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

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

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

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

WARNING: This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

AVERTISSEMENT: Cet équipement est expédié avec des mots de passe par défaut. À l'installation, les mots de passe par défaut devront être changés pour des mots de passe confidentiels. Dans le cas contraire, un accès non-autorisé à l'équipement pourrait être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accès non-autorisé.

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

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

<table>
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<tr>
<td>20011205</td>
<td>Reissued entire manual to reflect the following changes:</td>
</tr>
<tr>
<td></td>
<td>Updated Section 2 and Section 3 figure references throughout the manual.</td>
</tr>
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<td><strong>Section 1:</strong></td>
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<tr>
<td></td>
<td>– Updated Terminal Connections information in <em>General Specifications</em>.</td>
</tr>
<tr>
<td></td>
<td>– Added Fast Hybrid High-Current Interrupting option information to <em>General Specifications</em>.</td>
</tr>
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<td><strong>Section 2:</strong></td>
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<td></td>
<td>– Added <em>Fast Hybrid High-Current Interrupting Output Contacts</em> rear-panel drawings.</td>
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<td>– Added Connectorized® rear-panel drawings.</td>
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<td></td>
<td>– Added <em>Fast Hybrid High-Current Interrupting Output Contacts</em> section.</td>
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<tr>
<td></td>
<td>– Added new figure: <em>Possible Connections for Fast High-Current Interrupting Output Contacts</em> (Circuit Load not Shown, Third Terminal Connection Is Optional).</td>
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<tr>
<td></td>
<td>– Added <em>Interface Board 5 Component Layout</em> drawing.</td>
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<td><strong>Section 3:</strong></td>
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<td></td>
<td>– Added two drawings: <em>Ground and Phase Distance Speed Curves</em>—<em>Standard Output</em> and <em>Ground and Phase Distance Speed Curves</em>—<em>Fast Hybrid Output</em>.</td>
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<tr>
<td></td>
<td>– Added <em>Distance Element Operating Time Curves at Nominal Frequency</em> section.</td>
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<td></td>
<td>– Updated <em>Frequency Elements</em> section and the <em>Undervoltage Block for Frequency Elements</em> drawing.</td>
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<td>Summary of Revisions</td>
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<td><strong>Section 5:</strong></td>
<td>Updated <em>Three-Pole Open Logic (Top) and Switch-Ongo-Fault Logic (Bottom)</em> drawing.</td>
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<td></td>
<td>Updated <em>POTT Logic</em> drawing.</td>
</tr>
<tr>
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<td>Updated <em>SEL-311C Relay Connections to Communications Equipment for a Three-Terminal Line DCB Scheme</em> drawing.</td>
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| **Section 7:** | Updated *Input Debounce Timers* section. |
|               | Added *Displaying Time-Overcurrent Elements on the Rotating Default Display* and following sections. |
|               | Added descriptions of the ELAT, ESV, and EDP settings. |

| **Section 8:** | Modified breaker reset options to include the internal and external trips and currents in the *Via Serial Port* subsection in the *View or Reset Breaker Monitor Information* section. |
| **Section 9:** | Updated *Event Report Parameters* section in the Settings Sheets. |
|               | Updated *Optoisolated Input Timers* section in the Settings Sheets. |
|               | Added ELAT and EDP settings in the *Other Enable Settings* section in the Settings Sheets. |

| **Section 10:** | Added *STA C* command information to *Access Level 2 Commands* in the Command Summary. |

| **Section 12:** | Added 180-cycle event report information. Also updated the number of event reports that are maintained. |

| **Section 13:** | Added *Ground Quadrilateral Distance Element Reactive Reach Test Using Three Voltage Sources and One Current Source* section. |
|               | Added *Ground Quadrilateral Distance Element Resistive Reach Test Using Three Voltage Sources and One Current Source* section. |

<p>| <strong>Section 14:</strong> | Updated <em>SELOGIC Equivalent to SEL-221F Relay Word Bits</em> table. |
|               | Updated <em>SELOGIC Equivalent to SEL-221F-3 Relay Word Bits</em> table. |</p>
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<tr>
<td><strong>Appendix A:</strong></td>
<td>Updated firmware.</td>
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<td><strong>Appendix D:</strong></td>
<td>Updated <em>A5C0 Relay Definition Block</em> section.</td>
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<td>Updated information in <em>ID Message</em> and <em>DNA Message</em> sections.</td>
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<td><strong>Appendix H:</strong></td>
<td>Updated <em>SEL-311C-Wye DNP Data Map</em> table.</td>
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<td><strong>Appendix J:</strong></td>
<td>Added <em>Appendix J: Unsolicited Fast SER Protocol</em>.</td>
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<td>20010820</td>
<td><strong>Section 1:</strong></td>
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<td>Added 220 V control input voltage specification to <em>General Specifications</em>.</td>
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<td>Added Terminal Connections information to <em>General Specifications</em>.</td>
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<tr>
<td><strong>Section 2:</strong></td>
<td>Updated Figure 2.3, Figure 2.8, Figure 2.9, and Figure 2.10.</td>
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<td><strong>Section 3:</strong></td>
<td>Updated Figure 3.4, Figure 3.5, and Figure 3.6.</td>
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<td><strong>Section 12:</strong></td>
<td>Updated Table 12.3.</td>
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<td><strong>Section 14:</strong></td>
<td>Corrected figure reference error in Application Setting 221C, sheet 2.</td>
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<td></td>
<td>Modified SEL-311 Relays to record consecutive event reports.</td>
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<td>Modified the <strong>SUM</strong> command so that the Breaker Status reports the status from the last row of the event report.</td>
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<td>Changed the E21P default setting to 3C in application settings 221G, 221G5, and 221H.</td>
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<td>20010516</td>
<td><strong>Appendix A:</strong></td>
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<td>Improved overflow supervision for distance elements.</td>
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| 20010124      | Reissued entire manual to reflect the following changes:  
|               | – Added cautions, warnings, and dangers in English and French to the reverse of the title page.  
|               | **Section 1:**  
|               | – Updated Relay Specifications format.  
|               | – Added information on Tightening Torque in *General Specifications*.  
|               | – Updated Power Supply information to include medium range Power Supply Specification.  
|               | – Updated Output Contacts information.  
|               | **Section 2:**  
|               | – Updated Relay Dimensions drawing.  
|               | – Added Product Safety Compliance paragraph.  
|               | – Corrected Figure Reference in Table 2.5.  
|               | – Added Danger statement to *Accessing the Relay Circuit Boards* subsection.  
|               | – Added Caution statement to the *Clock Battery* subsection.  
|               | **Section 3:**  
|               | – Updated Table 3.11.  
|               | **Section 4:**  
|               | – Updated figure cross-references in Figure 4.2.  
|               | **Section 5:**  
|               | – Corrected *Zone LED* subsection.  
|               | **Section 8:**  
|               | – Removed reference to NDEMP in the *Demand Meter Settings* subsection.  
|               | **Section 9 (Settings Sheets):**  
|               | – Added E81 enable setting in Setting Sheet 2.  
|               | – Corrected Frequency Element Time Delays to read 2.00 - 16000.00 cycles (Setting Sheet 10)  
|               | **Section 10:**  
|               | – Added Warning statement to change default passwords to private passwords at relay installation.  
|               | **Appendix H:**  
|               | – Updated first row of Table H.3.  
<p>|               | – Correctly identify binary output point 23 in the <em>Relay Summary Event Data</em> subsection.  |</p>
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| 20000922      | Reissued entire manual to reflect updated format and added the following changes:  
|               | – Added frequency elements.  
|               | – Added compensator distance elements.  
|               | – Added Application Settings Sheets for the SEL-221C, SEL-221-16, and SEL-2PG10 Relays. |
| 20000619      | **Appendix A**  
<p>|               | – Internal changes to support Flash memory revision and battery-backed clock hardware change. |
| 20000421      | Switched JMP23 drawings in Table 2.3 in <strong>Section 2: Installation</strong>. |
| 991201        | New Manual Release. |</p>
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<td>INSTALLATION</td>
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<td>DISTANCE, OUT-OF-STEP, OVERCURRENT, VOLTAGE, SYNCHRONISM CHECK, AND FREQUENCY ELEMENTS</td>
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<td>Appendix J: Unsolicited Fast SER Protocol</td>
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SECTION 1: INTRODUCTION AND SPECIFICATIONS

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

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

SEL-311C RELAY MODELS

This instruction manual covers the following SEL-311C Relay models:

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Rack Unit Height</th>
<th>Number of Isolated I/O Contacts</th>
<th>Rear-Panel Connection Type</th>
<th>Output Contact Type</th>
<th>Reference Figures</th>
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<tr>
<td>0311C00x</td>
<td>2U</td>
<td>6/8</td>
<td>screw-terminal block</td>
<td>standard</td>
<td>1.2, 2.2-2.10, 7.1, 7.27</td>
</tr>
<tr>
<td>0311C0Wx</td>
<td>2U</td>
<td>6/8</td>
<td>connectorized</td>
<td>standard</td>
<td>2.2-2.10</td>
</tr>
<tr>
<td>0311C01x</td>
<td>3U</td>
<td>6/8 (main board)</td>
<td>screw-terminal block</td>
<td>standard</td>
<td>1.2, 2.2–2.10, 7.1, 7.27</td>
</tr>
<tr>
<td>0311C01x</td>
<td>3U</td>
<td>8/12 (extra I/O board)</td>
<td>screw-terminal block</td>
<td>standard or high-current interrupting</td>
<td>1.3, 2.2–2.10, 7.2, 7.28</td>
</tr>
<tr>
<td>0311C0Yx</td>
<td>3U</td>
<td>8/8 (extra I/O board)</td>
<td>connectorized</td>
<td>standard or high-current interrupting</td>
<td>2.2–2.10</td>
</tr>
</tbody>
</table>

The model numbers are derived from the SEL-311C Relay ordering information sheet. The model numbers in Table 1.1 are only the first part of an actual ordering number—enough to distinguish one model type from another. The “x” field indicates horizontal, vertical, rack, or panel mounting. These numbers should not be used to order an SEL-311C Relay. To order an SEL-311C Relay, refer to the actual ordering information sheets.
Model 0311C00x and 0311C01x differ only in that model 0311C01x is available with an extra I/O board (and thus increased rack unit height—see Figure 2.1).

A vertical SEL-311C Relay is available in both 0311C00x and 0311C01x models. The vertical relays use the same rear panels as the horizontal models in Figure 2.2, Figure 2.3, and Figure 2.7 through Figure 2.10.

Throughout this instruction manual, when differences among the SEL-311C Relay models in Table 1.1 are explained, model numbers are referenced for clarity.

Differences between models 0311C00x and 0311C01x appear in references to optoisolated inputs, output contacts, and board jumpers. Figure 2.15 and Figure 2.16 and Table 2.2 through Table 2.4 show the labeling differences between the board jumpers.

**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-311C Relay, application connections, and the operation of circuit board jumpers. Figure 2.2 through Figure 2.10 show the SEL-311C Relay front and rear panels.

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

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

**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
- Communications-assisted trip logic
- Front-panel target LEDs

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

Section 6: Close and Reclose Logic describes the close logic operation for:

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

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

- Optoisolated inputs IN101 through IN106 (models 0311C00x and 0311C01x) and IN201 through IN208 (model 0311C01x)
- 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 (models 0311C00x and 0311C01x) and OUT201 through OUT212 (model 0311C01x)
- 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-311C 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 = 221G, 221G5, 221H, 221F, 221F3, 221C, 221-16, 2PG10)

**Section 10: Serial Port Communications and Commands** describes:

- Serial port connector pinout/terminal functions
- Communications cables
- Communications protocol
- Serial port commands
  See SHO Command (Show/View Settings) in Section 10 for a list of the SEL-311C factory default relay settings.

**Section 11: Front-Panel Interface** describes the front-panel operation of:

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

**Section 12: Standard Event Reports and SER** describes:

- Standard 15-, 30-, 60-, and 180-cycle event reports
- Event summaries
- Sequential events recorder (SER) report

**Section 13: Testing and Troubleshooting** describes:

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

**Section 14: Application Settings for SEL-221 Series Relays**

- Conversion guides for the SEL-221G, SEL-221G-5, SEL-221H, SEL-221F, SEL-221F-3, SEL-221C, SEL-221-16, and SEL-2PG10 relays
- Settings Sheets for the SEL-221G, SEL-221G-5, SEL-221H, SEL-221F, SEL-221F-3, SEL-221C, SEL-221-16, and SEL-2PG10 relays

**Section 15: Appendices** contains the following appendices:

- Appendix A: Firmware Versions
- Appendix B: Firmware Upgrade Instructions
- Appendix C: SEL Distributed Port Switch Protocol
- Appendix D: Configuration, Fast Meter, and Fast Operate Commands
- Appendix E: Compressed ASCII Commands
- Appendix F: Setting Negative-Sequence Overcurrent Elements
- **Appendix G:** Setting SELOGIC® Control Equations
- **Appendix H:** Distributed Network Protocol (DNP) 3.00
- **Appendix I:** MIRRORED BITSTM Communications
- **Appendix J:** SEL-311C Unsolicited SER Protocol

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

**APPLICATIONS**

![Diagram](image)

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

**AC/DC CONNECTIONS**

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

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

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

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

See Figure 2.2 and Figure 2.7 through Figure 2.10 for rear-panel drawings.

---

**Figure 1.2:** SEL-311C Relay Inputs, Outputs, and Communications Ports (Models 0311C00x and 0311C01x)
Output Contacts:

If the output contacts are high-current interrupting output contacts, they are polarity dependent. See Table 1.1 for information on SEL-311C Relay models with the high-current interrupting output contact option. See Output Contacts in Section 2: Installation for more information on the polarity dependence of high-current interrupting output contacts.

---

Figure 1.3: SEL-311C Relay Extra I/O Board (Model 0311C01x)
COMMUNICATIONS CONNECTIONS

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

![Diagram of SEL-311C Relay Communications Connections Examples](image.png)

Figure 1.4: SEL-311C Relay Communications Connections Examples
Figure 1.5: SEL-311C Relay Communications Connections Examples (Continued)
**RELAY SPECIFICATIONS**

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

**General Specifications**

**Terminal Connections:**

Rear Screw-Terminal Tightening Torque

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

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

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

**AC Current Inputs:**

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

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

**AC Voltage Inputs:**

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

**Power Supply:**

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

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

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

**Standard**

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

**Breaking Capacity (10,000 operations):**

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

**Cyclic Capacity (2.5 cycles/second):**

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

**High-current interrupting option (DC only)**

- 30 A make
- 6 A continuous carry at 70°C; 4 A continuous carry at 85°C
- 50 A for one second
- MOV protected: 330 Vdc, 40 J; Pickup time: < 5 ms;
  - Dropout time: < 8 ms, typical

**Breaking Capacity (10,000 operations):**

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

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

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

**Note:** Do not use high-current interrupting output contacts to switch ac control signals. These outputs are polarity dependent.

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

**Fast hybrid high-current interrupting option**

- 30 A make
- 6 A continuous carry at 70°C; 4 A continuous carry at 85°C
- 50 A for one second
- MOV protected: 330 Vdc, 40 J; Pickup time: < 200 μs;
  - Dropout time: < 8 ms, typical

**Breaking Capacity (10,000 operations):**

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

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

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

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

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

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

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

Routine Dielectric Test:

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

The following IEC 60255-5 Dielectric Tests–1977 are performed on all units with the CE mark:

- 2500 Vac for 10 seconds on analog inputs
- 3100 Vdc for 10 seconds on power supply, optoisolated inputs, and output contacts

Frequency and Rotation:

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

**Note:** V_A required for frequency tracking.

Communications Ports:

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

Time-Code Input:

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

Operating Temperature Range:

- -40° to +85°C (-40° to +185°F)

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

Relay Weight:

- 2U Rack unit: 13 lbs. (5.92 kg)
- 3U Rack unit: 16 lbs (7.24 kg)
Type Tests:

**Electromagnetic Compatibility Immunity**

- **Electrostatic Discharge:** IEC 60255-22-2–1996, Severity Level 4 
  (8000 V contact, 15,000 V air)
- **Fast Transient Disturbance:** IEC 60255-22-4–1992; 
  IEC 61000-4-4–1995, 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°C
- **Dry Heat:** IEC 60068-2-2–1974, Test Bd; 16 hr. 
  @ +85°C
- **Damp Heat, Cyclic:** IEC 60068-2-30–1980, Test Db; 55°C, 
  6 cycles, 95% humidity
- **Object Penetration:** IEC 60529–1989, IP30, IP54
- **Vibration:** IEC 60255-21-1–1988, Class 1 
  IEC 60255-21-2–1988, Class 1 
  IEC 60255-21-3–1993, Class 2

**Safety**

- **Impulse:** IEC 60255-5–1977, 0.5 J, 5000 V

**Certifications:**

- **ISO:** Relay is designed and manufactured using 
  ISO 9001 certified quality program.
- **UL Listed, CSA Certified, CE Mark.**

**Processing Specifications**

- **AC Voltage and Current Inputs:** 16 samples per power system cycle, 3 dB low-pass filter cut-off frequency of 560 Hz.
- **Digital Filtering:** One cycle cosine after low-pass analog filtering.
  Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
- **Protection and Control Processing:** 4 times per power system cycle.
Relay Element Settings Ranges and Accuracies

Metering Accuracy

- Voltages: \( V_a, V_b, V_c, V_{sk} \) ±0.67 V secondary
- Currents: \( I_a, I_b, I_c, I_{sk} \)
  - ±0.05 A secondary (5 A nominal)
  - ±0.01 A secondary (1 A nominal)

Substation Battery Voltage Monitor Specifications

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

Timer Specifications

- Reclosing Relay Pickup: 0.00–999,999.00 cycles, 0.25-cycle steps
- Other Timers: 0.00–16,000.00 cycles, 0.25-cycle steps
- Pickup/dropout accuracy for all timers: ±0.25 cycle and ±0.1% of setting

Mho Phase Distance Elements

Zones 1–4 Impedance Reach

- Setting Range:
  - OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal)
  - OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal)
- Minimum sensitivity is controlled by the pickup of the supervising phase-to-phase overcurrent elements for each zone.
- Accuracy:
  - ±5% of setting at line angle for \( 30 \leq \text{SIR} \leq 60 \)
  - ±3% of setting at line angle for SIR < 30
- Transient Overreach: < 5% of setting plus steady state accuracy
**Zones 1–4 Phase-to-Phase Current Fault Detectors (FD)**

**Setting Range:**
- 0.5–170.00 $\text{A}_{\text{p-p}}$ secondary, 0.01 A steps (5 A nominal)
- 0.1–34.00 $\text{A}_{\text{p-p}}$-secondary, 0.01 A steps (1 A nominal)

**Accuracy:**
- $\pm 0.05$ A and $\pm 3\%$ of setting (5 A nominal)
- $\pm 0.01$ 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 3.18 and Figure 3.19

**Mho and Quadrilateral Ground Distance Element**

**Zones 1–4 Impedance Reach**

**Mho Element Reach:**
- OFF, 0.05 to 64 $\Omega$ sec, 0.01 $\Omega$ steps (5 A nominal)
- OFF, 0.25 to 320 $\Omega$ sec, 0.01 $\Omega$ steps (1 A nominal)

**Quadrilateral Reactance Reach:**
- OFF, 0.05 to 64 $\Omega$ sec, 0.01 $\Omega$ steps (5 A nominal)
- OFF, 0.25 to 320 $\Omega$ sec, 0.01 $\Omega$ steps (1 A nominal)

**Quadrilateral Resistance Reach:**
- OFF, 0.05 to 50 $\Omega$ sec, 0.01 $\Omega$ steps (5 A nominal)
- OFF, 0.25 to 250 $\Omega$ sec, 0.01 $\Omega$ steps (1 A nominal)

Minimum sensitivity is controlled by the pickup of the supervising phase and residual 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 1–4 Phase and Residual Current Fault Detectors (FD)**

**Setting Range:**
- 0.5–100.00 A secondary, 0.01 A steps (5 A nominal)
- 0.1–20.00 A secondary, 0.01 A steps (1 A nominal)

**Accuracy:**
- $\pm 0.05$ A and $\pm 3\%$ of setting (5 A nominal)
- $\pm 0.01$ 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 3.18 and Figure 3.19

**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:**
- $\pm 0.05$ A and $\pm 3\%$ of setting (5 A nominal)
- $\pm 0.01$ 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:**
- $\pm 0.25$ cycle and $\pm 0.1\%$ of setting

**Max. Operating Time:**
- See pickup and reset time curves in Figure 3.18 and Figure 3.19
**Time-Overcurrent Elements**

- **Pickup Range:**
  - OFF, 0.50–16.00 A, 0.01 A steps (5 A nominal)
  - OFF, 0.10–3.20 A, 0.01 A steps (1 A nominal)

- **Steady-State Pickup Accuracy:**
  - ±0.05 A and ±3% of setting (5 A nominal)
  - ±0.01 A and ±3% of setting (1 A nominal)

- **Time Dial Range:**
  - 0.50–15.00, 0.01 steps (US)
  - 0.05–1.00, 0.01 steps (IEC)

- **Curve Timing Accuracy:**
  - ±1.50 cycles and ±4% of curve time for current between 2 and 30 multiples of pickup

**Under- and Overvoltage Elements**

- **Pickup Range:**
  - OFF, 0.00–150.00 V, 0.01 V steps (various elements)
  - OFF, 0.00–260.00 V, 0.01 V steps (phase-to-phase elements)

- **Steady-State Pickup Accuracy:** ±1 V and ±5% of setting

- **Transient Overreach:** < 5% of pickup

**Synchronism-Check Elements**

- **Slip Frequency Pickup Range:** 0.005–0.500 Hz, 0.001 Hz steps

- **Slip Frequency Pickup Accuracy:** ±0.003 Hz

- **Phase Angle Range:** 0–80°, 1° steps

- **Phase Angle Accuracy:** ±4°

**Definite-Time Over- or Underfrequency Elements (81)**

- **Pickup Range:** 41–65 Hz, 0.01 Hz steps

- **Pickup Time:** 32 ms at 60 Hz (Max)

- **Time Delays:** 2–16,000 cycles, 0.25-cycle steps

- **Maximum Definite-Time Delay Accuracy:** ±0.25 cycles, ±1% of setting at 60 Hz

- **Steady-State plus Transient Overshoot:** ±0.01 Hz

- **Supervisory 27:** 20–150 V, ±5%, ±0.1 V
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SECTION 2: INSTALLATION

RELAY MOUNTING

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

To better use Figure 2.1, refer to Table 1.1 for rack unit height information on the SEL-311C Relay models (2U or 3U).
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MAKING REAR-PANEL CONNECTIONS

Refer to Figure 2.12 and Figure 2.13 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-311C two rack-unit height relays and three rack-unit height relays without the additional I/O board have SEL-221 wire-alike terminals. Both SEL-311C standard terminal numbers and SEL-221 terminal numbers are shown on the rear-panel wiring connections for those models. A properly programmed SEL-311C Relay may be installed in place of an SEL-221 Relay with no changes to the terminal numbers in a user’s wiring diagram.

Power Supply

Connect control voltage to the POWER terminals. Note the polarity indicators on terminals Z25(+) and Z26(-). Control power passes through these terminals to a fuse and to the switching power supply. The control power circuitry is isolated from the relay chassis ground.

Refer to Section 1: Introduction and Specifications for power supply ratings. The relay power supply rating is listed on the serial number sticker on the relay rear panel.

Output Contacts

Note: Do not use the following part numbers to order SEL-311C Relays. Contact the SEL factory for ordering information.

Model 0311C00x

Model 0311C00x 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.

Model 0311C01x

Model 0311C01x has output contacts on two rows of rear-panel screw terminals:

- upper row OUT101 through OUT107, plus ALARM (ordered as standard output contacts only)
- lower row OUT201 through OUT212 (ordered as standard or high-current interrupting output contacts—all of one type or the other)

Refer to General Specifications in Section 1: Introduction and Specifications for output contact ratings. To determine the type of output contacts on the extra I/O board of your Model 0311C01x relay, refer to the part number on the serial number sticker on the relay rear panel.
Standard Output Contacts

Model 0311C01x part numbers with a numeral “2” in the field underlined below (sample part numbers) indicate standard output contacts on the extra I/O board (OUT201 through OUT212):

0311C01H2425421

Standard output contacts are not polarity dependent.

High-Current Interrupting Output Contacts

Model 0311C01x part numbers with a numeral “6” in the field underlined below (sample part numbers) indicate high-current interrupting output contacts on the extra I/O board (OUT201 through OUT212):

0311C01H2425461

High-current interrupting output contacts are polarity dependent. The extra I/O board of the Model 0311C01x relay in Figure 2.7 does not show “+” polarity markings (because it is the rear panel for an extra I/O board with standard output contacts).

As an example, consider the connection of terminals B01 and B02 (high-current interrupting output contact OUT201) in a circuit. Terminal B02 (+) has to be at a higher voltage potential than terminal B01 in the circuit.

The same holds true for output contacts OUT202 through OUT212 (if they are also high-current interrupting output contacts).

Note: Do not use the high-current interrupting output contacts to switch ac control signals.

Fast Hybrid High-Current Interrupting Output Contacts

Model 0311C01x part numbers with a numeral “5” in the field underlined below (sample part numbers) indicate fast hybrid high-current interrupting output contacts on the extra I/O board (OUT201 through OUT208):

0311C01H2425451

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

Short transient inrush current may flow when a switch that is in series with the contact is closed, and the contact is open. This transient will not energize the circuit used in typical applications. Trip and close coils and standard auxiliary relays will not pick up; however, an extremely sensitive digital input or light-duty, high-speed auxiliary may pick up for this condition. The transient occurs when the capacitance of the output contact circuitry charged. A third terminal (B03 in Figure 2.8) provides a path for charging the capacitance when the circuit is open.

Figure 2.11 shows some possible connections for this third terminal that will eliminate the possibility of transients when closing a switch. Circuit load is not shown. In general, the third terminal must be connected to the dc rail that is on the same side as the open switch condition. If an open switch may exist on either side of the output contact, only one condition may be considered. Two open switches (one on each side of the contact) defeat the charge circuit.
Optoisolated Inputs

The optoisolated inputs in any of the SEL-311C Relay models (e.g., IN102, IN207) 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 2.12 and Figure 2.13 for typical CT wiring examples.

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

Potential Transformer Inputs

Note the signal labels (VA, VB, VC, N, VS, NS) on terminals Z09 through Z14. Figure 1.2 shows the internal connection for terminals VA, VB, VC, and VN. Note also that VS/NS is a separate single-phase voltage input.

Wye-Connected Voltages

Any of the single-phase voltage inputs (i.e., VA-N, VB-N, VC-N, or VS-NS) can be connected to voltages up to 150 V continuous. Figure 2.12 and Figure 2.13 show examples of wye-connected voltages. System frequency is determined from the voltages connected to terminals VA-N.

Serial Ports

All ports are independent—you can communicate to any combination simultaneously.
Serial Port 1 on all the SEL-311C Relay models is an EIA-485 port (4-wire). The Serial Port 1 plug-in connector accepts wire size AWG 24 to 12. Strip the wires 0.31 inches (8 mm) and install with a small slotted-tip screwdriver. The Serial Port 1 connector has extra positions for IRIG-B time-code signal input (see Table 10.2; also see following discussion on IRIG-B time code input).

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

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

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

Note: Devices not manufactured by SEL are listed in Table 2.1 for the convenience of our customers. SEL does not specifically endorse or recommend such products, nor does SEL guarantee proper operation of those products, or the correctness of connections, over which SEL has no control.

For example, to connect any EIA-232 port to the 9-pin male connector on a laptop computer, order cable number C234A and specify the length needed (standard length is eight feet). To connect the SEL-311C 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-311C Relay to Other Devices

<table>
<thead>
<tr>
<th>SEL-311C EIA-232 Serial Ports</th>
<th>Connect to Device (gender refers to the device)</th>
<th>SEL Cable No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>all EIA-232 ports</td>
<td>PC, 25-Pin Male (DTE)</td>
<td>C227A</td>
</tr>
<tr>
<td>all EIA-232 ports</td>
<td>Laptop PC, 9-Pin Male (DTE)</td>
<td>C234A</td>
</tr>
<tr>
<td>all EIA-232 ports</td>
<td>SEL-2020 or SEL-2030 without IRIG-B</td>
<td>C272A</td>
</tr>
<tr>
<td>2</td>
<td>SEL-2020 or SEL-2030 with IRIG-B</td>
<td>C273A</td>
</tr>
<tr>
<td>all EIA-232 ports</td>
<td>SEL-DTA2</td>
<td>C272A</td>
</tr>
<tr>
<td>2*</td>
<td>Telenetics Modem, 5 Vdc Powered</td>
<td>C220*</td>
</tr>
<tr>
<td>3*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>all EIA-232 ports</td>
<td>Standard Modem, 25-Pin Female (DCE)</td>
<td>C222</td>
</tr>
<tr>
<td>all EIA-232 ports</td>
<td>RFL-9660</td>
<td>C245A</td>
</tr>
<tr>
<td>all EIA-232 ports</td>
<td>SEL-2100</td>
<td>C272A</td>
</tr>
<tr>
<td>2</td>
<td>SEL-2100 with IRIG</td>
<td>C273A</td>
</tr>
<tr>
<td>2</td>
<td>SEL-2505</td>
<td>SEL-2800</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* A corresponding main board jumper must be installed to power the Telenetics Modem with +5 Vdc (0.5 A limit) from the SEL-311C Relay. See Figure 2.15 and Table 2.5.

**IRIG-B Time-Code Input**

The SEL-311C 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-311C Relay models (see Table 10.1) by connecting Serial Port 2 of the SEL-311C 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-311C Relay AC/DC Connection Diagrams for Various Applications

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

Figure 2.12: SEL-311C Relay Provides Distance and Overcurrent Protection, Reclosing, and Synch Check for a Transmission Line
1. Voltage Channel VS does not need to be connected. It is used only in voltage and synchronism check elements and voltage metering.

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

Figure 2.13: SEL-311C Relay Provides Distance and Overcurrent Protection, and Reclosing for a Transmission Line (Current-Polarization Source Connected to Channel IP)
1. Use compensator distance elements for line protection through a delta-wye transformer.
2. Voltage VS does not need to be connected.

Figure 2.14: SEL-311C Line Protection Through a Delta-Wye Transformer Using Compensator Distance Elements
CIRCUIT BOARD CONNECTIONS

Accessing the Relay Circuit Boards

To change circuit board jumpers or replace the clock battery, refer to Figure 2.15 and Figure 2.16 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. Identify which drawout tray needs to be removed. SEL-311C Relay model 0311C00x has only a main board. Model 0311C01x has space for an extra I/O board below the main board.

5. Disconnect circuit board cables as necessary to allow the desired board and drawout tray to be removed. Removal of the extra I/O board requires removal of the main board first. Ribbon cables can be removed by 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 board and pull the assembly from the relay chassis.

7. Locate the jumper(s) or battery to be changed (refer to Figure 2.15 and Figure 2.16). 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.
Figure 2.15: Jumper, Connector, and Major Component Locations on the SEL-311C Relay Main Board
Figure 2.16: Jumper, Connector, and Major Component Locations on the SEL-311C Relay
Extra I/O Board
**Figure 2.17: Interface Board 5 Component Layout**

**Optoisolated Inputs (8)**

**Output Contacts (8)
(Fast High Current Interrupting)**

<table>
<thead>
<tr>
<th>Solder Jumper Position</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Contact closes when asserted</td>
</tr>
<tr>
<td>B</td>
<td>Contact opens when asserted</td>
</tr>
</tbody>
</table>
Output Contact Jumpers

Table 2.2 shows the correspondence between output contact jumpers and the output contacts they control. The referenced figures show the exact location and correspondence. With a jumper in the A position, the corresponding output contact is an “a” type output contact. An “a” type output contact is closed when the associated SELOGIC equation is asserted, and open when the associated SELOGIC equation is deasserted. With a jumper in the B position, the corresponding output contact is a “b” type output contact. A “b” type output contact is closed when the associated SELOGIC equation is deasserted, and open when the associated SELOGIC equation is asserted. These jumpers are soldered in place.

In Figure 2.15, 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 7.27 and Figure 7.28 for examples of output contact operation for different output contact types.

Table 2.2: Output Contact Jumpers and Corresponding Output Contacts

<table>
<thead>
<tr>
<th>SEL-311C Relay Model Number</th>
<th>Output Contact Jumpers</th>
<th>Corresponding Output Contacts</th>
<th>Reference Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>0311C00x and 0311C01x</td>
<td>JMP21–JMP29 (but not JMP23)</td>
<td>ALARM–OUT101</td>
<td>Figure 2.15</td>
</tr>
<tr>
<td>0311C01x</td>
<td>JMP17–JMP28</td>
<td>OUT212–OUT201</td>
<td>Figure 2.16</td>
</tr>
</tbody>
</table>

“Extra Alarm” Output Contact Control Jumper

All the SEL-311C Relays have dedicated alarm output contacts (labeled ALARM—see Figure 2.2, Figure 2.3, and Figure 2.7). Often more than one alarm output contact is needed for such applications as local or remote annunciation, backup schemes, etc.

Convert the output contact adjacent to the dedicated ALARM output contact to operate as an “extra alarm” output contact by moving jumper JMP23 on the main board (see Table 2.3).

With the jumper in one position, the output contact operates regularly. With the jumper in the other position, the output contact is driven by the same signal that operates the dedicated ALARM output contact (see Table 2.3).
Table 2.3: Move Jumper JMP23 to Select Extra Alarm

<table>
<thead>
<tr>
<th>Position</th>
<th>Output Contact OUT107 Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td>Output contact OUT107 is operated by Relay Word bit OUT107. Jumper JMP23 comes in this position in a standard relay shipment (see Figure 7.27).</td>
</tr>
<tr>
<td><img src="image2.png" alt="Diagram" /></td>
<td>“Extra Alarm” output contact is operated by alarm logic/circuitry. Relay Word bit OUT107 does not have any effect on output contact OUT107 when jumper JMP23 is in this position (see Figure 7.27).</td>
</tr>
</tbody>
</table>

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 2.4: Password and Breaker Jumper Operation

<table>
<thead>
<tr>
<th>Jumper</th>
<th>Jumper Position</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Password JMP6-A</td>
<td>ON (in place)</td>
<td>Disable password protection(^1) for serial ports and front panel.</td>
</tr>
<tr>
<td></td>
<td>OFF (removed/not in place)</td>
<td>Enable password protection(^1) for serial ports and front panel.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Passwords are enabled in a standard relay shipment.</td>
</tr>
<tr>
<td>Breaker JMP6-B</td>
<td>ON (in place)</td>
<td>Enable serial port commands OPEN, CLOSE, and PULSE(^2). These commands are disabled in a standard relay shipment.</td>
</tr>
<tr>
<td></td>
<td>OFF (removed/not in place)</td>
<td>Disable serial port commands OPEN, CLOSE, and PULSE(^2). These commands are disabled in a standard relay shipment.</td>
</tr>
</tbody>
</table>

\(^1\) 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 2.15 has multiple jumpers A through D. Jumpers A and B are used (see Table 2.4). Since jumpers C and D are not used, the positions (ON or OFF) of jumpers C and D are of no consequence.

EIA-232 Serial Port Voltage Jumpers

The jumpers listed in Table 2.5 connect or disconnect +5 Vdc to Pin 1 on the corresponding EIA-232 serial ports. The +5 Vdc is rated at 0.5 A maximum for each port. See Table 10.1 in Section 10: Serial Port Communications and Commands for EIA-232 serial port pin functions.

In a standard relay shipment, the jumpers are “OFF” (removed/not in place) so that the +5 Vdc is not connected to Pin 1 on the corresponding EIA-232 serial ports. Put the jumpers “ON” (in place) so that the +5 Vdc is connected to Pin 1 on the corresponding EIA-232 serial ports.

Table 2.5: EIA-232 Serial Port Voltage Jumper Positions for Standard Relay Shipments

<table>
<thead>
<tr>
<th>SEL-311C Relay Model Number</th>
<th>EIA-232 Serial Port 2 (rear panel)</th>
<th>EIA-232 Serial Port 3 (rear panel)</th>
<th>Reference Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0311C00x 0311C01x</td>
<td>JMP2 = OFF</td>
<td>JMP1 = OFF</td>
<td>Figure 2.15</td>
</tr>
</tbody>
</table>
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 2.15 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).
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SECTION 3: DISTANCE, OUT-OF-STEP, OVERCURRENT, VOLTAGE, SYNCHRONISM CHECK, AND FREQUENCY ELEMENTS

DISTANCE ELEMENTS

Mho Phase Distance Elements

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

Compensator distance elements are included for distance relaying through wye-delta transformer banks and for users who desire a different operating principle for backup relaying. Compensator distance-phase elements implemented in the SEL-311C 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 $V_1 = |V_1|/\theta_1$ and vector $V_2 = |V_2|/\theta_2$, then $V_1 \cdot (V_2 \text{ conjugate}) = V_1 \cdot V_2^* = [|V_1| \cdot |V_2|]/\theta_1 - \theta_2$
  The angle of the vector quantity $V_1 \cdot V_2^*$ 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 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 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 “|ZI|”, 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.

$$0 = \text{Re}[(Z \cdot I - V) \cdot V^*] \text{mem}$$  \hspace{1cm} \text{Equation 1}
### Table 3.1: Phase Distance Calculations

<table>
<thead>
<tr>
<th>Distance Calculation in a Digital Relay</th>
<th>Positive-Sequence Polarized Mho Element</th>
<th>Compensator-Distance Mho Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase A-B</td>
<td>$</td>
<td>Z</td>
</tr>
<tr>
<td>Phase B-C</td>
<td>$</td>
<td>Z</td>
</tr>
<tr>
<td>Phase C-A</td>
<td>$</td>
<td>Z</td>
</tr>
</tbody>
</table>

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 $V_{1mem}$ 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 $(-jV_{AB} - 0.25 \cdot V_{Cmem})$ and the line drop compensated voltage is $(V_{AB} - Z \cdot I_{AB})$. 

$Z = $ Impedance measurement at the line angle
Figure 3.1: Positive-Sequence Polarized Mho Element
Figure 3.2:  Compensator-Distance Phase-to-Phase Element Operation
Positive-sequence polarized and compensator distance mho elements each have different operating advantages in different protection environments, but work equally well in the majority of transmission line applications. Consider using compensator distance elements when:

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

- Blocking reclose on three-phase faults. Relay Word bits MPPₙ (Zone/Level n phase-to-phase compensator distance element) and MABCₙ (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).

\[
79\text{DTL} = \text{MABC}2 \times \lnot \text{MPP}2 \ldots
\]

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

Compensator distance and positive-sequence polarized distance may not be applied at the same time. The user selects compensator distance with a “C” suffix to the number of zones in the E21P setting (e.g., 3C is three zones of compensator distance relaying). If EADVS = N and compensator distance elements are selected, E21MG is set to “N” and hidden. If EADVS = Y, setting E21MG is visible and the user may apply ground distance relaying along with compensator distance phase relaying.

Mho Phase Distance Elements (Zones 1–4)

Enable Setting: E21P

Setting range for Mho Phase Distance Elements (Z1P through Z4P):
- OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal)
- OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal)

Minimum sensitivity is controlled by the pickup of the supervising phase-to-phase overcurrent elements for each zone.

Accuracy:
- ±5% of setting at line angle for 30 \(\leq\) SIR \(\leq\) 60
- ±3% of setting at line angle for SIR < 30

Transient Overreach: < 5% of setting plus steady state accuracy

Phase-to-Phase Current Fault Detectors (Zones 1–4)

Setting Range for Phase-to-Phase Current Fault Detectors (50PP1–50PP4):
- 0.50–170.00 Aₚₚ,secondary, 0.01 A steps (5 A nominal)
- 0.10–34.00 Aₚₚ,secondary, 0.01 A steps (1 A nominal)

Note: If setting EADVS = N, settings 50PP2–50PP4 are at minimum values and are 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 3.20 and Figure 3.21.
Mho Phase Distance Elements

 Relay Word Bits (unless noted)
1. 32OF
2. F32P
3. OSBH
4. S50PP1
5. 50Q1
6. CVTBL
7. ILOP
8. FSB

See Figure 3.4: Zone 1 AB Phase Distance Logic

From Figure 4.14
From Figure 4.15
From Figure 3.18
From Figure 3.23
From Figure 4.2
From Figure 4.1
From Figure 3.15
From Figure 3.23
Figure 3.5: Zone 2 AB Phase Distance Logic

1. From Figure 4.14
2. From Figure 4.15
3. From Figure 3.18
4. From Figure 3.23
5. From Figure 4.1
6. From Figure 3.18
Figure 3.6: Zones 3 and 4 AB Phase Distance Logic
Ground Distance Elements

The SEL-311C Relay has four independent zones of mho and quadrilateral ground distance protection. All zones are independently set. Zones 1 and 2 are forward direction only, and Zones 3 and 4 can be set in either a forward or reverse direction. The mho ground distance elements use positive-sequence voltage polarization for security and to create an expanded mho characteristic. The directional polarizing quantity for the reactance portion of the quadrilateral ground distance element may be selected from negative-sequence current or zero-sequence current if Advanced Settings are enabled (Setting EADVS = Y).

Impedance Reach (Zones 1–4)

Enable Setting:

<table>
<thead>
<tr>
<th></th>
<th>Mho Ground</th>
<th>Quadrilateral Ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>E21MG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E21XG</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Settings range for Mho elements (Z1MG through Z4MG):

| OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal) |
| OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal) |

Settings range for Quadrilateral Reactance elements (XG1 through XG4):

| OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal) |
| OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal) |

Settings range for Quadrilateral Resistance elements (RG1 through RG4):

| OFF, 0.05 to 50 Ω sec, 0.01 Ω steps (5 A nominal) |
| OFF, 0.25 to 250 Ω sec, 0.01 Ω steps (1 A nominal) |

Minimum sensitivity is controlled by the pickup of the supervising phase and residual overcurrent elements for each zone.

Accuracy:

±5% of setting at line angle for 30 ≤ SIR ≤ 60
±3% of setting at line angle for SIR < 30

Transient Overreach:

< 5% of setting plus steady-state accuracy

Phase and Residual Current Fault Detectors (Zones 1–4)

Setting Range for Phase and Residual Current Fault Detectors (50L1 through 50L4 and 50GZ1 through 50GZ4):

| 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 EADVS = N, levels 2–4 fault detectors are set at their minimum values and are 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 3.20 and Figure 3.21.

Other Settings

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

\[ k_0^{M1} = 0.000\text{–}6.000 \text{ unitless (Zone 1)} \]

\[ k_0^{M} = 0.000\text{–}6.000 \text{ unitless (Zone 2, 3, 4 advanced setting hidden and set to } k_0^{M1} \text{ when } EADVS = N) \]

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

\[ k_0^{A1} = -180.0 \text{ to } +180.0 \text{ degrees (Zone 1)} \]

\[ k_0^{A} = -180.0 \text{ to } +180.0 \text{ degrees (Zone 2, 3, 4 advanced setting hidden and set to } k_0^{A1} \text{ when } EADVS = N) \]

where

\[ k_0^{M1\vartriangle k_0^{A1}} = \frac{(Z0^{MAG}\vartriangle Z0^{ANG}) - (Z1^{MAG}\vartriangle Z1^{ANG})}{3\times(Z1^{MAG}\vartriangle Z1^{ANG})} \]

Settings range for quadrilateral ground polarizing quantity (hidden and set to I2 when EADVS = N):

\[ X^{GPOL} = I2 \text{ (negative-sequence current) or I0 (zero-sequence current) (advanced setting)} \]

Settings range for non-homogenous correction angle (hidden and set to -3 when EADVS = N):

\[ T^{ANG} = -40 \text{ to } +40 \text{ degrees (advanced setting)} \]
Zone 1 A-Phase Mho Ground Distance Logic. B and C Phase Are Similar.

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

① From Figure 4.12  ④ From Figure 4.1
② From Figure 4.2  ⑤ From Figure 3.15
③ From Figure 5.3

Figure 3.7: Zone 1 Mho Ground Distance Logic
Figure 3.8: Zone 2 Mho Ground Distance Logic

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

① From Figure 4.12  ③ From Figure 4.1
② From Figure 5.3
3-14 Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements
SEL-311C Instruction Manual

Figure 3.9: Zones 3 and 4 Mho Ground Distance Logic

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

Note 1: mAG = A-Phase to Ground Distance Calculation
ZnMG = Zone n Distance Setting
n = 3 for Zone 3
n = 4 for Zone 4

DIRn = F (Setting)
|IA|
SOLn (Advanced Setting)
|IG|
SOGZn (Advanced Setting)
|IG|

See Note 1

3PO
LLOP
VPOLV

Zone 3 and 4 A-Phase Mho Ground Distance Logic.
B- and C-Phase Logic Is Similar.

mAG < ZnMG
mAG > ZnMG

FSA

\[ mAG > -ZnMG \]
See Note 1

Relay Word Bits (unless noted)

1 2 1 3

From Figure 4.12  From Figure 4.1

From Figure 5.3

From Figure 5.3

From Figure 5.3

DIW: M311C045a
Zone 1 A-Phase Quadrilateral Ground Distance Logic. B- and C-Phase Are Similar.

Note 1: $x_{AG} = A$-Phase to Ground Reactance Calculation

$X_{G1} = Zone 1 Reactance Setting$

$X_1 = Zone 1 Extension$

$r_{AG} = A$-Phase to Ground Resistance Calculation

$R_{G1} = Zone 1 Resistance Setting$

From Figure 4.7
From Figure 4.6
From Figure 4.12
From Figure 5.3

From Figure 4.1
From Figure 4.2
From Figure 3.10
From Figure 3.10

Figure 3.10: Zone 1 Quadrilateral Ground Distance Logic
Zone 2 A-Phase Quadrilateral Ground Distance Logic.

B- and C-Phase Are Similar.

Note 1: xAG = A-Phase to Ground Reactance Calculation
XG2 = Zone 2 Reactance Setting
rAG = A-Phase to Ground Resistance Calculation
RG2 = Zone 2 Resistance Setting

M311C047a

① From Figure 4.7  ④ From Figure 5.3
② From Figure 4.6  ⑤ From Figure 4.12
③ From Figure 4.12

Figure 3.11: Zone 2 Quadrilateral Ground Distance Logic
Zone 3 and 4 A-Phase Quadrilateral Ground Distance Logic
B- and C-Phase Logic Are Similar.

Note 1: \( x_{AG} = A\)-Phase to Ground Reactance Calculation
\( X_{Gn} = Zone \ n \) Reactance Setting
\( r_{AG} = A\)-Phase to Ground Resistance Calculation
\( R_{Gn} = Zone \ n \) Resistance Setting

\( n = 3 \) for Zone 3
\( n = 4 \) for Zone 4

Figure 3.12: Zones 3 and 4 Quadrilateral Ground Distance Logic

From Figure 4.7
From Figure 4.6
From Figure 4.12
From Figure 4.12
From Figure 5.3
DISTANCE ELEMENT OPERATING TIME CURVES AT NOMINAL FREQUENCY

Figure 3.13 and Figure 3.14 show operating times for the SEL-311C Relay distance elements. The diagrams show operating times at each test point. Operating times include output contact closure time.

For the distance element test, a fault was applied at a location representing a percentage of the Zone 1 relay reach setting. Tests were performed for source impedance ratios (SIR) of 0.1, 1.0, 10.0, and 30.0. No pre-fault load current or fault resistance was included. Operating times are the same for both 50 Hz and 60 Hz.
Figure 3.13: Ground and Phase Distance Speed Curves—Standard Output
Figure 3.14: Ground and Phase Distance Speed Curves—Fast Hybrid Output
**Additional Distance Element Supervision**

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

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

**Zone 1 Extension**

See Figure 3.15. When enabled, this logic modifies the reach of all Zone 1 distance elements by multiplier setting Z1EXTM once all three poles are closed for Z1EXTD time. All Zone 1 reaches retreat to their set reach when 3PO asserts.

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

**Settings**

- **Enable Zone 1 Extension** (EZ1EXT)
- **Zone 1 Extension Delay** (Z1EXTD)
- **Zone 1 Extension Multiplier** (Z1EXTM)

Sets the minimum time the breaker must be closed before extending the Zone 1 reach.

Sets the scalar by which all Zone 1 reaches are multiplied. Z1EXTM times the Zone 1 distance setting is never set less than the Zone 1 distance setting or greater than 90 percent of Zone 2 reach.

\[
Z1P < (Z1EXTM \times Z1P) < (0.9 \times Z2P) \quad \text{and}
\]
\[
Z1MG < (Z1EXTM \times ZMG) < (0.9 \times Z2MG) \quad \text{and}
\]
\[
X1G < (Z1EXTM \times X1G) < (0.9 \times X2G)
\]

must all be true or the SEL-311C will not allow the Z1EXTM setting.
Zone Time Delay Elements

The SEL-311C Relay supports two philosophies of zone timing: independent or common timing (see Figure 3.16). For the independent timing mode, the phase and ground distance elements drive separate timers for each zone. For the common mode, the phase and ground distance elements both drive a common timer.

Common Timer Settings: Z1D through Z4D

Independent Phase Timer Settings: Z1PD through Z4PD

Independent Ground Timer Settings: Z1GD through Z4GD

Pickup Ranges: OFF, 0.00–16,000.00 cycles, 0.25-cycle steps

Pickup and dropout accuracy for all timers: ±0.25 cycle and ±0.1% of setting

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

\[ TR = M1P + Z1G + M2PT + Z2GT + 51GT + 51QT \]

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

\[ TR = M1P + Z1G + Z2T + 51GT + 51QT \]
The timing of the common zone timer is frozen or suspended if the timer is timing and the timer input drops out. The duration of the suspension is one cycle. This feature prevents the timer resetting when a fault evolves (e.g., $\phi \phi$ to $3 \phi$, SLG to $\phi G \phi$). If the timer expires, the suspension logic is blocked.

---

**Out-of-Step (OOS) Characteristics**

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

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

Normally, the Zone 5 and Zone 6 bottom reactance and left resistance element settings are mirror images of the top reactance and right resistance element settings (e.g., $X_{1B5} = -X_{1T5}$). The SEL-311C makes these settings automatically. Enable the advanced user settings to set these elements individually ($EADVS = Y$).

---

**Figure 3.16: Zone Timing Elements**

---
Note: The out-of-step logic cannot be used when setting Z1ANG is less than 45 degrees. In that case, setting EOOS must equal N.

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


The timer setting UBOSBD, shown in Figure 3.17, is an adaptive setting calculated by the relay. This adaptive setting, which is the expected duration of the swing within the inner blinders, is based on the actual time it takes for the swing to travel between the Zone 6 and Zone 5 blinders prior to moving into inner blinders. If the swing stays between the inner blinders for a period longer than UBOSBD cycles, an unblock signal is asserted.

In the SEL-311C, the user can increase the adaptive setting UBOSBD in multiples of setting UBOSBF. If UBOSBF is set at a multiplier of one, the relay will calculate the expected time to traverse the inner blinders based on the rate at which the swing transitions from Zone 6 to Zone 5. Similarly, if UBOSBF is set at a multiplier of 4, the relay will multiply the adaptive time setting by four.

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

Zones 5 and 6 Reactance and Resistance Elements
Settings range for Zone 5 and Zone 6 Reactance Reach (X1T5 and X1T6):
- 0.05 to 96 Ω sec, 0.01 Ω steps (5 A nominal)
- 0.25 to 480 Ω sec, 0.01 Ω steps (1 A nominal)

Settings range for Zone 5 and Zone 6 Resistance Reach (R1R5 and R1R6):
- 0.05 to 70 Ω sec, 0.01 Ω steps (5 A nominal)
- 0.25 to 350 Ω sec, 0.01 Ω steps (1 A nominal)

Advanced Settings (EADVS = Y) range for Zone 5 and Zone 6 Reactance Reach (X1B5 and X1B6):
- -96 to -0.05 Ω sec, 0.01 Ω steps (5 A nominal)
- -480 to -0.25 Ω sec, 0.01 Ω steps (1 A nominal)

Advanced Settings (EADVS = Y) range for Zone 5 and Zone 6 Resistance Reach (R1L5 and R1L6):
- -70 to -0.05 Ω sec, 0.01 Ω steps (5 A nominal)
- -350 to -0.25 Ω sec, 0.01 Ω steps (1 A nominal)
Inner Blinders: Set by the relay internally at 0.1 • Z1MAG or 0.25/I_{nom}, whichever is greater.
Accuracy: ±5% of setting at line angle for 30 ≤ SIR ≤ 60
±3% of setting at line angle for SIR < 30
Transient Overreach: < 5% of setting plus steady state accuracy

Positive Sequence Current Supervision Element 50ABC
Setting Range for Positive Sequence Current Supervision (50ABCP):
0.50–100.00 A secondary, 0.01 A steps (5 A nominal)
0.10–20.00 A secondary, 0.01 A steps (1 A nominal)
Accuracy:
±0.05 A and ±3% of setting (5 A nominal)
±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:
< 5% of pickup
Max. Operating Time:
See pickup and reset time curves in Figure 3.20 and Figure 3.21

Negative-Sequence Current Unblock Time Delay:
Pickup Ranges:
0.5–120.0 cycles, 0.25-cycle steps
Out-of-Step Angle Change Unblock Rate (Advanced Setting: EADVS = Y):
UBOSBF
Pickup Ranges:
1–10 unitless

Table 3.2: OOS Relay Word Bits

<table>
<thead>
<tr>
<th>Relay Word Bits</th>
<th>Description</th>
<th>Relay Word Bits</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>50ABC</td>
<td>Positive-sequence current above threshold</td>
<td>OSTO</td>
<td>Outgoing out-of-step trip</td>
</tr>
<tr>
<td>X6ABC</td>
<td>Impedance inside Zone 6</td>
<td>OST</td>
<td>Out-of-step trip</td>
</tr>
<tr>
<td>X5ABC</td>
<td>Impedance inside Zone 5</td>
<td>OSB1</td>
<td>Block Zone 1 during an out-of-step condition</td>
</tr>
<tr>
<td>UBOSB</td>
<td>Unblock out-of-step blocking</td>
<td>OSB2</td>
<td>Block Zone 2 during an out-of-step condition</td>
</tr>
<tr>
<td>OSB</td>
<td>Out-of-step block</td>
<td>OSB3</td>
<td>Block Zone 3 during an out-of-step condition</td>
</tr>
<tr>
<td>OSTI</td>
<td>Incoming out-of-step trip</td>
<td>OSB4</td>
<td>Block Zone 4 during an out-of-step condition</td>
</tr>
</tbody>
</table>
Figure 3.17: Out-of-Step Zone Detection Logic
Figure 3.18: Out-of-Step Logic
INSTANTANEOUS/DEFINITE-TIME OVERCURRENT ELEMENTS

Phase Instantaneous/Definite-Time Overcurrent Elements

Three levels of phase instantaneous/definite-time overcurrent elements are available. The different levels are enabled with the E50P enable setting, as shown in Figure 3.19.

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

Settings Ranges

Settings range for pickup settings 50P1P through 50P3P:

- OFF, 0.25–100.00 A secondary (5 A nominal phase current inputs, IA, IB, IC)
- OFF, 0.05–20.00 A secondary (1 A nominal phase current inputs, IA, IB, IC)

Settings range for definite-time settings 67P1D through 67P3D:

- 0.00–16000.00 cycles, in 0.25-cycle steps

Accuracy

Pickup:

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

Timer:

- ±0.25 cycles and ±0.1% of setting

Transient Overreach: < 5% of setting

Pickup Operation

See the phase instantaneous/definite-time overcurrent element logic in Figure 3.19. The pickup settings for each level (50P1P through 50P3P) are compared to the magnitudes of the individual phase currents $I_a$, $I_b$, and $I_c$. The logic outputs in Figure 3.19 are Relay Word bits and operate as follows (Level 1 example shown):

- 50P1 = 1 (logical 1), if at least one phase current exceeds the 50P1P setting
- 50P1 = 0 (logical 0), if no phase current exceeds the 50P1P setting

Ideally, set 50P1P > 50P2P > 50P3P so that overcurrent elements will display in an organized fashion in event reports (see Figure 3.19 and Table 12.3).
Figure 3.19: Levels 1 through 3 Phase Instantaneous/Definite-Time Overcurrent Elements

Torque Control

Levels 1 through 3 in Figure 3.19 have corresponding SELOGIC control equation torque control settings 67P1TC through 67P3TC. SELOGIC control equation torque control settings cannot be set directly to logical 0. The following are torque control setting examples for Level 1 phase instantaneous/definite-time overcurrent elements 67P1/67P1T.

67P1TC = 1  Setting 67P1TC set to logical 1:
Then 67P1/67P1T follows 50P1.

Note: All overcurrent element SELOGIC control equation torque control settings are set directly to logical 1 (e.g., 67P1TC = 1) for the factory default settings. See SHO Command (Show/View Settings) in Section 10: Serial Port Communications and Commands for a list of the factory default settings.
67P1TC = IN105  Input IN105 deasserted (67P1TC = IN105 = logical 0):
    Phase instantaneous/definite-time overcurrent elements 67P1/67P1T are defeated and nonoperational, regardless of any other setting.

Input IN105 asserted (67P1TC = IN105 = logical 1):
    67P1/67P1T follows 50P1.

67P1TC = M2P  The 67P1/67P1T uses the Zone 2 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 3.20 and Figure 3.21 show pickup and reset time curves applicable to all nondirectional instantaneous overcurrent elements in the SEL-311C 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 3.20 is adjusted as follows:

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

![Pickup Time Curve](image-url)

**Figure 3.20**: SEL-311C Relay Nondirectional Instantaneous Overcurrent Element Pickup Time Curve
Residual Ground Instantaneous/Definite-Time Overcurrent Elements

Four levels of residual ground instantaneous/definite-time overcurrent elements are available. The different levels are enabled with the E50G enable setting, as shown in Figure 3.22.

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

To understand the operation of Figure 3.22, follow the explanation given for Figure 3.19 in the preceding Phase Instantaneous/Definite-Time Overcurrent Elements subsection, substituting residual ground current $I_0$ ($I_0 = 3I_a = I_a + I_b + I_c$) for phase currents and substituting like settings and Relay Word bits.

In Figure 3.22 Levels 1 and 2 67Gn elements have their directional control fixed forward. Levels 3 and 4 have selectable forward and reverse directional controls. See Figure 4.12 in Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic for more information on directional control.
Figure 3.22: Levels 1 Through 4 Residual Ground Instantaneous/Definite-Time Overcurrent Elements With Directional and Torque Control
**Settings Ranges**

Setting range for pickup settings 50G1P through 50G4P:

- OFF, 0.25–100.00 A secondary (5 A nominal phase current inputs, IA, IB, IC)
- OFF, 0.05–20.00 A secondary (1 A nominal phase current inputs, IA, IB, IC)

Setting range for definite-time settings 67G1D through 67G4D:

- 0.00–16000.00 cycles, in 0.25-cycle steps

**Accuracy**

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

Timer: ±0.25 cycles and ±0.1% of setting

Transient Overreach: ±5% of setting

**Pickup and Reset Time Curves**

See Figure 3.20 and Figure 3.21.

**Negative-Sequence Instantaneous/Definite-Time Overcurrent Elements**

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

Four levels of negative-sequence instantaneous/definite-time overcurrent elements are available. The different levels are enabled with the E50Q enable setting, as shown in Figure 3.23.

To understand the operation of Figure 3.23, follow the explanation given for Figure 3.19 in the preceding Phase Instantaneous/Definite-Time Overcurrent Elements subsection, substituting negative-sequence current \(3I_2\) \[3I_2 = I_A + a^2 \cdot I_B + a \cdot I_C\] (ABC rotation), \(3I_2 = I_A + a^2 \cdot I_C + a \cdot I_B\] (ACB rotation), where \(a = 1 \angle 120^\circ\) and \(a^2 = 1 \angle -120^\circ\) for phase currents and substituting like settings and Relay Word bits.

In Figure 3.23, Levels 1 and 2 67Q\(n\) elements have directional controls fixed forward. Levels 3 and 4 have selectable forward and reverse directional controls. See Figure 4.14 in Section 4: Loss-of-Potential, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic for more information on this optional directional control.

**Settings Ranges**

Settings range for pickup settings 50Q1P through 50Q4P:

- OFF, 0.25–100.00 A secondary (5 A nominal phase current inputs, IA, IB, IC)
- OFF, 0.05–20.00 A secondary (1 A nominal phase current inputs, IA, IB, IC)

Settings range for definite-time settings 67Q1D through 67Q4D:

- 0.00–16000.00 cycles, in 0.25-cycle steps
Accuracy

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

Timer:  ±0.25 cycles and ±0.1% of setting

Transient Overreach:  < 5% of setting

Pickup and Reset Time Curves

See Figure 3.20 and Figure 3.21.
Figure 3.23: Levels 1 Through 4 Negative-Sequence Instantaneous/Definite-Time Overcurrent Elements With Directional and Torque Control

From Figure 4.14
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 3.3: Available Phase Time-Overcurrent Elements

<table>
<thead>
<tr>
<th>Time-Overcurrent Element</th>
<th>Enabled with Setting</th>
<th>Operating Current</th>
<th>See Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>51PT</td>
<td>E51P = Y</td>
<td>$I_{ABC}$, maximum of A-, B-, and C-phase currents</td>
<td>Figure 3.24</td>
</tr>
</tbody>
</table>

51PT Element Settings Ranges

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

Table 3.4: Phase Time-Overcurrent Element (Maximum Phase) Settings

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

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 3.24: Phase Time-Overcurrent Element 51PT

Accuracy

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

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

51PT Element Logic Outputs

The logic outputs in Figure 3.24 are the Relay Word bits shown in Table 3.5.
Table 3.5: Phase Time-Overcurrent Element (Maximum Phase) Logic Outputs

<table>
<thead>
<tr>
<th>Relay Word Bit</th>
<th>Definition/Indication</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>51P</td>
<td>Maximum phase current, $I_{ABC}$, is greater than phase time-overcurrent element pickup setting 51PP.</td>
<td>Element pickup testing or other control applications. See <em>Trip Logic</em> in <em>Section 5: Trip and Target Logic</em>.</td>
</tr>
<tr>
<td>51PT</td>
<td>Phase time-overcurrent element is timed out on its curve.</td>
<td>Tripping and other control applications. See <em>Trip Logic</em> in <em>Section 5: Trip and Target Logic</em>.</td>
</tr>
<tr>
<td>51PR</td>
<td>Phase time-overcurrent element is fully reset.</td>
<td>Element reset testing or other control applications.</td>
</tr>
</tbody>
</table>

51PT Element Torque Control Switch Operation

Torque Control Switch Closed

The pickup comparator in Figure 3.24 compares the pickup setting (51PP) to the maximum phase current, $I_{ABC}$, if the Torque Control Switch is closed. $I_{ABC}$ is also routed to the curve timing/reset timing functions. The Relay Word Bit logic outputs operate as follows with the Torque Control Switch closed:

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

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

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

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

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

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

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

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

If the Torque Control Switch in Figure 3.24 is open, maximum phase current, \( I_{ABC} \), cannot get through to the pickup comparator (setting 51PP) and the curve timing/reset timing functions. For example, suppose that the Torque Control Switch is closed, \( I_{ABC} \) is:

\[
I_{ABC} > \text{pickup setting 51PP}
\]

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:

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

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 3.24.

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 3.24.

Any time current $I_{ABC}$ goes above pickup setting 51PP and the phase time-overcurrent element starts timing, Relay Word bit 51PR (reset indication) = logical 0. If the phase time-overcurrent element times out on its curve, Relay Word bit 51PT (curve time-out indication) = logical 1.

Setting 51PRS = Y

If electromechanical reset timing setting 51PRS = Y, the phase time-overcurrent element reset timing emulates electromechanical reset timing. If maximum phase current, $I_{ABC}$, goes above pickup setting 51PP (element is timing or already timed out) and then current $I_{ABC}$ goes below 51PP, the element starts to time to reset, emulating electromechanical reset timing. Relay Word bit 51PR (resetting indication) = logical 1 when the element is fully reset. See Time-Overcurrent Curves 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 3.25, follow the explanation given for Figure 3.24 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 3.25: Residual Ground Time-Overcurrent Element 51GT**

**Settings Ranges**

**Table 3.6: Residual Ground Time-Overcurrent Element Settings**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Definition</th>
<th>Range</th>
</tr>
</thead>
</table>
| 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 equation torque control setting              | Relay Word bits referenced in Tables 9.3 and 9.4  
           |                                                      | or set directly to logical 1—see note below.                            |

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

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

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

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

**Negative-Sequence Time-Overcurrent Element**

To understand the operation of Figure 3.26, follow the explanation given for Figure 3.24 in the preceding *Phase Time-Overcurrent Elements* subsection, substituting negative-sequence current $3I_2 = I_A + a^2 \cdot I_B + a \cdot I_C$ (ABC rotation), $3I_2 = I_A + a^2 \cdot I_C + a \cdot I_B$ (ACB rotation), where $a = 1 \angle 120^\circ$ and $a^2 = 1 \angle -120^\circ$ for maximum phase current $I_{ABC}$ and like settings and Relay Word bits.

**Figure 3.26: Negative-Sequence Time-Overcurrent Element 51QT**

**IMPORTANT:** See Appendix F for information on setting negative-sequence overcurrent elements.
Table 3.7: Negative-Sequence Time-Overcurrent Element Settings

<table>
<thead>
<tr>
<th>Setting</th>
<th>Definition</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>51QP</td>
<td>pickup</td>
<td>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)</td>
</tr>
<tr>
<td>51QC</td>
<td>curve type</td>
<td>U1–U5 (US curves) see Figure 9.1–Figure 9.10 C1–C5 (IEC curves) C1–C5 (IEC curves)</td>
</tr>
<tr>
<td>51QTD</td>
<td>time dial</td>
<td>0.50–15.00 (US curves) see Figure 9.1–Figure 9.10 0.05–1.00 (IEC curves)</td>
</tr>
<tr>
<td>51QRS</td>
<td>electromechanical reset timing</td>
<td>Y = Enable electromechanical reset timing N = 1 cycle reset delay</td>
</tr>
<tr>
<td>51QTC</td>
<td>SELOGIC control equation torque control setting</td>
<td>Relay Word bits referenced in Tables 9.3 and 9.4 or set directly to logical 1—see note below.</td>
</tr>
</tbody>
</table>

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

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

**Accuracy**

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

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

**Voltage Elements**

Enable SEL-311C voltage elements by making the enable setting:

`EVOLT = Y`

**Voltage Values**

Voltage elements operate from the voltage values shown in Table 3.8.
Table 3.8: Voltage Values Used by Voltage Elements

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_A$</td>
<td>A-phase voltage, from SEL-311C Relay rear-panel voltage input VA</td>
</tr>
<tr>
<td>$V_B$</td>
<td>B-phase voltage, from SEL-311C Relay rear-panel voltage input VB</td>
</tr>
<tr>
<td>$V_C$</td>
<td>C-phase voltage, from SEL-311C Relay rear-panel voltage input VC</td>
</tr>
<tr>
<td>$V_{AB}$</td>
<td>Calculated phase-to-phase voltage</td>
</tr>
<tr>
<td>$V_{BC}$</td>
<td>Calculated phase-to-phase voltage</td>
</tr>
<tr>
<td>$V_{CA}$</td>
<td>Calculated phase-to-phase voltage</td>
</tr>
<tr>
<td>$3V_0$</td>
<td>Residual voltage (VA + VB + VC)</td>
</tr>
<tr>
<td>$V_2$</td>
<td>Negative-sequence voltage</td>
</tr>
<tr>
<td>$V_1$</td>
<td>Positive-sequence voltage</td>
</tr>
<tr>
<td>$V_S$</td>
<td>Synchronism check voltage, from SEL-311C Relay rear-panel voltage input $V_S$—see note below.</td>
</tr>
</tbody>
</table>

Note: Voltage $V_S$ is used in the synchronism check elements described in the following subsection Synchronism Check Elements. Voltage $V_S$ is also used in the three voltage elements described at the end of Table 3.9 and in Figure 3.29. These voltage elements are independent of the synchronism check elements, even though voltage $V_S$ is used in both.

Voltage Element Settings

Table 3.9 lists available voltage elements and the corresponding voltage inputs and settings ranges for the SEL-311C Relay (see Figure 1.2 for voltage input connection).

Table 3.9: Voltage Elements Settings and Settings Ranges

<table>
<thead>
<tr>
<th>Voltage Element (Relay Word bits)</th>
<th>Operating Voltage</th>
<th>Pickup Setting/Range</th>
<th>See Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>27A</td>
<td>$V_A$</td>
<td>27P</td>
<td>Figure 3.27</td>
</tr>
<tr>
<td>27B</td>
<td>$V_B$</td>
<td>OFF, 0.00–150.00 V secondary</td>
<td></td>
</tr>
<tr>
<td>27C</td>
<td>$V_C$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3P27</td>
<td>$27A \times 27B \times 27C$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>59A</td>
<td>$V_A$</td>
<td>59P</td>
<td></td>
</tr>
<tr>
<td>59B</td>
<td>$V_B$</td>
<td>OFF, 0.00–150.00 V secondary</td>
<td></td>
</tr>
<tr>
<td>59C</td>
<td>$V_C$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3P59</td>
<td>$59A \times 59B \times 59C$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27AB</td>
<td>$V_{AB}$</td>
<td>27PP</td>
<td>Figure 3.28</td>
</tr>
<tr>
<td>27BC</td>
<td>$V_{BC}$</td>
<td>OFF, 0.00–260.00 V secondary</td>
<td></td>
</tr>
<tr>
<td>27CA</td>
<td>$V_{CA}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Voltage Element (Relay Word bits)-table

<table>
<thead>
<tr>
<th>Voltage Element (Relay Word bits)</th>
<th>Operating Voltage</th>
<th>Pickup Setting/Range</th>
<th>See Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>59AB</td>
<td>$V_{AB}$</td>
<td>59PP</td>
<td></td>
</tr>
<tr>
<td>59BC</td>
<td>$V_{BC}$</td>
<td>OFF, 0.00–260.00 V secondary</td>
<td></td>
</tr>
<tr>
<td>59CA</td>
<td>$V_{CA}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>59N1</td>
<td>$3V_0$</td>
<td>59N1P</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(V_A + V_B + V_C)$</td>
<td>OFF, 0.00–150.00 V secondary</td>
<td></td>
</tr>
<tr>
<td>59N2</td>
<td>$3V_0$</td>
<td>59N2P</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(V_A + V_B + V_C)$</td>
<td>OFF, 0.00–150.00 V secondary</td>
<td></td>
</tr>
<tr>
<td>59Q</td>
<td>$V_1$</td>
<td>59QP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(V_A + aV_B + V_C)$</td>
<td>OFF, 0.00–100.00 V secondary</td>
<td></td>
</tr>
<tr>
<td>59V1</td>
<td>$V_1$</td>
<td>59V1P</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(V_A + aV_B + aV_C)$</td>
<td>OFF, 0.00–150.00 V secondary</td>
<td></td>
</tr>
<tr>
<td>27S</td>
<td>$V_S$</td>
<td>27SP</td>
<td>Figure 3.29</td>
</tr>
<tr>
<td>59S</td>
<td>$V_S$</td>
<td>59SP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OFF, 0.00–150.00 V secondary</td>
<td></td>
</tr>
</tbody>
</table>

### Accuracy

- **Pickup:** $\pm 1$ V and $\pm 5\%$ of setting
- **Transient Overreach:** $< 5\%$ of setting
Figure 3.27: Single-Phase and Three-Phase Voltage Elements
Figure 3.28: Phase-to-Phase and Sequence Voltage Elements
Figure 3.29: Channel VS Voltage Elements

Voltage Element Operation

Note that the voltage elements in Table 3.9 and Figure 3.27 through Figure 3.29 are a combination of “undervoltage” (Device 27) and “overvoltage” (Device 59) type elements. Undervoltage elements (Device 27) assert when the operating voltage goes below the corresponding pickup setting. Overvoltage elements (Device 59) assert when the operating voltage goes above the corresponding pickup setting.

Undervoltage Element Operation Example

Refer to Figure 3.27 (top of the figure).

Pickup setting 27P is compared to the magnitudes of the individual phase voltages $V_A$, $V_B$, and $V_C$. The logic outputs in Figure 3.27 are the following Relay Word bits:

\[
\begin{align*}
27A &= 1 \text{ (logical 1)}, \text{ if } V_A < \text{ pickup setting } 27P \\
 &= 0 \text{ (logical 0)}, \text{ if } V_A \geq \text{ pickup setting } 27P \\
27B &= 1 \text{ (logical 1)}, \text{ if } V_B < \text{ pickup setting } 27P \\
 &= 0 \text{ (logical 0)}, \text{ if } V_B \geq \text{ pickup setting } 27P \\
27C &= 1 \text{ (logical 1)}, \text{ if } V_C < \text{ pickup setting } 27P \\
 &= 0 \text{ (logical 0)}, \text{ if } V_C \geq \text{ pickup setting } 27P \\
3P27 &= 1 \text{ (logical 1)}, \text{ if all three Relay Word bits } 27A, 27B, \text{ and } 27C \text{ are asserted} \\
& \quad (27A = 1, 27B = 1, \text{ and } 27C = 1) \\
& = 0 \text{ (logical 0)}, \text{ if at least one of the Relay Word bits } 27A, 27B, \text{ or } 27C \text{ is deasserted} \\
& \quad (\text{e.g., } 27A = 0)
\end{align*}
\]

Overvoltage Element Operation Example

Refer to Figure 3.27 (bottom of the figure).

Pickup setting 59P is compared to the magnitudes of the individual phase voltages $V_A$, $V_B$, and $V_C$. The logic outputs in Figure 3.27 are the following Relay Word bits:

\[
\begin{align*}
59A &= 1 \text{ (logical 1)}, \text{ if } V_A > \text{ pickup setting } 59P \\
 &= 0 \text{ (logical 0)}, \text{ if } V_A \leq \text{ pickup setting } 59P
\end{align*}
\]
59B = 1 (logical 1), if $V_B >$ pickup setting 59P
   = 0 (logical 0), if $V_B \leq$ pickup setting 59P

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

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

**Synchronism Check Elements**

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

$$E25 = Y$$

Figure 2.12 and Figure 2.13 in *Section 2: Installation* show examples where synchronism check can be applied. Synchronism check voltage input VS is connected to a potential transformer secondary on one side of the circuit breaker, on any desired phase or between any two phases. The other synchronizing phase (VA, VB, VC, VAB, VBC, or VCA) taken from a potential transformer secondary on the other side of the circuit breaker is selected by setting SYNCP.

The two synchronism check elements use the same voltage magnitude window (to ensure healthy voltage) and slip frequency settings (see Figure 3.30). They have separate angle settings (see Figure 3.31).

**Fixed Angle Synchronism Check**

To implement a simple fixed-angle synchronism check scheme, set TCLOSD = OFF and 25SF = 0.500. With these settings, the synchronism check is performed as described in the top of Figure 3.31.

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

$$SV1 = 25A1$$
$$CL = CC + SV1T$$

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

**Dynamic Synchronism Check**

The remainder of this discussion assumes TCLOSD is not set to OFF. With TCLOSD not set to OFF, the synchronism check is performed as described in either the top or bottom of Figure 3.31, depending on the slip frequency.
If the voltages are static (voltages not slipping with respect to one another), the two synchronism check elements operate as shown in the top of Figure 3.31. The angle settings are checked for synchronism check closing.

If the voltages are not static (voltages slipping with respect to one another), the two synchronism check elements operate as shown in the bottom of Figure 3.31. The angle difference is compensated by breaker close time, and the breaker is ideally closed at a zero degree phase angle difference, to minimize system shock.

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

**Synchronism Check Elements Settings**

Table 3.10: Synchronism Check Elements Settings and Settings Ranges

<table>
<thead>
<tr>
<th>Setting</th>
<th>Definition</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>25VLO</td>
<td>low voltage threshold for “healthy voltage” window</td>
<td>0.00–150.00 V secondary</td>
</tr>
<tr>
<td>25VHI</td>
<td>high voltage threshold for “healthy voltage” window</td>
<td>0.00–150.00 V secondary</td>
</tr>
<tr>
<td>25SF</td>
<td>maximum slip frequency</td>
<td>0.005–0.500 Hz</td>
</tr>
<tr>
<td>25ANG1</td>
<td>synchronism check element 25A1 maximum angle</td>
<td>0°–80°</td>
</tr>
<tr>
<td>25ANG2</td>
<td>synchronism check element 25A2 maximum angle</td>
<td>0°–80°</td>
</tr>
<tr>
<td>SYNCP</td>
<td>synchronizing phase</td>
<td>VA, VB, VC, VAB, VBC, or VCA</td>
</tr>
<tr>
<td>TCLOSD</td>
<td>breaker close time for angle compensation</td>
<td>OFF, 1.00–60.00 cycles</td>
</tr>
<tr>
<td>BSYNCH</td>
<td>SELOGIC control equation that blocks synchronism check</td>
<td>Relay Word bits referenced in Tables 9.3 and 9.4</td>
</tr>
</tbody>
</table>

**Accuracy**

Voltage Pickup: ±1 V and ±5% of setting
Voltage Transient Overreach: < 5% of setting
Slip Pickup: ±0.003 Hz
Angle Pickup: ±4°
See bottom of Figure 3.31  
To Figure 3.31

Figure 3.30: Synchronism Check Voltage Window and Slip Frequency Elements
From Figure 3.30  See Figure 6.1

Figure 3.31: Synchronism Check Elements
**Synchronism Check Elements Voltage Inputs**

The two synchronism check elements use voltage inputs $V_p$ and $V_s$ for both elements:

- $V_p$: Phase input voltage ($V_{A^*}$, $V_{B^*}$, $V_{C^*}$, $V_{AB}$, $V_{BC}$, or $V_{CA}$), designated by setting SYNCP (e.g., if SYNCP = VB, then $V_p = V_p$)
- $V_s$: Synchronism check voltage, from SEL-311C Relay rear-panel voltage input VS

For example, if $V_p$ is designated as phase input voltage VB (setting SYNCP = VB), then rear-panel voltage input VS is connected to B-phase on the other side of the circuit breaker. The voltage across terminals VB-N is synchronism checked with the voltage across terminals VS-NS (see Figure 1.2 and Figures 2.12 and 2.13).

**System Frequencies Determined from Voltages $V_A$ and $V_s$**

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

**Synchronism Check Elements Operation**

Refer to Figure 3.30 and Figure 3.31.

**Voltage Window**

Refer to Figure 3.30.

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

- 59VP indicates that voltage $V_p$ is within voltage window setting limits 25VLO and 25VHI
- 59VS indicates that voltage $V_s$ is within voltage window setting limits 25VLO and 25VHI

As discussed previously, voltage $V_s$ determines the frequency on the voltage $V_p$ side of the circuit breaker. Voltage $V_s$ is also compared against voltage limits 25VLO and 25VHI to assure “healthy voltage” for frequency determination, with corresponding Relay Word bit output 59VA. If $V_p$ is a phase-to-phase voltage, $V_A$ is multiplied internally by $\sqrt{3}$ for the 25VLO and 25VHI checks.

**Other Uses for Voltage Window Elements**

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

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

Refer to Figure 3.30.

The synchronism check element slip frequency calculator runs if voltages $V_A$, $V_p$, and $V_s$ are healthy (59VA, 59VP, and 59VS asserted to logical 1) and the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). Setting BSYNCH is most commonly set to block synchronism check operation when the circuit breaker is closed (synchronism check is only needed when the circuit breaker is open):

- $\text{BSYNCH} = \text{IN101}$ (input IN101 connected to a breaker auxiliary 52a contact)
- $\text{BSYNCH} = \text{!IN101}$ (input IN101 connected to a breaker auxiliary 52b contact)

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

- $\text{BSYNCH} = ... + \text{TRIP}$

**Slip Frequency Calculator**

Refer to Figure 3.30.

The synchronism check element Slip Frequency Calculator in Figure 3.30 runs if voltages $V_p$, $V_s$, and $V_A$ are healthy (59VP, 59VS, and 59VA asserted to logical 1) and the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). The Slip Frequency Calculator output is:

- $\text{Slip Frequency} = f_p - f_s$ (in units of Hz = slip cycles/second)
- $f_p$ = frequency of voltage $V_p$ (in units of Hz = cycles/second) [determined from $V_A$]
- $f_s$ = frequency of voltage $V_s$ (in units of Hz = cycles/second)

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

For example, in Figure 3.30, if voltage $V_p$ has a frequency of 59.95 Hz and voltage $V_s$ has a frequency of 60.05 Hz, the difference between them is the slip frequency:

- $\text{Slip Frequency} = 59.95 \text{ Hz} - 60.05 \text{ Hz} = -0.10 \text{ Hz} = -0.10 \text{ slip cycles/second}$

The slip frequency in this example is negative, indicating that voltage $V_s$ is not “slipping” behind voltage $V_p$, but in fact “slipping” ahead of voltage $V_p$. In a time period of one second, the angular distance between voltage $V_p$ and voltage $V_s$ changes by 0.10 slip cycles, which translates into:

- $0.10 \text{ slip cycles/second} \times (360^\circ / \text{slip cycle}) \times 1 \text{ second} = 36^\circ$

Thus, in a time period of one second, the angular distance between voltage $V_p$ and voltage $V_s$ changes by 36 degrees.

The absolute value of the Slip Frequency output is run through a comparator and if the slip frequency is less than the maximum slip frequency setting, 25SF, Relay Word bit SF asserts to logical 1.
**Angle Difference Calculator**

The synchronism check element Angle Difference Calculator in Figure 3.31 runs if the slip frequency is less than the maximum slip frequency setting 25SF (Relay Word bit SF is asserted).

**Voltages \( V_p \) and \( V_s \) are "Static"**

Refer to top of Figure 3.31.

If the slip frequency is less than or equal to 0.005 Hz or TCLOSD = OFF, the Angle Difference Calculator does not take into account breaker close time—it presumes voltages \( V_p \) and \( V_s \) are “static” (not “slipping” with respect to one another). This would usually be the case for an open breaker with voltages \( V_p \) and \( V_s \) that are paralleled via some other electric path in the power system. The Angle Difference Calculator calculates the angle difference between voltages \( V_p \) and \( V_s \):

\[
\text{Angle Difference} = \left| \angle V_p - \angle V_s \right|
\]

**Voltages \( V_p \) and \( V_s \) are "Slipping"**

Refer to bottom of Figure 3.31.
Figure 3.32: Angle Difference Between $V_p$ and $V_s$, Compensated by Breaker Close Time
($f_p < f_S$ and $V_p$ Shown as Reference in This Example)
If the slip frequency is greater than 0.005 Hz, the Angle Difference Calculator takes the breaker close time into account with breaker close time setting TCLOSD (set in cycles; see Figure 3.32). The Angle Difference Calculator calculates the Angle Difference between voltages $V_p$ and $V_s$, compensated with the breaker close time:

$$\text{Angle Difference} = \left| (\angle V_p - \angle V_s) + [(f_p - f_s) \times \text{TCLOSD} \times \left(\frac{1\text{ second}}{60\text{ cycles}}\right) \times \left(\frac{360^\circ}{\text{slip cycle}}\right)] \right|$$

**Angle Difference Example (Voltages $V_p$ and $V_s$ are “Slipping”)**

Refer to bottom of Figure 3.31 and Figure 3.32.

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

$$\text{Angle Difference} = \left| (\angle V_p - \angle V_s) + [(f_p - f_s) \times \text{TCLOSD} \times \left(\frac{1\text{ second}}{60\text{ cycles}}\right) \times \left(\frac{360^\circ}{\text{slip cycle}}\right)] \right|$$

Intermediate calculations:

\[
\begin{align*}
(f_p - f_s) &= (59.95 \text{ Hz} - 60.05 \text{ Hz}) = -0.10 \text{ Hz} = -0.10 \text{ slip cycles/second} \\
\text{TCLOSD} \times \left(\frac{1\text{ second}}{60\text{ cycles}}\right) &= 10 \text{ cycles} \times \left(\frac{1\text{ second}}{60\text{ cycles}}\right) = 0.167 \text{ second}
\end{align*}
\]

Resulting in:

$$\text{Angle Difference} = \left| (\angle V_p - \angle V_s) + [-0.10 \times 0.167 \times 360^\circ] \right|$$

During the breaker close time (TCLOSD), the voltage angle difference between voltages $V_p$ and $V_s$ changes by 6 degrees. This 6 degree angle compensation is applied to voltage $V_s$, resulting in derived voltage $V_s^*$, as shown in Figure 3.32.

**Note:** The angle compensation in Figure 3.32 appears much greater than 6 degrees. Figure 3.32 is for general illustrative purposes only.

The top of Figure 3.32 shows the Angle Difference decreasing; $V_s^*$ is approaching $V_p$. Ideally, circuit breaker closing is initiated when $V_s^*$ is in phase with $V_p$ (Angle Difference = 0 degrees). When the circuit breaker main contacts finally close, $V_s$ is in phase with $V_p$, minimizing system shock.

The bottom of Figure 3.32 shows the Angle Difference increasing; $V_s^*$ is moving away from $V_p$. Ideally, circuit breaker closing is initiated when $V_s^*$ is in phase with $V_p$ (Angle Difference = 0 degrees). When the circuit breaker main contacts finally close, $V_s$ is in phase with $V_p$. But in this case, $V_s^*$ has already moved past $V_p$. In order to initiate circuit breaker closing when $V_s^*$ is in phase with $V_p$ (Angle Difference = 0 degrees), $V_s^*$ has to slip around another revolution, relative to $V_p$. 
Synchronism Check Element Outputs

Synchronism check element outputs (Relay Word bits 25A1 and 25A2 in Figure 3.31) assert to logical 1 for the conditions explained in the following text.

Voltages \( V_p \) and \( V_s \) are “Static”

Refer to top of Figure 3.31.

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

Voltages \( V_p \) and \( V_s \) are “Slipping”

Refer to bottom of Figure 3.31. If \( V_p \) and \( V_s \) are “slipping” with respect to one another, the Angle Difference (compensated by breaker close time TCLOSD) changes through time. Synchronism check element 25A1 or 25A2 asserts to logical 1 for any one of the following three scenarios.

1. The top of Figure 3.32 shows the Angle Difference decreasing—\( V_s^* \) is approaching \( V_p \). When \( V_s^* \) is in phase with \( V_p \) (Angle Difference = 0 degrees), synchronism check elements 25A1 and 25A2 assert to logical 1.

2. The bottom of Figure 3.32 shows the Angle Difference increasing—\( V_s^* \) is moving away from \( V_p \). \( V_s^* \) was in phase with \( V_p \) (Angle Difference = 0 degrees), but has now moved past \( V_p \). If the Angle Difference is increasing, but the Angle Difference is still less than maximum angle settings 25ANG1 or 25ANG2, then corresponding synchronism check elements 25A1 or 25A2 assert to logical 1.

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

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

Refer to the bottom of Figure 6.2 in Section 6: Close and Reclose Logic. If timer 79CLSD is set greater than zero (e.g., 79CLSD = 60.00 cycles) and it times out without SELOGIC control equation setting 79CLS (Reclose Supervision) asserting to logical 1, the relay goes to the Lockout State (see top of Figure 6.3).

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

Refer to the top of Figure 3.32. Ideally, circuit breaker closing is initiated when \( V_s^* \) is in phase with \( V_p \) (Angle Difference = 0 degrees). Then when the circuit breaker main contacts finally close, \( V_s \) is in phase with \( V_p \), minimizing system shock. But with time limitations
imposed by timer 79CLSD, this may not be possible. To try to avoid going to the Lockout State, the following logic is employed:

If 79CLS has not asserted to logical 1 while timer 79CLSD is timing (or timer 79CLSD is set to zero and only one check of 79CLS is made), the synchronism check logic at the bottom of Figure 3.31 becomes less restrictive at the “instant” timer 79CLSD is going to time out (or making the single check). It drops the requirement of waiting until the decreasing Angle Difference ($V_s^*$ approaching $V_p$) brings $V_s^*$ in phase with $V_p$ (Angle Difference $= 0$ degrees). Instead, it just checks to see that the Angle Difference is less than angle settings 25ANG1 or 25ANG2.

If the Angle Difference is less than angle setting 25ANG1 or 25ANG2, then the corresponding Relay Word bit, 25A1 or 25A2, asserts to logical 1 for 1/4 cycle.

For example, if SELOGIC control equation setting 79CLS (Reclose Supervision) is set as follows:

$$79CLS = 25A1 + ...$$

and the angle difference is less than angle setting 25ANG1 at that “instant,” setting 79CLS asserts to logical 1 for 1/4 cycle, allowing the sealed-in open interval time-out to propagate on to the close logic in Figure 6.1 in Section 6: Close and Reclose Logic. Element 25A2 operates similarly.

**Synchronism Check Applications for Automatic Reclosing and Manual Closing**

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

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

$$e.g., \ 79CLS = 25A1 + ... \quad (see \ Figure \ 6.2)$$

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

$$e.g., \ CL = IN106 \times (25A2 + ... \ ) \quad (see \ Figure \ 6.1)$$

In this example, the angular difference across the circuit breaker can be greater for a manual close (25 degrees) than for an automatic reclose (15 degrees).

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

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

\[ E81 = \text{N (none), 1 through 6} \]

as shown in Figure 3.34. Frequency is determined from the connections to voltage terminals VA-N, VS, and positive-sequence current.

**Frequency Element Settings**

![Diagram of Frequency Element Settings]

*Fig. 3.33: Undervoltage Block for Frequency Elements*
Figure 3.34: Levels 1 Through 6 Frequency Elements
Table 3.11: Frequency Elements Settings and Settings Ranges

<table>
<thead>
<tr>
<th>Setting</th>
<th>Definition</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>27B81P</td>
<td>undervoltage frequency element block</td>
<td>20.00–150.00 V secondary (wye-connected voltages, {150 V voltage inputs})</td>
</tr>
<tr>
<td>81D1P</td>
<td>frequency element 1 pickup</td>
<td>OFF, 40.10–65.00 Hz</td>
</tr>
<tr>
<td>81D1D</td>
<td>frequency element 1 time delay</td>
<td>2.00–16000.00 cycles, in 0.25-cycle steps</td>
</tr>
<tr>
<td>81D2P</td>
<td>frequency element 2 pickup</td>
<td>OFF, 40.10–65.00 Hz</td>
</tr>
<tr>
<td>81D2D</td>
<td>frequency element 2 time delay</td>
<td>2.00–16000.00 cycles, in 0.25-cycle steps</td>
</tr>
<tr>
<td>81D3P</td>
<td>frequency element 3 pickup</td>
<td>OFF, 40.10–65.00 Hz</td>
</tr>
<tr>
<td>81D3D</td>
<td>frequency element 3 time delay</td>
<td>2.00–16000.00 cycles, in 0.25-cycle steps</td>
</tr>
<tr>
<td>81D4P</td>
<td>frequency element 4 pickup</td>
<td>OFF, 40.10–65.00 Hz</td>
</tr>
<tr>
<td>81D4D</td>
<td>frequency element 4 time delay</td>
<td>2.00–16000.00 cycles, in 0.25-cycle steps</td>
</tr>
<tr>
<td>81D5P</td>
<td>frequency element 5 pickup</td>
<td>OFF, 40.10–65.00 Hz</td>
</tr>
<tr>
<td>81D5D</td>
<td>frequency element 5 time delay</td>
<td>2.00–16000.00 cycles, in 0.25-cycle steps</td>
</tr>
<tr>
<td>81D6P</td>
<td>frequency element 6 pickup</td>
<td>OFF, 40.10–65.00 Hz</td>
</tr>
<tr>
<td>81D6D</td>
<td>frequency element 6 time delay</td>
<td>2.00–16000.00 cycles, in 0.25-cycle steps</td>
</tr>
</tbody>
</table>

**Accuracy**

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

**Create Over- and Underfrequency Elements**

Refer to Figure 3.34.

Note that pickup settings 81D1P through 81D6P are compared to setting NFREQ. NFREQ is the nominal frequency setting (a global setting), set to 50 or 60 Hz.
Overfrequency Element

For example, make settings:

\[
\begin{align*}
\text{NFREQ} & = 60 \text{ Hz} \quad \text{(nominal system frequency is 60 Hz)} \\
E81 & \geq 1 \quad \text{(enable frequency element 1)} \\
81D1P & = 61.25 \text{ Hz.} \quad \text{(frequency element 1 pickup)}
\end{align*}
\]

With these settings: \(81D1P \geq \text{NFREQ}\)

the overfrequency part of frequency element 1 logic is enabled. 81D1 and 81D1T operate as overfrequency elements. 81D1 is used in testing only.

Underfrequency Element

For example, make settings:

\[
\begin{align*}
\text{NFREQ} & = 60 \text{ Hz} \quad \text{(nominal system frequency is 60 Hz)} \\
E81 & \geq 2 \quad \text{(enable frequency element 2)} \\
81D2P & = 59.65 \text{ Hz} \quad \text{(frequency element 2 pickup)}
\end{align*}
\]

With these settings: \(81D2P < \text{NFREQ}\)

the underfrequency part of frequency element 2 logic is enabled. 81D2 and 81D2T operate as underfrequency elements. 81D2 is used in testing only.

Frequency Element Operation

Refer to Figure 3.34.

Overfrequency Element Operation

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

\[
\begin{align*}
81D1 & = \text{logical 0} \quad \text{(instantaneous element)} \\
81D1T & = \text{logical 0} \quad \text{(time delayed element)}
\end{align*}
\]

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

\[
\begin{align*}
81D1 & = \text{logical 1} \quad \text{(instantaneous element)} \\
81D1T & = \text{logical 1} \quad \text{(time delayed element)}
\end{align*}
\]

Relay Word bit 81D1T asserts to logical 1 only after time delay 81D1D.
**Underfrequency Element Operation**

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

\[
\begin{align*}
81D2 &= \text{logical 1} \quad \text{(instantaneous element)} \\
81D2T &= \text{logical 1} \quad \text{(time delayed element)}
\end{align*}
\]

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

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

\[
\begin{align*}
81D2 &= \text{logical 0} \quad \text{(instantaneous element)} \\
81D2T &= \text{logical 0} \quad \text{(time delayed element)}
\end{align*}
\]

**Frequency Element Voltage Control**

Refer to Figure 3.33 and Figure 3.34.

Note that all six frequency elements are controlled by the same undervoltage element (Relay Word bit 27B81). Relay Word bit 27B81 asserts to logical 1 and blocks the frequency element operation if any voltage (V_a, V_b, or V_c) goes below voltage pickup 27B81P. This control prevents erroneous frequency element operation following fault inception.

**Other Uses for Undervoltage Element 27B81**

If voltage pickup setting 27B81P is applicable to other control schemes, Relay Word bit 27B81 can be used in other logic at the same time it is used in the frequency element logic.

If frequency elements are not being used, Relay Word bit 27B81 can still be used in other logic, with voltage setting 27B81P set as desired. Enable the frequency elements (setting E81 ≥ 1) and make setting 27B81P. Apply Relay Word bit 27B81 in desired logic scheme, using SELOGIC Control Equations. Even though frequency elements are enabled, the frequency element outputs (Relay Word bits 81D1T through 81D6T) do not have to be used.

**Frequency Element Uses**

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

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

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

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.

Figure 4.1: Loss-of-Potential Logic
Loss-of-potential is declared (Relay Word bit LOP = logical 1) when a 10 percent drop in V₁ is detected, with no corresponding change in I₁ or I₀. If the LOP condition persists for 60 cycles, it latches in. LOP resets (Relay Word bit LOP = logical 0) when V₁ returns above 50 V secondary and V₀ 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 3.12).

LOP is disabled while 3PO is asserted (breaker open). If an input potential is lost during this time, LOP will not assert when 3PO deasserts (breaker close) since the 10 percent drop in V₁ has already occurred. This is the case for systems using either line-side or bus-side potential transformers.

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

\[
SV1 = 3PO \\
OUT105 = !3P59 * SV1T + LOP
\]

See Figure 3.27. Relay Word bit 3P59 asserts when A-phase, B-phase, and C-phase voltage magnitudes are greater than setting 59P. Setting 59P should be at least 80 percent of nominal voltage. Relay Word bit 3PO asserts when the circuit breaker is open. Set SV1PU longer than the reclose open-time interval. In this expression, if any phase voltage is less than setting 59P while the circuit breaker is open, or LOP is asserted, the expression is true (logical 1).

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

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

**Setting ELOP = Y or Y1**

If setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit LOP asserts to logical 1), negative-sequence voltage-polarized, zero-sequence voltage-polarized, and positive-sequence voltage-polarized directional elements, plus all distance elements, are disabled by relay word bit ILOP (see Figure 4.9, Figure 4.10, Figure 4.14, Figure 4.15, and Figure 3.4 through Figure 3.12). The loss-of-potential condition makes these voltage-polarized directional elements and distance elements unreliable. Thus, they are disabled. The overcurrent elements controlled by these voltage-polarized directional elements are disabled also (unless overridden by conditions explained in the following Setting ELOP = Y discussion).

In Figure 4.11, the assertion of ILOP is an additional enable for the channel IP current-polarized directional element. This directional element is not voltage polarized and is automatically enabled during LOP conditions if ELOP = Y or Y1.

In Figure 5.6, if setting ELOP = Y1 and LOP asserts, keying and echo keying in the permissive overreaching transfer trip (POTT) logic are blocked.
Setting ELOP = Y

Additionally, if setting ELOP = Y and a loss-of-potential condition occurs (Relay Word bit LOP asserts to logical 1), overcurrent elements set direction forward are enabled (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-311C detects CCVT transients that may cause Zone 1 distance overreach. If CCVT transient blocking is enabled (setting ECCVT = Y), and the relay detects a 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-311C Relay uses distance-calculation smoothness detection to override the tripping delay caused by low voltage and low current. Distance elements operate without significant delay for close-in faults.

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

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

CCVT transients may be aggravated when you have:

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

For a description of CCVT transients and transient detection, see the following technical paper available on the SEL website or FaxBack system: Capacitive Voltage Transformer: Transient Overreach Concerns and Solutions for Distance Relaying.
Figure 4.2: CCVT Transient Blocking Logic

**LOAD-ENCROACHMENT LOGIC**

The load-encroachment logic (see Figure 4.3) and settings are enabled/disabled with setting ELOAD (= Y or N).

The load-encroachment feature allows distance and phase overcurrent elements to be set independent of load levels. Relay Word bit ZLOAD is used to block the positive-sequence, voltage-polarized directional element (see Figure 4.15), which may assert for three-phase load. The distance elements, M1P through M4P, will not operate without directional control. Set !ZLOAD in the phase overcurrent torque control equation to block phase overcurrent operation.
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, $I_1 = \text{phase current magnitude}$.

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:

\[ \text{ZLOAD} = \text{ZLOUT} + \text{ZLIN} \]

**Settings Ranges**

Refer to Figure 4.3.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description and Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZLF</td>
<td><strong>Forward Minimum Load Impedance</strong>—corresponding to maximum load flowing out 0.05–64.00 Ω secondary (5 A nominal phase current inputs, IA, IB, IC)</td>
</tr>
<tr>
<td>ZLR</td>
<td><strong>Reverse Minimum Load Impedance</strong>—corresponding to maximum load flowing in 0.25–320.00 Ω secondary (1 A nominal phase current inputs, IA, IB, IC)</td>
</tr>
<tr>
<td>PLAF</td>
<td><strong>Maximum Positive Load Angle Forward</strong> (-90° to +90°)</td>
</tr>
<tr>
<td>NLAF</td>
<td><strong>Maximum Negative Load Angle Forward</strong> (-90° to +90°)</td>
</tr>
<tr>
<td>PLAR</td>
<td><strong>Maximum Positive Load Angle Reverse</strong> (+90° to +270°)</td>
</tr>
<tr>
<td>NLAR</td>
<td><strong>Maximum Negative Load Angle Reverse</strong> (+90° to +270°)</td>
</tr>
</tbody>
</table>

**Load-Encroachment Setting Example**

Example system conditions:

- Nominal Line-Line Voltage: 230 kV
- Maximum Forward Load: 800 MVA
- Maximum Reverse Load: 500 MVA
- Power Factor (Forward Load): 0.90 lag to 0.95 lead
- Power Factor (Reverse Load): 0.80 lag to 0.95 lead
- CT ratio: 2000/5 = 400
- PT ratio: 134000/67 = 2000

The PTs are connected line-to-neutral.

**Convert Maximum Loads to Equivalent Secondary Impedances**

Start with maximum forward load:

- 800 MVA \( \times (1/3) = 267 \text{ MVA per phase} \)
- 230 kV \( \times (1/\sqrt{3}) = 132.8 \text{ kV line-to-neutral} \)
- 267 MVA \( \times (1 / 132.8 \text{ kV}) = 2010 \text{ A primary} \)
- 2010 A primary \( \times (1 / \text{CT ratio}) = 2010 \text{ A primary} \times (1 \text{ A secondary} / 400 \text{ A primary}) \)
  \[= 5.03 \text{ A secondary} \]
- 132.8 kV \( \times (1000 \text{ V} / \text{kV}) = 132800 \text{ V primary} \)
- 132800 V primary \( \times (1 / \text{PT ratio}) = 132800 \text{ V primary} \times (1 \text{ V secondary} / 2000 \text{ V primary}) \)
  \[= 66.4 \text{ V secondary} \]
Now, calculate the equivalent secondary impedance:

\[
\frac{66.4 \, \text{V secondary}}{5.03 \, \text{A secondary}} = 13.2 \, \Omega \text{ secondary}
\]

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

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

Again, for the maximum forward load:

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

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

\[
\text{ZLF} = 13.2 \, \Omega \text{ secondary} \cdot 0.9 = 11.90 \, \Omega \text{ secondary}
\]

For the maximum reverse load:

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

Again, to provide a margin for setting ZLR:

\[
\text{ZLR} = 21.1 \, \Omega \text{ secondary} \cdot 0.9 = 19.00 \, \Omega \text{ secondary}
\]

**Convert Power Factors to Equivalent Load Angles**

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

- Setting PLAF = \(\cos^{-1}(0.90) = 26^\circ\)
- Setting NLAF = \(\cos^{-1}(0.95) = -18^\circ\)

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

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

\[
\text{ZLOAD} = \text{ZLOUT} + \text{ZLIN}
\]
Refer to Figure 4.4. In a load condition, the apparent positive-sequence impedance is within the ZLOUT area, resulting in:

\[ Z_{LOAD} = Z_{LOUT} + Z_{LIN} = \text{logical } 1 + Z_{LIN} = \text{logical } 1 \]

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

\[ Z_{LOAD} = Z_{LOUT} + Z_{LIN} = \text{logical } 0 + \text{logical } 0 = \text{logical } 0 \]

Refer to Figure 3.22 in Section 3: Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements. To prevent phase time-overcurrent element 51PT from operating for high load conditions, make the following SELOGIC® control equation torque control setting:

\[ 51PTC = \neg Z_{LOAD} \]

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

\[ 51PTC = \neg(\text{logical } 1) = \text{NOT( logical } 1) = \text{logical } 0 \]

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

\[ 51PTC = \neg Z_{LOAD} = \neg(\text{logical } 0) = \text{NOT( logical } 0) = \text{logical } 1 \]
Use SEL-321 Relay Application Guide for the SEL-311C Relay

The load-encroachment logic and settings in the SEL-311C 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-311C 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
Figure 4.5: General Logic Flow of Directional Control for Ground Distance and Residual Ground Overcurrent Elements

Figure 4.5 gives an overview of how these directional elements are enabled and routed to control the ground distance and residual ground overcurrent elements.

Note in Figure 4.5 that setting ORDER enables the directional elements. Setting ORDER can be set with any combination of Q, V, and I. They have the following correspondence to the directional elements:

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

The order in which these directional elements are listed in setting ORDER determines the priority in which they operate to provide Best Choice Ground Directional™ logic control. See discussion on setting ORDER in the following subsection Directional Control Settings.
**Directional Element Enables**

Refer to Figure 4.5, Figure 4.6, and Figure 4.7.

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

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

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

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

**Best Choice Ground Directional Logic**

Refer to Figure 4.5 and Figure 4.8.

