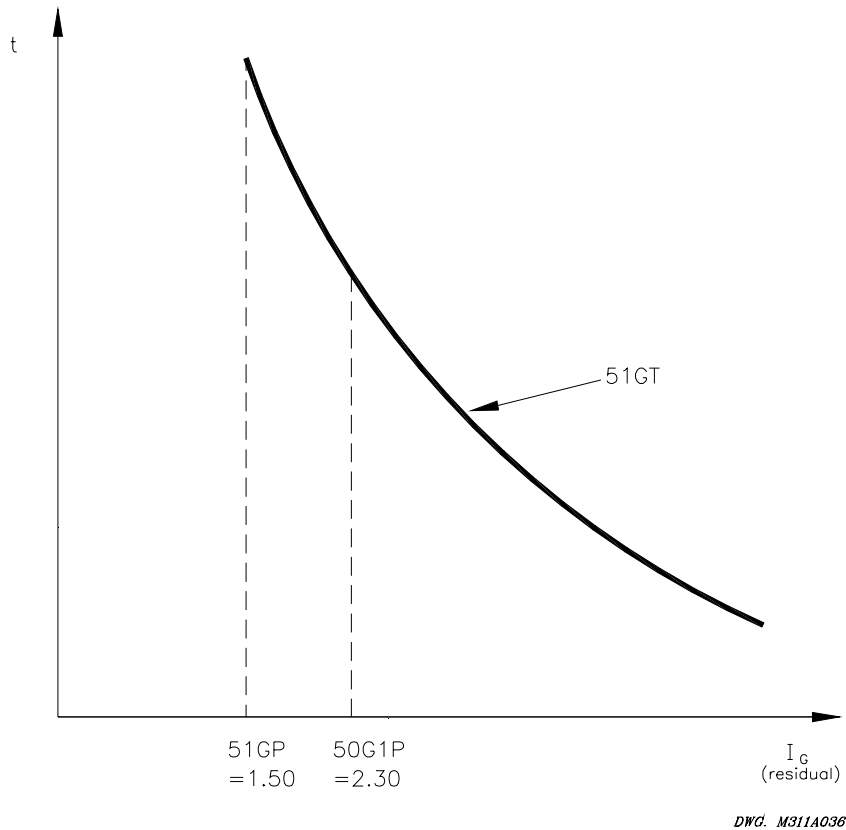


Figure 8.14: Raise Pickup of Residual Ground Time-Overcurrent Element for Unbalance Current

Residual Ground Demand Current Below Pickup GDEMP

When unbalance current I_G is low, unbalance demand current $I_{G(\text{DEM})}$ is below corresponding demand pickup $\text{GDEMP} = 1.00$ 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:

$$\begin{aligned} 51\text{GTC} &= \text{!GDEM} + \text{GDEM} * 50\text{G1} = \text{NOT}(\text{GDEM}) + \text{GDEM} * 50\text{G1} \\ &= \text{NOT}(\text{logical } 0) + (\text{logical } 0) * 50\text{G1} = \text{logical } 1 \end{aligned}$$

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

$$51\text{GP} = 1.50 \text{ A secondary}$$

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 SELLOGIC control equation torque control setting 51GTC being in the state:

$$\begin{aligned} 51GTC &= !GDEM + GDEM * 50G1 = \text{NOT}(GDEM) + GDEM * 50G1 \\ &= \text{NOT}(\text{logical } 1) + (\text{logical } 1) * 50G1 = \text{logical } 0 + 50G1 = 50G1 \end{aligned}$$

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

$$50G1P = 2.30 \text{ A secondary}$$

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 SELLOGIC control equation torque control setting 51GTC being in the state:

$$\begin{aligned} 51GTC &= !GDEM + GDEM * 50G1 = \text{NOT}(GDEM) + GDEM * 50G1 \\ &= \text{NOT}(\text{logical } 0) + (\text{logical } 0) * 50G1 = \text{logical } 1 \end{aligned}$$

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

$$51GP = 1.50 \text{ A secondary}$$

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-311A 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-311A 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)
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-311A 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:
$$\text{FAULT} = 51\text{G} + \text{M2P} + \text{Z2G}$$

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-311A Relay stores maximum/minimum values to nonvolatile storage once per day (it overwrites the previous stored value if it is exceeded). Should the relay lose control power, it will restore the maximum/minimum values saved by the relay at 23:50 hours on the previous day.

TABLE OF CONTENTS

SECTION 9: SETTING THE RELAY 9-1

Introduction.....	9-1
Settings Changes via the Front Panel.....	9-1
Settings Changes via the Serial Port.....	9-2
Time-Overcurrent Curves.....	9-3
Relay Word Bits (Used in SELOGIC [®] Control Equations).....	9-7
Settings Explanations.....	9-20
Identifier Labels.....	9-20
Current Transformer Ratios.....	9-20
Line Settings.....	9-21
Enable Settings.....	9-21
Other System Parameters.....	9-21
Settings Sheets.....	9-22
Settings Sheets for the SEL-311A Relay.....	9-23

TABLES

Table 9.1: Serial Port SET Commands.....	9-1
Table 9.2: Set Command Editing Keystrokes.....	9-2
Table 9.3: SEL-311A Relay Word Bits.....	9-7
Table 9.4: Relay Word Bit Definitions for the SEL-311A.....	9-8

FIGURES

Figure 9.1: U.S. Moderately Inverse Curve: U1.....	9-4
Figure 9.2: U.S. Inverse Curve: U2.....	9-4
Figure 9.3: U.S. Very Inverse Curve: U3.....	9-4
Figure 9.4: U.S. Extremely Inverse Curve: U4.....	9-4
Figure 9.5: U.S. Short-Time Inverse Curve: U5.....	9-5
Figure 9.6: I.E.C. Class A Curve (Standard Inverse): C1.....	9-5
Figure 9.7: I.E.C. Class B Curve (Very Inverse): C2.....	9-5
Figure 9.8: I.E.C. Class C Curve (Extremely Inverse): C3.....	9-6
Figure 9.9: I.E.C. Long-Time Inverse Curve: C4.....	9-6
Figure 9.10: I.E.C. Short-Time Inverse Curve: C5.....	9-6

SECTION 9: SETTING THE RELAY

INTRODUCTION

Change or view settings with the **SET** and **SHO** 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 <i>m</i>	Relay	Distance, overcurrent and voltage elements, reclosing relay, timers, etc., for settings group <i>m</i> (<i>m</i> = 1, 2, 3, 4, 5, 6).	1–7
SET L <i>m</i>	Logic	SELOGIC [®] control equations for settings group <i>m</i> (<i>m</i> = 1, 2, 3, 4, 5, 6).	8–11
SET G	Global	Battery and breaker monitors, optoisolated input debounce timers, etc.	12–13
SET R	SER	Sequential Events Recorder trigger conditions.	14
SET T	Text	Front-panel default display and local control text.	15–18
SET P <i>m</i>	Port	Serial port settings for Serial Port <i>m</i> (<i>m</i> = 1, 2, 3, or F).	19

* 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 Figure 3.14 and Figure 3.15). 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

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

U.S. Inverse Curve: U2

$$\begin{aligned} tp &= TD \cdot (0.180 + 5.95/(M^2-1)) \\ tr &= TD \cdot (5.95/(1-M^2)) \end{aligned}$$

U.S. Very Inverse Curve: U3

$$\begin{aligned} tp &= TD \cdot (0.0963 + 3.88/(M^2-1)) \\ tr &= TD \cdot (3.88/(1-M^2)) \end{aligned}$$

U.S. Extremely Inverse Curve: U4

$$\begin{aligned} tp &= TD \cdot (0.0352 + 5.67/(M^2-1)) \\ tr &= TD \cdot (5.67/(1-M^2)) \end{aligned}$$

U.S. Short-Time Inverse Curve: U5

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

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

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

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

$$\begin{aligned} tp &= TD \cdot (13.5/(M-1)) \\ tr &= TD \cdot (47.3/(1-M^2)) \end{aligned}$$

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

$$\begin{aligned} tp &= TD \cdot (80.0/(M^2-1)) \\ tr &= TD \cdot (80.0/(1-M^2)) \end{aligned}$$

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

$$\begin{aligned} tp &= TD \cdot (120.0/(M-1)) \\ tr &= TD \cdot (120.0/(1-M)) \end{aligned}$$

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

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

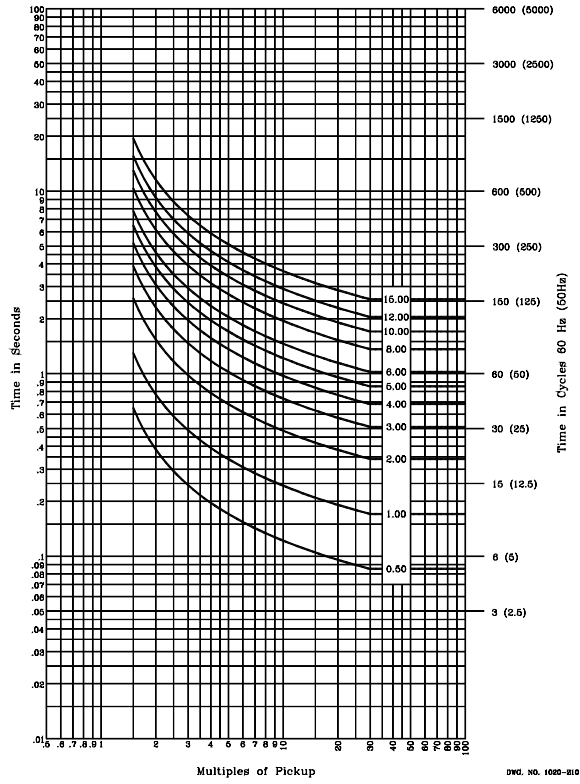


Figure 9.1: U.S. Moderately Inverse Curve: U1

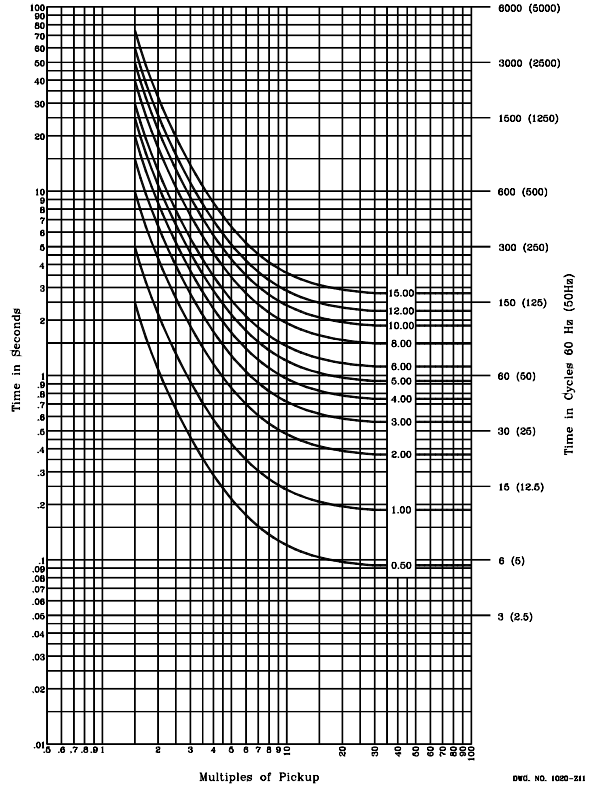


Figure 9.2: U.S. Inverse Curve: U2

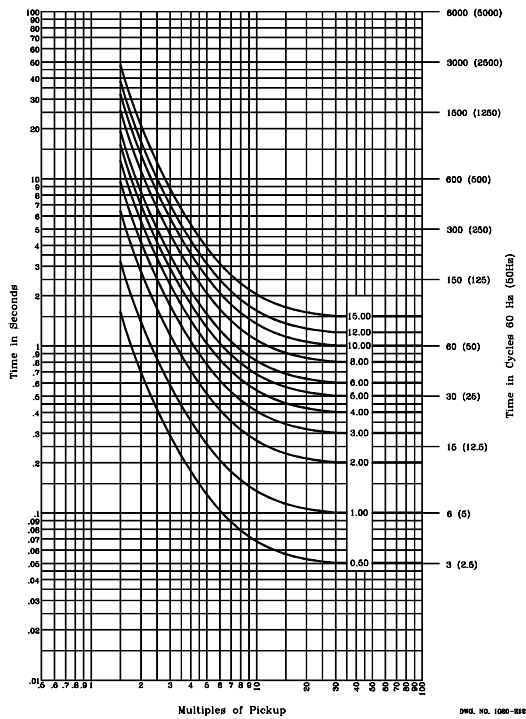


Figure 9.3: U.S. Very Inverse Curve: U3

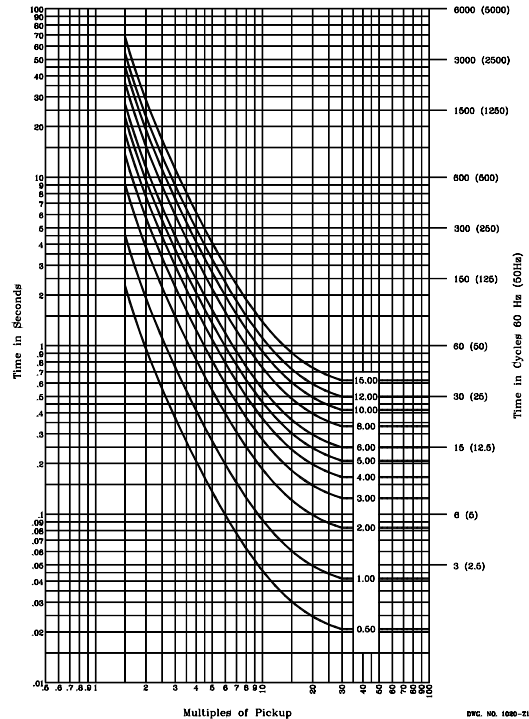


Figure 9.4: U.S. Extremely Inverse Curve: U4

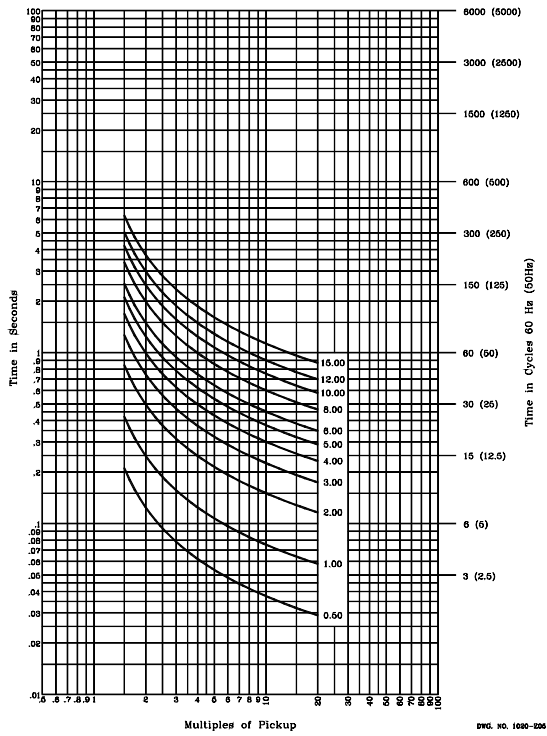


Figure 9.5: U.S. Short-Time Inverse Curve: U5

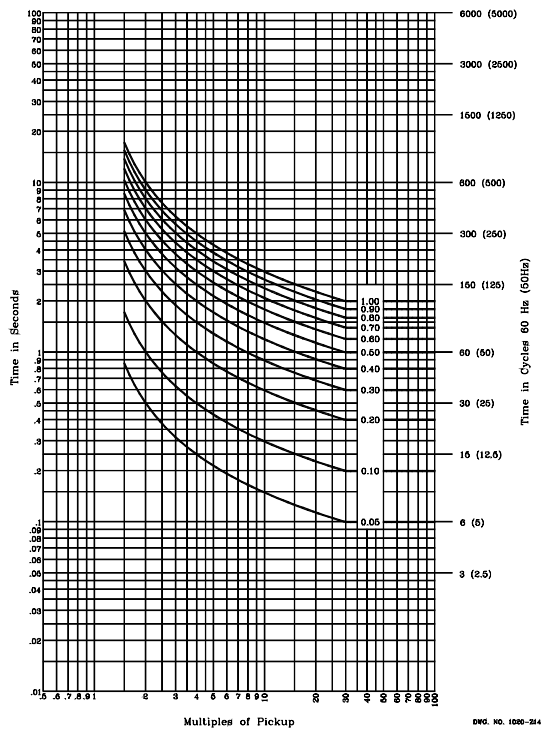


Figure 9.6: I.E.C. Class A Curve (Standard Inverse): C1

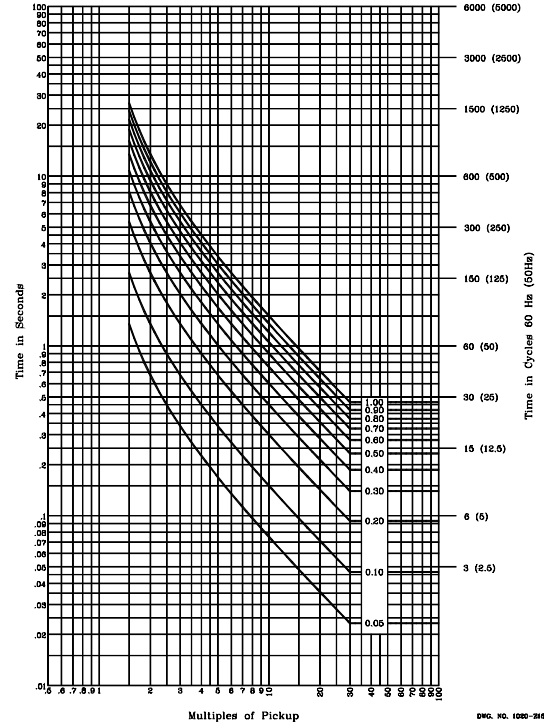


Figure 9.7: I.E.C. Class B Curve (Very Inverse): C2

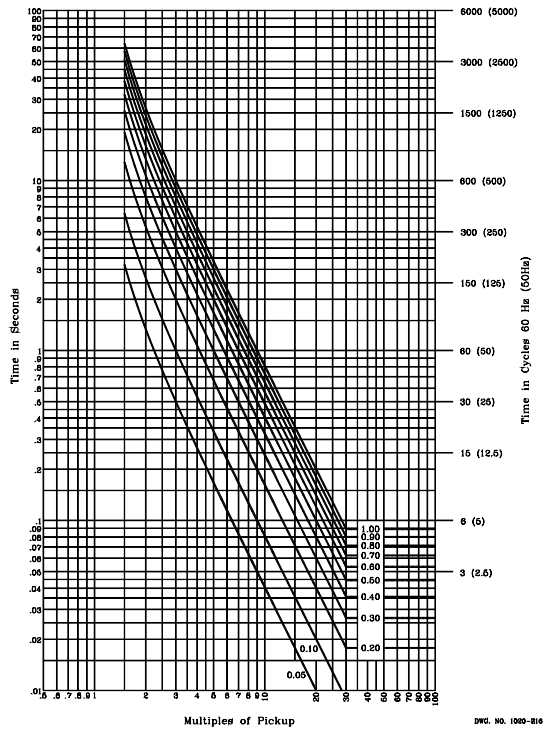


Figure 9.8: I.E.C. Class C Curve (Extremely Inverse): C3

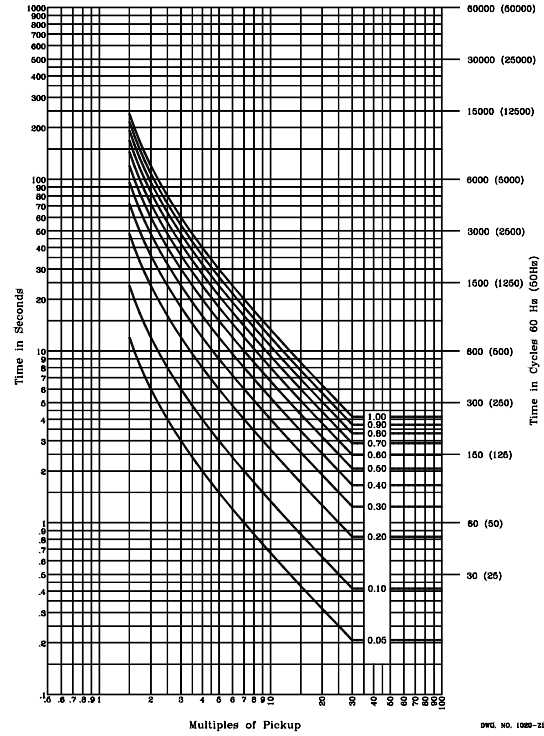


Figure 9.9: I.E.C. Long-Time Inverse Curve: C4

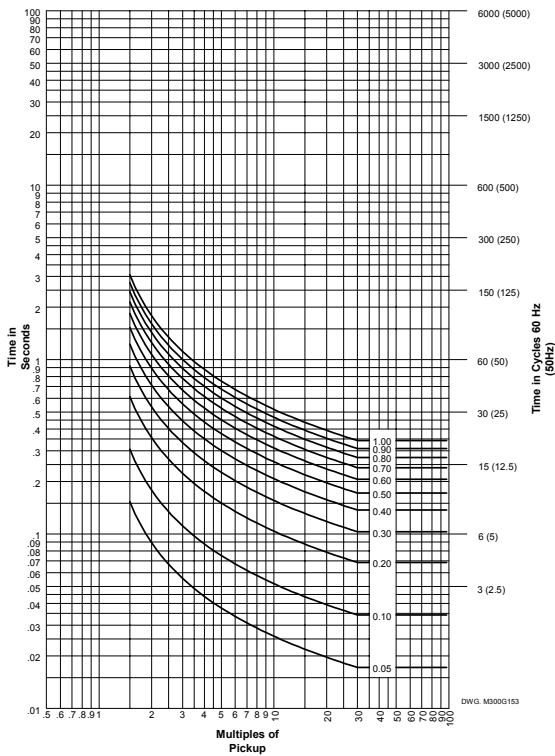


Figure 9.10: I.E.C. Short-Time Inverse Curve: C5

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-311A Relay Word Bits

Row	Relay Word Bits							
0	EN	TRP	TIME	TARDT	SOTF	TARLOP	TAR51P	TAR51G
1	A	B	C	G	ZONE1	ZONE2	TAR67P	TAR67G
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	*	50GF	*
21	32QF	*	32GF	*	32VE	32QGE	32IE	32QE
22	F32I	*	F32Q	*	F32QG	*	F32V	*
23	*	*	IN106	IN105	IN104	IN103	IN102	IN101 ¹
24	ALARM	OUT107	OUT106	OUT105	OUT104	OUT103	OUT102	OUT101 ²
25	*	*	*	*	*	*	*	*
26	*	*	*	*	*	*	*	*
27	*	*	*	*	*	*	*	*
28	51P	51PT	51PR	*	*	*	*	*
29	*	*	*	*	*	*	*	*
30	*	*	*	*	*	*	*	*
31	*	*	*	*	*	*	*	*
32	*	*	*	*	*	*	*	*
33	*	*	*	*	*	*	*	*
34	*	*	*	*	*	*	*	*

Row	Relay Word Bits							
35	*	*	*	*	*	*	*	*
36	*	*	*	*	MPP1	MABC1	MPP2	MABC2
37	*	*	*	*	*	*	*	*
38	*	*	*	*	*	*	*	*
39	*	*	*	*	*	*	*	*
40	*	*	*	*	*	*	*	*
41	*	*	*	*	*	*	*	*
42	*	*	*	*	*	*	*	*
43	*	*	*	*	*	*	*	*
44	*	*	*	*	*	*	*	*
45	*	*	*	*	*	*	*	*
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-311A

Row	Bit	Definition	Primary Application
0	EN TRP TIME TARDT SOTF TARLOP TAR51P TAR51G	Relay enabled (see Table 5.1) Relay trip Time delayed trip Direct trip target Switch-onto-fault trip Loss-of-potential target Phase time-overcurrent target Residual ground time-overcurrent target	Target
1	A B C G	Phase A is involved in the fault (see Table 5.1) Phase B is involved in the fault Phase C is involved in the fault Residual ground element tripped for fault or residual ground current above pickup of residual ground element at time of trip	

Row	Bit	Definition	Primary Application
	ZONE1	Fault in Zone 1/Level 1	
	ZONE2	Fault in Zone 2/Level 2	
	TAR67P	Torque-controlled phase instantaneous/definite time-overcurrent target	
	TAR67G	Directional residual ground instantaneous/definite time-overcurrent target	
2	M1P	Zone 1 phase distance, instantaneous (see Figure 3.4)	Tripping, Control
	M1PT	Zone 1 phase distance, time delayed (see Figure 3.9)	
	Z1G	Zone 1 ground distance, instantaneous (see Figure 3.6)	
	Z1GT	Zone 1 ground distance, time delayed (see Figure 3.9)	
	M2P	Zone 2 phase distance, instantaneous (see Figure 3.5)	
	M2PT	Zone 2 phase distance, time delayed (see Figure 3.9)	
	Z2G	Zone 2 ground distance, instantaneous (see Figure 3.7)	
	Z2GT	Zone 2 ground distance, time delayed (see Figure 3.9)	
3	Z1T	Zone 1 phase and/or ground distance, time delayed (see Figure 3.9)	
	Z2T	Zone 2 phase and/or ground distance, time delayed (see Figure 3.9)	
	50P1	Phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P1P; see Figure 3.10)	
	67P1	Torque controlled phase instantaneous overcurrent element (derived from 50P1; see Figure 3.10)	
	67P1T	Phase definite-time overcurrent element 67P1T timed out (derived from 67P1; see Figure 3.10)	
	50G1	Residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G1P; see Figure 3.13)	
	67G1	Torque controlled residual ground instantaneous overcurrent element (derived from 50G1; see Figure 3.13)	

Row	Bit	Definition	Primary Application
	67G1T	Residual ground definite-time overcurrent element 67G1T timed out (derived from 67G1; see Figure 3.13)	
4	51G	Residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see Figure 3.15)	Testing, Control
	51GT	Residual ground time-overcurrent element 51GT timed out (see Figure 3.15)	Tripping
	51GR	Residual ground time-overcurrent element 51GT reset (see Figure 3.15)	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 LB10 LB11 LB12 LB13 LB14 LB15 LB16	Local Bit 9 asserted (see Figure 7.3) Local Bit 10 asserted (see Figure 7.3) Local Bit 11 asserted (see Figure 7.3) Local Bit 12 asserted (see Figure 7.3) Local Bit 13 asserted (see Figure 7.3) Local Bit 14 asserted (see Figure 7.3) Local Bit 15 asserted (see Figure 7.3) Local Bit 16 asserted (see Figure 7.3)	
7	RB1 RB2 RB3 RB4 RB5 RB6 RB7 RB8	Remote Bit 1 asserted (see Figure 7.9) Remote Bit 2 asserted (see Figure 7.9) Remote Bit 3 asserted (see Figure 7.9) Remote Bit 4 asserted (see Figure 7.9) Remote Bit 5 asserted (see Figure 7.9) Remote Bit 6 asserted (see Figure 7.9) Remote Bit 7 asserted (see Figure 7.9) Remote Bit 8 asserted (see Figure 7.9)	Remote control via serial port
8	RB9 RB10 RB11 RB12 RB13 RB14 RB15 RB16	Remote Bit 9 asserted (see Figure 7.9) Remote Bit 10 asserted (see Figure 7.9) Remote Bit 11 asserted (see Figure 7.9) Remote Bit 12 asserted (see Figure 7.9) Remote Bit 13 asserted (see Figure 7.9) Remote Bit 14 asserted (see Figure 7.9) Remote Bit 15 asserted (see Figure 7.9) Remote Bit 16 asserted (see Figure 7.9)	
9	LT1 LT2 LT3 LT4 LT5 LT6 LT7 LT8	Latch Bit 1 asserted (see Figure 7.11) Latch Bit 2 asserted (see Figure 7.11) Latch Bit 3 asserted (see Figure 7.11) Latch Bit 4 asserted (see Figure 7.11) Latch Bit 5 asserted (see Figure 7.11) Latch Bit 6 asserted (see Figure 7.11) Latch Bit 7 asserted (see Figure 7.11) Latch Bit 8 asserted (see Figure 7.11)	Latched control –replacing traditional latching relays