Relay Word bits 32QGE, 32VE, and 32IE and setting ORDER are used in the Best Choice Ground Directional logic in Figure 4.8. The Best Choice Ground Directional logic determines the order in which the directional element should be enabled to operate. The ground distance and residual ground overcurrent elements set for directional control are then controlled by this directional element.

**Directional Elements**

Refer to Figure 4.5, Figure 4.9, Figure 4.10, and Figure 4.11.

The enable output of Best Choice Ground Directional logic in Figure 4.8 determines which directional element will run.

Additionally, note that if enable setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit ILOP asserts), the negative-sequence voltage-polarized and zero-sequence voltage-polarized directional elements are disabled (see Figure 4.9 and Figure 4.10).

The channel IP current-polarized directional element does not use voltage in making direction decisions, thus a loss-of-potential condition does not disable the element, but rather aids in enabling it. When the internal enable 32IE is asserted, the channel IP current-polarized directional element (Figure 4.11) is enabled if enable setting ELOP = Y or Y1 and a loss-of-potential condition occurs (Relay Word bit ILOP asserts).

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

**Directional Element Routing**

Refer to Figure 4.5 and Figure 4.12.

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

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

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

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

As detailed in Figure 4.9 and Figure 4.10, voltage-based directional elements are disabled during a loss-of-potential condition. Thus, the overcurrent elements that are directionally controlled by these voltage-based directional elements are disabled also. But this disable condition is overridden if setting ELOP = Y.

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

As shown in Figure 3.4 through Figure 3.12, ILOP also disables all ground distance elements.
**Figure 4.6: Internal Enables (32QE and 32QGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements**

1. From Figure 4.7
2. To Figure 4.9
3. To Figure 4.14
Figure 4.7: Internal Enables (32VE and 32IE) Logic for Zero-Sequence Voltage-Polarized and Channel IP Current-Polarized Directional Elements

① To Figure 4.10  ③ To Figure 4.6
② To Figure 4.11  ④ To Figure 4.8
Figure 4.8: Best Choice Ground Directional Logic

① From Figure 4.6  ④ Figure 4.10
② From Figure 4.7  ⑤ Figure 4.11
③ Figure 4.9
Figure 4.9: Negative-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements

From Figure 4.6  From Figure 4.8
From Figure 4.1  To Figure 4.12
Figure 4.10: Zero-Sequence Voltage-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements
Figure 4.11: Channel IP Current-Polarized Directional Element for Ground Distance and Residual Ground Overcurrent Elements

Forward Threshold
Forward Threshold = \((\text{channel } I_{\text{F nominal rating}}) \times (\text{phase channels nominal rating}) \times (0.05)^2\)

Reverse Threshold
Reverse Threshold = \(-(\text{channel } I_{\text{R nominal rating}}) \times (\text{phase channels nominal rating}) \times (0.05)^2\)

1. From Figure 4.7
2. From Figure 4.1
3. From Figure 4.8
4. To Figure 4.12
Figure 4.12: Ground Distance and Residual Ground Directional Logic

1. From Figure 4.1
2. From Figure 4.7
3. From Figure 4.9
4. From Figure 4.10
5. From Figure 4.11
6. To Figure 3.7–Figure 3.12 and Figure 3.22
**Directional Control for Phase Distance and Negative-Sequence Elements**

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

Negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements control the phase distance elements. The negative-sequence voltage-polarized directional element operates for unbalanced faults, while the positive-sequence voltage-polarized directional element operates for three-phase faults. Figure 4.13 gives an overview of how the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements are enabled and routed.

**Internal Enables**

Refer to Figure 4.6 and Figure 4.13.

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

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

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

If enable setting \( ELOP = Y \) or \( Y1 \) and a loss-of-potential condition occurs (Relay Word bit LOP asserts), the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements and the phase distance elements are disabled by ILOP (see Figure 4.14 and Figure 4.15).

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

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

Note in Figure 4.15 that the assertion of ZLOAD disables the positive-sequence voltage-polarized directional element. ZLOAD asserts when the relay is operating in a user-defined load region (see Figure 4.3).

Directional Element Routing

Refer to Figure 4.13 and Figure 4.14.

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

Loss-of-Potential

Note if both the following are true:

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

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

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

As shown in Figure 3.4 through Figure 3.6, ILOP also disables all phase distance elements.
From Figure 4.1  

To Figure 3.4, Figure 3.5, Figure 3.6, and Figure 3.23

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

\[
E32 = \text{AUTO}
\]

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

- Z2F, Z2R, 50QFP, 50QRP, a2, k2, 50GFP, 50GRP, a0, Z0F, and Z0R

Once these settings are calculated automatically, they can only be modified if the user goes back and changes the directional control enable setting to \(E32 = Y\).
The remaining directional control settings are **not** set automatically if setting E32 = AUTO. They have to be set by the user, whether setting E32 = AUTO or Y. These settings are:

\[ \text{DIR3, DIR4, ORDER, and E32IV} \]

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

**Settings**

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

**DIR3—Zone 3-Level 3 Element Direction Setting**

**DIR4—Zone 4-Level 4 Element Direction Setting**

Setting Range:

\[ \begin{align*}
\text{F} &= \text{Direction Forward} \\
\text{R} &= \text{Direction Reverse}
\end{align*} \]

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

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

<table>
<thead>
<tr>
<th>Level Direction Settings</th>
<th>Phase Distance</th>
<th>Ground Distance</th>
<th>Residual Ground</th>
<th>Negative-Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward</td>
<td>M1P (3.4)</td>
<td>Z1G (3.7)</td>
<td>67G1 (3.22)</td>
<td>67Q1 (3.23)</td>
</tr>
<tr>
<td></td>
<td>M1PT (3.16)</td>
<td>Z1GT (3.16)</td>
<td>67G1T (3.22)</td>
<td></td>
</tr>
<tr>
<td>Forward</td>
<td>M2P (3.5)</td>
<td>Z2G (3.8)</td>
<td>67G2 (3.22)</td>
<td>67Q2 (3.23)</td>
</tr>
<tr>
<td></td>
<td>M2PT (3.16)</td>
<td>Z2GT (3.16)</td>
<td>67G2T (3.22)</td>
<td></td>
</tr>
<tr>
<td>DIR3 = F or R</td>
<td>M3P (3.6)</td>
<td>Z3G (3.9)</td>
<td>67G3 (3.22)</td>
<td>67Q3 (3.23)</td>
</tr>
<tr>
<td></td>
<td>M3PT (3.16)</td>
<td>Z3GT (3.16)</td>
<td>67G3T (3.22)</td>
<td></td>
</tr>
<tr>
<td>DIR4 = F or R</td>
<td>M4P (3.6)</td>
<td>Z4G (3.9)</td>
<td>67G4 (3.22)</td>
<td>67Q4 (3.23)</td>
</tr>
<tr>
<td></td>
<td>M4PT (3.16)</td>
<td>Z4GT (3.16)</td>
<td>67G4T (3.22)</td>
<td></td>
</tr>
</tbody>
</table>

Most communications-assisted trip schemes set with Zone 3-Level 3 element direction reverse (DIR3 = R).

**ORDER—Ground Directional Element Priority Setting**

Setting Range:

\[ \begin{align*}
\text{Q} &= \text{Negative-sequence voltage-polarized directional element} \\
\text{V} &= \text{Zero-sequence voltage-polarized directional element} \\
\text{I} &= \text{Channel IP current-polarized directional element}
\end{align*} \]
Setting ORDER can be set with any combination of Q, V, and I. The order in which these directional elements are listed determines the priority in which they operate to provide Best Choice Ground Directional logic control. See Figure 4.8.

For example, if setting:

ORDER = QV

then the first listed directional element (Q = negative-sequence voltage-polarized directional element; see Figure 4.9) is the first priority directional element to provide directional control for the ground distance and residual ground overcurrent elements.

If the negative-sequence voltage-polarized directional element is not operable (i.e., it does not have sufficient operating quantity as indicated by its internal enable, 32QGE, not being asserted), then the second listed directional element (V = zero-sequence voltage-polarized directional element; see Figure 4.10) provides directional control for the ground distance and residual ground overcurrent elements.

Another example, if setting:

ORDER = V

then the zero-sequence voltage-polarized directional element (V = zero-sequence voltage-polarized directional element; see Figure 4.10) provides directional control for the ground distance and residual ground overcurrent elements all the time.

Setting ORDER can be set with any element combination (e.g., ORDER = IQV, ORDER = QVI, ORDER = IV, ORDER = VQ, ORDER = I, ORDER = Q).

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

<table>
<thead>
<tr>
<th>Setting XGPOL</th>
<th>First Element of ORDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1G</td>
<td>Q or V</td>
</tr>
<tr>
<td>12</td>
<td>Q</td>
</tr>
</tbody>
</table>

**Z2F—Forward Directional Z2 Threshold**

**Z2R—Reverse Directional Z2 Threshold**

Setting Range:

-64.00 to 64.00 \( \Omega \) secondary (5 A nominal phase current inputs, IA, IB, IC)
-320.00 to 320.00 \( \Omega \) secondary (1 A nominal phase current inputs, IA, IB, IC)

Z2F and Z2R are used to calculate the Forward and Reverse Thresholds, respectively, for the negative-sequence voltage-polarized directional elements (see Figure 4.9 and Figure 4.14).

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

If configuration setting E32 = AUTO, settings Z2F and Z2R (negative-sequence impedance values) are calculated automatically, using the positive-sequence line impedance magnitude setting Z1MAG as follows:

\[
\begin{align*}
Z2F &= \frac{Z1MAG}{2} \quad (\Omega \text{ secondary}) \\
Z2R &= \frac{Z1MAG}{2} + 0.1 \quad (\Omega \text{ secondary; 5A nominal}) \\
Z2R &= \frac{Z1MAG}{2} + 0.5 \quad (\Omega \text{ secondary; 1A nominal})
\end{align*}
\]

50QFP—Forward Directional Negative-Sequence Current Pickup

50QRP—Reverse Directional Negative-Sequence Current Pickup

Setting Range:

- 0.25–5.00 A secondary (5 A nominal phase current inputs, IA, IB, IC)
- 0.05–1.00 A secondary (1 A nominal phase current inputs, IA, IB, IC)

The 50QFP setting (3I2 current value) is the pickup for the forward fault detector 50QF of the negative-sequence voltage-polarized directional elements (see Figure 4.6). Ideally, the setting is above normal load unbalance and below the lowest expected negative-sequence current magnitude for unbalanced forward faults.

The 50QRP setting (3I2 current value) is the pickup for the reverse fault detector 50QR of the negative-sequence voltage-polarized directional elements (see Figure 4.6). Ideally, the setting is above normal load unbalance and below the lowest expected negative-sequence current magnitude for unbalanced reverse faults.

50QFP and 50QRP Set Automatically

If configuration setting E32 = AUTO, settings 50QFP and 50QRP are set automatically at:

- 50QFP = 0.50 A secondary (5 A nominal phase current inputs, IA, IB, IC)
- 50QRP = 0.25 A secondary (5 A nominal phase current inputs, IA, IB, IC)
- 50QFP = 0.10 A secondary (1 A nominal phase current inputs, IA, IB, IC)
- 50QRP = 0.05 A secondary (1 A nominal phase current inputs, IA, IB, IC)

a2—Positive-Sequence Current Restraint Factor, I2/I1

Setting Range:

- 0.02–0.50 (unitless)

Refer to Figure 4.6.

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

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

\[ a2 = 0.1 \]

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

**k2—Zero-Sequence Current Restraint Factor, \( I_2/I_0 \)**

Setting Range:

\[ 0.10–1.20 \] (unitless)

Note the directional enable logic outputs in Figure 4.6:

- 32QE enable for the negative-sequence voltage-polarized directional element that controls the phase distance and negative-sequence overcurrent elements
- 32QGE enable for the negative-sequence voltage-polarized directional element that controls the ground distance and residual ground overcurrent elements

The k2 factor is applied to enable 32QGE. The negative-sequence current (\( I_2 \)) magnitude has to be greater than the zero-sequence current (\( I_0 \)) magnitude multiplied by k2 in order for the 32QGE enable (and following negative-sequence voltage-polarized directional element in Figure 4.9) to be enabled:

\[ |I_2| > k_2 \cdot |I_0| \]

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

If both of the internal enables:

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

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

**k2 Set Automatically**

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

\[ k2 = 0.2 \]

For setting \( k2 = 0.2 \), the negative-sequence current (\( I_2 \)) magnitude has to be greater than 1/5 of the zero-sequence current (\( I_0 \)) magnitude in order for the negative-sequence voltage-polarized directional elements to be enabled (\( |I_2| > 0.2 \cdot |I_0| \)). Again, this presumes at least one of the enables 32VE or 32IE is asserted.
**50GFP—Forward Directional Residual Ground Current Pickup**

**50GRP—Reverse Directional Residual Ground Current Pickup**

Setting Range:
- 0.25–5.00 A secondary (5 A nominal phase current inputs, IA, IB, IC)
- 0.05–1.00 A secondary (1 A nominal phase current inputs, IA, IB, IC)

If preceding setting ORDER does not contain V or I (no zero-sequence voltage-polarized or channel IP current-polarized directional elements are enabled), then settings 50GFP and 50GRP are not made or displayed.

The 50GFP setting (3I₀ current value) is the pickup for the forward fault detector 50GF of the zero-sequence voltage-polarized and channel IP current-polarized directional elements (see Figure 4.7). Ideally, the setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced forward faults.

The 50GRP setting (3I₀ current value) is the pickup for the reverse fault detector 50GR of the zero-sequence voltage-polarized and channel IP current-polarized directional elements (see Figure 4.7). Ideally, the setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced reverse faults.

**50GFP and 50GRP Set Automatically**

If configuration setting E32 = AUTO, settings 50GFP and 50GRP are set automatically at:
- 50GFP = 0.50 A secondary (5 A nominal phase current inputs, IA, IB, IC)
- 50GRP = 0.25 A secondary (5 A nominal phase current inputs, IA, IB, IC)
- 50GFP = 0.10 A secondary (1 A nominal phase current inputs, IA, IB, IC)
- 50GRP = 0.05 A secondary (1 A nominal phase current inputs, IA, IB, IC)

**a₀—Positive-Sequence Current Restraint Factor, I₀/I₁**

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 \( (|I_0| > 0.1 \cdot |I_1|) \).

Z0F—Forward Directional Z0 Threshold

Z0R—Reverse Directional Z0 Threshold

Setting Range:

-64.00 to 64.00 \( \Omega \) secondary (5 A nominal phase current inputs, IA, IB, IC)

-320.00 to 320.00 \( \Omega \) secondary (1 A nominal phase current inputs, IA, IB, IC)

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

Z0F and Z0R are used to calculate the Forward and Reverse Thresholds, respectively, for the zero-sequence voltage-polarized directional elements (see Figure 4.10).

If configuration setting E32 = Y, settings Z0F and Z0R (zero-sequence impedance values) are calculated by the user and entered by the user, but setting Z0R must be greater in value than setting Z0F by 0.1 \( \Omega \) (5A nominal) or 0.5 \( \Omega \) (1A nominal).

Z0F and Z0R Set Automatically

If configuration setting E32 = AUTO, settings Z0F and Z0R (zero-sequence impedance values) are calculated automatically, using the zero-sequence line impedance magnitude setting Z0MAG as follows:

\[
\begin{align*}
Z0F &= Z0MAG/2 \\
Z0R &= Z0MAG/2 + 0.1 \\
Z0R &= Z0MAG/2 + 0.5
\end{align*}
\]

(\( \Omega \) 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:

\[ E32IV = 1 \] (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-311C Relay:

\[ E32IV = \text{IN106} \]  
(52a connected to optoisolated input IN106)

Almost any desired control can be set in SELOGIC control equation setting E32IV.

**Overcurrent Directional Control Provided by Torque Control Settings**

Directional and additional control for phase, ground and negative-sequence overcurrent elements is available with SELOGIC torque control settings. Elements that do not have directional control, such as 67P1, may be directionally controlled with SELOGIC control equations.

For example, the SELOGIC control equation

\[ 67P1TC = M2P \]

will enable 67P1 and 67P1T when the Zone 2 phase distance element asserts (forward).

The default settings for all torque control equations is logic “1”, or “enabled”. Torque control equations may not be set directly to logic “0”.

**Table 4.2: Torque Control Settings and Elements**

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<th>Directional and Additional Control Settings</th>
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SECTION 5: TRIP AND TARGET LOGIC

TRIP LOGIC

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

TRCOMM Communications-Assisted Trip Conditions.

Setting TRCOMM is supervised by communications-assisted trip logic. See Communications-Assisted Trip Logic—General Overview later in this section for more information on communications-assisted tripping.

DTT Direct Transfer Trip Conditions.

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

Although setting TR is also unsupervised, setting DTT is provided separately from setting TR for target LED purposes. (COMM target LED on the front panel illuminates when DTT asserts to logical 1; see COMM target LED discussion in the Front-Panel Target LEDs subsection at the end of this section).

Typical settings for DTT are:

\[
\text{DTT} = \text{IN106} \text{ or } \text{DTT} = \text{RMB1A}
\]

where input IN106 is connected to the output of direct transfer trip communications equipment or receive MIRRORED BIT RMB1A is asserted by the transfer trip condition in a remote SEL relay.

Setting DTT is also used for Direct Underreaching Transfer Trip (DUTT) schemes.

TRSOTF Switch-Onto-Fault Trip Conditions.

Setting TRSOTF is supervised by the switch-onto-fault condition SOTFE. See Switch-Onto-Fault (SOTF) Trip Logic on page 5-6 for more information on switch-onto-fault logic.

TR Other Trip Conditions.

Setting TR is the SELOGIC control equation trip setting most often used if tripping does not involve communications-assisted (settings TRCOMM and DTT) or switch-onto-fault (setting TRSOTF) trip logic.

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

ULTR Unlatch Trip Conditions.

TDURD Minimum Trip Duration Time.

This timer establishes the minimum time duration for which the TRIP Relay Word bit asserts. The settable range for this timer is 4–16,000 cycles. See Figure 5.2.
More than one trip setting (or all four trip settings TRCOMM, DTT, TRSOTF, and TR) can be set. For example, in a communications-assisted trip scheme, TRCOMM is set with direction forward overreaching Zone 2 distance elements, TR is set with direction forward underreaching Zone 1 distance elements and other time delayed elements (e.g., Zone 2 definite-time distance elements), and TRSOTF is set with instantaneous directional and non-directional elements.

Figure 5.1: Trip Logic

1. From Figure 5.7
2. From Figure 5.6
3. From Figure 5.11
4. From Figure 5.14
5. From Figure 5.3
Set Trip

Refer to Figure 5.1. All trip conditions:

- Communications-Assisted Trip, including Direct Transfer Trip
- Switch-Onto-Fault Trip
- Other Trips

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

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.

![Diagram of Minimum Trip Duration Timer Operation](image)

**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:

\[ TR = \ldots + OC \]

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:

\[
TR = \ldots + OC^*IN105
\]

With this setting, the OPEN command can provide a trip only if optoisolated input IN105 is asserted. This is just one OPEN command supervision example—many variations are possible.

To prevent the execution of the OPEN command from initiating reclosing, Relay Word bit OC is entered in the SELOGIC control equation setting 79DTL (Drive-to-Lockout) in the factory settings. See the Note in the Lockout State discussion, following Table 6.1.

A COMM target LED option for the OPEN command is discussed in the *Front-Panel Target LEDs* subsection at the end of this section.

**Unlatch Trip**

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

- Minimum Trip Duration Timer stops timing (logic output of the TDURD timer goes to logical 0)
- Output of OR-1 gate in Figure 5.1 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 5.17 and accompanying text for applications for Relay Word bit TRGTR.

**Factory Settings Example (Using Setting TR)**

In this example the “communications-assisted” and “switch-onto-fault” trip logic at the top of Figure 5.1 are not used. The SELOGIC control equation trip setting TR is now the only input into OR-1 gate and flows into the “seal-in and unlatch” logic for Relay Word bit TRIP.

The factory settings for the trip logic SELOGIC control equation settings are:

- \( TR = M1P + Z1G + M2PT + Z2GT + 51GT + 51QT + OC \)
- \( ULTR = !\left(50L + 51G\right) \)
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 \( TR = M1P + Z1G + M2PT + Z2GT + 51GT + 51QT + OC \):

- Distance elements M1P, M2PT, Z1G, and Z2GT and time-overcurrent elements 51GT and 51QT trip directly. Time-overcurrent and definite-time overcurrent elements can be torque controlled (e.g., elements 51GT and 51QT are torque controlled by SELOGIC control equation settings 51GTC and 51QTC, respectively). Check torque control settings to see if any control is applied to time-overcurrent and definite-time overcurrent elements. Such control is not apparent by mere inspection of trip setting TR or any other SELOGIC control equation setting.

- Relay Word bit OC asserts for execution of the OPEN Command. See OPE Command (Open Breaker) in Section 10: Serial Port Communications and Commands for more information on the OPEN Command.

With setting TDURD = 9.000 cycles, once the TRIP Relay Word bit asserts via SELOGIC control equation setting TR, it remains asserted at logical 1 for a minimum of 9 cycles.

**Unlatch Trip**

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

Both elements must be deasserted before the trip logic unlatches and the TRIP Relay Word bit deasserts to logical 0.

**Additional Settings Examples**

The factory setting for SELOGIC control equation setting ULTR is a trip element unlatch condition. A circuit breaker status unlatch trip condition can be programmed as shown in the following examples.

**Unlatch Trip with 52a Circuit Breaker Auxiliary Contact**

A 52a circuit breaker auxiliary contact is wired to optoisolated input IN101.

\[ 52A = \text{IN101} \]

\[ ULTR = !52A \]

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.

\[ ULTR = !52A = \text{NOT}(52A) \]
**Unlatch Trip With 52b Circuit Breaker Auxiliary Contact**

A 52b circuit breaker auxiliary contact is wired to optoisolated input IN101.

\[
52A = \neg IN101
\]

(SELOGIC control equation circuit breaker status setting—see Optoisolated Inputs in Section 7: Inputs, Outputs, Timers, and Other Control Logic)

\[
ULTR = \neg 52A
\]

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:

\[
\text{OUT101} = \text{TRIP}
\]
\[
\text{OUT102} = \text{TRIP}
\]

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.
Three-Pole Open Logic

Three-pole open (3PO) logic is the top half of Figure 5.3. It is not affected by enable setting ESOTF (see Settings Sheet 2 in Section 9: Setting the Relay).

The open circuit breaker condition is determined by load current (50L) and either one of:

- Circuit breaker status (52A = logical 0)
- Positive-sequence voltage (|V1| < 27PO)

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

If OPO = 52, 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:

\[ 3PO = \text{logical} \ 1 \]  
(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:

\[ 3PO = \text{logical} \ 0 \]  
(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-311C 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:

\[ 3PO = \text{logical} \ 1 \]  
(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:

\[ 3PO = \text{logical} \ 0 \]  
(circuit breaker closed)

Note that the 3PO condition is also routed to the permissive overreaching transfer trip (POTT) logic (see Figure 5.6) and 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:

\[ \text{SOTFE} = \text{logical} \ 1 \]

Note that SOTFE is asserted when the circuit breaker is open. This allows elements set in the SELOGIC control equation trip setting TRSOTF to operate if a fault occurs when the circuit breaker is open (see Figure 5.1). In such a scenario (e.g., flashover inside the circuit breaker tank), the tripping via setting TRSOTF cannot help in tripping the circuit breaker (the circuit breaker is already open), but can initiate breaker failure protection, if a breaker failure scheme is implemented in the SEL-311C Relay or externally (see example in Figure 7.26).

When the circuit breaker is closed, the 3PO condition deasserts (3PO = logical 0) after the 3POD dropout time (setting 3POD is usually set for no more than a cycle). The SOTF logic output, SOTFE, continues to remain asserted at logical 1 for dropout time SOTFD time.
Close Bus Operated Switch-Onto-Fault Logic

Close bus operated switch-onto-fault logic is enabled by making time setting CLOEND (CLOEND ≠ OFF). Time setting CLOEND qualifies the deassertion of the load detection element 50L (indicating that the circuit breaker is open).

Circuit breaker closure is detected by monitoring the dc close bus. This is accomplished by wiring an optoisolated input on the SEL-311C Relay (e.g., IN105) to the dc close bus. When a manual close or automatic reclosure occurs, optoisolated input IN105 is energized. SELOGIC control equation setting CLMON (close bus monitor) monitors the optoisolated input IN105:

CLMON = IN105

When optoisolated input IN105 is energized, CLMON asserts to logical 1. At the instant that optoisolated input IN105 is energized (close bus is energized), the circuit breaker is still open so the output of the CLOEND timer continues to be asserted to logical 1. Thus, the ANDed combination of these conditions latches in the SOTFD timer. The SOTFD timer outputs a logical 1 for a time duration of “SOTFD” cycles any time it sees a rising edge on its input (logical 0 to logical 1 transition), if it is not already timing. The SOTF logic output, SOTFE, asserts to logical 1 for SOTFD time.

Switch-Onto-Fault Logic Output (SOTFE)

Relay Word bit SOTFE is the output of the circuit breaker operated SOTF logic or the close bus operated SOTF logic described previously. Time setting SOTFD in each of these logic paths provides the effective time window for the instantaneous elements in SELOGIC control equation trip setting TRSOTF to trip after the circuit breaker closes (see Figure 5.1—middle of figure). Time setting SOTFD is usually set around 30 cycles.

A SOTF trip illuminates the SOTF front-panel LED.

Switch-Onto-Fault Trip Logic Trip Setting (TRSOTF)

An instantaneous element is usually set to trip in the SELOGIC control equation trip setting TRSOTF (e.g., TRSOTF = M2P + Z2G + 50P1).

If the voltage potential for the relay is from the line-side of the circuit breaker, the instantaneous overcurrent element in the SELOGIC control equation trip setting TRSOTF should be nondirectional. When the circuit breaker is open and the line is deenergized, the relay sees zero voltage. If a close-in three-phase fault condition exists on the line (e.g., safety grounds accidentally left attached to the line after a clearance) and then the circuit breaker is closed, the relay continues to see zero voltage. The directional elements have no voltage for reference and cannot operate. In this case, the instantaneous overcurrent element in the SOTF trip logic should be nondirectional.
COMMUNICATIONS-ASSISTED TRIP LOGIC—GENERAL OVERVIEW

The SEL-311C Relay includes communications-assisted tripping schemes that provide unit-protection for transmission lines with the help of communications. No external coordination devices are required.

The six available tripping schemes are:

- Direct Transfer Trip (DTT)
- Direct Underreaching Transfer Trip (DUTT)
- Permissive Overreaching Transfer Trip (POTT)
- Permissive Underreaching Transfer Trip (PUTT)
- Directional Comparison Unblocking (DCUB)
- Directional Comparison Blocking (DCB)

Enable Setting ECOMM

The POTT, PUTT, DCUB, and DCB tripping schemes are enabled with enable setting ECOMM. Setting choices are:

- ECOMM = N (no communications-assisted trip scheme enabled)
- ECOMM = POTT (POTT or PUTT scheme)
- ECOMM = DCUB1 (DCUB scheme for two-terminal line [communications from one remote terminal])
ECOMM = DCUB2 (DCUB scheme for three-terminal line [communications from two remote terminals])

ECOMM = DCB (DCB scheme)

These tripping schemes can all work in two-terminal or three-terminal line applications. The DCUB scheme requires separate settings choices for these applications (ECOMM = DCUB1 or DCUB2) because of unique DCUB logic considerations.

In most cases, these tripping schemes require Zone/Level 3 elements set direction reverse (setting DIR3 = R); see Figure 5.4. Note that Zone 1 and Zone 2 are fixed in the forward direction.

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

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

Use MIRRORED BITS communications to implement any of these tripping schemes efficiently and economically. MIRRORED BITS technology is generally used with either POTT or DCUB tripping schemes. If the communications channel is reliable and noise-free, e.g. dark fiber, then POTT gives unsurpassed security and very good dependability. If the communications channel is less than perfect, but communications channel failures are not likely to be coincident with external faults, then DCUB gives a very good combination of security and dependability.

**Trip Setting TRCOMM**

The POTT, PUTT, DCUB, and DCB tripping schemes use SELOGIC control equation trip setting TRCOMM for those tripping elements that are supervised by the communications-assisted trip logic (see top half of Figure 5.1). Setting TRCOMM is typically set with Zone 2 overreaching distance elements (fixed direction forward):

- **M2P** Zone 2 phase distance instantaneous element
- **Z2G** Zone 2 ground distance instantaneous element

The exception is a DCB scheme, where Zone 2 overreaching distance elements (set direction forward) with a short delay are used instead. The short delays provide necessary carrier coordination delays (waiting for the block trip signal). See Figure 5.14. These elements are entered in trip setting TRCOMM.

**Trip Settings TRSOTF and TR**

In a communications-assisted trip scheme, the SELOGIC control equation trip settings TRSOTF and TR can also be used, in addition to setting TRCOMM.

Setting TRSOTF can be set as described in preceding subsection Switch-Onto-Fault (SOTF) Trip Logic.
Setting TR is typically set with unsupervised Level 1 underreaching elements (fixed direction forward):

- M1P Zone 1 phase distance instantaneous element
- Z1G Zone 1 ground distance instantaneous element
- 67G1 Level 1 directional residual ground instantaneous overcurrent element
- 67Q1 Level 1 directional negative-sequence instantaneous overcurrent element

and other time-delayed elements (e.g., Level 2 definite-time overcurrent elements).

**Trip Setting DTT**

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

**Use Existing SEL-321 Relay Application Guides for the SEL-311C Relay**

The communications-assisted tripping schemes settings in the SEL-311C Relay are very similar to those in the SEL-321 Relay. Existing SEL-321 Relay application guides can also be used in setting up these schemes in the SEL-311C Relay. The following application guides are available from SEL:

- AG93-06 Applying the SEL-321 Relay to Directional Comparison Blocking (DCB) Schemes
- AG95-29 Applying the SEL-321 Relay to Permissive Overreaching Transfer Trip (POTT) Schemes
- AG96-19 Applying the SEL-321 Relay to Directional Comparison Unblocking (DCUB) Schemes

The major differences are how the optoisolated input settings and the trip settings are made. The following explanations describe these differences.

**Optoisolated Input Settings Differences Between the SEL-321 and SEL-311C Relays**

The SEL-311C Relay does not have optoisolated input settings like the SEL-321 Relay. Rather, the optoisolated inputs of the SEL-311C Relay are available as Relay Word bits used in SELOGIC control equations. The following optoisolated input setting example is for a Permissive Overreaching Transfer Trip (POTT) scheme.

<table>
<thead>
<tr>
<th>SEL-321 Relay</th>
<th>SEL-311C Relay</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN102 = PT</td>
<td>PT1 = IN102</td>
</tr>
</tbody>
</table>

In the above SEL-311C Relay setting example, Relay Word bit IN102 is set in the PT1 SELOGIC control equation. Optoisolated input IN102 is wired to a communications equipment receiver output contact. Relay Word bit IN102 can also be used in other SELOGIC control equations in the SEL-311C Relay. See *Optoisolated Inputs* in *Section 7: Inputs, Outputs, Timers, and Other Control Logic* for more information on optoisolated inputs.
Trip Settings Differences Between the SEL-321 and SEL-311C Relays

Some of the SELOGIC control equation trip settings of the SEL-321 and SEL-311C Relays are not operationally different, just labeled differently. The correspondence is:

<table>
<thead>
<tr>
<th>SEL-321 Relay</th>
<th>SEL-311C Relay</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTCS</td>
<td>TRCOMM</td>
</tr>
<tr>
<td></td>
<td>(Communications-Assisted Trip Conditions)</td>
</tr>
<tr>
<td>MTO</td>
<td>TRSOTF</td>
</tr>
<tr>
<td></td>
<td>(Switch-Onto-Fault Trip Conditions)</td>
</tr>
<tr>
<td>MTU</td>
<td>TR</td>
</tr>
<tr>
<td></td>
<td>(Unconditional or Other Trip Conditions)</td>
</tr>
</tbody>
</table>

The SEL-321 Relay handles trip unlatching with setting TULO. The SEL-311C Relay handles trip unlatching with SELOGIC control equation setting ULTR.

The SEL-321 Relay has single-pole trip logic. The SEL-311C Relay does not have single-pole trip logic.

Permissive Overreaching Transfer Trip (POTT) Logic

Enable the POTT logic by setting ECOMM = POTT. The POTT logic in Figure 5.6 is also enabled for directional comparison unblocking schemes (ECOMM = DCUB1 or ECOMM = DCUB2). The POTT logic performs the following tasks:

- Keys communication equipment to send permissive trip when any element included in the SELOGIC control equation communications-assisted trip equation TRCOMM asserts and the current reversal logic is not asserted.
- Prevents keying and tripping by the POTT logic following a current reversal.
- Echoes the received permissive signal to the remote terminal.
- Prevents channel lockup during echo and test.
- Provides a secure means of tripping for weak- and/or zero-infeed line terminals.

Use Existing SEL-321 Relay POTT Application Guide for the SEL-311C Relay

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

External Inputs

See Optoisolated Inputs in Section 7: Inputs, Outputs, Timers, and Other Control Logic for more information on optoisolated inputs.
PT1—Received Permissive Trip Signal(s)

In two-terminal line POTT applications, a permissive trip signal is received from one remote terminal. One optoisolated input on the SEL-311C Relay (e.g., input IN104) is driven by a communications equipment receiver output (see Figure 5.8). Make SELOGIC control equation setting PT1:

\[ PT1 = \text{IN104} \quad \text{(two-terminal line application)} \]

In three-terminal line POTT applications, permissive trip signals are received from two remote terminals. Two optoisolated inputs on the SEL-311C Relay (e.g., input IN104 and IN106) are driven by communications equipment receiver outputs (see Figure 5.9). Make SELOGIC control equation setting PT1 as follows:

\[ PT1 = \text{IN104} \cdot \text{IN106} \quad \text{(three-terminal line application)} \]

SELOGIC control equation setting PT1 in Figure 5.5 is routed to control Relay Word bit PT if enable setting ECOMM = POTT. Relay Word bit PT is then an input into the POTT logic in Figure 5.6 (for echo keying).

![Diagram](image)

To Figure 5.6

**Figure 5.5: Permissive Input Logic Routing to POTT Logic**

Also note that SELOGIC control equation setting PT1 in Figure 5.7 is routed to control Relay Word bit PTRX if enable setting ECOMM = POTT. Relay Word bit PTRX is the permissive trip receive input into the trip logic in Figure 5.1.

**Timer Settings**

See Section 9: Setting the Relay for setting ranges.
**Z3RBD—Zone (Level) 3 Reverse Block Delay**

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

**EBLKD—Echo Block Delay**

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

**ETDPU—Echo Time Delay Pickup**

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

**EDURD—Echo Duration**

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

**Logic Outputs**

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

**Z3RB—Zone (Level) 3 Reverse Block**

Current-reversal guard asserted (operates as an input into the trip logic in Figure 5.1 and the DCUB logic in Figure 5.10).

**ECTT—Echo Conversion to Trip**

PT received, converted to a trip condition for a Weak-Infeed Condition (operates as an input into the trip logic in Figure 5.1).

**Weak-Infeed Logic and Settings**

In some applications, with all sources in service, one terminal may not contribute enough fault current to operate the protective elements. If the fault lies within the Zone 1 reach of the strong terminal, the fault currents may redistribute after the strong terminal line breaker opens to permit sequential tripping of the weak-infeed terminal line breaker. If currents do not redistribute sufficiently to operate the protective elements at the weak-infeed terminal, it is still desirable to open the local breaker. This prevents the low-level currents from maintaining the fault arc and allows successful autoreclosure from the strong terminal. When the fault location is near the weak terminal, the Zone 1 elements of the strong terminal do not pick up, and the fault is not cleared rapidly. This is because the weak terminal protective elements do not operate. Note that while the weak-infeed terminal contributes little fault current, the phase voltage(s) are depressed.
SEL-311C Relay Weak-Infeed Logic

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

The SEL-311C Relay provides additional logic (see Figure 5.6) for weak-infeed terminals to permit rapid tripping of both line terminals for internal faults near the weak terminal. The strong terminal is permitted to trip via the permissive signal echoed back from the weak terminal. The weak-infeed logic generates a trip at the weak terminal if all of the following are true:

1. A permissive trip (PT) signal is received for ETDPu time.
2. A phase undervoltage or residual overvoltage element is picked up.
3. No reverse-looking elements are picked up.
4. The circuit breaker is closed.

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

Typical phase undervoltage setting (27PPW) is 70–80 percent of the lowest expected system operating voltage. The residual overvoltage setting should be set to approximately twice the expected standing 3V₀ voltage. With the 59NW element set at twice the nominal standing 3V₀ voltage, the instrument measures only fault-induced zero-sequence voltage.

KEY—Key Permissive Trip

Signals communications equipment to transmit permissive trip. For example, SELOGIC control equation setting OUT105 is set:

\[ \text{OUT105} = \text{KEY} \]

Output contact OUT105 drives a communications equipment transmitter input in a two-terminal line application (see Figure 5.8).

In a three-terminal line scheme, output contact OUT107 is set the same as OUT105 (see Figure 5.9):

\[ \text{OUT107} = \text{KEY} \]

EKEY—Echo Key Permissive Trip

Permissive trip signal keyed by Echo logic (used in testing).
Figure 5.6: POTT Logic
Figure 5.7: Permissive Input Logic Routing to Trip Logic

Variations for Permissive Underreaching Transfer Trip (PUTT) Scheme

Refer to Figure 5.4 and Figure 5.6. In a PUTT scheme, keying is provided by Level 1 underreaching elements (fixed direction forward), instead of with Relay Word bit KEY. This is accomplished by setting the output contact used to key permissive trip, OUT105 for example, with these elements:

- M1P  Zone 1 phase distance instantaneous element
- Z1G  Zone 1 ground distance instantaneous element
- 67G1 Zone 1 directional residual ground instantaneous overcurrent element
- 67Q1 Zone 1 directional negative-sequence instantaneous overcurrent element

Instead of with element KEY (see Figure 5.8):

\[ \text{OUT105} = \text{M1P + Z1G + 67G1 + 67Q1} \quad (\text{Note: only use enabled elements}) \]

If echo keying is desired, add the echo key permissive trip logic output, as follows:

\[ \text{OUT105} = \text{M1P + Z1G + 67G1 + 67Q1 + EKEY} \]

In a three-terminal line scheme, another output contact (e.g., OUT107) is set the same as OUT105 (see Figure 5.9).
**Installation Variations**

Figure 5.9 shows output contacts OUT105 and OUT107 connected to separate communications equipment, for the two remote terminals. Both output contacts are programmed the same (OUT105 = KEY and OUT107 = KEY).

Depending on the installation, perhaps one output contact (e.g., OUT105 = KEY) could be connected in parallel to both transmitter inputs (TX) on the communication equipment in Figure 5.9. Then output contact OUT107 can be used for another function.

![Figure 5.8: SEL-311C Relay Connections to Communications Equipment for a Two-Terminal Line POTT Scheme](image1)

![Figure 5.9: SEL-311C Relay Connections to Communications Equipment for a Three-Terminal Line POTT Scheme](image2)
**Directional Comparison Unblocking (DCUB) Logic**

Enable the DCUB logic by setting $ECOMM = DCUB1$ or $ECOMM = DCUB2$. The DCUB logic in Figure 5.10 is an extension of the POTT logic in Figure 5.6. Thus, the relay requires all the POTT settings and logic, plus settings and logic exclusive to DCUB. The difference between setting choices DCUB1 and DCUB2 is:

- **DCUB1** directional comparison unblocking scheme for two-terminal line (communications from one remote terminal)
- **DCUB2** directional comparison unblocking scheme for three-terminal line (communications from two remote terminals)

The DCUB logic in Figure 5.10 takes in the loss-of-guard and permissive trip outputs from the communications receivers (see Figure 5.12 and Figure 5.13) and makes permissive (PTRX1/PTRX2) and unblocking block (UBB1/UBB2) logic output decisions.

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

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

**External Inputs**

See *Optoisolated Inputs* in *Section 7: Inputs, Outputs, Timers, and Other Control Logic* for more information on optoisolated inputs.

**PT1, PT2—Received Permissive Trip Signal(s)**

In two-terminal line DCUB applications (setting $ECOMM = DCUB1$), a permissive trip signal is received from one remote terminal. One optoisolated input on the SEL-311C Relay (e.g., input IN104) is driven by a communications equipment receiver output (see Figure 5.12). Make SELOGIC control equation setting PT1:

- **PT1 = IN104** (two-terminal line application)

In three-terminal line DCUB applications (setting $ECOMM = DCUB2$), permissive trip signals are received from two remote terminals. Two optoisolated inputs on the SEL-311C Relay (e.g., inputs IN104 and IN106) are driven by communications equipment receiver outputs (see Figure 5.13). Make SELOGIC control equation settings PT1 and PT2 as follows:

- **PT1 = IN104** (three-terminal line application)
- **PT2 = IN106**

SELOGIC control equation settings PT1 and PT2 are routed into the DCUB logic in Figure 5.10 for “unblocking block” and “permissive trip receive” logic decisions.

As explained in the preceding POTT subsection, the SELOGIC control equation settings PT1 and PT2 in Figure 5.5 are routed in various combinations to control Relay Word bit PT, depending...
on enable setting ECOMM = DCUB1 or DCUB2. Relay Word bit PT is then an input into the POTT logic in Figure 5.6 (for echo keying).

**LOG1, LOG2—Loss-of-Guard Signal(s)**

In two-terminal line DCUB applications (setting ECOMM = DCUB1), a loss-of-guard signal is received from one remote terminal. One optoisolated input on the SEL-311C Relay (e.g., input IN105) is driven by a communications equipment receiver output (see Figure 5.12). Make SELOGIC control equation setting LOG1:

\[ \text{LOG1} = \text{IN105} \]  

(two-terminal line application)

In three-terminal line DCUB applications (setting ECOMM = DCUB2), loss-of-guard signals are received from two remote terminals. Two optoisolated inputs on the SEL-311C Relay (e.g., input IN105 and IN207) are driven by communications equipment receiver outputs (see Figure 5.13). Make SELOGIC control equation settings LOG1 and LOG2 as follows:

\[ \begin{align*}
\text{LOG1} &= \text{IN105} \\
\text{LOG2} &= \text{IN207}
\end{align*} \]  

(three-terminal line application)

SELOGIC control equation settings LOG1 and LOG2 are routed into the DCUB logic in Figure 5.10 for “unblocking block” and “permissive trip receive” logic decisions.

**Timer Settings**

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

**GARD1D—Guard-Present Delay**

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

**UBDURD—DCUB Disable Delay**

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

**UBEND—DCUB Duration Delay**

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

**Logic Outputs**

The following logic outputs can be tested by assigning them to output contacts. See *Output Contacts in Section 7: Inputs, Outputs, Timers, and Other Control Logic* for more information on output contacts.
UBB1, UBB2—Unblocking Block Output(s)

In two-terminal line DCUB applications (setting ECOMM = DCUB1), UBB1 disables tripping if the loss-of-channel condition continues for longer than time UBDURD.

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

The UBB1 and UBB2 are routed in various combinations in Figure 5.11 to control Relay Word bit UBB, depending on enable setting ECOMM = DCUB1 or DCUB2. Relay Word bit UBB is the unblock block input into the trip logic in Figure 5.1. When UBB asserts to logical 1, tripping is blocked.
Figure 5.10: DCUB Logic
**Figure 5.11: Unblocking Block Logic Routing to Trip Logic**

**PTRX1, PTRX2—Permissive Trip Receive Outputs**

In two-terminal line DCUB applications (setting $\text{ECOMM} = \text{DCUB1}$), PTRX1 asserts for loss-of-channel or an actual received permissive trip.

In three-terminal line DCUB applications (setting $\text{ECOMM} = \text{DCUB2}$), PTRX1 or PTRX2 assert for loss-of-channel or an actual received permissive trip (for the respective Channel 1 or 2).

The PTRX1/PTRX2 Relay Word bits are then routed in various combinations in Figure 5.7 to control Relay Word bit PTRX, depending on enable setting $\text{ECOMM} = \text{DCUB1}$ or DCUB2. Relay Word bit PTRX is the permissive trip receive input into the trip logic in Figure 5.1.

**Installation Variations**

Figure 5.13 shows output contacts OUT105 and OUT107 connected to separate communications equipment, for the two remote terminals. Both output contacts are programmed the same (OUT105 = KEY and OUT107 = KEY).

Depending on the installation, perhaps one output contact (e.g., OUT105 = KEY) could be connected in parallel to both transmitter inputs (TX) on the communications equipment in Figure 5.13. Then output contact OUT107 can be used for another function.
**Figure 5.12:** SEL-311C Relay Connections to Communications Equipment for a Two-Terminal Line DCUB Scheme (Setting ECOMM = DCUB1)

**Figure 5.13:** SEL-311C Relay Connections to Communications Equipment for a Three-Terminal Line DCUB Scheme (Setting ECOMM = DCUB2)
**Directional Comparison Blocking (DCB) Logic**

Enable the DCB logic by setting ECOMM = DCB. The DCB logic in Figure 5.14 performs the following tasks:

- Provides the individual carrier coordination timers for the Level 2 directional elements M2P, Z2G, 67G2, and 67Q2 via the Z2PGS and 67QG2S Relay Word bits. These delays allow time for the block trip signal to arrive from the remote terminal. For example:

  \[
  \text{TRCOMM} = \text{Z2PGS} + \text{67QG2S}
  \]

- Instantaneously keys the communications equipment to transmit block trip for reverse faults and extends this signal for a settable time following the dropout of all Level 3 directional elements (M3P, Z3G, 67G3, and 67Q3).

- Latches the block trip send condition by the directional overcurrent following a close-in zero-voltage three-phase fault where the polarizing memory expires. Latch is removed when the polarizing memory voltage returns or current is removed.

- Extends the received block signal by a settable time.

**Use Existing SEL-321 Relay DCB Application Guide for the SEL-311C Relay**

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

**External Inputs**

See **Optoisolated Inputs** in Section 7: **Inputs, Outputs, Timers, and Other Control Logic** for more information on optoisolated inputs.

**BT—Received Block Trip Signal(s)**

In two-terminal line DCB applications, a block trip signal is received from one remote terminal. One optoisolated input on the SEL-311C Relay (e.g., input IN104) is driven by a communications equipment receiver output (see Figure 5.15). Make SELOGIC control equation setting BT:

\[
\text{BT} = \text{IN104} \\
\text{two-terminal line application}
\]

In three-terminal line DCB applications, block trip signals are received from two remote terminals. Two optoisolated inputs on the SEL-311C Relay (e.g., input IN104 and IN106) are driven by communications equipment receiver outputs (see Figure 5.16). Make SELOGIC control equation setting BT as follows:

\[
\text{BT} = \text{IN104} + \text{IN106} \\
\text{three-terminal line application}
\]

SELOGIC control equation setting BT is routed through a dropout timer (BTXD) in the DCB logic in Figure 5.14. The timer output, Relay Word bit BTX, is routed to the trip logic in Figure 5.1.
Timer Settings

See Section 9: Setting the Relay for setting ranges.

Z3XPU—Zone (Level) 3 Reverse Pickup Time Delay

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

Z3XD—Zone (Level) 3 Reverse Dropout Extension

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

BTXD—Block Trip Receive Extension

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

21SD and 67SD—Zone 2 Short Delay

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

Logic Outputs

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

DSTRT—Directional Carrier Start

Program an output contact for directional carrier start. For example, SELOGiC control equation setting OUT105 is set:

\[ \text{OUT105} = \text{DSTRT} \]

Output contact OUT105 drives a communications equipment transmitter input in a two-terminal line application (see Figure 5.15).

In a three-terminal line scheme, output contact OUT106 is set the same as OUT104 (see Figure 5.16):

\[ \text{OUT106} = \text{DSTRT} \]

DSTRT includes current reversal guard logic.

NSTRT—Nondirectional Carrier Start

Program an output contact to include nondirectional carrier start, in addition to directional start. For example, SELOGiC control equation setting OUT105 is set:

\[ \text{OUT105} = \text{DSTRT} + \text{NSTRT} \]
Output contact OUT105 drives a communications equipment transmitter input in a two-terminal line application (see Figure 5.15).

In a three-terminal line scheme, output contact OUT106 is set the same as OUT104 (see Figure 5.16):

\[ \text{OUT106} = \text{DSTRT} + \text{NSTRT} \]

**STOP—Stop Carrier**

Program to an output contact to stop carrier. For example, SELOGiC control equation setting OUT106 is set:

\[ \text{OUT106} = \text{STOP} \]

Output contact OUT106 drives a communications equipment transmitter input in a two-terminal line application (see Figure 5.15).

In a three-terminal line scheme, another output contact (e.g., OUT107) is set the same as OUT105 (see Figure 5.16):

\[ \text{OUT107} = \text{STOP} \]

**BTX—Block Trip Extension**

The received block trip input (e.g., BT = IN104) is routed through a dropout timer (BTXD) in the DCB logic in Figure 5.14. The timer output (BTX) is routed to the trip logic in Figure 5.1.
From this Figure  DSTRT

BT (Setting)  0  BTXD

Figure 5.14: DCB Logic

1. From Figure 3.6
2. From Figure 3.9
3. From Figure 3.23
4. From Figure 3.22
5. From Figure 3.5
6. From Figure 3.8
7. To Figure 5.1
Installation Variations

Figure 5.16 shows output contacts OUT104, OUT105, OUT106, and OUT107 connected to separate communications equipment, for the two remote terminals. Both output contact pairs are programmed the same (OUT104 = DSTRT + NSTRT and OUT106 = DSTRT + NSTRT; OUT105 = STOP and OUT107 = STOP).

Depending on the installation, perhaps one output contact (e.g., OUT104 = DSTRT + NSTRT) can be connected in parallel to both START inputs on the communications equipment in Figure 5.16. Then output contact OUT106 can be used for another function.

Depending on the installation, perhaps one output contact (e.g., OUT105 = STOP) can be connected in parallel to both STOP inputs on the communications equipment in Figure 5.16. Then output contact OUT107 can be used for another function.

Figure 5.16 also shows communications equipment RX (receive) output contacts from each remote terminal connected to separate inputs IN104 and IN106 on the SEL-311C Relay. The inputs operate as block trip receive inputs for the two remote terminals and are used in the SELOGIC control equation setting:

\[
BT = IN104 + IN106
\]

Depending on the installation, perhaps one input (e.g., IN104) can be connected in parallel to both communications equipment RX (receive) output contacts in Figure 5.16. Then setting BT would be programmed as:

\[
BT = IN104
\]

and input IN106 can be used for another function.

In Figure 5.15 and Figure 5.16, the carrier scheme cutout switch contact (85CO) should be closed when the communications equipment is taken out of service so that the BT input of the relay remains asserted. An alternative to asserting the BT input is to change to a settings group where the DCB logic is not enabled.
Figure 5.15: SEL-311C Relay Connections to Communications Equipment for a Two-Terminal Line DCB Scheme

Figure 5.16: SEL-311C Relay Connections to Communications Equipment for a Three-Terminal Line DCB Scheme
**FRONT-PANEL TARGET LEDs**

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

<table>
<thead>
<tr>
<th>LED Number</th>
<th>LED Label</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EN</td>
<td>Relay Enabled—see subsection <em>Relay Self-Tests</em> in <em>Section 13: Testing and Troubleshooting</em></td>
</tr>
<tr>
<td>2</td>
<td>TRIP</td>
<td>Indication that a trip occurred, by a protection or control element</td>
</tr>
<tr>
<td>3</td>
<td>TIME</td>
<td>Time delayed trip</td>
</tr>
<tr>
<td>4</td>
<td>COMM</td>
<td>Communications-assisted trip</td>
</tr>
<tr>
<td>5</td>
<td>SOTF</td>
<td>Switch-onto-fault trip</td>
</tr>
<tr>
<td>6</td>
<td>RS</td>
<td>Recloser reset</td>
</tr>
<tr>
<td>7</td>
<td>LO</td>
<td>Recloser locked out</td>
</tr>
<tr>
<td>8</td>
<td>51</td>
<td>Time-overcurrent element trip</td>
</tr>
<tr>
<td>9</td>
<td>A</td>
<td>Phase A involved in the fault</td>
</tr>
<tr>
<td>10</td>
<td>B</td>
<td>Phase B involved in the fault</td>
</tr>
<tr>
<td>11</td>
<td>C</td>
<td>Phase C involved in the fault</td>
</tr>
<tr>
<td>12</td>
<td>G</td>
<td>Ground distance or residual ground element picked up at time of trip</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>Zone/Level 1 element picked up at time of trip</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>Zone/Level 2 element picked up at time of trip</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>Zone/Level 3 element picked up at time of trip</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>Zone/Level 4 element picked up at time of trip</td>
</tr>
</tbody>
</table>

Target LEDs numbered 2 through 5 and 8 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 through Figure 2.6 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 8 through 16), but the TRIP target LED still illuminates. Thus, tripping via the front-panel local control (local bits), serial port (remote bits...
or OPEN command), or voltage elements is indicated only by the illumination of the TRIP target LED.

**TIME Target LED**

The TIME target LED illuminates at the rising edge of trip if SELOGIC control equation setting FAULT has been asserted for more than 3 cycles. FAULT is usually set with distance and time-overcurrent element pickups (e.g., FAULT = 51G + 51Q + M2P + Z2G) to detect fault inception. If tripping occurs more than 3 cycles after fault inception, the TIME target illuminates.

SELOGIC control equation setting FAULT also controls max./min. metering. If FAULT is asserted, maximum/minimum metering is blocked (see Maximum/Minimum Metering in Section 8: Breaker Monitor and Metering Functions). Fault current values are not to be accrued as maximum current values in maximum/minimum metering.

**COMM Target LED**

The COMM target LED illuminates at the rising edge of trip if the trip is the result of SELOGIC control equation setting TRCOMM and associated communications-assisted trip logic, Relay Word bit ECTT, or SELOGIC control equation setting DTT (see Figure 5.1, top half of figure).

Another Application for the COMM Target LED

If none of the traditional communications-assisted trip logic is used (i.e., SELOGIC control equation setting TRCOMM is not used), consideration can be given to using the COMM target LED to indicate tripping via remote communications channels (e.g., via serial port commands or SCADA asserting optoisolated inputs). Use SELOGIC control equation setting DTT (Direct Transfer Trip) to accomplish this (see Figure 5.1).

For example, if the OPEN command or remote bit RB1 (see CON Command in Section 10: Serial Port Communications and Commands) are used to trip via the serial port and they should illuminate the COMM target LED, set them in SELOGIC control equation setting DTT:

\[
DTT = \ldots + OC + RB1
\]

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

\[
DTT = \ldots + IN104 + \ldots
\]

Relay Word bits set in SELOGIC control equation setting DTT do not have to be set in SELOGIC control equation setting TR—both settings directly assert the TRIP Relay Word bit. The only difference between settings DTT and TR is that setting DTT causes the COMM target LED to illuminate.

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

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

79 Target LEDs

If the reclosing relay is turned off (enable setting E79 = N or 79OI1 = 0), all the Device 79 (reclosing relay) target LEDs are extinguished.

51 Target LED

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

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


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 8 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 7.26 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):

\[
SV8 = (SV8 + SV7T) \times \neg TRGTR
\]

\[
DP3 = SV8
\]

\[
DP3_1 = BREAKER FAILURE
\]

\[
DP3_0 = \text{ (blank) }
\]

**Figure 5.17: 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 5.17 to seal-in. Asserted SV8 in turn asserts DP3, causing the message:  

```
BREAKER FAILURE
```

to display in the rotating default display.

This message can be removed from the display rotation by pushing the TARGET RESET Pushbutton (Relay Word bit TRGTR pulses to logical 1, unlatching SV8 and in turn deasserting DP3). Thus, front-panel rotating default displays can be easily reset along with the front-panel targets by pushing the TARGET RESET Pushbutton.
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SECTION 6: CLOSE AND RECLOSE LOGIC

OVERVIEW

This section is made up of three subsections:

Close Logic

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

If automatic reclosing is not needed, but the SEL-311C Relay is to close the circuit breaker for other close conditions (e.g., manual close initiation via serial port or optoisolated inputs), then this subsection is the only subsection that needs to be read in this section (particularly the description of SELOGIC® control equation setting CL).

Reclose Supervision Logic

This subsection describes the logic that supervises automatic reclosing when an open interval time times out—a final condition check right before the close logic asserts the close output contact.

Reclose Logic

This subsection describes all the reclosing relay settings and logic needed for automatic reclosing (besides the final close logic and reclose supervision logic described in the previous subsections).

The reclose enable setting, E79, has setting choices N, 1, 2, 3, and 4. Setting E79 = N defeats the reclosing relay. Setting choices 1 through 4 are the number of desired automatic reclosures.

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

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

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

and setting:

- **CFD** (Close Failure Time)

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

**Figure 6.1: Close Logic**

**Set Close**

If all the following are true:

- The unlatch close condition is not asserted (ULCL = logical 0).
- The circuit breaker is open (52A = logical 0).
- The reclose initiation condition (79RI) is not making a rising edge (logical 0 to logical 1) transition.
- And a close failure condition does not exist (Relay Word bit CF = 0).
Then the CLOSE Relay Word bit can be asserted to logical 1 if either of the following occurs:

- A reclosing relay open interval times out (qualified by SELOGIC control equation setting 79CLS—see Figure 6.2).
- Or SELOGIC control equation setting CL goes from logical 0 to logical 1 (rising edge transition).

The CLOSE command is included in the close logic in the factory settings:

\[ \text{CL} = \ldots + \text{CC} \]

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:

\[ \text{CL} = \ldots + \text{CC} \times \text{IN106} \]

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

**Unlatch Close**

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

- The unlatch close condition asserts (ULCL = logical 1).
- The circuit breaker closes (52A = logical 1).
- The reclose initiation condition (79RI) makes a rising edge (logical 0 to logical 1) transition.
- The Close Failure Timer times out (Relay Word bit CF = 1).

The Close Failure Timer is inoperative if setting CFD = OFF.

**Factory Settings Example**

The factory settings for the close logic SELOGIC control equation settings are:

\[
\begin{align*}
52A & = \text{IN101} \\
\text{CL} & = \text{CC} \\
\text{ULCL} & = \text{TRIP}
\end{align*}
\]

The factory setting for the Close Failure Timer setting is:

\[ \text{CFD} = 60.00 \text{ cycles} \]

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

If the Reclosing Relay Open Interval Time-Out logic input at the top of Figure 6.1 is ignored (reclosing is discussed in detail in a following subsection), then SELOGIC control equation setting CL is the only logic input that can set the CLOSE Relay Word bit.

In SELOGIC control equation setting CL = CC, Relay Word bit CC asserts for execution of the CLOSE Command. See CLO Command (Close Breaker) in Section 10: Serial Port Communications and Commands for more information on the CLOSE Command.

Unlatch Close

SELOGIC control equation setting ULCL is usually set with the TRIP Relay Word bit. This prevents the CLOSE Relay Word bit from being asserted any time the TRIP Relay Word bit is asserted (TRIP takes priority). See Trip Logic in Section 5: Trip and Target Logic.

SELOGIC control equation setting 52A is set with optoisolated input IN101. Input IN101 is connected to a 52a circuit breaker auxiliary contact. When a closed circuit breaker condition is detected, the CLOSE Relay Word bit is deasserted to logical 0. Setting 52A can handle a 52a or 52b circuit breaker auxiliary contact connected to an optoisolated input (see Optoisolated Inputs in Section 7: Inputs, Outputs, Timers, and Other Control Logic for more 52A setting examples).

With setting CFD = 60.00 cycles, once the CLOSE Relay Word bit asserts, it remains asserted at logical 1 no longer than a maximum of 60 cycles. If the Close Failure Timer times out, Relay Word bit CF asserts to logical 1, forcing the CLOSE Relay Word bit to logical 0.

Defeat the Close Logic

If SELOGIC control equation circuit breaker auxiliary setting 52A is set with numeral 0 (52A = 0), then the close logic is inoperable. Also, the reclosing relay is defeated (see Reclosing Relay later in this section).

Circuit Breaker Status

Refer to the bottom of Figure 6.1. Note that SELOGIC control equation setting 52A (circuit breaker status) is available as Relay Word bit 52A. This makes it convenient to set other SELOGIC control equations. For example, if the following setting is made:

52A = IN101  
(52a auxiliary contact wired to input IN101)

or

52A = !IN101  
(52b auxiliary contact wired to input IN101)

then if breaker status is used in other SELOGIC control equations, it can be entered as 52A—the user doesn’t have to enter IN101 (for a 52a) or !IN101 (for a 52b). For example, refer to Rotating Default Display in Section 7: Inputs, Outputs, Timers, and Other Control Logic. If circuit breaker status indication is controlled by display point setting DP2:

DP2 = IN101
This can be entered instead as:

\[ DP2 = 52A \]

(presuming SELOGIC control equation setting \( 52A = \text{IN101} \) 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.

**Reclose Supervision Logic**

Note that one of the inputs into the close logic in Figure 6.1 is:

Reclosing Relay Open Interval Time-Out (qualified by 79CLS)

This input into the close logic in Figure 6.1 is the indication that a reclosing relay open interval has timed out, a qualifying condition (SELOGIC control equation setting 79CLS) has been met, and thus automatic reclosing of the circuit breaker should proceed by asserting the CLOSE Relay Word bit to logical 1. This input into the close logic in Figure 6.1 is an output of the reclose supervision logic in the following Figure 6.2.
Figure 6.2: Reclose Supervision Logic (Following Open Interval Time-Out)
Figure 6.3: Reclose Supervision Limit Timer Operation (Refer to Bottom of Figure 6.2)
**Settings and General Operation**

Figure 6.2 contains the following SELOGIC control equation setting:

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

and setting:

- **79CLSD** (Reclose Supervision Limit Time)

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

**For Most Applications (Top of Figure 6.2)**

For most applications, the Reclose Supervision Limit Time setting should be set to zero cycles:

- **79CLSD = 0.00**

With this setting, the logic in the top of Figure 6.2 is operative. When an open interval times out, the SELOGIC control equation reclose supervision setting 79CLS is checked just once.

If 79CLS is **asserted** to logical 1 at the instant of an open interval time-out, then the open interval time-out will propagate onto the final close logic in Figure 6.1 to automatically reclose the circuit breaker.

If 79CLS is **deasserted** to logical 0 at the instant of an open interval time-out, the following occurs:

- No automatic reclosing takes place.
- Relay Word bit RCSF (Reclose Supervision Failure indication) asserts to logical 1 for one processing interval.
- The reclosing relay is driven to the Lockout State.

See **Settings Example** and **Additional Settings Example 1** that follow in this subsection.

**For A Few, Unique Applications (Bottom of Figure 6.2 and Figure 6.3)**

For a few unique applications, the Reclose Supervision Limit Time setting is **not** set equal to zero cycles:

- **e.g., 79CLSD = 60.00**

With this setting, the logic in the bottom of Figure 6.2 is operative. When an open interval times out, the SELOGIC control equation reclose supervision setting 79CLS is then **checked for a time window** equal to setting 79CLSD.

If 79CLS **asserts** to logical 1 at any time during this 79CLSD time window, then the open interval time-out will propagate onto the final close logic in Figure 6.1 to automatically reclose the circuit breaker.
If 79CLS remains deasserted to logical 0 during this entire 79CLSD time window, when the time window times out, the following occurs:

- No automatic reclosing takes place.
- Relay Word bit RCSF (Reclose Supervision Failure indication) asserts to logical 1 for one processing interval.
- The reclosing relay is driven to the Lockout State.

The logic in the bottom of Figure 6.2 is explained in more detail in the following text.

**Set Reclose Supervision Logic (Bottom of Figure 6.2)**

Refer to the bottom of Figure 6.2. If **all** the following are true:

- The close logic output CLOSE is **not** asserted (Relay Word bit CLOSE = logical 0).
- The reclosing relay is **not** in the Lockout State (Relay Word bit 79LO = logical 0).
- The circuit breaker is open (52A = logical 0).
- The reclose initiation condition (79RI) is **not** making a rising edge (logical 0 to logical 1) transition.
- The Reclose Supervision Limit Timer is **not** timed out (Relay Word bit RCSF = logical 0).

then a reclosing relay open interval time-out seals in Figure 6.2. Then, when 79CLS asserts to logical 1, the sealed-in reclosing relay open interval time-out condition will propagate through Figure 6.2 and on to the close logic in Figure 6.1.

**Unlatch Reclose Supervision Logic (Bottom of Figure 6.2)**

Refer to the bottom of Figure 6.2. If the reclosing relay open interval time-out condition is sealed-in, it stays sealed-in until **one** of the following occurs:

- The close logic output CLOSE (also see Figure 6.1) asserts (Relay Word bit CLOSE = logical 1).
- The reclosing relay goes to the Lockout State (Relay Word bit 79LO = logical 1).
- The circuit breaker closes (52A = logical 1).
- The reclose initiation condition (79RI) makes a rising edge (logical 0 to logical 1) transition.
- SELOGIC control equation setting 79CLS asserts (79CLS = logical 1).
- The Reclose Supervision Limit Timer times out (Relay Word bit RCSF = logical 1 for one processing interval).

The Reclose Supervision Limit Timer is inoperative if setting 79CLSD = OFF. With 79CLSD = OFF, reclose supervision condition 79CLS is not time limited. When an open interval times out, reclose supervision condition 79CLS is checked indefinitely until one of the other above unlatch conditions comes true.
The unlatching of the sealed-in reclosing relay open interval time-out condition by the assertion of SELOGIC control equation setting 79CLS indicates successful propagation of a reclosing relay open interval time-out condition on to the close logic in Figure 6.1.

See Additional Settings Example 2 that follows in this subsection.

**Settings Example**

Refer to the top of Figure 6.2.

The example setting for the SELOGIC control equation reclose supervision setting is:

\[
79\text{CLS} = 1 \quad \text{(numeral 1)}
\]

The example setting for the Reclose Supervision Limit Timer setting is:

\[
79\text{CLSD} = 0.00 \text{ cycles}
\]

Any time a reclosing relay open interval times out, it propagates immediately through Figure 6.2 and then on to Figure 6.1, because SELOGIC control equation setting 79CLS is always asserted to logical 1. Effectively, there is no special reclose supervision.

**Additional Settings Example 1**

Refer to the top of Figure 6.2 and Figure 6.4.

SEL-311C Relays are installed at both ends of a transmission line in a high-speed reclose scheme. After both circuit breakers open for a transmission line fault, the SEL-311C(1) Relay recloses circuit breaker 52/1 first, followed by the SEL-311C(2) Relay reclosing circuit breaker 52/2, after a synchronism check across circuit breaker 52/2.

![Figure 6.4: SEL-311C Relays Installed at Both Ends of a Transmission Line in a High-Speed Reclose Scheme](image)

**Figure 6.4:** SEL-311C Relays Installed at Both Ends of a Transmission Line in a High-Speed Reclose Scheme
SEL-311C(1) Relay

Before allowing circuit breaker 52/1 to be reclosed after an open interval time-out, the SEL-311C(1) Relay verifies that Bus 1 voltage is hot and the transmission line voltage is dead. This requires reclose supervision settings:

\[
\begin{align*}
79\text{CLSD} & = 0.00 \text{ cycles} \\
(\text{only one check}) \\
79\text{CLS} & = 3\text{P59} \times 27\text{S} \\
\end{align*}
\]

where:

\[
\begin{align*}
3\text{P59} & = \text{all three Bus 1 phase voltages (VA, VB, and VC) are hot} \\
27\text{S} & = \text{monitored single-phase transmission line voltage (channel VS) is dead} \\
\end{align*}
\]

SEL-311C(2) Relay

The SEL-311C(2) Relay verifies that Bus 2 voltage is hot, the transmission line voltage is hot, and in synchronism after the reclosing relay open interval times out, before allowing circuit breaker 52/2 to be reclosed. This requires reclose supervision settings:

\[
\begin{align*}
79\text{CLSD} & = 0.00 \text{ cycles} \\
(\text{only one check}) \\
79\text{CLS} & = 25\text{A1} \\
\end{align*}
\]

where:

\[
\begin{align*}
25\text{A1} & = \text{selected Bus 2 phase voltage (VA, VB, VC, VAB, VBC, or VCA) is in synchronism with monitored single-phase transmission line voltage (channel VS) and both are hot.} \\
\end{align*}
\]

Other Setting Considerations for SEL-311C(1) and SEL-311C(2) Relays

Refer to *Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, Respectively)* in the following *Reclosing Relay* subsection.

SELOGIC control equation setting 79STL stalls open interval timing if it asserts to logical 1. If setting 79STL is deasserted to logical 0, open interval timing can continue.

The SEL-311C(1) Relay has no intentional open interval timing stall condition (circuit breaker 52/1 closes first after a transmission line fault):

\[
79\text{STL} = 0 \quad \text{(numeral 0)}
\]

The SEL-311C(2) Relay starts open interval timing after circuit breaker 52/1 at the remote end has reenergized the line. The SEL-311C(2) Relay has to see Bus 2 hot, transmission line hot, and in synchronism across open circuit breaker 52/2 for open interval timing to begin. Thus, SEL-311C(2) Relay open interval timing is stalled when the transmission line voltage and Bus 2 voltage are not in synchronism across open circuit breaker 52/2:

\[
79\text{STL} = !25\text{A1} \quad [=\text{NOT}(25\text{A1})]
\]
**Note:** A transient synchronism check condition across open circuit breaker 52/2 could possibly occur if circuit breaker 52/1 recloses into a fault on one phase of the transmission line. The other two unfaulted phases would be briefly energized until circuit breaker 52/1 is tripped again. If channel VS of the SEL-311C(2) Relay is connected to one of these briefly energized phases, synchronism check element 25A1 could momentarily assert to logical 1.

So that this possible momentary assertion of synchronism check element 25A1 does not cause any inadvertent reclose of circuit breaker 52/2, make sure the open interval timers in the SEL-311C(2) Relay are set with some appreciable time greater than the momentary energization time of the faulted transmission line. Or, run the synchronism check element 25A1 through a programmable timer before using it in the preceding 79CLS and 79STL settings for the SEL-311C(2) Relay (see Figure 7.24 and Figure 7.25). Note the built-in 3-cycle qualification of the synchronism check voltages shown in Figure 3.30.

### Additional Settings Example 2

Refer to subsection *Synchronism Check Elements* in Section 3: *Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements*. Also refer to Figure 6.3 and Figure 6.4.

If the synchronizing voltages across open circuit breaker 52/2 are “slipping” with respect to one another, the Reclose Supervision Limit Timer setting 79CLSD should be set greater than zero so there is time for the slipping voltages to come into synchronism. For example:

\[
\begin{align*}
\text{79CLSD} &= 60.00 \text{ cycles} \\
\text{79CLS} &= 25A1
\end{align*}
\]

The status of synchronism check element 25A1 is checked continuously during the 60-cycle window. If the slipping voltages come into synchronism while timer 79CLSD is timing, synchronism check element 25A1 asserts to logical 1 and reclosing proceeds.

In the above referenced subsection *Synchronism Check Elements*, note item 3 under *Synchronism Check Element Outputs*, Voltages \(V_p\) and \(V_s\) are “Slipping.” Item 3 describes a last attempt for a synchronism check reclose before timer 79CLSD times out (or setting 79CLSD = 0.00 and only one check is made).

### Reclosing Relay

Note that input:

**Reclosing Relay Open Interval Time-Out**

in Figure 6.2 is the logic input that is qualified by SELOGIC control equation setting 79CLS, and then propagated onto the close logic in Figure 6.1 to automatically reclose a circuit breaker. The explanation that follows in this reclosing relay subsection describes all the reclosing relay settings and logic that eventually result in this open interval time-out logic input into Figure 6.2. Other aspects of the reclosing relay are also explained. Up to four (4) automatic reclosures (shots) are available.
The reclose enable setting, E79, has setting choices N, 1, 2, 3, and 4. Setting E79 = N defeats the reclosing relay. Setting choices 1 through 4 are the number of desired automatic reclosures (see Open Interval Timers that follows in this subsection).

Reclosing Relay States and General Operation

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

![Figure 6.5: Reclosing Relay States and General Operation](image)

Table 6.1: Relay Word Bit and Front-Panel Correspondence to Reclosing Relay States

<table>
<thead>
<tr>
<th>Reclosing Relay State</th>
<th>Corresponding Relay Word Bit</th>
<th>Corresponding Front-Panel LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reset</td>
<td>79RS</td>
<td>RS</td>
</tr>
<tr>
<td>Lockout</td>
<td>79LO</td>
<td>LO</td>
</tr>
</tbody>
</table>

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

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

- The shot counter is equal to or greater than the last shot at the time of reclose initiation (e.g., all automatic reclosing attempts are unsuccessful—see Figure 6.6).
- Reclose initiation is unsuccessful because of SELOGIC control equation setting 79RIS (see Reclose Initiate and Reclose Initiate Supervision Settings [79RI and 79RIS, Respectively] later in this subsection).
- The circuit breaker opens without reclose initiation (e.g., an external trip).
- The shot counter is equal to or greater than last shot, and the circuit breaker is open (e.g., the shot counter is driven to last shot with SELOGIC control equation setting 79DLS while open interval timing is in progress. See Drive-to-Lockout and Drive-to-Last Shot Settings [79DTL and 79DLS, Respectively] later in this subsection).
- The close failure timer (setting CFD) times out (see Figure 6.1).
- SELOGIC control equation setting 79DTL = logical 1 (see Drive-to-Lockout and Drive-to-Last Shot Settings [79DTL and 79DLS, Respectively] later in this subsection).
- The Reclose Supervision Limit Timer (setting 79CLSD) times out (see Figure 6.2 and top of Figure 6.3).

The OPEN (OPE) command is included in the reclosing relay logic via SELOGIC control equation settings. For example:

\[ 79DTL = \ldots + OC \]  
(drive-to-lockout)

Relay Word bit OC asserts for execution of the OPE command. See OPE Command (Open Breaker) in Section 10: Serial Port Communications and Commands for more information on the OPE command. Also, see Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) later in this subsection.

If the OPE command is set to trip (TR = \ldots + OC), then the following reclosing relay SELOGIC control equation settings should also be made (presuming that an OPE command trip should not initiate reclosing):

\[ 79RI = TRIP \]  
(reclose initiate)
\[ 79DTL = \ldots + OC \]  
(drive-to-lockout)

Reclosing Relay States After a Settings or Setting Group Change

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

- The reclosing relay remains in the state it was in before the settings change.
- The shot counter is driven to last shot (last shot corresponding to the new settings; see discussion on last shot that follows).
- The reset timer is loaded with reset time setting 79RSLD (see discussion on reset timing later in this section).
If the relay happened to be in the Reclose Cycle State and was timing on an open interval before the settings change, the relay would be in the Reclose Cycle State after the settings change, but the relay would immediately go to the Lockout State. This is because the breaker is open, and the relay is at last shot after the settings change, and thus no more automatic reclosures are available.

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

**Defeat the Reclosing Relay**

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

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

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

If the reclosing relay is defeated, the following also occur:

- Both reclosing relay state Relay Word bits (79RS and 79LO) are forced to logical 0 (see Table 6.1).
- All shot counter Relay Word bits (SH0, SH1, SH2, SH3, and SH4) are forced to logical 0 (the shot counter is explained later in this section).
- The front-panel LEDs RS and LO are both extinguished.

**Close Logic Can Still Operate When the Reclosing Relay is Defeated**

If the reclosing relay is defeated, the close logic (see Figure 6.1) can still operate if SELOGIC control equation circuit breaker status setting 52A is set to something other than numeral 0. Making the setting 52A = 0 defeats the close logic and also defeats the reclosing relay.

For example, if 52A = IN101, a 52a circuit breaker auxiliary contact is connected to input IN101. If the reclosing relay does not exist, the close logic still operates, allowing closing to take place via SELOGIC control equation setting CL (close conditions, other than automatic reclosing). See Close Logic earlier in this section for more discussion on SELOGIC control equation settings 52A and CL. Also see Optoisolated Inputs in Section 7: Inputs, Outputs, Timers, and Other Control Logic for more discussion on SELOGIC control equation setting 52A.
Reclosing Relay Timer Settings

Example open interval and reset timer settings are shown in Table 6.2.

<table>
<thead>
<tr>
<th>Timer Setting (range)</th>
<th>Setting (in cycles)</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>79OI1 (0.00–999999 cyc)</td>
<td>30.00</td>
<td>open interval 1 time</td>
</tr>
<tr>
<td>79OI2 (0.00–999999 cyc)</td>
<td>600.00</td>
<td>open interval 2 time</td>
</tr>
<tr>
<td>79OI3 (0.00–999999 cyc)</td>
<td>0.00</td>
<td>open interval 3 time, shot 3 and shot 4 disabled</td>
</tr>
<tr>
<td>79OI4 (0.00–999999 cyc)</td>
<td>0.00</td>
<td>open interval 4 time</td>
</tr>
<tr>
<td>79RSD (0.00–999999 cyc)</td>
<td>1800.00</td>
<td>reset time from reclose cycle state</td>
</tr>
<tr>
<td>79RSLD (0.00–999999 cyc)</td>
<td>300.00</td>
<td>reset time from lockout state</td>
</tr>
<tr>
<td>79CLSD (OFF, 0.00–999999 cyc)</td>
<td>OFF</td>
<td>reclose supervise time limit</td>
</tr>
</tbody>
</table>

The operation of these timers is affected by SELOGIC control equation settings discussed later in this section. Also see the settings sheets at the end of Section 9: Setting the Relay.

Open Interval Timers

The reclose enable setting, E79, determines the number of open interval time settings that can be set. For example, if setting E79 = 3, the first three open interval time settings in Table 6.2 are made available for setting.

If an open interval time is set to zero, then that open interval time is not operable, and neither are the open interval times that follow it.

In the example settings in Table 6.2, the open interval 3 time setting 79OI3 is the first open interval time setting set equal to zero:

79OI3 = 0.00 cycles

Thus, open interval times 79OI3 and 79OI4 are not operable. In the example settings, both open interval times 79OI3 and 79OI4 are set to zero. But if the settings were:

79OI3 = 0.00 cycles
79OI4 = 900.00 cycles (set to some value other than zero)

open interval time 79OI4 would still be inoperative, because a preceding open interval time is set to zero (i.e., 79OI3 = 0.00).

If open interval 1 time setting, 79OI1, is set to zero (79OI1 = 0.00 cycles), no open interval timing takes place, and the reclosing relay is defeated.

The open interval timers time consecutively; they do not have the same beginning time reference point. In the above example settings, open interval 1 time setting, 79OI1, times first. If the
subsequent first reclosure is not successful, then open interval 2 time setting, 79OI2, starts timing. If the subsequent second reclosure is not successful, the relay goes to the Lockout State. See the example time line in Figure 6.6.

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

SELOGIC control equation setting 79STL (stall open interval timing) can be set to control open interval timing (see *Skip Shot and Stall Open Interval Timing Settings [79SKP and 79STL, Respectively]* later in this subsection).

**Determination of Number of Reclosures (Last Shot)**

The number of reclosures is equal to the number of open interval time settings that precede the first open interval time setting set equal to zero. The “last shot” value is also equal to the number of reclosures.

In the above example settings, two set open interval times precede open interval 3 time, which is set to zero (79OI3 = 0.00):

\[
\begin{align*}
79OI1 &= 30.00 \\
79OI2 &= 600.00 \\
79OI3 &= 0.00
\end{align*}
\]

For this example:

The number of reclosures (last shot) is 2, the number of set open interval times that precede the first open interval set to zero.

**Observe Shot Counter Operation**

Observe the reclosing relay shot counter operation, especially during testing, with the front-panel shot counter screen (accessed via the OTHER pushbutton). See *Functions Unique to the Front-Panel Interface* in Section 11: Front-Panel Interface.

**Reset Timer**

The reset timer qualifies circuit breaker closure before taking the relay to the Reset State from the Reclose Cycle State or the Lockout State. Circuit breaker status is determined by the SELOGIC control equation setting 52A. (See *Close Logic* earlier in this section for more discussion on SELOGIC control equation setting 52A. Also see *Optoisolated Inputs* in
Section 7: Inputs, Outputs, Timers, and Other Control Logic for more discussion on SELOGIC control equation setting 52A.)

Setting 79RSD:

Qualifies closures when the relay is in the Reclose Cycle State. These closures are usually automatic reclosures resulting from open interval time-out.

Setting 79RSLD:

Qualifies closures when the relay is in the Lockout State. These closures are usually manual closures. These manual closures can originate external to the relay, via the CLOSE command, or via the SELOGIC control equation setting CL (see Figure 6.1).

Setting 79RSLD is also the reset timer used when the relay powers up, has individual settings changed for the active setting group, or the active setting group is changed (see Reclosing Relay States and Settings/Setting Group Changes earlier in this subsection).

Typically, setting 79RSLD is set less than setting 79RSD. Setting 79RSLD emulates reclosing relays with motor-driven timers that have a relatively short reset time from the lockout position to the reset position.

The 79RSD and 79RSLD settings are set independently (setting 79RSLD can even be set greater than setting 79RSD, if desired). SELOGIC control equation setting 79BRS (block reset timing) can be set to control reset timing (see Block Reset Timing Setting [79BRS] later in this subsection).

Monitoring Open Interval and Reset Timing

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

<table>
<thead>
<tr>
<th>Relay Word Bits</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPTMN</td>
<td>Indicates that the open interval timer is actively timing</td>
</tr>
<tr>
<td>RSTMN</td>
<td>Indicates that the reset timer is actively timing</td>
</tr>
</tbody>
</table>

If the open interval timer is actively timing, OPTMN asserts to logical 1. When the relay is not timing on an open interval (e.g., it is in the Reset State or in the Lockout State), OPTMN deasserts to logical 0. The relay can only time on an open interval when it is in the Reclose Cycle State, but just because the relay is in the Reclose Cycle State does not necessarily mean the relay is timing on an open interval. The relay only times on an open interval after successful reclose initiation and if no stall conditions are present (see Skip Shot and Stall Open Interval Timing Settings [79SKP and 79STL, Respectively] later in this subsection).

If the reset timer is actively timing, RSTMN asserts to logical 1. If the reset timer is not timing, RSTMN deasserts to logical 0. See Block Reset Timing Setting (79BRS) later in this subsection.
Reclosing Relay Shot Counter

Refer to Figure 6.6.

The shot counter increments for each reclose operation. For example, when the relay is timing on open interval 1, 79OI1, it is at shot = 0. When the open interval times out, the shot counter increments to shot = 1 and so forth for the set open intervals that follow. The shot counter cannot increment beyond the last shot for automatic reclosing (see Determination of Number of Reclosures [Last Shot] earlier in this subsection). The shot counter resets back to shot = 0 when the reclosing relay returns to the Reset State.

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

<table>
<thead>
<tr>
<th>Shot</th>
<th>Corresponding Relay Word Bit</th>
<th>Corresponding Open Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>SH0</td>
<td>79OI1</td>
</tr>
<tr>
<td>1</td>
<td>SH1</td>
<td>79OI2</td>
</tr>
<tr>
<td>2</td>
<td>SH2</td>
<td>79OI3</td>
</tr>
<tr>
<td>3</td>
<td>SH3</td>
<td>79OI4</td>
</tr>
<tr>
<td>4</td>
<td>SH4</td>
<td></td>
</tr>
</tbody>
</table>

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

Reclosing Relay SELOGIC Control Equation Settings Overview

Table 6.4: Reclosing Relay SELOGIC Control Equation Settings Example

<table>
<thead>
<tr>
<th>SELOGIC Control Equation Setting</th>
<th>Setting</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>79RI</td>
<td>TRIP</td>
<td>Reclose Initiate</td>
</tr>
<tr>
<td>79RIS</td>
<td>52A + 79CY</td>
<td>Reclose Initiate Supervision</td>
</tr>
<tr>
<td>79DTL</td>
<td>!IN102 + LB3</td>
<td>Drive-to-Lockout</td>
</tr>
<tr>
<td>79DLS</td>
<td>79LO</td>
<td>Drive-to-Last Shot</td>
</tr>
<tr>
<td>79SKP</td>
<td>0</td>
<td>Skip Shot</td>
</tr>
<tr>
<td>79STL</td>
<td>TRIP</td>
<td>Stall Open Interval Timing</td>
</tr>
<tr>
<td>79BRS</td>
<td>0</td>
<td>Block Reset Timing</td>
</tr>
<tr>
<td>79SEQ</td>
<td>0</td>
<td>Sequence Coordination</td>
</tr>
<tr>
<td>79CLS</td>
<td>1</td>
<td>Reclose Supervision</td>
</tr>
</tbody>
</table>

These example settings are discussed in detail in the remainder of this subsection.
Reclose Initiate and Reclose Initiate Supervision Settings (79RI and 79RIS, Respectively)

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

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

Settings Example

With settings:

\[
\begin{align*}
79RI &= \text{TRIP} \\
79RIS &= 52A + 79CY
\end{align*}
\]

the transition of the TRIP Relay Word bit from logical 0 to logical 1 initiates open interval timing only if the 52A + 79CY Relay Word bit is at logical 1 (52A = logical 1, or 79CY = logical 1). Input IN101 is assigned as the breaker status input in the factory settings (52A = IN101).

The circuit breaker has to be closed (circuit breaker status 52A = logical 1) at the instant of the first trip of the auto-reclose cycle in order for the SEL-311C to successfully initiate reclosing and start timing on the first open interval. The SEL-311C is not yet in the reclose cycle state (79CY = logical 0) at the instant of the first trip.

Then for any subsequent trip operations in the auto-reclose cycle, the SEL-311C is in the reclose cycle state (79CY = logical 1) and the SEL-311C successfully initiates reclosing for each trip. Because of setting 79RIS = 52A + 79CY, successful reclose initiation in the reclose cycle state (79CY = logical 1) is not dependent on the circuit breaker status (52A). This allows successful reclose initiation for the case of an instantaneous trip, but the circuit breaker status indication is slow—the instantaneous trip (reclose initiation) occurs before the SEL-311C sees the circuit breaker close.

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

Additional Settings Example

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

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

With setting:

\[
79RI = \neg 52A
\]

the transition of the 52A Relay Word bit from logical 1 to logical 0 (breaker opening) initiates open interval timing. Setting 79RI looks for a logical 0 to logical 1 transition, thus Relay Word bit 52A is inverted in the 79RI setting \([\neg 52A = \text{NOT}(52A)]\).
The reclose initiate supervision setting 79RIS supervises setting 79RI. With settings:

\[
79RI = !52A \\
79RIS = TRIP
\]

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

If the TRIP Relay Word bit is at logical 0 (TRIP = logical 0) when the circuit breaker opens (logical 1 to logical 0 transition), the relay goes to the Lockout State. This helps prevent reclose initiation for circuit breaker openings caused by trips external to the relay.

If circuit breaker status indication (52A) is slow, additional setting change ULCL = 0 (unlatch close; refer to Figure 6.1 and accompanying explanation) may need to be made when 79RI = !52A. ULCL = 0 avoids going to lockout prematurely for an instantaneous trip after an auto-reclose by not turning CLOSE off until the circuit breaker status indication tells the relay that the breaker is closed. The circuit breaker anti-pump circuitry should take care of the TRIP and CLOSE being on together for a short period of time.

Other Settings Considerations

1. In the preceding additional setting example, the reclose initiate settings (79RI) includes input IN101, that is connected to a 52a breaker auxiliary contact (52A = IN101).

\[
79RI = !52A
\]

If a 52b breaker auxiliary contact is connected to input IN101 (52A = !IN101), the reclose initiate setting (79RI) remains the same.

2. If no reclose initiate supervision is desired, make the following setting:

\[
79RIS = 1 \quad \text{(numeral 1)}
\]

Setting 79RIS = logical 1 at all times. Any time a logical 0 to logical 1 transition is detected by setting 79RI, open interval timing will be initiated (unless prevented by other means).

3. If the following setting is made:

\[
79RI = 0 \quad \text{(numeral 0)}
\]

reclosing will never take place (reclosing is never initiated). The reclosing relay is effectively inoperative.

4. If the following setting is made:

\[
79RIS = 0 \quad \text{(numeral 0)}
\]

reclosing will never take place (the reclosing relay goes directly to the lockout state any time reclosing is initiated). The reclosing relay is effectively inoperative.
Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively)

When 79DTL = logical 1, the reclosing relay goes to the Lockout State (Relay Word bit 79LO = logical 1), and the front-panel LO (Lockout) LED illuminates.

79DTL has a 60-cycle dropout time. This keeps the drive-to-lockout condition up 60 more cycles after 79DTL has reverted back to 79DTL = logical 0. This is useful for situations where both of the following are true:

- Any of the trip and drive-to-lockout conditions are “pulsed” conditions (e.g., the OPE command Relay Word bit, OC, asserts for only 1/4 cycle—refer to the following Settings Example).
- Reclose initiation is by the breaker contact opening (e.g., 79RI = !52A—refer to Additional Settings Example in the preceding setting 79RI [reclose initiation] discussion).

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

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

Settings Example

The drive-to-lockout example setting is:

\[
79DTL = \neg\text{IN102} + \text{LB3} + \text{OC}
\]

Optoisolated input IN102 is set to operate as a reclose enable switch (see Optoisolated Inputs in Section 7: Inputs, Outputs, Timers, and Other Control Logic). When Relay Word bit IN102 = logical 1 (reclosing enabled), the relay is not driven to the Lockout State (assuming local bit LB3 = logical 0, too):

\[
\neg\text{IN102} = \neg(\text{logical 1}) = \text{NOT(\text{logical 1})} = \text{logical 0}
\]

\[
79DTL = \neg\text{IN102} + \text{LB3} + \text{OC} = (\text{logical 0}) + \text{LB3} = \text{LB3} + \text{OC}
\]

When Relay Word bit IN102 = logical 0 (reclosing disabled), the relay is driven to the Lockout State:

\[
\neg\text{IN102} = \neg(\text{logical 0}) = \text{NOT(\text{logical 0})} = \text{logical 1}
\]

\[
79DTL = \neg\text{IN102} + \text{LB3} + \text{OC} = (\text{logical 1}) + \text{LB3} + \text{OC} = \text{logical 1}
\]

Local bit LB3 is set to operate as a manual trip switch (see Local Control Switches in Section 7: Inputs, Outputs, Timers, and Other Control Logic and Trip Logic in Section 5: Trip and Target Logic). When Relay Word bit LB3 = logical 0 (no manual trip), the relay is not driven to the Lockout State (assuming optoisolated input IN102 = logical 1, too):

\[
79DTL = \neg\text{IN102} + \text{LB3} + \text{OC} = \text{NOT(IN102)} + (\text{logical 0}) + \text{OC} = \text{NOT(IN102)} + \text{OC}
\]

When Relay Word bit LB3 = logical 1 (manual trip), the relay is driven to the Lockout State:

\[
79DTL = \neg\text{IN102} + \text{LB3} + \text{OC} = \text{NOT(IN102)} + (\text{logical 1}) + \text{OC} = \text{logical 1}
\]
Relay Word bit OC asserts for execution of the OPE command.

The drive-to-last shot setting is:

\[ 79DLS = 79LO \]

Two open intervals are also set in the example settings, resulting in last shot = 2. Any time the relay is in the lockout state (Relay Word bit 79LO = logical 1), the relay is driven to last shot (if the shot counter is not already at a shot value greater than or equal to shot = 2):

\[ 79DLS = 79LO = \text{logical 1} \]

Thus, if optoisolated input IN102 (reclose enable switch) is in the “disable reclosing” position (Relay Word bit IN102 = logical 0) or local bit LB3 (manual trip switch) is operated, then the relay is driven to the Lockout State (by setting 79DTL) and, subsequently, last shot (by setting 79DLS).

**Additional Settings Example 1**

The preceding drive-to-lockout settings example drives the relay to the Lockout State immediately when the reclose enable switch (optoisolated input IN102) is put in the “reclosing disabled” position (Relay Word bit IN102 = logical 0):

\[ 79DTL = \neg\text{IN102} + \ldots = \text{NOT} (\text{IN102}) + \ldots = \text{NOT} (\text{logical 0}) + \ldots = \text{logical 1} \]

To disable reclosing, but not drive the relay to the Lockout State until the relay trips, make settings similar to the following:

\[ 79DTL = \neg\text{IN102} \times \text{TRIP} + \ldots \]

**Additional Settings Example 2**

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

\[ 79DTL = \text{TRIP} \times 50P3 + \ldots \]

**Other Settings Considerations**

If no special drive-to-lockout or drive-to-last shot conditions are desired, make the following settings:

\[ 79DTL = 0 \] (numeral 0)

\[ 79DLS = 0 \] (numeral 0)

With settings 79DTL and 79DLS inoperative, the relay still goes to the Lockout State (and to last shot) if an entire automatic reclose sequence is unsuccessful.

Overall, settings 79DTL or 79DLS are needed to take the relay to the Lockout State (or to last shot) for immediate circumstances.
**Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, Respectively)**

The skip shot setting 79SKP causes a reclose shot to be skipped. Thus, an open interval time is skipped, and the next open interval time is used instead.

If 79SKP = logical 1 at the instant of successful reclose initiation (see preceding discussion on settings 79RI and 79RIS), the relay increments the shot counter to the next shot and then loads the open interval time corresponding to the new shot (see Table 6.3). If the new shot is the “last shot,” no open interval timing takes place, and the relay goes to the Lockout State if the circuit breaker is open (see *Lockout State* earlier in this subsection).

After successful reclose initiation, open interval timing does not start until allowed by the stall open interval timing setting 79STL. If 79STL = logical 1, open interval timing is stalled. If 79STL = logical 0, open interval timing can proceed.

If an open interval time has not yet started timing (79STL = logical 1 still), the 79SKP setting is still processed. In such conditions (open interval timing has not yet started timing), if 79SKP = logical 1, the relay increments the shot counter to the next shot and then loads the open interval time corresponding to the new shot (see Table 6.3). If the new shot turns out to be the “last shot,” no open interval timing takes place, and the relay goes to the Lockout State if the circuit breaker is open (see *Lockout State* earlier in this subsection).

If the relay is in the middle of timing on an open interval and 79STL changes state to 79STL = logical 1, open interval timing stops where it is. If 79STL changes state back to 79STL = logical 0, open interval timing resumes where it left off. Use the OPTMN Relay Word bit to monitor open interval timing (see *Monitoring Open Interval and Reset Timing* earlier in this subsection).

**Settings Example**

The skip shot function is not enabled in the example settings:

\[
\begin{align*}
79SKP &= 0 \quad \text{(numeral 0)} \\
79STL &= \text{TRIP}
\end{align*}
\]

The stall open interval timing setting is:

\[
\begin{align*}
79STL &= \text{TRIP}
\end{align*}
\]

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

**Additional Settings Example 1**

With skip shot setting:

\[
\begin{align*}
79SKP &= 50P2 * SH0
\end{align*}
\]

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

### Table 6.5: Open Interval Time Settings Example

<table>
<thead>
<tr>
<th>Shot</th>
<th>Corresponding Relay Word Bit</th>
<th>Corresponding Open Interval</th>
<th>Open Interval Time Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>SH0</td>
<td>79O11</td>
<td>30 cycles</td>
</tr>
<tr>
<td>1</td>
<td>SH1</td>
<td>79O12</td>
<td>600 cycles</td>
</tr>
</tbody>
</table>

In Table 6.5, note that the open interval 1 time (setting 79O11) is a short time, while the following open interval 2 time (setting 79O12) is significantly longer. For a high magnitude fault (greater than the phase instantaneous overcurrent element 50P2 threshold), open interval 1 time is skipped, and open interval timing proceeds on the following open interval 2 time.

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

**Additional Settings Example 2**

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

![Figure 6.7: Reclose Blocking for Islanded Generator](image)

**Figure 6.7: Reclose Blocking for Islanded Generator**

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

\[ 79STL = 59S1 + \ldots \]
If line voltage is present, Relay Word bit 59S1 asserts, stalling open interval timing (reclose block). If line voltage is not present, Relay Word bit 59S1 deasserts, allowing open interval timing to proceed (unless some other set condition stalls open interval timing).

**Additional Settings Example 3**

Refer to Figure 6.4 and accompanying setting example, showing an application for setting 79STL.

**Other Settings Considerations**

If no special skip shot or stall open interval timing conditions are desired, make the following settings:

- \(79SKP = 0\) (numeral 0)
- \(79STL = 0\) (numeral 0)

**Block Reset Timing Setting (79BRS)**

The block reset timing setting 79BRS keeps the reset timer from timing. Depending on the reclosing relay state, the reset timer can be loaded with either reset time:

- \(79RSD\) (Reset Time from Reclose Cycle)
- \(79RSLD\) (Reset Time from Lockout)

Depending on how setting 79BRS is set, none, one, or both of these reset times can be controlled. If the reset timer is timing and then 79BRS asserts to:

- \(79BRS = \text{logical } 1\)

reset timing is stopped and does not begin timing again until 79BRS deasserts to:

- \(79BRS = \text{logical } 0\)

When reset timing starts again, the reset timer is fully loaded. Thus, successful reset timing has to be continuous. Use the RSTMN Relay Word bit to monitor reset timing (see *Monitoring Open Interval and Reset Timing* earlier in this subsection).

**Settings Example 1**

The block reset timing setting is:

- \(79BRS = (51P + 51G) \times 79CY\)

Relay Word bit 79CY corresponds to the Reclose Cycle State. The reclosing relay is in one of the three reclosing relay states at any one time (see Figure 6.5).

When the relay is in the Reset or Lockout States, Relay Word bit 79CY is deasserted to logical 0. Thus, the 79BRS setting has no effect when the relay is in the Reset or Lockout States. When a circuit breaker is closed from lockout, there could be cold load inrush current that momentarily picks up a time-overcurrent element (e.g., phase time-overcurrent element 51PT pickup [51P]
asserts momentarily). But, this assertion of pickup 51P has no effect on reset timing because the relay is in the Lockout State (79CY = logical 0). The relay will time immediately on reset time 79RSLD and take the relay from the Lockout State to the Reset State with no additional delay because 79BRS is deasserted to logical 0.

When the relay is in the Reclose Cycle State, Relay Word bit 79CY is asserted to logical 1. Thus, the 79BRS setting can function to block reset timing if time-overcurrent pickup 51P or 51G is picked up while the relay is in the Reclose Cycle State. This helps prevent repetitive “trip-reclose” cycling.

**Additional Settings Example 2**

If the block reset timing setting is:

\[ 79\text{BRS} = 51\text{P} + 51\text{G} \]

then reset timing is blocked if time-overcurrent pickup 51P or 51G is picked up, regardless of the reclosing relay state.

**Sequence Coordination Setting (79SEQ)**

The 79SEQ setting is applicable to distribution applications, for transmission system applications set 79SEQ = 0. See the SEL-351 Instruction Manual for a description of setting 79SEQ.
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## SECTION 7: INPUTS, OUTPUTS, TIMERS, AND OTHER CONTROL LOGIC

This section explains the settings and operation of:

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<td>Rotating default displays</td>
<td>display points DP1–DP16</td>
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The above items are relay logic inputs and outputs. They are combined with the distance, overcurrent, voltage, and reclosing elements in SELOGIC control equation settings to realize numerous protection and control schemes.

Relay Word bits and SELOGIC control equation setting examples are used throughout this section. See Section 9: Setting the Relay for more information on Relay Word bits and SELOGIC control equation settings. See Section 10: Serial Port Communications and Commands for more information on viewing and making SELOGIC control equation settings (commands SHO L and SET L).

### OPTOISOLATED INPUTS

Figure 7.1 and Figure 7.2 show the resultant Relay Word bits that follow corresponding optoisolated inputs for the different SEL-311C 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 Figure 1.3, and Figure 2.2 and Figure 2.7 through Figure 2.10).

Figure 7.1 is used for following discussion/examples. The optoisolated inputs in Figure 7.2 operate similarly.
Figure 7.1: Example Operation of Optoisolated Inputs IN101 Through IN106 (Models 0311C00x and 0311C01x)

Figure 7.2: Example Operation of Optoisolated Inputs IN201 Through IN208—Extra I/O Board (Model 0311C01x)
**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 INn (n = 101 through 106) through a SELOGIC control equation variable timer and use the output of the timer for input functions (see Figure 7.24 and Figure 7.25).

**Input Functions**

There are no optoisolated input settings such as:

\[
\begin{align*}
\text{IN101} &= \text{ } \\
\text{IN102} &= \text{ }
\end{align*}
\]

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**

![Settings Example 1 Diagram](image)

Figure 7.3: Circuit Breaker Auxiliary Contact and Reclose Enable Switch Connected to Optoisolated Inputs IN101 and IN102
The functions for inputs IN101 and IN102 (Figure 7.3) are described in the following discussions.

**Input IN101**

Relay Word bit IN101 (Figure 7.3) is used in the settings for the SELOGIC control equation circuit breaker status setting:

\[ 52A = \text{IN101} \]

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:

\[ 52A = \neg \text{IN101} \quad [[\neg \text{IN101} = \text{NOT(IN101)}]] \]

See *Close Logic* in *Section 6: Close and Reclose Logic* for more information on SELOGIC control equation setting 52A.

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

\[ \text{IN101D} = 0.75 \text{ cycles} \]

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 7.3) is used in the settings for the SELOGIC control equation drive-to-lockout setting:

\[ 79\text{DTL} = \neg \text{IN102} + ... \quad [\neg \text{NOT(IN102)} + ...] \]

Connect input IN102 to a reclose enable switch.

When the reclose enable switch is open, input IN102 is deenergized and the reclosing relay is driven to lockout:

\[ 79\text{DTL} = \neg \text{IN102} + ... = \text{NOT(IN102)} + ... = \text{NOT(logical 0)} + ... = \text{logical 1} \]

When the reclose enable switch is closed, input IN102 is energized and the reclosing relay is enabled, if no other setting condition is driving the reclosing relay to lockout:

\[ 79\text{DTL} = \neg \text{IN102} + ... = \text{NOT(IN102)} + ... = \text{NOT(logical 1)} + ... = \text{logical 0} + ... \]

See *Section 6: Close and Reclose Logic* for more information on SELOGIC control equation setting 79DTL.

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

\[ \text{IN102D} = 1.00 \text{ cycle} \]

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).

Figure 7.4: Local Control Switches Drive Local Bits LB1 Through LB16

The output of the local control switch in Figure 7.4 is a Relay Word bit LB\(n\) (\(n = 1\) through 16), called a local bit. The local control switch logic in Figure 7.4 repeats for each local bit LB1 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-311C 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

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<th>Label Setting</th>
<th>Setting Definition</th>
<th>Logic State</th>
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<tr>
<td>not applicable</td>
<td>NLB&lt;sub&gt;n&lt;/sub&gt;</td>
<td>Name of Local Control Switch</td>
<td>not applicable</td>
</tr>
<tr>
<td>ON</td>
<td>SLB&lt;sub&gt;n&lt;/sub&gt;</td>
<td>“Set” Local bit LB&lt;sub&gt;n&lt;/sub&gt;</td>
<td>logical 1</td>
</tr>
<tr>
<td>OFF</td>
<td>CLB&lt;sub&gt;n&lt;/sub&gt;</td>
<td>“Clear” Local bit LB&lt;sub&gt;n&lt;/sub&gt;</td>
<td>logical 0</td>
</tr>
<tr>
<td>MOMENTARY</td>
<td>PLB&lt;sub&gt;n&lt;/sub&gt;</td>
<td>“Pulse” Local bit LB&lt;sub&gt;n&lt;/sub&gt;</td>
<td>logical 1 for one processing interval</td>
</tr>
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</table>

Note the first setting in **Error! Reference source not found.** (NLB<sub>n</sub>) 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<sub>n</sub> is in either the ON (LB<sub>n</sub> = logical 1) or OFF (LB<sub>n</sub> = logical 0) position.

![Figure 7.5: Local Control Switch Configured as an ON/OFF Switch](image)

**OFF/MOMENTARY Switch**

The local bit LB<sub>n</sub> is maintained in the OFF (LB<sub>n</sub> = logical 0) position and pulses to the MOMENTARY (LB<sub>n</sub> = logical 1) position for one processing interval (1/4 cycle).
**ON/OFF/MOMENTARY Switch**

The local bit LB\(n\):

- is in either the ON (LB\(n\) = logical 1) or OFF (LB\(n\) = logical 0) position

  or

- is in the OFF (LB\(n\) = logical 0) position and pulses to the MOMENTARY (LB\(n\) = logical 1) position for one processing interval (1/4 cycle).

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

<table>
<thead>
<tr>
<th>Local Switch Type</th>
<th>Label NL(Bn)</th>
<th>Label CL(Bn)</th>
<th>Label SL(Bn)</th>
<th>Label PL(Bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON/OFF</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>OFF/MOMENTARY</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>ON/OFF/MOMENTARY</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
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:

<table>
<thead>
<tr>
<th>Local Bit</th>
<th>Label Settings</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB3</td>
<td>NLB3 = MANUAL TRIP</td>
<td>trips breaker and drives reclosing relay to lockout</td>
</tr>
<tr>
<td></td>
<td>CLB3 = RETURN</td>
<td>OFF position (“return” from MOMENTARY position)</td>
</tr>
<tr>
<td></td>
<td>SLB3 =</td>
<td>ON position—not used (left “blank”)</td>
</tr>
<tr>
<td></td>
<td>PLB3 = TRIP</td>
<td>MOMENTARY position</td>
</tr>
<tr>
<td>LB4</td>
<td>NLB4 = MANUAL CLOSE</td>
<td>closes breaker, separate from automatic reclosing</td>
</tr>
<tr>
<td></td>
<td>CLB4 = RETURN</td>
<td>OFF position (“return” from MOMENTARY position)</td>
</tr>
<tr>
<td></td>
<td>SLB4 =</td>
<td>ON position—not used (left “blank”)</td>
</tr>
<tr>
<td></td>
<td>PLB3 = CLOSE</td>
<td>MOMENTARY position</td>
</tr>
</tbody>
</table>

Following Figure 7.8 and Figure 7.9 show local control switches with example settings.

**Figure 7.8:** Configured Manual Trip Switch Drives Local Bit LB3

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

\[ TR = ... + LB3 + ... \]

To keep reclosing from being initiated for this trip, set local bit LB3 to drive the reclosing relay to lockout for a manual trip (see Section 6: Close and Reclose Logic):

\[ 79DTL = ... + LB3 \]
Figure 7.9: Configured Manual Close Switch Drives Local Bit LB4

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

\[ CL = \ldots + LB4 + \ldots \]

SELOGIC control equation setting CL is for close conditions, other than automatic reclosing or serial port CLOSE command (see Figure 6.1 in Section 6: Close and Reclose Logic).

Additional Local Control Switch Application Ideas

Local control switches can be applied to almost any control scheme that traditionally requires front-panel switches. The preceding settings examples are OFF/MOMENTARY switches. Local control switches configured as ON/OFF switches can be used for such applications as:

- Reclosing relay enable/disable
- Ground relay enable/disable
- Remote control supervision
- Sequence coordination enable/disable

Local Control Switch States Retained

Power Loss

The states of the local bits (Relay Word bits LB1 through LB16) are retained if power to the relay is lost and then restored. If a local control switch is in the ON position (corresponding local bit is asserted to logical 1) when power is lost, it comes back in the ON position (corresponding local bit is still asserted to logical 1) when power is restored. If a local control switch is in the OFF position (corresponding local bit is deasserted to logical 0) when power is lost, it comes back in the OFF position (corresponding local bit is still deasserted to logical 0) when power is restored. This feature makes the local bit feature behave the same as a traditional installation with panel-mounted control switches. If power is lost to the panel, the front-panel control switch positions remain unchanged.

Settings Change or Active Setting Group Change

If settings are changed (for the active setting group or one of the other setting groups) or the active setting group is changed, the states of the local bits (Relay Word bits LB1 through LB16) are retained, much like in the preceding Power Loss explanation.
If settings are changed for a setting group other than the active setting group, there is no interruption of the local bits (the relay is not momentarily disabled).

If a local control switch is made inoperable because of a settings change (i.e., the corresponding label settings are nulled), the corresponding local bit is then fixed at logical 0, regardless of the local bit state before the settings change. If a local control switch is made newly operable because of a settings change (i.e., the corresponding label settings are set), the corresponding local bit starts out at logical 0.

**REMOTE CONTROL SWITCHES**

Remote control switches are operated via the serial communications port only (see *CON Command (Control Remote Bit)* in Section 10: Serial Port Communications and Commands).

The outputs of the remote control switches in Figure 7.10 are Relay Word bits RBn \((n = 1 \text{ to } 16)\), 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)

**Figure 7.10: Remote Control Switches Drive Remote Bits RB1 Through RB16**

The outputs of the remote control switches in Figure 7.10 are Relay Word bits RBn \((n = 1 \text{ to } 16)\), called remote bits. Use these remote bits in SELOGIC control equations.
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 7.15). Pulse (momentarily operate) the remote bits for this application.

Remote Bit States Not Retained When Power Is Lost

The states of the remote bits (Relay Word bits RB1 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-311C 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 7.11). Pulse the set input to close (“set”) the latching relay output contact. Pulse the reset input to open (“reset”) the latching relay output contact. Often the external contacts wired to the latching relay inputs are from remote control equipment (e.g., SCADA, RTU).
The sixteen (16) latch control switches in the SEL-311C Relay provide latching relay type functions.

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

- **SETn** (set latch bit LTn to logical 1)
- **RSTn** (reset latch bit LTn to logical 0)

If setting SETn asserts to logical 1, latch bit LTn asserts to logical 1. If setting RSTn asserts to logical 1, latch bit LTn deasserts to logical 0. If both settings SETn and RSTn assert to logical 1, setting RSTn has priority and latch bit LTn deasserts to logical 0.
**Latch Control Switch Application Ideas**

Latch control switches can be used for such applications as:

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

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

**Reclosing Relay Enable/Disable Setting Example**

Use a latch control switch to enable/disable the reclosing relay in the SEL-311C Relay. In this example, a SCADA contact is connected to optoisolated input IN104. Each pulse of the SCADA contact changes the state of the reclosing relay. The SCADA contact is not maintained, just pulsed to enable/disable the reclosing relay.

![Diagram](image)

**Figure 7.13: SCADA Contact Pulses Input IN104 to Enable/Disable Reclosing Relay**

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

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

This reclosing relay logic is implemented in the following SELOGIC control equation settings and displayed in Figure 7.14.

\[
\begin{align*}
\text{SET1} &= \text{/IN104} \times \text{!LT1} \quad [= \text{(rising edge of input IN104 AND NOT(LT1))}] \\
\text{RST1} &= \text{/IN104} \times \text{LT1} \quad [= \text{(rising edge of input IN104 AND LT1)}] \\
\text{79DTL} &= \text{!LT1} \quad [= \text{NOT(LT1); drive-to-lockout setting}] 
\end{align*}
\]
Figure 7.14:Latch Control Switch Controlled by a Single Input to Enable/Disable Reclosing

Note: Refer to preceding subsection Optoisolated Inputs and Figure 7.1. Relay Word bit IN104 shows the state of optoisolated input IN104 after the input pickup/dropout debounce timer IN104D. Thus, when using Relay Word bit IN104 in Figure 7.14 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 7.14 that the latch control switch output (latch bit LT1) is effectively used as feedback for SELOGIC control equation settings SET1 and RST1. The feedback of latch bit LT1 “guides” input IN104 to the correct latch control switch input.

If latch bit LT1 = logical 0, input IN104 is routed to setting SET1 (set latch bit LT1):

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

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

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

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

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

Rising Edge Operators

Refer to Figure 7.14 and Figure 7.15.

The rising edge operator in front of Relay Word bit IN104 (/IN104) sees a logical 0 to logical 1 transition as a “rising edge,” and /IN104 asserts to logical 1 for one processing interval.
The rising edge operator on input IN104 is necessary because any single assertion of optoisolated input IN104 by the SCADA contact will last for at least a few cycles, and each individual assertion of input IN104 should only change the state of the latch control switch once (e.g., latch bit LT1 changes state from logical 0 to logical 1).

For example in Figure 7.14, if:

\[ LT1 = \text{logical 0} \]

input IN104 is routed to setting SET1 (as discussed previously):

\[ \text{SET1} = \overline{\text{IN104}} = \text{rising edge of input IN104} \]

If input IN104 is then asserted for a few cycles by the SCADA contact (see Pulse 1 in Figure 7.15), SET1 is asserted to logical 1 for one processing interval. This causes latch bit LT1 to change state to:

\[ LT1 = \text{logical 1} \]

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):

\[ \text{RST1} = \overline{\text{IN104}} = \text{rising edge of input IN104} \]

This would then appear to enable the “reset” input (setting RST1) the next processing interval. But the “rising edge” condition occurred during the preceding processing interval. /IN104 is now at logical 0, so setting RST1 does not assert, even though input IN104 remains asserted for at least a few cycles by the SCADA contact.

If the SCADA contact deasserts and then asserts again (new rising edge—see Pulse 2 in Figure 7.15), the “reset” input (setting RST1) asserts and latch bit LT1 deasserts back to logical 0 again. Thus each individual assertion of input IN104 (Pulse 1, Pulse 2, Pulse 3, and Pulse 4 in Figure 7.15) changes the state of the latch control switch just once.
Use a Remote Bit Instead to Enable/Disable the Reclosing Relay

Use a remote bit to enable/disable the reclosing relay, instead of an optoisolated input. For example, substitute remote bit RB1 for optoisolated input IN104 in the settings accompanying Figure 7.14:

- \[ \text{SET1} = /RB1 \times !LT1 \quad [= \text{rising edge of remote bit RB1 AND NOT(LT1)}] \]
- \[ \text{RST1} = /RB1 \times LT1 \quad [= \text{rising edge of remote bit RB1 AND LT1}] \]
- \[ 79\text{DTL} = !LT1 \quad [= \text{NOT(LT1); drive-to-lockout setting}] \]

Pulse remote bit RB1 to enable reclosing, pulse remote bit RB1 to disable reclosing, etc.—much like the operation of optoisolated input IN104 in the previous example. Remote bits (Relay Word bits RB1 through RB16) are operated through the serial port. See Figure 7.10 and Section 10: Serial Port Communications and Commands for more information on remote bits.

These are just a few control logic examples—many variations are possible.
Latch Control Switch States Retained

Power Loss

The states of the latch bits (LT1 through LT16) are retained if power to the relay is lost and then restored. If a latch bit is asserted (e.g., LT2 = logical 1) when power is lost, it comes back asserted (LT2 = logical 1) when power is restored. If a latch bit is deasserted (e.g., LT3 = logical 0) when power is lost, it comes back deasserted (LT3 = logical 0) when power is restored. This feature makes the latch bit feature behave the same as traditional latching relays. In a traditional installation, if power is lost to the panel, the latching relay output contact position remains unchanged.

Note: Although the relay retains the state of a latched bit when power is cycled, the relay cannot hold output contact closure when power is removed from the relay (output contacts go to their deenergized states).

Settings Change or Active Setting Group Change

If individual settings are changed (for the active setting group or one of the other setting groups) or the active setting group is changed, the states of the latch bits (Relay Word bits LT1 through LT16) are retained, much like in the preceding “Power Loss” explanation.

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

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

Reset Latch Bits for Active Setting Group Change

If desired, the latch bits can be reset to logical 0 right after a settings group change, using SELOGIC control equation setting RST_n (n = 1 through 16). Relay Word bits SG1 through SG6 indicate the active setting Group 1 through 6, respectively (see Error! Reference source not found.).

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:

\[ SV7 = SG4 \]
\[ RST2 = !SV7T + \ldots \quad [= \text{NOT}(SV7T) + \ldots] \]
In Figure 7.16, latch bit LT2 is reset (deasserted to logical 0) when reset setting RST2 asserts to logical 1 for the short time right after setting Group 4 is activated. This logic can be repeated for other latch bits.

**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 SETn and RSTn for any given latch bit LTn be set with care. Settings SETn and RSTn cannot result in continuous cyclical operation of latch bit LTn. Use timers to qualify conditions set in settings SETn and RSTn. If any optoisolated inputs IN101 through IN106 are used in settings SETn and RSTn, the inputs have their own debounce timer that can help in providing the necessary time qualification (see Figure 7.1).

In the preceding reclosing relay enable/disable example application (Figure 7.13 through Figure 7.15), the SCADA contact cannot be asserting/deasserting continuously, thus causing latch bit LT1 to change state continuously. Note that the rising edge operators in the SET1 and RST1 settings keep latch bit LT1 from cyclically operating for any single assertion of the SCADA contact.

Another variation to the example application in Figure 7.13 through Figure 7.15 that adds more security is a timer with pickup/dropout times set the same (see Figure 7.17 and Figure 7.18).
Suppose that SV6PU and SV6DO are both set to 300 cycles. Then the SV6T timer keeps the state of latch bit LT1 from being able to be changed at a rate faster than once every 300 cycles (5 seconds).

Figure 7.17: Latch Control Switch (with Time Delay Feedback) Controlled by a Single Input to Enable/Disable Reclosing

Figure 7.18: Latch Control Switch (with Time Delay Feedback) Operation Time Line
MULTIPLE SETTING GROUPS

The relay has six (6) independent setting groups. Each setting group has complete relay (distance, overcurrent, reclosing, etc.) and SELOGIC control equation settings.

Active Setting Group Indication

Only one setting group can be active at a time. Relay Word bits SG1 through SG6 indicate the active setting group:

Table 7.3: Definitions for Active Setting Group Indication

<table>
<thead>
<tr>
<th>Relay Word bit</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG1</td>
<td>Indication that setting Group 1 is the active setting group</td>
</tr>
<tr>
<td>SG2</td>
<td>Indication that setting Group 2 is the active setting group</td>
</tr>
<tr>
<td>SG3</td>
<td>Indication that setting Group 3 is the active setting group</td>
</tr>
<tr>
<td>SG4</td>
<td>Indication that setting Group 4 is the active setting group</td>
</tr>
<tr>
<td>SG5</td>
<td>Indication that setting Group 5 is the active setting group</td>
</tr>
<tr>
<td>SG6</td>
<td>Indication that setting Group 6 is the active setting group</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Setting</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS1</td>
<td>go to (or remain in) setting Group 1</td>
</tr>
<tr>
<td>SS2</td>
<td>go to (or remain in) setting Group 2</td>
</tr>
<tr>
<td>SS3</td>
<td>go to (or remain in) setting Group 3</td>
</tr>
<tr>
<td>SS4</td>
<td>go to (or remain in) setting Group 4</td>
</tr>
<tr>
<td>SS5</td>
<td>go to (or remain in) setting Group 5</td>
</tr>
<tr>
<td>SS6</td>
<td>go to (or remain in) setting Group 6</td>
</tr>
</tbody>
</table>

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.

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-311C Relay. In this example, optoisolated input IN105 on the relay is connected to a SCADA contact in Figure 7.19. Each pulse of the SCADA contact changes the active setting group from one setting group (e.g., setting Group 1) to another (e.g., setting Group 4). The SCADA contact is not maintained, just pulsed to switch from one active setting group to another.

![Figure 7.19: SCADA Contact Pulses Input IN105 to Switch Active Setting Group Between Setting Groups 1 and 4](image)

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 Error! Reference source not found..
Table 7.5: SELOGIC Control Equation Settings for Switching Active Setting Group Between Setting Groups 1 and 4

<table>
<thead>
<tr>
<th>Setting Group 1</th>
<th>Setting Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV8 = SG1</td>
<td>SV8 = SG4</td>
</tr>
<tr>
<td>SS1 = 0</td>
<td>SS1 = IN105 * SV8T</td>
</tr>
<tr>
<td>SS2 = 0</td>
<td>SS2 = 0</td>
</tr>
<tr>
<td>SS3 = 0</td>
<td>SS3 = 0</td>
</tr>
<tr>
<td>SS4 = IN105 * SV8T</td>
<td>SS4 = 0</td>
</tr>
<tr>
<td>SS5 = 0</td>
<td>SS5 = 0</td>
</tr>
<tr>
<td>SS6 = 0</td>
<td>SS6 = 0</td>
</tr>
</tbody>
</table>

SELOGIC control equation timer input setting SV8 in Error! Reference source not found. has logic output SV8T, shown in operation in Figure 7.20 for both setting Groups 1 and 4.

![Setting Group 1](image1)

![Setting Group 2](image2)

Figure 7.20: SELOGIC Control Equation Variable Timer SV8T Used in Setting Group Switching

In this example, timer SV8T is used in both setting groups — different timers could have been used with the same operational result. The timers reset during the setting group change, allowing the same timer to be used in both setting groups.

Timer pickup setting SV8PU is set greater than the pulse width of the SCADA contact (Figure 7.19). This allows only one active setting group change (e.g., from setting Group 1 to 4) for each pulse of the SCADA contact (and subsequent assertion of input IN105). The functions of the SELOGIC control equations in Error! Reference source not found. are explained in the following example.
**Start Out in Setting Group 1**

Refer to Figure 7.21.

The relay has been in setting Group 1 for some time, with timer logic output SV8T asserted to logical 1, thus enabling SELOGIC control equation setting SS4 for the assertion of input IN105.

**Switch to Setting Group 4**

Refer to Figure 7.21.

The SCADA contact pulses input IN105, and the active setting group changes to setting Group 4 after qualifying time setting TGR (perhaps set at a cycle or so to qualify the assertion of setting SS4). Optoisolated input IN105 also has its own built-in debounce timer (IN105D; see Figure 7.1).

Note that Figure 7.21 shows both setting Group 1 and setting Group 4 settings. The setting Group 1 settings (top of Figure 7.21) are enabled only when setting Group 1 is the active setting group and likewise for the setting Group 4 settings at the bottom of the figure.

Setting Group 4 is now the active setting group, and Relay Word bit SG4 asserts to logical 1. After the relay has been in setting Group 4 for a time period equal to SV8PU, the timer logic output SV8T asserts to logical 1, thus enabling SELOGIC control equation setting SS1 for a new assertion of input IN105.

Note that input IN105 is still asserted as setting Group 4 is activated. Pickup time SV8PU keeps the continued assertion of input IN105 from causing the active setting group to revert back again to setting Group 1 for a single assertion of input IN105. This keeps the active setting group from being changed at a time interval less than time SV8PU.

**Switch Back to Setting Group 1**

Refer to Figure 7.21.

The SCADA contact pulses input IN105 a second time, and the active setting group changes back to setting Group 1 after qualifying time setting TGR (perhaps set at a cycle or so to qualify the assertion of setting SS1). Optoisolated input IN105 also has its own built-in debounce timer, IN105D (see Figure 7.1).
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 Error! Reference source not found..

<table>
<thead>
<tr>
<th>Input States</th>
<th>Active Setting Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN103 IN102 IN101</td>
<td>Setting Group</td>
</tr>
<tr>
<td>0 0 0</td>
<td>Remote</td>
</tr>
<tr>
<td>0 0 1</td>
<td>Group 1</td>
</tr>
<tr>
<td>0 1 0</td>
<td>Group 2</td>
</tr>
<tr>
<td>0 1 1</td>
<td>Group 3</td>
</tr>
<tr>
<td>1 0 0</td>
<td>Group 4</td>
</tr>
<tr>
<td>1 0 1</td>
<td>Group 5</td>
</tr>
<tr>
<td>1 1 0</td>
<td>Group 6</td>
</tr>
</tbody>
</table>

The SEL-311C Relay can be programmed to operate similarly. Use three optoisolated inputs to switch between the six setting groups in the SEL-311C Relay. In this example, optoisolated inputs IN101, IN102, and IN103 on the relay are connected to a rotating selector switch in Figure 7.22.
Figure 7.22: Rotating Selector Switch Connected to Inputs IN101, IN102, and IN103 for Active Setting Group Switching

The selector switch has multiple internal contacts arranged to assert inputs IN101, IN102, and IN103, dependent on the switch position. As shown in Error! Reference source not found., when the selector switch is moved from one position to another, a different setting group is activated. The logic in Error! Reference source not found. is implemented in the SELOGIC control equation settings in Error! Reference source not found..

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

<table>
<thead>
<tr>
<th>Setting</th>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS1</td>
<td>!IN103 * !IN102 * IN101</td>
<td>NOT(IN103) * NOT(IN102) * IN101</td>
</tr>
<tr>
<td>SS2</td>
<td>!IN103 * IN102 * !IN101</td>
<td>NOT(IN103) * IN102 * NOT(IN101)</td>
</tr>
<tr>
<td>SS3</td>
<td>!IN103 * IN102 * !IN101</td>
<td>NOT(IN103) * IN102 * IN101</td>
</tr>
<tr>
<td>SS4</td>
<td>IN103 * !IN102 * !IN101</td>
<td>IN103 * NOT(IN102) * NOT(IN101)</td>
</tr>
<tr>
<td>SS5</td>
<td>IN103 * !IN102 * IN101</td>
<td>IN103 * NOT(IN102) * IN101</td>
</tr>
<tr>
<td>SS6</td>
<td>IN103 * IN102 * !IN101</td>
<td>IN103 * IN102 * NOT(IN101)</td>
</tr>
</tbody>
</table>

The settings in Error! Reference source not found. are made in each setting Group 1 through 6.
Selector Switch Starts Out in Position 3

Refer to Error! Reference source not found. and Figure 7.23.

If the selector switch is in position 3 in Figure 7.22, setting Group 3 is the active setting group (Relay Word bit SG3 = logical 1). Inputs IN101 and IN102 are energized and IN103 is deenergized:

\[ SS3 = \overline{IN103} \times IN102 \times IN101 = \overline{NOT(IN103)} \times IN102 \times IN101 \]
\[ = \overline{NOT(0)} \times 1 \times 1 = 1 \]

To get from the position 3 to position 5 on the selector switch, the switch passes through the position 4. The switch is only briefly in position 4:

\[ SS4 = IN103 \times \overline{IN102} \times \overline{IN101} = IN103 \times \overline{NOT(IN102)} \times \overline{NOT(IN101)} \]
\[ = 1 \times \overline{0} \times \overline{0} = 1 \]

but not long enough to be qualified by time setting TGR in order to change the active setting group to setting Group 4. For such a rotating selector switch application, qualifying time setting TGR is typically set at 180 to 300 cycles. Set TGR long enough to allow the selector switch to pass through intermediate positions without changing the active setting group, until the switch rests on the desired setting group position.

Selector Switch Switched to Position 5

Refer to Figure 7.23.

If the selector switch is rested on position 5 in Figure 7.22, setting Group 5 becomes the active setting group (after qualifying time setting TGR; Relay Word bit SG5 = logical 1). Inputs IN101 and IN103 are energized and IN102 is deenergized:

\[ SS5 = IN103 \times \overline{IN102} \times IN101 = IN103 \times \overline{NOT(IN102)} \times IN101 \]
\[ = 1 \times \overline{0} \times 1 = 1 \]

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

Selector Switch Now Rests on Position REMOTE

Refer to Figure 7.23.

If the selector switch is rested on position REMOTE, all inputs IN101, IN102, and IN103 are deenergized and all settings SS1 through SS6 in Error! Reference source not found. 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.
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.

Figure 7.23: Active Setting Group Switching (with Rotating Selector Switch) Time Line
**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 [Error! Reference source not found.](#)) 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 7.24 and Figure 7.25.

Timers SV1T through SV6T in Figure 7.24 have a setting range of a little over 4.5 hours:

- 0.00–999999.00 cycles in 0.25-cycle increments

Timers SV7T through SV16T in Figure 7.25 have a setting range of almost 4.5 minutes:

- 0.00–16000.00 cycles in 0.25-cycle increments

These timer setting ranges apply to both pickup and dropout times (SV\text{n}PU and SV\text{n}DO, \( n = 1 \) through 16).
Figure 7.24: SELOGIC Control Equation Variables/Timers SV1/SV1T Through SV6/SV6T

Figure 7.25: SELOGIC Control Equation Variables/Timers SV7/SV7T Through SV16/SV16T
**Settings Example**

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

\[ SV1 = \text{TRIP} \]

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.

\[ \text{OUT103} = \text{SV1T} \]

**Additional Settings Example 1**

Another application idea is dedicated breaker failure protection (see Figure 7.26):

\[ SV6 = \text{IN101} \quad \text{(breaker failure initiate)} \]
\[ SV7 = (SV7 + \text{IN101}) \times (50P1 + 50G1) \]
\[ \text{OUT101} = SV6T \quad \text{(retrip)} \]
\[ \text{OUT102} = SV7T \quad \text{(breaker failure trip)} \]

![Diagram](image.png)

**Figure 7.26: Dedicated Breaker Failure Scheme Created with SELOGIC Control Equation Variables/Timers**

Note that the above SELOGIC control equation setting SV7 creates a seal-in logic circuit (as shown in Figure 7.26) by virtue of SELOGIC control equation setting SV7 being set equal to Relay Word bit SV7 (SELOGIC control equation variable SV7):

\[ SV7 = (SV7 + \text{IN101}) \times (50P1 + 50G1) \]
Optoisolated input IN101 functions as a breaker failure initiate input. Phase instantaneous overcurrent element 50P1 and residual ground instantaneous overcurrent element 50G1 function as fault detectors.

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

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

Note that Figure 7.26 suggests the option of having output contacts OUT103 and OUT104 operate as additional breaker failure trip outputs. This is done by making the following SELOGIC control equation settings:

\[
\begin{align*}
\text{OUT103} &= \text{SV7T} \\
\text{OUT104} &= \text{SV7T}
\end{align*}
\]

**(Additional Settings Example 2)**

The seal-in logic circuit in the dedicated breaker failure scheme in Figure 7.26 can be removed by changing the SELOGIC control equation setting SV7 to:

\[
\text{SV7} = \text{IN101} \times (50P1 + 50G1)
\]

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\_nT (n = 1 through 16) are reset to logical 0 and corresponding timer settings SVnPU and SVnDO load up again after power restoration, settings change, or active setting group switch.

Preceding Figure 7.26 shows an effective seal-in logic circuit, created by use of Relay Word bit SV7 (SELOGIC control equation variable SV7) in SELOGIC control equation SV7:

\[
\text{SV7} = (\text{SV7} + \text{IN101}) \times (50P1 + 50G1)
\]

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 7.27 and Figure 7.28 show the example operation of output contact Relay Word bits due to:

- SELOGIC control equation operation
- **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 7.27).

Figure 7.27 is used for the following discussion/examples. The output contacts in Figure 7.28 operate similarly.

**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 and Reclose Logic*)
- OUT104 = KEY (POTT key permissive trip; see *Section 5: Trip and Target 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 7.27.

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 7.27. 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 7.27 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 7.27 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 7.27. 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 7.27 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.
Figure 7.27: Logic Flow for Example Output Contact Operation (Models 0311C00x and 0311C01x)
The rotating default display on the relay front panel replaces indicating panel lights. Traditional indicating panel lights are turned on and off by circuit breaker auxiliary contacts, front-panel switches, SCADA contacts, etc. They indicate such conditions as:

- circuit breaker open/closed
- reclosing relay enabled/disabled

**Figure 7.28: Logic Flow for Example Output Contact Operation—Extra I/O Board (Model 0311C01x)**

**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:
**Traditional Indicating Panel Lights**

Figure 7.29 shows traditional indicating panel lights wired in parallel with SEL-311C Relay optoisolated inputs. Input IN101 provides circuit breaker status to the relay, and input IN102 enables/disables reclosing in the relay via the following SELOGIC control equation settings:

\[
52A = \text{IN101} \\
79\text{DTL} = !\text{IN102} \quad (= \text{NOT(IN102); drive-to-lockout setting})
\]

![Traditional Panel Light Installations](image)

**Figure 7.29: Traditional Panel Light Installations**

Note that Figure 7.29 corresponds to Figure 7.3.

**Reclosing Relay Status Indication**

In Figure 7.29, the 79 ENABLED panel light illuminates when the “79 Enable” switch is closed. When the “79 Enable” switch is open, the 79 ENABLED panel light extinguishes, and it is understood that the reclosing relay is disabled.

**Circuit Breaker Status Indication**

In Figure 7.29, 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-311C Relay is used. Figure 7.30 shows the elimination of the indicating panel lights by using the rotating default display.
There are sixteen (16) of these default displays available in the SEL-311C Relay. Each default display has two complementary screens (e.g., BREAKER CLOSED and BREAKER OPEN) available.

**General Operation of Rotating Default Display Settings**

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

SELOGIC control equation display point setting DP\(_n\) (\(n = 1\) through 16) controls the display of corresponding, complementary text settings:

\[
\text{DP}_n . 1 \quad (\text{displayed when } \text{DP}_n = \text{logical 1})
\]
\[
\text{DP}_n . 0 \quad (\text{displayed when } \text{DP}_n = \text{logical 0})
\]

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-311C Relay front-panel display on a time-variable rotation using Global setting SCROLD (see Rotating Default Display in Section 11: Front-Panel Interface for more specific operation information).

The following settings examples use optoisolated inputs IN101 and IN102 in the display points settings. Local bits (LB1 through LB4), latch bits (LT1 through LT4), remote bits (RB1 through RB8), setting group indicators (SG1 through SG6), and any other combination of Relay Word bits in a SELOGIC control equation setting can also be used in display point setting DP\(_n\).

**Settings Examples**

The settings examples provide the replacement solution shown in Figure 7.30 for the traditional indicating panel lights in Figure 7.29.
**Reclosing Relay Status Indication**

Make SELOGIC control equation display point setting DP1:

\[ DP1 = \text{IN102} \]

Make corresponding, complementary text settings:

\[ DP1_1 = 79 \text{ ENABLED} \]
\[ DP1_0 = 79 \text{ DISABLED} \]

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

**Reclosing Relay Enabled**

In Figure 7.30, optoisolated input IN102 is energized to enable the reclosing relay, resulting in:

\[ DP1 = \text{IN102} = \text{logical 1} \]

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

79 ENABLED

**Reclosing Relay Disabled**

In Figure 7.30, optoisolated input IN102 is deenergized to disable the reclosing relay, resulting in:

\[ DP1 = \text{IN102} = \text{logical 0} \]

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

79 DISABLED

**Circuit Breaker Status Indication**

Make SELOGIC control equation display point setting DP2:

\[ DP2 = \text{IN101} \]

Make corresponding, complementary text settings:

\[ DP2_1 = \text{BREAKER CLOSED} \]
\[ DP2_0 = \text{BREAKER OPEN} \]

Display point setting DP2 controls the display of the text settings.
Circuit Breaker Closed

In Figure 7.30, optoisolated input IN101 is energized when the 52a circuit breaker auxiliary contact is closed, resulting in:

\[ DP2 = IN101 = \text{logical 1} \]

This results in the display of corresponding text setting DP2\_1 on the front-panel display:

\[ \text{BREAKER CLOSED} \]

Circuit Breaker Open

In Figure 7.30, optoisolated input IN101 is deenergized when the 52a circuit breaker auxiliary contact is open, resulting in:

\[ DP2 = IN101 = \text{logical 0} \]

This results in the display of corresponding text setting DP2\_0 on the front-panel display:

\[ \text{BREAKER OPEN} \]

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:

\[ DP2 = \text{IN101} \quad \text{(52a circuit breaker auxiliary contact connected to input IN101—see Figure 7.30)} \]

\[ DP2\_1 = \text{BREAKER CLOSED} \quad \text{(displays when DP2 = logical 1)} \]

\[ DP2\_0 = \quad \text{(blank)} \]

Circuit Breaker Closed

In Figure 7.30, optoisolated input IN101 is energized when the 52a circuit breaker auxiliary contact is closed, resulting in:

\[ DP2 = IN101 = \text{logical 1} \]

This results in the display of corresponding text setting DP2\_1 on the front-panel display:

\[ \text{BREAKER CLOSED} \]
Circuit Breaker Open

In Figure 7.30, optoisolated input IN101 is deenergized when the 52a circuit breaker auxiliary contact is open, resulting in:

\[ DP2 = \text{IN101} = \text{logical 0} \]

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-311C 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)
- \( DP5_1 = \text{LINE 1204} \) (displays when \( DP5 = \text{logical 1} \))
- \( DP5_0 = \) (“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”)
- \( DP5_0 = \text{LINE 1204} \) (displays when \( DP5 = \text{logical 0} \))

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 \( DP_n \) \((n = 1 \text{ through } 16)\) 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 7.30 and the following discussion of an example setting group switching discussion.
Setting Group 1 is the Active Setting Group

When setting Group 1 is the active setting group, optoisolated input IN102 operates as a reclose enable/disable switch with the following settings:

SELOGIC control equation settings:

\[ 79\text{DTL} = \neg\text{IN102} + \ldots \]  
\[ \text{DP1} = \text{IN102} \]

Text settings:

\[ \text{DP1}_1 = 79 \text{ ENABLED} \]  
\[ \text{DP1}_0 = 79 \text{ DISABLED} \]

Reclosing Relay Enabled

In Figure 7.30, optoisolated input IN102 is energized to enable the reclosing relay, resulting in:

\[ \text{DP1} = \text{IN102} = \text{logical } 1 \]

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

```
79 ENABLED
```

Reclosing Relay Disabled

In Figure 7.30, optoisolated input IN102 is deenergized to disable the reclosing relay, resulting in:

\[ \text{DP1} = \text{IN102} = \text{logical } 0 \]

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

```
79 DISABLED
```

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

Switch to Setting Group 4 as the Active Setting Group

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

SELOGIC control equation settings:

\[ 79\text{DTL} = 1 \]  
\[ \text{DP1} = 0 \]

(set directly to logical 1—reclosing relay permanently “driven-to-lockout”)

(set directly to logical 0)
Text settings (remain the same for all setting groups):

\[
\begin{align*}
\text{DP1}_1 &= \text{79 ENABLED} \quad \text{(displayed when DP1 = logical 1)} \\
\text{DP1}_0 &= \text{79 DISABLED} \quad \text{(displayed when DP1 = logical 0)}
\end{align*}
\]

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

79 DISABLED

**Additional Rotating Default Display Example**

See Figure 5.17 and accompanying text in *Section 5: Trip and Target Logic* for an example of resetting a rotating default display with the TARGET RESET pushbutton.

**Displaying Time-Overcurrent Elements on the Rotating Default Display**

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

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

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

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

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

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

**Displaying Time-Overcurrent Elements Example**

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

<table>
<thead>
<tr>
<th>SET</th>
<th>SET T</th>
<th>SET L</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTR = 200</td>
<td>DP1_0 = PHASE TRIPS AT</td>
<td>DP1 = 0</td>
</tr>
<tr>
<td>CTRP = 200</td>
<td>DP2_0 = \text{::51PP}</td>
<td>DP2 = 0</td>
</tr>
<tr>
<td>E51P = Y</td>
<td>DP3_0 = NEUTRAL TRIPS AT</td>
<td>DP3 = 0</td>
</tr>
<tr>
<td>E51G = Y</td>
<td>DP4_0 = \text{::51GP}</td>
<td>DP4 = 0</td>
</tr>
<tr>
<td>51PP = 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GP = 0.75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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

then,

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

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

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

```
Dpi_j = XXX;[:;]ABCDE;YYY
```

where:

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

<table>
<thead>
<tr>
<th>SET T Setting Variable</th>
<th>Displays Relay Setting Value</th>
<th>Display Format/Resolution</th>
<th>Maximum Label Character Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>;;51PP</td>
<td>51PP</td>
<td>xxxxxxxxx.xx</td>
<td>6</td>
</tr>
<tr>
<td>;;51GP</td>
<td>51GP</td>
<td>xxxxxxxxx.xx</td>
<td>6</td>
</tr>
<tr>
<td>;;51QP</td>
<td>51QP</td>
<td>xxxxxxxxx.xx</td>
<td>6</td>
</tr>
<tr>
<td>;;:000</td>
<td>51PP</td>
<td>xxxxxxxxx</td>
<td>9</td>
</tr>
<tr>
<td>;;:001</td>
<td>51GP</td>
<td>xxxxxxxxx</td>
<td>9</td>
</tr>
<tr>
<td>;;:002</td>
<td>51QP</td>
<td>xxxxxxxxx</td>
<td>9</td>
</tr>
</tbody>
</table>
For example, setting DP1_0 = OC PU;;51PP;A will display:

\[
\text{OC PU 1200.00A}
\]

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

\[
\text{OC PU 1200A}
\]

### 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

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Display Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>IA input current</td>
</tr>
<tr>
<td>IB</td>
<td>IB input current</td>
</tr>
<tr>
<td>IC</td>
<td>IC input current</td>
</tr>
<tr>
<td>IP</td>
<td>IN input current</td>
</tr>
<tr>
<td>VA</td>
<td>VA input voltage</td>
</tr>
<tr>
<td>VB</td>
<td>VB input voltage</td>
</tr>
<tr>
<td>VC</td>
<td>VC input voltage</td>
</tr>
<tr>
<td>VS</td>
<td>VS input voltage</td>
</tr>
<tr>
<td>IG</td>
<td>IG = IA + IB + IC (residual)</td>
</tr>
<tr>
<td>3I0</td>
<td>3IO = IG (zero-sequence)</td>
</tr>
<tr>
<td>I1</td>
<td>positive-sequence current</td>
</tr>
<tr>
<td>3I2</td>
<td>negative-sequence current</td>
</tr>
<tr>
<td>3V0</td>
<td>zero-sequence voltage</td>
</tr>
<tr>
<td>V1</td>
<td>positive-sequence voltage</td>
</tr>
<tr>
<td>V2</td>
<td>negative-sequence voltage</td>
</tr>
<tr>
<td>MWA</td>
<td>A megawatts</td>
</tr>
<tr>
<td>MWB</td>
<td>B megawatts</td>
</tr>
<tr>
<td>MWC</td>
<td>C megawatts</td>
</tr>
<tr>
<td>MW3</td>
<td>three-phase megawatts</td>
</tr>
<tr>
<td>MVARA</td>
<td>A megavars</td>
</tr>
<tr>
<td>MVARB</td>
<td>B megavars</td>
</tr>
<tr>
<td>MVARC</td>
<td>C megavars</td>
</tr>
<tr>
<td>MVAR3</td>
<td>three-phase megavars</td>
</tr>
<tr>
<td>PFA</td>
<td>A power factor</td>
</tr>
<tr>
<td>Mnemonic</td>
<td>Display</td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td>PFB</td>
<td>P F B = x . x x L A G</td>
</tr>
<tr>
<td>PFC</td>
<td>P F C = x . x x L A G</td>
</tr>
<tr>
<td>PF3</td>
<td>P F 3 P = x . x x L E A D</td>
</tr>
<tr>
<td>FREQ</td>
<td>F R Q = x x . x</td>
</tr>
<tr>
<td>VDC</td>
<td>V D C = x x x . x v</td>
</tr>
<tr>
<td>IADEM</td>
<td>I A D E M = x . x x x</td>
</tr>
<tr>
<td>IAPK</td>
<td>I A P E A K = x . x x x</td>
</tr>
<tr>
<td>IBDEM</td>
<td>I B D E M = x . x x x</td>
</tr>
<tr>
<td>IBPK</td>
<td>I B P E A K = x . x x x</td>
</tr>
<tr>
<td>ICPK</td>
<td>I C P E A K = x . x x x</td>
</tr>
<tr>
<td>IPDEM</td>
<td>I P D E M = x . x x x</td>
</tr>
<tr>
<td>IPPK</td>
<td>I P P E A K = x . x x x</td>
</tr>
<tr>
<td>3I2DEM</td>
<td>3 I 2 D E M = x . x x x</td>
</tr>
<tr>
<td>3I2PK</td>
<td>3 I 2 P E A K = x . x x x</td>
</tr>
<tr>
<td>MWADI</td>
<td>M W A I N D E M = x . x x x</td>
</tr>
<tr>
<td>MWAPI</td>
<td>M W A I N P K = x . x x x</td>
</tr>
<tr>
<td>MWBDI</td>
<td>M W B I N D E M = x . x x x</td>
</tr>
<tr>
<td>MWBPI</td>
<td>M W B I N P K = x . x x x</td>
</tr>
<tr>
<td>MWCDI</td>
<td>M W C I N D E M = x . x x x</td>
</tr>
<tr>
<td>MWCPI</td>
<td>M W C I N P K = x . x x x</td>
</tr>
<tr>
<td>MW3DI</td>
<td>M W 3 I N D E M = x . x x x</td>
</tr>
<tr>
<td>MW3PI</td>
<td>M W 3 I N P K = x . x x x</td>
</tr>
<tr>
<td>MVRADI</td>
<td>M V R A I D E M = x . x x x</td>
</tr>
<tr>
<td>MVRAPI</td>
<td>M V R A I P K = x . x x x</td>
</tr>
<tr>
<td>MVRBDI</td>
<td>M V R B I D E M = x . x x x</td>
</tr>
<tr>
<td>MVRBPI</td>
<td>M V R B I P K = x . x x x</td>
</tr>
<tr>
<td>MVRCDI</td>
<td>M V R C I D E M = x . x x x</td>
</tr>
<tr>
<td>MVRCPI</td>
<td>M V R C I P K = x . x x x</td>
</tr>
<tr>
<td>MVR3DI</td>
<td>M V R 3 I D E M = x . x x x</td>
</tr>
<tr>
<td>MVR3PI</td>
<td>M V R 3 I P K = x . x x x</td>
</tr>
<tr>
<td>MWADO</td>
<td>M W A O D E M = x . x x x</td>
</tr>
<tr>
<td>MWAPO</td>
<td>M W A O P K = x . x x x</td>
</tr>
<tr>
<td>MWBDO</td>
<td>M W B O D E M = x . x x x</td>
</tr>
<tr>
<td>MWBPO</td>
<td>M W B O P K = x . x x x</td>
</tr>
<tr>
<td>MWCDO</td>
<td>M W C O D E M = x . x x x</td>
</tr>
<tr>
<td>MWCPO</td>
<td>M W C O P K = x . x x x</td>
</tr>
<tr>
<td>MW3DO</td>
<td>M W 3 O D E M = x . x x x</td>
</tr>
<tr>
<td>MW3PO</td>
<td>M W 3 O P K = x . x x x</td>
</tr>
<tr>
<td>Mnemonic</td>
<td>Display</td>
</tr>
<tr>
<td>------------</td>
<td>------------------</td>
</tr>
<tr>
<td>MVRADO</td>
<td>M V R A O D E M = x . x x x</td>
</tr>
<tr>
<td>MVRAP0</td>
<td>M V R A O P K = x . x x x</td>
</tr>
<tr>
<td>MVRBDO</td>
<td>M V R B O D E M = x . x x x</td>
</tr>
<tr>
<td>MVRBPO</td>
<td>M V R B O P K = x . x x x</td>
</tr>
<tr>
<td>MVRCD0</td>
<td>M V R C O D E M = x . x x x</td>
</tr>
<tr>
<td>MVRCP0</td>
<td>M V R C O P K = x . x x x</td>
</tr>
<tr>
<td>MVR3DO</td>
<td>M V R 3 O D E M = x . x x x</td>
</tr>
<tr>
<td>MVR3PO</td>
<td>M V R 3 O P K = x . x x x</td>
</tr>
<tr>
<td>MWHAI</td>
<td>M W h A I N = x . x x x</td>
</tr>
<tr>
<td>MWHAO</td>
<td>M W h A O U T = x x . x x x</td>
</tr>
<tr>
<td>MWHBI</td>
<td>M W h B I N = x x . x x x</td>
</tr>
<tr>
<td>MWHBO</td>
<td>M W h B O U T = x x . x x x</td>
</tr>
<tr>
<td>MWHCI</td>
<td>M W h C I N = x x . x x x</td>
</tr>
<tr>
<td>MWHCO</td>
<td>M W h C O U T = x x . x x x</td>
</tr>
<tr>
<td>MWH3I</td>
<td>M W h 3 I N = x x . x x x</td>
</tr>
<tr>
<td>MWH3O</td>
<td>M W h 3 O U T = x x . x x x</td>
</tr>
<tr>
<td>MVRHAI</td>
<td>M V A R h A I = x x . x x x</td>
</tr>
<tr>
<td>MVRHAO</td>
<td>M V A R h A O = x x . x x x</td>
</tr>
<tr>
<td>MVRHBI</td>
<td>M V A R h B I = x x . x x x</td>
</tr>
<tr>
<td>MVRHBO</td>
<td>M V A R h B O = x x . x x x</td>
</tr>
<tr>
<td>MVRHCI</td>
<td>M V A R h C I = x x . x x x</td>
</tr>
<tr>
<td>MVRHCO</td>
<td>M V A R h C O = x x . x x x</td>
</tr>
<tr>
<td>MVRH3I</td>
<td>M V A R h 3 I = x x . x x x</td>
</tr>
<tr>
<td>MVRH3O</td>
<td>M V A R h 3 O = x x . x x x</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>SET T</th>
<th>SET L</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP1_0 = ::MW3</td>
<td>DP1 = 0</td>
</tr>
<tr>
<td>DP2_0 = ::MVAR3</td>
<td>DP2 = 0</td>
</tr>
<tr>
<td>DP3_0 = ::PF3</td>
<td>DP3 = 0</td>
</tr>
<tr>
<td>DP4_0 = ::FREQ</td>
<td>DP4 = 0</td>
</tr>
</tbody>
</table>

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

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

then,

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

**Displaying Breaker Monitor Output Information on the Rotating Default Display**

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

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

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Display</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRKDATE</td>
<td>R S T D A T : m m / d d / y y</td>
<td>last reset date</td>
</tr>
<tr>
<td>BRKTIME</td>
<td>R S T T I M : h h : m m : s s</td>
<td>last reset time</td>
</tr>
<tr>
<td>CTRLTR</td>
<td>C T R L T R I P S = x x x x x</td>
<td>internal trip count</td>
</tr>
<tr>
<td>OPSCTR</td>
<td>O P S C N T R = x x x x x</td>
<td>internal trip count</td>
</tr>
<tr>
<td>CTRLIA</td>
<td>C T R L I A = x x x x x k A</td>
<td>internal trip Σ IA</td>
</tr>
<tr>
<td>CTRLIB</td>
<td>C T R L I B = x x x x x k A</td>
<td>internal trip Σ IB</td>
</tr>
<tr>
<td>CTRLIC</td>
<td>C T R L I C = x x x x x k A</td>
<td>internal trip Σ IC</td>
</tr>
<tr>
<td>EXTRTR</td>
<td>E X T T R I P S = x x x x x</td>
<td>external trip count</td>
</tr>
<tr>
<td>EXTIA</td>
<td>E X T I A = x x x x x k A</td>
<td>external trip Σ IA</td>
</tr>
<tr>
<td>EXTIB</td>
<td>E X T I B = x x x x x k A</td>
<td>external trip Σ IB</td>
</tr>
<tr>
<td>EXTIC</td>
<td>E X T I C = x x x x x k A</td>
<td>external trip Σ IC</td>
</tr>
<tr>
<td>WEARA</td>
<td>W E A R A = y y y %</td>
<td>A phase wear monitor</td>
</tr>
<tr>
<td>WEARB</td>
<td>W E A R B = y y y %</td>
<td>B phase wear monitor</td>
</tr>
<tr>
<td>WEARC</td>
<td>W E A R C = y y y %</td>
<td>C phase wear monitor</td>
</tr>
</tbody>
</table>
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:

<table>
<thead>
<tr>
<th>SET T</th>
<th>SET L</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP1_0 = ::EXTTR</td>
<td>DP1 = 0</td>
</tr>
<tr>
<td>DP2_0 = ::CTRLTR</td>
<td>DP2 = 0</td>
</tr>
<tr>
<td>DP3_0 = ::CTRLIA</td>
<td>DP3 = 0</td>
</tr>
<tr>
<td>DP4_0 = ::EXTIA</td>
<td>DP4 = 0</td>
</tr>
<tr>
<td>DP5_0 = ::WEARA</td>
<td>DP5 = 0</td>
</tr>
</tbody>
</table>

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

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

then,

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

and then,

```
WEAR A= XXX %
```
INTRODUCTION

SECTION 8: BREAKER MONITOR AND METERING FUNCTIONS

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Figure 8.10: Create DC Voltage Elements with SELOGIC Control Equations
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Figure 8.14: Raise Pickup of Residual Ground Time-Overcurrent Element for Unbalance Current
SECTION 8: BREAKER MONITOR AND METERING FUNCTIONS

INTRODUCTION

The SEL-311C Relay monitoring functions include:

- Breaker Monitor
- Station DC Battery Monitor

In addition to instantaneous metering, the SEL-311C 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-311C 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 20 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

<table>
<thead>
<tr>
<th>Current Interruption Level (kA)</th>
<th>Permissible Number of Close/Open Operations*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00–1.20</td>
<td>10,000</td>
</tr>
<tr>
<td>2.00</td>
<td>3,700</td>
</tr>
<tr>
<td>3.00</td>
<td>1,500</td>
</tr>
<tr>
<td>5.00</td>
<td>400</td>
</tr>
<tr>
<td>8.00</td>
<td>150</td>
</tr>
<tr>
<td>10.00</td>
<td>85</td>
</tr>
<tr>
<td>20.00</td>
<td>12</td>
</tr>
</tbody>
</table>

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

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

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

Set Point 1 maximum number of close/open operations with corresponding current interruption level.

Set Point 2 number of close/open operations that correspond to some midpoint current interruption level.

Set Point 3 number of close/open operations that correspond to the maximum current interruption level.

These three points are entered with the settings in Table 8.2.
Figure 8.1: Plotted Breaker Maintenance Points for an Example Circuit Breaker
Breaker Monitor Setting Example

Table 8.2: Breaker Monitor Settings and Settings Ranges

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

* The ratio of settings KASP3/KASP1 must be: \(5 \leq \frac{KASP3}{KASP1} \leq 100\)

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-311C 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](image)

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. 2.5 kA is interrupted 290 times (290 close/open operations = 480 - 190), pushing the breaker maintenance curve from the 10 percent wear level to the 25 percent wear level.

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

**25 Percent to 50 Percent Breaker Wear**

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

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

**50 Percent to 100 Percent Breaker Wear**

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

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

Additionally, logic outputs assert for alarm or other control applications—see the following discussion.
Figure 8.4: Breaker Monitor Accumulates 10 Percent Wear
Figure 8.5: Breaker Monitor Accumulates 25 Percent Wear
Figure 8.6: Breaker Monitor Accumulates 50 Percent Wear
Figure 8.7: Breaker Monitor Accumulates 100 Percent Wear
Breaker Monitor Output

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

<table>
<thead>
<tr>
<th>Relay Word Bits</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCWA</td>
<td>Phase A breaker contact wear has reached the 100 percent wear level</td>
</tr>
<tr>
<td>BCWB</td>
<td>Phase B breaker contact wear has reached the 100 percent wear level</td>
</tr>
<tr>
<td>BCWC</td>
<td>Phase C breaker contact wear has reached the 100 percent wear level</td>
</tr>
<tr>
<td>BCW</td>
<td>BCWA + BCWB + BCWC</td>
</tr>
</tbody>
</table>

Example Applications

These logic outputs can be used to alarm:

OUT105 = BCW

View or Reset Breaker Monitor Information

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

Via Serial Port

See BRE Command (Breaker Monitor Data) in Section 10: Serial Port Communications and Commands. The BRE command displays the following information:

- Accumulated number of relay-initiated trips
- Accumulated interrupted current from relay-initiated trips
- Accumulated number of externally initiated trips
- Accumulated interrupted current from externally initiated trips
- Percent circuit breaker contact wear for each phase
- Date when the preceding items were last reset (via the BRE R command)

See BRE n Command (Preload/Reset Breaker Wear) in Section 10: Serial Port Communications and Commands. The BRE W command allows the internal trips and currents, the external trips and currents, and the percent breaker wear to be preloaded for each individual phase.

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

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

Determination of Relay-Initiated Trips and Externally Initiated Trips

See BRE Command (Breaker Monitor Data) in Section 10: Serial Port Communications and Commands. Note in the BRE command response that the accumulated number of trips and accumulated interrupted current are separated into two groups of data: that generated by relay-initiated trips (Rly Trips) and that generated by externally initiated trips (Ext Trips). The categorization of this data is determined by the status of the TRIP Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON operates.

Refer to Figure 8.3 and the accompanying explanation. If BKMON newly asserts (logical 0 to logical 1 transition), the relay reads in the current values (Phases A, B, and C). Now the decision has to be made: where is this current and trip count information accumulated? Under relay-initiated trips or externally initiated trips?

To make this determination, the status of the TRIP Relay Word bit is checked at the instant BKMON newly asserts (TRIP is the logic output of Figure 5.1). If TRIP is asserted (TRIP = logical 1), the current and trip count information is accumulated under relay-initiated trips (Rly Trips). If TRIP is deasserted (TRIP = logical 0), the current and trip count information is accumulated under externally initiated trips (Ext Trips).

Regardless of whether the current and trip count information is accumulated under relay-initiated trips or externally initiated trips, this same information is routed to the breaker maintenance curve for continued breaker wear integration (see Figure 8.3 through Figure 8.7).

Setting Example

As discussed previously, the SELOGIC control equation breaker monitor initiation may be set:

$$BKMON = TRIP$$

Thus, any new assertion of BKMON will be deemed a relay trip, and the current and trip count information is accumulated under relay-initiated trips (Rly Trips).

Additional Example

Refer to Figure 8.8. Output contact OUT101 is set to provide tripping:

$$OUT101 = TRIP$$

Note that optoisolated input IN106 monitors the trip bus. If the trip bus is energized by output contact OUT101, an external control switch, or some other external trip, then IN106 is asserted.
Figure 8.8: Input IN106 Connected to Trip Bus for Breaker Monitor Initiation

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

\[ BKMON = \text{IN106} \]

then the SEL-311C 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-311C 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 19 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-311C 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-311C Relay outside of the power supply limits listed in *Section 1: Introduction and Specifications*.

![Diagram of DC Under- and Overvoltage Elements](image)

**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:

\[ V_{dc} \leq \text{DCLO} \quad \text{or} \quad V_{dc} \geq \text{DCHIP} \]

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 (\( V_{dc} = 0 \text{ Vdc} \))

\[ V_{dc} = < \text{DCLOP} \]

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:

\[ \text{DCHIP} \leq V_{dc} \leq \text{DCLOP} \]

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 \( (V_{dc} = 0 \text{ Vdc}) \)
\[ V_{dc} = < \text{DCHIP} \]

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

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

- closed (“a” type output contact)
- open (“b” type output contact)

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

- open (“a” type output contact)
- closed (“b” type output contact)

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

- open (“a” type output contact)
- closed (“b” type output contact)

Additional Application

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

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

\[ 79\text{DTL} = !SV4T + \ldots \]  

\[ [= \text{NOT}(SV4T) + \ldots] \]
Timer output SV4T is from the bottom of Figure 8.10. When dc voltage falls below pickup DCHIP, timer output SV4T drops out (= logical 0), driving the relay to lockout:

\[ 79DTL = \neg SV4T + \ldots = \neg\text{NOT}(SV4T) + \ldots = \neg\text{NOT}(\text{logical 0}) + \ldots = \text{logical 1} \]

**View Station DC Battery Voltage**

**Via Serial Port**

See *MET Command (Metering Data)—Instantaneous Metering in Section 10: Serial Port Communications and Commands*. The MET command displays the station dc battery voltage (labeled VDC).

**Via Front Panel**

The information available via the previously discussed MET serial port command is also available via the front-panel METER pushbutton. See Figure 11.2 in *Section 11: Front-Panel Interface*.

**Analyze Station DC Battery Voltage**

See *Standard 15/30/60-Cycle Event Reports in Section 12: Standard Event Reports and SER*. The station dc battery voltage is displayed in column Vdc in the example event report in Figure 12.2. Changes in station dc battery voltage for an event (e.g., circuit breaker tripping) can be observed. Use the EVE command to retrieve event reports as discussed in *Section 12*.

**Station DC Battery Voltage Dips During Circuit Breaker Tripping**

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

\[ \text{OUT101} = \text{TRIP} \]

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:

\[ \text{e.g., ER} = /\text{IN106} + \ldots \]

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-311C Relay closes the circuit breaker, make the SELOGIC control equation event report generation setting:

\[ \text{ER} = /\text{OUT102} + \ldots \]
In this example, output contact OUT102 is set to close:

\[ \text{OUT102} = \text{CLOSE} \]  \hspace{1cm} (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:

\[ \text{ER} = \backslash \text{SV4T} + ... \]

Timer output SV4T is an example dc voltage element from the bottom of Figure 8.10. Any time dc voltage falls below pickup DCHIP, timer output SV4T drops out (logical 1 to logical 0 transition), creating a falling-edge condition that generates an event report.

Also, the Sequential Event Recorder (SER) report can be used to time-tag station dc battery voltage dips (see Sequential Events Recorder [SER] Report in Section 12: Standard Event Reports and SER).

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

If the SEL-311C Relay has a 125/250 Vac/Vdc supply, it can be powered by ac voltage (85 to 264 Vac) connected to the rear-panel terminals labeled POWER. When powering the relay with ac voltage, the dc voltage elements in Figure 8.9 see the average of the sampled ac voltage powering the relay—which is very near zero volts (as displayed in column Vdc in event reports). Pickup settings DCLOP and DCHIP should be set off (DCLOP = OFF, DCHIP = OFF) since they are of no real use.

If a “raw” event report is displayed (with the **EVE R** command), column Vdc will display the sampled ac voltage waveform, rather than the average.

**DEMAND METERING**

The SEL-311C Relay offers the choice between two types of demand metering, settable with the enable setting:

\[ \text{EDEM} = \text{THM} \text{ (Thermal Demand Meter)} \]

or

\[ \text{EDEM} = \text{ROL} \text{ (Rolling Demand Meter)} \]

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-311C Relay provides demand and peak demand metering for the following values:

<table>
<thead>
<tr>
<th>Currents</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{A,B,C}$</td>
<td>Input currents (A primary)</td>
</tr>
<tr>
<td>$I_g$</td>
<td>Residual ground current (A primary; $I_g = 3I_0 = I_A + I_B + I_C$)</td>
</tr>
<tr>
<td>$3I_2$</td>
<td>Negative-sequence current (A primary)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$MW_{A,B,C,3P}$</td>
<td>Single- and three-phase megawatts</td>
</tr>
<tr>
<td>$MVAR_{A,B,C,3P}$</td>
<td>Single- and three-phase megavars</td>
</tr>
</tbody>
</table>

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.

![Parallel RC Circuit](image)

**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-311C 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:

<table>
<thead>
<tr>
<th>5-Minute Totals</th>
<th>Corresponding 5-Minute Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 per unit</td>
<td>-15 to -10 minutes</td>
</tr>
<tr>
<td>0.0 per unit</td>
<td>-10 to -5 minutes</td>
</tr>
<tr>
<td>0.0 per unit</td>
<td>-5 to 0 minutes</td>
</tr>
<tr>
<td>0.0 per unit</td>
<td></td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>5-Minute Totals</th>
<th>Corresponding 5-Minute Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 per unit</td>
<td>-10 to -5 minutes</td>
</tr>
<tr>
<td>0.0 per unit</td>
<td>-5 to 0 minutes</td>
</tr>
<tr>
<td>1.0 per unit</td>
<td>0 to 5 minutes</td>
</tr>
<tr>
<td>1.0 per unit</td>
<td></td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>5-Minute Totals</th>
<th>Corresponding 5-Minute Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 per unit</td>
<td>-5 to 0 minutes</td>
</tr>
<tr>
<td>1.0 per unit</td>
<td>0 to 5 minutes</td>
</tr>
<tr>
<td>1.0 per unit</td>
<td>5 to 10 minutes</td>
</tr>
<tr>
<td>2.0 per unit</td>
<td></td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>5-Minute Totals</th>
<th>Corresponding 5-Minute Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 per unit</td>
<td>0 to 5 minutes</td>
</tr>
<tr>
<td>1.0 per unit</td>
<td>5 to 10 minutes</td>
</tr>
<tr>
<td>1.0 per unit</td>
<td>10 to 15 minutes</td>
</tr>
<tr>
<td>3.0 per unit</td>
<td></td>
</tr>
</tbody>
</table>

Rolling demand meter response at “Time = 15 minutes” = 3.0/3 = 1.0 per unit

Demand Meter Settings

<table>
<thead>
<tr>
<th>Setting</th>
<th>Definition</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDEM</td>
<td>Demand meter type</td>
<td>THM = thermal\</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ROL = rolling</td>
</tr>
<tr>
<td>DMTC</td>
<td>Demand meter time constant</td>
<td>5, 10, 15, 30, or 60 minutes</td>
</tr>
<tr>
<td>PDEMP</td>
<td>Phase demand current pickup</td>
<td>OFF</td>
</tr>
<tr>
<td>GDEMP</td>
<td>Residual ground demand current pickup</td>
<td>0.10–3.20 A {1 A nominal}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.50–16.0 A {5 A nominal}</td>
</tr>
<tr>
<td>QDEMP</td>
<td>Negative-sequence demand current pickup</td>
<td>in 0.01 A steps</td>
</tr>
</tbody>
</table>
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 $I_{GDEM}$ 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 $I_g$ ($I_g = 3I_o$). To avoid tripping on unbalance current $I_g$, use Relay Word bit GDEM to detect the residual ground (unbalance) demand current $I_{gDEM}$ and effectively raise the pickup of the residual ground time-overcurrent element 51GT. This is accomplished with the following settings from Table 8.3, pertinent residual ground overcurrent element settings, and SELOGIC control equation torque control setting 51GTC:

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

Refer to Figure 8.13, Figure 8.14, and Figure 3.25.

---

**Figure 8.14: Raise Pickup of Residual Ground Time-Overcurrent Element for Unbalance Current**
Residual Ground Demand Current Below Pickup GDEMP

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

$$51GTC = \neg GDEM + GDEM \times 50G2 = \neg (\text{GDEM}) + \text{GDEM} \times 50G2$$

$$= \neg (\text{logical} \ 0) + (\text{logical} \ 0) \times 50G2 = \text{logical} \ 1$$

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

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

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

$$51GTC = \neg GDEM + GDEM \times 50G2 = \neg (\text{GDEM}) + \text{GDEM} \times 50G2$$

$$= \neg (\text{logical} \ 1) + (\text{logical} \ 1) \times 50G2 = \text{logical} \ 0 + 50G2 = 50G2$$

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

$$50G2P = 2.30 \ \text{A secondary}$$

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

Residual Ground Demand Current Goes Below Pickup GDEMP Again

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

$$51GTC = \neg GDEM + GDEM \times 50G2 = \neg (\text{GDEM}) + \text{GDEM} \times 50G2$$

$$= \neg (\text{logical} \ 0) + (\text{logical} \ 0) \times 50G2 = \text{logical} \ 1$$

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:

<table>
<thead>
<tr>
<th>Currents</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{A,B,C}$</td>
<td>$\text{MW}_{A,B,C}$</td>
</tr>
<tr>
<td>$I_g$</td>
<td>$\text{MVAR}_{A,B,C}$</td>
</tr>
<tr>
<td>$3I_2$</td>
<td>$\text{MW}_{3P}$</td>
</tr>
<tr>
<td></td>
<td>$\text{MVAR}_{3P}$</td>
</tr>
</tbody>
</table>

Input currents (A primary)
Residual ground current (A primary; $I_g = 3I_0 = I_A + I_B + I_C$)
Negative-sequence current (A primary)

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-311C 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-311C Relay updates energy values approximately every 2 seconds.

The relay stores energy values to nonvolatile storage once per day (it overwrites the previous stored value). Should the relay lose control power, it will restore the energy values saved by the relay at 23:50 hours on the previous day.

MAXIMUM/MINIMUM METERING

View or Reset Maximum/Minimum Metering Information

Via Serial Port

See MET Command (Metering Data), MET M—Maximum/Minimum Metering in Section 10: Serial Port Communications and Commands. The MET M command displays maximum/minimum metering for the following values:

- **Currents**
  - $I_{A,B,C}$: Input currents (A primary)
  - $I_G$: Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)

- **Voltages**
  - $V_{A,B,C}$: Input voltages (kV primary)
  - $V_S$: Input voltage (kV primary)

- **Power**
  - $MW_{3P}$: Three-phase megawatts
  - $MVAR_{3P}$: Three-phase megavars

The MET RM command resets the maximum/minimum metering values.

Via Front Panel

The information and reset functions available via the previously discussed serial port commands MET M and MET RM are also available via the front-panel METER pushbutton. See Figure 11.2 in Section 11: Front-Panel Interface.
**Maximum/Minimum Metering Updating and Storage**

The SEL-311C Relay updates maximum/minimum values, if the following conditions are met:

- SELOGIC control equation setting FAULT is deasserted (= logical 0).
  The factory default setting is set with time-overcurrent and distance element pickups:
  FAULT = 51G + 51Q + M2P + Z2G
  If there is a fault, these elements pick up and block updating of maximum/minimum metering values.

- The metering value is above the previous maximum or below the previous minimum for 2 cycles.

- For voltage values, the voltage is above 13 V secondary.

- For current values, the currents are above:
  0.25 A secondary {5 A nominal}
  0.05 A secondary {1 A nominal}

- Megawatt and megavar values are subject to the above voltage and current thresholds.

The SEL-311C Relay stores maximum/minimum values to nonvolatile storage once per day (it overwrites the previous stored value if it is exceeded). Should the relay lose control power, it will restore the maximum/minimum values saved by the relay at 23:50 hours on the previous day.
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SECTION 9: SETTING THE RELAY

INTRODUCTION

Change or view settings with the SET and SHOWSET serial port commands and the front-panel SET pushbutton. Table 9.1 lists the serial port SET commands.

Table 9.1: Serial Port SET Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Settings Type</th>
<th>Description</th>
<th>Settings Sheets*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SET $m$</td>
<td>Relay</td>
<td>Distance, overcurrent and voltage elements, reclosing relay, timers, etc., for settings group $m$ ($m = 1, 2, 3, 4, 5, 6$).</td>
<td>1–13</td>
</tr>
<tr>
<td>SET $L \cdot m$</td>
<td>Logic</td>
<td>SELOGIC® control equations for settings group $m$ ($m = 1, 2, 3, 4, 5, 6$).</td>
<td>14–18</td>
</tr>
<tr>
<td>SET $G$</td>
<td>Global</td>
<td>Battery and breaker monitors, optoisolated input debounce timers, etc.</td>
<td>19–20</td>
</tr>
<tr>
<td>SET $R$</td>
<td>SER</td>
<td>Sequential Events Recorder trigger conditions.</td>
<td>21</td>
</tr>
<tr>
<td>SET $T$</td>
<td>Text</td>
<td>Front-panel default display and local control text.</td>
<td>22–25</td>
</tr>
<tr>
<td>SET $P \cdot m$</td>
<td>Port</td>
<td>Serial port settings for Serial Port $m$ ($m = 1, 2, 3, \text{ or F}$).</td>
<td>26</td>
</tr>
</tbody>
</table>

* 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  
\[ n = L, G, R, T, \text{ or } P \] (parameter \( n \) is not entered for the Relay settings. See Table 9.1).  
\[ m = \text{ group (1…6) or port (1…3). } \] The relay selects the active group or port if \( m \) is not specified.  
\[ s = \text{ the name of the specific setting you wish to jump to and begin setting. } \] If \( s \) is not entered, the relay starts at the first setting.  
\[ \text{TERSE} = \text{ instructs the relay to skip the SHOWSET display after the last setting. Use this parameter to speed up the SET command. If you wish to review the settings before saving, do not use the TERSE option.} \]

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

<table>
<thead>
<tr>
<th>Press Key(s)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;ENTER&gt;</code></td>
<td>Retains setting and moves to the next setting.</td>
</tr>
<tr>
<td><code>^ &lt;ENTER&gt;</code></td>
<td>Returns to previous setting.</td>
</tr>
<tr>
<td><code>&lt; &lt;ENTER&gt;</code></td>
<td>Returns to previous section.</td>
</tr>
<tr>
<td><code>&gt; &lt;ENTER&gt;</code></td>
<td>Moves to next section.</td>
</tr>
<tr>
<td><strong>END&lt;ENTER&gt;</strong></td>
<td>Exits editing session, then prompts you to save the settings.</td>
</tr>
<tr>
<td><code>&lt;CTRL&gt; X</code></td>
<td>Aborts editing session without saving changes.</td>
</tr>
</tbody>
</table>

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 7.27) 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 7.27), but the EN LED remains on (see Table 5.1) while the new settings are saved.

**TIME-OVERCURRENT CURVES**

The following information describes the curve timing for the curve and time dial settings made for the time-overcurrent elements (see Figure 3.24 through Figure 3.26). 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≤1].

### U.S. Moderately Inverse Curve: U1

\[
\begin{align*}
\text{tp} &= \text{TD} \cdot (0.0226 + 0.0104/(M^{0.02} - 1)) \\
\text{tr} &= \text{TD} \cdot (1.08/(1-M^2))
\end{align*}
\]

### U.S. Very Inverse Curve: U3

\[
\begin{align*}
\text{tp} &= \text{TD} \cdot (0.0963 + 3.88/(M^2 - 1)) \\
\text{tr} &= \text{TD} \cdot (3.88/(1-M^2))
\end{align*}
\]

### U.S. Short-Time Inverse Curve: U5

\[
\begin{align*}
\text{tp} &= \text{TD} \cdot (0.00262 + 0.00342/(M^{0.02} - 1)) \\
\text{tr} &= \text{TD} \cdot (0.323/(1-M^2))
\end{align*}
\]

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

\[
\begin{align*}
\text{tp} &= \text{TD} \cdot (0.14/(M^{0.02} - 1)) \\
\text{tr} &= \text{TD} \cdot (13.5/(1-M^2))
\end{align*}
\]

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

\[
\begin{align*}
\text{tp} &= \text{TD} \cdot (13.5/(M-1)) \\
\text{tr} &= \text{TD} \cdot (47.3/(1-M^2))
\end{align*}
\]

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

\[
\begin{align*}
\text{tp} &= \text{TD} \cdot (80.0/(M^2 - 1)) \\
\text{tr} &= \text{TD} \cdot (80.0/(1-M^2))
\end{align*}
\]

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

\[
\begin{align*}
\text{tp} &= \text{TD} \cdot (0.05/(M^{0.02} - 1)) \\
\text{tr} &= \text{TD} \cdot (4.85/(1-M^2))
\end{align*}
\]

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

\[
\begin{align*}
\text{tp} &= \text{TD} \cdot (0.05/(M^{0.02} - 1)) \\
\text{tr} &= \text{TD} \cdot (4.85/(1-M^2))
\end{align*}
\]
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-311C Relay Models 0311C00x and 0311C01x Relay Word Bits**

<table>
<thead>
<tr>
<th>Row</th>
<th>Relay Word Bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>EN TRP TIME COMM SOTF RCRS RCLO 51</td>
</tr>
<tr>
<td>1</td>
<td>A B C G ZONE1 ZONE2 ZONE3 ZONE4</td>
</tr>
<tr>
<td>2</td>
<td>M1P M1PT Z1G Z1GT M2P M2PT Z2G Z2GT</td>
</tr>
<tr>
<td>3</td>
<td>Z1T Z2T 50P1 67P1 67P1T 50G1 67G1 67G1T</td>
</tr>
<tr>
<td>4</td>
<td>51G 51GT 51GR LOP ILOP ZLOAD ZLOUT ZLIN</td>
</tr>
<tr>
<td>5</td>
<td>LB1 LB2 LB3 LB4 LB5 LB6 LB7 LB8</td>
</tr>
<tr>
<td>6</td>
<td>LB9 LB10 LB11 LB12 LB13 LB14 LB15 LB16</td>
</tr>
<tr>
<td>7</td>
<td>RB1 RB2 RB3 RB4 RB5 RB6 RB7 RB8</td>
</tr>
<tr>
<td>8</td>
<td>RB9 RB10 RB11 RB12 RB13 RB14 RB15 RB16</td>
</tr>
<tr>
<td>9</td>
<td>LT1 LT2 LT3 LT4 LT5 LT6 LT7 LT8</td>
</tr>
<tr>
<td>10</td>
<td>LT9 LT10 LT11 LT12 LT13 LT14 LT15 LT16</td>
</tr>
<tr>
<td>11</td>
<td>SV1 SV2 SV3 SV4 SV1T SV2T SV3T SV4T</td>
</tr>
<tr>
<td>12</td>
<td>SV5 SV6 SV7 SV8 SV5T SV6T SV7T SV8T</td>
</tr>
<tr>
<td>13</td>
<td>SV9 SV10 SV11 SV12 SV9T SV10T SV11T SV12T</td>
</tr>
<tr>
<td>14</td>
<td>SV13 SV14 SV15 SV16 SV13T SV14T SV15T SV16T</td>
</tr>
<tr>
<td>15</td>
<td>MAB1 MBC1 MCA1 MAB2 MB2 MBC2 MCA2 CVTBL SOTFT</td>
</tr>
<tr>
<td>16</td>
<td>MAG1 MBG1 MCG1 MAG2 MBG2 MCG2 DCHI DCLO</td>
</tr>
<tr>
<td>17</td>
<td>BCW BCWA BCWB BCWC FIDEN FSA FSB FSC</td>
</tr>
<tr>
<td>18</td>
<td>SG1 SG2 SG3 SG4 SG5 SG6 OC CC</td>
</tr>
<tr>
<td>19</td>
<td>CLOSE CF TRGTR 52A 3PO SOTFE VPOLV 50L</td>
</tr>
<tr>
<td>20</td>
<td>PDEM GDEM QDEM TRIP 50QF 50QR 50GF 50GR</td>
</tr>
<tr>
<td>21</td>
<td>32QF 32QR 32GF 32GR 32VE 32QGE 32IE 32QE</td>
</tr>
<tr>
<td>22</td>
<td>F32I R32I F32Q R32Q F32G R32Q R32V R32V</td>
</tr>
<tr>
<td>23</td>
<td>* * IN106 IN105 IN104 IN103 IN102 IN101</td>
</tr>
<tr>
<td>24</td>
<td>ALARM OUT107 OUT106 OUT105 OUT104 OUT103 OUT102 OUT101</td>
</tr>
<tr>
<td>25</td>
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<td>X5ABC X6ABC OSB OSB1 OSB2 OSB3 OSB4 UBOSB</td>
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<td>50G4 67G4 67G4T * MPP1 MABC1 MPP2 MABC2</td>
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<td>50Q1 67Q1 67Q1T 50Q2 67Q2 67Q2T 59N1 59N2</td>
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<td>50Q3 67Q3 67Q3T 50Q4 67Q4 67Q4T 59Q 59V1</td>
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<td>51Q 51QT 51QR * * Z2PGS 67Q2S BTX</td>
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<td>Z3XT DSTRT NSTRT STOP Z3RB KEY EKEY ECTT</td>
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<td>27A 27B 27C 59A 59B 59C 3P27 3P59</td>
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<td>43</td>
<td>27AB 27BC 27CA 59AB 59BC 59CA * *</td>
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<td>45</td>
<td>OUT209 OUT210 OUT211 OUT212' MPP3 MABC3 MPP4 MABC4</td>
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<td>IN208 IN207 IN206 IN205 IN203 IN202 IN201'</td>
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<td>RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A</td>
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<td>81D1 81D2 81D3 81D4 81D5 81D6 27B81 *</td>
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<td>53</td>
<td>81D1T 81D2T 81D3T 81D4T 81D5T 81D6T * *</td>
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1. See Figure 7.1 for more information on the operation of optoisolated inputs IN101 through IN106. See Figure 7.2 for more information on the operation of optoisolated inputs IN201 through IN208.

2. All output contacts can be “a” or “b” type contacts. See Figure 2.15 and Figure 7.27 for more information on the operation of output contacts OUT101 through ALARM. See Figure 2.16 and Figure 7.28 for more information on the operation of output contacts OUT201 through OUT212.

3. OUT201 through OUT212 and IN201 through IN208 only available on model 0311C01x.
### Table 9.4: Relay Word Bit Definitions for the SEL-311C

Row numbers for Models 0311C00x and 0311C01x.

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<th>Primary Application</th>
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<td>Relay Trip</td>
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<td>TIME</td>
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<td>Communications Assisted Trip</td>
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<td>Recloser in Reset State</td>
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<td>RCLO</td>
<td>Recloser in Lockout State</td>
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<td>51</td>
<td>Time-Overcurrent Trip</td>
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<td>Phase A is involved in the fault (see Table 5.1)</td>
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<td>Phase B is involved in the fault</td>
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<td>Phase C is involved in the fault</td>
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<td>Level 1 phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P1P; see Figure 3.19</td>
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<td>Testing, Special directional control schemes</td>
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ZLIN Load encroachment “load in” element (see Figure 4.3)
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<td>Testing, Seal-in functions, etc. (see Figure 7.26)</td>
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<td>Station dc battery instantaneous overvoltage element (see Figure 8.9)</td>
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<td>A-phase breaker contact wear has reached 100% wear level (see Breaker Monitor in Section 8: Breaker Monitor and Metering Functions)</td>
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<td>B-phase breaker contact wear has reached 100% wear level (see Breaker Monitor in Section 8: Breaker Monitor and Metering Functions)</td>
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<td>BCWC</td>
<td>C-phase breaker contact wear has reached 100% wear level (see Breaker Monitor in Section 8: Breaker Monitor and Metering Functions)</td>
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<td>A-phase to ground or B-C phases to ground fault identification logic output used in distance element logic</td>
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<td>FSB</td>
<td>B-phase to ground or A-C phases to ground fault identification logic output used in distance element logic</td>
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<td>Setting group 1 active (see Table 7.3)</td>
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<td>Setting group 2 active (see Table 7.3)</td>
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<td>Setting group 5 active (see Table 7.3)</td>
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<td>SG6</td>
<td>Setting group 6 active (see Table 7.3)</td>
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<td>Asserts 1/4 cycle for Open Command execution (see OPE Command (Open Breaker) in Section 10: Serial Port Communications and Commands)</td>
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<td>CC</td>
<td>Asserts 1/4 cycle for Close Command execution</td>
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<td><em>(see CLO Command (Close Breaker) in Section 10: Serial Port Communications and Commands)</em></td>
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<td>CLOSE</td>
<td>Close logic output asserted (see Figure 6.1)</td>
<td>Output contact assignment</td>
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<td>Close failure condition (asserts for 1/4 cycle; see Figure 6.1)</td>
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<td>TRGTR</td>
<td>Target Reset. TRGTR pulses to logical 1 for one processing interval when either the TARGET RESET Pushbutton is pushed or the TAR R serial port command is executed (see Figures 5.1 and 5.17)</td>
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<td>52A</td>
<td>Circuit breaker status (asserts to logical 1 when circuit breaker is closed; see Figure 6.1)</td>
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<td>Three pole open condition (see Figure 5.3)</td>
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<td>Switch-onto-fault condition (see Figure 5.3)</td>
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<td>Positive-sequence polarization voltage valid (see Figure 3.4 through Figure 3.12 and Figure 4.15)</td>
<td>Indication</td>
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<td>50L</td>
<td>Phase instantaneous overcurrent element for closed circuit breaker detection (any phase current above pickup setting 50LP; see Figure 5.3)</td>
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<td>PDEM</td>
<td>Phase demand current above pickup setting PDEMP (see Figure 8.13)</td>
<td>Indication</td>
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<td>GDEM</td>
<td>Residual ground demand current above pickup setting GDEMP (see Figure 8.13)</td>
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<td>Negative-sequence demand current above pickup setting QDEMP (see Figure 8.13)</td>
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<td>Trip logic output asserted (see Figure 5.1)</td>
<td>Output contact assignment</td>
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<td>50QF</td>
<td>Forward direction negative-sequence overcurrent threshold exceeded (see Figures 4.5, 4.6, and 4.14)</td>
<td>Directional threshold</td>
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<td>50QR</td>
<td>Reverse direction negative-sequence overcurrent threshold exceeded (see Figures 4.5, 4.6, and 4.14)</td>
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<td>Forward direction residual ground overcurrent threshold exceeded (see Figures 4.5 and 4.7)</td>
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<td>50GR</td>
<td>Reverse direction residual ground overcurrent threshold exceeded (see Figures 4.5 and 4.7)</td>
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<td>32QF</td>
<td>Forward directional control routed to phase-distance elements (see Figures 4.13 and 4.14)</td>
<td>Directional control</td>
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<td>Reverse directional control routed to phase-distance elements (see Figures 4.13 and 4.14)</td>
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<td>Forward directional control routed to ground distance elements (see Figures 4.5 and 4.12)</td>
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<td>Reverse directional control routed to ground distance elements (see Figures 4.5 and 4.12)</td>
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<td>32VE</td>
<td>Enable for zero-sequence voltage-polarized directional element (see Figures 4.5 and 4.7)</td>
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<td>32QGE</td>
<td>Enable for negative-sequence voltage-polarized directional element (see Figures 4.5 and 4.6)</td>
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<td>32IE</td>
<td>Enable for channel IP current-polarized directional element (see Figures 4.5 and 4.7)</td>
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<td>32QE</td>
<td>Enable for negative-sequence voltage-polarized directional element (see Figure 4.13 and Figure 4.14)</td>
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<td>F32QG</td>
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<td>R32V</td>
<td>Reverse zero-sequence voltage-polarized directional element (see Figure 4.5 and 4.10)</td>
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<td>Optoisolated input IN106 asserted (see Figure 7.1)</td>
<td>Relay input status, Control via optoisolated inputs</td>
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<td>Optoisolated input IN105 asserted (see Figure 7.1)</td>
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<td>Optoisolated input IN102 asserted (see Figure 7.1)</td>
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<td>Optoisolated input IN101 asserted (see Figure 7.1)</td>
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<td>Optoisolated input IN106 asserted (see Figure 7.1)</td>
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<td>IN101</td>
<td>Optoisolated input IN105 asserted (see Figure 7.1)</td>
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<td>ALARM</td>
<td>ALARM output contact indicating that relay failed or PULSE ALARM command executed (see Figure 7.27)</td>
<td>Relay output status, Control</td>
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<td>Output contact OUT107 asserted (see Figure 7.27)</td>
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<td>Output contact OUT106 asserted (see Figure 7.27)</td>
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<td>M3P</td>
<td>Zone 3 phase distance, instantaneous (see Figure 3.6)</td>
<td>Tripping, Control</td>
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<td>M3PT</td>
<td>Zone 3 phase distance, time delayed (see Figure 3.16)</td>
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<td>Zone 3 mho and/or quad. distance, instantaneous (see Figure 3.9)</td>
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<td>Zone 3 ground distance, time delayed (see Figure 3.16)</td>
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<td>Zone 4 phase distance, instantaneous (see Figure 3.6)</td>
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<td>Zone 4 phase distance, time delayed (see Figure 3.16)</td>
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<td>Zone 4 mho and/or quad. distance, instantaneous (see Figure 3.9)</td>
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<td>Zone 4 ground distance, time delayed (see Figure 3.16)</td>
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<td>Z3T</td>
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<td>Zone 4 phase and/or ground distance, time delayed (see Figure 3.16)</td>
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<td>Level 2 Phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P2P; see Figure 3.19</td>
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<td>67P2</td>
<td>Level 2 torque controlled phase instantaneous overcurrent element (derived from 50P2; see Figure 3.19)</td>
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<td>67P2T</td>
<td>Level 2 phase definite-time overcurrent element 67P2T timed out (derived from 67P2; see Figure 3.19)</td>
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<td>50P3</td>
<td>Level 3 Phase instantaneous overcurrent element (A, B, or C) above pickup setting 50P3P; see Figure 3.19</td>
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<td>67P3</td>
<td>Level 3 torque controlled phase instantaneous overcurrent element (derived from 50P3; see Figure 3.19)</td>
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<td>67P3T</td>
<td>Level 3 phase definite-time overcurrent element 67P3T timed out (derived from 67P3; see Figure 3.19)</td>
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<td>50G2</td>
<td>Level 2 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G2P; see Figure 3.22)</td>
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<td>Level 2 torque controlled residual ground instantaneous overcurrent element (derived from 50G2; see Figure 3.22)</td>
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<td>Level 2 residual ground definite-time overcurrent element 67G2T timed out (derived from 67G2; see Figure 3.22)</td>
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<td>50G3</td>
<td>Level 3 residual ground instantaneous overcurrent element (residual ground current above pickup setting 50G3P; see Figure 3.22)</td>
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<td>67G3</td>
<td>Level 3 torque controlled residual ground instantaneous overcurrent element (derived from 50G3; see Figure 3.22)</td>
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<td>Level 3 residual ground definite-time overcurrent element 67G3T timed out (derived from 67G3; see Figure 3.22)</td>
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<td>51P</td>
<td>Maximum phase current above pickup setting 51PP for phase time-overcurrent element 51PT (see Figure 3.24)</td>
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<td>Phase time-overcurrent element 51PT timed out (see Figure 3.24)</td>
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<td>Phase time-overcurrent element 51PT reset (see Figure 3.24)</td>
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<td>Z1X</td>
<td>Zone 1 extension element picked up (see Figure 3.15)</td>
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<td>59VA</td>
<td>Channel VA voltage window element (channel VA voltage between threshold settings 25VLO and 25VHI; see Figure 3.30)</td>
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<td>MAB3</td>
<td>Mho AB phase distance zone 3 instantaneous (see Figure 3.6)</td>
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<td>MBC3</td>
<td>Mho BC phase distance zone 3, instantaneous (see Figure 3.6)</td>
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<tr>
<td>MCA3</td>
<td>Mho CA phase distance zone 3, instantaneous (see Figure 3.6)</td>
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Primary Application:
- Testing, Control
- Tripping
- Testing
- Indication
- Testing

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<td>OUT209</td>
<td>Output contact OUT209 asserted (see Figure 7.28)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OUT210</td>
<td>Output contact OUT210 asserted (see Figure 7.28)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OUT211</td>
<td>Output contact OUT211 asserted (see Figure 7.28)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OUT212</td>
<td>Output contact OUT212 asserted (see Figure 7.28)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MPP3</td>
<td>Zone 3 phase-to-phase compensator distance element (see Figure 3.6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MABC3</td>
<td>Zone 3 three-phase compensator distance element (see Figure 3.6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MPP4</td>
<td>Zone 4 phase-to-phase compensator distance element (see Figure 3.6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MABC4</td>
<td>Zone 4 three-phase compensator distance element (see Figure 3.6)</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>IN208</td>
<td>Optoisolated input IN208 asserted (see Figure 7.2)</td>
<td>Relay input status, Control via optoisolated inputs</td>
</tr>
<tr>
<td></td>
<td>IN207</td>
<td>Optoisolated input IN207 asserted (see Figure 7.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IN206</td>
<td>Optoisolated input IN206 asserted (see Figure 7.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IN205</td>
<td>Optoisolated input IN205 asserted (see Figure 7.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IN204</td>
<td>Optoisolated input IN204 asserted (see Figure 7.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IN203</td>
<td>Optoisolated input IN203 asserted (see Figure 7.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IN202</td>
<td>Optoisolated input IN202 asserted (see Figure 7.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IN201</td>
<td>Optoisolated input IN201 asserted (see Figure 7.2)</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>RMB8A</td>
<td>Channel A, received bit 8</td>
<td>Relay-to-relay communication (see Appendix I: Mirrored Bits)</td>
</tr>
<tr>
<td></td>
<td>RMB7A</td>
<td>Channel A, received bit 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB6A</td>
<td>Channel A, received bit 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB5A</td>
<td>Channel A, received bit 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB4A</td>
<td>Channel A, received bit 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB3A</td>
<td>Channel A, received bit 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB2A</td>
<td>Channel A, received bit 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB1A</td>
<td>Channel A, received bit 1</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>TMB8A</td>
<td>Channel A, transmit bit 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB7A</td>
<td>Channel A, transmit bit 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB6A</td>
<td>Channel A, transmit bit 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB5A</td>
<td>Channel A, transmit bit 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB4A</td>
<td>Channel A, transmit bit 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB3A</td>
<td>Channel A, transmit bit 3</td>
<td></td>
</tr>
<tr>
<td>Row</td>
<td>Bit</td>
<td>Definition</td>
<td>Primary Application</td>
</tr>
<tr>
<td>-----</td>
<td>-------</td>
<td>-------------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td>TMB2A</td>
<td>Channel A, transmit bit 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB1A</td>
<td>Channel A, transmit bit 1</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>RMB8B</td>
<td>Channel B, received bit 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB7B</td>
<td>Channel B, received bit 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB6B</td>
<td>Channel B, received bit 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB5B</td>
<td>Channel B, received bit 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB4B</td>
<td>Channel B, received bit 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB3B</td>
<td>Channel B, received bit 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB2B</td>
<td>Channel B, received bit 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMB1B</td>
<td>Channel B, received bit 1</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>TMB8B</td>
<td>Channel B, transmit bit 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB7B</td>
<td>Channel B, transmit bit 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB6B</td>
<td>Channel B, transmit bit 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB5B</td>
<td>Channel B, transmit bit 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB4B</td>
<td>Channel B, transmit bit 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB3B</td>
<td>Channel B, transmit bit 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB2B</td>
<td>Channel B, transmit bit 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMB1B</td>
<td>Channel B, transmit bit 1</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>LBOKB</td>
<td>Channel B, received data OK in loop back mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CBADB</td>
<td>Channel B, channel unavailability over threshold</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RBADB</td>
<td>Channel B, outage duration over threshold</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ROKB</td>
<td>Channel B, received data OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LBOKA</td>
<td>Channel A, received data OK in loop back mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CBADA</td>
<td>Channel A, channel unavailability over threshold</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RBADA</td>
<td>Channel A, outage duration over threshold</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ROKA</td>
<td>Channel A, received data OK</td>
<td></td>
</tr>
<tr>
<td>Row</td>
<td>Bit</td>
<td>Definition</td>
<td>Primary Application</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>52</td>
<td>81D1</td>
<td>Level 1 instantaneous frequency element (with corresponding pickup setting 81D1P; see Figure 3.34)</td>
<td>Testing</td>
</tr>
<tr>
<td></td>
<td>81D2</td>
<td>Level 2 instantaneous frequency element (with corresponding pickup setting 81D2P; see Figure 3.34)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>81D3</td>
<td>Level 3 instantaneous frequency element (with corresponding pickup setting 81D3P; see Figure 3.34)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>81D4</td>
<td>Level 4 instantaneous frequency element (with corresponding pickup setting 81D4P; see Figure 3.34)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>81D5</td>
<td>Level 5 instantaneous frequency element (with corresponding pickup setting 81D5P; see Figure 3.34)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>81D6</td>
<td>Level 6 instantaneous frequency element (with corresponding pickup setting 81D6P; see Figure 3.34)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>27B81</td>
<td>Undervoltage element for frequency element blocking (any phase voltage below pickup setting 27B81P; see Figure 3.33)</td>
<td></td>
</tr>
</tbody>
</table>

** IMPORTANT: ** See Appendix F for special instructions on setting negative-sequence overcurrent elements.
SETTINGS EXPLANATIONS

Note that most of the settings in the settings sheets that follow include references for additional information. The following explanations are for settings that do not have reference information anywhere else in the instruction manual.

**Identifier Labels**

Refer to Settings Sheet 1.

The SEL-311C Relay has two identifier labels: the Relay Identifier (RID) and the Terminal Identifier (TID). The Relay Identifier is typically used to identify the relay or the type of protection scheme. Typical terminal identifiers include an abbreviation of the substation name and line terminal.

The relay tags each report (event report, meter report, etc.) with the Relay Identifier and Terminal Identifier. This allows you to distinguish the report as one generated for a specific breaker and substation.

RID and TID settings may include the following characters: 0–9, A–Z, #, &, @, -, /, ., space. These two settings cannot be made via the front-panel interface.

**Current Transformer Ratios**

Refer to Settings Sheet 1.

Phase and polarizing current transformer ratios are set independently.

**Line Settings**

Refer to Settings Sheet 1.

Line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG are used in distance relaying, fault locator (see Fault Location in Section 12: Standard Event Reports and SER) and in automatically making directional element settings Z2F, Z2R, Z0F, and Z0R (see Settings Made Automatically in Section 4: Loss-of-Potential Logic, CCVT Transient Detection, Load-Encroachment, and Directional Element Logic). A corresponding line length setting (LL) is also used in the fault locator.

The line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG are set in Ω secondary. To convert line impedance (Ω primary) to Ω secondary:

\[ \Omega_{\text{primary}} \cdot (\text{CTR/PTR}) = \Omega_{\text{secondary}} \]

where:

\[ \text{CTR} = \text{phase (IA, IB, IC) current transformer ratio} \]

\[ \text{PTR} = \text{phase (VA, VB, VC) potential transformer ratio (wye-connected)} \]

Line length setting LL is unitless and corresponds to the line impedance settings. For example, if a particular line length is 15 miles, enter the line impedance values (Ω secondary) and then enter the corresponding line length:

\[ LL = 15.00 \text{ (miles)} \]
If the same length of line is measured in kilometers rather than miles, then enter:

\[ LL = 24.14 \text{ (kilometers)} \]

**Enable Settings**

Refer to Settings Sheets 1, 2, and 20.

The enable settings on Settings Sheets 1 and 2 (E21P through EADVS) control the settings that follow, through Sheet 13. Enable setting, EBMON, on Settings Sheet 20 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 13 has a reference back to the controlling enable setting. For example, the residual time-overcurrent element settings on Sheet 7 (settings 51GP through 51GRS) are controlled by enable setting E51G.

**Other System Parameters**

Refer to Settings Sheet 19.

The global settings NFREQ and PHROT allow you to configure the SEL-311C 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-311C RELAY

RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

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

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relay Identifier (30 characters)</td>
<td>RID =</td>
</tr>
<tr>
<td>Terminal Identifier (30 characters)</td>
<td>TID =</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Transformer</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase (IA, IB, IC) Current Transformer Ratio (1–6000)</td>
<td>CTR =</td>
</tr>
<tr>
<td>Polarizing (IPOL) Current Transformer Ratio (1–6000)</td>
<td>CTRP =</td>
</tr>
<tr>
<td>Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00)</td>
<td>PTR =</td>
</tr>
<tr>
<td>Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00)</td>
<td>PTRS =</td>
</tr>
</tbody>
</table>

**Line Settings (See Settings Explanations in Section 9)**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive-sequence line impedance magnitude</td>
<td>Z1MAG =</td>
</tr>
<tr>
<td>0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.}</td>
<td></td>
</tr>
<tr>
<td>Positive-sequence line impedance angle (5.00–90.00 degrees)</td>
<td>Z1ANG =</td>
</tr>
<tr>
<td>Zero-sequence line impedance magnitude</td>
<td>Z0MAG =</td>
</tr>
<tr>
<td>0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.}</td>
<td></td>
</tr>
<tr>
<td>Zero-sequence line impedance angle (5.00–90.00 degrees)</td>
<td>Z0ANG =</td>
</tr>
<tr>
<td>Line length (0.10–999.00, unitless)</td>
<td>LL =</td>
</tr>
</tbody>
</table>

**Application Settings (See Section 14)**

<table>
<thead>
<tr>
<th>Application</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application (311C, 221G, 221G5, 221H, 221F, 221F3, 221C, 221-16, 2PG10)</td>
<td>APP =</td>
</tr>
</tbody>
</table>

**Distance Settings**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mho phase distance element zones (N, 1–4, 1C–4C) (see Figures 3.1–3.3)</td>
<td>E21P =</td>
</tr>
<tr>
<td>Mho ground distance element zones (N, 1–4) (see Figures 3.4–3.6)</td>
<td>E21MG =</td>
</tr>
<tr>
<td>Quadrilateral ground distance element zones (N, 1–4) (see Figures 3.7–3.9)</td>
<td>E21XG =</td>
</tr>
</tbody>
</table>

**Instantaneous/Definite-Time Overcurrent Enable Settings**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase element levels (N, 1–3) (see Figure 3.19)</td>
<td>E50P =</td>
</tr>
<tr>
<td>Residual ground element levels (N, 1–4) (see Figure 3.22)</td>
<td>E50G =</td>
</tr>
<tr>
<td>Negative-sequence element levels (N, 1–4) (see Figure 3.23)</td>
<td>E50Q =</td>
</tr>
</tbody>
</table>

**Time-Overcurrent Enable Settings**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase element (Y, N) (see Figure 3.24)</td>
<td>E51P =</td>
</tr>
<tr>
<td>Residual ground element (Y, N) (see Figure 3.25)</td>
<td>E51G =</td>
</tr>
<tr>
<td>Negative-sequence element (Y, N) (see Figure 3.26)</td>
<td>E51Q =</td>
</tr>
</tbody>
</table>

Date Code 20011205
Other Enable Settings

Directional control (Y, AUTO) (see Directional Control Settings in Section 4) E32 = ____________
Out-of-Step (Y, N) (see Figure 3.18) EOOS = ____________
Load encroachment (Y, N) (see Figure 4.3) ELOAD = ____________
Switch-onto-fault (Y, N) (see Figure 5.3) ESOTF = ____________
Voltage elements (Y, N) (see Figures 3.27, 3.28, 3.29, and 3.30) EVOLT = ____________
Synchronism check (Y, N) (see Figures 3.30 and 3.31) E25 = ____________
Frequency elements (N, 1–6) (see Figures 3.33 and 3.34) E81 = ____________
Fault location (Y, N) (see Table 12.1 and Fault Location in Section 12) EFLOC = ____________
Loss-of-potential (Y, Y1, N) (see Figure 4.1) ELOP = ____________
Communications-assisted trip scheme (N, DCB, POTT, DCUB1, DCUB2) ECOMM = ____________
(see Communications-Assisted Trip Logic—General Overview in Section 5)
Reclosures (N, 1–4) (see Reclosing Relay in Section 6) E79 = ____________
Zone 1 extension (N, Y) (see Figure 3.15) EZ1EXT = ____________
CCVT transient detection (Y, N) (see Figure 4.2) ECCVT = ____________
SELOGIC® control equation Variable Timers (N, 1–16) ESV = ____________
(see Figures 7.24 and 7.25)
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 = 1–4.)
Zone 1 (OFF, 0.05–64.00  Ω secondary {5 A nom.}; 0.25–320.00  Ω secondary {1 A nom.}) (see Figure 3.4) Z1P = ____________
Zone 2 (OFF, 0.05–64.00  Ω secondary {5 A nom.}; 0.25–320.00  Ω secondary {1 A nom.}) (see Figure 3.5) Z2P = ____________
Zone 3 (OFF, 0.05–64.00  Ω secondary {5 A nom.}; 0.25–320.00  Ω secondary {1 A nom.}) (see Figure 3.6) Z3P = ____________
Zone 4 (OFF, 0.05–64.00  Ω secondary {5 A nom.}; 0.25–320.00  Ω secondary {1 A nom.}) (see Figure 3.6) Z4P = ____________
**Mho Phase Distance Fault Detector Settings**

Zone 1 phase-to-phase current FD (0.5–170.00 A secondary {5 A nom.}; 0.1–34.00 A secondary {1 A nom.}) (see Figure 3.4)

\[50PP1 = \ldots\]

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)

\[50PP2 = \ldots\]

Zone 3 phase-to-phase current FD (0.5–170.00 A secondary {5 A nom.}; 0.1–34.00 A secondary {1 A nom.}) (see Figure 3.6)

\[50PP3 = \ldots\]

Zone 4 phase-to-phase current FD (0.5–170.00 A secondary {5 A nom.}; 0.1–34.00 A secondary {1 A nom.}) (see Figure 3.6)

\[50PP4 = \ldots\]

**Mho Ground Distance Elements**

(Number of mho ground distance element settings dependent on preceding enable setting E21MG = 1–4.)

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.7)

\[Z1MG = \ldots\]

Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.8)

\[Z2MG = \ldots\]

Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.9)

\[Z3MG = \ldots\]

Zone 4 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.9)

\[Z4MG = \ldots\]

**Quadrilateral Ground Distance Elements**

(Number of quadrilateral ground distance element settings dependent on preceding enable setting E21XG = 1–4.)

Zone 1 reactance (OFF, 0.05–64.00 Ω secondary {5 A nom.}; OFF, 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.10)

\[XG1 = \ldots\]

Zone 2 reactance (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.11)

\[XG2 = \ldots\]

Zone 3 reactance (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.12)

\[XG3 = \ldots\]

Zone 4 reactance (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.12)

\[XG4 = \ldots\]

Zone 1 resistance (0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.}) (see Figure 3.10)

\[RG1 = \ldots\]

Zone 2 resistance (0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.}) (see Figure 3.11)

\[RG2 = \ldots\]

Zone 3 resistance (0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.}) (see Figure 3.12)

\[RG3 = \ldots\]

Zone 4 resistance (0.05–50.00 Ω secondary {5 A nom.}; 0.25–250.00 Ω secondary {1 A nom.}) (see Figure 3.12)

\[RG4 = \ldots\]

Quadrilateral ground polarizing quantity (I2, IG) (see Figures 3.10–3.12)

\[XGPOL = \ldots\]
Non-homogenous correction angle (-40.0° to +45.0°)  

TANG = ____________

Quadrilateral and Mho Ground Distance Fault Detector Settings

(Number of quadrilateral and mho ground distance element settings dependent on the larger of preceding enable settings E21MG = 1–4 or E21XG = 1–4.)

Zone 1 phase current FD (0.5–100.00 A secondary {5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figures 3.7 and 3.10)  
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 Figures 3.8 and 3.11)  
50L2 = ____________

Zone 3 phase current FD (0.5–100.00 A secondary {5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figures 3.9 and 3.12)  
50L3 = ____________

Zone 4 phase current FD (0.5–100.00 A secondary {5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figures 3.9 and 3.12)  
50L4 = ____________

Zone 1 residual current FD (0.5–100.00 A secondary {5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figures 3.7 and 3.10)  
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 Figures 3.8 and 3.11)  
50GZ2 = ____________

Zone 3 residual current FD (0.5–100.00 A secondary {5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figures 3.9 and 3.12)  
50GZ3 = ____________

Zone 4 residual current FD (0.5–100.00 A secondary {5 A nom.}; 0.1–20.00 A secondary {1 A nom.}) (see Figures 3.9 and 3.12)  
50GZ4 = ____________

Zero Sequence Compensation (ZSC) Settings (see Ground Distance Elements in Section 3)

Zone 1 ZSC factor magnitude (0.000–6.000 unitless)  
k0M1 = ____________

Zone 1 ZSC factor angle (-180.0° to +180.0°)  
k0A1 = ____________

* Zones 2, 3, and 4 ZSC factor magnitude (0.000–6.000 unitless)  
k0M = ____________

* Zones 2, 3, and 4 ZSC factor angle (-180.0° to +180.0°)  
k0A = ____________

* Indicates a setting is active when advanced user setting enable EADVS = Y. Otherwise, setting is made automatically.
Mho Phase Distance Element Time Delays (See Figure 3.16)
(Number of mho phase distance element time delay settings dependent on preceding enable setting E21P = 1–4.)
Zone 1 time delay (OFF, 0–16000 cycles) Z1PD = __________
Zone 2 time delay (OFF, 0–16000 cycles) Z2PD = __________
Zone 3 time delay (OFF, 0–16000 cycles) Z3PD = __________
Zone 4 time delay (OFF, 0–16000 cycles) Z4PD = __________

Quadrilateral and Mho Ground Distance Element Time Delays (See Figure 3.16)
(Number of time delay element settings dependent on the larger of preceding enable settings E21MG = 1–4 or E21XG = 1–4.)
Zone 1 time delay (OFF, 0–16000 cycles) Z1GD = __________
Zone 2 time delay (OFF, 0–16000 cycles) Z2GD = __________
Zone 3 time delay (OFF, 0–16000 cycles) Z3GD = __________
Zone 4 time delay (OFF, 0–16000 cycles) Z4GD = __________

Common Phase/Ground Distance Element Time Delay (See Figure 3.16)
(Number of time delay element settings dependent on the larger of preceding enable settings E21P = 1–4 or E21MG = 1–4 or E21XG = 1–4.)
Zone 1 time delay (OFF, 0–16000 cycles) Z1D = __________
Zone 2 time delay (OFF, 0–16000 cycles) Z2D = __________
Zone 3 time delay (OFF, 0–16000 cycles) Z3D = __________
Zone 4 time delay (OFF, 0–16000 cycles) Z4D = __________

Phase Inst./Def.-Time Overcurrent Elements (See Figure 3.19)
(Number of phase element pickup settings dependent on preceding enable setting E50P = 1–3.)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}) 50P1P = __________
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}) 50P2P = __________
Level 3 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}) 50P3P = __________

Phase Definite-Time Overcurrent Element Time Delays (See Figure 3.19)
(Number of phase element time delay settings dependent on preceding enable setting E50P = 1–3.)
Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) 67P1D = __________
Level 2 (0.00–16000.00 cycles in 0.25-cycle steps) 67P2D = __________
Level 3 (0.00–16000.00 cycles in 0.25-cycle steps) 67P3D = __________
Residual Ground Inst./Def.-Time Overcurrent Elements (See Figure 3.22)
(Number of residual ground element pickup settings dependent on preceding enable setting E50G = 1–4.)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
50G1P =
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
50G2P =
Level 3 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
50G3P =
Level 4 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
50G4P =

Residual Ground Definite-Time Overcurrent Element Time Delay (See Figure 3.22)
(Number of residual ground element time delay settings dependent on preceding enable setting E50G = 1–4.)
Level 1 (0.00–16000.00 cycles in 0.25-cycle steps)
67G1D =
Level 2 (0.00–16000.00 cycles in 0.25-cycle steps)
67G2D =
Level 3 (0.00–16000.00 cycles in 0.25-cycle steps)
67G3D =
Level 4 (0.00–16000.00 cycles in 0.25-cycle steps)
67G4D =

Negative-Sequence Inst./Def.-Time Overcurrent Elements (See Figure 3.23)*
(Number of negative-sequence element time delay settings dependent on preceding enable setting E50Q = 1–4.)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
50Q1P =
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
50Q2P =
Level 3 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
50Q3P =
Level 4 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
50Q4P =

Negative-Sequence Definite-Time Overcurrent Element Time Delay (See Figure 3.23)*
(Number of negative-sequence element time delay settings dependent on preceding enable setting E50Q = 1–4.)
Level 1 (0.00–16000.00 cycles in 0.25-cycle steps)
67Q1D =
Level 2 (0.00–16000.00 cycles in 0.25-cycle steps)
67Q2D =
Level 3 (0.00–16000.00 cycles in 0.25-cycle steps)
67Q3D =
Level 4 (0.00–16000.00 cycles in 0.25-cycle steps)
67Q4D =

* IMPORTANT: See Appendix F for information on setting negative-sequence overcurrent elements.
Phase Time-Overcurrent Element (See Figure 3.24)
(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.})
Curve (U1–U5, C1–C5) (see Figures 9.1 through 9.10)
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)
Electromechanical Reset (Y, N)

Residual Ground Time-Overcurrent Element (See Figure 3.25)
(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.})
Curve (U1–U5, C1–C5) (see Figures 9.1 through 9.10)
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)
Electromechanical Reset (Y, N)

Negative-Sequence Time-Overcurrent Element (See Figure 3.26)*
(Make the following settings if preceding enable setting E51Q = Y.)
Pickup (OFF, 0.50–16.00 A secondary {5 A nom.};
0.10–3.20 A secondary {1 A nom.})
Curve (U1–U5, C1–C5) (see Figures 9.1 through 9.10)
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)
Electromechanical Reset (Y, N)

* IMPORTANT: See Appendix F for information on setting negative-sequence overcurrent elements.
**Out-of-Step Settings (See Figures 3.17 and 3.18)**
(Make the following settings if preceding enable setting EOOS = Y.)