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 4.2)	Indication, Testing
SOTFT	Switch-onto-fault trip		
16	MAG1	Mho ground distance A-phase, zone 1 (see Figure 3.6)	Testing
	MBG1	Mho ground distance B-phase, zone 1 (see Figure 3.6)	
	MCG1	Mho ground distance C-phase, zone 1 (see Figure 3.6)	
	MAG2	Mho ground distance A-phase, zone 2 (see Figure 3.7)	
	MBG2	Mho ground distance B-phase, zone 2 (see Figure 3.7)	
	MCG2	Mho ground distance C-phase, zone 2 (see Figure 3.7)	
	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 Figure 5.1 and Figure 5.4)	
	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 Figure 3.4 through Figure 3.7 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
	*		
	50GF	Forward 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
	*		
	32GF	Forward 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)	
	*		
	F32Q	Forward 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)	
	*		
23	F32V	Forward zero-sequence voltage-polarized directional element (see Figure 4.5 and 4.10)	
	*		
	*		
	IN106	Optoisolated input IN106 asserted (see Figure 7.1)	
	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)	Relay input status, Control via optoisolated inputs	
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
25–27	*		
28	51P	Maximum phase current above pickup setting 51PP for phase time-overcurrent element 51PT (see Figure 3.14)	Testing, Control
	51PT	Phase time-overcurrent element 51PT timed out (see Figure 3.14)	Tripping
	51PR	Phase time-overcurrent element 51PT reset (see Figure 3.14)	Testing
	*		
	*		
	*		
29–35	*		
36	*		Tripping
	*		
	*		
	*		
	MPP1	Zone 1 compensator distance phase-to-phase element (see Figure 3.4)	
	MABC1	Zone 1 compensator distance three-phase element (see Figure 3.4)	
MPP2	Zone 2 compensator distance phase-to-phase element (see Figure 3.5)		
MABC2	Zone 2 compensator distance three-phase element (see Figure 3.5)		
37–46	*		

Row	Bit	Definition	Primary Application
47	RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A	Channel A, received bit 8 Channel A, received bit 7 Channel A, received bit 6 Channel A, received bit 5 Channel A, received bit 4 Channel A, received bit 3 Channel A, received bit 2 Channel A, received bit 1	Relay-to-relay communication (see <i>Appendix I: MIRRORED BITS</i>)
48	TMB8A TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A	Channel A, transmit bit 8 Channel A, transmit bit 7 Channel A, transmit bit 6 Channel A, transmit bit 5 Channel A, transmit bit 4 Channel A, transmit bit 3 Channel A, transmit bit 2 Channel A, transmit bit 1	
49	RMB8B RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B RMB1B	Channel B, received bit 8 Channel B, received bit 7 Channel B, received bit 6 Channel B, received bit 5 Channel B, received bit 4 Channel B, received bit 3 Channel B, received bit 2 Channel B, received bit 1	
50	TMB8B TMB7B TMB6B TMB5B TMB4B TMB3B	Channel B, transmit bit 8 Channel B, transmit bit 7 Channel B, transmit bit 6 Channel B, transmit bit 5 Channel B, transmit bit 4 Channel B, transmit bit 3	

Row	Bit	Definition	Primary Application
	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	

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-311A 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 and Z0F (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:

$$\Omega \text{ primary} \cdot (\text{CTR/PTR}) = \Omega \text{ secondary}$$

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:

$$\text{LL} = 15.00 \quad (\text{miles})$$

If the same length of line is measured in kilometers rather than miles, then enter:

$$\text{LL} = 24.14 \quad (\text{kilometers})$$

Enable Settings

Refer to Settings Sheets 1, 2, and 13.

The enable settings on Settings Sheets 1 and 2 (E21P through EADVS) control the settings that follow, through Sheet 7. Enable setting, EBMON, on Settings Sheet 13 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 7 has a reference back to the controlling enable setting. For example, the residual time-overcurrent element settings on Sheet 4 (settings 51GP through 51GRS) are controlled by enable setting E51G.

Other System Parameters

Refer to Settings Sheet 12.

The global settings NFREQ and PHROT allow you to configure the SEL-311A 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-311A RELAY
RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

Page 1 of 19

Date _____

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 Z1MAG = _____
(0.05–255.00 Ω secondary {5 A nom.};
0.25–1275.00 Ω secondary {1 A nom.})
Positive-sequence line impedance angle (5.00–90.00 degrees) Z1ANG = _____
Zero-sequence line impedance magnitude Z0MAG = _____
(0.05–255.00 Ω secondary {5 A nom.};
0.25–1275.00 Ω secondary {1 A nom.})
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 (311A, 2PG10) APP = _____

Distance Settings

Mho phase distance element zones (N, 1, 2, 1C, 2C) (see Figure 3.4 and Figure 3.5) E21P = _____
Mho ground distance element zones (N, 1, 2) (see Figure 3.6 and Figure 3.7) E21MG = _____

Instantaneous/Definite-Time Overcurrent Enable Settings

Phase element levels (Y, N) (see Figure 3.10) E50P = _____
Residual ground element levels (Y, N) (see Figure 3.13) E50G = _____

Time-Overcurrent Enable Settings

Phase element (Y, N) (see Figure 3.14) E51P = _____
Residual ground element (Y, N) (see Figure 3.15) E51G = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

Other Enable Settings

Directional control (Y, AUTO) (see <i>Directional Control Settings</i> in <i>Section 4</i>)	E32 = _____
Load encroachment (Y, N) (see Figure 4.3)	ELOAD = _____
Switch-onto-fault (Y, N) (see Figure 5.3)	ESOTF = _____
Fault location (Y, N) (see Table 12.1 and <i>Fault Location</i> in <i>Section 12</i>)	EFLOC = _____
Loss-of-potential (Y, Y1, N) (see Figure 4.1)	ELOP = _____
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 = _____

Mho Phase Distance Elements

(Number of mho phase distance element settings dependent on preceding enable setting E21P = 1–2.)

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 = _____

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 3.4)	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 3.5)	50PP2 = _____

Mho Ground Distance Elements

(Number of mho ground distance element settings dependent on preceding enable setting E21MG = 1–2.)

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.6)	Z1MG = _____
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.7)	Z2MG = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

Mho Ground Distance Fault Detector Settings

(Number of mho ground distance element settings dependent on the larger of preceding enable settings E21MG = 1–2.)

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 3.6) 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 3.7) 50L2 = _____

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 3.6) 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 3.7) 50GZ2 = _____

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 (-180.00° to +180.00°) k0A1 = _____

*Zone 2 ZSC factor magnitude (0.000–6.000 unitless) k0M = _____

*Zone 2 ZSC factor angle (-180.00° to +180.00°) k0A = _____

Mho Phase Distance Element Time Delays (See Figure 3.9)

(Number of mho phase distance element time delay settings dependent on preceding enable setting E21P = 1–2.)

Zone 1 time delay (OFF, 0.00–16000.00 cycles) Z1PD = _____

Zone 2 time delay (OFF, 0.00–16000.00 cycles) Z2PD = _____

Mho Ground Distance Element Time Delays (See Figure 3.9)

(Number of time delay element settings dependent on preceding enable settings E21MG = 1–2.)

Zone 1 time delay (OFF, 0.00–16000.00 cycles) Z1GD = _____

Zone 2 time delay (OFF, 0.00–16000.00 cycles) Z2GD = _____

Common Phase/Ground Distance Element Time Delay (See Figure 3.9)

(Number of time delay element settings dependent on the larger of preceding enable settings E21P = 1–2 or E21MG = 1–2.)

Zone 1 time delay (OFF, 0.00–16000.00 cycles) Z1D = _____

Zone 2 time delay (OFF, 0.00–16000.00 cycles) Z2D = _____

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

Phase Inst./Def.-Time Overcurrent Elements (See Figure 3.10)

Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.};
 0.05–20.00 A secondary {1 A nom.}) 50P1P = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

Page 4 of 19

Date _____

Phase Definite-Time Overcurrent Element Time Delays (See Figure 3.10)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) 67P1D = _____

Residual Ground 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.}) 50G1P = _____

Residual Ground Definite-Time Overcurrent Element Time Delay (See Figure 3.13)

(Number of residual ground element time delay settings dependent on preceding enable setting
E50G = Y, N.)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) 67G1D = _____

Phase Time-Overcurrent Element (See Figure 3.14)

(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 3.15)

(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 = _____

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 = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

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, 50QFP, 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 = _____

Forward directional 3I2 pickup (0.25–5.00 A secondary {5 A nom.};
0.05–1.00 A secondary {1 A nom.}) 50QFP = _____

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 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 = _____

Positive-sequence current restraint factor, I0/I1 (0.02–0.50, unitless) a0 = _____

(Make setting Z0F if preceding enable setting E32 = Y and preceding setting ORDER contains V. If E32 = AUTO and ORDER contains V, this setting is 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 = _____

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 = _____

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 = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

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 (0.00–150.00 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 = _____

**SETTINGS SHEET
FOR THE SEL-311A RELAY**

Page 7 of 19

Date _____

RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

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 = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY

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 F: 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 = _____

Latch Bits Set/Reset Equations (See Figure 7.11)

Set Latch Bit LT1	SET1 = _____
Reset Latch Bit LT1	RST1 = _____
Set Latch Bit LT2	SET2 = _____
Reset Latch Bit LT2	RST2 = _____
Set Latch Bit LT3	SET3 = _____
Reset Latch Bit LT3	RST3 = _____
Set Latch Bit LT4	SET4 = _____
Reset Latch Bit LT4	RST4 = _____
Set Latch Bit LT5	SET5 = _____
Reset Latch Bit LT5	RST5 = _____
Set Latch Bit LT6	SET6 = _____
Reset latch Bit LT6	RST6 = _____
Set Latch Bit LT7	SET7 = _____
Reset Latch Bit LT7	RST7 = _____
Set Latch Bit LT8	SET8 = _____
Reset Latch Bit LT8	RST8 = _____
Set Latch Bit LT9	SET9 = _____
Reset Latch Bit LT9	RST9 = _____
Set Latch Bit LT10	SET10 = _____
Reset Latch Bit LT10	RST10 = _____
Set Latch Bit LT11	SET11 = _____
Reset Latch Bit LT11	RST11 = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY

Page 9 of 19

Date _____

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

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 3.10)	67P1TC = _____
Level 1 residual ground (see Figure 3.13)	67G1TC = _____

Torque Control Equations for Time-Overcurrent Elements

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

Phase (see Figure 3.14)	51PTC = _____
Residual Ground (see Figure 3.15)	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 = _____
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 = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

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 Sections 7 and 11)

Display Point DP1	DP1 = _____
Display Point DP2	DP2 = _____
Display Point DP3	DP3 = _____
Display Point DP4	DP4 = _____
Display Point DP5	DP5 = _____
Display Point DP6	DP6 = _____
Display Point DP7	DP7 = _____
Display Point DP8	DP8 = _____
Display Point DP9	DP9 = _____
Display Point DP10	DP10 = _____
Display Point DP11	DP11 = _____
Display Point DP12	DP12 = _____
Display Point DP13	DP13 = _____
Display Point DP14	DP14 = _____
Display Point DP15	DP15 = _____
Display Point DP16	DP16 = _____

Setting Group Selection Equations (See Table 7.4)

Select Setting Group 1	SS1 = _____
Select Setting Group 2	SS2 = _____
Select Setting Group 3	SS3 = _____
Select Setting Group 4	SS4 = _____
Select Setting Group 5	SS5 = _____
Select Setting Group 6	SS6 = _____

Other Equations

Event report trigger conditions (see <i>Section 12</i>)	ER = _____
--	------------

**SETTINGS SHEET
FOR THE SEL-311A RELAY**

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

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 <i>Demand Metering</i> and <i>Maximum/Minimum Metering</i> in Section 8)]	FAULT = _____
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 H)

Channel A, transmit bit 1	TMB1A = _____
Channel A, transmit bit 2	TMB2A = _____
Channel A, transmit bit 3	TMB3A = _____
Channel A, transmit bit 4	TMB4A = _____
Channel A, transmit bit 5	TMB5A = _____
Channel A, transmit bit 6	TMB6A = _____
Channel A, transmit bit 7	TMB7A = _____
Channel A, transmit bit 8	TMB8A = _____
Channel B, transmit bit 1	TMB1B = _____
Channel B, transmit bit 2	TMB2B = _____
Channel B, transmit bit 3	TMB3B = _____
Channel B, transmit bit 4	TMB4B = _____
Channel B, transmit bit 5	TMB5B = _____
Channel B, transmit bit 6	TMB6B = _____
Channel B, transmit bit 7	TMB7B = _____
Channel B, transmit bit 8	TMB8B = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
GLOBAL SETTINGS (SERIAL PORT COMMAND SET G AND FRONT PANEL)

Page 12 OF 19

Date _____

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) SCROLLD = _____

Event Report Parameters (See Section 12)

Length of event report (15, 30, 60 cycles) LER = _____

Length of pre-fault in event report PRE = _____

(1–14 cycles in 1-cycle steps for LER = 15)

(1–29 cycles in 1-cycle steps for LER = 30)

(1–59 cycles in 1-cycle steps for LER = 60)

(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, 20.00–300.00 Vdc) DCLOP = _____

DC battery instantaneous overvoltage pickup (OFF, 20.00–300.00 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 = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
GLOBAL SETTINGS (SERIAL PORT COMMAND SET G AND FRONT PANEL)

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= _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
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-311A 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 = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
TEXT LABEL SETTINGS (SERIAL PORT COMMAND SET T)

Page 16 OF 19

Date _____

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-311A RELAY
TEXT LABEL SETTINGS (SERIAL PORT COMMAND SET T)

Page 17 OF 19

Date _____

Local Bit LB16 Name (14 characters)	NLB16 = _____
Clear Local Bit LB16 Label (7 characters)	CLB16 = _____
Set Local Bit LB16 Label (7 characters)	SLB16 = _____
Pulse Local Bit LB16 Label (7 characters)	PLB16 = _____

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

Display if DP1 = logical 1 (16 characters)	DP1_1 = _____
Display if DP1 = logical 0 (16 characters)	DP1_0 = _____
Display if DP2 = logical 1 (16 characters)	DP2_1 = _____
Display if DP2 = logical 0 (16 characters)	DP2_0 = _____
Display if DP3 = logical 1 (16 characters)	DP3_1 = _____
Display if DP3 = logical 0 (16 characters)	DP3_0 = _____
Display if DP4 = logical 1 (16 characters)	DP4_1 = _____
Display if DP4 = logical 0 (16 characters)	DP4_0 = _____
Display if DP5 = logical 1 (16 characters)	DP5_1 = _____
Display if DP5 = logical 0 (16 characters)	DP5_0 = _____
Display if DP6 = logical 1 (16 characters)	DP6_1 = _____
Display if DP6 = logical 0 (16 characters)	DP6_0 = _____
Display if DP7 = logical 1 (16 characters)	DP7_1 = _____
Display if DP7 = logical 0 (16 characters)	DP7_0 = _____
Display if DP8 = logical 1 (16 characters)	DP8_1 = _____
Display if DP8 = logical 0 (16 characters)	DP8_0 = _____
Display if DP9 = logical 1 (16 characters)	DP9_1 = _____
Display if DP9 = logical 0 (16 characters)	DP9_0 = _____
Display if DP10 = logical 1 (16 characters)	DP10_1 = _____
Display if DP10 = logical 0 (16 characters)	DP10_0 = _____
Display if DP11 = logical 1 (16 characters)	DP11_1 = _____
Display if DP11 = logical 0 (16 characters)	DP11_0 = _____
Display if DP12 = logical 1 (16 characters)	DP12_1 = _____
Display if DP12 = logical 0 (16 characters)	DP12_0 = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
TEXT LABEL SETTINGS (SERIAL PORT COMMAND SET T)

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 = _____

SETTINGS SHEET
FOR THE SEL-311A RELAY
PORT SETTINGS (SERIAL PORT COMMAND SET P AND FRONT PANEL)

Page 19 OF 19

Date _____

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 G* for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, or MB8B. Refer to *Appendix H* 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.

TABLE OF CONTENTS

SECTION 10: SERIAL PORT COMMUNICATIONS AND COMMANDS..... 10-1

Introduction.....	10-1
Port Connector and Communications Cables.....	10-1
IRIG-B.....	10-1
SEL-311A to Computer.....	10-3
SEL-311A to Modem or Other DCE.....	10-3
SEL-311A to SEL-2020, SEL-2030, or SEL-2100.....	10-4
SEL-311A to SEL-DTA2.....	10-4
SEL-311A to SEL-PRTU.....	10-4
Communications Protocols.....	10-5
Hardware Protocol.....	10-5
Software Protocols.....	10-5
Serial Port Automatic Messages.....	10-7
SEL-DTA Protocol.....	10-8
Serial Port Access Levels.....	10-8
Access Level 0.....	10-8
Access Level 1.....	10-9
Access Level B.....	10-9
Access Level 2.....	10-10
Command Summary.....	10-10
Command Explanations.....	10-12
Access Level 0 Commands.....	10-12
Access Level 1 Commands.....	10-14
Access Level B Commands.....	10-32
Access Level 2 Commands.....	10-35
SEL-311A Relay Command Summary.....	10-39

TABLES

Table 10.1: Pinout Functions for EIA-232 Serial Ports 2, 3, and F.....	10-2
Table 10.2: Terminal Functions for EIA-485 Serial Port 1.....	10-2
Table 10.3: Serial Communications Port Pin/Terminal Function Definitions.....	10-5
Table 10.4: Serial Port Automatic Messages.....	10-8
Table 10.5: Serial Port Command Summary.....	10-11
Table 10.6: Event Types.....	10-18
Table 10.7: SEL-311A Relay Word and Its Correspondence to TAR Command.....	10-30
Table 10.8: SEL-311A Relay Control Subcommands.....	10-35

FIGURES

Figure 10.1: DB-9 Connector Pinout for EIA-232 Serial Ports.....	10-1
--	------

SECTION 10: SERIAL PORT COMMUNICATIONS AND COMMANDS

INTRODUCTION

All SEL-311A 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

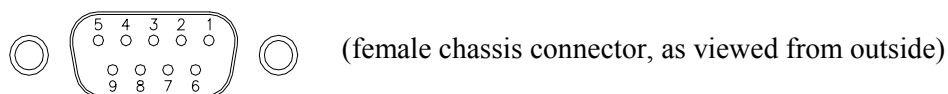


Figure 10.1: DB-9 Connector Pinout for EIA-232 Serial Ports

IRIG-B

Refer to Figure 1.2 and Figure 2.2 through Figure 2.4. Note that demodulated IRIG-B time code can be input into Serial Port 1 or Serial Port 2 on any of the SEL-311A Relay models. This is easily handled by connecting Serial Port 2 of the SEL-311A 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*.

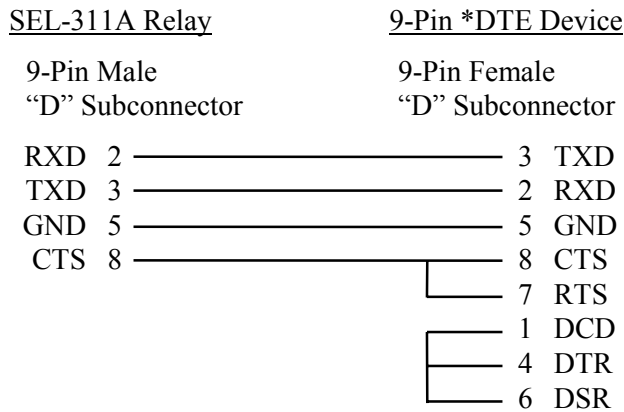
Table 10.2: Terminal Functions for EIA-485 Serial Port 1

Terminal	Function
1	+TX
2	-TX
3	+RX
4	-RX
5	SHIELD
6	N/C
7	+IRIG-B
8	-IRIG-B

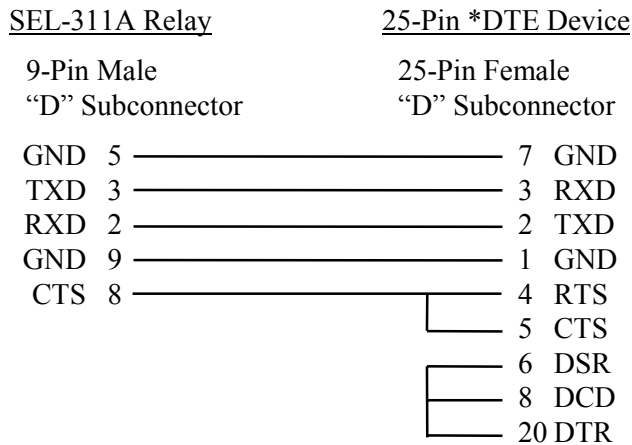
The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-311A Relay to other devices. SEL provides fiber-optic transceivers and cable for communications links with improved safety, noise immunity, and distance as compared to copper links. The equivalent fiber cables are listed following each copper cable description. These and other cables are available from SEL. Contact the factory for more information.

SEL-311A to Computer

Cable C234A

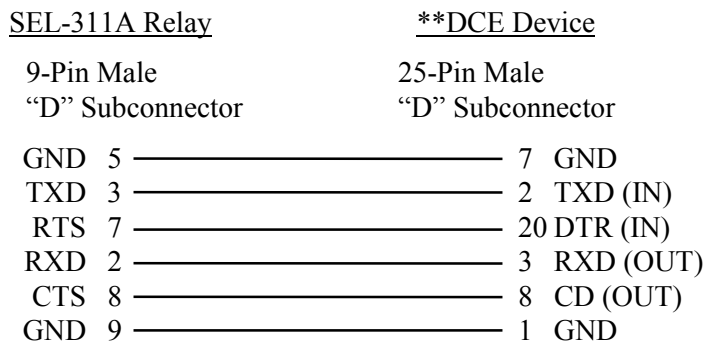


Cable C227A



SEL-311A to Modem or Other DCE

Cable C222



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

Cable C273A

<u>SEL-2020/2030 or SEL-2100</u>		<u>SEL-311A Relay</u>
9-Pin Male		9-Pin Male
“D” Subconnector		“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-311A to SEL-DTA2

Cable C272A

<u>SEL-DTA2</u>		<u>SEL-311A Relay</u>
9-Pin Male		9-Pin Male
“D” Subconnector		“D” Subconnector
RXD	2 —————	3 TXD
TXD	3 —————	2 RXD
GND	5 —————	5 GND
RTS	7 <input type="checkbox"/>	7 RTS
CTS	8 <input type="checkbox"/>	8 CTS

SEL-311A to SEL-PRTU

Cable C231

<u>SEL-PRTU</u>		<u>SEL-311A Relay</u>
9-Pin Male		9-Pin Male
Round Conxall		“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-311A 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-311A Relay is compatible with the SEL-DTA2 Display/Transducer Adapter. See Settings Sheet 19 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 G*.

MIRRORED BITS Communications

The SEL-311A Relay supports MIRRORED BITS relay-to-relay communications on two ports simultaneously. See *Appendix H*.

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 <i>Section 12: Standard Event Reports and SER</i> .
Group Switch	The relay displays the active settings group after a group switch occurs. See <i>GRO n Command</i> (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 <i>STA Command</i> (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-311A 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 <i>n</i>	Preload/reset breaker wear	OTHER
B	==>	CLO	Close breaker	
B	==>	GRO <i>n</i>	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-311A                               Date: 03/01/00   Time: 16:15:39.372  
EXAMPLE: BUS B, BREAKER 3  
-----
```

The definitions are:

- SEL-311A: This is the RID setting (the relay is shipped with the default setting RID =SEL-311A; 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 2.3 for Password jumper information. See *PAS Command (View/Change Passwords)* explanation later in this section for more information on password.

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

<u>Access Level</u>	<u>Factory Default Password</u>
1	OTTER
B	EDITH
2	TAIL



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-311A                               Date: 03/01/00   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-311A                               Date: 03/01/00   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-311A                               Date: 03/10/00   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 03/01/00 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 H: MIRRORED BITS*. To get a summary report, enter the **COM** command with the channel parameter (A or B).

```
=>COM A <ENTER>
SEL-311A                               Date: 03/10/00   Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311A-R100-V0-Z001001-D20000301  CID=FF27
Summary for Mirrored Bits channel A

For 03/05/00 18:36:09.279 to 03/09/00 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-311A                               Date: 03/10/00   Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311A-R100-V0-Z001001-D20000301  CID=FF27
Summary for Mirrored Bits channel A

For 03/05/00 17:18:12.993 to 03/09/00 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  03/05/00 18:36:09.279 03/05/00 18:37:36.114 2.835 Relay Disabled
    2  03/06/00 13:18:09.236 03/06/00 13:18:09.736 0.499 Parity error
    3  03/07/00 11:43:35.547 03/07/00 11:43:35.637 0.089 Underrun
    4  03/09/00 17:18:12.993 03/09/00 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 MIRRORRED 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 June 1, 2000, enter when DATE_F = MDY:

```
=>DAT 6/1/00 <ENTER>
06/01/00
=>
```

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-311A                               Date: 03/04/00   Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

#    DATE      TIME      EVENT  LOCAT  CURR  FREQ  GRP  TARGETS
1  03/01/00  08:33:00.365  TRIG  $$$$$$  1  60.00  3
2  03/02/00  20:32:58.361  ER    $$$$$$  231  60.00  2
3  03/03/00  07:30:11.055  AG T   9.65  2279  60.00  3  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 51P 51G 67P 67G Zone 1 Zone 2

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-311A                               Date: 03/01/00   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	$V_{A,B,C}$	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-311A Relay is shown:

```

=>MET <ENTER>

SEL-311A                               Date: 03/01/00   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
V MAG (KV)  11.691    11.686   11.669
V ANG (DEG)  0.00     -119.79   120.15

      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-311A Relay is shown:

```

=>MET D <ENTER>

SEL-311A                               Date: 03/12/00   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 03/01/00 15:31:51.238  LAST PEAK RESET 03/01/00 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-311A Relay is shown:

```

=>MET E <ENTER>

SEL-311A                               Date: 03/01/00   Time: 15:11:24.056
EXAMPLE: BUS B, BREAKER 3
      MWhA  MWhB  MWhC  MWh3P  MVARhA  MVARhB  MVARhC  MVARh3P
IN     0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
OUT    36.0  36.6  36.7  109.2  5.1   5.2   5.3   15.6
LAST RESET 02/10/00 23:31:28.864
=>

```

Reset the energy values using the **MET RE** command. For more information on energy metering, see *Energy Metering* in **Section 8: Breaker Monitor and Metering Functions**.