- Block Zone 1 (Y, N) \( \text{OOSB1} = \) ________
- Block Zone 2 (Y, N) \( \text{OOSB2} = \) ________
- Block Zone 3 (Y, N) \( \text{OOSB3} = \) ________
- Block Zone 4 (Y, N) \( \text{OOSB4} = \) ________
- Out-of-Step block time delay (0.5–8000.0 cycles) \( \text{OSBD} = \) ________
- Enable Out-of-Step tripping (N, I, O) \( \text{EOOST} = \) ________
- Out-of-Step trip delay (0.5–8000.0 cycles) \( \text{OSTD} = \) ________
- Zone 6 reactance—Top (0.05 to 96.00 \( \Omega \) secondary {5 A nom.}; 0.25 to 480.00 \( \Omega \) secondary {1 A nom.}) \( \text{X1T6} = \) ________
- Zone 5 reactance—Top (0.05 to 96.00 \( \Omega \) secondary {5 A nom.}; 0.25 to 480.00 \( \Omega \) secondary {1 A nom.}) \( \text{X1T5} = \) ________
- Zone 6 resistance—Right (0.05 to 70.00 \( \Omega \) secondary {5 A nom.}; 0.25 to 350.00 \( \Omega \) secondary {1 A nom.}) \( \text{R1R6} = \) ________
- Zone 5 resistance—Right (0.05 to 70.00 \( \Omega \) secondary {5 A nom.}; 0.25 to 350.00 \( \Omega \) secondary {1 A nom.}) \( \text{R1R5} = \) ________
- Zone 6 reactance—Bottom (-96.00 to -0.05 \( \Omega \) secondary {5 A nom.}; -480.00 to -0.25 \( \Omega \) secondary {1 A nom.}) \( \text{X1B6} = \) ________
- Zone 5 reactance—Bottom (-96.00 to -0.05 \( \Omega \) secondary {5 A nom.}; -480.00 to -0.25 \( \Omega \) secondary {1 A nom.}) \( \text{X1B5} = \) ________
- Zone 6 resistance—Left (-70.00 to -0.05 \( \Omega \) secondary {5 A nom.}; -350.00 to -0.25 \( \Omega \) secondary {1 A nom.}) \( \text{R1L6} = \) ________
- Zone 5 resistance—Left (-70.00 to -0.05 \( \Omega \) secondary {5 A nom.}; -350.00 to -0.25 \( \Omega \) secondary {1 A nom.}) \( \text{R1L5} = \) ________
- Positive-Sequence current supervision (1–100 A secondary{5 A nom.}) \( \text{50ABCP} = \) ________
- Negative-Sequence current unblock delay (0.5–120.0 cycles) \( \text{UBD} = \) ________
- Out-of-Step angle change unblock rate (1–10 unitless) \( \text{UBOSBF} = \) ________

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

**Load-Encroachment Elements (See Figure 4.3)**
(Make the following settings if preceding enable setting ELOAD = Y.)

- Forward load impedance (0.05–64.00 \( \Omega \) secondary {5 A nom.}; 0.25–320.00 \( \Omega \) secondary {1 A nom.}) \( \text{ZLF} = \) ________
- Reverse load impedance (0.05–64.00 \( \Omega \) secondary {5 A nom.}; 0.25–320.00 \( \Omega \) secondary {1 A nom.}) \( \text{ZLR} = \) ________
- Positive forward load angle (-90.00° to +90.00°) \( \text{PLAF} = \) ________
- Negative forward load angle (-90.00° to +90.00°) \( \text{NLAF} = \) ________
Positive reverse load angle (+90.00° to +270.00°)  PLAR =
Negative reverse load angle (+90.00° to +270.00°)  NLAR =

Zone/Level 3 and 4 Directional Control
Zone/Level 3 direction: Forward, Reverse (F, R)  DIR3 =
Zone/Level 4 direction: Forward, Reverse (F, R)  DIR4 =

Directional Elements (See Directional Control Settings in Section 4)
(Make setting ORDER if preceding enable setting E32 = Y or AUTO.)
Ground directional element priority: combination of Q, V, or I  ORDER =
(Make settings Z2F, Z2R, 50QFP, 50QRP, a2, and k2 if preceding enable setting E32 = Y.
If E32 = AUTO, these settings are made automatically.)
Forward directional Z2 threshold (-64.00–64.00 Ω secondary {5 A nom.};
-320.00–320.00 Ω secondary {1 A nom.})  Z2F =
Reverse directional Z2 threshold (-64.00–64.00 Ω secondary {5 A nom.};
-320.00–320.00 Ω secondary {1 A nom.})  Z2R =
Forward directional 3I2 pickup (0.25–5.00 A secondary {5 A nom.};
0.05–1.00 A secondary {1 A nom.})  50QFP =
Reverse directional 3I2 pickup (0.25–5.00 A secondary {5 A nom.};
0.05–1.00 A secondary {1 A nom.})  50QRP =
Positive-sequence current restraint factor, I2/I1 (0.02–0.50, unitless)  a2 =
Zero-sequence current restraint factor, I2/I0 (0.10–1.20, unitless)  k2 =
(Make settings 50GFP, 50GRP, and a0 if preceding enable setting E32 = Y and preceding setting
ORDER contains V or I.  If E32 = AUTO and ORDER contains V or I, these settings are made
automatically.)
Forward directional 3I0 pickup (0.25–5.00 A secondary {5 A nom.};
0.05–1.00 A secondary {1 A nom.})  50GFP =
Reverse directional 3I0 pickup (0.25–5.00 A secondary {5 A nom.};
0.05–1.00 A secondary {1 A nom.})  50GRP =
Positive-sequence current restraint factor, I0/I1 (0.02–0.50, unitless)  a0 =
(Make settings Z0F and Z0R if preceding enable setting E32 = Y and preceding setting ORDER
contains V.  If E32 = AUTO and ORDER contains V, these settings are made automatically.)
Forward directional Z0 threshold (-64.00–64.00 Ω secondary {5 A nom.})
(-320.00–320.00 Ω secondary {1 A nom.})  Z0F =
Reverse directional Z0 threshold (-64.00–64.00 Ω secondary {5 A nom.})
(-320.00–320.00 Ω secondary {1 A nom.})  Z0R =
Voltage Elements (See Figures 3.27, 3.28, and 3.29)

(Make the following settings if preceding enable setting EVOLT = Y.)

- Phase undervoltage pickup (OFF, 0.0–150.0 V secondary) 27P = ____________
- Phase overvoltage pickup (OFF, 0.0–150.0 V secondary) 59P = ____________
- Zero-sequence (3V0) overvoltage pickup (OFF, 0.0–150.0 V secondary) 59N1P = ____________
- Zero-sequence (3V0) overvoltage pickup (OFF, 0.0–150.0 V secondary) 59N2P = ____________
- Negative-sequence (V2) overvoltage pickup (OFF, 0.0–100.0 V secondary) 59QP = ____________
- Positive-sequence (V1) overvoltage pickup (OFF, 0.0–150.0 V secondary) 59V1P = ____________
- Channel VS undervoltage pickup (OFF, 0.0–150.0 V secondary) 27SP = ____________
- Channel VS overvoltage pickup (OFF, 0.0–150.0 V secondary) 59SP = ____________
- Phase-to-phase undervoltage pickup (OFF, 0.0–260.0 V secondary) 27PP = ____________
- Phase-to-phase overvoltage pickup (OFF, 0.0–260.0 V secondary) 59PP = ____________

Synchronism Check Elements (See Figures 3.30 and 3.31)

(Make the following settings if preceding enable setting E25 = Y.)

- Voltage window—low threshold (0.00–150.00 V secondary) 25VLO = ____________
- Voltage window—high threshold (0.00–150.00 V secondary) 25VHI = ____________
- Maximum slip frequency (0.005–0.500 Hz) 25SF = ____________
- Maximum angle 1 (0.00°–80.00°) 25ANG1 = ____________
- Maximum angle 2 (0.00°–80.00°) 25ANG2 = ____________
- Synchronizing phase (VA, VB, VC, VAB, VBC, VAC) SYNCP = ____________
- Breaker close time for angle compensation TCLOS = ____________

Frequency Elements (See Figures 3.33 and 3.34)

(Make the following settings if preceding enable setting E81 = 1–6.)

- Phase undervoltage block 27B81P = ____________
- (20.00–150.00 V secondary, 150 V wye-connected voltage inputs)
- Level 1 pickup (OFF, 41.00–65.00 Hz) 81D1P = ____________
- Level 1 time delay (2.00–16000.00 cycles in 0.25-cycle steps) 81D1D = ____________
- Level 2 pickup (OFF, 41.00–65.00 Hz) 81D2P = ____________
- Level 2 time delay (2.00–16000.00 cycles in 0.25-cycle steps) 81D2D = ____________
- Level 3 pickup (OFF, 41.00–65.00 Hz) 81D3P = ____________
- Level 3 time delay (2.00–16000.00 cycles in 0.25-cycle steps) 81D3D = ____________
- Level 4 pickup (OFF, 41.00–65.00 Hz) 81D4P = ____________
- Level 4 time delay (2.00–16000.00 cycles in 0.25-cycle steps) 81D4D = ____________
- Level 5 pickup (OFF, 41.00–65.00 Hz) 81D5P = ____________
- Level 5 time delay (2.00–16000.00 cycles in 0.25-cycle steps) 81D5D = ____________
RESETTING SHEET
FOR THE SEL-311C RELAY

Date Code 20011205

RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

Level 6 pickup (OFF, 41.00–65.00 Hz) 81D6P =
Level 6 time delay (2.00–16000.00 cycles in 0.25-cycle steps) 81D6D =

Reclosing Relay (See Tables 6.2 and 6.3)
(Make the following settings if preceding enable setting E79 = 1–4.)
Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI1 =
Open interval 2 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI2 =
Open interval 3 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI3 =
Open interval 4 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI4 =
Reset time from reclose cycle (0.00–999999.00 cycles in 0.25-cycle steps) 79RSD =
Reset time from lockout (0.00–999999.00 cycles in 0.25-cycle steps) 79RSLD =
Reclose supervision time limit (OFF, 0.00–999999.00 cycles in 0.25-cycle steps) (set 79CLSD = 0.00 for most applications; see Figure 6.2) 79CLSD =

Switch-Onto-Fault (See Figure 5.3)
(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 =

POTT Trip Scheme Settings (Also Used in DCUB Trip Schemes) (See Figure 5.6)
(Make the following settings if preceding enable setting ECOMM = POTT, DCUB1, or DCUB2.)
Zone (level) 3 reverse block time delay (0.00–16000.00 cycles in 0.25-cycle steps) Z3RBD =
Echo block time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) EBLKD =
Echo time delay pickup (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) ETPDU =
Echo duration time delay (0.00–16000.00 cycles in 0.25-cycle steps) EDURD =
Weak-infeed enable (Y, N) EWFC =
WIF phase-to-phase undervoltage (0.0–260.0 V secondary) 27PPW =
WIF zero-sequence (3V0) overvoltage (0.0–150.0 V secondary) 59NW =

Additional DCUB Trip Scheme Settings (See Figure 5.10)
(Make the following settings if preceding enable setting ECOMM = DCUB1 or DCUB2.)
Guard present security time delay (0.00–16000.00 cycles in 0.25-cycle steps) GARD1D =
DCUB disabling time delay (0.25–16000.00 cycles in 0.25-cycle steps) UBDURD =
DCUB duration time delay (0.00–16000.00 cycles in 0.25-cycle steps) UBEND =

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DCB Trip Scheme Settings (See Figure 5.14)
(Make the following settings if preceding enable setting ECOMM = DCB.)
Zone (level) 3 reverse pickup time delay
(0.00–16000.00 cycles in 0.25-cycle steps)  Z3XPU =
Zone (level) 3 reverse dropout extension
(0.00–16000.00 cycles in 0.25-cycle steps)  Z3XD =
Block trip receive extension (0.00–16000.00 cycles in 0.25-cycle steps)  BTXD =
Zone 2 distance short delay (0.00–60.00 cycles in 0.25-cycle steps)  21SD =
Level 2 overcurrent short delay (0.00–60.00 cycles in 0.25-cycle steps)  67SD =

Zone 1 Extension Scheme Settings (See Figure 3.15)
(Make the following settings if preceding enable setting EZ1EXT = Y.)
Zone 1 extension delay time (0.00–16000.00 cycles)  Z1EXTD =
Zone 1 distance multiplier (1.00–4.00)  Z1EXTM =

Demand Metering Settings (See Figures 8.11 and 8.13)
(Make the following settings, whether preceding enable setting EDEM = THM or ROL.)
Time constant (5, 10, 15, 30, 60 minutes)  DMTC =
Phase pickup (OFF, 0.50–16.00 A secondary {5 A nom.};  PDEMP =
0.10–3.20 A secondary {1 A nom.})
Residual ground pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; GDEMP =
0.10–3.20 A secondary {1 A nom.})
Negative-sequence pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; QDEMP =
0.10–3.20 A secondary {1 A nom.})

Other Settings
Minimum trip duration time (4.00–16000.00 cycles in 0.25-cycle steps)  TDURD =
(see Figure 5.1)
Close failure time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)  CFD =
(see Figure 6.1)
Three-pole open time delay (0.00–60.00 cycles in 0.25-cycle steps)  3POD =
(usually set for no more than a cycle; see Figure 5.3)
Open pole option (52, 27)  OPO =
Three-pole open undervoltage (0.0–150.0 V secondary)  27PO =
Load detection phase pickup (OFF, 0.25–100.00A {5 A nom.};  50LP =
0.05–20.00 A {1 A nom.}) (see Figure 5.3)
**SELogic Control Equation Variable Timers (See Figures 7.24 and 7.25)**

(Number of timer pickup/dropout settings dependent on preceding enable setting ESV = 1–16.)

SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV1PU = \) 
SV1 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV1DO = \) 
SV2 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV2PU = \) 
SV2 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV2DO = \) 
SV3 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV3PU = \) 
SV3 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV3DO = \) 
SV4 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV4PU = \) 
SV4 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV4DO = \) 
SV5 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV5PU = \) 
SV5 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV5DO = \) 
SV6 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV6PU = \) 
SV6 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) \( SV6DO = \) 
SV7 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV7PU = \) 
SV7 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV7DO = \) 
SV8 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV8PU = \) 
SV8 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV8DO = \) 
SV9 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV9PU = \) 
SV9 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV9DO = \) 
SV10 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV10PU = \) 
SV10 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV10DO = \) 
SV11 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV11PU = \) 
SV11 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV11DO = \) 
SV12 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV12PU = \) 
SV12 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV12DO = \) 
SV13 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV13PU = \) 
SV13 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV13DO = \) 
SV14 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV14PU = \) 
SV14 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV14DO = \) 
SV15 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV15PU = \) 
SV15 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV15DO = \) 
SV16 Pickup Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV16PU = \) 
SV16 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps) \( SV16DO = \)
SELOGIC control equation settings consist of Relay Word bits (see Tables 9.3 and 9.4) and SELOGIC control equation operators * (AND), + (OR), ! (NOT), / (rising edge), \ (falling edge), and ( ) (parentheses). Numerous SELOGIC control equation settings examples are given in Sections 3 through 8. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0). Appendix G: Setting SELOGIC Control Equations gives SELOGIC control equation details, examples, and limitations.

### Trip Logic Equations (See Figure 5.1)

Direct trip conditions

\[
TR = \underline{\text{__________________________}}
\]

Communications-assisted trip conditions

\[
TRCOMM = \underline{\text{__________________________}}
\]

Switch-onto-fault trip conditions

\[
TRSOTF = \underline{\text{__________________________}}
\]

Direct transfer trip conditions

\[
DTT = \underline{\text{__________________________}}
\]

Unlatch trip conditions

\[
ULTR = \underline{\text{__________________________}}
\]

### Communications-Assisted Trip Scheme Input Equations

Permissive trip 1 (used for ECOMM = POTT, DCUB1, or DCUB2; see Figures 5.5, 5.7, and 5.10)

\[
PT1 = \underline{\text{__________________________}}
\]

Loss-of-guard 1 (used for ECOMM = DCUB1 or DCUB2; see Figure 5.10)

\[
LOG1 = \underline{\text{__________________________}}
\]

Permissive trip 2 (used for ECOMM = DCUB2; see Figures 5.5 and 5.10)

\[
PT2 = \underline{\text{__________________________}}
\]

Loss of guard 2 (used for ECOMM = DCUB2; see Figure 5.10)

\[
LOG2 = \underline{\text{__________________________}}
\]

Block trip (used for ECOMM = DCB; see Figure 5.14)

\[
BT = \underline{\text{__________________________}}
\]

### Close Logic Equations (See Figure 6.1)

Circuit breaker status (used in Figure 5.3, also)

\[
52A = \underline{\text{__________________________}}
\]

Close conditions (other than automatic reclosing or CLOSE command)

\[
CL = \underline{\text{__________________________}}
\]

Unlatch close conditions

\[
ULCL = \underline{\text{__________________________}}
\]

### Reclosing Relay Equations (See Reclosing Relay in Section 6)

Reclose initiate

\[
79RI = \underline{\text{__________________________}}
\]

Reclose initiate supervision

\[
79RIS = \underline{\text{__________________________}}
\]

Drive-to-lockout

\[
79DTL = \underline{\text{__________________________}}
\]

Drive-to-last shot

\[
79DLS = \underline{\text{__________________________}}
\]

Skip shot

\[
79SKP = \underline{\text{__________________________}}
\]

Stall open interval timing

\[
79STL = \underline{\text{__________________________}}
\]

Block reset timing

\[
79BRS = \underline{\text{__________________________}}
\]

Sequence coordination

\[
79SEQ = \underline{\text{__________________________}}
\]

Reclose supervision (see Figure 6.2)

\[
79CLS = \underline{\text{__________________________}}
\]
Latch Bits Set/Reset Equations (See Figure 7.12)

Set Latch Bit LT1  \( \text{SET}1 = \) 
Reset Latch Bit LT1 \( \text{RST}1 = \) 

Set Latch Bit LT2 \( \text{SET}2 = \) 
Reset Latch Bit LT2 \( \text{RST}2 = \) 

Set Latch Bit LT3 \( \text{SET}3 = \) 
Reset Latch Bit LT3 \( \text{RST}3 = \) 

Set Latch Bit LT4 \( \text{SET}4 = \) 
Reset Latch Bit LT4 \( \text{RST}4 = \) 

Set Latch Bit LT5 \( \text{SET}5 = \) 
Reset Latch Bit LT5 \( \text{RST}5 = \) 

Set Latch Bit LT6 \( \text{SET}6 = \) 
Reset Latch Bit LT6 \( \text{RST}6 = \) 

Set Latch Bit LT7 \( \text{SET}7 = \) 
Reset Latch Bit LT7 \( \text{RST}7 = \) 

Set Latch Bit LT8 \( \text{SET}8 = \) 
Reset Latch Bit LT8 \( \text{RST}8 = \) 

Set Latch Bit LT9 \( \text{SET}9 = \) 
Reset Latch Bit LT9 \( \text{RST}9 = \) 

Set Latch Bit LT10 \( \text{SET}10 = \) 
Reset Latch Bit LT10 \( \text{RST}10 = \) 

Set Latch Bit LT11 \( \text{SET}11 = \) 
Reset Latch Bit LT11 \( \text{RST}11 = \) 

Set Latch Bit LT12 \( \text{SET}12 = \) 
Reset Latch Bit LT12 \( \text{RST}12 = \) 

Set Latch Bit LT13 \( \text{SET}13 = \) 
Reset Latch Bit LT13 \( \text{RST}13 = \) 

Set Latch Bit LT14 \( \text{SET}14 = \) 
Reset Latch Bit LT14 \( \text{RST}14 = \) 

Set Latch Bit LT15 \( \text{SET}15 = \) 
Reset Latch Bit LT15 \( \text{RST}15 = \) 

Set Latch Bit LT16 \( \text{SET}16 = \) 
Reset Latch Bit LT16 \( \text{RST}16 = \) 

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 3.19) \( 67\text{P}1\text{TC} = \) 
Level 2 phase (see Figure 3.19) \( 67\text{P}2\text{TC} = \)
### SElogic Control Equation Settings (Serial Port Command Set L)

<table>
<thead>
<tr>
<th>Description</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 3 phase (see Figure 3.19)</td>
<td>67P3TC</td>
</tr>
<tr>
<td>Level 1 residual ground (see Figure 3.22)</td>
<td>67G1TC</td>
</tr>
<tr>
<td>Level 2 residual ground (see Figure 3.22)</td>
<td>67G2TC</td>
</tr>
<tr>
<td>Level 3 residual ground (see Figure 3.22)</td>
<td>67G3TC</td>
</tr>
<tr>
<td>Level 4 residual ground (see Figure 3.22)</td>
<td>67G4TC</td>
</tr>
<tr>
<td>Level 1 negative-sequence (see Figure 3.23)</td>
<td>67Q1TC</td>
</tr>
<tr>
<td>Level 2 negative-sequence (see Figure 3.23)</td>
<td>67Q2TC</td>
</tr>
<tr>
<td>Level 3 negative-sequence (see Figure 3.23)</td>
<td>67Q3TC</td>
</tr>
<tr>
<td>Level 4 negative-sequence (see Figure 3.23)</td>
<td>67Q4TC</td>
</tr>
</tbody>
</table>

### Torque Control Equations for Time-Overcurrent Elements

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

<table>
<thead>
<tr>
<th>Description</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase (see Figure 3.24)</td>
<td>51PTC</td>
</tr>
<tr>
<td>Residual Ground (see Figure 3.25)</td>
<td>51GTC</td>
</tr>
<tr>
<td>Negative-Sequence (see Figure 3.26)</td>
<td>51QTC</td>
</tr>
</tbody>
</table>

### SElogic Control Equation Variable Timer Input Equations (See Figures 7.24 and 7.25)

<table>
<thead>
<tr>
<th>Description</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>SELOGIC control equation Variable SV1</td>
<td>SV1</td>
</tr>
<tr>
<td>SELOGIC control equation Variable SV2</td>
<td>SV2</td>
</tr>
<tr>
<td>SELOGIC control equation Variable SV3</td>
<td>SV3</td>
</tr>
<tr>
<td>SELOGIC control equation Variable SV4</td>
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</tr>
<tr>
<td>SELOGIC control equation Variable SV5</td>
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<tr>
<td>SELOGIC control equation Variable SV6</td>
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<tr>
<td>SELOGIC control equation Variable SV7</td>
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<tr>
<td>SELOGIC control equation Variable SV8</td>
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<td>SELOGIC control equation Variable SV9</td>
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<td>SELOGIC control equation Variable SV10</td>
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<tr>
<td>SELOGIC control equation Variable SV11</td>
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<td>SELOGIC control equation Variable SV12</td>
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<td>SELOGIC control equation Variable SV13</td>
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<td>SELOGIC control equation Variable SV14</td>
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<td>SELOGIC control equation Variable SV15</td>
<td>SV15</td>
</tr>
<tr>
<td>SELOGIC control equation Variable SV16</td>
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</tbody>
</table>

### Output Contact Equations (See Figure 7.27)

<table>
<thead>
<tr>
<th>Description</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Contact OUT101</td>
<td>OUT101</td>
</tr>
<tr>
<td>Output Contact OUT102</td>
<td>OUT102</td>
</tr>
<tr>
<td>Output Contact OUT103</td>
<td>OUT103</td>
</tr>
<tr>
<td>Output Contact OUT104</td>
<td>OUT104</td>
</tr>
</tbody>
</table>
SELogic Control Equation Settings (Serial Port Command SET L)

Output Contact Equations—Extra I/O Board (See Figure 7.28)

Output Contact OUT201 OUT201 = 
Output Contact OUT202 OUT202 = 
Output Contact OUT203 OUT203 = 
Output Contact OUT204 OUT204 = 
Output Contact OUT205 OUT205 = 
Output Contact OUT206 OUT206 = 
Output Contact OUT207 OUT207 = 
Output Contact OUT208 OUT208 = 
Output Contact OUT209 OUT209 = 
Output Contact OUT210 OUT210 = 
Output Contact OUT211 OUT211 = 
Output Contact OUT212 OUT212 = 

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 = 

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Setting Group Selection Equations (See Table 7.4)
Select Setting Group 1 SS1 = __________________________
Select Setting Group 2 SS2 = __________________________
Select Setting Group 3 SS3 = __________________________
Select Setting Group 4 SS4 = __________________________
Select Setting Group 5 SS5 = __________________________
Select Setting Group 6 SS6 = __________________________

Other Equations
Event report trigger conditions (see Section 12) ER = __________________________
Fault indication (used in time target logic [see Table 5.1]; used also to suspend demand metering updating and peak recording and block max./min. metering [see Demand Metering and Maximum/Minimum Metering in Section 8])
FAULT = __________________________
Block synchronism check elements (see Figure 3.30) BSYNCH = __________________________
Close bus monitor (see Figure 5.3) CLMON = __________________________
Breaker monitor initiation (see Figure 8.3) BKMON = __________________________
Enable for zero-sequence voltage-polarized and channel IP current-polarized directional elements (see Figure 4.7) E32IV = __________________________

MIRRORED BITS™ Transmit Equations (See Appendix I)
Channel A, transmit bit 1 TMB1A = __________________________
Channel A, transmit bit 2 TMB2A = __________________________
Channel A, transmit bit 3 TMB3A = __________________________
Channel A, transmit bit 4 TMB4A = __________________________
Channel A, transmit bit 5 TMB5A = __________________________
Channel A, transmit bit 6 TMB6A = __________________________
Channel A, transmit bit 7 TMB7A = __________________________
Channel A, transmit bit 8 TMB8A = __________________________
Channel B, transmit bit 1 TMB1B = __________________________
Channel B, transmit bit 2 TMB2B = __________________________
Channel B, transmit bit 3 TMB3B = __________________________
Channel B, transmit bit 4 TMB4B = __________________________
Channel B, transmit bit 5 TMB5B = __________________________
Channel B, transmit bit 6 TMB6B = __________________________
Channel B, transmit bit 7 TMB7B = __________________________
Channel B, transmit bit 8 TMB8B = __________________________
Settings Group Change Delay (See Multiple Setting Groups in Section 7)
Group change delay (0.00–16000.00 cycles in 0.25-cycle steps)  
TGR = __________

Power System Configuration and Date Format (See Settings Explanations in Section 9)
Nominal frequency (50 Hz, 60 Hz)  
NFREQ = __________  
Phase rotation (ABC, ACB)  
PHROT = __________  
Date format (MDY, YMD)  
DATE_F = __________

Front-Panel Display Operation (See Section 11)
Front-panel display time-out (0.00–30.00 minutes in 0.01-minute steps)  
FP_TO = __________  
(If FP_TO = 0, no time-out occurs and display remains on last display screen, e.g., continually display metering.)
Front-panel display update rate (1–60 seconds)  
SCROLD = ________

Event Report Parameters (See Section 12)
Length of event report (15, 30, 60, 180 cycles)  
LER = __________  
Length of pre-fault in event report  
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  
PRE = __________

Station DC Battery Monitor (See Figures 8.9 and 8.10)
DC battery instantaneous undervoltage pickup (OFF, 20–300 Vdc)  
DCLOP = __________  
DC battery instantaneous overvoltage pickup (OFF, 20–300 Vdc)  
DCHIP = __________

Optoisolated Input Timers for Models 0311C00x and 0311C01x (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 = __________
Optoisolated Input Timers for Models 0311C01x—Extra I/O Board (See Figure 7.2)

- Input IN201 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN201D = 
- Input IN202 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN202D = 
- Input IN203 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN203D = 
- Input IN204 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN204D = 
- Input IN205 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN205D = 
- Input IN206 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN206D = 
- Input IN207 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN207D = 
- Input IN208 debounce time (0.00–2.00 cycles in 0.25-cycle steps) IN208D = 

Breaker Monitor Settings (See Breaker Monitor in Section 8)

- Breaker monitor enable (Y, N) EBMON = 
- 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 = 

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Sequential Events Recorder settings are comprised of three trigger lists. Each trigger list can include up to 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See *Sequential Events Recorder (SER) Report* in Section 12.

SER Trigger List 1  SER1 = ________________________________
SER Trigger List 2  SER2 = ________________________________
SER Trigger List 3  SER3 = ________________________________
Enter the following characters: 0-9, A-Z, #, &, @, -, /, , space
for each text label setting, subject to the specified character limit. Enter NA to null a label.

**Local Bit Labels (See Tables 7.1 and 7.2)**

| Local Bit LB1 Name (14 characters) | NLB1 = __________________________ |
| Clear Local Bit LB1 Label (7 characters) | CLB1 = __________________________ |
| Set Local Bit LB1 Label (7 characters) | SLB1 = __________________________ |
| Pulse Local Bit LB1 Label (7 characters) | PLB1 = __________________________ |

| Local Bit LB2 Name (14 characters) | NLB2 = __________________________ |
| Clear Local Bit LB2 Label (7 characters) | CLB2 = __________________________ |
| Set Local Bit LB2 Label (7 characters) | SLB2 = __________________________ |
| Pulse Local Bit LB2 Label (7 characters) | PLB2 = __________________________ |

| Local Bit LB3 Name (14 characters) | NLB3 = __________________________ |
| Clear Local Bit LB3 Label (7 characters) | CLB3 = __________________________ |
| Set Local Bit LB3 Label (7 characters) | SLB3 = __________________________ |
| Pulse Local Bit LB3 Label (7 characters) | PLB3 = __________________________ |

| Local Bit LB4 Name (14 characters) | NLB4 = __________________________ |
| Clear Local Bit LB4 Label (7 characters) | CLB4 = __________________________ |
| Set Local Bit LB4 Label (7 characters) | SLB4 = __________________________ |
| Pulse Local Bit LB4 Label (7 characters) | PLB4 = __________________________ |

| Local Bit LB5 Name (14 characters) | NLB5 = __________________________ |
| Clear Local Bit LB5 Label (7 characters) | CLB5 = __________________________ |
| Set Local Bit LB5 Label (7 characters) | SLB5 = __________________________ |
| Pulse Local Bit LB5 Label (7 characters) | PLB5 = __________________________ |

| Local Bit LB6 Name (14 characters) | NLB6 = __________________________ |
| Clear Local Bit LB6 Label (7 characters) | CLB6 = __________________________ |
| Set Local Bit LB6 Label (7 characters) | SLB6 = __________________________ |
| Pulse Local Bit LB6 Label (7 characters) | PLB6 = __________________________ |

| Local Bit LB7 Name (14 characters) | NLB7 = __________________________ |
| Clear Local Bit LB7 Label (7 characters) | CLB7 = __________________________ |
| Set Local Bit LB7 Label (7 characters) | SLB7 = __________________________ |
| Pulse Local Bit LB7 Label (7 characters) | PLB7 = __________________________ |
Local Bit LB8 Name (14 characters)  NLB8 = ____________________________
Clear Local Bit LB8 Label (7 characters)  CLB8 = ________________________
Set Local Bit LB8 Label (7 characters)  SLB8 = _________________________
Pulse Local Bit LB8 Label (7 characters)  PLB8 = _______________________  

Local Bit LB9 Name (14 characters)  NLB9 = ____________________________
Clear Local Bit LB9 Label (7 characters)  CLB9 = ________________________
Set Local Bit LB9 Label (7 characters)  SLB9 = _________________________
Pulse Local Bit LB9 Label (7 characters)  PLB9 = _______________________  

Local Bit LB10 Name (14 characters)  NLB10 = _________________________
Clear Local Bit LB10 Label (7 characters)  CLB10 = _____________________
Set Local Bit LB10 Label (7 characters)  SLB10 = ______________________
Pulse Local Bit LB10 Label (7 characters)  PLB10 = _____________________  

Local Bit LB11 Name (14 characters)  NLB11 = _________________________
Clear Local Bit LB11 Label (7 characters)  CLB11 = _____________________
Set Local Bit LB11 Label (7 characters)  SLB11 = ______________________
Pulse Local Bit LB11 Label (7 characters)  PLB11 = _____________________  

Local Bit LB12 Name (14 characters)  NLB12 = _________________________
Clear Local Bit LB12 Label (7 characters)  CLB12 = _____________________
Set Local Bit LB12 Label (7 characters)  SLB12 = ______________________
Pulse Local Bit LB12 Label (7 characters)  PLB12 = _____________________  

Local Bit LB13 Name (14 characters)  NLB13 = _________________________
Clear Local Bit LB13 Label (7 characters)  CLB13 = _____________________
Set Local Bit LB13 Label (7 characters)  SLB13 = ______________________
Pulse Local Bit LB13 Label (7 characters)  PLB13 = _____________________  

Local Bit LB14 Name (14 characters)  NLB14 = _________________________
Clear Local Bit LB14 Label (7 characters)  CLB14 = _____________________
Set Local Bit LB14 Label (7 characters)  SLB14 = ______________________
Pulse Local Bit LB14 Label (7 characters)  PLB14 = _____________________  

Local Bit LB15 Name (14 characters)  NLB15 = _________________________
Clear Local Bit LB15 Label (7 characters)  CLB15 = _____________________
Set Local Bit LB15 Label (7 characters)  SLB15 = ______________________
Pulse Local Bit LB15 Label (7 characters)  PLB15 = _____________________
Local Bit LB16 Name (14 characters) NLB16 = ______________________
Clear Local Bit LB16 Label (7 characters) CLB16 = ____________________
Set Local Bit LB16 Label (7 characters) SLB16 = ______________________
Pulse Local Bit LB16 Label (7 characters) PLB16 = ____________________

Display Point Labels (See Rotating Default Display in Section 7 and 11)
Display if DP1 = logical 1 (16 characters) DP1_1 = ____________________
Display if DP1 = logical 0 (16 characters) DP1_0 = ____________________
Display if DP2 = logical 1 (16 characters) DP2_1 = ____________________
Display if DP2 = logical 0 (16 characters) DP2_0 = ____________________
Display if DP3 = logical 1 (16 characters) DP3_1 = ____________________
Display if DP3 = logical 0 (16 characters) DP3_0 = ____________________
Display if DP4 = logical 1 (16 characters) DP4_1 = ____________________
Display if DP4 = logical 0 (16 characters) DP4_0 = ____________________
Display if DP5 = logical 1 (16 characters) DP5_1 = ____________________
Display if DP5 = logical 0 (16 characters) DP5_0 = ____________________
Display if DP6 = logical 1 (16 characters) DP6_1 = ____________________
Display if DP6 = logical 0 (16 characters) DP6_0 = ____________________
Display if DP7 = logical 1 (16 characters) DP7_1 = ____________________
Display if DP7 = logical 0 (16 characters) DP7_0 = ____________________
Display if DP8 = logical 1 (16 characters) DP8_1 = ____________________
Display if DP8 = logical 0 (16 characters) DP8_0 = ____________________
Display if DP9 = logical 1 (16 characters) DP9_1 = ____________________
Display if DP9 = logical 0 (16 characters) DP9_0 = ____________________
Display if DP10 = logical 1 (16 characters) DP10_1 = __________________
Display if DP10 = logical 0 (16 characters) DP10_0 = __________________
Display if DP11 = logical 1 (16 characters) DP11_1 = __________________
Display if DP11 = logical 0 (16 characters) DP11_0 = __________________
Display if DP12 = logical 1 (16 characters) DP12_1 = __________________
Display if DP12 = logical 0 (16 characters) DP12_0 = __________________
Display if DP13 = logical 1 (16 characters) DP13_1 = __________________
Display if DP13 = logical 0 (16 characters) DP13_0 = __________________

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TEXT LABEL SETTINGS (SERIAL PORT COMMAND SET T)

Display if DP14 = logical 1 (16 characters)  \( \text{DP14}_1 = \) ________________
Display if DP14 = logical 0 (16 characters)  \( \text{DP14}_0 = \) ________________
Display if DP15 = logical 1 (16 characters)  \( \text{DP15}_1 = \) ________________
Display if DP15 = logical 0 (16 characters)  \( \text{DP15}_0 = \) ________________
Display if DP16 = logical 1 (16 characters)  \( \text{DP16}_1 = \) ________________
Display if DP16 = logical 0 (16 characters)  \( \text{DP16}_0 = \) ________________

Reclosing Relay Labels (See Functions Unique to the Front-Panel Interface in Section 11)
Reclosing Relay Last Shot Label (14 char.)  \( 79\text{LL} = \) ________________
Reclosing Relay Shot Counter Label (14 char.)  \( 79\text{SL} = \) ________________
Protocol Settings (See Below)
Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B) \[ \text{PROTO} = \] 

Protocol Settings: Set PROTO = SEL for standard SEL ASCII protocol. For SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD. Refer to Appendix C for details on the LMD protocol. For Distributed Network Protocol (DNP), set PROTO = DNP. Refer to Appendix H for details on DNP protocol. For MIRRORED BITS, set PROTO = MBA, MBB, MB8A, or MB8B. Refer to Appendix I for details on MIRRORED BITS.

The following settings are used if PROTO = LMD.

\[ \text{PREFIX} = \]  
\[ \text{ADDR} = \]  
\[ \text{SETTLE} = \] 

Communications Settings
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) \[ \text{SPEED} = \] 
Data Bits (6, 7, 8) \[ \text{BITS} = \] 
Parity (O, E, N) {Odd, Even, None} \[ \text{PARITY} = \] 
Stop Bits (1, 2) \[ \text{STOP} = \] 

Other Port Settings (See Below)
Time-out (0–30 minutes) \[ \text{T.OUT} = \] 
DTA Meter Format (Y, N) \[ \text{DTA} = \] 
Send Auto Messages to Port (Y, N) \[ \text{AUTO} = \] 
Enable Hardware Handshaking (Y, N, MBT) \[ \text{RTSCTS} = \] 
Fast Operate Enable (Y, N) \[ \text{FASTOP} = \] 

Other Port Settings: Set \( \text{T.OUT} \) to the number of minutes of serial port inactivity for an automatic log out. Set \( \text{T.OUT} = 0 \) for no port time-out.

Set \( \text{DTA} = Y \) to allow an SEL-DTA or SEL-DTA2 to communicate with the relay. This setting is available when \( \text{PROTO} = \text{SEL} \) or LMD.

Set \( \text{AUTO} = Y \) to allow automatic messages at the serial port.

Set \( \text{RTSCTS} = Y \) to enable hardware handshaking. With \( \text{RTSCTS} = Y \), 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 \( \text{FASTOP} = Y \) to enable binary Fast Operate messages at the serial port. Set \( \text{FASTOP} = N \) to block binary Fast Operate messages. Refer to Appendix D for the description of the SEL-311C Relay Fast Operate commands.
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SECTION 10: SERIAL PORT COMMUNICATIONS AND COMMANDS

INTRODUCTION

All SEL-311C 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 2.10. Note that demodulated IRIG-B time code can be input into Serial Port 1 or Serial Port 2 on any of the SEL-311C Relay models. This is easily handled by connecting Serial Port 2 of the SEL-311C 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

<table>
<thead>
<tr>
<th>Pin</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/C or +5 Vdc(^1)</td>
<td>N/C or +5 Vdc(^1)</td>
<td>N/C</td>
</tr>
<tr>
<td>2</td>
<td>RXD</td>
<td>RXD</td>
<td>RXD</td>
</tr>
<tr>
<td>3</td>
<td>TXD</td>
<td>TXD</td>
<td>TXD</td>
</tr>
<tr>
<td>4</td>
<td>+IRIG-B</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>5, 9</td>
<td>GND</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>6</td>
<td>-IRIG-B</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>7</td>
<td>RTS</td>
<td>RTS</td>
<td>RTS</td>
</tr>
<tr>
<td>8</td>
<td>CTS</td>
<td>CTS</td>
<td>CTS</td>
</tr>
</tbody>
</table>

\(^1\) See EIA-232 Serial Port Jumpers in Section 2: Installation.

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

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+TX</td>
</tr>
<tr>
<td>2</td>
<td>-TX</td>
</tr>
<tr>
<td>3</td>
<td>+RX</td>
</tr>
<tr>
<td>4</td>
<td>-RX</td>
</tr>
<tr>
<td>5</td>
<td>SHIELD</td>
</tr>
<tr>
<td>6</td>
<td>N/C</td>
</tr>
<tr>
<td>7</td>
<td>+IRIG-B</td>
</tr>
<tr>
<td>8</td>
<td>-IRIG-B</td>
</tr>
</tbody>
</table>

The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-311C 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-311C to Computer

**Cable C234A**

<table>
<thead>
<tr>
<th>SEL-311C Relay</th>
<th>9-Pin *DTE Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Pin Male</td>
<td>9-Pin Female</td>
</tr>
<tr>
<td>“D” Subconnector</td>
<td>“D” Subconnector</td>
</tr>
<tr>
<td>RXD 2</td>
<td>TXD 3</td>
</tr>
<tr>
<td>TXD 3</td>
<td>RXD 2</td>
</tr>
<tr>
<td>GND 5</td>
<td>GND 5</td>
</tr>
<tr>
<td>CTS 8</td>
<td>CTS 8</td>
</tr>
<tr>
<td></td>
<td>7 RTS</td>
</tr>
<tr>
<td></td>
<td>1 DCD</td>
</tr>
<tr>
<td></td>
<td>4 DTR</td>
</tr>
<tr>
<td></td>
<td>6 DSR</td>
</tr>
</tbody>
</table>

**Cable C227A**

<table>
<thead>
<tr>
<th>SEL-311C Relay</th>
<th>25-Pin *DTE Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Pin Male</td>
<td>25-Pin Female</td>
</tr>
<tr>
<td>“D” Subconnector</td>
<td>“D” Subconnector</td>
</tr>
<tr>
<td>GND 5</td>
<td>GND 7</td>
</tr>
<tr>
<td>TXD 3</td>
<td>TXD 3</td>
</tr>
<tr>
<td>RXD 2</td>
<td>RXD 2</td>
</tr>
<tr>
<td>GND 9</td>
<td>GND 1</td>
</tr>
<tr>
<td>CTS 8</td>
<td>CTS 4</td>
</tr>
<tr>
<td></td>
<td>5 CTS</td>
</tr>
<tr>
<td></td>
<td>6 DSR</td>
</tr>
<tr>
<td></td>
<td>8 DCD</td>
</tr>
<tr>
<td></td>
<td>20 DTR</td>
</tr>
</tbody>
</table>

### SEL-311C to Modem or Other DCE

**Cable C222**

<table>
<thead>
<tr>
<th>SEL-311C Relay</th>
<th><strong>DCE Device</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Pin Male</td>
<td>25-Pin Male</td>
</tr>
<tr>
<td>“D” Subconnector</td>
<td>“D” Subconnector</td>
</tr>
<tr>
<td>GND 5</td>
<td>GND 7</td>
</tr>
<tr>
<td>TXD 3</td>
<td>TXD (IN)</td>
</tr>
<tr>
<td>RTS 7</td>
<td>20 DTR (IN)</td>
</tr>
<tr>
<td>RXD 2</td>
<td>RXD (OUT)</td>
</tr>
<tr>
<td>CTS 8</td>
<td>CD (OUT)</td>
</tr>
<tr>
<td>GND 9</td>
<td>GND</td>
</tr>
</tbody>
</table>
### SEL-311C to SEL-2020, SEL-2030, or SEL-2100

Cable C273A

<table>
<thead>
<tr>
<th>SEL-2020/2030 or SEL-2100</th>
<th>SEL-311C Relay</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Pin Male</td>
<td>9-Pin Male</td>
</tr>
<tr>
<td>“D” Subconnector</td>
<td>“D” Subconnector</td>
</tr>
<tr>
<td>RXD 2</td>
<td>3 TXD</td>
</tr>
<tr>
<td>TXD 3</td>
<td>2 RXD</td>
</tr>
<tr>
<td>IRIG+ 4</td>
<td>4 IRIG+</td>
</tr>
<tr>
<td>GND 5</td>
<td>5 GND</td>
</tr>
<tr>
<td>IRIG- 6</td>
<td>6 IRIG-</td>
</tr>
<tr>
<td>RTS 7</td>
<td>8 CTS</td>
</tr>
<tr>
<td>CTS 8</td>
<td>7 RTS</td>
</tr>
</tbody>
</table>

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

### SEL-311C to SEL-DTA2

Cable C272A

<table>
<thead>
<tr>
<th>SEL-DTA2</th>
<th>SEL-311C Relay</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Pin Male</td>
<td>9-Pin Male</td>
</tr>
<tr>
<td>“D” Subconnector</td>
<td>“D” Subconnector</td>
</tr>
<tr>
<td>RXD 2</td>
<td>3 TXD</td>
</tr>
<tr>
<td>TXD 3</td>
<td>2 RXD</td>
</tr>
<tr>
<td>GND 5</td>
<td>5 GND</td>
</tr>
<tr>
<td>RTS 7</td>
<td>7 RTS</td>
</tr>
<tr>
<td>CTS 8</td>
<td>8 CTS</td>
</tr>
</tbody>
</table>

### SEL-311C to SEL-PRTU

Cable C231

<table>
<thead>
<tr>
<th>SEL-PRTU</th>
<th>SEL-311C Relay</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Pin Male</td>
<td>9-Pin Male</td>
</tr>
<tr>
<td>Round Conxall</td>
<td>“D” Subconnector</td>
</tr>
<tr>
<td>GND 1</td>
<td>5 GND</td>
</tr>
<tr>
<td>TXD 2</td>
<td>2 RXD</td>
</tr>
<tr>
<td>RXD 4</td>
<td>3 TXD</td>
</tr>
<tr>
<td>CTS 5</td>
<td>7 RTS</td>
</tr>
<tr>
<td>+12 7</td>
<td>8 CTS</td>
</tr>
<tr>
<td>GND 9</td>
<td>9 GND</td>
</tr>
</tbody>
</table>
Table 10.3: Serial Communications Port Pin/Terminal Function Definitions

<table>
<thead>
<tr>
<th>Pin Function</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/C</td>
<td>No Connection</td>
</tr>
<tr>
<td>+5 Vdc (0.5 A limit)</td>
<td>5 Vdc Power Connection</td>
</tr>
<tr>
<td>RXD, RX</td>
<td>Receive Data</td>
</tr>
<tr>
<td>TXD, TX</td>
<td>Transmit Data</td>
</tr>
<tr>
<td>IRIG-B</td>
<td>IRIG-B Time-Code Input</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>SHIELD</td>
<td>Grounded Shield</td>
</tr>
<tr>
<td>RTS</td>
<td>Request To Send</td>
</tr>
<tr>
<td>CTS</td>
<td>Clear To Send</td>
</tr>
<tr>
<td>DCD</td>
<td>Data Carrier Detect</td>
</tr>
<tr>
<td>DTR</td>
<td>Data Terminal Ready</td>
</tr>
<tr>
<td>DSR</td>
<td>Data Set Ready</td>
</tr>
</tbody>
</table>

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-311C 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-311C Relay is compatible with the SEL-DTA2 Display Transducer Adapter. See Settings Sheet 26 in Section 9: Setting the Relay.
To select SEL-ASCII protocol, set the port PROTO setting to SEL. To select SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD. To select DNP protocol, set PROTO = DNP.

SEL Fast Meter and SEL Compressed ASCII commands are active when PROTO is set to either SEL or LMD. The commands are not active when PROTO is set to DNP or MIRRORED BITS.

**SEL-ASCII Protocol**

SEL-ASCII protocol is designed for manual and automatic communications.

1. All commands received by the relay must be of the form:

   `<command><CR> or <command><CRLF>`

   A command transmitted to the relay should consist of the command followed by either a CR (carriage return) or a CRLF (carriage return and line feed). You may truncate commands to the first three characters. For example, `EVENT 1 <ENTER>` would become `EVE 1 <ENTER>`. Upper and lower case characters may be used without distinction, except in passwords.

   **Note:** The ENTER key on most keyboards is configured to send the ASCII character 13 (^M) for a carriage return. This manual instructs you to press the ENTER key after commands, which should send the proper ASCII code to the relay.

2. The relay transmits all messages in the following format:

   `<STX><MESSAGE LINE 1><CRLF>
   <MESSAGE LINE 2><CRLF>
   ...
   <LAST MESSAGE LINE><CRLF>< ETX>`

   Each message begins with the start-of-transmission character (ASCII 02) and ends with the end-of-transmission character (ASCII 03). Each line of the message ends with a carriage return and line feed.

3. The relay implements XON/XOFF flow control.

   The relay transmits XON (ASCII hex 11) and asserts the RTS output (if hardware handshaking is enabled) when the relay input buffer drops below 25 percent full.

   The relay transmits XOFF (ASCII hex 13) when the buffer is over 75 percent full. If hardware handshaking is enabled, the relay deasserts the RTS output when the buffer is approximately 95 percent full. Automatic transmission sources should monitor for the XOFF character so they do not overwrite the buffer. Transmission should terminate at the end of the message in progress when XOFF is received and may resume when the relay sends XON.

4. You can use the XON/XOFF protocol to control the relay during data transmission. When the relay receives XOFF during transmission, it pauses until it receives an XON character. If there is no message in progress when the relay receives XOFF, it blocks transmission of any message presented to its buffer. Messages will be accepted after the relay receives XON.
The CAN character (ASCII hex 18) aborts a pending transmission. This is useful in terminating an unwanted transmission.

Control characters can be sent from most keyboards with the following keystrokes:

- **XON**: `<CNTRL> Q` (hold down the Control key and press Q)
- **XOFF**: `<CNTRL> S` (hold down the Control key and press S)
- **CAN**: `<CNTRL> X` (hold down the Control key and press X)

**SEL Distributed Port Switch Protocol (LMD)**

The SEL Distributed Port Switch Protocol (LMD) permits multiple SEL relays to share a common communications channel. The protocol is selected by setting the port setting PROTO = LMD. See *Appendix C* for more information on SEL Distributed Port Switch Protocol (LMD).

**SEL Fast Meter Protocol**

SEL Fast Meter protocol supports binary messages to transfer metering and control messages. The protocol is described in *Appendix D*.

**SEL Compressed ASCII Protocol**

SEL Compressed ASCII protocol provides compressed versions of some of the relay ASCII commands. The protocol is described in *Appendix E*.

**Distributed Network Protocol (DNP) 3.00**

The relay provides Distributed Network Protocol (DNP) 3.00 slave support. DNP is an optional protocol and is described in *Appendix H*.

**MIRRORED BITS Communications**

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

**Serial Port Automatic Messages**

When the serial port AUTO setting is Y, the relay sends automatic messages to indicate specific conditions. The automatic messages are described in Table 10.4.
Table 10.4: Serial Port Automatic Messages

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Up</td>
<td>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.</td>
</tr>
<tr>
<td>Event Trigger</td>
<td>The relay sends an event summary each time an event report is triggered. See Section 12: Standard Event Reports and SER.</td>
</tr>
<tr>
<td>Group Switch</td>
<td>The relay displays the active settings group after a group switch occurs. See GRO n Command (Group) in this section.</td>
</tr>
<tr>
<td>Self-Test Warning or Failure</td>
<td>The relay sends a status report each time a self-test warning or failure condition is detected. See STA Command (Status) in this section.</td>
</tr>
</tbody>
</table>

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-311C 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)


Access Level 0

Once serial port communications are established with the relay, the relay sends the following prompt:

```
= ACC <ENTER>
```

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

<table>
<thead>
<tr>
<th>Access Level</th>
<th>Prompt</th>
<th>Serial Port Command</th>
<th>Command Description</th>
<th>Corresponding Front-Panel Pushbutton</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>=</td>
<td>ACC</td>
<td>Go to Access Level 1</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>=&gt;</td>
<td>QUI</td>
<td>Quit to Access Level 0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>2AC</td>
<td>Go to Access Level 2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>BAC</td>
<td>Go to Access Level B</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>BRE</td>
<td>Breaker monitor data</td>
<td>OTHER</td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>COM</td>
<td>MIRRORED BITS communications statistics</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>DAT</td>
<td>View/change date</td>
<td>OTHER</td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>EVE</td>
<td>Event reports</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>GRO</td>
<td>Display active setting group number</td>
<td>GROUP</td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>HIS</td>
<td>Event summaries/histories</td>
<td>EVENTS</td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>INI</td>
<td>Display I/O configuration</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>IRI</td>
<td>Synchronize to IRIG-B</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>MET</td>
<td>Metering data</td>
<td>METER</td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>SER</td>
<td>Sequential Events Recorder</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>SHO</td>
<td>Show/view settings</td>
<td>SET</td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>STA</td>
<td>Relay self-test status</td>
<td>STATUS</td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>SUM</td>
<td>Display Event Summary</td>
<td>EVENTS</td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>TAR</td>
<td>Display relay element status</td>
<td>OTHER</td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>TIM</td>
<td>View/change time</td>
<td>OTHER</td>
</tr>
<tr>
<td>1</td>
<td>=&gt;</td>
<td>TRI</td>
<td>Trigger an event report</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>=&gt;&gt;</td>
<td>BRE n</td>
<td>Preload/reset breaker wear</td>
<td>OTHER</td>
</tr>
<tr>
<td>B</td>
<td>=&gt;&gt;</td>
<td>CLO</td>
<td>Close breaker</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>=&gt;&gt;</td>
<td>GRO n</td>
<td>Change active setting group</td>
<td>GROUP</td>
</tr>
<tr>
<td>B</td>
<td>=&gt;&gt;</td>
<td>OPE</td>
<td>Open breaker</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>=&gt;&gt;</td>
<td>PUL</td>
<td>Pulse output contact</td>
<td>CNTRL</td>
</tr>
<tr>
<td>2</td>
<td>=&gt;&gt;</td>
<td>CON</td>
<td>Control remote bit</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>=&gt;&gt;</td>
<td>COP</td>
<td>Copy setting group</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>=&gt;&gt;</td>
<td>LOO</td>
<td>Loopback</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>=&gt;&gt;</td>
<td>PAS</td>
<td>View/change passwords</td>
<td>SET</td>
</tr>
<tr>
<td>2</td>
<td>=&gt;&gt;</td>
<td>SET</td>
<td>Change settings</td>
<td>SET</td>
</tr>
<tr>
<td>2</td>
<td>=&gt;&gt;</td>
<td>VER</td>
<td>Display version and configuration information</td>
<td></td>
</tr>
</tbody>
</table>

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-311C POTT                     Date: 10/12/99    Time: 16:15:39.372
EXAMPLE: BUS B, BREAKER 3
```

The definitions are:

**SEL-311C POTT:** This is the RID setting (the relay is shipped with the default setting RID =SEL-311C POTT; see *Identifier Labels* in *Section 9: Setting the Relay*).

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

**Date:** This is the date the command response was given (except for relay response to the **EVE** or **SUM** command [Event], where it is the date the event occurred). You can modify the date display format (Month/Day/Year or Year/Month/Day) by changing the DATE_F relay setting.

**Time:** This is the time the command response was given (except for relay response to the **EVE** or **SUM** command, where it is the time the event occurred).

The serial port command explanations that follow in the *Command Explanations* subsection are in the same order as the commands listed in Table 10.5.

**COMMAND EXPLANATIONS**

**Access Level 0 Commands**

**ACC Command (Go to Access Level 1)**

The ACC command provides entry to Access Level 1. Different commands are available at the different access levels as shown in Table 10.5.

ACC moves from any access level to Access Level 1.

**Password Requirements and Default Passwords**

Passwords are required if the main board Password jumper is not in place (Password jumper = OFF). Passwords are not required if the main board Password jumper is in place (Password jumper = ON). Refer to Table 2.4 for Password jumper information. See **PAS Command** later in this section for more information on passwords.
The factory default passwords for Access Levels 1, B, and 2 are:

<table>
<thead>
<tr>
<th>Access Level</th>
<th>Factory Default Password</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OTTER</td>
</tr>
<tr>
<td>B</td>
<td>EDITH</td>
</tr>
<tr>
<td>2</td>
<td>TAIL</td>
</tr>
</tbody>
</table>

**WARNING**

This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

**Access Level Attempt (Password Required)**

Assume the following conditions: Password jumper = OFF (not in place), Access Level = 0.

At the Access Level 0 prompt, enter the ACC command:

```
=ACC <ENTER>
```

Because the Password jumper is not in place, the relay asks for the Access Level 1 password to be entered:

```
Password: ? @@@@@@
```

The relay is shipped with the default Access Level 1 password “OTTER”. Enter the default password:

```
Password: ? OTTER <ENTER>
```

The relay responds:

```
SEL-311C POTT                     Date: 10/12/99    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3
Level 1
->
```

The “=>” prompt indicates the relay is now in Access Level 1.

If the entered password is incorrect, the relay asks for the password again (Password: ?). The relay will ask up to three times. If the requested password is incorrectly entered three times, the relay closes the ALARM contact for one second and remains at Access Level 0 (“=” prompt).

**Access Level Attempt (Password Not Required)**

Assume the following conditions: Password jumper = ON (in place), Access Level = 0.

At the Access Level 0 prompt, enter the ACC command:

```
=ACC <ENTER>
```
Because the Password jumper is in place, the relay does not ask for a password; it goes directly to Access Level 1. The relay responds:

```
SEL-311C POTT                     Date: 10/12/99    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3

Level 1
=>
```

The “=>” prompt indicates the relay is now in Access Level 1.

The above two examples demonstrate how to go from Access Level 0 to Access Level 1. The procedure to go from Access Level 1 to Access Level B, Access Level 1 to Access Level 2, or Access Level B to Access Level 2 is much the same, with command BAC or 2AC entered at the access level screen prompt. The relay closes the ALARM contact for one second after a successful Level B or Level 2 access. If access is denied, the ALARM contact closes for one second.

**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-311C POTT                     Date: 10/12/99    Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

Rly Trips= 9
IA= 40.7 IB= 41.4 IC= 53.8 kA
Ext Trips= 3
IA= 0.8 IB= 0.9 IC= 1.1 kA
Percent wear: A= 4 B= 4 C= 6
LAST RESET 10/12/99 15:32:59
=>
```

See **BRE n Command** in **Access Level B Commands** that follows in this section and **Breaker Monitor** in **Section 8: Breaker Monitor and Metering Functions** for further details on the breaker monitor.

### COM Command (Communication Data)

The COM command displays integral relay-to-relay (MIRRORED BITS) communications performance data. For more information on MIRRORED BITS, see **Appendix I: MIRRORED BITS**.

To get a summary report, enter the COM command with the channel parameter (A or B).
If only one MIRRORED BITS port is enabled, the channel specifier may be omitted. Use the L parameter to get a summary report, followed by a listing of the COMM records.

```
->COM A <ENTER>
SEL-311C POTT Date: 10/12/99 Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3
FID=SEL-311C-R100-V0-Z001001-D19991118 CID=FF27
Summary for Mirrored Bits channel A
For 10/05/99 18:36:09.279 to 10/10/99 18:36:11.746

<table>
<thead>
<tr>
<th>Total failures</th>
<th>Last error</th>
<th>Relay Disabled</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Relay Disabled</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.458 sec.</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Unavailability 0.996200</td>
<td></td>
</tr>
</tbody>
</table>

->

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-311C POTT Date: 10/12/99 Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3
FID=SEL-311C-R100-V0-Z001001-D19991118 CID=FF27
Summary for Mirrored Bits channel A
For 10/05/99 17:18:12.993 to 10/10/99 18:37:36.123

<table>
<thead>
<tr>
<th>Total failures</th>
<th>Last error</th>
<th>Relay Disabled</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Relay Disabled</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2.835 sec.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Unavailability 0.000003</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Failure</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td># Date</td>
<td>Time</td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>1 10/05/99 18:36:09.279 10/05/9918:37:36.114 2.835 Relay Disabled</td>
<td></td>
</tr>
<tr>
<td>2 10/06/99 13:18:09.236 10/06/99 13:18:09.736 0.499 Parity error</td>
<td></td>
</tr>
<tr>
<td>3 10/07/99 11:43:35.547 10/07/99 11:43:35.637 0.089 Underrun</td>
<td></td>
</tr>
</tbody>
</table>

->
There may be up to 255 records in the extended report. To limit the number of COMM records displayed in the report to the 10 most recent records, type **COM 10 L <ENTER>**. To select lines 10 through 20 of the COMM records for display in the report, type **COM 10 20 L <ENTER>**. To reverse the order of the COMM records in the report, supply a range of row numbers, with the larger number first, i.e., **COM 40 10 L <ENTER>**. To display all the COMM records that started on a particular day, supply that date as a parameter, i.e., **COM 2/8/98 L <ENTER>**. To display all the COMM records that started between a range of dates, supply both dates as parameters, i.e., **COM 2/21/98 2/7/98 L <ENTER>**. Reversing the order of the dates will reverse the order of the records in the report. To receive a summary report for a subset of the records, use one of the above methods while omitting the L parameter.

To clear the COMM records, type **COM C <ENTER>**. The prompting message “Are you sure (Y/N) ?” is displayed. Typing **N <ENTER>** aborts the clearing operation with the message “Canceled.” If both MIRRORED BITS channels are enabled, omitting the channel specifier in the clear command will cause both channels to be cleared.

**DAT Command (View/Change Date)**

**DAT** displays the date stored by the internal calendar/clock. If the date format setting DATE_F is set to MDY, the date is displayed as month/day/year. If the date format setting DATE_F is set to YMD, the date is displayed as year/month/day.

To set the date, type **DAT mm/dd/yy <ENTER>** if the DATE_F setting is MDY. If the DATE_F is set to YMD, enter **DAT yy/mm/dd <ENTER>**. To set the date to June 1, 1999, enter when DATE_F = MDY:

```
->DAT 6/1/99 <ENTER>
06/01/99
->
```

You can separate the month, day, and year parameters with spaces, commas, slashes, colons, and semicolons.

**Note:** After setting date or time, allow at least 60 seconds before powering down the relay or the new setting may be lost.

**EVE Command (Event Reports)**

Use the **EVE** command to view event reports. See **Section 12: Standard Event Reports and SER** for further details on retrieving event reports.

**GRO Command (Display Active Setting Group Number)**

Use the **GRO** command to display the active settings group number. See **GRO n Command** in **Access Level B Commands** that follows in this section and **Multiple Setting Groups** in **Section 7: Inputs, Outputs, Timers, and Other Control Logic** for further details on settings groups.
HIS Command (Event Summaries/History)

**HIS x** displays event summaries or allows you to clear event summaries (and corresponding event reports and event summaries) from nonvolatile memory.

If no parameters are specified with the **HIS** command:

```bash
=>HIS <ENTER>
```

the relay displays the most recent event summaries in reverse chronological order.

If *x* is the letter **E**

```bash
=>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:

```bash
=>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-311C POTT                     Date: 10/12/99    Time: 16:24:01.623
EXAMPLE: BUS B, BREAKER 3

<table>
<thead>
<tr>
<th>#</th>
<th>DATE</th>
<th>TIME</th>
<th>EVENT</th>
<th>LOCAT</th>
<th>CURR</th>
<th>FREQ</th>
<th>GRP</th>
<th>SHOT</th>
<th>TARGETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10/01/99  08:33:00.365 TRIG</td>
<td>$$$$$$$</td>
<td>1 60.00</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10/02/99  20:32:58.361 ER</td>
<td>$$$$$$$</td>
<td>231 60.00</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>10/03/99  07:30:11.055 AG T</td>
<td>9.65</td>
<td>2279 60.00</td>
<td>3</td>
<td>2</td>
<td>TIME</td>
<td>51</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Faulted Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>AG</td>
<td>A-phase to ground</td>
</tr>
<tr>
<td>BG</td>
<td>B-phase to ground</td>
</tr>
<tr>
<td>CG</td>
<td>C-phase to ground</td>
</tr>
<tr>
<td>AB</td>
<td>A-B phase-to-phase</td>
</tr>
<tr>
<td>BC</td>
<td>B-C phase-to-phase</td>
</tr>
<tr>
<td>CA</td>
<td>C-A phase-to-phase</td>
</tr>
<tr>
<td>ABG</td>
<td>A-B phase-to-phase to ground</td>
</tr>
<tr>
<td>BCG</td>
<td>B-C phase-to-phase to ground</td>
</tr>
<tr>
<td>CAG</td>
<td>C-A phase-to-phase to ground</td>
</tr>
<tr>
<td>ABC</td>
<td>three-phase</td>
</tr>
</tbody>
</table>

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 SEL OLOGY control equation event report trigger setting ER
- **PULSE** event report generated by execution of the PUL (Pulse) command
- **TRIG** event report generated by execution of the **TRI** (Trigger) command

The TARGETS column will display any of the following illuminated front-panel target LEDs if the event report is generated by a trip (assertion of TRIP Relay Word bit):

- **TIME**
- **COMM**
- **SOTF**
- **51**
- **Zone 1**
- **Zone 2**
- **Zone 3**
- **Zone 4**

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-311C POTT                     Date: 10/12/99    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3

EXAMPLE: BUS B, BREAKER 3

If no IRIG-B code is present at the serial port input or if the code cannot be read successfully, the relay responds:

IRIG-B DATA ERROR

If an IRIG-B signal is present, the relay synchronizes its internal clock with IRIG-B. It is not necessary to issue the IRI command to synchronize the relay clock with IRIG-B. Use the IRI command to determine if the relay is properly reading the IRIG-B signal.

**MET Command (Metering Data)**

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

**MET k—Instantaneous Metering**

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

- **Currents**
  - $I_{A,B,C,P}$: Input currents (A primary)
  - $I_G$: Residual ground current (A primary; $I_G = 3I_0 = I_a + I_b + I_c$)

- **Voltages**
  - $V_{A,B,C,S}$: Wye-connected voltage inputs (kV primary)

- **Power**
  - $MW_{A,B,C}$: Single-phase megawatts
  - $MW_{IP}$: Three-phase megawatts
  - $MVAR_{A,B,C}$: Single- and three-phase megavars
  - $MVAR_{IP}$: Three-phase megavars

- **Power Factor**
  - $PF_{A,B,C,IP}$: 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-311C Relay is shown:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>P</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>195.146</td>
<td>192.614</td>
<td>198.090</td>
<td>0.302</td>
<td>4.880</td>
</tr>
<tr>
<td>-8.03</td>
<td>-128.02</td>
<td>111.89</td>
<td>52.98</td>
<td>81.22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.691</td>
<td>11.686</td>
<td>11.669</td>
<td>11.695</td>
</tr>
<tr>
<td>0.00</td>
<td>-119.79</td>
<td>120.15</td>
<td>0.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>3P</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.259</td>
<td>2.228</td>
<td>2.288</td>
<td>6.774</td>
</tr>
<tr>
<td>0.319</td>
<td>0.322</td>
<td>0.332</td>
<td>0.973</td>
</tr>
<tr>
<td>0.990</td>
<td>0.990</td>
<td>0.990</td>
<td>0.990</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>3P</th>
</tr>
</thead>
<tbody>
<tr>
<td>195.283</td>
<td>4.630</td>
<td>4.880</td>
<td>11.682</td>
</tr>
<tr>
<td>-8.06</td>
<td>-103.93</td>
<td>81.22</td>
<td>0.12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FREQ (Hz)</th>
<th>VDC (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60.00</td>
<td>129.5</td>
</tr>
</tbody>
</table>

**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-311C Relay is shown:

```
SEL-311C POTT                   Date: 10/12/99    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3
IA   IB   IC   IG   3I2
DEMAND 188.6 186.6 191.8 4.5 4.7
PEAK   188.6 186.6 191.8 4.5 4.7

MWA     MWB     MWC     MW3P     MVARA     MVARB     MVARC     MVAR3P
DEMAND IN 0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
PEAK IN   0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
DEMAND OUT 2.2    2.2    2.2    6.6     0.3     0.3     0.3     0.9
PEAK OUT  3.1    3.1    3.1    9.3     0.4     0.4     0.4     1.2
LAST DEMAND RESET 01/27/97 15:31:51.238   LAST PEAK RESET 01/27/97 15:31:56.239
=>
```

Reset the accumulated demand values using the **MET RD** command. Reset the peak demand values using the **MET RP** command. For more information on demand metering, see *Demand Metering* in Section 8: *Breaker Monitor and Metering Functions*.

**MET E—Energy Metering**

The **MET E** command displays the following quantities:

- **Energy**: Single-phase megawatt hours (in and out)
- **MWH_{A,B,C}**: Single-phase megawatt hours (in and out)
- **MWH_{ip}**: Three-phase megawatt hours (in and out)
- **MVARh_{A,B,C}**: Single-phase megavar hours (in and out)
- **MVARh_{ip}**: 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-311C Relay is shown:

```
SEL-311C                     Date: 03/01/00    Time: 15:11:24.056
EXAMPLE: BUS B, BREAKER 3
MWH A  MWH B  MWH C  MWH 3P  MVARh A  MVARh B  MVARh C  MVARh 3P
IN   0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
OUT  36.0   36.6   36.7  109.2   5.1    5.2    5.3    15.6
LAST RESET 02/10/00 23:31:28.864
=>
```

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

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

**Currents**  
- $I_{A,B,C,P}$ Input currents (A primary)  
- $I_G$ Residual ground current (A primary; $I_G = 3I_0 = I_A + I_B + I_C$)

**Voltages**  
- $V_{A,B,C,S}$ Wye-connected voltage inputs (kV primary)

**Power**  
- $MW_{3P}$ Three-phase megawatts  
- $MVAR_{3P}$ Three-phase megavars

**Reset Time**  
Last time the maximum/minimum meter was reset

To view maximum/minimum metering values, enter the command:

`=>MET M <ENTER>`

The output from an SEL-311C Relay is shown:

```
MET M <ENTER>
SEL-311C POTT                     Date: 10/12/99    Time: 16:22:04.372
EXAMPLE: BUS B, BREAKER 3
Max    Date      Time             Min    Date      Time
IA(A)   196.8  10/01/99  15:00:42.574      30.0  10/01/99  14:51:02.391
IB(A)   195.0  10/01/99  15:05:19.558      31.8  10/01/99  14:50:55.536
IC(A)   200.4  10/01/99  15:00:42.578      52.2  10/01/99  14:51:02.332
IP(A)   42.6  10/01/99  14:51:02.328      42.6  10/01/99  14:51:02.328
IG(A)   42.0  10/01/99  14:50:55.294      42.0  10/01/99  14:50:55.294
VA(kV)  11.7  10/01/99  15:01:01.576       3.4  10/01/99  15:00:42.545
VB(kV)  11.7  10/01/99  15:00:42.937       2.4  10/01/99  15:00:42.541
VC(kV)  11.7  10/01/99  15:00:42.576       3.1  10/01/99  15:00:42.545
VS(kV)  11.7  10/01/99  15:01:01.576       3.4  10/01/99  15:00:42.545
MW3P    6.9  10/01/99  15:00:44.095       0.4  10/01/99  15:00:42.545
MVAR3P  1.0  10/01/99  15:00:42.578       0.1  10/01/99  15:00:42.545
LAST RESET 01/27/99 15:31:41.237
```

Reset the maximum/minimum values using the **MET RM** command. All values will display **RESET** until new maximum/minimum values are recorded. For more information on maximum/minimum metering, see *Maximum/Minimum Metering* in *Section 8: Breaker Monitor and Metering Functions*.

**QUI Command (Quit Access Level)**

The **QUI** command returns the relay to Access Level 0.

To return to Access Level 0, enter the command:

`=>QUI <ENTER>`
The relay sets the port access level to 0 and responds:

SEL-311C POTT                     Date: 10/12/99    Time: 16:32:10.747
EXAMPLE: BUS B, BREAKER 3
-

The “=” prompt indicates the relay is back in Access Level 0.

The QUI command terminates the SEL Distributed Port Switch Protocol (LMD) connection if it is established (see Appendix C for details on SEL Distributed Port Switch Protocol [LMD]).

**SER Command (Sequential Events Recorder Report)**

Use the SER command to view the Sequential Events Recorder report. For more information on SER reports, see Section 12: Standard Event Reports and SER.

**SHO Command (Show/View Settings)**

Use the SHO command to view relay settings, SELOGIC control equations, global settings, serial port settings, sequential events recorder (SER) settings, and text label settings. Below are the SHO command options.

- **SHO n**  
  Show relay settings.  
  - $n$ specifies the setting group (1, 2, 3, 4, 5, or 6); $n$ defaults to the active setting group if not listed.

- **SHO L n**  
  Show SELOGIC control equation settings.  
  - $n$ specifies the setting group (1, 2, 3, 4, 5, or 6); $n$ defaults to the active setting group if not listed.

- **SHO G**  
  Show global settings.

- **SHO P n**  
  Show serial port settings.  
  - $n$ specifies the port (1, 2, 3, or F); $n$ defaults to the active port if not listed.

- **SHO R**  
  Show sequential events recorder (SER) settings.

- **SHO T**  
  Show text label settings.

You may append a setting name to each of the commands to specify the first setting to display (e.g., **SHO 1 E50P** displays the setting Group 1 relay settings starting with setting E50P). The default is the first setting.

The SHO commands display only the enabled settings. To display all settings, including disabled/hidden settings, append an A to the SHO command (e.g., **SHO 1 A**).

Below are sample SHOWSET commands for the SEL-311C Relay model 0311C01x, showing all the factory default settings. The factory default settings for the SEL-311C Relay model 0311C00x are similar.
Group Settings:
RID  =SEL-311C POTT
TID  =EXAMPLE: BUS B, BREAKER 3
CTR  = 200
CTRP = 200  PTR  = 2000.00  PTRS = 2000.00
Z1MAG = 7.80  Z1ANG = 84.00
Z0MAG = 24.80  Z0ANG = 81.50  LL  = 100.00  APP  = 311C
E21P  = 3  E21MG = 3  E21XG = 3
E50P  = 1  E50G  = N  E50Q  = N
E51P  = N  E51G  = Y  E51Q  = Y
E32   = AUTO
E25   = N
E81   = N
E32   = AUTO
ELOM  = N
ELOD  = N
ELOAD = Y
ESOTF = Y
ELOP  = Y
ECOMM = POTT
E50   = 1  E50G  = N  E50Q  = N
E51   = N  E51G  = Y  E51Q  = Y
PRESS RETURN to continue
RG1   = 2.50  RG2  = 5.00  RG3  = 6.00
SOL1  = 0.50
SOLG1 = 0.50
k0M1  = 0.726  k0A1  =-3.69
Z1PD  = OFF  Z1GD  = OFF  Z1D   = OFF
Z2PD  = 20.00  Z2GD  = 20.00  Z2D   = OFF
Z3PD  = OFF  Z3GD  = OFF  Z3D   = OFF
SOP1P = 11.25
50P1L = 0.00
51GP  = 0.75  51GC  = U3  51GD  = 2.00  51GRS = Y
51QP  = 2.20  51QC  = U3  51QD  = 2.00  51QRS = N
PLAF  = 30.00  PLAR = 150.00  PLAF  =-30.00  PLAR  = 210.00
DIR3  = R  DIR4  = F
ORDER = QVI
CLOEND= OFF  S2AEND= 10.00  SOTFD = 30.00
Z3RBD = 5.00  EBLKD = 10.00  TDPFU = 2.00
EDURD = 4.00  EWFC = N
DMTC  = 60  PDEMP = OFF  QDEMP = OFF  QDEMP = OFF
TODUR = 9.00  CFD  = 60.00  3POD  = 0.50  OPO  = 52
Press RETURN to continue
SOLP = 0.25
->
SELogic control equations:

- TR = M1P + Z1G + M2PT + Z2GT + S1GT + S1QT + OC
- TRCOMM = M2P + Z2G
- TRSOTF = M2P + Z2G + S0P1
- DTT = 0
- ULTR = !(S0L + S1G)
- PT1 = IN102
- S2A = IN101
- CL = CC
- ULCL = TRIP
- SET1 = 0
- RST1 = 0
- SET2 = 0
- RST2 = 0
- SET3 = 0
- RST3 = 0
- SET4 = 0
- RST4 = 0

Press RETURN to continue

- SET5 = 0
- RST5 = 0
- SET6 = 0
- RST6 = 0
- SET7 = 0
- RST7 = 0
- SET8 = 0
- RST8 = 0
- SET9 = 0
- RST9 = 0
- SET10 = 0
- RST10 = 0
- SET11 = 0
- RST11 = 0
- SET12 = 0
- RST12 = 0
- SET13 = 0
- RST13 = 0
- SET14 = 0
- RST14 = 0

Press RETURN to continue

- SET15 = 0
- RST15 = 0
- SET16 = 0
- RST16 = 0
- 67P1TC = 1
- S1GTC = 1
- S1OTC = 1
- OUT101 = TRIP
- OUT102 = TRIP
- OUT103 = CLOSE
- OUT104 = KEY
- OUT105 = 0
- OUT106 = 0
- OUT107 = 0
- DP1 = S2A
- DP2 = 0
- DP3 = 0
- DP4 = 0
- DP5 = 0
- DP6 = 0
Press RETURN to continue

DP7 = 0
DP8 = 0
DP9 = 0
DP10 = 0
DP11 = 0
DP12 = 0
DP13 = 0
DP14 = 0
DP15 = 0
DP16 = 0
SS1 = 0
SS2 = 0
SS3 = 0
SS4 = 0
SS5 = 0
SS6 = 0
ER = /M2P + /Z2G + /51G + /51Q + /50P1 + /LOP
FAULT = 51G + 51Q + M2P + Z2G
BSYNCH = 0
CLMON = 0

Press RETURN to continue

E32IV = 1

=>

=>SHO G <ENTER>

Global Settings:
TGR = 180.00   NFREQ = 60   PHROT = ABC
DATE_F = MDY
LEP = 15
PRE = 4
DLOP = OFF
IN101D = 0.00
IN102D = 0.00
IN103D = 0.00
IN104D = 0.00
IN105D = 0.00
IN106D = 0.00
IN201D = 0.00
IN202D = 0.00
IN203D = 0.00
IN204D = 0.00
IN205D = 0.00
IN206D = 0.00
IN207D = 0.00
IN208D = 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:
SER2 = IN101,IN102,OUT101,OUT102,OUT103,OUT104,LOP
SER3 = KEY,Z3RB,PRTR

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

```
-><SH> T <ENTER>

Test Labels:
NLB1 = CLB1 = SLB1 = PLB1 =
NLB2 = CLB2 = SLB2 = PLB2 =
NLB3 = CLB3 = SLB3 = PLB3 =
NLB4 = CLB4 = SLB4 = PLB4 =
NLB5 = CLB5 = SLB5 = PLB5 =
NLB6 = CLB6 = SLB6 = PLB6 =
NLB7 = CLB7 = SLB7 = PLB7 =
NLB8 = CLB8 = SLB8 = PLB8 =
NLB9 = CLB9 = SLB9 = PLB9 =
NLB10 = CLB10 = SLB10 = PLB10 =
NLB11 = CLB11 = SLB11 = PLB11 =
NLB12 = CLB12 = SLB12 = PLB12 =
NLB13 = CLB13 = SLB13 = PLB13 =
NLB14 = CLB14 = SLB14 = PLB14 =
NLB15 = CLB15 = SLB15 = PLB15 =
NLB16 = CLB16 = SLB16 = PLB16 =
DP1_1 = BREAKER CLOSED   DP1_0 = BREAKER OPEN

Press RETURN to continue
DP2_1 = DP2_0 =
DP3_1 = DP3_0 =
DP4_1 = DP4_0 =
DP5_1 = DP5_0 =
DP6_1 = DP6_0 =
DP7_1 = DP7_0 =
DP8_1 = DP8_0 =
DP9_1 = DP9_0 =
DP10_1 = DP10_0 =
DP11_1 = DP11_0 =
DP12_1 = DP12_0 =
DP13_1 = DP13_0 =
DP14_1 = DP14_0 =
DP15_1 = DP15_0 =
DP16_1 = DP16_0 =
79LL = 79SL =
->
```

The STA command displays the status report, showing the relay self-test information.
### 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**
- Extra I/O board status—model 0311C01x only; see Table 1.1 and Figure 2.7, Figure 2.8, Figure 2.10, and Figure 2.15. On models without I/O boards, the I/O_BRD status is always okay.

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:

```plaintext
=>>STA C <ENTER>
```

The relay responds:

```
Reboot the relay and clear status
Are you sure (Y/N) ?
```
If you select “N” or “n”, the relay displays:

Canceled

and aborts the command.

If you select “Y”, the relay displays:

Rebooting the relay

The relay then restarts (just like powering down, then powering up the relay), and all diagnostics are rerun before the relay is enabled.

Refer to Section 13: Testing and Troubleshooting for self-test thresholds (in Table 13.1) and corrective actions.

SUM Command (Long Summary Event Report)

The SUM command displays a long summary event report (see TRI Command below). The long summary event report is displayed on all ports with AUTO = Y whenever an event is generated.

To view a summary event report, enter the command

=>SUM |ACK| n | N(ext) | <ENTER>

where:

no parameters Display the newest chronological summary event.
ACK Acknowledge the oldest unacknowledged summary event report available on this port, or if a number is supplied, acknowledge the specified summary.

n Display (or acknowledge if ACK present) the summary event with this corresponding number in the HIS E command.

N(ext) View oldest unacknowledged summary event report.

TAR Command (Display Relay Element Status)

The TAR command displays the status of front-panel target LEDs or relay elements, whether they are asserted or deasserted. The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. The first 2 rows correspond to Table 10.7. All rows of the Relay Word are described in Section 9: Setting the Relay.

A Relay Word bit is either at a logical 1 (asserted) or a logical 0 (deasserted). Relay Word bits are used in SELOGIC control equations. See Section 9: Setting the Relay and Appendix G: Setting SELOGIC Control Equations.

The TAR command does not remap the front-panel target LEDs, as is done in some previous SEL relays. But execution of the equivalent TAR command via the front-panel display does remap the bottom row of the front-panel target LEDs (see Figure 11.3, pushbutton OTHER).
The **TAR** command options are:

- **TAR n k**
  Shows Relay Word row number \( n \) (0–51). \( k \) is an optional parameter to specify the number of times (1-32767) to repeat the Relay Word row display. If \( k \) is not specified, the Relay Word row is displayed once.

- **TAR name k**
  Shows Relay Word row containing Relay Word bit *name* (e.g., **TAR 50P1** displays Relay Word Row 3). Valid names are shown in Table 9.3 and Table 9.4. \( k \) is an optional parameter to specify the number of times (1-32767) to repeat the Relay Word row display. If \( k \) is not specified, the Relay Word row is displayed once.

- **TAR R**
  Clears front-panel tripping target LEDs; TRIP, TIME, COMM, SOTF, 51, A, B, C, G, Zone 1, Zone 2, Zone 3, and Zone 4. Unlatches the trip logic for testing purposes (see Figure 5.1). Shows Relay Word Row 0.

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

<table>
<thead>
<tr>
<th>TAR 0 (Front-Panel LEDs)</th>
<th>EN</th>
<th>TRIP</th>
<th>TIME</th>
<th>COMM</th>
<th>SOTF</th>
<th>RS</th>
<th>LO</th>
<th>51</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAR 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAR 1</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>G</td>
<td>ZONE1</td>
<td>ZONE2</td>
<td>ZONE3</td>
<td>ZONE4</td>
</tr>
</tbody>
</table>

Command **TAR SH1 10** is executed in the following example:

```
<->TAR SH1 10 <ENTER>
```

Note that Relay Word row containing the SH1 bit is repeated 10 times. In this example, the reclosing relay is in the Lockout State (79LO = logical 1), and the shot is at shot = 2 (SH2 = logical 1). Command **TAR 31** will report the same data since the SH1 bit is in Row 31 of the Relay Word.
TIM Command (View/Change Time)

TIM displays the relay clock. To set the clock, type TIM and the desired setting, then press <ENTER>. Separate the hours, minutes, and seconds with colons, semicolons, spaces, commas, or slashes. To set the clock to 11:30 PM enter:

```
=>TIM 23:30:00 <ENTER>
23:30:00
=>
```

Note: After setting date or time, allow at least 60 seconds before powering down the relay or the new setting may be lost.

TRI Command (Trigger Event Report)

Issue the TRI command to generate an event report:

```
=>TRI <ENTER>
Triggered
=>
```

If the serial port AUTO setting = Y, the relay sends the summary event report:

```
=>
SEL-311C POTT  Date: 10/13/99  Time: 10:12:45.627
EXAMPLE: BUS B, BREAKER 3
Event: TRIG  Location: $$$$$$
      #: 00002  Shot:    Freq:  60.00  Group: 1
      Trip 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:B>1 RMBA TMBA RMBB TMBB A A A A B B B B
TRIG 00000000 00000000 00000000 00000000 0 0 0 0
TRIP 00000000 00000000 00000000 00000000 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.

$\text{>>> BRE W <ENTER>}$

Breaker Wear Preload

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Trips</td>
<td>ITTRIP</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Internal Current</td>
<td>IA</td>
<td>0.00</td>
<td>40.7</td>
</tr>
<tr>
<td></td>
<td>IB</td>
<td>0.00</td>
<td>40.8</td>
</tr>
<tr>
<td></td>
<td>IC</td>
<td>0.00</td>
<td>40.8</td>
</tr>
<tr>
<td>External Trips</td>
<td>EXTRIP</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>External Current</td>
<td>IA</td>
<td>0.00</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>IB</td>
<td>0.00</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>IC</td>
<td>0.00</td>
<td>1.1</td>
</tr>
<tr>
<td>Percent Wear</td>
<td>A-phase</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>B-phase</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>C-phase</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Are you sure</td>
<td>(Y/N)</td>
<td>Y</td>
<td></td>
</tr>
</tbody>
</table>

Use the BRE R command to reset the breaker monitor:

$\text{>>> BRE R <ENTER>}$

Reset Trip Counters and Accumulated Currents/Wear

Are you sure (Y/N) ? Y <ENTER>

SEL-311C POTT                  Date: 10/13/99    Time: 10:12:45.627
EXAMPLE: BUS B, BREAKER 3

Rly Trips= 0
IA= 0.0     IB= 0.0     IC= 0.0
Ext Trips= 0
IA= 0.0     IB= 0.0     IC= 0.0
Percent wear: A= 0 B= 0 C= 0
LAST RESET 02/03/99 05:41:07

$\text{>>>}$
See Breaker Monitor in Section 8: Breaker Monitor and Metering Functions for further details on the breaker monitor.

**CLO Command (Close Breaker)**

The CLO command asserts Relay Word bit CC for 1/4 cycle. Relay Word bit CC can then be programmed into the SELOGIC control equation CL to assert the CLOSE Relay Word bit, which in turn asserts an output contact (e.g., OUT102 = CLOSE) to close a circuit breaker. See Figure 6.1.

See the Set Close discussion, following Figure 6.1, for more information concerning Relay Word bit CC and its recommended use, as used in the factory settings.

To issue the CLO command, enter the following:

```
=>CLO <ENTER>
Close Breaker (Y/N)? Y <ENTER>
Are you sure (Y/N)? Y <ENTER>
```

Typing N <ENTER> after either of the above prompts will abort the command.

The CLO command is supervised by the main board Breaker jumper (see Table 2.4). If the Breaker jumper is not in place (Breaker jumper = OFF), the relay does not execute the CLO command and responds:

```
Aborted: No Breaker Jumper
```

**GRO n Command (Change Active Setting Group)**

The GRO n command changes the active setting group to setting Group n. To change to settings Group 2, enter the following:

```
=>GRO 2
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-311C POTT                        Date: 10/13/99    Time: 10:12:45.627
EXAMPLE: BUS B, BREAKER 3
Active Group = 2
```
If any of the SELOGIC control equations settings SS1 through SS6 are asserted to logical 1, the active setting group may not be changed with the **GRO** command. SELOGIC control equations settings SS1 through SS6 have priority over the **GRO** command in active setting group control.

For example, assume setting Group 1 is the active setting group and the SS1 setting is asserted to logical 1 (e.g., SS1 = IN101 and optoisolated input IN101 is asserted). An attempt to change to setting Group 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:

\[ \text{PUL } x \ y \]

where:
- \( x \) is the output name (e.g. OUT101, OUT107, ALARM, OUT211—see Figures 7.27 and 7.28).
- \( y \) is the pulse duration (1–30 seconds). If \( y \) is not specified, the pulse duration defaults to 1 second.

To pulse OUT101 for 5 seconds:

```
$> \text{PUL } \text{OUT101} \ 5 \ <\text{ENTER>}

Are you sure (Y/N) ? \ Y \ <\text{ENTER>}
```

If the response to the “Are you sure (Y/N) ?” prompt is “N” or “n”, the command is aborted.

The **PUL** command is supervised by the main board Breaker jumper (see Table 2.4). If the Breaker jumper is not in place (Breaker jumper = OFF), the relay does not execute the **PUL** command and responds:

```
Aborted: No Breaker Jumper
```

The relay generates an event report if any of the OUT101 through OUT107 contacts are pulsed. The **PUL** command is primarily used for testing purposes.

**Access Level 2 Commands**

**CON Command (Control Remote Bit)**

The **CON** command is a two-step command that allows you to control Relay Word bits RB1 through RB16 (see Rows 7 and 8 in Table 9.3). At the Access Level 2 prompt, type **CON**, a space, and the number of the remote bit you wish to control (1–16). The relay responds by repeating your command followed by a colon. At the colon, type the Control subcommand you wish to perform (see Table 10.8).

The following example shows the steps necessary to pulse Remote Bit 5 (RB5):

```
$> \text{CON } \text{5} \ <\text{ENTER>}

CONTROL RB5: PRB 5 \ <\text{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-311C Relay Control Subcommands

<table>
<thead>
<tr>
<th>Subcommand</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRB n</td>
<td>Set Remote Bit n (“ON” position)</td>
</tr>
<tr>
<td>CRB n</td>
<td>Clear Remote Bit n (“OFF” position)</td>
</tr>
<tr>
<td>PRB n</td>
<td>Pulse Remote Bit n for 1/4 cycle (“MOMENTARY” position)</td>
</tr>
</tbody>
</table>

See Remote Control Switches in Section 7: Inputs, Outputs, Timers, and Other Control Logic for more information.

**COP m n Command (Copy Setting Group)**

Copy relay and SELOGIC control equation settings from setting Group m to setting Group n with the COP m n command. Setting group numbers range from 1 to 6. After entering settings into one setting group with the SET and SET L commands, copy them to the other groups with the COP command. Use the SET and SET L commands to modify the copied settings. The ALARM output pulses if you copy settings into the active group.

For example, to copy settings from Group 1 to Group 3 issue the following command:

```
=>>COP 1 3 <ENTER>
Copy 1 to 3
Are you sure (Y/N) ? Y <ENTER>
Please wait...
Settings copied
=>>
```

**LOO Command (Loopback)**

The LOO command is used for testing the MIRRORED BITS communications channel. For more information on MIRRORED BITS, see Appendix I: MIRRORED BITS. With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing will be wrong and ROK will be de-asserted. The LOO command tells the MIRRORED BITS software to temporarily expect to see its own data looped back as its input. In this mode, LBOK will assert if error-free data is received.

The LOO command with just the channel specifier, enables looped-back mode on that channel for 5 minutes, while the inputs are forced to the default values.

```
=>>LOO A <ENTER>
Loopback will be enabled on Mirrored Bits channel A for the next 5 minutes.
The RMB values will be forced to default values while loopback is enabled
Are you sure (Y/N) ? 
=>>
```

If only one MIRRORED BITS port is enabled, the channel specifier may be omitted. To enable looped-back mode for other than the default 5 minutes, enter the desired number of minutes (1-5000) as a command parameter. To allow the looped-back data to modify the RMB values, include the DATA parameter.
To disable looped-back mode before the selected number of minutes, re-issue the **LOO** command with the **R** parameter. If both MIRRORED BITS channels are enabled, omitting the channel specifier in the disable command will cause both channels to be disabled.

```plaintext
>>>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:

```plaintext
>>>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:

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

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

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

OTTER  otter  Ot3456  TAIL    123456  12345.  12345-

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

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

The SET command allows the user to view or change the relay settings—see Table 9.1 in Section 9: Setting the Relay.
SEL-311C Relay Command Summary

Access Level 0

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

ACC
Enter Access Level 1. If the main board password jumper is not in place, the relay prompts for entry of the Access Level 1 password in order to enter Access Level 1.

Access Level 1

The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering), not change it. The screen prompt is: =>

2AC
Enter Access Level 2. If the main board password jumper is not in place, the relay prompts for entry of the Access Level 2 password in order to enter Access Level 2.

BAC
Enter Breaker Access Level (Access Level B). If the main board password jumper is not in place, the relay prompts for entry of the Access Level B password.

BRE
Display breaker monitor data (trips, interrupted current, wear).

COM p L
Show a long format communications summary report for all events on MIRRORED BITS™ Channel p.

COM p n
Show a communications summary for latest n events on MIRRORED BITS Channel p.

COM p m n
Show a communications summary report for events n through m on MIRRORED BITS Channel p.

COM p d1
Show a communications summary report for events occurring on date d1 on MIRRORED BITS Channel p.

COM p d1 d2
Show a communications summary report for events occurring between dates d1 and d2 on MIRRORED BITS Channel p. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).

COM C p
Clears the communications summary report for Channel p.

DAT
Show date.

DAT m/d/y
Enter date in this manner if Date Format setting DATE_F = MDY.

DAT y/m/d
Enter date in this manner if Date Format setting DATE_F = YMD.

EVE n
Show event report number n with 1/4-cycle resolution.

EVE L n
Show event report number n with 1/16-cycle resolution.

EVE R n
Show raw event report number n with 1/16-cycle resolution.

EVE C n
Show compressed event report number n for use with SEL-5601 Analytic Assistant.

GRO
Display active group number.

HIS n
Show brief summary of the n latest event reports.

HIS C
Clear the brief summary and corresponding event reports.

INI
Displays input/output contact information.

INI T
Displays I/O contact information and I/O board type.

IRI
Force synchronization attempt of internal relay clock to IRIG-B time-code input.

MET k
Display instantaneous metering data. Enter k for repeat count.

MET D
Display demand and peak demand data. Enter MET RD or MET RP to reset.

MET E
Display energy metering data. Enter MET RE to reset.

MET M
Display maximum/minimum metering data. Enter MET RM to reset.

QUI
Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) protocol connection. Available in all access levels.

SER n
Show the latest n rows in the Sequential Events Recorder (SER) event report.

SER m n
Show rows m through n in the Sequential Events Recorder (SER) event report.

SER d1
Show rows in the Sequential Events Recorder (SER) event report from date d1.

SER d1 d2
Show rows in the Sequential Events Recorder (SER) event report from date d1 to d2. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).

SER C
Clears the Sequential Events Recorder (SER).

SHO n
Show relay settings (overcurrent, reclosing, timers, etc.) for Group n.

SHO L n
Show SELoc™ control equation settings for Group n.

SHO G
Show global settings.

SHO P n
Show Port n settings.

SHO R
Show Sequential Events Recorder (SER) settings.

SHO T
Show text label settings.
STA  Show relay self-test status.
SUM  Show newest event summary.
SUM A Acknowledge oldest even summary.
SUM N View oldest unacknowledged event report.
SUM N [A] Display or acknowledge event summary number “N”.
TAR R Reset the front-panel tripping targets.
TAR n k Display Relay Word row. If n = 0 through 45, display row n. If n is an element name (e.g., 50G1) display the row containing element n. Enter k for repeat count.
TIM  Show or set time (24 hour time). Show time presently in the relay by entering just TIM. Example time 22:47:36 is entered with command TIM 22:47:36.
TRI  Trigger an event report.

Access Level B Commands
Access Level B commands primarily allow the user to operate output contacts. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>

BRE n Enter BRE W to preload breaker wear. Enter BRE R to reset breaker monitor data.
CLO  Close the circuit breaker. See the Note in the Set Close discussion, following Figure 6.1 for more information concerning the CLO command.
GRO n Change active group to Group n.
OPE  Open the circuit breaker. See the Note following Figure 5.2 and the Note in the Lockout State discussion, following Table 6.1 for more information concerning the OPE command.
PUL n k Pulse output contact n (OUT101–OUT107, ALARM, OUT201–OUT212) for k (1–30) seconds. Parameter n must be specified; k defaults to 1 if not specified.

Access Level 2 Commands
The Access Level 2 commands allow unlimited access to relay settings, parameters, and output contacts. All Access Level 1 and Access Level B commands are available from Access Level 2. The screen prompt is: =>>

CON n Control Remote Bit RBn (Remote Bit n; n = 1 through 8). Execute CON n and the relay responds:
CONTROL RBn. Then reply with one of the following:
      SRB n set Remote Bit n (assert RBn).
      CRB n clear Remote Bit n (deassert RBn).
      PRB n pulse Remote Bit n (assert RBn for 1/4 cycle).
COP m n Copy relay and logic settings from Group m to Group n.
LOO  Set M IRRORED BITS port to loopback.
PAS  Show existing Access Level 1, B, and 2 passwords.
PAS 1 xxxxxx Change Access Level 1 password to xxxxxx.
PAS B xxxxxx Change Access Level B password to xxxxxx.
PAS 2 xxxxxx Change Access Level 2 password to xxxxxx.
SET n Change relay settings (overcurrent, reclosing, timers, etc.) for Group n.
SET L n Change SELOGIC control equation settings for Group n.
SET G Change global settings.
SET P n Change Port n settings.
SET R Change Sequential Events Recorder (SER) settings.
SET T Change text label settings.
STA C Resets self-test warnings/failures and reboots relay.
VER  Displays version and configuration information.
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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-311C 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 19 at the end of Section 9: Setting the Relay; the relay is shipped with FP_TO = 15 minutes).

See Figure 11.4

Figure 11.1: SEL-311C Relay Front-Panel Pushbuttons—Overview
Primary Functions

Note in Figure 11.2 and Figure 11.3 that the front-panel pushbutton primary functions correspond to serial port commands—both retrieve the same information or perform the same function. To get more detail on the information provided by the front-panel pushbutton primary functions, refer to the corresponding serial port commands in Table 10.5 in Section 10: Serial Port Communications and Commands. For example, to get more information on the metering values available via the front-panel METER pushbutton, refer to the MET Command (Metering Data) in Section 10.

Some of the front-panel primary functions do not have serial port command equivalents. These are discussed in the following subsection Functions Unique to the Front-Panel Interface.

![Figure 11.2: SEL-311C Relay Front-Panel Pushbuttons—Primary Functions](image)

**Figure 11.2: SEL-311C 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:

<table>
<thead>
<tr>
<th>Access Level</th>
<th>Factory Default Password</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OTTER</td>
</tr>
<tr>
<td>B</td>
<td>EDITH</td>
</tr>
<tr>
<td>2</td>
<td>TAIL</td>
</tr>
</tbody>
</table>

**Function Description**
- View or Reset Breaker Monitor Data; View or Change Date or Time; View Assorted Relay Word Bits; View Reclosing Relay Shot Counter Action; Enable Scroll Lock
- View or Change Group, Global, or Serial Port Settings; Change Passwords
- Pulse Output Contacts****
- Display Active Setting Number; Change Active Setting Group

**Access Level 1***
- BRE
- DAT
- TIM
- TAR
- LCD

**Access Level B**
- BRE
- R

**Access Level 2***
- SET
- G
- P
- PAS

* 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 (†).

*** 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 (†).

**** 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.

† See Table 2.4

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

After a primary function is selected (see Figure 11.2 and Figure 11.3), the pushbuttons then revert to operating on their secondary functions (see Figure 11.4).

Use the left/right arrows to underscore a desired function. Then press the SELECT pushbutton to select the function.

Use left/right arrows to underscore a desired setting digit. Then use the up/down arrows to change the digit. After the setting changes are complete, press the SELECT pushbutton to select/enable the setting.

Press the CANCEL pushbutton to abort a setting change procedure and return to the previous display. Press the EXIT pushbutton to return to the default display and have the primary pushbutton functions activated again (see Figure 11.2 and Figure 11.3).
Figure 11.4: SEL-311C Relay Front-Panel Pushbuttons—Secondary Functions
FUNCTIONS UNIQUE TO THE FRONT-PANEL INTERFACE

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

- Reclosing relay shot counter screen (accessed via the OTHER pushbutton)
- Local control (accessed via the CNTRL pushbutton)
- Modified rotating display with scroll lock control (accessed via the OTHER pushbutton)

Reclosing Relay Shot Counter Screen

Use this screen to see the progression of the shot counter during reclosing relay testing.

Access the reclosing relay shot counter screen via the OTHER pushbutton. The following screen appears:

```
DATE   TIME   79
TAR   BRK_MON LCD
```

Scroll right with the right arrow button and select function “79”. Upon selecting function “79”, the following screen appears (shown here with demonstration settings):

```
SET RECLOSURES=2
RECLOSE COUNT =0
```

(or = 2)

If the reclosing relay doesn’t exist (see Reclosing Relay in Section 6: Close and Reclose Logic), the following screen appears:

```
No Reclosing set
```

The corresponding text label settings (shown with example settings) are:

- 79LL = SET RECLOSURES (Last Shot Label—limited to 14 characters)
- 79SL = RECLOSE COUNT (Shot Counter Label—limited to 14 characters)

If 79LL nor 79SL are set, upon selecting function “79,” the following screen appears (shown here with demonstration settings):

```
=2
=2
```

These text label settings are set with the SET T command or viewed with the SHO T command via the serial port (see Section 9: Setting the Relay and SHO Command [Show/View Settings] in Section 10: Serial Port Communications and Commands).

The top numeral in the above example screen (SET RECLOSURES=2) corresponds to the “last shot” value, which is a function of the number of set open intervals. There are two set open intervals in the demonstration settings, thus two reclosures (shots) are possible in a reclose sequence.
The bottom numeral in the above example screen [RECLOSE COUNT = 0 (or = 2)] corresponds to the “present shot” value. If the breaker is closed and the reclosing relay is reset (RS LED on front panel is illuminated), RECLOSE COUNT = 0. If the breaker is open and the reclosing relay is locked out after a reclose sequence (LO LED on front panel is illuminated), RECLOSE COUNT = 2.

**Reclosing Relay Shot Counter Screen Operation**

With the breaker closed and the reclosing relay in the reset state (front-panel RS LED illuminated), the reclosing relay shot counter screen appears as:

```
SET RECLOSURES=2
RECLOSE COUNT =0
```

The relay trips the breaker open, and the reclosing relay goes to the reclose cycle state. The reclosing relay shot counter screen still appears as:

```
SET RECLOSURES=2
RECLOSE COUNT =0
```

The first open interval (79OI1 = 30) times out, the shot counter increments from 0 to 1, and the relay recloses the breaker. The reclosing relay shot counter screen shows the incremented shot counter:

```
SET RECLOSURES=2
RECLOSE COUNT =1
```

The relay trips the breaker open again. The reclosing relay shot counter screen still appears as:

```
SET RECLOSURES=2
RECLOSE COUNT =1
```

The second open interval (79OI2 = 600) times out, the shot counter increments from 1 to 2, and the relay recloses the breaker. The reclosing relay shot counter screen shows the incremented shot counter:

```
SET RECLOSURES=2
RECLOSE COUNT =2
```

If the relay trips the breaker open again, the reclosing relay goes to the lockout state (front-panel LO LED illuminates). The reclosing relay shot counter screen still appears as:

```
SET RECLOSURES=2
RECLOSE COUNT =2
```
If the breaker is closed, the reclosing relay reset timer times out (79RSLD = 300), the relay goes to the reset state (front-panel LO LED extinguishes and RS LED illuminates), and the shot counter returns to 0. The reclosing relay shot counter screen appears as:

<table>
<thead>
<tr>
<th>SET RECLOSES=2</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECLOSE COUNT =0</td>
</tr>
</tbody>
</table>

**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**
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:

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.

The “Press CNTRL for Local Control” message displays in rotation (display time = SCROLD) with the default metering screen if at least one local control switch is operational. It is a reminder of how to access the local control function. See the preceding discussion in this section and *Local Control Switches in Section 7: Inputs, Outputs, Timers, and Other Control Logic* for more information on local control.
If display point labels (e.g., “79 DISABLED” and “BREAKER OPEN”) are enabled for display, they also enter into the display rotation (display time = SCROLD).

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

The display point example settings are:

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

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

<table>
<thead>
<tr>
<th>Example Display</th>
<th>Point States</th>
<th>Display Point Label Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP2 = LB1</td>
<td>= logical 0</td>
<td>DP2_1 = 79 ENABLED</td>
</tr>
<tr>
<td>DP2 = LB1</td>
<td></td>
<td>DP2_0 = 79 DISABLED</td>
</tr>
<tr>
<td>DP4 = IN101</td>
<td>= logical 0</td>
<td>DP4_1 = BREAKER CLOSED</td>
</tr>
<tr>
<td>DP4 = IN101</td>
<td></td>
<td>DP4_0 = BREAKER OPEN</td>
</tr>
<tr>
<td>DP2 = LB1</td>
<td>= logical 1</td>
<td>DP2_1 = 79 ENABLED</td>
</tr>
<tr>
<td>DP2 = LB1</td>
<td></td>
<td>DP2_0 = 79 DISABLED</td>
</tr>
<tr>
<td>DP4 = IN101</td>
<td>= logical 0</td>
<td>DP4_1 = BREAKER CLOSED</td>
</tr>
<tr>
<td>DP4 = IN101</td>
<td></td>
<td>DP4_0 = BREAKER OPEN</td>
</tr>
</tbody>
</table>
Display Points
(SELOGIC Control Equation Settings)  Example Display Point States  Display Point Label Settings

<table>
<thead>
<tr>
<th>DP2 = LB1</th>
<th>= logical 1</th>
<th>DP2_1 = 79 ENABLED</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DP2_0 = 79 DISABLED</td>
<td></td>
</tr>
<tr>
<td>DP4 = IN101</td>
<td>= logical 1</td>
<td>DP4_1 = BREAKER CLOSED</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DP4_0 = BREAKER OPEN</td>
<td></td>
</tr>
</tbody>
</table>

In the preceding example, only two display points (DP2 and DP4) and their corresponding display point labels are set. If additional display points and corresponding display point labels are set, the additional enabled display point labels join the rotation (display time = SCROLD) on the front-panel display. The SCROLD setting is made with the SET G command and reviewed with the SHO G command.
Display point label settings are set with the \texttt{SET T} command or viewed with the \texttt{SHO T} command via the serial port (see Section 9: Setting the Relay and \texttt{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.

\section*{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.

\begin{center}
\begin{tabular}{|c|c|c|}
\hline
\texttt{DATE} & \texttt{TIME} & \texttt{79} \\
\hline
\texttt{TAR BRK_MON LCD} & & \\
\hline
\end{tabular}
\end{center}

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.

\begin{center}
\begin{tabular}{|c|c|c|}
\hline
\texttt{Scroll lock OFF} & \\
\hline
\texttt{SELECT to Lock} & \\
\hline
\end{tabular}
\end{center}

\section*{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.

\begin{center}
\begin{tabular}{|c|c|c|}
\hline
\texttt{Scroll lock ON} & \\
\hline
\texttt{SELECT to Unlock} & \\
\hline
\end{tabular}
\end{center}

\section*{Restart Scrolling (Unlock)}

The SELECT key unlocks the LCD and resumes the rotating display.

\section*{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.

\section*{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.

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>79</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAR</td>
<td>BRK_MON</td>
<td>LCD</td>
</tr>
</tbody>
</table>

**Additional Rotating Default Display Example**

See Figure 5.17 and accompanying text in *Section 5: Trip and Target Logic* for an example of resetting a rotating default display with the TARGET RESET pushbutton.
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<td>Output, Input, and Protection, and Control Element Event Report Columns</td>
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</tr>
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<td>12.4</td>
<td>Derivation of Phasor RMS Current Values From Event Report Current Values</td>
</tr>
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<td>Example Sequential Events Recorder (SER) Event Report</td>
</tr>
</tbody>
</table>
SECTION 12: STANDARD EVENT REPORTS AND SER

INTRODUCTION

The SEL-311C 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-311C 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 19 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 (Models 311C00x and 311C01x) pulsed via the serial port or front-panel PUL (Pulse Output Contact) command
**Relay Word Bit TRIP**

Refer to Figure 5.1. If Relay Word bit TRIP asserts to logical 1, an event report is automatically generated. Thus, any condition that causes a trip does not have to be entered in SELOGIC control equation setting ER.

For example, SELOGIC control equation trip setting TR is unsupervised. Any trip condition that asserts in setting TR causes the TRIP Relay Word bit to assert immediately. The Relay Word bit TRIP asserts, and an event report is automatically generated. Thus, any element in setting TR 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-311C Relay is not already generating a report that encompasses the new transition). The factory setting is:

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

The elements in this example setting are:

- **M2P**: Zone 2 phase-distance element asserted.
- **Z2G**: Zone 2 ground-distance element asserted.
- **51G**: Residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see Figure 3.25).
- **51Q**: Negative-sequence current above pickup setting 51QP for negative-sequence time-overcurrent element 51QT (see Figure 3.26).
- **50P1**: Phase current above pickup setting 50P1P for phase overcurrent element 50P1.
- **LOP**: Loss of potential (LOP) asserts.

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

Rising edge operators are especially useful in generating an event report at fault inception and then generating another later if for example a breaker failure condition occurs. If at the inception of a ground fault, pickup indicator 51G asserts and an event report is generated:

\[
ER = \ldots + /51G + \ldots = \text{logical 1 (for one processing interval)}
\]

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 G.2 in Appendix G: Setting SELOGIC Control Equations for more information on falling edge operators.

**TRI (Trigger Event Report) and PUL (Pulse Output Contact) Commands**

The sole function of the **TRI** serial port command is to generate standard event reports, primarily for testing purposes.

The **PUL** command asserts the output contacts for testing purposes or for remote control. If output contact OUT101 through OUT107 (Models 311C00x and 311C01x) asserts via the **PUL** command, the relay triggers a standard event report. The **PUL** command is available at the serial port and the relay front-panel CNTRL pushbutton.

See Section 10: Serial Port Communications and Commands and Section 11: Front-Panel Interface (Figure 11.3) for more information on the **TRI** (Trigger Event Report) and **PUL** (Pulse Output Contact) commands.

**Event Summary**

Each time the relay generates a standard event report, it also generates a corresponding event summary (see Figure 12.1). Event summaries contain the following information:

- Relay and terminal identifiers (settings RID and TID)
- Date and time when the event was triggered
- Event type
- Fault location
- Breaker Trip Time
- Recloser shot count at the trigger time
- System frequency at trigger time
- Active Settings Group
- Breaker Close Time
- Front-panel fault type targets at the time of trip
- Breaker Status (Open or closed)
- Phase (IA, IB, IC, VA, VB, VC), calculated residual ground (I₀ = 3I₁), directional polarizing current IP, and negative-sequence (3I₂) 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-311C POTT  
Date: 10/14/99  
Time: 08:53:34.926

Example: BUS B, BREAKER 3

Event: BCG T  
Location: 48.84  
Trip Time: 08:53:34.930

#: 00008  
Shot:  
Freq: 60.01  
Group: 1  
Close Time: --:--:--.--

Targets: ZONE1  
Breaker: Closed

PreFault:  
IA  IB  IC  IP  IG  3I2  VA  VB  VC

MAG(A/kV) 199 200 201 0 2 0 131.500 131.610 131.730

ANG(DEG) -0.04-120.27 120.04 59.15 149.15 165.15 0.00 -120.03 119.94

Fault:  
MAG(A/kV) 200 2478 2480 0 212 4294 131.570 113.930 113.980

ANG(DEG) -0.46-172.34 6.65 59.15 -11.30 94.15 0.73 -123.36 124.67

L C R  
L C R  
B B R  B B R  
O A A 0 0 A A O  
K D D  K D D  K

MB: B->1  
RMBA  TMBA  RMBB  TMBB  
A 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**

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AG, BG, CG</td>
<td>Single phase-to-ground faults. Appends T if TRIP asserted.</td>
</tr>
<tr>
<td>ABC</td>
<td>Three-phase faults. Appends T if TRIP asserted.</td>
</tr>
<tr>
<td>AB, BC, CA</td>
<td>Phase-to-phase faults. Appends T if TRIP asserted.</td>
</tr>
<tr>
<td>ABG, BCG, CAG</td>
<td>Two phase-to-ground faults. Appends T if TRIP asserted.</td>
</tr>
<tr>
<td>TRIP</td>
<td>Assertion of Relay Word bit TRIP (fault locator could not operate successfully to determine the phase involvement, so just TRIP is displayed).</td>
</tr>
<tr>
<td>Event Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>ER</td>
<td>SELOGIC control equation setting ER. Phase involvement is indeterminate.</td>
</tr>
<tr>
<td>TRIG</td>
<td>Execution of TRIGGER command.</td>
</tr>
<tr>
<td>PULSE</td>
<td>Execution of PULSE command.</td>
</tr>
</tbody>
</table>

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 1 in Section 9: Setting the Relay for information on the line parameter settings.

# (Event Summary Number)

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

Shot

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

Frequency

Sampling frequency at trigger time.

Group

Active settings group at trigger time.

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 1-4; TIME; COMM; SOTF; and 51. If there is no rising edge of TRIP in the report, the Targets field is blank. See Front-Panel Target LEDs in Section 5: Trip and Target Logic.
**Currents and Voltages**

Pre-fault current and voltage magnitudes and phase angles are selected from the first cycle of the event report. Fault currents and voltages use the same data as the fault locator. If the fault locator does not operate, the fault data is sampled one and one-quarter cycles after the event report is triggered.

**Retrieving Full-Length Standard Event Reports**

The latest event reports are stored in nonvolatile memory. Each event report includes five sections:

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

Use the **EVE** command to retrieve 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.

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

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

“Invalid Event”

**Compressed ASCII Event Reports**

The SEL-311C 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-311C Relay samples the basic power system measurands (ac voltage, ac current, station battery, and optoisolated inputs) 16 times per power system cycle. The relay filters the measurands to remove transient signals. The relay operates on the filtered values and reports them in the event report.

To view the raw inputs to the relay, select the unfiltered event report (e.g., **EVE R**). Use the unfiltered event reports to observe:

- Power system harmonics on channels IA, IB, IC, IP, VA, VB, VC, VS
- Decaying dc offset during fault conditions on IA, IB, IC
- Optoisolated input contact bounce
- Transients on the station dc battery channel Vdc (power input terminals Z25 and Z26)

The filters for ac current and voltage and station battery are fixed. You can adjust the optoisolated input debounce via debounce settings (see Figures 7.1 through 7.3 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>
<thead>
<tr>
<th>Column Heading</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>Current measured by channel IA (primary A)</td>
</tr>
<tr>
<td>IB</td>
<td>Current measured by channel IB (primary A)</td>
</tr>
<tr>
<td>IC</td>
<td>Current measured by channel IC (primary A)</td>
</tr>
<tr>
<td>IP</td>
<td>Current measured by channel IP (primary A)</td>
</tr>
<tr>
<td>IG</td>
<td>Calculated residual current IG = 3I₀ = IA + IB + IC (primary A)</td>
</tr>
<tr>
<td>VA</td>
<td>Voltage measured by channel VA (primary kV)</td>
</tr>
<tr>
<td>VB</td>
<td>Voltage measured by channel VB (primary kV)</td>
</tr>
<tr>
<td>VC</td>
<td>Voltage measured by channel VC (primary kV)</td>
</tr>
<tr>
<td>VS</td>
<td>Voltage measured by channel VS (primary kV)</td>
</tr>
<tr>
<td>V1Mem</td>
<td>Positive-sequence memory voltage (primary kV)</td>
</tr>
<tr>
<td>FREQ</td>
<td>Frequency of Channel VA</td>
</tr>
<tr>
<td>Vdc</td>
<td>Voltage measured at power input terminals Z25 and Z26 (Vdc)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Column Heading</th>
<th>Corresponding Elements (Relay Word Bits)</th>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>All columns</td>
<td>.</td>
<td></td>
<td>Element/input/output not picked up or not asserted, unless otherwise stated.</td>
</tr>
<tr>
<td>ZAB¹</td>
<td>MAB1</td>
<td>1</td>
<td>If Zone 1 AB phase-phase distance element (MAB1) set</td>
</tr>
<tr>
<td></td>
<td>MAB2</td>
<td>2</td>
<td>If Zone 2 AB phase-phase distance element (MAB2) set, not ZAB1</td>
</tr>
<tr>
<td></td>
<td>MAB3</td>
<td>3</td>
<td>If Zone 3 AB phase-phase distance element (MAB3) set, not ZAB1 or ZAB2</td>
</tr>
<tr>
<td></td>
<td>MAB4</td>
<td>4</td>
<td>If Zone 4 AB phase-phase distance element (MAB4) set, not ZAB1 or ZAB2 or ZAB3</td>
</tr>
<tr>
<td>Z PP²</td>
<td>MPP1</td>
<td>1</td>
<td>If Zone 1 phase-phase distance element (MPP1) set</td>
</tr>
<tr>
<td></td>
<td>MPP2</td>
<td>2</td>
<td>If Zone 2 phase-phase distance element (MPP2) set, not ZPP1</td>
</tr>
<tr>
<td></td>
<td>MPP3</td>
<td>3</td>
<td>If Zone 3 phase-phase distance element (MPP3) set, not ZPP1 or ZPP2</td>
</tr>
<tr>
<td></td>
<td>MPP4</td>
<td>4</td>
<td>If Zone 4 phase-phase distance element (MPP4) set, not ZPP1, ZPP2, or ZPP3</td>
</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------------------------------</td>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>ZBC(^{i})</td>
<td>MBC1</td>
<td>1</td>
<td>If Zone 1 BC phase-phase distance element (MBC1) set</td>
</tr>
<tr>
<td></td>
<td>MBC2</td>
<td>2</td>
<td>If Zone 2 BC phase-phase distance element (MBC2) set, not ZBC1</td>
</tr>
<tr>
<td></td>
<td>MBC3</td>
<td>3</td>
<td>If Zone 3 BC phase-phase distance element (MBC3) set, not ZBC1 or ZBC2</td>
</tr>
<tr>
<td></td>
<td>MBC4</td>
<td>4</td>
<td>If Zone 4 BC phase-phase distance element (MBC4) set, not ZBC1 or ZBC2 or ZBC3</td>
</tr>
<tr>
<td>Z 3P(^{i})</td>
<td>MABC1</td>
<td>1</td>
<td>If Zone 1 3-phase distance element (MABC1) set</td>
</tr>
<tr>
<td></td>
<td>MABC2</td>
<td>2</td>
<td>If Zone 2 3-phase distance element (MABC2) set, not Z3P1</td>
</tr>
<tr>
<td></td>
<td>MABC3</td>
<td>3</td>
<td>If Zone 3 3-phase distance element (MABC3) set, not Z3P1 or Z3P2</td>
</tr>
<tr>
<td></td>
<td>MABC4</td>
<td>4</td>
<td>If Zone 4 3-phase distance element (MABC4) set, not Z3P1, Z3P2, or Z3P3</td>
</tr>
<tr>
<td>ZCA(^{i})</td>
<td>MCA1</td>
<td>1</td>
<td>If Zone 1 CA phase-phase distance element (MCA1) set</td>
</tr>
<tr>
<td></td>
<td>MCA2</td>
<td>2</td>
<td>If Zone 2 CA phase-phase distance element (MCA2) set, not ZCA1</td>
</tr>
<tr>
<td></td>
<td>MCA3</td>
<td>3</td>
<td>If Zone 3 CA phase-phase distance element (MCA3) set, not ZCA1 or ZCA2</td>
</tr>
<tr>
<td></td>
<td>MCA4</td>
<td>4</td>
<td>If Zone 4 CA phase-phase distance element (MCA4) set, not ZCA1 or ZCA2 or ZCA3</td>
</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
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<td>----------------------------------------</td>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>ZAG</td>
<td>ZAG1</td>
<td>1</td>
<td>If Zone 1 AG element (XAG1 or MAG1) set</td>
</tr>
<tr>
<td></td>
<td>ZAG2</td>
<td>2</td>
<td>If Zone 2 AG element (XAG2 or MAG2) set, not ZAG1</td>
</tr>
<tr>
<td></td>
<td>ZAG3</td>
<td>3</td>
<td>If Zone 3 AG element (XAG3 or MAG3) set, not ZAG1 or ZAG2</td>
</tr>
<tr>
<td></td>
<td>ZAG4</td>
<td>4</td>
<td>If Zone 4 AG element (XAG4 or MAG4) set, not ZAG1 or ZAG2 or ZAG3</td>
</tr>
<tr>
<td>ZBG</td>
<td>ZBG1</td>
<td>1</td>
<td>If Zone 1 BG element (XBG1 or MBG1) set</td>
</tr>
<tr>
<td></td>
<td>ZBG2</td>
<td>2</td>
<td>If Zone 2 BG element (XBG2 or MBG2) set, not ZBG1</td>
</tr>
<tr>
<td></td>
<td>ZBG3</td>
<td>3</td>
<td>If Zone 3 BG element (XBG3 or MBG3) set, not ZBG1 or ZBG2</td>
</tr>
<tr>
<td></td>
<td>ZBG4</td>
<td>4</td>
<td>If Zone 4 BG element (XBG4 or MBG4) set, not ZBG1 or ZBG2 or ZBG3</td>
</tr>
<tr>
<td>ZCG</td>
<td>ZCG1</td>
<td>1</td>
<td>If Zone 1 CG element (XCG1 or MCG1) set</td>
</tr>
<tr>
<td></td>
<td>ZCG2</td>
<td>2</td>
<td>If Zone 2 CG element (XCG2 or MCG2) set, not ZCG1</td>
</tr>
<tr>
<td></td>
<td>ZCG3</td>
<td>3</td>
<td>If Zone 3 CG element (XCG3 or MCG3) set, not ZCG1 or ZCG2</td>
</tr>
<tr>
<td></td>
<td>ZCG4</td>
<td>4</td>
<td>If Zone 4 CG element (XCG4 or MCG4) set, not ZCG1 or ZCG2 or ZCG3</td>
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<tr>
<td>OOS</td>
<td>OSB</td>
<td>t</td>
<td>OOS timing</td>
</tr>
<tr>
<td></td>
<td>OST</td>
<td>B</td>
<td>OOS Block (OSB*!OST)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T</td>
<td>OOS Trip (OST)</td>
</tr>
<tr>
<td>VPOL</td>
<td>VPOLV</td>
<td>V</td>
<td>VPOLV asserted</td>
</tr>
<tr>
<td>51 P</td>
<td>51P, 51PT, 51PR</td>
<td>p</td>
<td>Time-overcurrent element picked up and timing</td>
</tr>
<tr>
<td>51 G</td>
<td>51G, 51GT, 51GR</td>
<td>T</td>
<td>Time-overcurrent element timed out</td>
</tr>
<tr>
<td>51 Q</td>
<td>51Q, 51QT, 51QR</td>
<td>r</td>
<td>Time-overcurrent element timing to reset</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Time-overcurrent element timing to reset after having timed out (when element reset is set for 1 cycle, not electromechanical reset)</td>
</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
<tr>
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<td>-----------------------------------------</td>
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<td>50P 1 2</td>
<td>50P1, 50P2</td>
<td>1</td>
<td>50P1 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>50P2 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>both 50P1 and 50P2 asserted</td>
</tr>
<tr>
<td>50P 3</td>
<td>50P3</td>
<td>3</td>
<td>50P3 asserted</td>
</tr>
<tr>
<td>50G 1 2</td>
<td>50G1, 50G2</td>
<td>1</td>
<td>50G1 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>50G2 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>both 50G1 and 50G2 asserted</td>
</tr>
<tr>
<td>50G 3 4</td>
<td>50G3, 50G4</td>
<td>3</td>
<td>50G3 asserted</td>
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<td></td>
<td></td>
<td>4</td>
<td>50G4 asserted</td>
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<tr>
<td></td>
<td></td>
<td>b</td>
<td>both 50G3 and 50G4 asserted</td>
</tr>
<tr>
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<td>50Q1, 50Q2</td>
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<td>50Q1 asserted</td>
</tr>
<tr>
<td></td>
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<td>2</td>
<td>50Q2 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>both 50Q1 and 50Q2 asserted</td>
</tr>
<tr>
<td>50Q 3 4</td>
<td>50Q3, 50Q4</td>
<td>3</td>
<td>50Q3 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>50Q4 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>both 50Q3 and 50Q4 asserted</td>
</tr>
<tr>
<td>32 Q</td>
<td>F32Q</td>
<td>Q</td>
<td>Forward negative-sequence directional element F32Q picked up.</td>
</tr>
<tr>
<td></td>
<td>R32Q</td>
<td>q</td>
<td>Reverse negative-sequence directional element R32Q picked up.</td>
</tr>
<tr>
<td>32 QVI</td>
<td>F32QG</td>
<td>Q</td>
<td>Forward negative-sequence ground directional element F32Q picked up.</td>
</tr>
<tr>
<td></td>
<td>R32QG</td>
<td>q</td>
<td>Reverse negative-sequence ground directional element R32Q picked up.</td>
</tr>
<tr>
<td></td>
<td>F32V</td>
<td>V</td>
<td>Forward zero-sequence ground directional element F32V picked up.</td>
</tr>
<tr>
<td></td>
<td>R32V</td>
<td>v</td>
<td>Reverse zero-sequence ground directional element R32V picked up.</td>
</tr>
<tr>
<td></td>
<td>F32I</td>
<td>I</td>
<td>Forward current polarized ground directional element F32I picked up.</td>
</tr>
<tr>
<td></td>
<td>R32I</td>
<td>i</td>
<td>Reverse current polarized ground directional element R32I picked up.</td>
</tr>
<tr>
<td>67P 1 2</td>
<td>67P1, 67P2</td>
<td>1</td>
<td>67P1 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>67P2 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>both 67P1 and 67P2 asserted</td>
</tr>
<tr>
<td>67P 3</td>
<td>67P3</td>
<td>3</td>
<td>67P3 asserted</td>
</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------------------------------</td>
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<td>------------</td>
</tr>
<tr>
<td>67G 1 2</td>
<td>67G1, 67G2</td>
<td>1</td>
<td>67G1 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>67G2 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>both 67G1 and 67G2 asserted</td>
</tr>
<tr>
<td>67G 3 4</td>
<td>67G3, 67G4</td>
<td>3</td>
<td>67G3 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>67G4 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>both 67G3 and 67G4 asserted</td>
</tr>
<tr>
<td>67Q 1 2</td>
<td>67Q1, 67Q2</td>
<td>1</td>
<td>67Q1 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>67Q2 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>both 67Q1 and 67Q2 asserted</td>
</tr>
<tr>
<td>67Q 3 4</td>
<td>67Q3, 67Q4</td>
<td>3</td>
<td>67Q3 asserted</td>
</tr>
<tr>
<td></td>
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<td>4</td>
<td>67Q4 asserted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>both 67Q3 and 67Q4 asserted</td>
</tr>
<tr>
<td>DM P Q</td>
<td>PDEM, QDEM</td>
<td>P</td>
<td>Phase demand ammeter element PDEM picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Q</td>
<td>Negative-sequence demand ammeter element QDEM picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both PDEM and QDEM picked up.</td>
</tr>
<tr>
<td>DM G</td>
<td>GDEM</td>
<td>*</td>
<td>Residual ground demand ammeter element GDEM picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>B-phase instantaneous undervoltage element 27B picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>C-phase instantaneous undervoltage element 27C picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a</td>
<td>27A and 27B elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>27B and 27C elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c</td>
<td>27C and 27A elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>27A, 27B, and 27C elements picked up.</td>
</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
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<td>----------------</td>
<td>----------------------------------------</td>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>27 PP</td>
<td>27AB, 27BC, 27CA</td>
<td>A</td>
<td>AB phase-to-phase instantaneous undervoltage element 27AB picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>BC phase-to-phase instantaneous undervoltage element 27BC picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>CA phase-to-phase instantaneous undervoltage element 27CA picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a</td>
<td>27AB and 27CA elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>27AB and 27BC elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c</td>
<td>27BC and 27CA elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>27AB, 27BC and 27CA elements picked up.</td>
</tr>
<tr>
<td>27 S</td>
<td>27S</td>
<td>*</td>
<td>Channel VS instantaneous undervoltage element 27S picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>B-phase instantaneous overvoltage element 59B picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>C-phase instantaneous overvoltage element 59C picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a</td>
<td>59A and 59B elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>59B and 59C elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c</td>
<td>59C and 59A elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>59A, 59B and 59C elements picked up.</td>
</tr>
<tr>
<td>59 PP</td>
<td>59AB, 59BC, 59CA</td>
<td>A</td>
<td>AB phase-to-phase instantaneous overvoltage element 59AB picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>BC phase-to-phase instantaneous overvoltage element 59BC picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>CA phase-to-phase instantaneous overvoltage element 59CA picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a</td>
<td>59AB and 59CA elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>59AB and 59BC elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c</td>
<td>59BC and 59CA elements picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>59AB, 59BC and 59CA elements picked up.</td>
</tr>
<tr>
<td>59 S</td>
<td>59S</td>
<td>*</td>
<td>VS instantaneous overvoltage element 59S picked up.</td>
</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------------------------------</td>
<td>--------</td>
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</tr>
<tr>
<td>59 V1 Q</td>
<td>59V1, 59Q</td>
<td>1</td>
<td>Positive-sequence instantaneous overvoltage element 59V1 picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Q</td>
<td>Negative-sequence instantaneous overvoltage element 59Q picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both 59V1 and 59Q picked up.</td>
</tr>
<tr>
<td>59 N</td>
<td>59N1, 59N2</td>
<td>1</td>
<td>First ground instantaneous overvoltage element 59N1 picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Second ground instantaneous overvoltage element 59N2 picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both 59N1 and 59N2 picked up.</td>
</tr>
<tr>
<td>25 59 V</td>
<td>59VP, 59VS</td>
<td>P</td>
<td>Phase voltage window element 59VP picked up (used in synchronism check).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S</td>
<td>Channel VS voltage window element 59VS picked up (used in synchronism check).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both 59VP and 59VS picked up.</td>
</tr>
<tr>
<td>25 SF</td>
<td>SF</td>
<td>*</td>
<td>Slip frequency element SF picked up (used in synchronism check).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Second synchronism check element 25A2 picked up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both 25A1 and 25A2 picked up.</td>
</tr>
<tr>
<td>27B</td>
<td>27B81</td>
<td>*</td>
<td>Undervoltage element for frequency element blocking (any phase) asserted.</td>
</tr>
<tr>
<td>81 1 2</td>
<td>81D1, 81D2</td>
<td>1</td>
<td>Level 1 instantaneous frequency element asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Level 2 instantaneous frequency element asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Level 1 and 2 instantaneous frequency elements asserted.</td>
</tr>
<tr>
<td>81 3 4</td>
<td>81D3, 81D4</td>
<td>3</td>
<td>Level 3 instantaneous frequency element asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Level 4 instantaneous frequency element asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Level 3 and 4 instantaneous frequency elements asserted.</td>
</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------------------------------</td>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>81 5 6</td>
<td>81D5, 81D6</td>
<td>5</td>
<td>Level 5 instantaneous frequency element asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Level 6 instantaneous frequency element asserted.</td>
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<tr>
<td></td>
<td></td>
<td>b</td>
<td>Level 5 and 6 instantaneous frequency elements asserted.</td>
</tr>
<tr>
<td>Time</td>
<td>OPTMN, RSTMN</td>
<td>o r</td>
<td>Recloser open interval timer is timing. Recloser reset interval timer is timing.</td>
</tr>
<tr>
<td>Shot</td>
<td>SH0, SH1, SH2 SH3, SH4</td>
<td>. 0 1 2 3 4</td>
<td>Reclosing relay nonexistent.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>shot = 0 (SH0).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>shot = 1 (SH1).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>shot = 2 (SH2).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>shot = 3 (SH3).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>shot = 4 (SH4).</td>
</tr>
<tr>
<td>Zld</td>
<td>ZLIN, ZLOUT</td>
<td>i o</td>
<td>Load encroachment “load in” element ZLIN picked up. Load encroachment “load out” element ZLOUT picked up.</td>
</tr>
<tr>
<td>LOP</td>
<td>LOP</td>
<td>*</td>
<td>Loss-of-potential element LOP picked up.</td>
</tr>
<tr>
<td>Vdc</td>
<td>DCHI, DCLO</td>
<td>H L b</td>
<td>Station battery instantaneous overvoltage element DCHI picked up. Station battery instantaneous undervoltage element DCLO picked up. Both DCHI and DCLO asserted.</td>
</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
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<td>----------------</td>
<td>----------------------------------------</td>
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<td>------------</td>
</tr>
<tr>
<td>**Out1 1 2</td>
<td>OUT101, OUT102</td>
<td>1</td>
<td>Output contact OUT101 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Output contact OUT102 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both OUT101 and OUT102 asserted.</td>
</tr>
<tr>
<td>**Out1 3 4</td>
<td>OUT103, OUT104</td>
<td>3</td>
<td>Output contact OUT103 asserted.</td>
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<tr>
<td></td>
<td></td>
<td>4</td>
<td>Output contact OUT104 asserted.</td>
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<td></td>
<td>b</td>
<td>Both OUT103 and OUT104 asserted.</td>
</tr>
<tr>
<td>**Out1 5 6</td>
<td>OUT105, OUT106</td>
<td>5</td>
<td>Output contact OUT105 asserted.</td>
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<td>6</td>
<td>Output contact OUT106 asserted.</td>
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<td>b</td>
<td>Both OUT105 and OUT106 asserted.</td>
</tr>
<tr>
<td>**Out1 7 A</td>
<td>OUT107, ALARM</td>
<td>7</td>
<td>Output contact OUT107 asserted.</td>
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<tr>
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<td></td>
<td>A</td>
<td>Output contact ALARM asserted.</td>
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<td></td>
<td>b</td>
<td>Both OUT107 and ALARM asserted.</td>
</tr>
<tr>
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<td>(Models 311C00x and 311C01x)</td>
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<tr>
<td>**Out2 1 2</td>
<td>OUT201, OUT202</td>
<td>1</td>
<td>Output contact OUT201 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Output contact OUT202 asserted.</td>
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<td></td>
<td></td>
<td>b</td>
<td>Both OUT201 and OUT202 asserted.</td>
</tr>
<tr>
<td>**Out2 3 4</td>
<td>OUT203, OUT204</td>
<td>3</td>
<td>Output contact OUT203 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Output contact OUT204 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both OUT203 and OUT204 asserted.</td>
</tr>
<tr>
<td>**Out2 5 6</td>
<td>OUT205, OUT206</td>
<td>5</td>
<td>Output contact OUT205 asserted.</td>
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<tr>
<td></td>
<td></td>
<td>6</td>
<td>Output contact OUT206 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both OUT205 and OUT206 asserted.</td>
</tr>
<tr>
<td>**Out2 7 8</td>
<td>OUT207, OUT208</td>
<td>7</td>
<td>Output contact OUT207 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>Output contact OUT208 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both OUT207 and OUT208 asserted.</td>
</tr>
<tr>
<td>**Out2 9 0</td>
<td>OUT203, OUT204</td>
<td>9</td>
<td>Output contact OUT209 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>Output contact OUT210 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both OUT209 and OUT210 asserted.</td>
</tr>
<tr>
<td>**Out2 1 2</td>
<td>OUT205, OUT206</td>
<td>1</td>
<td>Output contact OUT211 asserted.</td>
</tr>
<tr>
<td></td>
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<td>2</td>
<td>Output contact OUT212 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both OUT211 and OUT212 asserted.</td>
</tr>
<tr>
<td></td>
<td>(Model 311C01x)</td>
<td></td>
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</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
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<tr>
<td>----------------</td>
<td>----------------------------------------</td>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>In1 1 2</td>
<td>IN101, IN102</td>
<td>1</td>
<td>Optoisolated input IN101 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Optoisolated input IN102 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both IN101 and IN102 asserted.</td>
</tr>
<tr>
<td>In1 3 4</td>
<td>IN103, IN104</td>
<td>3</td>
<td>Optoisolated input IN103 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Optoisolated input IN104 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both IN103 and IN104 asserted.</td>
</tr>
<tr>
<td>In1 5 6</td>
<td>IN105, IN106</td>
<td>5</td>
<td>Optoisolated input IN105 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Optoisolated input IN106 asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Both IN105 and IN106 asserted.</td>
</tr>
</tbody>
</table>

(Models 311C00x and 311C01x)

| In2 1 2        | IN201, IN202                           | 1      | Optoisolated input IN201 asserted. |
|               |                                        | 2      | Optoisolated input IN202 asserted. |
|               |                                        | b      | Both IN201 and IN202 asserted.     |
| In2 3 4        | IN203, IN204                           | 3      | Optoisolated input IN203 asserted. |
|               |                                        | 4      | Optoisolated input IN202 asserted. |
|               |                                        | b      | Both IN203 and IN204 asserted.     |
| In2 5 6        | IN205, IN206                           | 5      | Optoisolated input IN205 asserted. |
|               |                                        | 6      | Optoisolated input IN206 asserted. |
|               |                                        | b      | Both IN205 and IN206 asserted.     |
| In2 7 8        | IN207, IN208                           | 7      | Optoisolated input IN207 asserted. |
|               |                                        | 8      | Optoisolated input IN208 asserted. |
|               |                                        | b      | Both IN207 and IN208 asserted.     |

(Model 311C01x)

** Output contacts can be A or B type contacts (see Table 2.2 and Figures 7.27 through 7.28).

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

<table>
<thead>
<tr>
<th>Column Heading</th>
<th>Corresponding Elements (Relay Word Bits)</th>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>3PO</td>
<td>3PO</td>
<td>*</td>
<td>Three pole open condition 3PO asserted.</td>
</tr>
<tr>
<td>SOTF</td>
<td>SOTF</td>
<td>*</td>
<td>Switch-onto-fault condition SOTF asserted.</td>
</tr>
<tr>
<td>PT</td>
<td>PT</td>
<td>*</td>
<td>Permissive trip signal to POTT logic PT asserted.</td>
</tr>
<tr>
<td>PTRX</td>
<td>PTRX1, PTRX2</td>
<td>1, 2</td>
<td>Permissive trip 1 signal from DCUB logic PTRX1 asserted. Permissive trip 2 signal from DCUB logic PTRX2 asserted. Both PTRX1 and PTRX2 asserted</td>
</tr>
<tr>
<td>Z3RB</td>
<td>Z3RB</td>
<td>*</td>
<td>Zone /Level 3 reverse block Z3RB asserted.</td>
</tr>
<tr>
<td>KEY</td>
<td>KEY</td>
<td>*</td>
<td>Key permissive trip signal KEY asserted.</td>
</tr>
<tr>
<td>EKEY</td>
<td>EKEY</td>
<td>*</td>
<td>Echo key EKEY asserted.</td>
</tr>
<tr>
<td>ECTT</td>
<td>ECTT</td>
<td>*</td>
<td>Echo conversion to trip condition ECTT asserted.</td>
</tr>
<tr>
<td>WFC</td>
<td>WFC</td>
<td>*</td>
<td>Weak infeed condition WFC asserted.</td>
</tr>
<tr>
<td>UBB</td>
<td>UBB1, UBB2</td>
<td>1, 2</td>
<td>Unblocking block 1 from DCUB logic UBB1 asserted. Unblocking block 2 from DCUB logic UBB2 asserted. Both UBB1 and UBB2 asserted.</td>
</tr>
<tr>
<td>Z3XT</td>
<td>Z3XT</td>
<td>*</td>
<td>Logic output from Zone/Level 3 extension timer Z3XT asserted.</td>
</tr>
<tr>
<td>DSTR</td>
<td>DSTRT</td>
<td>*</td>
<td>Directional carrier start DSTRT asserted.</td>
</tr>
<tr>
<td>NSTR</td>
<td>NSTRT</td>
<td>*</td>
<td>Nondirectional carrier start NSTRT asserted.</td>
</tr>
<tr>
<td>STOP</td>
<td>STOP</td>
<td>*</td>
<td>Carrier stop STOP asserted.</td>
</tr>
<tr>
<td>BTX</td>
<td>BTX</td>
<td>*</td>
<td>Block trip input extension BTX asserted.</td>
</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------------------------------</td>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>TMB A 1 2</td>
<td>TMB1A, TMB2A</td>
<td>1</td>
<td>MIRRORED BITS™ channel A transmit bit 1 TMB1A asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>MIRRORED BITS channel A transmit bit 2 TMB2A asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both TMB1A and TMB2A asserted.</td>
</tr>
<tr>
<td>TMB A 3 4</td>
<td>TMB3A, TMB4A</td>
<td>3</td>
<td>MIRRORED BITS channel A transmit bit 3 TMB3A asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>MIRRORED BITS channel A transmit bit 4 TMB4A asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both TMB3A and TMB4A asserted.</td>
</tr>
<tr>
<td>TMB A 5 6</td>
<td>TMB5A, TMB6A</td>
<td>5</td>
<td>MIRRORED BITS channel A transmit bit 5 TMB5A asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>MIRRORED BITS channel A transmit bit 6 TMB6A asserted.</td>
</tr>
<tr>
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<td>b</td>
<td>Both TMB5A and TMB6A asserted.</td>
</tr>
<tr>
<td>TMB A 7 8</td>
<td>TMB7A, TMB8A</td>
<td>7</td>
<td>MIRRORED BITS channel A transmit bit 7 TMB7A asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>MIRRORED BITS channel A transmit bit 8 TMB8A asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both TMB7A and TMB8A asserted.</td>
</tr>
<tr>
<td>RMB A 1 2</td>
<td>RMB1A, RMB2A</td>
<td>1</td>
<td>MIRRORED BITS channel A receive bit 1 RMB1A asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>MIRRORED BITS channel A receive bit 2 RMB2A asserted.</td>
</tr>
<tr>
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<td></td>
<td>b</td>
<td>Both RMB1A and RMB2A asserted.</td>
</tr>
<tr>
<td>RMB A 3 4</td>
<td>RMB3A, RMB4A</td>
<td>3</td>
<td>MIRRORED BITS channel A receive bit 3 RMB3A asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>MIRRORED BITS channel A receive bit 4 RMB4A asserted.</td>
</tr>
<tr>
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</tr>
<tr>
<td>RMB A 5 6</td>
<td>RMB5A, RMB6A</td>
<td>5</td>
<td>MIRRORED BITS channel A receive bit 5 RMB5A asserted.</td>
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<tr>
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<td>MIRRORED BITS channel A receive bit 6 RMB6A asserted.</td>
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<tr>
<td>RMB A 7 8</td>
<td>RMB7A, RMB8A</td>
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<td>MIRRORED BITS channel A receive bit 8 RMB8A asserted.</td>
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<td>Both RMB7A and RMB8A asserted.</td>
</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
<tr>
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<td>------------------------------------------</td>
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<tr>
<td>TMB B 1 2</td>
<td>TMB1B, TMB2B</td>
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</tr>
<tr>
<td>TMB B 3 4</td>
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</tr>
<tr>
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<td>4</td>
<td>MIRRORED BITS channel B transmit bit 4 TMB4B asserted.</td>
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<tr>
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<td></td>
<td>b</td>
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</tr>
<tr>
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<td>MIRRORED BITS channel B transmit bit 6 TMB6B asserted.</td>
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<td>b</td>
<td>Both TMB5B and TMB6B asserted.</td>
</tr>
<tr>
<td>TMB B 7 8</td>
<td>TMB7B, TMB8B</td>
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<td>MIRRORED BITS channel B transmit bit 7 TMB7B asserted.</td>
</tr>
<tr>
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<td></td>
<td>8</td>
<td>MIRRORED BITS channel B transmit bit 8 TMB8B asserted.</td>
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<tr>
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<td></td>
<td>b</td>
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</tr>
<tr>
<td>RMB B 1 2</td>
<td>RMB1B, RMB2B</td>
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<tr>
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<td>2</td>
<td>MIRRORED BITS channel B receive bit 2 RMB2B asserted.</td>
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</tr>
<tr>
<td>RMB B 3 4</td>
<td>RMB3B, RMB4B</td>
<td>3</td>
<td>MIRRORED BITS channel B receive bit 3 RMB3B asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>MIRRORED BITS channel B receive bit 4 RMB4B asserted.</td>
</tr>
<tr>
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</tr>
<tr>
<td>RMB B 5 6</td>
<td>RMB5B, RMB6B</td>
<td>5</td>
<td>MIRRORED BITS channel B receive bit 5 RMB5B asserted.</td>
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<tr>
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<td></td>
<td>6</td>
<td>MIRRORED BITS channel B receive bit 6 RMB6B asserted.</td>
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</tr>
<tr>
<td>RMB B 7 8</td>
<td>RMB7B, RMB8B</td>
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<tr>
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<td>MIRRORED BITS channel B receive bit 8 RMB8B asserted.</td>
</tr>
<tr>
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</tr>
<tr>
<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------------------------------</td>
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<td>------------</td>
</tr>
<tr>
<td>ROK</td>
<td>ROKA, ROKB</td>
<td>A</td>
<td>MIRRORED BITS channel A receive OK ROKA asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>MIRRORED BITS channel B receive OK ROKB asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both ROKA and ROKB asserted.</td>
</tr>
<tr>
<td>RBAD</td>
<td>RBADA, RBADB</td>
<td>A</td>
<td>MIRRORED BITS channel A extended outage RBADA asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>MIRRORED BITS channel B extended outage RBADB asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both RBADA and RBADB asserted.</td>
</tr>
<tr>
<td>CBAD</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>MIRRORED BITS channel B unavailability CBADB asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>Both CBADA and CBADB asserted.</td>
</tr>
<tr>
<td>LBOK</td>
<td>LBOKA, LBOKB</td>
<td>A</td>
<td>MIRRORED BITS channel A loop back OK LBOKA asserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>MIRRORED BITS channel A loop back OK LBOKB asserted.</td>
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<td>b</td>
<td>Both LBOKA and LBOKB asserted.</td>
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<td>OC</td>
<td>OC, CC</td>
<td>o</td>
<td>OPE (Open) command executed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c</td>
<td>CLO (Close) command executed.</td>
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<tr>
<td>Lcl RW 5</td>
<td>LB1–LB8</td>
<td>00–FF **Hex</td>
<td>Hex value of Relay Word 5, LB1–LB8, Local Bits</td>
</tr>
<tr>
<td>Lcl RW 6</td>
<td>LB9–LB16</td>
<td>00–FF **Hex</td>
<td>Hex value of Relay Word 6, LB9–LB16, Local Bits</td>
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<tr>
<td>Rem RW 7</td>
<td>RB1–RB8</td>
<td>00–FF **Hex</td>
<td>Hex value of Relay Word 7, RB1–RB8, Remote Bits</td>
</tr>
<tr>
<td>Rem RW 8</td>
<td>RB9–RB16</td>
<td>00–FF **Hex</td>
<td>Hex value of Relay Word 8, RB9–RB16, Remote Bits</td>
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<tr>
<td>Ltch RW 9</td>
<td>LT1–LT8</td>
<td>00–FF **Hex</td>
<td>Hex value of Relay Word 9, LT1–LT8, Latch Bits</td>
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<tr>
<td>Ltch RW 10</td>
<td>LT9–LT16</td>
<td>00–FF **Hex</td>
<td>Hex value of Relay Word 10, LT9–LT16, Latch Bits</td>
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<td>Column Heading</td>
<td>Corresponding Elements (Relay Word Bits)</td>
<td>Symbol</td>
<td>Definition</td>
</tr>
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<td>----------------</td>
<td>---------------------------------------</td>
<td>--------</td>
<td>------------</td>
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<tr>
<td>SELOGIC</td>
<td>SV1, SV1T</td>
<td>p</td>
<td>SELOGIC control equation variable timer input SV_ asserted; timer timing on pickup time; timer output SV_T not asserted.</td>
</tr>
<tr>
<td>2</td>
<td>SV2, SV2T</td>
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<tr>
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<td></td>
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<td>4</td>
<td>SV4, SV4T</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>SV5, SV5T</td>
<td>T</td>
<td>SELOGIC control equation variable timer input SV_ asserted; timer timed out on pickup time; timer output SV_T asserted.</td>
</tr>
<tr>
<td>6</td>
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<td></td>
</tr>
<tr>
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<td>SV7, SV7T</td>
<td></td>
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<tr>
<td>8</td>
<td>SV8, SV8T</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>SV9, SV9T</td>
<td>d</td>
<td>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.</td>
</tr>
<tr>
<td>10</td>
<td>SV10, SV10T</td>
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** Hexadecimal values are constructed with the highest numbered bit (e.g., LB8) being the least significant, as follows:

<table>
<thead>
<tr>
<th>LB1</th>
<th>LB2</th>
<th>LB3</th>
<th>LB4</th>
<th>LB5</th>
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<th>LB7</th>
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<tbody>
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</table>

= 8A Hex

**EXAMPLE STANDARD 15-CYCLE EVENT REPORT**

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

In Figure 12.2, the arrow (>) in the column following the V1Mem column identifies the “trigger” row. This is the row that corresponds to the Date and Time values at the top of the event report.

The asterisk (*) in the column following the V1Mem column identifies the row corresponding to the “fault” values listed in the event summary report. See **Currents and Voltages** on page 12-6. The phase current is calculated from the row identified with the asterisk and the row one quarter-cycle previous (see Figure 12.2 and Table 12.1). These currents are listed at the end of the event report in the event summary. If the “trigger” row (>) and the faulted phase current row (*) are the same row, the * symbol takes precedence.
SEL-311C POTT
EXAMPLE: BUS B, BREAKER 3

SEL-311C Instruction Manual

FID=SEL-311C-R100-V0-Z001001-D19991118  CID=B142

Currents (Amps Pri)   Voltages (kV Pri)   V1   FREQ Vdc
IA  IB  IC  IP  IG  VA  VB  VC  VS  Mem

<p>| | | | | | | | | | |</p>
<table>
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<tr>
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<td>-131.6</td>
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<td>115.0</td>
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</tbody>
</table>

- See Figure 12.1
- Firmware identifier
- Firmware checksum

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</tbody>
</table>

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

<p>| | | | | | | | | | |</p>
<table>
<thead>
<tr>
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</tbody>
</table>

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

<p>| | | | | | | | | | |</p>
<table>
<thead>
<tr>
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- see Figure 12.1
- Currents (Amps Pri)
- Voltages (kV Pri)
- V1  FREQ Vdc

<p>| | | | | | | | | | |</p>
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<thead>
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- See Figure 12.3 and Figure 12.4 for details on this one cycle of Phase B (Channel IB) current.

<p>| | | | | | | | | | |</p>
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Protection and Contact I/O Elements

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<td>ABCABC</td>
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Date Code 20011205
Standard Event Reports and SER
SEL-311C Instruction Manual
Communication Elements

S  PZ EE ZDNS TMB RMB TMB RMB RRCL Lcl Rem Latch SELogic
30 T3KKCWU 3SSTB A A B B 0BBB
PT PREEFTB XTTOT 1357 1357 1357 KAAS 0 RW RW RW RW RW
OF TXBYTCTB TRRX 2468 2468 2468 2468 DDIX C 5 6 7 8 9 10 1234567890123456
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-311C POTT  TID  =EXAMPLE: BUS B, BREAKER 3
CTR  =200
CTP  =200  PTR  =2000.00  PTRS  =2000.00
ZIMAG =7.80  ZIANG =84.00
ZOMAG =24.80  ZOANG =81.50  LL  =100.00  APP  =311C
E21P  =3  E21MG  =3  E21XG  =3
E50P  =3  E50G  =Y  E50Q  =Y
E51P  =N  E51G  =Y  E51Q  =Y
Z1MAG =7.80  Z1ANG =84.00
Z0MAG =24.80  Z0ANG =81.50  LL  =100.00  APP  =311C
E21P  =3  E21MG  =3  E21XG  =3
E50P  =1  E50G  =N  E50Q  =N
E51P  =N  E51G  =Y  E51Q  =Y
E32   =AUTO  EOOS  =N  ELOAD  =Y  ESOTF  =Y
EVOLT =N  E25  =N  E81  =N  EFLOC  =Y
ELOP  =Y  ECOMM  =POTT  E79  =N  EZ1EXT  =N
ECCVT =N  EREV  =N  ELAT  =16  EDP  =16
Z1P   =6.24  Z2P   =9.36  Z3P   =1.87
50P1  =0.50
Z1MG  =6.24  Z2MG  =9.36  Z3MG  =1.87
XG1   =6.24  XG2   =9.36  XG3   =1.87
RG1   =2.50  RG2   =5.00  RG3   =6.00
50L1  =0.50
50GZ1 =0.50
k0M1  =0.726  k0A1  =-3.69
Z1PD  =OFF  Z2PD  =20.00  Z3PD  =OFF
Z1GD  =OFF  Z2GD  =20.00  Z3GD  =OFF
Z1D   =OFF  Z2D   =OFF  Z3D   =OFF
50P1P =11.25
67P1D =0.00
S1G1  =0.75  S1G2  =0.75  S1G3  =0.75  S1GRS  =Y
S1Q1  =2.20  S1Q2  =2.20  S1Q3  =2.20  S1QRS  =N
Z2F   =9.22  Z2R   =9.22
PLAF  =30.00  NLAF  =30.00  PLAR  =150.00  NLAR  =210.00
DIR3  =R  DIR4  =F
ORDER =QVI
CLOEND =OFF  S2AEND =10.00  SOTFD =30.00
Z3RBD =5.00  EBLKD =10.00  ETDPU =2.00
EDURD =4.00  EWFC  =N
TDURD =9.00  CFDF =60.00  3POD =0.50  OPO =52
SOLP =0.25

Selogic group 1

Selogic Control Equations:
TR  =M1P + Z1G + M2PT + Z2GT + S1GT + S1QT + OC
TRCOMM =M2P + Z2G
TRSOFF =M2P + Z2G + 50P1
DTR =0
ULTR  =1(S5OL + S5IG)
PT1  =IN102
S2A  =IN101
CL  =GC
ULCL  =TRIP
SET1  =0
RST1  =0
SET2  =0
RST2  =0
SET3  =0
RST3  =0
SET4  =0
RST4  =0
SET5  =0
RST5  =0
SET6  =0
RST6  =0
SET7  =0
RST7  =0
SET8 =0
RST8 =0
SET9 =0
RST9 =0
SET10 =0
RST10 =0
SET11 =0
RST11 =0
SET12 =0
RST12 =0
SET13 =0
RST13 =0
SET14 =0
RST14 =0
SET15 =0
RST15 =0
SET16 =0
RST16 =0
67PITC=I
51GTC =I
51QTC =I
OUT101=TRIP
OUT102=TRIP
OUT103=CLOSE
OUT104=KEY
OUT105=0
OUT106=0
OUT107=0
DP1 =52A
DP2 =0
DP3 =0
DP4 =0
DP5 =0
DP6 =0
DP7 =0
DP8 =0
DP9 =0
DP10 =0
DP11 =0
DP12 =0
DP13 =0
DP14 =0
DP15 =0
DP16 =0
SS1 =0
SS2 =0
SS3 =0
SS4 =0
SS5 =0
SS6 =0
ER =/M2P + /Z2G + /51G + /51Q + /50P1 + /LOP
FAULT =51G + 51Q + M2P + Z2G
BSYNCH=0
CLMON =0
E32IV =1

Global Settings:
TGR = 1800.00  NFREQ = 60  PHROT = ABC
DATE_MDY = 05.01.95  FP_TO = 15.00  SCROLL = 5
LER = 15  PRE = 4  DCLP = OFF  DCHIP = OFF
IN101D= 0.00  IN102D= 0.00  IN103D= 0.00  IN104D= 0.00
IN105D= 0.00  IN106D= 0.00
EBMON = N

Figure 12.2: Example Standard 15-Cycle Event Report 1/4 Cycle Resolution
Figure 12.3 and Figure 12.4 look in detail at 1 cycle of B-phase current (channel IB) identified in Figure 12.2. Figure 12.3 shows how the event report ac current column data relates to the actual sampled waveform and RMS values. Figure 12.4 shows how the event report current column data can be converted to phasor RMS values. Voltages are processed similarly.

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

In Figure 12.3, note that any two rows of current data from the event report in Figure 12.2, 1/4 cycle apart, can be used to calculate RMS current values.
Figure 12.4: Derivation of Phasor RMS Current Values From Event Report Current Values

$$\text{Magnitude} = \sqrt{(1945)^2 + (1531)^2}$$
$$= 2475$$

$$\text{Angle} = \arctan\left(\frac{1531}{1945}\right)$$
$$= 38.2^\circ$$
In Figure 12.4, note that two rows of current data from the event report in Figure 12.2, 1/4 cycle apart, can be used to calculate phasor RMS current values. In Figure 12.4, at the present sample, the phasor RMS current value is:

\[ IB = 2475 \, A \angle 38.2^\circ \]

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

\[ 2475 \, A \, \text{cos}(38.2^\circ) = 1945 \, A \]

**Sequential Events Recorder (SER) Report**

See Figure 12.5 for an example SER report.

**SER Triggering**

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

- SER2 = IN101, OUT101, OUT102, OUT103, OUT104, LOP
- SER3 = KEY, Z3RB, PTRX

The elements are Relay Word bits referenced in Table 9.4. The relay monitors each element in the SER lists every 1/4 cycle. 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 21 at the end of **Section 9: Setting the Relay**. Use commas to delimit the elements. For example, if you enter setting SER1 as:

\[ \text{SER1} = 51P,51G,51PT,51GT,50P1,50P2 \]

The relay displays the setting as:

\[ \text{SER1} = 51P,51G,51PT,51GT,50P1,50P2 \]

The relay can monitor up to 72 elements in the SER (24 in each of SER1, SER2, and SER3).
# Retrieving SER Reports

The relay saves the latest 512 rows of the SER in nonvolatile memory. Row 1 is the most recently triggered row, and row 512 is the oldest. View the SER report by date or SER row number as outlined in the examples below.

**Example SER**

<table>
<thead>
<tr>
<th>Serial Port Commands</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>SER</td>
<td>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.</td>
</tr>
<tr>
<td>SER 17</td>
<td>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.</td>
</tr>
<tr>
<td>SER 10 33</td>
<td>If SER is entered with two numbers following it (10 and 33 in this example; 10 &lt; 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.</td>
</tr>
<tr>
<td>SER 47 22</td>
<td>If SER is entered with two numbers following it (47 and 22 in this example; 47 &gt; 22), all the rows between (and including) rows 47 and 22 are displayed, if they exist. They display with the newest row (row 22) at the beginning (top) of the report and the oldest row (row 47) at the end (bottom) of the report. Reverse chronological progression through the report is down the page and in ascending row number.</td>
</tr>
<tr>
<td>SER 3/30/97</td>
<td>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.</td>
</tr>
<tr>
<td>SER 2/17/97 3/23/97</td>
<td>If SER is entered with two dates following it (date 2/17/97 chronologically precedes date 3/23/97 in this example), all the rows between (and including) dates 2/17/97 and 3/23/97 are displayed, if they exist. They display with the oldest row (date 2/17/97) at the beginning (top) of the report and the latest row (date 3/23/97) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.</td>
</tr>
</tbody>
</table>
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
->>>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.
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.

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

INTRODUCTION

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

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 *Section 10: Serial Port Communications and Commands* and *Section 11: Front-Panel Interface*.

- **EVENT Command**
  The relay generates a 15-, 30-, or 60-cycle event report in response to faults or disturbances. Each report contains current and voltage information, relay element states, and input/output contact information. If you question the relay response or your test method, use the event report for more information. The EVENT (EVE) command is available at the serial ports. See *Section 12: Standard Event Reports and SER*.

- **SUM Command**
  The relay generates an event summary for each oscillographic event report. Use the SUM command to view and acknowledge the event summaries. Use the event summary to quickly verify proper relay operation. Compare the reported fault current and voltage magnitudes and angles against the reported fault location and fault type. If you question the relay response, or your test method, obtain the oscillographic event report for a more detailed analysis. See *Section 12: Standard Event Reports and SER* for more information on the event summary.

- **SER Command**
  The relay provides a Sequential Events Recorder (SER) event report that time-tags changes in relay element and input/output contact states. The SER provides a convenient means to verify the pickup/dropout of any element in the relay. The SER command is available at the serial ports. See *Section 12: Standard Event Reports and SER*.

- **TARGET Command**
  Use the TARGET (TAR) command to view the state of relay control inputs, relay outputs, and relay elements individually during a test. The TARGET command is available at the serial ports and the front panel. See *Section 10: Serial Port Communications and Commands* and *Section 11: Front-Panel Interface*.

- **PULSE Command**
  Use the PULSE (PUL) command to test the contact output circuits. The PULSE command is available at the serial ports and the front panel. See *Section 10: Serial Port Communications and Commands*. 
Low-Level Test Interface

The SEL-311C Relay has a low-level test interface between the calibrated input module and the separately calibrated processing module. You may test the relay in either of two ways: by using secondary injection testing or by applying low magnitude ac voltage signals to the low-level test interface. Access the test interface by removing the relay front panel.

Figure 13.1 shows the low-level interface connections. This drawing also appears on the inside of the relay front panel. Remove the ribbon cable between the two modules to access the outputs of the input module and the inputs to the processing module (relay main board).

You can test the relay processing module using signals from the SEL-RTS Low-Level Relay Test System. Never apply voltage signals greater than 9 volts peak-peak to the low-level test interface. Figure 13.1 shows the signal scaling factors.

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

You can test the input module two different ways:

1. Measure the outputs from the input module with an accurate voltmeter (measure signal pin to GND pin), and compare the readings to accurate instruments in the relay input circuits, or
2. Replace the ribbon cable, press the front-panel <METER> button, and compare the relay readings to other accurate instruments in the relay input circuits.

Figure 13.1: Low-Level Test Interface
Test Methods

Test the pickup and dropout of relay elements using one of three methods: target command indication, output contact closure, or sequential events recorder (SER).

The examples below show the settings necessary to route the phase time-overcurrent element 51PT to the output contacts and the SER. The 51PT element, like many in the SEL-311C Relay, is controlled by enable settings and/or torque control SELOGIC® control equations. To enable the 51PT element, set the E51P enable setting and 51PTC torque control settings to the following:

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

Testing Via Front-Panel Indicators

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

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

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

Review TAR command descriptions in Section 10: 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 for Model 0311C00x) to the element under test. The available elements are the Relay Word bits referenced in Table 9.4.

Use this method especially for time testing time-overcurrent elements. For example, to test the phase time-overcurrent element 51PT via output contact OUT104, make the following SELOGIC setting:

\[ \text{OUT104} = \text{51PT} \]

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:

\[
\text{SER1} = 51P, \ 51\text{PT}
\]

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-311C 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-311C 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

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

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

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Output Relays</th>
<th>Target LEDs</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 miles</td>
<td>AG</td>
<td>OUT1, OUT2, OUT4</td>
<td>INST, Zone 1, A, G</td>
</tr>
<tr>
<td>75 miles</td>
<td>BC</td>
<td>OUT1, OUT2, OUT4</td>
<td>INST, Zone 1, B, C</td>
</tr>
<tr>
<td>85 miles</td>
<td>AG</td>
<td>OUT1, OUT2, OUT4</td>
<td>TIME, Zone 2, A, G</td>
</tr>
<tr>
<td>85 miles</td>
<td>BC</td>
<td>OUT1, OUT2, OUT4</td>
<td>TIME, Zone 2, B, C</td>
</tr>
</tbody>
</table>

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

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

This section includes outline test procedures for overcurrent, directional, phase distance, and ground distance elements included in the SEL-311C Relay. The procedures are general, so that they may be applied to any specific element or zone.

Overcurrent Elements

The SEL-311C 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-311C 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.

<table>
<thead>
<tr>
<th>Element Type</th>
<th>Operates based upon the magnitude of:</th>
<th>Relay Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase</td>
<td>A-phase or B-phase or C-phase current. Test using single-phase current.</td>
<td>50P1, 50P2, 50P3</td>
</tr>
<tr>
<td>Residual</td>
<td>Residual current: ( I_R = I_A + I_B + I_C ). Test using single-phase current.</td>
<td>50G1, 50G2, 50G3, 50G4, 50GF, 50GR</td>
</tr>
<tr>
<td>Negative-Sequence</td>
<td>( 3 \cdot I_3 = (I_A + a^2 \cdot I_B + a \cdot I_C) ) Test using single-phase current.</td>
<td>50Q1, 50Q2, 50Q3, 50Q4, 50QF, 50QR</td>
</tr>
<tr>
<td>Positive-Sequence</td>
<td>( I_1 = \frac{1}{3} (I_A + a \cdot I_B + a^2 \cdot I_C) ) Test using three-phase or single-phase current.</td>
<td>50ABC</td>
</tr>
</tbody>
</table>

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.
After you type \textbf{END <ENTER>} to end the set procedure, the relay displays the current logic settings. You must continue to type \textbf{<ENTER>} to review the full group of logic settings. At the prompt, type \textbf{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.

\textbf{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.

\textbf{Negative-Sequence Directional Element}

The SEL-311C 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.

\textbf{Negative-Sequence Directional Element Based Upon Negative-Sequence Impedance}

The SEL-311C 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:

\[ Z_{2e} = \frac{\text{Re}[V_2 \cdot (1 - Z^{\text{ANG}} \cdot I_2)^*]}{|I_2|^2} \]  

Equation 13.1
Where: Re indicates the real part of the term in brackets, for instance Re[A + jB] = A
* indicates the complex conjugate of the expression in parentheses, (A + jB)* = (A - jB).

The result of Equation 13.1 is an impedance magnitude value that varies with the magnitude and angle of applied current. An example illustrates this operation.

Consider the result of applying the following voltage and current signals to Equation 13.1:

\[ V_2 = 10 \angle 180^\circ \text{ volts, secondary} \]
\[ I_2 = 2 \angle -90^\circ \text{ amps, secondary} \]

\[ Z_{2c} = \frac{\text{Re}[10 \angle 180^\circ \cdot (1 \angle 90^\circ \cdot 2 \angle -90^\circ )^*]}{|2|^2} \]

\[ Z_{2c} = \frac{-20 \text{ ohms}}{4} \]

\[ Z_{2c} = -5 \text{ ohms} \]

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 Z_{2c} value.

Here is an example for a reverse single line-ground fault.

\[ V_2 = 10 \angle 180^\circ \text{ volts, secondary} \]
\[ I_2 = 2 \angle 90^\circ \text{ amps, secondary} \]

\[ Z_{2c} = \frac{\text{Re}[10 \angle 180^\circ \cdot (1 \angle 90^\circ \cdot 2 \angle +90^\circ )^*]}{|2|^2} \]

\[ Z_{2c} = \frac{20 \text{ ohms}}{4} \]

\[ Z_{2c} = 5 \text{ ohms} \]

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 Z_{2F} and Z_{2R} relay settings and the magnitude of negative-sequence voltage divided by the magnitude of negative-sequence current.

When Z_{2c} is less than the forward Z_{2} threshold, Z_{2FT}, the fault is in the forward direction, so the relay sets the F32Q and F32QG elements, if other supervisory conditions permit. When Z_{2c} is greater than the reverse Z_{2} threshold, Z_{2RT}, the fault is in the reverse direction, so the relay sets the R32Q and R32QG elements, if other supervisory conditions permit.
The forward directional threshold is calculated using Equation 13.2 when Z2F is negative or Equation 13.3 when Z2F is positive.

When \( Z2F \leq 0 \):
\[
Z2FT = 0.75 \cdot Z2F - 0.25 \cdot Z2m
\]
Equation 13.2

When \( Z2F > 0 \):
\[
Z2FT = 1.25 \cdot Z2F - 0.25 \cdot Z2m
\]
Equation 13.3

Where:
\[
Z2m = \frac{|V_3|}{|I_3|}
\]

The reverse directional threshold is calculated using Equation 13.4 when Z2R is positive or Equation 13.5 when Z2R is negative.

When \( Z2R \geq 0 \):
\[
Z2RT = 0.75 \cdot Z2R + 0.25 \cdot Z2m
\]
Equation 13.4

When \( Z2R < 0 \):
\[
Z2RT = 1.25 \cdot Z2R + 0.25 \cdot Z2m
\]
Equation 13.5

The threshold equations have a unique property. When \( Z2m = |Z2R| \), \( Z2RT = Z2R \) and when \( Z2m = |Z2F| \), \( Z2FT = Z2F \). This property is used to simplify the test procedures outlined on the following pages.

It is possible to create test conditions for a Z2c that lies between the forward and reverse thresholds. In this case the relay does not set the F32Q, F32QG, R32Q, or R32QG elements. While these conditions can be contrived in the lab, correct Z2F and Z2R settings prevent this from occurring for real power system faults.

Settings for both Z2F and Z2R may be either positive or negative, depending upon the constraints of the relay application.

**Negative-Sequence Directional Element Supervisory Conditions**

There are a number of supervisory conditions that must be fulfilled before the relay asserts the negative-sequence directional elements. These supervisory conditions are described below:

**Magnitude of 3I₂**

The SEL-311C Relay uses the 50QF and 50QR negative-sequence overcurrent elements to supervise operation of the directional element. If the magnitude of applied 3I₂ is not greater than the 50QFP setting, the F32Q and F32QG elements do not assert to indicate direction. If the magnitude of 3I₂, 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 (I1) magnitude by the a2 setting, then compares the result to the measured magnitude of negative-sequence current (I2). The magnitude of I1 must be greater than the magnitude of I1 multiplied by a2 for the directional elements (F32Q, F32QG, R32Q or R32QG) to operate.

Relay word bit 32QE asserts when both the 3I1 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 (I0) magnitude by the k2 setting, then compares the result to the measured magnitude of negative-sequence current (I2). The magnitude of I2 must be greater than the magnitude of I0 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; 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>
SEL logic group 1
OUT106 =0

? F32Q <ENTER>
OUT107 =0

? R32Q <ENTER>
DP1 =52A

? END <ENTER>
After you type **END <ENTER>** to end the set procedure, the relay displays the current logic settings. At the prompt, type **Y <ENTER>** to accept those settings.

Connect outputs OUT106 and OUT107 to the sense input of your test set, an ohmmeter, or some other contact sensing device.

**Step 3.** Connect the voltage source to the A-phase to neutral relay voltage input. Connect the current source to the A-phase relay current input. Refer to the A-phase voltage and current connections shown in Figure 13.5 as an example. The B-phase and C-phase voltage connections are not required for this test.

**Step 4.** As described above, the relay 32Q element operates based upon the magnitude and angle of negative-sequence voltages and currents. You can calculate the magnitude and angle of \( V_2 \) and \( I_2 \), given the magnitude and angle of each of the phase quantities using the equations below.

\[
V_2 = \frac{1}{3} \left( V_A + a^2 V_B + a V_C \right) \\
I_2 = \frac{1}{3} \left( I_A + a^2 I_B + a I_C \right)
\]

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

\[
\begin{align*}
V_B &= V_C = 0 \text{ volts} \\
I_B &= I_C = 0 \text{ amps} \\
V_2 &= \frac{1}{3} \left( V_A \right) \\
I_2 &= \frac{1}{3} \left( I_A \right)
\end{align*}
\]

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

\[
\begin{align*}
V_2 &= \frac{1}{3} \left( 18.0 \angle 180^\circ \right) \text{ volts} \\
V_2 &= 6.0 \angle 180^\circ \text{ volts}
\end{align*}
\]

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\(^\circ\). Equation 13.1 yields a negative result when \( I_2 \) leads \( V_2 \) by \( 180^\circ - \angle \text{Z1ANG}^\circ \).

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 \( Z_2 \) equals \( Z_{2R} \) or \( Z_{2F} \) using Equation 13.6:

\[
|I_A| = 3 \cdot (|V_2|/|Z_2|) \\
|I_A| = 3.3 \text{ amps}
\]

For \( Z_{2R} = 5.45 \Omega \):

\[
\begin{align*}
|I_A| &= 3 \cdot (6.0 \text{ volts}/5.45 \text{ ohms}) \\
|I_A| &= 3.3 \text{ amps}
\end{align*}
\]
Calculate \( Z_{2m} \):

\[
Z_{2m} = \frac{|V_2|}{|I_2|} = \frac{6.0}{1.1} \text{ ohms} \\
Z_{2m} = 5.45 \text{ ohms}
\]

Because \( Z_{2R} \) is positive, use Equation 13.4 to calculate \( Z_{2RT} \).

\[
Z_{2RT} = 0.75 \cdot Z_{2R} + 0.25 \cdot Z_{2m} \\
Z_{2RT} = 0.75 \cdot (5.45) + 0.25 \cdot (5.45) \\
Z_{2RT} = 5.45 \text{ ohms}
\]

The \( R_{32Q} \) element asserts when \( Z_{2c} \) applied is greater than \( Z_{2RT} \). As the magnitude of \( I_\alpha \) is increased, the magnitudes of \( Z_{2c} \) and \( Z_{2m} \) decrease. For magnitudes of \( I_\alpha \) less than 3.3 amps, \( R_{32Q} \) asserts, given the other test quantities. For \( I_\alpha \) magnitudes greater than 3.3 amps, \( Z_{2c} \) is less than \( Z_{2RT} \), so \( R_{32Q} \) deasserts.

For \( Z_{2F} = 0.77 \Omega \):

\[
|I_\alpha| = 3 \cdot (6.0 \text{ volts/0.77 ohms}) \\
|I_\alpha| = 23.4 \text{ amps}
\]

Calculate \( Z_{2m} \):

\[
Z_{2m} = \frac{|V_2|}{|I_2|} = \frac{7.7}{7.8} \text{ ohms} \\
Z_{2m} = 0.77 \text{ ohms}
\]

Because \( Z_{2F} \) is positive, use Equation 13.3 to calculate \( Z_{2FT} \).

\[
Z_{2FT} = 1.25 \cdot Z_{2F} - 0.25 \cdot Z_{2m} \\
Z_{2FT} = 1.25 \cdot (0.77) - 0.25 \cdot (0.77) \\
Z_{2FT} = 0.77 \text{ ohms}
\]

The \( F_{32Q} \) element asserts when \( Z_{2c} \) is less than \( Z_{2FT} \). As the magnitude of \( I_\alpha \) is less than \( Z_{2FT} \), the magnitudes of \( Z_{2c} \) and \( Z_{2m} \) decrease. For magnitudes of \( I_\alpha \) less than 23.4 amps, \( F_{32Q} \) should not assert, given the other test quantities. For \( I_\alpha \) magnitudes greater than 23.4 amps, \( Z_{2c} \) applied is less than \( Z_{2FT} \), so \( F_{32Q} \) asserts.

**Step 5.**

Turn on the voltage source.

Apply \( V_\alpha = 18.0 \text{ V} \angle 180^\circ \) \( I_\alpha = 0.0 \text{ A} \angle 96^\circ \).

Slowly increase the magnitude of \( I_\alpha \), without varying the phase angle.

The relay \( R_{32Q} \) element asserts, closing OUT107 when \( |I_\alpha| = 0.5 \text{ amps} \). This indicates that \( Z_{2c} \) applied is greater than \( Z_{2RT} \), \( 3I_\alpha \) is greater than 50QR, and \( I_\alpha \) is greater than \( a_2 \cdot I_\alpha \), where \( a_2 \) 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 \( \text{OUT106} \) when \( |I_A| = 23.4 \) amps, indicating that \( Z2c \) is less than \( Z2FT \).

Verify the performance described above by calculating \( Z2c \) using Equation 13.1 and the test quantities listed above.

For \( V_A = 18.0 \) V \( \angle 180^\circ \), \( I_A = 3.3 \) A \( \angle 96^\circ \):

\[
Z2c = \frac{\text{Re}[V_2 \cdot (1 \angle Z1\text{ANG}^\circ \cdot I_2)^*]}{|I_2|^2}
\]

\[
Z2c = \frac{\text{Re}[6 \angle 180^\circ \cdot (1 \angle 83.97^\circ \cdot 1.10 \angle 96^\circ)^*]}{|1.10|^2}
\]

Equation 13.1

\[
Z2c = 6.6 \text{ ohms} \\
\quad \frac{1.21}{Z2c = 5.45 \text{ ohms} = Z2RT \text{ when } Z2m = 5.45 \text{ ohms}}
\]

For \( V_A = 18.0 \) V \( \angle 180^\circ \), \( I_A = 23.4 \) A \( \angle 96^\circ \), and using the equation above:

\[
V_2 = 6.0 \text{ V} \angle 180^\circ \\
I_2 = 7.80 \\
1 \angle Z1\text{ANG}^\circ = 1 \angle 83.97^\circ
\]

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

\[
Z2c = \frac{46.8 \text{ ohms}}{60.84} \quad Z2c = 0.77 \text{ ohms} = Z2FT \text{ when } Z2m = 0.77 \text{ ohms}
\]

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 \texttt{SHOWSET} command and verify the following relay settings: \( Z1\text{MAG} \), \( Z1\text{ANG} \), \( Z2F \), \( 50\text{QF} \), \( Z2R \), \( 50\text{QR} \), and \( a2 \). The example relay settings use the following settings: \( Z1\text{MAG} = 7.8 \Omega \), \( Z1\text{ANG} = 83.97^\circ \), \( Z2F = 0.77 \Omega \); \( 50\text{QF} = 0.5 \) amps secondary; \( Z2R = 5.45 \Omega \); \( 50\text{QR} = 0.5 \) amps secondary; \( a2 = 0.07 \), \( k2 = 0.2 \)

Execute the \texttt{SET} command and change the example \texttt{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 \texttt{OUT106} and \texttt{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.

```plaintext
->>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.

\[
V_2 = \frac{1}{3} \left( V_A + a^2 \cdot V_B + a \cdot V_C \right)
\]

\[
I_2 = \frac{1}{3} \left( I_A + a^2 \cdot I_B + a \cdot I_C \right)
\]

Using a single-phase current source simplifies the \( I_2 \) calculation.

\[
I_B = I_C = 0 \text{ amps}
\]

\[
I_2 = \frac{1}{3} \cdot (I_A)
\]

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, V₂ is 180° out of phase from Vₐ.
Take this into account, and calculate the angle of Iₐ with respect to the angle of Vₐ.
Equation 13.1 yields a positive result when Iₐ leads Vₐ by \((180° - \angle Z₁ₐ锗°)\).
Equation 13.1 yields a negative result when Iₐ lags Vₐ by \(\angle Z₁ₐ锗°\).

We are testing for positive values of Z₂c, so Iₐ should lead Vₐ by \((180° - \angle Z₁ₐ锗°)\). Assuming that \(Vₐ = 49.0 \angle 0°\) volts, the angle of Iₐ for this test should be 96°.

Calculate the magnitude of A-phase current where Z₂c equals Z₂RT or Z₂FT using Equation 13.6:

\[
|Iₐ| = 3 \cdot (|V₂|/|Z₂|)
\]

Equation 13.6

For Z₂R = 5.45 Ω:

\[
|Iₐ| = 3 \cdot (6.0 \text{ volts}/5.45 \text{ ohms})
\]

\[
|Iₐ| = 3.3 \text{ amps}
\]

Calculate Z₂m:

\[
Z₂m = \frac{|V₂|}{|I₂|}
\]

\[
Z₂m = \frac{6.0 \text{ V}}{1.1 \text{ A}}
\]

\[
Z₂m = 5.45 \text{ ohms}
\]

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 Iₐ is increased, the magnitudes of Z₂c and Z₂m decrease. For magnitudes of Iₐ less than 3.3 amps, R₃₂Q asserts, given the other test quantities. For Iₐ magnitudes greater than 3.3 amps, Z₂c is less than Z₂RT, so R₃₂Q deasserts.

For Z₂F = 0.77 Ω:

\[
|Iₐ| = 3 \cdot (6.0 \text{ volts}/0.77 \text{ ohms})
\]

\[
|Iₐ| = 23.4 \text{ amps}
\]

Calculate Z₂m:

\[
Z₂m = \frac{|V₂|}{|I₂|}
\]

\[
Z₂m = \frac{6.0 \text{ V}}{7.8 \text{ A}}
\]

\[
Z₂m = 0.77 \text{ ohms}
\]
Because Z2F is positive, use Equation 13.3 to calculate Z2FT.

\[
\begin{align*}
Z2FT &= 1.25 \cdot Z2F - 0.25 \cdot Z2m \\
Z2FT &= 1.25 \cdot (0.77) - 0.25 \cdot (0.77) \\
Z2FT &= 0.77 \text{ ohms}
\end{align*}
\]

The F32Q element asserts when Z2c is less than Z2FT. As the magnitude of I_A is increased, the magnitudes of Z2c and Z2m decrease. For magnitudes of I_A less than 23.4 amps, F32Q should not assert, given the other test quantities. For I_A magnitudes greater than 23.4 amps, Z2c applied is less than Z2FT, so F32Q asserts.

**Step 5.** Turn on the voltage sources.

Apply:

- \( V_A = 49.0 \, \text{V} \angle 0^\circ \)
- \( V_B = 67.0 \, \text{V} \angle -120^\circ \)
- \( V_C = 67.0 \, \text{V} \angle 120^\circ \)
- \( I_A = 0.0 \, \text{A} \angle 96^\circ \)

Slowly increase the magnitude of I_A, without varying the phase angle.

The relay R32Q element asserts, closing OUT107 when \(|I_A| = 0.5 \, \text{amps}\). This indicates that Z2c applied is greater than Z2RT, 3I_1 is greater than 50QR, and I_2 is greater than \(a_2 \cdot I_1\), where \(a_2\) is the relay setting.

Continue to increase the magnitude of I_A. R32Q deasserts when \(|I_A| = 3.3 \, \text{amps}\), indicating that Z2c is now less than Z2RT. F32Q asserts, closing OUT106 when \(|I_A| = 23.4 \, \text{amps}\), indicating that Z2c is less than Z2FT.

Verify that the relay operated properly by calculating Z2c using Equation 13.1 and the test quantities listed below.

For:

- \( I_A = 3.30 \, \text{A} \angle 96^\circ \)
- \( V_A = 49.0 \, \text{V} \angle 0^\circ \)
- \( V_B = 67.0 \, \text{V} \angle -120^\circ \)
- \( V_C = 67.0 \, \text{V} \angle 120^\circ \)

\[
\begin{align*}
V_2 &= 6.0 \, \text{V} \angle 180^\circ \\
I_2 &= 1.10 \\
I_2 \angle Z1\text{ANG}^\circ &= 1 \angle 83.97^\circ
\end{align*}
\]
\[ Z_{2c} = \frac{\text{Re}[V_2 \cdot (1 \angle Z_{1\text{ANG}} \cdot I_2)]}{|I_2|^2} \]
\[ Z_{2c} = \frac{\text{Re}[6 \angle 180^\circ \cdot (1 \angle 83.97^\circ \cdot 1.10 \angle 96^\circ)]}{|1.10|^2} \]  \hspace{1cm} \text{Equation 13.1} \\
\[ Z_{2c} = \frac{6.6 \text{ ohms}}{1.21} \] \\
\[ Z_{2c} = 5.45 \text{ ohms} = Z_{2\text{RT}} \text{ when } Z_{2m} = 5.45 \text{ ohms} \]

For:

\[ I_A = 23.4 \text{ A} \angle 96^\circ \] \\
\[ V_A = 49.0 \text{ V} \angle 0^\circ \] \\
\[ V_B = 67.0 \text{ V} \angle -120^\circ \] \\
\[ V_C = 67.0 \text{ V} \angle 120^\circ \] \\
\[ V_2 = 6.0 \text{ V} \angle 180^\circ \] \\
\[ I_2 = 7.80 \] \\
\[ 1 \angle Z_{1\text{ANG}} = 1 \angle 83.97^\circ \]

\[ Z_{2c} = \frac{\text{Re}[6 \angle 180^\circ \cdot (1 \angle 83.97^\circ \cdot 7.80 \angle 96^\circ)]}{|7.80|^2} \] \\
\[ Z_{2c} = \frac{46.8 \text{ ohms}}{60.84} \] \\
\[ Z_{2c} = 0.77 \text{ ohms} = Z_{2\text{F}} \text{ when } Z_{2m} = 0.77 \text{ ohms} \]

**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-311C 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.

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, V, and V.

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

<table>
<thead>
<tr>
<th>Test Voltages</th>
<th>Test Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_A = 67 \angle 0^\circ$ volts</td>
<td>$I_{\text{TEST}} = 2.5 \angle -173.97^\circ$ amps</td>
</tr>
<tr>
<td>$V_B = 46.8 \angle -150^\circ$ volts</td>
<td></td>
</tr>
<tr>
<td>$V_C = 46.8 \angle 150^\circ$ volts</td>
<td></td>
</tr>
</tbody>
</table>

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.

\[
I_{\text{TEST}} = I_B = -I_C \\
I_{BC} = I_B - I_C \\
I_{BC} = 2 \cdot I_B \\
I_{BC} = 2 \cdot I_{\text{TEST}}
\]

With a 50PP2 setting of 2.22 amps, 50PP2 picks up when $I_{\text{TEST}}$ 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 $I_{\text{TEST}}$.

\[
I_2 = \frac{1}{3} \cdot \left( I_A + a^2 \cdot I_B + a \cdot I_C \right) \\
3 \cdot I_2 = \left( I_A + a^2 \cdot I_B + a \cdot I_C \right) \\
I_A = 0 \text{ and } I_C = -I_B, \text{ so:} \\
3 \cdot I_2 = (a^2 \cdot I_B - a \cdot I_B) \\
3 \cdot I_2 = I_B \cdot (a^2 - a) \\
3 \cdot I_2 = I_B \cdot (1.732 \angle -90^\circ)
\]
Because the 50QF element operates based upon magnitude only, the equation above is simplified.

$$|3 \cdot I_2| = |I_{\text{TEST}}| \cdot 1.732$$

With a 50QF setting of 0.5 amps, 50QF picks up when $I_{\text{TEST}}$ is greater than 0.288 amps.

In this example, select $|I_{\text{TEST}}| = 2.5$ amps, thus $I_{\text{bc}} = 5.0$ 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 $Z_{2P} = 9.36$ secondary ohms.

Calculate the magnitude of $V_{bc}$ using Equation 13.7.

$$|V_{bc}| = |I_{bc}| \cdot |Z_{bc}|$$

$$|V_{bc}| = 5.0 \cdot 9.36$$

$$|V_{bc}| = 46.8 \text{ volts secondary}$$

Refer to Figure 13.8 and use the equations below to calculate the magnitude and angle of $V_a$ and $V_c$ based upon the magnitude of $V_{bc}$ calculated above.

![Figure 13.8: Phase Distance Element Test Voltage Signals](image)

When the magnitude of $V_{bc}$ calculated above lies between 67 and 35 volts, use $\beta = 150^\circ$ and $|V_a| = |V_c| = |V_{ac}|$.

When the magnitude of $V_{bc}$ calculated above is greater than 67 volts, use $|V_a| = |V_c| = 67 V$. Calculate the angle $\beta$ using Equation 13.8.

When the magnitude of $V_{bc}$ calculated above is less than 35 volts, use $|V_a| = |V_c| = 35 V$. Calculate the angle $\beta$ using Equation 13.8.

$$\beta = 180^\circ - \sin \left[\frac{|V_{bc}|}{(2 \cdot |V_c|)}\right] \text{deg}$$

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.
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-311C Relay, the phase distance element maximum torque angle is defined by the angle of the relay Z1ANG setting.

For the example relay settings, I_{nc} should lag V_{nc} by 83.97°. Based upon the test voltages selected above, V_{nc} lags V_A by 90°, so I_{nc} 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, Z_{2c}, applied using Equation 13.1 and compare Z_{2c} to the Z_{2FT} threshold which is a function of the Z_{2F} setting and Z_{2m}.

\[
V_2 = \frac{1}{3} \left( V_A + a^2 \cdot V_B + a \cdot V_C \right)
\]
\[
I_2 = \frac{1}{3} \left( I_A + a^2 \cdot I_B + a \cdot I_C \right)
\]

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

Equation 13.1

\[
Z_{2m} = \frac{|V_2|}{|I_2|}
\]

\[
Z_{2FT} = 1.25 \cdot Z_{2F} - 0.25 \cdot Z_{2m}
\]

Equation 13.3

Taking the test signals from Table 13.3.

\[
V_A = 67.0 V \angle 0^\circ \text{ volts}
\]
\[
V_B = 46.8 V \angle -150^\circ \text{ volts}
\]
\[
V_C = 46.8 V \angle 150^\circ \text{ volts}
\]

\[
V_2 = \frac{1}{3} \left( 67.0 \angle 0^\circ +1 \angle 240^\circ \cdot 46.8 \angle -150^\circ +1 \angle 120^\circ \cdot 46.8 \angle 150^\circ \right) \text{ volts}
\]

\[
V_2 = 22.3 \angle 0^\circ \text{ volts}
\]

Due to the test connections used, I_{n} = -I_{c} = I_{test}:

\[
I_A = 0.0 A \angle 0^\circ
\]
\[
I_B = 2.5 A \angle -173.97^\circ
\]
\[
I_C = 2.5 A \angle 60.3^\circ
\]
Using Equation 13.1 to calculate $Z_2c$, the result is:

$Z_2c = -15.47 \text{ ohms}$

$Z_2m = 15.47 \text{ ohms}$

$Z_{2FT} = 1.25 \cdot (0.77) - 0.25 \cdot (15.47)$

$Z_{2FT} = -2.91 \text{ ohms}$

The $Z_{2FT}$ threshold is -2.91 $\Omega$. $Z_2c$ applied (-15.47 $\Omega$) is less than the $Z_{2FT}$ threshold based on the $Z_2F$ setting (0.77 $\Omega$) and $Z_2m$ (15.47 $\Omega$), therefore, the 32QF element asserts when these signals are applied. If $Z_2c$ applied is greater than the $Z_{2FT}$ 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:

$$Z_{BC} = \frac{V_{BC}}{2 \cdot I_{TEST}} \text{ ohms, sec}$$

Equation 13.9

You may wish to test the distance element characteristic at impedance angles other than the line positive-sequence impedance angle. To do this, you must adjust the magnitude and angle of $I_{TEST}$ from the values shown in Table 13.3. As an example, calculate the current signal necessary to test the distance element at an angle of 38.97°.

First, the new desired impedance angle (38.97°) is 45° less than the original test impedance angle (83.97°). Add 45° to the angle of $I_{TEST1}$.

$\angle I_{TEST2} = \angle I_{TEST1} + 45^\circ$

$\angle I_{TEST2} = -173.97^\circ + 45^\circ$

$\angle I_{TEST2} = -128.97^\circ$

Calculate the magnitude of $I_{TEST2}$ using Equation 13.10.

$$|I_{TEST2}| = \frac{|I_{TEST1}|}{\cos(\text{Line Impedance Angle} - \text{New Test Impedance Angle})} \text{ amps, sec}$$
Ground Mho Distance Elements

The SEL-311C 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.

\[
|I_{\text{TEST2}}| = \frac{2.5}{\cos(83.97^\circ - 38.97^\circ)} \text{ amps}
\]

\[
|I_{\text{TEST2}}| = \frac{2.5}{\cos(45^\circ)} \text{ amps}
\]

\[
|I_{\text{TEST2}}| = 3.54 \text{ amps}
\]

Note: As you perform this test, other protection elements may assert, causing the relay to close other output contacts and assert relay targets. This is normal and is not a cause for concern.
Ground 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-311C 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: Z1MG, Z1ANG, E21MG, E32, Z2MG, 50L2, 50GZ2, k0M1, k0A1, ORDER, Z2F, and 50QF. The example relay settings use the following settings: Z1MG = 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>
<thead>
<tr>
<th>Test Voltages</th>
<th>Test Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_A = 40.4 \angle 0^\circ \text{ volts} )</td>
<td>( I_{\text{TEST}} = 2.5 \angle -82.42^\circ \text{ amps} )</td>
</tr>
<tr>
<td>( V_B = 67.0 \angle -120^\circ \text{ volts} )</td>
<td></td>
</tr>
<tr>
<td>( V_C = 67.0 \angle 120^\circ \text{ volts} )</td>
<td></td>
</tr>
</tbody>
</table>

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 3I₂ 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 Iₐ is equal to the magnitude of the applied test current. With a 50L2 setting of 0.50 amps, 50L2 picks up when Iₜᵉˢᵗ 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 Iᵣ is equal to the magnitude of the applied test current, Iₐ. With a 50GZ2 setting of 0.50 amps, 50G2 picks up when Iₜᵉˢᵗ is greater than 0.50 amps.

The 50QF negative-sequence overcurrent element operates based upon the magnitude of 3I₂ applied. Using the current connections shown in Figure 13.5, we can calculate the magnitude of 3I₂ applied based upon the magnitude of Iₜᵉˢᵗ. With a 50QF setting of 0.5 amps, 50QF picks up when Iₜᵉˢᵗ is greater than 0.5 amps.

Select the magnitude of Iₐ 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 |Iₜᵉˢᵗ| = 2.5 amps. This selection fulfills the supervisory overcurrent conditions described above.

The reach of the distance element under test in secondary ohms is defined by the element setting. In this case Z2MG = 9.36 Ω. The impedance measured by the relay for a ground fault is determined by the faulted phase voltage, faulted phase current, and the residual current multiplied by the zero-sequence current compensation factor, k₀. The SEL-311C 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:

\[
Z_{AG} = \frac{V_A}{I_A + k₀ \cdot I_R}
\]

Equation 13.11

Where: k₀ = k₀M ≤ k₀A°

For a fault on a radial system and when testing a ground distance element using a single current source, Iₐ = Iᵣ. In this case, Equation 13.11 can be simplified:
If we multiply both sides of Equation 13.12 by the quantity \((1 + k_0)\), the result is the impedance applied by the A-phase test signals, \(V_A\) and \(I_A\).

\[
Z_{AG} \cdot (1 + k_0) = \frac{V_A}{I_A} \quad \text{Equation 13.13}
\]

Since we are testing the Zone 2 mho ground distance element, the intended value of \(Z_{AG} = Z_{2MG} = 9.36 \, \Omega\). The angle of \(Z_{2MG}\) is equal to the angle of positive-sequence impedance, \(Z_{1ANG}\).

Because the element under test is not a Zone 1 element, the \(k_0\) value is defined by the relay settings \(k_{0M}\) and \(k_{0A}\). When you test the relay Zone 1 ground elements, use \(k_{01M}\) and \(k_{01A}\) to define the magnitude and angle of \(k_0\).

Calculate the value of \(Z_{AG} \cdot (1 + k_0)\) based upon the information above.

\[
Z_{AG} \cdot (1 + k_0) = Z_{TEST} = Z_{2MG} \cdot (1 + k_{0M} \angle k_{0A}) \quad \text{Equation 13.14}
\]

\[
Z_{TEST} = 9.36 \angle 83.97^\circ \cdot (1 + 0.726 \angle -3.69^\circ)
\]

\[
Z_{TEST} = 9.36 \angle 83.97^\circ \cdot (1.725 \angle -1.55^\circ)
\]

\[
Z_{TEST} = 16.15 \angle 82.42^\circ
\]

\(I_A\) 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 \(0^\circ\), the angle of \(I_A\) is:

\[
I_A = 2.5 \angle -82.42^\circ
\]

Calculate the magnitude of \(V_A\) using Equation 13.15

\[
V_A = I_A \cdot Z_{TEST}
\]

\[
V_A = 2.5 \angle -82.42^\circ \cdot 16.15 \angle 82.42^\circ
\]

\[
V_A = 40.4 \angle 0.0^\circ \text{ volts secondary}
\]

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, \(Z_{2c}\), applied using Equation 13.1 and compare \(Z_{2c}\) to the \(Z_{2FT}\) threshold that is a function of the \(Z_{2F}\) setting and \(Z_{2m}\).

\[
V_2 = \frac{1}{3} \left( V_A + a^2 \cdot V_B + a \cdot V_C \right)
\]

\[
I_2 = \frac{1}{3} \left( I_A + a^2 \cdot I_B + a \cdot I_C \right)
\]
\[ Z_{2c} = \text{Re}[V_2 \cdot (1 \angle Z1\text{ANG}^\circ \cdot I_2)^*] \]
\[ Z_{2m} = \frac{|V_2|}{|I_2|} \]
\[ Z_{2FT} = 1.25 \cdot Z_{2F} - 0.25 \cdot Z_{2m} \]

Taking the test signals from Table 13.4:

\[ V_A = 40.4 \text{ V} \angle 0^\circ \]
\[ V_B = 67.0 \text{ V} \angle -120^\circ \]
\[ V_C = 67.0 \text{ V} \angle 120^\circ \]

\[ V_2 = \frac{1}{2} \cdot (40.4 \angle 0^\circ + 1 \angle 240^\circ \cdot 67.0 \angle -120^\circ + 1 \angle 120^\circ \cdot 67.0 \angle 120^\circ) \text{ volts} \]
\[ V_2 = 8.88 \angle 180^\circ \text{ volts} \]

\[ I_A = 2.5 \angle -82.42^\circ \]
\[ I_B = 0.0 \angle 0.0^\circ \]
\[ I_C = 0.0 \angle 0.0^\circ \]

\[ I_2 = \frac{1}{3} \cdot (2.5 \angle -82.42^\circ) \text{ amps} \]
\[ I_2 = 0.83 \angle -82.42^\circ \text{ amps} \]

Using Equation 13.1 to calculate \( Z_2 \), the result is:

\[ Z_{2c} = -10.66 \text{ ohms} \]
\[ Z_{2m} = 15.47 \text{ ohms} \]
\[ Z_{2FT} = 1.25 \cdot (0.77) - 0.25 \cdot (15.47) \]
\[ Z_{2FT} = -2.91 \text{ ohms} \]

The relay example \( Z_{2F} \) setting is 0.77 \( \Omega \). \( Z_{2c} \) applied (-10.66 \( \Omega \)) is less than the \( Z_{2FT} \) threshold (-2.91 \( \Omega \)), therefore, the 32GF element asserts when these signals are applied. If \( Z_{2c} \) applied is greater than the \( Z_{2FT} \) 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 \( Z_{2G} \) 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 \( I_{\text{TEST}} \) 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 \( I_{T_2} \):

\[
\angle I_{T2} = \angle I_{T1} + 45°
\]

\[
\angle I_{T2} = -173.97° + 45°
\]

\[
\angle I_{T2} = -128.97°
\]

Calculate the magnitude of \( I_{T2} \) using Equation 13.10.

\[
|I_{T2}| = \left| I_{T1} \right| \frac{\cos\text{(Line Impedance Angle – New Test Impedance Angle)}}{\cos(83.97° - 38.97°)} \text{amps, sec}
\]

\[
|I_{T2}| = \frac{2.5}{\cos(45°)} \text{amps}
\]

\[
|I_{T2}| = 3.54 \text{ amps}
\]

**Note:** As you perform this test, other protection elements may assert, causing the relay to close other output contacts and assert relay targets. This is normal and is not a cause for concern.

**Ground Quadrilateral Distance Element Reactive Reach Test Using Three Voltage Sources and One Current Source**

**Note:** This test refers directly to the Zone 2 ground quadrilateral distance element, but may be applied to any other forward-reaching ground quadrilateral 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 of this section.

**Step 1.** Execute the **SHOWSET** command and verify the following relay settings: Z1MAG, Z1ANG, E21XG, E32, XG2, RG2, 50L2, 50GZ2, k0M, k0A, T, ORDER, Z2F, and 50QF. The example relay settings use the following settings: Z1MAG = 7.8 Ω; Z1ANG = 83.97°; E21XG = 3; E32= Y; XG2 = 9.36 Ω; RG2 = 5.00 Ω; 50L2 = 0.50; 50GZ2 = 0.50; k0M = 0.726; k0A = -3.69; T = 0.00; ORDER = Q, Z2F = 0.77; 50QF = 0.5 amps secondary.

Execute the **SET** command and change the following settings. Change E21MG to N, E21XG to 3, XG1 = 6.24, XG2 = 9.36, XG3 = 1.87, RG1 = 2.5, RG2 = 5.0, and RG3 = 6.0. Changing the E21MG setting prevents the relay ground mho distance elements from interfering with the test.

**Step 2.** Select output contacts 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.
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 13.5 summarizes the test quantities for the Zone 2 A-G ground quadrilateral distance element based upon the example relay settings.

<table>
<thead>
<tr>
<th>Test Voltages</th>
<th>Test Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_A = 40.4 \angle 0^\circ$ volts</td>
<td>$I_{TEST} = 2.49 \angle -90.0^\circ$ amps</td>
</tr>
<tr>
<td>$V_B = 67.0 \angle -120^\circ$ volts</td>
<td></td>
</tr>
<tr>
<td>$V_C = 67.0 \angle 120^\circ$ volts</td>
<td></td>
</tr>
</tbody>
</table>

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 reactive reach of the quadrilateral distance element under test is defined by the XG2 element setting. In this case XG2 = 9.36 secondary ohms. 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, $k_0$. The SEL-311C Relay uses k01M and k01A settings to define the zero-sequence current compensation factor for Zone 1 ground
distance elements and the k0M and k0A settings to define that factor for the remaining zones.

The reactance measured by the relay ground quadrilateral distance element for a Zone 2 fault is defined by the following equation:

\[ X_{AG} = \frac{\text{Im}(V_A (I_R \cdot 1 \angle T^\circ)*)}{\text{Im}(I \angle Z1ANG \cdot (I_A + k0 \cdot I_R) \cdot (I_R \cdot 1 \angle T^\circ)*)} \]  
Equation 13.16

Where:

- \( k0 = k0M \leq k0A^\circ \)
- \( T = \) Non-homogenous system compensation setting

For a fault on a radial system and when testing a ground distance element using a single current source, \( I_A = I_R \). Equation 13.16 can be simplified:

\[ X_{AG} = \frac{\text{Im}(V_A (I_A \cdot 1 \angle T^\circ)*)}{\text{Im}(I \angle Z1ANG \cdot (1 + k0) \cdot I_A \cdot (I_A \cdot 1 \angle T^\circ)*)} \]  
Equation 13.17

When \( T = 0^\circ \), as it does in the example relay settings, Equation 13.17 can be further simplified using the following identity:

\[ |I_A|^2 = (I_A) \cdot (I_A)^* \]
\[ X_{AG} = \frac{\text{Im}(V_A (I_A)^*)}{\text{Im}(I \angle Z1ANG \cdot |I_A|^2 \cdot (1 + k0))} \]  
Equation 13.18

If we select a value for \( V_A \), it then becomes possible to use Equation 13.18 to calculate the magnitude and angle of \( I_A \) required to test the Zone 2 ground quadrilateral distance element reactive reach.

For the example, select \( V_A = 40.0 \angle 0^\circ \). To simplify the reactance calculation, select the angle of \( I_A = -90^\circ \) with respect to \( V_A \). For the Zone 2 element, \( XG2 = 9.36 \Omega, \angle Z1ANG = 83.97^\circ, \) and \( k0 = 0.726 \leq -3.69^\circ \).

\[ 9.36 = \frac{\text{Im}(40.0 \angle 0^\circ \cdot |I_A| \angle 90^\circ)}{|I_A|^2 \cdot \text{Im}(1 \angle 83.97^\circ \cdot (1 + 0.726 \angle -3.69^\circ))} \]

The result of computing the imaginary portion of \( V_A \cdot I_A^* \) when \( I_A \) lags \( V_A \) by 90° is:

\[ \text{Im}(V_A \angle 0^\circ, I_A \angle 90^\circ) = |V_A| \cdot |I_A| \]

Substituting this into the equation above yields:

\[ 9.36 = \frac{40.0 \cdot |I_A|}{|I_A|^2 \cdot (1.71)} \]
Solving for the magnitude of $I_A$ yields:

$$|I_A| = \frac{40.0}{(9.39) \cdot (1.71)} = 2.49 \text{ amps}$$

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 3I2 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 0.50 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.

With a 50GZ2 setting of 0.50 amps, 50GZ2 picks up when $I_{TEST}$ is greater than 0.50 amps.

The 50QF negative-sequence overcurrent element operates based upon the magnitude of 3I2 applied. Using the current connections shown in Figure 13.5, calculate the magnitude of 3I2 applied based upon the magnitude of $I_{TEST}$.

$$I_2 = \frac{1}{3} \left( I_A + a^2 \cdot I_B + a \cdot I_C \right)$$

$$3 \cdot I_2 = \left( I_A + a^2 \cdot I_B + a \cdot I_C \right)$$

$$I_A = I_{TEST} \text{ and } I_B = I_C = 0, \text{ so :}$$

$$3 \cdot I_2 = I_{TEST}$$

With a 50QF setting of 0.5 amps, 50QF picks up when $I_{TEST}$ is greater than 0.5 amps.

We calculated $|I_A| = |I_{TEST}| = 2.49 \text{ amps}$ which satisfies the supervisory overcurrent conditions described above.

Select $V_B = 67 \angle -120^\circ \text{ volts}$ and $V_C = 67 \angle 120^\circ \text{ volts}$.