MET M—Maximum/Minimum Metering

The **MET M** command displays the maximum and minimum values of the following quantities:

Currents	$I_{A,B,C,P}$ I_G	Input currents (A primary) Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C}$	Wye-connected voltage inputs (kV primary)
Power	MW_{3P} $MVAR_{3P}$	Three-phase megawatts 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-311A Relay is shown:

```
=>MET M <ENTER>
SEL-311A                               Date: 03/12/00   Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3
      Max   Date   Time           Min   Date   Time
IA(A)  196.8 03/01/00 15:00:42.574  30.0 03/01/00 14:51:02.391
IB(A)  195.0 03/01/00 15:05:19.558  31.8 03/01/00 14:50:55.536
IC(A)  200.4 03/01/00 15:00:42.578  52.2 03/01/00 14:51:02.332
IP(A)   42.6 03/01/00 14:51:02.328  42.6 03/01/00 14:51:02.328
IG(A)   42.0 03/01/00 14:50:55.294  42.0 03/01/00 14:50:55.294
VA(kV)  11.7 03/01/00 15:01:01.576   3.4 03/01/00 15:00:42.545
VB(kV)  11.7 03/01/00 15:00:42.937   2.4 03/01/00 15:00:42.541
VC(kV)  11.7 03/01/00 15:00:42.578   3.1 03/01/00 15:00:42.545
MW3P     6.9 03/01/00 15:00:44.095   0.4 03/01/00 15:00:42.545
MVAR3P   1.0 03/01/00 15:00:42.578   0.1 03/01/00 15:00:42.545
LAST RESET 03/01/00 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-311A                               Date: 03/01/00   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. <i>n</i> specifies the setting group (1, 2, 3, 4, 5, or 6); <i>n</i> defaults to the active setting group if not listed.
SHO L n	Show SELOGIC control equation settings. <i>n</i> specifies the setting group (1, 2, 3, 4, 5, or 6); <i>n</i> defaults to the active setting group if not listed.
SHO G	Show global settings.
SHO P n	Show serial port settings. <i>n</i> specifies the port (1, 2, 3, or F); <i>n</i> 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-311A Relay, showing all the **factory default settings**.

=>SHO <ENTER>

Group 1

Group Settings:

RID =SEL-311A TID =EXAMPLE: BUS B, BREAKER 3

CTR = 200

CTRP = 200 PTR = 2000.00

Z1MAG = 7.80 Z1ANG = 84.00

Z0MAG = 24.80 Z0ANG = 81.50 LL = 100.00 APP = 311A

E21P = 2 E21MG = 2

E50P = Y E50G = N

E51P = N E51G = Y

E32 = AUTO ELOAD = Y ESOTF = Y

EFLOC = Y

ELOP = Y

ELOP = Y

EDEM = THM EADVS = N

Z1P = 6.24 Z2P = 9.36

50PP1 = 0.50

Z1MG = 6.24 Z2MG = 9.36

50L1 = 0.50

Press RETURN to continue

50GZ1 = 0.50

k0M1 = 0.726 k0A1 = -3.69

Z1PD = OFF Z2PD = 20.00

Z1GD = OFF Z2GD = 20.00

Z1D = OFF Z2D = OFF

50P1P = 11.25

67PID = 0.00

51GP = 0.75 51GC = U3 51GTD = 2.00 51GRS = Y

ZLF = 9.22 ZLR = 9.22

PLAF = 30.00 NLAF = -30.00 PLAR = 150.00 NLAR = 210.00

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 + 0C

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

67PITC=1

51GTC =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

Press RETURN to continue
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 + /50P1 + /LOP
FAULT =51G + M2P + Z2G
CLMON =0
E32IV =1

=>

```

==>SHO G <ENTER>

```

Global Settings:
TGR   = 180.00  NFREQ = 60      PHROT = ABC
DATE_F= MDY    FP_TO = 15.00   SCROLL= 5
LER   = 15     PRE   = 4       DCLOP = OFF   DCHIP = OFF
IN101D= 0.00  IN102D= 0.00  IN103D= 0.00  IN104D= 0.00
IN105D= 0.00  IN106D= 0.00
EBMON = N

=>

```

==>SHO P <ENTER>

```

Port F

PROTO = SEL
SPEED = 2400  BITS = 8      PARITY= N      STOP = 1
T_OUT = 15   DTA  = N      AUTO  = N      RTSCTS= N      FASTOP= N

=>

```

==>SHO R <ENTER>

```

Sequential Events Recorder trigger lists:
SER1 =M1P,Z1G,M2P,Z2G,51G,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 =

=>

```

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-311A Relay is shown:

```

=>STA <ENTER>

SEL-311A                               Date: 03/01/00   Time: 16:46:08.998
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311A-R100-V0-Z001001-D20000301   CID=B142

SELF TESTS

W=Warn   F=Fail

      IA      IB      IC      IP      VA      VB      VC      MOF
OS    1        0        0       -1      1       -1      1       -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 F: Setting SELOGIC Control Equations*.

The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL relays. But 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, 51P, 51G, A, B, C, G, Zone 1, Zone 2, 67P, and 67G. Unlatches the trip logic for testing purposes (see Figure 5.1). Shows Relay Word Row 0.

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

TAR 0 (Front-Panel LEDs)	EN	TRIP	TIME	TARDT	SOTF	TARLOP	TAR51P	TAR51G
TAR 1 (Front-Panel LEDs)	A	B	C	G	ZONE1	ZONE2	TAR67P	TAR67G

Command **TAR 51G 10** is executed in the following example:

```

=>TAR 51G 10 <ENTER>
51G  51GT  51GR  LOP  ILOP  ZLOAD  ZLOUT  ZLIN
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
51G  51GT  51GR  LOP  ILOP  ZLOAD  ZLOUT  ZLIN
0    0    1    0    0    1    0    0
0    0    1    0    0    1    0    0
=>

```

Note that Relay Word row containing the 51G bit is repeated 10 times.

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-311A                      Date: 03/01/00   Time: 10:12:45.627
EXAMPLE: BUS B, BREAKER 3

Event: TRIG      Location: $$$$$$      Trip Time: --:--:--:--
#: 00002        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 0
TRIP 00000000 00000000 00000000 00000000 0 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-311A                        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-311A                        Date: 03/13/00   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 03/03/00 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 2.3). 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
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-311A                               Date: 03/13/00   Time: 10:12:45.627
EXAMPLE: BUS B, BREAKER 3

Active Group = 2
==>
```

If any of the SELOGIC control equations settings SS1 through SS6 are asserted to logical 1, the active setting group may not 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 2.3). 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-311A Relay Control Subcommands

Subcommand	Description
SRB <i>n</i>	Set Remote Bit <i>n</i> (“ON” position)
CRB <i>n</i>	Clear Remote Bit <i>n</i> (“OFF” position)
PRB <i>n</i>	Pulse Remote Bit <i>n</i> 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 H: 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 MIRRORRED 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 2.3 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-311A Relay Command Summary

Access

Level 0

Command

ACC

The only thing that can be done at Access level 0 is to go to Access Level 1. The screen prompt is: =

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

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.

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 <i>n k</i>	Display Relay Word row. If <i>n</i> = 0 through 45, display row <i>n</i> . If <i>n</i> is an element name (e.g., 50G1) display the row containing element <i>n</i> . Enter <i>k</i> 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 <i>n</i>	Enter BRE W to preload breaker wear. Enter BRE R to reset breaker monitor data.
CLO	Close the circuit breaker.
GRO <i>n</i>	Change active group to Group <i>n</i> .
OPE	Open the circuit breaker.
PUL <i>n k</i>	Pulse output contact <i>n</i> (OUT101–OUT107, ALARM) for <i>k</i> (1–30) seconds. Parameter <i>n</i> must be specified; <i>k</i> 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 <i>n</i>	Control Remote Bit RB <i>n</i> (Remote Bit <i>n</i> ; <i>n</i> = 1–8). Execute CON <i>n</i> and the relay responds: CONTROL RB <i>n</i> . Then reply with one of the following: SRB <i>n</i> set Remote Bit <i>n</i> (assert RB <i>n</i>). CRB <i>n</i> clear Remote Bit <i>n</i> (deassert RB <i>n</i>). PRB <i>n</i> pulse Remote Bit <i>n</i> (assert RB <i>n</i> for 1/4 cycle).
COP <i>m n</i>	Copy relay and logic settings from Group <i>m</i> to Group <i>n</i> .
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 <i>n</i>	Change relay settings (overcurrent, reclosing, timers, etc.) for Group <i>n</i> .
SET L <i>n</i>	Change SELOGIC control equation settings for Group <i>n</i> .
SET G	Change global settings.
SET P <i>n</i>	Change Port <i>n</i> 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.

TABLE OF CONTENTS

SECTION 11: FRONT-PANEL INTERFACE (ONLY ON MODELS WITH LCD)	11-1
Introduction.....	11-1
Front-Panel Pushbutton Operation	11-1
Overview.....	11-1
Primary Functions.....	11-2
Front-Panel Password Security	11-2
Secondary Functions.....	11-4
Functions Unique to the Front-Panel Interface.....	11-6
Local Control	11-6
View Local Control (with Example Settings).....	11-7
Operate Local Control (with Example Settings).....	11-8
Local Control State Retained When Relay Deenergized	11-9
Rotating Default Display	11-9
Scroll Lock Control of Front Panel LCD.....	11-12
Stop Scrolling (Lock).....	11-13
Restart Scrolling (Unlock)	11-13
Single Step	11-13
Exit	11-13
Cancel	11-13
Additional Rotating Default Display Example	11-13

FIGURES

Figure 11.1: SEL-311A Relay Front-Panel Pushbuttons—Overview.....	11-1
Figure 11.2: SEL-311A Relay Front-Panel Pushbuttons—Primary Functions.....	11-2
Figure 11.3: SEL-311A Relay Front-Panel Pushbuttons—Primary Functions (Continued)	11-3
Figure 11.4: SEL-311A Relay Front-Panel Pushbuttons—Secondary Functions.....	11-5
Figure 11.5: Local Control Switch Configured as an ON/OFF Switch	11-6
Figure 11.6: Local Control Switch Configured as an OFF/MOMENTARY Switch.....	11-6
Figure 11.7: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch.....	11-6

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-311A Relay models with an LCD. Disregard this section for relays ordered with Targets Only (no LCD).

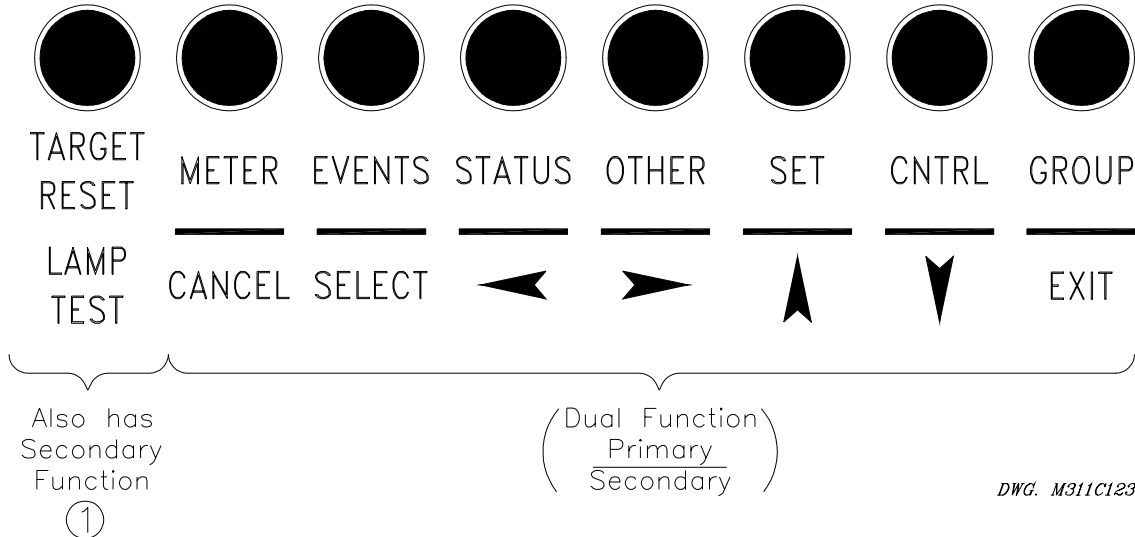
FRONT-PANEL PUSHBUTTON OPERATION

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



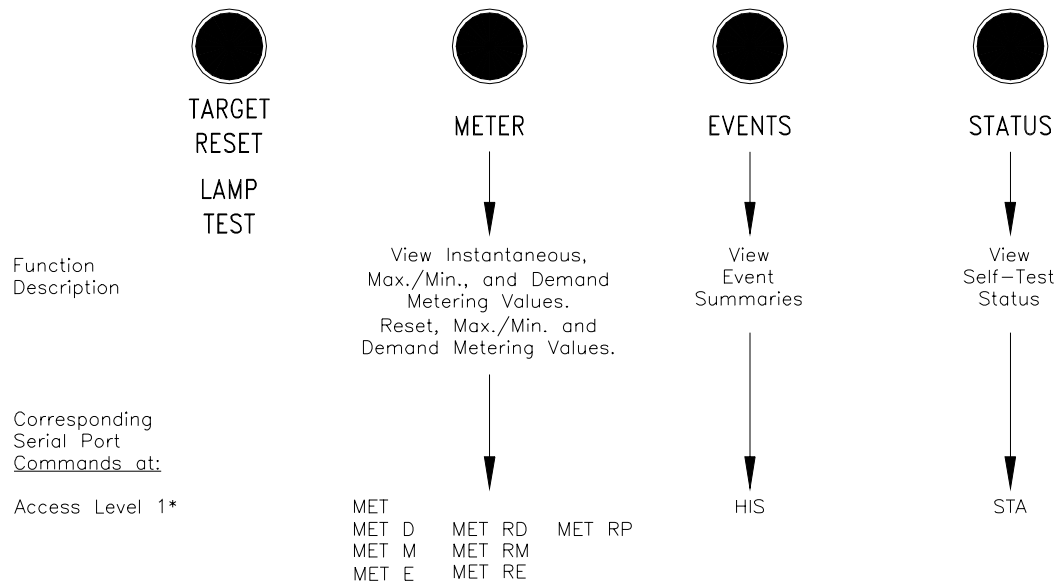
① See Figure 11.4

Figure 11.1: SEL-311A 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**.



* Front-panel pushbutton functions that correspond to Access Level 1 serial port commands do not require the entry of the Access Level 1 password through the front panel.

DWG. M311C072

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

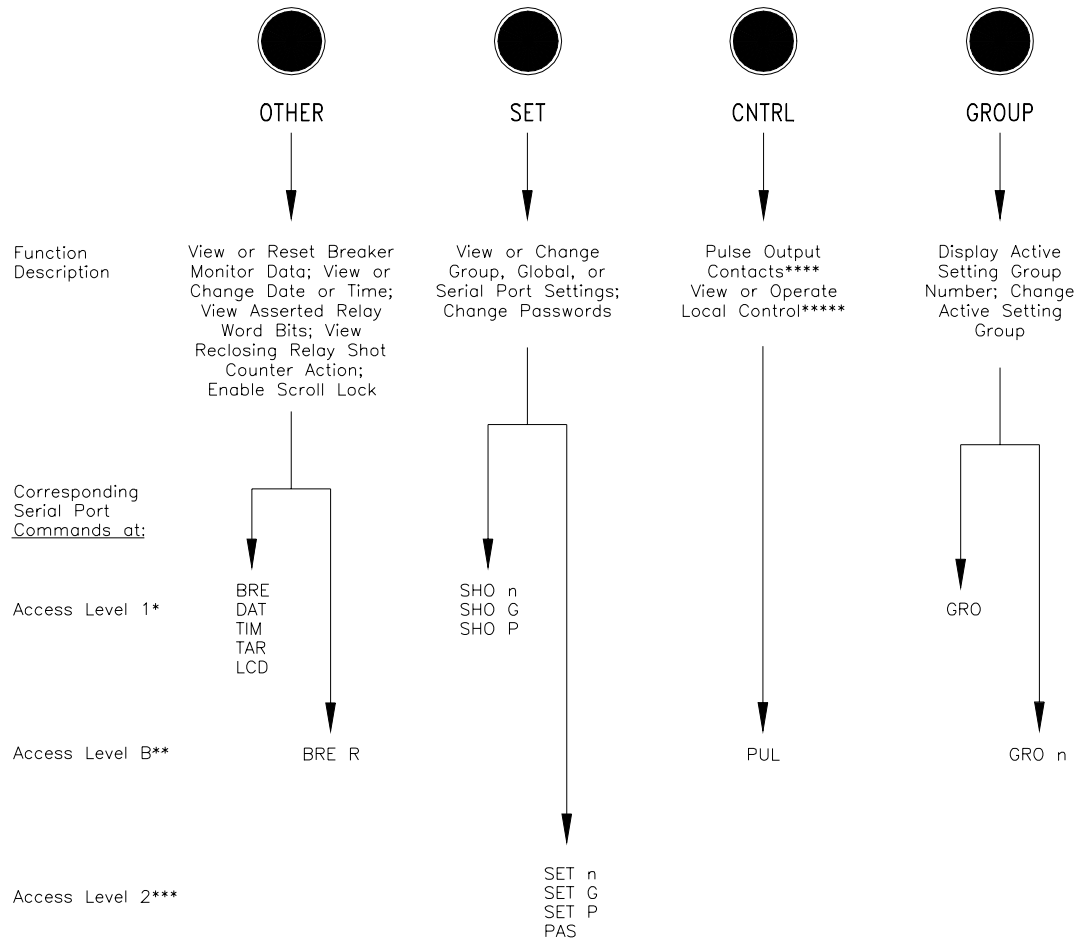
Front-Panel Password Security

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:

<u>Access Level</u>	<u>Factory Default Password</u>
1	OTTER
B	EDITH
2	TAIL



* Front-panel pushbutton functions that correspond to Access Level 1 serial port commands do not require the entry of the Access Level 1 password through the front panel.

** Front-panel pushbutton functions that correspond to Access Level B serial port commands do require the entry of the Access Level B or Access Level 2 passwords through the front panel if the main board Password jumper is not in place (see ①).

*** Front-panel pushbutton functions that correspond to Access Level 2 serial port commands do require the entry of the Access Level 2 password through the front panel if the main board Password jumper is not in place (see ①).

**** Output contacts are pulsed for only 1 second from the front panel.

***** Local control is not available through the serial port and does not require the entry of a password.

DWG. M311A037a

① Table 2.3

Figure 11.3: SEL-311A Relay Front-Panel Pushbuttons—Primary Functions (Continued)

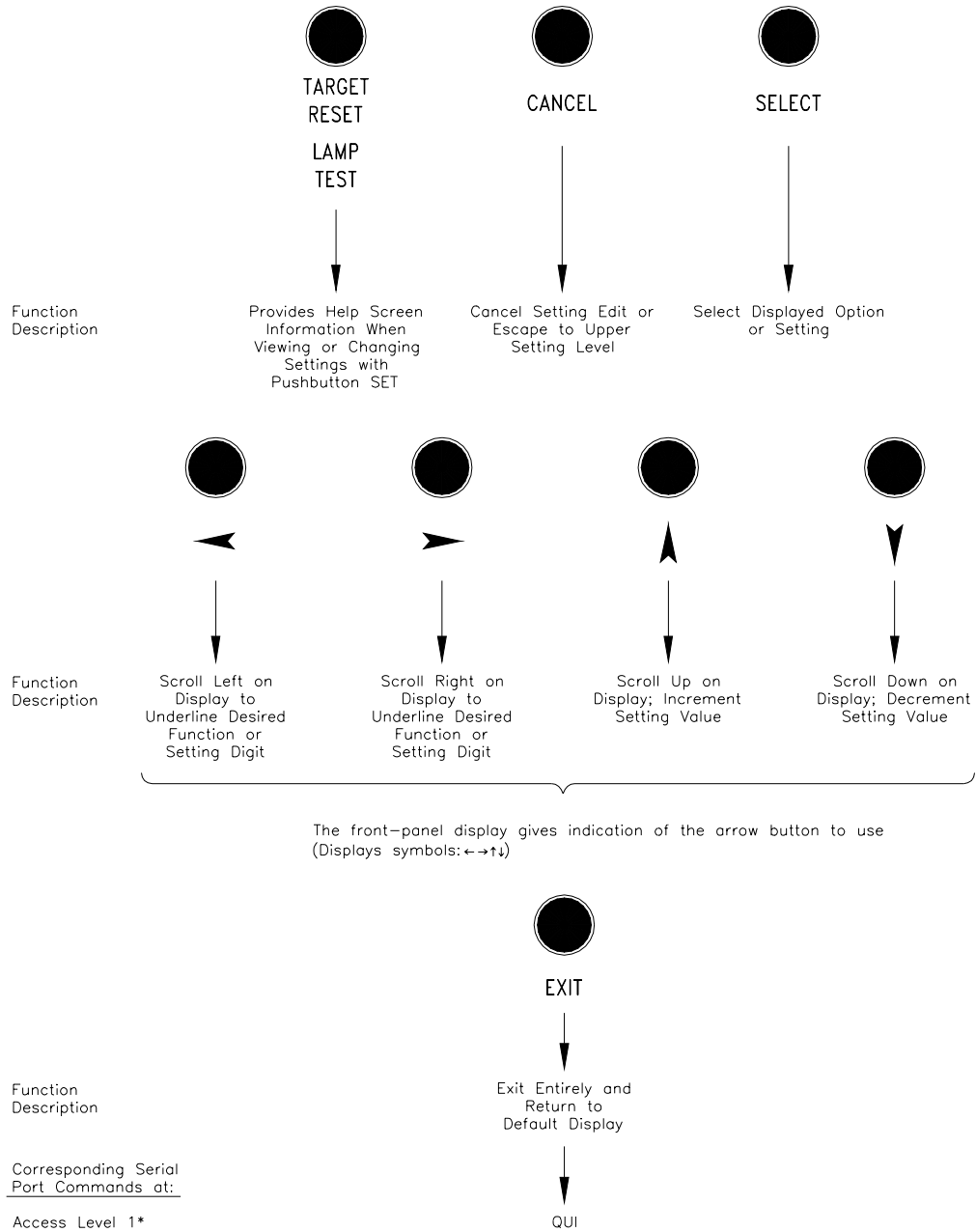
Secondary Functions

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).



* Front-panel pushbutton functions that correspond to Access Level 1 serial port commands do not require the entry of the Access Level 1 password through the front panel.

DWG. M351142

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

FUNCTIONS UNIQUE TO THE FRONT-PANEL INTERFACE

Two front-panel primary functions do not have serial port command equivalents. These are:

- Local control (accessed via the CNTRL pushbutton)
- Modified rotating display with scroll lock control (accessed via the OTHER pushbutton)

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 Tables 9.3 and 9.4).

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

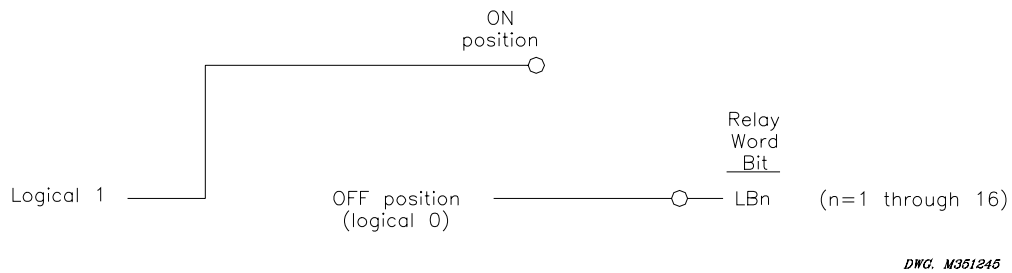


Figure 11.5: Local Control Switch Configured as an ON/OFF Switch

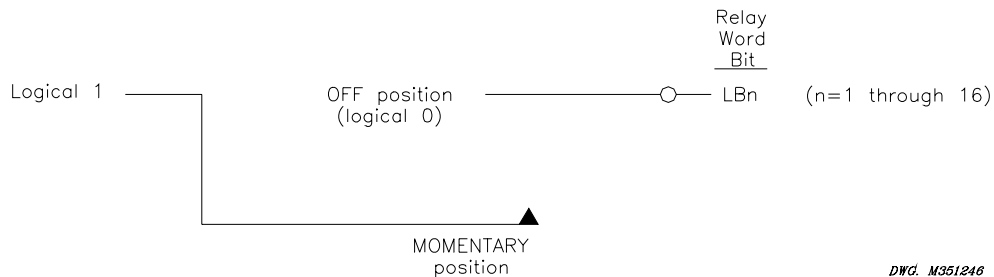


Figure 11.6: Local Control Switch Configured as an OFF/MOMENTARY Switch

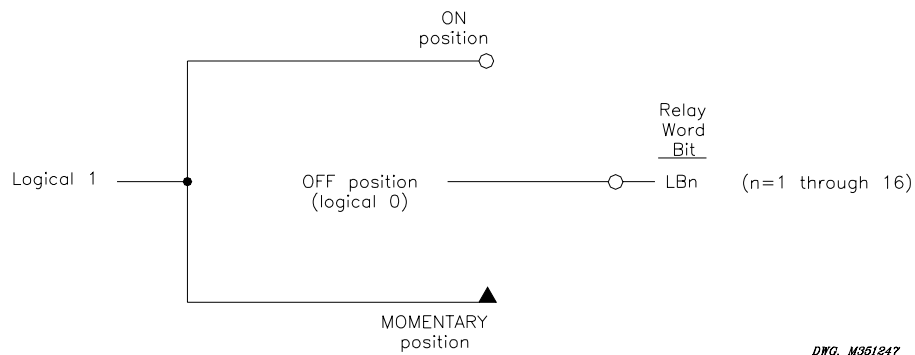


Figure 11.7: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

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)

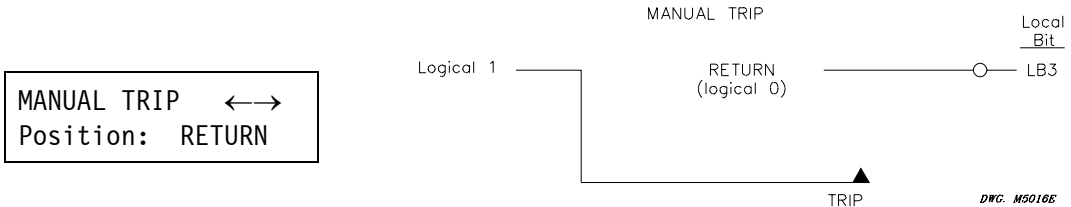
Access local control via the CNTRL pushbutton. If local control switches exist (i.e., corresponding switch position label settings were made), the following message displays with the rotating default display messages.

Press CNTRL for
Local Control

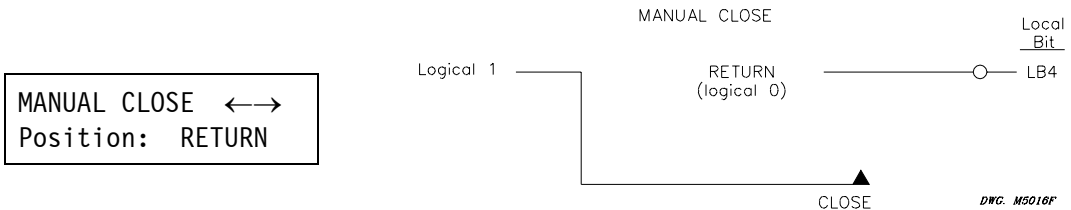
Assume the following settings:

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



Press the right arrow pushbutton, and scroll to the next set local control switch:



The MANUAL TRIP: RETURN/TRIP and MANUAL CLOSE: RETURN/CLOSE switches are both OFF/MOMENTARY switches (see Figure 11.6).

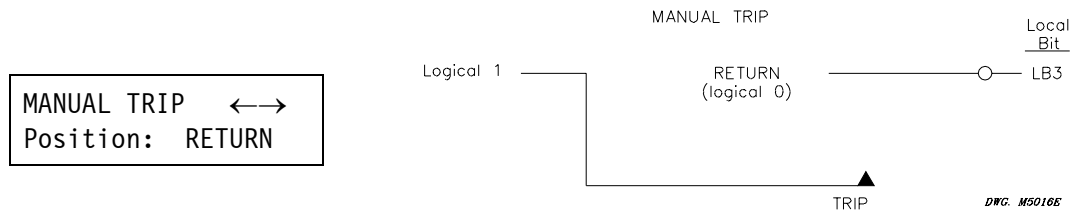
There are no more local control switches in the example setting. Press the right arrow pushbutton, and scroll to the “output contact testing” function:

Output Contact ←→
Testing

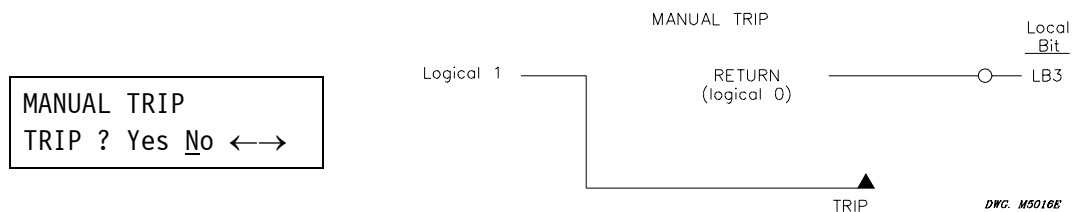
This front-panel function provides the same function as the serial port **PUL** command (see Figure 11.3).

Operate Local Control (with Example Settings)

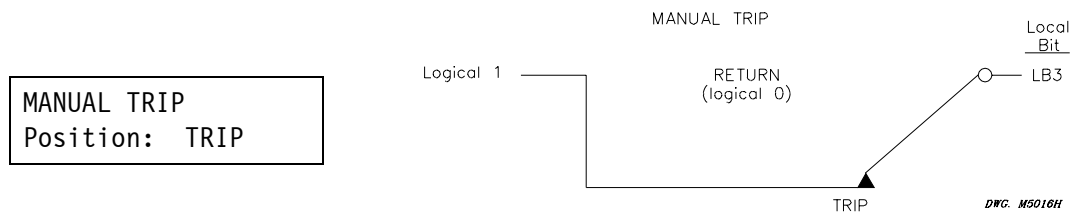
Press the right arrow pushbutton, and scroll back to the first set local control switch in the example settings:



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

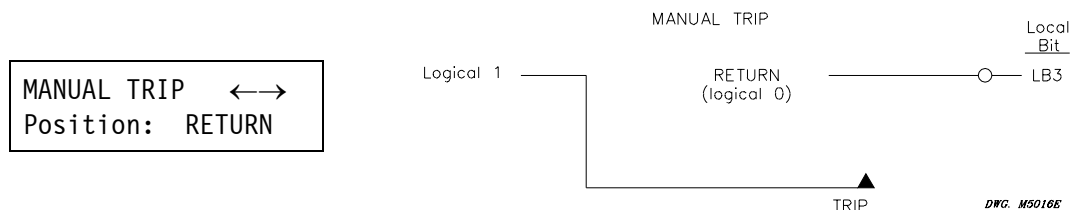


Scroll left with the left arrow button and then select “Yes”. The display then shows the new local control switch position:



Because this is an OFF/MOMENTARY type switch, the MANUAL TRIP switch returns to the RETURN position after momentarily being in the TRIP position. Technically, the MANUAL TRIP switch (being an OFF/MOMENTARY type switch) is in the TRIP position for one processing interval (1/4 cycle; 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:



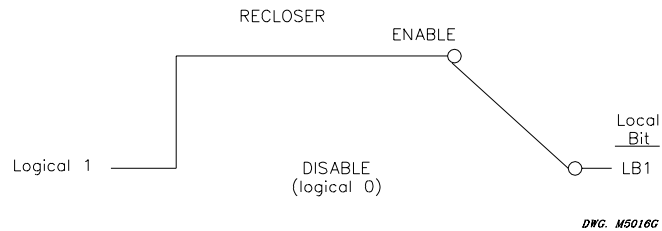
The MANUAL CLOSE switch is an OFF/MOMENTARY type switch, like the MANUAL TRIP switch, and operates similarly.

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.

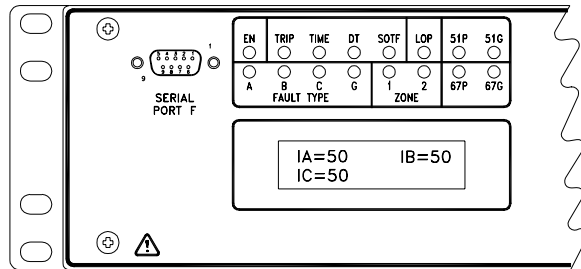
For example, suppose the local control switch with local bit output LB1 is configured as an ON/OFF type switch (see Figure 11.5). Additionally, suppose it is used to enable/disable reclosing. If local bit LB1 is at logical 1, reclosing is enabled:



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.

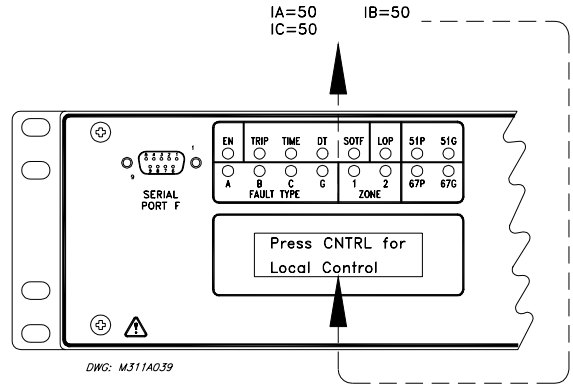
ROTATING DEFAULT DISPLAY

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.

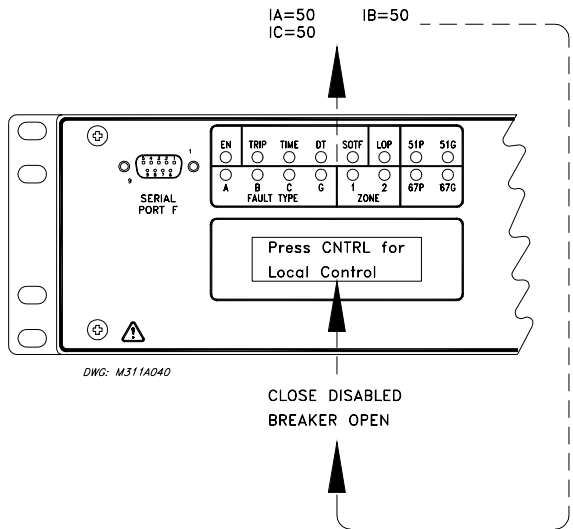


DWG: M311A038

The “Press CNTRL for Local Control” message displays in rotation (display time = SCROLL) 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., “CLOSE DISABLED” and “BREAKER OPEN”) are enabled for display, they also enter into the display rotation (display time = SCROLL).



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 SCROLL for each screen.

The display point example settings are:

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

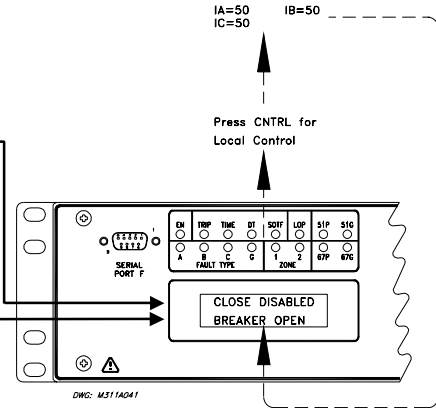
Local bit LB1 is used as a circuit breaker closing enable/disable. Optoisolated input IN101 is used as a circuit breaker status input (a 52a circuit breaker auxiliary contact is connected to input IN101; see *Optoisolated Inputs* in *Section 7: Inputs, Outputs, Timers and Other Control Logic*).

**Display Points
(SELOGIC
Control
Equation
Settings)**

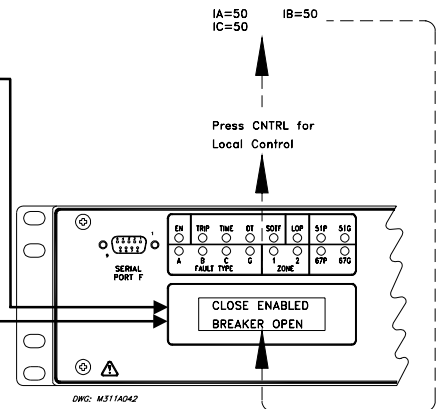
**Example
Display
Point States**

**Display Point
Label Settings**

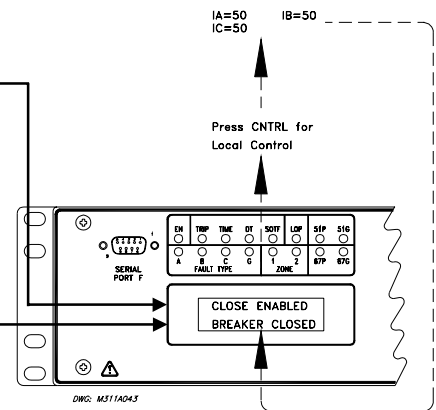
DP2 = LB1 = logical 0
 DP2_1 = CLOSE ENABLED
 DP2_0 = CLOSE DISABLED
 DP4 = IN101 = logical 0
 DP4_1 = BREAKER CLOSED
 DP4_0 = BREAKER OPEN



DP2 = LB1 = logical 1
 DP2_1 = CLOSE ENABLED
 DP2_0 = CLOSE DISABLED
 DP4 = IN101 = logical 0
 DP4_1 = BREAKER CLOSED
 DP4_0 = BREAKER OPEN



DP2 = LB1 = logical 1
 DP2_1 = CLOSE ENABLED
 DP2_0 = CLOSE DISABLED
 DP4 = IN101 = logical 1
 DP4_1 = BREAKER CLOSED
 DP4_0 = BREAKER OPEN



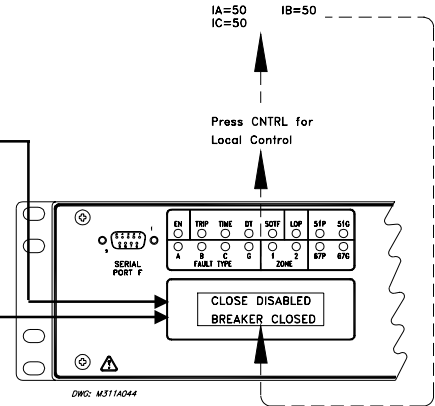
Display Points (SELOGIC Control Equation Settings)

Example Display Point States

Display Point Label Settings

DP2 = LB1 = logical 0
 DP2_1 = CLOSE ENABLED
 DP2_0 = CLOSE DISABLED

DP4 = IN101 = logical 1
 DP4_1 = BREAKER CLOSED
 DP4_0 = BREAKER OPEN



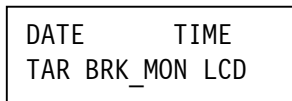
In the preceding example, only two display points (DP2 and DP4) and their corresponding display point labels are set. If additional display points and corresponding display point labels are set, the additional enabled display point labels join the rotation (display time = SCROLL) on the front-panel display. The SCROLL 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*).

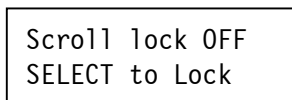
For more detailed information on the logic behind the rotating default display, see *Rotating Default Display* in *Section 7: Inputs, Outputs, Timers, and Other Control Logic*.

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.



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.



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
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.

TABLE OF CONTENTS

SECTION 12: STANDARD EVENT REPORTS AND SER 12-1

Introduction.....	12-1
Standard 15/30/60/180-Cycle Event Reports	12-1
Event Report Length (Settings LER and PRE).....	12-1
Standard Event Report Triggering	12-1
Event Summary.....	12-3
Retrieving Full-Length Standard Event Reports.....	12-6
Compressed ASCII Event Reports.....	12-7
Filtered and Unfiltered Event Reports.....	12-7
Clearing Standard Event Report Buffer.....	12-8
Standard Event Report Column Definitions	12-8
Example Standard 15-Cycle Event Report	12-15
Sequential Events Recorder (SER) Report.....	12-24
SER Triggering.....	12-24
Making SER Trigger Settings.....	12-24
Retrieving SER Reports.....	12-25
Clearing SER Report.....	12-26
Example Sequential Events Recorder (SER) Report.....	12-26

TABLES

Table 12.1: Event Types	12-4
Table 12.2: Standard Event Report Current, Voltage, and Frequency Columns.....	12-8
Table 12.3: Output, Input, and Protection, and Control Element Event Report Columns	12-9
Table 12.4: Communication Elements Event Report Columns	12-12

FIGURES

Figure 12.1: Example Event Summary	12-4
Figure 12.2: Example Standard 15-Cycle Event Report 1/4 Cycle Resolution	12-21
Figure 12.3: Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform.....	12-22
Figure 12.4: Derivation of Phasor RMS Current Values From Event Report Current Values.....	12-23
Figure 12.5: Example Sequential Events Recorder (SER) Event Report	12-27

SECTION 12: STANDARD EVENT REPORTS AND SER

INTRODUCTION

The SEL-311A 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-311A 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 12 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. 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. Any condition that causes a trip does not have to be entered in SELOGIC control equation setting ER.

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

Programmable SELOGIC Control Equation Setting ER

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

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

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 3.7). |
| 51G | Residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see Figure 3.15). |
| 50P1 | Phase current above pickup setting 50P1P for phase overcurrent element 50P1 (see Figure 3.10). |
| LOP | Loss of potential (LOP) asserts (see Figure 4.1). |

Note the rising edge operator/in front of each of these elements. See *Appendix F: Setting SELOGIC Control Equations* for more information on rising edge operators and SELOGIC control equations in general.

Rising edge operators are especially useful in generating an event report at fault inception and then generating another later if 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:

$$ER = \dots + /51G + \dots = \text{logical 1 (for one processing interval)}$$

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 F.2 in *Appendix F: 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
- 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-311A                               Date: 03/01/00   Time: 08:53:34.926
EXAMPLE: BUS B, BREAKER 3

Event: BCG T      Location: 48.84      Trip Time: 08:53:34.930
#: 00008         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 R   B B R
                                O A A   O A A
                                K D D   K D D
MB:8->1  RMBA   TMBA   RMBB   TMBB  A A A   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).

Event Type	Description
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 the EFLOC setting = Y and the fault locator operates successfully after an event report is generated. If the fault locator does not operate successfully or if EFLOC = N, \$\$\$\$\$\$ is listed in the field. Fault location is based upon the line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG and corresponding line length setting LL. See the SET command in Table 9.1 and corresponding Settings Sheet 2 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.

Targets

The relay reports the targets at the rising edge of TRIP. The targets include: ZONE/LEVEL 1–2; TIME; DT; SOTF; 51P; 51G; 67P; and 67G. 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
- Communications, control, and MIRRORED BITS 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 Sx Ly 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.
- Sx* Display *x* samples per cycle (4 or 16); defaults to 4 if not listed.
- Ly* 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 *Sx* parameter.
- A* Specifies that only the analog section of the event is displayed (current, voltage, station battery, polarizing voltage).
- D* Specifies that only the digital section (protection and control elements) of the event is displayed.
- C* Display the report in Compressed ASCII format.
- M* Specifies only that the communication elements section of the event is displayed.

Below are example **EVE** commands.

<u>Serial Port Command</u>	<u>Description</u>
EVE	Display the most recent event report at 1/4-cycle resolution.
EVE 2	Display the second event report at 1/4-cycle resolution.
EVE S16 L10	Display 10 cycles of the most recent report at 1/16-cycle resolution.
EVE C 2	Display the second report in Compressed ASCII format at 1/4-cycle resolution.
EVE L	Display most recent report at 1/16-cycle resolution.
EVE R	Display most recent report at 1/16-cycle resolution; analog and digital data are unfiltered (raw).
EVE 2 D L10	Display 10 cycles of the protection and control elements section of the second event report at 1/4-cycle resolution.
EVE 2 A R S4	Display the unfiltered analog section of the second event report at 1/4-cycle resolution.

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

“Invalid Event”

Compressed ASCII Event Reports

The SEL-311A 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-311A 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
- 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.

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)
Vdc	Voltage measured at power input terminals Z25 and Z26 (Vdc)
V1Mem	Positive-sequence memory voltage (primary kV)

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.

Output, Input, Protection, and Control Columns

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

Table 12.3: 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
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
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
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
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
ZAG	ZAG1	1	If Zone 1 AG element (MAG1) set
	ZAG2	2	If Zone 2 AG element (MAG2) set, not ZAG1
ZBG	ZBG1	1	If Zone 1 BG element (MBG1) set
	ZBG2	2	If Zone 2 BG element (MBG2) set, not ZBG1
ZCG	ZCG1	1	If Zone 1 CG element (MCG1) set
	ZCG2	2	If Zone 2 CG element (MCG2) set, not ZCG1

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
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
		r	Time-overcurrent element timing to reset
		l	Time-overcurrent element timing to reset after having timed out (when element reset is set for 1 cycle, not electromechanical reset)
50P	50P1, 50P2	1	50P1 asserted
		2	50P2 asserted
		b	both 50P1 and 50P2 asserted
50G	50G1, 50G2	1	50G1 asserted
		2	50G2 asserted
		b	both 50G1 and 50G2 asserted
32 Q	F32Q	Q	Forward negative-sequence directional element F32Q picked up.
32 QVI	F32QG	Q	Forward negative-sequence ground directional element F32Q picked up.
	F32V	V	Forward zero-sequence ground directional element F32V picked up.
	F32I	I	Forward current polarized ground directional element F32I picked up.
67P	67P1	1	67P1 asserted
67G	67G1	1	67G1 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.
Zld	ZLIN, ZLOUT	i	Load encroachment "load in" element ZLIN picked up.
		o	Load encroachment "load out" element ZLOUT picked up.
LOP	LOP	*	Loss-of-potential element LOP picked up.

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

** 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	MIRRORED BITS™ channel A transmit bit 1 TMB1A asserted.
		2	MIRRORED BITS channel A transmit bit 2 TMB2A asserted.
		b	Both TMB1A and TMB2A asserted.
TMB A 3 4	TMB3A, TMB4A	3	MIRRORED BITS channel A transmit bit 3 TMB3A asserted.
		4	MIRRORED BITS channel A transmit bit 4 TMB4A asserted.
		b	Both TMB3A and TMB4A asserted.
TMB A 5 6	TMB5A, TMB6A	5	MIRRORED BITS channel A transmit bit 5 TMB5A asserted.
		6	MIRRORED BITS channel A transmit bit 6 TMB6A asserted.
		b	Both TMB5A and TMB6A asserted.
TMB A 7 8	TMB7A, TMB8A	7	MIRRORED BITS channel A transmit bit 7 TMB7A asserted.
		8	MIRRORED BITS channel A transmit bit 8 TMB8A asserted.
		b	Both TMB7A and TMB8A asserted.
RMB A 1 2	RMB1A, RMB2A	1	MIRRORED BITS channel A receive bit 1 RMB1A asserted.
		2	MIRRORED BITS channel A receive bit 2 RMB2A asserted.
		b	Both RMB1A and RMB2A asserted.
RMB A 3 4	RMB3A, RMB4A	3	MIRRORED BITS channel A receive bit 3 RMB3A asserted.
		4	MIRRORED BITS channel A receive bit 4 RMB4A asserted.
		b	Both RMB3A and RMB4A asserted.
RMB A 5 6	RMB5A, RMB6A	5	MIRRORED BITS channel A receive bit 5 RMB5A asserted.
		6	MIRRORED BITS channel A receive bit 6 RMB6A asserted.
		b	Both RMB5A and RMB6A asserted.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
RMB A 7 8	RMB7A, RMB8A	7	MIRRORED BITS channel A receive bit 7 RMB7A asserted.
		8	MIRRORED BITS channel A receive bit 8 RMB8A asserted.
		b	Both RMB7A and RMB8A asserted.
TMB B 1 2	TMB1B, TMB2B	1	MIRRORED BITS channel B transmit bit 1 TMB1B asserted.
		2	MIRRORED BITS channel B transmit bit 2 bit TMB2B asserted.
		b	Both TMB1B and TMB2B asserted.
TMB B 3 4	TMB3B, TMB4B	3	MIRRORED BITS channel B transmit bit 3 TMB3B asserted.
		4	MIRRORED BITS channel B transmit bit 4 TMB4B asserted.
		b	Both TMB3B and TMB4B asserted.
TMB B 5 6	TMB5B, TMB6B	5	MIRRORED BITS channel B transmit bit 5 TMB5B asserted.
		6	MIRRORED BITS channel B transmit bit 6 TMB6B asserted.
		b	Both TMB5B and TMB6B asserted.
TMB B 7 8	TMB7B, TMB8B	7	MIRRORED BITS channel B transmit bit 7 TMB7B asserted.
		8	MIRRORED BITS channel B transmit bit 8 TMB8B asserted.
		b	Both TMB7B and TMB8B asserted.
RMB B 1 2	RMB1B, RMB2B	1	MIRRORED BITS channel B receive bit 1 RMB1B asserted.
		2	MIRRORED BITS channel B receive bit 2 RMB2B asserted.
		b	Both RMB1B and RMB2B asserted.
RMB B 3 4	RMB3B, RMB4B	3	MIRRORED BITS channel B receive bit 3 RMB3B asserted.
		4	MIRRORED BITS channel B receive bit 4 RMB4B asserted.
		b	Both RMB3B and RMB4B asserted.
RMB B 5 6	RMB5B, RMB6B	5	MIRRORED BITS channel B receive bit 5 RMB5B asserted.
		6	MIRRORED BITS channel B receive bit 6 RMB6B asserted.
		b	Both RMB5B and RMB6B asserted.

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
RMB B 7 8	RMB7B, RMB8B	7	MIRRORED BITS channel B receive bit 7 RMB7B asserted.
		8	MIRRORED BITS channel B receive bit 8 RMB8B asserted.
		b	Both RMB7B and RMB8B asserted.
ROK	ROKA, ROKB	A	MIRRORED BITS channel A receive OK ROKA asserted.
		B	MIRRORED BITS channel B receive OK ROKB asserted.
		b	Both ROKA and ROKB asserted.
RBAD	RBADA, RBADB	A	MIRRORED BITS channel A extended outage RBADA asserted.
		B	MIRRORED BITS channel B extended outage RBADB asserted.
		b	Both RBADA and RBADB asserted.
CBAD	CBADA, CBADB	A	MIRRORED BITS channel A unavailability CBADA asserted.
		B	MIRRORED BITS channel B unavailability CBADB asserted.
		b	Both CBADA and CBADB asserted.
LBOK	LBOKA, LBOKB	A	MIRRORED BITS channel A loopback OK LBOKA asserted.
		B	MIRRORED BITS channel A loopback OK LBOKB asserted.
		b	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

Column Heading	Corresponding Elements (Relay Word Bits)	Symbol	Definition
SELOGIC			
1	SV1, SV1T	p	SELOGIC control equation variable timer input SV_ asserted; timer timing on pickup time; timer output SV_T not asserted.
2	SV2, SV2T		
3	SV3, SV3T		
4	SV4, SV4T		
5	SV5, SV5T	T	SELOGIC control equation variable timer input SV_ asserted; timer timed out on pickup time; timer output SV_T asserted.
6	SV6, SV6T		
7	SV7, SV7T		
8	SV8, SV8T		
9	SV9, SV9T	d	SELOGIC control equation variable timer input SV_ not asserted; timer previously timed out on pickup time; timer output SV_T remains asserted while timer timing on dropout time.
10	SV10, SV10T		
11	SV11, SV11T		
12	SV12, SV12T		
13	SV13, SV13T		
14	SV14, SV14T		
15	SV15, SV15T		
16	SV16, SV16T		

** Hexadecimal values are constructed with the highest numbered bit (e.g., LB8) being the least significant, as follows:

LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8	
1	0	0	0	1	0	1	0	= 8A Hex

EXAMPLE STANDARD 15-CYCLE EVENT REPORT

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 VIMem 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 VIMem column identifies the row corresponding to the “fault” values listed in the event summary report. See *Currents and Voltages* on page 12-5. 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
SEL-311A                               Date: 03/01/00   Time: 08:53:34.926 ← see Figure 12.1
EXAMPLE: BUS B, BREAKER 3
FID=SEL-311A-R100-V0-Z001001-D120000301 ← firmware identifier
CID=B142 ← firmware checksum identifier

```

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

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

Protection and Contact I/O Elements

21 V 51 50 32 67 Dm
 ZZZZZZ P Q ZLV Out1 In1
 ABCABC O V P P 10d 1357 135
 BCAGGG L PG PG QI PG QG 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]

..... V o.. 1..
 V o.. 1..
 V QQ 1..
 V .p .. QQ 1..>

[5]

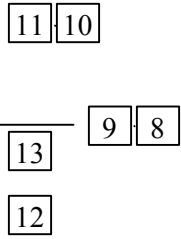
.1.... V .p 1. QQ 1. b4.. 1..
 .1.... V .p 1. QQ 1. b4.. 1..
 .1.... V .p 1. QQ 1. b4.. 1..
 .1.... V .p 1. QQ 1. b4.. 1..

[6]

.1.... V .p 1. QQ 1. b4.. 1..
 .1.... V .p 1. QQ 1. b4.. 1..
 .1.... V .p 1. QQ 1. b4.. 1..
 .1.... V .p 1. QQ 1. b4.. 1..

[7]

.1.... V .p 1. QQ 1. b4.. 1..
 .1.... V .p 1. QQ 1. b4.. 1..
 .1.... V .p 1. QQ 1. b4.. 1..
 .1.... V .p 1. QQ 1. b4.. 1..



```

[8]
.1.... V pp 1. QQ 1. . . . . b4.. 1..
.1.... V pp 1. QQ 1. . . . . b4.. 1..
.1.... V pp 1. QQ 1. . . . . b4.. 1..
.1.... V pp 1. QQ 1. . . . . b4.. 1..