The ground distance elements are supervised by the ground directional element. Check the negative-sequence quantities applied and verify that the 32GF element asserts. Calculate the magnitude and angle of negative-sequence voltage and current applied for the test quantities listed above. Then calculate the negative-sequence impedance, $Z_{2c}$, applied using Equation 13.1.

$$V_2 = \frac{1}{3} \left( V_A + a^2 \cdot V_B + a \cdot V_C \right)$$

$$I_2 = \frac{1}{3} \left( I_A + a^2 \cdot I_B + a \cdot I_C \right)$$
\[ Z_2 = \frac{\text{Re}\{V_2 \cdot (1\angle Z1A\angle A \cdot I_2)\}}{|I_2|^2} \]  
\[ \text{Equation 13.1} \]

\[ Z_{2m} = \frac{|V_2|}{|I_2|} \]

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

Taking the test signals from Table 13.5.

\[ V_A = 40.4 \text{ V} \angle 0^\circ \]
\[ V_B = 67.0 \text{ V} \angle -120^\circ \]
\[ V_C = 67.0 \text{ V} \angle 120^\circ \]

\[ V_2 = \frac{1}{3} \cdot (40.4 \angle 0^\circ + 1 \angle 240^\circ \cdot 67.0 \angle -120^\circ + 1 \angle 120^\circ \cdot 67.0 \angle 120^\circ) \text{ volts} \]
\[ V_2 = 9.0 \angle 180^\circ \text{ volts} \]

\[ I_A = 2.49 \text{ A} \angle -90.0^\circ \]
\[ I_B = 0.0 \text{ A} \angle 0.0^\circ \]
\[ I_C = 0.0 \text{ A} \angle 0.0^\circ \]

\[ I_2 = \frac{1}{3} \cdot (2.49 \angle -90.0^\circ) \text{ amps} \]
\[ I_2 = 0.83 \angle -90.0^\circ \text{ amps} \]

Using Equation 13.1 to calculate Z2c, the result is:

\[ Z_{2c} = -10.84 \text{ ohms} \]
\[ Z_{2m} = 10.84 \text{ ohms} \]
\[ Z_{2\text{FT}} = 1.25 \cdot (0.77) - 0.25 \cdot (10.84) \]
\[ Z_{2\text{FT}} = -4.46 \text{ ohms} \]

The relay example Z2F setting is 0.77 \( \Omega \). Z2c applied (-10.84 \( \Omega \)) is less than the Z2FT threshold (-4.46 \( \Omega \)), therefore, the 32GF element asserts when these signals are applied. If Z2c applied is greater than the Z2FT setting, 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 13.5. Turn on the current test source. Set the current angle to -90.0\(^\circ\). Slowly increase the magnitude of current applied until the Z2G element asserts, causing OUT106 to close. This occurs when current applied is approximately 2.49 amps.

**Note:** As you perform this test, other protection elements may assert, causing the relay to close other output contacts and assert relay targets. This is normal and is not a cause for concern.
Ground Quadrilateral Distance Element Resistive Reach Test Using Three Voltage Sources and One Current Source

Note: This test refers directly to the Zone 2 ground quadrilateral distance element, but may be applied to any other forward-reaching ground quadrilateral 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 6. Execute the **SHOWSET** command and verify the following relay settings: Z1MAG, Z1ANG, E21XG, E32, XG2, RG2, 50L2, 50GZ2, k0M, k0A, T, ORDER, Z2F, and 50QF. The example relay settings use the following settings: Z1MAG = 7.8 Ω; Z1ANG = 83.97°; E21XG = 3; E32= Y; XG2 = 9.36 Ω; RG2 = 5.00 Ω; 50L2 = 0.50; 50GZ2 = 0.50; k0M = 0.726; k0A = -3.69; T = 0.00; ORDER = Q, Z2F = 0.77; 50QF = 0.5 amps secondary.

 Execute the **SET** command and change the following settings. Change E21MG to N, E21XG to 3, and ELOP from Y to N. Changing the E21MG setting prevents the relay ground mho 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 1. Select an output contact to indicate operation of the Z2G element. In this example 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.

```bash
>>>SET L 1 OUT106 <ENTER>
SELogic group 1
OUT106 =0
? Z2G <ENTER>
OUT8 =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 2. 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 3. Select the magnitude of the test signals, $I_\alpha$ and $V_\alpha$.

Table 13.6 summarizes the test quantities for the Zone 2 A-G ground quadrilateral distance element based upon the example relay settings.
Table 13.6: Test Quantities for Zone 2 Ground Quadrilateral Distance Element: Resistive Reach

<table>
<thead>
<tr>
<th>Test Voltages</th>
<th>Test Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_A = 40.0 \angle 0^\circ$ volts</td>
<td>$I_{\text{TEST}} = 8.0 \angle 0.0^\circ$ amps</td>
</tr>
<tr>
<td>$V_B = 67.0 \angle -120^\circ$ volts</td>
<td></td>
</tr>
<tr>
<td>$V_C = 67.0 \angle 120^\circ$ volts</td>
<td></td>
</tr>
</tbody>
</table>

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 resistive reach of the quadrilateral distance element under test is defined by the RG2 element setting. In this case RG2 = 5.00 secondary ohms. 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, $k_0$. The SEL-321 Relay uses $k_{01M}$ and $k_{01A}$ settings to define the zero-sequence current compensation factor for all zones.

The reactance measured by the relay ground quadrilateral distance element for a Zone 2 fault is defined by the following equation:

$$R_{AG} = \frac{\text{Im}(V_A ((I_A + k_0 \cdot I_R) \cdot 1 \angle Z1\text{ANG})*)}{\text{Im}((\frac{1}{2} \cdot (I_{A2} + I_{A0}) (I_A + k_0 \cdot I_R) \cdot 1 \angle Z1\text{ANG})*)}$$

Equation 13.9

Where:

- $k_0 = k_{01M} \leq k_{01A}$ for Zone 1, 2, 3, and 4
- $I_{A2}$ = negative-sequence current flowing in A-phase for the fault
- $I_{A0}$ = zero-sequence current flowing in A-phase for the fault

For a fault on a radial system with no load and when testing a ground distance element using a single current source, $I_A = I_R$, $I_{A2} = I_A/3$, and $I_{A0} = I_A/3$. Equation 13.9 can be simplified:

$$R_{AG} = \frac{\text{Im}(V_A \cdot (I_A \cdot (1 + k_0) \cdot 1 \angle Z1\text{ANG})*)}{\text{Im}(I_A \cdot (1 + k_0) \cdot 1 \angle Z1\text{ANG})*)}$$

Equation 13.10

Select a value for $V_A$. Then it is possible to use Equation 13.10 to calculate the magnitude and angle of $I_A$ required to test the Zone 2 ground quadrilateral distance element resistive reach.
For the example, select $V_a = 40.0 \angle 0^\circ$. To simplify the resistance calculation, select the angle of $I_A = 0^\circ$. For the Zone 2 element, $RG2 = 5.00 \ \Omega$, $\angle Z1ANG = 83.97^\circ$, and $k01 = 0.726 \angle -3.69^\circ$.

$$5.00 = \frac{\text{Im}(40.0 \angle 0^\circ (I_A \cdot (1 + 0.726 \angle -3.69^\circ) \cdot 1 \angle 83.97^\circ))}{\text{Im}(I_A \cdot (1 + 0.726 \angle -3.69^\circ) \cdot 1 \angle 83.97^\circ))}$$

Equation 13.11

Because the angle of $I_A$ equals $0^\circ$, simplify the equation above:

$$5.00 = \frac{40.0 \cdot |I_A| \cdot \text{Im}(1.725 \angle -82.42^\circ)}{|I_A|^2 \cdot \text{Im}(1.725 \angle -82.42^\circ)}$$

Canceling the imaginary terms, and rearranging the equation to calculate $|I_A|$ yields:

$$|I_A| = \frac{40.0}{5.0}$$

$$|I_A| = 8.0 \text{ amps}$$

The Zone 2 ground distance element is forward. 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 3I2 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 $I_{\text{test}}$ is greater than 0.50 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.

With a 50GZ2 setting of 0.50 amps, 50GZ2 picks up when $I_{\text{test}}$ is greater than 0.50 amps.

The 50QF negative-sequence overcurrent element operates based upon the magnitude of 3I2 applied. Using the current connections shown in Figure 13.5, calculate the magnitude of 3I2 applied based upon the magnitude of $I_{\text{test}}$. 
\[
I_2 = \frac{1}{3} \left( I_A + a^2 \cdot I_B + a \cdot I_C \right) \\
3 \cdot I_2 = \left( I_A + a^2 \cdot I_B + a \cdot I_C \right) \\
I_A = I_{\text{TEST}} \quad \text{and} \quad I_B = I_C = 0, \quad \text{so} \\
3 \cdot I_2 = I_{\text{TEST}}
\]

With a 50QF setting of 0.5 amps, 50QF picks up when \( I_{\text{TEST}} \) is greater than 0.5 amps.

We calculated \( |I_A| = |I_{\text{TEST}}| = 8.0 \) amps which satisfies the supervisory overcurrent conditions described above.

Select \( V_B = 67 \angle -120^\circ \) volts and \( V_C = 67 \angle 120^\circ \) volts.

The ground distance elements are supervised by the negative-sequence directional element. Check the negative-sequence quantities applied and verify that the 32GF element should assert. Calculate the magnitude and angle of negative-sequence voltage and current applied for the test quantities listed above. Then calculate the negative-sequence impedance, \( Z_{2c} \), applied using Equation 13.1.

\[
V_2 = \frac{1}{3} \left( V_A + a^2 \cdot V_B + a \cdot V_C \right) \\
I_2 = \frac{1}{3} \left( I_A + a^2 \cdot I_B + a \cdot I_C \right) \\
Z_{2c} = \frac{\text{Re}[V_2 \cdot (1 \angle Z1ANG^\circ \cdot I_2)^*]}{|I_2|^2} \quad \text{Equation 13.1}
\]

\[
Z_{2m} = \frac{|V_2|}{|I_2|}
\]

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

Taking the test signals from Table 13.6.

\[
V_A = 40.0 \ \text{V} \angle 0^\circ \\
V_B = 67.0 \ \text{V} \angle -120^\circ \\
V_C = 67.0 \ \text{V} \angle 120^\circ \\
V_2 = \frac{1}{3} \cdot (40.0 \angle 0^\circ + I \angle 240^\circ \cdot 67.0 \angle -120^\circ + I \angle 120^\circ \cdot 67.0 \angle 120^\circ) \ \text{volts} \\
V_2 = 9.0 \angle 180^\circ \ \text{volts}
\]

\[
I_A = 8.0 \angle 0.0^\circ \\
I_B = 0.0 \angle 0.0^\circ \\
I_C = 0.0 \angle 0.0^\circ \\
I_2 = \frac{1}{3} \cdot (8.0 \angle 0.0^\circ) \ \text{amps} \\
I_2 = 2.67 \angle 0.0^\circ \ \text{amps}
\]
Using Equation 13.1 to calculate $Z_2c$, the result is:

$$Z_2c = -3.37 \text{ ohms}$$
$$Z_2m = 3.37 \text{ ohms}$$
$$Z_{2FT} = 1.25 \cdot (0.77) - 0.25 \cdot (3.37)$$
$$Z_{2FT} = 0.12 \text{ ohms}$$

The relay example $Z_{2F}$ setting is 0.77 $\Omega$. $Z_2c$ applied (-3.37 $\Omega$) is less than the $Z_{2FT}$ threshold (0.12 $\Omega$), therefore, the 32QF element should assert when these signals are applied. If $Z_2c$ applied is greater than the $Z_{2FT}$ threshold, select new test current and voltages using the steps outlined above.

**Step 4.** Turn on the voltage sources. Apply $V_A$, $V_B$, and $V_C$ at the magnitudes and angles listed in Table 13.6. Turn on the current test source. Set the current angle to 0.0°. Slowly increase the magnitude of current applied until the $Z_{2G}$ element asserts, causing OUT106 to close. This occurs when current applied is approximately 8.0 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.

**Troubleshooting Test Results**

The following information is intended to help you troubleshoot relay tests if the relay does not perform as you expected.

<table>
<thead>
<tr>
<th>Symptom: Incorrect Targets</th>
<th>What to check:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check the relay event report. Determine the asserted elements at the instant the TRIP output was asserted.</td>
<td></td>
</tr>
<tr>
<td>Verify the ac connections by plotting currents and voltages from event report data.</td>
<td></td>
</tr>
<tr>
<td>Verify the TR, TRCOMM, and TRSOTF settings to ensure the appropriate elements are enabled to trip.</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symptom: Incorrect Tripping</th>
<th>What to check:</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Check the TR, TRCOMM, and TRSOTF settings to determine which elements are enabled to trip.</td>
<td></td>
</tr>
<tr>
<td>Check the output logic equation settings to determine which outputs are enabled to trip.</td>
<td></td>
</tr>
<tr>
<td>Symptom: Incorrect Distance Element Characteristic Shape</td>
<td>What to check:</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td>• Check the settings of elements that are enabled to trip.</td>
</tr>
<tr>
<td></td>
<td>• Check the settings of elements that supervise elements that are enabled to trip.</td>
</tr>
<tr>
<td></td>
<td>• 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.</td>
</tr>
<tr>
<td></td>
<td>• Verify the distance element settings, including Zone 1 Extension logic settings.</td>
</tr>
<tr>
<td></td>
<td>• 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.</td>
</tr>
<tr>
<td></td>
<td>• Verify the directional element settings. 32QF supervises forward-reaching phase and ground distance elements. 32QR supervises reverse-reaching phase and ground distance elements.</td>
</tr>
<tr>
<td></td>
<td>• 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.</td>
</tr>
<tr>
<td></td>
<td>• 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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symptom: Incorrect Contact Operation</th>
<th>What to check:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Check the logic equation settings to determine which elements are enabled to operate the contact.</td>
</tr>
<tr>
<td></td>
<td>• Check the event report to determine which elements asserted during the event.</td>
</tr>
<tr>
<td></td>
<td>• Check the connections and test signals to ensure that the appropriate signals were applied to cause the element under test to assert.</td>
</tr>
</tbody>
</table>
**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 13.7):

- **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>
<thead>
<tr>
<th>Self-Test</th>
<th>Condition</th>
<th>Limits</th>
<th>Protection Disabled</th>
<th>ALARM Output</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA, IB, IC, IP, VA, VB, VC, VS Offset</td>
<td>Warning</td>
<td>30 mV</td>
<td>No</td>
<td>Pulsed</td>
<td>Measures the dc offset at each of the input channels every 10 seconds.</td>
</tr>
<tr>
<td>Master Offset</td>
<td>Warning</td>
<td>20 mV</td>
<td>No</td>
<td>Pulsed</td>
<td>Measures the dc offset at the A/D every 10 seconds.</td>
</tr>
<tr>
<td>+5 V PS</td>
<td>Failure</td>
<td>30 mV</td>
<td>Yes</td>
<td>Latched</td>
<td>Measures the +5 V power supply every 10 seconds.</td>
</tr>
<tr>
<td>+5 V PS</td>
<td>Warning</td>
<td>+4.80 V</td>
<td>No</td>
<td>Pulsed</td>
<td></td>
</tr>
<tr>
<td>+5 V PS</td>
<td>Failure</td>
<td>+4.65 V</td>
<td>Yes</td>
<td>Latched</td>
<td></td>
</tr>
<tr>
<td>+5 V PS</td>
<td>Failure</td>
<td>+5.20 V</td>
<td>Yes</td>
<td>Latched</td>
<td></td>
</tr>
<tr>
<td>+5 V PS</td>
<td>Failure</td>
<td>+5.40 V</td>
<td>Yes</td>
<td>Latched</td>
<td></td>
</tr>
<tr>
<td>Self-Test</td>
<td>Condition</td>
<td>Limits</td>
<td>Protection Disabled</td>
<td>ALARM Output</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-----------</td>
<td>-------------------------</td>
<td>---------------------</td>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>±5 V REG</td>
<td>Warning</td>
<td>+4.75 V, +5.20 V,</td>
<td>No</td>
<td>Pulsed</td>
<td>Measures the regulated 5 V power supply every 10 seconds.</td>
</tr>
<tr>
<td></td>
<td>Failure</td>
<td>-4.75 V, -5.25 V,</td>
<td>Yes</td>
<td>Latched</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>+4.50 V, +5.40 V,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-4.50 V, -5.50 V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>±12 V PS</td>
<td>Warning</td>
<td>+11.50 V, +12.50 V,</td>
<td>No</td>
<td>Pulsed</td>
<td>Measures the 12 V power supply every 10 seconds.</td>
</tr>
<tr>
<td></td>
<td>Failure</td>
<td>+11.20 V, +14.00 V</td>
<td>Yes</td>
<td>Latched</td>
<td></td>
</tr>
<tr>
<td>±15 V PS</td>
<td>Warning</td>
<td>+14.40 V, +15.60 V,</td>
<td>No</td>
<td>Pulsed</td>
<td>Measures the 15 V power supply every 10 seconds.</td>
</tr>
<tr>
<td></td>
<td>Failure</td>
<td>+14.00 V, +16.00 V</td>
<td>Yes</td>
<td>Latched</td>
<td></td>
</tr>
<tr>
<td>TEMP</td>
<td>Warning</td>
<td>-40° C, +85° C</td>
<td>No</td>
<td></td>
<td>Measures the temperature at the A/D voltage reference every 10 seconds.</td>
</tr>
<tr>
<td></td>
<td>Failure</td>
<td>-50° C, +100° C</td>
<td>Yes</td>
<td>Latched</td>
<td></td>
</tr>
<tr>
<td>RAM</td>
<td>Failure</td>
<td></td>
<td>Yes</td>
<td>Latched</td>
<td>Performs a read/write test on system RAM every 60 seconds.</td>
</tr>
<tr>
<td>ROM</td>
<td>Failure</td>
<td>checksum</td>
<td>Yes</td>
<td>Latched</td>
<td>Performs a checksum test on the relay program memory every 10 seconds.</td>
</tr>
<tr>
<td>A/D</td>
<td>Failure</td>
<td></td>
<td>Yes</td>
<td>Latched</td>
<td>Validates proper number of conversions each 1/4 cycle.</td>
</tr>
<tr>
<td>CR_RAM</td>
<td>Failure</td>
<td>checksum</td>
<td>Yes</td>
<td>Latched</td>
<td>Performs a checksum test on the active copy of the relay settings every 10 seconds.</td>
</tr>
</tbody>
</table>
### SEL-311C Instruction Manual

<table>
<thead>
<tr>
<th>Self-Test</th>
<th>Condition</th>
<th>Limits</th>
<th>Protection Disabled</th>
<th>ALARM Output</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEPROM</td>
<td>Failure</td>
<td>checksum</td>
<td>Yes</td>
<td>Latched</td>
<td>Performs a checksum test on the nonvolatile copy of the relay settings every 10 seconds.</td>
</tr>
<tr>
<td>Microprocessor Crystal</td>
<td>Failure</td>
<td>Yes</td>
<td>Latched</td>
<td>The relay monitors the microprocessor crystal. If the crystal fails, the relay displays “CLOCK STOPPED” on the LCD display. The test runs continuously.</td>
<td></td>
</tr>
<tr>
<td>Microprocessor</td>
<td>Failure</td>
<td>Yes</td>
<td>Latched</td>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

### 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-311C 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
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## SECTION 14: APPLICATION SETTINGS FOR SEL-221 SERIES RELAYS

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SECTION 14: APPLICATION SETTINGS
FOR SEL-221 SERIES RELAYS

SEL-221G to SEL-311C SETTINGS CONVERSION GUIDE

Set APP = 221G in the SEL-311C to configure the relay to closely approximate the features, performance, and settings of an SEL-221G. When APP = 221G, the SEL-311C:

1. Configures itself as a compensator distance relay for phase faults and a ground directional overcurrent relay for ground faults.
2. Configures contact inputs and contact outputs to emulate those in an SEL-221G.
3. Presents the user only with those settings associated with SEL-221G type features.
4. Automatically calculates all other settings required to simulate an SEL-221G.

If additional capability is needed (e.g., MIRRORED BITS™ or SELOGIC® control equations) the relay may be returned to the setting APP = 311C to make all of the SEL-311C settings visible. It is important to remember that changing from APP = 311C to APP = 221G changes settings in the SEL-311C. Changing from APP = 221G to APP = 311C makes more SEL-311C settings visible, but does not change any other settings. If SEL-311C functions are used after setting APP is changed from 221G to 311C, do not change setting APP back to 221G.

As described above, when setting APP = 221G, the user is presented only with SEL-311C settings associated with the features found in an SEL-221G. This section explains how to make SEL-311C settings directly from the settings used in an SEL-221G.

There are mainly two kinds of settings in the SEL-311C. Relay settings are settings for protective elements. SELOGIC settings are Boolean expressions used to customize the logic of the SEL-311C. To set the SEL-311C to emulate an SEL-221G, follow these four steps:

1. Turn on the SEL-221G application setting by making setting APP = 221G. See Application Settings below.
2. Convert the appropriate SEL-221G settings to SEL-311C settings using the simple equations shown in Table 14.1. Be sure to convert from primary quantities (SEL-221G settings) to secondary quantities (SEL-311C settings). See Convert SEL-221G Primary Quantities to SEL-311C Secondary Quantities below.
3. For each Mask Logic setting in the SEL-221G shown in Table 14.2, create an equivalent SELOGIC control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.3.
4. Test the relay to verify intended performance.

The remainder of this section shows how to perform steps 1 through 3 above, and also gives an example of Step 3.
**Key Differences Between the SEL-221G and the SEL-311C**

There are two key differences between the SEL-221G and the SEL-311C when setting APP = 221G.

1. The SEL-221G setting 50L and Relay Word 50L supervise the phase distance elements. In the SEL-311C, the phase overcurrent supervision is fixed at 0.5 amps for 5 amp nominal relays, and 0.1 amps for 1 amp nominal relays.

2. The SEL-221G uses a circular out-of-step characteristic (Zone 4). The SEL-311C uses a quadrilateral out-of-step characteristic (Zone 6). The Zone 6 reach is calculated from the Zone 3 phase mho reach as shown in Figure 14.1.

![Figure 14.1: SEL-221G and SEL-311C Out-of-Step Characteristics](M311C103)
Application Settings

From Access Level 2, set the SEL-311C application setting to “221G” as shown below:

-=>SET APP TERSE <ENTER>

Line Parameter Settings:

Application
(311C,221G,221G5,221H,221F,221F3,221C,221-16,2PG10)APP = 311C ? 221G <ENTER>

Enable Settings:

Fault Location(Y,N) EFLOC = Y ? END <ENTER>
Save Changes(Y/N)? Y <ENTER>
Settings saved

Convert SEL-221G Primary Quantities to SEL-311C Secondary Quantities

All SEL-221G current settings must be converted from primary to secondary amps to be used in the SEL-311C. Divide the SEL-221G current setting by the current transformer ratio setting (CTR) to make the change.

SEL-221G 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-311C (Z1P) is calculated as

\[
Z1P = \frac{Z1\%}{100} \cdot Z1MAG
\]

where: Z1% is the SEL-221G distance reach setting.

Z1MAG is the SEL-311C positive-sequence line impedance setting in secondary ohms.

Z1P is the SEL-311C Zone 1 reach setting in secondary ohms.

Convert SEL-221G Relay Settings to SEL-311C Relay Settings

Table 14.1 shows all the SEL-311C Relay settings that must be entered for the relay to perform protection similar to the SEL-221G when APP = 221G. Calculate each SEL-311C Relay setting from SEL-221G Relay settings using the formula shown. Instruction manual references are to subsection headings rather than to section headings.
Table 14.1: SEL-311C Settings Calculated From SEL-221G Settings

<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-221G Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221G Instruction Manual Section</th>
</tr>
</thead>
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<td>RID</td>
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<td>Section 9—Settings Sheets</td>
<td>Section 3—Set n</td>
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<tr>
<td>TID</td>
<td>= ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTR</td>
<td>= CTR</td>
<td>Section 9—Settings Sheets</td>
<td>Section 5—Choosing Current and Potential Transformers</td>
</tr>
<tr>
<td>CTRP</td>
<td>= CTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTR</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTRS</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1MAG</td>
<td>$= \sqrt{(R1^2 + X1^2) \cdot \frac{CTR}{PTR}}$</td>
<td>Section 9—Settings Sheets</td>
<td>Section 5—Choice of Line Impedances</td>
</tr>
<tr>
<td>Z1ANG</td>
<td>$= \text{Arc tan} \left( \frac{X1}{R1} \right)$ (degrees) = MTA</td>
<td></td>
<td>Section 5—Choice of Maximum Torque Angle (MTA)</td>
</tr>
<tr>
<td>Z0MAG</td>
<td>$= \sqrt{(R0^2 + X0^2) \cdot (CTR/PTR)}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z0ANG</td>
<td>$= \text{Arc tan} \left( \frac{X0}{R0} \right)$ (degrees)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>= LL</td>
<td>Section 9—Settings Sheets</td>
<td></td>
</tr>
<tr>
<td>APP</td>
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<tr>
<td>ELOP</td>
<td>= LOPE</td>
<td>Section 4—Loss of Potential</td>
<td>Section 5—Loss-of-Potential Logic</td>
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<tr>
<td>N</td>
<td>= N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>= Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EFLOC</td>
<td>= LOCAT</td>
<td>Section 9—Settings Sheets</td>
<td>Section 2—Fault Locator</td>
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<td>SEL-221G Instruction Manual Section</td>
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<td>------------------------</td>
<td>----------------------------------</td>
<td>-----------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Z1P</td>
<td>$\frac{Z1% \cdot Z1\text{MAG}}{100}$</td>
<td>Section 3—Phase Distance Elements</td>
<td>Section 2—Mho Elements</td>
</tr>
<tr>
<td></td>
<td>$\frac{Z2% \cdot Z1\text{MAG}}{100}$</td>
<td></td>
<td>Note: Z1MAG is an SEL-311C setting</td>
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<tr>
<td></td>
<td>$\frac{Z3% \cdot Z1\text{MAG}}{100}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$Z1\text{MAG} = \sqrt{R_1^2 + X_1^2} \left[ \frac{CTR}{PTR} \right]$</td>
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<td></td>
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<tr>
<td>Z1PD</td>
<td>= Z1DP</td>
<td>Section 3—Zone Time Delay Elements</td>
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</tr>
<tr>
<td>Z2PD</td>
<td>= Z2DP</td>
<td></td>
<td>Section 5—Choice of Zone 2 and Zone 3 Time Delay Settings</td>
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<tr>
<td>Z3PD</td>
<td>= Z3DP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50P1P</td>
<td>= $\frac{50H}{CTR}$</td>
<td>Section 5—Switch-On-to-Fault (SOTF) Trip Logic</td>
<td>Section 5—High Set Phase Overcurrent Setting (50H)</td>
</tr>
<tr>
<td>50P2P</td>
<td>= $\frac{50M}{CTR}$</td>
<td>Section 4—Loss-of-Potential Logic</td>
<td>Section 5—Medium Set Phase Overcurrent Setting (50M)</td>
</tr>
<tr>
<td>50G1P</td>
<td>= $\frac{50N1P}{CTR}$</td>
<td>Section 3—Inst./Def.-Time Overcurrent Elements</td>
<td>Section 2—Logic Diagrams</td>
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<tr>
<td>50G2P</td>
<td>= $\frac{50N2P}{CTR}$</td>
<td></td>
<td></td>
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<td>50G3P</td>
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<td></td>
<td></td>
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<tr>
<td>67G1D</td>
<td>= Z1DG</td>
<td>Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements</td>
<td>Section 5—Choice of Zones 1, 2, and 3 Residual Overcurrent Pickup Settings</td>
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<tr>
<td>67G2D</td>
<td>= Z2DG</td>
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<td>67G3D</td>
<td>= Z3DG</td>
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<td>SEL-311C Instruction Manual Section</td>
<td>SEL-221G Instruction Manual Section</td>
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<td>-----------------------------------</td>
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<tr>
<td>51GP</td>
<td>= 51NP/CTR</td>
<td>Section 3—Residual Ground Time-Overcurrent Element</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
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<tr>
<td>51GC</td>
<td>= 51NC</td>
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</tr>
<tr>
<td>U1*</td>
<td>= 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U2</td>
<td>= 2</td>
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<td>U3</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>U4</td>
<td>= 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTD</td>
<td>= 51NTD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTC</td>
<td>= 51NTC</td>
<td></td>
<td></td>
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<td>(= 1)</td>
<td>= N</td>
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<td></td>
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<tr>
<td>(= 32GF)</td>
<td>= Y</td>
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<td></td>
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<td>OOSB1**</td>
<td>= OSB1</td>
<td>Section 3—Out-of-Step Characteristics</td>
<td>Section 2—Out-of-Step Blocking</td>
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<td>OOSB2</td>
<td>= OSB2</td>
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</tr>
<tr>
<td>OOSB3</td>
<td>= OSB3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OOSBD</td>
<td>= OSBT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIR3</td>
<td>= ZONE 3</td>
<td>Section 4—Directional Control Settings</td>
<td>Section 5—Zone 3 Direction Setting</td>
</tr>
<tr>
<td>ORDER Q</td>
<td>= 32QE</td>
<td>Section 4—Directional Control for Ground Distance and Residual Ground Overcurrent Elements</td>
<td>Section 2—Directional Elements</td>
</tr>
<tr>
<td>V</td>
<td>= 32VE</td>
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<tr>
<td>I</td>
<td>= 32IE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79OI1</td>
<td>= 79OI1</td>
<td>Section 6—Close and Reclose Logic</td>
<td>Section 5—Reclose Logic</td>
</tr>
<tr>
<td>79OI2</td>
<td>= 79OI2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79OI3</td>
<td>= 79OI3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79RSD</td>
<td>None (SEL-221G setting 79RS serves a slightly different purpose.)</td>
<td>Section 6—Reclosing Relay Timer Settings</td>
<td>Section 6—79RS Timer Eliminates Standing Close</td>
</tr>
<tr>
<td>79RSLD</td>
<td>None</td>
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</tr>
</tbody>
</table>
### Table 14.2: SEL-311C SELOGIC Equation Equivalent to Each SEL-221G Mask Logic Setting

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<tr>
<th>SEL-221G Settings Mask</th>
<th>SEL-311C SELOGIC Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTU</td>
<td>TR</td>
</tr>
<tr>
<td>MPT</td>
<td>SV2 (DTT)</td>
</tr>
<tr>
<td>MTB</td>
<td>SV3 (DTT)</td>
</tr>
<tr>
<td>MTO</td>
<td>TRSOTF</td>
</tr>
<tr>
<td>MA1</td>
<td>OUT104</td>
</tr>
<tr>
<td>MA2</td>
<td>OUT105</td>
</tr>
<tr>
<td>MA3</td>
<td>OUT106</td>
</tr>
<tr>
<td>MA4</td>
<td>OUT107</td>
</tr>
<tr>
<td>MRI</td>
<td>79RI</td>
</tr>
<tr>
<td>MRC</td>
<td>79DTL</td>
</tr>
</tbody>
</table>

* Curve U1 in the SEL-311C is slightly different from curve 1 in the SEL-221G. Time dial adjustments may be necessary.


**Note:** SEL-311C phase-to-phase fault detector settings 50PP1, 50PP2, and 50PP3 are set to 0.1 \( I_{nom} \) and are hidden. This corresponds to SEL-221G setting 50L.
Table 14.3 shows all SEL-221G Relay Word bits, and an approximate equivalent SEL-311C SELOGIC expression, when setting APP = 221G in the SEL-311C. Table 14.2 shows each SEL-221G Mask Logic Setting and the equivalent SEL-311C SELOGIC control equation. To convert a SEL-221G Mask Logic Setting to a SELOGIC control equation, logically OR each appropriate SEL-221G Relay Word bit equivalent expression (Table 14.3) and enter the resultant expression in the related SELOGIC control equation listed in Table 14.2.

<table>
<thead>
<tr>
<th>SEL-221G Relay Word Bit</th>
<th>Equivalent SEL-311C SELOGIC Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>1ABC</td>
<td>M1P * !32QF</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>M1PT * !32QF if Z1PD is set</td>
</tr>
<tr>
<td>2ABC</td>
<td>M2P * !32QF</td>
</tr>
<tr>
<td>3ABC</td>
<td>M3P * !32QF if DIR3 = F</td>
</tr>
<tr>
<td></td>
<td>M3P * !32QR if DIR3 = R</td>
</tr>
<tr>
<td>4ABC</td>
<td>None</td>
</tr>
<tr>
<td>LOP</td>
<td>ILOP</td>
</tr>
<tr>
<td>50H</td>
<td>50P1</td>
</tr>
<tr>
<td>50M</td>
<td>50P2</td>
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<td>50L</td>
<td>None</td>
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<tr>
<td>51NT</td>
<td>51GT</td>
</tr>
<tr>
<td>67N1</td>
<td>67G1</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>67G1T if 67G1D is set</td>
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<td>67G2</td>
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<td>67G3</td>
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<td>51NP</td>
<td>51G</td>
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<tr>
<td>Z1P</td>
<td>M1P</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>M1PT if Z1PD is set</td>
</tr>
<tr>
<td>Z2P</td>
<td>M2P</td>
</tr>
<tr>
<td>Z3P</td>
<td>M3P</td>
</tr>
<tr>
<td>Z2PT</td>
<td>M2PT</td>
</tr>
<tr>
<td>Z3PT</td>
<td>M3PT</td>
</tr>
<tr>
<td>OSB</td>
<td>OSB</td>
</tr>
</tbody>
</table>

Table 14.3: SELOGIC Equivalent to SEL-221G Relay Word Bits
<table>
<thead>
<tr>
<th>SEL-221G Relay Word Bit</th>
<th>Equivalent SEL-311C SELOGIC Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>3P50</td>
<td>None</td>
</tr>
<tr>
<td>50MF</td>
<td>SV1T (SV1 = 50P2 * ILOP)</td>
</tr>
<tr>
<td>RC</td>
<td>None (SELOGIC equation 79DTL)</td>
</tr>
<tr>
<td>RI</td>
<td>None (SELOGIC equation 79RI)</td>
</tr>
<tr>
<td>DF</td>
<td>32GF</td>
</tr>
<tr>
<td>ALRM</td>
<td>ALARM</td>
</tr>
<tr>
<td>TRIP</td>
<td>TRIP or OUT101 or OUT102</td>
</tr>
<tr>
<td>TC</td>
<td>OC</td>
</tr>
<tr>
<td>DT</td>
<td>IN101</td>
</tr>
<tr>
<td>52BT</td>
<td>SOTFE</td>
</tr>
<tr>
<td>52AT</td>
<td>!SOTFE</td>
</tr>
<tr>
<td>Z2GT</td>
<td>67G2T</td>
</tr>
<tr>
<td>Z3GT</td>
<td>67G3T</td>
</tr>
</tbody>
</table>

For example, the factory default setting for MRC in the SEL-221G is shown in Table 14.4. From Table 14.2, the equivalent SEL-311C SELOGIC control equation to MRC is 79DTL. Constructing the logical OR of the equivalent of each element selected in the MRC mask from Table 14.3 gives:

\[
79DTL = M1P \cdot !32QF + M2P \cdot !32QF + M3P \cdot !32QF + 50P1 + 51GT + M2PT + M3PT + SV1T + OC + IN101 + 67G2T + 67G3T
\]

which can be simplified to:

\[
79DTL = (M1P + M2P + M3P) \cdot !32QF + 50P1 + 51GT + M2PT + M3PT + SV1T + OC + IN101 + 67G2T + 67G3T
\]

which is the default SELOGIC control equation for 79DTL when APP = 221G.

When setting APP = 221G, the SEL-311C automatically sets the following SELOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-221G to customize the relay logic.
Table 14.4: Default SEL-221G Mask Logic Setting for MRC

<table>
<thead>
<tr>
<th>1ABC</th>
<th>2ABC</th>
<th>3ABC</th>
<th>4ABC</th>
<th>LOP</th>
<th>50H</th>
<th>50M</th>
<th>50L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>51NT</td>
<td>67N1</td>
<td>67N2</td>
<td>67N3</td>
<td>51NP</td>
<td>Z1P</td>
<td>Z2P</td>
<td>Z3P</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Z2PT</td>
<td>Z3PT</td>
<td>OSB</td>
<td>3P50</td>
<td>50MF</td>
<td>RC</td>
<td>RI</td>
<td>DF</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ALRM</td>
<td>TRIP</td>
<td>TC</td>
<td>DT</td>
<td>52BT</td>
<td>52AT</td>
<td>Z2GT</td>
<td>Z3GT</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Default Tripping Logic Equations

\[
TR = M1P + M2PT + M3PT + 67G1 + 67G2T + 67G3T + 51GT + OC + SV1T
\]

\[
TRSOOTF = M1P + M2P + 67G1 + 67G2 + 51GT + 50P1
\]

\[
DTT = IN101 + SV2 * IN102 + SV3 * !IN103
\]

Default Reclose Logic Equations

\[
79RI = M1P * 32QF + 67G1
\]

\[
79DTL = (M1P + M2P + M3P) * !32QF + 50P1 + 51GT + M2PT + M3PT + SV1T + OC + IN101 + 67G2T + 67G3T
\]

Default Output Contact Logic Equations

\[
OUT101 = TRIP
\]

\[
OUT102 = TRIP
\]

\[
OUT103 = CLOSE
\]

\[
OUT104 = M3P + 67G3
\]

\[
OUT105 = 32GF
\]

\[
OUT106 = OSB
\]

\[
OUT107 = LOP
\]

SELogic Variables Equations

\[
SV1 = 50P2 * ILOP
\]

\[
SV2 = 0 \text{ (reserved for MPT)}
\]

\[
SV3 = 0 \text{ (reserved for MBT)}
\]

The following contact input assignments are made automatically by the SEL-311C when setting APP = 221G. These assignments cannot be changed unless setting APP is changed back to APP = 311C.
Default Contact Input Functions

IN101 = DT (Direct trip)
IN102 = PT (Permit trip)
IN103 = BT (Block trip)
IN104 = CL (Close breaker)
IN105 = 52A
IN106 = EXT (External event report trigger)
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 (311C, 221G, 221G5, 221H, 221F, 221F3, 221C, 221-16, 2PG10) APP = 221G
- Fault location (Y, N) (see Table 12.1 and Fault Location in Section 12) EFLOC = __________
- Loss-of-Potential (Y, Y1, N) (see Figure 4.1) ELOP = __________

Mho Phase Distance Elements (See Settings Explanations in Section 3)
- Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) Z1P = __________
- Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) Z2P = __________
- Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) Z3P = __________

Mho Phase Distance Element Time Delays (See Settings Explanations in Section 3)
- Zone 1 time delay (OFF, 0–16000 cycles) Z1PD = __________
- Zone 2 time delay (OFF, 0–16000 cycles) Z2PD = __________
- Zone 3 time delay (OFF, 0–16000 cycles) Z3PD = __________
Phase Inst./Def.-Time Overcurrent Elements (See Figure 3.19)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})  
50P1P = __________
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})  
50P2P = __________

Residual Ground Inst./Def.-Time Overcurrent Elements (See Figure 3.22)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})  
50G1P = __________
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})  
50G2P = __________
Level 3 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})  
50G3P = __________

Residual Ground Definite-Time Overcurrent Element Time Delay (See Figure 3.22)
Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) 67G1D = __________
Level 2 (0.00–16000.00 cycles in 0.25-cycle steps) 67G2D = __________
Level 3 (0.00–16000.00 cycles in 0.25-cycle steps) 67G3D = __________

Residual Ground Time-Overcurrent Element (See Figure 3.25)
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 = __________

Out-of-Step Settings (See Figures 3.17 and 3.18)
Block Zone 1 (Y, N) OOSB1 = __________
Block Zone 2 (Y, N) OOSB2 = __________
Block Zone 3 (Y, N) OOSB3 = __________
Out-of-Step block time delay (0.5–8000.0 cycles) OSBD = __________

Zone/Level 3 and 4 Directional Control
Zone/Level 3 direction: Forward, Reverse (F, R) DIR3 = __________

Directional Elements (See Directional Control Settings in Section 4)
Ground directional element priority: combination of Q, V, or I ORDER = __________
Reclosing Relay (See Tables 6.2 and 6.3)
- Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI1 = 
- Open interval 2 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI2 = 
- Open interval 3 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI3 = 
- Reset time from reclose cycle (0.00–999999.00 cycles in 0.25-cycle steps) 79RSD = 
- Reset time from lockout (0.00–999999.00 cycles in 0.25-cycle steps) 79RSLD = 

Switch-Onto-Fault (See Figure 5.3)
- 52 A enable time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) 52AEND = 
- SOTF duration (0.50–16000.00 cycles in 0.25-cycle steps) SOTFD = 

Other Settings
- Minimum trip duration time (4.00–16000.00 cycles in 0.25-cycle steps) TDURD = 

SELogic Control Equation Variable Timers (See Figures 7.24 and 7.25)
(SELogic control equation settings consist of Relay Word bits [see Table 9.4] and SELogic control.)
- SV1 Pickup Time (0.00-999999.00 cycles in 0.25-cycle steps) SV1PU = 
- SV1 Dropout Time (0.00-999999.00 cycles in 0.25-cycle steps) SV1DO = 

Trip Logic Equations (See Figure 5.1)
- Direct trip conditions TR = 
- Switch-onto-fault trip conditions TRSOTF = 
- Direct transfer trip conditions DTT = 

Reclosing Relay Equations (See Reclosing Relay in Section 6)
- Reclose initiate 79RI = 
- Drive-to-lockout 79DTL = 

Torque Control Equations for Inst./Def.-Time Overcurrent Elements
[Note: torque control equation settings cannot be set directly to logical 0]
- Residual Ground (see Figure 3.25) 51GTC = 

SELogic Control Equation Variable Timer Input Equations (See Figures 7.24 and 7.25)
- SELogic control equation Variable SV1 SV1 = 
- SELogic control equation Variable SV2 SV2 = 
- SELogic control equation Variable SV3 SV3 = 

Date Code 20011205
Output Contact Equations (See Figure 7.27)

Output Contact OUT101  OUT101 = ________________
Output Contact OUT102  OUT102 = ________________
Output Contact OUT103  OUT103 = ________________
Output Contact OUT104  OUT104 = ________________
Output Contact OUT105  OUT105 = ________________
Output Contact OUT106  OUT106 = ________________
Output Contact OUT107  OUT107 = ________________

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 = __________

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)  RTSCTS = __________
Fast Operate Enable (Y, N, MBT)  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-311C Relay Fast Operate commands.

**Power System Configuration (See Settings Explanations in Section 9)**

Phase rotation (ABC, ACB)  
PHROT = ___________
SEL-221G-5 to SEL-311C Settings Conversion Guide

Set APP = 221G5 in the SEL-311C to configure the relay to closely approximate the features, performance, and settings of an SEL-221G-5. When APP = 221G5, the SEL-311C:

1. Configures itself as a compensator distance relay for phase faults and a ground directional overcurrent relay for ground faults.
2. Configures contact inputs and contact outputs to emulate those in an SEL-221G-5.
3. Presents the user only with those settings associated with SEL-221G-5 type features.
4. Automatically calculates all other settings required to simulate an SEL-221G-5.

If additional capability is needed (e.g., MIRRORED BITS or SELOGIC control equations) the relay may be returned to the setting APP = 311C to make all of the SEL-311C settings visible. It is important to remember that changing from APP = 311C to APP = 221G5 changes settings in the SEL-311C. Changing from APP = 221G5 to APP = 311C makes more SEL-311C settings visible, but does not change any other settings. If SEL-311C functions are used after setting APP is changed from 221G5 to 311C, do not change setting APP back to 221G5.

As described above, when setting APP = 221G5, the user is presented only with SEL-311C settings associated with the features found in an SEL-221G-5. This section explains how to make SEL-311C settings directly from the settings used in an SEL-221G-5.

There are mainly two kinds of settings in the SEL-311C. Relay settings are settings for protective elements. SELOGIC settings are Boolean expressions used to customize the logic of the SEL-311C. To set the SEL-311C to emulate an SEL-221G-5, follow these four steps:

1. Turn on the SEL-221G-5 application setting by making setting APP = 221G5. See Application Settings below.
2. Convert the appropriate SEL-221G-5 settings to SEL-311C settings using the simple equations shown in Table 14.5. Be sure to convert from primary quantities (SEL-221G-5 settings) to secondary quantities (SEL-311C settings). See Convert SEL-221G-5 Primary Quantities to SEL-311C Secondary Quantities below.
3. For each Mask Logic setting in the SEL-221G-5 shown in Table 14.6, create an equivalent SELOGIC control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.7.
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.
Key Differences Between the SEL-221G-5 and the SEL-311C

There are two key differences between the SEL-221G-5 and the SEL-311C when setting APP = 221G5.

1. The SEL-221G-5 setting 50L and Relay Word 50L supervise the phase distance elements. In the SEL-311C, the phase overcurrent supervision is fixed at 0.5 amps for 5 amp nominal relays, and 0.1 amps for 1 amp nominal relays.

2. The SEL-221G-5 uses a circular out-of-step characteristic (Zone 4). The SEL-311C uses a quadrilateral out-of-step characteristic (Zone 6). The Zone 6 reach is calculated from the Zone 3 phase mho reach as shown in Figure 14.2.

![SEL-221G Out-of-Step Characteristic](image1)

![SEL-311C Out-of-Step Characteristic](image2)

Figure 14.2: SEL-221G-5 and SEL-311C Out-of-Step Characteristics
Application Settings

From Access Level 2, set the SEL-311C application setting to “221G5” as shown below:

```plaintext
=>>SET APP TERSE <ENTER>
Line Parameter Settings:
Application
(311C,221G,221G5,221H,221F,221F3,221C,221-16,2PG10)APP = 311C ? 221G5 <ENTER>
Enable Settings:
Fault Location(Y,N) EFLOC = Y ? END <ENTER>
Save Changes(Y/N)? Y <ENTER>
Settings saved
=>>
```

Convert SEL-221G-5 Primary Quantities to SEL-311C Secondary Quantities

All SEL-221G-5 current settings must be converted from primary to secondary amps to be used in the SEL-311C. Divide the SEL-221G-5 current setting by the current transformer ratio setting (CTR) to make the change.

SEL-221G-5 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-311C (Z1P) is calculated as

\[ Z1P = \frac{Z1\%}{100} \times Z1MAG \]

where:  
- Z1% is the SEL-221G-5 distance reach setting.
- Z1MAG is the SEL-311C positive-sequence line impedance setting in secondary ohms.
- Z1P is the SEL-311C Zone 1 reach setting in secondary ohms.

Convert SEL-221G-5 Relay Settings to SEL-311C Relay Settings

Table 14.5 shows all the SEL-311C Relay settings that must be entered for the relay to perform protection similar to the SEL-221G-5 when APP = 221G5. Calculate each SEL-311C Relay setting from SEL-221G-5 Relay settings using the formula shown. Instruction manual references are to subsection headings rather than to section headings.

<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-221G-5 Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221G-5 Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>RID</td>
<td>None</td>
<td>Section 9—Settings Sheets</td>
<td>Section 3—Set n</td>
</tr>
<tr>
<td>TID = ID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEL-311C Relay Setting</td>
<td>Calculated from SEL-221G-5 Settings</td>
<td>SEL-311C Instruction Manual Section</td>
<td>SEL-221G-5 Instruction Manual Section</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>CTR</td>
<td>= CTR</td>
<td>Section 9—Settings Sheets</td>
<td>Section 5—Choosing Current and Potential Transformers</td>
</tr>
<tr>
<td>CTRP</td>
<td>= CTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTR</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTRS</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1MAG</td>
<td>= ( \sqrt{(R1^2 + X1^2)} \cdot \left[ \frac{CTR}{PTR} \right] )</td>
<td>Section 9—Settings Sheets</td>
<td>Section 5—Choice of Line Impedances</td>
</tr>
<tr>
<td>Z1ANG</td>
<td>= ( \text{Arc tan} \left[ \frac{X1}{R1} \right] ) (degrees) = MTA</td>
<td></td>
<td>Section 5—Choice of Maximum Torque Angle (MTA)</td>
</tr>
<tr>
<td>Z0MAG</td>
<td>= ( \sqrt{R0^2 + X0^2} ) \cdot (CTR/PTR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z0ANG</td>
<td>= ( \text{Arc tan} \left[ \frac{X0}{R0} \right] ) (degrees)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>= LL</td>
<td>Section 9—Settings Sheets</td>
<td></td>
</tr>
<tr>
<td>APP</td>
<td>None</td>
<td>Section 4—Loss of Potential</td>
<td>Section 5—Loss-of-Potential Logic</td>
</tr>
<tr>
<td>ELOP</td>
<td>= LOPE</td>
<td>Section 9—Settings Sheets</td>
<td>Section 2—Fault Locator</td>
</tr>
<tr>
<td>N</td>
<td>= N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>= Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EFLOC</td>
<td>= LOCAT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1P</td>
<td>= ( \frac{Z1%}{100} \cdot Z1MAG )</td>
<td>Section 3—Phase Distance Elements</td>
<td>Section 2—Mho Elements</td>
</tr>
<tr>
<td>Z2P</td>
<td>= ( \frac{Z2%}{100} \cdot Z1MAG )</td>
<td></td>
<td>Note: Z1MAG is an SEL-311C setting</td>
</tr>
<tr>
<td>Z3P</td>
<td>= ( \frac{Z3%}{100} \cdot Z1MAG )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>where</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1MAG</td>
<td>= ( \sqrt{(R1^2 + X1^2)} \left[ \frac{CTR}{PTR} \right] )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEL-311C Relay Setting</td>
<td>Calculated from SEL-221G-5 Settings</td>
<td>SEL-311C Instruction Manual Section</td>
<td>SEL-221G-5 Instruction Manual Section</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------------</td>
<td>-----------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Z2PD</td>
<td>= Z2DP</td>
<td>Section 3—Zone Time Delay Elements</td>
<td>Section 5—Choice of Zone 2 and Zone 3 Time Delay Settings</td>
</tr>
<tr>
<td>Z3PD</td>
<td>= Z3DP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50P1P</td>
<td>= 50H/CTR</td>
<td>Section 5—Switch-Onto-Fault (SOTF) Trip Logic</td>
<td>Section 5—High Set Phase Overcurrent Setting (50H)</td>
</tr>
<tr>
<td>50P2P</td>
<td>= 50M/CTR</td>
<td>Section 4—Loss-of-Potential Logic</td>
<td>Section 5—Medium Set Phase Overcurrent Setting (50M)</td>
</tr>
<tr>
<td>50G1P</td>
<td>= 50N1P/CTR</td>
<td>Section 3—Inst./Def.-Time Overcurrent Elements</td>
<td>Section 2—Logic Diagrams</td>
</tr>
<tr>
<td>50G2P</td>
<td>= 50N2P/CTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50G3P</td>
<td>= 50N3P/CTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>67G2D</td>
<td>= Z2DG</td>
<td>Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements</td>
<td>Section 5—Choice of Zones 1, 2, and 3 Residual Overcurrent Pickup Settings</td>
</tr>
<tr>
<td>67G3D</td>
<td>= Z3DG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GP</td>
<td>= 51NP/CTR</td>
<td>Section 3—Residual Ground Time-Overcurrent Element</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
</tr>
<tr>
<td>51GC</td>
<td>= 51NC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U1*</td>
<td>= 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U2</td>
<td>= 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U3</td>
<td>= 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U4</td>
<td>= 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTD</td>
<td>= 51NTD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTC</td>
<td>= 51NTC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(= 1</td>
<td>= N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(= 32GF</td>
<td>= Y)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEL-311C Relay Setting</td>
<td>Calculated from SEL-221G-5 Settings</td>
<td>SEL-311C Instruction Manual Section</td>
<td>SEL-221G-5 Instruction Manual Section</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------------</td>
<td>-------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>OOSB1**</td>
<td>= OSB1</td>
<td>Section 3—Out-of-Step Characteristics</td>
<td>Section 2—Out-of-Step Blocking</td>
</tr>
<tr>
<td>OOSB2</td>
<td>= OSB2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OOSB3</td>
<td>= OSB3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSBD</td>
<td>= OSBT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIR3</td>
<td>= ZONE 3</td>
<td>Section 4—Directional Control Settings</td>
<td>Section 5—Zone 3 Direction Setting</td>
</tr>
<tr>
<td>ORDER Q</td>
<td>= 32QE</td>
<td>Section 4—Directional Control for Ground Distance and Residual Ground Overcurrent Elements</td>
<td>Section 2—Directional Elements</td>
</tr>
<tr>
<td>V</td>
<td>= 32VE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>= 32IE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79O11</td>
<td>= 79O11</td>
<td>Section 6—Close and Reclose Logic</td>
<td>Section 5—Reclose Logic</td>
</tr>
<tr>
<td>79O12</td>
<td>= 79O12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79O13</td>
<td>= 79O13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79RSD</td>
<td>None (SEL-221G-5 setting 79RS serves a slightly different purpose.)</td>
<td>Section 6—Reclosing Relay Timer Settings</td>
<td>Section 6—79RS Timer Eliminates Standing Close</td>
</tr>
<tr>
<td>79RSLD</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52AEND</td>
<td>= 52BT (Pickup)</td>
<td>Section 5—Switch-Onto-Fault (SOTF) Trip Logic</td>
<td>Section 5—High Set Phase Overcurrent Setting (50H)</td>
</tr>
<tr>
<td>SOTFD</td>
<td>= 52BT (Dropout)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z3XPU</td>
<td>None (221G-5 fixed at 2 cycles)</td>
<td>Section 5—DCB Logic</td>
<td>Section 5—Zone 2 Short Phase Time Delay; Zone 2 Short Residual Overcurrent Time Delay</td>
</tr>
<tr>
<td>Z3XD</td>
<td>None (221G-5 fixed at 5 cycles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTXD</td>
<td>None (221G-5 fixed at 0.5 cycles)</td>
<td>Section 5—Trip Duration Timer (TDUR)</td>
<td></td>
</tr>
<tr>
<td>21SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>67SD</td>
<td>= Z2SP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>= Z2SG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDURD</td>
<td>= TDUR</td>
<td>Section 4—Unlatch Trip</td>
<td></td>
</tr>
<tr>
<td>SV1PU</td>
<td>= 50MFD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
* Curve U1 in the SEL-311C is slightly different from curve 1 in the SEL-221G-5. Time dial adjustments may be necessary.


Note: SEL-311C phase-to-phase fault detector settings 50PP1, 50PP2, and 50PP3 are set to 0.1 * I_{nom} and are hidden. This corresponds to SEL-221G-5 setting 50L.

Convert SEL-221G-5 Output Mask Logic Settings to SELOGIC Control Equations

See Programmable Output Contact Mask Settings in Section 5: Applications in the SEL-221G-5 Instruction Manual for a description of output masks. In the SEL-311C, output masks are replaced by SELOGIC control equations as shown below:

<table>
<thead>
<tr>
<th>SEL-221G-5 Settings Mask</th>
<th>SEL-311C SELOGIC Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTU</td>
<td>TR</td>
</tr>
<tr>
<td>MPT</td>
<td>SV2 (DTT)</td>
</tr>
<tr>
<td>MTB</td>
<td>TRCOMM</td>
</tr>
<tr>
<td>MTO</td>
<td>TRSOTF</td>
</tr>
<tr>
<td>MA1</td>
<td>OUT104</td>
</tr>
<tr>
<td>MA2</td>
<td>OUT105</td>
</tr>
<tr>
<td>MA3</td>
<td>OUT106</td>
</tr>
<tr>
<td>MA4</td>
<td>OUT107</td>
</tr>
<tr>
<td>MRI</td>
<td>79RI</td>
</tr>
<tr>
<td>MRC</td>
<td>79DTL</td>
</tr>
</tbody>
</table>

Table 14.7 shows all SEL-221G-5 Relay Word bits, and an approximate equivalent SEL-311C SELOGIC expression, when setting APP = 221G5 in the SEL-311C. Table 14.6 shows each SEL-221G-5 Mask Logic Setting and the equivalent SEL-311C SELOGIC control equation. To convert a SEL-221G-5 Mask Logic Setting to a SELOGIC control equation, logically OR each appropriate SEL-221G-5 Relay Word bit equivalent expression (Table 14.7) and enter the resultant expression in the related SELOGIC control equation listed in Table 14.6.
Table 14.7: SELOGIC Equivalent to SEL-221G-5 Relay Word Bits

<table>
<thead>
<tr>
<th>SEL-221G-5 Relay Word Bit</th>
<th>Equivalent SEL-311C SELOGIC Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>1ABC</td>
<td>M1P * !32QF</td>
</tr>
<tr>
<td>2ABC</td>
<td>M2P * !32QF</td>
</tr>
<tr>
<td>3ABC</td>
<td>M3P * !32QF if DIR3 = F</td>
</tr>
<tr>
<td></td>
<td>M3P * !32QR if DIR3 = R</td>
</tr>
<tr>
<td>4ABC</td>
<td>None</td>
</tr>
<tr>
<td>LOP</td>
<td>ILOP</td>
</tr>
<tr>
<td>50H</td>
<td>50P1</td>
</tr>
<tr>
<td>50M</td>
<td>50P2</td>
</tr>
<tr>
<td>50L</td>
<td>None</td>
</tr>
<tr>
<td>51NT</td>
<td>51GT</td>
</tr>
<tr>
<td>67N1</td>
<td>67G1</td>
</tr>
<tr>
<td>67N2</td>
<td>67QG2S</td>
</tr>
<tr>
<td>67N3</td>
<td>67G3</td>
</tr>
<tr>
<td>51NP</td>
<td>51G</td>
</tr>
<tr>
<td>Z1P</td>
<td>M1P</td>
</tr>
<tr>
<td>Z2P</td>
<td>Z2PGS</td>
</tr>
<tr>
<td>Z3P</td>
<td>M3P</td>
</tr>
<tr>
<td>Z2PT</td>
<td>M2PT</td>
</tr>
<tr>
<td>Z3PT</td>
<td>M3PT</td>
</tr>
<tr>
<td>OSB</td>
<td>OSB</td>
</tr>
<tr>
<td>3P50</td>
<td>None</td>
</tr>
<tr>
<td>50MF</td>
<td>SV1T (SV1 = 50P1 * ILOP)</td>
</tr>
<tr>
<td>RC</td>
<td>None (SELOGIC equation 79DTL)</td>
</tr>
<tr>
<td>RI</td>
<td>None (SELOGIC equation 79RI)</td>
</tr>
<tr>
<td>STOP</td>
<td>STOP</td>
</tr>
<tr>
<td>50N3</td>
<td>50G3</td>
</tr>
<tr>
<td>TRIP</td>
<td>TRIP or OUT101 or OUT102</td>
</tr>
<tr>
<td>TC</td>
<td>OC</td>
</tr>
<tr>
<td>DT</td>
<td>IN101</td>
</tr>
</tbody>
</table>
For example, the factory default setting for MRC in the SEL-221G-5 is shown in Table 14.8. From Table 14.6, the equivalent SEL-311C SELOGIC control equation to MRC is 79DTL. Constructing the logical OR of the equivalent of each element selected in the MRC mask from Table 14.7 gives:

$$79DTL = M1P \cdot 32QF + M2P \cdot 32QF + M3P \cdot 32QF + 50P1 + 51GT + M2PT + M3PT + SV1T + OC + IN101 + 67G2T + 67G3T$$

which can be simplified to:

$$79DTL = (M1P + M2P + M3P) \cdot 32QF + 50P1 + 51GT + M2PT + M3PT + SV1T + OC + IN101 + 67G2T + 67G3T$$

which is the default SELOGIC control equation for 79DTL when APP = 221G5.

When setting APP = 221G5, the SEL-311C automatically sets the following SELOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-221G-5 to customize the relay logic.

Table 14.8: Default SEL-221G-5 Mask Logic Setting for MRC

<table>
<thead>
<tr>
<th>1ABC</th>
<th>2ABC</th>
<th>3ABC</th>
<th>4ABC</th>
<th>LOP</th>
<th>50H</th>
<th>50M</th>
<th>50L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>51NT</td>
<td>67N1</td>
<td>67N2</td>
<td>67N3</td>
<td>51NP</td>
<td>Z1P</td>
<td>Z2P</td>
<td>Z3P</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Z2PT</td>
<td>Z3PT</td>
<td>OSB</td>
<td>3P50</td>
<td>50MF</td>
<td>RC</td>
<td>RI</td>
<td>STOP</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>50N3</td>
<td>TRIP</td>
<td>TC</td>
<td>DT</td>
<td>52BT</td>
<td>Z3X</td>
<td>Z2GT</td>
<td>Z3GT</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Default Tripping Logic Equations

$$TR = M1P + M2PT + M3PT + 67G1 + 67G2T + 67G3T + 51GT + OC + SV1T$$

$$TRCOMM = Z2PGS + 67QG2S$$

$$TRSOTF = M1P + M2P + 67G1 + 67G2 + 51GT + 50P1$$

$$DTT = IN101 + SV2 \cdot IN102$$
Default Reclose Logic Equations

79RI  =  M1P * 32QF + 67G1
79DTL =  (M1P + M2P + M3P) * !32QF + 50P1 + 51GT + M2PT + M3PT + SV1T + OC + IN101 + 67G2T + 67G3T

Default Output Contact Logic Equations

OUT101 = TRIP
OUT102 = TRIP
OUT103 = CLOSE
OUT104 = DSTRT + NSTRT + Z3XT
OUT105 = STOP + TRIP
OUT106 = OSB
OUT107 = LOP

SELogic Variables Equations

SV1  =  50P2 * ILOP
SV2  =  0 (Reserved for MPT)

The following contact input assignments are made automatically by the SEL-311C when setting APP = 221G5. These assignments cannot be changed unless setting APP is changed back to APP = 311C.

Default Contact Input Functions

IN101 = DT (Direct trip)
IN102 = PT (Permit trip)
IN103 = BT (Block trip)
IN104 = CL (Close breaker)
IN105 = 52A
IN106 = EXT (External event report trigger)
**Identifier Labels (See Settings Explanations in Section 9)**

- Relay Identifier (30 characters) \( \text{RID} = \) ________________
- Terminal Identifier (30 characters) \( \text{TID} = \) ________________

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

- Phase (IA, IB, IC) Current Transformer Ratio (1–6000) \( \text{CTR} = \) ________________
- Polarizing (IPOL) Current Transformer Ratio (1–6000) \( \text{CTRP} = \) ________________
- Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00) \( \text{PTR} = \) ________________
- Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00) \( \text{PTRS} = \) ________________

**Line Settings (See Settings Explanations in Section 9)**

- Positive-sequence line impedance magnitude (0.05–255.00 \( \Omega \) secondary {5 A nom.; 0.25–1275.00 \( \Omega \) secondary {1 A nom.}) \( \text{Z1MAG} = \) ________________
- Positive-sequence line impedance angle (5.00–90.00 degrees) \( \text{Z1ANG} = \) ________________
- Zero-sequence line impedance magnitude (0.05–255.00 \( \Omega \) secondary {5 A nom.; 0.25–1275.00 \( \Omega \) secondary {1 A nom.}) \( \text{Z0MAG} = \) ________________
- Zero-sequence line impedance angle (5.00–90.00 degrees) \( \text{Z0ANG} = \) ________________
- Line length (0.10–999.00, unitless) \( \text{LL} = \) ________________
- Application (311C, 221G, 221G5, 221H, 221F, 221F3, 221C, 221-16, 2PG10) \( \text{APP} = \text{221G5} \)
- Fault location (Y, N) (see Table 12.1 and Fault Location in Section 12) \( \text{EFLOC} = \) ________________
- Loss-of-Potential (Y, Y1, N) (see Figure 4.1) \( \text{ELOP} = \) ________________

**Mho Phase Distance Elements (See Settings Explanations in Section 3)**

- Zone 1 (OFF, 0.05–64.00 \( \Omega \) secondary {5 A nom.; 0.25–320.00 \( \Omega \) secondary {1 A nom.}) \( \text{Z1P} = \) ________________
- Zone 2 (OFF, 0.05–64.00 \( \Omega \) secondary {5 A nom.; 0.25–320.00 \( \Omega \) secondary {1 A nom.}) \( \text{Z2P} = \) ________________
- Zone 3 (OFF, 0.05–64.00 \( \Omega \) secondary {5 A nom.; 0.25–320.00 \( \Omega \) secondary {1 A nom.}) \( \text{Z3P} = \) ________________

**Mho Phase Distance Element Time Delays (See Settings Explanations in Section 3)**

- Zone 2 time delay (OFF, 0–16000 cycles) \( \text{Z2PD} = \) ________________
- Zone 3 time delay (OFF, 0–16000 cycles) \( \text{Z3PD} = \) ________________

Date Code 20011205
Phase Inst./Def.-Time Overcurrent Elements (See Figure 3.19)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.};
0.05–20.00 A secondary {1 A nom.})
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.};
0.05–20.00 A secondary {1 A nom.})
50P1P =
50P2P =

Residual Ground Inst./Def.-Time Overcurrent Elements (See Figure 3.22)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.};
0.05–20.00 A secondary {1 A nom.})
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.};
0.05–20.00 A secondary {1 A nom.})
Level 3 (OFF, 0.25–100.00 A secondary {5 A nom.};
0.05–20.00 A secondary {1 A nom.})
50G1P =
50G2P =
50G3P =

Residual Ground Definite-Time Overcurrent Element Time Delay (See Figure 3.22)
Level 2 (0.00–16000.00 cycles in 0.25-cycle steps)
Level 3 (0.00–16000.00 cycles in 0.25-cycle steps)
67G2D =
67G3D =

Residual Ground Time-Overcurrent Element (See Figure 3.25)
Pickup (OFF, 0.50–16.00 A secondary {5 A nom.};
0.10–3.20 A secondary {1 A nom.})
Curve (U1–U5, C1–C5) (see Figures 9.1 through 9.10)
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)
51GP =
51GC =
51GTD =

Out-of-Step Settings (See Figures 3.17 and 3.18)
Block Zone 1 (Y, N)
Block Zone 2 (Y, N)
Block Zone 3 (Y, N)
Out-of-Step block time delay (0.5–8000.0 cycles)
OOSB1 =
OOSB2 =
OOSB3 =
OSBD =

Zone/Level 3 and 4 Directional Control
Zone/Level 3 direction: Forward, Reverse (F, R)
DIR3 =

Directional Elements (See Directional Control Settings in Section 4)
Ground directional element priority: combination of Q, V, or I
ORDER =

Reclosing Relay (See Tables 6.2 and 6.3)
Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps)
Open interval 2 time (0.00–999999.00 cycles in 0.25-cycle steps)
Open interval 3 time (0.00–999999.00 cycles in 0.25-cycle steps)
79O11 =
79O12 =
79O13 =
Reset time from reclose cycle (0.00–999999.00 cycles in 0.25-cycle steps) 79RSD = 
Reset time from lockout (0.00–999999.00 cycles in 0.25-cycle steps) 79RSLD = 

**Switch-Onto-Fault (See Figure 5.3)**
- 52 A enable time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) 52AEND = 
- SOTF duration (0.50–16000.00 cycles in 0.25-cycle steps) SOTFD = 

**DCB Trip Scheme Settings (See Figure 5.14)**
- Zone (level) 3 reverse pickup time delay (0.00–16000.00 cycles in 0.25-cycle steps) Z3XPU = 
- Zone (level) 3 reverse dropout extension (0.00–16000.00 cycles in 0.25-cycle steps) Z3XD = 
- Block trip receive extension (0.00–16000.00 cycles in 0.25-cycle steps) BTXD = 
- Zone 2 distance short delay (0.00–60.00 cycles in 0.25-cycle steps) 21SD = 
- Level 2 overcurrent short delay (0.00–60.00 cycles in 0.25-cycle steps) 67SD = 

**Other Settings**
- Minimum trip duration time (4.00–16000.00 cycles in 0.25-cycle steps) TDURD = 

**SELOGIC Control Equation Variable Timers (See Figures 7.24 and 7.25)**
(SELOGIC control equation settings consist of Relay Word bits [see Table 9.4] and SELOGIC control.)
- SV1 Pickup Time (0.00-999999.00 cycles in 0.25-cycle steps) SV1PU = 
- SV1 Dropout Time (0.00-999999.00 cycles in 0.25-cycle steps) SV1DO = 

**Trip Logic Equations (See Figure 5.1)**
- Direct trip conditions TR = 
- Communications-assisted trip conditions TRCOMM = 
- Switch-onto-fault trip conditions TRSOTF = 
- Direct transfer trip conditions DTT = 

**Reclosing Relay Equations (See Reclosing Relay in Section 6)**
- Reclose initiate 79RI = 
- Drive-to-lockout 79DTL = 

**Torque Control Equations for Inst./Def.-Time Overcurrent Elements**
[Note: torque control equation settings cannot be set directly to logical 0]
- Residual Ground (see Figure 3.25) 51GTC = 

Date Code 20011205
**SELogic Control Equation Variable Timer Input Equations (See Figures 7.24 and 7.25)**

SELOGIC control equation Variable SV1  
SV1 = ________________

SELOGIC control equation Variable SV2  
SV2 = __________________

**Output Contact Equations (See Figure 7.27)**

Output Contact OUT101  
OUT101 = ________________

Output Contact OUT102  
OUT102 = ________________

Output Contact OUT103  
OUT103 = ________________

Output Contact OUT104  
OUT104 = ________________

Output Contact OUT105  
OUT105 = ________________

Output Contact OUT106  
OUT106 = ________________

Output Contact OUT107  
OUT107 = ________________

**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 = ____________

**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-311C Relay Fast Operate commands.

Power System Configuration (See Settings Explanations in Section 9)

Phase rotation (ABC, ACB) PHROT = ____________
SEL-221H to SEL-311C Settings Conversion Guide

Set APP = 221H in the SEL-311C to configure the relay to closely approximate the features, performance, and settings of an SEL-221H. When APP = 221H, the SEL-311C:

1. Configures itself as a compensator distance relay for phase faults and a ground directional overcurrent relay for ground faults using Permissive Overreaching Transfer Tripping.
2. Configures contact inputs and contact outputs to emulate those in an SEL-221H.
3. Presents the user only with those settings associated with SEL-221H type features.
4. Automatically calculates all other settings required to simulate an SEL-221H.

If additional capability is needed (e.g., Mirrored Bits or SELogic control equations) the relay may be returned to the setting APP = 311C to make all of the SEL-311C settings visible. It is important to remember that changing from APP = 311C to APP = 221H changes settings in the SEL-311C. Changing from APP = 221H to APP = 311C makes more SEL-311C settings visible, but does not change any other settings. If SEL-311C functions are used after setting APP is changed from 221H to 311C, do not change setting APP back to 221H.

As described above, when setting APP = 221H, the user is presented only with SEL-311C settings associated with the features found in an SEL-221H. This section explains how to make those remaining SEL-311C settings directly from the settings used in an SEL-221H.

There are mainly two kinds of settings in the SEL-311C. Relay settings are settings for protective elements. SELogic settings are Boolean expressions used to customize the logic of the SEL-311C. To set the SEL-311C to emulate an SEL-221H, follow these four steps:

1. Turn on the SEL-221H application setting by making setting APP = 221H. See Application Settings below.
2. Convert the appropriate SEL-221H settings to SEL-311C settings using the simple equations shown in Table 14.9. Be sure to convert from primary quantities (SEL-221H settings) to secondary quantities (SEL-311C settings). See Convert SEL-221H Primary Quantities to SEL-311C Secondary Quantities below.
3. For each Mask Logic setting in the SEL-221H shown in Table 14.10, create an equivalent SELogic control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.11.
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-311C application setting to “221H” as shown below:

```plaintext
=>>SET APP TERSE <ENTER>
Line Parameter Settings:
Application
(311C,221G,221G5,221H,221F,221F3,221C,221-16,2PG10)APP = 311C ? 221GH <ENTER>
Enable Settings:
Fault Location(Y,N) EFLOC = Y ? END <ENTER>
Save Changes(Y,N)? Y <ENTER>
Settings saved
=>>
```

Convert SEL-221H Primary Quantities to SEL-311C Secondary Quantities

All SEL-221H current settings must be converted from primary to secondary amps to be used in the SEL-311C. Divide the SEL-221H current setting by the current transformer ratio setting (CTR) to make the change.

SEL-221H 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-311C (Z1P) is calculated as

$$Z1P = \frac{Z1\%}{100} \cdot Z1MAG$$

where:
- Z1\% is the SEL-221H distance reach setting.
- Z1MAG is the SEL-311C positive-sequence line impedance setting in secondary ohms.
- Z1P is the SEL-311C Zone 1 reach setting in secondary ohms.

Convert SEL-221H Relay Settings to SEL-311C Relay Settings

Table 14.9 shows all the SEL-311C Relay settings that must be entered for the relay to perform protection similar to the SEL-221H when APP = 221H. Calculate each SEL-311C Relay setting from SEL-221H Relay settings using the formula shown. Instruction manual references are to subsection headings rather than to section headings.
<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-221H Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221H Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>RID</td>
<td>None</td>
<td></td>
<td>Section 3—Set n</td>
</tr>
<tr>
<td>TID</td>
<td>= ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTR</td>
<td>= CTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTRP</td>
<td>= CTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTR</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTRS</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1MAG</td>
<td>$= \sqrt{(R_1^2 + X_1^2)} \cdot \left[ \frac{CTR}{PTR} \right]$</td>
<td>Section 9—Settings Sheets</td>
<td></td>
</tr>
<tr>
<td>Z1ANG</td>
<td>$= \arctan \left[ \frac{X_1}{R_1} \right]$ (degrees) = MTA</td>
<td></td>
<td>Section 5—Choice of Line Impedances</td>
</tr>
<tr>
<td>Z0MAG</td>
<td>$= \sqrt{(R_0^2 + X_0^2)} \cdot (CTR/ PTR)$</td>
<td></td>
<td>Section 5—Choice of Maximum Torque Angle (MTA)</td>
</tr>
<tr>
<td>Z0ANG</td>
<td>$= \arctan \left[ \frac{X_0}{R_0} \right]$ (degrees)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>= LL</td>
<td></td>
<td>Section 9—Settings Sheets</td>
</tr>
<tr>
<td>APP</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EFLOC</td>
<td>= LOCAT</td>
<td>Section 9—Settings Sheets</td>
<td>Section 2—Fault Locator</td>
</tr>
<tr>
<td>ELOP</td>
<td></td>
<td>Section 4—Loss of Potential</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>= LOPE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>= Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1P</td>
<td>$= \frac{Z1%}{100} \cdot Z1MAG$</td>
<td>Section 3—Phase Distance Elements</td>
<td>Section 2—Mho Elements</td>
</tr>
<tr>
<td>Z2P</td>
<td>$= \frac{Z2%}{100} \cdot Z1MAG$</td>
<td></td>
<td>Note: Z1MAG is an SEL-311C setting</td>
</tr>
<tr>
<td>SEL-311C Relay Setting</td>
<td>Calculated from SEL-221H Settings</td>
<td>SEL-311C Instruction Manual Section</td>
<td>SEL-221H Instruction Manual Section</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>Z3P</td>
<td>$Z_3P = \frac{Z_3%}{100} \cdot Z_1MAG$ &lt;br&gt; where &lt;br&gt; $Z_1MAG = \sqrt{(R_1^2 + X_1^2) \left[ CTR \right] PTR}$</td>
<td>Section 3—Zone Time Delay Elements</td>
<td>Section 5—Choice of Zone 2 and Zone 3 Time Delay Settings</td>
</tr>
<tr>
<td>Z2PD</td>
<td>$Z_2PD$</td>
<td>Section 5—Switch-onto-Fault (SOTF) Trip Logic</td>
<td>Section 5—50H, High Set Phase Overcurrent Element</td>
</tr>
<tr>
<td>Z3PD</td>
<td>$Z_3PD$</td>
<td>Section 4—Loss-of-Potential Logic</td>
<td>Section 5—50M, Medium Set Phase Overcurrent</td>
</tr>
<tr>
<td>50P1P</td>
<td>$= 50H/CTR$</td>
<td>Section 3—Inst./Def. Time Overcurrent Elements</td>
<td>Section 2—Logic Diagrams</td>
</tr>
<tr>
<td>50P2P</td>
<td>$= 50M/CTR$</td>
<td>Section 3—Inst./Def. Time Overcurrent Elements</td>
<td>Section 2—Logic Diagrams</td>
</tr>
<tr>
<td>50G1P</td>
<td>$= 50N1P/CTR$</td>
<td>Section 3—Inst./Def. Time Overcurrent Elements</td>
<td>Section 2—Logic Diagrams</td>
</tr>
<tr>
<td>50G2P</td>
<td>$= 50N2P/CTR$</td>
<td>Section 3—Inst./Def. Time Overcurrent Elements</td>
<td>Section 2—Logic Diagrams</td>
</tr>
<tr>
<td>50G3P</td>
<td>$= 50N3P/CTR$</td>
<td>Section 3—Inst./Def. Time Overcurrent Elements</td>
<td>Section 2—Logic Diagrams</td>
</tr>
<tr>
<td>67G2D</td>
<td>$= Z2DG$</td>
<td>Section 2—Logic Diagrams</td>
<td>Section 3—Inst./Def. Time Overcurrent Elements</td>
</tr>
<tr>
<td>67G3D</td>
<td>$= Z3DG$</td>
<td>Section 3—Inst./Def. Time Overcurrent Elements</td>
<td>Section 2—Logic Diagrams</td>
</tr>
<tr>
<td>51GP</td>
<td>$= 51NP$</td>
<td>Section 3—Residual Ground Time-Overcurrent Element</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
</tr>
<tr>
<td>51GC*</td>
<td>$= 51NC$</td>
<td>Section 3—Residual Ground Time-Overcurrent Element</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
</tr>
<tr>
<td>U1</td>
<td>$= 1$</td>
<td>Section 3—Residual Ground Time-Overcurrent Element</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
</tr>
<tr>
<td>U2</td>
<td>$= 2$</td>
<td>Section 3—Residual Ground Time-Overcurrent Element</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
</tr>
<tr>
<td>U3</td>
<td>$= 3$</td>
<td>Section 3—Residual Ground Time-Overcurrent Element</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
</tr>
<tr>
<td>U4</td>
<td>$= 4$</td>
<td>Section 3—Residual Ground Time-Overcurrent Element</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
</tr>
<tr>
<td>51GTD</td>
<td>$= 51NTD$</td>
<td>Section 3—Time-Overcurrent Elements</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
</tr>
<tr>
<td>51GTC</td>
<td>$= 51NCT$ (51GTC is an SEL-311C SELOGIC setting)</td>
<td>Section 3—Time-Overcurrent Elements</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
</tr>
<tr>
<td>(= 1)</td>
<td>$= N$</td>
<td>Section 3—Time-Overcurrent Elements</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
</tr>
<tr>
<td>(= 32GF)</td>
<td>$= Y$</td>
<td>Section 3—Time-Overcurrent Elements</td>
<td>Section 2—51N Residual Time-Overcurrent Element</td>
</tr>
<tr>
<td>SEL-311C Relay Setting</td>
<td>Calculated from SEL-221H Settings</td>
<td>SEL-311C Instruction Manual Section</td>
<td>SEL-221H Instruction Manual Section</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>DIR3</td>
<td>= ZONE 3</td>
<td>Section 4—Directional Control Settings</td>
<td>Section 5—Zone 3 Direction Setting</td>
</tr>
<tr>
<td>ORDER Q</td>
<td>= 32QE</td>
<td>Section 4—Directional Control for Ground Distance and Residual Ground Overcurrent Elements</td>
<td>Section 2—Directional Elements</td>
</tr>
<tr>
<td>V</td>
<td>= 32VE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>= 32IE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52AEND</td>
<td>= 52BT (Pickup)</td>
<td>Section 5—Switch-On-Fault (SOTF) Trip Logic</td>
<td>Section 5—High Set Phase Overcurrent Setting (50H)</td>
</tr>
<tr>
<td>SOTFD</td>
<td>= 52BT (Dropout)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z3RBD</td>
<td>= Z3RBT</td>
<td>Section 5—Permissive Overreaching Transfer Trip (POTT) Logic</td>
<td>Section 5—Zone 3 Reverse Block Timer Setting (Z3RBT)</td>
</tr>
<tr>
<td>EBLKD</td>
<td>= None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ETDPU</td>
<td>= ETDPU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDURD</td>
<td>= EDUR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EWFC</td>
<td>= WFCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27PPW</td>
<td>= 27PP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>59NW</td>
<td>= 59N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDURD</td>
<td>= TDUR</td>
<td>Section 4—Unlatch Trip</td>
<td>Section 5—Trip Duration Timer (TDUR)</td>
</tr>
<tr>
<td>SV1PU</td>
<td>= A1TP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SV1DO</td>
<td>= A1TD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SV2PU</td>
<td>= 50MFD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Curve U1 in the SEL-311C is slightly different from curve 1 in the SEL-221H. Time dial adjustments may be necessary.

**Note:** SEL-311C phase-to-phase fault detector settings 50PP1, 50PP2, and 50PP3 are set to $0.1 \times I_{nom}$ and are hidden. This corresponds to SEL-221H setting 50L.
Convert SEL-221H Output Mask Logic Settings to SELOGIC Control Equations

See *Programmable Output Contact Mask Settings* in *Section 5: Applications* in the SEL-221H Instruction Manual for a description of output masks. In the SEL-311C, output masks are replaced by SELOGIC control equations as shown below:

Table 14.10: SEL-311C SELOGIC Equation Equivalent to Each SEL-221H Mask Logic Setting

<table>
<thead>
<tr>
<th>SEL-221H Settings Mask</th>
<th>SEL-311C SELOGIC Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTU</td>
<td>TR</td>
</tr>
<tr>
<td>MPT</td>
<td>TRCOMM</td>
</tr>
<tr>
<td>MTB</td>
<td>SV4</td>
</tr>
<tr>
<td>MTO</td>
<td>TRSOTF</td>
</tr>
<tr>
<td>MA1</td>
<td>OUT104</td>
</tr>
<tr>
<td>MA2</td>
<td>OUT105</td>
</tr>
<tr>
<td>MA3</td>
<td>OUT106</td>
</tr>
<tr>
<td>MA4</td>
<td>OUT107</td>
</tr>
</tbody>
</table>

Table 14.11 shows all SEL-221H Relay Word bits, and an approximate equivalent SEL-311C SELOGIC expression, when setting APP = 221H in the SEL-311C. Table 14.10 shows each SEL-221H Mask Logic Setting and the equivalent SEL-311C SELOGIC control equation. To convert a SEL-221H Mask Logic Setting to a SELOGIC control equation, logically OR each appropriate SEL-221H Relay Word bit equivalent expression (Table 14.11) and enter the resultant expression in the related SELOGIC control equation listed in Table 14.10.

Table 14.11: SELOGIC Equivalent to SEL-221H Relay Word Bits

<table>
<thead>
<tr>
<th>SEL-221H Relay Word Bit</th>
<th>Equivalent SEL-311C SELOGIC Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>1ABC</td>
<td>M1P * 32QF</td>
</tr>
<tr>
<td>2ABC</td>
<td>M2P * 32QF</td>
</tr>
<tr>
<td>3ABC</td>
<td>M3P * 32QF if DIR3 = F</td>
</tr>
<tr>
<td></td>
<td>M3P * 32QR if DIR3 = R</td>
</tr>
<tr>
<td>4ABC</td>
<td>None</td>
</tr>
<tr>
<td>LOP</td>
<td>ILOP</td>
</tr>
<tr>
<td>50H</td>
<td>50P1</td>
</tr>
<tr>
<td>50M</td>
<td>50P2</td>
</tr>
<tr>
<td>50L</td>
<td>None</td>
</tr>
<tr>
<td>51NT</td>
<td>51GT</td>
</tr>
<tr>
<td>SEL-221H Relay Word Bit</td>
<td>Equivalent SEL-311C SELOGIC Expression</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>67N1</td>
<td>67G1</td>
</tr>
<tr>
<td>67N2</td>
<td>67G2</td>
</tr>
<tr>
<td>67N3</td>
<td>67G3</td>
</tr>
<tr>
<td>51NP</td>
<td>51G</td>
</tr>
<tr>
<td>Z1P</td>
<td>M1P</td>
</tr>
<tr>
<td>Z2P</td>
<td>M2P</td>
</tr>
<tr>
<td>Z3P</td>
<td>M3P</td>
</tr>
<tr>
<td>Z2PT</td>
<td>M2PT</td>
</tr>
<tr>
<td>Z3PT</td>
<td>M3PT</td>
</tr>
<tr>
<td>Z3RB</td>
<td>Z3RB</td>
</tr>
<tr>
<td>KEY</td>
<td>KEY</td>
</tr>
<tr>
<td>50MF</td>
<td>SV1T (SV1 = 50P1 * ILOP)</td>
</tr>
<tr>
<td>PTEE</td>
<td>None</td>
</tr>
<tr>
<td>ECTT</td>
<td>ECTT</td>
</tr>
<tr>
<td>DF</td>
<td>32GF</td>
</tr>
<tr>
<td>ALRM</td>
<td>ALARM</td>
</tr>
<tr>
<td>TRIP</td>
<td>TRIP or OUT101 or OUT102</td>
</tr>
<tr>
<td>TC</td>
<td>OC</td>
</tr>
<tr>
<td>DT</td>
<td>IN101</td>
</tr>
<tr>
<td>52BT</td>
<td>SOTFE</td>
</tr>
<tr>
<td>WFC</td>
<td>WFC</td>
</tr>
<tr>
<td>Z2GT</td>
<td>67G2T</td>
</tr>
<tr>
<td>Z3GT</td>
<td>67G3T</td>
</tr>
</tbody>
</table>

For example, the factory default setting for MPT in the SEL-221H is shown in Table 14.12. From Table 14.10, the equivalent SEL-311C SELOGIC control equation to MPT is TRCOMM. Constructing the logical OR of the equivalent of each element selected in the MPT mask from Table 14.11 gives:

\[
TRCOMM = M2P \cdot \neg 32QF + 67G2 + M2P + IN101
\]
Since IN101 (DT) is also included in the DTT tripping logic equation, it can be eliminated from the TRCOMM equation. The term M2P * !32QF + M2P simplifies to just M2P. So,

\[
\text{TRCOMM} = M2P + 67G2
\]

which is the default SELOGIC control equation for TRCOMM when APP = 221H.

When setting APP = 221H, the SEL-311C automatically sets the following SELOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-221H to customize the relay logic.

Table 14.12: Default SEL-221H Mask Logic Setting for MPT

<table>
<thead>
<tr>
<th></th>
<th>1ABC</th>
<th>2ABC</th>
<th>3ABC</th>
<th>4ABC</th>
<th>LOP</th>
<th>50H</th>
<th>50M</th>
<th>50L</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>51NT</td>
<td>67N1</td>
<td>67N2</td>
<td>67N3</td>
<td>51NP</td>
<td>Z1P</td>
<td>Z2P</td>
<td>Z3P</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Z2PT</td>
<td>Z3PT</td>
<td>Z3RB</td>
<td>KEY</td>
<td>50MF</td>
<td>PTEE</td>
<td>ECTT</td>
<td>DF</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>ALRM</td>
<td>TRIP</td>
<td>TC</td>
<td>DT</td>
<td>52BT</td>
<td>WFC</td>
<td>Z2GT</td>
<td>Z3GT</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Default Tripping Logic Equations

\[
\text{TR} = M1P + M2PT + M3PT + 67G1 + 67G2T + 67G3T + 51GT + OC + SV2T
\]
\[
\text{TRCOMM} = M2P + 67G2
\]
\[
\text{TRSOTF} = M1P + M2P + 67G1 + 67G2 + 51GT + 50P1
\]
\[
\text{DTT} = \text{IN101 + SV4 * !IN103}
\]

Default Output Contact Logic Equations

\[
\text{OUT101} = \text{TRIP}
\]
\[
\text{OUT102} = \text{TRIP}
\]
\[
\text{OUT103} = \text{CLOSE}
\]
\[
\text{OUT104} = \text{SV1T}
\]
\[
\text{OUT105} = \text{LOP}
\]
\[
\text{OUT106} = \text{WFC}
\]
\[
\text{OUT107} = \text{M1P * !32QF}
\]
**SELogic Variables Equations**

\[
\begin{align*}
SV1 & = \text{KEY} \\
SV2 & = 50P2 \times \text{ILOP} \\
SV3 & = 0 \text{ (Not used)} \\
SV4 & = 0 \text{ (Reserved for SELOGIC equivalent to MBT)}
\end{align*}
\]

The following contact input assignments are made automatically by the SEL-311C when setting APP = 221H. These assignments cannot be changed unless setting APP is changed back to APP = 311C.

**Default Contact Input Functions**

\[
\begin{align*}
\text{IN101} & = \text{DT (Direct trip)} \\
\text{IN102} & = \text{PT (Permit trip)} \\
\text{IN103} & = \text{BT (Block trip)} \\
\text{IN104} & = \text{CL (Close breaker)} \\
\text{IN105} & = \text{52A} \\
\text{IN106} & = \text{EXT (External event report trigger)}
\end{align*}
\]
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 (311C, 221G, 221G5, 221H, 221F, 221F3) APP = ___221H___
Fault location (Y, N) (see Table 12.1 and Fault Location in Section 12) EFLOC = ____________
Loss-of-Potential (Y, Y1, N) (see Figure 4.1) ELOP = ____________

Mho Phase Distance Elements (See Settings Explanations in Section 3)
Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) Z1P = ____________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) Z2P = ____________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25–320.00 Ω secondary {1 A nom.}) Z3P = ____________

Mho Phase Distance Element Time Delays (See Settings Explanations in Section 3)
Zone 2 time delay (OFF, 0–16000 cycles) Z2PD = ____________
Zone 3 time delay (OFF, 0–16000 cycles) Z3PD = ____________
Phase Inst./Def.-Time Overcurrent Elements (See Figure 3.19)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})

Residual Ground Inst./Def.-Time Overcurrent Elements (See Figure 3.22)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
Level 3 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})

Residual Ground Definite-Time Overcurrent Element Time Delay (See Figure 3.22)
Level 2 (0.00–16000.00 cycles in 0.25-cycle steps) 67G2D = _________
Level 3 (0.00–16000.00 cycles in 0.25-cycle steps) 67G3D = _________

Residual Ground Time-Overcurrent Element (See Figure 3.25)
Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})
Curve (U1–U5, C1–C5) (see Figures 9.1 through 9.10) 51GC = _________
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5) 51GTD = _________

Zone/Level 3 and 4 Directional Control
Zone/Level 3 direction: Forward, Reverse (F, R) DIR3 = _________

Directional Elements (See Directional Control Settings in Section 4)
Ground directional element priority: combination of Q, V, or I ORDER = _________

Switch-Onto-Fault (See Figure 5.3)
52 A enable time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) 52AEND = _________
SOTF duration (0.50–16000.00 cycles in 0.25-cycle steps) SOTFD = _________

POTT Trip Scheme Settings (Also Used in DCUB Trip Schemes) (See Figure 5.6)
Zone (level) 3 reverse block time delay
(0.00–16000.00 cycles in 0.25-cycle steps) Z3RBD = _________
Echo block time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) EBLKD = _________
Echo time delay pickup (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) ETPDU = _________
Echo duration time delay (0.00–16000.00 cycles in 0.25-cycle steps) EDURD = _________
Weak-infeed enable (Y, N) EWFC = _________
WIF phase-to-phase undervoltage (0.0–260.0 V secondary) 27PPW = ________
WIF zero-sequence (3V0) overvoltage (0.0–150.0 V secondary) 59NW = ________

**Other Settings**
Minimum trip duration time (4.00–16000.00 cycles in 0.25-cycle steps) TDURD = ________

**SELogic Control Equation Variable Timers (See Figures 7.24 and 7.25)**
SV1 Pickup Time (0.00-999999.00 cycles in 0.25-cycle steps) SV1PU = ________
SV1 Dropout Time (0.00-999999.00 cycles in 0.25-cycle steps) SV1DO = ________
SV2 Pickup Time (0.00-999999.00 cycles in 0.25-cycle steps) SV2PU = ________
SV2 Dropout Time (0.00-999999.00 cycles in 0.25-cycle steps) SV2DO = ________

**Trip Logic Equations (See Figure 5.1)**
Direct trip conditions TR = ________________
Communications-assisted trip conditions TRCOMM = ________________
Switch-onto-fault trip conditions TRSOTF = ________________
Direct transfer trip conditions DTT = ________________

**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 3.25) 51GTC = ________________

**SELogic Control Equation Variable Timer Input Equations (See Figures 7.24 and 7.25)**
SELOGIC control equation Variable SV1 SV1 = ________________
SELOGIC control equation Variable SV2 SV2 = ________________
SELOGIC control equation Variable SV3 SV3 = ________________
SELOGIC control equation Variable SV4 SV4 = ________________

**Output Contact Equations (See Figure 7.27)**
Output Contact OUT101 OUT101 = ________________
Output Contact OUT102 OUT102 = ________________
Output Contact OUT103 OUT103 = ________________
Output Contact OUT104 OUT104 = ________________
Output Contact OUT105 OUT105 = ________________
Output Contact OUT106 OUT106 = ________________
Output Contact OUT107 OUT107 = ________________
Protocol Settings (See Below)

Protocol Settings

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 =

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-311C Relay Fast Operate commands.

Power System Configuration (See Settings Explanations in Section 9)

Phase rotation (ABC, ACB) PHROT =

Date Code 20011205
SEL-221F to SEL-311C Settings Conversion Guide

Set APP = 221F in the SEL-311C to configure the relay to closely approximate the features, performance, and settings of an SEL-221F. When APP = 221F, the SEL-311C:

1. Configures itself as a phase and ground distance relay and a ground directional overcurrent relay.
2. Performs reclosing and synchronism check functions.
3. Configures contact inputs and outputs to emulate those in an SEL-221F.
4. Presents the user only with those settings associated with SEL-221F type features.
5. Automatically calculates all other settings required to simulate an SEL-221F.

If additional capability is needed (e.g., Mirrored Bits or SELogic control equations) the relay may be returned to the setting APP = 311C to make all of the SEL-311C settings visible. It is important to remember that changing from APP = 311C to APP = 221F changes settings in the relay. Changing from APP = 221F to APP = 311C makes more SEL-311C settings visible, but does not change any other settings. If SEL-311C functions are used after setting APP is changed from 221F to 311C, do not change setting APP back to 221F.

As described above, when setting APP = 221F, the user is presented only with SEL-311C settings associated with the features found in an SEL-221F. This section explains how to make those remaining SEL-311C settings directly from the settings used in an SEL-221F.

There are mainly two kinds of settings in the SEL-311C. Relay settings are settings for protective elements. SELogic settings are Boolean expressions used to customize the logic of the SEL-311C. To set the SEL-311C to emulate an SEL-221F, follow these four steps:

1. Turn on the SEL-221F application setting by making setting APP = 221F. See Application Settings below.
2. Convert the appropriate SEL-221F settings to SEL-311C settings using the simple equations shown in Table 14.13. Be sure to convert from primary quantities (SEL-221F settings) to secondary quantities (SEL-311C settings). See Convert SEL-221F Primary Quantities to SEL-311C Secondary Quantities below.
3. For each Mask Logic setting in the SEL-221F shown in Table 14.14, create an equivalent SELogic control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.15.
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-311C application setting to “221F” as shown below:

```
>>>SET APP TERSE <ENTER>
Line Parameter Settings:
Application
(311C,221G,221G5,221H,221F,221F3,221C,221-16,2PG10) APP = 311C ? 221GF <ENTER>
Enable Settings:
Fault Location(Y,N) EFLOC = Y ? END <ENTER>
Save Changes(Y,N)? Y <ENTER>
Settings saved
```

**Convert SEL-221F Primary Quantities to SEL-311C Secondary Quantities**

All SEL-221F current settings must be converted from primary to secondary amps to be used in the SEL-311C. Divide the SEL-221F current setting by the current transformer ratio setting (CTR) to make the change.

SEL-221F impedance settings must be converted from percent of primary line impedance to secondary impedance in ohms. For example, the Zone 1 distance setting in the SEL-311C (Z1P) is calculated as

\[
Z1P = \frac{Z1\%}{100} \cdot Z1MAG
\]

where:  
- Z1\% is the SEL-221F distance reach setting.
- Z1MAG is the SEL-311C positive-sequence line impedance setting in secondary ohms.
- Z1P is the SEL-311C Zone 1 reach setting in secondary ohms.

**Convert SEL-221F Relay Settings to SEL-311C Relay Settings**

Table 14.13 shows all the SEL-311C Relay settings that must be entered for the relay to perform protection similar to the SEL-221F when APP = 221F. Calculate each SEL-311C Relay setting from the corresponding SEL-221F Relay setting using the formula shown. Instruction manual references are to subsection headings rather than to section headings.

Please carefully note the difference between the SEL-311C and SEL-221F in the implementation of certain protection and logic schemes. For example, reclosing and synchronism check settings do not correspond exactly between the two relays. Always thoroughly test logic schemes to be sure they operate as intended.
Table 14.13: SEL-311C Settings Calculated From SEL-221F Settings

<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-221F Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221F Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>RID</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TID</td>
<td>= ID</td>
<td></td>
<td>Section 3—Set</td>
</tr>
<tr>
<td>CTR</td>
<td>= CTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTRP</td>
<td>= CTR</td>
<td></td>
<td>Section 9—Settings Sheets</td>
</tr>
<tr>
<td>PTR</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTRS</td>
<td>= SPTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1MAG</td>
<td>$= \sqrt{R1^2 + X1^2} \times \left[\frac{CTR}{PTR}\right]$</td>
<td>Section 9—Settings Sheets</td>
<td>Section 5—R1, X1, R0, X0, and Line Length (LL)</td>
</tr>
<tr>
<td>Z1ANG</td>
<td>$= \arctan\left[\frac{X1}{R1}\right]\text{ (degrees)} = MTA$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z0MAG</td>
<td>$= \sqrt{R0^2 + X0^2} \times (CTR/PTR)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z0ANG</td>
<td>$= \arctan\left[\frac{X0}{R0}\right]\text{ (degrees)}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>= LL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APP</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELOP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>= LOPE</td>
<td>Section 4—Loss of Potential</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>= N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1P</td>
<td>$= \frac{Z1%}{100} \times Z1MAG$</td>
<td>Section 3—Phase Distance Elements</td>
<td></td>
</tr>
<tr>
<td>Z1MG</td>
<td>$= \frac{Z1%}{100} \times Z1MAG$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z2P</td>
<td>$= \frac{Z2%}{100} \times Z1MAG$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z2MG</td>
<td>$= \frac{Z2%}{100} \times Z1MAG$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z3P</td>
<td>$= \frac{Z3%}{100} \times Z1MAG$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z3MG</td>
<td>$= \frac{Z3%}{100} \times Z1MAG$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Z1MAG is an SEL-311C setting.
<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-221F Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221F Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z2PD</td>
<td>= Z2DP</td>
<td>Section 3—Zone Time Delay Elements</td>
<td>Section 5—Zone 2 Phase and Ground Distance</td>
</tr>
<tr>
<td>Z2GD</td>
<td>= Z2DG</td>
<td></td>
<td>Section 5—Time Delays (Z2DP, Z2DG)</td>
</tr>
<tr>
<td>Z3D</td>
<td>= Z3D</td>
<td></td>
<td>Section 5—Zone 3 Phase and Ground Time Delay (Z3D)</td>
</tr>
<tr>
<td>50P1P</td>
<td>= 50H/CTR</td>
<td>Section 5—Switch- Onto-Fault (SOTF) Trip Logic</td>
<td>Section 5—High Set Phase Overcurrent Element Setting</td>
</tr>
<tr>
<td>50G1P</td>
<td>= 67NP/CTR</td>
<td>Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements</td>
<td>Section 5—67NP Residual Overcurrent Settings (67NP, 67NTC)</td>
</tr>
<tr>
<td>N/A (67G1TC = 1)</td>
<td>= 67NTC (In the SEL-311C, 50G1P is fixed forward)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GP</td>
<td>= 51NP/CTR</td>
<td>Section 3—Residual Ground Time-Overcurrent Element</td>
<td>Section 5—Residual Time-Overcurrent Settings (51NP, 51NC, 51NTD, 51NTC)</td>
</tr>
<tr>
<td>51GC</td>
<td>= 51NC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U1*</td>
<td>= 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U2</td>
<td>= 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U3</td>
<td>= 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U4</td>
<td>= 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTD</td>
<td>= 51NTD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTC</td>
<td>= 51NTC (51GTC is an SEL-311C SELOGIC setting)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(= 1)</td>
<td>= N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(= 32GF)</td>
<td>= Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25VLO</td>
<td>= 27VLO • (1000/PTR)</td>
<td>Section 4—Synchronism Check Element Settings</td>
<td>Section 5—Synchronism Checking Function</td>
</tr>
<tr>
<td>25VHI</td>
<td>= 59VHI • (1000/PTR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25SF</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25ANG1</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25ANG2</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEL-311C Relay Setting</td>
<td>Calculated from SEL-221F Settings</td>
<td>SEL-311C Instruction Manual Section</td>
<td>SEL-221F Instruction Manual Section</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>SYNCP</td>
<td>SYNCP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCLOSD</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79OI1</td>
<td>= 79OI1</td>
<td>Section 6—Close and Reclose Logic</td>
<td>Section 5—Reclose Logic</td>
</tr>
<tr>
<td>79RSD</td>
<td>= 79RS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79RSLD</td>
<td>= 79RS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52AEND</td>
<td>= 52BT (Pickup)</td>
<td>Section 5—Switch-Onto-Fault (SOTF) Trip Logic</td>
<td>Section 5—52BT Setting (52BT) And Switch- Onto-Fault Protection</td>
</tr>
<tr>
<td>SOTFD</td>
<td>= 52BT (Dropout)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDURD</td>
<td>= TDUR</td>
<td>Section 4—Unlatch Trip Duration Timer (TDUR)</td>
<td>Section 5—Trip Duration Timer (TDUR)</td>
</tr>
<tr>
<td>SV1PU</td>
<td>= A1TP</td>
<td>Section 7—SELOGIC control equation Variables/Timers</td>
<td>Section 2—Miscellaneous Timers</td>
</tr>
<tr>
<td>SV1DO</td>
<td>= A1TD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SV2PU</td>
<td>= VCT</td>
<td>Section 3—Voltage Elements</td>
<td></td>
</tr>
<tr>
<td>SV2DO</td>
<td>None</td>
<td>Section 7—Latch Control Switches</td>
<td></td>
</tr>
</tbody>
</table>

* Curve U1 in the SEL-311C is slightly different from curve 1 in the SEL-221F. Time dial adjustments may be necessary.

**Note:** SEL-311C phase-to-phase fault detector settings (50PP1, 50PP2, 50PP3) are set to their minimum values and hidden. This corresponds to SEL-221F setting 50P.
SEL-311C phase-to-ground and residual fault detector settings (50L1, 50L2, 50L3, 50GZ1, 50GZ2, and 50GZ3) are set to their minimum values and hidden. This corresponds to SEL-221F setting 50NG.
SEL-221F function “Remote End Just Opened” (REJO) is not implemented in the SEL-311C.
Convert SEL-221F Output Mask Logic Settings to SELogic Control Equations

See Programmable Output Contact Mask Settings in Section 5: Applications in the SEL-221F Instruction Manual for a description of output masks. In the SEL-311C, output masks are replaced by SELogic control equations as shown below:

Table 14.14: SEL-311C SELogic Equation Equivalent to Each SEL-221F Mask Logic Setting

<table>
<thead>
<tr>
<th>SEL-221F Settings Mask</th>
<th>SEL-311C SELogic Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTU</td>
<td>TR</td>
</tr>
<tr>
<td>MPT</td>
<td>SV3 (DTT)</td>
</tr>
<tr>
<td>MTB</td>
<td>SV4 (DTT)</td>
</tr>
<tr>
<td>MTO</td>
<td>TRSOTF</td>
</tr>
<tr>
<td>MA1</td>
<td>OUT104</td>
</tr>
<tr>
<td>MA2</td>
<td>OUT105</td>
</tr>
<tr>
<td>MA3</td>
<td>OUT106</td>
</tr>
<tr>
<td>MA4</td>
<td>OUT107</td>
</tr>
<tr>
<td>MRI</td>
<td>79RI</td>
</tr>
<tr>
<td>MRC</td>
<td>79DTL</td>
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</tbody>
</table>

Table 14.15 shows all SEL-221F Relay Word bits, and an approximate equivalent SEL-311C SELogic expression, when setting APP = 221F in the SEL-311C. Table 14.14 shows each SEL-221F Mask Logic Setting and the equivalent SEL-311C SELogic control equation. To convert a SEL-221F Mask Logic Setting to a SELogic control equation, logically OR each appropriate SEL-221F Relay Word bit equivalent expression (Table 14.15) and enter the resultant expression in the related SELogic control equation (Table 14.14).

Table 14.15: SELogic Equivalent to SEL-221F Relay Word Bits

<table>
<thead>
<tr>
<th>SEL-221F Relay Word Bit</th>
<th>Equivalent SEL-311C SELogic Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z1P</td>
<td>M1P</td>
</tr>
<tr>
<td>Z1G</td>
<td>Z1G</td>
</tr>
<tr>
<td>Z2PT</td>
<td>M2PT</td>
</tr>
<tr>
<td>Z2GT</td>
<td>Z2GT</td>
</tr>
<tr>
<td>Z3</td>
<td>M3P + M3G</td>
</tr>
<tr>
<td>Z3T</td>
<td>Z3T</td>
</tr>
<tr>
<td>3P21</td>
<td>M3P * !32QF</td>
</tr>
<tr>
<td>32Q</td>
<td>32GF + 32QF</td>
</tr>
<tr>
<td>SEL-221F Relay Word Bit</td>
<td>Equivalent SEL-311C SELOGIC Expression</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>67N</td>
<td>67G1</td>
</tr>
<tr>
<td>51NP</td>
<td>51G</td>
</tr>
<tr>
<td>51NT</td>
<td>51GT</td>
</tr>
<tr>
<td>50NG</td>
<td>None</td>
</tr>
<tr>
<td>50P</td>
<td>None</td>
</tr>
<tr>
<td>50H</td>
<td>50P1</td>
</tr>
<tr>
<td>IN1</td>
<td>IN101</td>
</tr>
<tr>
<td>REJO</td>
<td>None</td>
</tr>
<tr>
<td>LOP</td>
<td>ILOP</td>
</tr>
<tr>
<td>52BT</td>
<td>SOTFE</td>
</tr>
<tr>
<td>27S</td>
<td>!59VS</td>
</tr>
<tr>
<td>27P</td>
<td>!59VP</td>
</tr>
<tr>
<td>59S</td>
<td>59VS</td>
</tr>
<tr>
<td>59P</td>
<td>59VP</td>
</tr>
<tr>
<td>SSC</td>
<td>25A1</td>
</tr>
<tr>
<td>VSC</td>
<td>SV2T</td>
</tr>
<tr>
<td>(LSDP)</td>
<td>(59VS * !59VP * !50L)</td>
</tr>
<tr>
<td>(LPDS)</td>
<td>(59VP * !59VS * !50L)</td>
</tr>
</tbody>
</table>

For example, the factory default setting for MRC in the SEL-221F is shown in Table 14.16. From Table 14.14, the equivalent SEL-311C SELOGIC control equation to MRC is 79DTL. Constructing the logical OR of the equivalent of each element selected in the MRC mask from Table 14.15 gives:

$$79DTL = Z3T + 51GT$$

Include the open command OC:

$$79DTL = Z3T + 51GT + OC$$

This is the default SELOGIC control equation for 79DTL when APP = 221F.

When setting APP = 221F, the SEL-311C automatically sets the following SELOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-221F to customize the relay logic.
Table 14.16: Default SEL-221F Mask Logic Setting for MRC

<table>
<thead>
<tr>
<th>Z1P</th>
<th>Z1G</th>
<th>Z2PT</th>
<th>Z2GT</th>
<th>Z3</th>
<th>Z3T</th>
<th>3P21</th>
<th>32Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>67N</td>
<td>51NP</td>
<td>51NT</td>
<td>50NG</td>
<td>50P</td>
<td>50H</td>
<td>IN1</td>
<td>REJO</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LOP</td>
<td>52BT</td>
<td>27S</td>
<td>27P</td>
<td>59S</td>
<td>59P</td>
<td>SSC</td>
<td>VSC</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Default Tripping Logic Equations

\[
TR = M1P + Z1G + M2PT + Z2GT + Z3 + 67G1 + 51GT + OC
\]

\[
TRSOTF = M1P + Z1G + M2PT + Z2GT + Z3 + 67G1 + 51GT + 50P1
\]

\[
DTT = IN101 + SV3 * IN102 + SV4 * !IN103
\]

Default Reclose Logic Equations

\[
79RI = M1P + Z1G + M2PT + Z2GT + 67G1
\]

\[
79DTL = Z3 + 51GT + OC
\]

Default Output Contact Logic Equations

\[
OUT101 = TRIP
\]

\[
OUT102 = TRIP
\]

\[
OUT103 = CLOSE
\]

\[
OUT104 = SV1T
\]

\[
OUT105 = SV2T
\]

\[
OUT106 = M1P + Z1G + M2PT + Z2GT + 67G1
\]

\[
OUT107 = Z3 + 51GT
\]

SELogic Variables Equations

\[
SV1 = 25A1
\]

\[
SV2 = 59VP * !59VS * !50L * LT1 + 59VS * !59VP * !50L * LT2
\]

\[
SV3 = M3P + Z3G
\]

\[
SV4 = 0
\]
SELogic Latch Equations

The SELogic latch equations emulate the SEL-221F setting PSVC for settings P, S, and E.

Table 14.17: SEL-221F Setting PSVC for Settings P, S, and E

<table>
<thead>
<tr>
<th>SEL-311C Relay Word Bit</th>
<th>PSVC = S (Default)</th>
<th>PSVC = P</th>
<th>PSVC = E</th>
</tr>
</thead>
<tbody>
<tr>
<td>SET1</td>
<td>= 0</td>
<td>= 1</td>
<td>= 1</td>
</tr>
<tr>
<td>RST1</td>
<td>= 1</td>
<td>= 0</td>
<td>= 0</td>
</tr>
<tr>
<td>SET2</td>
<td>= 1</td>
<td>= 0</td>
<td>= 1</td>
</tr>
<tr>
<td>RST2</td>
<td>= 0</td>
<td>= 1</td>
<td>= 0</td>
</tr>
</tbody>
</table>

The following contact input assignments are made automatically by the SEL-311C when setting APP = 221F. These assignments cannot be changed unless setting APP is changed back to APP = 311C.

Default Contact Input Functions

IN101 = Programmable Input (Direct Trip)
IN102 = PT (Permit trip)
IN103 = BT (Block trip)
IN104 = CL (Close breaker)
IN105 = 52A
IN106 = EXT (External event report trigger)
Identifier Labels (See Settings Explanations in Section 9)
Relay Identifier (30 characters)  RID = ________________
Terminal Identifier (30 characters)  TID = ________________

Current and Potential Transformer Ratios (See Settings Explanations in Section 9)
Phase (IA, IB, IC) Current Transformer Ratio (1–6000)  CTR = ____________
Polarizing (IPOL) Current Transformer Ratio (1–6000)  CTRP = ____________
Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00)  PTR = ____________
Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00)  PTRS = ____________

Line Settings (See Settings Explanations in Section 9)
Positive-sequence line impedance magnitude
(0.05–255.00 Ω secondary {5 A nom.};
0.25–1275.00 Ω secondary {1 A nom.})  Z1MAG = ____________
Positive-sequence line impedance angle (5.00–90.00 degrees)  Z1ANG = ____________
Zero-sequence line impedance magnitude
(0.05–255.00 Ω secondary {5 A nom.};
(0.25–1275.00 Ω secondary {1 A nom.})  Z0MAG = ____________
Zero-sequence line impedance angle (5.00–90.00 degrees)  Z0ANG = ____________
Line length (0.10–999.00, unitless)  LL = ____________
Application (311C, 221G, 221G5, 221H, 221F, 221F3, 221C, 221-16, 2PG10)  APP = 221F
Loss-of-Potential (Y, Y1, N) (see Figure 4.1)  ELOP = ____________

Mho Phase Distance Elements (See Settings Explanations in Section 3)
Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25 -320.00 Ω secondary {1 A nom.})  Z1P = ____________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25 -320.00 Ω secondary {1 A nom.})  Z2P = ____________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25 -320.00 Ω secondary {1 A nom.})  Z3P = ____________

Mho Ground Distance Elements
Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.7)  Z1MG = ____________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.8)  Z2MG = ____________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.9)  Z3MG = ____________
SEL-311C SETTINGS SHEET
APPLICATION SETTING 221F

Mho Phase and Ground Distance Element Time Delays (See Settings Explanations in Section 3)
Zone 2 phase distance time delay (OFF, 0–16000 cycles) Z2PD = __________
Zone 2 ground distance time delay (OFF, 0–16000 cycles) Z2GD = __________
Zone 3 time delay (OFF, 0–16000 cycles) Z3D = __________

Phase Inst./Def.-Time Overcurrent Element (See Figure 3.19)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
50P1P = __________

Residual Ground Inst./Def.-Time Overcurrent Element (See Figure 3.22)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
50G1P = __________

Residual Ground Time-Overcurrent Element (See Figure 3.25)
Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})
51GP = __________
Curve (U1–U5, C1–C5) (see Figures 9.1 through 9.10)
51GC = __________
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)
51GTD = __________

Synchronism Check Elements (See Figures 3.30 and 3.31)
Voltage window—low threshold (0.00–150.00 V secondary) 25VLO = __________
Voltage window—high threshold (0.00–150.00 V secondary) 25VHI = __________
Maximum slip frequency (0.005–0.500 Hz) 25SF = __________
Maximum angle 1 (0.00°–80.00°) 25ANG1 = __________
Maximum angle 2 (0.00°–80.00°) 25ANG2 = __________
Synchronizing phase (VA, VB, VC, VAB, VBC, VAC) SYNCP = __________
Breaker close time for angle compensation
(1.00–60.00 cycles in 0.25-cycle steps)
TCLOSD = __________

Reclosing Relay (See Tables 6.2 and 6.3)
Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI1 = __________
Reset time from reclose cycle (0.00–999999.00 cycles in 0.25-cycle steps) 79RSD = __________
Reset time from lockout (0.00–999999.00 cycles in 0.25-cycle steps) 79RSLD = __________

Switch-Onto-Fault (See Figure 5.3)
52 A enable time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) 52AEND = __________
SOTF duration (0.50–16000.00 cycles in 0.25-cycle steps) SOTFD = __________
Other Settings
Minimum trip duration time (4.00–16000.00 cycles in 0.25-cycle steps) TDURD = ________

SELogic Control Equation Variable Timers (See Figures 7.24 and 7.25)
SV1 Pickup Time (0.00-999999.00 cycles in 0.25-cycle steps) SV1PU = ________
SV1 Dropout Time (0.00-999999.00 cycles in 0.25-cycle steps) SV1DO = ________
SV2 Pickup Time (0.00-999999.00 cycles in 0.25-cycle steps) SV2PU = ________
SV2 Dropout Time (0.00-999999.00 cycles in 0.25-cycle steps) SV2DO = ________

Trip Logic Equations (See Figure 5.1)
Direct trip conditions TR = ______________________
Switch-onto-fault trip conditions TRSOTF = ______________________
Direct transfer trip conditions DTT = ______________________

Reclosing Relay Equations (See Reclosing Relay in Section 6)
Reclose initiate 79RI = ______________________
Drive-to-lockout 79DTL = ______________________

Latch Bits Set/Reset Equations (See Figure 7.12)
Set Latch Bit LT1 SET1 = ______________________
Reset Latch Bit LT1 RST1 = ______________________
Set Latch Bit LT2 SET2 = ______________________
Reset Latch Bit LT2 RST2 = ______________________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements
[Note: torque control equation settings cannot be set directly to logical 0]
Level 1 residual ground (see Figure 3.22) 67G1TC = ______________________
Residual Ground (see Figure 3.25) 51GTC = ______________________

SELogic Control Equation Variable Timer Input Equations (See Figures 7.24 and 7.25)
SELOGIC control equation Variable SV1 SV1 = ______________________
SELOGIC control equation Variable SV2 SV2 = ______________________
SELOGIC control equation Variable SV3 SV3 = ______________________
SELOGIC control equation Variable SV4 SV4 = ______________________

Output Contact Equations (See Figure 7.27)
Output Contact OUT101 OUT101 = ______________________
Output Contact OUT102 OUT102 = ______________________
Output Contact OUT103 OUT103 = ______________________
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 = _________

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, MBT) 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-311C Relay Fast Operate commands.

Power System Configuration (See Settings Explanations in Section 9)
Phase rotation (ABC, ACB) PHROT = ______________
Set APP = 221F3 in the SEL-311C to configure the relay to closely approximate the features, performance, and settings of an SEL-221F-3. When APP = 221F3, the SEL-311C:

1. Configures itself as a compensator distance relay for phase faults and a ground directional overcurrent relay for ground faults.

2. Performs reclosing and synchronism check functions.

3. Configures contact inputs and outputs to emulate those in an SEL-221F-3.

4. Presents the user only with those settings associated with SEL-221F-3 type features.

5. Automatically calculates all other settings required to simulate an SEL-221F-3.

If additional capability is needed (e.g., MIRRORED BITS or SELOGIC control equations) the relay may be returned to the setting APP = 311C to make all of the SEL-311C settings visible. It is important to remember that changing from APP = 311C to APP = 221F3 changes settings in the relay. Changing from APP = 221F3 to APP = 311C makes more SEL-311C settings visible, but does not change any other settings. If SEL-311C functions are used after setting APP is changed from 221F3 to 311C, do not change setting APP back to 221F3.

As described above, when setting APP = 221F3, the user is presented only with SEL-311C settings associated with the features found in an SEL-221F-3. This section explains how to make those remaining SEL-311C settings directly from the settings used in an SEL-221F-3.

There are mainly two kinds of settings in the SEL-311C. Relay settings are settings for protective elements. SELOGIC settings are Boolean expressions used to customize the logic of the SEL-311C. To set the SEL-311C to emulate an SEL-221F-3, follow these four steps:

1. Turn on the SEL-221F-3 application setting by making setting APP = 221F3. See Application Settings below.

2. Convert the appropriate SEL-221F settings to SEL-311C settings using the simple equations shown in Table 14.18. Be sure to convert from primary quantities (SEL-221F-3 settings) to secondary quantities (SEL-311C settings). See Convert SEL-221F-3 Primary Quantities to SEL-311C Secondary Quantities below.

3. For each Mask Logic setting in the SEL-221F-3 shown in Table 14.19, create an equivalent SELOGIC control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.20.

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-311C application setting to “221F3” as shown below:

```plaintext
=>>SET APP TERSE <ENTER>
Line Parameter Settings:
Application (311C,221G,221G5,221H,221F,221F3,221C,221-16,2PG10)APP = 311C ? 221F <ENTER>
Enable Settings:
Fault Location(Y,N) EFLOC = Y ? END <ENTER>
Save Changes(Y/N)? Y <ENTER>
Settings saved
=>>
```

Convert SEL-221F-3 Primary Quantities to SEL-311C Secondary Quantities

All SEL-221F-3 current settings must be converted from primary to secondary amps to be used in the SEL-311C. Divide the SEL-221F-3 current setting by the current transformer ratio setting (CTR) to make the change.

SEL-221F-3 impedance settings must be converted from percent of primary line impedance to secondary impedance in ohms. For example, the Zone 1 distance setting in the SEL-311C (Z1P) is calculated as

\[
Z1P = \frac{Z1\%}{100} \cdot Z1\text{MAG}
\]

where: \( Z1\% \) is the SEL-221F-3 distance reach setting.

\( Z1\text{MAG} \) is the SEL-311C positive-sequence line impedance setting in secondary ohms.

\( Z1P \) is the SEL-311C Zone 1 reach setting in secondary ohms.

Convert SEL-221F-3 Relay Settings to SEL-311C Relay Settings

Table 14.18 shows all the SEL-311C Relay settings that must be entered for the relay to perform protection similar to the SEL-221F-3 when APP = 221F3. Calculate each SEL-311C Relay setting from the corresponding SEL-221F-3 Relay setting using the formula shown. Instruction manual references are to sub-section headings rather than to section headings.

Please carefully note the difference between the SEL-311C and SEL-221F-3 in the implementation of certain protection and logic schemes. For example, reclosing and synchronism check settings do not correspond exactly between the two relays. Always thoroughly test logic schemes to be sure they operate as intended.
Table 14.18: SEL-311C Settings Calculated From SEL-221F-3 Settings

<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-221F-3 Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221F-3 Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>RID</td>
<td>None</td>
<td></td>
<td>Section 3—Set</td>
</tr>
<tr>
<td>TID</td>
<td>= ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTR</td>
<td>= CTR</td>
<td>Section 9—Settings Sheets</td>
<td></td>
</tr>
<tr>
<td>CTRP</td>
<td>= CTR</td>
<td>Section 5—Current and Potential Transformer Ratio Selection</td>
<td></td>
</tr>
<tr>
<td>PTR</td>
<td>= PTR</td>
<td>Section 5—Current and Potential Transformer Ratio Selection</td>
<td></td>
</tr>
<tr>
<td>PTRS</td>
<td>= SPTR</td>
<td>Section 5—Current and Potential Transformer Ratio Selection</td>
<td></td>
</tr>
<tr>
<td>Z1MAG</td>
<td>= $\sqrt{(R1^2 + X1^2) \cdot \frac{CTR}{PTR}}$</td>
<td>Section 9—Settings Sheets</td>
<td>Section 5—R1, X1, R0, X0, and Line Length (LL)</td>
</tr>
<tr>
<td>Z1ANG</td>
<td>= Arc tan $\frac{X1}{R1}$ (degrees) = MTA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z0MAG</td>
<td>= $\sqrt{(R0^2 + X0^2) \cdot (CTR/PTR)}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z0ANG</td>
<td>= Arc tan $\frac{X0}{R0}$ (degrees)</td>
<td>Section 5—Zone 3 Reach Setting (Z3%)</td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>= LL</td>
<td>Section 5—Zone 3 Reach Setting (Z3%)</td>
<td></td>
</tr>
<tr>
<td>APP</td>
<td>None</td>
<td>Section 4—Loss of Potential</td>
<td>Section 5—Loss-of-Potential (LOP) Enable Setting (LOPE)</td>
</tr>
<tr>
<td>ELOP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>= LOPE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>= Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1P</td>
<td></td>
<td>Section 3—Phase Distance Elements</td>
<td></td>
</tr>
<tr>
<td>Z1MG</td>
<td>= $\frac{Z1%}{100} \cdot Z1MAG$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z2P</td>
<td></td>
<td>Section 5—Zone 2 Reach Setting (Z2%)</td>
<td></td>
</tr>
<tr>
<td>Z2MG</td>
<td>= $\frac{Z2%}{100} \cdot Z1MAG$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z3P</td>
<td></td>
<td>Section 5—Zone 3 Reach Setting (Z3%)</td>
<td></td>
</tr>
<tr>
<td>Z3MG</td>
<td>= $\frac{Z3%}{100} \cdot Z1MAG$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>where Z1MAG = $\sqrt{(R1^2 + X1^2) \cdot \frac{CTR}{PTR}}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Z1MAG is an SEL-311C setting.
<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-221F-3 Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221F-3 Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z2PD</td>
<td>= Z2DP</td>
<td>Section 3—Zone Time Delay Elements</td>
<td>Section 5—Zone 2 Phase and Ground Distance</td>
</tr>
<tr>
<td>Z2GD</td>
<td>= Z2DG</td>
<td></td>
<td>Time Delays (Z2DP, Z2DG)</td>
</tr>
<tr>
<td>Z3D</td>
<td>= Z3D</td>
<td></td>
<td>Section 5—Zone 3 Phase and Ground Time Delay (Z3D)</td>
</tr>
<tr>
<td>50P1P</td>
<td>= 50H/CTR</td>
<td>Section 5—Switch-onto-Fault (SOTF)</td>
<td>Section 5—High Set Phase Overcurrent Element Setting</td>
</tr>
<tr>
<td>50P2P</td>
<td>None: Breaker failure phase overcurrent pickup.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50G1P</td>
<td>= 67NP/CTR</td>
<td>Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements</td>
<td>Section 5—67NP Residual Overcurrent Settings (67NP, 67NTC)</td>
</tr>
<tr>
<td>N/A</td>
<td>= 67NTC (In the SEL-311C, 50G1P is fixed forward)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50G2P</td>
<td>None: Breaker failure residual overcurrent pickup.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GP</td>
<td>= 51NP/CTR</td>
<td>Section 3—Residual Ground Time-Overcurrent Element</td>
<td>Section 5—Residual Time-Overcurrent Settings (51NP, 51NC, 51NTD, 51NTC)</td>
</tr>
<tr>
<td>51GC</td>
<td>= 51NC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U1*</td>
<td>= 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U2</td>
<td>= 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U3</td>
<td>= 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U4</td>
<td>= 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTD</td>
<td>= 51NTD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTC</td>
<td>= 51NTC (51GTC is an SEL-311C SELOGIC setting)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(= 1)</td>
<td>= N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(= 32GF)</td>
<td>= Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEL-311C Relay Setting</td>
<td>Calculated from SEL-221F-3 Settings</td>
<td>SEL-311C Instruction Manual Section</td>
<td>SEL-221F-3 Instruction Manual Section</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------------------</td>
<td>-------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>25VLO</td>
<td>= 27VLO • (1000/PTR)</td>
<td>Section 4—Synchronism Check Element Settings</td>
<td>Section 5—Synchronism Checking Function</td>
</tr>
<tr>
<td>25VHI</td>
<td>= 59VHI • (1000/PTR)</td>
<td>Section 4—Synchronism Check Element Settings</td>
<td>Section 5—Synchronism Checking Function</td>
</tr>
<tr>
<td>25SF</td>
<td>None</td>
<td>Section 6—Close and Reclose Logic</td>
<td>Section 5—Reclose Logic</td>
</tr>
<tr>
<td>25ANG1</td>
<td>None</td>
<td>Section 6—Close and Reclose Logic</td>
<td>Section 5—Reclose Logic</td>
</tr>
<tr>
<td>25ANG2</td>
<td>None</td>
<td>Section 6—Close and Reclose Logic</td>
<td>Section 5—Reclose Logic</td>
</tr>
<tr>
<td>SYNCP</td>
<td>SYNCP</td>
<td>Section 6—Close and Reclose Logic</td>
<td>Section 5—Reclose Logic</td>
</tr>
<tr>
<td>TCLOSJD</td>
<td>None</td>
<td>Section 6—Close and Reclose Logic</td>
<td>Section 5—Reclose Logic</td>
</tr>
<tr>
<td>79OII</td>
<td>= 79OII</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79RSD</td>
<td>= 79RS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79RSLD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52AEND</td>
<td>= 52BT (Pickup)</td>
<td>Section 5—Switch-Onto-Fault (SOTF) Trip Logic</td>
<td>Section 5—52BT Setting (52BT) And Switch-Onto-Fault Protection</td>
</tr>
<tr>
<td>SOTFD</td>
<td>= 52BT (Dropout)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDURD</td>
<td>= TDUR</td>
<td>Section 4—Unlatch Trip</td>
<td>Section 5—Trip Duration Timer (TDUR)</td>
</tr>
<tr>
<td>SV1PU</td>
<td>= BFTD</td>
<td>Section 3—Inst./Def.-Time-Overcurrent Elements</td>
<td>Section 2—Breaker Failure Features of the SEL-221-3/121F-3 and 221F-4 Relays</td>
</tr>
<tr>
<td>SV1DO</td>
<td>None</td>
<td>Section 7—Latch Control Switches</td>
<td></td>
</tr>
<tr>
<td>SV2PU</td>
<td>VCT</td>
<td>Section 3—Voltage Elements</td>
<td></td>
</tr>
<tr>
<td>SV2DO</td>
<td>None</td>
<td>Section 7—Latch Control Switches</td>
<td></td>
</tr>
</tbody>
</table>

* Curve U1 in the SEL-311C is slightly different from curve 1 in the SEL-221F-3. Time dial adjustments may be necessary.
**Note:** SEL-311C phase-to-phase fault detector settings (50PP1, 50PP2, 50PP3) are set to their minimum values and hidden. This corresponds to SEL-221F-3 setting 50P.

SEL-311C phase-to-ground and residual fault detector settings (50L1, 50L2, 50L3, 50GZ1, 50GZ2, and 50GZ3) are set to their minimum values and hidden. This corresponds to SEL-221F-3 setting 50NG.

SEL-221F-3 function “Remote End Just Opened” (REJO) is not implemented in the SEL-311C.

**Convert SEL-221F-3 Output Mask Logic Settings to SELogic Control Equations**

See *Programmable Output Contact Mask Settings* in *Section 5: Applications* in the SEL-221F-3 Instruction Manual for a description of output masks. In the SEL-311C, output masks are replaced by SELogic control equations as shown below:

<table>
<thead>
<tr>
<th>SEL-221F-3 Settings Mask</th>
<th>SEL-311C SELogic Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTU</td>
<td>TR</td>
</tr>
<tr>
<td>MPT</td>
<td>SV3 (DTT)</td>
</tr>
<tr>
<td>MTB</td>
<td>SV4 (DTT)</td>
</tr>
<tr>
<td>MTO</td>
<td>TRSOTF</td>
</tr>
<tr>
<td>MA1</td>
<td>OUT104</td>
</tr>
<tr>
<td>MA2</td>
<td>OUT105</td>
</tr>
<tr>
<td>MA3</td>
<td>OUT106</td>
</tr>
<tr>
<td>MA4</td>
<td>OUT107</td>
</tr>
<tr>
<td>MRI</td>
<td>79RI</td>
</tr>
<tr>
<td>MRC</td>
<td>79DTL</td>
</tr>
</tbody>
</table>

Table 14.20 shows all SEL-221F-3 Relay Word bits, and an approximate equivalent SEL-311C SELogic expression, when setting APP = 221F3 in the SEL-311C. Table 14.19 shows each SEL-221F-3 Mask Logic Setting and the equivalent SEL-311C SELogic control equation. To convert a SEL-221F-3 Mask Logic Setting to a SELogic control equation, logically OR each appropriate SEL-221F-3 Relay Word bit equivalent expression (Table 14.20) and enter the resultant expression in the related SELogic control equation (Table 14.19).
<table>
<thead>
<tr>
<th>SEL-221F-3 Relay Word Bit</th>
<th>Equivalent SEL-311C SELOGIC Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z1P</td>
<td>M1P</td>
</tr>
<tr>
<td>Z1G</td>
<td>Z1G</td>
</tr>
<tr>
<td>Z2PT</td>
<td>M2PT</td>
</tr>
<tr>
<td>Z2GT</td>
<td>Z2GT</td>
</tr>
<tr>
<td>Z3</td>
<td>M3P + M3G</td>
</tr>
<tr>
<td>Z3T</td>
<td>Z3T</td>
</tr>
<tr>
<td>3P21</td>
<td>M3P * !32QF</td>
</tr>
<tr>
<td>32Q</td>
<td>32GF + 32QF</td>
</tr>
<tr>
<td>67N</td>
<td>67G1</td>
</tr>
<tr>
<td>51NP</td>
<td>51G</td>
</tr>
<tr>
<td>51NT</td>
<td>51GT</td>
</tr>
<tr>
<td>50NG</td>
<td>None</td>
</tr>
<tr>
<td>50P</td>
<td>None</td>
</tr>
<tr>
<td>50H</td>
<td>50P1</td>
</tr>
<tr>
<td>IN1</td>
<td>IN101</td>
</tr>
<tr>
<td>REJO</td>
<td>None</td>
</tr>
<tr>
<td>LOP</td>
<td>ILOP</td>
</tr>
<tr>
<td>BFT</td>
<td>SV1T</td>
</tr>
<tr>
<td>27S</td>
<td>!59VS</td>
</tr>
<tr>
<td>27P</td>
<td>!59VP</td>
</tr>
<tr>
<td>59S</td>
<td>59VS</td>
</tr>
<tr>
<td>59P</td>
<td>59VP</td>
</tr>
<tr>
<td>SSC</td>
<td>25A1</td>
</tr>
<tr>
<td>VSC</td>
<td>SV2T</td>
</tr>
<tr>
<td>(LSDP)</td>
<td>(59VS * !59VP * !50L)</td>
</tr>
<tr>
<td>(LPDS)</td>
<td>(59VP * !59VS * !50L)</td>
</tr>
</tbody>
</table>
For example, the factory default setting for MRC in the SEL-221F-3 is shown in Table 14.21. From Table 14.19, the equivalent SEL-311C SELOGIC control equation to MRC is 79DTL. Constructing the logical OR of the equivalent of each element selected in the MRC mask from Table 14.20 gives:

\[ 79DTL = Z3T + 51GT \]

Include the open command OC:

\[ 79DTL = Z3T + 51GT + OC \]

This is the default SELOGIC control equation for 79DTL when APP = 221F3.

When setting APP = 221F3, the SEL-311C automatically sets the following SELOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-221F-3 to customize the relay logic.

**Table 14.21: Default SEL-221F-3 Mask Logic Setting for MRC**

<table>
<thead>
<tr>
<th>Z1P</th>
<th>Z1G</th>
<th>Z2PT</th>
<th>Z2GT</th>
<th>Z3</th>
<th>Z3T</th>
<th>3P21</th>
<th>32Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>67N</td>
<td>51NP</td>
<td>51NT</td>
<td>50NG</td>
<td>50P</td>
<td>50H</td>
<td>IN1</td>
<td>REJO</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LOP</td>
<td>BFT</td>
<td>27S</td>
<td>27P</td>
<td>59S</td>
<td>59P</td>
<td>SSC</td>
<td>VSC</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Default Tripping Logic Equations**

\[ TR = M1P + Z1G + M2PT + Z2GT + Z3T + 67G1 + 51GT + OC \]
\[ TRSOTF = M1P + Z1G + M2PT + Z2GT + M3P + Z3G + Z3T + 67G1 + 51GT + 50P1 \]
\[ DTT = IN101 + SV3 \times IN102 + SV4 \times !IN103 \]

**Default Reclose Logic Equations**

\[ 79RI = M1P + Z1G + M2PT + Z2GT + 67G1 \]
\[ 79DTL = Z3T + 51GT + OC \]
**Default Output Contact Logic Equations**

\[
\begin{align*}
\text{OUT101} &= \text{TRIP} \\
\text{OUT102} &= \text{TRIP} \\
\text{OUT103} &= \text{CLOSE} \\
\text{OUT104} &= 25A1 \\
\text{OUT105} &= \text{SV4T} \\
\text{OUT106} &= \text{M1P + Z1G + M2PT + Z2GT + 67G1} \\
\text{OUT107} &= \text{Z3T + 51GT}
\end{align*}
\]

**SELogic Variables Equations**

\[
\begin{align*}
\text{SV1} &= (\text{LT3} \ast \text{IN101} + \text{TRIP}) \ast (50P2 + 50G2) \ast \neg \text{SV5} \\
\text{SV2} &= 59VP \ast \neg 59VS \ast \neg 50L \ast \text{LT1} + 59VS \ast \neg 50L \ast \text{LT2} \\
\text{SV3} &= \text{M3P + Z3G} \\
\text{SV4} &= 0 \\
\text{SV5} &= (\text{OC} \ast \text{SV5}) \ast \text{TRIP}
\end{align*}
\]

**SELogic Latch Equations**

The SELogic latch equations SET1 and SET 2 emulate the SEL-221F-3 setting PSVC for settings S, P, and E.

<table>
<thead>
<tr>
<th>SEL-311C Relay Word Bit</th>
<th>PSVC = S (Default)</th>
<th>PSVC = P</th>
<th>PSVC = E</th>
</tr>
</thead>
<tbody>
<tr>
<td>SET1</td>
<td>= 0</td>
<td>= 1</td>
<td>= 1</td>
</tr>
<tr>
<td>RST1</td>
<td>= 1</td>
<td>= 0</td>
<td>= 0</td>
</tr>
<tr>
<td>SET2</td>
<td>= 1</td>
<td>= 0</td>
<td>= 0</td>
</tr>
<tr>
<td>RST2</td>
<td>= 0</td>
<td>= 1</td>
<td>= 1</td>
</tr>
</tbody>
</table>

The SELogic latch equation SET3 emulates the SEL-221F-3 setting BFIN1.
Table 14.23: SEL-221F-3 Setting BFIN1

<table>
<thead>
<tr>
<th>SEL-311C Relay Word Bit</th>
<th>BFIN1 = N (Default)</th>
<th>BFIN1 = Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>SET3</td>
<td>= 0</td>
<td>= 1</td>
</tr>
<tr>
<td>RST3</td>
<td>= 1</td>
<td>= 0</td>
</tr>
</tbody>
</table>

The following contact input assignments are made automatically by the SEL-311C when setting APP = 221F3. These assignments cannot be changed unless setting APP is changed back to APP = 311C.

**Default Contact Input Functions**

IN101 = Programmable Input (Direct Trip)
IN102 = PT (Permit trip)
IN103 = BT (Block trip)
IN104 = CL (Close breaker)
IN105 = 52A
IN106 = EXT (External event report trigger)
**SEL-311C SETTINGS SHEET**  
**APPLICATION SETTING 221F-3**  

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

- Relay Identifier (30 characters)  
  \[ \text{RID} = \rule{10cm}{0.2pt} \]
- Terminal Identifier (30 characters)  
  \[ \text{TID} = \rule{10cm}{0.2pt} \]

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

- Phase (IA, IB, IC) Current Transformer Ratio (1–6000)  
  \[ \text{CTR} = \rule{10cm}{0.2pt} \]
- Polarizing (IPOL) Current Transformer Ratio (1–6000)  
  \[ \text{CTR}_P = \rule{10cm}{0.2pt} \]
- Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00)  
  \[ \text{PTR} = \rule{10cm}{0.2pt} \]
- Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00)  
  \[ \text{PTR}_S = \rule{10cm}{0.2pt} \]

**Line Settings (See Settings Explanations in Section 9)**

- Positive-sequence line impedance magnitude  
  (0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.})  
  \[ \text{Z}_1\text{MAG} = \rule{10cm}{0.2pt} \]
- Positive-sequence line impedance angle (5.00–90.00 degrees)  
  \[ \text{Z}_1\text{ANG} = \rule{10cm}{0.2pt} \]
- Zero-sequence line impedance magnitude  
  (0.05–255.00 Ω secondary {5 A nom.}; 0.25–1275.00 Ω secondary {1 A nom.})  
  \[ \text{Z}_0\text{MAG} = \rule{10cm}{0.2pt} \]
- Zero-sequence line impedance angle (5.00–90.00 degrees)  
  \[ \text{Z}_0\text{ANG} = \rule{10cm}{0.2pt} \]
- Line length (0.10–999.00, unitless)  
  \[ \text{LL} = \rule{10cm}{0.2pt} \]
- Application (311C, 221G, 221G5, 221H, 221F, 221F3, 221C, 221-16, 2PG10)  
  \[ \text{APP} = \text{221F3} \]
- Loss-of-Potential (Y, Y1, N) (see Figure 4.1)  
  \[ \text{ELOP} = \rule{10cm}{0.2pt} \]

**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.})  
  \[ \text{Z}_1\text{P} = \rule{10cm}{0.2pt} \]
- Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.})  
  \[ \text{Z}_2\text{P} = \rule{10cm}{0.2pt} \]
- Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.})  
  \[ \text{Z}_3\text{P} = \rule{10cm}{0.2pt} \]

**Mho Ground Distance Elements**

- Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.7)  
  \[ \text{Z}_1\text{MG} = \rule{10cm}{0.2pt} \]
- Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.8)  
  \[ \text{Z}_2\text{MG} = \rule{10cm}{0.2pt} \]
- Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.}; 0.25 -320.00 Ω secondary {1 A nom.}) (see Figure 3.9)  
  \[ \text{Z}_3\text{MG} = \rule{10cm}{0.2pt} \]
Mho Phase and Ground Distance Element Time Delays (See **Settings Explanations** in **Section 3**)

Zone 2 phase distance time delay (OFF, 0–16000 cycles) \( Z2PD = \) 
Zone 2 ground distance time delay (OFF, 0–16000 cycles) \( Z2GD = \) 
Zone 3 time delay (OFF, 0–16000 cycles) \( Z3D = \) 

**Phase INST./DEF.-Time Overcurrent Element (See Figure 3.19)**

Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}) \( 50P1P = \) 
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}) \( 50P2P = \) 

**Residual Ground INST./DEF.-Time Overcurrent Elements (See Figure 3.22)**

Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}) \( 50G1P = \) 
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.}) \( 50G2P = \) 

**Residual Ground Time-Overcurrent Element (See Figure 3.25)**

Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.}) \( 51GP = \) 
Curve (U1–U5, C1–C5) (see Figures 9.1 through 9.10) \( 51GC = \) 
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5) \( 51GTD = \) 

**Synchronism Check Elements (See Figures 3.30 and 3.31)**

Voltage window—low threshold (0.00–150.00 V secondary) \( 25VLO = \) 
Voltage window—high threshold (0.00–150.00 V secondary) \( 25VHI = \) 
Maximum slip frequency (0.005–0.500 Hz) \( 25SF = \) 
Maximum angle 1 (0.00°–80.00°) \( 25ANG1 = \) 
Maximum angle 2 (0.00°–80.00°) \( 25ANG2 = \) 
Synchronizing phase (VA, VB, VC, VAB, VBC, VAC) \( SYNCP = \) 
Breaker close time for angle compensation \( TCLOSD = \) 

**Reclosing Relay (See Tables 6.2 and 6.3)**

Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps) \( 79O11 = \) 
Reset time from reclose cycle (0.00–999999.00 cycles in 0.25-cycle steps) \( 79RSD = \) 
Reset time from lockout (0.00–999999.00 cycles in 0.25-cycle steps) \( 79RSLD = \)
Switch-On-Fault (See Figure 5.3)
52 A enable time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) 52AEND = 
SOTF duration (0.50–16000.00 cycles in 0.25-cycle steps) SOTFD = 

Other Settings
Minimum trip duration time (4.00–16000.00 cycles in 0.25-cycle steps) TDURD = 

**SELogic Control Equation Variable Timers (See Figures 7.24 and 7.25)**
SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) SV1PU = 
SV1 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) SV1DO = 
SV2 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) SV2PU = 
SV2 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) SV2DO = 

**Trip Logic Equations (See Figure 5.1)**
Direct trip conditions TR = 
Switch-onto-fault trip conditions TRSOTF = 
Direct transfer trip conditions DTT = 

**Reclosing Relay Equations (See Reclosing Relay in Section 6)**
Reclose initiate 79RI = 
Drive-to-lockout 79DTL = 

**Latch Bits Set/Reset Equations (See Figure 7.12)**
Set Latch Bit LT1 SET1 = 
Reset Latch Bit LT1 RST1 = 
Set Latch Bit LT2 SET2 = 
Reset Latch Bit LT2 RST2 = 
Set Latch Bit LT3 SET3 = 
Reset Latch Bit LT3 RST3 = 

**Torque Control Equations for Inst./Def.-Time Overcurrent Elements**
[Note: torque control equation settings cannot be set directly to logical 0]
Level 1 residual ground (see Figure 3.22) 67G1TC = 
Residual Ground (see Figure 3.25) 51GTC = 

Date Code 20011205
**SELogic Control Equation Variable Timer Input Equations (See Figures 7.24 and 7.25)**

SELOGIC control equation Variable SV1
SV1 = ________________

SELOGIC control equation Variable SV2
SV2 = ________________

SELOGIC control equation Variable SV3
SV3 = ________________

SELOGIC control equation Variable SV4
SV4 = ________________

SELOGIC control equation Variable SV5
SV5 = ________________

**Output Contact Equations (See Figure 7.27)**

Output Contact OUT101
OUT101 = ________________

Output Contact OUT102
OUT102 = ________________

Output Contact OUT103
OUT103 = ________________

Output Contact OUT104
OUT104 = ________________

Output Contact OUT105
OUT105 = ________________

Output Contact OUT106
OUT106 = ________________

Output Contact OUT107
OUT107 = ________________

**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 = _____________

**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-311C Relay Fast Operate commands.

**Power System Configuration (See Settings Explanations in Section 9)**

Phase rotation (ABC, ACB)  
PHROT = ___________
**SEL-221C to SEL-311C Settings Conversion Guide**

Set APP = 221C in the SEL-311C to configure the relay to closely approximate the features, performance, and settings of an SEL-221C. When APP = 221C, the SEL-311C:

1. Configures itself as a phase distance and phase and ground directional overcurrent relay with voltage supervised reclosing.
2. Configures contact inputs and contact outputs to emulate those in an SEL-221C.
3. Presents the user only with those settings associated with SEL-221C type features.
4. Automatically calculates all other settings required to simulate an SEL-221C.

If additional capability is needed (e.g., MIRRORED BITS or SELOGIC control equations) the relay may be returned to the setting APP = 311C to make all of the SEL-311C settings visible. It is important to remember that changing from APP = 311C to APP = 221C changes settings in the SEL-311C. Changing from APP = 221C to APP = 311C makes more SEL-311C settings visible, but does not change any other settings. If SEL-311C functions are used after setting APP is changed from 221C to 311C, do not change setting APP back to 221C.

As described above, when setting APP = 221C, the user is presented only with SEL-311C settings associated with the features found in an SEL-221C. This section explains how to make those remaining SEL-311C settings directly from the settings used in an SEL-221C.

There are mainly two kinds of settings in the SEL-311C, 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-311C. To set the SEL-311C to emulate an SEL-221C, follow these four steps:

1. Turn on the SEL-221C application setting by making setting APP = 221C. See Application Settings below.
2. Convert the appropriate SEL-221C settings to SEL-311C settings using the simple equations shown in Table 14.24. Be sure to convert from primary quantities (SEL-221C settings) to secondary quantities (SEL-311C settings). See Convert SEL-221C Primary Quantities to SEL-311C Secondary Quantities below.
3. For each Mask Logic setting in the SEL-221C shown in Table 14.10, create an equivalent SELOGIC control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.11.
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-311C application setting to “221C” as shown below:

~~>SET APP TERSE <ENTER>
Line Parameter Settings:
Application
(311C,221G,221G5,221H,221F,221F3,221C,221-16,2PG10)APP = 311C ? 221C <ENTER>
Enable Settings:
Fault Location(Y,N) EFLOC = Y ? END <ENTER>
Save Changes(Y/N)? Y <ENTER>
Settings saved

Convert SEL-221C Primary Quantities to SEL-311C Secondary Quantities

All SEL-221C current settings must be converted from primary to secondary amps to be used in the SEL-311C. Divide the SEL-221C current setting by the current transformer ratio setting (CTR) to make the change.

SEL-221C impedance settings must be converted from percent of primary line impedance to secondary impedance in ohms. For example, the Zone 1 distance setting in the SEL-311C (Z1P) is calculated as

\[ Z1P = \frac{Z1\%}{100} \cdot Z1\text{MAG} \]

where:  
- Z1\% is the SEL-221C distance reach setting.  
- Z1\text{MAG} is the SEL-311C positive-sequence line impedance setting in secondary ohms.  
- Z1P is the SEL-311C Zone 1 reach setting in secondary ohms.

Convert SEL-221C Relay Settings to SEL-311C Relay Settings

Table 14.24 shows all the SEL-311C Relay settings that must be entered for the relay to perform protection similar to the SEL-221C when APP = 221C. Calculate each SEL-311C Relay setting from SEL-221C Relay settings using the formula shown. Instruction manual references are to subsection headings rather than to section headings.
<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-221C Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221C Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>RID</td>
<td>None = ID</td>
<td>Section 9—Settings Sheets</td>
<td>Section 3—Set n</td>
</tr>
<tr>
<td>TID</td>
<td>= CTR</td>
<td>Section 9—Settings Sheets</td>
<td>Section 5—Current and Potential Transformer Ratio Selection</td>
</tr>
<tr>
<td>CTRP</td>
<td>= CTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTR</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTRS</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1MAG</td>
<td>$= \sqrt{(R1^2 + X1^2) \cdot \left(\frac{CTR}{PTR}\right)}$</td>
<td>Section 9—Settings Sheets</td>
<td>Section 5—R1, X1, R0, X0, and Line Length</td>
</tr>
<tr>
<td>Z1ANG</td>
<td>Arc tan $\left(\frac{X1}{R1}\right)$ (degrees) = MTA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z0MAG</td>
<td>$= \sqrt{(R0^2 + X0^2) \cdot (CTR/PTR)}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z0ANG</td>
<td>Arc tan $\left(\frac{X0}{R0}\right)$ (degrees)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>= LL</td>
<td>Section 9—Settings Sheets</td>
<td></td>
</tr>
<tr>
<td>APP</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EFLOC</td>
<td>= LOCAT</td>
<td>Section 9—Settings Sheets</td>
<td>Section 2—Fault Location</td>
</tr>
<tr>
<td>ELOP</td>
<td>= LOPE</td>
<td>Section 4—Loss of Potential</td>
<td>Section 5—Loss-of-Potential (LOP) Enable Setting (LOPE)</td>
</tr>
<tr>
<td>N</td>
<td>= N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>= Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1P</td>
<td>$= \frac{Z1% \cdot Z1MAG}{100}$</td>
<td>Section 3—Phase Distance Elements</td>
<td></td>
</tr>
<tr>
<td>Z2P</td>
<td>$= \frac{Z2% \cdot Z1MAG}{100}$</td>
<td></td>
<td>Note: Z1MAG is an SEL-311C setting</td>
</tr>
<tr>
<td>SEL-311C Relay Setting</td>
<td>Calculated from SEL-221C Settings</td>
<td>SEL-311C Instruction Manual Section</td>
<td>SEL-221C Instruction Manual Section</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>Z3P</td>
<td>( \frac{Z3%}{100} \cdot Z1\text{MAG} ) [ Z1\text{MAG} = \sqrt{R1^2 + X1^2} \left[ \frac{\text{CTR}}{\text{PTR}} \right] ]</td>
<td>Section 3—Zone Time Delay Elements</td>
<td>Section 5—Zone 3 Distance Element Timer</td>
</tr>
<tr>
<td>Z3PD</td>
<td>= Z3DP</td>
<td>Section 3—Zone Time Delay Elements</td>
<td>Section 5—Zone 3 Distance Element Timer</td>
</tr>
<tr>
<td>50P1P</td>
<td>= 50H/CTR</td>
<td>Section 5—Switch-Onto-Fault (SOTF) Trip Logic</td>
<td>Section 5—High Set Phase Overcurrent Setting</td>
</tr>
<tr>
<td>50P2P</td>
<td>= 50M/CTR</td>
<td>Section 4—Loss-of-Potential Logic</td>
<td>Section 5—Medium Set Phase Overcurrent Setting (50M)</td>
</tr>
<tr>
<td>50G1P</td>
<td>= 50N1P/CTR</td>
<td>Section 3—Inst./Def.-Time Overcurrent Elements</td>
<td>Section 5—Residual Overcurrent Setting (50N1P)</td>
</tr>
<tr>
<td>50G2P</td>
<td>= 50N2P/CTR</td>
<td>Section 5—Residual Overcurrent Setting (50N2P)</td>
<td>Section 5—Residual Overcurrent Setting (50N3P)</td>
</tr>
<tr>
<td>50G3P</td>
<td>= 50N3P/CTR</td>
<td>Section 5—Residual Overcurrent Setting (50N3P)</td>
<td>Section 5—Residual Overcurrent Setting (50N3P)</td>
</tr>
<tr>
<td>67G2D</td>
<td>= Z2DG</td>
<td>Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements</td>
<td>Section 5—Choice of Zones 1, 2, and 3 Residual Overcurrent Pickup Settings</td>
</tr>
<tr>
<td>67G3D</td>
<td>= Z3DG</td>
<td>Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements</td>
<td>Section 5—Choice of Zones 1, 2, and 3 Residual Overcurrent Pickup Settings</td>
</tr>
<tr>
<td>51PP</td>
<td>= 51PP/CTR</td>
<td>Section 3—Phase Time-Overcurrent Element</td>
<td>Section 5—Phase Time-Overcurrent Settings (51PP, 51PC, 51PTD)</td>
</tr>
<tr>
<td>51PC</td>
<td>= 51PC</td>
<td>Section 3—Phase Time-Overcurrent Element</td>
<td>Section 5—Phase Time-Overcurrent Settings (51PP, 51PC, 51PTD)</td>
</tr>
<tr>
<td>U1*</td>
<td>= 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U2</td>
<td>= 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U3</td>
<td>= 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U4</td>
<td>= 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51TD</td>
<td>= 51PTD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEL-311C Relay Setting</td>
<td>Calculated from SEL-221C Settings</td>
<td>SEL-311C Instruction Manual Section</td>
<td>SEL-221C Instruction Manual Section</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------</td>
<td>-------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>51GP</td>
<td>= 51NP/CTR</td>
<td>Section 3—Residual</td>
<td>Section 5—Residual Time-</td>
</tr>
<tr>
<td>51GC</td>
<td>= 51NC</td>
<td></td>
<td>Overcurrent Element</td>
</tr>
<tr>
<td>U1*</td>
<td>= 1</td>
<td></td>
<td>Settings (51PP, 51PC, 51PTD, 51NTC)</td>
</tr>
<tr>
<td>U2</td>
<td>= 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U3</td>
<td>= 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U4</td>
<td>= 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTD</td>
<td>= 51NTD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTC</td>
<td>= 51NTC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(= 1</td>
<td>= N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(= 32GF</td>
<td>= Y)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIR3</td>
<td>= ZONE 3</td>
<td>Section 4—Directional</td>
<td>Section 5—Zone 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control Settings</td>
<td>Direction Setting</td>
</tr>
<tr>
<td>ORDER Q</td>
<td>= 32QE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>= 32VE</td>
<td>Section 4—Directional</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>= 32IE</td>
<td>Control for Ground</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distance and Residual</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ground Overcurrent Elements</td>
<td></td>
</tr>
<tr>
<td>27P</td>
<td>= (59N • 1000)/(√3 • PTR)</td>
<td>Section 3—Voltage Elements</td>
<td>Section 2—Reclosing Relay</td>
</tr>
<tr>
<td>59P</td>
<td>= (47 PXD • 1000)/(√3 • PTR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27PP</td>
<td>= 47PXD • 1000/PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>59PP</td>
<td>= 47PXL • 1000/PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79OI1</td>
<td>= 79OI1</td>
<td>Section 6—Close and Reclose Logic</td>
<td>Section 2—Reclosing Relay</td>
</tr>
<tr>
<td>79OI2</td>
<td>= 79OI2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79OI3</td>
<td>= 79OI3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79RSD</td>
<td>None (SEL-221C setting 79RS</td>
<td>Section 6—Reclosing Relay Timer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>serves a slightly different</td>
<td>Settings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>purpose.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79RSLD</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52AEND</td>
<td>= 52BT (Pickup)</td>
<td>Section 5—Switch-Onto-Fault (SOTF)</td>
<td>Section 5—52BT Setting (52BT) and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trip Logic</td>
<td>Switch-Onto-Fault Protection</td>
</tr>
</tbody>
</table>
### SEL-311C Relay Setting Calculated from SEL-221C Settings SEL-311C Instruction Manual Section SEL-221C Instruction Manual Section

<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-221C Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221C Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOTFD</td>
<td>= 52BT (Dropout)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDURD</td>
<td>= TDUR</td>
<td>Section 4—Unlatch Trip</td>
<td>Section 5—Trip Duration Timer (TDUR)</td>
</tr>
<tr>
<td>SV1PU</td>
<td>= 50MFD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SV9DO</td>
<td>= VCT</td>
<td></td>
<td>Section 2—Reclosing Relay</td>
</tr>
</tbody>
</table>

* Curve U1 in the SEL-311C is slightly different from curve 1 in the SEL-221C. Time dial adjustments may be necessary.

**Note:** SEL-311C phase-to-phase fault detector settings 50PP1, 50PP2, and 50PP3 are set to 0.1 * I_{nom} and are hidden. This corresponds to SEL-221C setting 50L.

### Convert SEL-221C Output Mask Logic Settings to SELogic Control Equations

See *Programmable Output Contact Mask Settings* in *Section 5: Applications* in the SEL-221C Instruction Manual for a description of output masks. In the SEL-311C, output masks are replaced by SELogic control equations as shown below:

**Table 14.25: SEL-311C SELogic Equation Equivalent to Each SEL-221C Mask Logic Setting**

<table>
<thead>
<tr>
<th>SEL-221C Settings Mask</th>
<th>SEL-311C SELogic Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTU</td>
<td>TR</td>
</tr>
<tr>
<td>MPT</td>
<td>SV2 (DTT)</td>
</tr>
<tr>
<td>MTB</td>
<td>SV3 (DTT)</td>
</tr>
<tr>
<td>MTO</td>
<td>TRSOTF</td>
</tr>
<tr>
<td>MA1</td>
<td>OUT104</td>
</tr>
<tr>
<td>MA2</td>
<td>OUT105</td>
</tr>
<tr>
<td>MA3</td>
<td>OUT106</td>
</tr>
<tr>
<td>MA4</td>
<td>OUT107</td>
</tr>
<tr>
<td>MRI</td>
<td>79RI</td>
</tr>
<tr>
<td>MRC</td>
<td>79DTL</td>
</tr>
</tbody>
</table>

Table 14.11 shows all SEL-221C Relay Word bits, and an approximate equivalent SEL-311C SELogic expression, when setting APP = 221C in the SEL-311C. Table 14.10 shows each SEL-221C Mask Logic Setting and the equivalent SEL-311C SELogic control equation. To
convert a SEL-221C Mask Logic Setting to a SELOGIC control equation, logically OR each appropriate SEL-221C Relay Word bit equivalent expression (Table 14.11) and enter the resultant expression in the related SELOGIC control equation listed in Table 14.10.

### Table 14.26: SELOGIC Equivalent to SEL-221C Relay Word Bits

<table>
<thead>
<tr>
<th>SEL-221C Relay Word Bit</th>
<th>Equivalent SEL-311C SELOGIC Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>51PT</td>
<td>51PT</td>
</tr>
<tr>
<td>1ABC</td>
<td>MABC1</td>
</tr>
<tr>
<td>2ABC</td>
<td>MABC2</td>
</tr>
<tr>
<td>3ABC</td>
<td>MABC3</td>
</tr>
<tr>
<td>51PP</td>
<td>51P</td>
</tr>
<tr>
<td>50H</td>
<td>50P1</td>
</tr>
<tr>
<td>50L</td>
<td>None (Phase-Phase Current Fault Detector Setting 50PP1)</td>
</tr>
<tr>
<td>LOP</td>
<td>ILOP</td>
</tr>
<tr>
<td>51NT</td>
<td>51GT</td>
</tr>
<tr>
<td>67N1</td>
<td>67G1</td>
</tr>
<tr>
<td>67N2</td>
<td>67G2</td>
</tr>
<tr>
<td>67N3</td>
<td>67G3</td>
</tr>
<tr>
<td>51NP</td>
<td>51G</td>
</tr>
<tr>
<td>Z1P</td>
<td>MPP1</td>
</tr>
<tr>
<td>Z2P</td>
<td>MPP2</td>
</tr>
<tr>
<td>Z3P</td>
<td>MPP3</td>
</tr>
<tr>
<td>DF</td>
<td>32GF</td>
</tr>
<tr>
<td>DR</td>
<td>32GR</td>
</tr>
<tr>
<td>Z2GT</td>
<td>67G2T</td>
</tr>
<tr>
<td>Z3GT</td>
<td>67G3T</td>
</tr>
<tr>
<td>50MF</td>
<td>SV1T (SV1 = 50P2 * ILOP)</td>
</tr>
<tr>
<td>RC</td>
<td>None (SELOGIC equation 79DTL)</td>
</tr>
<tr>
<td>RI</td>
<td>None (SELOGIC equation 79RI)</td>
</tr>
<tr>
<td>Z3PT</td>
<td>M3PT</td>
</tr>
<tr>
<td>50M</td>
<td>50P2</td>
</tr>
<tr>
<td>TRIP</td>
<td>TRIP or OUT101 or OUT102</td>
</tr>
</tbody>
</table>
For example, the factory default setting for MTU in the SEL-221C is shown in Table 14.12. From Table 14.10, the equivalent SEL-311C SELLOGIC control equation to MTU is TR. Constructing the logical OR of the equivalent of each element selected in the MTU mask from Table 14.11 gives:

\[
\text{TR} = 51\text{PT} + \text{MABC1} + 51\text{GT} + 67\text{G1} + \text{MPP1} + 67\text{G2T} + 67\text{G3T} + \text{M3PT} + \text{OC} + \text{IN101}
\]

Since IN101 (DT) is also included in the DTT tripping logic equation, it can be eliminated from the TR equation. Also, MABC1 + MPP1 can be replaced by M1P. Therefore, the TR equation becomes:

\[
\text{TR} = \text{M1P} + \text{M3PT} + 67\text{G1} + 67\text{G2T} + 67\text{G3T} + 51\text{PT} + 51\text{GT} + \text{OC}
\]

which is the default SELLOGIC control equation for TR when APP = 221C.

When setting APP = 221C, the SEL-311C automatically sets the following SELLOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-221C to customize the relay logic.

### Table 14.27: Default SEL-221C Mask Logic Setting for MTU

<table>
<thead>
<tr>
<th>51PT</th>
<th>1ABC</th>
<th>2ABC</th>
<th>3ABC</th>
<th>51PP</th>
<th>50H</th>
<th>50L</th>
<th>LOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>51NT</td>
<td>67N1</td>
<td>67N2</td>
<td>67N3</td>
<td>51NP</td>
<td>Z1P</td>
<td>Z2P</td>
<td>Z3P</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DF</td>
<td>DR</td>
<td>Z2GT</td>
<td>Z3GT</td>
<td>50MF</td>
<td>RC</td>
<td>RI</td>
<td>Z3PT</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>50M</td>
<td>TRIP</td>
<td>TC</td>
<td>DT</td>
<td>52BT</td>
<td>59N</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Default Tripping Logic Equations

\[
\begin{align*}
\text{TR} &= \text{M1P} + \text{M3PT} + 67\text{G1} + 67\text{G2T} + 67\text{G3T} + 51\text{PT} + 51\text{GT} + \text{OC} \\
\text{TRSOTF} &= \text{M1P} + \text{M2P} + \text{M3P} + 67\text{G1} + 67\text{G2} + 67\text{G3} + 51\text{PT} + 51\text{GT} + 50\text{P1} \\
\text{DTT} &= \text{IN101} + \text{SV2} \times \text{IN102} + \text{SV3} \times \text{!IN103}
\end{align*}
\]
Default Reclose Logic Equations

\[ 79RI = MPP1 + 67G1 \]
\[ 79DTL = MABC1 + MABC2 + MABC3 + M3PT + 50P1 + 51PT + 51GT + 67G2T + 67G3T + OC + IN101 + SV13 \]

**Note:** SELOGIC variable SV13 must be in the 79DTL equation for the correct operation of voltage supervised reclosing.

Default Output Contact Logic Equations

\[ \text{OUT101} = \text{TRIP} \]
\[ \text{OUT102} = \text{TRIP} \]
\[ \text{OUT103} = \text{CLOSE} \]
\[ \text{OUT104} = M2P + 67G2 \] (Reserved for MA1)
\[ \text{OUT105} = 51PT + 51GT \] (Reserved for MA2)
\[ \text{OUT106} = MPP1 + 67G1 \] (Reserved for MA3)
\[ \text{OUT107} = \text{LOP} \] (Reserved for MA4)

SELOGIC Variables Equations

\[ SV1 = 50P2 \times ILOP \]
\[ SV2 = 0 \] (Reserved for MPT)
\[ SV3 = 0 \] (Reserved for MBT)
\[ SV4 = 1 \] (Reserved for DLC)
\[ SV5 = 0 \] (Reserved for LLC)
\[ SV6 = 1 \] (Reserved for CVC)
\[ SV7 = 1 \] (Reserved for VSA)

⚠️ **WARNING** Do not set SV4 (DLC) and SV5 (LLC) equal to a logical 1 at the same time. This is an illegal condition in the SEL-221C, and will cause misoperation of voltage supervised reclosing!

Figure 14.3 shows the implementation of SEL-221C voltage supervised reclosing in the SEL-311C. These settings are made automatically by the SEL-311C when setting APP = 221C. These assignments cannot be changed unless setting APP is changed back to APP = 311C.

SELOGIC variables SV4–SV7 are used for SEL-221C settings DLC, LLC, CVC, and VSA. SELOGIC variables SV13 must be entered into the 79DTL equation or voltage supervised reclosing will misoperate. It is recommended that, after making voltage supervised reclosing settings, the reclosing should be tested to verify intended performance.
Figure 14.3: Voltage Supervised Reclosing Logic

The following contact input assignments are made automatically by the SEL-311C when setting APP = 221C. These assignments cannot be changed unless setting APP is changed back to APP = 311C.

**Default Input Logic Equations**

- IN101 = DT - DIRECT TRIP
- IN102 = PT - PERMIT TO TRIP
- IN103 = BT - BLOCK TRIP
- IN104 = DC - DIRECT CLOSE
- IN105 = 52A
- IN106 = ET - EXTERNAL EVENT TRIGGER
**SEL-311C SETTINGS SHEET**  
**APPLICATION SETTING 221C**

---

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

Relay Identifier (30 characters)  
RID = ____________________________

Terminal Identifier (30 characters)  
TID = ____________________________

---

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

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

Polarizing (IPOL) Current Transformer Ratio (1–6000)  
CTRP = __________

Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00)  
PTR = __________

Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00)  
PTRS = __________

---

**Line Settings (See Settings Explanations in Section 9)**

Positive-sequence line impedance magnitude  
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 (311C, 221G, 221G5, 221H, 221F, 221F3, 221C, 221-16, 2PG10)  
APP = 221C

Fault location (Y, N) (see Table 12.1 and Fault Location in Section 12)  
EFLOC = __________

Loss-of-Potential (Y, Y1, N) (see Figure 4.1)  
ELOP = __________

---

**Mho Phase Distance Elements (See Settings Explanations in Section 3)**

Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.};  
0.25 -320.00 Ω secondary {1 A nom.})  
Z1P = __________

Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.};  
0.25 -320.00 Ω secondary {1 A nom.})  
Z2P = __________

Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.};  
0.25 -320.00 Ω secondary {1 A nom.})  
Z3P = __________

---

**Mho Phase Distance Element Time Delays (See Settings Explanations in Section 3)**

Zone 3 time delay (OFF, 0–16000 cycles)  
Z3PD = __________

---

**Phase Inst./Def.-Time Overcurrent Elements (See Figure 3.19)**

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

Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.};  
0.05–20.00 A secondary {1 A nom.})  
50P2P = __________

---

Date Code 20011205
Residual Ground Inst./Def.-Time Overcurrent Elements (See Figure 3.22)
Level 1 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
Level 2 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})
Level 3 (OFF, 0.25–100.00 A secondary {5 A nom.}; 0.05–20.00 A secondary {1 A nom.})

Residual Ground Definite-Time Overcurrent Element Time Delay (See Figure 3.22)
Level 2 (0.00–16000.00 cycles in 0.25-cycle steps) 67G2D = ________
Level 3 (0.00–16000.00 cycles in 0.25-cycle steps) 67G3D = ________

Phase Time-Overcurrent Element (See Figure 3.25)
Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})
Curve (U1–U5, C1–C5) (see Figures 9.1 through 9.10) 51PC = ________
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5) 51PTD = ________

Residual Ground Time-Overcurrent Element (See Figure 3.25)
Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})
Curve (U1–U5, C1–C5) (see Figures 9.1 through 9.10) 51GC = ________
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5) 51GTD = ________

Zone/Level 3 and 4 Directional Control
Zone/Level 3 direction: Forward, Reverse (F, R) DIR3 = ________

Directional Elements (See Directional Control Settings in Section 4)
Ground directional element priority: combination of Q, V, or I ORDER = ________

Voltage Elements (See Figures 3.27, 3.28, and 3.29)
(Make the following settings if preceding enable setting EVOLT = Y.)
Phase undervoltage pickup (OFF, 0.00–150.00 V secondary) 27P = ________
Phase overvoltage pickup (OFF, 0.00–150.00 V secondary) 59P = ________
Phase-to-phase undervoltage pickup (OFF, 0.00–260.00 V secondary) 27PP = ________
Phase-to-phase overvoltage pickup (OFF, 0.00–260.00 V secondary) 59PP = ________

Date Code 20011205
Reclosing Relay (See Tables 6.2 and 6.3)
Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI1 = __________
Open interval 2 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI2 = __________
Open interval 3 time (0.00–999999.00 cycles in 0.25-cycle steps) 79OI3 = __________
Reset time from reclose cycle (0.00–999999.00 cycles in 0.25-cycle steps) 79RSD = __________
Reset time from lockout (0.00–999999.00 cycles in 0.25-cycle steps) 79RSLD = __________

Switch-Onto-Fault (See Figure 5.3)
52 A enable time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps) 52AEND = __________
SOTF duration (0.50–16000.00 cycles in 0.25-cycle steps) SOTFD = __________

Other Settings
Minimum trip duration time (4.00–16000.00 cycles in 0.25-cycle steps) TDURD = __________

SELogic Control Equation Variable Timers (See Figures 7.23 and 7.24)
(SELogic control equation settings consist of Relay Word bits [see Table 9.4] and SELogic control.)
SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps) SV1PU = __________
SV1 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps) SV1DO = __________
SV9 Dropout Time (0.00–16000.00 cycles in 0.25-cycle steps) SV9DO = __________

Trip Logic Equations (See Figure 5.1)
Direct trip conditions TR = ________________
Switch-onto-fault trip conditions TRSOTF = ________________
Direct transfer trip conditions DTT = ________________

Reclosing Relay Equations (See Reclosing Relay in Section 6)
Reclose initiate 79RI = ________________
Drive-to-lockout 79DTL = ________________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements
[Note: torque control equation settings cannot be set directly to logical 0]
Residual Ground (see Figure 3.25) 51GTC = ________________
SELogic Control Equation Variable Timer Input Equations (See Figures 7.23 and 7.24)

SELOGIC control equation Variable SV1
SV1 = ________________

SELOGIC control equation Variable SV2
SV2 = ________________

SELOGIC control equation Variable SV3
SV3 = ________________

SELOGIC control equation Variable SV4
SV4 = ________________

SELOGIC control equation Variable SV5
SV5 = ________________

SELOGIC control equation Variable SV6
SV6 = ________________

SELOGIC control equation Variable SV7
SV7 = ________________

Output Contact Equations (See Figure 7.26)

Output Contact OUT101
OUT101 = ________________

Output Contact OUT102
OUT102 = ________________

Output Contact OUT103
OUT103 = ________________

Output Contact OUT104
OUT104 = ________________

Output Contact OUT105
OUT105 = ________________

Output Contact OUT106
OUT106 = ________________

Output Contact OUT107
OUT107 = ________________

Protocol Settings (See Below)

Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B) PROTO = ____________

Protocol Settings Set PROTO = SEL for standard SEL-ASCII protocol. For SEL Distributed Port Switch Protocol (LMD), set PROTO = LMD. Do not use MIRRORED BITS (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 = ____________

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 = ____________

Date Code 20011205
Other Port Settings (See Below)

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-out (0–30 minutes)</td>
<td>T_OUT</td>
</tr>
<tr>
<td>DTA Meter Format (Y, N)</td>
<td>DTA</td>
</tr>
<tr>
<td>Send Auto Messages to Port (Y, N)</td>
<td>AUTO</td>
</tr>
<tr>
<td>Enable Hardware Handshaking (Y, N, MBT)</td>
<td>RTSCTS</td>
</tr>
<tr>
<td>Fast Operate Enable (Y, N)</td>
<td>FASTOP</td>
</tr>
</tbody>
</table>

**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-311C Relay Fast Operate commands.

**Power System Configuration (See Settings Explanations in Section 9)**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase rotation (ABC, ACB)</td>
<td>PHROT</td>
</tr>
</tbody>
</table>

Date Code 20011205
SEL-221-16 to SEL-311C Settings Conversion Guide

Set APP = 221-16 in the SEL-311C to configure the relay to closely approximate the features, performance, and settings of an SEL-221-16. When APP = 221-16, the SEL-311C:

1. Configures itself as a phase and ground distance relay with ground directional overcurrent elements, and reclosing functions.
2. Configures contact inputs and outputs to emulate those in an SEL-221-16.
3. Presents the user only with those settings associated with SEL-221-16 type features.
4. Automatically calculates all other settings required to simulate an SEL-221-16.

If additional capability is needed (e.g., Mirrored Bits or SELOGIC control equations) the relay may be returned to the setting APP = 311C to make all of the SEL-311C settings visible. It is important to remember that changing from APP = 311C to APP = 221-16 changes settings in the relay. Changing from APP = 221-16 to APP = 311C makes more SEL-311C settings visible, but does not change any other settings. If SEL-311C functions are used after setting APP is changed from 221-16 to 311C, do not change setting APP back to 221-16.

As described above, when setting APP = 221-16, the user is presented only with SEL-311C settings associated with the features found in an SEL-221-16. This section explains how to make those remaining SEL-311C settings directly from the settings used in an SEL-221-16.

There are mainly two kinds of settings in the SEL-311C, 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-311C. To set the SEL-311C to emulate an SEL-221-16, follow these four steps:

1. Turn on the SEL-221-16 application setting by making setting APP = 221-16. See Application Settings below.
2. Convert the appropriate SEL-221-16 settings to SEL-311C settings using the simple equations shown in Table 14.28. Be sure to convert from primary quantities (SEL-221-16 settings) to secondary quantities (SEL-311C settings). See Convert SEL-221-16 Primary Quantities to SEL-311C Secondary Quantities below.
3. For each Mask Logic setting in the SEL-221-16 shown in Table 14.29, create an equivalent SELOGIC control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.15.
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-311C application setting to “221-16” as shown below:

```plaintext
=>>SET APP TERSE <ENTER>

Line Parameter Settings:

Application
(311C,221G,221G5,221H,221F,221F3,221C,221-16,2PG10)APP = 311C ? 221-16 <ENTER>

Enable Settings:

Fault Location(Y,N) EFLOC = Y ? END <ENTER>

Save Changes(Y/N)? Y <ENTER>

Settings saved
=>>
```

Convert SEL-221-16 Primary Quantities to SEL-311C Secondary Quantities

All SEL-221-16 current settings must be converted from primary to secondary amps to be used in the SEL-311C. Divide the SEL-221-16 current setting by the current transformer ratio setting (CTR) to make the change.

SEL-221-16 impedance settings must be converted from percent of primary line impedance to secondary impedance in ohms. For example, the Zone 1 distance setting in the SEL-311C (Z1P) is calculated as

\[
Z1P = \frac{Z1\%}{100} \cdot Z1MAG
\]

where:  
- Z1% is the SEL-221-16 distance reach setting.
- Z1MAG is the SEL-311C positive-sequence line impedance setting in secondary ohms.
- Z1P is the SEL-311C Zone 1 reach setting in secondary ohms.

Convert SEL-221-16 Relay Settings to SEL-311C Relay Settings

Table 14.28 shows all the SEL-311C Relay settings that must be entered for the relay to perform protection similar to the SEL-221-16 when APP = 221-16. Calculate each SEL-311C Relay setting from the corresponding SEL-221-16 Relay setting using the formula shown. Instruction manual references are to subsection headings rather than to section headings.

Please carefully note the difference between the SEL-311C and SEL-221-16 in the implementation of certain protection and logic schemes. For example, reclosing settings do not correspond exactly between the two relays. Always thoroughly test logic schemes to be sure they operate as intended.
### Table 14.28: SEL-311C Settings Calculated From SEL-221-16 Settings

<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-221-16 Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221-16 Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>RID</td>
<td>None</td>
<td></td>
<td>Section 3—Set</td>
</tr>
<tr>
<td>TID</td>
<td>= ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTR</td>
<td>= CTR</td>
<td></td>
<td>Section 9—Settings Sheets</td>
</tr>
<tr>
<td>CTRP</td>
<td>= CTR</td>
<td></td>
<td>Section 5—Current and Potential Transformer Ratio Selection</td>
</tr>
<tr>
<td>PTR</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTRS</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1MAG</td>
<td>$\sqrt{(R1^2 + X1^2) \cdot \frac{CTR}{PTR}}$</td>
<td>Section 9—Settings Sheets</td>
<td>Section 5—R1, X1, R0, X0, and Line Length (LL)</td>
</tr>
<tr>
<td>Z1ANG</td>
<td>$\text{Arc tan} \left( \frac{X1}{R1} \right)$ (degrees) = MTA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z0MAG</td>
<td>$\sqrt{(R0^2 + X0^2) \cdot (CTR/PTR)}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z0ANG</td>
<td>$\text{Arc tan} \left( \frac{X0}{R0} \right)$ (degrees)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>= LL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APP (=221-16)</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELOP</td>
<td>= LOPE</td>
<td>Section 4—Loss of Potential</td>
<td>Section 5—Loss-of-Potential (LOP) Enable Setting (LOPE)</td>
</tr>
<tr>
<td>N</td>
<td>= N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>= Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1P</td>
<td>$\frac{Z1%}{100} \cdot Z1MAG$</td>
<td>Section 3—Phase Distance Elements</td>
<td>Section 5—Zone 1 Reach Setting (Z1%)</td>
</tr>
<tr>
<td>Z1MG</td>
<td>$\frac{Z1%}{100} \cdot Z1MAG$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z2P</td>
<td>$\frac{Z2%}{100} \cdot Z1MAG$</td>
<td></td>
<td>Section 5—Zone 2 Reach Setting (Z2%)</td>
</tr>
<tr>
<td>Z2MG</td>
<td>$\frac{Z2%}{100} \cdot Z1MAG$</td>
<td></td>
<td>Section 5—Zone 3 Reach Setting (Z3%)</td>
</tr>
<tr>
<td>Z3P</td>
<td>$\frac{Z3%}{100} \cdot Z1MAG$</td>
<td></td>
<td>Note: Z1MAG is an SEL-311C setting</td>
</tr>
<tr>
<td>Z3MG</td>
<td>$\frac{Z3%}{100} \cdot Z1MAG$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>where</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Z1MAG is an SEL-311C setting.
<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-221-16 Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221-16 Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z2PD</td>
<td>= Z2DP</td>
<td>Section 3—Zone Time Delay Elements</td>
<td>Section 5—Zone 2 Phase and Ground Distance Time Delays (Z2DP, Z2DG)</td>
</tr>
<tr>
<td>Z2GD</td>
<td>= Z2DG</td>
<td>Section 5—Zone 3 Phase and Ground Time Delay (Z3D)</td>
<td></td>
</tr>
<tr>
<td>Z3D</td>
<td>= Z3D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50P1P</td>
<td>= 50H/CTR</td>
<td>Section 5—Switch-On-Fault (SOTF) Trip Logic</td>
<td>Section 5—High Set Phase Overcurrent Element Setting</td>
</tr>
<tr>
<td>50G1P</td>
<td>= 67NP/CTR</td>
<td>Section 3—Residual Ground Inst./Def.-Time Overcurrent Elements</td>
<td>Section 5—67NP Residual Overcurrent Settings (67NP, 67NTC)</td>
</tr>
<tr>
<td>N/A (67G1TC = 1)</td>
<td>67NTC (In the SEL-311C, 50G1P is fixed forward)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GP</td>
<td>= 51NP/CTR</td>
<td>Section 3—Residual Time-Overcurrent Element</td>
<td>Section 5—Residual Time-Overcurrent Settings (51NP, 51NC, 51NTD, 51NTC)</td>
</tr>
<tr>
<td>51GC</td>
<td>= 51NC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U1*</td>
<td>= 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U2</td>
<td>= 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U3</td>
<td>= 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U4</td>
<td>= 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTD</td>
<td>= 51NTD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTC</td>
<td>= 51NTC (51GTC is an SEL-311C SELOGIC setting)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(= 1)</td>
<td>= N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(= 32GF)</td>
<td>= Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79OI1</td>
<td>= 79OI1</td>
<td>Section 6—Close and Reclose Logic</td>
<td>Section 5—Reclose Logic</td>
</tr>
<tr>
<td>79RSD</td>
<td>= 79RS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79RSLD</td>
<td>= 79RS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Calculated from SEL-221-16 Settings

<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-221-16 Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>52AEND</td>
<td>Section 5—Switch-Onto-Fault (SOTF) Trip Logic</td>
<td>Section 5—52BT Setting (52BT) And Switch-Onto-Fault Protection</td>
</tr>
<tr>
<td>SOTFD</td>
<td>Section 5—Switch-Onto-Fault (SOTF) Trip Logic</td>
<td>Section 5—52BT Setting (52BT) And Switch-Onto-Fault Protection</td>
</tr>
<tr>
<td>TDURD</td>
<td>Section 4—Unlatch Trip</td>
<td>Section 5—Trip Duration Timer (TDUR)</td>
</tr>
<tr>
<td>SV1PU</td>
<td>Section 7—SELOGIC control equation Variables/Timers</td>
<td>Section 2—Miscellaneous Timers</td>
</tr>
<tr>
<td>SV1DO</td>
<td>Section 7—SELOGIC control equation Variables/Timers</td>
<td>Section 2—Miscellaneous Timers</td>
</tr>
</tbody>
</table>

* Curve U1 in the SEL-311C is slightly different from curve 1 in the SEL-221-16. Time dial adjustments may be necessary.

**Note:** SEL-311C phase-to-phase fault detector settings (50PP1, 50PP2, 50PP3) are set to their minimum values and hidden. This corresponds to SEL-221-16 setting 50P. SEL-311C phase-to-ground and residual fault detector settings (50L1, 50L2, 50L3, 50GZ1, 50GZ2, and 50GZ3) are set to their minimum values and hidden. This corresponds to SEL-221-16 setting 50NG. SEL-221-16 function “Remote End Just Opened” (REJO) is not implemented in the SEL-311C.

### Convert SEL-221-16 Output Mask Logic Settings to SELogic Control Equations

See *Programmable Output Contact Mask Settings* in Section 5: Applications in the SEL-221-16 Instruction Manual for a description of output masks. In the SEL-311C, output masks are replaced by SELogic control equations as shown below:

#### Table 14.29: SEL-311C SELOGIC Equation Equivalent to Each SEL-221-16 Mask Logic Setting

<table>
<thead>
<tr>
<th>SEL-221-16 Settings Mask</th>
<th>SEL-311C SELOGIC Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTU</td>
<td>TR</td>
</tr>
<tr>
<td>MPT</td>
<td>None</td>
</tr>
<tr>
<td>MTB</td>
<td>None</td>
</tr>
<tr>
<td>MTO</td>
<td>TRSOTF</td>
</tr>
<tr>
<td>MA1</td>
<td>OUT104</td>
</tr>
<tr>
<td>MA2</td>
<td>OUT105</td>
</tr>
</tbody>
</table>
Table 14.15 shows all SEL-221-16 Relay Word bits, and an approximate equivalent SEL-311C SELOGIC expression, when setting APP = 221-16 in the SEL-311C. Table 14.29 shows each SEL-221-16 Mask Logic Setting and the equivalent SEL-311C SELOGIC control equation. To convert a SEL-221-16 Mask Logic Setting to a SELOGIC control equation, logically OR each appropriate SEL-221-16 Relay Word bit equivalent expression (Table 14.15) and enter the resultant expression in the related SELOGIC control equation (Table 14.29).

Table 14.30: SELOGIC Equivalent to SEL-221-16 Relay Word Bits

<table>
<thead>
<tr>
<th>SEL-221-16 Settings Mask</th>
<th>SEL-311C SELOGIC Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA3</td>
<td>OUT106</td>
</tr>
<tr>
<td>MA4</td>
<td>OUT107</td>
</tr>
<tr>
<td>MRI</td>
<td>79RI</td>
</tr>
<tr>
<td>MRC</td>
<td>79DTL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEL-221-16 Relay Word Bit</th>
<th>Equivalent SEL-311C SELOGIC Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z1P</td>
<td>M1P</td>
</tr>
<tr>
<td>Z1G</td>
<td>M1G</td>
</tr>
<tr>
<td>Z2PT</td>
<td>M2PT</td>
</tr>
<tr>
<td>Z2GT</td>
<td>Z2GT</td>
</tr>
<tr>
<td>Z3</td>
<td>M3P + M3G</td>
</tr>
<tr>
<td>Z3T</td>
<td>Z3T</td>
</tr>
<tr>
<td>3P21</td>
<td>M3P * !32QF</td>
</tr>
<tr>
<td>32Q</td>
<td>32GF + 32QF</td>
</tr>
<tr>
<td>67N</td>
<td>67G1</td>
</tr>
<tr>
<td>51NP</td>
<td>51G</td>
</tr>
<tr>
<td>51NT</td>
<td>51GT</td>
</tr>
<tr>
<td>50NG</td>
<td>None</td>
</tr>
<tr>
<td>50P</td>
<td>None</td>
</tr>
<tr>
<td>50H</td>
<td>50P1</td>
</tr>
<tr>
<td>IN1</td>
<td>IN101</td>
</tr>
<tr>
<td>REJO</td>
<td>None</td>
</tr>
<tr>
<td>LOP</td>
<td>ILOP</td>
</tr>
<tr>
<td>TRIP</td>
<td>TRIP</td>
</tr>
</tbody>
</table>
For example, the factory default setting for MRC in the SEL-221-16 is shown in Table 14.16. From Table 14.29, the equivalent SEL-311C SELOGIC control equation to MRC is 79DTL. Constructing the logical OR of the equivalent of each element selected in the MRC mask from Table 14.15 gives:

\[ 79DTL = Z3T + 51GT \]

Include the open command OC:

\[ 79DTL = Z3T + 51GT + OC \]

This is the default SELOGIC control equation for 79DTL when APP = 221-16.

When setting APP = 221-16, the SEL-311C automatically sets the following SELOGIC control equations. Change the settings just as you would change the Mask Logic settings in an SEL-221-16 to customize the relay logic.

**Table 14.31: Default SEL-221-16 Mask Logic Setting for MRC**

<table>
<thead>
<tr>
<th>Z1P</th>
<th>Z1G</th>
<th>Z2PT</th>
<th>Z2GT</th>
<th>Z3</th>
<th>Z3T</th>
<th>3P21</th>
<th>32Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>67N</td>
<td>51NP</td>
<td>51NT</td>
<td>50NG</td>
<td>50P</td>
<td>50H</td>
<td>IN1</td>
<td>REJO</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LOP</td>
<td>TRIP</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Default Tripping Logic Equations**

\[ TR = M1P + Z1G + M2PT + Z2GT + Z3T + 67G1 + 51GT + OC \]

\[ TRSOTF = M1P + Z1G + M2PT + Z2GT + M3P + Z3G + Z3T + 67G1 + 51GT + 50P1 \]

**Default Reclose Logic Equations**

\[ 79RI = M1P + Z1G + M2PT + Z2GT + 67G1 \]

\[ 79DTL = Z3T + 51GT + OC \]

**SELOGIC Torque Control Equations**

\[ 51GTC = M2P \quad \text{(Setting 51NTC = 1)} \]

**SELOGIC Variables Equations**

\[ SV1 = 0 \quad \text{(Reserved for MA1)} \]
Default Contact Input Functions

<table>
<thead>
<tr>
<th>311 Input</th>
<th>221-16 Label</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN101</td>
<td>IN1</td>
<td>Monitor</td>
</tr>
<tr>
<td>IN102</td>
<td>PT</td>
<td>Monitor</td>
</tr>
<tr>
<td>IN103</td>
<td>BT</td>
<td>Monitor</td>
</tr>
<tr>
<td>IN104</td>
<td>DC</td>
<td>Monitor</td>
</tr>
<tr>
<td>IN105</td>
<td>52A</td>
<td>Circuit Breaker Aux. Contact</td>
</tr>
<tr>
<td>IN106</td>
<td>ET</td>
<td>External Event Report Trigger</td>
</tr>
</tbody>
</table>

Default Output Contact Logic Equations

\[
\begin{align*}
\text{OUT101} &= \text{TRIP} \\
\text{OUT102} &= \text{TRIP} \\
\text{OUT103} &= \text{CLOSE} \\
\text{OUT104} &= 0 \quad \text{(Reserved for MA1)} \\
\text{OUT105} &= 0 \quad \text{(Reserved for MA2)} \\
\text{OUT106} &= \text{M1P} + \text{Z1G} + \text{M2PT} + \text{Z2GT} + 67G1 \quad \text{(Reserved for MA3)} \\
\text{OUT107} &= \text{Z3T} + 51GT \quad \text{(Reserved for MA4)}
\end{align*}
\]
Identifier Labels (See Settings Explanations in Section 9)
Relay Identifier (30 characters) RID = __________________________
Terminal Identifier (30 characters) TID = __________________________

Current and Potential Transformer Ratios (See Settings Explanations in Section 9)
Phase (IA, IB, IC) Current Transformer Ratio (1–6000) CTR = ________
Polarizing (IPOL) Current Transformer Ratio (1–6000) CTRP = ________
Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00) PTR = ________
Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00) PTRS = ________

Line Settings (See Settings Explanations in Section 9)
Positive-sequence line impedance magnitude
(0.05–255.00 Ω secondary {5 A nom.};
0.25–1275.00 Ω secondary {1 A nom.}) Z1MAG = ________
Positive-sequence line impedance angle (5.00–90.00 degrees) Z1ANG = ________
Zero-sequence line impedance magnitude
(0.05–255.00 Ω secondary {5 A nom.};
0.25–1275.00 Ω secondary {1 A nom.}) Z0MAG = ________
Zero-sequence line impedance angle (5.00–90.00 degrees) Z0ANG = ________
Line length (0.10–999.00, unitless) LL = ________
Application (311C, 221G, 221G5, 221H, 221F, 221F3, 221C, 221-16, 2PG10) APP = 221-16
Loss-of-Potential (Y, Y1, N) (see Figure 4.1) ELOP = ________

Phase Distance Elements (See Settings Explanations in Section 3)
Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25–320.00 Ω secondary {1 A nom.}) (See Figure 3.4) Z1P = ________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25–320.00 Ω secondary {1 A nom.}) (See Figure 3.5) Z2P = ________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25–320.00 Ω secondary {1 A nom.}) (See Figure 3.6) Z3P = ________

Mho Ground Distance Elements
Zone 1 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.7) Z1MG = ________
Zone 2 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.8) Z2MG = ________
Zone 3 (OFF, 0.05–64.00 Ω secondary {5 A nom.};
0.25–320.00 Ω secondary {1 A nom.}) (see Figure 3.9) Z3MG = ________
Phase and Ground Distance Element Time Delays (See Settings Explanations in Section 3 and Figure 3.6)

Zone 2 phase distance time delay (OFF, 0–16000 cycles)  
Zone 2 ground distance time delay (OFF, 0–16000 cycles)  
Zone 3 time delay (OFF, 0–16000 cycles)

\[ Z2PD = \_\_\_\_\_\_\_\_\_ \]
\[ Z2GD = \_\_\_\_\_\_\_\_\_ \]
\[ Z3D = \_\_\_\_\_\_\_\_\_ \]

Phase Inst./Def.-Time Overcurrent Element (See Figure 3.6)

Level 1 (OFF, 0.25–100.00 A secondary \{5 A nom.\}; 0.05–20.00 A secondary \{1 A nom.\})

\[ 50P1P = \_\_\_\_\_\_\_\_\_ \]

Residual Ground Inst./Def.-Time Overcurrent Element (See Figure 3.6)

Level 1 (OFF, 0.25–100.00 A secondary \{5 A nom.\}; 0.05–20.00 A secondary \{1 A nom.\})

\[ 50G1P = \_\_\_\_\_\_\_\_\_ \]

Residual Ground Time-Overcurrent Element (See Figure 3.6)

Pickup (OFF, 0.50–16.00 A secondary \{5 A nom.\}; 0.10–3.20 A secondary \{1 A nom.\})

Curve (U1–U5, C1–C5) (see Figures 9.1 through 9.10)

\[ 51GP = \_\_\_\_\_\_\_\_\_ \]
\[ 51GC = \_\_\_\_\_\_\_\_\_ \]
\[ 51GTD = \_\_\_\_\_\_\_\_\_ \]

Reclosing Relay (See Tables 6.2 and 6.3)

Open interval 1 time (0.00–999999.00 cycles in 0.25-cycle steps)
Reset time from reclose cycle (0.00–999999.00 cycles in 0.25-cycle steps)
Reset time from lockout (0.00–999999.00 cycles in 0.25-cycle steps)

\[ 79OI1 = \_\_\_\_\_\_\_\_\_ \]
\[ 79RSD = \_\_\_\_\_\_\_\_\_ \]
\[ 79RSLD = \_\_\_\_\_\_\_\_\_ \]

Switch-Onto-Fault (See Figure 5.3)

52 A enable time delay (OFF, 0.00–16000.00 cycles in 0.25-cycle steps)
SOTF duration (0.50–16000.00 cycles in 0.25-cycle steps)

\[ 52AEND = \_\_\_\_\_\_\_\_\_ \]
\[ SOTFD = \_\_\_\_\_\_\_\_\_ \]

Other Settings

Minimum trip duration time (4.00–16000.00 cycles in 0.25-cycle steps)

\[ TDURD = \_\_\_\_\_\_\_\_\_ \]

SELogic Control Equation Variable Timers (See Figures 7.24 and 7.25)

SV1 Pickup Time (0.00–999999.00 cycles in 0.25-cycle steps)
SV1 Dropout Time (0.00–999999.00 cycles in 0.25-cycle steps)

\[ SV1PU = \_\_\_\_\_\_\_\_\_ \]
\[ SV1DO = \_\_\_\_\_\_\_\_\_ \]

Trip Logic Equations (See Figure 5.1)

Direct trip conditions
Switch-onto-fault trip conditions

\[ TR = \_\_\_\_\_\_\_\_\_ \]
\[ TRSOTF = \_\_\_\_\_\_\_\_\_ \]

Date Code 20011205
Reclosing Relay Equations (See Reclosing Relay in Section 6)
Reclose initiate 79RI = ________________
Drive-to-lockout 79DTL = ________________

Torque Control Equations for Inst./Def.-Time Overcurrent Elements
[Note: torque control equation settings cannot be set directly to logical 0]
Level 1 residual ground (see Figure 3.22) 67G1TC = ________________
Residual Ground (see Figure 3.25) 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 = __________

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-311C Relay Fast Operate commands.

**Power System Configuration (See Settings Explanations in Section 9)**

- **Phase rotation (ABC, ACB)**
  
  \[ PHROT = \_\_\_\_\_\_ \]
SEL-2PG10 to SEL-311C Settings Conversion Guide

Set APP = 2PG10 in the SEL-311C to configure the relay to closely approximate the features, performance, and settings of an SEL-2PG10. When APP = 2PG10, the SEL-311C:

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 = 311C to make all of the SEL-311C settings visible. It is important to remember that changing from APP = 311C to APP = 2PG10 changes settings in the relay. Changing from APP = 2PG10 to APP = 311C makes more SEL-311C settings visible, but does not change any other settings. If SEL-311C functions are used after setting APP is changed from 2PG10 to 311C, do not change setting APP back to 2PG10.

As described above, when setting APP = 2PG10, the user is presented only with SEL-311C settings associated with the features found in an SEL-2PG10. This section explains how to make those remaining SEL-311C settings directly from the settings used in an SEL-2PG10.

There are mainly two kinds of settings in the SEL-311C, 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-311C. To set the SEL-311C 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-311C settings using the simple equations shown in Table 14.28. Be sure to convert from primary quantities (SEL-2PG10 settings) to secondary quantities (SEL-311C settings). See Convert SEL-2PG10 Primary Quantities to SEL-311C Secondary Quantities below.
3. For each Mask Logic setting in the SEL-2PG10 shown in Table 14.29, create an equivalent SELOGIC control equation using the logical OR of each bit asserted in the mask, as shown in Table 14.15.
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-311C application setting to “2PG10” as shown below:

```plaintext
~~>SET APP TERSE <ENTER>
Line Parameter Settings:
Application
(311C,221G,221G5,221H,221F,221F3,221C,221-16,2PG10)APP = 311C ? 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-311C Secondary Quantities

All SEL-2PG10 current settings must be converted from primary to secondary amps to be used in the SEL-311C. 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-311C (Z1P) is calculated as

\[ Z1P = \frac{Z1\%}{100} \cdot Z1MAG \]

where:  
- Z1% is the SEL-2PG10 distance reach setting.
- Z1MAG is the SEL-311C positive-sequence line impedance setting in secondary ohms.
- Z1P is the SEL-311C Zone 1 reach setting in secondary ohms.

Convert SEL-2PG10 Relay Settings to SEL-311C Relay Settings

Table 14.28 shows all the SEL-311C Relay settings that must be entered for the relay to perform protection similar to the SEL-2PG10 when APP = 2PG10. Calculate each SEL-311C 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-311C 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 14.32: SEL-311C Settings Calculated From SEL-2PG10 Settings

<table>
<thead>
<tr>
<th>SEL-311C Relay Setting</th>
<th>Calculated from SEL-2PG10 Settings</th>
<th>SEL-311C Instruction Manual Section</th>
<th>SEL-2PG10 Instruction Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>RID</td>
<td>None</td>
<td></td>
<td>Section 4—Set</td>
</tr>
<tr>
<td>TID</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>= ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTR</td>
<td>= CTR</td>
<td>Section 9—Settings</td>
<td></td>
</tr>
<tr>
<td>CTRP</td>
<td>= CTR</td>
<td>Sheets</td>
<td></td>
</tr>
<tr>
<td>PTR</td>
<td>= PTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTRS</td>
<td>= SPTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1MAG</td>
<td>$= \sqrt{(R1^2 + X1^2)} \cdot \left[ \frac{CTR}{PTR} \right]$</td>
<td>Section 9—Settings</td>
<td></td>
</tr>
<tr>
<td>Z1ANG</td>
<td>$= \text{Arc tan} \left[ \frac{X1}{R1} \right]$ (degrees) = MTA</td>
<td>Sheets</td>
<td></td>
</tr>
<tr>
<td>Z0MAG</td>
<td>$= \sqrt{(R0^2 + X0^2)} \cdot (CTR/PTR)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z0ANG</td>
<td>$= \text{Arc tan} \left[ \frac{X0}{R0} \right]$ (degrees)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>= LL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APP</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1P</td>
<td>$= \frac{Z%}{100} \cdot Z1MAG$</td>
<td>Section 3—Phase</td>
<td></td>
</tr>
<tr>
<td></td>
<td>where</td>
<td>Distance Elements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$Z1MAG = \sqrt{(R1^2 + X1^2)} \cdot \left[ \frac{CTR}{PTR} \right]$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1PD</td>
<td>= PTMR</td>
<td>Section 3—Zone Time</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Delay Elements</td>
<td></td>
</tr>
<tr>
<td>50G1P</td>
<td>= 67NIP/CTR</td>
<td>Section 3—Residual</td>
<td></td>
</tr>
<tr>
<td>(SV1 = 50G1)</td>
<td>= 67NIP Non-directional</td>
<td>Ground Inst./Def.-Time</td>
<td></td>
</tr>
<tr>
<td>67G1D</td>
<td>= GTMR (Directional)</td>
<td>Overcurrent Elements</td>
<td></td>
</tr>
<tr>
<td>SV1T</td>
<td>= GTMR (Non-directional)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEL-311C Relay Setting</td>
<td>Calculated from SEL-2PG10 Settings</td>
<td>SEL-311C Instruction Manual Section</td>
<td>SEL-2PG10 Instruction Manual Section</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>51GP</td>
<td>= 67NP/CTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GC</td>
<td>= 67NC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U1*</td>
<td>= 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U2</td>
<td>= 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U3</td>
<td>= 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U4</td>
<td>= 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTD</td>
<td>= 67NTD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51GTC</td>
<td>= 67NC (51GTC is an SEL-311C SELOGIC setting) (= 1 = Non-Directional) (= 32GF = Torque Controlled)</td>
<td>Section 4—Directional Control for Ground Distance and Residual Ground Overcurrent Elements</td>
<td></td>
</tr>
<tr>
<td>ORDER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>= 32QE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>= 32VE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>= 32IE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Curve U1 in the SEL-311C is slightly different from curve 1 in the SEL-2PG10. Time dial adjustments may be necessary.

**Note:** SEL-311C 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-311C, output masks are replaced by SELOGIC control equations as shown below:

Table 14.33: SEL-311C SELOGIC Equation Equivalent to Each SEL-2PG10 Mask Logic Setting

<table>
<thead>
<tr>
<th>SEL-2PG10 Settings Mask</th>
<th>SEL-311C SELOGIC Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT</td>
<td>TR</td>
</tr>
<tr>
<td>MA1</td>
<td>OUT101</td>
</tr>
<tr>
<td>MA2</td>
<td>OUT102</td>
</tr>
<tr>
<td>MA3</td>
<td>OUT103</td>
</tr>
<tr>
<td>MA4</td>
<td>OUT104</td>
</tr>
<tr>
<td>MA5</td>
<td>OUT105</td>
</tr>
</tbody>
</table>

Table 14.15 shows all SEL-2PG10 Relay Word bits, and an approximate equivalent SEL-311C SELOGIC expression, when setting APP = 2PG10 in the SEL-311C. Table 14.29 shows each SEL-2PG10 Mask Logic Setting and the equivalent SEL-311C 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 14.15) and enter the resultant expression in the related SELOGIC control equation (Table 14.29).

Table 14.34: SELOGIC Equivalent to SEL-2PG10 Relay Word Bits

<table>
<thead>
<tr>
<th>SEL-2PG10 Relay Word Bit</th>
<th>Equivalent SEL-311C SELOGIC Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>50L</td>
<td>None</td>
</tr>
<tr>
<td>ZABC</td>
<td>MABC1</td>
</tr>
<tr>
<td>ZP</td>
<td>MPP1</td>
</tr>
<tr>
<td>ZPT</td>
<td>M1PT</td>
</tr>
<tr>
<td>67NP</td>
<td>51G</td>
</tr>
<tr>
<td>67NT</td>
<td>51GT</td>
</tr>
<tr>
<td>67NI</td>
<td>67G1 (Directional)</td>
</tr>
<tr>
<td></td>
<td>50G1 (Non-directional)</td>
</tr>
<tr>
<td>67DT</td>
<td>67G1T (Directional)</td>
</tr>
<tr>
<td></td>
<td>SVIT (Non-directional)</td>
</tr>
</tbody>
</table>

For example, the factory default setting for MT in the SEL-2PG10 is shown in Table 14.16. From Table 14.29, the equivalent SEL-311C SELOGIC control equation to MT is TR.
Constructing the logical OR of the equivalent of each element selected in the MT mask from Table 14.15 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-311C 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 14.35: Default SEL-2PG10 Mask Logic Setting for MT

<table>
<thead>
<tr>
<th>50L</th>
<th>ZABC</th>
<th>ZP</th>
<th>ZPT</th>
<th>67NP</th>
<th>67NT</th>
<th>67NI</th>
<th>67DT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Default Tripping Logic Equations

$$TR = MABC1 + MPP1 + 51GT + 67G1T + OC$$

SELOGIC Torque Control Equations

$$51GTC = M2P$$  (Setting 51NTC = 1)

SELOGIC Variables Equations

$$SV1 = 0$$  (Reserved for non-directional instantaneous overcurrent timer)

Default Contact Input Functions

<table>
<thead>
<tr>
<th>311 Input</th>
<th>2PG10 Label</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN101</td>
<td>ET1</td>
<td>External Trigger 1</td>
</tr>
<tr>
<td>IN102</td>
<td>ET2</td>
<td>External Trigger 2</td>
</tr>
<tr>
<td>IN103</td>
<td>E1</td>
<td>Monitor 1</td>
</tr>
<tr>
<td>IN104</td>
<td>E2</td>
<td>Monitor 2</td>
</tr>
<tr>
<td>IN105</td>
<td>E3</td>
<td>Monitor 3</td>
</tr>
<tr>
<td>IN106</td>
<td>52A</td>
<td>Circuit breaker auxiliary contact</td>
</tr>
</tbody>
</table>
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-311C SETTINGS SHEET**

**APPLICATION SETTING 2PG10**

**Date Code 20011205**

---

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

- Relay Identifier (30 characters) \( \text{RID} = \) __________
- Terminal Identifier (30 characters) \( \text{TID} = \) __________

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

- Phase (IA, IB, IC) Current Transformer Ratio (1–6000) \( \text{CTR} = \) __________
- Polarizing (IPOL) Current Transformer Ratio (1–6000) \( \text{CTRP} = \) __________
- Phase (VA, VB, VC) Potential Transformer Ratio (1.00–10000.00) \( \text{PTR} = \) __________
- Synchronism Voltage (VS) Potential Transformer Ratio (1.00–10000.00) \( \text{PTRS} = \) __________

**Line Settings** *(See Settings Explanations in Section 9)*

- Positive-sequence line impedance magnitude \( Z_{1MAG} = \) __________
  - (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) \( Z_{1ANG} = \) __________
- Zero-sequence line impedance magnitude \( Z_{0MAG} = \) __________
  - (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) \( Z_{0ANG} = \) __________
- Line length (0.10–999.00, unitless) \( \text{LL} = \) __________
- Application (311C, 221G, 221G5, 221H, 221F, 221F3, 221C, 221-16, 2PG10) \( \text{APP} = 2\text{PG10} \)

**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.\}) \( Z_{1P} = \) __________

**Mho Phase Distance Element Time Delays** *(See Settings Explanations in Section 3)*

- Zone 1 time delay (OFF, 0–16000 cycles) \( Z_{1PD} = \) __________

**Residual Ground Inst./Def.-Time Overcurrent Element** *(See Figure 3.25)*

- 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 3.25)*

- Level 1 (0.00–16000.00 cycles in 0.25-cycle steps) \( 67G1D = \) __________
Residual Ground Time-Overcurrent Element (See Figure 3.28)
Pickup (OFF, 0.50–16.00 A secondary {5 A nom.}; 0.10–3.20 A secondary {1 A nom.})
Curve (U1–U5, C1–C5) (see Figures 9.1 through 9.10)
Time Dial (0.50–15.00 for curves U1–U5; 0.05–1.00 for curves C1–C5)
51GP =
51GC =
51GTD =

Directional Elements (See Directional Control Settings in Section 4)
Ground directional element priority: combination of Q, V, or I
ORDER =

SELogic Control Equation Variable Timers (See 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 3.25)
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.
SEL-311C SETTINGS SHEET  
APPLICATION SETTING 2PG10

Date Code 20011205

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-311C Relay Fast Operate commands.

Power System Configuration (See Settings Explanations in Section 9)
Phase rotation (ABC, ACB) PHROT = _________
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## APPENDIX A: FIRMWARE VERSIONS

This manual covers SEL-311C Relays that contain firmware bearing the following part numbers and revision numbers (most recent firmware listed at top):

<table>
<thead>
<tr>
<th>Firmware Part/Revision No.</th>
<th>Description of Firmware</th>
</tr>
</thead>
</table>
| SEL-311C-R105-V0-Z003003-D20011205 | This firmware differs from the original as follows:  
  – Added 180-cycle event report option.  
  – Modified input debounce time.  
  – Modified rotating display to include settings values.  
  – Added ELAT and EDP settings.  
  – Modified breaker reset (BRE W) option.  
  – Added STA C command.  
  – Added Fast SER. |
| SEL-311C-R104-V0-Z002002-D200010625 | This firmware differs from the original as follows:  
  – Modified SEL-311 Relays to record consecutive event reports.  
  – Modified the SUM command so that the Breaker Status reports the status from the last row of the event report.  
  – Changed the E21P default setting to 3C in application settings 221G, 221G5, and 221H. |
| SEL-311C-R103-V0-Z002002-D200010516 | This firmware differs from the original as follows:  
  – Improved overflow supervision for distance elements. |
| SEL-311C-R102-V0-Z002002-D20000922 | This firmware differs from the original as follows:  
  – Added compensator distance elements.  
  – Added application settings 221C, 221-16, 2PG10.  
  – Added frequency elements. |
| SEL-311C-R101-V0-Z001001-D20000619 | This firmware differs from the original as follows:  
  – Internal changes in firmware to support Flash memory revision. |
| SEL-311C-R100-V0-Z001001-D19991203 | Original Version  
SEL-311C; 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-311C-R100-V0-Z001001-D19991203
APPENDIX B: FIRMWARE UPGRADE INSTRUCTIONS

FIRMWARE (FLASH) UPGRADE INSTRUCTIONS

SEL may occasionally offer firmware upgrades to improve the performance of your relay. The SEL-311C Relay stores firmware in Flash memory; therefore, changing physical components is not necessary. A firmware loader program called SELBOOT resides in the SEL-311C 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-311C 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 1, SHO 2, SHO L 2, SHO 3, SHO L 3, SHO 4, SHO L 4, SHO 5, SHO L 5, SHO 6, SHO L 6, SHO P 1, SHO P 2, SHO P 3, SHO P F, SHO R, and SHO T.

Issue the Password (PAS) command and save the original password settings in case they are needed later.

Normally, the relay will preserve the settings during the firmware upgrade. However, depending on the firmware version that was previously installed and the use of relay memory, this cannot be ensured. Saving settings is always recommended.

4. Set your communication connection to the highest possible baud rate. The relay will support speeds up to 38,400 baud. Use the SET P command to change the SPEED setting to the desired baud rate.