[9]
.1.... V pp 1. QQ 1. . . . . b4.. 1..
.1.... V pp 1. QQ 1. . . . . b4.. 1..
.1.... V pp 1. QQ 1. . . . . b4.. 1..
.1.... V pp 1. QQ 1. . . . . b4.. 1..

[10]
.1.... V pp 1. QQ 1. . . . . b4.. 1..
.1.... V pp 1. QQ 1. . . . . b4.. 1..
.1.... V pp 1. QQ 1. . . . . b4.. 1..
.2.... V rp 1. QQ . . . . . b4.. 1..

[11]
..... V rp . . QQ . . . . . b... ..
..... V rp . . QQ . . . . . b... ..
..... V rp . . QQ . . . . . b... ..
..... V rp . . . . . 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 . . . . .
..... V .r . . . . .
..... V .r . . . . .

[15]
..... V .r . . . . .
..... V .r . . . . .
..... V .r . . . . .
..... 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 0 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 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 00 00 00 00 40 00 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 00 00 00 00 40 00 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 00 00 00 00 40 00 . . . . . . . . . . .

[2]
. . . . . . . . . . . . . . . . . 00 00 00 00 40 00 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 00 00 00 00 40 00 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 00 00 00 00 40 00 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 00 00 00 00 40 00 . . . . . . . . . . .

[3]
. . . . . . . . . . . . . . . . . 00 00 00 00 40 00 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 00 00 00 00 40 00 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 00 00 00 00 40 00 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 00 00 00 00 40 00 . . . . . . . . . . .

```

```

[4]
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....>

[5]
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....

[6]
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....

[7]
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....

[8]
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....

[9]
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....

[10]
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....

[11]
.. .. . 00 00 00 00 40 00 .....
.. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....

[12]
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....

[13]
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....

[14]
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....

[15]
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 00 00 00 00 40 00 .....
* .. .. . 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-311A          TID =EXAMPLE: BUS B, BREAKER 3
CTR = 200
CTR = 200      PTR = 2000.00
Z1MAG = 7.80   Z1ANG = 84.00
ZOMAG = 24.80  ZOANG = 81.50  LL = 100.00  APP = 311A
E21P = 2       E21MG = 2
E50P = Y       E50G = N
E51P = N       E51G = Y
E32 = AUTO     ELOAD = Y      ESOTF = Y
EFLOC = Y
ELOP = Y
ECCVT = N      ESV = N      ELAT = 16      EDP = 16
EDEM = THM     EADVS = N
Z1P = 6.24     Z2P = 9.36
50PP1 = 0.50
Z1MG = 6.24    Z2MG = 9.36
50L1 = 0.50
50GZ1 = 0.50
KOM1 = 0.726   KOA1 = -3.69
Z1PD = OFF     Z2PD = 20.00
Z1GD = OFF     Z2GD = 20.00
Z1D = OFF      Z2D = OFF
50P1P = 11.25
67P1D = 0.00
51GP = 0.75    51GC = U3      51GTD = 2.00   51GRS = Y
ZLF = 9.22     ZLR = 9.22
PLAF = 30.00   NLAF = -30.00  PLAR = 150.00  NLAR = 210.00
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 + 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

```


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.

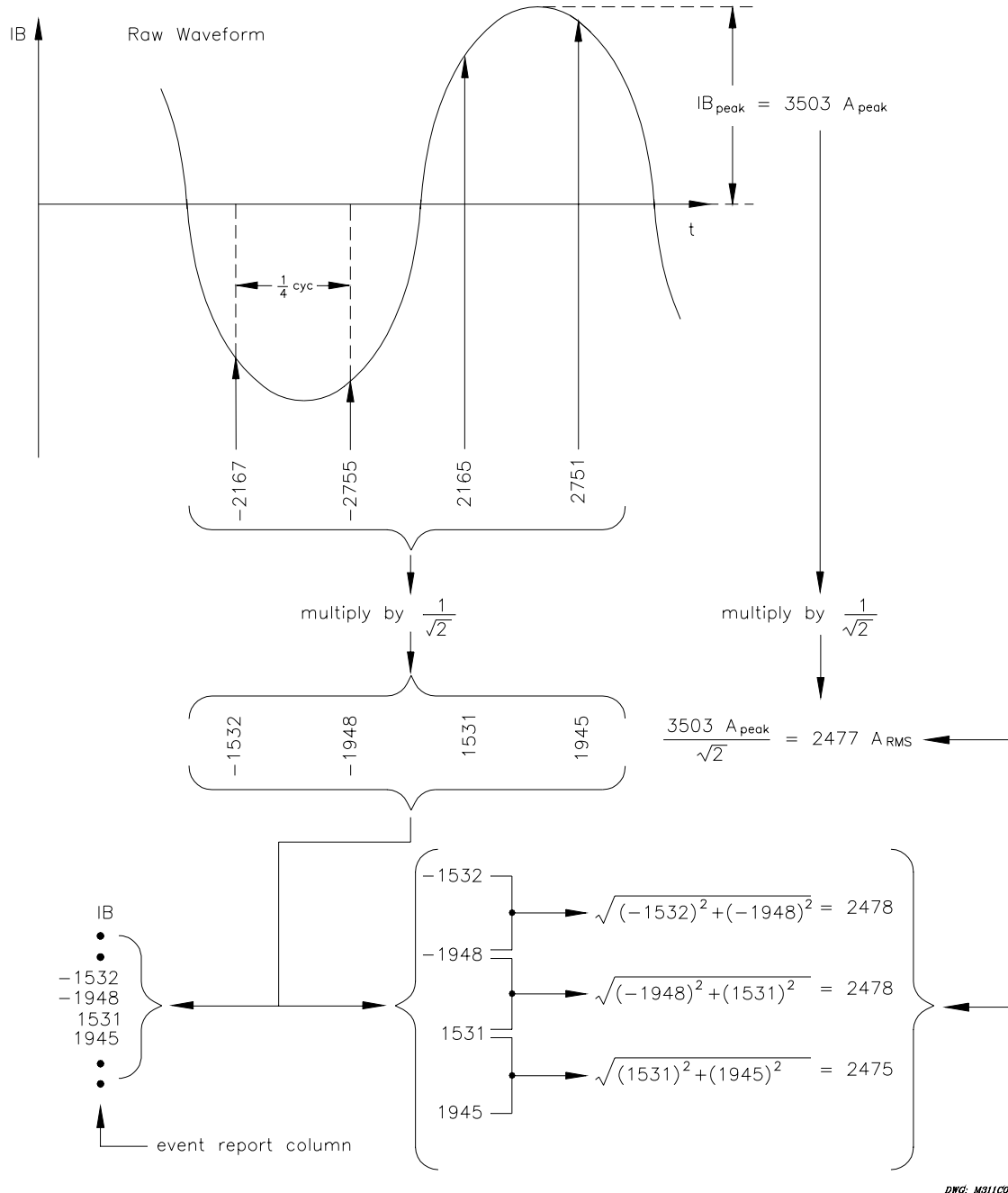
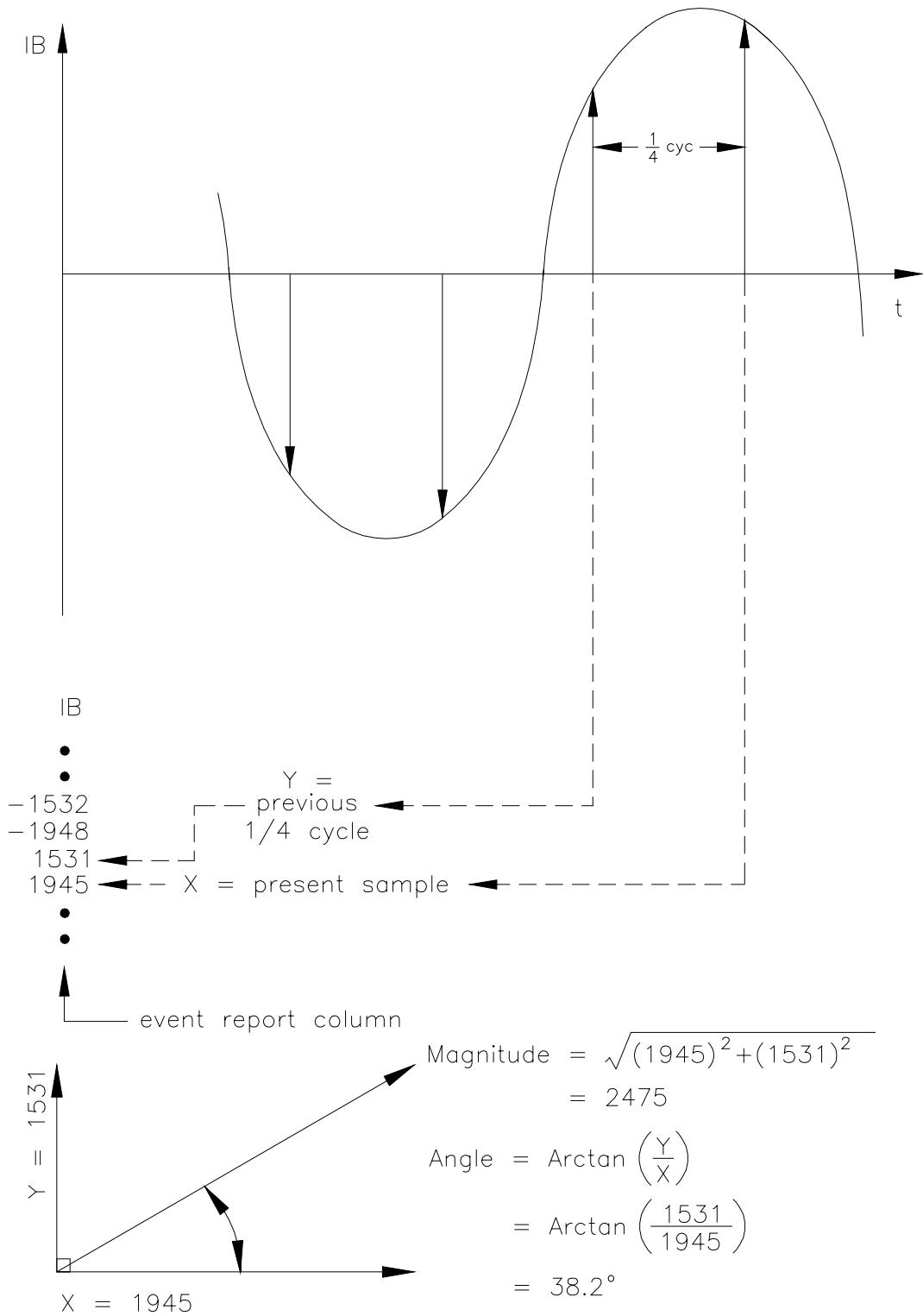


Figure 12.3: Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

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.



DWG: M311C089

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:

$$IB = 2475 \text{ A} \angle 38.2^\circ$$

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

$$2475 \text{ A} * \cos(38.2^\circ) = 1945 \text{ A}$$

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, 51G, 50P1

SER2 = IN101, IN102, OUT101, OUT102, OUT103, LOP

SER3 = 0

The elements are Relay Word bits referenced in Tables 9.3 and 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 14 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

The relay displays the setting as:

SER1 = 51P,51G,51PT,51GT,50P1

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. <u>Reverse</u> 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 <u>precedes</u> 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-311A                               Date: 03/01/00   Time: 08:56:47.400
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311A-R100-V0-Z001001-D20000301   CID=B142

#    DATE    TIME        ELEMENT      STATE
14   03/01/00 08:53:34.083  IN101       Asserted
13   03/01/00 08:53:34.926  51G         Asserted
12   03/01/00 08:53:34.930  50P1       Asserted
11   03/01/00 08:53:34.930  M2P        Asserted
10   03/01/00 08:53:34.930  M1P        Asserted
9    03/01/00 08:53:34.930  OUT101     Asserted
8    03/01/00 08:53:34.930  OUT102     Asserted
7    03/01/00 08:53:35.026  50P1       Deasserted
6    03/01/00 08:53:35.026  M1P        Deasserted
5    03/01/00 08:53:35.026  51G        Deasserted
4    03/01/00 08:53:35.030  M2P        Deasserted
3    03/01/00 08:53:35.030  IN101     Deasserted
2    03/01/00 08:53:35.079  OUT101     Deasserted
1    03/01/00 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

<u>Row No.</u>	<u>Explanation</u>
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 + OC
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.

TABLE OF CONTENTS

SECTION 13: TESTING AND TROUBLESHOOTING 13-1

Introduction.....	13-1
Testing Philosophy	13-1
Acceptance Testing.....	13-1
Commissioning Testing	13-1
Maintenance Testing.....	13-2
Testing Methods and Tools	13-3
Test Features Provided by the Relay	13-3
Low-Level Test Interface.....	13-4
Test Methods.....	13-5
Relay Testing	13-6
Equipment Required	13-6
Checkout Procedure	13-6
Output Contact Explanation.....	13-10
Target LED Explanation.....	13-10
Front Panel LCD Explanation.....	13-11
Test Setup	13-11
Test Source Connections	13-11
Serial Communication Equipment Connections.....	13-16
Test Procedures.....	13-17
Overcurrent Elements	13-17
Negative-Sequence Directional Element	13-19
Phase Mho Distance Elements.....	13-29
Ground Mho Distance Elements.....	13-35
Troubleshooting Test Results	13-42
Relay Self-Tests.....	13-43
Relay Troubleshooting.....	13-46
Inspection Procedure.....	13-46
Troubleshooting Procedure.....	13-46
Relay Calibration	13-47
Factory Assistance	13-47

TABLES

Table 13.1: Fault Locator Test Values	13-10
Table 13.2: Output Contact and Target LED Results.....	13-10
Table 13.3: Test Quantities for Zone 2 Phase Distance Element	13-31
Table 13.4: Test Quantities for Zone 2 Ground Mho Distance Element.....	13-38
Table 13.5: Relay Self-Tests.....	13-44

FIGURES

Figure 13.1: Low-Level Test Interface	13-4
Figure 13.2: Three Voltage Source and Three Current Source Test Connections	13-12
Figure 13.3: Phase-to-Phase, Phase-to-Ground, and Two-Phase-to-Ground Fault Test Connections Using Two Current Sources	13-13
Figure 13.4: Three-Phase Fault and METER Test Connections Using Two Current Sources.....	13-14
Figure 13.5: Phase-to-Ground Fault Test Connections Using a Single Current Source.....	13-15
Figure 13.6: Phase-to-Phase Fault Test Connections Using a Single Current Source.....	13-16
Figure 13.7: Communications Connections Between the SEL-311A Relay and a Terminal	13-17
Figure 13.8: Phase Distance Element Test Voltage Signals	13-33

SECTION 13: TESTING AND TROUBLESHOOTING

INTRODUCTION

This section provides guidelines for determining and establishing test routines for the SEL-311A Relay. Included are discussions on testing philosophies, methods, and tools. Relay self-tests and troubleshooting procedures are shown at the end of the section.

TESTING PHILOSOPHY

Protective relay testing may be divided into three categories: acceptance, commissioning, and maintenance testing. The categories are differentiated by when they take place in the life cycle of the relay as well as by the test complexity.

The paragraphs below describe when to perform each type of test, the goals of testing at that time, and the relay functions that you need to test at each point. This information is intended as a guideline for testing SEL relays.

Acceptance Testing

When: When qualifying a relay model to be used on the utility system.

- Goals:
- a) Ensure that the relay meets published critical performance specifications such as operating speed and element accuracy.
 - b) Ensure that the relay meets the requirements of the intended application.
 - c) Gain familiarity with relay settings and capabilities.

What to test: All protection elements and logic functions critical to the intended application.

SEL performs detailed acceptance testing on all new relay models and versions. We are certain the relays we ship meet their published specifications. It is important for you to perform acceptance testing on a relay if you are unfamiliar with its operating theory, protection scheme logic, or settings. This helps ensure the accuracy and correctness of the relay settings when you issue them.

Commissioning Testing

When: When installing a new protection system.

- Goals:
- a) Ensure that all system ac and dc connections are correct.
 - b) Ensure that the relay functions as intended using your settings.
 - c) Ensure that all auxiliary equipment operates as intended.

What to test: All connected or monitored inputs and outputs, polarity and phase rotation of ac connections, simple check of protection elements.

SEL performs a complete functional check and calibration of each relay before it is shipped. This helps ensure that you receive a relay that operates correctly and accurately. Commissioning tests should verify that the relay is properly connected to the power system and all auxiliary equipment. Verify control signal inputs and outputs. Check breaker auxiliary inputs, SCADA control inputs, and monitoring outputs. Use an ac connection check to verify that the relay current and voltage inputs are of the proper magnitude and phase rotation.

Brief fault tests ensure that the relay settings are correct. It is not necessary to test every relay element, timer, and function in these tests.

At commissioning time, use the relay METER command to verify the ac current and voltage magnitude and phase rotation. Use the PULSE command to verify relay output contact operation. Use the TARGET command to verify optoisolated input operation.

Maintenance Testing

When: At regularly scheduled intervals or when there is an indication of a problem with the relay or system.

Goals: a) Ensure that the relay is measuring ac quantities accurately.
b) Ensure that scheme logic and protection elements are functioning correctly.
c) Ensure that auxiliary equipment is functioning correctly.

What to test: Anything not shown to have operated during an actual fault within the past maintenance interval.

SEL relays use extensive self-testing capabilities and feature detailed metering and event reporting functions that lower the utility dependence on routine maintenance testing.

Use the SEL relay reporting functions as maintenance tools. Periodically verify that the relay is making correct and accurate current and voltage measurements by comparing the relay METER output to other meter readings on that line. Review relay event reports in detail after each fault. Using the event report current, voltage, and relay element data, you can determine that the relay protection elements are operating properly. Using the event report input and output data, you can determine that the relay is asserting outputs at the correct instants and that auxiliary equipment is operating properly. At the end of your maintenance interval, the only items that need testing are those that have not operated during the maintenance interval.

The basis of this testing philosophy is simple: If the relay is correctly set and connected, is measuring properly, and no self-test has failed, there is no reason to test it further.

Each time a fault occurs, the protection system is tested. Use event report data to determine areas requiring attention. Slow breaker auxiliary contact operations and increasing or varying breaker operating time can be detected through detailed analysis of relay event reports.

Because SEL relays are microprocessor-based, their operating characteristics do not change over time. Time-overcurrent operating times are affected only by the relay settings and applied signals. It is not necessary to verify operating characteristics as part of maintenance checks.

At SEL, we recommend that maintenance tests on SEL relays be limited under the guidelines provided above. The time saved may be spent analyzing event data and thoroughly testing those systems that require more attention.

TESTING METHODS AND TOOLS

Test Features Provided by the Relay

The following features assist you during relay testing.

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 <i>Section 10: Serial Port Communications and Commands</i> and <i>Section 11: Front-Panel Interface</i> .
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 <i>Section 12: Standard Event Reports and SER</i> .
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 <i>Section 12: Standard Event Reports and SER</i> 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 <i>Section 12: Standard Event Reports and SER</i> .
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 <i>Section 10: Serial Port Communications and Commands</i> and <i>Section 11: Front-Panel Interface</i> .
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 <i>Section 10: Serial Port Communications and Commands</i> .

Low-Level Test Interface

The SEL-311A 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-to-peak to the low-level test interface. Figure 13.1 shows the signal scaling factors.



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.

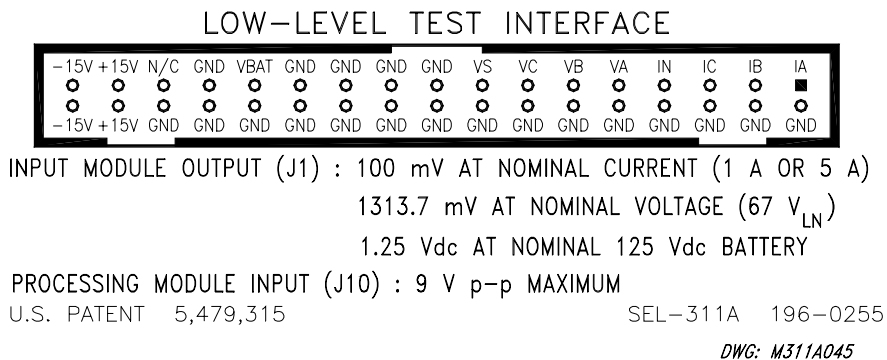


Figure 13.1: Low-Level Test Interface

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-311A Relay, is controlled by enable settings and/or torque control SELOGIC[®] control equations. To enable the 51PT element, set the E51P enable setting and 51PTC torque control settings to the following:

- E51P = Y (via the **SET** command)
- 51PTC = 1 (set directly to logical 1, via the **SET L** command)

Testing Via Front-Panel Indicators

Display the state of relay elements, inputs, and outputs using the front-panel or serial port **TAR** commands. Use this method to verify the pickup settings of protection elements.

Access the front-panel **TAR** command from the front-panel OTHER pushbutton menu. To display the state of the 51PT element on the front-panel display, press the OTHER pushbutton, cursor to the TAR option, and press SELECT. Press the up arrow pushbutton until TAR 28 is displayed on the top row of the LCD. The bottom row of the LCD displays all elements asserted in Relay Word Row 28. The relay maps the state of the elements in Relay Word Row 28 on the bottom row of LEDs. The 51PT element state is reflected on the LED labeled B. See Table 9.3 and Table 9.4 for the correspondence between the Relay Word elements and the **TAR** command.

To view the 51PT element status from the serial port, issue the **TAR 51PT** command. The relay will display the state of all elements in the Relay Word row containing the 51PT element.

Review **TAR** command descriptions in *Section 10: 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 OUT108) 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-311A 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 labeled **SELECT**. Using the arrow keys, move the cursor to the menu item **2AC**. Press the button labeled **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 remaining 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 select the menu item **SET**, then press **SELECT** again.

Note: The SEL-311A 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-311A 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.

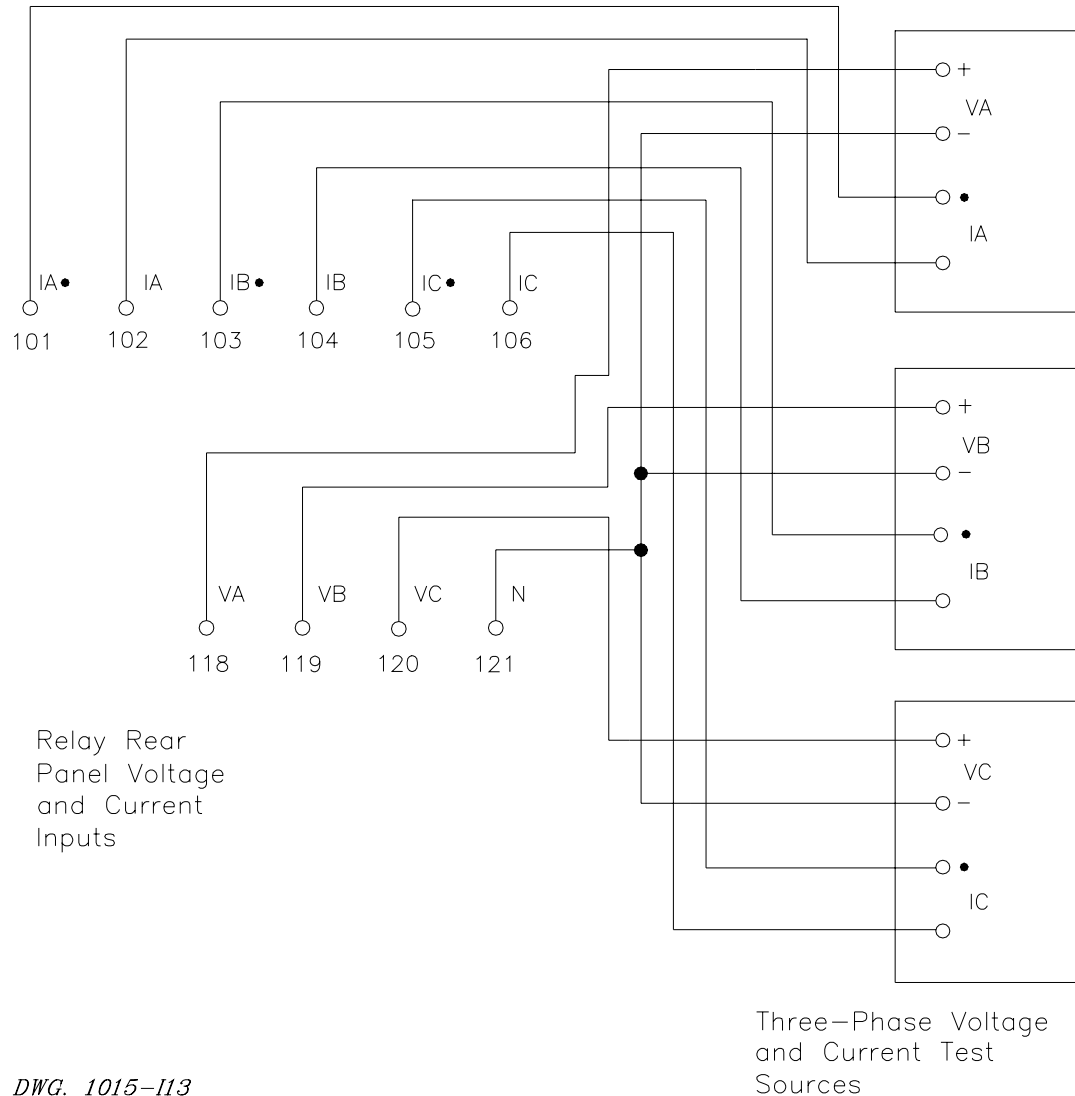


Figure 13.2: Three Voltage Source and Three Current Source Test Connections

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.

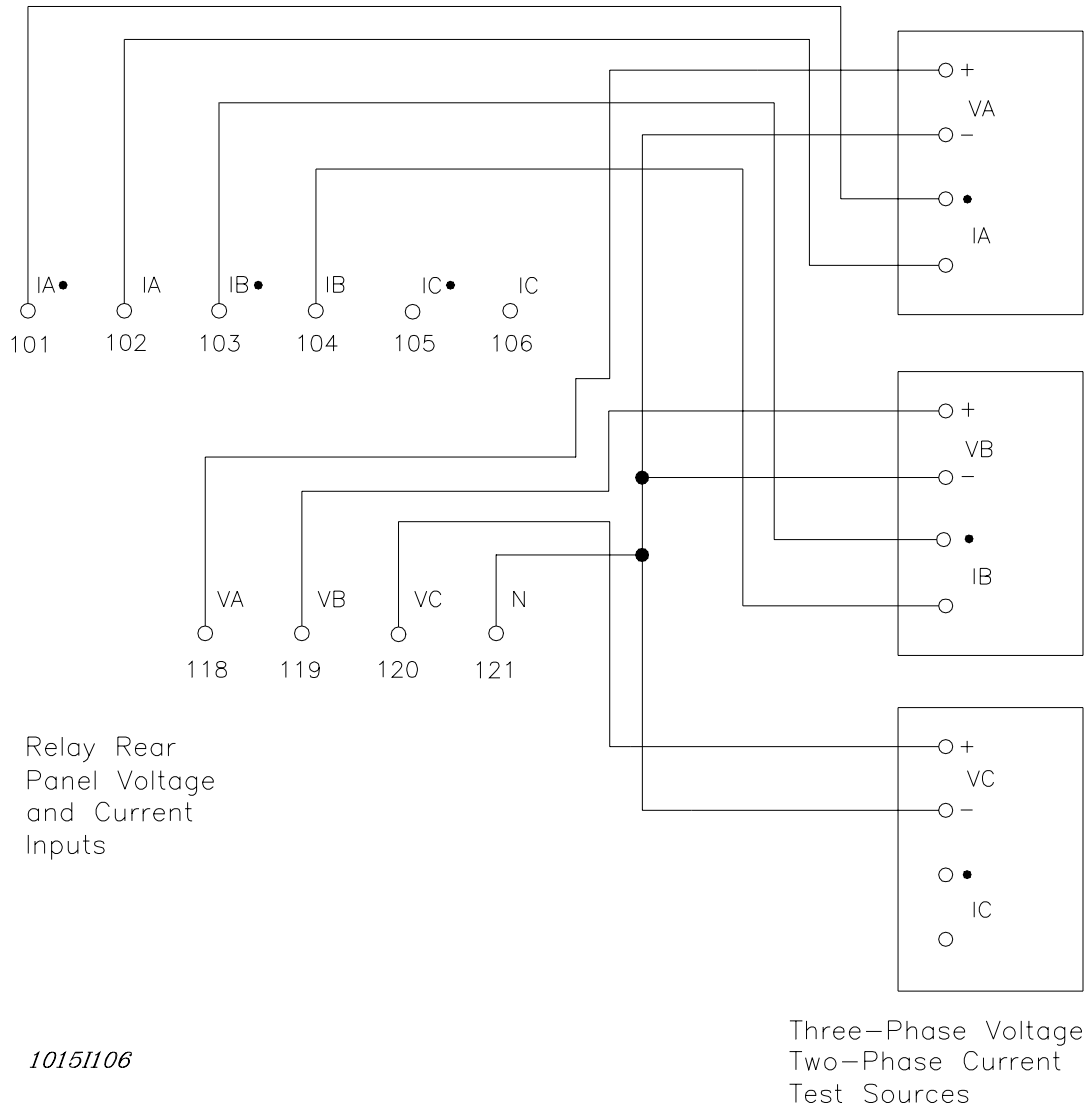
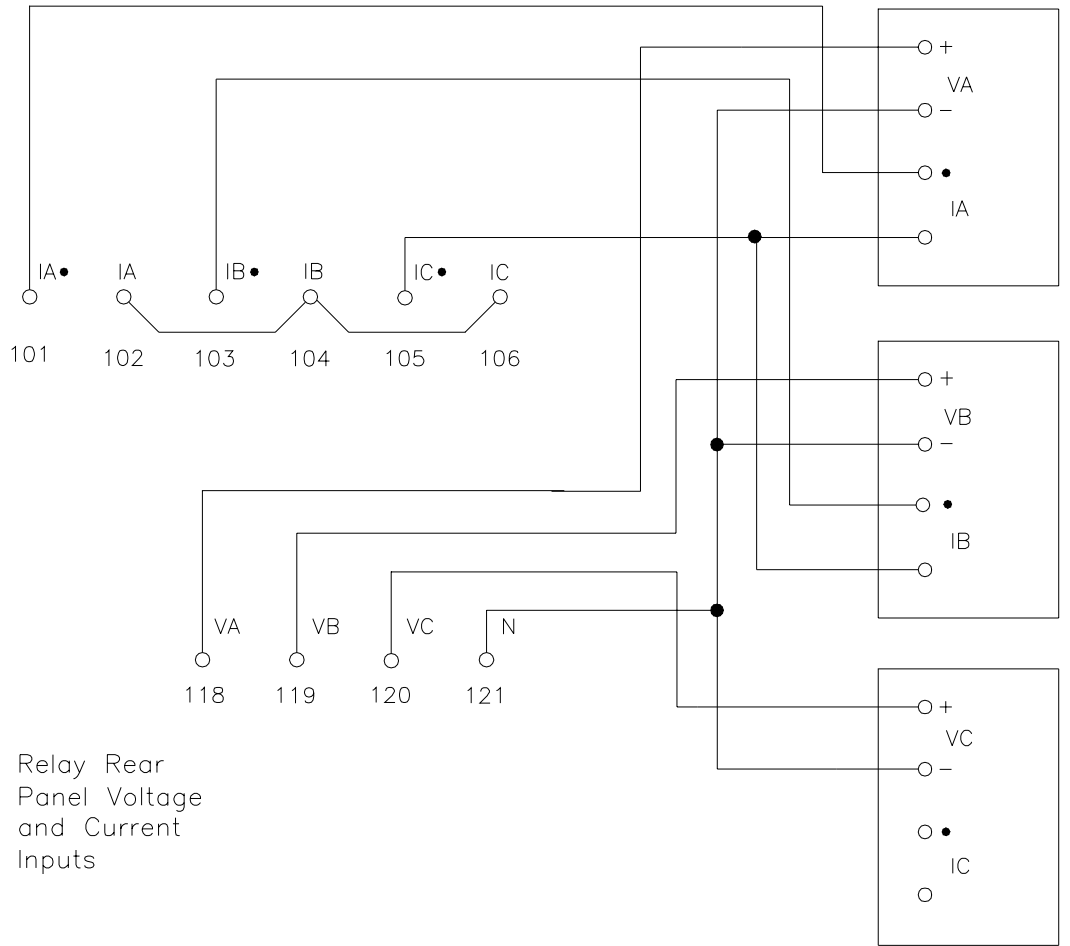


Figure 13.3: Phase-to-Phase, Phase-to-Ground, and Two-Phase-to-Ground Fault Test Connections Using Two Current Sources



DWG. 1015-114

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.

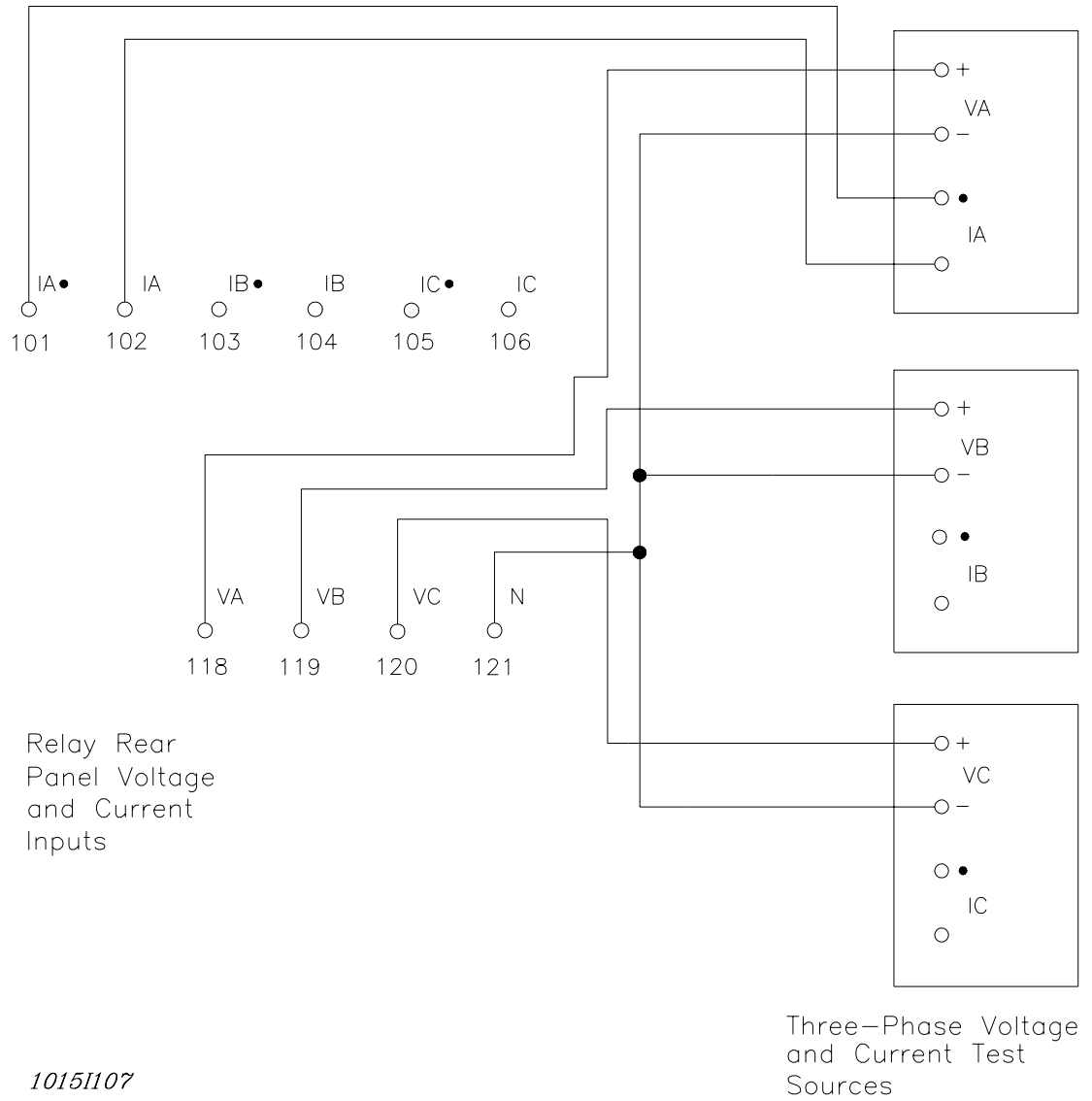


Figure 13.5: Phase-to-Ground Fault Test Connections Using a Single Current Source

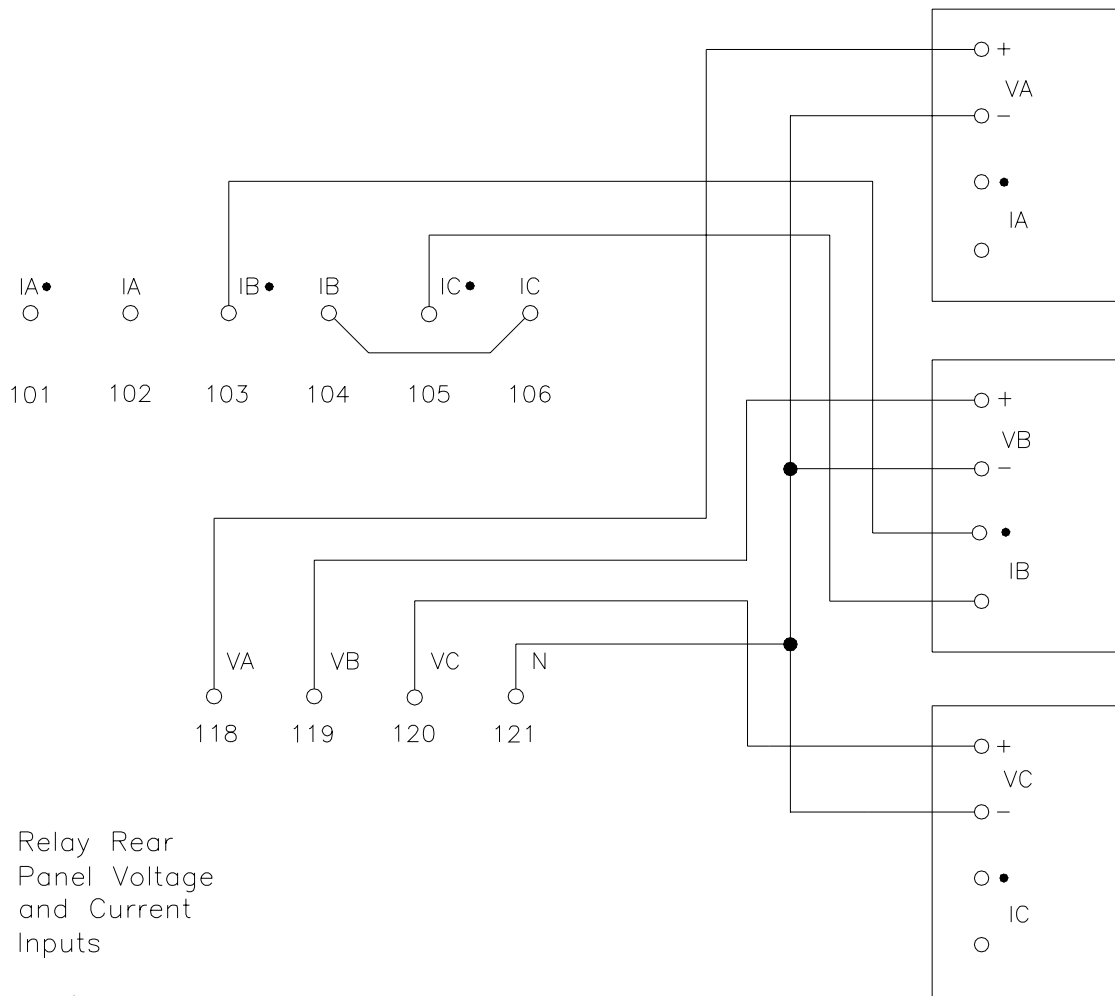


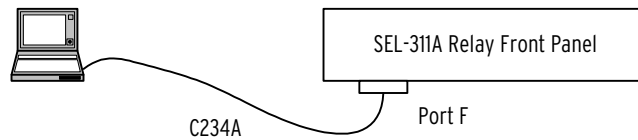
Figure 13.6: Phase-to-Phase Fault Test Connections Using a Single Current Source

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-311A Relay Port F. Complete details regarding serial communications with the relay may be found in ***Section 10: Serial Port Communications and Commands***.



Use only serial communications cables manufactured by SEL or built to SEL specifications with the SEL-311A Relay. Damage to the relay or your communication equipment may result from the use of incorrect communication connections.



Connect to the SEL-311A Relays
via the front-panel serial port.

M311A050

Figure 13.7: Communications Connections Between the SEL-311A 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-311A Relay. The procedures are general, so that they may be applied to any specific element or zone.

Overcurrent Elements

The SEL-311A 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-311A 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.

<u>Element Type</u>	<u>Operates based upon the magnitude of:</u>	<u>Relay Elements</u>
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	$3 \cdot I_2 = (I_A + a^2 \cdot I_B + a \cdot I_C)$ Test using single-phase current.	50Q1, 50Q2, 50Q3, 50Q4, 50QF, 50QR
Positive-Sequence	$I_1 = 1/3 (I_A + a \cdot I_B + a^2 \cdot I_C)$ 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-311A 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-311A 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:

$$Z_{2c} = \frac{\text{Re}[V_2 \cdot (1 \angle Z1ANG^\circ \cdot I_2)^*]}{|I_2|^2} \tag{Equation 13.1}$$

Where: Re indicates the real part of the term in brackets, for instance $\text{Re}[A + jB] = A$
 * 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:

$$\begin{aligned} \angle Z1ANG &= 90^\circ \\ V_2 &= 10 \angle 180^\circ \text{ volts, secondary} \\ I_2 &= 2 \angle -90^\circ \text{ amps, secondary} \\ Z2c &= \frac{\text{Re}[10 \angle 180^\circ \cdot (1 \angle 90^\circ \cdot 2 \angle -90^\circ)^*]}{|2|^2} \end{aligned}$$

$$Z2c = \frac{-20 \text{ ohms}}{4}$$

$$Z2c = -5 \text{ ohms}$$

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.

$$\begin{aligned} \angle Z1ANG &= 90^\circ \\ V_2 &= 10 \angle 180^\circ \text{ volts, secondary} \\ I_2 &= 2 \angle 90^\circ \text{ amps, secondary} \\ Z2c &= \frac{\text{Re}[10 \angle 180^\circ \cdot (1 \angle 90^\circ \cdot 2 \angle +90^\circ)^*]}{|2|^2} \end{aligned}$$

$$Z2c = \frac{20 \text{ ohms}}{4}$$

$$Z2c = 5 \text{ ohms}$$

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 $Z_{2F} \leq 0$:

$$Z_{2FT} = 0.75 \cdot Z_{2F} - 0.25 \cdot Z_{2m} \quad \text{Equation 13.2}$$

When $Z_{2F} > 0$:

$$Z_{2FT} = 1.25 \cdot Z_{2F} - 0.25 \cdot Z_{2m} \quad \text{Equation 13.3}$$

Where:

$$Z_{2m} = \frac{|V_2|}{|I_2|}$$

The reverse directional threshold is calculated using Equation 13.4 when Z_{2R} is positive or Equation 13.5 when Z_{2R} is negative.

When $Z_{2R} \geq 0$:

$$Z_{2RT} = 0.75 \cdot Z_{2R} + 0.25 \cdot Z_{2m} \quad \text{Equation 13.4}$$

When $Z_{2R} < 0$:

$$Z_{2RT} = 1.25 \cdot Z_{2R} + 0.25 \cdot Z_{2m} \quad \text{Equation 13.5}$$

The threshold equations have a unique property. When $Z_{2m} = |Z_{2R}|$, $Z_{2RT} = Z_{2R}$ and when $Z_{2m} = |Z_{2F}|$, $Z_{2FT} = Z_{2F}$. This property is used to simplify the test procedures outlined on the following pages.

It is possible to create test conditions for a Z_{2c} 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 Z_{2F} and Z_{2R} settings prevent this from occurring for real power system faults.

Settings for both Z_{2F} and Z_{2R} 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-311A 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_0) 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.

$$\begin{aligned} V_2 &= \frac{1}{3} \cdot (V_A + a^2 \cdot V_B + a \cdot V_C) \\ I_2 &= \frac{1}{3} \cdot (I_A + a^2 \cdot I_B + a \cdot I_C) \end{aligned}$$

Using single-phase signals simplifies the V_2 and I_2 calculations.

$$\begin{aligned} V_B &= V_C = 0 \text{ volts} \\ I_B &= I_C = 0 \text{ amps} \\ V_2 &= \frac{1}{3} \cdot (V_A) \\ I_2 &= \frac{1}{3} \cdot (I_A) \end{aligned}$$

Assume that you apply a test voltage $V_A = 18.0 \angle 180^\circ$ volts secondary.

$$\begin{aligned} V_2 &= \frac{1}{3} \cdot (18.0 \angle 180^\circ) \text{ volts} \\ V_2 &= 6.0 \angle 180^\circ \text{ volts} \end{aligned}$$

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 $(180^\circ - \angle Z1ANG^\circ)$.

We are testing for positive values of Z2c, so I_2 should lag V_2 by Z1ANG.

Assuming that $V_A = 18.0 \angle 180^\circ$ 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:

$$|I_A| = 3 \cdot (|V_2| / |Z_2|) \quad \text{Equation 13.6}$$

For Z2R = 5.45 Ω :

$$\begin{aligned} |I_A| &= 3 \cdot (6.0 \text{ volts} / 5.45 \text{ ohms}) \\ |I_A| &= 3.3 \text{ amps} \end{aligned}$$

Calculate Z2m:

$$\begin{aligned} Z2m &= \frac{|V_2|}{|I_2|} \\ Z2m &= \frac{6.0V}{1.1A} \\ Z2m &= 5.45 \text{ ohms} \end{aligned}$$

Because Z2R is positive, use Equation 13.4 to calculate Z2RT.

$$\begin{aligned} Z2RT &= 0.75 \cdot Z2R + 0.25 \cdot Z2m \\ Z2RT &= 0.75 \cdot (5.45) + 0.25 \cdot (5.45) \\ Z2RT &= 5.45 \text{ ohms} \end{aligned}$$

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:

$$\begin{aligned} |I_A| &= 3 \cdot (6.0 \text{ volts} / 0.77 \text{ ohms}) \\ |I_A| &= 23.4 \text{ amps} \end{aligned}$$

Calculate Z2m:

$$\begin{aligned} Z2m &= \frac{|V_2|}{|I_2|} \\ Z2m &= \frac{6.0V}{7.8A} \\ Z2m &= 0.77 \text{ ohms} \end{aligned}$$

Because Z2F is positive, use Equation 13.3 to calculate Z2FT.

$$\begin{aligned} Z2FT &= 1.25 \cdot Z2F - 0.25 \cdot Z2m \\ Z2FT &= 1.25 \cdot (0.77) - 0.25 \cdot (0.77) \\ Z2FT &= 0.77 \text{ ohms} \end{aligned}$$

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 V ∠180° I_A = 0.0 A ∠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, 3I₂ is greater than 50QR, and I₂ is greater than a2 · I₁, 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 $V_A = 18.0 \text{ V } \angle 180^\circ$, $I_A = 3.3 \text{ A } \angle 96^\circ$:

$$\begin{aligned} V_2 &= 6.0 \angle 180^\circ \\ I_2 &= 1.10 \\ 1 \angle Z1ANG^\circ &= 1 \angle 83.97^\circ \end{aligned}$$

$$\begin{aligned} Z2c &= \frac{\text{Re}[V_2 \cdot (1 \angle Z1ANG^\circ \cdot I_2)^*]}{|I_2|^2} \\ Z2c &= \frac{\text{Re}[6 \angle 180^\circ \cdot (1 \angle 83.97^\circ \cdot 1.10 \angle 96^\circ)^*]}{|1.10|^2} \end{aligned}$$

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 $V_A = 18.0 \text{ V } \angle 180^\circ$, $I_A = 23.4 \text{ A } \angle 96^\circ$, and using the equation above:

$$\begin{aligned} V_2 &= 6.0 \text{ V } \angle 180^\circ \\ I_2 &= 7.80 \\ 1 \angle Z1ANG^\circ &= 1 \angle 83.97^\circ \end{aligned}$$

$$Z2c = \frac{\text{Re}[6 \angle 180^\circ \cdot (1 \angle 83.97^\circ \cdot 7.80 \angle 96^\circ)^*]}{|7.80|^2}$$

$$Z2c = \frac{46.8 \text{ ohms}}{60.84}$$

$$Z2c = 0.77 \text{ ohms} = Z2FT \text{ when } Z2m = 0.77 \text{ ohms}$$

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 Ln** 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 V_2 and I_2 , given the magnitude and angle of each of the phase quantities using the equations below.

$$V_2 = \frac{1}{3} \cdot (V_A + a^2 \cdot V_B + a \cdot V_C)$$

$$I_2 = \frac{1}{3} \cdot (I_A + a^2 \cdot I_B + a \cdot I_C)$$

Using a single-phase current source simplifies the I_2 calculation.

$$I_B = I_C = 0 \text{ amps}$$

$$I_2 = \frac{1}{3} \cdot (I_A)$$

Assume that you apply the following test voltages:

$$V_A = 49.0 \text{ V } \angle 0^\circ$$

$$V_B = 67.0 \text{ V } \angle -120^\circ$$

$$V_C = 67.0 \text{ V } \angle 120^\circ$$

$$V_2 = \frac{1}{3} \cdot (49.0 \angle 0^\circ + 1 \angle 240^\circ \cdot 67 \angle -120^\circ + 1 \angle 120^\circ \cdot 67 \angle 120^\circ) \text{ volts}$$

$$V_2 = \frac{1}{3} \cdot (49.0 \angle 0^\circ + 67 \angle 120^\circ + 67 \angle -120^\circ) \text{ volts}$$

$$V_2 = 6.0 \angle 180^\circ \text{ volts}$$

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 $(180^\circ - \angle Z1ANG^\circ)$.

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 $(180^\circ - \angle Z1ANG^\circ)$.
Equation 13.1 yields a negative result when I_A lags V_A by $\angle Z1ANG^\circ$.

We are testing for positive values of $Z2c$, so I_A should lead V_A by $(180^\circ - \angle Z1ANG^\circ)$. Assuming that $V_A = 49.0 \angle 0^\circ$ 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:

$$|I_A| = 3 \cdot (|V_2| / |Z_2|) \quad \text{Equation 13.6}$$

For $Z2R = 5.45 \Omega$:

$$|I_A| = 3 \cdot (6.0 \text{ volts} / 5.45 \text{ ohms})$$
$$|I_A| = 3.3 \text{ amps}$$

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 $Z2RT$.

$$Z2RT = 0.75 \cdot Z2R + 0.25 \cdot Z2m$$
$$Z2RT = 0.75 \cdot (5.45) + 0.25 \cdot (5.45)$$
$$Z2RT = 5.45 \text{ ohms}$$

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 $Z2F = 0.77 \Omega$:

$$|I_A| = 3 \cdot (6.0 \text{ volts} / 0.77 \text{ ohms})$$
$$|I_A| = 23.4 \text{ amps}$$

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 $Z2FT$.

$$\begin{aligned} Z2FT &= 1.25 \cdot Z2F - 0.25 \cdot Z2m \\ Z2FT &= 1.25 \cdot (0.77) - 0.25 \cdot (0.77) \\ Z2FT &= 0.77 \text{ ohms} \end{aligned}$$

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:

$$\begin{aligned} V_A &= 49.0 \text{ V } \angle 0^\circ \\ V_B &= 67.0 \text{ V } \angle -120^\circ \\ V_C &= 67.0 \text{ V } \angle 120^\circ \\ I_A &= 0.0 \text{ A } \angle 96^\circ \end{aligned}$$

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, 3I₂ is greater than 50QR, and I₂ is greater than a2 · I₁, 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:

$$\begin{aligned} I_A &= 3.30 \text{ A } \angle 96^\circ \\ V_A &= 49.0 \text{ V } \angle 0^\circ \\ V_B &= 67.0 \text{ V } \angle -120^\circ \\ V_C &= 67.0 \text{ V } \angle 120^\circ \end{aligned}$$

$$V_2 = 6.0 \text{ V } \angle 180^\circ$$

$$I_2 = 1.10$$

$$\angle Z1ANG^\circ = 1 \angle 83.97^\circ$$

$$Z2c = \frac{\text{Re}[V_2 \cdot (1 \angle Z1ANG^\circ \cdot I_2)^*]}{|I_2|^2}$$

$$Z2c = \frac{\text{Re}[6 \angle 180^\circ \cdot (1 \angle 83.97^\circ \cdot 1.10 \angle 96^\circ)^*]}{|1.10|^2}$$

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:

$$I_A = 23.4 \text{ A } \angle 96^\circ$$

$$V_A = 49.0 \text{ V } \angle 0^\circ$$

$$V_B = 67.0 \text{ V } \angle -120^\circ$$

$$V_C = 67.0 \text{ V } \angle 120^\circ$$

$$V_2 = 6.0 \text{ V } \angle 180^\circ$$

$$I_2 = 7.80$$

$$1 \angle Z1ANG^\circ = 1 \angle 83.97^\circ$$

$$Z2c = \frac{\text{Re}[6 \angle 180^\circ \cdot (1 \angle 83.97^\circ \cdot 7.80 \angle 96^\circ)^*]}{|7.80|^2}$$

$$Z2c = \frac{46.8 \text{ ohms}}{60.84}$$

$$Z2c = 0.77 \text{ ohms} = Z2F \text{ when } Z2m = 0.77 \text{ ohms}$$

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.

Phase Mho Distance Elements

The SEL-311A 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
$V_A = 67 \angle 0^\circ$ volts	$I_{TEST} = 2.5 \angle -173.97^\circ$ amps
$V_B = 46.8 \angle -150^\circ$ volts	
$V_C = 46.8 \angle 150^\circ$ 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.

$$\begin{aligned} I_{TEST} &= I_B = -I_C \\ I_{BC} &= I_B - I_C \\ I_{BC} &= 2 \cdot I_B \\ I_{BC} &= 2 \cdot I_{TEST} \end{aligned}$$

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} .

$$\begin{aligned} I_2 &= \frac{1}{3} \cdot (I_A + a^2 \cdot I_B + a \cdot I_C) \\ 3 \cdot I_2 &= (I_A + a^2 \cdot I_B + a \cdot I_C) \\ I_A &= 0 \text{ and } I_C = -I_B, \text{ so:} \\ 3 \cdot I_2 &= (a^2 \cdot I_B - a \cdot I_B) \\ 3 \cdot I_2 &= I_B \cdot (a^2 - a) \\ 3 \cdot I_2 &= I_B \cdot (1.732 \angle -90^\circ) \end{aligned}$$

Because the 50QF element operates based upon magnitude only, the equation above is simplified.

$$|3 \cdot I_2| = |I_{TEST}| \cdot 1.732$$

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.

$$\begin{aligned}
 |V_{BC}| &= |I_{BC}| \cdot |Z_{BC}| \\
 |V_{BC}| &= |5.0| \cdot |9.36| \\
 |V_{BC}| &= 46.8 \text{ volts secondary}
 \end{aligned}
 \tag{Equation 13.7}$$

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.

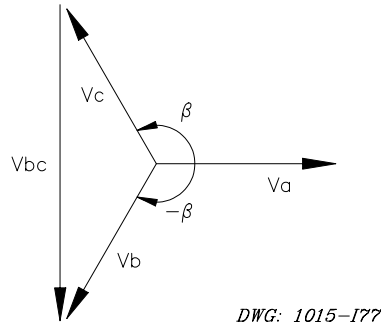


Figure 13.8: Phase Distance Element Test Voltage Signals

When the magnitude of V_{BC} calculated above lies between 67 and 35 volts, use $\beta = 150^\circ$ and $|V_B| = |V_C| = |V_{BC}|$.

When the magnitude of V_{BC} calculated above is greater than 67 volts, use $|V_B| = |V_C| = 67 \text{ V}$. Calculate the angle β using Equation 13.8.

When the magnitude of V_{BC} calculated above is less than 35 volts, use $|V_B| = |V_C| = 35 \text{ V}$. Calculate the angle β using Equation 13.8.

$$\beta = 180^\circ - \arcsin \left[\frac{|V_{BC}|}{2 \cdot |V_C|} \right] \text{ deg}
 \tag{Equation 13.8}$$

Select $V_A = 67 \angle 0^\circ$ 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.

$$\begin{aligned}
 V_A &= 67.0 \angle 0^\circ \text{ volts} \\
 V_B &= 46.8 \angle -150^\circ \text{ volts} \\
 V_C &= 46.8 \angle 150^\circ \text{ volts}
 \end{aligned}$$

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-311A 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.

$$V_2 = \frac{1}{3} \cdot (V_A + a^2 \cdot V_B + a \cdot V_C)$$

$$I_2 = \frac{1}{3} \cdot (I_A + a^2 \cdot I_B + a \cdot I_C)$$

$$Z2c = \frac{\text{Re}[V_2 \cdot (1 \angle Z1ANG^\circ \cdot I_2)^*]}{|I_2|^2} \quad \text{Equation 13.1}$$

$$Z2m = \frac{|V_2|}{|I_2|}$$

$$Z2FT = 1.25 \cdot Z2F - 0.25 \cdot Z2m \quad \text{Equation 13.3}$$

Taking the test signals from Table 13.3.

$$V_A = 67.0 \text{ V} \angle 0^\circ \text{ volts}$$

$$V_B = 46.8 \text{ V} \angle -150^\circ \text{ volts}$$

$$V_C = 46.8 \text{ V} \angle 150^\circ \text{ volts}$$

$$V_2 = \frac{1}{3} \cdot (67.0 \angle 0^\circ + 1 \angle 240^\circ \cdot 46.8 \angle -150^\circ + 1 \angle 120^\circ \cdot 46.8 \angle 150^\circ) \text{ volts}$$

$$V_2 = 22.3 \angle 0^\circ \text{ volts}$$

Due to the test connections used, $I_B = -I_C = I_{\text{TEST}}$.

$$I_A = 0.0 \text{ A} \angle 0^\circ$$

$$I_B = 2.5 \text{ A} \angle -173.97^\circ$$

$$I_C = 2.5 \text{ A} \angle 6.03^\circ$$

$$I_2 = \frac{1}{3} \cdot (0.0 \angle 0^\circ + 1 \angle 240^\circ \cdot 2.5 \angle -173.97^\circ + 1 \angle 120^\circ \cdot 2.5 \angle 6.03^\circ) \text{ amps}$$

$$I_2 = 1.44 \angle 96.03^\circ \text{ amps}$$

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:

$$Z_{BC} = \frac{V_{BC}}{2 \cdot I_{TEST}} \text{ ohms, sec} \quad \text{Equation 13.9}$$

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} .

$$\begin{aligned} \angle I_{TEST2} &= \angle I_{TEST1} + 45^\circ \\ \angle I_{TEST2} &= -173.97^\circ + 45^\circ \\ \angle I_{TEST2} &= -128.97^\circ \end{aligned}$$

Calculate the magnitude of I_{TEST2} using Equation 13.10.

$$\begin{aligned} |I_{TEST2}| &= \frac{|I_{TEST1}|}{\cos(\text{Line Impedance Angle} - \text{New Test Impedance Angle})} \text{ amps, sec} \\ |I_{TEST2}| &= \frac{2.5}{\cos(83.97^\circ - 38.97^\circ)} \text{ amps} \\ |I_{TEST2}| &= \frac{2.5}{\cos(45^\circ)} \text{ amps} \\ |I_{TEST2}| &= 3.54 \text{ amps} \end{aligned} \quad \text{Equation 13.10}$$

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-311A 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-311A 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
$V_A = 40.4 \angle 0^\circ$ volts	$I_{TEST} = 2.5 \angle -82.42^\circ$ amps
$V_B = 67.0 \angle -120^\circ$ volts	
$V_C = 67.0 \angle 120^\circ$ 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} .

$$I_2 = \frac{1}{3} \cdot (I_A + a^2 \cdot I_B + a \cdot I_C)$$

$$3 \cdot I_2 = (I_A + a^2 \cdot I_B + a \cdot I_C)$$

$$I_A = I_{TEST} \text{ and } I_B = I_C = 0, \text{ so:}$$

$$3 \cdot I_2 = I_{TEST}$$

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 $Z2MG = 9.36 \Omega$. 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-311A 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:

$$Z_{AG} = \frac{V_A}{I_A + k0 \cdot I_R} \quad \text{Equation 13.11}$$

Where: $k0 = k0M \angle k0A^\circ$

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:

$$Z_{AG} = \frac{V_A}{I_A \cdot (1 + k0)} \quad \text{Equation 13.12}$$

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 .

$$Z_{AG} \cdot (1 + k0) = \frac{V_A}{I_A} \quad \text{Equation 13.13}$$

Since we are testing the Zone 2 mho ground distance element, the intended value of $Z_{AG} = Z2MG = 9.36 \Omega$. 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.

$$Z_{AG} \cdot (1 + k0) = Z_{TEST} = Z2MG \cdot (1 + k0M \angle k0A) \quad \text{Equation 13.14}$$

$$Z_{TEST} = 9.36 \angle 83.97^\circ \cdot (1 + 0.726 \angle -3.69^\circ)$$

$$Z_{TEST} = 9.36 \angle 83.97^\circ \cdot (1.725 \angle -1.55^\circ)$$

$$Z_{TEST} = 16.15 \angle 82.42^\circ$$

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:

$$I_A = 2.5 \angle -82.42^\circ$$

Calculate the magnitude of V_A using Equation 13.15

$$V_A = I_A \cdot Z_{TEST}$$

$$V_A = 2.5 \angle -82.42^\circ \cdot 16.15 \angle 82.42^\circ \quad \text{Equation 13.15}$$

$$V_A = 40.4 \angle 0.0^\circ \text{ volts secondary}$$

Select $V_B = 67 \angle -120^\circ$ volts and $V_C = 67 \angle 120^\circ$ 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 $Z2m$.

$$V_2 = \frac{1}{3} \cdot (V_A + a^2 \cdot V_B + a \cdot V_C)$$

$$I_2 = \frac{1}{3} \cdot (I_A + a^2 \cdot I_B + a \cdot I_C)$$

$$Z2c = \frac{\text{Re}[V_2 \cdot (1 \angle Z1ANG^\circ \cdot I_2)^*]}{|I_2|^2} \quad \text{Equation 13.1}$$

$$Z2m = \frac{|V_2|}{|I_2|}$$

$$Z2FT = 1.25 \cdot Z2F - 0.25 \cdot Z2m$$

Taking the test signals from Table 13.4.

$$V_A = 40.4 \text{ V} \angle 0^\circ$$

$$V_B = 67.0 \text{ V} \angle -120^\circ$$

$$V_C = 67.0 \text{ V} \angle 120^\circ$$

$$V_2 = \frac{1}{3} \cdot (40.4 \angle 0^\circ + 1 \angle 240^\circ \cdot 67.0 \angle -120^\circ + 1 \angle 120^\circ \cdot 67.0 \angle 120^\circ) \text{ volts}$$

$$V_2 = 8.88 \angle 180^\circ \text{ volts}$$

$$I_A = 2.5 \angle -82.42^\circ$$

$$I_B = 0.0 \angle 0.0^\circ$$

$$I_C = 0.0 \angle 0.0^\circ$$

$$I_2 = \frac{1}{3} \cdot (2.5 \angle -82.42^\circ) \text{ amps}$$

$$I_2 = 0.83 \angle -82.42^\circ \text{ amps}$$

Using Equation 13.1 to calculate Z2, the result is:

$$Z2c = -10.66 \text{ ohms}$$

$$Z2m = 15.47 \text{ ohms}$$

$$Z2FT = 1.25 \cdot (0.77) - 0.25 \cdot (15.47)$$

$$Z2FT = -2.91 \text{ ohms}$$

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} .

$$\angle I_{TEST2} = \angle I_{TEST1} + 45^\circ$$

$$\angle I_{TEST2} = -173.97^\circ + 45^\circ$$

$$\angle I_{TEST2} = -128.97^\circ$$

Calculate the magnitude of I_{TEST2} using Equation 13.10.

$$|I_{TEST2}| = \frac{|I_{TEST1}|}{\cos(\text{Line Impedance Angle} - \text{New Test Impedance Angle})} \text{ amps, sec}$$

$$|I_{TEST2}| = \frac{2.5}{\cos(83.97^\circ - 38.97^\circ)} \text{ amps}$$

$$|I_{TEST2}| = \frac{2.5}{\cos(45^\circ)} \text{ amps}$$

$$|I_{TEST2}| = 3.54 \text{ amps}$$

Equation 13.10

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.

<u>Symptom:</u>	<u>What to check:</u>
Incorrect Targets	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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 overcurrent elements and trip/close logic. All output contacts are deenergized. The EN front-panel LED is extinguished.
- ALARM Output: The ALARM output contact signals an alarm condition by going to its deenergized state. If the ALARM output contact is a B contact (normally closed), it closes for an alarm condition or if the relay is deenergized. If the ALARM output contact is an A contact (normally open), it opens for an alarm condition or if the relay is deenergized. Alarm condition signaling can be a single 5-second pulse (Pulsed) or permanent (Latched).
- 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, Offset	Warning	30 mV	No	Pulsed	Measures the dc offset at each of the input channels every 10 seconds.
Master Offset +5 V PS	Warning	20 mV	No	Pulsed	Measures the dc offset at the A/D every 10 seconds. Measures the +5 V power supply every 10 seconds.
	Failure	30 mV	Yes	Latched	
	Warning	+4.80 V +5.20 V	No	Pulsed	
+5 V PS	Failure	+4.65 V +5.40 V	Yes	Latched	
	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.
<p>The following self-tests are performed by dedicated circuitry in the microprocessor and the SEL-311A Relay main board. Failures in these tests shut down the microprocessor and are not shown in the STATUS report.</p>					
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-311A 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

TABLE OF CONTENTS

SECTION 14: APPLICATION SETTINGS FOR SEL-2PG10 RELAYS 14-1

SEL-2PG10 to SEL-311A Settings Conversion Guide 14-1

 Application Settings..... 14-2

 Convert SEL-2PG10 Primary Quantities to SEL-311A Secondary Quantities 14-2

 Convert SEL-2PG10 Relay Settings to SEL-311A Relay Settings 14-2

 Convert SEL-2PG10 Output Mask Logic Settings to SELOGIC[®] Control Equations..... 14-5

SEL-2PG10 Settings Sheets..... 14-9

TABLES

Table 14.1: SEL-311A Settings Calculated From SEL-2PG10 Settings..... 14-3

Table 14.2: SEL-311A SELOGIC Equation Equivalent to Each SEL-2PG10 Mask Logic Setting 14-5

Table 14.3: SELOGIC Equivalent to SEL-2PG10 Relay Word Bits 14-5

Table 14.4: Default SEL-2PG10 Mask Logic Setting for MT 14-6

SECTION 14: APPLICATION SETTINGS FOR SEL-2PG10 RELAYS

SEL-2PG10 TO SEL-311A SETTINGS CONVERSION GUIDE

Set APP = 2PG10 in the SEL-311A to configure the relay to closely approximate the features, performance, and settings of an SEL-2PG10. When APP = 2PG10, the SEL-311A:

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 = 311A to make all of the SEL-311A settings visible. It is important to remember that changing from APP = 311A to APP = 2PG10 changes settings in the relay. Changing from APP = 2PG10 to APP = 311A makes more SEL-311A settings visible, but does not change any other settings. If SEL-311A functions are used after setting APP is changed from 2PG10 to 311A, do not change setting APP back to 2PG10.

As described above, when setting APP = 2PG10, the user is presented only with SEL-311A settings associated with the features found in an SEL-2PG10. This section explains how to make those remaining SEL-311A settings directly from the settings used in an SEL-2PG10.

There are mainly two kinds of settings in the SEL-311A, 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-311A. To set the SEL-311A 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-311A settings using the simple equations shown in Table 14.1. Be sure to convert from primary quantities (SEL-2PG10 settings) to secondary quantities (SEL-311A settings). See *Convert SEL-2PG10 Primary Quantities to SEL-311A Secondary Quantities* below.
3. For each Mask Logic setting in the SEL-2PG10 shown in Table 14.1, create an equivalent SELOGIC control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.1.
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-311A application setting to “2PG10” as shown below:

```
=>>SET APP TERSE <ENTER>

Line Parameter Settings:
Application (311A,2PG10) APP = 311A      ? 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-311A Secondary Quantities

All SEL-2PG10 current settings must be converted from primary to secondary amps to be used in the SEL-311A. 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-311A (Z1P) is calculated as

$$Z1P = \frac{Z1\%}{100} \cdot Z1MAG$$

where: Z1% is the SEL-2PG10 distance reach setting.

Z1MAG is the SEL-311A positive-sequence line impedance setting in secondary ohms.

Z1P is the SEL-311A Zone 1 reach setting in secondary ohms.

Convert SEL-2PG10 Relay Settings to SEL-311A Relay Settings

Table 14.1 shows all the SEL-311A Relay settings that must be entered for the relay to perform protection similar to the SEL-2PG10 when APP = 2PG10. Calculate each SEL-311A 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-311A 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 14.1: SEL-311A Settings Calculated From SEL-2PG10 Settings

SEL-311A Relay Setting	Calculated from SEL-2PG10 Settings	SEL-311A 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	$= \sqrt{(R1^2 + X1^2)} \cdot \left[\frac{CTR}{PTR} \right]$ $= \text{Arc tan} \left[\frac{X1}{R1} \right]$ (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	
APP Z1P	None $= \frac{Z\%}{100} \cdot Z1MAG$ where $Z1MAG = \sqrt{(R1^2 + X1^2)} \left[\frac{CTR}{PTR} \right]$	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-311A Relay Setting	Calculated from SEL-2PG10 Settings	SEL-311A 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-311A 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-311A is slightly different from curve 1 in the SEL-2PG10. Time dial adjustments may be necessary.

Note: SEL-311A 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-311A, output masks are replaced by SELOGIC control equations as shown below:

Table 14.2: SEL-311A SELOGIC Equation Equivalent to Each SEL-2PG10 Mask Logic Setting

SEL-2PG10 Settings Mask	SEL-311A SELOGIC Equations
MT	TR
MA1	OUT101
MA2	OUT102
MA3	OUT103
MA4	OUT104
MA5	OUT105

Table 14.3 shows all SEL-2PG10 Relay Word bits, and an approximate equivalent SEL-311A SELOGIC expression, when setting APP = 2PG10 in the SEL-311A. Table 14.2 shows each SEL-2PG10 Mask Logic Setting and the equivalent SEL-311A 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 14.3) and enter the resultant expression in the related SELOGIC control equation (Table 14.3).

Table 14.3: SELOGIC Equivalent to SEL-2PG10 Relay Word Bits

SEL-2PG10 Relay Word Bit	Equivalent SEL-311A SELOGIC Expression
50L	None
ZABC	MABC1
ZP	MPP1
ZPT	MIPT
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 14.4. From Table 14.2, the equivalent SEL-311A SELOGIC control equation to MT is TR. Constructing the logical OR of the equivalent of each element selected in the MT mask from Table 14.3 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-311A 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 14.4: 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

$$51GTC = M2P \quad (\text{Setting } 51NTC = 1)$$

SELogic Variables Equations

$$SV1 = 0 \quad (\text{Reserved for non-directional instantaneous overcurrent timer})$$

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-311A SETTINGS SHEET
APPLICATION SETTING 2PG10

Page 1 of 3

Date _____

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 Z1MAG = _____
(0.05–255.00 Ω secondary {5 A nom.};
0.25–1275.00 Ω secondary {1 A nom.})

Positive-sequence line impedance angle (5.00–90.00 degrees) Z1ANG = _____

Zero-sequence line impedance magnitude Z0MAG = _____
(0.05–255.00 Ω secondary {5 A nom.};
0.25–1275.00 Ω secondary {1 A nom.})

Zero-sequence line impedance angle (5.00–90.00 degrees) Z0ANG = _____

Line length (0.10–999.00, unitless) LL = _____

Application (311A, 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 3.13)

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 3.13)

Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) 67G1D = _____

Residual Ground Time-Overcurrent Element (See Figure 3.15)

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 = _____

**SEL-311A SETTINGS SHEET
APPLICATION SETTING 2PG10**

Page 2 OF 3

Date _____

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 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 = _____

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 3.13) 51GTC = _____

SELOGIC Control Equation Variable Timer Input Equations (See Figures 7.23 and 7.24)

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 (MBx) 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 = _____

SEL-311A SETTINGS SHEET
APPLICATION SETTING 2PG10

Page 3 OF 3

Date _____

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)

Data Bits (6, 7, 8)

Parity (O, E, N) {Odd, Even, None}

Stop Bits (1, 2)

SPEED = _____

BITS = _____

PARITY = _____

STOP = _____

Other Port Settings (See Below)

Time-out (0–30 minutes)

DTA Meter Format (Y, N)

Send Auto Messages to Port (Y, N)

Enable Hardware Handshaking (Y, N, MBT)

Fast Operate Enable (Y, N)

T_OUT = _____

DTA = _____

AUTO = _____

RTSCTS = _____

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 = _____

TABLE OF CONTENTS

APPENDIX A: FIRMWARE VERSIONS..... A-1

APPENDIX B: FIRMWARE UPGRADE INSTRUCTIONS.....B-1

Firmware (Flash) Upgrade Instructions	B-1
Important Note Regarding Settings	B-1
Required Equipment	B-1
Upgrade Procedure	B-1

APPENDIX C: SEL DISTRIBUTED PORT SWITCH PROTOCOL C-1

Settings	C-1
Operation	C-1

APPENDIX D: CONFIGURATION, FAST METER, AND FAST OPERATE COMMANDS.....D-1

Introduction.....	D-1
Message Lists.....	D-1
Binary Message List	D-1
ASCII Configuration Message List.....	D-2
Message Definitions	D-2
A5C0 Relay Definition Block.....	D-2
A5C1 Fast Meter Configuration Block.....	D-3
A5D1 Fast Meter Data Block	D-4
A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages	D-4
A5D2/A5D3 Demand/Peak Demand Fast Meter Message.....	D-7
A5B9 Fast Meter Status Acknowledge Message.....	D-7
A5CE Fast Operate Configuration Block	D-7
A5E0 Fast Operate Remote Bit Control	D-9
A5E3 Fast Operate Breaker Control	D-10
A5CD Fast Operate Reset Definition Block.....	D-10
A5ED Fast Operate Reset Command.....	D-10
ID Message	D-11
DNA Message.....	D-11
BNA Message	D-13
SNS Message	D-13

APPENDIX E: COMPRESSED ASCII COMMANDS.....E-1

Introduction.....	E-1
CASCII Command—General Format.....	E-1
CASCII Command—SEL-311A.....	E-2
CSTATUS Command—SEL-311A.....	E-4
CHISTORY Command—SEL-311A.....	E-4
CEVENT Command—SEL-311A.....	E-5
CSU Command—SEL-311A.....	E-7

APPENDIX F: SETTING SELogic® CONTROL EQUATIONS.....F-1

Relay Word Bits	F-1
Relay Word Bit Operation Example—Phase Time-Overcurrent Element 51PT.....	F-1
Other Relay Word Bits.....	F-3
SELOGIC Control Equations	F-3
SELOGIC Control Equation Operators.....	F-3
All SELOGIC Control Equations Must Be Set	F-7
SELOGIC Control Equation Limitations	F-8
Processing Order and Processing Interval	F-9

APPENDIX G: DISTRIBUTED NETWORK PROTOCOL (DNP) 3.00 ...G-1

Overview.....	G-1
Configuration.....	G-1
Data-Link Operation.....	G-2
Data Access Method.....	G-2
Device Profile.....	G-3
Object Table	G-6
Data Map	G-9
Relay Summary Event Data.....	G-13
Point Remapping.....	G-13

APPENDIX H: MIRRORED BITS™ COMMUNICATIONSH-1

Overview.....	H-1
Operation	H-1
Message Transmission.....	H-1
Message Decoding and Integrity Checks.....	H-1
Synchronization	H-2
Loopback Testing.....	H-3
Channel Monitoring.....	H-3
MIRRORED BITS Protocol for the Pulsar 9600 Baud Modem.....	H-4
Settings	H-4

APPENDIX I: UNSOLICITED FAST SER PROTOCOL..... I-1

Introduction.....	I-1
Make Sequential Events Recorder (SER) Settings With Care	I-1
Recommended Message Usage.....	I-1
Functions and Function Codes.....	I-2
01—Function Code: Enable Unsolicited Data Transfer, Sent From Master to Relay.....	I-2
02—Function Code: Disable Unsolicited Data Transfer, Sent From Master to Relay	I-3
18—Function: Unsolicited Fast SER Response, Sent From Relay to Master.....	I-3
Acknowledge Message Sent from Master to Relay, and from Relay to Master.....	I-5

TABLES

Table F.1: SELOGIC Control Equation Operators (Listed in Processing Order).....	F-3
Table G.1: Data Access Methods	G-3
Table G.2: SEL-311A DNP Object Table	G-6
Table G.3: SEL-311A-Wye DNP Data Map	G-9

FIGURES

Figure F.1: Result of Rising Edge Operators on Individual Elements in Setting ER	F-6
Figure F.2: Result of Falling Edge Operator on a Deasserting Overcurrent Element	F-7

APPENDIX A: FIRMWARE VERSIONS

This manual covers SEL-311A 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-311A-R103-V0-Z002002-D20011205	This firmware differs from the original as follows: <ul style="list-style-type: none"> – 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-311A-R102-V0-Z001001-D20010625	This firmware differs from the original as follows: <ul style="list-style-type: none"> – 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-311A-R101-V0-Z001001-D20010518	This firmware differs from the original as follows: <ul style="list-style-type: none"> – Improved overflow supervision for distance elements.
SEL-311A-R100-V0-Z001001-D20000911	Original Version <ul style="list-style-type: none"> – SEL-311A; 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-311A-R100-V0-Z001001-D20000911

APPENDIX B: FIRMWARE UPGRADE INSTRUCTIONS

FIRMWARE (FLASH) UPGRADE INSTRUCTIONS

SEL may occasionally offer firmware upgrades to improve the performance of your relay. The SEL-311A Relay stores firmware in Flash memory; therefore, changing physical components is not necessary. A firmware loader program called SELBOOT resides in the SEL-311A 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, or SmartCOM).
- Serial communications cable (SEL-234A or equivalent).
- Disk containing firmware upgrade file.

UPGRADE PROCEDURE

The instructions below assume you have a working knowledge of your personal computer terminal emulation software. In particular, you must be able to modify your serial communications parameters (baud rate, data bits, parity, etc.), disable any hardware or software flow control in your computer terminal emulation software, select transfer protocol (i.e., XMODEM/CRC), and transfer files (e.g., send and receive binary files).

1. If the relay is in service, disable its control functions.

Note: If the SEL-311A 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 nonalphanumeric 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., 311A_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 an 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-311A Relay.

MESSAGE LISTS

Binary Message List

<u>Request to Relay (hex)</u>	<u>Response From Relay</u>
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

<u>Request to Relay (ASCII)</u>	<u>Response From Relay</u>
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:

<u>Data</u>	<u>Description</u>
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:

<u>Data</u>	<u>Description</u>
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:

<u>Data</u>	<u>Description</u>
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:

<u>Data</u>	<u>Description</u>
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:

<u>Data</u>	<u>Description</u>
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-311A 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:

<u>Data</u>	<u>Description</u>
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:

<u>Data</u>	<u>Description</u>
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: $4 \cdot \text{Operate code} + 1$
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 = $4 \cdot \text{Operate code} + 1$.
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:

<u>Data</u>	<u>Description</u>
A5E3	Command
06	Length
1 byte	Operate code: 31–OPEN breaker 11–CLOSE breaker
1 byte checksum	Operate Validation: $4 \cdot \text{Operate code} + 1$ 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-311A 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:

<u>Data</u>	<u>Description</u>
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:

<u>Data</u>	<u>Description</u>
A5ED	Command
06	Message Length—always 6
00	Operate Code (e.g., “00” for target reset, “TAR R”)
01	Operate Validation - $(4 + \text{Operate Code}) + 1$
xx	Checksum

ID Message

In response to the ID command, the relay sends the following information described below.

```
<STX>"FID=SEL-311A-Rrrr-Vv-Zzzzzz-Dyyyymmdd","aaaa"<CR><LF>
"CID=cccc","aaaa"<CR><LF>
"DEVID=[TID SETTING]","aaaa"<CR><LF>
"DEVCODE=46","aaaa"<CR><LF>
"PARTNO=[PARTNO SETTING]","aaaa"<CR><LF>
"CONFIG=bbbbbb","aaaa"<CR><LF><ETX>
```

Where: rrr is the firmware revision.

zzzzz 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-311A.