5. Issue the L_D <ENTER> command to the relay (L underscore D ENTER) to start the SELBOOT program.

6. Type Y <ENTER> to the “Disable relay to send or receive firmware (Y/N)?” prompt and Y <ENTER> to the “Are you sure (Y/N)?” prompt. The relay will send (Relay Disabled) and will then send the SELBOOT prompt !> after a few seconds.

   **Note:** SELBOOT does not echo nonalphabetic characters as the first character of a line. This may make it appear that the relay is not functioning properly when just the <ENTER> key is pressed on the connected PC, even though everything is OK.

7. Make a copy of the firmware currently in the relay. This is recommended in case the new firmware download is unsuccessful. To make a backup of the firmware, you will need approximately 2.3 MB of free disk space. The procedure takes approximately 11 minutes at 38,400 baud.

   Issue the Send (SEN) command to the relay to initiate the firmware transfer from the relay to your computer. No activity will be seen on the PC screen, because the relay is waiting for the PC to request the first XMODEM data packet. Select the “Receive File” function with the XMODEM protocol in your terminal emulation software. Give the file a unique name to clearly identify the firmware version (e.g., 311C_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.

```
=>>LD <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 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-311C Relay.

MESSAGE LISTS

Binary Message List

<table>
<thead>
<tr>
<th>Request to Relay (hex)</th>
<th>Response From Relay</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5C0</td>
<td>Relay Definition Block</td>
</tr>
<tr>
<td>A5C1</td>
<td>Fast Meter Configuration Block</td>
</tr>
<tr>
<td>A5D1</td>
<td>Fast Meter Data Block</td>
</tr>
<tr>
<td>A5C2</td>
<td>Demand Fast Meter Configuration Block</td>
</tr>
<tr>
<td>A5D2</td>
<td>Demand Fast Meter Data Message</td>
</tr>
<tr>
<td>A5C3</td>
<td>Peak Demand Fast Meter Configuration Block</td>
</tr>
<tr>
<td>A5D3</td>
<td>Peak Demand Fast Meter Data Message</td>
</tr>
<tr>
<td>A5B9</td>
<td>Fast Meter Status Acknowledge</td>
</tr>
<tr>
<td>A5CE</td>
<td>Fast Operate Configuration Block</td>
</tr>
<tr>
<td>A5E0</td>
<td>Fast Operate Remote Bit Control</td>
</tr>
<tr>
<td>A5E3</td>
<td>Fast Operate Breaker Control</td>
</tr>
<tr>
<td>A5CD</td>
<td>Fast Operate Reset Definition Block</td>
</tr>
<tr>
<td>A5ED</td>
<td>Fast Operate Reset Command</td>
</tr>
</tbody>
</table>
ASCII Configuration Message List

Request to Relay (ASCII) | Response From Relay
--- | ---
ID | ASCII Firmware ID String and Terminal ID Setting (TID)
DNA | ASCII Names of Relay Word bits
BNA | ASCII Names of bits in the A5B9 Status Byte
SNS | ASCII Names of strings in SER settings

MESSAGE DEFINITIONS

A5C0 Relay Definition Block

In response to the A5C0 request, the relay sends the following block:

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5C0</td>
<td>Command</td>
</tr>
<tr>
<td>34</td>
<td>Message length (74)</td>
</tr>
<tr>
<td>04</td>
<td>Support SEL, LMD, DNP 3.00, and R6 SEL protocols</td>
</tr>
<tr>
<td>03</td>
<td>Support Fast Meter, fast demand, and fast peak</td>
</tr>
<tr>
<td>03</td>
<td>Status flag for Warn, Fail, Group, or Settings change</td>
</tr>
<tr>
<td>A5C1</td>
<td>Fast Meter configuration</td>
</tr>
<tr>
<td>A5D1</td>
<td>Fast Meter message</td>
</tr>
<tr>
<td>A5C2</td>
<td>Fast demand configuration</td>
</tr>
<tr>
<td>A5D2</td>
<td>Fast demand message</td>
</tr>
<tr>
<td>A5C3</td>
<td>Fast peak configuration</td>
</tr>
<tr>
<td>A5D3</td>
<td>Fast peak message</td>
</tr>
<tr>
<td>0004</td>
<td>Settings change bit</td>
</tr>
<tr>
<td>A5C100000000</td>
<td>Reconfigure Fast Meter on settings change</td>
</tr>
<tr>
<td>0004</td>
<td>Settings change bit</td>
</tr>
<tr>
<td>A5C200000000</td>
<td>Reconfigure demand FM on settings change</td>
</tr>
<tr>
<td>0004</td>
<td>Settings change bit</td>
</tr>
<tr>
<td>A5C300000000</td>
<td>Reconfigure peak demand FM on settings change</td>
</tr>
<tr>
<td>0300</td>
<td>SEL protocol has Fast Operate</td>
</tr>
<tr>
<td>0101</td>
<td>LMD protocol has Fast Operate</td>
</tr>
<tr>
<td>0005</td>
<td>DNP 3.00</td>
</tr>
<tr>
<td>0006</td>
<td>R6 SEL (relay-to-relay) MIRRORED BITS protocol</td>
</tr>
<tr>
<td>00</td>
<td>Reserved</td>
</tr>
<tr>
<td>xx</td>
<td>Checksum</td>
</tr>
</tbody>
</table>
**A5C1 Fast Meter Configuration Block**

In response to the A5C1 request, the relay sends the following block:

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5C1</td>
<td>Fast Meter command</td>
</tr>
<tr>
<td>84</td>
<td>Length</td>
</tr>
<tr>
<td>01</td>
<td>One status flag byte</td>
</tr>
<tr>
<td>00</td>
<td>Scale factors in Fast Meter message</td>
</tr>
<tr>
<td>00</td>
<td>No scale factors</td>
</tr>
<tr>
<td>0A</td>
<td># of analog input channels</td>
</tr>
<tr>
<td>02</td>
<td># of samples per channel</td>
</tr>
<tr>
<td>36</td>
<td># of digital banks</td>
</tr>
<tr>
<td>01</td>
<td>One calculation block</td>
</tr>
<tr>
<td>0004</td>
<td>Analog channel offset</td>
</tr>
<tr>
<td>0054</td>
<td>Time stamp offset</td>
</tr>
<tr>
<td>005C</td>
<td>Digital offset</td>
</tr>
<tr>
<td>494100000000</td>
<td>Analog channel name (IA)</td>
</tr>
<tr>
<td>01</td>
<td>Analog channel type (float)</td>
</tr>
<tr>
<td>FF</td>
<td>Scale factor type</td>
</tr>
<tr>
<td>0000</td>
<td>Scale factor offset in Fast Meter message (HEX)</td>
</tr>
<tr>
<td>494200000000</td>
<td>Analog channel name (IB)</td>
</tr>
<tr>
<td>01</td>
<td>Analog channel type (float)</td>
</tr>
<tr>
<td>FF</td>
<td>Scale factor type</td>
</tr>
<tr>
<td>0000</td>
<td>Scale factor offset in Fast Meter message</td>
</tr>
<tr>
<td>494300000000</td>
<td>Analog channel name (IC)</td>
</tr>
<tr>
<td>01</td>
<td>Analog channel type (float)</td>
</tr>
<tr>
<td>FF</td>
<td>Scale factor type</td>
</tr>
<tr>
<td>0000</td>
<td>Scale factor offset in Fast Meter message</td>
</tr>
<tr>
<td>495000000000</td>
<td>Analog channel name (IP)</td>
</tr>
<tr>
<td>01</td>
<td>Analog channel type (float)</td>
</tr>
<tr>
<td>FF</td>
<td>Scale factor type</td>
</tr>
<tr>
<td>0000</td>
<td>Scale factor offset in Fast Meter message</td>
</tr>
<tr>
<td>564100000000</td>
<td>Analog channel name (VA)</td>
</tr>
<tr>
<td>01</td>
<td>Analog channel type (float)</td>
</tr>
<tr>
<td>FF</td>
<td>Scale factor type</td>
</tr>
<tr>
<td>0000</td>
<td>Scale factor offset in Fast Meter message</td>
</tr>
<tr>
<td>564200000000</td>
<td>Analog channel name (VB)</td>
</tr>
<tr>
<td>01</td>
<td>Analog channel type (float)</td>
</tr>
<tr>
<td>FF</td>
<td>Scale factor type</td>
</tr>
<tr>
<td>0000</td>
<td>Scale factor offset in Fast Meter message</td>
</tr>
<tr>
<td>564300000000</td>
<td>Analog channel name (VC)</td>
</tr>
<tr>
<td>01</td>
<td>Analog channel type (float)</td>
</tr>
<tr>
<td>FF</td>
<td>Scale factor type</td>
</tr>
<tr>
<td>0000</td>
<td>Scale factor offset in Fast Meter message</td>
</tr>
<tr>
<td>565300000000</td>
<td>Analog channel name (VS)</td>
</tr>
<tr>
<td>01</td>
<td>Analog channel type (float)</td>
</tr>
<tr>
<td>FF</td>
<td>Scale factor type</td>
</tr>
<tr>
<td>0000</td>
<td>Scale factor offset in Fast Meter message</td>
</tr>
<tr>
<td>Analog channel name</td>
<td>Analog channel type</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>465245510000</td>
<td>Analog channel name (FREQ)</td>
</tr>
</tbody>
</table>

**A5D1 Fast Meter Data Block**

In response to the A5D1 request, the relay sends the following block:

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5D1</td>
<td>Command</td>
</tr>
<tr>
<td>94</td>
<td>Length</td>
</tr>
<tr>
<td>1 byte</td>
<td>1 Status Byte</td>
</tr>
<tr>
<td>80 bytes</td>
<td>X and Y components of: IA, IB, IC, IP, VA, VB, VC, VS, Freq and Vbatt in 4-byte IEEE FPS</td>
</tr>
<tr>
<td>8 bytes</td>
<td>Time stamp</td>
</tr>
<tr>
<td>54 bytes</td>
<td>54 Digital banks: TAR0–TAR53</td>
</tr>
<tr>
<td>1 byte</td>
<td>Reserved</td>
</tr>
<tr>
<td>checksum</td>
<td>1-byte checksum of all preceding bytes</td>
</tr>
</tbody>
</table>

**A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages**

In response to the A5C2 or A5C3 request, the relay sends the following block:

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5C2 or A5C3</td>
<td>Command; Demand (A5C2) or Peak Demand (A5C3)</td>
</tr>
<tr>
<td>E4</td>
<td>Length</td>
</tr>
<tr>
<td>01</td>
<td># of status flag bytes</td>
</tr>
<tr>
<td>00</td>
<td>Scale factors in meter message</td>
</tr>
<tr>
<td>00</td>
<td># of scale factors</td>
</tr>
<tr>
<td>16</td>
<td># of analog input channels</td>
</tr>
<tr>
<td>01</td>
<td># of samples per channel</td>
</tr>
</tbody>
</table>
00 # of digital banks
00 # of calculation blocks
0004 Analog channel offset
00AC Time stamp offset
FFFF Digital offset
491000000000 Analog channel name (IA)
02 Analog channel type
FF Scale factor type
0000 Scale factor offset in Fast Meter message
492000000000 Analog channel name (IB)
02 Analog channel type
FF Scale factor type
0000 Scale factor offset in Fast Meter message
493000000000 Analog channel name (IC)
02 Analog channel type
FF Scale factor type
0000 Scale factor offset in Fast Meter message
494000000000 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
5012B0000000 Analog channel name (PA+)
02 Analog channel type
FF Scale factor type
0000 Scale factor offset in Fast Meter message
5022B0000000 Analog channel name (PB+)
02 Analog channel type
FF Scale factor type
0000 Scale factor offset in Fast Meter message
5032B0000000 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
5141B0000000 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
<table>
<thead>
<tr>
<th>Code</th>
<th>Analog channel name</th>
<th>Analog channel type</th>
<th>Scale factor type</th>
<th>Scale factor offset in Fast Meter message</th>
</tr>
</thead>
<tbody>
<tr>
<td>51432B000000</td>
<td>QC+</td>
<td>02</td>
<td>FF</td>
<td>0000</td>
</tr>
<tr>
<td>51332B000000</td>
<td>Q3+</td>
<td>02</td>
<td>FF</td>
<td>0000</td>
</tr>
<tr>
<td>50412D000000</td>
<td>PA-</td>
<td>02</td>
<td>FF</td>
<td>0000</td>
</tr>
<tr>
<td>50422D000000</td>
<td>PB-</td>
<td>02</td>
<td>FF</td>
<td>0000</td>
</tr>
<tr>
<td>50432D000000</td>
<td>PC-</td>
<td>02</td>
<td>FF</td>
<td>0000</td>
</tr>
<tr>
<td>50332D000000</td>
<td>P3-</td>
<td>02</td>
<td>FF</td>
<td>0000</td>
</tr>
<tr>
<td>51412D000000</td>
<td>QA-</td>
<td>02</td>
<td>FF</td>
<td>0000</td>
</tr>
<tr>
<td>51422D000000</td>
<td>QB-</td>
<td>02</td>
<td>FF</td>
<td>0000</td>
</tr>
<tr>
<td>51432D000000</td>
<td>QC-</td>
<td>02</td>
<td>FF</td>
<td>0000</td>
</tr>
<tr>
<td>51332D000000</td>
<td>Q3-</td>
<td>02</td>
<td>FF</td>
<td>0000</td>
</tr>
<tr>
<td>00</td>
<td>Reserved</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>checksum</td>
<td></td>
<td></td>
<td></td>
<td>1-byte checksum of preceding bytes</td>
</tr>
</tbody>
</table>
**A5D2/A5D3 Demand/Peak Demand Fast Meter Message**

In response to the A5D2 or A5D3 request, the relay sends the following block:

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5D2 or A5D3</td>
<td>Command</td>
</tr>
<tr>
<td>B6</td>
<td>Length</td>
</tr>
<tr>
<td>1 byte</td>
<td>1 Status Byte</td>
</tr>
<tr>
<td>168-bytes</td>
<td>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</td>
</tr>
<tr>
<td>8 bytes</td>
<td>Time stamp</td>
</tr>
<tr>
<td>1 byte</td>
<td>Reserved</td>
</tr>
<tr>
<td>1 byte</td>
<td>1-byte checksum of all preceding bytes</td>
</tr>
</tbody>
</table>

**A5B9 Fast Meter Status Acknowledge Message**

In response to the A5B9 request, the relay clears the Fast Meter (message A5D1) Status Byte. The SEL-311C Status Byte contains 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:

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5CE</td>
<td>Command</td>
</tr>
<tr>
<td>3C</td>
<td>Length</td>
</tr>
<tr>
<td>01</td>
<td>Support 1 circuit breaker</td>
</tr>
<tr>
<td>0010</td>
<td>Support 16 remote bit set/clear commands</td>
</tr>
<tr>
<td>0100</td>
<td>Allow remote bit pulse commands</td>
</tr>
<tr>
<td>31</td>
<td>Operate code, open breaker 1</td>
</tr>
<tr>
<td>11</td>
<td>Operate code, close breaker 1</td>
</tr>
<tr>
<td>00</td>
<td>Operate code, clear remote bit RB1</td>
</tr>
<tr>
<td>20</td>
<td>Operate code, set remote bit RB1</td>
</tr>
<tr>
<td>40</td>
<td>Operate code, pulse remote bit RB1</td>
</tr>
<tr>
<td>01</td>
<td>Operate code, clear remote bit RB2</td>
</tr>
<tr>
<td>21</td>
<td>Operate code, set remote bit RB2</td>
</tr>
<tr>
<td>41</td>
<td>Operate code, pulse remote bit RB2</td>
</tr>
<tr>
<td>02</td>
<td>Operate code, clear remote bit RB3</td>
</tr>
<tr>
<td>22</td>
<td>Operate code, set remote bit RB3</td>
</tr>
<tr>
<td>42</td>
<td>Operate code, pulse remote bit RB3</td>
</tr>
<tr>
<td>03</td>
<td>Operate code, clear remote bit RB4</td>
</tr>
<tr>
<td>23</td>
<td>Operate code, set remote bit RB4</td>
</tr>
<tr>
<td>43</td>
<td>Operate code, pulse remote bit RB4</td>
</tr>
<tr>
<td>04</td>
<td>Operate code, clear remote bit RB5</td>
</tr>
<tr>
<td>24</td>
<td>Operate code, set remote bit RB5</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>44</td>
<td>Operate code, pulse remote bit RB5</td>
</tr>
<tr>
<td>05</td>
<td>Operate code, clear remote bit RB6</td>
</tr>
<tr>
<td>25</td>
<td>Operate code, set remote bit RB6</td>
</tr>
<tr>
<td>45</td>
<td>Operate code, pulse remote bit RB6</td>
</tr>
<tr>
<td>06</td>
<td>Operate code, clear remote bit RB7</td>
</tr>
<tr>
<td>26</td>
<td>Operate code, set remote bit RB7</td>
</tr>
<tr>
<td>46</td>
<td>Operate code, pulse remote bit RB7</td>
</tr>
<tr>
<td>07</td>
<td>Operate code, clear remote bit RB8</td>
</tr>
<tr>
<td>27</td>
<td>Operate code, set remote bit RB8</td>
</tr>
<tr>
<td>47</td>
<td>Operate code, pulse remote bit RB8</td>
</tr>
<tr>
<td>08</td>
<td>Operate code, clear remote bit RB9</td>
</tr>
<tr>
<td>28</td>
<td>Operate code, set remote bit RB9</td>
</tr>
<tr>
<td>48</td>
<td>Operate code, pulse remote bit RB9</td>
</tr>
<tr>
<td>09</td>
<td>Operate code, clear remote bit RB10</td>
</tr>
<tr>
<td>29</td>
<td>Operate code, set remote bit RB10</td>
</tr>
<tr>
<td>49</td>
<td>Operate code, pulse remote bit RB10</td>
</tr>
<tr>
<td>0A</td>
<td>Operate code, clear remote bit RB11</td>
</tr>
<tr>
<td>2A</td>
<td>Operate code, set remote bit RB11</td>
</tr>
<tr>
<td>4A</td>
<td>Operate code, pulse remote bit RB11</td>
</tr>
<tr>
<td>0B</td>
<td>Operate code, clear remote bit RB12</td>
</tr>
<tr>
<td>2B</td>
<td>Operate code, set remote bit RB12</td>
</tr>
<tr>
<td>4B</td>
<td>Operate code, pulse remote bit RB12</td>
</tr>
<tr>
<td>0C</td>
<td>Operate code, clear remote bit RB13</td>
</tr>
<tr>
<td>2C</td>
<td>Operate code, set remote bit RB13</td>
</tr>
<tr>
<td>4C</td>
<td>Operate code, pulse remote bit RB13</td>
</tr>
<tr>
<td>0D</td>
<td>Operate code, clear remote bit RB14</td>
</tr>
<tr>
<td>2D</td>
<td>Operate code, set remote bit RB14</td>
</tr>
<tr>
<td>4D</td>
<td>Operate code, pulse remote bit RB14</td>
</tr>
<tr>
<td>0E</td>
<td>Operate code, clear remote bit RB15</td>
</tr>
<tr>
<td>2E</td>
<td>Operate code, set remote bit RB15</td>
</tr>
<tr>
<td>4E</td>
<td>Operate code, pulse remote bit RB15</td>
</tr>
<tr>
<td>0F</td>
<td>Operate code, clear remote bit RB16</td>
</tr>
<tr>
<td>2F</td>
<td>Operate code, set remote bit RB16</td>
</tr>
<tr>
<td>4F</td>
<td>Operate code, pulse remote bit RB16</td>
</tr>
<tr>
<td>00</td>
<td>Reserved</td>
</tr>
<tr>
<td></td>
<td>checksum 1-byte checksum of all preceding bytes</td>
</tr>
</tbody>
</table>
**A5E0 Fast Operate Remote Bit Control**

The external device sends the following message to perform a remote bit operation:

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5E0</td>
<td>Command</td>
</tr>
<tr>
<td>06</td>
<td>Length</td>
</tr>
<tr>
<td>1 byte</td>
<td>Operate code:</td>
</tr>
<tr>
<td></td>
<td>00–0F clear remote bit RB1–RB16</td>
</tr>
<tr>
<td></td>
<td>20–2F set remote bit RB1–RB16</td>
</tr>
<tr>
<td></td>
<td>40–4F pulse remote bit for RB1–RB16 for one processing interval</td>
</tr>
<tr>
<td>1 byte</td>
<td>Operate validation: 4 · Operate code + 1</td>
</tr>
<tr>
<td>checksum</td>
<td>1-byte checksum of preceding bytes</td>
</tr>
</tbody>
</table>

The relay performs the specified remote bit operation if the following conditions are true:

1. The Operate code is valid.
2. The Operate validation = 4 · Operate code + 1.
3. The message checksum is valid.
4. The FASTOP port setting is set to Y.
5. The relay is enabled.

Remote bit set and clear operations are latched by the relay. Remote bit pulse operations assert the remote bit for one processing interval (1/4 cycle).

It is common practice to route remote bits to output contacts to provide remote control of the relay outputs. If you wish to pulse an output contact closed for a specific duration, SEL recommends using the remote bit pulse command and SELOGic® control equations to provide secure and accurate contact control. The remote device sends the remote bit pulse command; the relay controls the timing of the output contact assertion. You can use any remote bit (RB1 through RB16), and any SELOGic control equation timer (SV1 through SV16) to control any of the output contacts (OUT101 through OUT108). For example, to pulse output contact OUT104 for 30 cycles with Remote Bit RB4 and SELOGic control equation timer SV4, issue the following relay settings:

*via the SET L command,*

\[
\begin{align*}
SV4 & = RB4 & \text{SV4 input is RB4} \\
OUT104 & = SV4T & \text{route SV4 timer output to OUT104}
\end{align*}
\]

*via the SET command,*

\[
\begin{align*}
SV4PU & = 0 & \text{SV4 pickup time} = 0 \\
SV4DO & = 30 & \text{SV4 dropout time} = 30 \text{ cycles}
\end{align*}
\]

To pulse the contact, send the A5E006430DDB command to the relay.
**A5E3 Fast Operate Breaker Control**

The external device sends the following message to perform a fast breaker open/close:

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5E3</td>
<td>Command</td>
</tr>
<tr>
<td>06</td>
<td>Length</td>
</tr>
<tr>
<td>1 byte</td>
<td>Operate code:</td>
</tr>
<tr>
<td></td>
<td>31—OPEN breaker</td>
</tr>
<tr>
<td></td>
<td>11—CLOSE breaker</td>
</tr>
<tr>
<td>1 byte</td>
<td>Operate Validation: 4 · Operate code + 1</td>
</tr>
<tr>
<td>checksum</td>
<td>1-byte checksum of preceding bytes</td>
</tr>
</tbody>
</table>

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-311C 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:

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5CD</td>
<td>Command</td>
</tr>
<tr>
<td>0E</td>
<td>Message length</td>
</tr>
<tr>
<td>01</td>
<td>The number of Fast Operate reset codes supported</td>
</tr>
<tr>
<td>00</td>
<td>Reserved for future use</td>
</tr>
</tbody>
</table>

**Per Fast Operate reset code, repeat:**

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Fast Operate reset code (e.g., “00” for target reset)</td>
</tr>
<tr>
<td>54415220520000</td>
<td>Fast Operate reset description string (e.g., “TAR R”)</td>
</tr>
<tr>
<td>xx</td>
<td>Checksum</td>
</tr>
</tbody>
</table>

**A5ED Fast Operate Reset Command**

The Fast Operate Reset commands take the following form:

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5ED</td>
<td>Command</td>
</tr>
<tr>
<td>06</td>
<td>Message Length—always 6</td>
</tr>
<tr>
<td>00</td>
<td>Operate Code (e.g., “00” for target reset, “TAR R”)</td>
</tr>
<tr>
<td>01</td>
<td>Operate Validation - (4 + Operate Code) + 1</td>
</tr>
<tr>
<td>xx</td>
<td>Checksum</td>
</tr>
</tbody>
</table>
**ID Message**

In response to the ID command, the relay sends the following information described below.

```
<STX>"FID=SEL-311C-Rrrr-Vv-Zzzzzz-Dyyyymmdd",aaaa"<CR><LF>
"CID=cccc","aaaa"<CR><LF>
"DEVID=[TID SETTING],"aaaa"<CR><LF>
"DEVCODE=48","aaaa"<CR><LF>
"PARTNO=[PARTNO SETTING],"aaaa"<CR><LF>
"CONFIG=bbbbbb","aaaa"<CR><LF><ETX>
```

Where:
- rrr is the firmware revision.
- zzzzzz is settings and protocol version numbers.
- cccc is the 4-digit firmware checksum.
- yyyy is the 4-digit year code.
- mm is the 2 digit month code.
- dd is the 2-digit day code.
- bbbbbbb 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-311C.
PARTNO is the part number that matches the Model Option Table number.

The ID message is available from Access Level 1 and higher.

**DNA Message**

In response to the DNA command, the relay sends names of the Relay Word bits transmitted in the A5D1 message. The first name is associated with the MSB, the last name with the LSB. These names are listed in the Relay Word Bits table for the appropriate model in Section 9: Setting the Relay of this manual. The DNA command is available from Access Level 1 and higher.

The DNA message is:

```
<STX>
"EN","TRP","TIME","COMM","SOTF","RCRS","RCLO","51","0B70"
"A","B","C","G","ZONE1","ZONE2","ZONE3","ZONE4","0A47"
"M1P","M1PT","Z1G","Z1GT","M2P","M2PT","Z2G","Z2GT","0B54"
"Z1T","Z2T","50P1","67P1","67P1T","50G1","67G1","67G1T","0B50"
"51G","51GT","51GR","LOP","ILOP","ZLOAD","ZLOUT","ZLIN","0CA1"
"LB1","LB2","LB3","LB4","LB5","LB6","LB7","LB8","0994"
"LB9","LB10","LB11","LB12","LB13","LB14","LB15","LB16","0AE5"
"RB1","RB2","RB3","RB4","RB5","RB6","RB7","RB8","09C4"
"RB9","RB10","RB11","RB12","RB13","RB14","RB15","RB16","0B15"
"LT1","LT2","LT3","LT4","LT5","LT6","LT7","LT8","0A24"
"LT9","LT10","LT11","LT12","LT13","LT14","LT15","LT16","0B75"
"SV1","SV2","SV3","SV4","SV1T","SV2T","SV3T","SV4T","0BAC"
```


"SV5", "SV6", "SV7", "SV8", "SV5T", "SV6T", "SV7T", "SV8T", "0BCC"
"SV9", "SV10", "SV11", "SV12", "SV9T", "SV10T", "SV11T", "SV12T", "0CD6"
"SV13", "SV14", "SV15", "SV16", "SV13T", "SV14T", "SV15T", "SV16T", "0D44"
"MAB1", "MBC1", "MCA1", "MAB2", "MBC2", "MCA2", "CVTBL", "SOTFT", "0C9A"
"MAG1", "MBG1", "MCG1", "MAG2", "MBG2", "MCG2", "DCHI", "DCLO", "0BE7"
"BCW", "BCWA", "BCWB", "BCWC", "FIDEN", "FSA", "FSB", "FSC", "0BAD"
"SG1", "SG2", "SG3", "SG4", "SG5", "SG6", "OC", "CC", "0969"
"CLOSE", "CF", "TRGTR", "52A", "3PO", "SOTFE", "VPOLV", "50L", "0C55"
"PDEM", "GDEM", "QDEM", "TRIP", "50QF", "50QR", "50GF", "50GR", "0C1D"
"32QF", "32QR", "32GF", "32VE", "32QGE", "32IE", "32QE", "0BA4"
"F32I", "F32I", "F32Q", "F32QG", "F32V", "F32V", "0C18"
"*", "*", "*", "*", "*", "*", "*", "*", "0AD9"
"ALARM", "OUT107", "OUT106", "OUT105", "OUT104", "OUT103", "OUT102", "OUT101", "0FC8"
"M3P", "M3PT", "Z3G", "Z3GT", "M4P", "M4PT", "Z4G", "Z4GT", "0B64"
"Z3T", "Z4T", "50P2", "67P2", "67P2T", "50P3", "67P3", "67P3T", "0B78"
"51P", "51PT", "51PR", "Z1X", "59VA", "MAB3", "MBC3", "MCA3", "0B3C"
"MAG3", "MBG3", "MCG3", "27S", "59S", "*", "*", "59VP", "59VS", "0A6D"
"SF", "25A1", "25A2", "RCSE", "OPTMN", "RSTMN", "*", "*", "0A70"
"79RS", "79CY", "79LO", "SH0", "SH1", "SH2", "SH3", "SH4", "0AAD"
"MAB4", "MBC4", "MCA4", "MAG4", "MBG4", "MCG4", "*", "*", "0A01"
"XAG1", "XBG1", "XCG1", "XAG2", "XBG2", "XCG2", "XAG3", "XBG3", "0C16"
"XAGC", "XAG4", "XBG4", "XCG4", "OSTT", "OSTO", "OST", "50ABC", "0C79"
"X5ABC", "X6ABC", "OSB", "OSB1", "OSB2", "OSB3", "OSB4", "UBOSB", "0CE0"
"50G4", "67G4", "67G4T", "*", "*", "MAB1", "MPP2", "MABC2", "0B74"
"50Q1", "67Q1", "67Q1T", "50Q2", "67Q2", "67Q2T", "59N1", "59N2", "0B90"
"50Q3", "67Q3", "67Q3T", "50Q4", "67Q4", "67Q4T", "59Q", "59V1", "0B75"
"51Q", "51QT", "51QR", "*", "*", "*", "Z2PGS", "67QG2S", "BTX", "0A8D"
"Z3XT", "DSTRT", "NSTRT", "STOP", "Z3RB", "KEY", "EKEY", "ECTT", "0D93"
"PTRX", "UBB1", "UBB2", "UBB", "WFC", "PT", "PTRX1", "PTRX2", "0C3F"
"27AB", "27BC", "27CA", "59AB", "59BC", "59CA", "*", "*", "0971"
"OUT201", "OUT202", "OUT203", "OUT204", "OUT205", "OUT206", "OUT207", "OUT208", "0FF4"
"OUT209", "OUT210", "OUT211", "OUT212", "MPP3", "MPP4", "MABB3", "MPP4", "0E85"
"IN208", "IN207", "IN206", "IN205", "IN204", "IN203", "IN202", "IN201", "0CEC"
"RMB8A", "RMB7A", "RMB6A", "RMB5A", "RMB4A", "RMB3A", "RMB2A", "RMB1A", "0E34"
"TMB8A", "TMB7A", "TMB6A", "TMB5A", "TMB4A", "TMB3A", "TMB2A", "TMB1A", "0E44"
"RMB8B", "RMB7B", "RMB6B", "RMB5B", "RMB4B", "RMB3B", "RMB2B", "0E3C"
"TMB8B", "TMB7B", "TMB6B", "TMB5B", "TMB4B", "TMB3B", "TMB2B", "0E4C"
"LBOKB", "CBADB", "RBAOB", "KOBK", "LAOKA", "CBADA", "RBAOD", "ROK", "0DFA"
"81D1", "81D2", "81D3", "81D4", "81D5", "81D6", "27B1", "*", "0A01"
"81D1T", "81D2T", "81D3T", "81D4T", "81D5T", "81D6T", "*", "*", "0B0F"</ETX>

where <STX> is the STX character (02).
<ETX> is the ETX character (03).
the last field in each line is the 4-byte ASCII hex representation of the checksum for
the line.
"*" indicates an unused bit location.
Messages for other relay models may be derived from the appropriate tables in Section 9: Setting the Relay of this manual, using the above format.

**BNA Message**

In response to the **BNA** command, the relay sends names of the bits transmitted in the Status Byte in the A5D1 message. The first name is the MSB, the last name is the LSB. The BNA message is:

<STX>"*","*","*","STSET","*","*","*","*","yyyy"<ETX>

where: "yyyy" is the 4-byte ASCII representation of the checksum.

"*" indicates an unused bit location.

The **BNA** command is available from Access Level 1 and higher.

**SNS Message**

In response to the **SNS** command, the relay sends the name string of the SER (SER1 SER2 SER3) settings. **SNS** command is available at Access Level 1.

The relay responds to the **SNS** command with the name string in the SER settings. The name string starts with SER1, followed by SER2 and SER3.

For example: If SER1 = 50G1 OUT101; SER2 = 67P1T; SER3 = OUT102 52A; the name string will be "50G1","OUT101","67P1T","OUT102","52A".

If there are more than eight settings in SER, the SNS message will have several rows. Each row will have eight strings, followed by the checksum and cartridge return. The last row may have fewer than eight strings.

SNS message for the SEL-311C is:

<STX>"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR>

"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-311C 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-311C Relay provides the following compressed ASCII commands:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASCII</td>
<td>Configuration message</td>
</tr>
<tr>
<td>CSTATUS</td>
<td>Status message</td>
</tr>
<tr>
<td>CHISTORY</td>
<td>History message</td>
</tr>
<tr>
<td>CEVENT</td>
<td>Event message</td>
</tr>
<tr>
<td>CSUMMARY</td>
<td>Event summary message</td>
</tr>
</tbody>
</table>

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-311C**

Display the SEL-311C Relay compressed ASCII configuration message by sending:

**CAS <CR>**

The relay sends:

<STX>
"CAS",6,"01A9"<CR>
"CST",1,"01B7"<CR>
"1H","FID","022C"<CR>
"1D","45S","0211"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0BB9"<CR>
"1D","I","I","I","I","I","I","I","05F4"<CR>
"23H","IA","IB","IC","IP","VA","VB","VC","VS","MOF","+5V_PS","+5V_REG","-5V_REG","+12V_PS","-12V_PS","+15V_PS","-15V_PS","TEMP","RAM","ROM","A/D","CR_RAM","EEPROM","IO_BRD","271F"<CR>
"1D","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","1789"<CR>
"CHI",1,"01A1"<CR>
"1H","FID","022C"<CR>
"1D","45S","0211"<CR>
"18H","1A","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","0DC3"<CR>
"2H","TRIG","RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A TMB8A TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A RMB8B RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B TMB7B TMB6B TMB5B TMB4B TMB3B TMB2B TMB1B LBOKB CBADB RBADB ROKB LBOKA CBADA RBADA ROKA","3D5A"<CR>
"2D","1S","10S","02FE"<CR>
<ETX>

"YYYY" is the 4-byte hex ASCII representation of the checksum. See CEVENT Command for the definition of the “Names of elements in the relay word separated by spaces” field.

CSTATUS Command—SEL-311C

Display status data in compressed ASCII format by sending:

   CST <CR>

The relay sends:

<STX>"FID","yyyy"<CR>
"Relay FID string","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"IA","IB","IC","IP","VA","VB","VC","VS","MOF","+5V_PS","+5V_REG","-5V_REG","+12V_PS","-12V_PS","+15V_PS","-15V_PS","TEMP","RAM","ROM","A/D","CR_RAM","EEPROM","IO_BRD","yyyy"<CR>
,,xxxx,"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","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-311C

Display history data in compressed ASCII format by sending:

   CHI <CR>

The relay sends:

<STX>"FID","yyyy"<CR>
"Relay FID string","yyyy"<CR>
"REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT","LOCATION","CURR","FREQ","GROUP","SHOT","TARGETS","EVE_ID","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR><ETX>
(the last line is then repeated for each record)

where: "xxxx" are the data values corresponding to the first line labels and
"yyyy" is the 4-byte hex ASCII representation of the checksum.

If the history buffer is empty, the relay responds:

<STX>"No Data Available","0668"<CR><ETX>

**CEVENT Command—SEL-311C**

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","HOUR","MIN","SEC","MSEC","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT",
"LOCATION","SHOT","TARGETS","IA","IB","IC","IP","IG","3I2","yyyy"<CR>
"IA","IB","IC","IP","IG","VAkV","VBkV","VCkV","VSkV","V1MEM","FREQ","VDC",
"TRIG","Names of elements in the relay word separated by spaces ","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"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><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-311C.
"EN TRP TIME COMM SOTF RCRS RCLO 51 A B C G ZONE1 ZONE2 ZONE3 ZONE4 M1P
M1PT Z1G Z1GT M2P M2PT Z2G Z2GT Z1T Z2T 50P1 67P1 67P1T 50G1 67G1 67G1T 51G
51GT 51GR LOP ILOP ZLOAD ZLOUT ZLIN LB1 LB2 LB3 LB4 LB5 LB6 LB7 LB8 LB9
LB10 LB11 LB12 LB13 LB14 LB15 LB16 RB1 RB2 RB3 RB4 RB5 RB6 RB7 RB8 RB9 RB10
RB11 RB12 RB13 RB14 RB15 RB16 LT1 LT2 LT3 LT4 LT5 LT6 LT7 LT8 LT9 LT10 LT11
LT12 LT13 LT14 LT15 LT16 SV1 SV2 SV3 SV4 SV1T SV2T SV3T SV4T SV5 SV6 SV7 SV8
SV5T SV6T SV7T SV8T SV9 SV10 SV11 SV12 SV9T SV10T SV11T SV12T SV13 SV14
SV15 SV16 SV13T SV14T SV15T SV16T MAB1 MBC1 MCA1 MAB2 MBC2 MCA2 CVTBL
SOTFT MAG1 MBG1 MCG1 MAG2 MBG2 MCG2 DCHI DCLO BCW BCWA BCWB BCWC
FIDEN FSA FSB FSC SG1 SG2 SG3 SG4 SG5 SG6 OC CC CLOSE CF TRGTR 52A 3PO
SOTFE VPOLV 50L PDEM GDEM QDEM TRIP 50QF 50QR 50GF 50GR 32QF 32QR 32GF
32GR 32VE 32QGE 32IE 32QE F32I R32I F32Q R32Q F32QG R32QG F32V R32V * * IN106
IN105 IN104 IN103 IN102 IN101 ALARM OUT107 OUT106 OUT105 OUT104 OUT103
OUT102 OUT101 M3P M3PT Z3G Z3GT M4P M4PT Z4G Z4GT Z3T Z4T 50P2 67P2 67P2T
50P3 67P3 67P3T 50G2 67G2 67G2T 50G3 67G3 67G3T * * 51P 51PT 51PR Z1X 59VA
MAB3 MBC3 MCA3 MAG3 MBG3 MCG3 27S 59S * 59VP 59VS SF 25A1 25A2 RCSF
OPTMN RSTMN * * 79RS 79CY 79LO SH0 SH1 SH2 SH3 SH4 MAB4 MBC4 MCA4 MAG4
MBG4 MCG4 * * XAG1 XBG1 XCG1 XAG2 XBG2 XCG2 XAG3 XBG3 XCG3 XAG4 XBG4
XCG4 OSTI OSTO OST 50ABC X5ABC X6ABC OSB OSB1 OSB2 OSB3 OSB4 UBOSB
50G4 67G4 67G4T * MPP1 MABC1 MPP2 MABC2 50Q1 67Q1 67Q1T 50Q2 67Q2 67Q2T
59N1 59N2 50Q3 67Q3 67Q3T 50Q4 67Q4 67Q4T 59Q 59V1 51Q 51QT 51QR * * Z2PGS
67QG2S BTX Z3XT DSTRT NSTRT STOP Z3RB KEY EKEY ECTT PTRX UBB1 UBB2
UBB WFC PT PTRX1 PTRX2 27A 27B 27C 59A 59B 59C 3P27 3P59 27AB 27BC 27CA 59AB
59BC 59CA * * OUT201 OUT202 OUT203 OUT204 OUT205 OUT206 OUT207 OUT208
OUT209 OUT210 OUT211 OUT212 MPP3 MABC3 MPP4 MABC4 IN208 IN207 IN206 IN205
IN204 IN203 IN202 IN201 RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A
RMB1A TMB8A TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A RMB8B
RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B TMB7B TMB6B
TMB5B TMB4B TMB3B TMB2B TMB1B LBOKB CBADB RBADB ROKB LBOKA CBADA
RBADA ROKA 81D1 81D2 81D3 81D4 81D5 81D6 27B81 * 81D1T 81D2T 81D3T 81D4T
81D5T 81D6T * * ","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:
10000004924900000000000000000000000000000200000000000000000000000024000080
0000C0000100000000000000000000000000

Date Code 20011205

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Each bit in the *HEX-ASCII Relay Word* reflects the status of a Relay Word bit. The order of the labels in the “Names of elements in the relay word separated by spaces” field matches the order of the *HEX-ASCII Relay Word*. In the example above, the first two bytes in the *HEX-ASCII Relay Word* are “10”. In binary, this evaluates to 00010000. Mapping the labels to the bits yields:

<table>
<thead>
<tr>
<th>Labels</th>
<th>Z1T</th>
<th>Z2T</th>
<th>50P1</th>
<th>67P1</th>
<th>67P1T</th>
<th>50G1</th>
<th>67G1</th>
<th>67G1T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bits</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

In this example, the 67P1 element is asserted (logical 1); all others are deasserted (logical 0).

**CSU Command—SEL-311C**

Display long summary event report in compressed ASCII format by sending:

```
CSU [N[EXT]] [TERSE]
```

or

```
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-311C-R100-V0-Z001001-D19991203","08E1"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"<CR>
8,23,2000,11,51,17,643,"0460"<CR>
"EVENT","LOCATION","HOUR_T","MIN_T","SEC_T","MSEC_T","EVENT_ID","SHOT",
"FREQ","GROUP","HOUR_C","MIN_C","SEC_C","MSEC_C","TARGETS","BREAKER",
"22F6"<CR>
"CAG_T",-0.11,11,51,17,643,4,.60.00,1,1,0,0,,"SOTF",Open,"0C48"<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>
2,0.00,1,0.00,1,0.00,4,0.00,0.97.00,0.010,0.00,0.010,45.00,0.010,0.00,"0E35"<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>
542,-150.42,9743,-178.72,5523,-178.02,10097,-179.15,15746,-177.54,6384,-16.00,101.190,-
179.31,19.430,-177.38,19.610,-179.61,"183D"<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>
">","0000000000","02FE"<CR>
"*","0000000000","02EA"

If the specified event does not exist, the relay responds:

<STX>"No Data Available","067F"<CR><ETX>
APPENDIX F: SETTING NEGATIVE-SEQUENCE OVERCURRENT ELEMENTS

SETTING NEGATIVE-SEQUENCE DEFINITE-TIME OVERCURRENT ELEMENTS

Negative-sequence instantaneous overcurrent elements 50Q1 through 50Q4 and 67Q1 through 67Q4 should not be set to trip directly. This is because negative-sequence current can transiently appear when a circuit breaker is closed and balanced load current suddenly appears.

To avoid tripping for this transient condition, use negative-sequence definite-time overcurrent elements 67Q1T through 67Q4T with at least 1.5 cycles of time delay (transient condition lasts less than 1.5 cycles). For example, make time delay setting:

\[ 67Q1D = 1.50 \]

for negative-sequence definite-time overcurrent element 67Q1T. Refer to Figure 3.23 for more information on negative-sequence instantaneous and definite-time overcurrent elements.

SETTING NEGATIVE-SEQUENCE TIME-OVERCURRENT ELEMENTS

Negative-sequence time-overcurrent element 51QT should not be set to trip directly when it is set with a low time-dial setting 51QTD, that results in curve times below 3 cycles (see curves in Figures 9.1 through 9.10 in Section 9: Setting the Relay). This is because negative-sequence current can transiently appear when a circuit breaker is closed and balanced load current suddenly appears. Refer to Figure 3.26 for more information on negative-sequence time-overcurrent element 51QT.

To avoid having negative-sequence time-overcurrent element 51QT with such low time dial settings trip for this transient negative-sequence current condition, make settings similar to the following:

\[ SV6PU = 1.50 \text{ cycles} \]

(minimum response time; transient condition lasts less than 1.5 cycles)

\[ SV6 = 51Q \]

(run pickup of negative-sequence time-overcurrent element 51QT through SELOGIC control equation variable timer SV6)

\[ \text{TR} = \ldots + 51QT * SV6T + \ldots \]

(trip conditions; SV6T is the output of the SELOGIC control equation variable timer SV6)
OTHER NEGATIVE-SEQUENCE OVERCURRENT ELEMENT REFERENCES


This IEEE paper is the source of the coordination guidelines and example given in this appendix. The paper also contains analyses of system unbalances and faults and the negative-sequence current generated by such conditions.


This conference paper gives many good application examples for negative-sequence overcurrent elements. The focus is on the transmission system, where negative-sequence overcurrent elements provide better sensitivity than zero-sequence overcurrent elements in detecting some single-line-to-ground faults.

Figure F.1: Minimum Response Time Added to a Negative-Sequence Time-Overcurrent Element 51QT
APPENDIX G: SETTING SELogIC® CONTROL EQUATIONS

SELogIC® control equations combine relay protection and control elements with logic operators to create custom protection and control schemes. This appendix shows how to set the protection and control elements (Relay Word bits) in the SELogIC control equations.

Additional SELogIC control equation setting details are available in Section 9: Setting the Relay (see also Settings Sheets 14 through 18 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-311C Relay.

RELAY WORD BITS

Most of the protection and control element logic outputs shown in the various figures in Section 3 through Section 8 are Relay Word bits (labeled as such in the figures). Each Relay Word bit has a label name and can be in either of the following states:

1 (logical 1) or 0 (logical 0)

Logical 1 represents an element being picked up, timed out, or otherwise asserted.

Logical 0 represents an element being dropped out or otherwise deasserted.

Complete listings of Relay Word bits and their descriptions are referenced in Tables 9.3 and 9.4 in Section 9: Setting the Relay.

Relay Word Bit Operation Example—Phase Time-Overcurrent Element 51PT

As an example of protection element operation via the logic output of Relay Word bits, a phase time-overcurrent element is examined. Refer to phase time-overcurrent element 51PT in Figure 3.24 in Section 3: Distance, Out of Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements. Read the text that accompanies Figure 3.24 (Table 3.5 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:

\[ 51P = 1 \text{ (logical 1)} \]

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:

\[ 51PT = 0 \text{ (logical 0)} \]

If phase time-overcurrent element 51PT is timed out on its curve, Relay Word bit 51PT is in the following state:

\[ 51PT = 1 \text{ (logical 1)} \]

**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:

\[ 51PR = 0 \text{ (logical 0)} \]

If phase time-overcurrent element is fully reset, Relay Word bit 51PR is in the following state:

\[ 51PR = 1 \text{ (logical 1)} \]

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 G.1.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Logic Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>/</td>
<td>rising edge detect</td>
</tr>
<tr>
<td>\</td>
<td>falling edge detect</td>
</tr>
<tr>
<td>()</td>
<td>parentheses</td>
</tr>
<tr>
<td>!</td>
<td>NOT</td>
</tr>
<tr>
<td>*</td>
<td>AND</td>
</tr>
<tr>
<td>+</td>
<td>OR</td>
</tr>
</tbody>
</table>

Operators in a SELOGIC control equation setting are processed in the order shown in Table G.1.
**SELogic Control Equation Parentheses Operator ( )**

More than one set of parentheses ( ) can be used in a SELogic control equation setting. For example, the following SELogic control equation setting has two sets of parentheses:

\[ SV7 = (SV7 + IN101) \times (50P1 + 50G1) \]

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-311C Relay operates on 52a circuit breaker auxiliary contact logic. The SELogic control equation circuit breaker status setting is labeled 52A. See Optoisolated Inputs in Section 7: Inputs, Outputs, Timers, and Other Control Logic and Close Logic in Section 6: Close and Reclose Logic for more information on SELogic control equation circuit breaker status setting 52A.

When a circuit breaker is closed, the 52a circuit breaker auxiliary contact is closed. When a circuit breaker is open, the 52a contact is open.

The opposite is true for a 52b circuit breaker auxiliary contact. When a circuit breaker is closed, the 52b circuit breaker auxiliary contact is open. When the circuit breaker is open, the 52b contact is closed.

If a 52a contact is connected to optoisolated input IN101, the SELogic control equation circuit breaker status setting 52A is set:

\[ 52A = \text{IN101} \]

Conversely, if a 52b contact is connected to optoisolated input IN101, the SELogic control equation circuit breaker status setting 52A is set:

\[ 52A = \neg \text{IN101} \quad \text{[= NOT(IN101)]} \]

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)]:

\[ 52A = \neg \text{IN101} = \text{NOT(IN101)} = \text{NOT}(0) = 1 \]

Thus, the SELogic control equation circuit breaker status setting 52A sees a closed circuit breaker.
With a 52b contact connected, if the circuit breaker is open, the 52b contact is closed and input IN101 is energized [IN101 = 1 (logical 1)]:

\[ 52A = !IN101 = NOT(IN101) = NOT(1) = 0 \]

Thus, the SELOGIC control equation circuit breaker status setting 52A sees an open circuit breaker.

**Example of NOT Operator ! Applied to Multiple Elements (Within Parentheses)**

The SELOGIC control equation trip unlatch setting is set as follows:

\[ ULTR = !(50L + 51G) \]

Refer also to *Trip Logic* in Section 5: *Trip and Target Logic*.

In this factory setting example, the unlatch condition comes true only when both the 50L (low-set overcurrent element pickup indication) and 51G (residual ground time-overcurrent element pickup indication) Relay Word bits deassert:

\[ ULTR = !(50L + 51G) = NOT(50L + 51G) \]

As stated previously, the logic within the parentheses is performed first. In this example, the states of Relay Word bits 50L and 51G are ORed together. Then the NOT operator is applied to the logic resultant from the parentheses.

If either one of 50L or 51G is still asserted [e.g., 51G = 1 (logical 1)], the unlatch condition is not true:

\[ ULTR = NOT(50L + 51G) = NOT(0 + 1) = NOT(1) = 0 \]

If both 50L and 51G are deasserted [i.e., 50L = 0 and 51G = 0 (logical 0)], the unlatch condition is true:

\[ ULTR = NOT(50L + 51G) = NOT(0 + 0) = NOT(0) = 1 \]

and the trip condition can unlatch, subject to other conditions in the trip logic (see Figure 5.1).

**SELogic Control Equation Rising Edge Operator /**

The rising edge operator / is applied to individual Relay Word bits only—not to groups of elements within parentheses. In this example, the SELogic control equation event report generation setting uses rising edge operators:

\[ ER = /51P + /51G + /OUT103 \]
The Relay Word bits in this example are:

- **51P** Maximum phase current above pickup setting 51PP for phase time-overcurrent element 51PT (see Figure 3.24)
- **51G** Maximum residual ground current above pickup setting 51GP for residual ground time-overcurrent element 51GT (see Figure 3.25)

**OUT103** Output contact OUT103 is set as a breaker failure trip output (see Output Contacts in Section 7: Inputs, Outputs, Timers, and Other Control Logic)

When setting ER sees a logical 0 to logical 1 transition, it generates an event report (if the relay is not already generating a report that encompasses the new transition). The rising edge operators in the above factory-setting example allow setting ER to see each transition individually.

Suppose a ground fault occurs and a breaker failure condition finally results. Figure G.1 demonstrates the action of the rising edge operator / on the individual elements in setting ER.

![Diagram showing the action of rising edge operators on individual elements in setting ER](image)

**Figure G.1: Result of Rising Edge Operators on Individual Elements in Setting ER**

Note in Figure G.1 that setting ER sees three separate rising edges, due to the application of rising edge operators / . The rising edge operator / in front of a Relay Word bit sees this logical 0 to logical 1 transition as a “rising edge” and the resultant asserts to logical 1 for one processing interval. The assertions of 51G and 51P are close enough that they will be on the same event report (generated by 51G asserting first). The assertion of OUT103 for a breaker failure condition is some appreciable time later and will generate another event report, if the first event report capture has ended when OUT103 asserts.
If the rising edge operators / were not applied and setting ER was:

\[
ER = 51P + 51G + \text{OUT103}
\]

the ER setting would not see the assertion of OUT103, because 51G and 51P would continue to be asserted at logical 1, as shown in Figure G.1.

**SELogic Control Equation Falling Edge Operator \**

The falling edge operator \ is applied to individual Relay Word bits only—not to groups of elements within parentheses. The falling edge operator \ operates similarly to the rising edge operator, but looks for Relay Word bit deassertion (element going from logical 1 to logical 0). The falling edge operator \ in front of a Relay Word bit sees this logical 1 to logical 0 transition as a “falling edge” and asserts to logical 1 for one processing interval.

For example, suppose the SELOGIC control equation event report generation setting is set with the detection of the falling edge of an out-of-step block element:

\[
ER = \ldots + \text{\textbackslash OSB}
\]

This allows recovery from a power swing condition to be observed. Figure G.2 demonstrates the action of the falling edge operator \ on the out-of-step blocking element in setting ER.

![Figure G.2: Result of Falling Edge Operator on a Deasserting Out-of-Step Blocking Element](image)

**All SELogic Control Equations Must Be Set**

All SELOGIC control equations must be set one of the following ways (they cannot be “blank”):

- single Relay Word bit (e.g., 52A = IN101)
- combination of Relay Word bits (e.g., TR = 51PT+51GT+50P1*SH0)
- directly to logical 1 (e.g., 67P1TC = 1)
- directly to logical 0 (e.g., TRCOMM = 0)
Set SELOGIC Control Equations Directly to 1 or 0

SELOGIC control equations can be set directly to:

1 (logical 1) or 0 (logical 0)

instead of with Relay Word bits. If a SELOGIC control equation setting is set directly to 1, it is always “asserted/on/enabled.” If a SELOGIC control equation setting is set equal to 0, it is always “deasserted/off/disabled.”

Note: SELOGIC control equation torque control settings (e.g., 67P1TC, 51P1TC) cannot be set directly to logical 0.

Under the SHO Command (Show/View Settings) in Section 10: Serial Port Communications and Commands, note that a number of the factory SELOGIC control equation settings are set directly to 1 or 0.

The individual SELOGIC control equation settings explanations (referenced in Settings Sheets 14 through 18 at the end of Section 9: Setting the Relay) discuss whether it makes logical sense to set the given SELOGIC control equation setting to 0 or 1 for certain criteria.

Set SELOGIC Control Equations Directly to 1 or 0—Example

Of special concern are the SELOGIC control equation torque control settings 67P1TC through 51QTC for the overcurrent elements. In the factory settings included in a standard shipment of a SEL-311C Relay, these are all set directly to logical 1. See these factory settings in SHO Command (Show/View Settings) in Section 10: Serial Port Communications and Commands.

If one of these torque control settings is set directly to logical 1

e.g., 67QTC = 1 (set directly to logical 1)

then the corresponding overcurrent element is subject only to the directional control. See Figure 3.23 in Section 3: Distance, Out-of-Step, Overcurrent, Voltage, Synchronism Check, and Frequency Elements for negative-sequence overcurrent element 67QTC logic.

SELOGIC Control Equation Limitations

Any single SELOGIC control equation setting is limited to 15 Relay Word bits that can be combined together with the SELOGIC control equation operators listed in Table G.1. If this limit must be exceeded, use a SELOGIC control equation variable (SELOGIC control equation settings SV1 through SV16) as an intermediate setting step.

For example, assume that the trip equation (SELOGIC control equation trip setting TR) needs more than 15 Relay Word bits in its equation setting. Instead of placing all Relay Word bits into TR, program some of them into the SELOGIC control equation setting SV1. Next use the resultant SELOGIC control equation variable output (Relay Word bit SV1) in the SELOGIC control equation trip setting TR.

Note that the SELOGIC control equation variables (SELOGIC control equation settings SV1 through SV16) are processed after the trip equation (SELOGIC control equation trip setting TR). Thus, any tripping via Relay Word bits SV1 through SV16 can be delayed as much as 1/4 cycle. For most applications, this is probably of no consequence.
The SELOGIC control equation settings as a whole are limited to no more than 447 elements and 49 rising-edge or falling-edge operators.

SELOGIC control equation settings that are set directly to 1 (logical 1) or 0 (logical 0) also have to be included in these limitations—each such setting counted as one element.

After SELOGIC control equation settings changes have been made and the settings are saved, the SEL-311C responds with the following message:

xxx Elements and yy Edges remain available

indicating that “xxx” Relay Word bits can still be used and “yy” rising or falling edge operators can still be applied in the SELOGIC control equations for the particular settings group.

**PROCESSING ORDER AND PROCESSING INTERVAL**

The relay elements and logic (and corresponding SELOGIC control equation settings and resultant Relay Word bits) are processed in a predetermined order. They are processed every quarter-cycle (1/4-cycle), and the Relay Word bit states (logical 1 or logical 0) are updated with each quarter-cycle pass. Thus, the relay-processing interval is 1/4-cycle. Once a Relay Word bit is asserted, it retains the state (logical 1 or logical 0) until it is updated again in the next processing interval. Logical outputs of SELOGIC control equations may be delayed by 1/4-cycle due to relay element processing order.
APPENDIX H: DISTRIBUTED NETWORK PROTOCOL (DNP) 3.00

OVERVIEW

The SEL-311C family of relays are available with the option to support Distributed Network Protocol (DNP) 3.00 Level 2 Slave protocol. This includes access to metering data, protection elements (Relay Word), contact I/O, targets, sequential events recorder, breaker monitor, relay summary event reports, settings groups, and time synchronization. The SEL-311C 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:

<table>
<thead>
<tr>
<th>Label</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPEED</td>
<td>Baud rate (300–38400)</td>
<td>2400</td>
</tr>
<tr>
<td>DNPADR</td>
<td>DNP Address (0–65534)</td>
<td>0</td>
</tr>
<tr>
<td>ECLASS</td>
<td>Class for event data (0–3)</td>
<td>2</td>
</tr>
<tr>
<td>TIMERQ</td>
<td>Time-set request interval (0–32767 min.)</td>
<td>0</td>
</tr>
<tr>
<td>DECPHA</td>
<td>Currents scaling (0–3 decimal places)</td>
<td>1</td>
</tr>
<tr>
<td>DECPVL</td>
<td>Voltages scaling (0–3 decimal places)</td>
<td>1</td>
</tr>
<tr>
<td>DECPLM</td>
<td>Miscellaneous data scaling (0–3 decimal places)</td>
<td>1</td>
</tr>
<tr>
<td>STIMEO</td>
<td>Select/operate time-out (0–30 sec.)</td>
<td>1.0</td>
</tr>
<tr>
<td>DRETRY</td>
<td>Data link retries (0–15)</td>
<td>3</td>
</tr>
<tr>
<td>DTIMEO</td>
<td>Data link time-out (0–5 sec.)</td>
<td>1</td>
</tr>
<tr>
<td>MINDLY</td>
<td>Minimum time from DCD to Tx (0–1 sec.)</td>
<td>0.05</td>
</tr>
<tr>
<td>MAXDLY</td>
<td>Maximum time from DCD to Tx (0–1 sec.)</td>
<td>0.10</td>
</tr>
<tr>
<td>PREDLY</td>
<td>Settle time from RTS on to Tx (OFF, 0–30 sec.)</td>
<td>0</td>
</tr>
<tr>
<td>PSTDLY</td>
<td>Settle time after Tx to RTS off (0–30 sec.)</td>
<td>0</td>
</tr>
<tr>
<td>ANADB</td>
<td>Analog reporting dead band (0–32767 counts)</td>
<td>100</td>
</tr>
<tr>
<td>UNSOL</td>
<td>Enable Unsolicited reporting (Y, N)</td>
<td>N</td>
</tr>
<tr>
<td>PUNSOL</td>
<td>Enable Unsolicited reporting at power-up (Y, N)</td>
<td>N</td>
</tr>
<tr>
<td>REPADR</td>
<td>DNP Address to report to (0–65534)</td>
<td>0</td>
</tr>
<tr>
<td>NUMEVE</td>
<td>Number of events to transmit on (1–200)</td>
<td>10</td>
</tr>
<tr>
<td>AGEEVE</td>
<td>Age of oldest event to transmit on (0–60 sec.)</td>
<td>2.0</td>
</tr>
<tr>
<td>UTIMEO</td>
<td>Unsolicited confirmation timeout (0–50 sec.)</td>
<td>2</td>
</tr>
</tbody>
</table>

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-311C 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-311C 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-311C 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-311C 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-311C decides to transmit on the DNP link, it has to wait if the physical connection is in use. The SEL-311C 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-311C 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>
<thead>
<tr>
<th>Data Retrieval Method</th>
<th>Description</th>
<th>Relevant SEL-311C Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polled Static</td>
<td>The master polls for static (Class 0) data only.</td>
<td>Set ECLASS = 0, Set UNSOL = N.</td>
</tr>
<tr>
<td>Polled Report-by-Exception</td>
<td>The master polls frequently for event data and occasionally for static data.</td>
<td>Set ECLASS to a non-zero value, Set UNSOL = N.</td>
</tr>
</tbody>
</table>
Data Retrieval Method | Description | Relevant SEL-311C Settings
--- | --- | ---
Unsolicited Report-by-Exception | The slave devices send unsolicited event data to the master and the master occasionally sends integrity polls for static data. | Set ECLASS to a non-zero value, Set UNSOL = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent.
Quiescent | The master never polls and relies on unsolicited reports only. | Set ECLASS to a non-zero value, Set UNSOL = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent.

**DEVICE PROFILE**

The following is the device profile as specified in the *DNP 3.00 Subset Definitions* document:

<table>
<thead>
<tr>
<th>DNP 3.00 DEVICE PROFILE DOCUMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>This document must be accompanied by a table having the following headings:</td>
</tr>
<tr>
<td>Object Group</td>
</tr>
<tr>
<td>Object Variation</td>
</tr>
<tr>
<td>Object Name (optional)</td>
</tr>
</tbody>
</table>

Vendor Name: Schweitzer Engineering Laboratories, Inc.

Device Name: SEL-311C

Highest DNP Level Supported:
  - For Requests: **Level 2**
  - For Responses: **Level 2**

Device Function:
- [ ] Master
- [x] Slave

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

- Supports enabling and disabling of unsolicited reports on a class basis.

<table>
<thead>
<tr>
<th>Maximum Data Link Frame Size (octets):</th>
<th>Maximum Application Fragment Size (octets):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitted: <strong>292</strong></td>
<td>Transmitted: <strong>2048</strong> (if &gt;2048, must be configurable)</td>
</tr>
<tr>
<td>Received: (must be 292)</td>
<td>Received: <strong>2048</strong> (must be &gt;249)</td>
</tr>
</tbody>
</table>

---

SEL-311C Instruction Manual
Maximum Data Link Re-tries:
- None
- Fixed at
- Configurable, range 0 to 15

Maximum Application Layer Re-tries:
- None
- Configurable, range to (Fixed is not permitted)

Requires Data Link Layer Confirmation:
- Never
- Always
- Sometimes If ‘Sometimes’, when?
- Configurable If ‘Configurable’, how? by settings.

Requires Application Layer Confirmation:
- Never
- Always (not recommended)
- Sometimes If ‘Sometimes’, when?
- Configurable If ‘Configurable’, how?

Timeouts while waiting for:
- Data Link Confirm
- Complete Appl. Fragment
- Application Confirm
- Complete Appl. Response
- Others

Attaches explanation if ‘Variable’ or ‘Configurable’ was checked for any timeout.

Sends/Executes Control Operations:
- WRITE Binary Outputs
- SELECT/OPERATE
- DIRECT OPERATE
- DIRECT OPERATE—NO ACK
- Count > 1
- Pulse On
- Pulse Off
- Latch On
- Latch Off
- Queue
- Clear Queue

Attaches explanation if ‘Sometimes’ or ‘Configurable’ was checked for any operation.

**FILL OUT THE FOLLOWING ITEM FOR MASTER DEVICES ONLY:**

Expects Binary Input Change Events:
- Either time-tagged or non-time-tagged for a single event
- Both time-tagged and non-time-tagged for a single event
- Configurable (attach explanation)
FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY

Reports Binary Input Change Events when no specific variation requested:
- Never
- Only time-tagged
- Only non-time-tagged
- Configurable to send both, one or the other (attach explanation)

Reports time-tagged Binary Input Change Events when no specific variation requested:
- Never
- Binary Input Change With Time
- Binary Input Change With Relative Time
- Configurable (attach explanation)

Sends Unsolicited Responses:
- Never
- Configurable (attach explanation)
- Only certain objects
- Sometimes (attach explanation)
- ENABLE/DISABLE UNSOLICITED

Function codes supported

Sends Static Data in Unsolicited Responses:
- Never
- When Device Restarts
- When Status Flags Change

No other options are permitted.

Default Counter Object/Variation:
- No Counters Reported
- Configurable (attach explanation)
- Default object 20
- Default variation 6
- Point-by-point list attached

Counters Roll Over at:
- No Counters Reported
- Configurable (attach explanation)
- 16 Bits
- 32 Bits
- Other Value ____________
- Point-by-point list attached

Sends Multi-Fragment Responses:  ☑ Yes  ☐ No

In all cases within the device profile that an item is configurable, it is controlled by SEL-311C settings.

OBJECT TABLE

The supported object, function, and qualifier code combinations are given by the following object table.

Table H.2: SEL-311C DNP Object Table

<table>
<thead>
<tr>
<th>Obj</th>
<th>Var</th>
<th>Description</th>
<th>Func Codes (dec)</th>
<th>Qual Codes (hex)</th>
<th>Func Codes (dec)</th>
<th>Qual Codes (hex)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>Binary Input—All Variations</td>
<td>1</td>
<td>0,1,6,7,8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Binary Input</td>
<td>1</td>
<td>0,1,6,7,8</td>
<td>129</td>
<td>0,1,7,8</td>
</tr>
<tr>
<td>1</td>
<td>2*</td>
<td>Binary Input with Status</td>
<td>1</td>
<td>0,1,6,7,8</td>
<td>129</td>
<td>0,1,7,8</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>Binary Input Change—All Variations</td>
<td>1</td>
<td>6,7,8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obj</td>
<td>Var</td>
<td>Description</td>
<td>Func Codes (dec)</td>
<td>Qual Codes (hex)</td>
<td>Func Codes (dec)</td>
<td>Qual Codes (hex)</td>
</tr>
<tr>
<td>-----</td>
<td>-----</td>
<td>--------------------------------------------------</td>
<td>------------------</td>
<td>------------------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Binary Input Change without Time</td>
<td>1</td>
<td>6,7,8</td>
<td>129</td>
<td>17,28</td>
</tr>
<tr>
<td>2</td>
<td>2*</td>
<td>Binary Input Change with Time</td>
<td>1</td>
<td>6,7,8</td>
<td>129,130</td>
<td>17,28</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Binary Input Change with Relative Time</td>
<td>1</td>
<td>6,7,8</td>
<td>129</td>
<td>17,28</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>Binary Output—All Variations</td>
<td>1</td>
<td>0,1,6,7,8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>Binary Output</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2*</td>
<td>Binary Output Status</td>
<td>1</td>
<td>0,1,6,7,8</td>
<td>129</td>
<td>0,1</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>Control Block—All Variations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>Control Relay Output Block</td>
<td>3,4,5,6</td>
<td>17,28</td>
<td>129</td>
<td>echo of request</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>Pattern Control Block</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>Pattern Mask</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>Binary Counter—All Variations</td>
<td>1</td>
<td>0,1,6,7,8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>32-Bit Binary Counter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>2</td>
<td>16-Bit Binary Counter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>32-Bit Delta Counter</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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Each version of the SEL-311C has a slightly different data map. The following is the default object map supported by the SEL-311C wye-connected PTs (FID = SEL-311C-Rxxx-VM-Dxxxxxxxx).

**Table H.3: SEL-311C-Wye DNP Data Map**

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<th>Index</th>
<th>Description</th>
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<td>01,02</td>
<td>000–499</td>
<td>Relay Word, where 51 is 0 and 81D1T is 431.</td>
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<td>500–999</td>
<td>Relay Word from the SER, encoded same as inputs 000–499 with 500 added.</td>
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<td>01,02</td>
<td>1000–1015</td>
<td>Relay front-panel targets, where 1015 is A, 1008 is ZONE4, 1007 is EN and 1000 is 51.</td>
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<td>01,02</td>
<td>1016–1019</td>
<td>Power factor leading for A-, B-, C-, and 3-phase.</td>
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<td>Relay Disabled.</td>
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<td>Relay diagnostic failure.</td>
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<td>Relay diagnostic warning.</td>
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<td>Settings change or relay restart.</td>
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<td>00–15</td>
<td>Remote bits RB1–RB16</td>
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<td>Pulse Open command OC.</td>
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<td>Pulse Close command CC.</td>
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<td>Reset energies.</td>
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<td>Read next relay event.</td>
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<td>10,12</td>
<td>24–31</td>
<td>Remote bit pairs RB1–RB16.</td>
</tr>
<tr>
<td>10,12</td>
<td>32</td>
<td>Open/Close pair OC &amp; CC.</td>
</tr>
<tr>
<td>20,22</td>
<td>00</td>
<td>Active settings group.</td>
</tr>
<tr>
<td>20,22</td>
<td>01</td>
<td>Internal breaker trips.</td>
</tr>
<tr>
<td>20,22</td>
<td>02</td>
<td>External breaker trips.</td>
</tr>
<tr>
<td>30,32</td>
<td>00,01</td>
<td>IA magnitude and angle.</td>
</tr>
<tr>
<td>DNP Object Type</td>
<td>Index</td>
<td>Description</td>
</tr>
<tr>
<td>----------------</td>
<td>--------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>30,32</td>
<td>02,03</td>
<td>IB magnitude and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>04,05</td>
<td>IC magnitude and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>06,07</td>
<td>IP magnitude and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>08,09</td>
<td>VA magnitude (kV) and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>10,11</td>
<td>VB magnitude (kV) and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>12,13</td>
<td>VC magnitude (kV) and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>14,15</td>
<td>VS magnitude (kV) and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>16,17</td>
<td>IG magnitude and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>18,19</td>
<td>I1 magnitude and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>20,21</td>
<td>3I2 magnitude and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>22,23</td>
<td>3V0 magnitude (kV) and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>24,25</td>
<td>V1 magnitude (kV) and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>26,27</td>
<td>V2 magnitude (kV) and angle.</td>
</tr>
<tr>
<td>30,32</td>
<td>40</td>
<td>Frequency.</td>
</tr>
<tr>
<td>30,32</td>
<td>41</td>
<td>VDC.</td>
</tr>
<tr>
<td>30,32</td>
<td>42,43</td>
<td>A-phase MWhr in and out.</td>
</tr>
<tr>
<td>30,32</td>
<td>44,45</td>
<td>B-phase MWhr in and out.</td>
</tr>
<tr>
<td>30,32</td>
<td>46,47</td>
<td>C-phase MWhr in and out.</td>
</tr>
<tr>
<td>30,32</td>
<td>48,49</td>
<td>3-phase MWhr in and out.</td>
</tr>
<tr>
<td>30,32</td>
<td>50,51</td>
<td>A-phase MVARhr in and out.</td>
</tr>
<tr>
<td>30,32</td>
<td>52,53</td>
<td>B-phase MVARhr in and out.</td>
</tr>
<tr>
<td>30,32</td>
<td>54,55</td>
<td>C-phase MVARhr in and out.</td>
</tr>
<tr>
<td>30,32</td>
<td>56,57</td>
<td>3-phase MVARhr in and out.</td>
</tr>
<tr>
<td>30,32</td>
<td>58–62</td>
<td>Demand IA, IB, IC, IG, and 3I2 magnitudes.</td>
</tr>
<tr>
<td>30,32</td>
<td>63–66</td>
<td>A-, B-, C-, and 3-phase demand MW in.</td>
</tr>
<tr>
<td>30,32</td>
<td>67–70</td>
<td>A-, B-, C-, and 3-phase demand MVAR in.</td>
</tr>
<tr>
<td>30,32</td>
<td>71–74</td>
<td>A-, B-, C-, and 3-phase demand MW out.</td>
</tr>
<tr>
<td>30,32</td>
<td>75–78</td>
<td>A-, B-, C-, and 3-phase demand MVAR out.</td>
</tr>
<tr>
<td>30,32</td>
<td>79–83</td>
<td>Peak demand IA, IB, IC, IG, and 3I2 magnitudes.</td>
</tr>
<tr>
<td>30,32</td>
<td>84–87</td>
<td>A-, B-, C-, and 3-phase peak demand MW in.</td>
</tr>
<tr>
<td>30,32</td>
<td>88–91</td>
<td>A-, B-, C-, and 3-phase peak demand MVAR in.</td>
</tr>
<tr>
<td>DNP Object Type</td>
<td>Index</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>30,32</td>
<td>92–95</td>
<td>A-, B-, C-, and 3-phase peak demand MW out.</td>
</tr>
<tr>
<td>30,32</td>
<td>96–99</td>
<td>A-, B-, C-, and 3-phase peak demand MVAR out.</td>
</tr>
<tr>
<td>30,32</td>
<td>100–102</td>
<td>Breaker contact wear percentage (A, B, C).</td>
</tr>
<tr>
<td>30</td>
<td>103</td>
<td>Fault type (see table for definition).</td>
</tr>
<tr>
<td>30</td>
<td>104</td>
<td>Fault location.</td>
</tr>
<tr>
<td>30</td>
<td>105</td>
<td>Fault current.</td>
</tr>
<tr>
<td>30</td>
<td>106</td>
<td>Fault frequency.</td>
</tr>
<tr>
<td>30</td>
<td>107</td>
<td>Fault settings group.</td>
</tr>
<tr>
<td>30</td>
<td>108</td>
<td>Fault recloser shot counter.</td>
</tr>
<tr>
<td>30</td>
<td>109–111</td>
<td>Fault time in DNP format (high, middle, and low 16 bits).</td>
</tr>
<tr>
<td>40,41</td>
<td>00</td>
<td>Active settings group.</td>
</tr>
</tbody>
</table>

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 DECLPL setting. Analog inputs 36–41, 106, and the odd-numbered points in 0–27 (angles) are scaled by 100. The remaining analogs are not scaled.

Event-class messages are generated whenever an input changes beyond the value given by the ANADB setting. The dead-band check is done after any scaling is applied. The angles (the odd numbered points in 0–27) will only generate an event if, in addition to their dead-band check, the corresponding magnitude (the preceding point) contains a value greater than the value given by the ANADB setting. Analog inputs are scanned at approximately a 1-second rate, except for
analogs 103–111. During a scan, all events generated will use the time the scan was initiated. Analogs 103–111 are derived from the history queue data for the most recently read fault and do not generate event messages. Analog 103 is a 16-bit composite value, where the upper byte is defined as follows:

<table>
<thead>
<tr>
<th>Value</th>
<th>Event Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trigger command</td>
</tr>
<tr>
<td>2</td>
<td>Pulse command</td>
</tr>
<tr>
<td>4</td>
<td>Trip element</td>
</tr>
<tr>
<td>8</td>
<td>ER element</td>
</tr>
</tbody>
</table>

And the lower byte is defined as follows:

<table>
<thead>
<tr>
<th>Value</th>
<th>Fault Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Indeterminate</td>
</tr>
<tr>
<td>1</td>
<td>A-Phase</td>
</tr>
<tr>
<td>2</td>
<td>B-Phase</td>
</tr>
<tr>
<td>4</td>
<td>C-Phase</td>
</tr>
<tr>
<td>8</td>
<td>Ground</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Index</th>
<th>Close (0x4X)</th>
<th>Trip (0x8X)</th>
<th>Latch On (3)</th>
<th>Latch Off (4)</th>
<th>Pulse On (1)</th>
<th>Pulse Off (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
<td>Set</td>
<td>Clear</td>
<td>Set</td>
<td>Clear</td>
<td>Pulse</td>
<td>Clear</td>
</tr>
<tr>
<td>16-23</td>
<td>Pulse</td>
<td>Do nothing</td>
<td>Pulse</td>
<td>Do nothing</td>
<td>Pulse</td>
<td>Do nothing</td>
</tr>
<tr>
<td>24</td>
<td>Pulse RB2</td>
<td>Pulse RB1</td>
<td>Pulse RB2</td>
<td>Pulse RB1</td>
<td>Pulse RB2</td>
<td>Pulse RB1</td>
</tr>
<tr>
<td>25</td>
<td>Pulse RB4</td>
<td>Pulse RB3</td>
<td>Pulse RB4</td>
<td>Pulse RB3</td>
<td>Pulse RB4</td>
<td>Pulse RB3</td>
</tr>
<tr>
<td>26</td>
<td>Pulse RB6</td>
<td>Pulse RB5</td>
<td>Pulse RB6</td>
<td>Pulse RB5</td>
<td>Pulse RB6</td>
<td>Pulse RB5</td>
</tr>
<tr>
<td>27</td>
<td>Pulse RB8</td>
<td>Pulse RB7</td>
<td>Pulse RB8</td>
<td>Pulse RB7</td>
<td>Pulse RB8</td>
<td>Pulse RB7</td>
</tr>
<tr>
<td>28</td>
<td>Pulse RB10</td>
<td>Pulse RB9</td>
<td>Pulse RB10</td>
<td>Pulse RB9</td>
<td>Pulse RB10</td>
<td>Pulse RB9</td>
</tr>
<tr>
<td>29</td>
<td>Pulse RB12</td>
<td>Pulse RB11</td>
<td>Pulse RB12</td>
<td>Pulse RB11</td>
<td>Pulse RB12</td>
<td>Pulse RB11</td>
</tr>
<tr>
<td>30</td>
<td>Pulse RB14</td>
<td>Pulse RB13</td>
<td>Pulse RB14</td>
<td>Pulse RB13</td>
<td>Pulse RB14</td>
<td>Pulse RB13</td>
</tr>
<tr>
<td>31</td>
<td>Pulse RB16</td>
<td>Pulse RB15</td>
<td>Pulse RB16</td>
<td>Pulse RB15</td>
<td>Pulse RB16</td>
<td>Pulse RB15</td>
</tr>
<tr>
<td>32</td>
<td>Pulse CC</td>
<td>Pulse OC</td>
<td>Pulse CC</td>
<td>Pulse OC</td>
<td>Pulse CC</td>
<td>Pulse OC</td>
</tr>
</tbody>
</table>

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:

\[
\text{DNP [type]}
\]

where type may be A, B, S, T, or omitted.

If the DNP command is issued without parameters, the relay displays both the analog and the binary maps, which have the following format:

```
    DNP<STX>
  Analogs =  112 28 17 35 1 56 58 59 60 61 62 63 64 65 \n      66 67 100 101 102 103
  Binaries = Default Map<ETX>
```

If the DNP command is issued with an S parameter, the relay displays only the analog map; likewise, a T causes the relay to display only the binary map. If the map checksum is determined to be invalid, the map will be reported as corrupted during a display command, as follows:

```
    DNP T<STX>
  Binaries = Map Corrupted<ETX>
```
If the map is determined to be corrupted, DNP will respond to all master data requests with an unknown point error. If the **DNP** command is issued with an A or B parameter at level 2 or greater, the relay requests that the user enter indices for the corresponding list, where a parameter of A specifies the Analog list and B specifies the Binary list. The relay accepts lines of indices until a line without a final continuation character (\) is entered. Each line of input is constrained to 80 characters, but all the points may be remapped, using multiple lines with continuation characters (\) at the end of the intermediate lines. If a single blank line is entered as the first line, the remapping is disabled for that type (i.e., the relay uses the default analog or binary map). For example, the first example remap could be produced with the following commands:

```dnp
--DNP A
Enter the new DNP Analog map
112 28 17 <CR>
35 1 56 57 58 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**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8B)</td>
<td>PROTO = DNP</td>
</tr>
<tr>
<td>Baud rate (300,600,1200,2400,4800,9600,19200,38400)</td>
<td>SPEED =</td>
</tr>
<tr>
<td>DNP Address (0–65534)</td>
<td>DNPADR =</td>
</tr>
<tr>
<td>Class for event data (0 for no event, 1–3)</td>
<td>ECLASS =</td>
</tr>
<tr>
<td>Time-set request interval, minutes (0 for never, 1–32767)</td>
<td>TIMERQ =</td>
</tr>
<tr>
<td>Currents scaling (0–3 decimal places)</td>
<td>DECPLA =</td>
</tr>
<tr>
<td>Voltages scaling (0–3 decimal places)</td>
<td>DECPLV =</td>
</tr>
<tr>
<td>Miscellaneous data scaling (0–3 decimal places)</td>
<td>DECPLM =</td>
</tr>
<tr>
<td>Select/Operate time-out interval, seconds (0.0–30.0)</td>
<td>STIMEO =</td>
</tr>
<tr>
<td>Number of data-link retries (0 for no confirm, 1–15)</td>
<td>DRETRY =</td>
</tr>
<tr>
<td>Data Link Time-out interval, seconds (0–5)</td>
<td>DTIMEO =</td>
</tr>
<tr>
<td>Minimum Delay from DCD to transmission, seconds (0.00–1.00)</td>
<td>MINDLY =</td>
</tr>
<tr>
<td>Maximum Delay from DCD to transmission, seconds (0.00–1.00)</td>
<td>MAXDLY =</td>
</tr>
<tr>
<td>Transmission delay from RTS assertion, seconds (OFF, 0.00–30.00)</td>
<td>PREDLY =</td>
</tr>
<tr>
<td>Post-transmit RTS deassertion delay, seconds (0.00–30.00)</td>
<td>PSTDLY =</td>
</tr>
<tr>
<td>Analog reporting dead band, counts (0–32767)</td>
<td>ANADB =</td>
</tr>
<tr>
<td>Allow Unsolicited Reporting (Y/N)</td>
<td>UNSOL =</td>
</tr>
<tr>
<td>Enable unsolicited messages on power-up (Y/N)</td>
<td>PUNSOL =</td>
</tr>
<tr>
<td>Address of master to Report to (0–65534)</td>
<td>REPADR =</td>
</tr>
<tr>
<td>Number of events to transmit on (1–200)</td>
<td>NUMEVE =</td>
</tr>
<tr>
<td>Age of oldest event to force transmit on, seconds (0.0–60.0)</td>
<td>AGEEVE =</td>
</tr>
<tr>
<td>Time-out for confirmation of unsolicited message, seconds (0–50)</td>
<td>UTIMEO =</td>
</tr>
</tbody>
</table>
APPENDIX I: MIRRORED BITS™ COMMUNICATIONS

OVERVIEW

MIRRORED BITS is a direct relay-to-relay communications protocol that allows protective relays to exchange information quickly and securely, and with minimal expense. The information exchanged can facilitate remote control, remote sensing, or communications-assisted protection schemes such as POTT, DCB, etc. The SEL-311C supports two MIRRORED BITS channels, differentiated by the channel specifiers A and B. Bits transmitted are called TMB1x through TMB8x, where x is the channel specifier (e.g., A or B), and are controlled by the corresponding SELOGIC control equations. Bits received are called RMB1x through RMB8x and are usable as inputs to any SELOGIC control equations. Channel status bits are called ROKx, RBADx, CBADx and LBOKx and are also usable as inputs to any SELOGIC control equations. Further channel status information is available via the COM command.

Important: Do not connect an unconfigured port to a MIRRORED BITS device. Otherwise the relay will appear to be locked up. Configure the port first, then connect the device.

OPERATION

Message Transmission

All messages are transmitted without idle bits between characters. Idle bits are allowed between messages.

- At 4800 baud, one message is transmitted each 1/2-power system cycle.
- At 9600 baud, one message is transmitted each 1/4-power system cycle.
- At 19200 and 38400 baud, one message is transmitted each 1/8-power system cycle for the SEL-321 and 1/4 power system cycle for the SEL-311C.

Message Decoding and Integrity Checks

The relay will deassert a user-accessible flag per channel (hereafter called ROKx) 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 ROKx 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 ROKx only after successful synchronization as described below and two consecutive messages pass all of the data checks described above. After ROKx is reasserted, received data may be delayed while passing through the security counters described below.

Transfer of received data to RMB1x–RMB8x 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-311C talking to another SEL-311C sends and receives MIRRORED BITS messages four times per power system cycle. Therefore, a security counter set to two counts will delay a bit by about 1/2 power system cycle. Things get a little more complicated when two relays of different processing rates are connected via MIRRORED BITS, such as a SEL-321 talking to a SEL-311C. The SEL-321 processes power system information each 1/8 power system cycle, but processes the pickup/dropout security counters as messages are received. Since the SEL-321 is receiving messages from the SEL-311C, 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-311C will delay a bit by 1/4 cycle, because the SEL-311C is receiving new MIRRORED BITS messages each 1/8 cycle from the SEL-321.

**Synchronization**

When a node detects a communications error, it deasserts ROKx 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 ROKx, 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 ROKx 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 downside, 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 **COM** command to generate a long or summary report of the communications errors.

There is only a single record for each outage, but an outage can evolve. For example, the initial cause could be a data disagreement, but the outage can be perpetuated by framing errors. If the channel is presently down, the **COMM** record will only show the initial cause, but the **COMM** summary will display the present cause of failure.

When the duration of an outage exceeds a user-settable threshold, the relay will assert a user-accessible flag, hereafter called **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)**

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)**

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:

<table>
<thead>
<tr>
<th>SPEED</th>
<th>SEL-321</th>
<th>SEL-311C</th>
</tr>
</thead>
<tbody>
<tr>
<td>38400</td>
<td>1 message per 1/8 cycle</td>
<td>1 message per 1/4 cycle</td>
</tr>
<tr>
<td>19200</td>
<td>1 message per 1/8 cycle</td>
<td>1 message per 1/4 cycle</td>
</tr>
<tr>
<td>9600</td>
<td>1 message per 1/4 cycle</td>
<td>1 message per 1/4 cycle</td>
</tr>
<tr>
<td>4800</td>
<td>1 message per 1/2 cycle</td>
<td>1 message per 1/2 cycle</td>
</tr>
</tbody>
</table>

**enable hardware handshaking (Y,N,MBT)**

Use the MBT option if you are using a Pulsar MBT 9600 baud modem. With this option set, the relay will transmit a message every 1/2-power system cycle and the relay will deassert the RTS signal on the EIA-232 connector. Also, the relay will monitor the CTS signal on the EIA-232 connector, which the modem will deassert if the channel has too many errors. The modem uses the relay’s RTS signal to determine whether the new or old MIRRORED BITS protocol is in use.

**Mirrored Bits Receive bad pickup (1-10000 sec)**

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)**

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 311C 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:

<table>
<thead>
<tr>
<th>Relay</th>
<th>TX_ID</th>
<th>RX_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relay X</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Relay Y</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Relay Z</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Mirrored Bits receive default state (string of 1s, 0s or Xs)
RXDFLT=00000X11

Use the RXDFLT setting to determine the default state the Mirrored Bits should use in place of received data if an error condition is detected. The setting is a mask of 1s, 0s and/or Xs, for RMB1A–RMB8A, where X represents the most recently received valid value.

Mirrored Bits RMB_ Debounce PU msgs (1-8)  RMB1PU= 1  
Mirrored Bits RMB_ Debounce DO msgs (1-8)  RMB1DO= 1  
Mirrored Bits RMB_ Debounce PU msgs (1-8)  RMB2PU= 1  
Mirrored Bits RMB_ Debounce DO msgs (1-8)  RMB2DO= 1  
Mirrored Bits RMB_ Debounce PU msgs (1-8)  RMB3PU= 1  
Mirrored Bits RMB_ Debounce DO msgs (1-8)  RMB3DO= 1  
Mirrored Bits RMB_ Debounce PU msgs (1-8)  RMB4PU= 1  
Mirrored Bits RMB_ Debounce DO msgs (1-8)  RMB4DO= 1  
Mirrored Bits RMB_ Debounce PU msgs (1-8)  RMB5PU= 1  
Mirrored Bits RMB_ Debounce DO msgs (1-8)  RMB5DO= 1  
Mirrored Bits RMB_ Debounce PU msgs (1-8)  RMB6PU= 1  
Mirrored Bits RMB_ Debounce DO msgs (1-8)  RMB6DO= 1  
Mirrored Bits RMB_ Debounce PU msgs (1-8)  RMB7PU= 1  
Mirrored Bits RMB_ Debounce DO msgs (1-8)  RMB7DO= 1  
Mirrored Bits RMB_ Debounce PU msgs (1-8)  RMB8PU= 1  
Mirrored Bits RMB_ Debounce DO msgs (1-8)  RMB8DO= 1  

Supervise the transfer of received data (or default data) to RMB1A–RMB8A with the Mirrored Bits pickup and dropout security counters. Set the pickup and dropout counters individually for each bit.
APPENDIX J: UNSOLICITED FAST SER PROTOCOL

INTRODUCTION

This appendix describes special binary Sequential Events Recorder (Fast SER) messages that are not included in Section 10: Serial Port Communications and Commands of the instruction manual. Devices with embedded processing capability can use these messages to enable and accept unsolicited Fast SER messages from the SEL-311C 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-311C 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-311C Relay to transmit unsolicited Fast SER messages.

2. When SER records are triggered in the SEL-311C, 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-311C Relay disables its own unsolicited transmissions. This function enables the SEL-311C Relay to begin sending unsolicited data to the device which sent the enable message, if the SEL-311C has such data to transfer. The message format for function code 01 is shown below.

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A546</td>
<td>Message header</td>
</tr>
<tr>
<td>12</td>
<td>Message length in bytes (18 decimal)</td>
</tr>
<tr>
<td>0000000000</td>
<td>Five bytes reserved for future use as a routing address</td>
</tr>
<tr>
<td>YY</td>
<td>Status byte (LSB = 1 indicates an acknowledge is requested)</td>
</tr>
<tr>
<td>01</td>
<td>Function code</td>
</tr>
<tr>
<td>C0</td>
<td>Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)</td>
</tr>
<tr>
<td>XX</td>
<td>Response number (XX = 00, 01, 02, 03, 00, 01...)</td>
</tr>
<tr>
<td>18</td>
<td>Function to enable (18—unsolicited Fast SER messages)</td>
</tr>
<tr>
<td>0000</td>
<td>Reserved for future use as function code data</td>
</tr>
<tr>
<td>nn</td>
<td>Maximum number of SER records per message, 01–20 hex</td>
</tr>
<tr>
<td>cccc</td>
<td>Two byte CRC-16 check code for message</td>
</tr>
</tbody>
</table>

The SEL-311C 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-311C Relay from transferring Fast SER data. The message format for function code 02 is shown below.

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A546</td>
<td>Message header</td>
</tr>
<tr>
<td>10</td>
<td>Message length (16 decimal)</td>
</tr>
<tr>
<td>0000000000</td>
<td>Five bytes reserved for future use as a routing address.</td>
</tr>
<tr>
<td>YY</td>
<td>Status byte (LSB = 1 indicates an acknowledge is requested)</td>
</tr>
<tr>
<td>02</td>
<td>Function code</td>
</tr>
<tr>
<td>C0</td>
<td>Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)</td>
</tr>
<tr>
<td>XX</td>
<td>Response number (XX = 00, 01, 02, 03, 01, 02...)</td>
</tr>
<tr>
<td>18</td>
<td>Function to disable (18 = Unsolicited Fast SER)</td>
</tr>
<tr>
<td>00</td>
<td>Reserved for future use as function code data</td>
</tr>
<tr>
<td>cccc</td>
<td>Two byte CRC-16 check code for message</td>
</tr>
</tbody>
</table>

The SEL-311C 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-311C 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.
<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A546</td>
<td>Message header</td>
</tr>
<tr>
<td>ZZ</td>
<td>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.)</td>
</tr>
<tr>
<td>0000000000</td>
<td>Five bytes reserved for future use as a routing address.</td>
</tr>
<tr>
<td>YY</td>
<td>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.)</td>
</tr>
<tr>
<td>18</td>
<td>Function code</td>
</tr>
<tr>
<td>C0</td>
<td>Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)</td>
</tr>
<tr>
<td>XX</td>
<td>Response number (XX = 00, 01, 02, 03, 01, 02...)</td>
</tr>
<tr>
<td>00000000</td>
<td>Four bytes reserved for future use as a return routing address.</td>
</tr>
<tr>
<td>dddd</td>
<td>Two-byte day of year (1–366)</td>
</tr>
<tr>
<td>yyyy</td>
<td>Two-byte, four-digit year (e.g., 1999 or 07CF hex)</td>
</tr>
<tr>
<td>mmmmmmm</td>
<td>Four-byte time of day in milliseconds since midnight</td>
</tr>
<tr>
<td>XX</td>
<td>1st element index (match with the response to the SNS command; 00 for 1st element, 01 for second element, and so on)</td>
</tr>
<tr>
<td>uuuuuu</td>
<td>Three-byte time tag offset of 1st element in microseconds since time indicated in the time of day field.</td>
</tr>
<tr>
<td>XX</td>
<td>2nd element index</td>
</tr>
<tr>
<td>uuuuuu</td>
<td>Three-byte time tag offset of 2nd element in microseconds since time indicated in the time of day field.</td>
</tr>
<tr>
<td>xx</td>
<td>last element index</td>
</tr>
<tr>
<td>uuuuuu</td>
<td>Three-byte time tag offset of last element in microseconds since time indicated in the time of day field.</td>
</tr>
<tr>
<td>FFFFFFFE</td>
<td>Four-byte end-of-records flag</td>
</tr>
<tr>
<td>sssssss</td>
<td>Packed four-byte element status for up to 32 elements (LSB for the 1st element)</td>
</tr>
<tr>
<td>cccc</td>
<td>Two-byte CRC-16 checkcode for message</td>
</tr>
</tbody>
</table>
If the relay determines that SER records have been lost, it sends a message with the following format:

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A546</td>
<td>Message header</td>
</tr>
<tr>
<td>22</td>
<td>Message length (34 decimal)</td>
</tr>
<tr>
<td>00000000000</td>
<td>Five bytes reserved for future use as a routing address.</td>
</tr>
<tr>
<td>YY</td>
<td>Status Byte (01 = need acknowledgement; 03 = settings changed and need acknowledgement)</td>
</tr>
<tr>
<td>18</td>
<td>Function code</td>
</tr>
<tr>
<td>C0</td>
<td>Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)</td>
</tr>
<tr>
<td>XX</td>
<td>Response number (XX = 00, 01, 02, 03, 00, 01, ...)</td>
</tr>
<tr>
<td>00000000</td>
<td>Four bytes reserved for future use as a return routing address.</td>
</tr>
<tr>
<td>dddd</td>
<td>Two-byte day of year (1–366) of overflow message generation</td>
</tr>
<tr>
<td>yyyy</td>
<td>Two-byte, four-digit year (e.g., 1999 or 07CF hex) of overflow message generation.</td>
</tr>
<tr>
<td>mmmmmmmmm</td>
<td>Four-byte time of day in milliseconds since midnight</td>
</tr>
<tr>
<td>FFFFFFFFE</td>
<td>Four-byte end-of-records flag</td>
</tr>
<tr>
<td>00000000</td>
<td>Element status (unused)</td>
</tr>
<tr>
<td>cccc</td>
<td>Two byte CRC-16 checkcode for message</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A546</td>
<td>Message header</td>
</tr>
<tr>
<td>0E</td>
<td>Message length (14 decimal)</td>
</tr>
<tr>
<td>00000000000</td>
<td>Five bytes reserved for future use as a routing address.</td>
</tr>
<tr>
<td>00</td>
<td>Status byte (always 00)</td>
</tr>
<tr>
<td>XX</td>
<td>Function code, echo of acknowledged function code with MSB set.</td>
</tr>
<tr>
<td>RR</td>
<td>Response code (see below)</td>
</tr>
<tr>
<td>XX</td>
<td>Response number (XX = 00, 01, 02, 03, 00, 01, ...) must match response number from message being acknowledged.)</td>
</tr>
<tr>
<td>cccc</td>
<td>Two byte CRC-16 checkcode for message</td>
</tr>
</tbody>
</table>
The SEL-311C supports the following response codes:

<table>
<thead>
<tr>
<th>RR</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Success.</td>
</tr>
<tr>
<td>01</td>
<td>Function code not recognized.</td>
</tr>
</tbody>
</table>

**Examples**

1. Successful acknowledge for “Enable Unsolicited Data Transfer” message from a relay with at least one of SER1, SER2, or SER3 not set to NA:
   
   A5 46 0E 00 00 00 00 00 00 81 00 XX cc cc
   
   (XX is as same as the Response Number in the “Enable Unsolicited Data Transfer” message to which it responds)

2. Unsuccessful acknowledge for “Enable Unsolicited Data Transfer” message from a relay with all of SER1, SER2, and SER3 set to NA:
   
   A5 46 0E 00 00 00 00 00 00 81 02 XX cc cc
   
   (XX is as same as the response number in the “Enable Unsolicited Data Transfer” message to which it responds.)

3. Disable Unsolicited Data Transfer message, acknowledge requested:
   
   A5 46 10 00 00 00 00 00 01 02 C0 XX 18 00 cc cc
   
   (XX = 0, 1, 2, 3)

4. Successful acknowledge from the relay for the “Disable Unsolicited Data Transfer” message:
   
   A5 46 0E 00 00 00 00 00 00 82 00 XX cc cc
   
   (XX is as same as the response number in the “Disable Unsolicited Data Transfer” message to which it responds.)

5. Successful acknowledge message from the master for a Fast SER message:
   
   A5 46 0E 00 00 00 00 00 00 98 00 XX cccc
   
   (XX is as same as the response number in the Fast SER message to which it responds.)

**Notes:**

Once the relay receives an acknowledge with response code 00 from the master, it will clear the settings changed bit (bit 1) in its status byte, if that bit is asserted, and it will clear the settings changed bit in Fast Meter, if that bit is asserted.

An element index of FE indicates that the SER record is due to power up. An element index of FF indicates that the SER record is due to setting change. An element index of FD indicates that the element identified in this SER record is no longer in the SER trigger settings.
When the relay sends an SER message packet, it will put a sequential number (0, 1, 2, 3, 0, 1, ...) into the response number. If the relay does not receive an acknowledge from the master before approximately 500 mS, the relay will resend the same message packet with the same response number until it receives an acknowledge message with that response number. For the next SER message, the relay will increment the response number (it will wrap around to zero from three).

A single SER message packet from the relay can have a maximum number 32 records and the data may span a time period of no more than 16 seconds. The master may limit the number records in a packet with the third byte of function code data in the “Enable Unsolicited Data Transfer” message (function code 01). The relay may generate a Fast SER packet that with less than the requested number of records, if the record time stamps span more than 16 seconds.

The relay always requests acknowledgment in Fast SER messages (LSB of the status byte is set).

Fast SER messages can be enabled on multiple ports simultaneously.
SEL-311C Relay Command Summary

Access Level 0

Command

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

ACC

Enter Access Level 1. If the main board password jumper is not in place, the relay prompts for entry of the Access Level 1 password in order to enter Access Level 1.

Access Level 1

Commands

The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering), not change it. The screen prompt is: =>

2AC

Enter Access Level 2. If the main board password jumper is not in place, the relay prompts for entry of the Access Level 2 password in order to enter Access Level 2.

BAC

Enter Breaker Access Level (Access Level B). If the main board password jumper is not in place, the relay prompts for entry of the Access Level B password.

BRE

Display breaker monitor data (trips, interrupted current, wear).

COM \( p \) L

Show a long format communications summary report for all events on MIRRORED BITS™ Channel \( p \).

COM \( p \) n

Show a communications summary for latest \( n \) events on MIRRORED BITS Channel \( p \).

COM \( p \) m n

Show a communications summary report for events \( n \) through \( m \) on MIRRORED BITS Channel \( p \).

COM \( p \) d1

Show a communications summary report for events occurring on date \( d1 \) on MIRRORED BITS Channel \( p \).

COM \( p \) d1 d2

Show a communications summary report for events occurring between dates \( d1 \) and \( d2 \) on MIRRORED BITS Channel \( p \). Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).

COM C \( p \)

Clears the communications summary report for Channel \( p \).

DAT

Show date.

DAT m/d/y

Enter date in this manner if Date Format setting DATE_F = MDY.

DAT y/m/d

Enter date in this manner if Date Format setting DATE_F = YMD.

EVE \( n \)

Show event report number \( n \) with 1/4-cycle resolution.

EVE L \( n \)

Show event report number \( n \) with 1/16-cycle resolution.

EVE R \( n \)

Show raw event report number \( n \) with 1/16-cycle resolution.

EVE C \( n \)

Show compressed event report number \( n \) for use with SEL-5601 Analytic Assistant.

GRO

Display active group number.

HIS \( n \)

Show brief summary of the \( n \) latest event reports.

HIS C

Clear the brief summary and corresponding event reports.

INI

Displays input/output contact information.

INI T

Displays I/O contact information and I/O board type.

IRI

Force synchronization attempt of internal relay clock to IRIG-B time-code input.

MET \( k \)

Display instantaneous metering data. Enter \( k \) for repeat count.

MET D

Display demand and peak demand data. Enter MET RD or MET RP to reset.

MET E

Display energy metering data. Enter MET RE to reset.

MET M

Display maximum/minimum metering data. Enter MET RM to reset.

QUI

Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) protocol connection. Available in all access levels.

SER \( n \)

Show the latest \( n \) rows in the Sequential Events Recorder (SER) event report.

SER m n

Show rows \( m \) through \( n \) in the Sequential Events Recorder (SER) event report.

SER d1

Show rows in the Sequential Events Recorder (SER) event report from date \( d1 \).

SER d1 d2

Show rows in the Sequential Events Recorder (SER) event report from date \( d1 \) to \( d2 \). Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).

SER C

Clears the Sequential Events Recorder (SER).

SHO \( n \)

Show relay settings (overcurrent, reclosing, timers, etc.) for Group \( n \).

SHO L \( n \)

Show SELogic™ control equation settings for Group \( n \).

SHO G

Show global settings.

SHO P \( n \)

Show Port \( n \) settings.

SHO R

Show Sequential Events Recorder (SER) settings.

SHO T

Show text label settings.
STA Show relay self-test status.
SUM Show newest event summary.
SUM A Acknowledge oldest even summary.
SUM N View oldest unacknowledged event report.
SUM N [A] Display or acknowledge event summary number “N”.
TAR R Reset the front-panel tripping targets.
TAR n k Display Relay Word row. If \( n = 0 \) through 45, display row \( n \). If \( n \) is an element name (e.g., 50G1) display the row containing element \( n \). Enter \( k \) for repeat count.
TIM Show or set time (24 hour time). Show time presently in the relay by entering just TIM. Example time 22:47:36 is entered with command TIM 22:47:36.
TRI Trigger an event report.

**Access Level B Commands**
Access Level B commands primarily allow the user to operate output contacts. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: 

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BRE \( n \) Enter BRE W to preload breaker wear. Enter BRE R to reset breaker monitor data.
CLO Close the circuit breaker. See the Note in the Set Close discussion, following Figure 6.1 for more information concerning the CLO command.
GRO \( n \) Change active group to Group \( n \).
OPE Open the circuit breaker. See the Note following Figure 5.2 and the Note in the Lockout State discussion, following Table 6.1 for more information concerning the OPE command.
PUL \( n \) k Pulse output contact \( n \) (OUT101–OUT107, ALARM, OUT201–OUT212) for \( k \) (1–30) seconds. Parameter \( n \) must be specified; \( k \) defaults to 1 if not specified.

**Access Level 2 Commands**
The Access Level 2 commands allow unlimited access to relay settings, parameters, and output contacts. All Access Level 1 and Access Level B commands are available from Access Level 2. The screen prompt is: 

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CON \( n \) Control Remote Bit RB\( n \) (Remote Bit \( n \); \( n = 1 \) through 8). Execute CON \( n \) and the relay responds:
CONTROL RB\( n \). Then reply with one of the following:
- SRB \( n \) set Remote Bit \( n \) (assert RB\( n \)).
- CRB \( n \) clear Remote Bit \( n \) (deassert RB\( n \)).
- PRB \( n \) pulse Remote Bit \( n \) (assert RB\( n \) for 1/4 cycle).
COP \( m \) n Copy relay and logic settings from Group \( m \) to Group \( n \).
LOO Set M IRRORED BITS port to loopback.
PAS Show existing Access Level 1, B, and 2 passwords.
PAS 1 xxxxxx Change Access Level 1 password to xxxxxx.
PAS B xxxxxx Change Access Level B password to xxxxxx.
PAS 2 xxxxxx Change Access Level 2 password to xxxxxx.
SET \( n \) Change relay settings (overcurrent, reclosing, timers, etc.) for Group \( n \).
SET L \( n \) Change SELOGIC control equation settings for Group \( n \).
SET G Change global settings.
SET P \( n \) Change Port \( n \) settings.
SET R Change Sequential Events Recorder (SER) settings.
SET T Change text label settings.
STA C Resets self-test warnings/failures and reboots relay.
VER Displays version and configuration information.