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","TARLOP","TAR51P","TAR51G","0DF6"
"A","B","C","G","ZONE1","ZONE2","TAR67P","TAR67G","0AA7"
"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","*","50GF","*","0A6B"
"32QF","*","32GF","*","32VE","32QGE","32IE","32QE","09F2"
"F32I","*","F32Q","*","F32QG","*","F32V","*","085C"
"*","*","IN106","IN105","IN104","IN103","IN102","IN101","0AD9"
"ALARM","OUT107","OUT106","OUT105","OUT104","OUT103","OUT102","OUT101","0FC8"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"51P","51PT","51PR","*","*","*","*","*","071A"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"*","*","*","*","*","*","*","*","04D0"
"RMB8A","RMB7A","RMB6A","RMB5A","RMB4A","RMB3A","RMB2A","RMB1A","0E34"
"TM8A","TMB7A","TMB6A","TMB5A","TMB4A","TMB3A","TMB2A","TMB1A","0E44"
"RMB8B","RMB7B","RMB6B","RMB5B","RMB4B","RMB3B","RMB2B","RMB1B","0E3C"
"TM8B","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","*","*","*","*","yyyy"<ETX>
```

where: "yyyy" is the 4-byte ASCII representation of the checksum.
"*" indicates an unused bit location.

The BNA command is available from Access Level 1 and higher.

SNS Message

In response to the SNS command, the relay sends the name string of the SER (SER1 SER2 SER3) settings. SNS command is available at Access Level 1.

The relay responds to the SNS command with the name string in the SER settings. The name string starts with SER1, followed by SER2 and SER3.

For example: If SER1 = 50A1 OUT101; SER2 = 67P1T; SER3 = OUT102 52A; the name string will be "50A1","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 carriage return. The last row may have fewer than eight strings.

SNS message for the SEL-311A 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-311A 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-311A Relay provides the following compressed ASCII commands:

<u>Command</u>	<u>Description</u>
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-311A

Display the SEL-311A 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>
"22H","IA","IB","IC","IP","VA","VB","VC","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","2605"<CR>
"1D","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S",
"9S","9S","9S","9S","9S","9S","168D"<CR>
"CHI",1,"01A1"<CR>
"1H","FID","022C"<CR>
"1D","45S","0211"<CR>
```

```

"15H","REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT",
"LOCATION","CURR","FREQ","GROUP","TARGETS","EVE_ID","1D49"<CR>
"44D","I","I","I","I","I","I","I","I","6S","F","I","F","I","22S","I","0C9B"<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>
"13H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"TARGETS","IA","IB","IC","IP","IG","3I2","19AA"<CR>
"1D","F","I","I","I","6S","F","22S","I","I","I","I","I","I","0AF2"<CR>
"12H","IA","IB","IC","IP","IG","VA(kV)","VB(kV)","VC(kV)","V1MEM","VDC","TRIG",
"Names of elements in Relay Word separated by spaces","YYYY"<CR>
"60D","I","I","I","I","I","F","F","F","I","F","2S","104S","0A95"<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>
"13H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"TARGETS","IA","IB","IC","IP","IG","3I2","19AA"<CR>
"1D","F","I","I","I","6S","F","22S","I","I","I","I","I","I","0AF2"<CR>
"12H","IA","IB","IC","IP","IG","VA(kV)","VB(kV)","VC(kV)","V1MEM","VDC","TRIG",
"Names of elements in Relay Word separated by spaces","YYYY"<CR>
"240D","I","I","I","I","I","F","F","F","I","F","2S","104S","0AC5"<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>
"13H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","LOCATION",
"TARGETS","IA","IB","IC","IP","IG","3I2","19AA"<CR>
"1D","F","I","I","I","6S","F","22S","I","I","I","I","I","I","0AF2"<CR>
"12H","IA","IB","IC","IP","IG","VA(kV)","VB(kV)","VC(kV)","V1MEM","VDC","TRIG",
"Names of elements in Relay Word separated by spaces","YYYY"<CR>
"256D","I","I","I","I","I","F","F","F","I","F","2S","104S","0ACC"<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>
"15H","EVENT","LOCATION","HOUR_T","MIN_T","SEC_T","MSEC_T","EVENT_ID",
"FREQ","GROUP","HOUR_C","MIN_C","SEC_C","MSEC_C","TARGETS","BREAKER",
"2266"<CR>
"1D","6S","F","I","I","I","I","I","F","I","I","I","I","I","22S","6S","0CA4"<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","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","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>
<EXT>

```

"YYYY" is the 4-byte hex ASCII representation of the checksum. See *CEVENT Command* for definition of the “*Names of elements in Relay Word separated by spaces*” field.

CSTATUS COMMAND—SEL-311A

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,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","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-311A

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","TARGETS","EVE_ID","yyyy"<CR>
xxxx,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-311A

Display event report in compressed ASCII format by sending:

```
CEV [n Sx Ly 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.

Sx x samples per cycle (4 or 16); defaults to 4
If Sx parameter is present, it overrides the L parameter

Ly 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 Sx parameter, if present

R specifies raw (unfiltered) data; defaults to 16 samples per cycle unless
overridden by the Sx 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","HOURL","MIN","SEC","MSEC","yyyy"<CR>  
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>  
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT",  
"LOCATION","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","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-311A.

```
"EN TRP TIME TARDT SOTF TARLOP TAR51P TAR51G A B C G ZONE1 ZONE2 TAR67P
TAR67G 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 * 50GF * 32QF *
32GF * 32VE 32QGE 32IE 32QE F32I * F32Q * F32QG * F32V * * * IN106 IN105 IN104
IN103 IN102 IN101 ALARM OUT107 OUT106 OUT105 OUT104 OUT103 OUT102 OUT101
* * * * * 51P 51PT 51PR * * * * *
* * * * * MPP1
MABC1 MPP2 MABC2 * * * * *
* * * * * 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:

```
1000000492490000000000000000000000000000000000002000000000000000000000000240000800000
C000010000000000000000000000000000000000
```

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 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-311A

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-311A-R100-V0-Z001001-D20000911","08F7"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"<CR>
03,01,2000,10,39,4,614,"046F"<CR>
"EVENT","LOCATION","HOUR_T","MIN_T","SEC_T","MSEC_T","EVENT_ID","FREQ",
"GROUP","HOUR_C","MIN_C","SEC_C","MSEC_C","TARGETS","BREAKER",
"2148"<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 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 8 through 11 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-311A 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 Table 9.3 and Table 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 3.14 in *Section 3: Distance and Overcurrent Elements*. Read the text that accompanies Figure 3.14 (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:

$$51PT = 0 \quad (\text{logical } 0)$$

If phase time-overcurrent element 51PT is timed out on its curve, Relay Word bit 51PT is in the following state:

$$51PT = 1 \quad (\text{logical } 1)$$

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:

$$51PR = 0 \quad (\text{logical } 0)$$

If phase time-overcurrent element is fully reset, Relay Word bit 51PR is in the following state:

$$51PR = 1 \quad (\text{logical } 1)$$

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 F.1.

Table F.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 F.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-311A 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 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:

$$52A = !IN101 \quad [=NOT(IN101)]$$

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)]:

$$52A = !IN101 = \text{NOT}(IN101) = \text{NOT}(1) = 0$$

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:

$$ULTR = !(50L + 51G) = \text{NOT}(50L + 51G)$$

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:

$$ULTR = \text{NOT}(50L + 51G) = \text{NOT}(0 + 1) = \text{NOT}(1) = 0$$

If both 50L and 51G are deasserted [i.e., 50L = 0 and 51G = 0 (logical 0)], the unlatch condition is true:

$$ULTR = \text{NOT}(50L + 51G) = \text{NOT}(0 + 0) = \text{NOT}(0) = 1$$

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 3.14)
- 51G Maximum residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see Figure 3.15)
- 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 F.1 demonstrates the action of the rising edge operator / on the individual elements in setting ER.

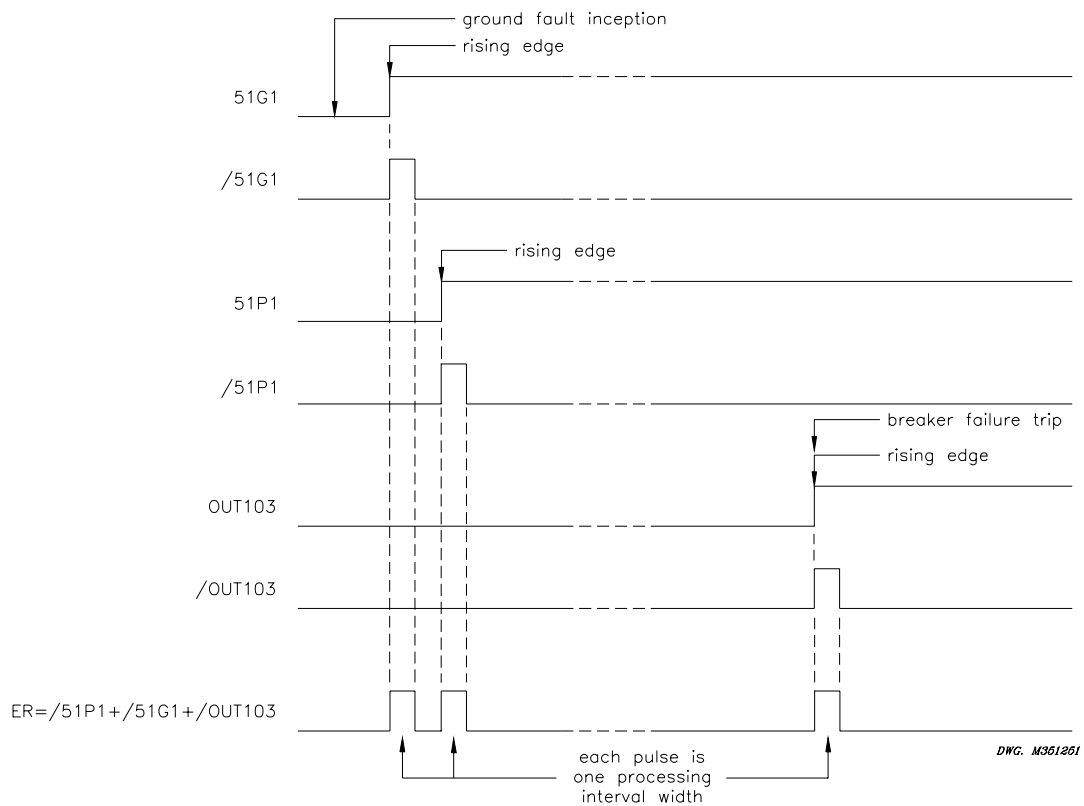


Figure F.1: Result of Rising Edge Operators on Individual Elements in Setting ER

Note in Figure F.1 that setting ER sees three separate rising edges, 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 Table F.1.

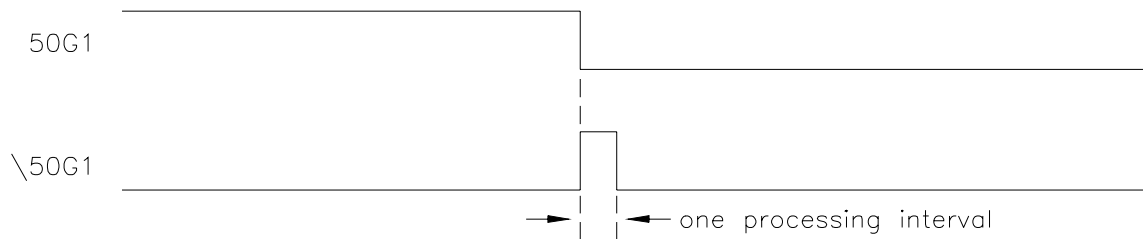
SELogic Control Equation Falling Edge Operator \

The falling edge operator \ is applied to individual Relay Word bits only—not to groups of elements within parentheses. The falling edge operator \ operates 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:

$$ER = \dots + \backslash 50G1$$

This allows recovery from an overcurrent condition to be observed. Figure F.2 demonstrates the action of the falling edge operator \ on the overcurrent element 50G1 in setting ER.



DWG: M311A046

Figure F.2: Result of Falling Edge Operator on a Deasserting Overcurrent Element

All SELogic Control Equations Must Be Set

All SELOGIC control equations must be set one of the following ways (they cannot be “blank”):

- single Relay Word bit (e.g., 52A = IN101)
- combination of Relay Word bits (e.g., TR = 51PT+51GT+50P1 * SH0)
- directly to logical 1 (e.g., 67P1TC = 1)
- directly to logical 0 (e.g., TRCOMM = 0)

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-311A 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 G: DISTRIBUTED NETWORK PROTOCOL (DNP) 3.00

OVERVIEW

The SEL-311A 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-311A 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-311A 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-311A 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-311A 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-311A 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-311A decides to transmit on the DNP link, it has to wait if the physical connection is in use. The SEL-311A 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-311A 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 G.1: Data Access Methods

Data Retrieval Method	Description	Relevant SEL-311A 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:

<p>DNP 3.00 DEVICE PROFILE DOCUMENT</p> <p>This document must be accompanied by a table having the following headings:</p> <table> <tr> <td>Object Group</td> <td>Request Function Codes</td> <td>Response Function Codes</td> </tr> <tr> <td>Object Variation</td> <td>Request Qualifiers</td> <td>Response Qualifiers</td> </tr> <tr> <td>Object Name (optional)</td> <td></td> <td></td> </tr> </table>		Object Group	Request Function Codes	Response Function Codes	Object Variation	Request Qualifiers	Response Qualifiers	Object Name (optional)		
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-311A										
<p>Highest DNP Level Supported:</p> <table> <tr> <td>For Requests</td> <td>Level 2</td> </tr> <tr> <td>For Responses</td> <td>Level 2</td> </tr> </table>	For Requests	Level 2	For Responses	Level 2	<p>Device Function:</p> <p><input type="checkbox"/> Master <input checked="" type="checkbox"/> Slave</p>					
For Requests	Level 2									
For Responses	Level 2									
<p>Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):</p> <p><u>Supports enabling and disabling of unsolicited reports on a class basis.</u></p>										

Maximum Data Link Frame Size (octets): Transmitted <u> 292 </u> Received (must be 292)	Maximum Application Fragment Size (octets): Transmitted <u> 2048 </u> (if >2048, must be configurable) Received <u> 2048 </u> (must be >249)
Maximum Data Link Re-tries: <input type="checkbox"/> None <input type="checkbox"/> Fixed at _____ <input checked="" type="checkbox"/> Configurable, range <u> 0 </u> to <u> 15 </u>	Maximum Application Layer Re-tries: <input checked="" type="checkbox"/> None <input type="checkbox"/> Configurable, range _____ to _____ (Fixed is not permitted)
Requires Data Link Layer Confirmation: <input type="checkbox"/> Never <input type="checkbox"/> Always <input type="checkbox"/> Sometimes If 'Sometimes', when? _____ <input checked="" type="checkbox"/> Configurable If 'Configurable', how? <u> by settings. </u>	
Requires Application Layer Confirmation: <input type="checkbox"/> Never <input type="checkbox"/> Always (not recommended) <input checked="" type="checkbox"/> When reporting Event Data (Slave devices only) <input type="checkbox"/> When sending multi-fragment responses (Slave devices only) <input type="checkbox"/> Sometimes If 'Sometimes', when? _____ <input type="checkbox"/> Configurable If 'Configurable', how? _____	
Timeouts while waiting for: Data Link Confirm <input type="checkbox"/> None <input type="checkbox"/> Fixed at _____ <input type="checkbox"/> Variable <input checked="" type="checkbox"/> Configurable Complete Appl. Fragment <input checked="" type="checkbox"/> None <input type="checkbox"/> Fixed at _____ <input type="checkbox"/> Variable <input type="checkbox"/> Configurable Application Confirm <input type="checkbox"/> None <input type="checkbox"/> Fixed at _____ <input type="checkbox"/> Variable <input checked="" type="checkbox"/> Configurable Complete Appl. Response <input checked="" type="checkbox"/> None <input type="checkbox"/> Fixed at _____ <input type="checkbox"/> Variable <input type="checkbox"/> Configurable Others _____	
Attach explanation if 'Variable' or 'Configurable' was checked for any timeout.	
Sends/Executes Control Operations: WRITE Binary Outputs <input type="checkbox"/> Never <input checked="" type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable SELECT/OPERATE <input type="checkbox"/> Never <input checked="" type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable DIRECT OPERATE <input type="checkbox"/> Never <input checked="" type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable DIRECT OPERATE—NO ACK <input type="checkbox"/> Never <input checked="" type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable Count > 1 <input checked="" type="checkbox"/> Never <input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable Pulse On <input type="checkbox"/> Never <input checked="" type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable Pulse Off <input type="checkbox"/> Never <input checked="" type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable Latch On <input type="checkbox"/> Never <input checked="" type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable Latch Off <input type="checkbox"/> Never <input checked="" type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable Queue <input checked="" type="checkbox"/> Never <input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable Clear Queue <input checked="" type="checkbox"/> Never <input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable	
Attach explanation if 'Sometimes' or 'Configurable' was checked for any operation.	

FILL OUT THE FOLLOWING ITEM FOR MASTER DEVICES ONLY:	
Expects Binary Input Change Events: <ul style="list-style-type: none"> <input type="checkbox"/> Either time-tagged or non-time-tagged for a single event <input type="checkbox"/> Both time-tagged and non-time-tagged for a single event <input type="checkbox"/> Configurable (attach explanation) 	
FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY	
Reports Binary Input Change Events when no specific variation requested: <ul style="list-style-type: none"> <input type="checkbox"/> Never <input checked="" type="checkbox"/> Only time-tagged <input type="checkbox"/> Only non-time-tagged <input type="checkbox"/> Configurable to send both, one or the other (attach explanation) 	Reports time-tagged Binary Input Change Events when no specific variation requested: <ul style="list-style-type: none"> <input type="checkbox"/> Never <input checked="" type="checkbox"/> Binary Input Change With Time <input type="checkbox"/> Binary Input Change With Relative Time <input type="checkbox"/> Configurable (attach explanation)
Sends Unsolicited Responses: <ul style="list-style-type: none"> <input type="checkbox"/> Never <input checked="" type="checkbox"/> Configurable (attach explanation) <input type="checkbox"/> Only certain objects <input type="checkbox"/> Sometimes (attach explanation) <input checked="" type="checkbox"/> ENABLE/DISABLE UNSOLICITED Function codes supported	Sends Static Data in Unsolicited Responses: <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Never <input type="checkbox"/> When Device Restarts <input type="checkbox"/> When Status Flags Change No other options are permitted.
Default Counter Object/Variation: <ul style="list-style-type: none"> <input type="checkbox"/> No Counters Reported <input type="checkbox"/> Configurable (attach explanation) <input checked="" type="checkbox"/> Default object <u>20</u> <input type="checkbox"/> Default variation <u>6</u> <input type="checkbox"/> Point-by-point list attached 	Counters Roll Over at: <ul style="list-style-type: none"> <input type="checkbox"/> No Counters Reported <input type="checkbox"/> Configurable (attach explanation) <input checked="" type="checkbox"/> 16 Bits <input type="checkbox"/> 32 Bits <input type="checkbox"/> Other Value _____ <input type="checkbox"/> Point-by-point list attached
Sends Multi-Fragment Responses: <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	

In all cases within the device profile that an item is configurable, it is controlled by SEL-311A settings.

OBJECT TABLE

The supported object, function, and qualifier code combinations are given by the following object table.

Table G.2: SEL-311A 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-311A has a slightly different data map. The following is the default object map supported by the SEL-311A wye-connected PTs (FID = SEL-311A-Rxxx-VM-Dxxxxxxxx).

Table G.3: SEL-311A-Wye DNP Data Map

DNP Object Type	Index	Description
01,02	000–499	Relay Word, where TAR51G 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 TAR67G, 1007 is EN and 1000 is TAR51G.
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	N/A.
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. Analog 103–111 are derived from the history queue data for the most recently read fault and do not generate event messages. Analog 103 is a 16-bit composite value, where the upper byte is defined as follows:

Value	Event Cause
1	Trigger command
2	Pulse command
4	Trip element
8	ER element

And the lower byte is defined as follows:

Value	Fault Type
0	Indeterminate
1	A-Phase
2	B-Phase
4	C-Phase
8	Ground

The lower byte may contain any combination of the above bits (e.g., a 6 is a B to C fault and a 9 is an A to Ground fault). If Analog 103 is 0, fault information has not been read and the related analogs (104–111) do not contain valid data.

Control Relay Output Blocks (object 12, variation 1) are supported. The control relays correspond to the remote bits and other functions, as shown above. The Trip/Close bits take precedence over the control field. The control field is interpreted as follows:

Index	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
0-15	Set	Clear	Set	Clear	Pulse	Clear
16-23	Pulse	Do nothing	Pulse	Do nothing	Pulse	Do nothing
24	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1
25	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3
26	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5
27	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7
28	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9
29	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11
30	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13
31	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15
32	Pulse CC	Pulse OC	Pulse CC	Pulse OC	Pulse CC	Pulse OC

The Status field is used exactly as defined. All other fields are ignored. A pulse operation asserts a point for a single processing interval. Caution should be exercised with multiple remote bit pulses in a single message (i.e., point count > 1), as this may result in some of the pulse commands being ignored and returning an already active status.

Analog Outputs (objects 40 and 41) are supported as defined by the preceding table. Flags returned with object 40 responses are always set to 0. The Control Status field of object 41 requests is ignored. If the value written to index 0 is outside of the range 1 through 6, the relay will not accept the value and will return a hardware error status.

Relay Summary Event Data

Whenever there is unread relay event summary data (fault data), binary input point 1023 will be set. In order to load the next available relay event summary, the master should pulse binary output point 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>
Analog = 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 re-mapped, 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	=	<u> DNP </u>
Baud rate (300,600,1200,2400,4800,9600,19200,38400)	SPEED	=	<u> </u>
DNP Address (0–65534)	DNPADR	=	<u> </u>
Class for event data (0 for no event, 1–3)	ECLASS	=	<u> </u>
Time-set request interval, minutes (0 for never, 1–32767)	TIMERQ	=	<u> </u>
Currents scaling (0–3 decimal places)	DECPLA	=	<u> </u>
Voltages scaling (0–3 decimal places)	DECPLV	=	<u> </u>
Miscellaneous data scaling (0–3 decimal places)	DECPLM	=	<u> </u>
Select/Operate time-out interval, seconds (0.0–30.0)	STIMEO	=	<u> </u>
Number of data-link retries (0 for no confirm, 1–15)	DRETRY	=	<u> </u>
Data Link Time-out interval, seconds (0–5)	DTIMEO	=	<u> </u>
Minimum Delay from DCD to transmission, seconds (0.00–1.00)	MINDLY	=	<u> </u>
Maximum Delay from DCD to transmission, seconds (0.00–1.00)	MAXDLY	=	<u> </u>
Transmission delay from RTS assertion, seconds (OFF, 0.00–30.00)	PREDLY	=	<u> </u>
Post-transmit RTS deassertion delay, seconds (0.00–30.00)	PSTDLY	=	<u> </u>
Analog reporting dead band, counts (0–32767)	ANADB	=	<u> </u>
Allow Unsolicited Reporting (Y/N)	UNSOL	=	<u> </u>
Enable unsolicited messages on power-up (Y/N)	PUNSOL	=	<u> </u>
Address of master to Report to (0–65534)	REPADR	=	<u> </u>
Number of events to transmit on (1–200)	NUMEVE	=	<u> </u>
Age of oldest event to force transmit on, seconds (0.0–60.0)	AGEEVE	=	<u> </u>
Time-out for confirmation of unsolicited message, seconds (0–50)	UTIMEO	=	<u> </u>

APPENDIX H: MİRRORED BITS™ COMMUNICATIONS

OVERVIEW

MİRRORED BITS is a direct relay-to-relay communications protocol that allows protective relays to exchange information quickly and securely, and with minimal expense. The information exchanged can facilitate remote control, remote sensing, or communications-assisted protection schemes such as POTT, DCB, etc. The SEL-311A supports two MİRRORED 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 MİRRORED 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-311A.

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-311A talking to another SEL-311A sends and receives MIRRORRED 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 MIRRORRED BITS, such as a SEL-321 talking to a SEL-311A. 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-311A, 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-311A will delay a bit by 1/4 cycle, because the SEL-311A is receiving new MIRRORRED 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, ROKx is deasserted, and another user-accessible flag, LBOKx 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 **RBADx**. Note: The user will typically combine **RBADx** 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 **CBADx**. Note: The user will typically combine **CBADx** 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-311A
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 MIRRORRED 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 311A 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 MIRRORRED 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 I: 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-311A 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. An average of four state changes per minute can be made for a 25-year relay service life.

RECOMMENDED MESSAGE USAGE

Use the following sequence of commands to enable unsolicited Fast SER messaging in the SEL-311A 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-311A Relay to transmit unsolicited Fast SER messages.
2. When SER records are triggered in the SEL-311A, 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-311A Relay disables its own unsolicited transmissions. This function enables the SEL-311A Relay to begin sending unsolicited data to the device which sent the enable message, if the SEL-311A has such data to transfer. The message format for function code 01 is shown below.

<u>Data</u>	<u>Description</u>
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-311A 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-311A Relay from transferring Fast SER data. The message format for function code 02 is shown below.

<u>Data</u>	<u>Description</u>
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-311A 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-311A 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.

<u>Data</u>	<u>Description</u>
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
sssssss	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:

<u>Data</u>	<u>Description</u>
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.

<u>Data</u>	<u>Description</u>
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-311A 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 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 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 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 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-311A Relay Command Summary

Access

Level 0

Command

ACC

The only thing that can be done at Access level 0 is to go to Access Level 1. The screen prompt is: =

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

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.

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 <i>n k</i>	Display Relay Word row. If <i>n</i> = 0 through 45, display row <i>n</i> . If <i>n</i> is an element name (e.g., 50G1) display the row containing element <i>n</i> . Enter <i>k</i> 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 <i>n</i>	Enter BRE W to preload breaker wear. Enter BRE R to reset breaker monitor data.
CLO	Close the circuit breaker.
GRO <i>n</i>	Change active group to Group <i>n</i> .
OPE	Open the circuit breaker.
PUL <i>n k</i>	Pulse output contact <i>n</i> (OUT101–OUT107, ALARM) for <i>k</i> (1–30) seconds. Parameter <i>n</i> must be specified; <i>k</i> 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 <i>n</i>	Control Remote Bit RB <i>n</i> (Remote Bit <i>n</i> ; <i>n</i> = 1–8). Execute CON <i>n</i> and the relay responds: CONTROL RB <i>n</i> . Then reply with one of the following: SRB <i>n</i> set Remote Bit <i>n</i> (assert RB <i>n</i>). CRB <i>n</i> clear Remote Bit <i>n</i> (deassert RB <i>n</i>). PRB <i>n</i> pulse Remote Bit <i>n</i> (assert RB <i>n</i> for 1/4 cycle).
COP <i>m n</i>	Copy relay and logic settings from Group <i>m</i> to Group <i>n</i> .
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 <i>n</i>	Change relay settings (overcurrent, reclosing, timers, etc.) for Group <i>n</i> .
SET L <i>n</i>	Change SELOGIC control equation settings for Group <i>n</i> .
SET G	Change global settings.
SET P <i>n</i>	Change Port <i>n</i> 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.